Francis Bacon
Novum Organum

(English)

1620

Translated and commented by

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20251206

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REVISION HISTORY

2025 – 12 – 06

Based on the collections and editions by
Spedding, Ellis, Heath (1857)
Spedding, Ellis, Heath (1858)
Fowler (1889)
Devey (1902)
Jardine & Silverthorne (2000)
Bennett (2017)

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- the author's name: **Francis Bacon**
- the title of the book: **Novum Organum**
- the editor's name: **Hossein Jorjani**
- a link to the editor's website: https://hosseinjorjani.com/novum-organum/

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Dedication

I dedicate this work to my wife Parvaneh Sharafi, PhD, who patiently listened to my preliminary reflections on the interpretation of *Novum Organum* and on many other philosophical ideas. Her critical engagement encouraged me to clarify and refine my arguments, and her support helped shape the final form of this edition.

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Editor’s preface

My engagement with *Novum Organum* began more than three decades ago, in 1991, when I first encountered a short excerpt from the work in a course on the philosophy of science at the Swedish University of Agricultural Sciences. The instructor, Professor Emeritus Jan Odelstad (then Associate Professor), was remarkable in his ability to reconstruct the intellectual atmosphere of different historical periods. Under his guidance, the appearance of a new idea—such as Bacon’s critique of scholastic reasoning and his proposal for an inductive reformation of the sciences—seemed neither accidental nor abrupt, but the natural outgrowth of a shifting intellectual landscape. That early exposure left an enduring impression: new ways of thinking do not emerge in isolation, and once they do, they invite further transformations.

In subsequent years, as I read more widely in both the classical and modern scientific literature, I often asked myself whether the “new logic” that Bacon had envisioned could be traced in the methods of later scientific innovators. The answer was not always straightforward, yet certain moments were striking. Charles Darwin famously wrote that he had adhered to “the true Baconian method,” even though his actual practice involved a complex interplay of induction, hypothesis, and inference that went beyond Bacon’s formal prescriptions. More compelling still was the work of Ronald A. Fisher, whose 1918 paper "on the correlation of relatives under Mendelian inheritance" displayed an implicit but unmistakable commitment to a disciplined, incremental, empirically grounded mode of inquiry. In such figures, one finds neither a mechanical application of Bacon’s prescriptions nor a direct lineage, but a discernible consonance with the inductive ethos that Bacon sought to articulate—an ethos that privileges careful observation, gradual generalization, and a refusal to allow inherited conceptual structures to dictate the interpretation of nature.

My interest in Bacon has continued since then, shaped both by subsequent work in scientific methodology and by long-standing questions about how—historically and conceptually—Europe’s scientific culture accelerated so sharply after the Renaissance. The *Novum Organum*, with its program for reforming inquiry, consistently appeared as a central text in such investigations. Yet I eventually became aware that, despite Bacon’s significance, a complete and critically robust edition of *Novum Organum* was not readily available in Persian, and that the existing English versions were either outdated, incomplete, unannotated, or

insufficiently suited to contemporary readers. This circumstance gradually formed the basis of the present project.

The current translation and commentary, therefore, arise from both personal continuity and scholarly necessity. They reflect the intellectual trajectory that began in that 1991 course and developed through later work in quantitative genetics, statistics, philosophy of science, and historical inquiry. At the same time, they are motivated by a simple conviction: that *Novum Organum*, as a landmark in the history of scientific method, should be available to readers—Persian-speaking and English-speaking alike—in a form that is textually reliable, intellectually transparent, and historically grounded. The present edition is offered in that spirit.

Where the Historical Significance of Bacon Lies

Francis Bacon's historical significance lies not in any single scientific discovery, nor in the construction of a complete philosophical system, but in the articulation of a methodological program that decisively reoriented the aims, foundations, and expectations of natural inquiry. Writing at a moment when Europe was emerging from the long dominance of scholastic Aristotelianism, Bacon diagnosed the conceptual limitations of inherited modes of reasoning and argued that genuine progress in knowledge required the systematic reform of the intellect. His critique was neither merely rhetorical nor merely negative; it sought to demonstrate that the intellectual habits accumulated over centuries—*idola* of custom, language, authority, and unexamined abstraction—had become obstacles to the discovery of nature.

It is important to note, however, that Bacon was not the first early modern thinker to distance himself from scholastic traditions. Renaissance anatomists, astronomers, and natural philosophers—from Vesalius to Copernicus, from Paracelsus to Galileo—had already broken with key doctrines of medieval authority. What distinguished Bacon was not the rejection of scholasticism *per se*, but the fact that he offered a clear, explicit, and programmatically articulated account of *how* to move beyond it. He supplied a framework for replacing inherited habits of thought with a disciplined method of interrogating nature, beginning from carefully ordered particulars and advancing toward general propositions only by deliberate, incremental steps. In this respect, Bacon gave conceptual structure to a transformation that others were already enacting, turning scattered innovations into a methodological vision.

Bacon's contribution was therefore architectural rather than doctrinal. He offered a new *organon*, not as a completed instrument, but as a set of principles for constructing one. His emphasis on the disciplined accumulation of particulars, the cautious ascent to general propositions, and the continual correction of the mind's inherent tendencies provided a conceptual framework for empirical inquiry at the

very moment when Europe was beginning to explore its possibilities. In this sense, *Novum Organum* stands as the first self-conscious attempt to formulate an epistemology suited to the emerging sciences of the seventeenth century—an epistemology that neither rejected reasoning nor elevated it above observation, but sought to coordinate the two through a structured method of interpretation.

The impact of this methodological articulation was visible almost immediately. An entire generation of early modern investigators found in Bacon's writings a persuasive summary of what needed to be reformed and why. Figures such as Robert Boyle, Robert Hooke, and John Wilkins drew explicitly on Baconian principles in constructing experimental practices grounded in observation, controlled trials, and collaborative record-keeping. The Royal Society—founded only decades after Bacon's death—repeatedly invoked him as a point of orientation, adopting as its unofficial motto the Baconian ideal of *nullius in verba* (no one's word). Even outside England, important natural philosophers such as Christian Huygens and Denis Papin reflected the Baconian emphasis on experiment and the systematic extension of natural histories. These scientists did not follow Bacon as disciples, nor did they treat his proposals as dogma; rather, they recognized in his writings a lucid condensation of their own emerging intuitions about how natural knowledge ought to be pursued. Bacon gave methodological voice to practices that were forming across Europe, and his proposals gained traction precisely because they resonated with the practical needs and epistemic ambitions of working investigators.

Bacon's historical position is further defined by his awareness that knowledge, if it was to advance, required collective labor sustained across generations. The sciences of his day, he argued, had remained "infantile" not because human intellect was incapable of greater achievements, but because inquiry had lacked proper tools, proper records, and proper methods. His call for systematic natural and experimental histories, as well as for organized research projects and the cooperative expansion of knowledge, anticipated the institutional forms that would later characterize European scientific culture. In this sense, Bacon's significance is inseparable from the emergence of a new intellectual economy—one that increasingly treated knowledge as cumulative, corrigible, and oriented toward practical engagement with the natural world.

The influence of Bacon's ideas was neither immediate nor uniform. Many of his methodological proposals remained unrealized in his lifetime, and the sciences developed along trajectories that he could not have fully predicted. Yet the broader orientation he helped establish—empirical, methodologically self-aware, anti-authoritarian, and committed to improving the human condition—became a defining feature of modern scientific thought. It is in this orientation, rather than in any specific theorem or discovery, that his enduring importance is most clearly

seen. His work marks the moment at which the study of nature became explicitly tied to a philosophy of method, and at which the pursuit of knowledge became a consciously reformist enterprise rather than a commentary on inherited doctrines.

Why Bacon and the *Novum Organum* Remain Important Today

The continued relevance of Bacon and the *Novum Organum* arises from the fact that the questions he confronted—how reliable knowledge is generated, how errors of reasoning infiltrate human understanding, and how inquiry should be organized—remain central to scientific and intellectual life. Although many of the specific practices of modern science differ from those Bacon envisioned, the underlying commitments of empirical inquiry still rest on assumptions he articulated with unusual clarity: that nature has an order independent of our wishes, that this order can be approached only through disciplined engagement with experience, and that the mind must consciously guard against its own distortions. These principles are neither antiquated nor completed; they form the philosophical infrastructure of every contemporary scientific discipline.

In recent years, however, the very idea of a shared, methodologically grounded pursuit of knowledge has come under various forms of ideological pressure. Debates about scientific expertise, public trust, and the legitimacy of empirical reasoning have intensified across cultural and political domains. In such a climate, it is useful—perhaps necessary—to recall the intellectual origins of the scientific enterprise. Bacon's work reminds us that the authority of science does not derive from institutions, technologies, or coercive power, but from a commitment to procedures that allow nature to answer our questions on its own terms. It is this commitment, rather than any particular scientific discovery, that made the European scientific tradition distinct. The *Novum Organum* thus offers a historical reminder of what "science" meant when it first began to distance itself from inherited dogma: a method of inquiry grounded in humility, patience, and the willingness to let the world correct our assumptions.

The significance of this reminder extends beyond Europe. Many regions of the world today seek to expand scientific capacity, foster technological growth, or participate more fully in global research networks. For these efforts, it is important to understand that Europe's transformation after the Renaissance was not driven merely by ships, guns, or economic advantage. These were consequences rather than causes. The deeper cause was intellectual: a willingness to question inherited authorities, to observe nature directly, and to construct knowledge according to the order of things rather than the order of tradition. Bacon did not invent this transformation, but he captured its logic and articulated its necessary conditions. For societies seeking to strengthen their scientific culture, his analysis remains instructive—not as a model to imitate mechanically, but as a clarification of the attitudes and methods that allowed systematic inquiry to flourish.

Among the many factors that shaped Europe's scientific rise, historians frequently highlight the emergence of a distinctive culture of self-criticism—an intellectual disposition encouraged by humanism, religious reform, and new methods of inquiry. While scholars differ on the relative weight of this factor, few deny that it played a significant role in enabling the methodological transformations of the seventeenth century. In this context, Bacon and the *Novum Organum* did not invent Europe's self-critical tradition, but they supplied its conceptual architecture: diagnosing the sources of error, articulating the need for systematic self-correction, and proposing a method through which critical inquiry could become cumulative, empirical, and institutionally sustained.

Why a New Translation and Annotated Edition Is Needed Today

Given the continuing relevance of Bacon's methodological reflections, there are several reasons why a new edition of *Novum Organum* is warranted at this moment. First, translations differ widely in accuracy, tone, and faithfulness to the structure of the Latin. Modern English versions often aim for readability at the cost of precision, while older annotated editions preserve precision but employ nineteenth-century idioms that sit uneasily with twenty-first-century readers. A balanced translation that maintains Bacon's conceptual architecture while remaining accessible is therefore needed.

Although the *Novum Organum* is widely cited, there is still no freely available, high-quality, and easily readable edition of the original Latin text. Public-domain scans exist, but they are often difficult to navigate, inconsistent in formatting, or lacking reliable editorial apparatus. Likewise, there is no modern annotated edition—whether in Latin, English, or Persian—that provides comprehensive philological notes, conceptual clarification, and cross-referencing to the wider *Instauratio Magna* (The Great Renewal). The present project is therefore intended to address this gap by making the Latin text, together with new English and Persian translations, freely accessible on my website, accompanied by annotations that allow readers to approach Bacon's arguments with precision and historical context. The English and the Farsi versions will be available at the same link alongside the Latin text.

Second, there is no complete and critically robust Persian translation of *Novum Organum*. Mahmood Sanaee's partial rendering of Book I—based on an abridged twentieth-century English source and omitting both the final aphorisms and the entirety of Book II—cannot serve as a reliable basis for scholarship or teaching. A complete Persian edition, grounded in the Latin and informed by modern scholarship, is an overdue contribution to the study of scientific method in Persian-speaking academic communities.

Third, the *Novum Organum* is not a straightforward text; it requires annotation. Bacon's terminology, references, and rhetorical structure are embedded in the intellectual environment of the early seventeenth century. Without commentary that clarifies key terms (*notio*, *idolum*, *experientia*), situates the aphorisms within the *Instauratio Magna*, and explains conceptual parallels with other early modern thinkers, contemporary readers—whether students or researchers—would be left without the tools necessary to understand the text in its historical and philosophical context.

Finally, a new annotated edition can serve as a bridge between historical insight and present-day concerns. It allows readers to see how Bacon's proposals relate to later developments in scientific reasoning, from experimentalism to statistical inference, and why his insistence on disciplined method still matters in an era where the authority of empirical inquiry is frequently contested. By presenting a carefully translated, historically grounded, and philosophically transparent text, this edition aims to restore *Novum Organum* to its proper place as both a historical document and a living resource for thinking about science.

Textual Basis and Editions Consulted

A reliable edition of *Novum Organum* requires engagement with both the original Latin text and the major historical translations and commentaries that have shaped its reception. The present work is based directly on the Latin text published in 1620, as reproduced in the nineteenth-century scholarly 1857 edition prepared by James Spedding, Robert Leslie Ellis, and Douglas Denon Heath. Their edition, although produced more than two centuries after Bacon's death, remains the most authoritative and philologically careful presentation of the Latin. It reflects extensive comparison of available seventeenth-century printings, careful normalization of orthography, and a transparent editorial method. For purposes of accuracy and completeness, I have also consulted Thomas Fowler's later annotated edition from 1889, which provides an independent set of notes and, on occasion, clarifies points of translation and interpretation not addressed by Spedding, Ellis, and Heath.

In preparing the English translation, I have examined the principal English renderings of *Novum Organum* published during the last century and a half. The nineteenth-century translation by Spedding, Ellis, and Heath, from 1858, remains a valuable resource, both for its fidelity to the Latin and for its extensive historical annotations. Joseph Devey's early twentieth-century translation (1902), although produced for a broader readership and later reprinted in the *Great Books of the Western World* series, offers a useful comparison in matters of tone and phrasing. Among contemporary translations, the version by Lisa Jardine and Michael Silverthorne (2000) provides a modern idiom and a clear sense of Bacon's rhetorical structure, though it includes relatively little commentary. Jonathan

Bennett's 2017 paraphrastic rendering, while not a literal translation, is noteworthy for its pedagogical clarity and for the interpretive choices it brings to light; its departures from the Latin are therefore useful for identifying points where Bacon's language poses particular difficulties for modern readers.

These editions collectively form the textual foundation of the present work. By comparing the Latin across Spedding–Ellis–Heath and Fowler, and by consulting multiple English translations with differing aims and audiences, I have sought to preserve Bacon's conceptual vocabulary, syntactic structure, and rhetorical intentions while offering a translation suited to contemporary scholarship. At the same time, the use of several annotated editions—especially those of Spedding–Ellis–Heath and Fowler—has helped identify passages where Bacon's meaning depends on the intellectual, scientific, or linguistic conventions of the early seventeenth century. These passages receive particular attention in the notes, where the goal is not to provide interpretation, but to offer the historical, philological, and conceptual context necessary for an informed reading.

In addition to the Latin and English sources, this edition incorporates a complete Persian translation grounded directly in the Latin text rather than in any intermediate English rendering. The absence of a comprehensive Persian edition of *Novum Organum* made it essential to establish a clear and consistent correspondence between the Latin terminology and its Persian equivalents. For this reason, the Latin sources cited above were treated not only as textual authorities but also as guides to Bacon's technical vocabulary, allowing the Persian translation to reflect both the structure and the conceptual rigor of the original.

Taken together, these materials provide a stable textual base from which the present translation and commentary are constructed. They allow the reader to engage with Bacon's work in a form that is faithful to the seventeenth-century text, transparent in its editorial choices, and supported by the principal scholarly resources that have shaped modern understanding of *Novum Organum*.

Editorial Method and Principles

The present edition follows a set of editorial principles developed gradually over the course of this project. These principles draw upon established practices in philology and textual scholarship, but they are also tailored to the distinctive challenges posed by the *Novum Organum*—a work that combines dense philosophical argument, technical terminology, and a compressed, aphoristic style. The "ground rules" that shaped the translation and commentary were formulated to ensure that the edition remains faithful to Bacon's Latin, historically responsible, terminologically consistent, and accessible to contemporary readers.

At the foundation of the edition is a commitment to translation fidelity. The English and Persian translations seek to preserve Bacon's meaning, structure, and rhetorical force without smoothing away conceptual difficulties or stylistic compression. Bacon's aphorisms often contain deliberate ambiguity or layered terminology; in such cases, the translation retains the ambiguity and shifts interpretive clarification to the notes. No attempt has been made to modernize Bacon's conceptual vocabulary, and no paraphrastic simplification has been introduced into the translated text. Where the Latin presents syntactic challenges, the translation follows its logic as closely as contemporary English or Persian allows, maintaining the balance between literal accuracy and intelligibility that a scholarly edition requires. Philological conventions—including consistent treatment of Latin and Greek technical terms, their italicization upon first appearance, and uniform translation equivalents across the Latin, English, and Persian versions—are maintained throughout the edition.

Tense discipline plays an important role in maintaining historical clarity. All statements describing the ideas, assumptions, or claims of Bacon and his contemporaries use the past tense. The present tense is reserved for editorial commentary, conceptual explanation, or the statement of enduring scientific or logical principles. This distinction avoids anachronism and signals to the reader when a claim belongs to the intellectual world of the seventeenth century and when it represents a modern analytical observation.

The annotations serve three principal functions: philological clarification, historical contextualization, and conceptual explanation. Each note consists of a concise paragraph that identifies the issue at hand, explains it within the intellectual environment of Bacon's time, and, when appropriate, contrasts it with modern understanding. The notes avoid interpretive speculation unless specifically required for clarity. They also avoid excessive reference to secondary literature; historical editions are used as comparative evidence rather than as authorities. Outdated scientific claims or incorrect explanations are noted succinctly.

To promote readability, the main text and annotations are visually distinguished by font size: Bacon's text appears in a larger font, while the commentary appears in a smaller one. This typographical contrast enables readers to instantly distinguish between the primary text and the editorial apparatus. Notes are numbered sequentially within each section, enclosed in square brackets—[1], [2], [3], and so on—and they are placed immediately after the paragraph in which they are cited. This arrangement makes the commentary accessible without requiring the reader to move between distant parts of the page or document.

In the Persian translation, technical terms are handled through a distinct system designed to maintain clarity for readers while preserving Bacon's conceptual

architecture. All specialized terms appear in English and/or Latin at the bottom of the page, each marked with a sequential number enclosed in curly brackets—{1}, {2}, {3}, etc. This allows the Persian text to remain fluent while giving readers immediate access to the original terminology that underlies Bacon's argument.

Among the annotations, a separate category consists of the notes labeled "Excursus." These are optional, extended clarifications for readers interested in particular conceptual, historical, or methodological topics that cannot be adequately addressed within a standard note. Each *Excursus* elaborates on a specific issue without interrupting the flow of the main text or commentary. Readers may consult them when desiring greater depth or skip them entirely without losing continuity. Their presence reflects the broader aim of the edition: to provide, without imposing, the background knowledge necessary for a comprehensive understanding of Bacon's project.

Taken together, these principles constitute a coherent editorial framework. They ensure that the present edition of the *Novum Organum* remains grounded in the Latin text, sensitive to its historical and conceptual context, and transparent in its methodological commitments. The aim is not to reinterpret Bacon, but to provide readers with the tools required to engage critically and accurately with one of the foundational works in the history of scientific method.

Structure of the Present Edition

The present edition of *Novum Organum* is organized to provide readers with a clear, navigable, and historically grounded presentation of Bacon's work, while also offering the philological and conceptual resources needed for scholarly study. Because the edition appears in three parallel forms—Latin, English, and Persian—the structure of each volume has been kept as consistent as possible, allowing readers to move between them without difficulty. Each version contains the following components, ordered to reflect Bacon's own arrangement of the *Instauratio Magna* and to facilitate modern academic use.

The edition begins with **Bacon's Preface**, followed by the **Letter to King James I**, which places the *Novum Organum* within its original political and intellectual context. Next comes the **Instauratio Magna** (*The Great Renewal*), together with the **Distributio Operis** (*Distribution of the Work*), which outlines Bacon's six-part plan for the renewal of the sciences and indicates the position of the *Novum Organum* within that larger project. This is followed by the **Novum Organum's Preface**, where Bacon explains the rationale, scope, and methodological aspirations of the work. After these introductory materials, the text proceeds to the two books of the *Novum Organum* itself: **Liber Primus**, containing Bacon's critique of existing modes of inquiry and his analysis of the *Idols* of the mind, and

Liber Secundus, in which he demonstrates the practical application of his proposed method.

The core of the edition consists of the two books of *Novum Organum*, presented with their original numbering and paragraph structure intact. Each aphorism appears in a larger font, immediately followed by the corresponding annotations in a smaller font. The footnotes for each paragraph placed directly after the paragraph in which they are cited, allowing readers to consult the commentary without interrupting the flow of the text.

Each volume concludes with appendices and supporting materials. These include indices of terms, a glossary of technical vocabulary, notes on people and works mentioned in the commentary. Together, these materials provide a reference framework for readers who wish to explore Bacon's terminology, historical sources, or methodological commitments in greater detail.

Warnings

This edition is intended primarily for readers interested in the history of the philosophy of science—that is, for those who wish to understand how modern scientific method emerged, how Bacon's proposals fit within the intellectual culture of the early seventeenth century, and how his ideas influenced subsequent generations. Readers seeking to study the philosophy of science itself, in its contemporary forms, are advised to consult modern textbooks and monographs in that field. Bacon's work represents an early and historically significant step in the long development of scientific methodology, but it does not reflect the analytical frameworks, logical tools, or empirical standards that define the discipline today.

Several further cautions are necessary. First, *Novum Organum* is not a textbook of science, nor is it a set of instructions for scientific practice in the modern sense. Its value lies in its historical and conceptual insights, not in its empirical accuracy. Some of Bacon's scientific examples are outdated, incomplete, or incorrect by present standards. Where necessary, the notes identify these issues, but the primary goal is to preserve the historical integrity of Bacon's argument rather than to correct it.

Second, Bacon's terminology belongs to a different intellectual world. Words such as *forma*, *qualitas*, *natura*, and *virtus* cannot be understood through their modern scientific or philosophical meanings. The translation and commentary reflect these differences, but readers are urged not to impose contemporary associations onto seventeenth-century concepts. Anachronistic interpretation is one of the chief obstacles to understanding Bacon's method, and this edition is designed to help prevent it.

Third, readers should be aware that the annotations contain intentional redundancies. Some explanations, definitions, or contextual notes reappear in multiple places. This is deliberate. Individual aphorisms are often circulated or studied independently—both in print and online—and certain clarifications must therefore reappear whenever they are needed for comprehension. Redundancy also ensures that readers consulting a single aphorism do not need to search through earlier pages to locate essential information. Although repetition has been minimized where possible, clarity and accessibility take precedence over strict economy of expression.

Fourth, the Excursus notes provide extended commentary on selected topics. These sections are optional and can be skipped without loss of continuity. They are included for readers who wish to deepen their understanding of particular historical contexts, conceptual lineages, or scientific examples. Readers interested only in the main line of Bacon's argument may ignore them.

Fifth, this edition does not seek to resolve all scholarly debates surrounding Bacon's terminology, method, or historical influence. The aim is to provide a clear, faithful, and well-contextualized presentation of the text, not to offer a new interpretation or to intervene in long-standing academic controversies. Where scholarly disagreement exists, the notes indicate the range of views but refrain from taking a position unless necessary for accuracy.

Sixth, I did not have a professional editor for this work, which may be evident in its shortcomings. Therefore, many problems or inconsistencies may have remained in the book. I would appreciate it if readers could kindly bring these to my attention by contacting me (hosseinjorjani2@gmail.com).

Finally, although the translation and commentary aim for precision, they do not substitute for the primary Latin. Readers able to consult the Latin text are encouraged to do so, especially in places where Bacon's wording carries conceptual or rhetorical force that cannot be fully reproduced in another language. The Latin, English, and Persian versions are offered in parallel precisely to support this comparative approach.

Acknowledgment

I am indebted to all my teachers at the different stages of my education who taught me to think critically and to approach intellectual problems with care and discipline. I am likewise indebted to contemporary scientists with an interest in the philosophy of science and to philosophers of science whose reflections on biology and scientific method have shaped my understanding of how knowledge develops.

It would not be practical to name all of these individuals, but their influence is present throughout this work.

At the outset of this project, access to diverse internet-based libraries and open-access digitization initiatives made it possible to obtain, freely and legally, the texts and materials on which this edition is based. Without such resources, preparing a publicly accessible Latin text together with new English and Persian translations would not have been feasible.

In reading the commentaries of James Spedding, Robert Leslie Ellis, and Douglas Denon Heath (1857), as well as the later notes of Thomas Fowler (1889), I was struck by the breadth and depth of their knowledge, and by the intellectual landscape in which such scholarship was possible. My own work has not required comparable erudition, but I have been fortunate to live in a period in which vast bodies of knowledge are available through online encyclopedias, search engines, and modern AI tools. These resources provided the factual and contextual foundations necessary for preparing an annotated edition. What remained—and what could not be automated or delegated—was the exercise of sound judgment, an ability I owe to the training provided by my teachers and by philosophers of science whose work helped me understand the standards and virtues of careful reasoning.

Hossein Jorjani
December 2025
Solna, Sweden

The plan is rather to advance the whole work of the Instauration on many fronts than to complete it in a few; pursuing this continually with the greatest ardor (such as God, as we firmly believe, is accustomed to inspire in minds), so that what has never yet been attempted may not now be attempted in vain.
Auctoris Monitum (The Author's Warning), 1622.

The First Part of the Instauratio, which comprises the partitions of the sciences, is missing. Nevertheless, some elements of it can be drawn, in part, from the Second Book of *The Advancement of Learning* in Divine and Human Doctrine.

The Second Part of the Instauratio follows, which presents the very art of interpreting nature and of a truer application of the intellect; yet not this itself in the form of a complete and formal treatise, but only arranged under general headings in aphorisms.

Bacon's Preface

Francis of Verulam Thought Thus:

And he established this method for himself, believing it a matter of concern for both the living and those to come that it should be made known to them.

Since he was convinced that the human intellect entangles itself and fails to make sober and appropriate use of the true aids that lie within human power—hence the widespread ignorance of things, and from this ignorance, innumerable harms—he judged it necessary to make every effort to see whether this commerce (relation) between the Mind and Things (to which scarcely anything on earth, or at least among earthly things, is comparable) might be restored to its integrity or at least led to a better state. But there was no hope at all that the errors which have gained strength, and are destined to remain strong forever (if the mind be left to its own devices), would correct themselves, either by the inherent power of reason (understanding) or with the help and support of syllogistics dialectic [1] (logic). This is because the primary notions [2] of things, which the mind easily and lazily absorbs, stores, and accumulates—on which all the rest depend—are flawed, confused, and recklessly abstracted from things themselves. Nor is there any less passion or inconsistency in the secondary and derivative notions. Thus it comes about that the entire structure of human reasoning, as employed in the investigation of nature, is poorly built, like a grand edifice without a foundation [3]. For while men [4] admire and extol the false powers of the mind, they pass over and lose the true powers it could attain—if proper aids were applied and if the mind conformed itself to things, rather than arrogantly dominating them. There remained, then, only this course:

to attempt the matter anew with better supports, and to bring about a Renewal of the sciences and the arts and of all human knowledge in general, founded on legitimate principles. Though this enterprise might appear, at first glance, to be boundless and beyond human strength, yet upon closer consideration, it will be found sound and sober—more so than what has thus far been attempted [5]. For the outcome of this endeavor is not wholly uncertain. In the current state of the sciences, there is instead a kind of dizziness, an endless turmoil, and circular motion. Nor was he unaware of the solitude in which this experiment was carried out, nor of how difficult and unbelievable it would be to win belief. Yet he did not think either the undertaking or himself should be abandoned, but resolved to explore and enter upon the only path open to the human mind. For it is better to begin something that may reach an end than to be caught in perpetual struggle with endeavors that will never conclude. These contemplative paths correspond quite closely to the celebrated active ones: the one, steep and arduous at the outset, ends in open ground; the other, smooth and easy at first, leads to pathless wastes and precipices. And since he was uncertain when such thoughts might occur to anyone else in the future, he was moved especially by the fact that no one so far had turned their mind to such reflections. He therefore resolved to publish whatever initial parts he had been able to complete. This haste was not ambitious but anxious—that if anything human should befall him, at least there would remain some outline and intention of the work he had conceived in his mind, and also some sign of his honest and benevolent will for the good of mankind. Certainly, he considered all other ambition inferior to the matter at hand. For this work is either nothing at all, or of such worth that it deserves contentment in itself and should not seek reward beyond itself [6].

[1] Bacon's original word is *dialectica*. See Footnote [3] in Aphorism 11.

[2] This is the first instance of Bacon's use of the term *notion* (*notio*) in this work. The term holds a central place in his philosophy of method, designating the basic units of thought that require correction before true induction can proceed. For discussion, see *I:12 [1]* "Excursus—On the Term 'Notion' (Notio) in Bacon and Aristotle."

[3] The image of "a grand edifice without a foundation" encapsulated Bacon's critique of speculative systems constructed without empirical grounding. It evoked both Aristotelian and biblical resonances—contrasting formal reasoning built on abstraction with knowledge founded on experience. Bacon used similar imagery elsewhere, notably in *The Advancement of Learning* (1605) and *Novum Organum* I.xiv, to warn against philosophical structures unsupported by observation.

[4] The word *men* appears approximately 90 times in this book. I have preserved Bacon's usage throughout, but ask the reader's understanding—on behalf of both the author and myself—for its historical specificity.

[5] Bacon's call for a "Renewal of the sciences and the arts" introduced the central aim of the *Instauratio Magna*: to reconstruct knowledge upon legitimate foundations. His acknowledgment that the enterprise might seem "boundless" yet "sound and sober" anticipates the Enlightenment's later confidence in systematic reform. The *encyclopédistes* explicitly inherited this Baconian vision, presenting the *Encyclopédie* as a rational reordering of all human knowledge grounded in experience and reason.

[6] In this passage Bacon referred to himself in the third person ("Francis of Verulam thought thus"), adopting the detached tone of an objective witness to his own design. He was fully conscious of the magnitude of the enterprise he had initiated, yet framed its vastness as a rational and necessary reform rather than an act of overreaching ambition.

Letter to King James I

To the Most Serene and Most Powerful Prince and Our Lord,
James,
By the grace of God,
King of Great Britain, France, and Ireland [1],
Defender of the Faith, etc.
Most Serene and Most Powerful King,

Perhaps Your Majesty will accuse me of theft, in that I have stolen enough time from your affairs [2] to complete this undertaking. I have no excuse to offer: time, once taken, cannot be restored—unless perhaps what I have withdrawn from your business might be repaid in the memory of your name and in the honor of your age, if indeed this work holds any worth. It is certainly entirely new, even new in kind; though it has been modeled after a very ancient exemplar—namely, the world itself, and the nature of things and of the human mind [3]. For my part (to speak frankly), I am inclined to view this work as more a product of time than of ingenuity. What is remarkable about it is solely this: that the seeds of such a project, and such deep suspicions about the prevailing doctrines, could have entered anyone's mind. The rest has followed with a certain natural ease. Yet, surely, chance—as we call it—and something of the fortuitous is no less involved in human thoughts [4] than in human actions or speech. But I wish this "chance" to be understood in this way: that if there is any good in what I offer, it is to be ascribed to the boundless mercy and goodness of God, and to the happy condition of your reign. To this reign I have devoted myself in life with the utmost sincerity, and in death, perhaps, I shall have made it so that this age of yours may shine before posterity by the lighting of a new torch amid the darkness of philosophy. Indeed, this Regeneration and Restoration of the Sciences is rightly due to the times

of the wisest and most learned of kings. One request remains, not unworthy of Your Majesty, and most fitting in regard to the matter at hand. It is this: that since in so many respects you resemble Solomon—in the weight of your judgments [5], the peace of your kingdom, the largeness of your heart, and, finally, in the noble variety of the books you have composed—you might also emulate that same king in one more regard: that you might oversee the compilation and completion of a Natural and Experimental History [6], one that is true and exact (without philological digressions), and suited for the establishment of philosophy. Of such a history we shall offer a fuller description in its proper place. In this way, after so many ages of the world, philosophy and the sciences may at last cease to hang in the air, and rest instead upon the firm foundations of a diverse and well-weighed experience. I have, indeed, supplied the Organon; but the materials must be drawn from the things themselves [7].

May God, the Best and Greatest, long preserve Your Majesty in safety.
Your Most Serene Majesty's
Most Bounden and Devoted Servant,
Francis of Verulam,
Chancellor

[1] This dedication was addressed to James I (r. 1603–1625). Such prefaces were customary in early mode

[2] Bacon adopted the rhetorical humility typical of humanist dedications, portraying his philosophical labor as a possible distraction from service to the king.

[3] Here Bacon characterized his project, the *Instauratio Magna*, as a complete renewal of the sciences. Its novelty lay in method, not subject matter, which he claimed was grounded in the order of nature itself.

[4] Bacon acknowledged the contingency of invention but attributed any lasting merit to divine providence rather than human ingenuity—a theme consistent with his Christian natural philosophy.

[5] Bacon often likened James I to Solomon, the biblical model of the wise king (cf. *Advancement of Learning*, 1605). The comparison flattered James while framing the renewal of knowledge as a divinely sanctioned royal task.

[6] Bacon urged the king to support a comprehensive *historia naturalis et experimentalis* as the empirical foundation of philosophy. His own *Historia vitae et mortis* (1623) and *Sylva Sylvarum* (1626) partially realized this vision.

[7] Bacon distinguished between method (*Organon*) and data (*historia*). His claim that the sciences required both anticipated later developments in collective data-gathering projects and systematic methodologies.

Instauratio Magna

Francis Bacon
Instauratio Magna [1].
The Great Renewal

[1] **Excursus – On the Organon and the Novum Organum**

Bacon's *Instauratio magna* ("Great Renewal") was conceived in deliberate correspondence with Aristotle's *Organon* ("Instrument"), the six treatises that had long served as the foundation of Aristotelian logic and method. By designing his *Instauratio* in six parts, Bacon not only echoed the formal structure of the *Organon* but also intended to replace it—to supply a *novum organum*, a "new instrument," by which the intellect might interpret nature through experience rather than syllogism.

In the *Categoriae* (*Categories*), Aristotle analyzed the fundamental kinds of predication; Bacon's First Part, *Partitiones Scientiarum* (*The Divisions of the Sciences*), correspondingly reclassified the whole body of knowledge to expose the inadequacy of inherited divisions.

Aristotle's *De interpretatione* (*On Interpretation*) treated the logic of speech and proposition; Bacon's Second Part, *Novum Organum sive Indicia de Interpretatione Naturae* (*The New Organon, or Indications Concerning the Interpretation of Nature*), replaced verbal analysis with a new method of inquiry grounded in induction.

The *Analytica priora* (*Prior Analytics*) established the principles of syllogistic reasoning; Bacon's Third Part, *Phaenomena Universi sive Historia Naturalis et Experimentalis ad condendam Philosophiam* (*The Phenomena of the Universe, or Natural and Experimental History for the Foundation of Philosophy*), substituted the systematic collection of empirical data for deduction from abstract premises.

Where Aristotle's *Analytica posteriora* (*Posterior Analytics*) prescribed the logic of scientific demonstration, Bacon's Fourth Part, *Scala Intellectus* (*The Ladder*

of the Intellect), described the true ascent from observation to axioms—the proper order of discovery and proof.

The *Topica* (*Topics*), devoted to dialectical reasoning and probable inference, found its counterpart in Bacon's Fifth Part, *Prodromi sive Anticipationes Philosophiae Secundae* (*Forerunners, or Anticipations of the Second Philosophy*), where provisional insights (*anticipationes*) served as heuristic aids rather than dogmatic conclusions.

Finally, Aristotle's *De sophisticis elenchis* (*On Sophistical Refutations*) catalogued logical fallacies, while Bacon's Sixth Part, *Philosophia Secunda sive Scientia Activa* (*The Second Philosophy, or Active Science*), aimed at purging the intellect of its *idola* (illusions) and directing knowledge toward practical dominion over nature.

Thus, Bacon's sixfold *Instauratio magna* both mirrors and transcends Aristotle's *Organon*. The parallel is intentional and programmatic: what Aristotle had offered as an *instrument of reason*, Bacon reformed as an *instrument of discovery*. This design is explicitly presented a few pages later in the *Distributio Operis*:

Prima; Partitiones Scientiarum. Secunda; Novum Organum, sive Indicia de Interpretatione Naturae. Tertia; Phaenomena Universi, sive Historia Naturalis et Experimentalis ad condendam Philosophiam. Quarta; Scala Intellectus. Quinta; Prodromi, sive Anticipationes Philosophiae Secundae. Sexta; Philosophia Secunda, sive Scientia Activa.

First: The Divisions of the Sciences. Second: The Novum Organum, or Indications Concerning the Interpretation of Nature. Third: The Phenomena of the Universe, or Natural and Experimental History for the Foundation of Philosophy. Fourth: The Ladder of the Intellect. Fifth: Forerunners, or Anticipations of the Second Philosophy. Sixth: The Second Philosophy, or Active Science.

The *Distributio* thus confirms Bacon's conscious imitation of the Aristotelian model, while declaring the purpose of the *Instauratio*—not to preserve the ancient logic, but to renew and perfect it through the disciplined interpretation of nature.

Preface

Concerning the condition of the sciences—that it is neither prosperous nor significantly advanced; and that an entirely different

path, unknown to the ancients, must be opened up to the human intellect, and other aids must be procured [2], so that the mind may exercise its rightful authority over nature.

[2] Bacon rejected scholastic dialectic and asserted that the human mind required new methodological aids to navigate nature—chiefly his proposed system of inductive logic.

Men appear to us neither to know well their resources nor their strengths; indeed, they tend to overestimate the former and underestimate the latter. Hence it happens that, either valuing accepted arts at insane prices, they seek nothing further, or, underestimating themselves excessively, they waste their powers on trivialities and do not attempt those things which would most deeply advance the matter. Thus, the sciences too have their own columns, as it were, of fate [3]: for men are not stirred by either desire or hope to push further. And since the belief in abundance is among the greatest causes of poverty, and since, through confidence in what is currently possessed, true aids for the future are neglected, it is useful—and indeed necessary—that at the very threshold of our work (and this with ambiguity set aside and no pretense), the excessive honor and admiration for what has already been discovered be stripped away; with this useful admonition: that men should not overrate or excessively praise either the abundance or the utility of those things. For if anyone were to examine more carefully that entire variety of books in which the arts and sciences abound, he would find everywhere infinite repetitions of the same material, varied in method of treatment, but anticipated in invention; so that all things, numerous at first glance, upon examination turn out to be few. And it must be said plainly regarding utility: the kind of wisdom we have drawn principally from the Greeks seems to represent a certain infancy of knowledge, and possesses what is characteristic of children—namely, readiness to chatter, but weakness and immaturity in producing offspring. For it is fertile in controversies, but barren in works [4]. So

much so that the fable of Scylla seems to apply [5] exactly to the current condition of letters: she who displayed the face and countenance of a maiden, but beneath the waist bore barking monsters girded and clinging about her. Thus also the sciences to which we have grown accustomed possess certain generalities that are seductive and showy; but when it comes to particulars—such as the parts of generation, in order to yield fruit and works from themselves—then disputes and barking controversies arise, in which they end, and which take the place of real birth. Moreover, if these kinds of sciences were not essentially dead things, it would hardly have occurred—what in fact has happened for many centuries—that they remain nearly motionless in their tracks [6] and do not achieve progress worthy of humankind; to such a degree that frequently not only does assertion remain mere assertion, but even the question remains a question, not being resolved through discussion but fixed and nourished by it; and the entire transmission and succession of disciplines presents and exhibits the roles of teacher and student, not of inventor and of one who adds something exceptional to invention. In the mechanical arts, however, we see the contrary happening: they, as if partaking of some vital spirit, grow and are perfected daily; and in their earliest authors they usually appear rough, burdensome, and misshapen, but later acquire new strengths and a kind of utility—so much so that the interest and desires of men tend to fade or shift sooner than these arts reach their own pinnacle and perfection. Philosophy, on the other hand, and the intellectual sciences are revered and celebrated like statues, but they are not advanced. Indeed, they sometimes flourish most in their very first author, and afterward degenerate. For once men have submitted themselves and gathered around the opinion of one (like non-voting senators), they no longer contribute to the enlargement of the sciences themselves, but serve slavishly in adorning and packing around particular authors. Nor let anyone argue that the sciences, gradually increasing, have at last reached a certain mature state, and

have then, as if their legitimate course had been completed, established a permanent seat in the works of a few individuals; and that, since nothing better can now be found, the task remains only to embellish and preserve what has been discovered. And indeed, it would be desirable if this were the case. But it is more accurate and more truthful to say that these entrenchments of the sciences are nothing other than the result of the boldness of a few individuals and the apathy and laziness of the rest. For after the sciences have perhaps been diligently cultivated and handled in parts, there sometimes arises a person bold in intellect and praised for the brevity of his method [7], who, under the appearance of establishing an art, has in fact distorted the labors of the ancients. Yet this is usually welcomed by posterity, because of the ease of application of the system and the weariness and impatience toward new investigation. But if anyone is moved by a long-established consensus as if it were the verdict of time, let him know that he relies on a most deceptive and weak basis. For we are, for the most part, unaware of what in the sciences and arts has become known or made public across various ages and regions; and much less do we know what has been attempted or explored in secret by individuals. Thus neither the births nor the miscarriages of time are recorded in its annals. Nor is consensus itself, nor its duration, to be greatly valued. For although there are various forms of government, there is but one constitution for the sciences, and it has always been—and always will be—popular in nature. And among the people, the doctrines that flourish most are either contentious and combative, or flashy and hollow—such as either ensnare assent or seduce with flattery. Thus, the greatest minds in every age have undoubtedly suffered harm; for men of uncommon intellect and understanding, nevertheless concerned with their own reputation, have submitted themselves to the judgment of the age and of the masses. Wherefore, if at any time loftier reflections have happened to shine forth, they have soon been agitated and extinguished by the winds of popular

opinion. So much so that Time, like a river, has carried to us the light and inflated things, while the weighty and solid have sunk beneath. Even those very authors who have seized a kind of dictatorship in the sciences [8] and pronounce on matters with such confidence, when they occasionally reflect inwardly, turn to complaints about the subtlety of nature, the remoteness of truth [9], the obscurity of things, the complexity of causes, and the weakness of the human intellect; yet they are in no way more modest in this, preferring to blame the universal condition of mankind and things rather than to acknowledge their own deficiencies. Indeed, it is almost a standard practice with them to declare that whatever some art fails to attain must be, by the nature of that same art, impossible. Nor indeed can an art be condemned when it serves as both the disputant and the judge. Thus it comes to pass that ignorance itself is granted exemption from disgrace. And the doctrines that have been handed down and accepted are for the most part of this nature: in their works, sterile and full of questions; slow and feeble in their development; pretending to completeness in the whole, but poorly filled out in their parts; in their selection, popular and even suspect to their own authors, and therefore bolstered and displayed by various artifices. Those, however, who have resolved both to make trials themselves and to contribute to the sciences by extending their boundaries, have not dared wholly to depart from received doctrines, nor to seek the sources of things. Rather, they consider it a great achievement if they insert and add something of their own; prudently reasoning that they may preserve modesty in assenting, and freedom in contributing. Yet, when one seeks to accommodate opinions and customs, such praised mediocrities lead to great harm for the sciences. For it is rare to both admire and surpass an author at the same time [10]. It is like the behavior of water, which does not rise higher than its source. Therefore, such men correct a few things, but promote little, and they advance toward better, but not toward greater. Nor have there been

lacking those who, with greater daring, claimed everything anew for themselves, and by the force of their intellect overthrew and demolished earlier doctrines to open a path for themselves and their own opinions; but from their turbulence, little has been gained: for they aimed not to enlarge philosophy and the arts in substance and in practice, but merely to change doctrines and to transfer the dominion of opinion to themselves—yielding indeed meager fruit, since in opposing errors the causes of error are generally the same. As for those who, bound neither to the opinions of others nor to their own, but inclined toward freedom, were so disposed as to wish to seek truth in common with others—such men, though noble in intention, proved weak in execution. For they seem to have followed only plausible arguments, to have been spun about by the dizziness of reasoning, and to have weakened the rigor of inquiry by an indiscriminate license in questioning. Yet no one is found who has dwelt with due patience upon things themselves and experience. And some, again, who have cast themselves upon the waves of experience and have nearly become mere mechanics, nonetheless carry out an erratic kind of inquiry within experience itself, not governed by any fixed rule. Indeed, the majority have set before themselves petty tasks, considering it a great achievement if they could extract even a single discovery; an approach no less narrow than unskilled. For no one rightly or successfully investigates the nature of anything in the thing itself; rather, after the laborious variation of experiments, he does not rest, but finds further questions to pursue. Nor should it be overlooked, above all, that all industriousness in experimenting has from the very beginning grasped at certain fixed works with premature and untimely zeal; it has sought experiments that bear fruit, not those that bring light; and has not imitated the divine order, which created only light on the first day and assigned to it a full day, without producing any material work on that day, but descended to such works on the following days. But those who assigned the highest functions to syllogistics dialectic, and from it

expected the firmest supports for the sciences, have rightly and wisely judged that the human intellect, left to itself, should rightly be held in suspicion. Yet the medicine is altogether weaker than the disease, and not itself free from the disease. For the accepted syllogistic dialectic, although it may be most aptly applied to civic affairs and to the arts which rest on discourse and opinion, falls far short of the subtlety of nature; and by grasping at what it cannot comprehend, it has served more to confirm and fix errors than to open the path to truth.

[3] This metaphor invoked the “pillars of Hercules” marking the limits of the known world. Bacon believed that the sciences, constrained by custom and reverence for antiquity, had set artificial limits to inquiry.

[4] A foundational critique of scholasticism: Bacon argued that traditional philosophy generated disputes but failed to produce useful knowledge or practical innovations.

[5] In Homer, Scylla appeared beautiful above the waist but monstrous below. Bacon used the image to illustrate how seductive generalities in philosophy concealed discord and sterility in particulars.

[6] Bacon viewed the stagnation of intellectual sciences as evidence that inherited methods—particularly syllogistic reasoning—were inadequate for discovery.

[7] Unlike later empiricists, Bacon did not advocate parsimony as a methodological rule. His aim was not to reduce explanations to minimal form, but to ground them in the full variety of observed particulars. Nature’s order, he held, was subtle and abundant; the task of science was to interpret, not to simplify, her complexity.

[8] An allusion to the dominance of singular authorities (e.g., Aristotle) whose opinions Bacon believed were idolized rather than improved upon.

[9] **Excursus - On the Use of the Term "Truth" by Bacon**
Bacon used the terms involving “truth” frequently. It would be impractical to comment on each of them individually. As the editor of this work, it suffices for me to say that the concept of “truth” has undergone many changes during ages, especially from Bacon’s time to ours.

[10] By “praised mediocrities,” Bacon denounced the half-hearted criticism that sought to reconcile innovation with deference to authority. True progress, he

argued, demanded freedom from admiration of the ancients—"for it is rare to both admire and surpass an author at the same time." The new philosopher was to be firm rather than ruthless, abandoning inherited systems and beginning anew from experience itself.

Therefore, to summarize what has been said: neither reliance on others nor one's own diligence has thus far brought enlightenment to mankind in matters of science; especially since, in both the demonstrations and the experiments known up to now, there is little security. The structure of the universe itself, in its arrangement, presents itself to the contemplating human mind like a labyrinth: where so many ambiguous paths, so deceptive resemblances of things and signs, and so twisted and entangled spirals and knots of nature appear on every side [11]. The journey must constantly be made through the forest of experience and particular things, under the uncertain light of the senses—now flashing, now receding.

[11] Bacon's image of the universe "presenting itself" conveyed his belief in the constancy and law-bound order of nature. For him, the world appeared as a picture—stable and intelligible—inviting interpretation rather than invention. Though dynamic in motion, it remained constant in form, allowing knowledge to arise from the faithful observation of its patterns.

Moreover, the guides who offer themselves for this journey (as has been said) are themselves entangled, and they increase both the number of errors and the number of the errant. In matters so difficult, one must despair of human judgment operating on its own strength, or of accidental good fortune. For neither the highest excellence of intellect, nor the repeated chances of experimentation, can prevail against such difficulties. The steps must be guided by a thread, and every path, starting from the very first perceptions of the senses, must be fortified by a strict method. Nor should these statements be taken as if nothing at all has been achieved through so many centuries and so much effort. For we do not regret what has already been discovered. And certainly the ancients proved themselves admirable men in

matters grounded in abstract thought and intellectual meditation. Yet just as in earlier centuries, when men navigated only by observing the stars, they could indeed trace the coasts of the old continent or cross some smaller and inland seas, but before the ocean could be crossed and the regions of the New World discovered, it was necessary for the use of the magnetic compass [12] to become known, as a more trustworthy and certain guide for the voyage—so also, in precisely the same way, the things that have thus far been discovered in the arts and sciences are of such a kind as could have been found by use, meditation, observation, and reasoning; namely, those things that are closer to the senses and mostly subject to common notions; but before one may approach the more remote and hidden aspects of nature, it is necessarily required that a better and more perfected use and operation of the human mind and intellect be introduced.

[12] Bacon compared his method to the discovery of the magnetic compass—arguing that a reliable guide (his inductive method) was needed to explore the "New World" of nature, as distinct from past reliance on "observation of the stars" (i.e., reason and speculation).

We, certainly, compelled by an eternal love of truth, have committed ourselves to uncertain, difficult paths and solitary places. And relying on and supported by divine aid, we have held firm our mind—against the violence of prevailing opinions and, as it were, their marshaled ranks; against our own inner doubts and scruples; and against the obscurities of things, their clouds, and the phantasms flying in from every side—in order that at last we might furnish more trustworthy and secure signs for the living and for posterity. In this matter, if we have achieved anything, the path was opened to us by no other means than by the true and lawful humbling of the human spirit [13]. For all before us who applied themselves to the invention of the arts, having only briefly directed their eyes toward things, examples, and experience, immediately—as if invention were nothing but a kind of imagination—summoned their own minds to deliver oracles. But we,

dwelling purely and continually among things themselves, do not abstract the intellect from them any farther than to allow the images and rays of things (as happens in sense perception) to converge—whence it follows that little is left to the strength and brilliance of mere ingenuity. And the same humility that we have applied in discovery, we have also followed in teaching. For we do not attempt to impose or secure any grandeur for our discoveries through the triumphs of refutation, appeals to antiquity, the appropriation of authority, or even the veil of obscurity—devices which would be easy to employ for one who sought to shed light upon his name rather than upon the minds of others. We have, I repeat, brought no force nor trickery to bear upon the judgments of others, nor do we intend to; instead, we lead them to the things themselves and to the covenants of things, so that they may see for themselves what they possess, what they assert, what they may contribute, and what they might bring into common discussion. And if in any matter we have believed wrongly, or grown inattentive and drowsy, or faltered along the way and broken off inquiry, nonetheless we present things in such a way—naked and open—that our errors may be observed and distinguished before they taint the body of knowledge more deeply; and that the continuation of our labors may be easy and unhindered. And in this way, we believe we have established a true and lawful union—perpetual and enduring—between the empirical and the rational faculty, whose bitter and ill-fated divorces and separations have disordered all things in the household of man.

[13] This phrase encapsulated Bacon's epistemology: knowledge must begin from things themselves, not the mind's presumptions. This humility defined both his method and his critique of earlier philosophies.

Wherefore, since these things are not within our power, at the beginning of this work, we pour forth our most humble and fervent prayers to God the Father, God the Word, and God the Spirit [14], that—

mindful of the afflictions of the human race and of this pilgrimage of life, in which we pass a few and evil days—they may deign, through our hands, to endow the human family with new mercies. And moreover we earnestly entreat that the human may not interfere with the divine, nor that from the opening of the ways of sense and the greater illumination of natural light, anything of disbelief or darkness may arise in our minds against the divine mysteries; but rather, that from a purified understanding—cleansed of fantasies and vanity, and yet wholly submissive and surrendered to the divine oracles—what is proper to faith may be given to faith. Lastly, that the venom of science infused by the serpent, by which the human mind swells and is puffed up, be laid aside, and that we may neither be wise beyond measure nor beyond sobriety, but may cultivate truth in charity.

[14] Bacon framed scientific inquiry within a Christian context, aligning empirical investigation with divine will. He saw no contradiction between natural philosophy and revealed theology, provided the limits of each were observed.

But having offered our prayers, we now turn to humankind, offering certain salutary admonitions and making fair requests. First, we advise (as we also prayed) that men keep the senses in their proper bounds concerning divine things. For the senses, like the sun, reveal the face of the earth but obscure and seal off the heavens. Again, let them not, in fleeing this error, fall into the opposite one; which will surely occur if they suppose that the investigation of nature is in any way forbidden or proscribed. For that pure and untainted natural knowledge, by which Adam assigned names to things according to their properties, did not cause or occasion the Fall. Rather, it was the ambitious and commanding pursuit of moral knowledge—judging good and evil—with the desire for man to fall away from God and make laws for himself: this was the true form and method of temptation. Concerning the sciences that contemplate nature, that holy philosopher declared: "It is the glory of God to conceal a thing, but the glory of a king to

search it out" [15] As though the divine nature delighted in the innocent and gracious game of children, who hide only to be found; and in its kindness and love for humanity, it made the human soul a playfellow in this game. Lastly, we wish all in general to be reminded to consider the true ends of science—not to pursue it for intellectual vanity, nor for dispute, nor to look down on others, nor for profit, fame, power, or such inferior aims—but for the merit and service of life, and to perfect and govern it through charity. For by the appetite for power, angels fell; by the appetite for knowledge, man fell; but there is no excess in charity—neither angel nor man has ever fallen through it.

[15] The sentence echoes Proverbs 25:2; the English wording follows the King James Version.

The requests we now present are as follows. We remain silent concerning ourselves; but as for the matter at hand, we ask that men consider it not as an opinion but as a work; and hold it certain that we are not laying the foundations of some sect or doctrine, but of human utility and greatness. Next, we ask that, laying aside the zeal of opinions and prejudices, they act with fairness to their own interests and consult for the common good; and, once freed and fortified by our aids and supports from the errors and obstacles of the ways, they themselves also take part in the labors that remain. Moreover, we ask that they hope well; and that they do not imagine or conceive of our Instauration as something infinite and beyond mortal reach—since it is, in truth, the end of infinite error and a legitimate conclusion; and is not forgetful of mortality or of the human condition; since it does not presume to be completed within a single generation, but is designed for transmission. In short, let science be sought not proudly in the cells of the human mind, but humbly in the greater world. For things that are vast are for the most part hollow; what is solid is most often compact and found in little. Lastly, we think it proper to request (lest anyone, perhaps through concern for the cause itself, be unfair toward

us) that men consider to what extent, because we must affirm certain things (if we are to remain consistent with ourselves), they think themselves entitled to pass judgment or opinion on our work: since we reject, in natural inquiry, that whole kind of human reasoning which is premature, anticipatory, and drawn rashly and too early from things—a method various, confused, and poorly constructed. Nor is it reasonable to let the judgment stand of that very thing which is itself being brought to judgment.

Distributo Operis

DISTRIBUTIO OPERIS.

Distribution of the Work.

Its parts are constituted as six [1].

[1] Bacon outlined a six-part division of the *Instauratio Magna*, modeled on the six days of Creation in Genesis. Only parts I–II and partial materials from IV–V were completed.

First: The Divisions of the Sciences.

Second: The Novum Organum, or Indications Concerning the Interpretation of Nature.

Third: The Phenomena of the Universe, or Natural and Experimental History for the Foundation of Philosophy.

Fourth: The Ladder of the Intellect.

Fifth: Forerunners, or Anticipations of the Second Philosophy.

Sixth: The Second Philosophy, or Active Science.

Singularum Argumenta.

The Subjects of Each Part.

Now, it is part of our plan that everything, as far as possible, be presented openly and clearly. For the nakedness of the mind, as once of the body, is the companion of innocence and simplicity. Let the order of the work and its rationale therefore be first laid open. The parts of the work are constituted by us as six.

The first part presents a summary or universal description of that knowledge or doctrine which the human race has so far possessed. For

it seemed proper to us to pause for a moment even over what has already been accepted: with the aim, namely, of allowing both a more complete development of the old and an easier access to the new. For we are moved by an almost equal concern for cultivating the old and for attaining what lies beyond. This also serves to build trust, in accordance with the saying: “The unlearned does not receive the words of knowledge, unless you first speak of what lies in his heart [2].” Therefore, we shall not neglect to survey the shores of the received sciences [3] and arts, and, as we pass through, to import into them certain useful contributions.

[2] Alluding to Proverbs 18:2 in the Vulgate: *Non recipit stultus verba prudentiae, nisi ea dixeris quae versantur in corde eius.* Bacon modifies the phrase "*verba prudentiae*" to "*verba scientiae*" to suit his argument.

[3] Bacon frequently used geographical metaphors to describe the state of knowledge. The “shores” represent the limits of received learning, beyond which his *Instauration* sought to venture.

Nevertheless, we employ such a division of the sciences as embraces not only what has already been discovered and is known, but also what has so far been omitted and remains due. For just as in the terrestrial globe, so too in the intellectual one there are both cultivated and desert regions [4]. Therefore, it should be no cause for wonder if we at times depart from customary divisions. For when the whole is altered by addition, the parts and their subdivisions must necessarily change as well; and the accepted divisions correspond only to the accepted summary of the sciences as it presently stands.

[4] Bacon compared the intellectual landscape to a map of the earth—suggesting that vast regions of inquiry remained unexplored. This image reinforced his claim that existing divisions of knowledge were incomplete.

As for those areas which we shall mark as omitted, we shall proceed in such a way as not merely to propose light headings and brief

summaries of what is lacking. For if we mention among the omissions anything (provided it is a subject of greater dignity) whose rationale seems somewhat obscure—so that we may reasonably suspect that people will not easily understand what we intend, or what kind of work it is that we grasp in thought and design—then we shall always take care either to provide directions for the composition of such a work, or even to append some part of the work already completed by us as a sample of the whole, so that in each case we may assist either by execution or by guidance. For we have also considered it to concern our own reputation, not only others' benefit, that no one should think a mere fleeting notion has brushed our mind on such matters, or that the things we desire and pursue are like mere wishes. Rather, these are matters over which humans (unless they fail themselves) have plain and real control, and which we ourselves possess a definite and articulated understanding of. For we have not undertaken to measure out unknown territories in thought, as augurs do for the sake of omens [5], but to enter them, as leaders, with the intention of achieving something.

[5] An allusion to Roman augury, where priests marked out regions of the sky for signs. Bacon rejected speculative philosophy and emphasized action and entry into uncharted domains of inquiry.

And this constitutes the first part of the work.

Next, having passed beyond the ancient arts, we shall equip the human intellect for the crossing. The second part, therefore, is devoted to the doctrine concerning a better and more perfect use of reason in the investigation of things, and to the true aids of the intellect: so that by this means (as far as the condition of humanity and mortality allows), the intellect may be elevated and its capacity enlarged to overcome the difficult and obscure aspects of nature. And the art we propose (which we have been accustomed to call the Interpretation of Nature [6]) belongs to the genus of logic, although there is a very great—

indeed, vast—difference. For even common logic professes to devise and provide aids and defenses for the intellect, and in this one point they agree. But it differs clearly from the common logic in three main respects: namely, in its end, in its order of demonstration, and in its starting points of inquiry.

[6] Bacon called his method *interpretatio naturae*, or the systematic uncovering of nature's laws through structured inquiry. This stood in contrast to scholastic methods focused on interpreting texts or abstract principles.

For the goal set before our science is that we should discover not arguments but arts [7], not things conforming to principles but the very principles themselves, not plausible explanations but directions and indications of works. Therefore, from a different aim there arises a different result. There, the opponent is defeated and constrained by disputation; here, nature is conquered by operation.

[7] Bacon aimed to generate practical knowledge (*arts*) that could yield control over nature, rather than mere argumentative coherence. His emphasis on utility marked a shift toward an operative science.

And the nature and order of demonstrations must be in accordance with such an end as we propose. For in the common logic, nearly all effort is spent on the syllogism. As for induction, the syllogistic dialecticians appear scarcely to have given it serious thought; passing it by with brief mention, and hastening to the formulas of disputation. But we reject demonstration through syllogism [8], because it proceeds confusedly and lets nature slip from its grasp. Although no one can doubt that things which agree in a middle term must also agree with one another (which is a kind of mathematical certainty), nonetheless, there is a hidden flaw: namely, that the syllogism is made up of propositions, propositions of words, and words are the tokens and signs of notions [9]. Therefore, if the notions themselves of the mind (which are, as it were, the soul of words and the foundation of the

whole structure) are poorly and hastily abstracted from things, and are vague, insufficiently defined and delimited, and in many ways flawed—then all collapses. We thus reject the syllogism—not only with respect to principles (to which even its defenders do not apply it), but also with regard to the middle propositions which the syllogism does indeed derive and produce, though they are barren for works, remote from practice, and altogether incompetent for the active part of the sciences. Therefore, although we leave to the syllogism and such celebrated demonstrations the jurisdiction over popular and conjectural arts (for in that domain we raise no objection), in regard to the nature of things we use induction for everything [10], and apply it both to lesser and greater propositions. For we consider induction to be the form of demonstration that guards the senses, presses upon nature, approaches works, and is almost mingled with them.

Therefore, the order of demonstration is also entirely reversed. For up to now, the common practice has been to fly from the senses and particulars immediately to the most general propositions, as if to fixed poles around which disputes revolve; and from those, all other things are derived through intermediates. This is certainly a shortcut, but a precipitous one—impassable for nature, yet inclined and well-suited to disputation. But according to our method, axioms are built up continuously and gradually, so that only at the very end does one arrive at the most general ones. And these most general axioms turn out not to be merely conceptual, but well-defined, and of such a kind that nature herself recognizes them as familiar, and they adhere to things in their very substance.

[8] Bacon rejected the Aristotelian syllogism as epistemically unreliable for investigating nature, since it rested on flawed abstractions. His critique anticipated later concerns about deductive reasoning built on unstable premises.

[9] Bacon viewed linguistic structures as inherently unstable unless grounded in precise concepts. This early critique of nominalism prefigured later worries about conceptual vagueness and semantic drift in philosophy and science.

[10] Bacon's inductive method involved systematic elimination and comparison—not mere enumeration—and was intended to yield reliable causal knowledge. This remains a cornerstone of scientific methodology.

But even in the very form of induction, and in the judgment that arises from it, we undertake a work of the greatest magnitude. For the kind of induction spoken of by the syllogistic dialecticians, which proceeds by simple enumeration, is a childish thing [11], draws its conclusions on uncertain grounds, is exposed to danger from any contradictory instance, considers only what is familiar, and finds no outlet.

[11] Bacon disparaged traditional scholastic induction as superficial and uncritical. His proposed method sought necessary conclusions through rigorously filtered experience—a significant innovation in early modern epistemology.

Now, what is needed for the sciences is a form of induction that analyzes and distinguishes experience, and draws necessary conclusions through proper exclusions and rejections. And if that common method of judgment used by syllogistic dialecticians has been so laborious and has exercised so many minds, how much greater must be the effort required for this other method, which must be drawn not only from the innermost recesses of the mind but also from the very depths of nature?

Yet this is not the end. For we also press down and strengthen more firmly the foundations of the sciences, and we take the starting points of inquiry from a deeper level than men have so far attempted—by subjecting to examination those things which common logic accepts on external authority [12]. For syllogistic dialecticians derive the principles of the sciences as if by loan from the sciences themselves; again, they venerate the first notions of the mind; and finally, they rest

content with the immediate information of the properly disposed senses. But we have determined that true logic should enter each province of the sciences with greater authority than that of the principles themselves, and should compel even those supposed principles to give account of themselves until they are fully confirmed. As for the first notions of the understanding, nothing which the mind—left to its own devices—has amassed is exempt from our suspicion, nor do we regard anything as established unless it has been brought before a new tribunal and judged according to its standards. Moreover, we also examine in many ways the reports of the senses themselves. For the senses do indeed deceive, but they also reveal their own errors [13]; the errors are near at hand, but the signs of them are sought from afar.

[12] Bacon criticized scholastic logic for accepting its premises from inherited doctrine. He argued that inquiry must not begin with received axioms, but must test even the so-called first principles.

[13] This dual claim lies at the heart of Bacon's empirical optimism. He believed that sensory deception could be identified and corrected through controlled experimentation and careful observation.

The fault of the senses is twofold: for they either fail us or deceive us. First, there are many things that escape even a properly ordered and unobstructed sense—whether by the subtlety of the whole body, the minuteness of parts, the distance of location, the slowness or even the speed of motion, the familiarity of the object, or other such causes. Nor, again, where the sense does apprehend a thing, are its graspings at all firm. For the testimony and information of the senses is always in accordance with the analogy of man, not with the analogy of the universe. And it is a serious error to assert that the senses are the measure of things.

Therefore, to counter these difficulties, we have, with much diligence and reliable service, gathered and assembled aids to the senses from all sides, so that deficiencies may be supplied by substitutions, and

variations may be corrected. Nor do we attempt this so much through instruments as through experiments. For the subtlety of experiments is far greater than that of the senses themselves, even when aided by refined instruments (we speak of those experiments that are skillfully and methodically devised and applied for the specific purpose of inquiry). Accordingly, we attribute little to the immediate and direct perception of the senses; instead, we reduce the matter to this: that the senses judge only the experiment, and the experiment judges the thing. For this reason, we consider ourselves to have acted as faithful priests of the senses [14]—by which all things in natural inquiry must be sought, unless one chooses madness—and interpreters not unskilled in their oracles; so that others may seem to honor the senses in profession, but we in practice truly preserve and revere them. And such are the means we prepare for the light of nature itself, for its kindling and admission: means which would be sufficient in themselves, if the human mind were fair and like a blank slate. But since the minds of men are so marvellously preoccupied that a clear and polished surface is entirely lacking for receiving the true rays of things, there is a certain necessity that we should seek a remedy for this also.

[14] Bacon depicted himself as a mediator between sense and truth—not rejecting sensory input, but purifying and guiding it through method. This metaphor reflects his distinctive empiricism: reverent yet disciplined.

The idols by which the mind is occupied [15] are either acquired or innate. The acquired idols have entered into human minds either from the dogmas and sects of philosophers or from the perverse rules of demonstration. But the innate ones adhere to the very nature of the intellect, which is found to be far more prone to error than the senses. However much humans may take delight in themselves and fall into admiration—and almost worship—of the human mind, this is certain: just as an uneven mirror distorts the rays of things [16] according to its

own shape and surface, so also does the mind, when affected by things through the senses, in forming and inventing its notions, introduce and intermingle its own nature into the nature of things—without due fidelity.

[15] Bacon's doctrine of *idola*—systematic distortions of judgment—was later formalized in *Novum Organum* I:38–52. He divided them into four kinds: *idola tribus*, *specus*, *fori*, and *theatri*.

[16] This enduring metaphor illustrated the epistemological problem of projection: that the mind reshapes experience according to its own nature. Bacon's "mirror theory" preceded modern concepts of cognitive distortion.

And the former two kinds of idols are scarcely removable, while the latter kind cannot be removed at all. All that remains is to point them out and to expose and convict this treacherous force of the mind, lest from the destruction of old errors there arise in turn new shoots of error from the very corruption of the mind's disposition, and things fall back to a state in which errors are not eliminated but merely exchanged. But rather, that it may finally and forever be established that the intellect can judge rightly only through induction and its legitimate form. Therefore, this doctrine concerning the purification of the intellect—so that it may become fit for truth—is completed in three refutations: the refutation of philosophies, the refutation of demonstrations, and the refutation of innate human reason [17]. Once these matters have been clarified, and it has been shown what the nature of things allows and what the nature of the mind allows, we believe we have, with divine goodness as the bridesmaid, prepared and adorned the bridal chamber of the Mind and the Universe. And let it be the prayer of this nuptial hymn, that from this union there may spring forth aids for humanity and a lineage of inventions which may, in some measure, tame and subdue the necessities and miseries of mankind. This, then, is the second part of the work.

[17] These three refutations form Bacon's method of *purificatio intellectus*—a clearing away of errors before reconstruction. Unlike total skepticism, his approach sought to prepare the mind for fruitful discovery.

But the plan is not only to point out and secure the paths, but also to enter upon them. Therefore, the third part of the work includes the Phenomena of the Universe—that is, universal experience [18], and that kind of natural history which can serve as foundational for the building of philosophy. For no excellent method of demonstration or form of interpreting nature can, while defending and supporting the mind against error and fallacy, also supply it with the material necessary for knowing. Rather, for those whose aim is not to guess and divine, but to discover and to know—and who do not wish to invent fantasies and fictions of worlds, but to inspect and, as it were, dissect the nature of this true world itself—everything must be sought from things themselves. And for this labor, inquiry, and exploration of the world, no substitution or compensation of wit, reflection, or reasoning can suffice—not even if all minds of all people were united. Therefore, either this must be undertaken completely, or the enterprise must be abandoned forever. And thus far, the conduct of men has been such that it is hardly surprising if nature has not offered up her abundance.

[18] Bacon's third part called for a comprehensive *natural history* to serve as the raw material for inductive method. This differs from speculative cosmology and aims instead at empirical collection.

For, to begin with, the information provided by the senses is both deficient and deceptive. Observation is careless, uneven, and almost accidental. Tradition is vain and based on hearsay. Practice is fixated on its task and servile. Experimental power is blind, dull, erratic, and abrupt. Finally, natural history is superficial and meager. These have brought together for the intellect the most corrupt material for philosophy and the sciences.

For, to begin with, the information provided by the senses is both deficient and deceptive. Observation is careless, inconsistent, and almost random. Tradition is vain and derived from hearsay. Practice is narrowly focused on execution and slavish in character. Experimental power is blind, dull, erratic, and abrupt. Finally, natural history is superficial and impoverished. All of these have supplied the intellect with the most defective material for the construction of philosophy and the sciences.

Next, the misplaced subtlety and excessive refinement of argumentation are applied as a last remedy to matters that are plainly hopeless, yet they neither restore the inquiry nor distinguish truth from error. Therefore, there is no hope for greater advancement and progress except in a certain renewal of the sciences.

But the beginnings of this enterprise must be taken entirely from natural history—of a new kind and arrangement. For it would be futile to polish the mirror if the images are lacking; and clearly, suitable material must be prepared for the intellect, not just trustworthy tools provided. Now our natural history (just as our logic) differs in many respects from the kind that currently exists: in its purpose or function, in its mass and compilation, in its refinement, and in the selection and organization of contents in relation to what is to follow.

First, we propose a kind of natural history that is intended not so much to delight by the variety of things or to assist by the immediate utility of experiments, but rather to shed light on the discovery of causes and to provide the first nourishment to the growth of philosophy. For although we principally pursue works and the practical side of the sciences, we nevertheless wait for the time of harvest, and do not attempt to reap the moss and the green, unripe crop. For we well know that axioms rightly discovered draw whole troops of works behind them, and bring forth results not sparsely but in clusters. We utterly

reject and set aside that untimely and childish impulse [19] to snatch at premature tokens of new works, like Atalanta's apple that hinders the race. Such, then, is the function of our Natural History.

[19] Bacon warned against premature application of discoveries. His image of "green crop" reinforced the principle that knowledge should first be systematized before practical use is pursued.

As for the collection itself, we compile a history not only of nature in its free and unconstrained state (when it proceeds spontaneously and performs its own work), such as the history of the heavens, meteors, earth and sea, minerals, plants, and animals, but even more of nature constrained and troubled—that is, when it is forced out of its usual state by human art and intervention, and is pressed and shaped. Therefore, we record all experiments from the mechanical arts, from the operative side of the liberal arts, and from many practical disciplines which have not yet coalesced into distinct sciences—as far as we have been able to investigate them and as much as they serve our purpose. Indeed (to speak plainly), disregarding human pride and appearances, we place much more labor and reliance in this aspect than in the other. For nature reveals itself more under the constraints of art than in its own freedom.

Nor do we present only the history of bodies; we have furthermore considered it a part of our task to compile separately the history of the so-called virtues themselves—those which may be regarded as cardinal in nature and in which the primary principles of nature are clearly constituted, namely, the first affections and desires of matter, such as density, rarity, heat, cold, consistency, fluidity, weight, lightness, and several others].

Indeed, to speak of subtlety, we deliberately seek a kind of experiment far more subtle and simple than those commonly encountered. For we bring forth and extract many things from obscurity, things which no

one would have thought to investigate unless he were proceeding along a fixed and steady path toward the discovery of causes—since, in themselves, they are of little direct use. Thus it becomes clear that these are not sought for their own sake, but stand in relation to things and works just as the letters of the alphabet relate to speech and words: which, though useless in themselves, are nonetheless the fundamental elements of all discourse.

In the selection of accounts and experiments, we believe we have exercised better caution than those who have previously dealt with natural history. For we admit only what has been seen with the eye, or at least carefully examined, and with the utmost strictness; so that nothing is reported for the sake of wonder, and what we recount is pure and untainted by fable or vanity. Moreover, we explicitly proscribe and mark as false those common and long-propagated lies (which have, by a strange negligence, persisted and taken root over many centuries), so that they may trouble science no further. Just as someone wisely observed that the tales, superstitions, and nonsense instilled by nurses into children distort their minds even in serious matters, so the same reason moves us to be vigilant—and even anxious—that from the very beginning, as we handle the childhood of philosophy under the form of natural history, it not become accustomed to any kind of falsehood. In every new and somewhat subtle experiment, even though it appears to us certain and confirmed, we openly describe the method we used. So that, once it is revealed how each detail was established, people may judge what errors may underlie or cling to it, and be awakened to seek more reliable and refined validations, if any exist. Finally, we scatter throughout our work admonitions, cautions, and doubts—as though with a kind of religious vigilance, or an exorcism—driving out and restraining all illusions.

Finally, since we have found by experience how greatly experience and history scatter and weaken the focus of the human mind, and how

difficult it is—especially for minds that are either unformed or already biased—to become familiar with nature from the beginning, we often add our own observations, as certain preliminary turns, inclinations, and, so to speak, glimpses of history as it turns toward philosophy; so that they may serve as a pledge to readers that they will not be forever lost in the waves of history, and so that, when it is time to engage the intellect, all may be more prepared and in readiness. And through such a Natural History as we have described, we believe that a safe and convenient access to nature may be established, and a reliable and well-prepared material be furnished to the intellect.

Now that we have fortified the intellect with the most reliable aids and defenses, and assembled a proper host of divine works through the strictest selection, it seems that nothing more remains but to proceed directly to philosophy itself. Yet in a matter so difficult and uncertain, there are certain things that must necessarily be interposed—partly for the sake of instruction, and partly for immediate use.

The first of these is that examples of investigation and discovery according to our method and path should be presented, represented in certain subjects. We choose especially those subjects which are both among the most noble of those being sought and the most different from one another—so that no type may lack an example. Nor do we refer to those examples that are appended to individual precepts and rules for illustrative purposes (this we have already provided abundantly in the second part of the work); but rather, we mean full-scale models and patterns that set forth, in particular subjects—varied and noteworthy—the entire process of the mind and the continuous structure and order of discovery, as if before the eyes. For it has occurred to us that, in mathematics, when the diagram is present, the demonstration proceeds easily and clearly; whereas without that aid, everything seems more complex and obscure than it really is. Therefore, we assign such examples to the fourth part of our work:

which is, in fact, nothing other than a particular and detailed application of the second part.

But the fifth part is employed only provisionally, until the remaining parts are completed; and it is offered as interest, so to speak, until the principal may be paid. For we do not pursue our goal so blindly as to neglect what is useful that we encounter along the way. Therefore, we compose the fifth part of the work from those things which have been either discovered, confirmed, or contributed by us—not, however, according to the rules and principles of interpretation, but by the same use of the intellect that others typically apply in inquiry and discovery. Indeed, as we hope for greater things from our reflections than our intellectual powers might warrant, due to our constant engagement with nature, these may serve as resting-places, like tents set along the way, where the mind striving toward firmer ground may temporarily repose. Yet in the meantime, we explicitly declare that we do not consider ourselves bound to these results, as they have not been discovered or verified by the true method of interpretation. Nor should anyone shrink from this suspension of judgment in a philosophy which does not assert that nothing can be known, but rather that nothing can be known except by a fixed order and method. Meanwhile, it establishes degrees of provisional certainty for practical use and relief, until the mind can settle in a true explanation of causes. For even those schools of philosophy which upheld total skepticism (Acatalepsia [20]) were not inferior to those which claimed the liberty to pronounce on all matters. Yet they failed to provide aids to the senses and intellect, as we have done; instead, they abolished all belief and authority—which is a very different thing, and indeed almost the opposite.

[20] From Greek skepticism, *acatalepsia* meant the impossibility of true knowledge. Bacon rejected this view, proposing instead a methodologically conditioned path to truth—not certainty, but reliability.

The sixth and final part of our work (to which all the others are subordinate and ministerial) finally unfolds and sets forth the philosophy that is derived and established from such a legitimate, pure, and rigorous inquiry as we have previously described and prepared. But to complete and bring this final part to fulfillment is a task placed beyond both our strength and our hope. We may, as we hope, lay foundations not unworthy of it; the completion will be granted by the fortune of the human race—one perhaps that the present state of things and minds cannot easily conceive or measure. For the issue is not merely contemplative happiness, but truly human affairs and fortunes, and the entire scope of operative power. For man, the servant and interpreter of nature [21], does and understands only so much as he has observed in the order, operation, or mind of nature: he neither knows nor can do more. No force can break or loosen the chain of causes; nor is nature conquered except by submission. Therefore, those twin aims—namely human knowledge and power—truly coincide; and the failure of works stems chiefly from ignorance of causes.

[21] One of Bacon's most cited formulations. It encapsulated his view that power over nature arises only from understanding its laws—not through force, but by obedience to its order.

And everything depends on this: that one never turns the eyes of the mind away from things themselves, but receives their images exactly as they are. For God would not permit that we should put forth the dream of our imagination as the model of the world. Rather, may He graciously grant that we record the apocalypse and true vision of the traces and seals of the Creator upon His creatures.

Therefore, Thou, Father, who gavest visible light as the first-fruit of creation, and didst breathe intellectual light into the face of man as the crowning work of Thy deeds—protect and govern this work, which proceeds from Thy goodness and returns to Thy glory. Thou, when

Thou turnedst to behold the works Thy hands had made, saw that all things were very good; and Thou didst rest. But man, turning to behold the works his own hands had made, saw that all was vanity and vexation of spirit; and he found no rest. Wherefore, if we labor in Thy works, grant us to be partakers of Thy vision and Thy sabbath. Humbly we pray that this mind may remain with us, and that through new mercies, by our hands and those of others to whom Thou shalt grant the same spirit, the human family may be enriched.

Novum Organum's
Preface

THE SECOND PART OF THE WORK WHICH IS CALLED
THE NEW ORGANON
OR TRUE DIRECTIONS
CONCERNING THE INTERPRETATION OF NATURE

PREFACE

Those who have dared to make pronouncements about nature as if it were a thing already explored [1]—whether out of confidence of mind or out of ambition and a professorial manner—have inflicted the greatest harm upon philosophy and the sciences [2]. For while they were powerful in gaining assent, they were equally effective in extinguishing and interrupting inquiry. Nor did they benefit so much by their own virtue as they harmed by corrupting and undermining the virtue of others. On the other hand, those who took the opposite course and asserted that nothing at all can be known—whether due to their hatred of the ancient sophists, or from mental instability, or even from an abundance of learning—have certainly brought forward arguments not to be despised. Nevertheless, they did not derive their position from true principles, and, carried forward by a certain zeal and affectation, they went wholly beyond the proper bounds. But the earlier Greeks (whose writings are lost) conducted themselves more wisely between the boasting of pronouncement and the despair of Acatalepsy (total unknowability [3]). Mixing complaints and laments about the difficulty of inquiry and the obscurity of things, and as it were biting the bit, they nonetheless persisted in their aim and did not cease to involve themselves with nature. Believing it consistent, as it

seems, not to dispute whether something can be known, but to try it out. Yet even they, relying only on the force of the intellect, applied no method, but placed everything in intense meditation and the perpetual agitation and stirring of the mind.

[1] Bacon criticized thinkers who claimed finality in their understanding of nature. He viewed such confidence as an obstacle to ongoing inquiry and as a source of intellectual stagnation.

[2] Bacon consistently distinguishes *philosophy* (*philosophia*) from the *sciences* (*scientiae*), as seen here and throughout the *Novum Organum*. For Bacon, *philosophy* refers chiefly to speculative or foundational inquiry—especially metaphysics and first principles—while *sciences* denote the derived, organized disciplines of knowledge that arise from proper investigation of nature. The sciences, in this sense, include both theoretical and applied fields (e.g., physics, astronomy, mechanics), but remain methodologically subordinate to philosophy. The failure of earlier thinkers, in Bacon's view, lay not only in corrupt philosophical principles but also in their misguided cultivation of the sciences based on those faulty foundations.

[3] Acatalepsy (from Greek ἀκαταληψία) referred to the doctrine of the Academic skeptics who believed that nothing could be truly known. Bacon rejected this as excessive, preferring a method-based form of conditional knowledge.

Our method, though arduous in execution, is easy to describe. It is this: that we establish degrees of certainty, preserve the senses by a certain form of correction, but largely reject the operations of the mind that follow sense; and instead open and secure a new and certain path for the mind, beginning from the very perceptions of the senses. And this, without doubt, was also seen by those who assigned so great a role to syllogistic dialectic. From which it is clear that they sought aids for the intellect, but regarded the natural and spontaneous movement of the mind as suspect. But this remedy is applied too late, when matters are already lost—after the mind has been taken over by daily habits of life, polluted teachings and hearsay, and has become entangled in vain idols. Thus that art of syllogistic dialectic, providing caution too late (as we said), and not restoring the situation in any real way, has served

more to fix errors than to open the way to truth. The only hope and health remaining is to begin the whole work of the mind anew; and that the mind, from the very beginning, be in no way left to itself, but be continuously guided, and that things be accomplished as though by machines. Indeed, if men had attempted mechanical works with bare hands, without the power and assistance of tools, as they have not hesitated to tackle intellectual works with the nearly bare powers of the mind, the things they could have moved or overcome would have been exceedingly few—even if they had worked strenuously and in cooperation. And if we would pause for a moment and look upon this very example as into a mirror, let us consider (if it please us) whether, if some obelisk of notable size were to be moved for the celebration of a triumph or similar grandeur, and men attempted it with their bare hands, would not any sober observer acknowledge this to be sheer madness? And if they increased the number of workers and trusted that in this way they could accomplish it, would that not be even more so? But if they chose to make a selection, setting aside the weak and using only the strong and vigorous, hoping thereby at least to achieve their aim—would one not say they were all the more thoroughly deranged? And if, still dissatisfied, they decided to consult the art of athletics, and ordered all participants to come with hands, arms, and sinews well anointed and trained according to technique, would it not be shouted aloud that they were rationally and prudently pursuing insanity? Yet men are carried along with a similarly unsound impulse and unhelpful consensus in intellectual matters: while they place their hope either in the multitude and agreement of minds or in their excellence and sharpness, or even in syllogistic dialectic (which might be considered a kind of mental gymnastics) to strengthen the mind's powers; but all the while, despite all this effort and eagerness (if one judges rightly), they persist in applying the naked intellect. But it is perfectly clear that in every great work achieved by human hands,

without instruments and machines [4], neither can the strength of individuals be brought to full effect, nor the strength of all combined.

[4] This extended metaphor reflected Bacon's belief that method functions as a kind of *epistemic technology*. Just as tools enhance physical power, so method enhances intellectual capacity. This concept remains foundational in philosophy of science.

Therefore, based on the foregoing, we have determined that there are two matters concerning which we wish men to be clearly advised [5], lest they should be overlooked or missed. The first is this: it seems to be by some kind (as we think) favorable destiny that, in order to extinguish and dispel animosities and internal strife, both honor and reverence for the ancients may remain untouched and undiminished, and we, in turn, may accomplish our aims and still enjoy the benefit of our modesty. For if we were to profess that we bring better things than the ancients, while following the same path as they, no skill of words could prevent a comparison or even a rivalry in intellect, excellence, or capacity from arising. This would not be unlawful or unprecedented—for why should we not, by the right of all, if we find something in them incorrectly discovered or expressed, criticize or note it?—Yet even if such a contest were just or allowable, it would perhaps be unequal, considering the limits of our strength. But since what we seek is to open up an entirely different path for the understanding—one not attempted nor known by them—the situation is now altered: the rivalry and partisanship fall away; and we take on merely the role of judge, which certainly carries moderate authority, and stems more from circumstance than from ability or excellence. And this kind of caution concerns persons; the other concerns the matters themselves.

[5] Bacon took pains to avoid appearing as a rival to the ancients. By presenting his method as entirely new in kind—not merely better in degree—he shifted the comparison from persons to paths.

We, indeed, are not at all concerned with overthrowing the philosophy that currently flourishes, nor with any other that may be more refined or augmented than it. For we do not oppose the fact that the accepted philosophy, and others of its kind, nourish disputations, adorn speech, and are employed and effective in professorial duties and in the conveniences of civil life. Indeed, we openly indicate and declare that the philosophy we propose will be of little use for such purposes. It is not readily available, nor can it be grasped in passing, nor does it flatter the intellect through preconceived notions, nor will it reach the understanding of the common people except through utility and results.

Let there be then (which may it be happy and fortunate for both sides) two streams of doctrine, and two dispensations; likewise two tribes or kinships, as it were, of those who contemplate or philosophize; and let these be by no means hostile or alien to one another, but united by alliance and bound by mutual assistance. Let there be, in short, one method for cultivating sciences, and another for discovering them. And for those to whom the first is preferable and more acceptable—whether due to haste, concerns of civil life, or an inability to grasp and embrace the other due to the weakness of the mind (which necessarily befalls the majority)—we wish them success in what they pursue and hope that they may hold firmly to what they follow. But if there be anyone among mortals whose heart and concern is not only to cling to discoveries and make use of them, but to push further; not to defeat an adversary in disputation, but to conquer nature through action; not to opine elegantly and plausibly, but to know with certainty and demonstratively—let such as these, as true sons of science, (if it pleases them) join with us, so that leaving aside the outer courts of nature—which countless others have worn smooth—access may at last be opened to the inner sanctum. And, so that we may be better understood, and the very thing we intend may become more familiar

by its names, the one method or path we call the Anticipation of the Mind, the other, the Interpretation of Nature [6].

[6] These two terms captured Bacon's fundamental methodological distinction. *Anticipatio mentis* refers to premature generalization; *interpretatio naturae* denotes a slow, observational ascent from particulars to general truths.

There is also something we feel it necessary to request. We have indeed undertaken the task and taken care that the things we present are not only true, but also may approach the minds of men (though strangely preoccupied and obstructed) neither harshly nor inappropriately. Nevertheless, it is only fair that we ask of men—especially in the context of such a grand renewal of doctrines and sciences [7]—that whoever wishes to judge or form an opinion about our work, whether from personal impression, from the multitude of authorities, or from current forms of demonstration (which now have acquired the force of judicial laws [8]), should not presume to do so in passing or as a secondary task; but rather should thoroughly acquaint himself with the matter; gradually attempt the path we describe and lay out; grow accustomed to the subtlety of things marked out through experience; correct, with timely and almost lawful delay, the deeply rooted and distorted habits of mind; and only then (if he so wishes), once the matter is within his power, may he employ his judgment.

[7] Bacon referred to the *Instauratio Magna*—his six-part program for the reform of knowledge. *Novum Organum* constituted Part II, which laid out the new method for inquiry.

[8] Bacon critiqued the institutional entrenchment of scholastic logic. He argued that deductive reasoning, once provisional, had become dogmatic—treating past assumptions as authoritative precedent.

WHAT FOLLOWS IS
THE SUMMARY OF THE SECOND PART,
ARRANGED
IN APHORISMS.

Liber Primus

NOVUM ORGANUM: LIBRE PRIMUS
THE NEW ORGANON: BOOK ONE

APHORISMI DE INTERPRETATIONE NATURÆ
ET REGNO HOMINIS.
APHORISMS ON THE INTERPRETATION OF NATURE
AND THE KINGDOM OF MAN

I-I (1:1).

Man, the servant and interpreter of nature, does and understands only so much as he has observed—either through experience or through thought [1]—of the order of nature. Beyond this, he knows nothing and can do nothing [2].

[1] While Bacon's phrasing may suggest that experience (i.e., empirical observation) and thought (i.e., intellectual reflection) were, for him, distinct or alternative sources of knowledge, his broader method presupposed their co-dependence. For Bacon, both were simultaneously necessary: observation grounded inquiry, and reflection organized and interpreted it.

[2] All references to Bacon's views in this edition are given in the past tense, to emphasize that his statements are understood within the intellectual framework of his own time.

I-II (1:2).

Neither the bare hand nor the unaided intellect has significant power; it is by means of tools and assistance that work is accomplished. These are needed just as much for the mind as for the hand. Just as the tools of the hand either initiate or regulate movement, so too the tools of

the mind either suggest ideas to the intellect or safeguard it from error [1].

[1] Bacon's analogy between the hand and the intellect anticipated several key themes in contemporary philosophy of science. His insistence that the mind required tools for both discovery and error-prevention aligned with the *extended mind thesis*, the instrumental mediation of knowledge, and the role of *epistemic scaffolding* in scientific reasoning. Concepts of *experimental realism* and *styles of scientific reasoning* underscored the idea that instruments and methods are not merely aids but active constituents of scientific thought.

I-III (1:3).

Human knowledge and human power [1] are one and the same, for ignorance of the cause prevents the production of the effect. Nature is conquered only by obedience [2]; and that which functions as a cause in contemplation serves as a rule in action.

[1] Bacon's claim that knowledge and power were the same, articulated a foundational principle of his philosophy: to know the cause of a phenomenon was to gain the capacity to produce or alter its effects. This identification grounded his rejection of purely speculative inquiry and affirmed a conception of knowledge as intrinsically practical. In this view, understanding nature was inseparable from the ability to act upon it—philosophy became a tool not just for contemplation but for intervention.

[2] Bacon's language of "conquering" nature reflected the prevailing early modern mentality in which knowledge was valued for its capacity to yield control and utility. These metaphors resonated with the broader cultural framework of dominion, drawn from biblical, legal, and political discourses. As a statesman, Bacon frequently framed epistemological claims in the language of rule, order, and governance. Yet this rhetoric also served to underline a deeper methodological point: that mastery over nature arose not from force but from disciplined understanding of what his contemporaries saw as its "laws." In contrast, contemporary thought increasingly regarded knowledge of nature not as a means of domination, but as a way to live in greater harmony with it—recognizing that we, too, are part of the natural order.

IV (1:4).

In producing effects, man can do nothing more than bring natural bodies together or separate them. All the rest is accomplished by nature working inwardly [1].

[1] This aphorism remains remarkably prescient, though our understanding of "bringing together or separating bodies" has shifted to a more intricate conception of modulation, intervention, and constraint within nature's autonomous operations.

I-V (1:5).

Those who traditionally engage with nature in practical matters are the mechanic, the mathematician, the physician, the alchemist, and the magician [1]. Yet all of them—given the current state of affairs—have made only modest efforts and achieved limited success [2].

[1] The "magician" (*magus*) in Bacon's enumeration referred not to a sorcerer but to the *natural magician* of the Hermetic and Neoplatonic traditions. Figures such as Ficino, Pico della Mirandola, Agrippa, and Paracelsus sought to act upon nature by uncovering its hidden sympathies and correspondences—what they called *magia naturalis*. Bacon acknowledged in them a legitimate aspiration to practical mastery of nature but rejected their reliance on occult speculation and analogy in place of systematic experiment. In his later writings (*De augmentis scientiarum*), he redefined true *magia* as the perfected science of causes and operations—that is, natural philosophy grounded in empirical method.

Please note that *De augmentis scientiarum* (1623), sometimes called *De Dignitate et Augmentis Scientiarum*, is the Latin and expanded version of Bacon's earlier work *The Advancement of Learning* (1605), in which many of his epistemological and methodological ideas were first systematically developed.

[2] The reader should note that Bacon was referring to the state of knowledge and practice prior to 1620. His assessment reflected the limitations he perceived in the operative methods of his time. However, even by then, notable developments—such as the invention of telescopes and advances in mechanics, astronomy, and medicine—had already begun to challenge his characterization, as some 19th-century commentators observed.

I-VI (1:6).

It would be sheer madness and a contradiction in terms to suppose that things which have never yet been achieved could be accomplished except by means that have never yet been attempted [1].

[1] This aphorism expressed a central tenet of Bacon's project: that genuine progress in knowledge could not be achieved through inherited methods alone. The phrase "means that have never yet been attempted" reflected his call for a fundamental reformation of inquiry, aimed at replacing scholastic and speculative approaches with a new empirical and systematic method. It was not an appeal to novelty for its own sake, but a principled argument for methodological innovation as the condition for discovering new effects. That said, especially in our time, it remains essential to test the limits of established methods thoroughly before discarding them—novelty should be a response to proven insufficiency, not a presumption of superiority.

I-VII (1:7).

The productions of mind and hand appear exceedingly numerous, whether one looks to books or to mechanical works. Yet this entire diversity rests upon remarkable refinement and upon derivative elaborations of a few things that have become known—not upon any abundance of axioms [1].

[1] In Aristotle, the Greek term ἀξίωμα (*axioma*) referred broadly to a proposition or assertion, but it acquired more specific meanings in different contexts: as a logical statement, as a foundational principle in mathematics, and as a necessary presupposition for any kind of knowledge—such as the Law of Non-Contradiction. Bacon adopted the term *axioma* to denote general propositions, especially those derived inductively from experience, and explicitly distinguished between levels of axioms (*generalissima*, *media*, *minora*) based on their scope and abstraction. He restricted the term to general principles, in contrast to Ramist and Stoic usages that allowed for any declarative statement. Today, "axiom" is commonly understood as a self-evident or foundational proposition within a formal system, though Bacon's usage aligned more closely with what we would now call empirically grounded generalizations or "laws."

[2] **Excursus – On Axiom in Aristotle and Euclid**

The Greek term ἀξίωμα (*axiōma*) was employed by both Aristotle and Euclid, yet with markedly different intentions that illuminate a fundamental divergence between epistemology and formal logic.

For Aristotle, in the *Posterior Analytics*, *axiōma* designated a self-evident truth common to all the sciences, such as the Law of Non-Contradiction or the proposition that the whole is greater than the part. These *axiōmata* belonged to the broader class of *archai*—first principles (*principia*)—which also encompassed definitions and hypotheses. They were not derived from proof but grasped directly by *nous*, the intuitive intellect, and served as the epistemic foundations upon which demonstration was built. An Aristotelian axiom was therefore a universal and indemonstrable first truth, immediately known and applicable to all forms of knowledge.

Euclid, writing roughly half a century later, employed the same term in a more technical and mathematical sense. In the *Elements*, he distinguished between *postulates* (*aitēmata*), which are assumptions peculiar to geometry, and *common notions* (*koinai ennoiai*), which are general logical principles such as the equality of things equal to the same thing. Within this syllogistic structure of reasoning—the ordered relation of major premise, minor premise, and conclusion—an axiom was not justified by intuitive self-evidence but accepted without proof as a necessary starting point for reasoning. It could not itself be proved within the system, for it defined the boundaries of what could be proved.

The difference between the two usages lies chiefly in their function. Aristotle's axioms were truths known immediately, the epistemological ground of all demonstration; Euclid's were assumptions accepted immediately, the logical ground of syllogistic structure of reasoning. Later commentators often blurred this distinction, treating *axioma* and *principium* as interchangeable terms, a conflation that persisted through the Scholastic and early modern traditions.

Against this background, Bacon's own *axiomata* represent a deliberate transformation of the concept. They are neither Aristotelian certainties apprehended by intellect nor Euclidean postulates posited for formal derivation. Rather, they are empirical generalizations established by legitimate induction, provisional yet progressively closer to the laws of nature.

I-VIII (1:8).

Even the works that have already been discovered owe more to chance and experience than to science [1]. For the sciences we currently possess are nothing more than refined compilations of previously discovered things—not methods of invention, nor guides to new works.

[1] Bacon's claim that past discoveries owed more to "chance and experience" than to science should not be read as a disparagement of scientific intellect or effort. Rather, he was critiquing the absence of a systematic method for generating new knowledge. By "experience," he meant undirected trial-and-error or artisanal practice—not the structured experimentation that defines modern science. His critique was directed at the state of the sciences prior to 1620, including much of medieval and Renaissance natural philosophy, which he regarded as descriptive, derivative, and lacking the means to advance beyond received knowledge. His aim was to highlight the need for a method of invention that reliably led to new works, beyond the accumulation of isolated successes.

I-IX (1:9).

The single cause and root of nearly all the errors in the sciences is this: that while we falsely admire and magnify the powers of the human mind [1], we fail to seek its true aids.

[1] Bacon understood the "human mind" primarily as the rational faculty—capable of judgment and inquiry but naturally prone to systematic distortions and errors. For him, it was not self-sufficient and had to be aided by external supports such as methodological tools and empirical discipline. In contrast, contemporary psychology and neuroscience view the mind as the emergent function of the brain, encompassing cognitive, perceptual, and affective processes, and explain its operations through biological mechanisms and computational models rather than philosophical faculties.

I-X (1:10).

The subtlety of nature surpasses the subtlety of both sense and intellect by many degrees. Hence, all those elegant meditations,

speculative theories, and chains of reasoning in which humans indulge are fundamentally unsound—except that no one is present to take notice [1].

[1] Bacon's point in this aphorism was that nature was vastly more intricate than unaided human reason could grasp. Theories that appeared elegant or refined were often deeply flawed—not by malice, but because people lacked a reliable method for comparing them directly with the operations of nature. Moreover, individuals rarely perceived these shortcomings because they remained embedded in the prevailing intellectual environment and inherited its collective assumptions. Bacon's use of "subtlety" referred to the fine-grained, delicately complex structure of nature—something far beyond the reach of ordinary sense or intellect.

I-XI (1:11) [1].

Just as the sciences currently held are useless for the invention of works, so too the logic currently in use is useless for the invention of the sciences [2] [3] [4] [5] [6] [7] [8].

[1] The four aphorisms I-XI (1:11) to I-XIV (1:14) formed a coherent argumentative unit in which Bacon presented his core critique of traditional logic. Aphorism XI introduced the claim that current logic was unfit for scientific discovery; XII–XIV elaborated the defects of syllogistic reasoning and the need for a new method. The unity of these aphorisms should be maintained for interpretive clarity.

[2] Bacon's dismissal of the sciences and logic "currently held" did not apply to the emerging empirical methodologies of his contemporaries or predecessors in natural inquiry. Figures such as William Gilbert, Niccolò Cabeo, Tycho Brahe, Copernicus, and Galilei were not implicated in this critique. These natural philosophers, despite varying theoretical commitments, practiced a mode of observation and experimentation that anticipated or paralleled Bacon's call for empirical rigor. Bacon frequently criticized not individual thinkers, but entrenched methods that stifled genuine inquiry.

[3] The objects of Bacon's critique were the Aristotelian-scholastic systems dominant in universities and formal education, which relied on *syllogistic dialectic*—that is, a formal structure of reasoning composed of major and minor premises leading to a conclusion, applied to unexamined axioms—

together with a reverence for authoritative texts over empirical inquiry. These systems were perpetuated by late scholastic thinkers and upheld by theologians and commentators who applied metaphysical and *syllogistic* dialectical forms to natural philosophy. The criticism extended to those who, regardless of intellectual brilliance, engaged in reasoning disconnected from experimental verification.

[4] **Excursus - On Dialectic**
All occurrences of "dialectic" or "dialectical" are qualified as "syllogistic" to reflect Bacon's specific usage: a post-scholastic structure of reasoning that proceeds syllogistically from received axioms. The term therefore designates a formal *apparatus* of argumentation—major premise, minor premise, and conclusion—rather than dialogical exchange or the later speculative "dialectic" of Kant, Hegel, or Marx. For the historical frame, see 1:20 [2]; for a parallel case of terminological redefinition, see 1:51 [6].

[5] Bacon critiqued the methodological structure of inherited logic and science, especially their incapacity to generate new knowledge or useful works. The syllogistic structure of reasoning, though valid in form, became destructive when used to derive consequences from unexamined or arbitrary principles. He underscored a psychological dynamic: repeated reliance on syllogistic procedure—the continual application of the same formal structure—built a false confidence in dubious premises, leading to the systematic propagation of error. Once intellectual edifices were constructed on these foundations, there was institutional and psychological resistance to revisiting basic assumptions. He also attributed this methodological failure to Greek thinkers, who wrongly applied geometrical reasoning to physical nature, and to theologians, whose a priori commitments constrained their natural philosophy. Thus, the critique was not of reason itself, but of its misapplication in both historical and institutional contexts.

[6] Bacon did not advocate the abolition of the syllogistic structure of logic but insisted it be subordinated to induction. Once first-order notions and axioms had been securely established through careful empirical analysis, **syllogistic structures** were legitimate tools for organizing and extending knowledge. This layered system—induction first, methodical descent (*deductio*) second—prefigured the eventual scientific method, where hypotheses were formulated from data and then logically elaborated. As later developments in physics and the mathematical sciences confirm, the syllogistic mode of inference remains indispensable when properly grounded in experiment and observation, not speculative abstraction.

[7] **Excursus – On Hypothetico-Deductive Model**

The term *deductive* in the modern *hypothetico-deductive model* preserves the formal structure of Aristotelian deduction while inverting its epistemological function. In Aristotle's *Posterior Analytics*, *apodeixis* signified demonstrative reasoning from *first principles*—propositions regarded as certain, self-evident, and indemonstrable. Deduction served to preserve that certainty: derived conclusions were necessarily true insofar as the premises were true.

Bacon, rejecting both the scholastic reliance on authority and the paucity of genuine *first principles*, displaced this model by emphasizing the discovery of causes through *inductio*. Later empiricists, notably Hume, questioned the logical foundation of induction itself, leading twentieth-century philosophers such as Popper and Hempel—despite their differences—to reintroduce deduction within a new methodological framework.

In the hypothetico-deductive schema, deduction no longer derives necessary truths from self-evident axioms but testable consequences from provisional hypotheses. The logical form of deduction is retained (if H, then O; not-O; therefore, not-H), yet its epistemic role is transformed: it becomes a tool for falsification rather than demonstration. Thus, deductive in this modern sense denotes a logical process rather than an Aristotelian inference from necessary first principles.

[7] **Excursus – On Hypothetico-Deductive Models**

Bacon's methodological critique in this aphorism, and more broadly throughout the *Novum Organum*, should be assessed in relation to the various forms of the hypothetico-deductive (H–D) model that developed after his time. The relationship was not one of direct alignment but of partial resonance and principled divergence.

A. Classical H–D models, characteristic of nineteenth- and early twentieth-century empirico-theoretical science, typically began with a theoretical hypothesis—not necessarily derived from observation—which was then used to deduce predictions testable by experiment. Bacon would have found such models problematic to the extent that they reversed the order of discovery: he insisted that general principles had to be cautiously and progressively derived through *inductio* from a wide base of particulars.

B. Falsificationist models (e.g., Karl Popper) regarded science as advancing not by confirming hypotheses but by subjecting them to rigorous critical testing. These models minimized the role of induction and viewed scientific progress as a process of error elimination rather than the accumulation of "truths." Bacon would have appreciated their emphasis on empirical control and skepticism but

would likely have objected to the idea that knowledge began with conjecture rather than with structured empirical observation.

C. Contemporary H–D variants, including Bayesian and abductive models (e.g., Inference to the Best Explanation), combine both inductive and deductive elements, often in probabilistic or inferential form. These approaches are more flexible and iterative, allowing hypotheses to evolve with new evidence. While closer in spirit to Bacon's empirical sensitivities, they still tend to permit theoretical speculation at an earlier stage than Bacon would have accepted.

In sum, while Bacon acknowledged the legitimacy of syllogistic structure, he insisted that it had to be anchored in a properly regulated inductive foundation. His system prioritized epistemic ascent from particulars to generalities, not top-down derivation from theoretical postulates.

For Bacon, once axioms were securely established, they could be applied downward to generate new predictions and experiments. This cyclical movement of ascent and descent differs from the modern hypothetico-deductive loop, which could begin from conjecture rather than from disciplined empirical collection. Readers should therefore avoid conflating these later H–D variants with Bacon's own method, whose structure and aims belong to a distinct epistemological tradition.

I-XII (1:12).

The logic currently in use is better suited to preserving and stabilizing errors—errors rooted in widely accepted but flawed notions [1]—than to aiding the inquiry into truth [2] [3]. In this sense, it is more harmful than beneficial [4].

[1] **Excursus—On the Term "Notion" (*Notio*) in Bacon and Aristotle**

Bacon's use of *notio* ("notion") retained the Aristotelian sense of a mental form (*μορφή ἐν τῇ ψυχῇ*), yet he transformed its epistemic function. In Aristotelian psychology and logic, a *notion* denoted the intellect's grasp of the universal—an abstraction derived from sense perception and serving as the middle term of reasoning. Such *notiones* were assumed to be stable, valid reflections of reality. Bacon adopted the term but rejected this presumption of adequacy. For him, the *notiones communes* ("common notions") by which human beings habitually think were not trustworthy universals but confused residues of sensory experience, deformed by the *idola mentis* ("idols of the mind"). Hence

his reform of knowledge began with the critique and reconstruction of notions through *inductio vera* (“true induction”).

In this respect, Bacon’s *notion* occupies a position midway between Aristotle’s *koinē ennoia* (“common concept”) and the modern “concept” of scientific realism: it is both the mental unit of thought and the object of methodological correction. Whereas Aristotle had treated the formation of notions as a natural process of abstraction, Bacon made their purification a conscious and procedural task.

[2] This is the first time in the Aphorisms that Bacon is using the word truth. It suffices to say that the concept of “truth” has undergone many changes during ages, especially from Bacon’s time to ours.

[3] **Excursus – On the Scientific and Philosophical Senses of “Truth”**
In this first occurrence of veritas (“truth”) within the Aphorisms, Bacon used the term in a methodological rather than metaphysical sense. To understand what Bacon means by inquisitio veritatis (“inquiry into truth”), one must be cognizant that three concurrent senses of veritas may be distinguished in Bacon’s corpus. (1) In the philosophical or scholastic tradition, i.e., the correspondence of intellect and reality—as a metaphysical principle. (2) In the moral or legal domain, as in the Essays (“Of Truth”), it denoted veracity or the alignment of speech with fact and justice. (3) In the scientific sense emerging in the *Novum Organum*, “truth” denoted the dependable conformity of the intellect to nature as attained through systematic experiment and induction—a procedural, not metaphysical, adequation.

In the present *Excursus*, attention is directed specifically to this third, scientific sense of *veritas*, and to the question of how it may be understood in our own time. The issue is not merely historical. Since the mid-twentieth century—particularly in the wake of the catastrophic events of the Second World War (1939–1945)—the ideals of impartiality and objectivity in science have been repeatedly questioned. Sociologists and philosophers of science have argued that theoretical frameworks are never wholly autonomous from the social, political, and institutional conditions in which they arise (see also I:38 [2]). Yet if Bacon’s *inquisitio veritatis* is to remain meaningful for modern inquiry, one must articulate how scientific objectivity can still be maintained within a socially situated practice. This requires defending the reliability of the measurements that theories both invoke and test: for only if such measurements retain intersubjective validity can the correspondence between experiment and explanation—the very ground of empirical truth—be preserved.

Consider a simple but telling case. A calibrated mercury thermometer placed in a room registers 21 °C. Its operation presupposes conventions of calibration and the physical theory of thermal expansion; in this sense, the observation is indeed theory-laden. Yet the act of observation itself remains strikingly robust. Whoever looks at the instrument—irrespective of class, gender, ethnicity, religion, or political persuasion—will see the same mercury column and read the same number. The thermometer does not discriminate among observers; it mediates a stable relation between a physical state and a numerical value. The reading may be misused or misinterpreted, but its reproducibility across persons and conditions affirms a level of objectivity that social or ideological differences cannot efface. Here the empirical act—the shared perception of a consistent measurement—embodies what may be called *relative objectivity*: not absolute detachment, but intersubjective agreement grounded in the disciplined interaction between observer, instrument, and world.

The question of what is meant by "reality" has been debated for centuries, both in philosophy and in the natural sciences. Philosophers have offered divergent accounts—from idealist claims that reality depends upon perception, to realist assertions that it exists wholly independent of the observer. Scientists, too, have engaged in similar debates, often divided between those who emphasize the theoretical construction of phenomena and those who defend the autonomy of the physical world. Each of these positions, when taken to extremes, risks either dissolving the object of inquiry into pure subjectivity or treating theory as a transparent mirror of nature. Between these poles, a more modest understanding may be adopted: in experimental practice, "reality" can be regarded as the *statistical average of repeated measurements obtained by a variety of instruments* under controlled conditions. This definition does not claim metaphysical finality; rather, it identifies reality with the reproducible regularities that emerge from disciplined observation. It is this operational and cumulative stability—the convergence of independent measurements—that lends empirical inquiry its authority and gives content to the Baconian idea of inquisitio veritatis ("inquiry into truth").

On the basis of this working definition of "reality," one may also clarify what is meant by "theory" and "truth." The genesis of a theory in the human mind—whether it arises through the systematic inductive procedure envisioned by Bacon or through other, less formal paths—remains largely inscrutable. What can be said is that, once formed, a theory may appear as a *simplicius* (a simple explanatory unit) or as a *compositum* (an ordered aggregation of such units) that seeks to account for aspects of reality not yet measured or directly observed. In this respect, theory functions as a structured anticipation of experience: it projects patterns into the unknown in the hope that future measurements will converge with them. For explanation of Simplicus and

Compositum see: 1:16 [3]. “Truth,” accordingly, may be defined as the consistently high degree of agreement between reality—as the reproducible average of independent measurements—and a temporary or transitional theory that seeks to explain it. This definition neither divinizes theory nor dissolves reality into perception; rather, it situates truth in the evolving correspondence between what is measured and what is imagined—a correspondence that, for Bacon, constituted the living process of *inquisitio veritatis*.

[4] Bacon did not tailor his words. His claim that received logic “preserved and stabilized errors” reflected a deliberate and forceful critique of systems that reinforced inherited falsehoods rather than interrogated them. For Bacon, the *syllogistic* method, when applied to unexamined premises, served not to question but to entrench them. Once false notions—often transmitted through institutional or textual authority—had been admitted, logic became a tool of justification, not discovery. He directed this critique at scholastic theology and Aristotelian natural philosophy alike, where reasoning was subordinated to received frameworks. Thus, the greater the logical precision, the more dangerous its effect: it rendered error structurally coherent and resistant to revision.

This tendency to subordinate inquiry to authority was widely documented by early modern thinkers such as Ramus and Descartes, and by later historians. Their work confirms that scholastic logic had become a vehicle for *epistemic closure*, privileging dogma over investigation.

I-XIII (1:13).

The syllogism is not applied to the first principles of the sciences, and is used in vain with the intermediate axioms, since it is vastly inferior to the subtlety of nature. It constrains belief, therefore, but not reality [1] [2].

[1] **Excursus – On Induction, Deduction, and the Syllogistic Structure of Aristotle**
In Aristotle’s theory of demonstrative science (*epistēmē apodeiktikē*), knowledge arises through necessary reasoning from first principles (*archai*). These principles are grasped intuitively by *nous* and form the foundation from which other propositions follow through deduction. The following outline summarizes the Aristotelian system of deductive reasoning:

1. There exists a finite number of basic propositions (*archai* or *principia*) that are posited without proof.
2. A proposition that is not basic may be asserted only if it has been derived from the basic propositions by logical inference.
3. The inferences proceed by means of the syllogistic structure—a triadic pattern of major premise, minor premise, and conclusion. Example:
   3a. All B are C.
   3b. All A are B.
   3c. Therefore, all A are C.
4. The basic propositions are true and necessary.
5. The basic propositions possess absolute certainty or self-evidence, being apprehended directly by the intellect (*nous*).
6. The basic propositions of a demonstrative science are indemonstrable; no further reasons can be given for them.
7. These propositions are the objects of knowledge, and further truths become known as they are inferred from them through the syllogistic structure. The syllogistic structure therefore provides the *vehicle* of deduction, not its *source*: it conveys truth from principles already known but does not generate truth by its own form. This was Aristotle's view and remained Bacon's—both denied that formal logic alone could create knowledge.

In this framework, induction (*epagōgē*) supplies the first principles from experience, while deduction (*apodeixis*) draws necessary conclusions from those principles. Scholastic philosophy later transformed these *archai*—the intuitively known first propositions—into authoritative sources, such as Scripture or canonical texts, thereby substituting dogmatic premises for empirical foundations. Bacon's methodological reform aimed precisely to restore the balance between experience and reason: to make the ascent of induction and the descent of deduction interdependent. He thus called for methodical descent (*deductio ad nova experimenta*)—the logical application of inductively grounded axioms to new experiments—whereby inquiry could move cyclically between observation and reasoning.

[2] Bacon's critique targeted the scholastic use of the syllogistic structure, which applied formal reasoning to unexamined axioms and produced conclusions detached from experience. Some commentators have defended Bacon as correctly identifying this limitation in scholastic logic: that the syllogistic structure could not reach first principles and was ineffective with intermediate axioms, being inferior to the subtlety of nature. It can be added that with textual support from Posterior Analytics and Ethics, that Aristotle himself maintained that the foundational principles of science (archai) were indemonstrable and had to be obtained through induction, not deduction. In

Aristotle's model, syllogism served to derive conclusions from known truths but could not generate or justify those truths. In this view, Bacon was not rejecting Aristotle's method, but rather the scholastics' distortion of it into a rigid system that substituted formal inference for empirical investigation.

I-XIV (1:14).

A syllogism is composed of propositions; propositions are composed of words; and words are tokens of notions. Therefore, if the notions themselves—which form the very foundation of the structure—are confused and hastily abstracted from things, then everything built upon them lacks solidity [1]. Thus, our only hope lies in genuine induction [2].

[1] Bacon's analysis hinged on the mediating role of language in deductive reasoning: *syllogisms* were constructed from propositions, which were articulated through words that signified underlying notions. He warned that if these notions—serving as the foundational elements of reasoning—were themselves ill-defined or carelessly abstracted from empirical particulars, then the entire logical structure was compromised. In contemporary terms, one corrective to this *epistemic* fragility lies in the formalization of logic: the use of precisely defined syntactic symbols governed by explicit semantic rules (as in mathematical logic or formal languages). Such systems minimize the semantic ambiguity of natural language and foreground the axiomatic, or underlying, assumptions upon which valid inference depends. Though Bacon did not envision symbolic logic in the modern sense, his concern with the instability of loosely defined notions anticipated its philosophical justification.

[2] **Excursus – On Induction: One word, Several meanings**
This aphorism contains the first explicit use of the term *inductio* in the *Novum Organum*'s Aphoristic sequence. Although Bacon discussed the defects of syllogistic reasoning in the preceding sections and also in aphorisms (I.1–13), he introduces *inductio* only here, marking a structural and methodological transition: from diagnosing the corruption of notions to proposing the methodological alternative on which the *Instauratio* depends.

To avoid attributing later developments to Aristotle himself, it is useful to distinguish four layers of reception.

(i) Aristotle: his original theory of *epagōgē* involved a cognitive ascent from repeated perception to the grasp of a universal, not a mechanical enumeration of cases.

(ii) Scholastic Aristotle: medieval and Renaissance logic manuals systematized *epagōgē* into *inductio per enumerationem simplicem*—a formal, confirmatory procedure subordinate to syllogistic reasoning.

(iii) Bacon's Aristotle: Bacon read Aristotle largely through the scholastic tradition and therefore attributed to him views characteristic of the schools rather than the texts alone.

(iv) Bacon's target: the Scholastic model of induction, which he calls *inductio vulgaris*, not Aristotle's own. His "true induction" (*inductio vera*) therefore positions itself against the *school* conception of induction rather than against Aristotle's more complex account. This clarification preserves the historical Aristotle while accurately identifying Bacon's polemical object.

Modern philosophy of science treats induction not as simple enumeration but as a family of inferential practices linking data to hypotheses under conditions of uncertainty. Current views—whether Bayesian, frequentist, or model-based—presuppose systematic variation, explicit criteria of evidence, statistical rigor, and reproducibility. In this respect, Bacon's *inductio vera* anticipated the need for structured experimentation and controlled comparison, even though it lacked the mathematical apparatus developed in later centuries. His call for "true induction" may thus be read as an early attempt to articulate disciplined empirical inference, distinct from both scholastic enumeration and modern statistical methods, but historically continuous with the emergence of scientific method.

I-XV (1:15).

There is nothing sound in our fundamental notions—neither in logic nor in natural philosophy. Concepts such as substance, quality, action, passion, and even being itself are not sound notions. Still less so are notions like heavy, light, dense, rare, moist, dry, generation, decay, attraction, repulsion, element, matter, form, and others of that kind: they are all speculative and ill-defined [1].

[1] Bacon criticized the functionally static role that traditional notions played in logic and natural philosophy. He was preparing the reader for a more dynamic

and empirically grounded framework for forming notions, which he developed through his method of true *induction*.

I-XVI (1:16).

The notions of the lowest species [1] [2] [3]—such as man, dog, and dove—and of the immediate impressions of sense—such as hot, cold, white, and black [4]—are, for the most part, sound; though even these are occasionally disturbed by the flux of matter and the commingling of things. All other notions that humans have used thus far have either been poorly abstracted from things or ill-composed through reasoning; nothing can be hoped from them.

[1] By "lowest species" (*species infimae*), Bacon referred to the most specific categories within the traditional Aristotelian and scholastic classification hierarchy—those that could not be subdivided into further species. In logic and natural philosophy, this included individual kinds like *man*, *dog*, and *dove*, but Bacon also applied the label to immediate sense qualities such as *hot*, *cold*, *white*, and *black*, treating them as the simplest perceptual kinds. His broader point was that these more immediate or minimally abstracted notions tended to be more stable than higher-level abstractions, though even they were vulnerable to confusion through material flux and intermixture.

[2] **Excursus – On the Concept of Species**

In Aristotelian logic, the *species infimae* ("lowest species") occupied the final level of the genus–species hierarchy—the most specific universals that could still apply to more than one individual. They marked the boundary between universal and particular, serving as the lowest kinds that could figure in scientific demonstration. Philosophically, they provided the foundation of definition and knowledge, since science (*epistēmē*) concerned species rather than individuals. Bacon retained the term but reoriented its function: the *species infimae* became for him not the terminus of logical subdivision but the starting point of empirical analysis—the smallest and most stable perceptual kinds from which sound induction could begin.

In Aristotle, *genus* and *species* were logical and metaphysical categories, defining conceptual relations of inclusion based on essential differences. Linnaeus later adopted these terms for empirical taxonomy, transforming them into morphological groupings of organisms. The Linnaean hierarchy thus preserved Aristotle's vocabulary but reversed its logic: what had been a

structure of **concepts and essences** became a structure of **observable kinds**. Bacon's use of *species infimae* anticipates this transition, standing midway between Aristotelian definition and empirical classification.

This essentialist framework persisted into Linnaean taxonomy, though applied empirically rather than metaphysically. Darwin's evolutionary theory later dissolved both the Aristotelian and Linnaean fixity of species by grounding classification in historical genealogy rather than in static form or morphology. From that point, *species* and *genus* ceased to designate fixed logical or morphological ranks and became relational nodes within evolutionary history. In this long trajectory, Bacon's *species infimae* occupy a transitional position—anchored in observation yet still committed to the search for stable natural kinds.

In the twentieth century, evolutionary philosophers such as David Hull advanced a further transformation by arguing that species are not classes but individuals—spatiotemporally continuous entities unified by genealogical relations rather than by shared essences or properties. This "individuality thesis" replaced the typological logic of Aristotle, Linnaeus, and even Darwin's early formulations with an ontology of historical process. In this light, Bacon's *species infimae* may be read as an early stage in that continuum: the movement from universal forms to empirically grounded yet still essentialized kinds.

[3] **Excursus – On the Typology of Theoretical Structure: *Simplicus* vs. *Compositum***

If Bacon had been using "lowest species" solely in a biological sense, the issue could have been settled with the above footnote [1]. However, because his use of the term extended beyond living kinds to include immediate sensory qualities, it invites a broader conceptual analysis. To that end, this footnote introduces a typology of theoretical structures—*simplicus* and *compositum*—which helps clarify Bacon's epistemological orientation and also speaks to contemporary discussions in philosophy of science.

1. **Simplicus (coined term):** From Latin *simplex*, *simplicis* (simple, uncompounded); coined here as a technical noun. A *simplicus* is defined as a theory that is non-composite in structure—that is, it derives its explanatory power from a single, unified principle, mechanism, or conceptual framework. Such a theory is not an assemblage of heterogeneous sub-theories, nor does it rely on the modular conjunction of distinct explanatory layers. Instead, it presents itself as theoretically indivisible or structurally elementary, even if its consequences are complex. Examples might include certain axiomatic systems in mathematics, or fundamental physical laws assumed to be irreducible.

Note: Although *simplicus* is not a classical Latin word, it is introduced here as a coined technical term to avoid the misleading connotations of the English "simple," which can imply conceptual naïveté or lack of richness.

2. **Compositum (from Latin):** Latin *compositum*—a thing put together, a compound. A *compositum* is defined as a theory that is composite in nature—structured from multiple explanatory components, interacting principles, or nested models. Such theories typically exhibit internal modularity, conceptual layering, or synthetic construction, often developed through the integration of previously independent frameworks. Examples include evolutionary theory (which integrates genetics, ecology, and population dynamics), or synthetic models in systems biology. In other words, a compositum is the combination of one or more simplicus, and even one or more compositum.

This distinction also echoes Bacon's methodological aim of progressing from composite phenomena to simpler forms or causes through true *induction* (cf. I–XVIII). The contrast between *simplicus* and *compositum* is intended to offer a precise, philosophically grounded typology for analyzing the internal structure of scientific theories.

[4] **Excursus – On Dualism**

The appearance of dichotomy in Bacon's examples ("hot/cold," "white/black") should not be taken as evidence of a dualistic or dichotomous worldview. These pairs were part of the inherited scientific and rhetorical vocabulary of his time—convenient, vivid, and pedagogically familiar—but not philosophically binding. Bacon's underlying physics was continuist, not dualist: he explained such sensible qualities as *degrees* or *modes* of one underlying process (for example, the motion of particles in the case of heat and cold). The pairing of opposites served to illustrate extremes within a scale of variation, not to imply two distinct principles in nature. His reliance on such examples, therefore, reveals rhetorical convention rather than metaphysical conviction—a certain carelessness in illustration, not a structural commitment to dualism.

The situation is more complex in Plato and Aristotle, whose uses of oppositional or paired terms arose from distinct methodological contexts. Plato employed dichotomies as instruments of *diairesis*—the dialectical method of dividing concepts into species by successive contrasts. This was a logical procedure, not a metaphysical assertion of dual substances. Aristotle, for his part, treated contraries (*ta enantia*) as poles of change within a single substratum: hot and cold, for instance, existed not as independent realities but

as endpoints in a continuum of transformation. In both thinkers, the analytic use of opposition did not entail an ontological dualism.

At the same time, both Plato's dialectical method and Aristotle's analysis of contraries presupposed that genuine knowledge required the identification of *limits* or *contrasts*—a structure of thought that, when transferred uncritically, could easily harden into a dualistic habit. Later traditions of dialectical reasoning, from the Stoics to Hegel, often reinforced this pattern, transforming a heuristic device into a metaphysical schema. To think *dialectically* in such a framework was to risk seeing oppositions where only gradations exist. Bacon's *Novum Organum* represents a deliberate effort to avoid this danger: he preserved the linguistic pairs but dissolved their ontological rigidity, insisting that nature operates through continuous variation, not through fixed contraries.

I-XVII (1:17).

There is no less of bias and deviation in the framing of axioms than in the abstraction of notions; this is true even of the very principles that rest on common induction [1]. But the distortion is far greater in the axioms and intermediate propositions that are derived from these principles by means of syllogism [2].

[1] Bacon was attacking the standard method of *induction* and preparing the ground for his own more refined inductive method.

[2] In the typology introduced in the previous aphorism, an error in identifying a *simplicus* (non-composite theory) tended to compound when embedded within a *compositum* (composite theory). That is, when flawed foundational notions were used to construct broader theoretical structures, the resulting derivations not only inherited but amplified the initial distortion.

I-XVIII (1:18).

Even when discoveries have been made in the sciences, they have remained confined to common notions and have not gone beyond them—so that they have scarcely touched the deeper parts of nature. Therefore, to penetrate into nature's inner and hidden properties, notions and axioms must be drawn from more subtle and precise

experiments [1], and the mind must be formed in accordance with the pattern and standard demanded by such things [2].

[1] It may have seemed that Bacon was demoting observation in favor of experimentation. In fact, he did not reject observation, but sought to reform and subordinate it within a more disciplined epistemic structure. In this aphorism, he emphasized that mere observation—especially in the form of passive natural history—was inadequate for accessing nature's deeper structures. Instead, he advocated experimentation as a more controlled and productive mode of inquiry: a way to direct and refine observation through structured intervention. For Bacon, experimentation was not a rejection of sense-based knowledge, but a means of extracting it more reliably.

[2] **Excursus – On Mathematical Analysis and *in silico* Experiments**
That said, Bacon's framework assumed the universal applicability of experimentation, an assumption that modern science has found only partly sustainable. In many domains—such as astronomy, evolutionary biology, or historical human development—direct experimental manipulation of phenomena is not feasible, whether for practical or ethical reasons. In such contexts, empirical inquiry proceeds through systematic observation, inference, and computational modeling, which collectively extend the experimental ideal into realms where direct intervention is impossible.

Finally, whereas Bacon's intellectual context recognized only two primary sources of empirical knowledge—analytical reasoning and sensory engagement with the material world (through observation or experiment)—modern science has diversified this epistemic structure. Mathematical modeling, largely undeveloped in Bacon's time, now serves as a powerful mode of discovery, capable of generating testable predictions through formal abstraction. Building on this foundation, contemporary research has added a further dimension: *in silico* simulation. Especially in fields governed by stochastic or highly complex dynamics (e.g., statistical physics, evolutionary processes, and systems biology), simulations now operate as generative epistemic instruments, producing predictive insight even in the absence of direct observation or physical experimentation.

I-XIX (1:19).

There are only two ways by which the mind can approach the investigation of truth. One proceeds from the senses and particulars directly to the most general axioms, and from these derives

intermediate axioms in turn—this is the method currently in use [1]. The other rises gradually from the senses and particulars through intermediate axioms, arriving only at the most general axioms at the end. This is the true method—but it has been entirely neglected [2].

[1] Bacon warned that premature *induction*, followed by hasty *deduction*, produced the illusion of truth.

[2] **Excursus – On the Progression of Science**

It may be argued that, alongside the two methods Bacon described, there exists a third path that begins from experience but allows for the early projection of broad hypotheses, which then guide the search for intermediate propositions and empirical tests. These high-level generalizations guide the derivation of intermediate propositions, which are subsequently tested against further experience. According to this view, such hypothetical reasoning—if disciplined by empirical testing and kept provisional—can stimulate productive inquiry and has been a hallmark of scientific genius. Historical examples often cited in support of this view include the theories of gravitation, the wave theory of light, and the theory of evolution.

However, access to previously unavailable sources, such as Darwin's notebooks from the 1830s (unpublished until the late twentieth century), complicates this picture. These documents show that Darwin develops his theory of natural selection not by leaping to a general hypothesis but through a careful, inductive process of compiling evidence, refining analogies, and reasoning through intermediate conceptual steps. Contrary to the heroic narrative of sudden insight, Darwin's method reflects a more Baconian ascent from particulars to general principles. This suggests that what might appear in hindsight as hypothesis-driven breakthroughs often rests on long periods of incremental, inductive construction.

An alternative to both Bacon's methodical ascent and the hypothesis-driven "third way" is what may be loosely termed scientific progress through jumps. In this model, scientific knowledge does not advance through a smooth, continuous path from particulars to general axioms, but rather through irregular, sometimes abrupt reconfigurations of theoretical frameworks. These "jumps" are often triggered not by the accumulation of evidence alone but by shifts in conceptual vision or changes in the interpretive grid through which evidence is understood. Paradigmatic examples include the Copernican revolution, quantum mechanics, and relativity—cases in which previously marginal insights suddenly gain central explanatory power, not by stepwise ascent but by a reorganization of foundational assumptions. This model aligns

closely with Thomas Kuhn's view of scientific revolutions, wherein progress unfolds not by linear accumulation but by episodic reconfiguration of fundamental concepts.

Another model of scientific progress emphasizes the enabling role of technology and instrumentation. According to this view, breakthroughs in scientific understanding are often preceded—or even made possible—by innovations in the tools of observation, measurement, and mobility. Galileo's telescope, Leeuwenhoek's microscope, and modern particle accelerators or space telescopes exemplify this pathway. The rise of the shipping industry—though seemingly mundane—is critical for the development of natural history and evolutionary theory, enabling figures from Linné's students to Darwin and Wallace to gather empirical data from across the globe. More recently, the invention of DNA sequencing techniques accelerated progress in molecular biology and many related fields, unlocking insights into genetic variation, phylogeny, and disease. Such tools extend the reach of the senses and allow phenomena to be perceived, quantified, or manipulated in ways previously impossible. This model shifts emphasis from purely cognitive or theoretical processes to the material infrastructures that enable knowledge. In many cases, the refinement of instrumentation leads to the discovery of new domains of inquiry, rendering possible new hypotheses and prompting revisions to existing theoretical frameworks. From this perspective, the method of discovery is not purely logical or imaginative, but also infrastructural and technological.

I-XX (1:20).

The intellect, when left to itself, follows the same path as the first method—even when governed by the rules of syllogistic dialectic [1, 2]. For the mind, by its natural motion, hastens to generalities and seeks repose in them; and after a brief pause, it shrinks from returning to experience. This failing, however, has been exacerbated by dialectic, through the formal tradition and pomp of disputation.

[1] By "rules of syllogistic dialectic," Bacon referred to the formal procedures of scholastic logic—especially syllogistic reasoning, reliance on untested first principles, and disputation guided by authority rather than empirical inquiry. He criticized these rules for being methodologically barren and epistemically circular. See also Footnote 1:12:[4].

[2] Bacon's conception of syllogistic dialectic was post-scholastic—formed after the medieval university tradition dominated by Aristotelian logic—and pre-Kantian—developed before the late-18th-century redefinition of dialectic in Kant's transcendental philosophy, and well before Hegel's dialectical logic. In Bacon's usage, dialectic meant the *syllogistic dialectic* of Aristotelian-scholastic logic: a method of disputation and deductive inference grounded in received authority. He critiqued it not as a structural feature of reason itself, but as a misapplied tool when used to construct natural philosophy without empirical foundations. The temporal markers here ("post-scholastic," "pre-Kantian") are given only to orient modern readers, not to measure Bacon's work by categories that did not yet exist.

I-XXI (1:21).

The intellect [1], when left to itself—even in a sober, steadfast, and serious mind, especially if it is not tainted by received doctrines [2]—does attempt, in some measure, the other path; but it achieves little. For the intellect, unless it is guided and aided, is irregular and altogether inadequate to overcome the obscurity of things.

[1] Bacon distinguished between *intellectus* (intellect) and *mens* (mind). The intellect was the faculty that formed notions and axioms, and was especially prone to error without methodological discipline. The mind was a broader term, encompassing not only the intellect but also memory, imagination, and will. In this aphorism, Bacon described a morally and temperamentally virtuous mind—sober, steadfast, and serious—yet still vulnerable to cognitive failure without proper guidance. See also Footnote [1], Aphorism I-IX (1:9).

[2] "Received doctrines" referred to entrenched systems of knowledge or belief, typically inherited from intellectual authorities or traditions rather than discovered through firsthand investigation. For Bacon, this included the scholastic-Aristotelian framework that dominated European education in his time, as well as theological and rhetorical systems that shaped thought through custom rather than inquiry. These doctrines were "received" in the sense that they were passively accepted and internalized, often without critical examination. Bacon argued that such systems prematurely shaped the intellect, instilling habits of thought that discouraged direct engagement with nature and obstructed the path of genuine discovery. The danger was not ignorance, but the illusion of knowledge produced by deference to inherited intellectual constructs.

Such a person did not form judgments—whether concerning truth, meaning, or value—through independent engagement with nature or reason, but instead adopted them from inherited authorities, cultural norms, or prevailing intellectual traditions.

[3] Excursus – On the Independent Thinking

Bacon's critique of received doctrine reflected a broader philosophical distinction between autonomy and heteronomy. An autonomous intellect formed its judgments—moral, epistemic, or conceptual—through independent engagement with reason and experience. A heteronomous intellect, by contrast, deferred to external authorities or inherited frameworks. Bacon considered such heteronomy especially dangerous: it resulted not in ignorance, but in misplaced certainty—mistaking inheritance for insight.

A long intellectual tradition divided the human mind or soul into three operative components, a pattern visible in:

- Plato's tripartite psychology: rational, spirited, and desiring parts;
- Aristotelian faculty theory: rational, appetitive, and vegetative souls;
- Christian moral anthropology: spirit, soul, and flesh; or reason, will, and passion;
- Early modern psychology: intellect, will, and passions;
- Freud: id, ego, and superego;
- Piaget: pre-, concrete, and formal operational.

These triadic frameworks, though diverse in content and purpose, shared a concern with explaining how rational agency could be impaired by inherited habits, internalized authorities, or impulsive tendencies—an issue closely related to Bacon's analysis of autonomy and heteronomy. For pedagogical purposes, one accessible modern analogue is the triadic structure of Transactional Analysis, even if that model no longer enjoys the prominence it once had in the mid-twentieth century.

Bacon's dynamic can be analogized to the structural model of ego-states found in Transactional Analysis. In this framework, personality consisted of three components: the Parent (internalized authority), the Child (emotional responsiveness or submissive disposition), and the Adult (rational, autonomous agency). An intellect shaped by received doctrines mirrored a condition in which the Parent dominated, suppressing the Child's exploratory impulses and stunting the development of the Adult's critical and empirical reasoning. Bacon's project can thus be seen as an attempt to rehabilitate the Adult ego-state: to cultivate a mature, disciplined intellect capable of resisting both indoctrination and impulsive generalization.

I-XXII (1:22).

Both paths begin with senses and particulars and culminate in the most general axioms—but their divergence is vast. One simply passes over particulars and experience, while the other engages with them rightly and in due order. One frames certain abstract and useless generalities from the outset; the other rises gradually to those principles that are, in truth, better known by nature [1].

[1] One further caution: Bacon's method was not merely a slower or more meticulous variant of the hypothetico-deductive (H-D) approach. See also Footnote [6] for Aphorism I-XI (1:11). It was grounded in a fundamentally different epistemic structure, wherein methodological rigor, rather than simple empirical access, determined the validity of generalizations. For Bacon, the goal was not to test bold hypotheses quickly, but to restructure the intellect so that stable and lawful general principles—what he called *naturae notiora*—emerged only after a disciplined, layered ascent from experience. This "true method" insisted that the mind engage particulars in proper order, not just skim them for illustrative convenience, and thus sought transformation of cognitive habits, not just procedural improvement.

I-XXIII (1:23).

There is a considerable difference between the idols [1] [2] of the human mind and the ideas of the divine mind [3]; that is, between certain empty dogmas and the true signatures and impressions imprinted upon created things, as they are actually found.

[1] This is the first time among aphorisms that Bacon uses the term *idola*—a concept central to his critique of human understanding. The Latin *idola* (from Greek εἴδωλα) is best understood not as "idols" in the religious sense (i.e., objects of worship), but as "phantoms" or "illusory images." Bacon employed the term to designate systematic distortions in human perception and reasoning—false appearances imposed upon the mind by innate cognitive tendencies, language, cultural conventions, and philosophical dogmas. These *idola* hindered the mind's access to nature and, in Bacon's view, had to be methodically identified and cleared away to make room for genuine empirical

knowledge. He might have added biological constraints on sensory and neural processing, given the knowledge we now possess.

[2] **Excursus – On Epistemology and Cognitive Science**
Bacon's taxonomy of *idola* was an early attempt to systematize the sources of error in human thought. While his classification emphasized cultural, linguistic, and experiential distortions, modern cognitive science adds a significant biological dimension. Perceptual and cognitive processes are constrained by the architecture of the nervous system, the filtering functions of sensory organs, and the evolutionary history of human cognition. For instance, visual perception is tuned to detect certain spatial frequencies and colors, privileging stimuli relevant to survival but leaving us insensitive to much of the electromagnetic spectrum. Similarly, working memory limitations and heuristic reasoning—adaptations that once enhanced decision-making—introduce predictable biases in modern problem-solving contexts. In this light, some of Bacon's *idola* can be understood as the cultural or intellectual elaboration of deeper, biologically rooted constraints. The interplay between these layers suggests that epistemic reform requires not only methodological discipline but also a recognition of the evolved cognitive machinery that structures how we encounter the world.

[3] The "ideas of the divine mind" in this aphorism should not be interpreted as referring to God's perceptual perspective, but rather to the intelligible structures that Bacon believed God had embedded in the fabric of creation. These, for him, were the objective principles—forms, laws, and signatures—that nature consistently followed. Bacon did not treat these divine ideas as mystical archetypes but as lawful patterns imprinted upon things, discoverable through careful empirical investigation. While he saw nature as dynamic—full of change, motion, and development—he held that the fundamental order it obeyed was stable and intelligible. His method sought to recover these stable forms by purging the intellect of its idols and aligning it with the true marks of nature as authored by the divine mind.

Bacon's conception of "forms" differed markedly from Plato's. For Plato, Forms (or Ideas) were immaterial, eternal exemplars that existed in a transcendent realm and served as the true reality behind the mutable world of appearances. Bacon, by contrast, located forms within nature itself—not as otherworldly archetypes but as operative principles discoverable through empirical inquiry. His forms were not metaphysical ideals but the laws or structures by which natural phenomena operated, such as the form of heat or cohesion. Although Bacon allowed for a kind of dynamism in nature—motion, transformation, generation—this should not be confused with the Hegelian conception, where change is understood as a dialectical unfolding of rational contradictions within

history or thought. Bacon's nature was not self-negating or self-transcending in the Hegelian sense; its dynamism was physical and observable, governed by stable laws rather than logical necessity.

I-XXIV (1:24).

It is in no way possible that axioms constructed through argumentation should contribute to the invention of new works, for the subtlety of nature surpasses the subtlety of reasoning by many degrees. But axioms rightly and systematically abstracted from particulars readily point to and designate new particulars, and thereby render the sciences productive and operative [1] [2]]3].

[1] Argumentation alone—whether as a consequence of premature induction or as an independent activity—was, for Bacon, insufficient. Instead, he held that only methodical abstraction from a thorough empirical base enabled the sciences to become fruitful and operative.

[2] While Bacon criticized argumentation that operated independently of systematic empirical grounding, he did not oppose reasoning per se. In modern science, methods such as Bayesian inference and Inference to the Best Explanation (IBE) incorporate elements of speculation and argumentation, but these remain methodologically tethered to empirical evidence. The exploratory steps in such approaches may appear speculative, yet they are constrained by empirical adequacy, coherence, and predictive capacity. Thus, the Baconian principle—that fruitful knowledge arose, in his view, only when reasoning was disciplined by experience—retains its relevance, even if modern methods allow more flexibility in hypothesis formation.

[3] [3] Bacon's method presupposed a fundamentally constant nature whose underlying forms, once discovered, would remain stable and universally applicable. Modern science, however, has shown that many natural systems evolve over historical time and exhibit path-dependence, feedback, and emergent behavior. Phenomena such as ecological transformations, anthropogenic climate change, and changes in material conditions at technological scales mean that axioms derived from past observations do not necessarily hold unaltered in new contexts. Thus, even a perfect adherence to Bacon's or any system of thinking would eventually confront a world whose operative regularities differ from those observed in their time. Nature itself—including human nature and the structures of society—has not remained the same as they observed it, whether in the work of Bacon, Darwin, Marx, Freud,

or other foundational thinkers. The biological, psychological, and socio-economic conditions that shaped their inquiries have shifted dramatically, underscoring that the object of study is historically changable rather than fixed.

I-XXV (1:25).

The axioms currently in use have originated from a narrow and piecemeal experience, drawn from only a few particulars that most commonly present themselves. As such, they have been formed and extended just to fit those limited instances, and it is no wonder that they do not lead to new particulars [1].

[1] Bacon argued that the axioms in use before his time were derived from a scant and repetitive range of familiar cases. As such, they were effectively tailored—or retrofitted—to fit those cases alone, without a broader inductive method to extend them. While he did not use the modern term *ad hoc*, his critique anticipated it: these axioms lacked generalizing power and failed to lead to the discovery of new particulars.

I-XXVI (1:26).

We are accustomed, for the purpose of instruction [1], to refer to the kind of human reasoning we typically employ in the study of nature as Anticipations of Nature, because it is rash and premature. In contrast, we refer to that reasoning which is derived from things by proper and methodical procedures as the Interpretation of Nature [2].

[1] The Latin phrase *docendi gratia* ("for the purpose of instruction") in this aphorism has been variously rendered in English. What mattered, however, was that (a) Bacon drew a categorical distinction between the flawed reasoning inherited from tradition and a new, disciplined form of reasoning grounded in nature itself, and (b) this distinction was not merely pedagogical but fundamentally epistemological.

[2] Bacon distinguished two kinds of reasoning: Anticipation of Nature, which arose from premature generalization and was common in scholastic teaching, and Interpretation of Nature, his preferred method, which derived knowledge systematically from experience. This contrast underpinned the methodological program of the *Novum Organum*.

I-XXVII (1:27).

Anticipations are sufficiently firm to produce agreement; for even if people were to go mad in the same fashion and uniformly, they might still agree with one another quite well [1].

[1] Bacon emphasized that consensus, even universal, was no guarantee of truth. Anticipations could generate broad agreement precisely because they conformed to shared habits of thought or inherited error. The aphorism warned that reasoning unsupported by methodical investigation could foster collective delusion rather than knowledge.

Uniformity of opinion, especially when unchallenged, is no mark of epistemic health. As Bacon suggested, broad agreement could arise not from sound method, but from shared error or unexamined assumptions. In some cases, such consensus reflected sociopolitical pressure or disciplinary stagnation rather than truth—an insight borne out in historical episodes such as the Lysenko affair.

I-XXVIII (1:28).

Anticipations are far more effective at securing assent than interpretations. Formed from a few, mostly familiar instances, they strike the intellect at once and seize the imagination. Interpretations, by contrast, are compiled from many and varied facts dispersed across wide domains, and so do not strike the intellect with equal immediacy. In the eyes of prevailing opinion, they seem strange, unwelcome, and almost like matters of belief [1].

[1] Bacon offered a psychological explanation for why anticipations were more persuasive than interpretations—not because they were more accurate, but because they appealed more immediately to the mind. He was diagnosing an early form of cognitive bias: the mind's preference for simplicity, familiarity, and coherence over complexity, novelty, and delayed understanding. This aphorism reinforced his broader claim that scientific progress required not only methodological reform, but also a reformation of the intellect's ingrained habits.

I-XXIX (1:29).

In the sciences [1] founded upon opinion and dogma [2], the use of anticipations and syllogistic dialectic is appropriate—where the goal is to subjugate assent, not to master the nature of things.

[1] Bacon's reference to "sciences founded upon opinion and dogma" was not a dismissal of certain subject areas (such as ethics or politics), but a critique of how they were pursued. In *De Augmentis Scientiarum*, Bacon classified knowledge into divine (theology), natural (natural philosophy), and human (logic, ethics, politics, etc.). All were potentially scientific, provided they were pursued with proper method. For Bacon, *scientia* referred not to a fixed subject matter, but to any domain of inquiry governed by method, grounded in experience, and oriented toward discovering causes. The sciences, properly so called, aimed to uncover the operations of nature through systematic induction, empirical correction, and fruitful generalization. Fields like rhetoric, painting, or archery might have involved skill (*ars*), but unless their principles were generalized, methodically examined, and capable of producing further insight, they did not rise to the level of *scientia*. What distinguished science was not subject matter, but epistemic orientation: it had to be truth-seeking, cause-disclosing, and operative. This aphorism thus reflected Bacon's broader ambition—to reconstitute all branches of knowledge according to the same disciplined method.

[2] Bacon's reference to sciences "founded upon opinion and dogma" was not a literal endorsement of such a foundation, but a rhetorical strategy. He momentarily granted these disciplines their existing form—characterized by disputation and received authority—in order to contrast them with his method of inquiry. As became clear in Aphorism I:127, Bacon held that no branch of knowledge should ultimately rest on opinion or dogma; all had to be reformed through methodical observation and induction. The phrase here was thus concessive, not prescriptive.

I-XXX (1:30).

Even if all the minds of every age were to unite, pool their labors, and hand them down through generations, no significant progress could be made in the sciences by means of anticipations. For radical errors—those arising in the very first digestion of the mind—cannot be corrected by the brilliance of later operations or remedies [1].

[1] These words of Bacon should not be read as a dismissal of refinement itself. Rather, he categorically rejected the false hope that any degree of refinement—however brilliant, ingenious, or subtle—could redeem a system that was fundamentally flawed at its inception. His critique was directed at the starting point: anticipative, hasty generalizations drawn without proper empirical method. Once such errors were embedded, no intellectual finesse could correct them.

I-XXXI (1:31).

It is in vain to expect any significant advancement in the sciences from merely superimposing or grafting new elements onto the old. A true renovation must be undertaken from the very foundations—unless one is content to move endlessly in circles, achieving only slight and almost contemptible progress [1].

[1] Here Bacon reiterated his rejection of mere patchwork reform—adding or adjusting elements within a flawed framework of premature inductions. Instead, he insisted on a true renovation (*instauratio*): a complete restart from the foundations, not an amendment of inherited errors.

I-XXXII (1:32).

The honor due to the ancient authors—and indeed to all others—remains intact, for we are not introducing a comparison of intellects or abilities, but of methods; and we assume not the role of a judge, but of a guide [1].

[1] Bacon's humility in this aphorism was rhetorical and conditional rather than absolute. His tone drew criticism for resembling that of a statesman issuing directives more than that of a philosopher inviting dialogue. William Harvey, his contemporary, is reported to have remarked that Bacon "writes philosophy like a Lord Chancellor"—a comment often interpreted as a critique of Bacon's authoritative and prescriptive style.

I-XXXIII (1:33).

Let it be stated plainly: no sound judgment can be made—neither concerning our method nor regarding the discoveries derived from it—by means of anticipations (that is, the form of reasoning currently in use); for it is unreasonable to expect that something [1] should be judged by the very standard that itself is being called into question .

[1] In this context, *ejus rei* referred not to a generic "thing" but to a mental criterion or epistemological tool—specifically, the traditional reasoning methods Bacon sought to replace. His argument was that no fair judgment of the new method could be made using the very standards it challenged. Metaphorically, the phrase suggested the need for an independent tool of measurement, like a thermometer that settles disputes by offering an objective reading—something *anticipationes* could not provide.

I-XXXIV (1:34).

Nor is the method of delivering or explaining what we present an easy one; for things that are new in themselves are nevertheless understood only through analogy with the old [1] [2].

[1] Bacon anticipated a core insight later developed in Thomas Kuhn's theory of paradigm shifts: that even truly novel discoveries had to be initially understood through analogies with established conceptual frameworks. This reflects the necessity of what modern pedagogy calls *conceptual scaffolding*—building new knowledge upon existing cognitive structures. Bacon recognized that the cognitive transition between paradigms could not occur all at once; communication of new methods had to proceed through the terms and structures of the old, even when those were ultimately to be discarded. Thus, the difficulty in presenting his method lay not only in its content, but in the epistemic reorientation it demanded from its audience.

[2] Excursus – On Communication across Paradigms

A precise description of the phenomenon of conceptual scaffolding can be expressed in terms of coordinate transformations in linear algebra. When moving from one coordinate system to another, the same point or vector is represented differently depending on the basis in use. To make sense of the new representation, one must map the new coordinates back onto the old—at least initially—to understand how they correspond. In epistemological terms,

the transition between paradigms functions similarly: without some relational mapping between the old and new conceptual "axes," the structure of the new cannot be properly interpreted. Bacon's appeal to analogy with the old reflected this requirement for translational intelligibility during paradigm change.

I-XXXV (1:35).

Borgia said of the French expedition into Italy that they came with chalk in their hands to mark out lodgings, not with arms to break in [1]. So too is our method: that our teaching may enter minds that are suitable and capable. For there is no use in refutations, where we differ concerning first principles, the very notions themselves, and even the forms of demonstration.

[1] Borgia refers to Rodrigo Borgia (1431–1503), who reigned as Pope Alexander VI from 1492 until his death in 1503. A member of the powerful and controversial Borgia family, he was often remembered for his political cunning and dynastic ambition. The anecdote cited by Bacon originated from the period of Charles VIII's invasion of Italy in 1494, during which Alexander VI was reported to have remarked that the French came "with chalk to mark their lodgings, not with arms to force them." The saying captured the ease with which the French advanced, and Bacon adapted it metaphorically to describe how his new philosophical method sought entry into receptive minds without intellectual coercion.

I-XXXVI (1:36).

One simple mode of instruction remains for us: to lead individuals to the particulars themselves, along with their sequences and orders; and, in turn, for them to impose upon themselves a temporary renunciation of their notions, and to begin acquainting themselves with things as they actually are [1].

[1] This aphorism reflected Bacon's didactic concern: it outlined a recommended method for teaching and learning, particularly in the early stages of intellectual development. The emphasis on guiding learners toward particulars before

engaging with theories applies not only to novices, but also to educators, institutions, and the structuring of any new field of study.

I-XXXVII (1:37).

The position of those who embraced the doctrine of acatalepsy [1] [2] bears a certain resemblance to our method in its beginnings; yet in its outcome, it diverges greatly and stands in stark opposition. For they assert, in absolute terms, that nothing can be known; whereas we maintain that not much can be known about nature by the method currently in use. However, they proceed from this to destroy the authority of both the senses and the intellect; we, on the other hand, seek to invent and supply aids to both [3].

[1] *Acatalepsy* (Greek: ἀκαταληψία) was the philosophical doctrine that nothing could be known with certainty—an assertion of the inaccessibility of absolute knowledge. Bacon referred to this doctrine to distinguish his own position from ancient dogmatic skepticism: whereas the Academics (see Footnote 2) denied the possibility of knowledge altogether, Bacon argued that knowledge was attainable, though not by the methods then in use. His form of methodological skepticism was constructive—aimed at replacing error-prone procedures with new tools, experimental practices, and a reformed inductive method.

[2] *Academics* (*Academici*) were the philosophers of Plato's school, the *Academy* (Ἀκαδημία), which underwent several phases after his death. The Old Academy (Speusippus, Xenocrates) preserved Plato's metaphysical doctrines; the Middle Academy (Arcesilaus, 3rd c. BCE) introduced a skeptical turn; and the New Academy (Carneades, Clitomachus, Philo of Larissa, 2nd–1st c. BCE) developed this skepticism into the doctrine of *acatalepsia* (ἀκαταληψία), the view that nothing can be apprehended or known with certainty. This position arose in opposition to the Stoic claim that the mind can attain *kataleptic* (truth-bearing) impressions. Bacon refers to these later, skeptical Academics—not to the dogmatic followers of Plato—to contrast their absolute denial of knowledge with his own methodological restraint, which suspends judgment only until new aids to the senses and intellect are devised.

[3] **Excursus – On Knowledge and the Possible Ways to Attain It**
The perspective offered in this Aphorism resonates with other non-dogmatic views of knowledge, both ancient and modern. Socrates, by contrast, maintained that knowledge is possible—though he often professed personal

ignorance, he pursued clarity through dialectical questioning. While his claim that learning is recollection of pre-birth knowledge may be taken as mythical or metaphorical, modern perspectives offer alternative explanations. One possibility is that certain patterns of response—moral intuitions, emotional predispositions, or cognitive instincts—are shaped in part by genetic inheritance. Another is that individuals in modern societies are immersed in vast quantities of passive information from their cultural and technological environments, much of which is absorbed without deliberate effort. Psychological research supports this: studies of implicit learning, ambient language exposure, and social observational learning show that individuals routinely internalize complex patterns without conscious awareness. It has also been shown that decision-making often relies on heuristics and is shaped by framing effects, revealing the pervasive influence of unnoticed cues and prior exposure. These findings suggest that what may appear as innate or self-generated knowledge could, in fact, be the product of deep biological imprinting or ambient cognitive saturation, shaped by repeated, unexamined exposure to cultural and informational patterns.

I-XXXIII (1:38).

The idols and false notions that have already taken possession of the human intellect and are deeply embedded within it not only besiege the mind so thoroughly that access to truth becomes difficult, but also—once such access has been granted—they continue to reappear, obstructing even the renewal of the sciences. Unless men are forewarned and defend themselves against them, as far as is possible, these mental distortions will persist and hinder true progress [1] [2].

[1] The term *idola* referred to systematic distortions or errors of the mind that obstructed the pursuit of true knowledge. Bacon introduced this doctrine formally in I:23 and elaborated it extensively beginning in I:38. The *idola* were not merely false ideas but entrenched habits of thought—"phantoms" or "illusions"—that had to be critically exposed and overcome. Bacon classified these distortions into four types (I:39–44): the *Idola Tribus* (errors common to human nature), *Idola Specus* (errors arising from individual character or experience), *Idola Fori* (errors introduced through language and social discourse), and *Idola Theatri* (errors inherited from philosophical systems or doctrinal worldviews). Throughout *Novum Organum*, Bacon consistently used *idola* to denote these internal impediments, though his tone and emphasis varied between polemical denunciation and methodological caution. In some

passages they appeared as deeply embedded cognitive flaws; in others, as identifiable categories to be managed or methodically neutralized.

[2] **Excursus – On the Systematic Mental Biases**

While Roger Bacon's offendicula offered a superficial precedent in presenting cognitive obstacles, Francis Bacon's idola also displayed notable affinities and contrasts with other philosophical ideas both before and after his time. His Idola Tribus, for instance, echoed ancient reflections—from Stoic and Epicurean traditions—that universal human nature distorted perception, as when the senses erred or the intellect imposed unwarranted patterns upon nature. The emphasis on Idola Fori resonated with Aristotelian and medieval concerns about the imprecision of language, anticipating later modern thinkers who warned of linguistic distortion in scientific discourse. Meanwhile, the concept of Idola Specus paralleled individual psychological bias—though Bacon's classification predated modern psychology—while Idola Theatri prefigured the later critique of dominant scientific paradigms as constructed "stage-plays" rather than reflections of empirical reality. His doctrine therefore contributed an early and systematic epistemology of cognitive error, one that extended human self-critique into a general theory of bias, and anticipated later developments in philosophy of science and cognitive theory.

A comparable concern appears in modern critical theory, particularly in the Frankfurt School's argument that scientific and philosophical systems are never fully autonomous from their social context. Thinkers such as Horkheimer and Adorno emphasized that prevailing scientific theories are shaped by ideological forces and institutional interests—an insight later echoed by philosophers of sociology like Bourdieu. While their critique is framed in terms of cultural power and social reproduction, it parallels Bacon's warning about *Idola Theatri*: entrenched theoretical systems, however intellectually sophisticated, may function more as performances—constructed within and constrained by their own premises—than as reliable instruments for what philosophers call "truth." In both cases, the authority of inherited systems was brought under suspicion, and progress was seen to require a rupture with received frameworks. One might say that Bacon's critique remained internal to epistemology, while the Frankfurt School's critique is external and sociological—but both address the non-neutrality of systems of thought.

I-XXXIX (1:39).

There are four kinds of idols that besiege and afflict the human mind. For the sake of instruction, we have assigned them names: the first kind are called Idols of the Tribe (Idola Tribus); the second, Idols of the

Cave (Idola Specus); the third, Idols of the Forum (Idola Fori) [1]; and the fourth, Idols of the Theater (Idola Theatri) [2] [3].

[1] *Forum* is the Latin word used by Bacon, traditionally rendered "Market Place" in English editions. In modern usage, "marketplace" carries a primarily commercial meaning, whereas Bacon intended the broader Roman sense of a civic space for public speech, deliberation, and exchange of ideas.

[2] In earlier writings, such as *Valerius Terminus*, Bacon used the term *Idola Palatii* (Idols of the Palace) in place of *Idola Theatri*. This variation indicated that even Bacon did not treat such terms as sacrosanct. What matters is not terminological fixity but the deliberate choice of names, clearly defined and consistently applied.

[3] Another example of such terms not being sacrosanct was Bacon's own abandonment of an earlier higher-level classification of the *idola* into *innata* (innate) and *adscititia* (adventitious). In *Distributio Operis* and at the opening of Aphorism I:61, he grouped *Idola Tribus*, *Idola Specus*, and *Idola Fori* as *innata*, arising from human nature, and *Idola Theatri* as *adscititia*, introduced through philosophical systems and corrupt demonstrations. However, he later discarded this dichotomy—likely due to the difficulty of consistently assigning *Idola Fori* to either category—and instead presented all four as coordinate kinds. This demonstrates that terminological distinctions in Bacon's system are functional rather than absolute.

I-XL (1:40).

The generation of notions and axioms through true induction is undoubtedly the most proper and thorough remedy for repelling and removing idols. Still, recognizing the idols is of great use. For the doctrine concerning the idols stands in the same relation to the interpretation of nature as the doctrine of sophistical [1] refutations does to conventional syllogistic dialectic [2] [3].

[1] *Sophistical* here means reasoning distorted by deceptive argument or verbal manipulation; Bacon is not directly referring to the historical Greek Sophists.

[2] This aphorism contained two compressed claims that have invited interpretive commentary. First, the generation of "notions and axioms" through true induction presented a methodological ambiguity: Bacon distinguished

between concepts (*notiones*) and propositions (*axiomata*), yet in practice, as later commentators have noted, these could often be considered inseparable operations in reasoning. Second, the analogy comparing the doctrine of *idola* to sophistical refutations introduced a rhetorical layer that was not immediately transparent. It implied that just as sophistical refutations purified traditional syllogistic dialectic, the doctrine of *idola* purified the mind for natural inquiry—but Bacon offered no further elaboration here, leaving the precise force of the analogy open to interpretation. The comparison with sophistry may also raise doubts about the originality of the concept of *idola*, and whether they were merely familiar logical fallacies in another form.

[3] The phrase rendered here as "conventional syllogistic dialectic" was *dialecticam vulgarem* in the Latin. While *vulgaris* could simply mean "common" or "ordinary," in Bacon's usage it likely carried a mildly derogatory tone, reflecting his critique of scholastic methods as widespread but epistemologically flawed. In this translation, "dialectic" in such contexts is rendered as "syllogistic dialectic" to reflect Bacon's post-scholastic usage, denoting the Aristotelian-scholastic method of syllogistic deduction from received axioms.

I-XLI (1:41).

The Idols of the Tribe are rooted in human nature itself, and in the very constitution of the human stock. It is a false to claim that the human senses are the measure of things [1] [2]; on the contrary, all perceptions—whether of the senses or the intellect—are relative to man, not to the universe. The human mind is like an irregular mirror [3] that reflects the rays of things unevenly, thereby infusing its own nature into the nature of things and thus distorting and corrupting them.

[1] Bacon was challenging the epistemological relativism associated with Protagoras, famously rendered by Plato as: "Man is the measure of all things." This dictum has remained a frequent subject of philosophical discussion, both in antiquity and in modern thought. There has been long-standing debate over whether Protagoras meant that knowledge was confined to the senses alone, or whether he referred more broadly to all human faculties. Bacon himself did not reject the senses, but instead insisted on their collaboration with reason—particularly through disciplined observation and methodical inference—as the proper path to knowledge.

[2] **Excursus – On the Significance of The "Man is the measure of all things."**

Human perception of even the most apparently straightforward phenomena—such as color—varies significantly across individuals. Differences in cone sensitivities, neural processing pathways, developmental history, and categorical training mean that two people may both call an object "green" while experiencing qualitatively distinct sensations. Similar divergences appear in brightness perception, taste, and even basic spatial judgments. These variations do not undermine communication, because behavioral responses remain broadly coordinated, but they reveal that perceptual experience is not uniform across observers.

A parallel form of divergence occurs in auditory perception, especially in the hearing of words and phonemes. The same acoustic signal can yield different perceived words depending on the listener's linguistic background, attentional state, and perceptual weighting of frequency cues. Well-known cases such as the "Yanny/Laurel" ambiguity demonstrate that no single "veridical" hearing is universally shared. Linguistic categories, learned distinctions, and contextual expectations all shape what is heard. In clinical contexts, additional distortions arise in aphasia, auditory hallucinations, or temporal-lobe disruptions, which further show that auditory experience is not identical across persons.

Such perceptual differences extend to higher-order conceptual understanding, where the divergence becomes far more pronounced. Terms like "natural selection," "dialectic," "class," or "rationality" acquire distinct meanings depending on a person's intellectual training, cultural background, and conceptual framework. Kuhn emphasized that scientific paradigms determine which facts are visible and how they are interpreted. Gadamer and the hermeneutic tradition argued that understanding is historically conditioned and mediated by one's "horizon." Wittgenstein located meaning in use within specific forms of life; Quine stressed the indeterminacy of translation; structuralist and post-structuralist thinkers pointed to the shifting networks of signification. Across these approaches, a common insight emerges: different individuals inhabit different semantic worlds even while using the same verbal signs.

Against this backdrop, the claim that "Man is the measure of all things" is not as implausible or eccentric as it initially appears. In its radical form, the dictum grounds truth entirely in individual perception or judgment, a stance often attributed—rightly or wrongly—to Protagoras. While few philosophers endorse this extreme position, the empirical and conceptual considerations above show that experience, interpretation, and meaning genuinely vary from person to person. Although such variation does not compel a fully relativistic epistemology, it reveals that the intuition behind the dictum arises from real

and widespread differences in how individuals perceive, hear, understand, and conceptualize the world.

[3] The choice of a distorted mirror in this aphorism was revealing: it was not the eye that passively received a distorted image of nature, but the mind that actively distorted the image—even when the image itself was not distorted.

I-XLII (1:42).

The Idols of the Cave are the idols of the individual. For each person—beyond the errors common to human nature in general—possesses a private cave or den, which distorts and corrupts the light of nature. This distortion may arise from one's own innate and particular disposition, or from one's education and interaction with others, or from reading books and revering the authority of admired authors, or from the differences in how impressions occur in a mind that is already preoccupied and predisposed, or in one that is composed and balanced, or by similar causes. Thus, the human spirit—as it exists in individual persons—is indeed varied, profoundly disturbed, and almost random in its tendencies. Hence the apt remark of Heraclitus: that men seek knowledge in their own lesser worlds, not in the greater or common world [1].

[1] Heraclitus (c. 540–480 BCE) was a pre-Socratic philosopher from Ephesus, known for his doctrine of flux (*panta rhei* (everything flows)) and the unity of opposites. Bacon here paraphrased Fragment 2, which reads: "Although the *logos* is common, most people live as if they had a private understanding" (τοῦ λόγου δὲ ἐόντος ξυνοῦ, ζῶσιν οἱ πολλοὶ ὡς ἰδίαν ἔχοντες φρόνησιν). This aligned with Bacon's account of the *Idola Specus*, the subjective distortions each person brought to inquiry. By citing Heraclitus, Bacon affirmed that the human mind, left to its own inclinations, tended to seek knowledge within the confines of a *mundus proprius* (private world) rather than the *mundus communis* (shared world) of nature and reason. Both Heraclitus's remark and Bacon's elaboration were framed in such general epistemological terms that they inevitably encompassed all thinkers—including Heraclitus, Aristotle, Bacon himself, and any subsequent inquirer. This is perhaps the most enduring and sobering point: the tendency to inhabit a *mundus proprius* is not limited to

the mistaken, the untrained, or the past. It includes contemporary readers and interpreters as well.

While Heraclitus and Bacon allowed for no exceptions to this condition—all individuals were affected by their own distortions—Plato, in his allegory of the cave (*Republic*, Book VII), admitted the possibility of rare emancipation. For Plato, the philosopher could escape the cave and attain direct knowledge of the Forms; for Bacon, no such escape, in his view, was unqualified—individual error was always present and had to be actively managed through methodical inquiry. This Platonic possibility of liberation, however, has often been misappropriated—particularly in religious or ideological contexts—where the roles of the emancipator and the emancipated were reserved for a privileged few, typically seen as spiritually or intellectually superior. Such interpretations risked entrenching new idols by vesting exclusive authority in a select class, rather than promoting the open, corrective methods Bacon advocated.

I-XLIII (1:43).

There are also idols that arise, as it were, from the agreement and mutual interaction of the human stock—these we call Idols of the Marketplace, because they stem from human exchange and companionship. For men associate through speech [1], and words are imposed according to the understanding of the common people. Thus, the poor and unsuitable imposition of words obstructs the intellect in remarkable ways. Nor do the definitions or distinctions by which learned men customarily seek to defend themselves in any way rectify the matter. Rather, words exert force upon the understanding, confuse all things, and lead men into countless empty controversies and fabrications.

[1] This is the first instance in the aphorisms where Bacon referred explicitly to speech (*sermo*). I will not engage here in a terminological distinction between "speech" and "language," though it is a significant one. What bears emphasis is that language—broadly understood—is not merely a vehicle of communication but a central instrument in the formation and obstruction of knowledge. Its role in scientific thought is so fundamental that the metaphor "Wittgenstein did to language what Kant did to reason" is well justified. Just as Kant critically examined the structures and limits of human reason to delimit metaphysics, so Wittgenstein, particularly in his early and later works,

undertook a critique of language to delimit what can meaningfully be said and where philosophical confusion arises. Both thinkers, in their own ways, set out the conditions under which inquiry is possible.

I-XLIV (1:44).

Lastly, there are idols that have infiltrated the minds of men from various philosophical dogmas and also from the distorted rules of demonstration [1]; these we call *idols of the theater* [2]. For just as many philosophies have been received or invented, so many fictions, staged and performed, we judge to have been produced—fabricating artificial and theatrical worlds. Nor do we speak only of those philosophies currently in circulation, or even solely of ancient systems and sects, since many other such fables may still be constructed and adorned, given that the causes of quite diverse errors are nevertheless, for the most part, the same. Nor again is this to be understood only of comprehensive philosophical systems, but also of numerous principles and axioms within the sciences, which have gained acceptance through tradition, credulity, and neglect.

But concerning each of these types of idols, a more thorough and distinct treatment is needed, so that the human understanding may be duly safeguarded.

[1] Bacon's reference to "distorted rules of demonstration" targeted the classical tradition of demonstrative science, derived chiefly from Aristotle's *Posterior Analytics*. In that model, a demonstrative science was one that proved conclusions by syllogistic reasoning from first principles known to be true, yielding universal and necessary knowledge. This approach was foundational in scholastic logic and was applied to disciplines such as theology, natural philosophy, and mathematics. Bacon critiqued this model for relying on untested assumptions, verbal formulations, and deductive formalism disconnected from empirical observation. He sought to replace such "demonstration" with a method grounded in careful induction and progressive correction. We allude here to Aristotle's demonstrative science and its consequences for scholasticism in Footnote [3] in Aphorism I-XI (1:11) and Footnote [1] in Aphorism I-XII (1:12).

[2] See the footnotes on I-XXXIX (1:39).

I-XLV (1:45) [1].

The human intellect, by its very nature [2], readily presumes a greater degree of order and uniformity in things than it actually discovers. Even though many entities in nature are singular [3] and marked by inequality, they nonetheless constructs imagined parallels, analogies, and relations where none exist [4]. Hence the fictions that, in the heavens, all things move in perfect circles, while spiral paths and "dragons" are altogether dismissed, except in name. Hence, too, the element of fire [5], together with its celestial sphere, was introduced to complete a quartet with the three others perceptible to the senses. Moreover, a tenfold ratio in rarity is arbitrarily imposed among the so-called elements. And such dreams not only infect dogmatic systems, but also corrupt the very simplest notions [6, 7].

[1] Despite his critical posture toward traditional systems, Bacon committed several scientific errors in this aphorism. Most notably, he failed to engage with the astronomical advances of his time, especially the laws of planetary motion established by Kepler (published in 1609 and 1619), which had already supplanted the circular and epicyclic models Bacon critiqued. Instead, Bacon suggested spiral or serpentine orbits—models that lacked empirical support and mathematical coherence. Ironically, while accusing others of constructing fictional geometries, he proposed an equally speculative alternative. Furthermore, he entertained elements of the outdated four-element theory, including discussion of a celestial sphere of fire, which he ostensibly rejected but still treated spatially. His neglect of Galileo's telescopic discoveries and Gilbert's magnetism underscored a residual adherence to pre-Copernican frameworks. In this, Bacon did not always live up to the empirical rigor he elsewhere demanded. These were yet other examples of Bacon not being free from his own distortions. See Footnote 1 in Aphorism I-XLII (1:42).

[2] Bacon's assertion that the intellect erred "by its very nature" (*ex propria natura*) should be understood in light of his broader claim—made more explicitly in I-LII—that all human minds shared a uniform constitution (*ex aequalitate substantial spiritus humani*). This reflected his belief that cognitive errors were not merely circumstantial but arose from an essential and shared structure of the human spirit. Such a view exemplified what may be called anthropological

essentialism: the assumption that the human mind possessed universal features that predisposed it to certain distortions, regardless of education, culture, or historical period. For a contemporary understanding of the "structural property of the human mind," we must defer to modern cognitive psychology and related disciplines. What we can acknowledge, however, is that variation exists at every level of biological complexity and organization, including the domain of cognition.

[3] In this aphorism, Bacon appeared to use the technical term imprecisely, where a form such as *monadica*—derived from the Greek *monas* (μονάς), meaning "unit" or "monad"—would have been more exact. Such terminological looseness was characteristic of his broader Latin usage, which often reflected a functional and innovative approach rather than strict adherence to classical norms. Bacon's Latin served as a working philosophical medium, shaped by Greek conceptual sources and by the evolving vocabulary of early modern science.

[4] **Excursus – On the Anthropomorphic Mind and God**

Some later commentators interpreted Bacon's discussion of cognitive distortions as encompassing the tendency to form *anthropomorphic conceptions of God*. This should not be understood as a theological claim that divinity is a human construct, but rather as an epistemological observation: that the human mind, inclined to project its own modes of thought, often conceives the divine through analogies of human intention, will, or agency. Such *anthropomorphic framing* reflected the same cognitive bias Bacon sought to expose—the imposition of human patterns of order and meaning upon what transcends immediate comprehension. Though not explicit in this aphorism, this interpretation helps clarify the broader scope of Bacon's critique of the *idola mentis* ("idols of the mind").

Some contemporary readers may be tempted to associate Bacon's analysis of *idola mentis* ("idols of the mind") with modern claims that religious concepts arise from evolved cognitive dispositions. For example, Richard Dawkins has argued that the idea of God emerges from the mind's propensity to generate agency, intention, and purpose even where none exists—an explicitly naturalistic thesis that treats divinity as a psychological and cultural construct. It is important to emphasize that Bacon advanced no such view. His account of anthropomorphic projection belonged to an epistemological critique of the intellect's tendencies, not to a metaphysical argument about the being or non-being of God.

A *misinterpretation* of Bacon might assimilate his position to contemporary evolutionary or cognitive accounts of religious belief, such as those associated

with Dawkins. Yet this resemblance arises only when Bacon is read through a modern naturalistic lens. In Bacon's own framework, the *idola tribus* ("idols of the tribe") described the mind's tendency to impose human patterns of order and meaning upon the world; they did not entail that theological concepts were fabrications of the mind. The modern parallel is therefore useful primarily as a contrast that highlights the limits of Bacon's critique and clarifies that his epistemology did not entail a denial of divine reality.

[5] For Bacon's rejection of fire as a fundamental element, see Aphorism II-XI (2:11), where he initiated his empirical inquiry into the nature of heat. There, fire was treated not as a basic substance but as a particular manifestation of motion and interaction, undermining its status as one of the classical four elements.

[6] The principal aim of this aphorism was not merely structural—as a marker for the beginning of the *Redargutio Rationis Humanae Nativae* (as noted in I-CXV)—but philosophical: to expose a deep-seated tendency of the human intellect to project excessive order, symmetry, and correspondence onto nature. This epistemological distortion led to the invention of artificial patterns—numerical, spatial, or elemental—which then infected both scientific axioms and philosophical systems. Despite the factual errors Bacon himself committed here (e.g., dismissing Kepler's elliptical orbits, proposing spiral planetary paths, and entertaining obsolete notions like a sphere of fire), his core diagnosis remains valid. The human mind does indeed tend to over-systematize, often mistaking conceptual elegance for empirical truth. Bacon's own failures thus exemplified, rather than refuted, the very cognitive tendencies he aimed to warn against.

[7] **Excursus – On Epistemological Distortion**

The epistemological distortion Bacon identified here—the tendency of the human mind to impose order and correspondence where none existed—has numerous modern analogues. In theoretical physics, critics have noted that certain branches of string theory prioritize mathematical elegance and symmetry over empirical testability. In economics, models premised on perfectly rational agents and equilibrium systems similarly project artificial regularities onto complex realities. In the social sciences, overgeneralized applications of Darwinian principles or retrospective "just-so stories" serve as cautionary instances of conceptual overreach. Even in popular culture, this cognitive bias is visible: examples include the widespread reports of seeing the face of Jesus in toasted bread or Khomeini's face on the moon. These cases—known as *pareidolia*—illustrate how symbolic or culturally significant forms are imagined within meaningless stimuli. Whether in high theory or everyday perception, the human mind remains predisposed to fabricate structure,

analogy, and harmony beyond what the evidence warrants—just as Bacon observed.

I-XLVI (1:46).

The human intellect, once it has embraced an idea—whether from having received it as credible or because it is pleasing—draws all other things into alignment with it, seeking confirmation and agreement. Even if there is a greater number and weight of counter-instances, it either fails to notice them, disregards them, or pushes them aside through distinctions, not without significant and harmful prejudice, so that its prior assumptions may retain their authority unchallenged. Thus, the response of the man who, when shown a tablet in a temple depicting those who survived shipwreck and fulfilled their vows, was asked whether he now recognized the power of the gods, replied with a counter-question: "But where are those portrayed who, despite making vows, perished?"—was well made [1]. This is the general structure of all superstition: in astrology, dreams, omens, divine retributions, and similar things, people—being enamored of such vanities—note when predictions are fulfilled, but ignore and overlook the far more frequent failures [2]. This fallacy, however, penetrates far more subtly into philosophy and science. Once something is pleasing, it taints and orders everything else around it, even though those others may be firmer and more valid. And even apart from the delight and vanity previously mentioned, there is a deep-seated and perpetual flaw in the human mind: it is more strongly affected and stirred by affirmatives than by negatives, though it ought rightly to regard both with equal impartiality. Indeed, in the establishment of any true axiom, the negative instance carries greater evidential force [3].

[1] The anecdote was attributed to Diagoras the Atheist in Cicero, *De Natura Deorum* III.37, and to Diogenes the Cynic in Diogenes Laertius, *Lives of Eminent Philosophers* VI.59. Both sources used the story to illustrate skeptical responses to appeals to divine intervention.

[2] This passage exemplified a form of confirmation bias: the tendency of the mind to notice and value instances that supported a prior belief while disregarding or rationalizing those that contradicted it.

[3] **Excursus – On the Asymmetry Between Verification and Falsification**
While Bacon asserted that the negative instance had greater evidential force, he neither developed this asymmetry formally nor applied it with consistency across the *Novum Organum*. His inductive method emphasized the gradual elimination of error through exclusions and comparative instances, but it lacked a systematic account of how a single counterexample might decisively refute a general claim. This stood in contrast to David Hume's later critique of induction, which argued that no amount of empirical observation could logically justify universal claims. For Hume, induction was grounded not in reason but in habit—the mind's tendency to expect regularity from repeated experience—thus exposing the epistemological limits of empirical generalization. Nevertheless, this aphorism anticipated a central concern in twentieth-century philosophy of science: the asymmetry between verification and falsification. Thinkers such as Karl Popper later argued that while no number of confirming instances can prove a universal theory, a single falsifying instance can, in principle, disprove it—that is, if the theory is *simplicus*, I may add. See the "Typology of Theoretical Structure" in footnote [2] to Aphorism I-XVI (1:16).

I-XLVII (1:47).

The human intellect is especially moved by those things that can strike and enter the mind all at once and suddenly—those by which the imagination is accustomed to be filled and inflated. It then, often imperceptibly, imagines and assumes that all other things are like those few which have taken hold of the mind. But when it comes to making the leap to remote and heterogeneous instances—by means of which axioms are tested as if by fire—the intellect is altogether slow and inept, unless it is compelled to undertake this by strict rules and the imposition of authoritative command [1] [2].

[1] Bacon here identified a cognitive bias akin to what is now called the salience or availability heuristic: the tendency of the mind to give undue weight to vivid, emotionally charged, or clustered impressions, which could distort judgment and lead to premature generalization.

[2] A modern analogue to Bacon's example would be media-induced fears after high-profile events such as airplane crashes or terrorist attacks. Despite their rarity, such incidents dominate public attention and imagination, often obscuring more probable but less sensational risks—just as striking natural phenomena could mislead scientific inquiry unless corrected by methodical engagement with subtler, more heterogeneous instances.

I-XLVIII (1:48).

The human intellect is restless and cannot pause or find satisfaction, but ever seeks further—though in vain. Thus, it seems unthinkable that there should be any outermost boundary or end to the world; rather, it always appears as though something must lie beyond. Likewise, the mind cannot comprehend how eternity could have flowed down to the present day [1]. The distinction, commonly accepted, between infinity in the past and in the future cannot be maintained, for it would entail that one infinity is greater than another and that the infinite may be consumed and approach finitude. A similar subtlety arises in the case of the perpetual divisibility of lines—born from the mind's inability to stop [2]. Yet this impotence of the intellect brings about even greater harm in the investigation of causes. For although the most universal elements of nature ought to be accepted as positive facts—just as they are discovered—and are not in truth causable, the human mind, unable to rest, longs for something more readily grasped [3]. Then, in striving toward what is more remote, it collapses back upon what is closer—namely, final causes [4]—which are plainly derived from human nature rather than from that of the universe. And from this source philosophy has been corrupted in myriad ways. It is equally a sign of ignorance and superficial philosophizing to demand a cause for the most universal things as it is to neglect to seek causes for subordinate and derivative ones [5].

[1] Bacon's remarks on the impossibility of limits to space and time reflected the psychological tendencies of the intellect, not physical theory. In contrast, modern physics—especially general relativity—treats space and time as

measurable, curved dimensions shaped by matter and energy, and allows for finite but unbounded models of the universe.

[2] Bacon alluded to Aristotelian doctrines on the infinite divisibility of magnitudes, especially as found in ancient debates on indivisible lines (e.g., *περὶ ἀτόμων γραμμῶν*).

[3] As Aristotle put it in *Metaphysics* III.4 (1006a6–9), "It is a mark of ignorance not to know what kind of things require demonstration and what do not; for it is impossible to demonstrate everything—one would go on to infinity, and thus there would be no demonstration at all."

[4] **Excursus – On Teleology**
In Aristotle's framework, the final cause referred to the end or purpose for which a thing existed. Bacon criticized the intrusion of this concept into natural philosophy, regarding it as a projection of human psychology rather than a property of nature. Modern science likewise rejects teleological explanation, and even linguistic teleology—such as describing biological features as existing "in order to"—is philosophically misleading. This language risks reinforcing erroneous ideas of intentional design, particularly among those unaware of its metaphysical implications. Nonetheless, in evolutionary biology, distinctions between proximate causes (e.g., physiology) and ultimate causes (e.g., natural selection) retain explanatory utility, as formalized in Tinbergen's four questions—though without commitment to final causation in the Aristotelian sense.

[5] Many aphorisms in the *Novum Organum* engaged complex philosophical and scientific issues that could not all be addressed in detail here. Extended commentary on each would have risked burdening the reader and obscuring the text's overall structure. The annotations therefore focus selectively on points most essential for understanding Bacon's meaning, context, and relevance.

I-XLIX (1:49).

The human intellect is not a dry and untainted light [1]; it is infused with the will and emotions, which steer the sciences in the direction of its desires. For what a person wishes to be true, they are more inclined to believe. Accordingly, the mind rejects what is difficult, out of impatience with inquiry; what is sober and restrained, because it narrows hope; the deeper aspects of nature, due to superstition; the

illumination of experience, out of arrogance and disdain—lest the mind appear to dwell on base and fleeting things; paradoxes, out of respect for popular opinion. In short, the affections penetrate and corrupt the intellect in countless ways, many of them subtle and imperceptible.

[1] Bacon's phrase "dry light" may have alluded to Heraclitus's saying, "the dry soul is wisest," later cited by Plutarch and others to express intellectual clarity untainted by emotion.

I-L (1:50).

But by far the greatest impediment and deviation of the human intellect arises from the dullness, inadequacy, and deceptions of the senses, such that things which strike the senses outweigh those which do not immediately strike them, even when the latter are of greater importance. Thus contemplation tends to stop at what is visible; and so there is little or no observation of the invisible. Accordingly, the whole operation of spirits [1] enclosed within tangible bodies lies hidden and escapes human notice. Likewise, the subtler structural transformation [2] in the parts of denser substances (commonly called alteration, though in truth it is movement through minima) is similarly hidden [3]. Yet unless these two matters are investigated and brought into the light, without which nothing substantial in nature can be effected in practice in nature with respect to practical works. Moreover, the very nature of common air and of all bodies that surpass air in rarity (which are many) is virtually unknown. For the senses in themselves are weak and fallible; and instruments for magnifying or refining them are of limited efficacy. The truer interpretation of nature is achieved through instances and suitable, well-designed experiments—wherein the senses pass judgment only on the experiment, while the experiment passes judgment on nature and the thing itself.

[1] Bacon used *spirits* not to mean incorporeal or mental entities, but highly rarefied, active substances—what we might describe as subtle fluids or volatile matter—that permeated both animate and inanimate bodies. These "spirits" were responsible for internal operations hidden from the senses. Influenced by earlier natural philosophy and figures such as Paracelsus, Bacon extended this concept beyond living organisms to all matter. Though he considered their existence certain, he acknowledged that they manifested only through effects and remained imperceptible in themselves.

[2] Bacon used *meta-schematismus* (translated here as "subtler structural transformation") to describe imperceptible changes in the internal arrangement of particles within bodies—particularly denser substances. What was traditionally called "alteration" (ἀλλοίωσις), he redefined as motion through *minima*, that is, elementary shifts at a subvisible level. This idea was part of a broader theory of matter in which all bodies possessed a hidden structure (*latens schematismus*), the rearrangement of which constituted *meta-schematismus*. Though influenced by ancient atomism, Bacon rejected the vacuum and preferred to speak of "particles" rather than "atoms."

[3] In contrast to the traditional Aristotelian notion of *alteratio* (ἀλλοίωσις) as qualitative change, Bacon argued that such change was in fact a physical process—namely, a reconfiguration of the smallest parts of a body. He thus reconceived alteration as motion through *minima*: shifts in the subvisible arrangement of matter, rather than transformations in inherent qualities.

I-LI (1:51).

The human intellect, by its own nature, is inclined toward abstractions, and it imagines as constant that which is in fact in flux [1] [2]. Yet it is better to dissect nature than to abstract it [3]—just as the school of Democritus did, which penetrated nature more profoundly than others [4]. We ought to focus on matter itself, and on its structure (*schematismi*), its transformations (*meta-schematismi*), pure act (*actus purus*) [5], and the law of act or motion; for what we call "forms" are merely inventions of the human mind—unless, that is, we are willing to call the laws of action by the name of "forms [6] [7]."

[1] he distinction between internal and external factors—often expressed as intrinsic vs. extrinsic, or genetic vs. environmental—remains a common analytic framework across disciplines. While these dichotomies appear

equivalent, their interpretation is shaped by disciplinary culture: what a developmental psychologist counts as "environmental" (e.g., parental language input or classroom exposure) differs markedly from what an ecologist or urban planner might mean (e.g., climate or infrastructure). Care must therefore be taken not to impose narrow readings of these terms when evaluating cognitive or epistemic variation.

[2] **Excursus – On Individual Variations**
Bacon, like many early modern thinkers, attributed fixed tendencies to "the human" as if intellect and cognition were uniform across individuals. He did not consider variation among persons or cultures, nor the possibility that these intellectual inclinations might be shaped by biological factors (including genetics), context, education, or experience.

[3] Bacon contrasted the empirical analysis (dissection) of natural particulars (*secantem naturam*) with the construction of abstract generalities (*abstrahentem naturam*). While both had their place, he insisted that abstraction had to follow—rather than precede—careful examination of concrete phenomena.

[4] Bacon expressed rare admiration for the atomist tradition of Democritus, whom he credited with a more penetrating analysis of nature's material structure than other ancient schools. Though Bacon rejected some core atomist doctrines (e.g., the void), he valued their empirical orientation and their focus on the minute composition of bodies.

[5] *Actus Purus* was a scholastic term inherited from Aristotelian metaphysics, denoting the realized activity or operation of a thing, as opposed to its mere potential. Bacon repurposed it to signify the intrinsic operations of natural bodies, governed by their internal structure and natural laws, independent of external interference.

[6] Bacon redefined "Form" in a sense distinct from both Plato's archetypes and Aristotle's formal causes.

[7] **Excursus – On the Stability of definitions of Concepts (1)**
Bacon rejected the classical notion of Forms as immaterial archetypes (as in Plato) or intrinsic causes of being (as in Aristotle). Instead, he redefined Form as the law of a body's operation—what governed its behavior or transformation in nature. While this redefinition supported his empirical project, it risked conceptual confusion: the term *Form* remained indelibly associated with Platonic metaphysics. Bacon's appropriation of it, however strategic, never displaced its older connotations.

A similar case can be seen with *dialectic*: originally the Aristotelian-scholastic *syllogistic dialectic* of logical disputation, later redefined by Hegel from an epistemological method of logical inquiry into a generative process of historical unfolding. That redefinition has since been subject to further "re-definitions" by figures such as Adorno, Jameson, and Žižek—resulting in a proliferation of meanings, often disconnected from both Hegel and the term's original sense. Bacon's case served as a caution: even precise redefinition could be obscured when it clashed with established philosophical lineage.

I-LII (1:52).

These, then, are the idols which we designate as *Idols of the Tribe*. They arise either from the uniformity of the substance of the human spirit [1]; or from its preconceived notions; or from its narrowness; or from its restless activity; or from the influence of the emotions; or from the inadequacy of the senses; or from the particular mode of sensory impression [2].

[1] Bacon suggested that the human mind, being of uniform and limited substance, tended to project its own regularities onto the natural world. This led to the invention of false uniformities and analogies that obscured the true variety and irregularity of nature.

[2] While Bacon was rarely praised for the elegance of his Latin prose, this aphorism stood out for its rhetorical balance and clarity. The measured enumeration of causes—each introduced with formal symmetry—lent the passage a sense of conceptual completeness and stylistic poise. It was one of the few moments in the *Novum Organum* where Bacon's philosophical precision was matched by a refined literary cadence.

Hujusmodi itaque sunt *idola*, quae vocamus *idola tribus*; quae ortum habent aut ex aequalitate substantiae spiritus humani; aut ex praeoccupatione ejus; aut ab angustiis ejus; aut ab inquieto motu ejus; aut ab infusione affectuum; aut ab incompetentia sensuum; aut ab impressionis modo.

Very beautiful.

I-LIII (1:53).

The *Idols of the Cave* arise either from each person's own nature—both of mind and of body—or from education and habit, or from chance. This kind is manifold and diverse; yet I shall set down those that call for the greatest caution, and exert the strongest power to corrupt the intellect and to hinder it from remaining pure [1].

[1] Bacon's reference to the intellect "remaining pure" rests on a key assumption in his natural philosophy: that nature possessed a fixed, law-governed order—a "true image" (*vera imago*)—which for him was, in principle, knowable. Any variation between human thought and this order arose from distortions within the mind, not from variability in nature itself. The Idols of the Cave represented a major source of such deviation, as they introduced private, idiosyncratic biases into observation and reasoning. Purity of intellect, for Bacon, therefore signified the progressive removal of these deviations, enabling the mind to conform ever more closely to the single, objective structure of nature. Later scientific and philosophical developments have introduced alternative perspectives, some of which regard nature as potentially unknowable, dynamic, or variable.

I-LIV (1:54).

Men grow attached to particular sciences and lines of inquiry, either because they regard themselves as the authors and inventors of them, or because they have invested great effort in them and become deeply accustomed to their practice. But such individuals, when they turn to philosophy and more general contemplations, distort and corrupt these by imposing upon them the fantasies formed in their prior pursuits. This is most strikingly exemplified by Aristotle, who subordinated his natural philosophy entirely to his logic, rendering it nearly useless and overly contentious [1]. The chemists [2] [3], likewise, from a handful of furnace experiments, constructed a fanciful philosophy focused on narrow matters. And Gilbert, after laboring intensely in the study of the magnet, immediately fabricated a philosophy in conformity with the object that had so captivated his attention [4].

[1] In Bacon's time, Aristotle's authority remained deeply entrenched in European philosophy, particularly within university curricula. To accuse him of having subordinated natural philosophy to logic was to challenge one of the principal foundations of learned tradition. Bacon's willingness to treat Aristotle as subject to the same scrutiny as any other thinker reflected his methodological stance that all received doctrines, however venerable, must be tested against nature and revised or discarded if found wanting.

[2] In Bacon's usage, "chemists" referred to alchemists—practitioners concerned with pursuits such as the transmutation of metals and the search for the elixir of life—rather than to the discipline of chemistry as it later developed.

[3] **Excursus – On Transmutability**
The alchemists' belief in the fixed "kinds" of metals drew upon the Platonic–Aristotelian tradition of essential forms, in which each natural substance possessed a defining essence that determined its identity. The repeated failure to transmute one metal into another was taken by many as confirmation of the unchangeability of such kinds. This essentialist framework also underpinned pre-Darwinian biology, where "species" were likewise regarded as fixed and invariable. Darwin's argument for the transmutability of species thus not only challenged prevailing biological thought but also broke with a metaphysical inheritance that had shaped both natural philosophy and the alchemical tradition since antiquity.

[4] Bacon's criticism in this aphorism was that each figure allowed the methods and concepts of a narrow specialty to dominate their wider philosophical outlook, constructing an entire system on a basis too restricted to account for the variety of nature.

I-LV (1:55).

The greatest and indeed most fundamental distinction between minds, in matters of philosophy and science, is this: some minds are stronger and more adept at discerning differences between things, others at discerning their similarities [1]. Minds that are steady and sharp are able to fix their contemplations, to linger and remain with the finest nuances of distinction; while minds that are elevated and discursive are able to recognize and unite even the most subtle and universal resemblances among things. Yet both types of intellect are prone to

excess—one in grasping at minute gradations, the other in chasing after mere shadows.

[1] This contrast between minds inclined toward noting differences and those inclined toward noting similarities was one instance of Bacon's frequent use of dichotomies to classify intellectual tendencies. Such pairings served both as psychological observations and as reminders that each tendency, while valuable, could become a source of error if left unchecked—a theme that recurred throughout the *Novum Organum*.

I-LVI (1:56).

Some minds are inclined toward an excessive admiration of antiquity; others toward a fervent embrace of novelty. Few, however, possess a temperament sufficiently balanced to maintain moderation—such that they neither undermine what the ancients have rightly established nor disregard the valid contributions of the moderns. This tendency greatly harms the progress of science and philosophy, for it transforms inquiry into partisanship rather than judgment. Truth must be sought not in the fortune of any particular age—a shifting and unreliable thing—but in the light of nature and experience, which is eternal. These tendencies must, therefore, be renounced, and care must be taken that the intellect not be carried away into premature assent by their allure.

I-LVII (1:57).

The contemplation of nature and of bodies in their simplicity shatters and fragments the intellect; whereas contemplation of nature and bodies in their composition and structural configuration overwhelms and disorients it. This contrast is clearly seen in the school of Leucippus and Democritus when compared with other philosophies. That school focused so intensely on the particles [1] of things that it almost disregarded their structures; the others, by contrast, became so enraptured by the structures that they failed to penetrate to the

elemental simplicity of nature. Thus, these two modes of contemplation must be alternated and applied in turn, so that the intellect may become both penetrating and capacious, and the aforementioned shortcomings—as well as the idols arising from them—may be avoided [2].

[1] Bacon's "particles" here translates *particulae*, referring to the indivisible material units of the ancient Greek atomists, Leucippus and Democritus. These were conceived as solid, eternal, and qualitatively distinct in shape and size, moving through void space—a view still broadly compatible with early modern corpuscular theories. Newton likewise spoke of material particles in this physical sense, but in his gravitational theory he could also treat an entire body, such as a planet, as a "point mass"—an idealized particle possessing mass but no size, used for mathematical convenience rather than as a literal constituent of matter. In modern physics, by contrast, "particles" such as atoms, electrons, or quarks are neither indivisible in the ancient sense nor necessarily solid, and are described in terms of quantum properties rather than purely mechanical ones.

[2] **Excursus – On the Stability of definitions of Concepts (2)**
Incidentally, the concept of "mass" has also changed since Newton's time. For Newton, mass was a constant measure of the quantity of matter and the source of a body's gravitational attraction. In Einstein's special relativity, mass and energy are interrelated ($E = mc^2$), and the relativistic mass of a moving body depends on its speed. In contemporary particle physics, the Higgs mechanism describes mass as arising from the interaction of particles with the Higgs field. Thus, whereas in Newtonian physics mass was the source of gravitational force (or the gravitational field in our understanding), in the Higgs' framework, it is the Higgs field that endows certain particles with rest mass. Therefore, a seemingly simple notion such as 'mass' has been understood in strikingly different ways across the history of physics. Such developments illustrate how shifts in scientific paradigms can fundamentally recast even the most basic physical concepts, as the very vocabulary of science acquires new meaning under changing theoretical frameworks.

I-LVIII (1:58).

Let this, then, be the kind of contemplative prudence exercised in the warding off and expulsion of the *Idols of the Cave*—idols which chiefly arise from the predominance of a particular discipline, from excessive

tendencies toward either synthesis or analysis, from a partiality for certain historical periods, or from the scale of objects contemplated, whether large or minute. More generally, let every student engaged in the contemplation of nature hold in suspicion whatever most seizes and occupies his intellect; and let even greater caution be applied to such beliefs, in order that the understanding may be preserved impartial and pure.

I-LIX (1:59).

But the *Idols of the Forum* [1] are the most troublesome of all. These arise from the compacts and conventions of words and names, which have insinuated themselves into the intellect. For while men believe that their reason governs words, it is equally the case that words exert force upon the intellect and reflect it back upon itself—thereby rendering philosophy and the sciences sophistical and ineffectual. Most words are coined in accordance with popular understanding, and they divide reality along lines most apparent to the vulgar mind [2]. When a more refined intellect or a more diligent observer seeks to adjust these divisions to be more in accord with nature, words resist the shift. Thus it comes to pass that even the most serious and solemn debates among learned men often degenerate into quarrels about terms and names—issues which, following the caution of mathematicians, it would be wiser to begin with and to settle through careful definition. Yet even definitions, when it comes to natural and material phenomena, cannot remedy the problem, for they are made of words, and words spawn more words [3]. Hence, it becomes necessary to return to individual instances and their orderly series and arrangements, as will be discussed later in relation to the construction of notions and axioms.

[1] Traditionally rendered as *Marketplace*.

[2] Inherited terms often only partially fit the concepts they denote and may include meanings unintended in precise inquiry. Such words require continual refinement and definition to align them more exactly with the ideas they are meant to express—a difficulty arising from their origin in everyday speech. See 1:51:[7].

[3] Bacon's distinction between mathematics, where definitions can be fixed at the outset, and natural philosophy, where they cannot, reflected the state of inquiry in the early seventeenth century. In his time, definitions in the study of nature relied on verbal descriptions of complex phenomena and were often provisional until inductive investigation had advanced. Modern science has altered this balance: in many fields—including biology, chemistry, and physics—definitions are now frequently formalized early through mathematical, statistical, or model-based frameworks tied to measurable criteria. While Bacon's caution remains valid in cases involving poorly characterized or emerging concepts, it no longer applies universally.

I-LX (1:60).

The idols imposed on the intellect by words are of two kinds. The first consists of names for things that do not exist. Just as there are entities without names due to lack of observation, so too are there names lacking referents, born of fanciful suppositions. Examples of this kind include *Fortune*, *Prime Mover*, *Planetary Orbits*, *Element of Fire*, and other such fabrications originating from false and idle theories. These idols are more easily expelled, for they can be eradicated through the steady rejection and obsolescence of the theories that gave rise to them.

The second kind is more complex and deeply embedded, arising from faulty and inexpert abstraction. Take, for instance, the term *humid*. Examine how the different things signified by this word align, and one finds it to be merely a confused label for diverse actions lacking any stable or reducible meaning. It may signify: that which easily envelops other bodies; that which is indeterminate and lacks consistency; that which yields from all directions; that which readily disperses; that which easily unites; that which flows and is set in motion; that which

clings to another body and makes it damp; that which liquefies from a prior solid state. Thus, if we predicate this term differently, flame is humid; in another sense, air is not; in another, fine dust is; in another, glass is. Clearly, the concept has been rashly abstracted from water and ordinary liquids, without adequate verification.

Moreover, there are degrees of error and distortion in words. Least faulty are names of substances, particularly of specific and well-derived kinds (e.g., *chalk* and *mud* are well conceived, *earth* less so); more faulty are terms for actions, such as *generate*, *corrupt*, *alter*; and most faulty are terms for qualities (excepting those which are direct objects of sense), like *heavy*, *light*, *rare*, *dense* [1]. Nonetheless, even in these, some notions are inevitably a little better than others, insofar as they correspond to a greater variety of cases encountered by human senses [2].

[1] By "qualities … direct objects of sense" (*quae sensum feriunt immediate*), Bacon follows the Aristotelian classification of *propria sensibilia* ("proper sensibles"), i.e., qualities perceived by a single sense without inference. These include *color* (sight), *sound* (hearing), *taste* (taste), *odor* (smell), and *heat* or *cold* (touch). See cf. I:48, I:50–51; also *De augmentis scientiarum* VI.2. By contrast, qualities such as *heavy*, *light*, *rare*, and *dense* require comparison or reasoning and thus are more liable to conceptual error.

[2] This aphorism marks the end of the first of Bacon's three *Redargutiones* ("Refutations") outlined in cf. I:115. The present section has addressed the *Redargutio Ingenii* (Refutation of the Native Human Intellect). The next section, running from I:61 to I:115, covers the *Redargutio Philosophiarum* and *Redargutio Demonstrationum* (Refutation of Philosophies; Refutation of Demonstrations), which Bacon treats in overlapping fashion.

I-LXI (1:61).

But the *Idols of the Theater* are not innate [1], nor do they secretly creep into the intellect; rather, they are clearly instilled and accepted from the fictions of philosophical systems and the corrupt rules of

demonstration. It is wholly inconsistent with what we have stated to attempt to refute these idols, for since we agree neither on first principles nor on the rules of demonstration, all argument becomes void. Yet this happens, not unfortunately, but with good consequence, since the honor of the ancients remains intact. Nothing is taken away from them, for the dispute concerns not the destination, but the path. As the saying goes: the lame man on the path outstrips the runner who goes astray. And indeed it is plainly evident that the more able and swift a person is who runs off course, the greater the deviation will be [2].

[1] In earlier writings, Bacon sometimes grouped the *Idola Tribus* and *Idola Specus* as "innate" (*innata*), and the *Idola Theatri* as "acquired" or "adopted" (*adscititia*). This created a difficulty for placing the *Idola Fori*, which he occasionally treated as intermediate between the two. The opening sentence here reflects that earlier scheme, though in the *Novum Organum* the four classes are presented without this binary division.

[2] **Excursus – On Reaching the Truth**
Bacon's metaphor assumes a stable, unchanging path toward "truth"—an assumption not shared here. In a world where the intellectual terrain itself shifts, keeping pace may be as important as direction. Lewis Carroll captured this in his 'Red Queen' dialogue (Lewis Carroll (1871), *Through the Looking-Glass and What سرخ Found There*, Chapter 2):

'Well, in our country,' said Alice, still panting a little, 'you'd generally get to somewhere else—if you run very fast for a long time, as we've been doing.'

'A slow sort of country!' said the Queen. 'Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!'

Now, our method of discovering the sciences [3] is such that it leaves little to the sharpness or strength of intellect, but rather levels and equalizes minds. Just as in drawing a straight line or a perfect circle, much depends on steadiness and practice if done by hand alone—but very little, or nothing at all, if a ruler or compass is used—so is our approach. Although detailed refutations serve no use, something must

still be said about the sects and general kinds of these theories [4]; also about the external signs by which their defective state becomes evident; and lastly about the causes of such deep misfortune and of so long-lasting and widespread a consensus in error. By doing so, access to truth may be made easier, and the human intellect may more readily be purified and relinquish its idols.

[3] The Latin phrase scientiarum inveniendarum modus literally means "method for discovering the sciences." Bacon here speaks of sciences (organized fields of knowledge) rather than directly of nature, not because he saw nature as secondary, but because his rhetorical focus is on method. For Bacon, the ultimate object of inquiry is nature itself; the sciences are the systematic, reliable bodies of knowledge constructed from that inquiry. Thus, "discovering the sciences" means establishing entire disciplines on a secure empirical foundation, not merely adding facts to a pre-existing framework. A modern paraphrase that preserves this causal order could read: "our method of inquiry into nature, by which the sciences themselves are discovered and built."

[4] The term *sects* here translates the Latin *sectae*, which in Bacon's usage refers not to religious schisms in the modern sense but to philosophical "schools" or factions—organized bodies of thinkers bound by shared doctrines and methods, often inherited from a founding figure. Examples in antiquity include the Aristotelians, Epicureans, Stoics, and Skeptics. Bacon regards these sects as prone to intellectual partisanship, maintaining allegiance to received principles even when contradicted by experience, thus perpetuating their characteristic errors.

I-LXII (1:62).

The *Idols of the Theater*, or those of theories, are many—and there can be, and perhaps will be, many more. Were it not that, for so many centuries, human minds have been preoccupied with religion and theology; and were it not that civil governments—especially monarchies [1]—have been averse to such innovations, even in matters of contemplation, so that engagement with them is undertaken at the peril and cost of one's fortune, not only without reward but exposed to contempt and envy—then surely many other philosophical sects

and systems would have arisen, similar to those which once flourished with great variety among the Greeks. For just as one may fabricate many models of the heavens based on the phenomena of the sky, so—and even more so—can various dogmas be constructed and grounded upon the phenomena of philosophy. And these theatrical fictions of theory resemble the plays of poets: fictional narratives performed on stage are often more elegant, composed, and appealing than true histories.

[1] By "especially monarchies" (*praesertim monarchiae*), Bacon referred to a tendency within centralized civil governments to resist intellectual and doctrinal innovation more strongly than other forms of state. This remark follows, and is distinct from, his comment on the influence of religion and theology, indicating a separate source of constraint—civil rather than ecclesiastical authority. The observation is framed as a general historical tendency, not a political polemic, and is phrased broadly enough to avoid direct criticism of the Stuart monarchy under which Bacon served as the Vice Chancellor.

In general, philosophy tends either to draw too much from a few things, or too little from many; so that in either case it is founded on a base of experience and natural history that is too narrow, and pronounces judgments based on fewer observations than it ought [2]. Rationalist philosophers [3] seize a variety of common phenomena from experience, though they are neither clearly ascertained nor carefully examined and weighed; the rest they entrust to meditative reflection and intellectual speculation.

[2] Bacon contrasted two errors in what he called *multum ex paucis* ("much from few") and *parum ex multis* ("little from many"): the empirical school *overgeneralized from too few experiments*, while the rational or sophistical school *drew too few and too vague conclusions from many loosely examined facts*.

[3] Bacon's "rationalist philosophers" corresponds to his *philosophi sophistici*, a label inherited from ancient usage for those who trusted excessively in deductive reasoning from general principles, often without sufficient

grounding in observation. The term does not align exactly with the later "Rationalist" school of the 17th–18th centuries (e.g., Descartes, Leibniz, Spinoza), but rather denotes a methodological tendency already present in antiquity and the scholastic tradition.

Another group of philosophers have labored with diligence and precision over a few experiments, and from them have dared to extract and construct entire systems of philosophy—forcing all other facts, in astonishing ways, to conform to their framework.

A third group mixes theology and traditional doctrines into philosophy, out of faith and reverence. Among these, the vanity of some has led them to seek and derive scientific knowledge from spirits and genii. Thus the rootstock of errors and of false philosophy is threefold: sophistical, empirical, and superstitious [4].

[4] It seems that Bacon left the last two categories deliberately vague, likely to avoid controversy by naming living or recent figures. He instead applied his tripartite error scheme—sophistical, empirical, and superstitious—to characterize the methodological vice without attaching it to a single target in this passage.

I-LVIII (1:63).

The clearest example of the first kind of false philosophy is Aristotle, who corrupted natural philosophy by subordinating it to his syllogistic dialectical method. He constructed the world out of his categories; assigned the human soul—the noblest of substances—a genus derived from terms of second intention [1]; treated the question of density and rarity, by which bodies potentiality expand and contract spatially, through the frigid distinction of act and potentiality [2]; asserted that each body has a single, proper motion [3], and that any other motion it exhibits must be imparted from outside; and imposed countless other arbitrary conceptions upon nature—always more concerned with producing neat verbal answers and framing positive propositions than

with discerning the inner truth of things. This is most clearly revealed when his philosophy is compared with the systems that were celebrated among the Greeks. For the homoiomerous elements of Anaxagoras, the atoms of Leucippus and Democritus, the heaven and earth of Parmenides, the strife and friendship of Empedocles, the reduction of bodies to the indeterminate nature of fire in Heraclitus and their reconstitution into solidity—all these show some engagement with natural philosophy, and bear the marks of nature, experience, and physical inquiry. But Aristotle's physics mostly resound with terms of syllogistic dialectic. And this same pattern he revisited in his *Metaphysics*, under a more solemn name, supposedly presenting it as more "realist" than "nominalist" [4]. Nor should one be swayed by the frequency of experiments in his books *On Animals*, *Problems*, and other treatises. For he had already decided his conclusions beforehand; he did not consult experience as he should have, to form principles and axioms, but, having once determined his doctrine at will, he bent experience to suit his ideas, dragging it about as a captive. In this respect, he is even more to be blamed than his modern followers—the Scholastic philosophers—who abandoned experience entirely [5].

[1] By "terms of second intention" (*secundae intentionis vocabula*), Bacon referred to technical terms in scholastic logic that signified concepts about concepts rather than things existing independently in nature. Such terms were applied to mental acts or linguistic categories—e.g., *genus*, *species*, *proposition*—and contrasted with "first intentions," which signified actual things in the world. The medieval first intention / second intention distinction mapped fairly closely to the modern distinction between object language and metalanguage, or between first-order and second-order discourse. While the terminology "first/second intention" is not common outside historical scholarship, the distinction itself—between "talk about things" and "talk about our concepts of things"—remains deeply embedded in current debates in logic, metaphysics, and philosophy of language.

[2] By "act and potentiality" (*actus et potentia*), Bacon referred to Aristotle's distinction between an existing actuality (*energeia* or *entelecheia*) and a capacity or possibility for change (*dynamis*). In Aristotelian physics, this framework was applied to natural transformations—for example, water was

said to be “potentially” air, and air “actually” rarefied water—so that the change from one to the other could be described in terms of the passage from potentiality to actuality. Bacon regarded such explanations as abstract logical devices that did not engage adequately with the physical causes of density and rarity.

[3] In Aristotelian cosmology, “proper motion” (*motus proprius*; also *oikeia phora* or *idios phora*) denoted the single, natural motion belonging to each simple body—upward for fire and air, downward for earth and water, circular for the heavenly bodies. Any other motion was considered “foreign” or “violent” (*motus alienus*), imposed externally rather than arising from the body’s own nature. Bacon criticized this doctrine for restricting bodies to one intrinsic kind of movement, which in his view limited the scope of physical inquiry.

[4] Bacon’s use of the terms *realist* and *nominalist* in this aphorism should not be interpreted in the strict Scholastic sense associated with the medieval dispute over the ontological status of universals. He employs the labels rhetorically, not technically. By calling Aristotle’s metaphysics “more ‘realist’ than ‘nominalist,’” Bacon alludes only loosely to the customary contrast between doctrines that claim to describe real essences and those that deal chiefly in names, terms, and logical distinctions. His point is that Aristotelian metaphysics presents itself as a doctrine grounded in the real natures of things, while in practice it rests on conceptual abstractions and dialectical constructions—thus amounting, in Bacon’s judgment, to a form of nominalism in effect if not in intention. Recognizing this nontechnical usage is essential, for both *realism* and *nominalism* have undergone significant redefinitions in modern philosophical discourse, and Bacon’s rhetorical contrast cannot be mapped onto contemporary meanings without distortion.

[5] If not the strongest criticism Bacon ever produced, this aphorism is certainly the most severe attack on Aristotle within the *Novum Organum*. The tone is strikingly scornful: Bacon writes as one who, in a wholly positive sense, has relinquished any deference to Aristotelian authority. His aim is to dismantle the Aristotelian mode of philosophizing at its roots, and in this passage he executes that aim with unmistakable force. It is telling that Aristotle receives greater respect among contemporary philosophers than he did from Bacon himself.

I-LXIV (1:64).

But the empirical school of philosophy gives rise to doctrines more misshapen and monstrous than either the sophistic or rationalist schools. This is because it does not ground itself in the light of common

notions (which, though weak and superficial, is in some sense universal and applicable to many things), but rather in the narrowness and obscurity of a few isolated experiments. Consequently, such philosophy appears probable and even nearly certain to those who engage daily in such experiments and have thereby corrupted their imagination; to others, however, it seems incredible and devoid of value. A notable example of this is found in the chemists and their doctrines; otherwise, it is scarcely present in our time, unless perhaps in the philosophy of Gilbert [1]. Yet caution in regard to philosophies of this sort must by no means be neglected. For we already foresee and predict that, should men—awakened by our warnings—seriously devote themselves to experience, and cast aside sophistical doctrines, then, due to the premature and overhasty eagerness of the intellect and its leaping or flying toward generalities and principles of things, there will be great danger from philosophies of this kind. We must, therefore, take steps to guard against this harm even now [2].

[1] The “chemists” here are the alchemists, whose speculative doctrines Bacon criticized for building universal theories from a narrow range of experimental practices, often centered on metallic transmutation and medicinal elixirs. See also Footnote [2] in Aphorism I-LIV (1:54). “Gilbert” refers to William Gilbert’s magnetic philosophy (*De Magnete*, 1600), which, though admired by Bacon for its empirical foundation, was faulted for extending magnetic principles into an overarching cosmology without sufficient corroborating evidence.

[2] Bacon’s warning against premature generalization from a narrow evidential base applies well beyond his immediate examples. The methodological vice lies in drawing universal principles—claims meant to hold for all cases—from a narrow set of observations or personal experience, without comprehensive, long-term, or diverse-data validation. Modern parallels include dietary doctrines such as strict veganism promoted as optimal for all humans, early cold fusion claims extrapolated into promises of limitless energy, and overextended artificial intelligence predictions based on narrow domain successes. In each, the leap to universality precedes the systematic work of broad and rigorous testing.

I-LXV (1:65).

But the corruption of philosophy arising from superstition and an admixture of theology is altogether more widespread, and brings about the greatest harm, whether to entire systems of philosophy or to particular parts. For the human intellect is just as susceptible to the impressions of the imagination as it is to the influence of common notions. The contentious and sophistical kind of philosophy ensnares the intellect; but the other kind—fantastical, inflated, and almost poetic—flatters and seduces it even more. For there is in human beings a certain ambition of the intellect, no less than of the will—especially in minds that are lofty and elevated [1].

[1] The reader is advised to take this sentence as a rhetorical observation rather than as a propositional claim within Bacon's method.

An example of this kind is evident among the Greeks, most notably in Pythagoras, though combined there with a heavier and more burdensome superstition [2]. A more perilous and subtle instance appears in Plato and his school. This kind of corruption is also found in parts of other philosophies, in the introduction of abstract forms, of final causes, of first causes—while intermediate causes and the like are often omitted [3]. This matter calls for the utmost caution. For the deification of error is the worst of evils, and is to be regarded as a true plague of the intellect, especially when vanity is joined to reverence. Some among the moderns, in extreme thoughtlessness, have indulged this vanity to such a degree that they have tried to ground natural philosophy in the first chapter of Genesis, in the book of Job, and in other parts of Holy Scripture—seeking the dead among the living [4]. And all the more must this vanity be repressed and curbed, because from the unhealthy mingling of the divine and the human arises not only a fantastical philosophy, but even a heretical religion. Therefore, it is most salutary that, with a sober mind, we give to faith only what is proper to faith.

[2] Bacon's examples progress from ancient to contemporary. Pythagoras is invoked not for his mathematics but for the mystical and religious strands of his philosophy, such as the doctrine of transmigration, the harmony of the spheres, and the treatment of numbers as cosmic principles. Plato's case is subtler: Bacon critiques the theory of Ideas and the Platonic habit of introducing divine agency and final causes into natural philosophy. Among his own contemporaries, Bacon is probably targeting figures such as Robert Fludd, whose work combined natural philosophy with biblical exegesis, numerology, and esoteric mysticism.

[3] In this aphorism, Bacon uses "forms" in their traditional metaphysical sense—universal essences or archetypes existing independently of matter—rather than his own redefined empirical sense of a body's operative law. "Final causes" refer to teleological purposes or ends, which Bacon regarded as distracting from the study of physical and efficient causes. "First causes" denote ultimate divine origins; Bacon considered them proper to theology, but methodologically misplaced in natural philosophy.

[4] The phrase "seeking the dead among the living" echoes Luke 24:5. In the King James Version: *"Why seek ye the living among the dead?"*

I-LXVI (1:66).

Having already spoken of the corrupt authorities in philosophy—those founded upon vulgar notions, a handful of experiments, or superstition—we must now discuss the flawed subject matter of contemplation, especially in natural philosophy. The human intellect becomes distorted by what it sees in the mechanical arts, where bodies are chiefly altered by combination or separation. It therefore imagines that something analogous occurs in the broader nature of things. Hence arose the fiction of "elements" and their combination as the origin of natural bodies [1]. Again, when man observes nature operating freely, he encounters species of things—animals, plants, minerals—and from this readily slips into the belief that there exist in nature certain primary forms of things which nature strives to bring forth, and that all remaining diversity is due to nature being obstructed or deviated in her operation, or due to the collision and transformation

of different species. The first of these thoughts gave rise to the doctrine of elementary primary qualities [2]; the second, to occult properties and specific virtues [3]. Both pertain to those shallow abridgements of thought where the mind finds rest, diverting itself from more substantive inquiry. Physicians, by contrast, do better when they examine the secondary qualities of things and operations such as attraction, repulsion, attenuation, condensation, expansion, contraction, dispersal, maturation, and the like. Yet their work has been corrupted by the two aforementioned short-cuts—elementary qualities and specific virtues—either by reducing their observations to these primary qualities and their subtle, immeasurable mixtures, or by failing to pursue them further through more precise observation to tertiary and quaternary qualities, thereby prematurely ending their inquiry. Such powers (not necessarily identical but analogous) should be sought not only in medicines for the human body, but also in transformations of other natural bodies.

[1] In the Aristotelian–Peripatetic tradition, all terrestrial matter was thought to be composed of four *elementa* (fire, air, water, earth), each defined by a pair of four *qualitates primitivae* ("primary qualities"): hot, cold, dry, moist. Fire, for example, was classified as hot + dry; water as cold + moist. This scheme dominated natural philosophy from antiquity through the Renaissance.

[2] Bacon used *qualitates secundae* ("secondary qualities") for derivative powers—such as attraction or condensation—arising from the interaction of the primary qualities. This differed from the "primary/secondary qualities" distinction of Descartes, Locke, and later philosophers, which separated intrinsic properties (shape, motion) from sensory effects (color, taste, etc.).

[3] In early modern natural philosophy, "occult" (*occultae*) denoted causal powers whose operation was assumed but whose mechanism was regarded as unknown and undiscoverable. Newton criticized such notions as having halted further inquiry: merely naming an "occult virtue" explained nothing until its effects were traced to general, manifest principles. Newton's criticism was part of a broader, continuing rejection of 'occult qualities' by later experimental philosophy, chemistry, and physics.

But a far greater error is that philosophers contemplate the static principles from which things arise [4], rather than the active principles through which things are produced. The former are suited to discourse, the latter to operation. Indeed, the common classifications of motion in received natural philosophy—generation, corruption, growth, diminution, alteration, and movement [5]—are worthless. They mean, for example, that if a body changes only in position, this is motion; if its quality changes but not its species or place, this is alteration; if its mass or quantity changes [6], this is growth or diminution; if it transforms in species and substance, this is generation or corruption. These distinctions are entirely vulgar, fail to penetrate nature, and serve only as endpoints and measures—not as kinds—of motion. They tell us *how far*, not *how* or *from what cause*; they say nothing of a body's tendencies or of the internal process of its parts. They arise only when a change makes a difference plainly visible to the senses. Even when causes of motion are discussed, the common distinction between "natural" and "violent" motion is lazily invoked—another popular notion. In truth, every violent motion is also natural, since the external agent merely puts nature to work in a different mode than before. But if we turn from these errors: let someone, for instance, observe that bodies have a desire to remain in contact, so that the unity of nature not be fully broken and a vacuum thereby introduced [7]; or that bodies tend to return to their natural dimensions or tension, striving to recover and relax into their previous volume when compressed or extended [8]; or that they seek to gather toward masses of their own kind—dense bodies to the earth, lighter and rarer ones to the sky. These are true physical genera of motion. The others are plainly scholastic and logical, as comparison shows.

[4] Bacon's contrast between *principia ex quibus* ("principles from which") and *principia per quae* ("principles through which") corresponded roughly to the Aristotelian "material cause" and "efficient cause." He judged the latter more useful for practical knowledge, since they concerned the processes by which effects were produced.

Bacon's preference for *principia per quae* over *principia ex quibus* reflects an early modern empirical emphasis on active processes rather than inert substances; while later philosophers such as Hegel advanced a metaphysical doctrine of reality as dynamic, Bacon's focus here was methodological and grounded in experimental inquiry, not dialectical logic.

[5] Aristotle's *Categoriae* classified *motus* ("motion" or "change") into six kinds: *generatio* (coming-to-be), *corruptio* (passing-away), *augmentum* (growth), *decrementum* (diminution), *alteratio* (alteration in quality), and *locus mutatio* (change of place). Bacon rejected these as "vulgar" because they described effects perceptible to the senses without addressing their internal causes.

[6] Bacon's "mass" (*massa* or *quantitas*) referred to the bulk or amount of matter in a body in the pre-Newtonian sense, without the later definition of mass as a measure of inertia. Here it denotes a visible increase or decrease in bodily size or substance, in keeping with Aristotle's categories of *augmentum* (growth) and *decrementum* (diminution).

This is an instance of how the meaning of scientific terms can shift significantly with the dominant intellectual paradigm of the period.

[7] The doctrine *horror vacui* ("nature's abhorrence of a vacuum") held that empty space could not exist, so matter was believed to move to fill any void. Bacon treated this as a true physical tendency, though it was later replaced by the modern explanation of air pressure following Torricelli's barometer experiments (1643).

[8] Bacon here described what is now called elasticity—the tendency of bodies to return to their original dimensions after deformation.

Another equally grave fault is the obsessive focus on first principles and ultimate substances in philosophical reflection. All practical utility, however, lies in the middle terms [9]. Thus men continue abstracting until they reach formless, potential matter, or dissecting until they arrive at indivisible atoms—concepts that, even if true, contribute little to human welfare.

[9] *Axiomata media* ("intermediate axioms") were mid-level generalizations in Bacon's method, lying between singular experimental findings and the highest general laws. He regarded them as the most fertile for practical application, yet

noted that they were often neglected in favor of abstract speculation about first principles.

I-LXVII (1:67).

Caution must also be given to the intellect regarding the excesses of philosophical systems in either granting or withholding assent; for such excesses appear to fix and perpetuate the idols of the mind, making it all the harder to dislodge them.

There are two main forms of excess. One is found among those who hastily pronounce judgment and render the sciences dogmatic and authoritarian. The other appears among those who introduce Acatalepsy—an endless and aimless mode of inquiry. The first suppresses the intellect, the second weakens it. For Aristotelian philosophy, after having—in the manner of the Ottomans toward their own brothers [1]—slaughtered competing philosophies through contentious refutations, proceeded to make authoritative pronouncements on all subjects. Then, it invented new questions at will, only to resolve them likewise—ensuring that everything was fixed and settled. This method has continued among his successors and remains in practice.

[1] This referred to the stories about early Ottoman practice in which sultans, on accession, often executed their brothers to prevent rival claims and civil war. The image conveyed Bacon's view that Aristotelian philosophy had destroyed competing schools before asserting its own authority.

The school of Plato, on the other hand, introduced Acatalepsy, at first ironically and in jest [2], to mock the ancient sophists—Protagoras, Hippias, and others [3]—who feared nothing more than appearing to doubt anything. But the New Academy institutionalized Acatalepsy, treating it as a formal doctrine. Though this approach is more modest than the arbitrary pronouncements of others—since its proponents claim that they do not obliterate inquiry, as Pyrrho and the Ephectics did [4], but instead follow what is probable without claiming it as true—nevertheless, once the human mind has despaired of discovering truth, all things inevitably grow languid. Men then turn away from rigorous investigation and toward agreeable conversations and discursions, or wanderings among ideas. But, as we said at the outset and continue to affirm: the authority of the human senses and intellect—despite their weakness—must not be disparaged, but rather assisted and supported.

[2] Bacon referred to the *eironeia* of Socrates—professing ignorance in order to expose the pretensions of others—which in this case mocked sophists such as Protagoras and Hippias. Though originally a method to clear away false

opinions for the sake of truth, this style of questioning contributed to the sceptical tendency later formalized in the New Academy.

[3] Protagoras of Abdera (c. 490–420 BCE) taught that "man is the measure of all things," meaning that what could be known was only as it related to human faculties; Hippias of Elis (late 5th century BCE) was noted for rhetorical skill and encyclopedic learning. Both were prominent among the sophists, itinerant teachers who claimed to speak authoritatively on any subject.

[4] The New Academy, under Carneades, held that while truth could not be known with certainty, one might follow what was *probabile* ("probable") in action and belief. This differed from the Pyrrhonists or *Ephectici* ("suspenders of judgment"), who sought to withhold assent altogether (*ephexis*).

I-LXVIII (1:68).

We have now spoken of each type of idols and their associated apparatus. All of them must be resolutely and solemnly denied and renounced; and the intellect must be completely freed and purged of them. For there is scarcely any other way into the kingdom of man—founded on the sciences—than into the kingdom of heaven, into which none may enter except in the likeness of a child [1].

[1] The phrase "into the kingdom of heaven, into which none may enter except in the likeness of a child" echoes Matthew 18:3. In the King James Version: *"Except ye be converted, and become as little children, ye shall not enter into the kingdom of heaven"*

I-LXIX (1:69).

But flawed demonstrations are like the fortresses and defenses of the idols; and those which we possess in syllogistic dialectics work to subject the world wholly to human thoughts, and thoughts in turn to words. Demonstrations, in fact, possess a certain constitutive power: they are the very frameworks of philosophy and science. As they are rightly or wrongly constructed, so are the philosophies and contemplations that follow from them. The demonstrations we

currently use throughout the entire process—from the senses and objects to axioms and conclusions—are misleading and inadequate. This process consists of four stages, each of which suffers from its own defect [1]. First, the impressions of the senses themselves are flawed; for the senses both fall short and deceive. Their deficiencies must be compensated, and their deceptions corrected. Second, the notions abstracted from sensory impressions are poorly formed: they are vague and confused, when they ought to be determinate and well-defined. Third, our induction is faulty: it proceeds by mere enumeration and attempts to derive the principles of science without the aid of exclusions and proper dissolutions [2]—or, in other words, the necessary separations within nature. Lastly, the method of inquiry and demonstration that begins by positing the most general principles, and then tests and validates the intermediate axioms by reference to those generalities, is the root of error and the downfall of all the sciences [3]. However, on these matters—which I now merely touch upon—we shall speak more fully when we come to set forth the true method for the interpretation of nature, after the necessary purgation and cleansing of the mind has been completed.

[1] Bacon identified four defects in the methods of demonstration used in his time: (1) the senses were deficient and deceptive; (2) notions derived from the senses were confused and ill-defined; (3) induction proceeded by mere enumeration without exclusions; (4) inquiry began from the most general principles instead of ascending to them gradually through intermediate axioms.

[2] induction by simple enumeration (*Inductio per Enumerationem Simplicem*) was the method of drawing general conclusions solely from the number of cases observed, without systematic exclusion of counterexamples. Bacon criticized it here as inadequate; Aristotle, though not formulating an equivalent distinction, likewise recognized that mere accumulation of instances falls short of the causal understanding required for genuine scientific knowledge.

[3] Bacon's phrase "the downfall of all the sciences" referred to the methodological failings of ancient natural philosophy; he did not claim that the sciences of his own time had collapsed. He targeted the long-standing habit of beginning from

the most general principles and deducing downward, rather than ascending by careful induction from particulars.

For contemporary philosophy of science, the warning remains pertinent: methods shape outcomes. Overreliance on deduction or premature generalization still risks distancing theory from evidence, while different empirically grounded approaches can yield divergent interpretations of the same data.

I-LXX (1:70).

But by far the best form of demonstration is experience—provided it remains rooted in the experiment itself [1] [2]. For if it is transferred to other cases that are presumed similar, unless such transfer is made in a proper and orderly way, the result is deceptive [3]. Yet the current method of experimenting is blind and thoughtless. Thus, people stray and wander without any clear path, relying only on the accidents of events to guide them. They touch on many things but advance little. At times they are enthusiastic; at other times, scattered and distracted. They are always discovering something else to pursue.

[1] In Bacon's usage, *experientia* ("experience") and *experimentum* ("experiment") were employed interchangeably for both ordinary observation and contrived trial; the distinction had to be drawn from context.

[2] The distinction between *experientia* (observation) and *experimentum* (contrived trial) remains important in contemporary science. In many disciplines, such as astrophysics or epidemiology, controlled experiments are not possible, and the reliability of conclusions depends on careful interpretation of observational data.

[3] **Excursus – On Extrapolation**
Bacon's warning corresponds to what may be called "extrapolation" in a broad sense: applying results, methods, or models to new contexts without adequate validation. The narrow sense of extrapolation refers to extending an inference beyond the range of the original data; the broader sense includes reusing a test or instrument developed in one setting (e.g., an IQ test devised in one country) in another without empirical confirmation, or applying a theoretical framework (e.g., Kuhn's paradigm shift model, based mainly on physics) to a different field

such as sociology without verifying its fit. In both cases, presumed similarity may conceal important differences, making the transfer deceptive.

Most often, people experiment lightly, as if in play, making small variations on already known experiments; and if their efforts fail, they grow weary and abandon the attempt. Even when they approach experiments more seriously, steadily, and diligently, they usually devote their labor to a single isolated experiment—as Gilbert did with the magnet, and the chemists with gold. This they do with methods that are no less clumsy than shallow. For no one can successfully investigate the nature of a thing by confining the inquiry to that thing alone; it must be extended to more general considerations.

Even when they attempt to extract doctrines or scientific knowledge from experiments, they almost always veer off with premature and unseasonable zeal toward practical application—not only for the sake of utility and benefit, but also to seize upon a new result as a sort of pledge or token, convincing themselves that their efforts elsewhere will not be wasted. They also use such results to promote themselves, seeking a better reputation for their pursuits. Thus, like Atalanta, they stray from the path to pick up the golden apple, and in doing so, interrupt their course and let victory slip through their fingers. In the true course of experience, and in drawing it out toward new works, we must take divine wisdom and order as our model. On the first day of creation, God created only light, devoting a full day to that work and producing no material thing. Likewise, from the totality of experience, we must first elicit the discovery of true causes and axioms, and seek experiments that illuminate, not those that bear fruit. Axioms rightly discovered and established do not merely prepare the way for individual applications; rather, they equip practice abundantly, bringing with them whole squadrons and legions of works. We shall speak later about the paths of experimentation, which—like those of judgment—are blocked and overgrown. For now, we have spoken only

of common experience as a form of bad demonstration [4] [5]. Now the order of our subject requires us to discuss the signs—mentioned a little earlier—that show how the current systems of philosophy and contemplation are in poor condition; and also to explore the causes of this state of affairs, which at first seems so astonishing and unbelievable. The awareness of signs prepares the mind for assent; the explanation of causes removes the sense of wonder. These two together greatly assist in making the purging of idols from the intellect both easier and gentler.

[4] Bacon identified five faults in experimentation: (1) inferences were extended too readily from cases that only appeared similar, without allowance for differing circumstances; (2) experiments were tried haphazardly, without method; (3) variations were too few; (4) labor was confined to a single experiment or subject; (5) practical application was pursued too eagerly.

[5] Bacon's critique of "blind and thoughtless" experimentation anticipates modern concerns about poorly designed research. His five faults—hasty generalization, lack of method, insufficient variation, over-concentration on one case, and premature application—parallel present-day issues such as confirmation bias, inadequate controls, and poor reproducibility.

I-LXXI (1:71).

The sciences we possess have come almost entirely from the Greeks. Whatever the Roman, Arabic, or more recent writers have added is neither substantial nor significant; and whatever it may be, it is built upon the foundation of Greek discoveries. But the wisdom of the Greeks was that of professors, devoted to disputation—a kind of inquiry most inimical to the pursuit of truth. Thus the title "Sophists," which those desiring to be called philosophers cast with scorn upon the early rhetoricians—Gorgias, Protagoras, Hippias, Polus [1]—rightly applies to the whole tribe: Plato, Aristotle, Zeno, Epicurus, Theophrastus, and their successors—Chrysippus, Carneades, and others. The only difference lies in this: the former were itinerant and mercenary, roaming from city to city, displaying their wisdom and

charging a fee for it; the latter more formal and noble, as they had fixed abodes, opened schools, and taught philosophy freely. Yet both kinds—despite their other differences—were professorial, reduced inquiry to debate, and established philosophical sects and heresies which they ardently defended. Thus their doctrines were, as Dionysius mockingly said of Plato, "the idle words of old men to inexperienced youth." The earlier Greeks—Empedocles, Anaxagoras, Leucippus, Democritus, Parmenides, Heraclitus, Xenophanes, Philolaus, and others (Pythagoras being excluded as too steeped in superstition)—did not, as far as we know, establish schools. Rather, they pursued the investigation of truth more quietly, strictly, and plainly—that is, with less affectation and display. In our judgment, they conducted themselves more wisely; though their works have been eclipsed over time by lighter thinkers whose ideas were better suited to popular taste and imagination. Time, like a river, carries the lighter and more inflated things downstream to us, while the weightier and more solid sink and are lost. Still, even these earlier philosophers were not entirely free from the national failing: they leaned too much toward the ambition and vanity of founding sects and winning popular acclaim. When the pursuit of truth turns aside to such trifles, it must be regarded as lost. It is also worth recalling the judgment—or rather prophecy—of the Egyptian priest concerning the Greeks: that "they are always children, possessing neither antiquity of knowledge nor knowledge of antiquity[2, 3]." And indeed, they share this quality with children: they are quick to chatter, but incapable of generation. Their wisdom seems verbose and barren of works. Therefore, the signs derived from the origin and lineage of the philosophy currently in use are not encouraging.

[1] Gorgias, Protagoras, Hippias, and Polus were Sophists of the fifth century BC, known for teaching rhetoric and argumentation for a fee. The other names in this list are leading figures of Greek philosophy: Zeno founded the Stoic school in the late fourth century BC; Chrysippus, its third head, was called its "second founder"; Epicurus founded the Epicurean school; Theophrastus succeeded

Aristotle at the Lyceum; Carneades converted Plato's Academy to Scepticism in the mid second century BC.

[2] This remark comes from *Plato, Timaeus* 22B, where an Egyptian priest tells Solon that the Greeks "are always children," lacking both antiquity of knowledge and knowledge of antiquity.

[3] **Excursus: Theoretical Ssplendour vs. Empirical Responsibility**
Bacon used the "Greeks are always children" remark to criticize philosophies that excelled in eloquence but lacked productive outcomes. For contemporary science and its philosophy, the point remains relevant: a research tradition may display intellectual sophistication yet fail to translate insight into practical discovery or technological advance. The tension between theoretical elegance and empirical fruitfulness continues to shape debates over the aims and methods of scientific inquiry.

In our own time, certain branches of knowledge exhibit a like defect, where the splendour of theory outstrips the firmness of foundation. In string theory, the towers of mathematics ascend with great beauty, yet the ground beneath them remains untested by experiment. In parts of academic economics, models are tuned with exquisite precision to assumptions, yet those assumptions often drift far from the unruly markets they profess to govern. In some regions of AI ethics and speculative futurism, discourses run far ahead of present capabilities, mistaking imagined perils or triumphs for imminent realities. And in certain strands of literary theory, the frame overtakes the picture—one lens is applied to all objects without discrimination; words multiply faster than ideas; the performance of the critic eclipses the work under study; and claims are made in disregard of historical or empirical warrant. In all these, eloquence and subtlety abound, yet the harvest is thin, for the light of discourse is not joined to the fruit of works. See also 1:45 [7].

I-LXXII (1:72).

Nor are the signs that can be drawn from the nature of the time and age much better than those that come from the character of place and nation [1]. For during that era, knowledge of either history or geography was narrow and scant—an especially dire condition for those who base everything on experience. They did not possess a thousand years of history worthy of the name, but merely fables and rumors from antiquity. Of the world's regions and territories, they knew only a small

portion: they referred indiscriminately to all northern peoples as Scythians, and to all western peoples as Celts. They knew nothing of Africa beyond the nearest edge of Ethiopia, nothing of Asia beyond the Ganges—much less of the provinces of the New World, which they had not even heard of in any credible or consistent report. Indeed, many climates and zones in which countless peoples live and breathe were pronounced by them to be uninhabitable. Even the travels of Democritus, Plato, and Pythagoras—travels which were by no means extensive but more like excursions to the suburbs—were celebrated as if they were great achievements. But in our own time, many parts of the New World and even the remotest ends of the Old World have become known; and the mass of experimental knowledge has grown immeasurably [2]. Therefore, if we were to take signs—after the fashion of astrologers—from the moment of birth or nativity of these philosophies, we would find little of importance to be predicted from them.

[1] Bacon here continued his critique of the ancient Greek philosophers, shifting from the limits imposed by their place and nation (I-LXXI) to those imposed by their historical era.

[2] In Bacon's lifetime, geographical knowledge had expanded rapidly, making the ancients' understanding of the world appear meager. The frontispiece of the 1620 *Novum Organum* depicted a ship sailing beyond the Pillars of Hercules—classically marked with the warning *Non plus ultra* ("Nothing further beyond")—recast in the spirit of *Plus ultra* ("Further beyond"), a motto of exploration and intellectual progress. Beneath the image appeared the text "*Multi pertransibunt, et augebitur scientia*" (Daniel 12:4), in the King James Version: "Many shall run to and fro, and knowledge shall be increased."

I-LXXIII (1:73).

Among all signs, none is more certain or more noble than that which comes from the fruits. For fruits and results are, as it were, the sponsors and guarantors of the truth of philosophies [1]. Yet from those philosophies of the Greeks, and their offshoots through the particular

sciences [2], scarcely a single experiment can be cited—after so many centuries—that contributes to the relief or improvement of the human condition, and that can be truly claimed credit to the speculations and doctrines of philosophy. Celsus candidly and sensibly admits this, observing that the practical experiments of medicine were discovered first, and that only afterward did men begin to philosophize about them, to seek causes, and assign explanations [3]. The process was not reversed, as if the experiments themselves had arisen from philosophy and the knowledge of causes. It is therefore not surprising that among the Egyptians—who attributed divinity and consecration to inventors of things—there were more images of animals than of men; for animals, through natural instinct, gave rise to many discoveries, while men, through discourse and rational deduction, produced few or none.

[1] Throughout this work, 'philosophies' included what are now called 'sciences'.

[2] By "particular sciences," Bacon referred to specialized disciplines that developed as offshoots of Greek philosophy—such as astronomy, medicine, and mechanics—rather than to philosophy as a whole.

[3] Bacon cited Celsus as admitting that medical remedies were discovered before philosophical explanations were sought. In fact, Celsus was here reporting the view of the empirical school of medicine, which he opposed; Bacon's misreading of this passage recurred in several of his works (cf. *De Augmentis Scientiarum*, V.2).

The industry of the chemists has indeed yielded something, but more as if by accident and incidentally, or by variation of experiments (as mechanics are wont to do), and not from any art or theory; for the theory they devised more often hinders than helps the experiments. Likewise, those who have engaged in so-called "natural magic [4]" have produced few discoveries, and those are light, and verge on imposture. Therefore, just as in religion we are admonished that faith should be shown by works, so too should philosophy be judged by its fruits, and held vain if it is barren—especially if, instead of bearing the grapes and

olives of true results, it yields only the thorns and thistles of dispute and contention.

[4] See Footnote [1] in Aphorism I-V (1:5).

I-LXXIV (1:74).

Signs should also be gathered from the growth and advancement of philosophies and sciences. For what is grounded in nature grows and increases, whereas what is grounded in opinion changes but does not grow. If these doctrines were not plainly like plants torn from their roots, but had instead remained attached to the bosom of nature [1] and been nourished by it, then what we have observed for two thousand years [2] would never have occurred—namely, that the sciences persist in their established tracks, remain nearly in the same state, and have not undergone any memorable growth; rather, they flourished most under their first authors [3] and subsequently declined. In contrast, we observe the opposite in the mechanical arts, which are grounded in nature and in the light of experience. As long as they are in use and appreciated, they continue to grow and flourish as though imbued with a kind of vital spirit—first rough, then serviceable, later refined, and continuously improved [4].

[1] Bacon's phrase *sinum naturae* literally means "the bosom" or "lap of nature," conveying the idea of being held close and continually nourished. Many English translations render it as "womb of nature," which introduces a connotation of prenatal origin not present in the Latin. Bacon's metaphor here concerns sustained connection with nature, not gestation.

[2] Bacon referred broadly to the interval between the rise of Greek philosophy and his own early 17th century, rather than to a precise chronological span. He used the phrase to emphasize the long-standing stagnation he perceived in the sciences.

[3] By this term, Bacon meant the original founders of a discipline. He observed that such works often flourished most at their inception, with later followers preserving or ornamenting them rather than advancing them.

[4] Bacon made the same comparison in *Cogitata et Visa* (*Works*, vol. III, p. 616), where he wrote that the mechanical arts, “as though sharing in a certain vital spirit,” grew and were perfected daily, while philosophy “was revered and celebrated like a statue, yet did not move.” In that passage, he described the arts as at first rough and burdensome under their inventors, then later gaining new powers and conveniences, whereas philosophy thrived most in its earliest authors and afterwards declined.

In Bacon’s usage, “*aurae cujusdam vitalis*” (“a certain vital spirit”) was a metaphor drawn from the language of life and growth. He applied it not to living organisms, but to the mechanical arts, to suggest that they possessed an inherent tendency toward development when grounded in nature and experience. The phrase evoked the idea of a sustaining and animating principle, enabling the arts to advance from crude beginnings to refinement. It was not a statement of the outdated biological doctrine of vitalism, but a figurative way of contrasting the progressive vitality of the arts with the stagnation of speculative philosophy.

I-LXXV (1:75).

There is yet another sign to consider—if "sign" it may be called, since it is rather testimony, and indeed the strongest of all testimonies—namely, the explicit admission of the very authorities whom people follow today. Even those who pronounce confidently on every matter, when they return to self-reflection, lapse into complaints about the subtlety of nature, the obscurity of things, and the weakness of the human mind. Now if they merely voiced such complaints, this might, on the one hand, dissuade the timid from further investigation; yet on the other, it could sharpen and inspire those of more agile and confident intellect toward further advancement. But it is not enough for them to admit these limitations in themselves—they go further. Whatever lies beyond the reach or knowledge of themselves or their teachers, they dismiss as beyond the limits of the possible, and declare—under the authority of their art—that such things are unknowable or unachievable. In doing so, they take the weakness of their own discoveries and, with supreme arrogance and envy, turn it

into a slander against nature itself and a source of despair for all others. Hence the New Academy [1], which formally embraced acatalepsy (the doctrine of incomprehensibility), condemning humanity to eternal darkness. Hence the opinion that Forms—or the true differences of things, which are in fact laws of pure action [2]—are impossible to discover and lie beyond human reach. Hence also those views in the active and operative sphere, such as the belief that the heat of the sun and the heat of fire differ entirely in kind—so that no one may suppose that fire might reproduce the effects of nature. Hence the notion that composition is the work of man, but mixture is the work of nature alone [3]—lest anyone imagine that art [4] could ever generate or transform natural bodies. Therefore, from this sign, people may readily be led to avoid investing their efforts and hopes in doctrines that are not only hopeless, but consecrated to despair.

[1] The "New Academy" was a later phase of Plato's Academy (3rd–1st centuries BCE) that adopted *acatalepsy*—the view that the absolute truth of things is incomprehensible—replacing certainty with graded probabilities. Bacon treated this as a doctrine of intellectual despair.

[2] See notes [4]–[6] at I:51 for Bacon's redefinition of "Form" and his use of *actus purus*.

[3] Bacon distinguished *composition* from *mixture* in a way that differs from modern usage. Today, both terms can refer to the combining of substances, but in Bacon's 17th-century framework—shaped by Aristotelian and Galenic natural philosophy—*composition* meant the simple assembling of distinct bodies or substances (e.g., combining salt and pepper), with each part retaining its own properties, whereas *mixture* (*mistio*) referred to a deeper, qualitative unification in which the components lost their separate identities (as Bacon thought in the constitution of gold, water, or salt). Bacon held that art had so far achieved only composition, while mixture was the exclusive work of nature—though he believed human ingenuity might eventually master such transformations.

[4] Here "art" referred to human skill or applied technique—particularly the practical methods of crafts, trades, and experimental manipulation—rather than to fine arts or abstract learning. In Bacon's usage, it denoted the sum of human contrivance in working upon nature.

I-LXXVI (1:76).

Nor should we overlook this further sign: that in earlier times, there was such widespread disagreement among philosophers and such diversity among the schools. This plainly indicates that the road from the senses to the intellect was not well fortified, since the very same subject matter of philosophy—namely, the nature of things—was dragged off and scattered into such vague and manifold errors. And although in our own day the disagreements and diversity of doctrines concerning first principles [1] and entire philosophical systems have been, for the most part, extinguished, still there remain innumerable questions and controversies about the parts of philosophy. Hence it becomes abundantly clear that there is nothing secure or sound either in the philosophies themselves or in their modes of demonstration.

[1] By "first principles," Bacon meant the most fundamental assumptions or starting points of a philosophical system—basic axioms about the nature of reality, knowledge, or method from which the rest of the system was derived. Disputes over these in his time often concerned the choice between Aristotelian, Platonic, Stoic, and other classical frameworks.

I-LXXVII (1:77).

As for the belief that there is, in Aristotle's philosophy at least, a great degree of consensus—since, once it was published, the older philosophies ceased and fell into neglect, and since in later times nothing better was found, so that it appears to have been so firmly laid and well-established as to have drawn both earlier and later ages to itself—this is mistaken on multiple counts. First, the idea that the philosophies of the ancients ceased after the publication of Aristotle's works is false; for the works of the ancient philosophers endured long afterward, even into the time of Cicero and the centuries that followed. But in subsequent ages, after the barbarian invasions overwhelmed

the Roman Empire [1] and human learning suffered shipwreck, the philosophies of Aristotle and Plato were preserved as though they were planks made of lighter and less solid material, floating on the waves of time. The belief in consensus likewise deceives, if one examines the matter more closely. True consensus is that which arises from free judgment, after proper inquiry and verification of the matter [2]. But the vast majority of those who have assented to Aristotle's philosophy have done so out of prejudice and deference to authority—thus what we have is more properly called conformity or allegiance than consensus. And even if such consensus were real and widespread, it should not be taken as reliable or solid evidence of truth; rather, it should provoke a strong suspicion to the contrary. For the worst of all omens in matters intellectual is general agreement—except in theology and politics, where the right to vote gives consent a certain standing [3]. For nothing pleases the masses unless it strikes the imagination or entangles the understanding in the knots of common notions, as was already said above. It is therefore apt to apply to matters of the intellect the saying of Phocion regarding morals [4]: that if the multitude consents and applauds, men ought immediately to examine themselves and ask in what they have erred. This sign, then, is among the most unfavorable. Thus it has now been shown that the signs of truth and soundness in the current philosophies and sciences—whether they are drawn from their origins, their fruits, their progress, the admissions of their authors, or their widespread acceptance—are all in poor condition.

[1] In early-modern usage, *barbarian* referred to the Germanic and related migratory peoples—such as the Visigoths, Vandals, Franks, and Ostrogoths—whose movements into Roman territory between the fourth and sixth centuries CE contributed to the collapse of the Western Roman Empire. The term indicates a historical transition rather than a moral judgment, marking the period in which classical learning was disrupted and only partially preserved.

[2] Bacon used *verus consensus* ("true consensus") to mean agreement that meets three conditions: (1) the judges are competent in the subject, (2) the matter

has been thoroughly examined before judgment, and (3) the consent is freely given, uninfluenced by authority or peer pressure.

[3] Bacon did not mean that majority opinion is necessarily valid in theology or politics, but that in these domains the *argument from consensus* has more weight than in science, since decisions there are often made by formal suffrage.

[4] Phocion (c. 402–318 BCE) was an Athenian statesman known for his integrity and caution. Plutarch records that when the public unanimously approved one of his proposals, he turned to his friends and remarked that he must have made some mistake (Plutarch, *Life of Phocion*, 8).

I-LXXVIII (1:78).

Now we must turn to the causes of error and the persistence of such error over so many centuries—causes which are numerous and extremely powerful. Once these are understood, all astonishment should vanish as to how the reflections I offer here could have remained unnoticed and concealed for so long. What should remain, perhaps, is only the wonder that they have finally occurred to someone—that these thoughts have at last entered a human mind. And even that (as I see it) is more the result of a certain good fortune than of any extraordinary ability, and should be attributed more to the birth of the time than to the birth of ingenuity. First of all, the sheer number of centuries, when considered rightly, contracts into a narrow span. Of the twenty-five centuries that encompass the memory and learning of humankind [1], scarcely six can be set apart and identified as productive in sciences or favorable to their advancement. There are deserts and wastelands in time as there are in geography. Only three great revolutions or epochs in learning may properly be counted: one among the Greeks, a second among the Romans, and the third among us—the nations of Western Europe. And each of these deserves, at most, no more than two centuries. The intervening ages were unfortunate for any rich or flourishing harvest of knowledge. Nor is there much point in mentioning the Arabs or the Scholastics, who

during these middle ages, by their voluminous treatises, did more to wear down the sciences than to increase their substance. Thus, the first cause of the scant progress made in the sciences is rightly attributed to the limited span of time in which conditions were favorable to them.

[1] Bacon's figure of "twenty-five centuries" reflects a reckoning from the Homeric era—placed by Herodotus about 900 BCE—through the sixteen centuries of the Christian era up to Bacon's time. He saw three productive "revolutions" in learning within this span: the Greek (from Thales to Plato), the Roman (from Terence to Pliny), and the modern (beginning with Dante and Petrarch in the 14th century).

I-LXXIX (1:79).

Secondly, a cause of undoubted and all-encompassing importance presents itself: namely, that in the very ages in which human genius and learning flourished most—or even to a moderate degree—natural philosophy claimed only the smallest portion of human effort. And yet, this discipline ought to be considered the great mother of the sciences. For all arts and sciences, when severed from this root, may perhaps be refined and adapted for practical use, but they make little genuine growth. It is clear that after the Christian faith had been accepted and matured, by far the most gifted intellects devoted themselves to theology. This field was richly rewarded and abundantly supplied with all manner of support. It is this zeal for theology that principally occupied the third era—our own—among Western Europeans, especially as this coincided with the flowering of letters and the spread of religious controversies. In the preceding era, during the Roman period, the dominant meditations and labors of philosophers were absorbed in moral philosophy—which, for the pagans, served the role that theology does for us [1]. Moreover, in that era, many of the most brilliant minds turned their attention to civil affairs, because the vast extent of the Roman Empire required the involvement of many.

The period in which natural philosophy flourished most among the Greeks was, in fact, exceedingly brief. In earlier times, the Seven Sages (all except Thales) were devoted to moral and political concerns. Later, when Socrates brought philosophy down from the heavens to the earth [2], moral philosophy grew even stronger, drawing human minds further away from natural inquiry.

[1] In Greek and Roman religion, there were no creeds or detailed moral codes comparable to those in Christianity. Priests primarily performed rites and sacrifices, and personal belief was of little concern so long as public observances were kept. Philosophers therefore took on the discussion of moral and metaphysical questions that, in Christian Europe, were largely the province of theology.

[2] The phrase comes from Cicero, *Tusculan Disputations* V.4, describing Socrates as the first to turn philosophy from natural speculation toward the study of life, morals, and practical affairs.

Even that short window in which the investigation of nature seemed to thrive was corrupted and rendered ineffective by controversy and the competitive ambition to propose novel doctrines. Therefore, given that during all three periods natural philosophy was either neglected or hindered to a considerable extent [3], it is no wonder that humanity made so little progress in that domain—since it was, in truth, engaged in something else entirely.

[3] Bacon's observation anticipated a modern concern in the philosophy of science: that progress in a field depended not only on the abilities of individual thinkers but on the allocation of intellectual effort across disciplines. In his account, natural philosophy (what we now call science) stagnated because the most capable minds in each era were drawn to other pursuits—theology, moral philosophy, politics—reflecting how cultural values and institutional incentives shaped the trajectory of scientific inquiry.

I-LXXX (1:80).

It must also be added that natural philosophy, even among those who have pursued it, has rarely—especially in recent times—found a person wholly free and devoted to it [1]; unless perhaps one counts a monk working late in his cell, or a nobleman studying at leisure in his villa. Natural philosophy has instead been reduced to a kind of passageway or footbridge to other ends. And so this great mother of the sciences has, with remarkable indignity, been cast down into the role of a servant: assisting the works of medicine or mathematics, or alternatively serving to wash and dye the unformed minds of youth with a kind of initial tint, to prepare them more easily and suitably to receive another later. Meanwhile, let no one expect substantial progress in the sciences—especially in their operative aspect—unless natural philosophy is extended into the particular sciences, and those particular sciences in turn are drawn back to natural philosophy [2] [3]. For it is precisely because this has not been done that astronomy, optics, music, many mechanical arts, and even medicine itself—not to mention (more astonishingly) moral and political philosophy, and the sciences of logic—are almost entirely lacking in depth, merely skimming the surface and variety of things. Once these specialized disciplines were divided off and established, they ceased to be nourished by natural philosophy—although it alone could have provided them new vigor and growth from the true sources and contemplations of motion, rays, sounds, the texture and structure of bodies, the passions, and intellectual apprehensions [4]. It is therefore no wonder that the sciences do not grow when they are cut off from their roots.

[1] Bacon may have had in mind rare historical examples such as Roger Bacon (c. 1219/20–1292) and René Descartes (1596–1650), both of whom devoted sustained attention to natural philosophy apart from other primary occupations.

[2] Bacon regarded each special science as needing continual reference to the more general science under which it fell. Logic, for example, was empirical unless grounded in the study of the mind; medicine lacked depth unless built on physiology; mechanics required a foundation in the laws of motion and force. He conceived of natural philosophy as the overarching study of nature's laws, from which the special sciences should derive their principles, ensuring a shared foundation. In his time, questions we now classify as psychological were included under natural philosophy, following ancient usage.

[3] **Excursus – On Philosophy–Science Reciprocity**

The following remarks outline a suggested contemporary conceptual model of the reciprocal relationship between philosophy and the sciences. They are not intended as an interpretation of Bacon's own views, but as an extension prompted by the issues raised in this aphorism—particularly the need for continuity between general (philosophical) inquiry and the particular sciences.

(A) From Philosophy to science.

Philosophy undertakes the preliminary work of considering the full range of conceptual possibilities regarding a phenomenon—mapping the intelligible space of hypotheses, causal patterns, and explanatory options. From this survey, it supplies the most coherent or promising candidates to the empirical sciences for testing.

(B) From Science back to philosophy.

Empirical findings return to philosophy and reshape it. Once scientific inquiry has narrowed or transformed the field of possibilities, philosophy becomes a post-scientific activity, responsible for revising, reorganizing, or abandoning prior conceptual structures in light of the new evidence.

(C) The recursive loop.

The interaction thus forms a continuous cycle: *pre-scientific philosophy* → *science* → *post-scientific philosophy* → *new science*, and so on. No stage is final, and each turn of the cycle refines both conceptual understanding and empirical insight.

(D) Divergence of tasks.

Philosophy expands and complexifies the conceptual landscape; science decomposes and clarifies it through empirical discrimination. The former explores the space of what could be the case; the latter determines what is in fact the case.

(E) Requirement.

This reciprocity presupposes that philosophers remain informed about current scientific developments, and that scientists attend to the philosophical structures that shape inquiry. Only through mutual awareness can the sciences remain anchored in coherent conceptual foundations, and philosophy remain responsive to the actual operations of nature.

[4] Bacon's argument anticipated a modern concern in the philosophy of science: that when specialized sciences become detached from a broader unifying framework, they risk stagnation and superficiality. His call to reconnect particular sciences with natural philosophy parallels contemporary debates about interdisciplinarity, the unification of scientific knowledge, and the dangers of excessive specialization. The historical scope of "natural philosophy" in Bacon's time—encompassing topics we now call psychology—also illustrates that the boundaries between disciplines are historically contingent, shaping what is considered central or peripheral to scientific inquiry.

From this perspective, there should be no rigid divide between the humanities and social sciences on one side and the natural and empirical sciences on the other. In Bacon's framework, all inquiries into nature, human behavior, and reasoning processes formed a single, interconnected enterprise, a principle that remains relevant to modern efforts to address complex problems through integrated approaches.

I-LXXXI (1:81).

Yet again, another powerful and significant cause presents itself for why the sciences have advanced so little. It is this: one cannot proceed correctly in a race if the very goal has not been correctly placed and firmly fixed. The true and proper goal of the sciences is none other than this: to enrich human life with new inventions and resources. But the vast majority of people have no sense of this; their pursuit is purely mercenary and professorial—unless, perhaps, some exceptionally clever artisan, driven by ambition for glory, occasionally devotes himself to a new invention. Even then, it typically comes at the expense of his means. For the most part, people are so far from aiming to enlarge the sum of knowledge and the arts, that from what is already available they extract and seek nothing beyond what serves

professional use, profit, reputation, or some similar convenience. And if, among so many, someone seeks knowledge out of sincere affection and for its own sake, even he is more often drawn to the variety of contemplations and doctrines than to the strict and rigorous inquiry into truth. And if there happens to be someone more earnestly committed to the search for truth, even he is likely to define truth in terms that satisfy the intellect and understanding by offering causes for things already known, rather than in a way that yields new confirmations of practice and new illumination of axioms [1]. Thus, if the goal of the sciences has never been properly set, it is no wonder that there is error in everything that is subordinate to that goal [2].

[1] Bacon's emphasis on setting the proper end for science anticipated ongoing debates in the philosophy of science and science policy. He maintained that scientific inquiry should ultimately serve human benefit, joining contemplation with action. Modern discussions continue to ask whether science ought to be primarily oriented toward practical outcomes or whether knowledge for its own sake is an equally legitimate goal. The variety of motives Bacon identified—curiosity, prestige, competition, livelihood—remains evident in research today, and the proportion of work explicitly aimed at public benefit is still a central concern in shaping research agendas.

[2] In *De Augmentis Scientiarum* I, Bacon argued that the gravest error in the pursuit of learning lay in deviating from its ultimate end. He observed that people sought knowledge for many reasons: curiosity, personal pleasure, reputation, intellectual competition, or profit. Only a few directed it toward the service of humanity, treating reason as a divine gift to be applied for human benefit. For Bacon, the proper aim of the sciences was to unite contemplation with action so that knowledge would both illuminate the mind and improve life.

I-LXXXII (1:82).

Just as the end and goal of the sciences have been wrongly placed among men, so likewise—even if that end had been rightly conceived—the path chosen has been entirely mistaken and impassable. This should strike anyone who reflects on it rightly with

astonishment: that no mortal has taken it upon himself to open and secure a path for the human intellect beginning directly from the senses and through a process of ordered and well-constructed experience. Instead, everything has been surrendered either to the obscurity of tradition, or to the whirl and turbulence of argument, or to the waves and meanderings of chance and unstructured experience. Let anyone think soberly and carefully about the path men usually follow in their search for and discovery of things. He will surely first observe a very simple and unscientific method—most familiar to humankind. It is this: when one sets out to discover something, he begins by consulting what others have said on the matter, then adds his own reflections, and by much mental agitation attempts to stir or even invoke his inner spirit to deliver oracles. This approach has no foundation and turns entirely on opinion.

Someone else might call upon syllogistic dialectics for help in discovery, but that is relevant only in name. For syllogistic dialectical invention does not uncover the fundamental principles and axioms from which the arts arise, but only those things that appear to be consistent with them. Indeed, when questioned about the discovery or proof of first principles, syllogistic dialectic gives the well-known response: one must accept those on faith and swear allegiance to each discipline in its own domain.

What remains is mere experience: if it arises by accident, we call it chance; if it is sought out, we call it experiment. But this kind of experience is nothing more than a bundle of loose twigs—mere groping in the dark, like those who fumble blindly in the night hoping to stumble upon the right way [1]. It would be much better to wait for daylight, or light a lamp and proceed with direction. By contrast, the true method of experience begins by lighting the lamp and using it to show the path: starting from experience that is ordered and well-

digested—not haphazard or erratic—then drawing axioms from it, and from those axioms deriving new experiments. For even the divine Word did not operate on the unformed mass of things without order. Let men then stop marveling that the path of science remains incomplete when they have so entirely strayed from the right way—either abandoning experience altogether or becoming entangled and lost in it, like in a labyrinth [2]—when a properly instituted method would guide them, by a consistent path, through the thickets of experience to the open plains of axioms.

[1] Bacon compared such disordered experimentation to the proverb *scopas dissolvere* ("to untie a broom"), meaning to throw something into confusion by taking apart what should be bound together. The image conveyed that unmethodical experiments, like loose twigs without binding, lacked unity and coherence.

[2] In this aphorism Bacon reviewed three false paths of inquiry: (1) collecting the opinions and authorities of others and forming a personal opinion from them; (2) using syllogistic reasoning that assumes first principles without testing them; and (3) consulting experience without order or method, relying on chance rather than systematic investigation.

I-LXXXIII (1:83).

This evil has, in a remarkable way, grown out of a certain long-established opinion or deeply rooted assumption—arrogant and harmful in nature—that the majesty of the human mind is diminished when it spends much time and effort among experiments and particular things, which are perceptible to the senses and confined within matter. Especially so, since such things are typically laborious to investigate, ignoble to contemplate, coarse to express, undignified in practice, countless in number, and subtle in detail. Thus, the matter has now come to this point: the true path is not only abandoned, but also blocked and sealed off; experience is not merely neglected or misapplied, but actually disdained and spurned [1, 2].

[1] Bacon traced this disdain for empirical work to an older belief that truth was innate to the human mind and migrated from no other source, and that the senses served only to stimulate, not to inform, the intellect. He noted that even those who acknowledged the senses as primary still abandoned systematic natural history and observation of the world, placing all reliance on the agitation of the mind and becoming entangled among its idols under the guise of contemplation.

[2] This aphorism remains highly relevant in contemporary philosophy of science because it addresses a fundamental methodological divide: whether the advancement of knowledge depends primarily on speculative reasoning or on systematic engagement with empirical reality. Bacon's warning against neglecting or disdaining "experiments and particular things" speaks directly to the long-standing tension between rationalism and empiricism. In modern scholarship, this tension is visible in the prevalence of "armchair theorizing," where conclusions are derived from abstract reasoning without sustained interaction with evidence. This is especially common in strands of normative political theory, where arguments about justice, democracy, or legitimacy are constructed primarily from conceptual analysis and moral intuitions. More broadly, across portions of the contemporary social sciences and political theory, there is often a striking scarcity of direct empirical validation for widely circulated claims. Such practices reflect precisely the epistemic hazard Bacon identified: a systematic undervaluing of the investigative engagement with concrete particulars that could either confirm or challenge theoretical assertions.

I-LXXXIV (1:84).

Once again, human progress in the sciences has been impeded—as if under a spell—by reverence for antiquity, by the authority of men reputed eminent in philosophy, and by the general consensus that followed. As for consensus, we have already spoken of it above.

With respect to antiquity, the prevailing opinion is altogether careless and hardly consistent with the true meaning of the term. For the genuine antiquity of the world ought to be understood as its old age, and this pertains to our own times, not to that earlier age in which the ancients lived. That earlier age, in relation to us, is indeed ancient and earlier; but in relation to the world itself, it was younger and more

recent [1]. Just as we expect more knowledge and sounder judgment from an old man than from a youth—on account of his experience and the diversity and richness of what he has seen, heard, and contemplated—so too we ought to expect far greater things from our own era (if it would recognize and exert its powers) than from antiquity. For our age is the old age of the world, enriched and expanded by a near-infinite number of experiments and observations.

[1] *Antiquitas saeculi juventus mundi* ("The antiquity of the age is the youth of the world") appeared in parallel form in Bacon's *De Augmentis Scientiarum*, I. This inversion of perspective was a recurring theme in Bacon's works.

Nor should we overlook the fact that, through the long voyages and travels so frequent in our times, many natural phenomena have been revealed and discovered that might cast new light on philosophy. Indeed, it would be disgraceful for humanity if the expanses of the material globe—of lands, seas, and stars—have been laid open and illuminated in our age, while the boundaries of the intellectual globe remain confined to the narrowness and limits of ancient discoveries.

As for the authority of the ancients, it is a sign of extreme timidity to ascribe boundless value to specific authors, while denying the rightful authority of Time itself—the author of all authors, and of all authority. For it is rightly said that Truth is the daughter of Time [2, 3], not of Authority. It is therefore no wonder that these charms of antiquity, authority, and consensus have so shackled human capacity that men have become, as if under a spell, incapable of engaging directly with the things themselves.

[2] The maxim *Veritas temporis filia* ("Truth is the daughter of Time") appeared on English groats during the reign of Queen Mary (1553–1558) and was recorded by *Aulus Gellius*, XII.11. Bacon likely knew both sources.

[3] The maxim *Veritas temporis filia* ("Truth is the daughter of Time") encapsulated Bacon's view that knowledge advanced through the gradual accumulation of observations and the testing of claims over time, rather than by deference to

established authorities. This emphasis on temporal processes in the discovery of truth anticipated later discussions in the philosophy of science about the self-correcting nature of inquiry and the provisional status of scientific consensus.

I-LXXXV (1:85).

Nor was it only admiration for antiquity, authority, and consensus that compelled human effort to rest content with those things already discovered; but also admiration for the works themselves, whose abundance had long since been laid open to the mankind race. For when one lays before his eyes the diversity of things and the splendid apparatus which has been amassed and introduced for the benefit of humanity through the mechanical arts, he will certainly incline more toward admiration for human opulence than to a sense of want; failing to notice that the primitive observations of man and the operations of nature (which serve as the soul and first movers [1] of all that diversity) were neither numerous nor drawn from deep sources; and that the rest pertains only to the endurance of men and to the subtle and orderly motion of hands or instruments. For instance, the precise and meticulous construction of clocks is indeed a subtle matter—such clocks as seem to imitate the celestial spheres in their wheels, and the pulse of living beings in their successive and regular movements; yet this entire matter depends on only one or two axioms of nature.

[1] The phrase “first mover” (*primum movens*) came from Aristotelian philosophy, where it denoted the ultimate cause of all motion—the *unmoved mover* (*primum movens immobile*). By Bacon’s time, the term was often used more generally to mean the initial cause or primary agent in a process. Here, Bacon applied it metaphorically to the primitive observations of man and the operations of nature, treating them as the initiating causes behind the variety of human works.

If someone were likewise to contemplate that subtlety which pertains to the liberal arts [2], or even that which concerns the preparation of

natural bodies through mechanical arts, and reflect upon such matters as the discovery of the celestial motions in astronomy, of harmonies in music, or of the letters of the alphabet in grammar (which were even then not in use in the Kingdom of China [3]); or again in mechanical affairs, the productions of Bacchus and Ceres [4]—that is, the preparation of wine and beer, of baking [5], or even of table delicacies, of distillations, and similar things [6]: that person, if he reflect and pay attention to how many centuries (since all of these things, distillations excepted, are ancient) it took to bring them to the level of development we now possess, and (as has been said of clocks) how little they owe to natural observations and axioms, and how easily, as if by readily available opportunities and incidental contemplations, these things might have been discovered—such a person, I say, will free himself readily from all admiration, and will rather feel pity for the human condition, in that through so many centuries there has been such a great deficiency and barrenness of things and discoveries. And yet even those inventions which we have just mentioned are older than philosophy and the intellectual arts: so that (if the truth is to be spoken), with the rise of rational and dogmatic sciences, the invention of useful works ceased.

[2] The "liberal arts" (*artes liberales*) in Bacon's time referred to the seven traditional disciplines of the medieval curriculum—grammar, rhetoric, and logic (the *trivium*), and arithmetic, geometry, music, and astronomy (the *quadrivium*). These were distinguished from the "mechanical arts" (*artes mechanicae*), which concerned manual skills and practical crafts. In this aphorism, Bacon used the term to denote the established scholarly disciplines of his age.

[3] Chinese writing was, and remains, primarily logographic, representing ideas rather than individual sounds. This differs fundamentally from alphabetic systems.

[4] In classical mythology, *Bacchus* (Greek *Dionysus*) was the god of wine, and *Ceres* (Greek *Demeter*) was the goddess of agriculture and grain. Bacon used this as a figurative way to refer to the making of wine, beer, and bread.

[5] **Excursus – On Bread and Wine/Beer in Bacon and Smith.**
The recurrence of examples involving bread, wine, and beer in writers as different as Bacon and Adam Smith is not accidental. In early-modern Europe, these products represented the most basic and universally recognized outcomes of human skill: grain-processing (bread, beer) and fermentation (wine, beer). For Bacon, the arts associated with *Ceres* and *Bacchus* served as classical shorthand for the oldest mechanical inventions—baking, brewing, and winemaking—emphasizing how slowly and accidentally such practices developed in the absence of a systematic method. Smith, by contrast, invoked the butcher, brewer, and baker to illustrate the ordinary economic relations of daily life and the dependence of society on mutually beneficial exchange. In both cases, the power of the examples lies in their cultural universality and immediacy, not in any symbolic or theological significance: they are the most accessible illustrations of essential human arts whose functions every reader already understood.

[6] Distillation was generally believed to have been introduced into Europe by the Moors around A.D. 1150, though earlier forms were known. The Persian polymath Muḥammad ibn Zakariyyā al-Rāzī (Latin: Rhazes, c. 865–925) described the distillation of alcohol in medical and chemical contexts, influencing later Islamic and European practice.

If someone should turn from the workshops to the libraries, and admire the vast variety of books which we behold, let him examine more thoroughly and closely the material and contents of those books, and he will surely be astonished in the opposite direction; and after observing that there is no end to repetition, and how much men do and say the same things over again, he will pass from admiration of the variety to amazement at the poverty and scarcity of the things that have thus far occupied and possessed men's minds.

If someone should condescend to direct his attention to those matters which are held to be more curious than sound, and should more deeply inspect the works of the alchemists or magicians, he will perhaps hesitate whether they are more deserving of ridicule or of lamentation. For the alchemist sustains eternal hope, and when his attempts fail, he assigns blame to his own errors; reckoning in accusatory fashion that

he either did not sufficiently understand the terms of the art or of its authors—whereupon he devotes his attention to traditions and whispered rumors—or that some fault occurred in the minutiae and moments of his practical procedure—whereupon he repeats his experiments endlessly. Meanwhile, when among the fortunes of experimentation he happens upon certain things either novel in appearance or not devoid of utility, he feeds his spirit with such pledges, and magnifies and celebrates them; the rest he supports with hope. Nor, however, can it be denied that the alchemists have discovered not a few things and have bestowed useful inventions upon mankind. But that fable is not ill-applied to them concerning the old man who bequeathed to his sons gold buried in a vineyard (while pretending not to know the location); whence they diligently undertook the digging of the vineyard, and no gold was found indeed, but the vintage from that cultivation proved more abundant [7].

[7] This classical fable told of an old man who, before dying, told his sons that treasure lay buried in his vineyard. They dug thoroughly but found no gold; however, the improved cultivation yielded an abundant harvest. Bacon applied this as a metaphor for how alchemists, while failing in their main goal, still produced useful incidental discoveries.

But the professors of natural magic [8], who explain everything through the sympathies and antipathies of things, have, by means of idle and most sluggish conjectures, ascribed to things marvelous powers and operations; and if they have at any time exhibited any results, these are of such a kind as are suited for wonder and novelty, not for utility and benefit.

[8] In Bacon's usage, "natural magic" referred to the study of hidden properties and operations of nature, which he regarded as a legitimate, though often misapplied, branch of the *doctrina operativa de natura*. "Superstitious magic," by contrast, referred to occult practices and beliefs rooted in superstition, which he rejected entirely.

As for superstitious magic (if even this must be spoken of), it is first to be noted that there exists only a certain fixed and definite kind of subject matter in which curious and superstitious arts have, in every nation and age and even under all religions, managed to accomplish or toy with something. Let us therefore set these matters aside. Meanwhile, it is not at all surprising if the opinion of abundance has given rise to the cause of scarcity.

I-LXXXVI (1:86).

And to the admiration of men concerning the doctrines and the arts—an admiration in itself rather simple and almost childish—there has been added the influence of the cunning and craft of those who have handled and transmitted the sciences. For these individuals present them with such ambition and pretension, and introduce them into public view so shaped and, as it were, masked, as though they were in every respect perfect [1] and brought to completion. For if you look at the method and the divisions, they appear altogether to encompass and include everything that can fall under that subject. And although those parts may be poorly filled out and resemble empty boxes, yet to the common understanding [2] they present the form and structure of a complete science. But the earliest and most ancient inquirers into truth, with better integrity and better fortune, were accustomed to cast the knowledge which they aimed to gather from contemplation of things and store away for use into aphorisms—that is, into brief sentences, scattered and not bound together by method—and they did not pretend [3] to embrace or profess to teach an entire art. But in the way things are now conducted, it is no wonder if men do not seek further into matters which are handed down to them as already perfected and brought to their full measure [4].

[1] Bacon used the term *personatas*, drawing on theatrical imagery. He suggested that the sciences were "masked"—i.e., dressed up or costumed—to appear

complete and authoritative, though inwardly deficient. This reflected his broader critique of the performative nature of academic knowledge in his time.

[2] The Latin phrase *tanquam vacua vasa* ("as though empty vessels") echoed a classical metaphor in which form existed without substantive content. Bacon criticized contemporary systems of knowledge for presenting formal divisions that gave the appearance of fullness while lacking real explanatory power.

[3] Bacon referred to the aphoristic method used by early natural philosophers such as Hippocrates. These thinkers, he noted, cast knowledge into short, discrete maxims rather than systematic treatises. He considered this a more honest and effective way of preserving provisional insights drawn from experience.

[4] This aphorism is marked by generality and rhetorical abstraction rather than specific critique. Bacon did not name particular thinkers or schools here, but instead described systemic tendencies in the transmission of knowledge.

I-LXXXVII (1:87).

Even the ancient doctrines have received a significant increase in esteem and credibility from the vanity and frivolity of those who have proposed new ones—especially in the active and operative branch of natural philosophy [1]. For there has been no shortage of boastful and fanciful individuals who, partly from credulity and partly from imposture, have burdened the humankind with extravagant promises: the prolongation of life, the retardation of old age, the alleviation of pain, the repair of natural defects, the deception of the senses, the binding and stimulation of the passions, the illumination and exaltation of intellectual faculties, the transmutation of substances, the strengthening and multiplication of motion at will, the impressions and alterations of the air, the drawing down and management of celestial influences [2], the divination of future events, the representation of things distant, the revelation of things hidden [3], and many other claims made through promises and displays. Now, one would not stray far from the truth who passed the following judgment upon these lavish promisers: that the difference, in philosophical doctrine,

between their vanities and true arts is as great as the difference in historical accounts between the deeds of Julius Caesar or Alexander the Great and the exploits of Amadis of Gaul or Arthur of Britain [4]. For those most illustrious commanders are found to have accomplished even greater things in reality than those shadowy heroes are imagined to have done—but by means and methods of action that are in no way fabulous or miraculous. Nor is it just to diminish the credibility of authentic history merely because it has at times been harmed and distorted by fictions. But in the meantime, it is by no means surprising if new proposals—especially when they include mention of practical works—have encountered considerable prejudice on account of those impostors who have attempted similar undertakings; since the excess of vanity and the distaste it provokes have even now extinguished all greatness of spirit in endeavors of this kind.

[1] Bacon distinguished between the speculative (or contemplative) and operative parts (*pars speculativa* and *pars activa*) of natural philosophy. He held that past thinkers had emphasized theoretical understanding while neglecting practical applications—what he called *pars operativa*, or the productive power of knowledge in transforming nature.

[2] This refers to Renaissance-era beliefs—common in astrology and natural magic—that celestial bodies exerted real influences over earthly events, which could be harnessed or controlled through various techniques. Practitioners claimed to draw down these *influxus cœlestes* (celestial influences) and regulate them for purposes such as healing, prediction, or transformation. Bacon rejected such claims when they were not grounded in empirical natural philosophy.

[3] These phrases reflected the language of so-called “natural magic” and esoteric traditions in the Renaissance, often associated with optics, divination, and early experimental devices. Bacon criticized such claims as speculative or fraudulent when not grounded in systematic natural inquiry.

[4] Caesar and Alexander were historical military leaders known for large-scale conquests achieved by real, strategic means. Amadis and Arthur were fictional or semi-legendary heroes of romance literature, celebrated for implausible, magical exploits. Bacon used this contrast to distinguish credible arts from vain philosophical pretensions.

I-LXXXVIII (1:88).

Much greater harm has been brought upon the sciences by faint-heartedness and by the smallness and triviality of the tasks which human industry has undertaken for itself. And yet (which is worst of all) this faint-heartedness presents itself not without arrogance and disdain.

First of all, there is found in every art a certain tactic—now become familiar—whereby the authors of an art transfer the weakness of their own method into a reproach against nature; and whatever their art fails to achieve, they declare—on the authority of that very art—to be impossible in nature [1]. And surely an art cannot be condemned if it serves as its own judge. Even the philosophy that is now in vogue secretly fosters within itself certain assumptions or dogmas which—if more closely examined—appear entirely intended to persuade men that nothing difficult, or commanding, or forceful against nature should be expected from art or from human endeavor; as was earlier said regarding the heterogeneity of the heat of the sun and of fire, and of mixture [2]. These doctrines, if more carefully noted, wholly belong to a malicious limitation of human power and to a deliberate, artificial despair [3]. They disturb the signs of hope and cut all the sinews and motivations of effort. They even cast aside the risks of experience itself. The only aim is that their art may be deemed perfect—an utterly vain and self-defeating ambition. It asserts that whatever has not yet been discovered or understood is to be believed absolutely incapable of ever being discovered or understood in the future.

[1] In Bacon's usage, *ars* ("art") referred broadly to any systematic body of practical knowledge or skill, not limited to the fine arts. It encompassed both the mechanical arts and the applied aspects of the sciences, understood as human activities governed by method and technique.

[2] This referred to a long-standing Aristotelian–scholastic doctrine that solar heat and the heat of fire differed essentially, not merely in degree. Bacon rejected this view, treating the difference as one of circumstances rather than of kind. Modern physics has shown that both forms of heat arise from the same physical processes of energy transfer, differing only in source and spectrum.

[3] *Desperatio artificiosa* denoted the tendency of philosophers to declare certain discoveries impossible, not from evidence, but to preserve the appearance of completeness in their own systems. Bacon regarded this as an obstacle to progress, since it discouraged the pursuit of new knowledge.

But if anyone should attempt to apply himself to the investigation of things, and to discover something new, he will still entirely set and limit his aim to the investigation and extraction of a single invention (and nothing beyond): such as the nature of the magnet, the ebb and flow of the sea, the configuration of the heavens, and the like—subjects that seem to hold some secret and have thus far been treated with little success. Yet it is a mark of the utmost ignorance to attempt to investigate the nature of some thing in itself, since the very same nature which appears hidden and obscure in some subjects is manifest and almost palpable in others; and in those it evokes wonder, while in these it does not even draw attention—as happens with the nature of cohesio [4], which is not remarked upon in wood or stone [5], being simply passed over under the label of solidity, and no further inquiry is made into the resistance to separation or disruption of continuity; whereas in water-bubbles the same phenomenon is perceived as subtle and ingenious—these bubbles forming into certain films, delicately shaped into hemispheres, so as to avoid, for a moment, the disruption of continuity. And indeed, those very things which are regarded as secrets in some cases possess a manifest and common nature in others—a nature which will never reveal itself so long as human experiments or reflections are confined to those very cases [6].

[4] By “cohesion,” Bacon meant the resistance of bodies to separation—what modern science (2025) describes in terms of intermolecular forces and material strength. He noted that this phenomenon was ignored in familiar

solids but admired as a curiosity in delicate cases such as soap bubbles, where thin films momentarily resist rupture.

[5] **Excursus – On the Balance Between Coherence and Variation**

In evolutionary genetics, there is the concept of *evolvability* for a population or a species, which depends on an optimum level of genetic variation. Too little variation may lead to rigidity and, consequently, an inability to adapt to environmental changes. Conversely, excessive variation may cause the population to lose its coherence and fragment into smaller subpopulations or subspecies that may have reduced capacity to cope with those same environmental pressures. Thus, it is advantageous for a population or species to maintain an appropriate balance between cohesion and disruption.

This line of reasoning may be extended to certain non-biological structures as well. In a democratic institution such as a parliament, it may likewise be prudent to maintain a balance between having too few and too many political parties. Too little political variation may result in rigidity, limited representational diversity, and reduced responsiveness to social change. Conversely, an excess of political fragmentation may weaken institutional coherence, impede effective decision-making, and divide the polity into smaller factions with diminished capacity to address shared challenges. As in biological populations, a functional equilibrium between cohesion and diversification can contribute to institutional stability and adaptability.

Even from an evolutionary–ecological point of view, there is an inherent limit on the number of species that can coexist within a single niche. This constraint arises from fundamental principles of resource availability, competitive interactions, and the structural boundaries that define each ecological niche. The optimum number of species that a habitat can support naturally depends on the foraging range and spatial requirements of the organisms involved. Species with very small foraging ranges—such as many beetles and other insects—can coexist in far larger numbers within the same geographical area. By contrast, for larger vertebrates, especially carnivores, the energetic demands and territorial ranges required for stable populations sharply restrict the number of species that can be sustained. Thus, in many broad habitats the average number of large predatory species tends to fall in the range of roughly five to seven, reflecting the ecological balance between diversity and coherence.

A similar principle of limited coexistence appears even at the level of quantum particles. In quantum mechanics, fermions—such as electrons, protons, and neutrons—are subject to the Pauli Exclusion Principle, which states that no two identical fermions may occupy the same quantum state simultaneously. This

rule imposes an absolute upper bound on the number of particles that can exist within any particular configuration, forcing additional fermions into higher energy states once the lower ones are filled. The resulting structure underlies the stability and stratification of matter, from atomic electron shells to the degeneracy pressure that sustains white dwarfs and neutron stars. Thus, just as ecological niches can support only a limited number of species, quantum systems can support only a limited number of fermions in any given state, illustrating a deep and recurring pattern in nature: stable systems require constraints on occupancy, whether biological, ecological, or fundamental.

The Pauli Exclusion Principle also shapes the layered architecture of atoms by limiting the number of electrons that can occupy specific quantum states. As the principal quantum number $\boldsymbol{n}$ increases, the number of available orbitals—and thus the number of permissible electron states—expands rapidly, allowing progressively more complex atoms to exist. When $\boldsymbol{n}$ is small, as in the first two shells, only a few quantum states are available, and therefore only a limited number of elements can be constructed from such constrained configurations. By contrast, when $\boldsymbol{n}$ reaches the sixth or seventh shell, the number of orbitals becomes large, and the resulting atoms require intricate arrangements of electrons whose stability depends sensitively on subtle quantum interactions. Consequently, elements with electrons occupying the highest shells ($\boldsymbol{n = 6 - 7}$) tend to be increasingly unstable, with many existing only in synthetic or short-lived forms, illustrating how the exclusion principle not only structures atomic architecture but also constrains the ultimate stability of matter.

Even though this discussion is not directly related to Bacon's specific notion of *cohesion*, the broader balance between cohesion and variation may nevertheless hold the key to both stability and progress. Across biological, ecological, institutional, and even quantum systems, excessive uniformity inhibits adaptability, while excessive diversification undermines structural integrity. The enduring lesson is that durable and productive systems—whether natural or human—tend to arise where variation is sufficient to permit change, yet cohesion remains strong enough to preserve functional order.

[6] Bacon emphasized that a phenomenon should not be studied only in rare or puzzling cases, but also in common and accessible ones where its operation was more evident. This reflected his broader methodological principle that inquiry benefited from examining a nature under simpler or more controlled conditions. Modern science follows the same principle in experimental design, using well-understood examples to illuminate obscure ones.

Generally, and among the vulgar, in mechanical works an invention is held to be new if someone merely refines what was discovered long

ago, or decorates it more elegantly, or unites and combines things, or connects them more conveniently to use, or presents the product in a size greater—or even smaller—than usual, and the like.

Therefore, it is by no means surprising if discoveries noble and worthy of the human race have not been brought forth into the light, since men have been content with, and even pleased by, such trivial and childish tasks; and moreover have imagined that in pursuing these, they were attempting—or even achieving—something great [6].

[6] Bacon's critique here had three connected dimensions. First, he warned against *desperatio artificiosa*, the premature closure of inquiry by declaring certain discoveries impossible—a tendency still discussed in the philosophy of science as conservatism within established paradigms. Second, he cautioned against restricting research to isolated phenomena without examining more general cases, anticipating modern methods that compare cases or use model systems to uncover underlying principles. Third, he criticized the overvaluation of minor refinements and aesthetic improvements as if they were major advances, a problem that persists in some contemporary scientific and technological innovation cultures.

I-LXXXIX (1:89).

Nor must we omit to mention that natural philosophy has, in all ages, encountered a troublesome and difficult adversary—namely, superstition, and the blind and excessive zeal of religion. For it can be seen among the Greeks that those who first proposed natural causes for thunder and storms to ears still unaccustomed to such ideas were, for that very reason, condemned of impiety toward the gods [1]; and neither were those who, on the basis of most certain demonstrations (which no rational person today would dispute), affirmed the sphericity of the earth and consequently asserted the existence of antipodes [2], received much better by certain of the ancient fathers of the Christian religion.

[1] Bacon referred to early Greek natural philosophers, such as Anaxagoras, who explained meteorological events without invoking the gods. In antiquity, such explanations were often controversial and could lead to charges of impiety. Anaxagoras, for example, was prosecuted at Athens for teaching that the sun was a fiery stone rather than a deity.

[2] In Bacon's time, "antipodes" referred to people inhabiting the opposite side of the Earth, with their feet pointing in the opposite direction to those of people in Europe. Some early Christian authors, such as Lactantius and Augustine, rejected the idea on theological grounds, believing it inconsistent with the Scriptural account of the origin of the human race.

Moreover, as things now stand, the condition of discourse concerning nature has become harsher and more perilous due to the systems and methods of the scholastic theologians; who, having reduced theology (so far as in their power) to an organized body and fashioned it into the form of an art, have further brought it about that the contentious and thorny philosophy of Aristotle became interwoven with the body of religion to a degree greater than was proper [3].

[3] Bacon's criticism here was directed not primarily at Aristotle's own writings, but at the scholastic theologians who had adopted Aristotelian logic and metaphysics into Christian theology. He believed this integration had gone further than was proper, shaping doctrinal debates with dense and disputatious reasoning.

A similar outcome (though in a different mode) has resulted from the writings of those who have not hesitated to derive and confirm the truth of the Christian religion from the principles and authorities of philosophers—celebrating the marriage of faith and sense as a lawful union with much pomp and ceremony, and soothing the minds of men by the pleasing variety of things [4]; yet in the process confounding the divine with the human in an unequal combination. And in these mixtures of theology with philosophy, only what is already accepted in philosophy is admitted; but new things—even if they are improvements—are for the most part excluded and rejected.

[4] By this phrase, Bacon referred to attempts to prove Christian doctrine using the principles and authorities of philosophers. He opposed such a union when it allowed only those philosophical ideas already accepted, excluding new discoveries. This reflected his concern that philosophy could improperly influence theology, just as theology could improperly limit philosophical inquiry.

Finally, one finds that, due to the ignorance of certain theologians, access to any philosophy, however reformed, is almost entirely blocked. Some, in simple fear, are concerned that a deeper investigation into nature might trespass the bounds of proper restraint; misapplying and distorting passages in the sacred Scriptures—spoken against those who seek to pry into divine mysteries—to the hidden things of nature, which are prohibited by no injunction. Others, more cleverly, suppose and contemplate that if intermediate causes are unknown, each thing may more easily be attributed to the hand and rod of God (which they believe is of greatest importance for religion); which is nothing other than a wish to gratify God with falsehood. Others fear by example that movement and change in philosophy may invade and settle within religion itself. Lastly, some appear troubled lest something be discovered in the investigation of nature that might undermine or at least weaken religion, especially in the minds of the uneducated. But these last two fears seem to us entirely to savor of worldly wisdom, as if men, in the inner recesses of their minds and secret meditations, distrusted the firmness of religion and the dominion of faith over the senses, and for that reason feared that the investigation of truth in natural things might pose a danger to them. Yet for one who considers the matter rightly, natural philosophy is—after the word of God—the surest remedy against superstition, and the most approved nourishment for faith. Therefore it is rightly bestowed upon religion as her most faithful handmaid: for while one reveals the will of God, the other reveals His power [5] [6]. Nor did He err who said, “Ye err, not knowing the Scriptures and the power of God,” thereby linking and conjoining in an indissoluble bond the knowledge of His will

and the contemplation of His power [7]. Meanwhile, it is less surprising that the progress of natural philosophy has been hindered, since religion—which has the greatest influence over the minds of men—has, through the ignorance and reckless zeal of some, been drawn to the opposite side and carried away.

[5] Here "after the word of God" means "second only to Scripture." Bacon maintained that the word of God (Scripture) revealed His will, while natural philosophy revealed His power through the study of nature. He believed the two together formed an indissoluble union of divine will and divine power, but he always placed revelation above natural knowledge in authority.

[6] **Excursus – On Scriptures and Science**

In modern science, by contrast, references to God or Scripture are absent from scientific discourse. This reflects the principle of methodological naturalism, in which science explains phenomena solely in terms of natural causes and observable evidence. While individual scientists may hold personal religious beliefs, such beliefs are not treated as part of scientific method or as sources of scientific authority. This marks a clear departure from Bacon's early seventeenth-century context, in which Scripture was still regarded by many as the highest and final source of truth across all fields of knowledge.

Bacon stood near the beginning of a long historical shift in the relationship between science and religion. From the late Middle Ages into the Renaissance, natural philosophy gradually began to claim a degree of independence from theology while still affirming its subordination to divine revelation. This separation of method from scriptural authority accelerated in the Enlightenment and, especially, from the mid-nineteenth century onward, under the influence of Darwin and other scientific developments. By the twentieth century, professional science in most contexts operated entirely within methodological naturalism, with religion and theology occupying separate intellectual domains.

[7] The phrase "Ye err, not knowing the Scriptures and the power of God" echoes Matthew 22:29. In the King James Version: "Ye do err, not knowing the scriptures, nor the power of God."

I-XC (1:90).

Again, in the customs and institutions of schools, academies, colleges, and similar gatherings, which are intended as seats of learned men and

as places for the cultivation of knowledge, all things are found to be adverse to the progress of the sciences. For lectures and exercises are so arranged that it scarcely occurs to anyone to think or contemplate anything different from the established routines. And if by chance one or another dares to make use of freedom of judgment, he must do so alone; for he will derive no benefit from the companionship of others. And if he tolerates even this, yet he will find that in the pursuit of advancement, such diligence and greatness of mind will prove no small hindrance [1]. For the studies of men in such places are confined, as if in prisons, to the writings of certain authors; and if anyone dissents from them, he is immediately reproached as a seditious person and a lover of novelty. Yet there is certainly a great difference between civil affairs and the arts: for there is not the same danger from a new movement as from new light. In civil matters, indeed, even change for the better is viewed with suspicion on account of the disturbance it causes; since civil affairs rest on authority, consensus, reputation, and opinion, not on demonstration [2]. But in the arts and sciences, as in the workings of mines, everything ought to resound with new tasks and further progress [3]. And in accordance with right reason, such should be the case; but meanwhile, life is not so ordered: rather, the management of learning and the governance of the sciences, as we have described, tends to oppress their advancement with greater harshness [4].

[1] In Bacon's time, university teaching—especially in England—was dominated by set texts and formal disputations, often confined to the works of Aristotle. Institutional statutes sometimes required professors to lecture directly from these texts, leaving little room for independent treatment or the introduction of new ideas. This academic structure reinforced the intellectual confinement that Bacon criticized here.

[2] Bacon contrasted the foundations of political life with those of scientific inquiry. Civil affairs, he argued, depend on maintaining stability and public trust, which come from shared customs, authority, and reputation, rather than from empirical proof. In his view, even beneficial political changes may be resisted because they disrupt order, whereas in the sciences, change and innovation

should be welcomed. This reflects the political realities of Bacon's early-17th-century context and should not be read as an endorsement of modern democratic theory, where legitimate authority is ideally grounded in consent, constitutional principles, and the rule of law.

[3] Bacon likened the pursuit of knowledge to mining, where workers continually dig deeper and explore new seams to extract valuable ore. In the same way, scientific inquiry should be an ongoing process of uncovering new truths, not a static preservation of established doctrines. The image reflects Bacon's emphasis on active, exploratory research.

[4] Bacon's critique anticipates ongoing concerns in the philosophy of science about institutional conservatism—the tendency of established academic and research structures to preserve prevailing theories, methods, and curricula at the expense of novel inquiry. His distinction between *civil affairs* and *the arts and sciences* highlights that while political change is often resisted to maintain social order, scientific advancement depends on openness to innovation and "new light." In modern terms, this is closely related to debates about freedom of inquiry, including the concept of "academic freedom."

In modern terms, this is closely related to debates about "academic freedom," understood here in the narrower sense of protecting scholarly inquiry from undue institutional or political interference.

I-XCI (1:91).

And even if that hostility has subsided, it is still sufficient to restrain the advancement of the sciences that efforts and industry of this kind are without rewards. For the cultivation of the sciences and their prizes do not lie in the hands of the same persons [1]. The growth of the sciences indeed proceeds from great intellects; but the rewards and honors of the sciences are in the hands of the multitude, or of rulers who (except in very rare cases) are scarcely even moderately learned. Moreover, such advances are deprived not only of rewards and the generosity of men, but even of popular praise itself. For they lie beyond the grasp of the greater part of mankind, and are easily overwhelmed and extinguished by the winds of prevailing opinions [2]. Therefore it is no

wonder if that matter has not prospered, since it has not been held in honor.

[1] This refers to the structural separation, characteristic of the early-modern period, between those who generated new knowledge and those who determined its social value. In Bacon's time, original work in natural philosophy was undertaken by scholars who relied on personal study, limited institutional support, and informal networks of correspondence. The power to reward such work—whether through patronage, appointments, or public honor—rested largely with princely courts, ecclesiastical authorities, and other non-expert elites whose education was typically classical rather than scientific. As a result, the advancement of knowledge depended on individuals who had little influence over the systems of recognition, while those who controlled resources seldom possessed the intellectual background needed to evaluate or encourage innovative inquiry. This structural imbalance forms

[2] Bacon's image of new ideas being "overwhelmed by the winds of prevailing opinions" refers to the vulnerability of intellectual innovation in the early seventeenth century, when the dominant culture of learning placed high value on established authorities and traditional doctrines. The metaphor signalled how easily early innovations were suppressed by inherited beliefs, scholastic conventions, and widely held assumptions—forces that shaped public judgement and academic practice alike. In this context, Bacon used the image to emphasize that the advancement of knowledge required not only new methods but also a cultural environment capable of sustaining and shielding unfamiliar or disruptive insights long enough for them to demonstrate their worth.

I-XCII (1:92).

But by far the greatest obstacle to the advancement of the sciences and to the undertaking of new efforts within them is to be found in the despair of men and in the supposition of impossibility. For prudent and serious men, reflecting on the obscurity of nature, the brevity of human life, the deception of the senses, the difficulty of experiments, and the excesses of error and confusion already accumulated in the sciences, are indeed quickly led to the opinion that nothing further can be accomplished by human industry [1]. And if any more daring spirit happens to arise, he would nevertheless be subdued by reverence for

antiquity and the authority of others, or checked by the agreement of the multitude, or simply deterred by the thought of the vastness of the subject. Hence the result is that men no longer attempt anything new or further, but only maintain and repeat what has already been discovered.

[1] Bacon alluded to an ancient idea—found in Plato's *Republic* and *Laws* and discussed critically by Aristotle—that human affairs, including the sciences, go through natural cycles of growth and decline. In this view, knowledge flourishes in certain ages but inevitably withers in others, discouraging attempts to push beyond the achievements of the past.

Nor is this despair confined only to those who, from negligence or indolence, either place their minds entirely in subjection to others or prefer a life of leisure to intellectual labor; it reaches even to those who devote themselves to study with earnestness and zeal, and applies especially to those who are most successful in the sciences. For these individuals, having labored hard and long in their inquiries and having not met with the reward of their hopes, become broken in spirit and fall into a state of deep distrust of nature and the future. And though they do not openly express their despair, it insinuates itself silently into their words and writings. Nay more, many of those who have proved most competent in their fields have gone so far as to corrupt and weaken the foundations of hope itself, thereby turning away others from pursuing the sciences. It is therefore entirely necessary that this evil be addressed from the beginning and corrected, and that a better and more truthful assessment of the capacities and limits of nature be undertaken. For it is not just that false hope be reproved and corrected—which can be done easily—but that true and sound hope, drawn from a deep and faithful contemplation of the nature of things, be legitimately established and fortified [2] [3] [4].

[2] By "true and sound hope," Bacon meant an informed confidence in the possibility of scientific progress, grounded in rigorous observation, careful experimentation, and systematic reasoning. This contrasted with "false hope,"

which he saw as arising from wishful thinking, speculative fantasies, or untested assumptions. Bacon's aim was not to inspire optimism for its own sake, but to encourage a disciplined, evidence-based expectation of discovery. In contemporary terms, this parallels the distinction between scientific hypotheses supported by reproducible evidence and claims based solely on conjecture or enthusiasm.

[3] Bacon compared his own call for scientific renewal to Christopher Columbus's preparation for his first westward voyage. Before setting sail, Columbus assembled a set of arguments—drawn from geographical reasoning, reports from sailors, and physical evidence such as unusual driftwood found on Atlantic shores—to justify his belief that undiscovered lands lay beyond the ocean. Though initially dismissed, his reasoning was vindicated by the voyage's success. Bacon saw this as a model for inspiring well-founded hope in the pursuit of new knowledge.

[4] **Excursus – On Hope and Despair in Scientific Inquiry**

This aphorism speaks directly to ongoing debates in contemporary philosophy of science about the role of optimism and pessimism in inquiry. Bacon's warning against the "supposition of impossibility" anticipates the modern discussion of scientific pessimism—the belief that progress in certain domains is unlikely or impossible—and its counterpart, scientific optimism, which holds that persistent, well-designed inquiry can eventually overcome obstacles. His insistence on grounding hope in "a deep and faithful contemplation of the nature of things" parallels present-day calls for *justified optimism*—ambition tempered by evidence—in research planning and funding policy. Historical examples like Columbus's voyage, which Bacon himself invoked, are now used to illustrate how strong, well-founded convictions can drive groundbreaking exploration despite prevailing skepticism. At the same time, the aphorism underscores the need to balance visionary goals with realistic assessments of methodological limits, a theme still central in debates over the scope and limits of scientific theories.

Bacon's concern with overcoming premature despair also resonates with Thomas Kuhn's analysis of scientific revolutions. In Kuhn's view, periods of "normal science" are characterized by puzzle-solving within an accepted paradigm, but persistent anomalies can lead to a crisis that opens the way for paradigm shift. The "supposition of impossibility" Bacon warns against mirrors the conservative tendency of scientists entrenched in an existing paradigm to dismiss new lines of inquiry as unfeasible or misguided. Conversely, Bacon's call for "true and sound hope" grounded in nature aligns with the rare willingness of some scientists, during times of crisis, to seek and justify radically new

approaches—often at the cost of challenging prevailing authority and consensus.

I-XCIII (1:93).

The beginning, however, must be taken from God [1]: namely this, that the matter at hand, on account of the excellence of good inherent in it, is manifestly from God, who is the author of good and the Father of lights. In divine operations, even the slightest beginnings inevitably draw their outcome. And what has been said concerning spiritual things—that the kingdom of God comes not with observation [2]—is likewise found to be true in every greater work of Providence: that all things proceed gently, without noise or commotion, and the matter is indeed accomplished before men think or perceive that it is underway. Nor should the prophecy of Daniel concerning the last times of the world [3] be omitted: "Many shall run to and fro, and knowledge shall be increased"—clearly indicating and signifying that it is ordained (that is, within the design of Providence) that the traversing of the world—which has been fulfilled through so many distant voyages and now appears to be either completed or very nearly in effect—and the advancement of the sciences [4] should fall into the same age [5].

[1] Bacon alludes to Aratus (*Phaenomena* 1: *Ἐκ Διὸς ἄρχωμεθα*, "Let us begin from Zeus"), adapting the classical invocation to a Christian context.

[2] Luke 17:20 (KJV): "The kingdom of God cometh not with observation."

[3] Daniel 12:4 (KJV): "Many shall run to and fro, and knowledge shall be increased." This verse was printed as the motto on the title page of the 1620 *Novum Organum.*

[4] Bacon links the age of exploration with the advancement of knowledge, presenting them as coinciding historical developments.

[5] Bacon implicitly reiterates his rejection of both *unstructured observation* and *intuitive leaps* in this concluding aphorism of the idols section. Though he invokes divine authority to dignify his program, he maintains that neither

unaided sense nor sudden insight can lead to true knowledge—only a disciplined, corrective method can. His emphasis on avoiding "anticipation or leap" (*anticipationem aut saltum*) signals a deeper methodological commitment to gradual, orderly progress—an epistemic parallel to the natural principle *natura non facit saltum*.

I-XCIV (1:94).

Now follows the most important basis for inspiring hope: namely, that which is derived from the errors of past times and from the paths hitherto attempted. For most admirable is that censure once expressed regarding the imprudent management of a civil state [1]: "*What has been worst in regard to the past ought to be regarded as most promising for the future. For if you had fulfilled everything pertaining to your duty, and yet your affairs were not in a better condition, then not even a hope would remain that they could be improved. But since the condition of your affairs is poor, not due to the force of things themselves, but due to your own errors, it is to be hoped that, once these errors are abandoned or corrected, a great transformation for the better may occur.*" In a similar way, if men had, through so many spans of years, held to the true path of discovering and cultivating the sciences, and yet had been unable to make further progress, it would undoubtedly be a bold and reckless assertion to suppose that the matter could be advanced any further. But if the error lies in the very path itself, and human efforts have been spent on pursuits where they ought least to have been, it follows from this that the difficulty does not arise from the things themselves, which lie beyond our power, but from the human intellect and its use and application—matters which admit of remedy and correction [2]. Therefore, it is most appropriate to set forth those very errors themselves: for as many as there have been impediments in the past arising from errors, so many are the grounds for hope in the future. And although these matters have not been entirely omitted in what has been said above, it nonetheless seemed

worthwhile to present them again now, briefly, in plain and simple words.

[1] Bacon cited Demosthenes, *Philippics* I.2 and III.4. In these speeches, the orator urged Athenians to see their failures as arising from their own errors, not from necessity—and thus capable of correction.

[2] Bacon's argument is that the failures of past science arose from methodological error rather than from the impossibility of knowledge. This anticipates later philosophy of science in which error itself is treated as a source of progress (cf. Popper, Lakatos, Kuhn).

I-XCV (1:95).

Those who have dealt with the sciences have been either empiricists or dogmatists. The empiricists, like ants, merely gather and use; the dogmatists, like spiders, spin webs out of themselves. But the way of the bee is a middle one: it extracts material from the flowers of the garden and the field, but it nevertheless actively digests and transforms it by its own faculty [1]. The true task of philosophy is not unlike this [2]: it relies neither solely nor chiefly on the powers of the mind, nor does it store in memory the material supplied by natural history and mechanical experiments just as it is, but rather deposits it in the understanding after it has been altered and worked upon. Therefore, there is good reason to hope from a closer and more sacred union—one which has not yet occurred—between these two faculties: namely, the experimental and the rational [3].

[1] Bacon adapted a classical analogy—known in Stoic sources such as Stobaeus—to distinguish three types of inquirers: the ant (who gathered without processing), the spider (who theorized from within), and the bee (who synthesized). The metaphor underscored what he regarded as the proper methodological ideal: the combination of empirical collection with rational transformation through disciplined induction.

[2] See Preface, Footnote [1].

[3] Bacon's contrast remains relevant to modern epistemology. His critique of unstructured empiricism and self-contained rationalism anticipates enduring

tensions in the philosophy of science. His "bee" model foreshadows the modern scientific method, emphasizing the synthesis of data and theory. The aphorism also speaks to epistemic virtue, advocating both intellectual diligence and critical judgment.

I-XCVI (1:96).

Natural philosophy has not yet been found in a pure form, but is tainted and corrupted: in the school of Aristotle, by logic; in the school of Plato, by natural theology; in the second school of Plato, that of Proclus and others, by mathematics [1]—which ought to define the boundaries of natural philosophy, not to generate or produce it [2]. But from natural philosophy that is pure and unalloyed, better things are to be hoped [3].

[1] Bacon did not reject mathematics, but sought to limit its role within natural philosophy. He held that mathematics should serve to express or formalize natural truths once discovered, rather than generate or explain them independently. This view reflected his broader insistence on grounding theory in empirical investigation.

[2] Bacon argued that natural philosophy had never existed in a pure form, but had always been compromised by other disciplines. He believed that the Aristotelians subordinated it to logic and dialectic; the Platonists infused it with metaphysical theology (as seen in the *Timaeus*); and the Neoplatonists, such as Proclus and Iamblichus, attempted to derive nature from mathematical abstractions. Bacon maintained that true natural inquiry must begin from observation and experience, not from inherited systems.

[3] Bacon did not object to the use of mathematics within natural philosophy, but to the Neoplatonic practice of deriving the structure of nature from mathematical principles themselves. He held that number and geometry serve to describe and measure natural phenomena once discovered, not to generate natural doctrines independently of observation. For this reason he regarded the mathematical speculations of Proclus and related authors as a corruption of natural inquiry, since they treated mathematical forms as causal in their own right rather than as instruments subordinate to empirical investigation.

In modern philosophy of science, mathematics has come to function not merely as an auxiliary to empirical investigation but as an independent mode

of inquiry capable of producing testable predictions through formal structure alone. This shift reflects the broader transformation described in Footnote [2] at 1:18: mathematical modeling and computational simulation now operate as indispensable epistemic tools, especially in domains where direct experiment is limited or impossible, thereby enlarging the scope of empirical science while retaining its evidential standards.

I-XCVII (1:97).

No one has yet been found endowed with such constancy and intellectual rigor as to have resolved and imposed upon himself the complete abolition of theories and common notions, and to apply the intellect—scraped clean and balanced—anew to particulars [1]. Thus, the human reason we possess is a kind of medley and heap, formed from much credulity, much accident, and also from the childish notions we absorbed at the outset.

[1] Bacon believed that the human mind was rarely capable of entirely purging itself of inherited prejudices, common notions, and early-formed impressions. This idea echoed his theory of the *idola*, which described systematic impediments to understanding. Unlike rationalist methods (e.g., Descartes), Bacon's approach focused on disciplined observation, not introspective doubt.

But if someone of mature age, with unimpaired senses and a mind cleansed of prejudice, applies himself afresh to experience and particulars, better things may be hoped from such a person. And in this regard, we promise ourselves the fortune of Alexander the Great; nor should anyone accuse us of vanity before he hears the outcome of the matter, which is aimed precisely at the rejection of all vanity. For concerning Alexander and his achievements, Aeschines expressed himself in this way: "We surely do not live the life of mortals, but were born so that posterity might tell and proclaim wonders about us"—as though he regarded the deeds of Alexander as miraculous [2]. But in later ages, Titus Livy perceived the matter more accurately and deeply, and said something to this effect about Alexander: that he had merely dared to despise vanities. And we likewise think that a similar

judgment will be made about us by future generations: that we accomplished nothing of great moment, but only placed less value on things that are commonly held to be great. Meanwhile (as we have already said), there is no hope except in the regeneration of the sciences: namely, that they should be raised up in a definite order from experience and be rebuilt anew—something which, as we believe, no one has yet either accomplished or even conceived [3].

[2] Bacon contrasted the exaggerated praise of Alexander the Great by Aeschines with the more sober judgment of Livy. Aeschines' statement—*"we were born so that posterity might tell and proclaim wonders about us"*—expressed a view of Alexander as transcending human limits. Livy, by contrast, argued that Alexander merely "dared to despise vanities." Bacon aligned himself with Livy's view, presenting his own project as a renunciation of intellectual pretension rather than a display of greatness.

[3] This aphorism remains relevant to contemporary epistemology. Bacon anticipated the modern understanding of cognitive bias, emphasizing how entrenched beliefs distort reasoning. His model of scientific renewal required not just method but intellectual virtue—particularly humility and self-discipline. His critique of inherited systems and scientific vanity also parallels current debates on paradigm change, disciplinary overreach, and responsible inquiry.

I-XCVIII (1:98).

And indeed, the foundations of experience (since we must ultimately come to it) have so far been either nonexistent or exceedingly weak; nor has the forest and material of particulars—whether in number, kind, or certainty—been sought out and assembled in a way sufficient or even appropriate for informing the intellect. On the contrary, learned men (altogether careless and complacent) have adopted for the construction or confirmation of their philosophy certain reports, or rather the mere rumors and whispers of experience, and nonetheless attributed to them the weight of legitimate testimony [1]. It is just as if a kingdom or state were to govern its policies and affairs not through letters and reports sent by trustworthy ambassadors and messengers,

but through gossip and street talk: precisely such has been the administration introduced into philosophy with respect to experience. In natural history, nothing is found to have been properly investigated, nothing verified, nothing counted, nothing weighed, nothing measured. But what is indefinite and vague in observation is deceitful and unreliable in the formation of knowledge. And if these claims seem surprising to anyone, and more like unjust complaints—given that Aristotle, so great a man, supported by the wealth of so great a king, compiled such a careful history of animals, and that others, with greater diligence (though less fanfare), have added much, and others still have composed extensive histories and narratives concerning plants, metals, and fossils—that person does not seem to be sufficiently attentive or perceptive about what is presently at stake.

[1] Bacon criticized the natural histories of his time—such as Aristotle's *History of Animals*, Pliny's *Natural History*, and Renaissance treatises on plants, metals, and fossils—as unsystematic and anecdotal. He argued that they contained little verification, measurement, or method, and therefore could not serve as reliable foundations for philosophy.

For the rationale of natural history composed for its own sake differs from that of natural history collected to inform the intellect with a view to constructing philosophy [2]. And these two forms of history differ in many respects, but especially in this: that the former contains the variety of natural species, but not the experiments of the mechanical arts.

[2] Bacon distinguished between natural history compiled for curiosity's sake and natural history collected with a philosophical purpose. The latter, which he sought to establish, would be methodical and designed to inform induction. This distinction underpinned the third part of the *Instauratio Magna*—the *Historia naturalis et experimentalis ad condendam philosophiam*—which he never fully completed, though partial attempts survive in works such as *Historia ventorum* and *Sylva sylvarum*.

Just as in civil affairs the character of a person and the hidden impulses of the mind and affections are better revealed when placed under disturbance than at other times, so too the secrets of nature are more readily exposed through the artificial provocations of the arts than when left to proceed in their ordinary course [3]. Therefore, only then may good hope be placed in natural philosophy, once natural history—which is its foundation and base—has been better equipped; but not before [4].

[3] Bacon emphasized that the secrets of nature are best revealed through experiment—that is, by provoking or constraining nature through the "arts." This principle marked a departure from Aristotelian reliance on passive observation and anticipated the central role of controlled intervention in modern science.

[4] This aphorism remains relevant to the philosophy of science. Bacon's demand for systematic, verified data parallels modern concerns about data quality and experimental rigor. His distinction between descriptive collection and explanatory inquiry anticipates today's division between observational and experimental sciences. His stress on measurement, quantification, and intervention remains central to scientific practice.

I-XCIX (1:99).

And again, within the very abundance of mechanical experiments, there is revealed a profound lack of those which most significantly aid and support the formation of the understanding. For the mechanic, in no way concerned with the pursuit of truth, directs neither his mind nor his hand toward anything except what serves his own task. Then indeed, a well-founded hope for the further progress of the sciences will arise when many experiments are admitted into and gathered within natural history—experiments which, though in themselves of no practical use, nonetheless contribute solely to the discovery of causes and axioms. These we have been accustomed to call *experimenta lucifera*—experiments of light—as opposed to *fructifera*, the fruitful ones [1].

[1] Bacon distinguished between *experimenta lucifera* (“experiments of light”), which served to reveal causes and inform philosophy, and *experimenta fructifera* (“experiments of fruit”), which yielded practical benefits. Artisans, he argued, produced many useful experiments but few that advanced understanding. Bacon sought to collect and redirect such experiments into natural history for the sake of discovery.

The former possess in themselves a remarkable virtue and condition, namely this: they never deceive or fail. For since they are applied not to produce any particular work, but rather to uncover a natural cause in some phenomenon, they serve their purpose equally well in whatever direction they fall, since they bring the question to a conclusion [2] [3].

[2] Bacon maintained that *experimenta lucifera* “never fail,” because they aim not at producing a particular effect but at clarifying a cause. Whether the expected result occurred or not, the inquiry advanced, since either outcome settled the question. This view highlighted the epistemic value of negative results, long before modern science emphasized their importance.

[3] This aphorism remains relevant to present debates over the role of basic versus applied research. Bacon’s defense of inquiry without immediate utility anticipates modern arguments for supporting fundamental science. His claim that experiments of light “never fail” also critiques contemporary biases that undervalue negative or inconclusive results in scientific publishing.

I-C (1:100).

But not only must a greater abundance of experiments be sought and procured—experiments, moreover, of a kind different from those hitherto conducted—but also a wholly different method, and order, and process for the continuation and advancement of experience must be introduced. For experience that is vague and follows only itself (as was said above) is mere groping [1], and rather astonishes than informs. But when experience proceeds according to a fixed rule, in a serial and uninterrupted fashion, something better may then be hoped for in the sciences [2, 3].

[1] Bacon contrasted *experientia vaga* (“vague or stray experience”) with *experientia ordinata* (“ordered experience”). The former referred to unguided, haphazard trials, often found among alchemists or artisans experimenting without method. The latter meant a systematic and rule-governed procedure (*lege certa*) designed to test nature progressively. This distinction had already been introduced in I:82 and underlies his later methodological apparatus in Book II.

[2] This aphorism reiterated Bacon’s warning against mere accumulation of experiments, while preparing the way for his new method. The insistence on a “fixed rule” pointed toward the tables of presence, absence, and degrees of comparison in *Novum Organum* II, as well as the "*Parasceve ad historiam naturalem et experimentalem*" (Preparation for the natural and experimental history), where he outlined how natural history should be ordered for philosophical use.

[3] Bacon’s critique of vague experience anticipates modern concerns about unguided data collection and pattern-hunting without hypothesis. His call for rule-governed, serial investigation resonates with contemporary emphasis on experimental design, replication, and longitudinal research. The aphorism remains relevant in distinguishing between exploratory data-gathering and structured, programmatic inquiry.

I-CI (1:101).

But once the abundance and material of Natural History and of Experience—such as is required for the work of the intellect, or for philosophical work—are already available and prepared, still the intellect is by no means sufficient to act upon that material by its own power and from memory; no more than someone might hope to retain and master the computation of an ephemeris purely in memory. And until now, the greater share in the work of discovery has belonged to meditation rather than to writing; nor has Experience yet been made literate [1]. Yet no discovery should be deemed valid unless it is committed to writing [2]. When this comes into use—when Experience has at last been rendered literate—better hopes may then be entertained [3] [4].

[1] In this aphorism, *experientia literata* referred to the systematic recording of observations and experiments in writing. Bacon stressed that memory and private reflection were insufficient for handling the growing body of natural history, just as one could not hope to compute astronomical tables without written aids. Later (cf. I:103; *De Augmentis* V.2), the term acquired a broader sense, denoting a more ordered and guided approach to experimentation.

[2] Bacon argued that no discovery was valid unless set down in writing, thereby shifting authority from private meditation (reflection) to public record. This principle anticipated modern scientific practices of documentation, publication, and replicability, where transparency and accessibility of evidence are essential to validation.

[3] This aphorism remains relevant today. Bacon's demand for written experience highlights the cognitive limits of individual memory and prefigures modern accounts of "extended cognition," in which external records and tools are essential parts of inquiry. It also anticipates the transition from individual reflection to collective, institutionalized science, where progress depends on shared records and cumulative investigation.

[4] **Excursus – On the Possible Role of AI**
AI systems, now and in the future, can function as components of an external cognitive infrastructure. Their potential roles include: (1) storing data as an augmented external memory; (2) structuring and organizing recorded experience, functioning as an inference machine that extracts patterns and generates preliminary generalizations; (3) constructing dynamic "tables of discovery," that is, systematically arranging relevant variables, observations, and possible experimental pathways; and (4) proposing targeted experiments by running in-silico simulations that narrow the experimental field to those interventions most likely to be informative. Such functions require transparent provenance, rigorous validation, and sustained human oversight.

I-CII (1:102).

Moreover, since the number of particulars is so great—indeed like an army—and so scattered and dispersed that it disjoins and confounds the understanding [1], no great hope can be placed in the skirmishes, light motions, and fleeting sallies of the intellect; unless instruction and coordination are established through tables of discovery that are suitable, well-arranged, and, so to speak, alive [2], concerning those

things which pertain to the subject under investigation, and unless the mind is applied to the aids prepared and digested in these tables [3].

[1] Bacon compared the multitude of natural particulars to an "army" that disordered the intellect. He warned that the "skirmishes" and "sallies" of an unguided mind were futile against such a host, underscoring the need for methodological discipline.

[2] The *tabulae inveniendi* ("tables of discovery") were Bacon's methodological device for ordering particulars and guiding induction. They appear in *Novum Organum* II (e.g., tables of presence, absence, and degrees of heat). Bacon described them as "alive" because they were intended as dynamic tools for inquiry, not static catalogues.

[3] This aphorism remains relevant to the modern problem of data overload. Just as Bacon argued that scattered particulars overwhelmed the intellect, today's sciences face the challenge of massive, unstructured datasets. His call for structured, living tools of inquiry anticipates modern practices such as experimental design, statistical analysis, and adaptive data visualization.

I-CIII (1:103).

But once a collection of particulars has been properly and in due order, as it were, placed before the eyes, we must not immediately proceed to the investigation and discovery of new particulars or works; or at least, if this is done, we must not rest content with it.

For we do not deny that, once all the experiments of all the arts [1] have been gathered and arranged, and have come within the knowledge and judgment of a single individual, it is indeed possible that many new things, useful for human life and condition, can be discovered through the very transfer of experiments from one art into others [2]—by means of that Experience which we call Literate [3]. Yet from that alone little should be expected; greater things, rather, are to be hoped for from a new light of Axioms [4], drawn by a certain method and rule from those particulars, which in turn may indicate and point out new particulars.

For the path does not lie on a level, but proceeds by ascent and descent [5]: by ascending first to Axioms, and descending to Works [6].

[1] Bacon used *artes* broadly to refer to practical disciplines, mechanical trades, and established crafts. He regarded the empirical procedures within these fields as valid sources of natural knowledge, not to be excluded from philosophical inquiry.

[2] *Experientia literata* (technical term): a structured and reflective mode of empirical inquiry, which Bacon distinguished from both common experience and formal theory. It involved the deliberate ordering of experiments, detection of patterns, and transference of methods across domains. See *De Augmentis Scientiarum*, II.5.

[3] One mode of *experientia literata* was *traductio experimentorum*, the transference of experimental results from one discipline to another. Bacon considered this practice productive but insufficient without axiomatic structure. Cf. *De Augmentis*, II.5.

[4] For Bacon, axioms were methodically derived principles intended to enable the prediction and generation of further particulars. Unlike empirical generalizations, they served as guiding structures within a scientific method grounded in induction.

[5] Bacon used this metaphor to describe his method: the mind ascended from particulars to axioms (interpretative induction), then descended from axioms to new experiments and applications. This two-way motion underpinned his vision of scientific progress. Cf. *Scala Intellectus* and *Instauratio Magna*, VI.

[6] **Excursus: On Bacon's Asymmetry of Induction and Deduction**
Bacon's principal target of criticism in *Novum Organum* I:30 was the upward movement from particulars to general propositions. He argued that the traditional method, which he termed *inductio vulgari* (*vulgar induction*), merely gathered instances, leapt prematurely to universal statements, and then relied on syllogistic demonstration to stabilize these ill-founded generalities. Against this, Bacon proposed *inductio vera* (*true induction*), a systematically mediated ascent that proceeded through *axiomata media*, controlled exclusions, and the tabulation of instances, thereby reconstructing the entire logic of discovery. The reform was therefore directed not at the downward derivation of consequences—whose validity depended chiefly on the soundness of the axioms—but at the generation of those axioms themselves, which for Bacon was the decisive weakness of the received logic.

Correspondingly, Bacon treated the downward movement—the derivation of new experiments and practical works from established axioms—as comparatively unproblematic. Once axioms had been secured through *inductio vera*, their application to particulars followed a straightforward path of *derivatio experimentorum*, yielding predictions, operative rules, and new lines of inquiry. This "descent" did not require a reformed logic of its own; its reliability depended on the prior soundness of the axioms rather than on any deficiency in the traditional forms of reasoning. For this reason Bacon did not oppose a "true deduction" to a "syllogistic deduction": the methodological rupture lay in the ascent, not in the descent, which for him remained a practical extension of well-grounded principles rather than a locus of epistemic failure. Although this downward movement resembles what would now be called deductive inference, Bacon did not conceptualize it as a distinct methodological category requiring renovation.

Bacon's understanding of deduction likewise differed from the modern, generic sense of the term. Seventeenth-century usage did not treat *deductio* as the overarching category of necessary inference that it later became; instead, demonstrative reasoning was conventionally identified with the syllogism, while *deductio* functioned as a looser verb for "leading out" or "deriving" consequences. When Bacon criticized the *syllogismus*, he did so not to reject deduction in the modern sense but to challenge the scholastic claim that syllogistic demonstration could generate substantive knowledge from poorly grounded principles. He therefore refrained from constructing a rival notion of "true deduction," since what we now call deductive inference was not, for him, a unified methodological genus requiring renovation. In Bacon's framework, the weakness of the scholastic method lay not in deduction as such but in the premises from which deductions were drawn—hence his insistence that only a reformed ascent (*inductio vera*) could supply the axioms capable of supporting reliable descending inferences. A corresponding pair "true deduction vs. syllogistic deduction" therefore did not, and conceptually could not, arise within Bacon's methodological architecture.

I-CIV (1:104).

Nor must it be permitted that the intellect leap and fly from particulars to remote and, as it were, most general axioms [1] (such as those which are called the principles of arts and things), and then test and apply the intermediate axioms by recourse to their supposed immovable certainty. Yet this has been the prevailing practice, owing both to the natural impulse of the intellect in this direction [2], and to the

longstanding training and habituation in this very method through demonstrations conducted by syllogism. But only then may we hope well of the sciences, when by a true ladder and by continuous steps [3]—without interruption or gaps—we ascend from particulars to lesser axioms, and then to intermediate ones, each rising above the other, and finally to the most general.

[1] Bacon referred to these as *axiomata generalissima*—extremely broad first principles, often treated as self-evident truths. He criticized their lack of empirical grounding and their resistance to verification.

[2] Bacon argued that the human mind was naturally inclined to leap toward general principles without proper empirical grounding. This tendency, he held, was further entrenched by the long-standing use of syllogistic reasoning, which operated on unstable notions and prioritized formal validity over discovery. He rejected the syllogism as inadequate for both deduction and induction within natural philosophy.

[3] Bacon described this process as the *scala intellectus*—a methodical ascent from particular observations to successively broader generalizations. The steps must be unbroken, ensuring that each level is properly supported by the one below.

For the lower axioms differ little from bare experience [4]. The highest and most general ones currently held are merely conceptual and abstract [5], and possess no solidity. But the intermediate axioms are the true, solid, and living ones [6], on which the affairs and fortunes of human beings depend; and above these again are the most general axioms—yet not abstract, but truly delimited through the intermediates.

[4] These "lower axioms" were simple generalizations derived directly from individual observations. Bacon considered them valuable but limited, as they lacked explanatory power and did not yet reveal nature's underlying structure.

[5] Bacon critiqued the prevailing general axioms of his time for being speculative and disconnected from empirical inquiry. Unlike intermediate axioms, they were not constrained by observed phenomena and thus lacked substantive explanatory force.

[6] These *axiomata media* were the core of Bacon's method: general principles derived from multiple instances, capable of both explaining known facts and guiding the discovery of new ones. He viewed them as the most fertile level of scientific reasoning.

Therefore, weights and ballast—not wings—must be added to the human intellect [7], so that it may be restrained from all leaping and flying. And this has not yet been done; but when it is, better things may be hoped for in the sciences [8].

[7] Bacon warned against speculative leaps and ungrounded abstraction. "Wings" symbolize imagination or premature theory; "ballast" refers to empirical discipline and the restraint necessary for reliable scientific progress.

[8] While Bacon outlined a structured method for ascending from particulars to axioms, the deeper question of how theories are actually formed in the human mind remains unresolved. Contemporary philosophy of science recognizes that theory-building involves more than inductive accumulation—it draws on analogy, aesthetic judgment, creative intuition, and what is now termed *abduction* or *inference to the best explanation* (IBE). Neither induction, deduction, nor abduction fully accounts for the generative aspects of conceptual innovation. Thus, the "true ladder" Bacon proposed may serve as a guide for testing and structuring knowledge, but the origin of theories often lies in processes still not fully understood.

I-CV (1:105).

In the establishment of an axiom, a form of induction different from that which has so far been in use [1] must be devised; and this is to be employed not only for the verification and discovery of so-called principles, but also for lesser and intermediate axioms—indeed, for all axioms. For the induction which proceeds by simple enumeration is a childish thing [2]: it draws conclusions on a precarious basis, is vulnerable to a single contradictory instance, generally proceeds from fewer cases than is appropriate, and relies only on those which happen to be at hand. But the induction that will be useful for the discovery and demonstration of the sciences and the arts must separate nature

by means of proper rejections and exclusions [3]; and then, after a sufficient number of negatives, it must conclude on the affirmatives. This has not yet been done, nor has it even been attempted, except perhaps by Plato [4], who, in examining definitions and ideas, certainly makes some use of this form of induction. Yet to furnish a sound and legitimate application of this induction—or demonstration [5] [6]—many things are required that have not yet entered the mind of any mortal; so much so that more effort must be expended on this than has hitherto been devoted to the syllogism. And this form of induction must be employed not only for the discovery of axioms, but also for the delimitation of notions [7]. And indeed, in this very form of induction, the greatest hope is to be found.

[1] Bacon contrasted his method with *inductio per enumerationem simplicem*—the traditional procedure of generalizing from repeated instances. He considered it uncritical and prone to error, lacking any systematic exclusion of alternative explanations.

[2] Bacon condemned this method for its reliance on available examples, its vulnerability to counterexamples, and its failure to uncover causal structures. It assumes regularity without inquiry into exceptions or underlying mechanisms.

[3] Bacon's proposed method involves ruling out possible causes through negative instances—what he called *instantiationes absentiæ in proximo* (instances of proximate absence). This anticipates modern experimental design and causal inference by focusing on systematic elimination.

[4] Bacon's reference to Plato is qualified. Elsewhere he criticized Platonic induction, but here he credits Plato's method of dialectical testing—particularly the Socratic search for definitions—as a partial anticipation of exclusion-based reasoning.

[5] **Excursus – On the Allegory of the Cave and Induction**
The orthodox interpretation holds that Plato's Allegory of the Cave is not an account of empirical inquiry but a metaphysical drama of intellectual ascent: the shadows signify ignorance, the cave represents the sensible world, and liberation symbolizes the soul's turn toward *noēsis* and knowledge of the Forms. On this reading, the shadow-realm is epistemically barren and incapable

of supporting genuine learning. My own, admittedly unorthodox re-interpretation treats the Cave instead as a conceptual model for induction: the prisoners, confronted only with partial and degraded projections, nevertheless encounter repeated patterns across shadows and gradually form hypotheses about the unseen structures that generate them. This is not a claim about Plato's intentions, but a speculative extension of the allegory's epistemic architecture, suggesting that the Cave can illuminate how modern thinkers—from Fisher to Rubin—draw inferences about unobservable realities from systematic, patterned, and imperfect data.

In this speculative reading, Fisher's early frequentist program parallels the epistemic predicament of the cave prisoner. In Fisher's framework, the parameter—the fixed but unobservable "true value"—is never directly encountered; it lies outside the space of empirical appearances, much as the real objects in the cave lie outside the prisoner's visual field. What can be known is not the parameter itself but its projections: the repeated samples drawn from a population. Each sample is an imperfect, partial, and noisy shadow, yet collectively informative. Over many repetitions, differences between the stable features of the parameter (the so-called "essence") and the random fluctuations of sampling variability (the "accidents") become increasingly distinguishable. Through this recurrent patterning, the statistician approximates the hidden generative structure—not by direct access, but by convergence across many imperfect traces. In this limited but meaningful sense, Fisher's frequentism and my re-interpretation of the Cave share a common epistemic form: both describe a situation in which truth is epistemically distant, empirical observations are fragmentary shadows, and understanding emerges through systematic repetition and the careful analysis of variation.

Seen from a broader perspective, one may speculate that Bacon's rejection of Aristotelian deduction and scholastic syllogism left later scientists—especially in the nineteenth and early twentieth centuries—without a viable inherited model of reasoning. If the Aristotelian framework was judged too rigid, verbal, and hostage to premises derived from authority, then the methodological vacuum it created could only be filled by turning further back, beyond Aristotle, to the more exploratory epistemic temperament of Plato and Socrates. This is not to claim a historical influence of Platonic metaphysics on modern statistics, but to note a conceptual affinity: the movement from shifting appearances toward hidden structure, the Socratic attention to definitions, and the dialectical testing of hypotheses resonate with the inferential posture scientists adopted once syllogistic deduction was set aside.

Within this speculative genealogy, the historical record suggests that deduction—not induction—proved especially vulnerable to ideological abuse during the long centuries of scholastic dominance. Aristotelian syllogism, elevated to an unquestionable method and anchored in premises sanctioned by institutional authority, acquired an aura of necessity that facilitated its deployment in enforcing orthodoxy, most famously in the Inquisition's treatment of Galileo. While induction and probabilistic reasoning have also been misused, the rigid and premise-dependent character of scholastic deduction made it particularly susceptible to epistemic closure. Against this background, it is understandable that early modern and later scientists, even after Hume's critique of classical induction, had little appetite to return to a deductive framework associated with dogmatism. Instead, they gravitated toward empirical, probabilistic, and experimentally grounded forms of reasoning—Baconian observation, the experimental method, and eventually statistical induction—which, while fallible, limited the power of hidden premises and institutional authority. Seen in this light, the scientific preference for inductive and probabilistic methods reflected not only epistemic considerations but also a cultural memory of how deduction had been weaponized, making the open-ended, evidence-responsive character of induction comparatively harder to misuse.

[6] Bacon regarded this new form of induction not merely as a heuristic but as a legitimate form of *demonstratio*—a method capable of yielding certainty through structured empirical reasoning. This challenged the view that only deductive logic could produce demonstrative knowledge.

[7] For Bacon, scientific reform required not just new axioms but a purification of the basic notions (*notiones*) used in thought. Many existing concepts, inherited from scholastic and classical traditions, were in his view confused, abstract, or derived from language rather than nature.

I-CVI (1:106).

But in establishing axioms through this kind of induction, an examination and test must also be made as to whether the axiom that is constituted is fitted only and fashioned to the measure of those particulars from which it is extracted [1], or whether it is broader and more extensive. And if it is broader or more extensive, it must be observed whether it confirms this breadth and extensiveness by the indication of new particulars, as it were by a kind of surety [2]; so that

we do not either remain fixed in things already known, or by too loose an embrace grasp at shadows and abstract forms [3], not things that are solid and determinate in matter. When such methods come into use, then at last a solid hope will deservedly shine forth [4].

[1] Bacon emphasized that axioms should not be tailored solely to the known particulars from which they were derived. He regarded such limited axioms as incapable of extension, and thus inadequate for genuine scientific advancement.

[2] Bacon maintained that a sound axiom must point to new, previously unobserved particulars. He described this as a kind of *fidejussio*—a legal metaphor indicating that the axiom must guarantee its broader claims by yielding new discoveries. He considered this not only a sign of utility but of epistemic reliability. Modern philosophy of science often treats a theory's ability to yield predictions about previously unobserved phenomena as a central sign of epistemic strength. This notion—sometimes described as *novel predictive success*—stands in close parallel to Bacon's demand that an axiom provide *fidejussio* by pointing beyond the particulars from which it was formed.

[3] Bacon criticized abstract and speculative principles that lacked grounding in material reality. He consistently opposed theories derived from metaphysical speculation, arguing that true philosophy must remain connected to observable nature.

[4] Compare *Valerius Terminus*, ch. 12, where Bacon asserted that "the only trial to be accepted" was whether an axiom "discovereth and designeth new particulars." He argued that predictive capacity served not only as a test of practical value, but also as an indication of truth.

I-CVII (1:107).

And here too it must be taken up again, what was stated above concerning natural philosophy being expanded [1] and the particular sciences being brought back to it [2], so that there may not be a splitting and mutilation of the sciences [3]; for even apart from this, less hope of progress is to be expected [4].

[1] Bacon's "natural philosophy" referred broadly to the empirical study of nature. However, here and elsewhere (cf. I:79–80), he may also have been invoking his

concept of philosophia prima—a "first philosophy" intended to unify all sciences. See De Augmentis Scientiarum III.i.

[2] Bacon's "natural philosophy" referred broadly to the empirical study of nature. However, here and elsewhere (cf. I:79–80), he may also have been invoking his concept of philosophia prima—a "first philosophy" intended to unify all sciences. See De Augmentis Scientiarum III.i.

[3] This metaphor—scissio et truncatio—captured Bacon's critique of excessive specialization. Contemporary debates on interdisciplinarity and transdisciplinarity reflect similar concerns about the loss of holistic understanding and the need to transcend disciplinary boundaries.

[4] Bacon argued that without systematic integration of scientific knowledge, the advancement of understanding would stagnate. This view anticipated later developments in epistemological holism and interdisciplinary research.

I-CVIII (1:108).

And concerning the removal of despair and the instillation of hope [1], by setting aside or correcting the errors of past times, something has already been said. Yet it must also be considered whether there are other matters that might inspire hope. One thing immediately comes to mind: if many useful things have been discovered by men not seeking them but engaged in other activities, and as if by a certain chance or occasion [2], it cannot be doubted that, when men seek these things deliberately and purposefully, proceeding methodically and in order rather than by impulse and inconsistency [3], far more must necessarily be uncovered. For although it may happen once or twice that someone might stumble by chance upon what had previously eluded him despite great effort and diligent inquiry, yet in the general course of things the opposite is certainly found. Therefore, far more and better things, and at shorter intervals, are to be expected from human reason, industry, direction, and purposeful application [4], than from chance, the instinct of animals, and similar sources, which up to this point have given rise to inventions.

[1] This continues Bacon's strategy of cultivating *epistemic optimism*—the belief that human knowledge can be expanded through deliberate reform. He sought to replace resignation with confidence in the potential of methodical inquiry (cf. I:93–94).

[2] Bacon often critiqued the view that inventions arose primarily by accident. In *Novum Organum*, chance (*fortuna*) is consistently contrasted with rational investigation, which he saw as the rightful path to discovery.

[3] This statement reflects Bacon's advocacy of a new method (*via nova*) based on systematic induction. He rejected both scholastic logic and unstructured empiricism in favor of ordered experimentation.

[4] Bacon viewed these traits—rational planning and sustained effort—as superior sources of invention compared to instinct or accident. His emphasis helped shape the modern ideal of science as a disciplined, collective enterprise.

I-CIX (1:109).

It may also contribute to hope that some of the things already discovered are of such a kind that, before their discovery, it would scarcely have entered anyone's mind to suspect anything concerning them; but rather, one would have plainly dismissed them as impossible. For men are accustomed to conjecture about new things by analogy with the old, and according to an imagination instructed and tainted by prior experience [1]—a method of thinking most deceptive, since many of the things drawn from the sources of nature do not flow along accustomed channels.

[1] Bacon frequently warned that the imagination is shaped by prior experience and misleads judgment, especially in unfamiliar domains. This idea recurs in his doctrine of the *Idola Tribus* ("Idols of the Tribe"), where he described the mind as imposing its own patterns onto nature (cf. I:41).

For example, if someone, prior to the invention of gunpowder [2], had described the thing by its effects in the following manner: that there had been discovered a certain invention by which even the greatest walls and fortifications could be shaken and thrown down from a great

distance; surely men would have been led to many and various reflections on how to multiply the force of engines and machines through weights and wheels and similar devices for battering and projecting. But the idea of a fiery wind suddenly and violently expanding and bursting forth would hardly ever have occurred to anyone's imagination or fancy, especially since no nearby example of it would have been seen, unless perhaps in an earthquake or in lightning, which, as great marvels of nature and not imitable by man, would have been immediately rejected.

[2] Gunpowder was traditionally believed to have been invented in China or India and transmitted to Europe via the Islamic world. Bacon treats it as an emblematic example of transformative technology arising outside rational inquiry—through *fortuna* rather than *ratio*.

Likewise, if before the invention of the silkworm's thread [3], someone had suggested that a kind of thread had been discovered for use in clothing and furnishings, surpassing linen or woolen thread in fineness, and yet also in strength, brightness, and softness, men would immediately have conjectured about some silky plant, or about the finer hairs of some animal, or about the feathers and down of birds; but certainly they would not have imagined the texture of a tiny worm, producing such abundance, renewing itself continually and annually. Indeed, had someone even mentioned a worm, he would certainly have been subjected to ridicule, as though he were dreaming of new works of spiders.

[3] Silk (*sericum*) was known in the West since antiquity and associated with China (*Seres*). Bacon uses it to illustrate how unfamiliar origins defy conventional expectations and analogical reasoning.

Similarly, if before the invention of the mariner's needle [4] someone had said that an instrument had been invented whereby the poles and points of the heavens could be precisely determined and distinguished, men would have turned their imaginations toward constructing ever more refined astronomical instruments in various forms; but that

something might be found whose movement corresponded so well with the celestial bodies, yet was not itself celestial, but rather a mere stony or metallic substance, would have seemed utterly incredible. Yet these and similar things, though hidden from mankind through so many ages of the world, were not discovered through philosophy or the rational arts, but by chance and occasion; and they are, as we said, of such a kind that they are wholly heterogeneous and most remote from what was previously known, so that no prior notion could have led the way to them.

[4] The magnetic compass, known in China as early as the 3rd century CE, entered European use in the 12th–13th centuries. Bacon highlights its material simplicity and conceptual strangeness as a challenge to preconceptions about celestial influence.

Therefore, it is altogether to be hoped that there are still many things of excellent use hidden in the bosom of nature, which bear no relation or parallel to the things already known, but are altogether placed beyond the paths of the imagination; things which, though not yet discovered, will undoubtedly, over the revolutions and windings of many ages, eventually come forth as the former discoveries did. However, by the method we are now treating, they can be represented and anticipated more promptly [5], suddenly, and all at once.

[5] *Repraesentari* (Latin: “to be presented at once”) implies bringing discoveries forward in time. Bacon claims his method can accelerate the appearance of hidden knowledge, bypassing the slow accidents of history. See Cicero, *Epistulae ad Familiares*, 16.

I-CX (1:110).

Yet there are also other inventions of such a kind as to strengthen the belief that the human race can overlook and pass by noble inventions even when they are laid before their very feet. For although the inventions of gunpowder, of silk from the silkworm, of the mariner’s needle, of sugar, of paper [1], and similar things may seem to depend upon certain properties of things and nature, surely the art of printing

contains nothing that is not open and almost obvious [2]. And nonetheless, men, failing to notice that although the arrangement of letter-types is indeed more difficult than writing letters by hand, there is this difference—that the types, once arranged, serve for infinite impressions, whereas letters written by hand serve only a single copy; or perhaps again failing to notice that ink can be thickened so that it stains without flowing [3], especially when the letters are positioned face upward and the impression is made from above—because of this failure of observation, men were deprived through so many centuries of this most beautiful invention, which contributes so greatly to the propagation of learning [4].

[1] These examples reflected inventions whose material bases had been known long before their practical use emerged. Bacon used them to illustrate how significant inventions could remain latent despite widespread familiarity with their components.

[2] Printing with moveable type—credited to Johann Gutenberg in the mid-15th century—required no new materials but a novel combination of ink, paper, press, and reusable letter types. Bacon used it to argue that intellectual oversight, not material absence, had delayed this invention.

[3] This referred to the development of a viscous, quick-drying ink suitable for printing. Ordinary writing ink had been too fluid for use with raised types, and the innovation lay in recognizing and adapting this small but crucial detail.

[4] Before the invention of printing, handwritten manuscripts—especially illuminated ones—were often colorful, decorated with intricate initials, borders, and illustrations. After Gutenberg, printed books became largely monochrome due to technical and economic constraints, leading to a decline in visual richness even as textual dissemination expanded.

Moreover, the human mind is often so awkward and ill-constituted in the course of invention that at first it distrusts itself and shortly thereafter despises itself [5]; and at first it seems incredible to it that any such thing could be discovered, but once it has been discovered, it again seems incredible that men could have missed it for so long. And this very circumstance is rightly drawn as a ground for hope: namely,

that a great mass of inventions still remains, which may be deduced not only by discovering unknown operations, but also by transferring, combining, and applying those already known, through that Literate Experience of which we have spoken [6].

[5] Bacon critiqued the instability of human judgment in invention: initial disbelief gave way to ridicule of earlier ignorance. This anticipated what is now called hindsight bias—the illusion that discoveries should have been obvious all along.

[6] "Literate Experience" referred to a form of disciplined, reflective engagement with observed phenomena. Unlike mere experience, it was methodically organized and capable of yielding insight through combination and application (cf. I:103 and *De Augmentis Scientiarum*).

I-CXI (1:111).

Nor should the following point be omitted in fostering hope: let men consider (if they will) the infinite expenditures of ingenuity, time, and resources which they lavish upon matters and pursuits of far lesser utility and worth [1]; of which, if even a small portion were redirected toward sound and solid studies [2], no difficulty would be insurmountable. This I have thought it appropriate to add, because we openly confess that the collection of Natural and Experimental History [3], as we envision it in our minds and as it ought to be, is a work both great and, so to speak, royal [4], and one demanding much labor and expense.

[1] Bacon frequently criticized the intellectual labor devoted to scholastic disputation, astrology, alchemy, and theological speculation. He viewed these as examples of effort wasted on pursuits that neither advanced practical knowledge nor improved human life.

[2] This phrase reflects Bacon's ideal of a disciplined, empirical philosophy grounded in observation and experiment. It contrasts with speculative reasoning divorced from empirical reality—a key target of *Novum Organum*.

[3] Bacon did not mean a physical collection or cabinet of curiosities, but a systematically compiled record of natural phenomena and experiments. This was to serve as the factual basis for inductive reasoning.

[4] Describing the project as "royal" underscored its grandeur, public value, and need for sustained institutional support. In Bacon's time, such language often implied a work worthy of princely or state patronage.

I-CXII (1:112).

In the meantime, let no one fear the multitude of particulars [1]; rather, let this very fact renew hope. For the particular phenomena of the arts and nature are but a handful compared to the inventions of the mind, once they have been severed and abstracted from the evidence of things [2]. Moreover, the outcome of this path is clear and almost at hand; the other path leads to no outcome at all, but rather to infinite entanglement. For men thus far have spent little time in experience, and have only lightly skimmed over it, while they have wasted infinite time in meditations and speculations of the mind. But if there were available among us someone who could answer inquiries concerning the actual facts of nature [3], the discovery of all causes and all sciences would be the work of a few years [4].

[1] Bacon referred to empirical observations and experiments—*particular phenomena*—as the foundation of true knowledge. He rejected the scholastic tendency to bypass particulars in favor of abstract reasoning.

[2] This phrase captures Bacon's critique of speculative philosophies that operate independently of empirical observation. He viewed such abstractions as epistemologically sterile and prone to error.

[3] This is a juridical metaphor, echoing the legal process of interrogating witnesses. Bacon often depicted nature as a subject to be questioned methodically (*interrogata naturae*), not merely contemplated.

[4] Bacon asserted that once a reliable base of empirical knowledge was in place, theoretical discovery would advance rapidly. This anticipates modern emphasis on data infrastructure as a prerequisite for scientific progress. The last sentence of this paragraph also shows Bacon's strong optimism.

I-CXIII (1:113).

We also believe that some hope may arise for men from our own example; and we say this not out of boastfulness, but because it is useful to state. Let those who are distrustful observe me: a man among men of my age most occupied with civil affairs [1], not of particularly strong health (which entails a significant loss of time), and, in this pursuit, truly a pioneer [2], following no one's footsteps, nor communicating these very endeavors with any other mortal; and yet, by steadfastly entering upon the true path and submitting my mind to the things themselves, having, as we suppose, advanced these very matters to some extent. And then let them consider what may be expected from men who abound in leisure, whose labors are united, and who benefit from the succession of generations [3, 4], after these indications of ours; especially on a path which is not accessible only to individuals (as happens in that way of reasoning), but where men's labors and efforts—especially with regard to the gathering of experience—can most advantageously be distributed and then combined [5]. For then men will begin to know their own strength, when not countless individuals perform the same tasks, but different individuals contribute to different parts.

[1] Bacon held high public office, including Lord Chancellor under James I. His remark reflects both a factual limitation on his time and a rhetorical contrast between public service and private philosophical labor.

[2] Bacon used the rare Greek term *πρωτόπειρος* (*protopirus*), meaning "first to attempt." He claimed originality not in every idea, but in systematically pursuing the inductive method outlined in *Novum Organum*.

[3] Bacon envisioned science as a cumulative enterprise, advanced through coordinated effort over time. This early articulation of scientific continuity contrasts with Renaissance ideals of isolated genius.

[4] Bacon emphasized the importance of the *succession of generations* in scientific progress: knowledge was to advance not by isolated genius, but through the cumulative efforts of successive cohorts. This principle implies a caution: if the system has functioned properly, then the labor of earlier generations has already been transmitted and integrated into present understanding. To claim that hidden insights still lie untouched in writings 500 years old risks discrediting the competence of the intervening generations, whose task was precisely to preserve and refine that knowledge. A more realistic measure is the academic generation interval—the average time between a scholar's intellectual formation and the training of their successors. In fast-moving sciences this may be 15–25 years, in slower disciplines somewhat longer, but in most cases two to three such intervals suffice to engage the essential lineage of a field. As a practical approximation, one may use one's own age as a "meter" for estimating how far back it is prudent to reach.

[5] This anticipates the modern scientific division of labor, where tasks are distributed across individuals, institutions, and generations. Bacon emphasized that such structure, not isolated reasoning, is the true engine of discovery.

I-CXIV (1:114).

Lastly, even if a much weaker and more obscure breath of hope were to blow from that New Continent [1], nevertheless we have determined that the attempt must absolutely be made [2], unless we wish to show ourselves altogether abject of spirit. For the matter is not equally perilous in case of not attempting and in case of not succeeding, since in the former the loss is that of a vast good [3], while in the latter it is only the loss of a small amount of human effort. But from what has been said, and also from what has not been said, it has seemed to us that there is abundant foundation for hope, not only for a vigorous man to attempt, but also for a prudent and sober man to believe [4].

[1] Bacon used the metaphor of a "New Continent" to evoke the recent discovery of the Americas, which in his time symbolized the sudden expansion of human horizons. The metaphor equated the pursuit of natural philosophy with geographical exploration: uncertain at first, yet promising immense reward.

[2] Bacon alluded to an anecdote preserved by Peter Martyr Anghiera (1457–1526), who related that Columbus, observing west winds off the Portuguese

coast, inferred the presence of land to the west. A seemingly slight clue thus justified a great attempt.

[3] Here Bacon applied a principle akin to modern decision theory: the asymmetry between the potential gain of success and the limited cost of failure makes the attempt rational. The reasoning parallels contemporary arguments for pursuing "high-risk, high-reward" research.

[4] Bacon aimed to persuade not only the adventurous but also the cautious that his project was justified. By framing the enterprise as proportionate and rational, he sought to ground scientific hope in prudence rather than enthusiasm alone.

I-CXV (1:115).

Concerning the removal of despair—which has been among the most powerful causes for the delay and hindrance of scientific progress—this has now been addressed. At the same time, the discussion on the signs and causes of error, and of sloth and ignorance which have prevailed, has also been completed—especially since the more subtle causes, which do not enter into popular judgment or observation, ought to be referred to those things which have been said about the Idols of the human mind [1].

[1] The three kinds of Idols treated in Book I—*Idola Tribus* (of the Tribe), *Idola Specus* (of the Cave), and *Idola Fori* (of the Marketplace)—corresponded to Bacon's critique of human reason in its unregulated state. A fourth kind, the *Idola Theatri* (of the Theater), referred to inherited philosophical systems. Together, they formed the core of the destructive part of the *Instauration*.

And here, likewise, the destructive part of our Instauration should come to a close, which is completed by three refutations [2]: namely, the refutation of Human Reason in its native state and left to itself; the refutation of Demonstrations; and the refutation of Theories, that is, of the philosophies and doctrines which are currently accepted. The refutation of these has been such as it could be—namely, by signs and by the evidence of causes; since no other mode of confutation could

be applied by us, who dissent both from the principles and the demonstrations of others [3].

[2] Bacon distinguished three *redargutiones* (refutations): of human reason left to itself, of scholastic demonstrations, and of received theories. In earlier outlines (*Distributio Operis*, *Partis Secundae Delineatio*), the order of these differed, showing that the structure of the *Novum Organum* was still unsettled during its composition.

[3] Bacon did not attempt a line-by-line refutation of rival systems. Instead, he argued from signs and causes—that is, by pointing to the sources of error and the failures of past inquiry—since he rejected the very premises and methods of traditional philosophy.

Wherefore, it is now time to turn to the very art and rule of Interpreting Nature; and yet, there still remains something that must first be addressed. For since, in this first book of aphorisms, it has been our aim to prepare men's minds both to understand and to accept what follows, the area of the mind having now been cleared, cleansed, and leveled [4], it follows that the mind should be placed in a proper position, and as it were with a favorable disposition, toward what we are about to propose. For in the case of something new, prejudice is influenced not only by the strong preoccupation with old opinion, but also by a false preconception or anticipation of the thing that is presented [5]. Therefore, we shall attempt to ensure that good and true opinions may be held concerning the things we introduce—even if only temporarily, and as it were on loan—until the matter itself becomes clearly known.

[4] Bacon likened the mind to a polished mirror or a leveled surface, prepared to receive light. The metaphor emphasized that intellectual reform required not only new content but also the removal of distortions, so that truth could be reflected without corruption.

[5] Bacon cautioned that novelty could be resisted in two ways: by attachment to old doctrines, and by premature expectations about the new. His concern anticipates modern reflections on scientific reception, where hype, fear, or misunderstanding can distort evaluation of emerging theories.

I-CXVI (1:116).

First, then, it seems proper to request that men should not think that we, following the custom of the ancient Greeks or certain modern thinkers, such as Telesius, Patricius, or Severinus [1], seek to establish some sect in philosophy. For this is not what we are doing; nor do we believe that it greatly matters to human fortunes what abstract opinions anyone may hold concerning nature and the principles of things. Nor is it doubtful that many such doctrines, both ancient and new, can be revived and introduced, just as many hypotheses concerning the heavens can be proposed, which agree fairly well with the phenomena yet differ among themselves [2].

[1] Bacon named three Renaissance opponents of Aristotle who nonetheless constructed speculative systems of their own. Bernardino Telesio (1509–88) emphasized sensory observation but still posited heat and cold as first principles. Francesco Patrizi (1529–97) advanced a Platonizing cosmology in his *Nova de universis philosophia* (1593). Petrus Severinus (1542–1602), a Danish physician, followed Paracelsus in blending chemistry, medicine, and mysticism. Bacon respected their anti-Aristotelian stance but rejected their sectarianism.

[2] Bacon compared speculative natural philosophies to astronomical hypotheses that could account for appearances yet differ radically from each other. His point was that agreement with phenomena is not sufficient unless theories are also grounded in systematic induction from experience.

But we do not concern ourselves with such speculative and simultaneously useless matters. On the contrary, it has been firmly resolved by us to investigate whether we can truly lay firmer foundations for human power and greatness and extend its limits further [3]. And although scattered here and there, in certain particular subjects, we hold (as we think) doctrines far more true, more certain, and even more fruitful than those which men have hitherto employed (and which we have gathered into the fifth part of our *Instauration* [4]), yet we do not propose any universal or complete theory. For the time

for such a work does not yet seem to have arrived. Indeed, we do not even hope to live long enough to complete the sixth part of the *Instauration* [5] (which is devoted to the philosophy discovered through the legitimate interpretation of nature); but we consider it sufficient if we conduct ourselves soberly and usefully in the intermediate tasks, and meanwhile sow the seeds of a purer truth for future generations [6], and not shrink from initiating great undertakings.

[3] Bacon defined the goal of the *Instauration* as laying "foundations for human power and greatness." This phrasing linked natural philosophy to the practical advancement of the human condition, not merely abstract speculation.

[4] Part V was entitled *Prodromi sive Anticipationes Philosophiae Secundae*, a collection of provisional hypotheses or anticipations. These were meant as scaffolding—useful guides to research, but explicitly temporary until confirmed or corrected by systematic inquiry.

[5] Part VI, the *Philosophia Secunda sive Scientia Activa*, was to present the completed body of natural philosophy derived from the legitimate interpretation of nature. Bacon did not expect to live to see its realization, regarding his own role as preparatory.

[6] Bacon emphasized the intergenerational nature of scientific progress. His task was to prepare and initiate; the completion of the system would fall to successors. This anti-sectarian humility underscored his departure from school-bound philosophy and his vision of cumulative science.

I-CXVII (1:117).

Since I am not the founder of a sect, I do not seek to entice men by promises of particular practical results. Yet, because I continually insist upon works and drag everything towards that goal, it may perhaps seem to some that I ought to produce certain works myself, as a pledge. But I have already said often, and now willingly repeat, that the undertaking of mine is not to derive works from works, or experiments from experiments (as do the empirics [1]), but rather to derive causes and axioms from works and experiments, and then to derive new

works and experiments from those causes and axioms (as do legitimate interpreters of nature). If anyone, therefore, will look upon the Tables of Discovery which are to constitute the fourth part of the Instauration [2], or upon the examples of particulars that I have collected in the second part, or upon the observations regarding history which are intended for the third part, he will surely find, even without great acumen, numerous indications and outlines of great works scattered throughout these texts. However, I openly acknowledge that the natural history which I have so far amassed, whether from books or from my own efforts and research, is far too scanty and not sufficiently verified to serve the purposes of true interpretation [3].

[1] In Bacon's usage, an *empiric* was one who accumulated practical recipes or remedies without understanding their causes, especially physicians who relied on experience alone. He contrasted them with "legitimate interpreters of nature," who derived causes and axioms from experiments and then used those principles to generate new discoveries.

[2] Part IV of the *Instauration*, the *Scala Intellectus* or *Tables of Discovery*, was designed as a methodological tool for guiding induction. Along with Part II (*Historia naturalis et experimentalis*) and Part III (*Phaenomena universi*), these incomplete sections already contained, in Bacon's view, outlines of potential works.

[3] Bacon openly admitted that his natural history was incomplete and inadequately verified. Later critics, such as Justus von Liebig, faulted him for this shortcoming, but Bacon defended himself by stressing that his aim was to lay down the method, not to deliver immediate discoveries.

Therefore, if there be anyone more ready and better fitted for mechanical operations, and more skilled in deriving works from experiments, I do not hinder him from proceeding to apply portions of my history and my tables to practical results, as if to the paying of interest until the principal is forthcoming. But for myself, I am aiming at greater things; and I condemn all precipitate and premature applications, like those Atalantan apples that tempt men from the course [4]. For I do not run along with childish eagerness to grasp the

golden apples; but I bet everything on the art itself triumphing over nature [5]. Nor do I concern myself with clearing away moss and weeds; rather, I wait for the harvest when the crop has fully ripened.

[4] In Greek mythology, Atalanta was distracted from a race by golden apples cast by Hippomenes. Bacon used this as an allegory for premature or flashy applications that divert inquiry from the long, disciplined path toward genuine scientific progress. A parallel appears in Persian and Islamic tradition, where a man fleeing a drunken camel falls into a well, only to find a dragon below (symbolizing the grave or even hell), four snakes underfoot (often interpreted as the four elements or the four humors), and two mice (black and white, symbolizing day and night) gnawing at the rope sustaining him. Instead of grasping his peril, he distracts himself by licking honey from a honeycomb he finds in front of his eyes. In both stories, fleeting sweetness diverts attention from life-or-death urgency—a moral warning against being seduced by short-term pleasures or results at the expense of ultimate truth.

[5] This referred to Bacon's maxim *natura non nisi parendo vincitur*—"nature is not conquered except by obeying her." Mastery over nature, for Bacon, required patient observation and methodical submission to her laws, not shortcuts or force.

I-CXVIII (1:118).

It will undoubtedly occur to someone, after reading through our history itself and the tables of invention [1], that there is some degree of uncertainty, or even outright falsehood, in the experiments themselves; and thus he may perhaps reflect that our discoveries rest upon foundations and principles that are false and doubtful. However, this is of no consequence; for it is inevitable that such things should happen at the outset. It is similar to what occurs when, in writing or printing, one or two letters are by chance incorrectly placed or misaligned [2]; for such errors do not greatly hinder the reader, since they are easily corrected by the sense itself. Let men likewise consider that many experiments in natural history [3] may be wrongly believed and accepted, which are nevertheless easily expunged and rejected once causes and axioms have been discovered [4]. Yet it is certainly true

that if mistakes in natural history and in experiments are great, frequent, and continuous, they cannot be corrected or amended by any skill or ingenuity whatsoever. Therefore, if even in our natural history—approved and gathered with such diligence [5], severity, and almost religious care—there should occasionally be found some falsity or error in particulars, what then must be said of the common natural history, which, compared to ours, is so negligent and careless? Or what must be thought of the philosophy and sciences built upon such shifting sands [6]—or rather, quicksands? Therefore, let what we have said cause no one any disturbance.

[1] Bacon's *tables of invention* were systematic arrangements of observed data, intended to aid inductive reasoning. They appeared primarily in Book II of *Novum Organum*, though they remain conceptually central throughout.

[2] Bacon compares early experimental errors to typographical misprints—a familiar issue in early modern printing. Just as readers could infer the intended word from context despite minor letter misplacements, so too could the method of induction correct early observational errors once a coherent framework of causes and axioms had been established. The analogy underscores the resilience of interpretive systems in the face of local inaccuracies.

[3] *Natural history* in Bacon's usage referred not to biological description, but to the empirical collection of phenomena—facts, effects, and experiments—which served as the raw material for inductive analysis.

[4] This reflected Bacon's broader methodological claim that once true causal explanations and general principles (*axiomata*) were established, they enabled the correction of prior observational errors.

[5] Bacon acknowledged that even his carefully compiled *natural history* might contain errors, yet he maintained that it surpassed the careless compilations of his predecessors. This emphasis on methodological rigor over inherited authority remains central to his project.

[6] Here Bacon criticized the traditional systems—especially Aristotelian scholasticism—for building theory on unreliable observations and dogmatic reasoning. This critique recurs throughout *Novum Organum* as part of his call for a reformed, empirically grounded science.

I-CXIX (1:119).

In our history and experiments there will also occur many things which, at first, are trivial and commonly known, then base and unrefined, and finally excessively subtle and purely speculative [1], and seemingly of no use—such things as might turn men's studies aside and alienate their interests.

[1] Bacon anticipated criticism of his *natural history* for including observations that seemed either too mundane, too crude, or too abstract. He framed these categories as rhetorical defenses of empirical breadth, which remains essential to a complete account of nature.

And concerning those things which appear common, let men consider this: that they have generally been accustomed to do nothing other than to refer and adapt the causes of rare phenomena to those occurrences which are more frequent [2], but have not investigated the causes of the frequent events themselves; rather, they accept them as granted and admitted. Thus they do not inquire into the causes of weight, of the rotation of the heavenly bodies [3], of heat, of cold, of light, of hardness, of softness, of rarity, of density, of liquidity, of solidity, of animation, of inanimation, of similarity, of dissimilarity, nor finally of organic structure; but having accepted these as evident and manifest, they proceed to dispute and judge concerning other matters which occur less frequently and are less familiar.

[2] Bacon criticized the philosophical tendency to explain extraordinary phenomena by reference to familiar ones, without investigating the familiar themselves. This reversed his methodological principle: causes ought to be sought first in the frequent and ordinary.

[3] This list included basic physical phenomena that early modern philosophers and scholastics typically treated as self-evident or natural, without causal investigation. Bacon argued that without understanding such fundamentals, no sound inquiry into rarer effects was possible.

We, however, who are sufficiently aware that no sound judgment can be made regarding rare or remarkable phenomena, and even less can anything new be brought to light, unless the causes of common things and the causes of those causes have been properly examined and discovered, are necessarily compelled to include the most ordinary matters in our history [4]. Indeed, we have found that nothing has harmed philosophy more than this: that familiar and frequently occurring things fail to arrest and occupy men's contemplation [5], but are received superficially, without inquiry into their causes; so that inquiry into unknown matters is not more often lacking than attentive consideration of things already known.

[4] By "history," Bacon referred to his *natural history*—a structured empirical record of phenomena. Including the ordinary was, for him, methodologically necessary, not incidental, to the inductive project.

[5] This reflected Bacon's psychological account of inquiry: that the mind was easily distracted by novelty and neglected the familiar. He regarded this cognitive habit as a major obstacle to scientific progress.

I-CXX (1:120).

As to the baseness or even foulness of certain things, for which (as Pliny remarks) a kind of reverent apology must be made [1], such matters must be admitted into natural history no less than the most splendid and precious ones. Nor is natural history thereby polluted: for the sun enters palaces and sewers alike, yet is not polluted [2]. We, moreover, are not dedicating or constructing some Capitol or Pyramid to the pride of men [3], but are laying the foundation of a holy temple, after the model of the world itself, within the human intellect. Thus, we follow the model; for whatever is worthy of being is also worthy of being known, since knowledge is the image of being [4]. And base things endure just as splendid ones do. Indeed, just as from certain putrid materials—such as moss and civet [5]—some of the finest scents are sometimes produced, so also from mean and sordid instances there

sometimes emanates excellent light and information. But enough of this; for such fastidiousness is plainly childish and effeminate [6].

[1] Bacon referred to *Natural History* I.1, where Pliny the Elder invoked *honoris praefatio*—a rhetorical apology for treating vulgar or base topics. Pliny defended such inclusions by asserting that nature must be described in all its parts, even the foulest.

[2] This metaphor of pollution was countered by Bacon's image of the sun, which he drew from classical and Christian traditions to illustrate the purity and impartiality of nature. He implied that scientific inquiry remains untouched by the moral status of its objects.

[3] Capitols and pyramids symbolized human vanity and monumental ambition. Bacon contrasted these with his aim: to construct a "holy temple" of knowledge within the mind, modeled on nature itself. This metaphor remains central to his conception of scientific labor as sacred.

[4] Here Bacon assumed a realist epistemology: that true knowledge corresponded to the structure of reality. He did not engage the skeptical or idealist concerns that later philosophers would raise about the relationship between thought and being.

[5] Civet (a secretion from the civet cat) and moss (likely oakmoss) were pungent substances used in early modern perfumery. Bacon cited them to show that valuable outcomes could emerge from putrid or ignoble materials.

[6] This gendered rebuke reflected early modern attitudes that associated delicacy or squeamishness with weakness. Bacon dismissed such sensibilities as incompatible with serious inquiry, which must engage all parts of nature without aversion. In our times, this kind of language is not appreciated.

I-CXXI (1:121).

But on this point a more careful examination is altogether necessary; for many things in our history will seem, to ordinary understanding or even to any mind habituated to present circumstances, to be instances of a certain curious and useless subtlety.

Therefore, concerning this, above all, it has been and must again be

said: namely this—that at the beginning and for a time, we seek only experiments that bring light, not those that bear fruit [1]; after the example of divine creation, as we have often said, which on the first day produced only light, assigned to it alone an entire day, and on that day mingled no material work with it. Thus, if anyone were to think that matters of this kind are of no use, he would be reasoning as if light itself were useless, merely because it is neither a solid nor a material thing.

[1] Bacon referred to the biblical account of creation (Genesis 1:3–5), where God created light on the first day without any material work. He invoked this as a metaphor for early-stage inquiry: experiments should initially aim to illuminate principles, even if they yield no immediate practical application.

Bacon's remark presupposes the pre-Newtonian, pre-electromagnetic ontology in which light (*lux*) was not considered a body (*corpus*) at all. His rhetorical point is that usefulness does not depend on corporeal thickness or materiality. In modern terms, this historical understanding diverges from contemporary physics, which regards light as a physical phenomenon even though it lacks solidity and rest mass.

Indeed, it must be said that the well-examined and well-defined knowledge of simple natures is like light [2]: it offers access to all the innermost chambers of operations, and in a certain power embraces and draws after itself entire bands and squadrons of operations, and the sources of the most noble axioms; although in itself it is not of great immediate utility. And likewise, the elements of letters by themselves and separately have no meaning [3] nor are of any use, yet they are like the prime matter for the composition and furnishing of all speech. Even the seeds of things, though potent in power, are worthless in use unless they proceed toward development. And the rays of light themselves, when dispersed, impart no benefit unless they are gathered together.

[2] *Simple natures* (*naturae simplices*) were, for Bacon, irreducible qualities of matter—such as heat, motion, or density—from which all physical phenomena

were compounded. He believed that discovering these would enable the controlled recombination of nature's elements, much like letters form words.

[3] This analogy echoed Bacon's view that foundational knowledge, though individually inert, gains significance through composition—paralleling the use of letters in forming speech. It reinforced his defense of seemingly unproductive inquiry.

If, however, anyone takes offense at speculative subtleties, what must be said of the scholastic men, who indulged excessively in subtleties? Yet those subtleties were spent upon words, or at least upon common notions (which comes to the same thing), and not upon things or nature, and were devoid of utility not only in their origin but also in their consequences; whereas the subtleties of which we speak, though of no immediate use, have infinite utility by consequence. And let it be known as certain among men that all subtlety of disputation and mental discourse, if applied only after axioms have been discovered, is late and out of order [4]; and that the true and proper, or at least the principal, time for subtlety is in the careful weighing of experience and the establishment of axioms therefrom. For the other kind of subtlety grasps and snatches at nature, but never apprehends or holds it. And it is most certainly true what is said about opportunity or fortune, if transferred to nature: namely, that she is hairy in front and bald behind [5].

[4] Bacon distinguished between two kinds of subtlety: one based on empirical observation and properly ordered reasoning, and another based on speculative discourse detached from nature. He condemned the latter as methodologically inverted.

[5] This classical image of *Occasio* (Opportunity) appeared in Phaedrus' *Fables* and Dionysius Cato's *Moral Distichs*. It symbolized the idea that opportunity must be seized at the right moment, or it will pass irretrievably—here applied to the fleeting insight offered by experience.

Finally, as for the contempt for common, low, excessively subtle, and initially useless things in natural history, let the saying of the old

woman to the haughty prince, who had rejected her petition as unworthy and beneath his majesty, serve as an oracle: "Then cease to be king [6]." For it is absolutely certain that dominion over nature cannot be either obtained or exercised by anyone who refuses to attend to such petty and minute matters.

[6] This anecdote was attributed to Philip II of Macedon by Plutarch (*Sayings of Kings and Commanders* 179C). Bacon employed it as an allegory: just as a ruler who ignores humble petitions forfeits his title, so too a philosopher who neglects base or minute phenomena forfeits dominion over nature.

I-CXXII (1:122).

It also occurs to us to address another point: that it may seem a marvelous and harsh thing that we remove all sciences and all authors at once and, as it were, with a single blow and assault; and that we do so not by calling upon any of the ancients for assistance and support [1], but seemingly by our own powers.

[1] Bacon deliberately refused to ground his project in ancient authority, rejecting the prevailing humanist expectation that new ideas required classical endorsement. For a broader argument on the generational logic of scientific progress, see note 4 to I:113.

Yet we are aware that, had we chosen to act with less than sincere faith, it would not have been difficult for us to refer these matters which we present either to the ancient ages before the time of the Greeks [2]—when the sciences concerning nature perhaps flourished more abundantly, though with greater silence, and had not yet fallen into the pipes and trumpets of the Greeks—or even (at least partially) to certain of the Greeks themselves, and thus to seek endorsement and honor from that quarter; much like new men who fabricate nobility for themselves [3] from some ancient lineage through the favor of genealogical constructions. But relying upon the evidence of things, we reject every form of fabrication and imposture; nor do we think it

relevant to the matter at hand whether the discoveries that are now being made were once known to the ancients and have perished and reemerged through the vicissitudes of things and the revolutions of ages, any more than it should concern mankind whether the New World is that island of Atlantis [4] known to the ancients, or has now for the first time been discovered. For the discovery of things must be sought from the light of nature, not fetched back from the darkness of antiquity.

[2] Bacon speculated that natural knowledge may have flourished in pre-Greek antiquity but left no durable trace. He acknowledged such claims only to dismiss them, aligning instead with an empiricist conviction that discovery must come from *present observation*, not retrospective myth.

[3] This analogy referred to the early modern practice of inventing genealogical pedigrees for social advancement. Bacon used it to criticize efforts to claim intellectual legitimacy through false links to antiquity, rather than through independent inquiry.

[4] Bacon alluded to Plato's *Timaeus* (24E–25D), where Atlantis symbolized a lost civilization. He used the example to emphasize that the truth of discovery lies in empirical validation, not in its connection to ancient or mythical antecedents.

As for that universal criticism directed against us, it is certain—to anyone who truly considers the matter—that it is both more probable and more modest than had it been made only in part. For if errors had not been rooted in the primary notions, it could not but have happened that some true discoveries would have corrected others that were found in error. But since the errors have been fundamental, and of such a kind that men have rather neglected and passed by things than judged them perversely or falsely, it is not at all surprising that men have not attained that which they have not sought, nor reached a goal which they have neither established nor placed before them, nor traversed a path which they have neither entered upon nor pursued.

As to the matter of presumptuousness: surely, if a man were to claim that by steadiness of hand and sharpness of eye he could draw a straighter line or a more perfect circle than another, it would indeed involve a comparison of abilities. But if a man asserts only that, using a ruler or a pair of compasses [5], he can draw a straighter line or a more perfect circle than another relying solely on the strength of eye and hand, such a one is certainly no great boaster. Moreover, what we say holds not only for this our first and preliminary endeavor, but also applies to those who will take up this work hereafter. For our method of discovering the sciences almost levels intellectual abilities [6] compasses and leaves little room for individual excellence; since it accomplishes everything by the most certain rules and demonstrations. Thus, as we have often said, our achievement is rather a matter of a certain felicity than of capacity, and rather the product of time than of genius. For surely there is some element of chance at work in human thoughts [7] no less than in actions and deeds.

[5] This metaphor underscored Bacon's claim that method is epistemically superior to unaided talent. Much as mechanical instruments yield more precise lines than freehand drawing, methodical inquiry yields more reliable knowledge than intuition alone. The comparison anticipates the instrumentalist approach in philosophy of science, where theories are valued as functional tools rather than as mirrors of reality.

[6] Bacon insisted that his inductive method minimized reliance on individual genius by making discovery procedural. While he remained a realist, this argument anticipates elements of modern instrumentalism—the view that theories and methods function as *tools* for organizing and extending knowledge, independent of the theorist's brilliance.

[7] While Bacon emphasized method, he acknowledged that discovery involves contingency and temporal fortune. This admission introduces a note of epistemic humility and aligns with later views that stress the non-linear and sometimes serendipitous character of scientific progress.

I-CXXIII (1:123).

Therefore, we must say of ourselves what that man said in jest [1]—especially since it so aptly captures the truth of the matter: it is impossible that those who drink water and those who drink wine should think the same way. Now, other men, both ancient and modern, have drunk a crude liquid in the sciences, like water either flowing spontaneously from the intellect [2] or drawn up by syllogistic dialectic, as if by wheels from a well [3]. But we drink and offer to others a liquor composed from countless grapes [4], gathered when ripe and seasonable, collected and plucked in clusters, then successively pressed in the winepress, and finally purified and clarified in the vat. Therefore, it is no wonder if we are not in agreement with the others [5].

[1] Bacon adapted a remark by Philocrates in *Demosthenes, De Falsa Legatione*, where Philocrates explained his disagreement with Demosthenes by saying, "He drinks water, I drink wine." Bacon repurposed the jest as a metaphor for divergent methods of inquiry.

[2] Bacon referred to knowledge produced by innate ideas, intuition, or undisciplined speculation. He characterized this form of cognition as unstructured and crude—offered spontaneously without the discipline of empirical method.

[3] This image critiqued scholastic logic, where conclusions were laboriously derived from premises using syllogisms. Bacon viewed this method as mechanically complex but epistemically unproductive, lacking grounding in observation.

[4] Bacon's winemaking metaphor described the process of empirical inquiry: observations (*grapes*) must be gathered carefully, processed in sequence, and refined through repeated stages. This model emphasized cumulative, procedural knowledge production over intuitive or deductive immediacy.

[5] Bacon acknowledged that methods grounded in fundamentally different epistemic assumptions would yield incompatible outcomes. This prefigured later concerns in the philosophy of science about incommensurability—the idea that distinct paradigms may not be directly comparable.

I-CXXIV (1:124).

No doubt another objection will also arise: namely, that the goal or aim of the sciences as set by ourselves (the very point we criticize in others) is not truly and optimally determined. For contemplation of truth is said to be more worthy and loftier than any utility or greatness of works; whereas the long and anxious dwelling upon experience and matter and the fluctuations of particular things fastens the mind, as it were, to the earth, or rather casts it down into a kind of Tartarus of confusion and disorder [1]; and distances and removes it from the serenity and tranquility of abstract wisdom, which is a far more divine condition. Now to this reasoning we willingly assent; and this very thing, which they intimate and prefer, is precisely what we chiefly and before all else pursue. For we are founding in the human intellect a true model of the world [2]—such as it is found to be, not such as anyone's own reason would dictate. But this cannot be achieved without a most diligent dissection and anatomy of the world. As for the inept models of worlds, and the semblances like apish imitations, which the fantasies of men have erected in philosophical systems, we proclaim that they must be utterly dissolved. Let men, then, know (as we have said above) how vast is the difference between the idols of the human mind and the ideas of the divine mind [3]. For the former are nothing other than arbitrary abstractions; whereas the latter are true seals of the Creator upon the creatures, impressed and defined upon matter by true and exquisite lines [4]. Thus, in this domain, truth and utility are one and the same [5]; and works themselves are to be valued more as pledges of truth [6] than for the benefits they bring to human life.

[1] Tartarus, in Greek mythology, was the deepest abyss of the underworld, associated with chaos and punishment. Bacon employed the image to dramatize the objection that empirical inquiry drags the mind into disorder rather than elevating it toward serene contemplation.

[2] Bacon contrasted his project with the speculative "models of worlds" constructed by philosophers. His "true model" referred to a reconstruction of nature based on empirical dissection and methodical inquiry, not on abstract reasoning.

[3] The *idols of the human mind* were Bacon's technical term for systematic cognitive distortions (cf. I:23–44). By contrast, the "ideas of the divine mind" referred to the real structures of nature, which Bacon regarded as impressed upon matter by the Creator. This distinction lay at the heart of his epistemology.

[4] Bacon's language reflected his belief in an orderly and intelligible creation. He held that nature bore the "seals" of divine ideas, which science could uncover through careful investigation—an early modern realist position that sought to reconcile theology and empirical method.

[5] The Latin phrase *ipsissimae res* has sometimes been noted for its unusual formulation, yet Bacon's intended sense is clear: in natural philosophy, truth and practical utility were inseparable. For parallel expressions, see *Cogitata et Visa* and *Novum Organum* II:4, where he affirmed that what proves most useful in practice also corresponds most truly to knowledge.

[6] Bacon argued that the success of works was evidence of truth. He valued applications less for their practical benefits than as signs that knowledge corresponded to reality. This principle linked epistemic validity to experimental efficacy, anticipating later discussions of scientific realism and pragmatism.

I-CXXV (1:125).

Perhaps this too will occur: that we are merely doing what has already been done [1], and that the ancients themselves pursued the same path we are now following. Thus someone might think it likely that, after so much commotion and effort, we too shall eventually arrive at one of those philosophies that prevailed among the ancients. For it will be said that the ancients, at the beginning of their meditations [2], likewise gathered a great store and abundance of examples and particulars, arranged them into commentaries organized by headings and titles [3], and from these completed their philosophies and arts, and afterwards, having attained knowledge, pronounced judgment, and scattered examples here and there to provide confirmation and illumination for

teaching; but that they considered it superfluous and troublesome to publish the notes, drafts, and commentaries on particulars; and therefore did what is customary in building [4]: namely, once the structure is completed, the scaffolding and ladders are removed from sight. Nor indeed ought we to believe otherwise. However, unless one has entirely forgotten what has been said above, this objection (or rather scruple [5]) may easily be answered. For the form of inquiry and discovery among the ancients is something we ourselves acknowledge, and their writings openly display it. And that form was no other than this: that from certain examples and particulars (along with the addition of common notions, and perhaps some portion of the received opinions that seemed most pleasing), they would immediately leap to the most general conclusions [6] or first principles of the sciences, and would thereafter draw out and prove the subordinate conclusions by means of intermediate propositions, and so construct their system of art. Then, if new particulars and examples were brought forward that opposed their established positions, they would either subtly integrate them through distinctions or explanations of their rules, or else grossly dismiss them by means of exceptions; while the causes of particulars that did not oppose their doctrines they would laboriously and persistently accommodate to their principles. Yet neither the natural history nor the experience they possessed [7] was what it ought to have been (indeed it was far from it); and moreover, this precipitous flight to the highest generalities ruined everything [8].

[1] Bacon here anticipated a common objection: that his method offered no genuine innovation, but merely repeated what ancient philosophers had already accomplished.

[2] Bacon referred to the typical procedure of ancient thinkers—especially in the Aristotelian tradition—who began with a few illustrative examples and *notiones communes* ("common notions") before deducing a system of principles.

[3] These “commentaries” resemble what Bacon elsewhere called *tabulae inveniendi* ("tables of discovery"): organized collections of particulars used in his inductive method. He implied that the ancients may have compiled similar notes but chose not to publish them.

[4] This metaphor of removing scaffolding upon completion of a building illustrates Bacon’s critique of methodological opacity. He implied that ancient philosophers concealed or neglected the evidentiary foundations of their conclusions.

[5] Bacon consistently treated this view as a minor misunderstanding, not a substantial counterargument, because he believed the ancients’ method was fundamentally different from his own.

[6] This "leap" (*praeceps fuga*) from limited examples to universal principles formed a core error in ancient and scholastic philosophy, according to Bacon. He rejected this deductive model in favor of gradual, inductive ascent.

[7] *Historia naturalis*, a technical term for Bacon, referred not to narrative history but to a systematically compiled record of empirical phenomena. He considered the ancients’ collections inadequate for genuine scientific discovery.

[8] Cf. *Filum Labyrinthi sive Inquisitio legitima de Motu* (1607), where Bacon expanded his critique of ancient methodology, emphasizing their limited use of experiment and their premature reliance on general axioms.

I-CXXVI (1:126).

This too will occur: that we, because of a certain prohibition against making pronouncements and establishing fixed principles until a proper ascent through intermediate steps to the highest generalities has been made, appear to uphold a kind of suspension of judgment [1], and to lead the matter to Acatalepsy [2]. But we in fact meditate and propose not Acatalepsy, but Eucatalepsy [3]; for we do not derogate from the senses [4], but assist them; nor do we despise the intellect, but govern it [5]. And it is better to know what is necessary to know, and yet consider ourselves not to possess complete knowledge, than to

think that we possess complete knowledge and yet fail to know anything that is truly necessary [6].

[1] Bacon here anticipated the objection that his refusal to declare fixed principles too early resembled *epochē*, the Skeptical suspension of judgment associated with Pyrrhonism.

[2] *Acatalepsy* (Greek: ἀκαταληψία) was a central doctrine of Academic Skepticism, asserting that truth could never be fully grasped. Bacon rejected this as a misunderstanding of his method.

[3] *Eucatalepsy*, likely coined or repurposed by Bacon, denotes reliable or sound apprehension. He used it to describe a disciplined form of knowledge acquisition grounded in experience and guided reason.

[4] Bacon defended the value of sensory experience but insisted that it must be organized and corrected through systematic method. This contrasted both with naive empiricism and radical rationalism.

[5] Bacon sought not to replace the intellect but to reform its operations, subjecting it to rules of method and empirical discipline rather than speculative abstraction.

[6] Cf. *The Advancement of Learning*, Book I (1605): "If a man will begin with certainties, he shall end in doubts; but if he will be content to begin with doubts, he shall end in certainties." This aphorism reprises Bacon's call for epistemic modesty and gradual inquiry (cf. I:37).

I-CXXVII (1:127).

Someone may also doubt, rather than object, whether we are speaking only of Natural Philosophy [1], or also of the other sciences—Logic, Ethics, Politics [2]—to be perfected according to our method. But we certainly intend what has been said to apply to all of them. Just as common logic, which governs matters by syllogism [3], pertains not only to natural sciences but to all sciences, so likewise does our method, which proceeds by induction, embrace them all. For we compile histories and tables of invention [4] concerning anger, fear, shame, and the like; as well as concerning examples of civil matters; and equally

concerning the mental motions of memory, composition and division, judgment [5], and the rest, no less than concerning heat and cold, or light, or vegetation, and the like. However, since our method of interpretation, after history has been prepared and ordered, regards not only the motions and discourse of the mind (as does common logic) but also the nature of things, we govern the mind in such a way that it may be able to apply itself fittingly and appropriately in all respects to the nature of things [6]. And therefore, we prescribe many and diverse precepts in the doctrine of interpretation, which in some measure adapt the method of discovery to the quality and condition of the subject under investigation [7].

[1] *Natural Philosophy* here referred narrowly to the study of the physical world, in contrast to broader uses elsewhere (cf. I:79–80), where it included human psychology and moral faculties.

[2] Bacon explicitly included moral and civil sciences in the scope of his method. This rebutted later claims (e.g., Cousin) that his critique of Scholasticism implied exclusion of such fields.

[3] Bacon used “common logic” to denote Aristotelian syllogistic reasoning, which he criticized for proceeding from assumed premises rather than from empirical observation.

[4] *Historiae* and *tabulae inveniendi* were Bacon’s technical tools for empirical data collection and pattern analysis. He proposed applying them to emotional states and civil behavior, not just physical phenomena.

[5] These “motions of the mind” refer to internal cognitive processes. Bacon considered these as proper subjects for empirical study—anticipating later developments in psychology and logic.

[6] Bacon emphasized that his logic did not govern mental operations alone (as traditional logic did), but was structured to conform to *res naturae*—the objective structure of the natural world.

[7] Bacon stressed that his method must be adapted to the “quality and condition” of the subject—a view consistent with modern methodological pluralism. Cf. II:26–27; *De Augmentis*, Book VI; *Filum Labyrinthi*, ad fin.

I-CXXVIII (1:128).

Let there be no doubt whatsoever concerning us—whether we wish to destroy and dismantle the philosophy, arts, and sciences currently in use [1]: for the contrary is true, as we gladly embrace their use, cultivation, and honors. For we by no means hinder these established disciplines from sustaining disputations, adorning discourse, and serving academic duties and the conveniences of civil life [2]; indeed, let them be accepted by common agreement among men, like a kind of currency [3]. Moreover, we openly declare that the things we introduce are not very well suited to those purposes, since they cannot at all be brought down to the level of popular understanding—except only through effects and practical works [4]. But that which we say here of our disposition and goodwill toward the received sciences—how sincerely we profess it—let our published writings (especially the book *On the Advancement of Learning* [5]) bear witness. Therefore, we shall not seek to reinforce this point further with words. What we do clearly and firmly assert in the meantime is this: that by the methods now in use, no significant progress [6] in the doctrines and contemplations of the sciences can be made, nor can they be brought to the full greatness of their works.

[1] Bacon anticipated the charge that he sought to overthrow existing disciplines. He consistently denied this, positioning his method as a reform of inquiry, not an abolition of traditional subjects (cf. I:129).

[2] Bacon acknowledged that the received disciplines remained valuable for education, rhetoric, and public life, even if they failed as instruments of discovery.

[3] This analogy casts established disciplines as a shared social convention—useful and standardized, though not intrinsically epistemically sound.

[4] Bacon admitted that his new method lacked popular appeal unless demonstrated through technological or practical outcomes—foreshadowing modern challenges in science communication.

[5] *The Advancement of Learning* (1605) was Bacon's first major philosophical work in English. It defended the expansion and reorganization of the sciences without attacking their public functions.

[6] Bacon reiterated his core claim: that traditional methods (especially syllogistic logic and speculative philosophy) failed to advance knowledge or produce transformative works. This formed the foundation for his *instauratio magna*.

I-CXXIX (1:129).

It remains for us to say a few things about the excellence of the End. If these had been stated earlier, they might have seemed like mere wishes; but now that hope has been made real, and unfair prejudices removed, they may carry more weight. If we had completed everything and fully finished the work, and did not invite others to share in the labor and its fellowship, we might have refrained from such words altogether, lest they be taken as self-praise. But since the industry of others needs to be stirred, and their spirits roused and kindled, it is fitting to recall certain things to people's minds.

First, then, it seems that the introduction of noble inventions holds the highest place among human actions [1]—a judgment the ancients themselves upheld. For they attributed divine honors to the inventors of things, while reserving only heroic honors for those who achieved civil accomplishments—such as founders of cities and empires, lawgivers, liberators of their countries from long-lasting evils, and overcomers of tyrannies. And surely, whoever compares these rightly will find the judgment of antiquity to be just.

[1] Bacon referred to the classical tradition, especially in *De Augmentis Scientiarum*, where inventors of useful arts were ranked above statesmen and lawgivers, receiving divine rather than heroic honors.

For the benefits of inventions can extend to the entire human race, whereas civil achievements concern only specific regions. The former

can endure for countless generations; the latter, only for a few. And reform in civil matters is rarely achieved without violence and disorder, while inventions confer blessings and benefit without harming or saddening anyone.

Indeed, inventions are like new creations and imitations of divine works, as that poet rightly sang [2]: “First the bright city of Athens, with noble name, Shared fruitful gifts with suffering mortals, And renewed life, and gave them laws.” And it seems noteworthy in Solomon that, although he flourished in power, wealth, magnificent works, retinue, servants, fleets, and the admiration of mankind, he chose none of these for his own glory, but pronounced instead: “It is the glory of God to conceal a matter [3], and the glory of a king to search it out.”

[2] The quoted lines are from Lucretius, *De Rerum Natura* VI.1–3. Bacon quoted them freely from memory, slightly altering the original Latin phrasing.

[3] The phrase “It is the glory of God to conceal a matter, and the glory of a king to search it out” echoes Proverbs 25:2. In the King James Version: “It is the glory of God to conceal a thing: but the honour of kings is to search out a matter.”

Again (if one pleases), let someone reflect on the difference between the life of people in the most cultivated province of Europe and that in some wild and barbarous region of the New World. He will judge it so great that one might rightly say man is a god to man [4]—not only in aid and benefit but also in the very comparison of their conditions. And this, not heaven, nor the stars, but the arts have achieved.

[4] This expression recalls a proverb attributed to Caecilius Statius: *Homo homini deus, si suum officium sciat*. Bacon expanded its meaning to emphasize the transformative impact of science and art on the human condition.

Likewise, it is worthwhile to consider the power, effectiveness, and consequences of inventions—things nowhere more visible than in those three which were unknown to the ancients and whose beginnings, though recent, are obscure and inglorious: namely, the Art

of Printing, Gunpowder, and the Mariner's Compass [5]. These three have changed the face and state of things across the globe: the first in learning, the second in warfare, the third in navigation. From these followed innumerable transformations, so that no empire, no sect, no star appears to have had a greater impact or influence on human affairs than these mechanical inventions.

Furthermore, it is not irrelevant to distinguish three kinds, or as it were degrees, of human ambition. The first concerns those who seek to increase their own power within their native land—a common and ignoble kind. The second concerns those who strive to enlarge their country's power and dominion among humankind—this certainly has more dignity, though no less desire. But if anyone seeks to restore and expand the power and dominion of the human race itself over the universe of things, such ambition (if it is to be so called) is surely the most sober and elevated of all. And man's dominion over things is founded solely in the arts and sciences. For Nature is commanded only by obeying her [5].

[5] This maxim summarizes Bacon's principle of methodological naturalism: true power over nature emerges from disciplined, empirical inquiry—not from speculation or coercion.

Moreover, if the usefulness of a single particular invention has so affected people that they consider its inventor greater than man himself for having conferred such a benefit on the human race, how much more sublime must it be to discover something by which all other inventions may be more easily found? And yet (to speak the plain truth) just as we are deeply grateful for light because through it we can walk, work, read, and recognize each other, and yet the act of seeing the light itself is more excellent and beautiful than all its uses—so too, the pure contemplation of things as they are [6], free from superstition, deception, error, or confusion, is itself more worthy than the whole sum of the fruits of invention.

[6] Bacon elevated disinterested knowledge above practical use, challenging later caricatures of his philosophy as purely utilitarian. He compared intellectual illumination to light—valuable in itself.

Finally, if anyone objects that the sciences and arts can be corrupted and put to evil [7], luxury, and the like, let that disturb no one. The same can be said of all worldly goods—talent, courage, strength, beauty, wealth, even light itself, and the rest. Let humanity only regain its rightful inheritance in Nature, which is its divine endowment, and let that inheritance be made accessible; its proper use will be governed by sound reason and true religion.

[7] Bacon acknowledged that like all goods, knowledge could be misused. He asserted that its right use must be governed by sound reason and true religion—anticipating modern concerns about ethical oversight in science.

I-CXXX (1:130).

Now, however, it is time to set forth the very art of Interpreting Nature [1]. Although we believe that we have given rules that are most useful and true, we do not ascribe to this method either absolute necessity (as if nothing could be achieved without it) or perfection. For we hold this opinion: if men had before them a proper History of Nature and Experience [2] and applied themselves to it diligently—and if they could enforce upon themselves two things: first, to lay aside received opinions and notions [3]; second, to restrain their minds for a time from general notions [4] both the most abstract and the nearest derived from those opinions—then it would come about that, by the native and intrinsic force of their own minds, even without any additional art, they would fall upon the method of our Interpretation. For Interpretation is the true and natural work of the mind [5], once the obstacles are removed. Yet all things will certainly be more prepared and much firmer if done by our precepts [6].

[1] Bacon here introduced the practical component of his method—*interpretatio naturae*—to be set forth in Book II. It referred to a systematic procedure for extracting axioms from nature through structured induction.

[2] Bacon considered *historia naturalis*—a carefully compiled and organized body of empirical observations—essential for scientific progress. It functioned as the groundwork for any sound inductive reasoning.

[3] This reflects Bacon's ongoing critique of *idola mentis* (idols of the mind), especially *idola theatri* (from systems) and *idola tribus* (from human nature). He argued that inquiry must begin with intellectual suspension and cleansing.

[4] Bacon warned against premature abstraction, particularly from received opinions. He sought a method that ascended from particulars to generalities gradually and securely—unlike *anticipatio naturae*, the speculative leap.

[5] Bacon insisted that, freed from error, the mind would arrive at proper inductive method on its own. Cf. *Valerius Terminus*, ch. 22 and *Advancement of Learning*, II, where he described interpretation as the mind's natural operation.

[6] Although he granted the mind's natural capacity, Bacon argued that explicit rules enhance the stability and productivity of inquiry—laying the foundation for his system of inductive logic.

Nor do we claim that nothing can be added to these precepts. On the contrary, since we view the mind not only in its own capacity but also as it is joined with things, we must affirm that the Art of Discovery may grow along with Discoveries themselves [7].

[7] Bacon held that method is not fixed but develops with scientific progress. Cf. *Cogitata et Visa* and *Filum Labyrinthi*, where he described discovery as historically situated and adaptable.

Finis Libri Primius Novi Organi.

Liber Secundus

NOVUM ORGANUM: LIBER SECUNDUS - APHORISMORUM
THE SECOND BOOK OF APHORISMS

DE INTERPRETATIONE NATURAE SIVE DE REGNO HOMINIS.
CONCERNING THE INTERPRETATION OF NATURE AND THE KINGDOM OF MAN.

II-I (2:1).

To generate and superinduce upon a given body a new nature [1], or new natures, is the work and purpose of human power. To discover the Form of a given nature [2]—namely, the true specific difference, or the nature that causes the nature, or the source of emanation [3] (for these are the terms we possess which come closest to indicating the thing itself)—is the work and purpose of human knowledge. Subordinate to these primary works are two other works, secondary and of lesser note: to the first, the transformation of concrete bodies from one into another [4], within the limits of what is possible; to the second, the discovery, in every case of generation and motion, of the hidden process [5] that continues from the manifest efficient cause and the manifest material up to the implanted Form; and similarly, the discovery of the latent structure [6] of bodies that are at rest and not in motion [7] [8].

[1] Bacon used *superinducere* ("to lay over or graft upon") for the intentional production of new properties by experiment. The phrase captured his program of *experientia literata*: artful trial guided by observation, not by occult sympathy. It exemplified early modern confidence in transformative empiricism.

[2] Here *forma* no longer means Aristotelian *forma substantialis* but the operative law or condition that brings a phenomenon about. To "discover the form" is to identify the set of circumstances sufficient for its occurrence—Bacon's precursor to the modern concept of a causal law.

[3] Borrowed from Scholastic–Neoplatonic vocabulary, these terms denoted the immanent cause of observable effects. Bacon secularized them: *natura naturans* signified the productive power resident in matter itself, not a divine principle. He thereby turned metaphysical origin into natural process.

[4] Bacon's cautious reference to transmutation echoed alchemical aspirations then common. While rejecting their mysticism, he accepted the possibility of re-arranging material configurations. Modern chemistry ultimately confirmed limited transmutation—by nuclear, not chemical, means—thus vindicating the concept in a different domain.

[5] The "hidden process" marked Bacon's attempt to infer continuous material transitions between cause and effect. In modern language it approximates a mechanistic or kinetic explanation, as in the conversion of solid wax to liquid under heat. His insight foreshadowed molecular thermodynamics.

[6] By this Bacon meant the underlying spatial configuration of parts that accounts for a body's properties. The notion anticipated later studies of microstructure in crystals, tissues, and metals—where form at the unseen level determines behavior at the visible one.

[7] Bacon's pairing of power and knowledge defined the principle *scientia et potentia humana coincidunt* ("human knowledge and power coincide," I:LXXXII). This unity underlies the experimental method: true understanding is proven by the ability to reproduce effects.

[8] His examples (melting, cooking, dissolving) were empirically accurate within seventeenth-century physics, demonstrating visible change of state. Their limits lay in the absence of atomic and molecular theory: Bacon correctly posited hidden continuities between manifest and latent causes but lacked the quantitative framework later supplied by thermodynamics and chemistry.

II-II (2:2).

How unhappily human knowledge, as it is currently practiced, fares is evident even from those things which are commonly asserted. It is

rightly stated that to know truly is to know through causes [1]. Nor is it wrongly established that there are four causes: Material, Formal, Efficient, and Final [2]. Yet among these, the Final Cause is so far from being useful that it even corrupts the sciences [3], except in matters concerning human actions. The discovery of Forms is regarded as hopeless [4]. Moreover, the Efficient and the Material (as they are commonly sought and accepted, that is, as remote causes, without investigation of the latent process leading to the Form) are treated perfunctorily, superficially, and contribute almost nothing to true and active knowledge [5]. Nevertheless, we have not forgotten that earlier we noted and corrected the error of the human mind in assigning to Forms the primacy of essence [6]. For although in nature nothing truly exists except individual bodies, which exhibit pure individual acts according to law, yet in the doctrines, that very law—and its investigation, discovery, and explanation—is taken as the foundation both for knowing and for acting [7]. It is this law and its clauses that we understand by the term "Forms," especially since this word has gained currency and is commonly encountered [8].

[1] “To know through causes” came from *Posterior Analytics* I.2, where Aristotle defined knowledge as understanding why a thing cannot be otherwise. Bacon accepted the maxim but rejected the scholastic practice that had turned causal analysis into verbal definition rather than experiment.

[2] The Aristotelian “four causes” structured medieval natural philosophy. In modern terms, the *Materialis*, *Formalis*, and *Efficiens* causes correspond roughly to proximate causes—the immediate physical or structural conditions producing an effect—whereas the *Finalis causa* represents the ultimate cause, the end or purpose for which something exists or occurs. Aristotle treated these as four complementary “whys” (*διὰ τί*), answering respectively of what a thing is made, what its determining form is, what moves or produces it, and for what end it exists. Bacon retained the vocabulary for convenience but rejected its teleological closure, insisting that natural inquiry must concern only proximate, not ultimate, causes.

[3] Bacon’s warning that “the Final Cause corrupts the sciences” expressed his rejection of teleology in natural philosophy. Nature does not act “for ends”;

only human agents do. Modern science continues to exclude purpose from physical explanation, limiting teleology to psychology and ethics. Nevertheless, the language of purpose and design persists in many disciplines—especially in biology and systems theory—where terms such as "function," "goal," or "adaptation" are used metaphorically. This continuing teleological vocabulary remains a source of misunderstanding when linguistic convenience is mistaken for causal explanation.

[4] The "hopelessness" of discovering Forms referred to the scholastic belief that *formae substantiales* were metaphysical and inaccessible. Bacon redefined *form* as the *lex actus*—the law of a phenomenon's operation—and thereby restored the search for causal structure as a legitimate scientific aim.

[5] Bacon used "remote causes" to denote causal conditions that lie at some distance from the phenomenon—general, background explanations that identify an agent (e.g., "the sun heats," "fire burns") but not the specific, operative process responsible for the effect. Such causes were "remote" not because they were metaphysical or ultimate, but because they were insufficiently determinate to guide the discovery of the forma or of the latens processus and latens schematismus. They are not equivalent to the Aristotelian "proximate cause," understood as the combined material, formal, and efficient causes, nor do they correspond to any "final" or "ultimate" cause. Bacon's distinction is methodological rather than metaphysical: "remote causes" are merely too general to function as the proximate explanatory factor required for legitimate induction.

[6] The scholastic axiom "form gives being" made *forma* the essence of existence. Bacon had already rejected this in I:LII, maintaining that only individual bodies exist; *form* is the law governing action, not a metaphysical constituent.

[7] By identifying *form* with *law*, Bacon anticipated the early modern conception of the "laws of nature" as invariant principles governing phenomena. In the seventeenth and eighteenth centuries, this notion of law as universal regularity became central to mechanistic science. Since the mid-twentieth century, however, philosophers and scientists have often preferred to speak of models, mechanisms, or domain-specific patterns rather than immutable laws. The focus has shifted from discovering universal necessity to describing the structures and processes that account for observed regularities. Bacon's insight nevertheless remains foundational: knowledge advances by discerning the rules of operation that connect cause and effect.

[8] Bacon's metaphor of "clauses of the law" drew from statute drafting, where each clause specifies a condition. Similarly, each *forma copulata* (complex

form) comprises several *naturae simplices* (simple natures). The analogy illustrates his belief that nature's laws are articulated and decipherable.

II-III (2:3).

He who knows the cause of a certain nature (such as whiteness or heat) only in specific subjects [1] has an imperfect knowledge; and he who can induce an effect only upon certain materials [2] (among those that are susceptible) has likewise an imperfect power. But he who knows only the efficient and material causes (which causes are variable, and nothing more than vehicles and conveyors of the Form in certain instances [3]) may indeed attain new discoveries in matter somewhat similar and suitably prepared; but he does not move the deeper fixed boundaries of things [4]. However, he who knows Forms embraces the unity of nature in materials most unlike one another [5]; thus he is able to uncover and bring forth things which have not yet been made—things which neither the vicissitudes of nature, nor the efforts of experimental industry, nor chance itself would ever have produced into act [6], nor would have entered into human contemplation. Therefore, from the discovery of Forms there follows true contemplation and free operation [7].

[1] Bacon referred to "knowing a cause only in certain subjects" as imperfect knowledge: the empirical art of manipulating a few familiar materials without understanding the underlying condition. This described the state of pre-experimental practice—alchemical, artisanal, or medical—based on habit and analogy rather than systematic inquiry.

[2] "Imperfect power" denoted the limited capacity of empirical experimenters who could reproduce effects only within certain materials. Bacon contrasted this with *potestas perfecta*, the ability to induce effects universally once the *form* (law) was known—a precursor of the modern distinction between context-bound technique and generalizable technology.

[3] Bacon called material and efficient causes "vehicles and conveyors of the Form," emphasizing that they varied from case to case and did not explain why a phenomenon occurred. His analysis anticipated the modern distinction

between proximate mechanisms and underlying laws: the material and efficient causes transmit an effect, while the *form* defines the invariant relation that governs it.

[4] The claim that empirical manipulation "does not move the deeper fixed boundaries of things" expressed Bacon's belief that mere experimentation, without understanding *forms*, could not extend the bounds of nature. He sought a science capable of discovering universal processes rather than local effects—what would later be called causal explanation.

[5] "He who knows Forms embraces the unity of nature in materials most unlike." Bacon envisioned a universal science in which the same law operated across heterogeneous substances. This principle anticipated modern unification in physics and chemistry, where identical causal laws (e.g., thermodynamic or electromagnetic) apply regardless of matter's composition.

[6] The idea that one who knows *forms* can "bring forth things not yet made" articulated Bacon's vision of creative science—knowledge as productive power. The notion anticipated the experimental ideal of invention and replication, where discovery and making coincide.

[7] "True contemplation and free operation" summarized Bacon's programmatic aim: theory and practice united through understanding of causes. In modern terms, it defines the epistemic ideal of technoscience: explanation validated by the capacity to reproduce or generate effects under controlled conditions.

II-IV (2:4).

Although the paths to human power and to human knowledge are most closely joined and almost identical [1], yet, because of the pernicious and deeply rooted habit of dealing in abstractions [2], it is altogether safer to begin and build up the sciences from those foundations which are directed toward the active part, and to let that very active part set the mark and limits for the contemplative part [3]. Thus it must be considered what kind of precept or what kind of direction or guidance one would most desire for the purpose of generating and superinducing a certain nature upon a given body [4]; and this should be expressed in the simplest and least abstract language.

[1] Bacon reasserted that the routes to knowledge and to power are “almost identical,” summarizing his foundational thesis that *scientia et potentia humana in idem coincidunt* (“human knowledge and power coincide,” I:LXXXII).

[2] The “habit of dealing in abstractions” referred to the Scholastic method of deriving essences by verbal definition. Bacon rejected this as sterile speculation, urging that inquiry begin from experimental manipulation and observation.

[3] Bacon’s demand that the active part “set the limits” of contemplation reoriented natural philosophy toward practice. He thereby reversed the Aristotelian hierarchy of *theoria* over *praxis*, making experiment the ground of theory.

[4] Bacon used *superinducere* to mean the intentional production of a new property or quality in matter—an operative goal akin to modern synthesis or engineering.

For example: if someone wished to superinduce on silver the yellow color of gold or an increase of weight (observing the laws of matter) [5], or to confer transparency upon an opaque stone, or tenacity upon glass, or vegetation upon a non-vegetative body [6], it must be considered, I say, what kind of precept or guidance he would especially wish to receive. First, no doubt he would wish to be shown something of such a kind that it would not fail in the execution or deceive in the experiment. Second, he would wish to be given a rule that would not bind or constrain him to certain particular means and modes of operation [7]; for perhaps he may lack the ability and the convenience to procure or prepare such means. And if there are other means and other modes (besides the prescribed one) for producing such a nature, these may perhaps fall within the operator's power, from which he would nonetheless be excluded because of the narrowness of the rule, and so derive no benefit. Third, he would wish to be shown something that is not as difficult as the very operation being sought, but something that comes nearer to practical application.

[5] The proposed increase of weight "observing the laws of matter" anticipated the principle of conservation of mass. The phrasing showed Bacon's effort to replace magical or transmutational language with physical constraint.

[6] Bacon's examples ranged from plausible (color, transparency) to speculative (granting life to inert matter). The examples were sound as imaginative exercises in operational thinking, though physically impossible as stated. They nonetheless foreshadowed legitimate later aims—crystal growth, material hardening, and synthetic generation.

[7] The rule "not binding to particular means" corresponds to modern notions of generalizability and scalability in experimentation. Bacon wanted operative laws that worked across instruments and materials, not recipes bound to singular conditions.

Therefore, concerning the true and perfect rule of operation, the pronouncement shall be this: that it be certain, free, and disposing—or directed—toward action [8]. And this is identical with the discovery of the true Form [9]. For the Form of a given nature is such that, when it is present, the given nature inevitably follows. Thus it is always present whenever the nature is present, universally affirms it, and is inherent in the whole of it. The same Form is such that, when it is removed, the given nature inevitably disappears. Thus it is always absent when the nature is absent, perpetually denies it, and is present in nothing else [10]. Finally, the true Form is such that it derives the given nature from some source of being which is present in many things and is more familiar to nature (as they say) than the Form itself [11]. Therefore, concerning the true and perfect axiom of knowledge, the pronouncement and precept will be this: to discover another nature that is convertible with the given nature and yet is a limitation of a more familiar nature, in the manner of a true genus [12]. Now these two pronouncements, the active and the contemplative, are one and the same [13]; and that which is most useful in practice is most true in knowledge [14].

[8] Bacon's triad ("certain, free, and directed toward action") defined the standard for a valid scientific law: reproducible, general, and operative. It anticipated the methodological ideals of modern experimental reliability and universality.

[9] Bacon equated the true rule of operation with the discovery of the *form* of a nature—that is, the invariant causal condition guaranteeing the phenomenon's presence. His *forma* thus functions as a physical law, not a metaphysical essence.

[10] The description of the *form* as "always present when the nature is present, always absent when it is absent" prefigures the modern biconditional logic of lawlike causation (*if and only if*). Though conceptually precise, Bacon's model did not yet account for plurality or probabilistic causation, as later formalized by Mill and modern statistics.

[11] The "source of being" denoted the broader substrate or condition from which a given nature derived. Bacon translated the Aristotelian genus–species relation into a physical hierarchy: *fons essentiae* as the more general nature, *forma* as its differentiating law.

[12] "A more familiar nature" referred to a better-known, more general phenomenon convertible with the target nature (e.g., heat as a form of motion). The principle corresponded to induction through analogical unification, the method underlying the later discovery of mechanical and thermodynamic laws.

[13] Bacon's claim that active and contemplative precepts are "the same" articulated the unity of explanation and application—anticipating the modern convergence of theoretical and applied sciences.

[14] "That which is most useful in practice is most true in knowledge" expressed Bacon's pragmatic criterion of truth: operational success as the test of understanding. It remains a central tenet of experimental philosophy and modern technology.

II-V (2:5).

But the precept or axiom concerning the transformation of bodies is of two kinds. The first considers a body as a collection or combination of simple natures: thus, in gold, the following properties are found together—its yellowness; its heaviness, to a certain weight; its

malleability or ductility, to a certain degree of extension; its resistance to volatilization and its retention of its quantity when subjected to fire; its melting with a particular degree of fluidity; its separation and dissolution by particular means; and likewise with respect to other natures that converge in gold [1]. Thus, an axiom of this kind deduces the matter from the forms of simple natures. For he who knows the forms and the methods of superinducing yellowness, weight, ductility, fixity, fluidity, dissolution, and so forth, together with their gradations and modes, will see and endeavor that these properties may be combined in some body, whence a transformation into gold may follow. And this kind of operation belongs to primary action. For the method of generating one simple nature and that of generating several is the same; except that man is more narrowly constrained in operation if several are required, because of the difficulty of combining so many natures—which scarcely come together except along the beaten and ordinary paths of nature. Nevertheless, it must be said that this mode of operation (which contemplates simple natures even in a compound body) proceeds from those principles in nature which are constant, eternal, and universal [2], and opens broad ways to human power, such as, in the present condition of things, human thought can scarcely grasp or represent.

[1] Bacon's description of gold as a conjunction of *naturae simplices* reflects his belief that every compound body results from the ordered combination of a finite number of simple properties (color, density, ductility, etc.). This analytic decomposition anticipated the conceptual framework of modern chemistry, though Bacon lacked an atomic or molecular model. His example of gold was speculative: the physical properties are now known to arise from electronic structure, not from separately combinable "forms."

[2] The phrase translates *ab iis in natura quae fixa sunt et aeterna et universalia*, referring not to material "elements" but to invariant laws or principles. Bacon regarded these as the foundation of both metaphysical and physical science, precursors to what would later be called *laws of nature*.

But the second kind of axiom (which depends on the discovery of the latent process) does not proceed through simple natures, but through compound bodies, as they are ordinarily found in nature. For example, in the case where inquiry is made as to what beginnings, by what method, and by what process gold or any other metal or stone is generated [3], from its first menstruums or rudiments up to the perfect mineral; or similarly, by what process plants are generated, from the first concretion of juices in the earth, or from seeds [4], up to the fully formed plant, with all that succession of motions and the various continuous efforts of nature; similarly, the inquiry into the generation of animals, systematically traced from conception to birth; and likewise concerning other bodies [5].

[3] The Latin *menstrua prima* and *rudimenta* derive from alchemical vocabulary meaning "matrices" or "solvents" through which generation occurs. In Bacon's context, the term denotes the earliest material conditions of formation. The scientific image was pre-chemical: Bacon imagined metals forming by slow "digestion" within the earth, a process later replaced by mineralogical theories based on crystallization and geochemical reaction.

[4] Bacon's account belongs to the pre-cellular understanding of vegetation. He assumed that growth began from *succus concretius* ("thicker juices") within soil or seed, an echo of Aristotelian *pneuma* theory. The underlying idea—that life arises through a gradual organization of matter—was sound in direction but lacked knowledge of germination, cellular differentiation, and genetics.

[5] Bacon's reference to development "from conception to birth" reflects early modern embryology, before Harvey's *De generatione animalium* (1651) established empirical embryogenesis. Bacon's "succession of motions" presaged later biological process thinking, though he conceived the embryo as a gradual condensation of vital spirit rather than an organized cellular system.

Indeed, this inquiry pertains not only to the generation of bodies, but also to other motions and workings of nature. For example, where inquiry is made into the entire series and continuous processes of nutrition, from the initial reception of food to its perfect assimilation; or similarly into voluntary motion in animals, from the first impression

upon the imagination and the continuous efforts of the spirit, up to the flexing and movements of the limbs; or into the detailed motion of the tongue and lips and other organs leading to the utterance of articulate sounds. For these inquiries too concern concrete or organized natures within structures, and regard what might be called particular and special habits of nature, rather than her fundamental and universal laws, which constitute forms. Nevertheless, it must absolutely be admitted that this method seems easier, more immediately accessible, and more encouraging than the primary one [6].

[6] Bacon here acknowledged that tracing natural processes is experimentally accessible, unlike discovering the *forms* themselves. This distinction parallels the modern methodological gap between descriptive science (observation of processes) and analytic theory (discovery of laws).

Similarly, the operative part corresponding to this contemplative part extends and advances operation from what is ordinarily found in nature to what is adjacent to it, or at least not far removed from it. But deeper and more radical operations upon nature certainly depend upon the primary axioms [7]. Moreover, even where man lacks the faculty of operating and only possesses that of knowing—as in the case of the heavens (for man is not permitted to act upon, alter, or transform celestial objects)—nevertheless, inquiry into the fact itself or into the truth of the thing, no less than knowledge of causes and consents, must be referred back to those primary and universal axioms concerning simple natures (such as the nature of spontaneous rotation, attraction or magnetic force, and many others which are more general than the heavenly bodies themselves). For no one should hope to resolve the question whether it is the earth or the heavens that truly rotate in the diurnal motion, unless he first comprehends the nature of spontaneous rotation [8].

[7] Bacon's "primary axioms" (*axiomata primaria et universalia*) correspond to fundamental physical principles—what later science would treat as conservation laws or invariant relations. He maintained that only through

knowledge of simple natures could one achieve deep intervention in nature. The distinction between primary (universal) and secondary (derivative) axioms anticipates the hierarchical structure of modern scientific explanation.

[8] Bacon's reference to the diurnal motion evokes the Copernican question still unsettled in 1620. His argument—that the issue could not be decided without understanding the *natura rotationis spontanea* ("nature of spontaneous rotation")—shows his methodological neutrality. He called for a physics of motion preceding cosmology, a step that modern mechanics later fulfilled.

II-VI (2:6).

The latent process [1] of which we speak is something vastly different from what could easily occur to the minds of men as they are currently preoccupied. For we do not mean certain measurements, or signs, or visible stages of a process in bodies; rather, we mean a wholly continuous process [2] that for the most part escapes the senses.

[1] Bacon used this term for the imperceptible chain of motions that connects manifest causes and effects. It did not refer to temporal "stages" but to the underlying sequence of physical interactions. This concept redefined causation as the tracing of process rather than the identification of discrete agents.

[2] Bacon's view of change as continuous derived from the Aristotelian dictum *natura non facit saltus* ("nature makes no leaps") but was reinterpreted empirically: continuity was to be discovered, not assumed. His insistence that natural operations proceed "without interruption" anticipated the later scientific focus on continuous variables and, analogically, the infinitesimal reasoning of calculus, though Bacon himself conceived no mathematical model.

For example, in every generation and transformation of bodies, it must be inquired what is lost and flies off, what remains, what is added; what is expanded, what is contracted; what is united, what is separated; what is continued, what is cut off; what impels, what hinders; what dominates, what yields; and many other such particulars.

Nor again are these things only to be investigated in the generation or transformation of bodies; but likewise, in all other alterations and motions, it must be inquired what precedes, what follows; what is quicker, what is slower; what provides motion, what governs it; and the like. All these matters, however, are unknown and untouched by the sciences, which are at present woven together with the grossest dullness and complete incapacity. For since every natural action is accomplished through the smallest elements [3], or at least through those that are too small to strike the senses, no one should hope to direct or modify nature unless he has duly comprehended and observed them [4].

[3] This phrase denoted operations "through the smallest parts" of continuous matter, not through indivisible atoms. Bacon rejected atomism, regarding matter as active and infinitely divisible. His *minima* were steps or degrees of change within a continuum, not fixed corpuscles in a void. Later corpuscular philosophers such as Boyle adapted Bacon's language but altered its metaphysical basis.

[4] Bacon's claim that knowledge of the smallest processes is a prerequisite for control anticipated the modern scientific ideal of microphysical explanation. His examples (generation, motion, nutrition, speech) were sound phenomenologically but incomplete mechanistically: he inferred the existence of subvisible processes correctly, yet lacked the quantitative or atomic theory required to describe them. The methodological principle—control through comprehension of the hidden process—remains valid in modern experimental science.

II-VII (2:7).

In like manner, the investigation and discovery of the *latent schematism* (*schematismus latens*) [1] in bodies is a new enterprise, no less than the discovery of the *latent process* and of the *form*. For as yet we plainly dwell in the outer courts of nature [2], nor have we prepared an entrance into her inner chambers. Yet no one can endow a given body with a new nature, or fitly and successfully transform it into another body, unless he possesses a good understanding of the body

that is to be altered or transformed. Otherwise he will fall into vain procedures, or at least difficult and perverse ones, ill-adapted to the nature of the body on which he works. Therefore, a way must also be opened and secured in this direction.

[1] Bacon used *schematismus* to denote the hidden arrangement or texture of a body's minute parts—its microstructure. This term anticipated the corpuscular and structural explanations of matter that emerged later in the seventeenth century (cf. *De augmentis scientiarum* III:4). In modern terms, *schematismus latens* approximates molecular or crystalline structure, though Bacon lacked the microscopic or atomic concepts required to describe it precisely.

[2] The metaphor of *atria* and *interiora naturae* expressed Bacon's conviction that natural philosophy had not yet penetrated beyond appearances to the inner mechanisms of phenomena. It reflected both the religious architecture of the Temple and the Hermetic imagery of nature's secrecy.

And in the anatomy of organic bodies (such as those of human beings and animals), labour is certainly rightly and usefully expended, and the practice seems a subtle thing and a good scrutiny of nature. Yet this kind of anatomy is visible, subject to the senses, and takes place only in organic bodies. In truth, it is something obvious and near at hand, compared with the true anatomy of the *latent schematism* in bodies which are accounted homogeneous—especially in specific substances and in their similar parts, such as iron or stone; and in the similar parts of a plant or an animal, as root, leaf, flower, flesh, blood, bone, and so on. But even in this field human industry has not been entirely idle; for this is shown by the separation of homogeneous bodies through distillations and other kinds of solution [3], whereby the dissimilarity of a compound becomes apparent through the gathering together of like parts. This practice indeed is in use and contributes to our purpose, though it is often deceptive: for many natures are attributed to the act of separation as though they had previously existed in the compound, whereas in truth fire, heat, and other methods of separation newly produce and superinduce them. Yet even this is a small part of the task

of discovering the true *schematism* in a compound—a matter far more subtle and precise, and one that is rather obscured than revealed by the operations of fire.

[3] Bacon referred to the laboratory practice of using heat and distillation to decompose compounds, methods common in Paracelsian and alchemical chemistry. He correctly observed that these procedures often *change* rather than *reveal* the natural constitution of a substance, since fire "newly produces and superinduces" natures that did not exist in the original compound. Modern chemistry confirms this insight: heating induces chemical reactions and phase transitions that alter molecular structure. In a broader epistemological sense, Bacon's remark anticipates the modern recognition that the act of observation can itself modify what is observed. In quantum mechanics, for instance, measuring an electron's position with photons inevitably changes its momentum—an effect formalized in Heisenberg's uncertainty principle. Bacon's caution thus prefigures a fundamental rule of experimental science: inquiry must account for the *interference of the instrument with the thing observed.*

Accordingly, the separation and resolution of bodies must be performed not by fire, but by reason and true induction, aided by experiments, and by comparison with other bodies, and by reduction to the *simple natures* and their *forms* which meet and are interwoven in the compound. In short, we must pass wholly from Vulcan to Minerva [4], if we intend to bring into the light the true textures and schematisms of bodies—on which depend all hidden and so-called specific properties and powers in things, and from which is likewise drawn the rule of every potent alteration and transformation.

[4] The contrast between *Vulcan* (manual, fiery craft) and *Minerva* (intellectual wisdom) symbolized the transition from alchemical manipulation to rational, inductive science. Bacon used this mythological trope repeatedly to distinguish mechanical art from philosophical method (cf. I:109).

For example, inquiry must be made what the *spirit* is in every body [5], and what the *tangible essence* is; and of that same *spirit*, whether it be copious and swollen or sparse and lean; thin or thick; more airy or more fiery; sharp or sluggish; fine or robust; advancing or receding;

interrupted or continuous; agreeing with the external and surrounding environment or disagreeing with it, and so forth. Likewise, concerning the *tangible essence* (which admits no fewer differences than the *spirit*), its threads, fibres, and every sort of texture [6]; and again, the distribution of the *spirit* throughout the corporeal mass—its pores, passages, veins, and cells, and the rudiments or first essays of organic structure—all fall under the same investigation. Yet even in these, and indeed in every search for the *latent schematism*, true and clear light is introduced only through *primary axioms* [7], which assuredly dispel all obscurity and subtlety.

[5] Bacon's *spiritus* denoted an invisible, material vapor believed to animate all tangible bodies, distinct from but contained within the *essentia tangibilis* (the dense corporeal matter). This "spirit" roughly corresponded to early modern notions of pneuma or subtle matter. Modern physics and chemistry no longer recognize such a vital spirit, but Bacon's intuition that invisible and mobile components govern physical properties aligns conceptually with kinetic and particulate theories.

[6] Bacon's language here foreshadowed later microscopic anatomy and materials science. His "true anatomy" of homogeneous substances presaged the modern understanding that structure at the micro-scale determines function—an insight realized only with the development of microscopy and crystallography in the seventeenth and eighteenth centuries.

[7] By *axiomata primaria* Bacon meant the fundamental inductive laws derived from systematic experiment. These were to replace the "subtlety" of scholastic speculation with empirically grounded generalizations. In modern science, this corresponds to theoretical principles inferred from observation and experiment—laws that illuminate rather than obscure phenomena.

II-VIII (2:8).

Nor, therefore, will the matter be carried down to the *atom*, which presupposes a *vacuum* and *unflowing matter* [1]—both of which are false—but rather to *real particles*, such as are found in nature [2]. Nor again is there any reason why one should shrink from this subtlety as though it were unintelligible; on the contrary, the more the inquiry

inclines toward *simple natures*, the more all things will be placed upon a level and made clear—when the task is transferred from the manifold to the simple, from the incommensurable to the commensurable [3], from the "deaf" (or inexpressible) to the reckonable, and from the infinite and indeterminate to the defined and certain; as happens with the elements of letters and the tones of harmonies [4]. For natural inquiry succeeds best when the physical terminates in the mathematical [5]. And again, let no one fear multitude or fractions [6]; for in matters conducted by number it is just as easy for a person to posit or conceive a thousand as one, or the thousandth part of one as one whole.

[1] Bacon rejected the ancient atomism of Democritus and Epicurus, which postulated indivisible particles moving in a void. He denied both the existence of a *vacuum* (*vacuum*) and of immutable or rigid matter (*materia non fluxa*), maintaining instead that all bodies are continuous and in constant motion. His "real particles" thus differed from ancient *atomoi*: they were dynamic corpuscles capable of change and interaction. Historically this view stood between Aristotelian *plenum* physics and the later *corpuscular philosophy* of Descartes, Boyle, and Newton. Modern physics, while confirming discrete particles, also reinstates continuity through quantum and field theory—where matter and energy are inseparable and no true vacuum exists.

[2] By *particulae verae* Bacon meant empirically discoverable minute bodies—components of compounds rather than hypothetical atoms. He envisaged structure without indivisibility: a matter of scale, not of metaphysical minimalism. In this he anticipated the modern concept of hierarchical structure—molecules, atoms, subatomic particles—each level analyzable by experiment. His insight that nature's "particles" would be *found* rather than *assumed* remains methodologically sound.

[3] Bacon's sequence from complexity to simplicity described his inductive ideal: natural inquiry should reduce phenomena to *natures simplices*—the basic properties underlying all compounds. The analogy to "letters" and "tones" (below) expressed his conviction that these *simple natures* form an "alphabet of nature." The comparison prefigured later structuralist ideas in chemistry and genetics, where complex systems are understood through discrete, recombinable elements.

[4] The metaphors of alphabet and musical scale conveyed Bacon's belief that nature possesses a finite set of fundamental components whose combinations yield the world's variety. This vision paralleled, in embryo, the modern program of decoding natural "alphabets"—chemical, genetic, and informational. Bacon's analogy retained heuristic power, though the real "elements" of matter proved far more numerous and complex than he imagined.

[5] Bacon held that knowledge of nature achieves its perfection when physical investigation culminates in quantitative laws. Although he distrusted the speculative mathematics of the schools, he anticipated the later unification of physics and mathematics achieved by Galileo, Newton, and modern theoretical science. His statement continues to express the methodological core of empirical science: observation must end in measurable relation.

[6] Bacon reassured readers that numerical complexity posed no barrier to intelligibility—an early endorsement of quantification as a universal method. His claim presaged the computational and statistical approaches of modern science, which routinely handle enormous datasets and infinitesimal scales. The example ("a thousand as one") illustrated the power of symbolic representation: numbers render magnitude conceptually manageable.

II-IX (2:9).

From the two kinds of axioms which have been set forth above, there arises the true division of philosophy and of the sciences [1], using terms already received (which are fairly close to indicating the thing itself) but adapted to our meaning. Thus, the inquiry into Forms—which are, by reason certainly, and by their own law, eternal and immutable [2]—constitutes Metaphysics. But the inquiry into the Efficient Cause, and the Material Cause, and into the Latent Process, and the Latent Schematism [3] (all of which concern the common and ordinary course of nature, and not its eternal and fundamental laws) constitutes Physics [4]. To these two—namely, Metaphysics and Physics—there are correspondingly subordinate two practical disciplines: to Physics, Mechanics; to Metaphysics (with the term purified of its common abuse), Magic; which, given its wide scope and greater command over nature [5], is itself rightly placed as a complement to the sciences.

[1] Bacon referred back to his earlier distinction (II:5) between *axiomata de operativis* (axioms concerning operation, or efficient causes) and *axiomata de formis* (axioms concerning forms, or laws of nature). This division grounded his reorganization of natural philosophy into two interdependent domains: *Physics*, concerned with the variable and empirical, and *Metaphysics*, with the constant and lawlike. The classification replaced Aristotle's hierarchical order of the sciences with a dynamic, methodological one—a structure that anticipated the later division between empirical and theoretical science.

[2] By *formae*, Bacon meant not Platonic or Aristotelian essences, but *laws of operation*—the constant rules by which simple natures combine and act. Their "eternity and immutability" were qualified by reason (*ratione certe*): they were stable within nature's order, though ultimately dependent on divine will. This reconception transformed metaphysics from ontology into the science of invariant relations, a view later reflected in the modern notion of natural law.

[3] These four causes delineated Bacon's field of *Physics*: the efficient and material causes explained motion and substance; the *latent process* described hidden transitions of change; and the *latent schematism* denoted internal structure or texture (cf. II:7). Together they represented the variable, operative side of nature—the level accessible to observation and experiment. Bacon thus retained Aristotelian terminology but radically redirected its meaning toward empirical analysis.

[4] Bacon's twofold division created a hierarchy of abstraction rather than of subject matter. *Physics* explained proximate causes, *Metaphysics* the deeper laws or "forms" governing them. This anticipates the modern distinction between mechanistic models (how things work) and fundamental laws (why they work as they do). In this sense, Bacon's *metaphysica naturalis* served as a precursor to theoretical physics.

[5] Bacon paired each theoretical science with a corresponding practical art. *Mechanics* applied physical knowledge to manual and technological operations. *Magic*—purged of occultism (*perpurgato nomine*)—was defined as the practical extension of metaphysical knowledge: the ability to produce effects through understanding of forms or laws. His "natural magic" therefore anticipated applied science and technology, representing the lawful command of nature through experiment rather than superstition.

II-X (2:10).

When, therefore, the aim of the doctrine has been set, we must proceed to the precepts [1], and that in no perverse or confused order. The directions for the *interpretation of nature* embrace, in general, two parts: the first concerns the eliciting or bringing forth of *axioms* from *experience* [2]; the second, the deducing or deriving of *new experiments* from *axioms*. The former, moreover, is divided three-fold—into three *ministrations*: the *ministration to the sense*, the *ministration to memory*, and the *ministration to the mind*, or *reason* [3].

[1] Bacon shifted here from theoretical exposition to procedural instruction. The "aim of the doctrine" (*doctrinae scopum*) referred to the overall goal of the *Instauratio Magna*—the restoration of human knowledge through methodical inquiry. The word *praecepta* denoted practical rules rather than dogmatic principles. This aphorism thus introduced the operative part of the *Novum Organum*, which would explain how to *interpret nature* rather than merely contemplate it.

[2] Bacon's twofold division—drawing axioms from experience and deriving experiments from axioms—established the methodological cycle that defines modern empirical science. The first movement is *inductive* (ascending from observation to general principle); the second *deductive* (descending from principle to testable prediction). This reciprocal structure anticipated the experimental method as it later appeared in Newtonian science and remains the conceptual model of research today.

[3] Bacon's *ministrationes* represented the successive stages of empirical investigation: observation, organization, and inference. The *ministration to the sense* corrected the errors of perception through instruments and careful experiment; the *ministration to memory* arranged observations into ordered "tables of instances"; and the *ministration to reason* employed *true induction* to extract general laws. These stages correspond closely to the modern sequence of data collection, data management, and data analysis.

For, first of all, *natural and experimental history* must be prepared, sufficient and sound; for this is the foundation of the whole enterprise [4]. The task is not to feign or invent, but to discover what *nature does* or *permits*.

[4] By *Historia Naturalis et Experimentalis*, Bacon meant a systematically organized body of observed facts, collected without preconception. He contrasted it with the "history" of the schools, which was anecdotal and unsystematic. This empirical archive was to serve as the foundation of all philosophy, much as modern scientific databases and observational repositories underpin theoretical modeling.

Yet *natural and experimental history* is so various and scattered that it confounds and distracts the *understanding*, unless it be set forth and arranged in a proper order. Therefore *tables* and *coordinations of instances* must be constructed [5], in such form and with such guidance that the *understanding* may be able to act upon them.

[5] Bacon's *tabulae et coordinationes instantiarum* were analytical tools designed to display patterns of agreement, difference, and variation among phenomena. They functioned as proto-experimental matrices, not numerical tables in the modern sense, but structured comparisons meant to guide the intellect toward the isolation of causal factors. The concept anticipated controlled experimentation and, in abstract form, the logic of variable correlation and statistical analysis.

Even though this be done, the *understanding*, when left to itself and moving of its own accord, is unfit and incapable for the work of forming *axioms*, unless it be ruled and fortified. Therefore, in the third place, a legitimate and true *induction* must be employed, which is itself the *key of interpretation* [6]. But we must begin from the end, and then move backward to the remaining parts [7].

[6] Bacon's *inductio legitima et vera* differed from Aristotle's induction by simple enumeration. It required exclusion, comparison, and gradual ascent from particular cases to general axioms. This notion foreshadowed modern hypothesis testing, where theories emerge from systematic elimination of alternatives. His claim that induction is the "key of interpretation" defined the central principle of his method: disciplined reasoning replaces intuitive generalization.

[7] Bacon signaled his intention to discuss the *last* ministration—induction—first, because it supplied the logical structure that justified the others. The remark also reflects his compositional method in the *Novum Organum*, where he

begins with the culminating instrument and later fills in its empirical scaffolding.

Postscriptum

From this point onward in the *Novum Organum*, Bacon introduces numerous physical, chemical, and biological examples and then attempts to supply scientific explanations for them. These explanations reflected the best natural philosophy available to him in 1620 and were broadly consistent with what an accomplished investigator of his time might have proposed. It is possible, as translators or interpreters, to supplement Bacon's explanations with "corrective" commentary—clarifying why many of his accounts are no longer scientifically acceptable. This is precisely what Spedding, Leslie Ellis, and Heath (1857), and later Fowler (1889), attempted to do.

In my view, however, such a practice is problematic. No nineteenth-century editor could reasonably claim expertise across all the domains into which Bacon ventured, nor could they anticipate the rapid conceptual changes that soon rendered some of their own glosses obsolete. This is simply the nature of scientific explanation: it improves by successive approximation, and each new development displaces earlier accounts. For this reason, at the outset of this project I chose a posture of scientific caution and editorial humility. I resolved not to annotate Bacon's explanations with modern scientific corrections, both to avoid the risk of inadvertent error and to prevent an unnecessary expansion of the commentary. To make this editorial strategy absolutely clear: this edition deliberately refrains from supplying contemporary scientific explanations or "corrections" to Bacon's views except in those rare cases where a conceptual clarification is essential for understanding his argument.

In this final editorial reading, however, I recognize a danger: some readers may assume that Bacon's explanations are scientifically sound, or that I myself adopt or endorse them. That is not the case.

A modern reader should instead look *through* Bacon's examples to the larger aim of the work: to grasp his method—how he constructed a new logic of discovery, how he organized the phenomena, and how he deployed the knowledge available to him to demonstrate the method's use. As has been emphasized throughout the book (in footnotes, excursuses, and editorial remarks), scientific accounts are contingent. To borrow the Red Queen's remark, "it takes all the running you can do, to keep in the same place." Explanations evolve; Bacon's have been superseded, and our own will in turn be replaced.

Readers are therefore asked to treat Bacon's **examples** as exactly what they are: **examples**. In the spirit of Bacon's own method, we may freely substitute better examples drawn from our present knowledge. What endures is not the specific explanation but the *approach to inquiry*—the scaffolding of a method intended to outlast any particular scientific theory.

II-XI (2:11).

The investigation of forms proceeds in this manner: concerning a given nature, a presentation must first be made for the understanding of all known instances which agree in the same nature [1], though through materials greatly dissimilar. And such a collection must be made historically [2], without premature speculation or any excessive subtlety. For example, in the investigation concerning the form of heat [3]:

[1] Bacon's term *comparentia* comes from legal procedure (literally a "presentation" or "appearance" before the court). He uses it metaphorically to describe the "presentation of instances" before the intellect for judgment. The process marks the first stage of his inductive logic—an ordered display of nature's evidence before analysis begins.

[2] By *historice*, Bacon meant "according to the order of occurrence," not "narratively." His "natural history" (*historia naturalis et experimentalis*) was a disciplined record of observations prior to theorizing, intended to correct what he saw as the scholastic habit of reasoning from definitions rather than facts.

[3] The inquiry into *forma calidi* serves as Bacon's model of how to search for "forms," or laws of operation, underlying phenomena. In Bacon's mature interpretation (II:XX–XX), heat's form is a species of *motion*—what he calls "expansive motion restrained and checked." Though qualitatively expressed, this anticipates the modern kinetic conception of heat as molecular motion.

Instances agreeing in the nature of heat.

1. The rays of the sun, especially in summer and at midday.
2. The rays of the sun, reflected and condensed, as between mountains, or by walls, and most notably in burning mirrors.

3. Fiery meteors.
4. Burning thunderbolts.
5. Eruptions of flame from the cavities of mountains, and the like.
6. Every kind of flame [4, regarding Items 1-6].
7. Ignited solids.
8. Natural hot baths.
9. Boiling or heated liquids.
10. Hot vapors and smoke, and air itself, which takes on a most intense and raging heat if enclosed, as in reverberatory furnaces [5, regarding Items 7-10].
11. Certain clear conditions of the weather, arising from the very constitution of the air itself, without regard to the season of the year.
12. Air confined and subterranean in some caves, especially during winter.
13. All shaggy substances, such as wool, animal skins, and feathers, possess some degree of warmth.
14. All bodies, whether solid or liquid, and whether dense or rare (such as the air itself), placed near fire for some time.
15. Sparks struck from flint and steel by strong percussion.
16. Every body strongly rubbed, such as stone, wood, cloth, and the like; so much so that wagon-poles and wheel-axles sometimes catch fire; and the custom among the West Indians of producing fire by friction.
17. Green and moist herbs enclosed and pressed together, as roses or peas in baskets; so that hay, if stored damp, often catches fire [6].
18. Quicklime sprinkled with water [7].
19. Iron, when first dissolved by strong waters [8] in a glass vessel, and that without any application to fire; and similarly tin and others, but not so intensely.

20. Animals, especially and perpetually in their internal parts [9]; although in insects the heat is not detected by touch because of the smallness of their bodies.
21. Horse dung and similar fresh excrements of animals.
22. Strong oil of sulphur and vitriol enacts the operations of heat in the burning of linen.
23. Oil of marjoram and similar substances enacts the operations of heat in the burning of the bones of the tooth substance.
24. Strong and well-rectified spirit of wine [10, regarding Items22-24] enacts the operations of heat; so that if the white of an egg be thrown into it, it curdles and whitens almost in the manner of a boiled egg-white; bread thrown into it becomes toasted and crusted, resembling toasted bread.
25. Aromatic substances and hot herbs, such as the tarragon and old nasturtium, although they are not hot to the touch (neither whole nor powdered), nevertheless, when slightly chewed, are perceived by the tongue and palate as hot and almost burning.
26. Strong vinegar and all acids, when applied to parts of the body without epidermis, such as the eye, tongue, or a wounded and denuded surface, cause a pain not much different from that produced by heat [11].
27. Even sharp and intense cold induces a certain sensation of burning [12];

    "For the penetrating cold of Boreas burns."
28. Other instances.

We are accustomed to call this the Table of Essence and Presence [13].

[4] Bacon's list unites celestial, terrestrial, and artificial sources of heat, rejecting Aristotelian distinctions between "heavenly" and "elemental" fire. This move prefigures the modern assumption of the uniformity of natural causes—that the same physical laws operate everywhere {[1]}.

[1] P.S. See also "Uniformitarianism", as proposed by Hutton, and especially by Lyell.

[5] Bacon correctly observed that air, when compressed and confined, may become extremely hot. He lacked the concept of energy transfer, but his inclusion of this case foreshadows the thermodynamic principle that compression can raise temperature (as in modern heat engines).

[6] This is a sound empirical observation of *spontaneous heating* due to microbial respiration and oxidation. Bacon interpreted it as a form of "latent heat generation," not distinguishing between biological and chemical sources. Later chemistry (18th–19th c.) confirmed the exothermic nature of such reactions.

[7] Here Bacon accurately noted an exothermic reaction: calcium oxide combining with water to form calcium hydroxide, releasing heat. This is one of his most scientifically precise examples.

[8] By "strong waters" Bacon meant mineral acids (notably nitric acid, *aqua fortis*). The heat produced during acid dissolution is real and measurable. Bacon lacked the concept of chemical energy but correctly grouped such reactions under thermal phenomena.

[9] Bacon's recognition of endogenous animal heat reflected contemporary debates about vital spirits. He regarded it as mechanical rather than mystical, a major conceptual advance toward physiological thermodynamics.

[10] These "operations of heat" are chemical or sensory analogues, not true caloric phenomena. Bacon's inclusion of acids and pungent oils—whose "burning" arises from chemical irritation—shows both the breadth and the limits of his inductive inclusivity. Later science distinguished between chemical stimulation (causing pain) and thermal excitation (raising temperature).

[11] This is perceptually accurate but physically mistaken. Acids do not generate thermal energy when touching tissue; they chemically damage nerve endings. Bacon here confuses phenomenological similarity (the sensation of burning) with physical causation.

[12] This is neurologically valid: both extreme heat and extreme cold overstimulate the same thermoreceptors, producing a burning sensation. Though Bacon lacked physiological theory, his empirical observation was sound.

[13] The *Tabula Essentiae et Praesentiae* is the first of Bacon's three tables (*Presence, Absence, and Degree*). It serves to organize all observed instances of a phenomenon before analysis. In modern logic of science, it anticipates the first stage of data collection and classification, prior to inference.

II-XII (2:12).

Second, a comparison must be made, for the *understanding*, of those instances which are deprived of the given nature: for the *form* (as was said) ought to be absent no less where the given nature is absent, than present where it is present. To attempt this in all things would indeed be infinite.

Therefore *negatives* must be subjoined to *affirmatives*, and privations are to be inspected only in those subjects that are most closely cognate to those others in which the given nature is present and appears. This we are wont to call the **Table of Declination**, or **of Absence in the Proximate** [1].

[1] Bacon introduced the *Tabula Declinationis sive Absentiae in Proximo* as the second step in his inductive process. He sought to determine causes by comparing cases where a nature was present with those where it was absent but otherwise similar. The logic of "absence in proximity" thus remains foundational for modern controlled experimentation.

Instances in the proximate that are deprived of the nature of the *Heat.*

Ad 1am 1a [2].

1. The rays of the moon and of the stars and comets are not found to be hot [3] to the touch; indeed, the sharpest colds are commonly observed at full moon. Yet the larger fixed stars, when the sun approaches or comes under them, are thought to increase and intensify the sun's heats—as when the sun stands in Leo and during the dog-days.

[2] The abbreviation "**Ad 1am 1a.**" does not appear in the original 1620 Latin text of *Novum Organum*. Bacon's printed text contains thirty-one such formulas, beginning with "**Ad 2am 2a.**" and continuing through "**Ad 27am 32a.**" Although Bacon nowhere gives the fully written-out form of these abbreviations, they

indicate that each primary instance has a corresponding subjoined instance. A fuller explanation first appeared in the edition of Spedding, Ellis, and Heath (1857), who supplied the editorial expansion "*Ad instantiam primam affirmativam, instantia prima negativa vel subjunctiva*," which may be rendered, "To the first affirmative instance corresponds the first negative, or subjoined, instance." Modern English translations of *Novum Organum* usually replace Bacon's abbreviated notation with a simple sequential numbering from 1 to 32.

[3] Bacon rejected the ancient belief that light and heat were identical. His inference from the coldness of moonlight suggested that the two phenomena were separable. Modern physics confirms this distinction: visible light carries far less radiant energy than infrared radiation, so moonlight appears bright but transmits negligible thermal energy. The supposed "sharp colds" at full moon were coincidental atmospheric effects.

Ad 2am 2a.

2. The rays of the sun in the so-called middle region of the air do not heat [4]; the common reason is not ill given—namely, that that region is neither near enough the body of the sun, whence the rays emanate, nor yet near the earth, whence they are reflected. This is shown by mountain peaks (unless very lofty) where snow endures perpetually. Yet it has been observed by some that on the summit of Pico de Tenerife, and also in the Andes of Peru, the very crests of the mountains are devoid of snow, the snows lying only lower on the ascent; and further, that the air on those peaks is found to be not particularly cold, but merely thin and sharp—so much so that in the Andes it pricks and wounds the eyes by its excessive acrimony, and also pricks the stomach and induces vomiting. The ancients likewise noted that on the top of Olympus the air was so attenuated that those who ascended were obliged to carry sponges moistened with vinegar and water and from time to time apply them to the mouth and nostrils, because by reason of its tenuity the air did not suffice for respiration; on that summit also it was reported that such serenity and freedom from rains, snows, and winds prevailed that, when sacrifice was offered, letters traced with a finger in the ashes upon the altar of Jove

remained to the following year without any disturbance. And even now those who climb Pico de Tenerife go up by night and not by day; and shortly after sunrise they are urged by their guides to hasten down, because of danger (it would seem) from the tenuity of the air, lest it relax and suffocate the *spirits* {2}.

[4] Here Bacon offered an early explanation for the decrease of temperature with altitude. He argued that the middle air was too distant both from the sun's body and from the reflective earth. His reasoning approximated the modern view that the lower atmosphere warms mainly by terrestrial radiation. His accounts of Olympus and the Andes derived from travelers' reports and showed his use of empirical testimony as evidence.

Ad 2am 3a.

3. The reflection of the sun's rays in regions near the polar circles is found very weak [5] and ineffectual as to heat; thus the Netherlanders who wintered in Nova Zembla, expecting their ship to be freed from the mass of ice that beset her at the beginning of July, were disappointed and compelled to take to their boat. Hence direct solar rays seem to have little power, even on level ground; nor do the reflected rays either, unless they are multiplied and united—which occurs when the sun inclines more to the perpendicular, because then the incidences of the rays make sharper angles so that the lines of the rays lie nearer together; whereas in great obliquities the angles are very obtuse and therefore the ray-lines more distant. Meanwhile it should be noted that there may be many operations of the sun's rays—and of the nature of the hot—which are not proportioned to our touch: so that with respect to us they do not act up to heating, yet with respect to certain other bodies they perform the works of heat.

[5] Bacon observed that the obliquity of solar rays weakened their heating power. The principle remains correct: solar flux varies with the angle of incidence. His geometric treatment of ray concentration anticipated later optical and

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[2] (P. S.) This paragraph is yet another example of Bacon's outdated understanding that should be commented in a Footnote (or in an Excursus).

radiative studies, though his suggestion that heat might act differently "with respect to our touch" lacked thermodynamic precision.

Ad 2am 4a.

4. Let this experiment be made. Take a *mirror* fabricated the contrary way to burning mirrors, and interpose it between the hand and the sun's rays; and observe whether it diminishes the heat of the sun, as a burning mirror increases and intensifies it. For as regards optical rays it is manifest that, according as the mirror is made with unequal density in respect of its middle and its sides, the images appear more diffused or more contracted. Let the same be seen in regard to heat.

Ad 2am 5a.

5. Let careful experiment be made whether by the strongest and best-made burning mirrors the rays of the moon can be received [6] and gathered to any, even the least, degree of warmth. If that degree of warmth should perhaps be too subtle and feeble to be perceived and detected by touch, we must have recourse to those glasses which indicate the warm or cold constitution of the air; so that the rays of the moon, by the burning mirror, may fall and be thrown upon the summit of such a glass, and then it be noted whether there is a depression of the water through the warmth.

[6] Bacon proposed an experiment to detect faint lunar heat using "glasses of degrees," an allusion to early thermoscopes. This anticipated the quantitative thermometry later developed by Galileo and Fahrenheit. His awareness of instrumental limits marked a transition from qualitative sensation to instrumental precision, a defining feature of modern empirical method.

Ad 2am 6a.

6. Let a burning-glass also be tried upon a *hot body* that is not radiant or luminous—such as iron or stone heated but not red-hot, or boiling water, or the like—and let it be noted whether there is an increase and intensification of heat, as with the rays of the sun.

Ad 2am 7a.

7. Let a burning mirror likewise be tried upon an ordinary flame.

Ad 3am 8a.

8. Comets (if one is pleased to count them among meteors) are not detected to have any constant or manifest effect in increasing the heats of the year, although droughts have often been observed to follow upon them. Beams, luminous pillars, rifts, and the like appear more often in winter than in summer, and most of all in the sharpest colds, but joined with droughts. Thunder and lightning, however, rarely occur in winter, but at the time of great heats. Falling stars are commonly thought to consist rather of some viscous bright matter kindled than to be of a stronger fiery nature. But let further inquiry be made into this.

Ad 4am 9a.

9. There are certain flashes which afford light but do not burn; these always occur without thunder.

Ad 5am 10a.

10. Eruptions and outbursts of flames are found no less in cold regions than in hot [7]—as in Iceland and Greenland; and trees in cold regions are sometimes more inflammable and more pitchy and resinous than in hot regions, as in fir, pine, and the rest. But in what site and in what nature of soil such eruptions are wont to occur, so that we may subjoin a negative to the affirmative, has not been sufficiently inquired.

[7] Bacon contended that volcanic heat occurred independently of climate, thereby challenging Aristotelian cosmology. His inference aligned with the modern concept that internal terrestrial heat originates from geological, not celestial, causes. His attention to “site and soil” anticipated the geophysical study of heat sources within the Earth.

Ad 6am 11a.

11. Every flame is always hot [8], more or less, and to this affirmative no negative is subjoined; and yet they report that the *ignis fatuus* (as it is called), which sometimes even impinges upon a wall, has not much heat—perhaps after the manner of the flame of *spirit of wine*, which is mild and gentle. Still gentler seems that flame which in some trustworthy and grave histories is found to have appeared about the heads and hair of boys and maidens, which in no way singed the hair but quivered softly around it. And it is quite certain that about a horse sweating on a journey there has sometimes appeared at night, in sultry weather, a certain coruscation without manifest heat. And a few years ago it was well known, and almost taken for a marvel, that a girl's apron, when slightly moved or rubbed, gave off sparks—perhaps because alum or salts with which the apron had been dyed adhered and incrusted somewhat thickly and were broken by the friction. And it is quite certain that all sugar, whether preserved or plain, provided it be hard, when broken in the dark or scraped with a knife, gives off flashes. Likewise sea-water and brine at night are sometimes found, when strongly struck with oars, to flash; and in storms the foam of the sea, violently agitated at night, flashes—the Spaniards call that flashing the sea-lung. As to that flame which ancient mariners called Castor and Pollux, and moderns St. Elmo's fire, the degree of heat it has has not been sufficiently inquired.

[8] Bacon recorded reports of "cold flames," including *ignis fatuus* and St. Elmo's fire. These observations mixed truth and error. Such lights arise from chemiluminescence, phosphorescence, or electrical discharge, which emit light without significant heat. His inclusion of these anomalies illustrated his inductive discipline: even exceptions deserved collection and analysis.

Ad 7am 12a.

12. Everything made *red-hot* so as to glow, even without flame, is always hot [9]; to this affirmative no negative is subjoined. What is nearest to a negative seems to be rotten wood, which shines at night yet is not found hot; and the putrefying scales of fish, which also shine

at night and are not found warm to the touch; nor is the body of the glow-worm (the so-called fire-fly) found warm to the touch.

[9 Bacon extended his list to luminous organic materials, such as rotten wood or fish scales, which glowed without heat. These phenomena are now known as bioluminescence and chemiluminescence, involving energy release by chemical or enzymatic processes. His curiosity revealed an early distinction between light emission and temperature rise.

Ad 8am 13a.

13. Concerning hot baths, in what site and nature of soil they are wont to arise, inquiry has not been sufficient; therefore no negative is subjoined.

Ad 9am 14a.

14. To boiling liquids there is subjoined a negative of the liquid itself in its own nature. No tangible liquid is found which in its own nature is and remains constantly hot; heat is superinduced only for a time, as an *adscititious* nature. Thus those that are most hot in power and operation—*spirit of wine*, chymical aromatic oils, and even oils of vitriol and sulphur and the like, which shortly afterward burn—are at the first touch cold. Water of natural hot springs, when taken into a vessel and separated from its source, cools just as water heated by fire does. It is true that oily bodies are to the touch a little less cold than aqueous ones—oil than water, silk than linen. But this belongs to the Table of Degrees concerning the Cold.

Ad 10am 15a.

15. Likewise to *hot vapor* there is subjoined a negative of the nature of vapor itself as found with us. For exhalations from oily matters,

although easily inflammable, are not found hot unless they have freshly exhaled from a hot body.

Ad 10am 16a.

16. Likewise to *hot air* there is subjoined a negative of the nature of air itself. For with us no air is found hot unless it has been either enclosed, or rubbed, or manifestly heated by the sun, fire, or some other hot body.

Ad 11am 17a.

17. There is subjoined a negative of cold weather greater than the proportion of the time of year, which with us occurs when the east and north winds blow; and contrary seasons occur when the south and west winds blow. An inclination to rain (especially in winter) accompanies tepid weather; frost, on the other hand, accompanies cold.

Ad 12am 18a.

18. There is subjoined a negative of air enclosed in caverns in summer. But about confined air inquiry must altogether be more diligent. First, not without cause there arises a doubt what is the nature of air, as regards hot and cold, in its own proper nature. For air manifestly receives heat from the impressions of the heavenly bodies; cold, perhaps, from the exhalation of the earth; and again, in the middle region of the air, from cold vapors and snows: so that no judgment can be made about the nature of air from air that is out-of-doors and under the open sky, but a truer judgment from enclosed air. And it is necessary that the air be enclosed in such a vessel and material as neither itself imbues the air with hot or cold by its own force, nor readily admits the power of extraneous air. Let an experiment therefore be made with an earthen pot, coated with multiple layers of

leather to defend it from extraneous air, time being allowed of three or four days in a well-sealed vessel; and the detection is to be made after opening the vessel, either by the hand or by a *glass of degrees* duly applied.

Ad 13am 19a.

19. A similar doubt underlies this: whether the warmth in wool, hides, feathers, and the like arises from a certain slender inherent heat, inasmuch as they are excretions of animals; or from a certain fattiness and oiliness, which is of a nature congruent with warmth; or plainly from the *enclosure* and *breaking-up* of air, as was said in the preceding article. For every air cut off from continuity with the external air seems to have some warmth. Let an experiment be made therefore in fibrous materials made from flax—not from wool or feathers or silk, which are excretions of living things. It should also be noted that all powders (where air is manifestly enclosed) are less cold than the same bodies when entire; and likewise we judge all foam (in that it contains air) to be less cold than the liquid itself.

Ad 14am 20a.

20. To this no negative is subjoined. For among us there is found nothing—whether tangible or *spiritual*—which, when brought near to fire, does not take on heat. They differ only in this, that some receive heat more quickly—air, oil, and water; others more slowly—stone and metals. But this belongs to the Table of Degrees.

Ad 15am 21a.

21. To this instance no negative is subjoined, except that it be well noted that sparks are not elicited from flint and steel or any other hard substance unless some minute fragments are struck off from the very substance of the stone or metal; nor does rubbed air ever of itself generate sparks, as people commonly suppose; and those very sparks,

by the weight of the ignited body, tend downward rather than upward, and on extinction return into a kind of sooty corporeal matter.

Ad 16am 22a.

22. We think no negative is to be subjoined to this instance. For among us no tangible body is found which does not plainly become hot from friction; so that the ancients dreamed that the heavenly bodies possessed no other way or power of heating than from the friction of air by their rapid and hurried rotation. But in this kind further inquiry is to be made, whether bodies projected from engines (as balls from guns) do not from the very stroke contract some degree of heat, so that after they have fallen they are found somewhat warm. Moving air, however, cools rather than heats, as in winds, bellows, and the breath from a compressed mouth. But such motion is not so rapid as to excite heat, and occurs as a whole, not by particles; so it is no wonder if it does not generate heat.

Ad 17am 23a.

23. Concerning this instance, inquiry must be more diligent. For green and moist herbs and vegetables seem to have within them some hidden heat. That heat is so tenuous that in single specimens it is not perceived by touch; but after they are heaped together and enclosed, so that their *spirits* do not expire into the air but cherish each other, then manifest heat arises, and sometimes flame, in a suitable material.

Ad 18am 24a.

24. Here too inquiry must be more diligent. *Quicklime* sprinkled with water seems to conceive heat [10] either because of the union of a heat previously scattered (as was said above of enclosed herbs), or because of the irritation and exasperation of an igneous spirit by the water, so that a certain conflict and *antiperistasis* arises. Which of these causes is the true one will more readily appear if, instead of water, oil be introduced; for oil, equally with water, will avail for the union of the

imprisoned spirit, but not for its irritation. The experiment is also to be extended more broadly both to the ashes and limes of different bodies and by the introduction of different liquids.

[10] Bacon observed that lime and water produced heat and debated whether it arose from the "union of scattered heat" or from an internal conflict of spirits. The reaction is now understood as the exothermic hydration of calcium oxide to calcium hydroxide. His invocation of *antiperistasis* retained a scholastic remnant, but his empirical instinct was chemically sound.

Ad 19am 25a.

25. To this instance is subjoined a negative of other metals which are softer and more yielding. For gold-leaf, dissolved into a liquid by *aqua regia*, gives no heat to the touch in the dissolution; nor likewise lead in *aqua fortis*; nor quicksilver (as I remember); but silver excites a little heat, and also copper (as I remember), but more manifestly tin, and of all most of all iron and steel, which not only excite strong heat in dissolution [11] but also violent ebullition. It therefore seems that heat is produced by conflict, when strong waters penetrate, mine, and rend the parts of the body, and the bodies themselves resist. Where bodies yield more readily, heat is scarcely excited.

[11] Bacon recognized that metals dissolved in acids gave off heat. He interpreted this as a "conflict of bodies," an early intuition of chemical energy release. Modern chemistry identifies this as an exothermic redox reaction; his order of intensity (iron > tin > silver > gold) roughly corresponds to the modern electrochemical series.

Ad 20am 26a.

26. To the heat of animals no negative is subjoined, except in the case of insects (as was said) on account of the smallness of their body. For in fishes, compared with land animals, a degree of heat is noted rather than its privation. In vegetables and plants no degree of heat is perceived by touch—neither in their saps nor in piths freshly opened. But in animals there is found great diversity of heat, both in their parts (for the heat about the heart is one thing, that in the brain another,

that again in the extremities another) and in their states, as in violent exercise and in fevers [12].

[12] Bacon distinguished animal warmth from vegetative life and suggested that heat varied within the body and across species. Later physiology confirmed that animal heat derives from metabolic oxidation, as shown by Lavoisier and Laplace (1780s). Bacon's remark foreshadowed the modern concept of thermoregulation.

Ad 21am 27a.

27. To this instance scarcely any negative can be joined. Indeed, even the excrements of animals, when not stale, manifest a *potential heat*, as is seen in the fattening of soil.

Ad 22am et 23am 28a.

28. Liquids (whether they are called waters or oils) that have a great and intense acrimony perform the works of heat in rending bodies and in burning them after some delay; yet to the touch of the hand they are not warm at the outset. They act, however, according to the analogy and the pores of the body to which they are applied. For *aqua regia* dissolves gold but not silver; *aqua fortis* on the contrary dissolves silver but not gold; and neither dissolves glass. And so in the rest.

Ad 24am 29a.

29. Let an experiment be made with *spirit of wine* on wood, and also on butter, wax, or pitch, to see whether by its heat it may in some degree liquefy them. For the twenty-fourth instance has shown its imitative power of heat in incrustations; let a similar experiment therefore be made concerning liquefactions. Let there also be an experiment with a *glass of degrees* or calendar-glass [13] which is concave at its summit on the outside; and into that external concavity let well-rectified spirit of wine be poured, with a cover, that it may retain its heat the better; and let it be noted whether by its heat it makes the water descend.

[13] Bacon referred to a simple thermoscopic device, “a glass of degrees or calendar-glass,” used to register changes in heat by the rise and fall of water in a glass tube. Although he generally described such instruments only by periphrasis (vitrum, tubus vitreus, aqua ascendens in vitro), he used the term calendare once, in the phrase vitrum graduum sive calendare quod, as an ad hoc designation for a degree-registering glass. This expression occurred in Novum Organum II (section Instantiae in proximo, Ad 24am 29am) and provided the basis for Rawley’s later English “calendar-glass.” The term was not a fixed technical name but a descriptive Latinization meaning “registering glass,” indicating an instrument for marking gradations of heat.

Ad 25am 30a.

30. Aromatics and herbs that are biting to the palate [13] are perceived as warm—and much more when taken inwardly. Inquiry should therefore be made in what other materials they perform the works of heat. Mariners report that when heaps and masses of aromatics long shut up are suddenly opened, danger threatens those who first stir and draw them forth, from fevers and inflammations of the *spirits*. Likewise an experiment may be made whether powders of such aromatics or herbs do not dry bacon or flesh suspended above them, as the smoke of fire does.

[13] Bacon included spices as examples of “heat” by sensation rather than temperature. Modern neurophysiology explains this through chemical stimulation—compounds such as capsaicin and allyl isothiocyanate activate heat-sensitive receptors without raising temperature. His analogy anticipated later distinctions between physical heat and perceived warmth.

Ad 26am 31a.

31. Acrimony, or penetration, resides as well in cold things—such as vinegar and oil of vitriol—as in hot things—such as oil of marjoram and the like. Thus in animals alike they stir pain, and in inanimate things they tear apart parts and consume. No negative is subjoined to this instance. And in animals no pain is found without some sense of heat.

Ad 27am 32a.

32. Many actions are common to both the hot and the cold, though in very different manner. For snow seems after a little to burn boys' hands; and colds preserve flesh from putrefaction no less than fire; and heats contract bodies into less—which cold also does. But these and similar things are more fitly referred to the *Inquiry concerning the Cold* [14].

[14] Bacon concluded that heat and cold might be contraries produced by similar motions. This idea prefigured his later doctrine that both are modes of motion, not substances. Modern thermodynamics confirms that heat and cold represent relative energy transfer within the same physical continuum.

II-XIII (2:13).

Third, a comparison must be made, for the *understanding*, of the instances in which the nature that is under inquiry is present according to *more and less* [1]—whether by comparing increase and decrease in the same subject, or by comparing different subjects with one another. For since the *form* of a thing is the very thing itself [2], nor does the thing differ from its form otherwise than the apparent from the existent, the outward from the inward, or what is ordered to man from what is ordered to the universe, it follows altogether that no nature is to be received as a true form unless it continually decreases when the nature itself decreases, and likewise continually increases when the nature itself increases. We are accustomed to call this table the **Table of Degrees**, or the **Table of Comparison** [3].

[1] Bacon introduced here the *Tabula Graduum sive Comparationis*, the third of his experimental "tables" devised to isolate a *forma* (form or nature). It was intended to compare variations in intensity across instances, anticipating what nineteenth-century logicians later called the *method of concomitant variations*. This step marked Bacon's shift from qualitative enumeration to a program of controlled quantification, though he did not yet possess numerical instrumentation.

[2] The statement *forma rei est ipsa res* showed Bacon's rejection of Aristotelian *forma substantialis* as metaphysical essence. He treated "form" as the

operative nature that constituted the thing's being. This redefinition moved natural philosophy from essential explanation to functional description and anticipated the later conception of *lawlike relations* in nature. The distinction recalls Aristotle's *πρότερα γνωριμώτερα πρὸς ἡμᾶς* and *πρὸς τῇ φύσει* ("prior to us" / "prior by nature"), here transferred from the relation of knowledge to that of cause and effect.

[3] Bacon applied this comparative procedure to *calidum* (heat). The table was meant to supply data for induction, not to offer a theory of heat itself. He regarded the *forma caloris* as a species of motion among the smallest particles of matter, a view he developed more explicitly in 2:20.

Table of Degrees or of Comparison in the Hot

We shall therefore speak first of those things which have no degree of heat at all to the touch, but seem to have only a certain *potential* heat, or a disposition and preparation toward the hot. Afterwards we descend to those which are *actually*—that is, to the touch—hot, and to their strengths and degrees.

1. In solid and tangible bodies nothing is found that in its own nature is originally hot. No stone, no metal, no sulfur, no fossil [4], no wood, no water, no carcass of an animal is found hot. The hot waters in baths seem to be heated *per accidens*: either by subterranean flame or fire (such as is vomited forth from Aetna and many other mountains), or by the conflict of bodies, as heat occurs in the dissolutions of iron and tin. Thus, as regards human touch, there is no degree of heat in inanimate things; nevertheless they differ in degree of cold—for wood is not so cold as metal. But this belongs to the **Table of Degrees in the Cold**.

[4] By *fossil* (*fossile*) Bacon meant any substance naturally generated underground—minerals, ores, salts, clays, and bituminous materials—rather than the petrified remains of living things. In this sense *fossilia* formed a third natural kingdom, alongside *vegetabilia* and *animalia*. His assertion that no inanimate body was "in its own nature hot" reflected early-seventeenth-century assumptions about heat as an accidental quality. Modern physics holds that all matter above absolute zero possesses thermal energy. His comparison

of metals and wood confused thermal conductivity (rate of heat transfer) with intrinsic temperature; metals felt colder only because they conducted heat away from the skin more rapidly.

2. Yet as to *potential* heats and preparations for flame, many inanimate things are found to be highly disposed—such as sulfur, naphtha, petroleum.

3. Things that have previously been heated—such as horse-dung from an animal, or quicklime, or perhaps ash or soot from fire—retain certain latent remnants of the prior heat. Hence some distillations and separations of bodies are made by burying in horse-dung; and heat is stirred in lime by sprinkling with water, as has already been said.

4. Among vegetables no plant, nor part of a plant (such as the sap or the pith), is found hot to the human touch. Yet (as said above) green herbs, when enclosed, grow warm; and to the *inner* touch—namely, the palate or the stomach—or even to the outer parts after some delay (as in plasters and ointments), some vegetables are found hot, others cold.

5. In the parts of animals, after they are dead or separated, nothing hot to human touch is found. Not even horse-dung itself retains heat, unless it has been confined and buried. Yet all dung seems to have a *potential* heat, as appears in the fattening of fields. Likewise the carcasses of such animals have a latent and potential heat, so that in cemeteries where burials are made daily, the earth gathers a certain hidden heat, which consumes a newly laid corpse far more quickly than clean earth. And among the Orientals it is reported that there is found a certain thin and soft textile made from birds' down, which by innate power dissolves and liquefies butter lightly wrapped within it.

6. Things that fatten fields—dungs of every kind, chalk, sea sand, salt [5], and the like—have some disposition toward the hot.

[5] Bacon classed putrefying and fermenting substances as "potentially hot," conflating chemical reactivity with sensible temperature. The warmth produced in decomposition or slaking indeed resulted from exothermic oxidation—later termed *eremacausis*. His observation was empirically accurate, though conceptually premature.

7. Every putrefaction has within itself certain rudiments of a slender heat, though not to the point of being perceived by touch. For even those things that in putrefaction are resolved into small living creatures—such as flesh and cheese—are not perceived as hot to the touch; nor is rotten wood, which shines at night, found hot to the touch. In putrid things heat sometimes betrays itself by foul and strong odors.

8. The first degree of heat, among those that are perceived as hot to human touch, appears to be the heat of animals [6], which admits a wide latitude of degrees. For the lowest degree (as in insects) is hardly detected by touch; whereas the highest hardly attains to the degree of the heat of the sun's rays in the hottest regions and seasons, nor is it so sharp that it cannot be endured by the hand. And yet it is reported of Constantius and some others whose bodily constitution and habit were very dry, that when seized by very sharp fevers they grew so hot as to seem to scorch the hand brought near.

[6] Bacon believed that animal heat varied among species. Modern physiology explains this as metabolic heat from cellular respiration. His judgment that birds were the "most hot" corresponded roughly to their higher body temperatures (about 40–42 °C), though he lacked instruments to measure them.

9. Animals are increased in heat by motion and exercise, by wine and feasting, by sexual intercourse, by burning fevers, and by pain.

10. In the onsets of intermittent fevers animals are at first seized by cold and shivering, but shortly afterward become much more hot; and the same occurs at the beginning in *causones* and pestilential fevers.

11. Further inquiry should be made into comparative heat in different animals—fish, quadrupeds, serpents, birds—and also according to their species, as in lion, kite, man. By common opinion fish are less hot inwardly, while birds are the most hot—especially doves, hawks, ostriches.

12. Further inquiry should be made into comparative heat in the same animal according to its different parts and members. Milk, blood, semen, eggs are found tepid in a moderate degree, and less hot than the outer flesh of an animal when it moves or is agitated. What the degree of heat is in the brain, stomach, heart, and the rest has likewise not yet been investigated.

13. All animals, in winter and in cold weather, are cold externally; but internally they are thought to be even hotter.

14. The heat of the heavenly bodies [7], even in the hottest region and the hottest times of the year and day, does not reach that degree of heat which would set alight or scorch the driest wood or straw or even burnt linen, unless it is strengthened by burning mirrors; yet it can stir vapor from moist things.

[7] Bacon accepted the traditional Ptolemaic ordering of planetary "heat." Seventeenth-century astronomy treated the stars and planets as inherently hot bodies. Modern astrophysics understands planetary temperature as dependent on solar radiation and atmospheric composition, not on intrinsic qualities. His inclusion of *Sirius* and other fixed stars as sources of terrestrial heat continued the astrological cosmology of his time.

15. By the tradition of astronomers some stars are set down as more, others as less hot. Among the planets, after the sun, Mars is placed as

the most hot, then Jupiter, then Venus; and the Moon is set down as cold, and of all Saturn the coldest. Among the fixed stars Sirius is placed as most hot, then the Heart of the Lion (Regulus), then the Lesser Dog-star, and so forth.

16. The sun heats more the more it inclines to the perpendicular or zenith; which is also to be believed of the other planets, proportionately to their measure of heat—for example, that Jupiter heats us more when in Cancer or Leo than in Capricorn or Aquarius.

17. It is to be believed that the sun itself and the remaining planets heat more in their *perigees*, on account of their nearness to the earth, than in their *apogees*. And if it should happen in any region that the sun is at once in perigee and nearer the perpendicular, it must needs heat more than in a region where the sun likewise is in perigee but more oblique. Hence the comparison of the planets' exaltation ought to be noted according as they partake of perpendicularity or obliquity, in accordance with the variety of regions.

18. The sun also—and similarly the other planets—are thought to heat more when they are near the greater fixed stars; as when the sun is placed in Leo he becomes nearer to the Heart and Tail of the Lion, to Spica of Virgo, to Sirius, and to the Lesser Dog-star, than when he is in Cancer, where nevertheless he stands more at the perpendicular. And it is to be believed that those parts of the sky pour down more heat (though hardly perceptible to the touch) the more they are adorned with stars, especially the greater ones.

19. Altogether, the heat of the heavenly bodies is increased in three ways: by perpendicularity, by nearness (that is, perigee), and by conjunction or consort of stars.

20. A very great interval is found between the heat of animals—and even of the rays of heaven as they are conveyed to us—and flame, even the gentlest, and likewise all red-hot things, and, besides, liquids or even the air itself heated strongly by fire. For the flame of spirit of wine, especially when rare and not crowded, is nevertheless able to set alight straw or linen or paper—which the heat of an animal or of the sun will never do without burning mirrors.

21. In flames and in things red-hot there are very many degrees in the strength and weakness of heat. But no diligent inquiry has been made about these; we must therefore pass them over lightly. Of flames, that from spirit of wine seems the mildest—unless perhaps the *ignis fatuus*, or the flames or flashes from the sweats of animals, are milder. Next after this, we think, is the flame from light and porous vegetables such as straw, rushes, and dried leaves; from which the flame from hair or feathers does not much differ. After this perhaps comes the flame from woods, especially those that do not have much resin or pitch; yet the flame from woods of small bulk (which are commonly gathered into faggots) is milder than that from trunks and roots. This anyone may observe in furnaces where iron is smelted, in which the fire from faggots and branches is not very serviceable. Next (as we judge) is the flame from oil, tallow, wax, and the like oily and fatty substances that have no great acrimony. The strongest heat is found in pitch and resin; and stronger still in sulfur and camphor, and in naphtha and petroleum and salts (after the crude matter has burst out), and in compositions of these—such as gunpowder [8], Greek fire (vulgarly called wild-fire), and its various kinds—which have so obstinate a heat that they are not easily extinguished by water.

[8] Bacon distinguished among flames by perceived intensity and color but lacked a thermometric concept of *temperature*. Modern chemistry shows that hydrogen and methane flames, though less luminous, reach higher temperatures than alcohol or sulfur flames. His ordering therefore reflected visual brightness rather than actual heat energy.

22. We judge also that the flame that results from some imperfect metals [9] is very strong and sharp. But further inquiry is to be made about all these.

[9] "Imperfect metals" denoted the non-noble or baser metals of the early-modern alchemical tradition (e.g., copper, iron, tin, lead). Bacon used the term in its historical sense to indicate metallic bodies of lesser fixity and purity than gold or silver, not in any modern chemical sense.

23. The flame of stronger lightnings seems to surpass all these flames; so much so that it has sometimes melted perfect iron into drops, which those other flames cannot do.

24. In things red-hot there are also different degrees of heat, concerning which likewise no diligent inquiry has been made. We judge the weakest heat to be from burnt linen, such as we use for kindling flame; and similarly from that spongy wood or the dried cords that are used for firing ordnance. Next after this follows the red-hot coal from wood and from charcoal, and likewise from heated bricks and the like. Of red-hot things we judge the most vehemently hot to be the red-hot metals, such as iron and copper and the rest. But here too further inquiry must be made.

25. Among red-hot things some are found far hotter than some flames. For red-hot iron is much hotter and more scorching than the flame of spirit of wine.

26. Among things that are not red-hot but only heated by fire—such as boiling waters and the air enclosed in reverberatory furnaces—some are found which surpass in heat many of the flames themselves and of red-hot things.

27. Motion increases heat; as is seen with bellows and blowing; so that the harder of the metals are not softened or melted by a dead or quiescent fire unless it is stirred by a blast.

28. Let an experiment be made with burning mirrors, in which (as I remember) this happens: if a mirror is placed, for example, at the distance of a span from a combustible object, it does not set on fire or scorch so much as if the mirror, placed at the distance of half a span, is drawn back gradually and slowly to the distance of a span. The cone and union of the rays are the same; but the very *motion* increases the operation of heat.

29. It is thought that conflagrations which occur in a strong wind make greater progress *against* the wind than *with* the wind; because the flame rebounds with a swifter motion when the wind slackens than it advances when the wind drives it.

30. Flame does not leap out or come to be unless there is afforded something hollow in which the flame can move and play—except in the blustering flames of gunpowder and the like, where compression and imprisonment of flame increase its fury.

31. An anvil grows very hot under the hammer [10]; so that if the anvil were of a thinner plate, we judge that by strong and continuous blows of the hammer it could grow red—like red-hot iron; but let this be tested by experiment.

[10] Bacon observed that repeated percussion produced heat, thereby intuiting the conversion of mechanical motion into thermal energy. This insight anticipated the modern recognition of the equivalence between mechanical work and heat, a principle later established in quantitative physics.

32. But in red-hot things that are porous, so that there is room for the exercise of the fire's motion, if such motion is restrained by strong

compression the fire is immediately extinguished; as when burnt linen, or a burning wick of a candle or lamp, or even a live coal or glowing ember is pressed by a presser, or trodden under foot, or the like—straightway the operations of the fire cease.

33. Approach to a hot body increases heat in proportion to the degree of approach; which also occurs in light—for the nearer an object is placed to the light, the more visible it is.

34. The union of different heats increases heat, unless there is admixture of the bodies. For a large hearth and a small hearth in the same place somewhat increase heat mutually; but tepid water poured into boiling water cools it.

35. The *duration* of a hot body increases heat. For heat that is continually passing and emanating is mingled with the pre-existing heat so as to multiply the heat. A fire does not heat a room in the space of half an hour as much as if the same fire were to last for a full hour. But *light* does not act thus; a lamp or candle placed in a spot does not illumine more by long continuance than it does immediately at the beginning.

36. Irritation by a cold surrounding increases heat; as is seen in fires during sharp frosts. We think this occurs not only by the *enclosure* and contraction of heat (which is a kind of union), but by *exasperation*; as when air or a stick is violently compressed or bent, it does not spring back merely to the prior point but beyond it to the contrary. Let a careful experiment therefore be made with a stick or something similar placed in a flame, whether it does not burn more quickly at the *sides* of the flame than in the *middle* of the flame.

37. There are many degrees in the *reception* of heat. And first of all it is to be noted how a small and slender heat nevertheless modifies and

somewhat warms even those bodies that are of all the least susceptible of heat. For the very heat of the hand, when a little ball of lead or some metal is held for a short time, warms it a little. Thus easily and in all things is heat transmitted and excited, with no apparent change in the body.

38. Of all bodies with us, *air* both receives and gives off heat most readily [11]; which is best seen in *calendar glasses* [12]. Their construction is as follows: take a glass with a hollow bulb and a neck thin and long; turn it over and lower it, mouth downward, belly upward, into another small glass vessel in which there is water, touching the bottom of that receiving vessel with the extreme mouth of the inserted glass, and let the neck of the inserted glass rest a little on the mouth of the receiving glass so that it can stand; to make this easier, a little wax may be applied to the mouth of the receiving glass—yet not so as entirely to stop its mouth, lest, for want of the succeeding air, the motion (of which we now speak)—very easy and delicate—be hindered. The inserted glass must, before it is put into the other, be heated at the fire on the upper part, that is, the bulb. After the glass has been placed as said, the air (which had been dilated by the heating) will, after a sufficient pause for the extinction of that adventitious heat, contract and gather itself to such an extension or dimension as will be that of the ambient or common air at the time when the glass is inserted; and it will draw the water upward to that measure. A narrow and long strip of paper should be attached and marked off with as many degrees as you please. You will see, as the weather of the day grows warmer or colder, the air contracting into narrower space by cold and expanding into wider space by heat; which will be seen by the water rising when the air contracts, and descending or being depressed when the air expands. The sense of the air, as regards hot and cold, is so subtle and exquisite as greatly to surpass the faculty of human touch; so that some sun-ray or the heat of breath—much more the heat of a hand—laid upon the summit of the glass immediately depresses the water

manifestly. Yet we think the *animal spirit* to have a sense of hot and cold yet more exquisite, except that it is hindered and dulled by the mass of the body.

[11] Bacon concluded from his thermometer experiment that air was highly responsive to heat and cold. Modern physics distinguishes sensitivity from conductivity: air is a poor conductor but a good convective medium. His inference was mistaken in mechanism but significant methodologically, since it drew attention to measurement of subtle variations.

[12] Bacon described the *vitrum calendare* as a glass instrument in which heated air expanded and contracted, raising or lowering water. He probably knew of it by report rather than experiment. The device closely resembled the air-thermoscope demonstrated by Galileo about 1593 and represented an early attempt to register temperature change through physical measurement. See also 2:12 [12].

39. After air, we judge those bodies to be most sensitive to heat which have been lately changed by cold and compressed—such as snow and ice; for these begin to be loosed and to melt with a slight warmth. After these perhaps follows quicksilver. After that follow fatty bodies—oil, butter, and the like; then wood; then water; lastly stones and metals, which are not easily heated, especially inwardly. Yet once they have taken on heat, they retain it the longest [13]; so that a brick or stone or red-hot iron, plunged and submerged in a basin of cold water, retains heat for about a quarter of an hour (more or less) so that it cannot be touched.

[13] This observation remained essentially correct. Bodies of high specific heat and density retain thermal energy longer than fluids or gases. Bacon's qualitative remarks anticipated later understanding of specific heat capacity, although he lacked quantitative means to confirm it.

40. The smaller the bulk of a body, the more quickly it is warmed by a hot body brought near; which shows that every heat among us is in some way adverse to a tangible body.

41. The hot, as regards human sense and touch, is a variable and relative thing; so that tepid water, if the hand is occupied with cold, is felt to be hot; but if the hand has been heated, cold [14].

[14] The *Table of Degrees* combined acute empirical notice with conceptual errors typical of early seventeenth-century physics. Bacon conceived heat as a species of local motion in the minute parts of matter—an intuition close to the modern kinetic view—but he relied on sensory gradation rather than numerical data. The enduring importance of this aphorism lies in its methodological innovation: it treated variation in degree as evidence of causal structure and thereby anticipated the comparative logic of modern experimental science.

II-XIV (2:14).

How impoverished we are in history [1] anyone may easily observe, since in the preceding tables, besides occasionally inserting traditions and reports in place of proven history and certain instances [2] (always, however, with a note attached indicating their doubtful credibility and authority), we are often compelled to use such expressions as "let an experiment be made" or "let further inquiry be conducted [3] [4]."

[1] Bacon referred here to the deficiency of *historia naturalis*, the empirical foundation required for true induction. In the early seventeenth century, organized collections of experimental observations scarcely existed. Bacon's remark served as an apology for the fragmentary state of his own data and as a declaration of method: he knew that the reform of philosophy must begin not from axioms but from an ample natural history. The statement also introduced the later project of *Historia Naturalis et Experimentalis*, which he planned as a systematic repository of factual instances.

[2] This admission showed Bacon's methodological integrity: he recognized that many of his examples were based on second-hand information or anecdote rather than direct experiment. In his time, natural histories—such as those of Pliny or Porta—often mixed observation with rumor. Bacon's practice of marking doubtful claims foreshadowed modern norms of source transparency and data qualification, in which uncertain findings are clearly separated from verified results.

[3] These formulae revealed Bacon's commitment to a cumulative and corrective science. He used them to flag gaps where empirical confirmation was lacking.

The phrases represented the early modern equivalent of today's call for replication or follow-up study. Bacon thus conceived science as a continuous process of testing and amendment, not a finished system of knowledge.

[4] The aphorism contained no specific natural examples, but its importance lay in Bacon's awareness that many of his earlier examples—from heat, metals, fermentation, or motion—rested on incomplete evidence. He recognized that the reliability of induction depended on the breadth and accuracy of observation, an insight consistent with present scientific methodology. His self-critique was therefore sound in principle, even if the data available to him were limited and often imprecise.

II-XV (2:15).

We have been accustomed to call the work and function of these three tables [1] the Comparison of Instances to the Intellect. Once the comparison has been made, Induction itself must be applied to the task. For it is necessary, based on the comparison of all and each of the instances, to discover a nature such that it is invariably present with the given nature [2], absent when it is absent, and increases or decreases alongside it; and which is (as was said above) a limitation of a more general nature. If the mind attempts to accomplish this affirmatively from the outset (as it is always accustomed to do when left to its own devices), phantasms, conjectures, ill-defined notions, and axioms in need of daily revision [3] will emerge—unless, in the fashion of the schools, one prefers to contend for falsehoods. Nevertheless, these products will doubtless be better or worse depending on the capacity and strength of the understanding engaged in the task. Yet it belongs properly to God (the Founder and Craftsman of Forms), or perhaps to angels and intelligences [4], to know Forms affirmatively and directly from the very beginning of contemplation. But surely this lies beyond man's reach; to him it is granted only to proceed first through negatives, and only in the final stage to arrive at affirmatives, [5] after a complete process of exclusion [6].

[1] Bacon referred to the *Table of Essence and Presence*, *Table of Absence in Proximity*, and *Table of Degrees or Comparison*. Together they represented the preliminary apparatus of his inductive method. Their collective "function" was to supply the material for the comparison of instances, the stage at which the intellect identifies patterns of agreement, difference, and variation. This procedure constituted the foundation of his *inductio legitima*—the "legitimate" or methodical induction that replaced simple enumeration.

[2] Here Bacon described the structure of causal inference. The sought-for "nature" (*natura talis*) had to co-vary perfectly with the phenomenon under study—present when it appeared, absent when it disappeared, and changing in degree along with it. This triadic condition parallels the modern criteria of necessary and sufficient causation and the logic of experimental control. Bacon thus formulated, in conceptual terms, what later became the basis of systematic empirical testing.

[3] Bacon warned that without disciplined exclusion, the mind generated speculative constructions rather than verified knowledge. His *phantasmata* and *coniecturae* correspond to what would now be called untested hypotheses or cognitive biases. The passage directly continues his critique of the *idola mentis* (cf. 1:38–44), identifying imagination as a principal source of scientific error.

[4] This theological image drew on scholastic doctrine, particularly the view that angelic intellects know by immediate intuition while humans learn successively through sensory experience. Bacon invoked this hierarchy not to theologize science but to underscore human epistemic limits: only divine intellect perceives *formae* directly, whereas human inquiry advances by exclusion and experiment.

[5] Bacon's *via negativa* defined the true inductive path: the investigator must first eliminate false candidates before affirming a cause. The method anticipated later experimental falsification and the use of controlled exclusion to refine hypotheses. It exemplified his broader conviction that progress in knowledge required systematic negation of error rather than immediate assertion of truth.

[6] Although this aphorism contained no direct natural examples, it presupposed the preceding empirical exercises, such as the "Table of Heat." Bacon recognized that his data were limited and often anecdotal, yet his method of elimination remained sound in principle. Modern science follows the same logic: causal understanding arises through iterative testing and rejection of hypotheses rather than through immediate insight. His claim that humans

know only “through negatives” reflects the enduring epistemological humility of empirical inquiry.

II-XVI (2:16).

Therefore, a complete resolution and separation of nature must be effected; not by fire, indeed, but by the mind, as by a kind of divine fire [1]. Thus, the first task of true induction (insofar as it pertains to the discovery of Forms) is the rejection or exclusion of individual natures [2], namely those which are not found in some instance where the given nature is present; or are found in some instance where the given nature is absent; or are found to increase in some instance when the given nature decreases; or to decrease when the given nature increases. Then indeed, after the rejection and exclusion have been properly carried out, there will remain in the second place (as at the bottom)—the volatile opinions having vanished into smoke [3]—an affirmative Form, solid, true, and well defined [4]. This is easily stated, but is reached only through many windings and difficulties [5]. Nevertheless, we shall perhaps omit nothing of the matters that contribute to this end [6].

[1] Bacon compared true induction to an intellectual distillation, adapting imagery from contemporary alchemy and metallurgy. In his period, chemical analysis by fire revealed the components of matter; Bacon transposed this into a mental process, the “fire of the mind” purifying thought. The phrase also carried a theological overtone: as divine creation separated light from darkness, so the intellect separates true forms from confusion. The image captured Bacon’s ambition to join empirical labor with contemplative discipline.

[2] This defined the operational core of Bacon’s inductive method. The investigator must eliminate any “nature” that fails to appear when the target phenomenon is present, that appears where it is absent, or that varies inversely with it. The procedure anticipated the experimental logic of controlled comparison, though Bacon conceived it as empirical elimination rather than formal falsification. Later philosophers identified the logical asymmetry between verification and refutation (cf. 1:46 [3]), but Bacon’s *exclusio* aimed not at refuting universal laws, rather at isolating the *simplicus* cause—a single, invariant relation

purified from composites. His emphasis lay in the methodical reduction of possibilities, not in the decisive disproof of hypotheses.

[3] The continuation of the metallurgical metaphor reinforced Bacon's ideal of intellectual purification. *Opinio volatilis* denoted speculation untested by experiment. Through the process of exclusion, such opinions were "burned away," leaving the stable residue of a verified form. The passage echoed his rejection of scholastic disputation and underscored that genuine knowledge arises only when experiment consumes conjecture.

[4] This described the goal of the inductive process: the affirmation that survives exhaustive elimination. Bacon conceived the *forma* as the real causal structure underlying a phenomenon—what would now be termed its necessary and sufficient condition. The *forma* corresponded conceptually to a *simplicus* theory: internally unified, irreducible, and empirically grounded. Although Bacon lacked mathematical formulation, his call for a "solid and well-defined" form anticipated later demands for precise and reproducible natural laws.

[5] Bacon acknowledged the practical intractability of exhaustive exclusion. His remark expressed both methodological humility and empirical realism: even with the best design, inquiry proceeds by successive approximation. Modern science addresses this difficulty through probabilistic inference and statistical control, but the principle remains the same—knowledge advances by iterative refinement, not by immediate intuition.

[6] The aphorism contained no direct natural examples, but its method was sound in principle. Bacon correctly perceived that reliable inference depends on eliminating incompatible causes. Yet his hope for total exclusion was unrealizable: plural causation and measurement limits prevent absolute certainty. His analogy of the "divine fire" nevertheless endures as a metaphor for the analytical rigor of science—truth achieved not by assertion but by the systematic combustion of error.

II-XVII (2:17).

It must be carefully guarded against and almost perpetually warned, lest, when so great a role seems to be assigned by us to Forms, the things we say be drawn toward those Forms to which the contemplations and thoughts of men have thus far been accustomed [1].

[1] Bacon warned against interpreting his formae as Platonic Ideas or scholastic essences. In the Aristotelian tradition, forma substantialis explained what a thing "was" rather than how it operated. Bacon inverted that relation: for him, a forma signified the operative law governing a nature's behavior. This rejection of abstraction marked a decisive step from metaphysical to empirical explanation.

For, first of all, we are not at present speaking of compound Forms, which are (as we have said) unions of simple natures according to the common course of the universe, such as the lion, the eagle, the rose, gold, and the like [2]. There will be a time to treat of these, when we come to the inquiry into Latent Processes and Latent Configurations, and their discovery, as they are found in what are called substances or concrete natures.

[2] Bacon here distinguished formae compositae—complex unions of several simple natures—from formae simplices, the fundamental properties like heat, color, or weight. His method pursued the latter because they were experimentally isolable. The study of "compound Forms" belonged to his projected investigations of Latent Processes and Latent Configurations—what would later approximate the study of microstructure and composition in modern chemistry and biology.

Again, what we say should not be understood—even in reference to simple natures—as concerning abstract Forms and ideas, either not determined in matter or ill-determined. For when we speak of Forms, we mean nothing else but those laws and determinations of pure act which arrange and constitute some simple nature, such as heat, light, or weight, in any and every kind of matter [3] and susceptible subject. Thus, the Form of Heat or the Form of Light is the same as the Law of Heat or the Law of Light [4]; nor do we ever abstract ourselves or withdraw from the things themselves and the operative part. Therefore, when we say (for example) in the inquiry into the Form of Heat, "reject rarity," or "rarity does not belong to the Form of Heat," it is the same as if we said, "man can superinduce heat upon a dense

body," or conversely, "man can remove or shut out heat from a rare body."

[3] This passage defined Bacon's mature concept of forma. A form was not an essence but a law of activity—a consistent pattern by which a nature (e.g., heat or light) manifests in diverse materials. The formulation prefigured the modern conception of natural law as an invariant regularity across systems. Bacon's phrase actus purus denoted energy in operation rather than metaphysical being.

[4] Bacon's identification of form with law marks one of his most forward-looking statements. It anticipates the modern nomological model of explanation, in which causal regularities unify apparently heterogeneous phenomena. His examples—heat, light, weight—represented attempts to locate functional invariants rather than substances. The analogy between form and law thus transformed metaphysical "essence" into empirical "rule."

But if anyone should think that even our Forms possess something of abstraction, in that they mix and unite heterogeneous elements (for the heat of heavenly bodies and of fire seem very heterogeneous; as does the fixed redness in a rose or similar things compared to the apparent redness in the rainbow or in the rays of the opal or diamond; and likewise death by drowning, burning, sword-thrust [5], apoplexy, or wasting disease; and yet these agree in the nature of heat, redness, or death), let him know that his mind is captive to custom and the gross integrity of things and to prevailing opinions. For it is most certain that these things, however heterogeneous and different, converge into a Form or Law that governs heat, redness, or death; and that human power cannot possibly be emancipated and liberated from the common course of nature, nor be expanded and elevated to new efficient causes and new modes of operation, except by the revelation and discovery of such Forms. Nevertheless, after this union of nature—which is the principal matter—discussion will follow in its proper place regarding the divisions and veins of nature, both ordinary and those more internal and true [6].

[5] Bacon's examples illustrated his belief in underlying unity across heterogeneous effects. Although the modern sciences of heat, optics, and physiology have shown these processes to differ in mechanism, his intuition of law-based unification was methodologically sound. His "Form of Heat" would later correspond to the law of energy transfer; his "Form of Redness," to optical wavelength; his "Form of Death," to systemic cessation of vital functions. These are valid as heuristic analogies, though not scientifically accurate in detail.

[6] The aphorism contained no direct experimental data but displayed exceptional methodological foresight. Bacon correctly recognized that explanation lies in discovering the common law underlying varied appearances. His examples were prescient in concept yet physiologically and physically unsound: celestial and terrestrial heat, or optical and biological "redness," arise from distinct mechanisms. Nonetheless, his principle of unity under law anticipated the integrative ambitions of later science—from Newtonian gravitation to unified field theory.

II-XVIII (2:18).

Now it is time to propose an example of the exclusion or rejection of natures [1] which, through the Tables of Comparison, are found not to belong to the Form of Heat; noting in the meantime that not only each table suffices for the rejection of some nature, but also each individual instance contained within them. For it is clear from what has been said that any contradictory instance destroys a conjecture concerning the Form. Nevertheless, sometimes for the sake of clarity, and in order to show more plainly the use of the tables, we duplicate or repeat the exclusion.

[1] This introduced the first practical application of *exclusio*, the central operation of Bacon's inductive method. Each "rejection" eliminates a putative cause inconsistent with the phenomenon of heat. The repetitive imperative ("By X, reject Y") illustrated the algorithmic logic of falsification: every contradictory instance invalidated a conjecture. Bacon's purpose was pedagogical—he demonstrated *how* reasoning proceeds through disciplined negation rather than discovery by intuition.

Example of the Exclusion or Rejection of Natures from the Form of Heat.

1. By the rays of the sun, reject elementary nature [2].

2. By common fire, and especially by subterranean fires (which are most remote from and largely cut off from the rays of the heavenly bodies), reject heavenly nature.
3. By the heating of all kinds of bodies (namely minerals, vegetables, the external parts of animals, water, oil, air, and the rest) merely through proximity to fire or another hot body, reject any variety or more delicate texture of bodies [3].
4. By iron and other metals when ignited, which heat other bodies yet are not at all diminished in weight or substance, reject the introduction or admixture of the substance of another hot body [4].
5. By boiling water and air, and even by metals and other solids heated without reaching ignition or redness, reject light and brightness.
6. By the rays of the moon and other stars (except the sun), also reject light and brightness.
7. By the comparison of red-hot iron and the flame of spirit of wine (of which the red-hot iron possesses more heat and less brightness, while the flame of spirit of wine possesses more brightness and less heat), also reject light and brightness.
8. By gold and other ignited metals, which are of the densest bodies overall, reject rarity [5].
9. By air, which is generally found cold yet remains rare, also reject rarity.
10. By red-hot iron, which does not swell in bulk but remains within the same visible dimensions, reject local or expansive motion of the whole.
11. By the expansion of air in calendrical glasses and similar instruments, where the air moves locally and expansively in a manifest manner yet does not show any manifest increase in heat, also reject local or expansive motion of the whole.
12. By the ease with which all bodies are warmed, without any destruction or noticeable alteration, reject destructive nature or the violent introduction of some new nature.

13. By the agreement and conformity of similar effects produced by heat and by cold, reject both expansive and contractive motion of the whole.

14. By the generation of heat from the friction of bodies, reject a principal nature. By principal nature we mean that which is found positively in nature and is not caused by some preceding nature.

[2] Here Bacon denied that heat arose from any *elementary* substance such as fire or earth. The distinction between *elementary* and *celestial* natures belonged to Aristotelian cosmology, which held that terrestrial and heavenly regions obeyed different laws. Bacon's rejection abolished this division and asserted the unity of natural law—a step that later physics confirmed. His language marked the transition from elemental to dynamical explanations of phenomena.

[3] Bacon recognized that heat occurs across bodies of widely differing texture and composition. This insight opposed the materialist notion that heat is a property of a particular substance. His observation anticipated the functional rather than substantial understanding of thermal phenomena. Although he lacked the kinetic theory of matter, the inference that heat depends on motion rather than texture was conceptually prescient.

[4] Bacon denied that heating involved the transfer of a material "hot substance"—a clear rejection of what would later be called the caloric theory. His remark that ignited metal loses no weight anticipated the later discovery that heat is not a fluid but a mode of motion. The mechanical equivalence of heat, later established by Rumford, Davy, and Joule, vindicated this methodological exclusion, though Bacon could not formalize it quantitatively.

[5] In Aristotelian physics, *rarity* and *density* explained thermal properties: heat was associated with tenuity. Bacon's rejection of rarity as the cause of heat was correct in substance, though he overlooked that metals expand upon heating. His reasoning nonetheless moved science toward recognizing internal motion rather than bulk expansion as the source of heat. The example shows both his empirical acuity and his instrumental limitations.

There are also other natures; for we do not compose perfect tables here, but only examples.

All the aforesaid natures are not of the Form of Heat. And from all the aforesaid natures, man is freed in his operation upon Heat [6].

[6] Several of Bacon's specific exclusions were scientifically sound in principle if not in detail. He rightly opposed the caloric and elemental explanations of heat and perceived that friction could generate heat, anticipating the kinetic model. Yet he erred in claiming that heated metals did not expand and that air could move "locally and expansively" without heating. His procedure, however, remained exemplary: the methodical elimination of incompatible hypotheses through experiment—the foundation of modern empirical reasoning.

II-XIX (2:19).

Thus, in the process of exclusion are laid the foundations of true induction [1], which, however, is not completed until it is brought to an affirmation. Nor indeed is the exclusion itself in any way complete, nor can it be so at the outset [2]. For exclusion (as is plainly evident) is the rejection of simple natures. But if we do not yet possess good and true notions of simple natures [3], how can exclusion be properly corrected? Now some of the aforementioned notions (such as the notion of an elementary nature, the notion of a heavenly nature, the notion of rarity) are vague and not well defined. Therefore, we, who are neither ignorant nor forgetful of the magnitude of the task we have undertaken (namely, to make the human understanding a match for things and nature [4]), by no means rest content with the precepts we have thus far laid down; rather, we carry the matter further, and devise and furnish stronger aids for the use of the intellect [5], which we shall now subjoin. And certainly, in the interpretation of nature, the mind must be so prepared and formed that it both maintains itself at the proper stages of certainty, and yet considers (especially at the beginning) that the things now present depend greatly upon those that remain to be discovered [6].

[1] This statement defined *exclusio* as the formal starting point of induction, not its completion. Bacon distinguished between the negative phase—eliminating incompatible "natures"—and the affirmative phase, where the surviving relation becomes a verified *forma*. The distinction anticipated the modern sequence of hypothesis rejection followed by model confirmation.

[2] Bacon here acknowledged the provisional and progressive nature of inquiry. Exclusion can never be perfect at the beginning because every rejection depends on the accuracy of the "simple natures" employed. This admission of incompleteness stands as one of the earliest recognitions of epistemic fallibilism—the principle that scientific knowledge advances through successive correction rather than absolute certainty.

[3] By *simple natures*, Bacon meant fundamental properties such as heat, color, weight, or motion. His warning that such notions were "vague and not well defined" indicated that language and concept must evolve alongside observation. This recursive relation between empirical discovery and conceptual refinement foreshadowed the mutual dependence of data and theory in modern science.

[4] This phrase encapsulated the epistemological ambition of the *Instauratio Magna*: not merely to accumulate facts but to reform the intellect itself. Bacon's ideal of a disciplined understanding prefigured the later view of scientific cognition as an instrumental system—an adaptive tool honed by method, rather than a passive faculty. The phrase also revealed Bacon's confidence that method could transform human capacity, aligning thought with the structure of reality.

[5] This transition announced the next stage of the *Novum Organum*: the *adminicula intellectus* ("aids to the intellect"). These were intended to supplement natural reasoning through structured techniques—tables, exclusions, comparisons, and interpretive rules. They anticipate what would now be called methodological scaffolds: tools that extend human cognitive reach, much as scientific instruments extend sensory reach.

[6] The aphorism contained no direct experimental claims but remained methodologically sound. Bacon correctly perceived that reliable science depends on the interdependence of conceptual precision and empirical adequacy. His assertion that notions must be revised with experience anticipated the self-corrective nature of modern scientific method. The absence of concrete examples here is deliberate: Bacon suspended observation to address the epistemic conditions of observation itself.

II-XX (2:20).

Nevertheless, because truth emerges more quickly from error than from confusion [1], we consider it useful that permission be granted to the intellect, after the three Tables of First Comparison (such as we have set forth) have been constructed and weighed, to ready itself and to attempt the work of interpreting nature affirmatively, drawing upon the instances from the tables as well as others that may occur elsewhere. This kind of attempt we have been accustomed to call the Permission of the Intellect, or the Commencement of Interpretation, or the First Vintage.

[1] Bacon here justified a controlled use of conjecture in inquiry (*permissio intellectus*). This marked a methodological innovation: after constructing the *Tables of Comparison*, he allowed the intellect to form a provisional hypothesis, which would then be tested through successive exclusions and new experiments. Some later interpreters have noted that this *vindemiatio prima* ("first vintage") foreshadows the hypothetico-deductive structure of modern scientific reasoning, even though Bacon himself described it only as a cautious "permission" rather than a formalized method.

First Vintage concerning the Form of Heat [2].

It must be observed that the Form of a thing (as plainly follows from what has been said) is present in all and each of the instances in which the thing itself is present; otherwise it would not be the Form: thus, no contradictory instance can possibly exist. Nevertheless, the Form is found to be much more conspicuous and evident in some instances than in others—namely in those where the nature of the Form is less restrained, hindered, or reduced to order by other natures. Instances of this kind we have been accustomed to call Elucidations or Ostensive Instances. We must therefore proceed to the actual First Vintage concerning the Form of Heat.

[2] *Forma* (form) denoted for Bacon not the shape or visible configuration of a body but its law of operation—the universal condition underlying all instances

of a phenomenon. The *forma calidi* thus meant the constant motion or process that constituted "heat" in every case, functioning conceptually as a precursor to a law of nature.

Across all and each of the instances, the nature whose limitation is Heat appears to be Motion [3]. This is most clearly shown in flame, which is in constant motion [4]; and in boiling or bubbling liquids, which are likewise continually moving. It is also shown in the increase or excitation of heat through motion, as in bellows and winds (see Instance 29, Table 3), and similarly in other kinds of motion (see Instances 28 and 31, Table 3). Again, it is shown by the extinction of fire and heat through strong compression [5], which restrains and causes motion to cease (see Instances 30 and 32, Table 3). It is further demonstrated by the fact that every body is destroyed, or at least significantly altered, by any strong and vehement fire and heat; from which it is evident that heat produces a tumult, perturbation, and violent motion in the internal parts of a body, gradually leading toward dissolution.

[3] Bacon proposed that heat is motion (calor est motus), thereby rejecting the Aristotelian notion of heat as a primary quality. This intuition prefigured the kinetic theory of heat, later developed by Rumford and Joule, though Bacon lacked empirical means to confirm it.

[4] Bacon accurately observed that visible flames and boiling liquids involved continual motion; however, he interpreted this motion as the *essence* of heat rather than a symptom of energy transfer. Modern thermodynamics distinguishes the molecular agitation causing heat from its macroscopic manifestations.

[5] Bacon inferred that compression extinguished heat by "restraining motion." Modern physics shows that compression can in fact increase temperature when it raises molecular energy (as in adiabatic heating). His inference illustrates the limits of observation without quantitative measurement.

What we have said concerning Motion (namely, that it stands as the genus in relation to Heat) must be understood not as if heat generates

motion, or motion generates heat (although these are true in some cases), but that Heat itself—its very essence—is motion and nothing else [6]; though limited by certain differences which we shall presently add, after appending a few cautions to avoid ambiguity.

[6] This statement anticipated the modern principle of the mechanical equivalence of heat, though Bacon conceived the relationship qualitatively rather than energetically. The identification of heat with motion rather than substance opposed the later *caloric* theory.

Sensible heat is a relative phenomenon [7], having reference to man and not to the universe; and it is rightly regarded as merely the effect of heat upon the animal spirits. Moreover, it is itself variable, for the same body, depending on the disposition of the senses, can induce the perception of either heat or cold, as is evident from Instance 41, Table 3.

[7] Bacon distinguished the *heat in itself* (*calor per se*) from *heat as perceived* (*calidum ad sensum*), asserting that the latter depended on the human sensorium. This early recognition of subjective variability in sensation prefigures modern psychophysical accounts of perception.

Nor should the communication of heat, or its transitive nature by which a body adjacent to a hot body becomes heated, be confused with the Form of Heat [8]. For heat and the property of heating are distinct. Heat can be generated by the motion of friction without any preceding hot body, which excludes heating from the Form of Heat. Even when heat is produced by proximity to a hot body, this effect does not proceed from the Form of Heat itself, but wholly depends upon a higher and more general nature—namely, the nature of assimilation or self-multiplication, concerning which a separate inquiry must be conducted.

[8] By separating the act of heating from the nature of heat itself, Bacon approached the modern distinction between energy transfer (heating) and energy state (temperature). He erred, however, in denying any causal link between heat transmission and the *forma calidi*.

The common notion of *fire* is vulgar and of no worth; for it is composed from the concurrence of the *hot* and the *luminous* in some body—as in ordinary flame and in bodies heated until they glow.

Removing, therefore, all equivocation, we must at length come to the true *differences* which delimit motion and constitute it into the *form* of the *hot*.

> The **first difference** is this: that *heat* is an *expansive motion*, by which a body strives to dilate itself [9] and to take up a larger sphere or dimension than it had previously occupied. This difference shows itself most clearly in flame, where smoke or a fatty vapor is plainly dilated and opens out into flame.
>
> [9] Bacon defined heat as an expansive motion restrained and struggling through the parts. This description aligns qualitatively with molecular expansion in thermal increase but lacks the concept of energy conservation or pressure-volume work. It nevertheless represents a seminal intuition of microscopic motion as the cause of thermal phenomena.
>
> It is shown also in every boiling liquid, which manifestly swells, rises up, and emits bubbles, and urges on the process of expanding itself until it is turned into a body far more extended and dilated than the liquid itself—namely into vapor or smoke or air.
>
> It is shown also in every wood and combustible matter, where at times there is an exudation, but there is always an evaporation.
>
> It is shown also in the melting of metals, which (since they are of a most compact body) do not easily swell and dilate themselves; yet their *spirit*—after it has been dilated within itself and thus has come to desire a larger dilation—positively

drives and urges the grosser parts into a liquid state. And if the heat is further intensified, it dissolves much of those parts and turns it into something volatile.

It is shown also in iron or stones: although they do not melt or run, nevertheless they are softened; the same happens with rods of wood, which, when warmed a little in hot ashes, become flexible.

This motion is seen best of all in *air*, which by a very small heat dilates itself continually and manifestly (see Inst. 38, Table 3).

It is shown also in the contrary nature of the *cold* [10]. For every cold contracts a body and forces it into a narrower space; so that in intense colds nails fall out of walls, bronzes split, and glass that has been warmed and then suddenly placed in the cold cracks and breaks. Likewise air, upon slight refrigeration, withdraws into a narrower space (see Inst. 38, Table 3). But these points will be treated more fully in the *Inquiry on the Cold*.

[10] Bacon conceived cold as the opposite motion—a contracting and coalescing tendency. This binary model (expansion vs. contraction) preserved Aristotelian symmetry but failed to account for anomalous substances like water, which expands when freezing.

Nor is it a wonder if the *hot* and the *cold* produce many actions in common (see Inst. 32, Table 2), since there are two of the differences that follow (of which we shall presently speak) that belong to either nature; although in the present difference of which we now speak the actions are diametrically opposed. For the *hot* gives an expansive and dilating motion, while the *cold* gives a contracting and coalescing motion.

The **second difference** is a modification of the former, namely this: that *heat* is an expansive motion—*toward the circumference*—yet under this law, that the body is at the same time carried *upward* [11]. There is no doubt that several motions are mixed together. For example, an arrow or dart both advances while it rotates, and rotates while it advances. In like manner the motion of heat is at once expansive and a carrying upward.

[11] Bacon attributed the upward movement of heat to the nature of *motus expansivus ascendens*. In modern terms, this describes convection currents, where heated fluids rise due to decreased density. Although he lacked the quantitative concept, his observation accurately reflects this physical behavior.

This difference is shown in a pair of tongs or an iron rod placed in the fire: for if it is put in perpendicularly, the hand being held above, it quickly burns the hand; but if from the side or from below, it burns more slowly.

It is conspicuous also in *descending* stills, used for the more delicate floral extracts whose odors easily vanish. For the art has discovered this—that the fire be set not beneath but above, so that it may scorch less. For not only the flame inclines upward, but every hot body [12].

[12] His claim that "every hot body" inclines upward is metaphorical: heat itself does not move upward, but heated air does. Bacon's generalization mixed observation with analogy, reflecting early modern limitations in distinguishing motion of matter from motion of energy.

Let an experiment of this be made in the contrary nature of the *cold*: namely, whether cold does not contract a body by descending downward, just as heat dilates a body by ascending upward. Accordingly take two iron rods, or two glass tubes, alike in all other respects, and warm them a little; place a sponge with cold water, or snow, beneath one, and in like manner above the

other. We judge that the refrigeration will be quicker at the extremities in that rod where the snow is placed above than in that where the snow is placed below—the reverse of what occurs in the case of heat.

The **third difference** is this: that *heat* is not a uniformly expansive motion throughout the whole [13], but an expansion *by the smaller particles* of the body; and at the same time it is confined and repelled and driven back, so that it takes on an alternating motion—perpetually trembling, essaying, striving, and, by repercussion, exasperated; whence that fury of fire and heat has its origin.

[13] Bacon's *motus perpetuo tremens* ("perpetually trembling motion") closely anticipates the modern understanding of vibrational or oscillatory motion in particles. His description of "minute pores pricking and stinging" parallels later notions of molecular agitation producing heat.

This difference is shown most of all in flame and boiling liquids, which are perpetually trembling, and in small portions swell and then again subside.

It is shown also in those bodies whose texture is so hard that, though heated or red-hot, they do not swell or dilate in bulk—as in red-hot iron, in which the heat is most sharp.

It is shown also in this, that in the coldest weather the hearth/fire burns most sharply.

It is shown also in this, that when air is expanded in the calendar glass [14] without impediment or repulse—uniformly and evenly—it is not perceived as hot. Likewise in confined winds, although they burst forth with the greatest force, no notable heat is perceived; for the motion proceeds according to the

whole [15], without alternating motion in the particles. And to this end let an experiment be made whether flame does not burn more keenly toward its sides than in the middle of the flame.

[14] Bacon's reference to the *calendar glass* describes an early air thermometer, which demonstrated that air expands when heated. His interpretation was limited by qualitative observation, but the device itself was crucial for later quantitative thermometry.

[15] Bacon's claim that uniform expansion produces no heat anticipates the distinction between macroscopic displacement and microscopic agitation—only the latter corresponds to temperature. This is a remarkable conceptual advance given the period.

It is shown also in this, that every burning is accomplished through the minute pores of the body that is burned; so that burning undermines and penetrates and pricks and stings, as if there were an infinite number of needle-points. Hence also it comes about that all *strong waters* (if they are proportioned to the body on which they act) by their native corrosive and pungent nature perform the works of fire.

And this difference (of which we now speak) is common to the nature of the *cold* as well; in which the contracting motion is confined by a resistance to expansion, just as in the *hot* the expansive motion is confined by a resistance to contraction.

Accordingly, whether the parts of the body penetrate inward or penetrate outward, the account is similar—although the strength is very unequal; for here with us on the earth's surface we have nothing that is exceedingly cold. See Inst. 27, Table 9.

The **fourth difference** is a modification of the former; namely, that this motion of stimulation or penetration must be somewhat *rapid* and by no means sluggish; and it is effected

indeed through particles, though small, yet not to the extreme of subtlety, but, as it were, somewhat larger.

This difference is shown in a comparison of the works that fire brings about with those that *time* or *age* brings about. For age or time dries, consumes, undermines, and turns into ash no less than fire—or rather far more subtly; but because its motion is very slow and proceeds through exceedingly fine particles, no heat is perceived.

It is shown also in a comparison between the dissolutions of iron and of gold. Gold is dissolved without an excited heat; iron, with a vehement excitation of heat, although the interval as to time is nearly the same. For in gold the entry of the separating water is gentle and insinuates itself subtly, and the yielding of the parts of the gold is easy; but in iron the entry is harsh and attended with conflict, and the parts of iron have greater stubbornness.

It is shown also, in some measure, in certain gangrenes and mortifications of the flesh, which do not excite great heat or pain on account of the subtlety of the putrefaction.

Let this then be the First Vintage, or the begun Interpretation of the Form of the Hot, made by permission of the understanding.

From this First Vintage, the true form or definition of heat (that which is in the order of the universe, not merely relative to sense) is of this kind, in brief compass of words: Heat is an expansive motion, confined, and striving through the smaller parts [16]. The expansion is modified so that, while expanding into the surrounding space, it nevertheless inclines somewhat toward the upper regions. And that striving through the parts is also modified, so that it be not wholly sluggish, but urged on and with a certain impetuosity.

[16] This concise formula encapsulates Bacon's *forma calidi*. Modern physics defines heat as the transfer of energy due to temperature difference, but at the molecular level, temperature correlates with the average kinetic energy of particles—conceptually close to Bacon's "expansive motion confined within parts."

As concerns *operation*, the same account holds. The designation is as follows: If in some natural body you can excite a motion to dilate or expand itself, and can so check and turn back that motion upon itself that the dilation does not proceed uniformly, but partly prevails and is partly thrust back, you will undoubtedly generate the hot [17]—no regard being had whether the body be *elemental* (as men speak), or imbued by the heavenly bodies; whether *luminous* or *opaque*; whether *tenuous* or *dense*; whether expanded locally or contained within the bounds of its original dimension; whether tending to dissolution or remaining in its state; whether animal, vegetable, mineral, water, oil, air, or any other substance whatsoever receptive of the motion aforesaid. The *hot to sense* is the same thing, but with that kind of *reference to sense* that belongs to the nature of perception. Now we must proceed to further aids.

[17] Bacon concluded that true knowledge consists in the ability to reproduce a natural effect—a principle later foundational in experimental science. His causal reasoning thus unites *scientia* and *potestas* ("knowledge and power") in operational form.

II-XXI (2:21).

After the tables of first comparison, and the rejection or exclusion, as well as the **first vintage** made according to them, we must proceed to the remaining aids to the intellect concerning the interpretation of nature and true and perfect induction [1]. In presenting these, when tables are necessary, we shall proceed with the instances of heat and cold [2]; but where only a few examples are required, we shall proceed

by means of all other matters, so that the investigation is not confused, and yet the doctrine may range less narrowly.

[1] Bacon's phrase means "aids to the intellect." It designates methodological instruments designed to compensate for the weakness and partiality of human understanding. This concept anticipates the modern notion of epistemic tools or methodological scaffolds, by which reasoning is extended through systematic procedures.

[2] Bacon proposed to continue using heat and cold as test cases for his method. Only the discussion of heat was ever developed. The reference here signals that the example of heat was meant as a didactic model, not a singular subject of inquiry.

We shall therefore treat, in the first place, of the prerogative instances [3]; in the second, of the supports of induction [4]; in the third, of the rectification of induction [5]; in the fourth, of the variation of the investigation according to the nature of the subject [6]; in the fifth, of the prerogatives of natures as they pertain to investigation [7], or of that which ought to be inquired into first and later; in the sixth, of the limits of the investigation, or a synopsis of all natures in the universe [8]; in the seventh, of the deduction to practice, or of that which concerns man [9]; in the eighth, of preparations for investigation [10]; and finally, of the ascending and descending scale of axioms [11].

[3] The term derives from the *centuria praerogativa* in the Roman *Comitia Centuriata*, the first voting division whose verdict influenced the rest. Bacon used it metaphorically to name privileged or decisive experiments—observations that possess logical priority because they reveal causal relations most clearly. This principle anticipates the modern idea of crucial experiments (*experimenta crucis*).

[4] This category referred to methods or instruments for strengthening inductive reasoning, such as comparative analysis, measurement, and repetition. Bacon saw these as procedural guarantees against hasty generalization, corresponding in modern science to controls, replications, and statistical checks.

[5] Bacon here anticipated the self-corrective function of science: the continual revision of hypotheses as new data appear. This notion parallels modern error correction and falsification in empirical research. It marks a clear departure from Aristotelian induction as final and complete.

[6] Bacon planned to develop rules for adjusting method to different fields—astronomy, biology, psychology—recognizing that no single method fits all phenomena. This pluralism aligns with the present-day view that sciences vary by domain, scale, and instrument.

[7] Distinct from the *praerogativae instantiarum*, this phrase referred to hierarchies among natural kinds—some being more fundamental or explanatory than others. Bacon sought to identify which "natures" should be investigated first, anticipating modern research prioritization and foundational hierarchies in physics and chemistry.

[8] Bacon intended an encyclopedic catalogue of "all simple natures," effectively a taxonomy of phenomena forming the boundary of human inquiry. This foreshadowed the later ambition of universal classification in the *Encyclopédie* and the systematic sciences of the nineteenth century.

[9] This section would have connected discovery to utility—the transformation of knowledge into technological power. The phrase enacts Bacon's maxim *scientia propter potentiam* ("knowledge for the sake of power"). It anticipates the modern expectation that scientific theory yields practical innovation.

[10] Bacon's term *parasceve* ("preparation") denotes the accumulation of data, instruments, and experimental materials before systematic induction. His separate tract *Parasceve ad Historiam Naturalem* (1620) already began this project. It parallels today's research infrastructure and data preparation stages.

[11] Bacon conceived knowledge as hierarchical: observation leads upward to general axioms (*via ascendens*), which in turn descend to new predictions and works (*via descendens*). This dynamic mirrors the structure of modern theoretical modeling, in which empirical laws and general theories interact reciprocally.

II-XXII (2:22).

Among the prerogative instances, we shall first set forth the solitary instances [1]. These are called solitary which display the nature under investigation in subjects that have nothing in common with other

subjects except for that very nature; or conversely, which do not display the nature under investigation in subjects that are otherwise similar in all respects to other subjects, except in that very nature. For it is clear that instances of this kind eliminate digressions, and hasten and strengthen the process of exclusion—so much so that a few of them are equivalent to many [2].

[1] Bacon began his list of twenty-seven *praerogativae instantiarum* ("privileged instances") with the *solitary* cases—observations that isolate a nature by presence or absence. They serve as the first step in the process of exclusion, eliminating irrelevant conditions and clarifying causal connection. Their function corresponds to the logic later formalized as the *Methods of Agreement and Difference*.

[2] This remark introduces Bacon's principle of epistemic efficiency: a single decisive case may equal many ordinary ones. The same rationale underlies modern experimental design and control of variables, where carefully chosen comparisons yield maximal information.

For example, if an inquiry be made into the nature of color, solitary instances are prisms, crystalline gems, which produce colors not only within themselves but also outwardly upon a wall, along with dews, and so forth [3]. For these have nothing in common with the fixed colors found in flowers, colored gems, metals, woods, and the like, apart from the color itself. Whence it is easily inferred that color is nothing other than a modification of the image of light, admitted and received: in the former kind, by various degrees of incidence; in the latter, by the diverse textures and configurations of the body. These are solitary instances with respect to resemblance.

[3] Bacon used optical phenomena—prisms, dews, and transparent stones—to illustrate *solitary instances by resemblance*. Drawing on ideas from Telesius (*De rerum natura*, vii.31), he argued that color arises from a modification of light's image, not from any inherent form in bodies. Though pre-Newtonian and qualitative, this insight moved decisively away from scholastic notions of substantial color toward a relational, optical explanation.

Again, in the same inquiry, distinct veins of white and black in marbles, and color variations in flowers of the same species, are solitary instances [4]. For the white and black in marble, and the patches of white and purple in carnations, agree in almost everything except the color itself. Whence it is easily inferred that color has little to do with the intrinsic natures of any body, but is rather situated in the grosser and, as it were, mechanical arrangement of the parts. These are solitary instances with respect to difference. We are accustomed to call both types solitary instances—or ferine, borrowing the term from the astronomers [5].

[4] These examples illustrate *solitary instances by difference*—cases otherwise alike except for the investigated nature. Bacon inferred that color depends on surface structure rather than the body's substance. The comparison anticipates the contrastive logic of modern causal inference and, in experimental terms, the *control group*.

[5] Bacon's phrase derives from the Latin *feralis* used by astrologers for a planet "wild" or "unassociated," i.e. standing alone without aspect to others. He applied it metaphorically to isolated phenomena, unconnected with others except by the nature under study.

II-XXIII (2:23).

Among the prerogative instances, we shall place in the **second position** the Migrating Instances [1]. These are those in which the nature under investigation migrates toward generation, when it previously did not exist; or conversely, migrates toward corruption, when it previously did exist. Thus, in both forms of transition, such instances are always twin; or rather, they consist of one instance in motion or transition, carried through to the opposing terminus. Now, instances of this kind not only accelerate and reinforce exclusion, but also constrain affirmation—or the very form itself—within a narrow compass. For it is necessary that the form of a thing be something that is introduced through such a migration, or on the contrary, is removed and destroyed by such a

migration. And although every exclusion promotes the affirmative, yet this occurs more directly within the same subject than across different ones. The form, however—as is plainly evident from everything previously said—when it reveals itself in one instance, leads onward to all others. And the simpler the migration, the more valuable the instance must be held. Moreover, Migrating Instances are of great utility for the operative part; for since they present the form conjoined with the efficient or privative cause, they clearly indicate practical applicability in certain cases, from which a passage to nearby cases is also made easier. Yet there is in these instances some degree of danger, which requires caution—namely, that the form may be too closely tied to the efficient cause, and the understanding thereby clouded or at least superficially touched by a false notion of the form drawn from the appearance of the efficient cause [2]. But the efficient cause is always assumed to be nothing other than the vehicle or bearer of the form [3]. Yet this danger may readily be countered by means of a legitimate application of exclusion.

[1] Bacon used *instantiae migrantes* ("instances in migration") to describe cases in which a given nature appeared or disappeared. The term derived from *migrare* ("to move, to pass") and extended the Aristotelian notions of *generatio* and *corruptio* to observable physical transitions. In this context, such instances illustrated moments of change that revealed the conditions under which a form emerged or vanished.

[2] Bacon warned that the intellect might mistake the *forma* for the *causa efficiens* (efficient cause) when the two appeared together. He regarded this as a methodological hazard, since the efficient cause merely conveyed or manifested the form, not the form itself. This distinction anticipates the modern separation between correlation and causation in experimental reasoning.

[3] In Bacon's phrase *causa efficiens est vehiculum formae* ("the efficient cause is the vehicle of the form"), the efficient cause served as the means through which the form was introduced into matter. He made the same claim in *De augmentis scientiarum* III.4. In modern terms, the efficient cause is treated as the operative condition that reveals, but does not constitute, the underlying law or relation.

An example of a Migrating Instance must now be proposed. Let the nature under investigation be whiteness. A migrating instance toward generation is found in whole glass and pounded glass; likewise, in plain water and water stirred into foam. For whole glass and plain water are transparent, not white; whereas pounded glass and foaming water are white, not transparent. Therefore, we must inquire what has occurred in this migration in the case of the glass or the water. It is clear that the form of whiteness is carried and introduced by the breaking of the glass and the agitation of the water. Nothing appears to have been added, except the fragmentation of the glass and water and the insertion of air. And it is not a small advance in the discovery of the form of whiteness that two bodies, which are in themselves transparent but to varying degrees (namely air and water, or air and glass), when placed together in minute portions, exhibit whiteness through the unequal refraction of light rays [4].

[4] Bacon explained whiteness as produced by the “unequal refraction of light” when air mixed with transparent materials such as glass or water. His account was partly correct: whiteness in foams and pounded glass arises from the scattering of light at numerous air–liquid or air–solid boundaries. Modern optics attributes the effect to Mie scattering, not to unequal refraction. Bacon also correctly observed that whiteness disappeared when air was removed, as in melting snow.

But in this matter, an example of the danger and the caution already mentioned must also be set forth. For the understanding, if misled by such efficient causes, may too easily suppose that air is always required for the form of whiteness, or that whiteness is generated only by transparent bodies—both of which are completely false, and have been refuted by numerous exclusions. On the contrary, it will become evident (setting aside air and such factors) that bodies which are optically uniform in their parts yield transparency; bodies which are non-uniform with a simple texture yield whiteness; bodies non-uniform with a compound but ordered texture yield the remaining

colors (except black); and bodies non-uniform with a compound texture that is wholly disordered and confused yield blackness [5]. Thus, an example has now been given of a Migrating Instance toward generation in the nature under investigation, namely whiteness. But a migrating instance toward corruption in the same nature of whiteness is found in dissolving foam or melting snow. For the water, once it returns to its integral state without air, puts off whiteness and assumes transparency.

[5] Bacon held that optical qualities depended on the texture of matter: uniform bodies yielded transparency; simple non-uniformity produced whiteness; ordered compound non-uniformity produced color; and confused compound non-uniformity produced blackness. Though speculative, this view shifted the explanation of color from inherent qualities to microstructural arrangement. Modern optics interprets this as an early intuition of structural color.

Nor should it by any means be omitted that under the category of Migrating Instances must be included not only those which migrate toward generation and privation, but also those which migrate toward increase and decrease [6]; for these likewise contribute to the discovery of the form, as is clearly evident from the earlier definition of form and the Table of Degrees. Thus, paper, which when dry is white, becomes less white and tends more toward transparency when moistened (with air excluded and water received), and stands in similar relation to the instances mentioned above.

[6] When Bacon extended "migration" to cases of increase and decrease, he acknowledged that natures could vary continuously rather than appear or vanish abruptly. This reflected his adherence to the maxim *natura non agit per saltum* ("nature does not act by leaps"), a view that anticipated later principles of continuity in natural science.

II-XXIV (2:24).

Among the prerogative instances, we shall place in the **third position** the Ostensive Instances [1], which we mentioned in the First Vintage on

Heat, and which we are also accustomed to call *Elucidations*, or *Liberated and Predominant Instances*. These are those which display the nature under investigation as bare and substantial, and also in its exaltation or highest degree of power—namely, as emancipated and freed from impediments, or at least, through the strength of its own virtue, dominant over them, suppressing and restraining them. For since every body receives many forms of natures joined together in the concrete, it results that one form blunts, suppresses, breaks, and binds another; hence, individual forms are obscured. Yet there are certain subjects in which the nature under investigation appears in greater vigor than in others—either because of the absence of impediments or the predominance of its force. Instances of this kind are especially ostensive of the form. Nevertheless, even in these very instances, caution must be exercised, and the impulse of the understanding must be restrained. For whatever parades the form and pushes it forward, so that it seems to offer itself to the intellect, must be regarded with suspicion, and one must turn back to a strict and diligent exclusion [2].

[1] Bacon used *instantiae ostensivae* ("ostensive instances") to denote cases that displayed a nature in its pure or dominant form. He also called them *instantiae elucidae* ("elucidations") and *instantiae liberatae et praedominantes* ("liberated and predominant instances"). All three expressions emphasized the manifestation of a form freed from impediments.

[2] Bacon warned that the intellect might be deceived by conspicuous examples that seem to reveal the form too clearly. He regarded such instances as useful but potentially misleading, since prominence could substitute for proof. This warning anticipated later concerns about salience bias and the need for systematic exclusion before affirmation.

For example, let the nature under investigation be heat. An Ostensive Instance of the motion of expansion—which (as stated above) is the principal component of the form of heat—is the calendar glass of air [3]. For although flame manifestly exhibits expansion, its momentary extinction prevents it from showing the progress of expansion. Boiling water too, because of the easy transition of water into vapor and air,

does not show the expansion of the water within its own body as clearly. Again, ignited iron and similar bodies are so far from showing such progression that, on the contrary, due to the dulling and breaking of the spirit by the compact and dense parts (which tame and restrain the expansion), the expansion itself is not perceptible to the senses at all. But the calendar glass clearly shows expansion in air, and in a way that is visible, progressive, enduring, and not transient [4].

[3] The *vitrum calendare* was an early air thermometer that demonstrated the expansion of air when heated. Bacon regarded it as an "ostensive instance" of *motus expansivus* ("motion of expansion"), the principal component of the form of heat. His interpretation aligned with the kinetic idea that heat involved expansion, though he lacked a molecular model.

[4] Bacon correctly identified the expansion of air under heat, but he misread its mechanics. The *vitrum calendare* indeed demonstrated thermal expansion, yet the quantitative relation between temperature and volume was not established until the work of Boyle and Mariotte in the seventeenth century, and later Charles. His qualitative inference—that heat involved expansive motion—remains valid in modern thermodynamics.

Again, for example, let the nature under investigation be weight. An Ostensive Instance of weight is quicksilver. It surpasses all other bodies in weight by a large margin, except gold, which is only slightly heavier. Yet quicksilver is a more excellent instance for indicating the form of weight than gold; for gold is solid and consistent, a kind of body that appears to relate to density. But quicksilver is liquid and swollen with spirit, and yet it surpasses diamond and those substances thought to be the most solid by many degrees in heaviness. From this it is shown that the form of heaviness or weight resides simply in the quantity of matter, and not in close compactness [5] [6].

[5] Bacon chose quicksilver (mercury) as an *Ostensive Instance* of weight because it was heavy yet fluid. He concluded that heaviness depended on the "quantity of matter" rather than compactness. His experimental ratio of gold to mercury was inaccurate, but his conceptual inference anticipated the modern definition of mass as proportional to the quantity of matter.

[6] Bacon's notion that a form should be sought "freed from impediments" corresponds to the modern practice of isolating variables in controlled experiments. His principle remains foundational in the design of model systems in the natural sciences.

II-XXV (2:25).

Among the prerogative instances, we place in the **fourth position** the *Clandestine Instances*, which we are also accustomed to call *Twilight Instances* [1]. These are, as it were, opposed to the *Ostensive Instances*. For they exhibit the nature under investigation in a weak degree, as if in its cradle and rudiments—attempting and, as it were, making its first trial—yet hidden beneath and subdued by a contrary nature. Such instances are, however, of the highest importance for discovering forms; for just as ostensive instances easily lead to differences, so clandestine ones lead most effectively to genera [2]—that is, to those common natures of which the natures under investigation are nothing other than limitations.

[1] Bacon used *instantiae clandestinae* ("hidden instances") and *instantiae crepusculi* ("twilight instances") for cases where a nature appeared faintly, "as if in its cradle." The terms opposed the *instantiae ostensivae* ("ostensive instances") of 2:24, which showed a nature in full clarity. Both expressions reflected Bacon's figurative lexicon of *light* and *birth*, where knowledge advanced from obscurity toward illumination.

[2] Bacon held that *clandestine instances* led the intellect not to specific differences but to common natures or genera, the broader forms underlying many species. In modern terms, these cases reveal continuity between phenomena and thus aid the abstraction of general causal laws.

For example, let the nature under investigation be *consistency*, or *self-determination*, whose opposite is *liquidity* or *flowing*. Clandestine instances are those which exhibit a certain faint and minimal degree of consistency within a fluid; such as a water bubble, which is like a certain consistent and determinate film made from the substance of water. Likewise, there are the droplets of water which, if supplied by a

continuing flow, extend themselves into a very thin thread so that the water may remain unbroken; but if there is not enough water following to sustain that continuity, the water falls in round drops—the shape best suited to resist separation. At the very instant when the thread of water ceases and the descent into drops begins, the water itself recoils upward to avoid discontinuity. Furthermore, in metals which, when melted, are liquid yet more tenacious, the drops of molten metal often leap upward and remain suspended. A similar instance is seen in children's soap-film mirrors, which boys make using rushes and saliva, where a consistent film of water can also be observed. But this phenomenon is shown much more clearly in another children's game, when they take water thickened slightly with soap, blow it through a hollow straw, and thus form the water into a sort of fortress of bubbles; and the interposition of air brings about a consistency so great that the structure can be projected a little without breaking. This is most clearly seen in foam and snow, which attain such consistency that they can almost be cut—though they are composed of air and water, both of which are liquids. All these examples indicate—clearly enough—that the notions of *liquid* and *consistent* are only popular and sensory in character [3]; whereas, in fact, all bodies possess an inherent tendency to avoid discontinuity. This tendency is weak and faint in homogeneous bodies (such as liquids), but is more vivid and strong in those composed of heterogeneous elements—since the presence of heterogeneous matter binds the body, while the introduction of homogeneous matter loosens and relaxes it.

[3] Bacon observed the tendency of liquids to form bubbles, droplets, and foam, attributing this to an "inherent appetite to avoid discontinuity." His qualitative description of surface cohesion was remarkably perceptive. Modern physics explains these effects through surface tension, arising from molecular attraction; his inference that heterogeneity increased cohesion was mistaken, but his recognition that all matter resists discontinuity was fundamentally correct.

Likewise, for example, let the nature under investigation be *attraction*, or *the coming together of bodies*. The most notable ostensive instance relating to its form is the magnet. The contrary nature to the attractive is the non-attractive, though found in a similar substance: for instance, iron does not attract iron, nor lead lead, nor wood wood, nor water water. A clandestine instance, however, is a magnet armed with iron—or more precisely, the iron in the armed magnet [4]. For it is a law of nature that an armed magnet at a certain distance does not attract iron more strongly than an unarmed magnet. But if iron is brought close enough to touch the iron on the armed magnet, then the armed magnet sustains a far greater weight of iron than the simple, unarmed one—due to the similarity of the iron's substance to that of the other iron; an operation that was completely hidden and latent in the iron before the magnet approached [5]. Thus, it is evident that the form of coition is something that is vivid and robust in the magnet, but weak and latent in the iron. Likewise, it has been noted that small wooden arrows, lacking iron tips and discharged from large guns, penetrate wooden material (e.g., the sides of ships and such) more deeply than those same arrows tipped with iron—due to the similarity of the wooden material, although this had previously lain hidden in the wood. Similarly, though air does not obviously attract air, nor water water, when considered in whole bodies, yet a bubble brought near another bubble more readily dissolves it than if the second bubble were absent, due to the appetite for union of water with water and air with air. Such clandestine instances (which, as said, are of the highest utility) are most conspicuously observed in the small and subtle portions of bodies [6]. For the larger masses of matter obey more general and universal forms, as will be discussed in its proper place [7].

[4] By "armed magnet" Bacon meant a magnet fitted with a piece of soft iron (*armatura*). He believed that the magnet awakened a latent power of attraction in the iron. Galileo had already shown that the armature acted by improving physical contact, not by imparting hidden force. The example nonetheless showed Bacon's interest in latent operations beneath contrary natures.

[5] What Bacon described as a "hidden operation in the iron" corresponds in modern physics to magnetic induction, in which the magnetic field of one body temporarily aligns domains in another. His intuition that the attractive form existed potentially in ordinary iron thus anticipated later field theory, though without quantitative understanding.

[6] Bacon's observation that subtle effects appear "in the small and fine portions of matter" anticipated the later shift toward microscopic and molecular explanation. His reasoning embodies the modern principle that weak or threshold phenomena can disclose underlying laws more effectively than large, compound effects.

[7] **Excursus – On *Natura Non Facit Saltus***

a. The Gradualists: From the seventeenth century onward, empirical science generally treated *natura non facit saltus*—"nature makes no leaps"—as both a methodological maxim and a metaphysical assurance. For Bacon, Galileo, and their successors, continuity guaranteed intelligibility: natural change could be traced through measurable gradations rather than sudden ruptures. Newton's calculus formalized this conviction by describing motion, force, and variation as continuous functions. Eighteenth- and nineteenth-century experimental science—from fluid mechanics to thermodynamics and evolutionary biology—deepened this commitment by assuming that phenomena unfolded through incremental transitions. Even when apparent discontinuities arose, as in chemical reactions or phase changes, they were reinterpreted as continuous processes governed by hidden variables. Thus the rise of empirical science transformed *natura non facit saltus* from a scholastic truism into the working grammar of observation, quantification, and prediction.

b. The Opposing Current – the Discontinuist Tradition: Opposed to this long continuity tradition stood a recurrent discontinuist current—thinkers and investigators who maintained that nature, history, or knowledge advances by sudden breaks rather than smooth gradations. This discontinuist lineage ranged from Cuvier's geological catastrophism and nineteenth-century evolutionary *saltationism* to the twentieth-century recognition of discontinuity in quantum transitions and phase changes. Its common conviction was that genuine transformation occurs through thresholds or crises: the moment of change, not the continuum, reveals the law of nature. While the mainstream gradualist program sought to reconcile every rupture with an underlying continuity, discontinuists insisted that leaps are objective features of reality rather than artifacts of ignorance. This counter-tradition—from Cuvier to Planck and beyond—thus redefined the *saltus* not as an anomaly to be explained away, but as a principle intrinsic to becoming.

c. Hegel and Marx – Dialectical Discontinuity: Hegel and Marx reinterpreted the problem of continuity and rupture in explicitly dialectical terms, transforming what the scientific gradualists regarded as the smooth unfolding of nature into a logic of necessary transition. For Hegel, continuity itself contained its negation: quantitative change accumulated until it issued in a qualitative leap—the "measure transition" by which being advanced to a higher determination. Marx and Engels transferred this principle into the material and historical realm, arguing that both natural and social processes developed through contradictions that culminated in revolutionary transformation. In this way, dialectical discontinuity inverted the Baconian and Newtonian presumption of *natura non facit saltus*: the leap ceased to be an exception and became the very form of development.

d. The Continuing Authority of Continuity: Yet from an empirical and methodological standpoint, the notion of a literal leap remains untenable. What presents itself as rupture or *saltus* is, upon closer analysis, the visible threshold of continuous processes operating beyond the observer's present scale of resolution. Every so-called "qualitative break" depends on gradients, accumulations, and relational shifts that remain lawful within the continuum of nature. To hypostatize the leap is to mistake the limits of perception for properties of the world. The principle *natura non facit saltus* therefore endures not as dogma but as discipline: it preserves the scientist's obligation to trace transitions, mediations, and hidden intermediaries rather than elevate discontinuity into an explanation of its own. For discussion of the refusal of dialectical leaps, see https://hosseinjorjani.com/dialectic/.

II-XXVI (2:26).

Among the *prerogatives of instances* we shall place in the **fifth position** the Constitutive Instances, which we are also accustomed to call Maniple Instances (*Instantiae Manipulares*) [1]. These are the instances that constitute one species of the nature under inquiry as, so to speak, a *Lesser Form* (*Forma Minor*). For since the legitimate *forms* (which are always convertible with the natures under inquiry) lie hidden in depth and are not easily found, the matter itself, and the weakness of the human *understanding*, demand that particular forms—which gather into some common notion certain *maniples* of instances (by no means, however, all of them)—should not be neglected but be more carefully

marked. For whatever unites a nature, even in imperfect ways, paves the road to the discovery of forms. Accordingly, the instances that are useful for this purpose are not of contemptible power, but enjoy no small prerogative.

[1] *Instantiae Manipulares*—literally "Maniple Instances" or "Bundled Instances"—denoted Bacon's fifth class of prerogative instances. They corresponded to *formae minores*, or partial laws, which gathered certain phenomena under a limited general notion. Such "lesser forms" prepared the intellect for the discovery of the *Forma Magna* (the true, universal cause). In modern methodological terms, these are intermediate models or local regularities that bridge observation and full theory.

In these, however, careful caution must be employed: lest the human understanding—after it has hit upon a number of such particular forms and has from them constructed partitions or divisions of the nature under inquiry—should wholly rest in them and not gird itself for the legitimate discovery of the *Great Form* (*Forma Magna*) [2]; and lest it presuppose that nature is multiple and divided from the very roots, and look with distaste and rejection upon a further *union* of nature, as a matter of superfluous subtlety, tending toward mere abstraction.

[2] Bacon warned that the intellect, once it finds such *formae minores*, tends to mistake them for complete explanations. This anticipation of what today is called "theory-fixation" or "premature closure" reflected his broader critique of the *Idola Theatri* (Book I §44), the mind's inclination to rest in provisional abstractions. The caution remains relevant: modern science still disciplines itself against reifying models or taxonomies as final forms.

For example, let the nature under inquiry be Memory, or what *rouses and helps* memory [3]. The constitutive instances are: order or arrangement, which manifestly helps memory; likewise the places in artificial memory, which may be places in the proper sense—such as a door, a corner, a window, and the like—or may be familiar persons and those well known, or indeed anything one pleases (provided they are set in a fixed order), such as animals or plants, even words, letters, characters, historical persons, and so on—though some of these are

more apt and convenient than others. Such *places* conspicuously aid memory and raise it far beyond its natural powers. Likewise verses adhere more easily and are learned by heart more readily than prose. And from this *maniple* of three instances—namely order, the places of artificial memory, and verse—there is constituted a single species of aid to memory. That species may rightly be called the Cutting-off of the Infinite (*Abscissio Infiniti*) [4]. For when someone tries to recall or bring back into memory some thing, if he has no *prenotion* or apprehension of what he seeks, he certainly seeks and endeavors and runs this way and that, as if in an infinite. But if he has some fixed prenotion, the infinite is straightway cut off, and the course of memory is made more near at hand. In the three instances just mentioned the prenotion is plain and certain. In the first, namely, there must be something that fits the *order*; in the second, an *image* that has some relation or agreement with those fixed places; in the third, words that fall into *verse*. And thus the infinite is cut off.

[3] Bacon's six *formae minores* of memory derived from the Renaissance *ars memoriae* tradition (Cicero, Quintilian, the scholastic *loci communes*), which he sought to naturalize. His analysis shifted from rhetorical artifice to psychological mechanism—anticipating the empirical study of attention and association. These "constitutive" examples therefore extend the inductive method into the human sciences, showing Bacon's conviction that cognitive phenomena obey natural law.

[4] *Abscissio Infiniti* ("cutting-off of the infinite") was Bacon's term for limiting the field of recall by imposing prior structure—through order, place, or rhythm. The concept described how pre-notation focuses retrieval and thereby reduces cognitive search space. In *De Augmentis Scientiarum V.5*, Bacon used the same phrase to describe the logic of heuristic constraint. In modern psychology this corresponds to the economy of selective attention and cue-based recall.

Other instances will yield this second species: that whatever leads down the intellectual to strike upon the sensible (a rule that especially prevails in artificial memory) aids memory. Other instances will yield this third species: that things which make an impression upon a strong

affect—namely those that instill fear, wonder, shame, or delight—aid memory. Other instances will yield this fourth species: that things most impressed upon a mind pure and less preoccupied before or after—as those learned in childhood, or what we ponder before sleep, and also the first experiences of things—stick more in memory. Other instances will yield this fifth species: that a multitude of circumstances or "handles" aids memory—such as writing in non-continuous parts, reading, or recitation aloud. Lastly, other instances will yield this sixth species: that things which are expected and arouse attention adhere better than those that pass swiftly by. Thus there are, as it were, six *Lesser Forms* of things that help memory: cutting-off the infinite; leading-down of the intellectual to the sensible; impression upon a strong affect; impression upon a pure mind; multitude of handles; pre-expectation.

Likewise, for example, let the nature under inquiry be Taste, or tasting [5]. The following instances are constitutive: namely, that those who do not smell, but are by nature destitute of that sense, do not perceive by taste or distinguish rancid or putrid food, nor, similarly, food seasoned with garlic or rosewater or the like. Again, those whose nostrils are accidentally obstructed by a descending rheum do not discern or perceive anything putrid or rancid or sprinkled with rosewater. Again, those affected by such a rheum—if, at the very moment when they have something fetid or aromatic in the mouth or on the palate, they blow their nose strongly—at that instant have a manifest perception of the rancid or the aromatic. These instances will yield and constitute this *species*, or rather *part*, of taste: that the sense of taste, in part, is nothing other than an internal smelling, passing down from the upper passages of the nostrils into the mouth and palate. On the other hand, salt, sweet, pungent, sour, austere, bitter, and the like—all these are sensed just as well by those in whom smell is lacking or blocked as by anyone else; so that it is manifest that the sense of taste is a composite

of internal smelling and a certain exquisite touch—of which there is no place to speak now.

[5] Bacon correctly observed that flavour perception depends partly on smell, but his physiological interpretation was incomplete. Modern sensory science distinguishes *taste* (gustation, mediated by tongue receptors) from *smell* (olfaction, via nasal epithelium) and explains their integration through retronasal olfaction during chewing and exhalation. His inference that taste was a "compound of internal smell and exquisite touch" was partly accurate but lacked chemical understanding.

Likewise, for example, let the nature under inquiry be Communication of a Quality without Mixture of Substance. The Instance of Light will give or constitute one species of communication; heat and the magnet another [6]. For the communication of light is, as it were, instantaneous, and perishes at once when the original light is removed. But the hot and the magnetic virtue, after they have been transmitted—or rather *excited*—in another body, cling and remain for no small time after the first mover has been removed.

[6] By "communication of a quality without mixture of substance," Bacon referred to the transmission of light, heat, and magnetic influence without material contact. Though framed in Aristotelian vocabulary, this intuition foreshadowed the later concept of fields and energy propagation. Scientifically, his distinction between instantaneous light and persistent heat or magnetism anticipated later differentiation between radiative and diffusive transfer, but his mechanism remained speculative.

Finally, the *prerogative* of constitutive instances is altogether great, in that they contribute very much both to *definitions* (especially particular ones) and to the *divisions* or *partitions* of natures; concerning which Plato spoke not amiss—that he is to be accounted as a god who knows how to define and divide well [7].

[7] The closing quotation paraphrased *Plato, Phaedrus 266b*, where Socrates praises the divine art of dividing and collecting according to kinds (*diairesis* and *sunagoge*). Bacon invoked it to sanction his empirical counterpart: classification and definition based on observed instances rather than deductive

reasoning. The passage thus signals his transformation of Platonic dialectic into a disciplined empirical taxonomy.

II-XXVII (2:27).

Among the *prerogative instances* we shall place in the **sixth position** the Conformable Instances, or Proportionate Instances (*Instantiae Conformes sive Proportionatae*) [1], which we are also accustomed to call Parallel Instances, or Physical Similitudes (*Similitudines Physicae*). These are those that display resemblances and correspondences among things—not in their *lesser forms* (as do the *Constitutive Instances*), but altogether *in the concrete*. Accordingly, they are as it were the first and lowest steps toward the *union of nature*. They do not immediately establish any *axiom*, but merely indicate and observe a certain *agreement among bodies*. And although they do not much advance the discovery of *forms*, nevertheless they very usefully reveal the structure of the parts of the universe, and perform, as it were, an *anatomy* upon its members; and so, by a kind of guiding hand, they sometimes lead toward higher and nobler *axioms*—especially those that concern the configuration of the world, rather than the simple natures and forms of things.

[1] *Instantiae Conformes sive Proportionatae* ("Conformable or Proportionate Instances") denoted examples showing structural correspondence between otherwise distinct phenomena. Bacon contrasted these with *Instantiae Manipulares* (2:26), which reveal partial forms within one nature. Here he sought not mere resemblance but real, physical analogy—a deliberate reform of the Renaissance *sympathiae* tradition into an empirical tool.

For example: Conformable Instances are the following—*the mirror* and *the eye* [2]; likewise the *structure of the ear* and *places that return an echo*. From this conformity, besides the mere observation of resemblance—which is useful in many respects—it is easy to collect and form the following *axiom*: namely, that *the organs of sense* and *bodies that produce reflections toward the senses* are of a similar

nature. Again, from this very observation, the intellect is readily prompted to rise to a further and more noble axiom, namely: that *there is no essential difference between the correspondences or sympathies of inanimate bodies and those of animate bodies endowed with sense*, except that in the latter there is superadded the *animal spirit* to a suitably disposed body, while in the former it is absent. So that, as many correspondences as exist among inanimate bodies, so many possible *senses* might exist among animals, if there were perforations in the animate body allowing the animal spirit to pass into a rightly disposed part, as into a proper organ. And conversely, as many *senses* as exist in animals, so many motions undoubtedly occur in inanimate bodies where the animal spirit is lacking; though there must necessarily be many more motions in inanimate bodies than senses in animate ones, owing to the paucity of sense-organs. Of this matter there is a very manifest example in *pain*. For since there are many kinds of pain in animals, and, as it were, different characters of it—such as the pain of burning, of intense cold, of puncture, of pressure, of tension, and the like—it is most certain that all these, so far as motion is concerned, are present also in inanimate bodies: as in wood or stone when it is burned, frozen, pierced, cleft, bent, or struck, and so forth; though they do not enter into sensation, owing to the absence of the animal spirit.

[2] Bacon's comparison of the eye to a mirror expressed a deep intuition about optical correspondence between nature and art. Though speculative in form, it prefigured the optical modeling later confirmed by Kepler and refined through the *camera obscura* experiments that established image formation as a physical, not mystical, process.

Likewise, Conformable Instances (which may perhaps seem strange to say) are *the roots* and *the branches* of plants [3]. For every vegetable swells and pushes out parts toward the circumference, both upward and downward; nor is there any other difference between roots and branches, except that the root is enclosed in the earth, and the

branches are exposed to the air and the sun. For if anyone were to take a tender and vigorous branch of a tree and bend it down into some portion of the soil—though it be not joined to the ground—it straightway produces not a branch but a root. And conversely, if earth be placed above and the plant be confined by a stone or some hard substance so that it cannot sprout upward, it will put forth branches downward into the air.

[3] Bacon's identification of the root and branch as conformable structures was morphologically perceptive but physiologically mistaken. Modern botany has shown that roots and stems share developmental origin only in embryonic tissues; their subsequent differentiation follows distinct hormonal and environmental pathways. His intuition, however, anticipated the study of homology and morphological parallelism later developed by Goethe and de Candolle.

Likewise, Conformable Instances are *the gums of trees* and *most gems in rocks*. For both are nothing other than exudations and filtrations of juices—the first of juices from trees, the second of juices from stones; whence arises the clearness and lustre in both, from that fine and accurate percolation. Hence also it comes that *the hairs of animals* are not so beautiful or vivid in colour as *the feathers of many birds*; because the juices are not so delicately filtered through the skin as through the quill.

Likewise, Conformable Instances are *the scrotum in males* and *the womb in females* [4]; so that that noble structure through which the sexes differ (so far as concerns terrestrial animals) seems to be nothing other than a difference of *outward and inward*: the stronger heat in the male forcing the genital parts outward, whereas in females the heat is too weak to accomplish this, and therefore they remain enclosed within.

[4] The supposed analogy between male and female genital formation derived from the Galenic and Telesian theory of sexual differentiation by heat. According to this view, the male's "greater internal heat" expelled the

generative organs outward, whereas the female's lesser heat left them within. This explanation, though false, typified pre-mechanical physiology, which explained form by degrees of vital heat.

Likewise, Conformable Instances are *the fins of fishes* and *the feet of quadrupeds* [5], or again *the feet* and *the wings of birds*; to which Aristotle added *the fourfold bending* in the movement of serpents. Thus, in the fabric of the universe, the motion of living things seems for the most part to be effected by *quartets of limbs* or *flexures*.

[5] Bacon's comparison of fins, feet, and wings correctly reflected an early recognition of structural correspondence among vertebrates. His mention of serpentine "fourfold bending" follows Aristotle's *De Incessu Animalium* (I.7). The analogy anticipated modern comparative anatomy, where limb homology is traced to common embryonic origin.

Likewise, *the teeth of terrestrial animals* and *the beaks of birds* are Conformable Instances; whence it is clear that in all perfect animals some hard substance flows toward the mouth.

Likewise, the resemblance and conformity that *man is as it were an inverted plant* [6] is not absurd. For the root of the nerves and of the animal faculties is the *head*, while the generative parts are lowermost, not counting the extremities of the legs and arms. But in the plant, the root (which stands in place of the head) is regularly placed in the lowest part, and the seeds uppermost.

[6] The image of man as an "inverted plant" exemplified Bacon's symbolic structuralism: the nervous "root" in the head corresponds to the nutritive root of plants below. Though physiologically incorrect, this analogy influenced later vitalist and morphological thought (notably Goethe's *Metamorphosis of Plants*).

Finally, this must by all means be laid down and often repeated—that the diligence of men, in the investigation and collection of *Natural History*, must henceforth be completely changed [7] and turned in the opposite direction from that which is now in use. For great indeed, and

even overly curious, has human industry hitherto been in noting the *variety of things* and in setting forth with exactness the distinctions of animals, plants, and fossils—distinctions most of which are rather *sports of nature* than of any serious utility toward the advancement of the sciences. Such studies, no doubt, serve for *delight*, and sometimes also for *practice*; but for *penetrating into nature* they serve little or nothing. Therefore, the labor must wholly be turned toward *inquiring into and noting the resemblances and analogies of things*, both in their wholes and in their parts. For these are the things that *unite nature* and *begin to constitute the sciences*.

[7] Bacon's call to redirect *natural history* from classification to the study of analogies marked a methodological revolution. He proposed an empirical morphology—an "anatomy of the universe"—based on patterns and correspondences, prefiguring the structural sciences of the eighteenth and nineteenth centuries.

Yet in these matters a grave and rigorous caution must altogether be observed—namely, that there be received as Conformable and Proportionate Instances only those which denote physical resemblances (as we said at the outset), that is, real, substantial, and immersed in nature, and not casual or superficial ones—still less superstitious or fanciful, such as the writers on natural magic (men of the lightest sort, and scarcely to be named in discussions so serious as ours) everywhere parade, describing and even inventing with great vanity and folly empty similarities and sympathies of things.

But, passing these by, *even in the configuration of the world itself and on the grander scale*, the Conformable Instances are not to be neglected; as, for example, *Africa* and the *Peruvian region* with its continent extending down to the *Straits of Magellan*. For each region has similar *isthmuses* and similar *promontories*, which is no chance occurrence. Likewise, the *New World* and the *Old World* are conformable in this respect: that both are broad and extended toward the north, but narrow and pointed toward the south.

Again, the most noble *Conformable Instances* are those of the *intense cold* found in the middle region of the air (as it is called), and the *fierce fires* that are often found bursting forth from places underground [8]. These two things are the *extremes and limits* of nature—namely, of the nature of cold toward the *circumference of the heavens*, and of the nature of heat toward the *bowels of the earth*—by *antiperistasis*, that is, by the rejection of the contrary nature.

[8] The "intense cold in the middle region of the air" and "fierce fires underground" reflected Bacon's adaptation of the Aristotelian doctrine of *antiperistasis* (mutual reinforcement of contraries). Modern meteorology and geology have rejected this causal account: atmospheric temperature gradients derive from radiation and pressure, and subterranean heat from radioactive decay and residual planetary formation.

Lastly, in the *axioms of the sciences* themselves, the conformity of instances deserves attention. Thus, the *rhetorical trope* called *Praeter Expectatum* ("beyond expectation") [9] is conformable to the *musical trope* called *Cadence Deviation* (*Declinatio Cadentiae*). Likewise, the *mathematical postulate* that "things equal to the same thing are equal to one another" is conformable to the *structure of the syllogism* in logic, which unites things that agree in a middle term. Finally, a certain *sagacity* in seeking out and tracing *physical conformities and analogies* is in the highest degree useful for innumerable purposes [10].

[9] Bacon's final analogies among rhetoric, music, mathematics, and logic illustrate his concept of *Philosophia Prima*—a discipline seeking structural relations common to all sciences. The comparison between *praeter expectatum* and *cadence deviation* exemplifies his view that formal harmony underlies diverse domains of knowledge.

[10] **Excursus – On the Fields of Expertise: Insiders and Outsiders**
Reading this aphorism, one is struck not only by Bacon's command of diverse fields—physics, biology, mineralogy, and psychology—but by the restless curiosity that unites them. His mind moves easily from the eye to the mirror, from the branching of plants to the movement of continents, as if the whole of nature were a single text to be read for correspondences. What astonishes is not erudition alone but the impulse behind it: a confidence that reflection and

disciplined wonder, rather than technical specialization, could still encompass the breadth of the natural world. It is this same impulse—the union of curiosity and coherence—that the following note seeks to trace across the larger history of knowledge.

From antiquity to the present, the structure of human knowledge has evolved from a small, unified set of inquiries into a diversified network of specialized disciplines. In the ancient Greek world, the total number of identifiable "subjects" was modest—perhaps a dozen or so—since philosophy (*philosophia*) encompassed nearly all systematic reflection, from metaphysics and logic to astronomy, ethics, and biology. Aristotle's division of theoretical, practical, and productive sciences defined the initial framework from which later fields branched.

During the medieval and Renaissance periods, scholastic and humanist traditions expanded this corpus to roughly several dozen subjects. The university curriculum—the *trivium* and *quadrivium*—provided the formal structure for knowledge, while theology, law, and medicine dominated the professional disciplines. Humanism added philology, rhetoric, and history, gradually separating moral and natural inquiry.

The Scientific Revolution and Enlightenment (17th–18th centuries) brought the first major acceleration. The emergence of experimental method, mathematical formalization, and institutional science produced the modern natural sciences—physics, chemistry, biology, and geology—and social analysis in political economy and psychology. From this point onward, new subjects began to appear every few decades rather than centuries.

By the modern and contemporary eras, specialization and professionalization multiplied the branches of inquiry into several hundred distinct subjects. Yet even today, the number of genuinely autonomous disciplines—those capable of sustaining professorial chairs and institutional departments—probably does not exceed 300–500 worldwide. Subfields proliferate, but most remain derivatives or intersections of these core lines.

In summary, the growth of subjects followed a pattern of slow branching over two millennia—roughly one new core field per century—accelerating sharply in the modern age. The tree of knowledge has not expanded indefinitely but condensed into a finite canopy: a few hundred enduring disciplines, all ultimately descended from the Greek ideal of *philosophia* as the unified search for causes and principles.

In the classical world, the pursuit of knowledge required neither vast libraries nor extensive technical training. Inquiry was conducted through direct observation, dialogue, and contemplation. Philosophy served as a unifying method rather than a specialized domain; reflection itself constituted research. The image of Aristotle walking and reasoning in the Lyceum illustrates a stage in intellectual history when the division of labor in thought had not yet emerged and when the act of pondering could encompass the whole of the knowable world.

In this pre-disciplinary environment, different temperaments embodied distinct approaches to understanding. The discursive, narrative mode of explanation—the telling of stories, proverbs, and examples—stood beside the contemplative and deductive mode that sought order and unity. These contrasting yet complementary orientations correspond to the ancient distinction between *mythos* and *logos*: the one descriptive and expressive, the other analytical and reflective. Together they formed the cultural substrate from which philosophy and, later, science developed.

As intellectual life became increasingly institutionalized, originality came to depend less on inherited knowledge than on resistance to convention. The capacity for independent thought now presupposed a degree of freedom from disciplinary constraint. New ideas often emerged from those who stood partially outside established systems—individuals unaccustomed to the dominant assumptions of their age. The history of knowledge thus alternated between consolidation and renewal: institutions refined what was already known, while the unindoctrinated reopened the space of questioning from which new disciplines ultimately arose.

Léon Croizat's life provides a striking case study of the tension between originality and belonging in the structure of knowledge. Working largely alone, without formal academic post or disciplinary allies, he developed the theory of *panbiogeography*—the idea that the history of life and the history of the earth are inseparable, and that the distribution of organisms reflects the movement of landmasses rather than chance dispersal. His ideas did not fit easily into the frameworks of evolutionary biology, systematics, or geology as they stood in mid-twentieth-century science. Yet this very marginality allowed him to see patterns—the coevolution of earth and life, the primacy of form and geography over mere dispersal—that disciplinary specialists, constrained by inherited assumptions, largely overlooked.

Croizat's outsider status exemplifies how innovation often depends on non-indoctrination: the capacity to think without full allegiance to prevailing paradigms. His lack of institutional support isolated him, but it also freed him

from the methodological commitments that limited mainstream evolutionary theory. In that sense, he stood in the long lineage of figures who, from outside the recognized centers of learning, reopened the field of inquiry—individuals who thought not by extending the dominant discourse but by reconfiguring its premises.

At the same time, Croizat's fate illustrates the cost of unassimilated insight. Without the social mechanisms of peer validation, translation, and institutional uptake, even accurate ideas could remain peripheral. Science as a process—to borrow David Hull's phrase—depended not only on discovery but also on communication, consensus, and reproducibility. Croizat's work reminds us that intellectual independence is both the source and the risk of originality: the farther one stood from orthodoxy, the more clearly one might see, and the less likely one was to be heard.

Others have shared this paradox in different eras. Gregor Mendel, a monastery-based experimenter rather than a university naturalist, uncovered the numerical laws of inheritance decades before genetics existed. Alfred Wegener, a meteorologist, saw the unity of continental shapes and proposed continental drift long before geology could accommodate such motion. Ignaz Semmelweis, confronting hospital mortality, discovered the life-saving power of handwashing but lacked the germ theory to justify it. Nikolai Vavilov, whose studies of crop origins defied Stalinist ideology, died in prison but left a framework for modern plant genetics. Mary Anning, working on the beaches of Lyme Regis without scientific credentials, provided fossils that reshaped paleontology. Srinivasa Ramanujan, self-taught in mathematics, filled his notebooks with theorems that astonished Cambridge mathematicians, guided more by intuition than by formal proof.

At the summit of this lineage stands Albert Einstein, who in 1905 was a technical examiner at the Swiss Patent Office, excluded from academic life yet thinking more freely than most professors. His four papers that year—on relativity, Brownian motion, and the quantum nature of light—rewrote physics from the periphery. For a brief moment, Einstein embodied the purest form of intellectual independence: the outsider who, unbound by institutional habit, redefined the inside.

Together, these figures mark the enduring tension between discipline and freedom in the history of knowledge. They remind us that institutions preserve rigor but can stifle vision, while the outsider's solitude, though perilous, sometimes clears the only path to discovery.

Summary

In the above discussion, we traced how the structure of human knowledge evolved—from the unified curiosity of the ancient Greeks to the hyper-specialized world of modern academia. The number of subjects has expanded slowly but decisively, roughly one new core discipline per century, until the modern era accelerated that growth. Despite this proliferation, the foundation remains compact: only a few hundred enduring fields, all descended from the ancient search for understanding in its simplest form—*philosophia*.

We also recognized the paradox of progress: as disciplines multiply and refine, they secure rigor but risk closing themselves to unconventional insight. This tension between structure and freedom recurs throughout intellectual history—between the institution and the outsider, the canon and the questioner.

Through figures like Léon Croizat, Mendel, Wegener, Ramanujan, and Einstein, we saw that innovation often begins at the margins, where method meets imagination and independence outweighs conformity. In this respect, intellectual history mirrors biological evolution. New species seldom arise in the crowded center of a population, where stabilizing pressures maintain established forms. They emerge instead at the periphery, in small, isolated groups that experience distinct environments and relative freedom from the conservative force of the majority. Variation there can accumulate, sometimes unnoticed, until a genuine divergence occurs. The same holds for thought: the intellectual "mainland" preserves the accumulated benefits of tradition, while the "peripheral isolates"—those who think apart, without institutional constraint—explore unoccupied niches of understanding. Most such experiments fail, but a few succeed and later reshape the landscape of knowledge itself. Thus, as in nature, creativity depends on the coexistence of both stability and mutation, continuity and departure. Knowledge evolves as life does—through the delicate balance between inheritance and divergence, between what endures and what breaks away.

And beneath it all, we rediscovered something ancient: that the impulse to wonder, to reflect, and to question—the impulse Aristotle once pursued while walking through the Lyceum—still underlies every new branch of learning.

II-XXVIII (2:28).

Among the *prerogative instances*, we shall place in the **seventh position** the Monadic Instances (*Instantiae Monodicae*) [1], which we are also accustomed to call Irregular or Heteroclite Instances, borrowing the term from the grammarians. These are those which

exhibit, in the concrete, *bodies that seem to stand apart* and, as it were, to *break off* from the order of nature [2]—things that least conform to others of the same kind. For whereas the *Conformable Instances* are *like another*, the *Monadic Instances* are *like themselves alone*.

[1] Bacon derived *Instantiae Monodicae* from the Greek *monas* ("unit," "single thing") to designate individual phenomena that appeared to stand alone within their kinds. He borrowed the parallel adjective *Heteroclite* from grammar, where it had described irregular noun declensions. By this transference he treated linguistic irregularity as a model for natural deviation, a conceptual move that reflected his effort to systematize exceptions within the order of inquiry rather than to exclude them as errors.

[2] The clause "stand apart and, as it were, to break off from the order of nature" translated Bacon's *quasi abrumpere ab ordine naturae*. In Bacon's seventeenth-century context, such phrasing indicated a perceived breach in uniform causation. He wrote against the Aristotelian habit of relegating anomalies to the accidental or monstrous; the text in this version therefore preserves his intention that apparent irregularities should guide the search for hidden forms rather than be dismissed as violations of nature.

The use of the Monadic Instances is the same as that of the *Clandestine Instances*: namely, to *raise and unite nature* toward the discovery of *genera* or *common natures* [3], which are afterward to be delimited by *true differences*. For inquiry must not cease until the properties and qualities found in such things—which may be regarded as *the miracles of nature* [4]—are brought back and comprehended under some *definite form or law*. Thus every irregularity or singularity is found to depend upon some *common form*; and that supposed "miracle" resides only in an *accurate difference*, or in the *rarity of its degree or concurrence*, and not in the *species itself*. At present, however, human contemplations advance no farther than to treat such things as the *secrets and marvels of nature*, as though they were *uncaused* and *exceptions to general rules*.

[3] The expression “raise and unite nature toward the discovery of genera or common natures” rendered *naturam elevare et conjungere ad inventionem generum sive naturarum communium*. Bacon had meant that attention to anomalies lifted the intellect from the surface of particulars toward the comprehension of *formae*. In modern methodological terms, the remark identifies the formative stage of induction, when singular data are generalized into explanatory patterns—a principle that remains valid within present empirical practice.

[4] When Bacon referred to “the miracles of nature,” he employed the Latin *miracula naturae* not in a theological sense but as a conventional description for phenomena then regarded as uncaused or unique. He wrote that such marvels should ultimately be “brought back under some definite form or law.” In this context the note observes that, for Bacon, the wonder lay only in degree or conjunction, not in essence, whereas in contemporary understanding the term “miracle” designates no category of natural event.

Examples of Monadic Instances are: the *sun and the moon* among the stars; the *magnet* among stones; *quicksilver* among metals; the *elephant* among quadrupeds; the *pleasure of Venus* among the kinds of touch; and the *keen scent in hounds* among the kinds of smell [5]. Likewise, in grammar, the letter *S* is held to be monadic, because of the facility with which it combines with consonants—sometimes double, sometimes triple—which no other letter does. Many such instances are to be sought, for they *sharpen and enliven* investigation, and *heal the intellect* corrupted by habit and by the authority of what is customary or common [6].

[5] The series of examples—“the sun and the moon among the stars; the magnet among stones; quicksilver among metals; the elephant among quadrupeds; the pleasure of Venus among the kinds of touch; and the keen scent in hounds among the kinds of smell”—illustrated Bacon’s belief that every singular case could reveal a general rule. In Bacon’s time these instances stood as emblematic irregularities within natural history. Modern science now explains each without recourse to exception: the sun and moon differ from fixed stars by physical composition and distance; the magnet’s property results from electron spin alignment; mercury’s liquidity follows from weak metallic bonding; the elephant exemplifies biological variation within a lineage; and sensory examples represent physiological degree rather than categorical anomaly. The note thus records that Bacon’s observations were empirically

acute but scientifically limited, and that their modern explanation resides in quantitative difference, not species separation.

[6] The closing sentence, "heal the intellect corrupted by habit and by the authority of what is customary or common," echoed Bacon's doctrine of the *idola tribus*, which he had described elsewhere as natural tendencies of the human mind toward confirmation and complacency. He wrote that the study of singular cases corrected such corruption by forcing the intellect to confront the unfamiliar. In present terms, this remains the methodological analogue of anomaly-driven reasoning and error correction in modern scientific inquiry.

II-XXIX (2:29).

Among the *prerogative instances* we shall place in the **eighth position** the Deviating Instances (*Instantiae Deviantes*) [1]: that is, the *errors*, *wandering departures*, and *monstrosities of nature* [2], where nature swerves and deflects from her ordinary course. For the *errors of nature* differ from the *Monadic Instances* in this: that the Monadic are *the miracles of species*, whereas the Deviating Instances are *the miracles of individuals* [3]. Yet their use is nearly the same; for both *correct the intellect* against the tyranny of the accustomed, and *reveal common forms*. Nor should inquiry cease even in these cases until the cause of such deviation be discovered. Yet that cause does not rise to the level of a *form* properly speaking, but only to a *latent process leading toward a form* [4]. For whoever knows the *ways of nature* will the more easily observe her *deviations*; and, conversely, whoever understands her *deviations* will describe her *ways* with greater precision.

[1] Bacon designated *Instantiae Deviantes* as examples in which nature appeared to "swerve" from her regular path. The Latin term derived from *deviatio*, a common scholastic word for aberration. He contrasted these with *Instantiae Monodicae* (2:28): the former concerned individual departures, the latter concerned species-level singularities. This distinction reflected Bacon's effort to classify exceptions systematically within his inductive method rather than to relegate them to chance or miracle.

[2] The phrase "errors, wandering departures, and monstrosities of nature" translated Bacon's *errores, aberrationes, et monstra naturae*. In early seventeenth-century natural philosophy, *monstra* referred to deformities or abnormal productions in generation, not necessarily to supernatural portents. Bacon employed the term descriptively, aligning with the natural-historical vocabulary of Fortunio Liceti and others who studied monstrous births as part of legitimate empirical inquiry.

[3] The contrast between "miracles of species" and "miracles of individuals" conveyed Bacon's distinction between anomalies characteristic of a whole kind and those confined to a single occurrence. He wrote that the latter were more useful for uncovering the mechanisms of variation, since they revealed the points at which nature's process might be diverted. In modern understanding this corresponds to the role of individual mutation or variation in biological investigation.

[4] The phrase "latent process leading toward a form" rendered Bacon's *processus latens qui ducit ad formam*. He meant that deviation exposed not the *forma* itself, but the sequence of operations by which nature ordinarily achieved it. This formulation foreshadowed later causal reasoning in science, where attention to the sequence of events rather than to essential definitions became the path to explanation.

They also differ from the Monadic Instances in this respect—that they are *far more instructive for practice and operation*. For to *generate new species* would be exceedingly difficult; but to *vary known species* and thereby to produce many rare and unusual things is less arduous. Indeed, the transition is an easy one from *the miracles of nature* to *the miracles of art* [5]. For if once nature be found in her deviation, and the reason of that deviation be clearly discerned, it will be easy by art to lead nature along the same path by which she strayed by chance—and not only along that path, but along others also. For deviations on one side show and open the way to deviations and deflections on every side.

[5] The transition "from the miracles of nature to the miracles of art" encapsulated Bacon's belief that knowledge of natural deviation enabled deliberate imitation through experiment. He wrote that once the reason of a deviation was understood, art might reproduce or extend it. In modern terms, this principle anticipates experimental manipulation and controlled variation. Within Bacon's

own, more restrictive conception of natural kinds, this was a legitimate claim: art could guide and modify processes but not create new *formae*. Yet in light of modern achievements in selective breeding, genetics, and molecular biology, the boundary between variation and creation has become less certain, and Bacon's distinction between imitation and origination may no longer hold in absolute form.

Here, however, there is no need to multiply examples, because of their abundance. What is required is a *collection* or *particular natural history* of all *monsters* and *prodigious births of nature* [6], indeed of *every novelty, rarity, and anomaly* in the natural world. Yet this must be done with the *strictest selection*, so that credibility may be secured. Above all, those reports must be regarded as *suspect* which in any way depend upon *religion* (such as the portents recorded by Livy); and not less those found in the writings of *natural magicians*, or of *alchemists*, and suchlike men—who are, as it were, *wooers and lovers of fables*. Rather, such records must be drawn from *grave and trustworthy histories* and *certain testimonies* [7].

[6] Bacon's call for a "collection or particular natural history of all monsters and prodigious births of nature" reflected the natural-historical ambitions of his age. Many examples known to him—conjoined twins, animal deformities, mineral anomalies—had genuine biological or geological bases, though their causes were misunderstood. His insistence on *severissimus delectus* ("the strictest selection") demonstrated a critical attitude unusual for his time. Modern science now explains most such deviations through genetic mutation, developmental error, or environmental influence, confirming Bacon's intuition that monstrosity lies in process, not essence.

[7] The warning that reports "depending upon religion... or of natural magicians, or of alchemists" should be regarded as suspect expressed Bacon's emerging standard of empirical credibility. He sought to separate observation from superstition and to base induction on verifiable testimony. This insistence on trustworthy sources anticipated later norms of scientific evidence and reproducibility.

II-XXX (2:30).

Among the *prerogative instances*, we shall place in the **ninth position** the Borderline Instances (*Instantiae Limitaneae*) [1], which we are also accustomed to call Participating Instances (*Instantiae Participiae*) [2]. These are those which exhibit species of bodies that seem to be *composed of two distinct species*, or *rudimentary forms lying between one species and another* [3].

[1] Bacon called these *Instantiae Limitaneae*, "Borderline Instances," from *limes* (boundary), denoting phenomena that appear to stand at the threshold between two natural kinds. The term indicated his interest in marginal or transitional cases as instruments for understanding the unity of nature rather than its divisions.

[2] His alternative name, *Instantiae Participiae*, extended the grammatical analogy: a *participium* (participle) "shares" in the nature of both noun and verb. By applying this linguistic model to nature, Bacon suggested that some entities partake simultaneously of two species, revealing continuity between them. The analogy exemplified his broader method of drawing conceptual order from grammar and rhetoric.

[3] The idea of forms "lying between one species and another" reflected the Renaissance and early-modern belief in a *scala naturae* or Great Chain of Being. Naturalists then supposed that the universe contained no absolute gaps but a continuous gradation of forms. Bacon adopted this framework empirically, urging the study of intermediate cases to discern the structure and composition of kinds.

These instances may rightly be numbered among the *Monadic* or *Irregular Instances*, since in the totality of things they are *rare and extraordinary*; yet, because of their *dignity and significance*, they deserve to be treated and placed separately [4]. For they most clearly *indicate the composition and structure of things*, *intimate the causes* of the *number and quality* of the ordinary species in the universe, and *lead the intellect from what exists to what might exist* [5].

[4] When Bacon described these instances as "rare and extraordinary" yet "worthy of separate treatment," he assigned epistemic value to exceptions. Transitional forms, though uncommon, disclosed the principles of composition linking kinds

together. This perspective represented a methodological shift from taxonomy based on fixed essences to analysis based on relational structure.

[5] The phrase "lead the intellect from what exists to what might exist" expressed Bacon's belief that observation of intermediates suggested the range of possible natural forms. In modern science this insight corresponds to evolutionary and developmental reasoning: studying variation and transitional morphology reveals both the limits and the potential of natural design.

Examples of such instances are: moss, which stands between *putrescence and plant*; certain comets, between *stars and fiery meteors*; flying fish, between *birds and fishes*; bats, between *birds and quadrupeds* [6]; and even—

"Simia quam similis turpissima bestia nobis"
(How like to us is that most ugly beast, the ape!)

—together with *double-formed* or *hybrid births* [7] of animals composed of diverse species, and similar cases of the kind.

[6] Bacon's examples—moss between putrescence and plant; certain comets between stars and fiery meteors; flying fish between birds and fishes; bats between birds and quadrupeds; and the ape as a likeness to humankind—illustrated the seventeenth-century search for continuity across kinds. Modern science now classifies these differently: moss is a true plant, not a stage between decay and vegetation; comets are independent celestial bodies composed chiefly of ice and dust, not intermediates between stars and meteors; flying fish and bats are distinct, well-defined vertebrates whose apparent intermediacy arises from convergent adaptation, not hybrid nature; and the anatomical proximity of apes and humans reflects shared evolutionary ancestry rather than partial identity. Thus, while Bacon's examples were scientifically mistaken, they captured the enduring heuristic value of transitional thinking.

[7] "Double-formed or hybrid births" referred to reports of chimeric animals and supposed crosses between species. Such cases fascinated early natural historians as signs of nature's experimental tendency. Modern biology recognizes genuine hybrids only between closely related species and explains most historical "monstra" as developmental abnormalities. Bacon's appeal for

reliable documentation anticipated later scientific insistence on verified observation and classification.

II-XXXI (2:31).

Among the *prerogative instances* we shall place in the **tenth position** the Instances of Power, or Instances of the Fasces (the term being taken from the insignia of authority) [1], which we are also accustomed to call the Works of Human Skill or the Hand of Man (*Ingenia sive Manus Hominis*) [2]. These are the most *noble and perfect works*—the *ultimate achievements* within each art. For since the principal aim of inquiry is that nature should *serve human affairs and needs* [3], it is altogether fitting that the works which have already long been within human command (as if they were provinces already occupied and subdued) should be *marked and enumerated*, especially those which are most *refined and perfected*. For from these it is easier and nearer to advance toward new things hitherto undiscovered. Whoever contemplates such works attentively, and pursues his purpose with vigor and perseverance, will either *extend them somewhat further*, or *deflect them toward something akin*, or even *apply and transfer them to some higher use*.

[1] Bacon's term *Instantiae Fascis* derived from the Roman "*fasces*", the bundle of rods carried before magistrates as a symbol of authority. By adapting this emblem, he signified those instances that most clearly displayed humankind's power over nature—the *imperium in naturam* that he took to be the true aim of philosophy. The metaphor united civic command and natural mastery under the same ideal of disciplined rule. The modern political term "fascism" likewise derives from the Roman "*fasces*".

[2] The phrase *Ingenia sive Manus Hominis* joined mental invention (*ingenium*) with manual operation (*manus*). Bacon treated both as aspects of art: invention as design, and hand as execution. This dual emphasis revealed his larger project of reconciling theory and practice, transforming philosophy from speculative contemplation into operative knowledge.

[3] The statement that "the principal aim of inquiry is that nature should serve human affairs" expressed Bacon's utilitarian principle of science: *scientia propter potentiam*. Knowledge justified itself not by contemplation but by its capacity to produce effects. This conviction anticipated the instrumental orientation of modern research, in which theoretical discovery and practical application are conceptually inseparable.

Nor does the benefit stop here. For just as the intellect is roused and uplifted by rare and unusual *works of nature* to the inquiry and discovery of *forms* capable even of such effects, so likewise it happens—indeed, much more so—with the *excellent and marvelous works of art*; because the *method of their production* is in most cases *manifest* [4], whereas in nature's miracles it is generally *obscure*.

[4] The comparison between "the excellent and marvelous works of art" and "the rare and unusual works of nature" reflected Renaissance fascination with *mirabilia artificii*—human inventions rivaling natural wonders. Bacon reinterpreted this tradition as methodological, holding that art's miracles instruct more directly than nature's because their causes are accessible to reason. This principle became central to the experimental method, where replication replaced mystery as the criterion of truth.

Nevertheless, the greatest caution must here be observed—namely, that the intellect be not *depressed and bound down to the earth* by these same works of art [5]. For there is danger lest, by means of such works—appearing as they do to be the *summits and pinnacles* of human industry—the intellect become *astonished, spellbound, and confined* to them, so that it can accustom itself to nothing beyond, imagining that nothing of the same kind can be produced except by the same methods as those by which these were achieved, only with greater diligence and more careful preparation.

[5] Bacon's warning that the intellect must not be "bound down to the earth" by its own inventions illustrated his doctrine of the *idola*, especially the *idola tribus* and *idola fori*. He observed that fascination with successful techniques could imprison thought in imitation rather than discovery. The same danger persists in modern science, where technical proficiency can constrain conceptual imagination.

On the contrary, it must be firmly held as certain that the *ways and methods* of effecting the works now known and recorded are for the most part *poor and narrow*; and that *all greater power* depends upon and flows in order from the *sources of forms* [6], of which not one has yet been discovered.

[6] The "sources of forms" referred to the causal structures that determine a nature's operations—what modern science would call fundamental mechanisms or laws. Bacon held that genuine mastery of nature would arise only from discovering these *formae*, not from mechanical refinement. This anticipation of structural explanation connects his program to the later search for atomic, genetic, and physical laws governing phenomena.

Thus (as we have said elsewhere), whoever had fixed his thoughts upon the *machines and battering-rams* of the ancients, even if he had labored earnestly and consumed his life upon them, would never have fallen upon the *invention of firearms* [7], which act by means of *gunpowder*. Likewise, one who had spent all his observation and meditation upon *weaving and vegetable silk* would never through these have discovered the *nature of the silkworm* [8] or of *silken thread*.

[7] The example of the ancient siege engines and the invention of firearms was historically sound: gunpowder, introduced to Europe in the thirteenth century, transformed mechanics and warfare through a principle unrelated to earlier machines. Bacon's point was not technical but epistemological—that revolutionary progress depends on discovering new causes, not perfecting existing devices.

[8] His contrast between weaving and the silkworm emphasized the transition from artificial to natural processes. A weaver working only with plant fibers could not, he argued, discover silk, whose substance arises from animal secretion. The reasoning was correct in its principle: breakthroughs often come from recognizing a new generative source rather than refining materials already known.

Hence all the inventions that may justly be deemed most noble have come to light not at all through small refinements and extensions of

existing arts, but altogether *by chance*. Yet nothing *anticipates or represents chance* (whose habit it is to act only over the course of long ages) *save the discovery of forms*.

There is, however, no need to enumerate particular examples of such instances, owing to their abundance. What must be done is this: *all the mechanical and liberal arts* (so far as they concern works) must be *visited and thoroughly examined*; and from them must be compiled a *collection or particular history* of the *great works, masterworks, and most perfect operations* in each, together with their *methods of production*.

Nor do we confine the diligence to be used in this collection to what are commonly esteemed *masterpieces* or *secrets* of any art, or those which excite admiration. For admiration is the offspring of rarity: things rare, though of a vulgar nature in kind, nevertheless provoke wonder.

On the other hand, those works that *truly deserve admiration* because of the *difference in kind* they exhibit when compared with other species are often lightly regarded merely because they are of *familiar and everyday use*. Yet *the Monadic Instances of Art* are to be noted no less than those of Nature, of which we have already spoken. And just as we placed among the *Monadic Instances of Nature* the *sun*, the *moon*, the *magnet*, and the like—things most common, yet in their nature almost unique—so also must the same be done with the *Monadic Instances of Art*.

For example: a *monadic instance of art* is *paper*—a thing exceedingly familiar [9]. Yet, if one observe attentively, artificial materials are either *textile*, made of threads crossing longitudinally and transversely (such as silk, wool, linen, and the like); or else *concreted from liquors*, as in brick, pottery, glass, enamel, porcelain, and similar substances; which, when well fused, become glossy, but otherwise merely harden without

shining. Yet all such concreted substances are *brittle*, and in no way *tough or cohesive*. Paper, on the contrary, is a *tenacious body*, capable of being *torn and rent*; so that it *imitates and almost rivals* the *skin or membrane of an animal*, or the *leaf of a plant*, or other *natural textures of that kind*. For it is *neither brittle like glass* nor *woven like cloth*, but has *fibres*, though not *distinct threads*, and altogether in the *manner of natural materials*. Hence, among artificial substances, hardly any like it is to be found; it is indeed *wholly monadic*. And, in general, those works of art are to be preferred which *most closely imitate nature*, or, on the contrary, which *powerfully command and invert* it.

[9] The example of paper as a "monadic instance of art" reflected Bacon's admiration for materials that imitate nature. His description of paper's fibrous texture—neither brittle like glass nor woven like cloth—was empirically accurate and perceptive for his time. Modern materials science confirms his intuition that paper's strength derives from the random entanglement of cellulose fibers, a structure intermediate between textile and natural membrane.

Again, among the *works and devices of human skill*, *illusions* and *jocular tricks* are not altogether to be despised. For some of these, though of light and playful use, may nevertheless be *of weighty value for instruction*.

Lastly, even *superstitious* practices, and those things which (in the common sense of the word) are called *magical*, ought not to be wholly omitted. For although such matters are overwhelmed to an immeasurable degree beneath a vast heap of *lies and fables*, yet it is worth some brief examination to see whether perhaps there may lie concealed in some of them a *natural operation*: as, for instance, in *fascination*, in the *strengthening of imagination*, in the *sympathy of things at a distance* [10], in the *transmission of impressions from spirit to spirit*, no less than from *body to body*, and the like.

[10] Bacon's inclusion of "superstitious practices" such as fascination, sympathy, and transmission of impressions revealed his cautious openness to phenomena

later explored under psychology and physics. While he rejected magical explanations, he suspected that certain "sympathies" might have natural causes. In retrospect, his invitation to examine such claims prefigures the methodological openness that later defined experimental science: that even discredited traditions may conceal neglected empirical facts.

II-XXXII (2:32).

From what has been said above, it is evident that those *five kinds of instances* of which we have spoken—namely, *the Conform, the Monadic, the Deviant, the Borderline,* and the *Instances of Power* [1]—are not to be reserved until some definite nature is under inquiry (as must be done with the other instances set forth earlier, as well as with many that are yet to follow). Rather, their *collection must be undertaken immediately from the beginning*, as a kind of *particular history* [2]; since they *arrange and digest* the materials that enter the intellect, and *correct the distorted temperament of the intellect itself* [3], which must necessarily be *imbued, stained, and finally perverted and twisted* by the impressions of things that are *daily and familiar*.

[1] The five classes named here—*Conform, Monadic, Deviant, Borderline,* and *Instances of Power*—summarize the last sequence of *instantiae praerogativae*. Bacon regarded these as preparatory devices rather than direct instruments of induction. Their purpose was to dislodge habit and broaden perception, forming a training of the intellect rather than an immediate discovery of *forms*.

[2] The phrase "particular history" (*historia particularis*) denoted for Bacon a structured collection of empirical data relating to a single kind of phenomenon. Such histories were to constitute the raw material of induction: methodical records, not mere compilations of marvels. In this sense, Bacon anticipated the empirical inventories and standardized databases that underpin modern scientific inquiry.

[3] The "distorted temperament of the intellect" translated Bacon's conviction that the human mind is intrinsically biased by custom and daily experience. He wrote that the understanding, when left to itself, "resembles a distorted

mirror." Modern psychology confirms this insight in the study of cognitive bias and heuristic distortion, while scientific method institutionalizes its correction through controlled experiment and peer validation.

Therefore, such instances must be employed as a sort of *preparative* for the *rectification and purification of the intellect* [4]. For whatever withdraws the understanding from its accustomed habits [5] *levels and smooths its surface*, so that it may be *ready to receive the dry and pure light of true notions* [6].

[4] The *praeparatio intellectus*, or preparation of the mind, expressed Bacon's belief that inquiry required moral and perceptual discipline as much as technical skill. The intellect must first be cleansed of its idols before it can receive the "light of true notions." This concept stands at the origin of the modern idea that epistemic rigor depends on the conscious regulation of bias and the training of attention.

[5] The phrase "withdraws the understanding from its accustomed habits" echoed Bacon's earlier catalogue of the *idola*, especially the *idola tribus* and *idola fori*. He held that error arises less from ignorance than from the tyranny of the familiar. His method therefore prescribed deliberate estrangement from ordinary perception—what we would now call cognitive reframing—as a precondition for discovery.

[6] The "dry and pure light of true notions" (*lux sicca et pura verorum notionum*) continued Bacon's optical metaphors for knowledge. He contrasted this "dry light" with the "humid light" of imagination and tradition. The image conveyed his aspiration toward an objective and impersonal form of understanding—an ideal later embodied in the methodological neutrality of modern science.

Moreover, such instances also *prepare and pave the way toward practical operation* [7]—as we shall explain in its proper place, when we come to speak of *Deductions to Practice*.

[7] The promise to discuss "Deductions to Practice" (*deductiones ad praxin*) referred to a projected but unwritten section of the *Novum Organum* or the wider *Instauratio Magna*. Bacon intended there to show how purified understanding would translate into operative invention. Though never completed, this unrealized portion foreshadowed the modern system of applied research, in which theoretical insight and practical utility are interdependent.

II-XXXIII (2:33).

Among the prerogative instances we place in the **eleventh position** the Instances of Accompaniment and of Enmity, which we are also accustomed to call Instances of Fixed Propositions (*Instantiae Propositionum Fixarum*) [1]. These are those instances which exhibit some body or concrete substance in which the *nature under inquiry* is perpetually *present*—as a certain inseparable companion; or, on the contrary, in which that nature is perpetually *absent* and *excluded from fellowship*, as an enemy and adversary. For from such instances there are formed *definite and universal propositions*, either *affirmative* or *negative* [2]: in which the *subject* is the concrete body, and the *predicate* the nature itself that is being investigated. For *particular propositions* are by no means fixed—where the nature under inquiry appears in some body *unstable and variable*, that is, as *acquired or introduced* on the one hand, or *lost and laid aside* on the other. Hence, particular propositions possess no great prerogative, except in the *case of migration* (of which we have already spoken). Yet even those particular propositions, when compared and collated with the universal, are of great utility—as shall be shown in its proper place. Nor, even in these universal propositions, do we require an exact or absolute affirmation or denial. It is sufficient for our present purpose if they admit some *single or rare exception* [3].

[1] The *Instantiae Comitatûs et Hostilitatis*, also called *Instantiae Propositionum Fixarum*, defined Bacon's eleventh class of prerogative instances. They exhibited a body in which a given nature was either invariably present (*friendship*) or invariably absent (*enmity*). Bacon used them to establish what he termed "fixed propositions," empirical statements analogous to universal affirmations or denials in logic. Their purpose was not metaphysical certainty but operational reliability: to identify those associations in nature that held without known exception.

[2] Bacon reinterpreted the Aristotelian notion of the universal proposition. Rather than deriving universality from logical form or essence, he grounded it in

empirical constancy—the repeated conjunction or exclusion of properties. This shift from abstract necessity to observed regularity anticipated the modern concept of the law of nature as an inductive generalization rather than a deductive axiom.

[3] The qualification that universals may admit "some single or rare exception" signaled Bacon's awareness of the provisional character of empirical knowledge. His tolerance for exceptions foreshadowed the probabilistic reasoning of modern science, where universal statements are upheld not absolutely but statistically, and anomalies are treated as opportunities for refinement rather than refutation.

The *use* of the *Instances of Accompaniment* is to *narrow and constrain the affirmative of the form*. For just as in *migrating instances* the affirmative of the form is narrowed—so that it must necessarily be inferred that the form of the thing is something which is *imparted or destroyed by the act of migration*—so likewise, in *instances of accompaniment*, the affirmative of the form is narrowed—so that it must necessarily be inferred that the form of the thing is something which *enters into* the *composition* of such a concrete body, or, on the contrary, *abhors and refuses it*. Therefore, whoever is well acquainted with the *constitution or configuration* of such a body will not be far from bringing to light the *form of the nature under inquiry*.

For example: let the nature sought be *Heat*. An *Instance of Accompaniment* is *flame* [4]. For in water, air, stone, metal, and many other substances, heat is *mobile*, and can *come and go*; but *every flame is hot*, so that *heat perpetually attends the concretion of flame*. On the other hand, there is no *Hostile Instance* of heat found among us; for concerning the *interior of the earth* we have no evidence of sense, and among the bodies known to us there is absolutely *no concretion* which is *wholly unsusceptible of heat*.

[4] Bacon's example of flame as an "Instance of Accompaniment" for heat was rhetorically apt but physically naïve. He assumed that heat was an essential quality of flame, rather than a product of combustion and energy release. Modern thermodynamics distinguishes between temperature and the process

of oxidation, revealing that heat does not inhere in flame as a constant form but arises from energy transfer. The example remains methodologically sound, however, in illustrating a case of constant correlation used to infer a causal connection.

Again, let the nature sought be *Consistency* (or *Fixedness*). A *Hostile Instance* is *air* [5]. For metal can *flow* and can *harden*; so also glass; even water can *harden* when it freezes. But it is *impossible* that air should ever *harden* or *lay aside its fluidity*.

[5] The claim that air was a "Hostile Instance" to solidity reflected the seventeenth-century belief in the absolute fluidity of gases. Bacon regarded air as incapable of hardening, since liquefaction and solidification of gases were then unknown. Subsequent experiments by Cailletet and Pictet in 1877 demonstrated the contrary, showing that even oxygen and nitrogen could be liquefied under pressure and low temperature. His observation, though incorrect, nonetheless exemplified the use of exclusion to mark the limits of a nature—in this case, the boundary between the solid and the fluid state.

However, two cautions remain to be noted regarding these *instances of fixed propositions*, both of which are useful for our purpose. The first is, that if a *completely universal affirmative or negative* be altogether lacking, that very absence should be carefully recorded *as a non-being* [6]; as we did in the case of *heat*, where the *universal negative* (so far as concerns things within our knowledge) is *wanting in nature*. In like manner, if the nature sought be *Eternal* or *Incorruptible*, the *universal affirmative* is here wanting among us; for neither *Eternal* nor *Incorruptible* can be predicated of any of the bodies beneath the heavens or above the interior of the earth. The second caution is, that to *universal propositions*, whether *affirmative* or *negative*, regarding some concrete body, there should be *subjoined those concrete bodies which appear next in degree to that which is of the non-existent kind* [7]: as, for example, in the case of *heat*, *flames that are soft and least burning*; in the case of *incorruptibility*, *gold*, which approaches it most nearly. For all such examples *mark the boundaries of nature between being and non-being*; and they *assist in the circumscription of forms*,

lest these forms extend too far and *wander beyond the conditions of matter*.

[6] Bacon's instruction to record the absence of universal affirmatives or negatives "as a non-being" expressed an early recognition that negative evidence constitutes data. This principle survives in modern experimental design, where the failure to observe an effect—properly documented—has epistemic weight equal to positive detection. Bacon thereby articulated a rudimentary logic of falsifiability three centuries before its formal articulation.

[7] The direction to note bodies "next in degree" to those lacking a given nature illustrated Bacon's concept of *limina naturae*—the thresholds between being and non-being. These transitional cases, such as "soft and least burning flames" or nearly incorruptible metals like gold, represent what is now termed boundary or threshold phenomena, where continuous quantitative change produces discrete qualitative transition. His insight that such border cases delimit the range of a form remains philosophically and scientifically valid.

II-XXXIV (2:34).

Among the prerogative instances we place, in the **twelfth position**, those very Subjunctive Instances of which mention was made in the preceding aphorism—which we are also accustomed to call Instances of the Ultimate or of the Limit (*Instantiae Ultimitatis sive Termini*) [1]. For such instances are useful not only inasmuch as they are subjoined to the *fixed propositions*, but also *in themselves and in their own right*. For they plainly indicate the *true boundaries of nature*, the *measures of things* [2], and that point of "*how far* nature acts and endures," and then the *passage of nature into another state* [3]. Such are, for example: *gold* in regard to *weight*; *iron* in regard to *hardness*; the *whale*, in regard to the *size of animals*; the *dog*, in regard to *sense of smell*; the *explosion of gunpowder*, in regard to *swift expansion* [4]; and other things of the same kind. Nor should those things be exhibited *less*, which stand *at the lowest extreme of degree* [5] than those which stand at the highest: as, for instance, *spirit of wine* in regard to *lightness*; *silk*

in regard to *softness*; and *skin-worms* in regard to the *smallness of animals*; and so forth [6].

[1] The *Instantiae Subjunctivae sive Ultimitatis vel Termini* formed Bacon's twelfth class of prerogative instances, also referred to as "subjunctive" by analogy with grammatical forms. They designated extreme cases at which a natural property reached its greatest or least intensity, thereby marking the boundary of its operation. In the structure of the *Novum Organum*, they completed the transition from qualitative observation to quantitative measure, defining the termini at which one form passes into another.

[2] Bacon's phrase "the true boundaries of nature, the measures of things" reflected his conviction that the intelligibility of the world depends on discovering its limits rather than its absolutes. In the seventeenth century, such limits were empirical—based on the heaviest, hardest, or largest known objects. Yet the conceptual gesture anticipated the later scientific use of boundary conditions: the definition of a phenomenon's domain by determining the extremes at which its law holds.

[3] The expression *quantum natura agat et patiatur*—literally "how far nature acts and suffers"—summed up Bacon's understanding of causation as reciprocal activity and passivity. He viewed natural processes not as unilateral actions but as exchanges of force within constraint. Philosophically, this anticipates the modern insight that phenomena are defined by both their active range and their susceptibility to change—the precursor of dynamic equilibrium and limit analysis.

[4] Bacon's examples illustrate his empirical reach yet expose the limits of early modern knowledge. Gold is indeed among the densest common metals, though platinum and iridium are heavier. Iron, however, is not the hardest material; diamond exceeds it by far. The whale remains the largest living animal, though later paleontology uncovered far greater extinct species. Gunpowder's explosive force exemplified his interest in rapid expansion, yet it has since been surpassed by higher-energy reactions. Bacon's method—seeking maxima and minima as keys to natural law—remains sound even though his examples reflected the science of his age rather than enduring truths.

[5] The symmetry Bacon maintained between the highest and lowest extremes—the heaviest and lightest, hardest and softest—illustrated his principle that understanding requires mapping the entire scale of variation. This approach anticipated the modern technique of parametric exploration, in which both

upper and lower limits are experimentally determined to establish a law's continuity and threshold points.

[6] The concluding enumeration of minima, such as "spirit of wine in regard to lightness" and "skin-worms in regard to the smallness of animals," reaffirmed Bacon's belief that the laws of nature are most visible at their limits of being (*limina naturae*). In contemporary science, the same principle guides investigation at the edges of observability—quantum limits, biological minima, and cosmic maxima—where transition, not stability, discloses the structure of law.

II-XXXV (2:35).

Among the prerogative instances, we place in the **thirteenth position** the Instances of Alliance or Union [1]. These are those which conflate and unite natures that are considered heterogeneous, and are marked and noted as such through accepted divisions.

[1] Bacon introduced the *Instantiae Foederis sive Unionis* to denote those examples in which seemingly unlike phenomena were found to share a common nature. The Latin *foedus* ("league" or "treaty") signified the reconciliation of divided kinds under one law. He conceived these instances as instruments for elevating the intellect from apparent difference to generic unity. Modern commentators recognize in them a prototype of the unifying tendency of modern science, which seeks common explanatory forms across domains once regarded as distinct.

Now, instances of alliance show that operations and effects which are attributed to one of these heterogeneous kinds as proper, also belong to others among them; so that it is thereby demonstrated that this heterogeneity (which exists in opinion) is not real or essential, but is nothing other than a modification of a common nature. They are therefore of the greatest utility in raising and elevating the understanding from differences to genera; and in removing the masks and phantasms of things, insofar as they appear and present themselves in disguise in concrete substances. For example, let the nature in question be Heat. There appears to be a solemn and authoritative division, that there are three kinds of heat—namely, the

heat of heavenly bodies, the heat of animals, and the heat of fire [2]; and that these heats (especially when one is compared with the other two) differ in their very essence and species, or in specific nature, and are plainly heterogeneous: since the heat of the heavenly bodies and of animals generates and fosters, whereas the heat of fire, on the contrary, corrupts and destroys. An instance of alliance is therefore that common experiment, in which a branch of a vine is placed indoors where there is a constant fire [3], and thereby the grapes ripen even a full month earlier than they would outside; so that the ripening of fruit still hanging on the tree can be achieved, namely by fire—although this seems to be the proper work of the sun. Hence, from this beginning, the intellect easily proceeds—having set aside the notion of essential heterogeneity—to inquire what are those differences which are truly found between the heat of the sun and that of fire, by reason of which their operations are so dissimilar, even though both share in a common nature.

[2] When Bacon described the “three kinds of heat,” he repeated the traditional Aristotelian division among celestial, vital, and elemental fire, only to reject it as factitious. Thinkers such as Bernardino Telesio had already undermined that division by treating heat as a single principle differing only in degree. Bacon’s reference to the ripening of fruit by fire anticipated later greenhouse practice, although systematic climate control was unknown in his century. While his account depended on humoral notions of warmth and moisture, the modern understanding of radiant and conductive heating confirms his insight that solar and artificial heat share one physical nature.

[3] Bacon’s example of the vine kept near a constant fire illustrated his belief that experimental alteration of conditions could reproduce the effects of the sun. He argued that moderated, moist, and uneven heat was generative rather than destructive. Such reasoning expressed the early modern shift from passive observation to the active imitation of nature. His conclusion was sound in principle, since controlled warmth can indeed hasten ripening, yet his physiology of “moist” heat belonged to the pre-thermodynamic imagination.

Four such differences will be found: first, that the heat of the sun, in comparison to the heat of fire, is by degree much milder and gentler;

second, that it is (especially as it is transmitted to us through the air) qualitatively much more moist; third (which is the principal point), that it is exceedingly unequal—approaching and intensifying, then withdrawing and diminishing; and this inequality contributes most of all to the generation of bodies. For Aristotle rightly asserted that the principal cause of generations and corruptions which occur here on the surface of the earth is the oblique path of the sun through the zodiac; whence the sun's heat becomes, in marvelous ways, unequal—partly through the alternation of day and night, and partly through the succession of summer and winter. Yet that man does not refrain from immediately corrupting and perverting what he had rightly discovered. For, as an arbiter of nature (as is his custom), he most dogmatically assigns the cause of generation to the approach of the sun, and the cause of corruption to its withdrawal; whereas both events (the approach and the withdrawal of the sun) do not respectively, but rather indifferently, serve as causes for both generation and corruption; since inequality of heat ministers to the generation and corruption of things, while equality serves only for preservation. A fourth difference between the heat of the sun and of fire—one of great significance—is that the sun carries out its operations over long intervals of time, whereas the operations of fire (due to human impatience) are brought to completion in shorter durations. But if one should carefully endeavor to temper the heat of fire and reduce it to a more moderate and gentle degree (which can easily be done in many ways), and then also sprinkle and mix in some degree of moisture—especially if one imitates the sun's heat in its inequality, and finally exercises patience in delaying the process (not certainly to the extent proportionate to the sun's operations, but to a greater extent than humans are accustomed to when using fire)—then he will easily dismiss that supposed heterogeneity of heat, and may attempt, or even equal or in some respects surpass, the works of the sun by means of fire. A similar instance of alliance is the revival of butterflies from a

state of torpor induced by cold, where they appeared as though dead, through the gentle warmth of fire; so that one may easily perceive that it is no less within the power of fire to animate living beings than to ripen plants. Likewise, that celebrated discovery of Fracastorius, concerning a strongly heated pan which physicians apply around the heads of patients in desperate cases of apoplexy [4], clearly reveals how the vital spirits, compressed and as it were extinguished by the humors and obstructions of the brain, are expanded and stimulated into motion—just as fire acts upon water or air—and thus, by consequence, restores life. Eggs too are sometimes hatched by the heat of fire, which closely imitates animal heat; and many such examples exist; so that no one may reasonably doubt that the heat of fire can in many subjects be so modified as to resemble the heat of heavenly bodies and of animals.

[4] Girolamo Fracastoro (1478–1553) had been celebrated as a physician and poet who explained contagion by invisible “seminaria.” Bacon cited his supposed use of a heated metal vessel in apoplexy as evidence that fire could restore life by expanding “vital spirits.” The report belonged to the medical tradition of humoral balance rather than to neurological science. The practice of applying heat to the skull had, at most, the physical effect of local vasodilation; nevertheless, the case exemplified Bacon’s search for analogies between artificial and vital heat. Modern physiology, by contrast, recognizes no revivifying power in simple thermal stimulation of the brain.

In like manner, let the natures in question be Motion and Rest. There seems to be a solemn division, grounded in the very depths of philosophy, that natural bodies either rotate, move in straight lines, or remain at rest [5]. For motion is either without a terminus, or is a station at a terminus, or is a transit toward a terminus. Now, perpetual rotary motion appears to belong properly to the heavenly bodies; rest or station seems to belong to the globe of the earth itself; and the remaining bodies (those called heavy and light, situated outside the places of their natural conformity) are borne straight either toward masses or congregations of similar bodies—light ones upward, toward

the heavens; heavy ones downward, toward the earth. And such things are indeed pleasing to say.

[5] In discussing motion and rest, Bacon recalled Aristotle's tripartite doctrine that heavenly bodies move circularly, heavy bodies rectilinearly toward the earth, and light bodies rectilinearly away from it. He used "instances of alliance" to question the absolute distinction between celestial and terrestrial mechanics. Although he lacked the calculus of forces later introduced by Galileo and Newton, his conceptual move from "different motions" to a single physical principle anticipated the modern unification of dynamics.

Yet an instance of alliance is a certain low-lying comet, which, although far beneath the heavens, nevertheless rotates [6]. And Aristotle's fiction of the comet being bound to or following some star has long since been refuted—not only because the reasoning behind it is implausible, but also due to the clear experience of comets' wandering and irregular motion through various regions of the heavens.

[6] When Bacon referred to a "low-lying comet that rotates," he repeated the pre-Keplerian view that comets were atmospheric exhalations, not celestial bodies. Tycho Brahe and Kepler had already shown by parallax measurements that comets moved through planetary space. Bacon's observation was therefore empirically mistaken, though his attempt to dissolve the Aristotelian wall between the heavens and the sublunary world marked an important philosophical advance.

Žižek's later use of "parallax" to denote irreconcilable subjective perspectives likewise borrowed its terminology from this celestial phenomenon.

Again, another instance of alliance concerning this topic is the motion of the air, which within the tropics (where the circles of rotation are larger) seems likewise to rotate from east to west.

And another instance again would be the ebb and flow of the sea, if only the waters themselves could be shown to be carried by a rotary motion (though slow and subtle) from east to west [7]; such that they are nevertheless repelled twice daily. Thus, if these matters stand as described, it is evident that this rotary motion does not end in the heavens but is shared with the air and the waters.

[7] Bacon attributed the tides to a sluggish rotary motion of the ocean from east to west, intermittently repelled by terrestrial obstacles. This explanation preceded Newton's gravitational account and ignored lunar influence, which Galileo and Kepler had suspected but not quantified. The theory was scientifically false, yet it revealed Bacon's conviction that the same mechanical tendencies operated in air, water, and celestial bodies, a conviction vindicated in later fluid and gravitational physics.

Likewise, the property attributed to light bodies—that they are borne upward—becomes somewhat questionable. In this respect, a bubble of water may serve as an instance of alliance. For if air is trapped beneath water, it ascends swiftly toward the surface of the water by means of that motion of percussion (as Democritus calls it), whereby the descending water strikes and drives the air upward—not, however, through any effort or striving of the air itself. But when the air reaches the very surface of the water, it is then hindered from rising further by the slight resistance it encounters in the water, which does not readily permit itself to be broken apart; so that the appetite of air for rising appears to be exceedingly weak.

Likewise, let the nature in question be Weight. There is a widely accepted division, that dense and solid bodies are borne toward the center of the earth, while rare and tenuous ones are carried toward the circumference of the heavens [8], as if to their proper places. But as for these "places" (although such notions prevail in the schools), it is a notion altogether inept and childish to think that place can do anything. Thus, philosophers talk nonsense when they say that, if the earth were perforated, heavy bodies would come to rest at the very center. For such a conclusion would suppose a truly efficacious kind of nothing, or a mathematical point, capable either of affecting other things or of being desired by them—for a body is only acted upon by another body. Rather, this appetite for ascending or descending is either in the configuration of the moving body itself, or in a sympathy or agreement with another body. Now, if a dense and solid body were

to be found that nevertheless was not borne toward the earth, such a discovery would overthrow this sort of division. And if the opinion of Gilbert is accepted—that the magnetic force of the earth, by which it attracts heavy bodies, does not extend beyond the sphere of its virtue (which always operates at a certain distance, and not beyond)—and if this is verified through some instance, that would then be an instance of alliance concerning this subject. Yet, for the present, no certain and manifest instance concerning this is at hand. The phenomenon which comes closest seems to be the "cataracts of heaven," [9] which are frequently observed during oceanic voyages toward either of the Indies. For so great is the force and mass of the waters that suddenly pour down in such cataracts that it appears a prior accumulation of water had occurred, which remained suspended in those places; and that it was afterward discharged and thrust down by some violent cause, rather than having fallen by a natural motion of gravity. So one might conjecture that a dense and compact material mass at a great distance from the earth may be held aloft like the earth itself, and not fall unless driven down. However, we affirm nothing certain about this. In the meantime, in this and many other matters, it becomes easily apparent how impoverished we are in natural history, since in place of certain instances we are sometimes compelled to offer suppositions as examples.

[8] In rejecting the notion that bodies were drawn to their "natural places," Bacon attacked the Aristotelian idea that spatial position possessed causal efficacy. He proposed instead that descent resulted from "sympathy" between bodies, adapting William Gilbert's magnetic conception of terrestrial attraction. Though Bacon's magnetical model was mistaken, his denial that an abstract "place" could move bodies anticipated the mechanistic view that only bodies act upon bodies. Modern physics confirms the correctness of this logical rejection, replacing "sympathy" with gravitational field theory.

[9] The phrase *cataractae coeli* referred to torrential downpours reported by sailors in equatorial regions. Bacon conjectured that these resulted from great accumulations of water suspended aloft and suddenly released. His speculation, though imaginative, reflected ignorance of condensation and

atmospheric pressure, which were later clarified by Torricelli and Pascal. The passage nonetheless shows Bacon's empirical bent: he preferred descriptive natural history to cosmological dogma.

In like manner, let the nature in question be the Discursive Faculty of the Mind. There appears to be an entirely sound division between human reason and the cunning of brute animals. Yet there are certain instances of actions performed by animals through which even brute creatures seem to reason, as it were. It is recorded, for example, that a crow, nearly perishing of thirst during a great drought, saw water in the hollow trunk of a tree; and, being unable to reach it because of the narrow opening, did not cease from throwing in many small stones [10], by which the water rose so that he could drink—a story which later passed into a proverb.

[10] Bacon's story of the thirsty crow came from the *Fables of Avianus* and later entered Aesopian tradition. He used it as an "instance of alliance" between human reasoning and animal ingenuity, thereby questioning the categorical division between rational and instinctual behavior. While Bacon lacked evolutionary theory, his example coincides with modern ethological findings that corvids employ causal reasoning in problem solving, confirming his intuition of cognitive continuity across species.

Likewise, let the nature in question be Visibility. There appears to be a clear and definite division between light, which is the original visible and supplies vision with its primary source, and color, which is a secondary visible and cannot be seen without light—so that it seems to be nothing other than an image or modification of light. Nevertheless, on both sides there seem to be instances of alliance in this matter: namely, snow in great quantity, and the flame of sulfur [11]; in the former, there appears to be a color that verges toward light, and in the latter, a light that tends toward color.

[11] When Bacon compared the whiteness of snow with the flame of sulfur, he sought to show that light and color formed a continuous spectrum rather than distinct essences. He thereby opposed the Aristotelian doctrine that color was a mere affection of the transparent. Snow indeed reflects light but emits none,

while colored flames do emit light of varying wavelengths. Bacon's speculation, though partly incorrect, anticipated the later optical unification of light and color achieved by Newton's prism experiments and by modern wave theory.

II-XXXVI (2:36).

Among the prerogative instances we place, in the **fourteenth position**, the Instances of the Cross (*Instantiae Crucis*) [1], borrowing the term from the crosses erected at the meeting of two roads to mark the point of separation. These we are also accustomed to call Decisive or Judicial Instances, and in some cases Oracular or Commanding Instances. Their nature is as follows. When, in the investigation of any nature, the understanding is poised as though in a state of equilibrium—being uncertain to which of two (or sometimes more) natures the cause of the nature under inquiry ought to be ascribed, owing to the frequent and ordinary concurrence of several natures together—then the *Instances of the Cross* show that the *association of one of these natures* with the nature sought is *constant and indissoluble*, while that of another is *variable and separable*. Hence the question is decided, and the former nature is accepted as the cause, the latter dismissed and rejected. Such instances are of the *greatest illumination* and possess, as it were, *supreme authority*; so that the course of interpretation sometimes *terminates in them* and is *completed through them*. Occasionally, indeed, such Instances of the Cross occur among those already noted; but, for the most part, they are *newly sought and devised by design and forethought*, and are at length *brought to light by diligent and exact investigation*.

[1] The Latin *instantiae crucis* derived from the *crux viarum*—a crossroad marking the point of decision—was used by Bacon to denote decisive experiments that determine between rival causes. The metaphor soon entered scientific vocabulary as *experimentum crucis*. In the seventeenth century, Robert Boyle and later Isaac Newton adopted the phrase to describe the discriminating

experiment that compels assent. Bacon's expression thus prefigured the logic of the "crucial test" in modern scientific method.

For example, let the nature under inquiry be the ebb and flow of the sea [2], that twice-repeated daily motion with its six-hour intervals in each advance and retreat, accompanied by a certain variation corresponding to the motion of the moon. The *bifurcation* in this case is as follows.

[2] Bacon's tidal analysis reflected the confused state of early modern cosmology. He was aware of reports by José de Acosta and others that tides coincided on opposite shores, but he misinterpreted them under the assumption of an immobile Earth. Galileo, in the *Dialogo* (1632), attributed the tides to the combined motions of the Earth; Kepler and Gilbert invoked lunar attraction. Bacon's bifurcation between "progressive" and "uplifting" motion correctly sought a discriminating test but rested on false premises. Modern tidal theory, based on Newtonian gravitation, shows that lunar and solar gravitational gradients produce the phenomenon.

It is necessary that this motion be caused *either* by a *progression and regression of the waters*, after the manner of water in a basin which, when it strikes one side, abandons the other; *or* by a *rising and falling of the waters from the depths*, as in the boiling up and subsiding of water. To which of these causes the tidal motion ought to be ascribed, the doubt arises. If the *first assertion* be received, it follows that when there is *flood-tide* in one part of the sea, there must at the same time be *ebb-tide* elsewhere. The inquiry therefore reduces to this point. Now Acosta, together with certain others (having made diligent observation), reports that on the coasts of *Florida* and on the *opposite coasts of Spain and Africa*, the *tides rise at the same times*, and likewise the *ebb occurs at the same times*; not contrariwise, so that the tide of Florida should coincide with the ebb of Spain and Africa. Yet upon closer attention, this observation does not by itself disprove the *progressive motion*, nor establish the *uplifting motion*. For it may still be that the motion is one of progression, and that nevertheless the opposite shores of the same basin are overflowed simultaneously, if

the waters be driven and thrust from some other quarter—just as in rivers which flow and ebb upon both banks at the same hours, though the motion is plainly progressive, the waters entering from the sea into the river mouths.

So likewise it may happen that the waters, driven in great mass from the *Eastern Indian Ocean*, are forced into the *channel of the Atlantic*, and thereby overflow both its shores at once. Inquiry should therefore be made whether there exists another basin by which the waters may at the same times be diminished and withdrawn. And such a basin indeed exists—the *Southern Ocean*—not less, but rather more wide and spacious than the Atlantic, and fully sufficient for this effect.

We have therefore reached at length the *Instance of the Cross* concerning this subject. It is this: If it be certainly found that, when the tide rises upon the opposite coasts both of Florida and of Spain in the Atlantic, the tide likewise rises upon the coasts of Peru and along the back of China in the Southern Ocean, then by this *decisive instance* the assertion that the tides proceed by *progressive motion* must be rejected. For there will remain no other sea or place in which the simultaneous *recession or ebb* can occur. This might most conveniently be ascertained by inquiry among the inhabitants of *Panama* and *Lima* (where the two oceans, the Atlantic and the Southern, are separated only by a narrow isthmus), whether on the opposite sides of the isthmus the tides rise and fall together, or contrariwise. This decision, however, is valid on the supposition that the *earth stands immobile* [3]. But if the *earth rotates*, it might be that, from the *unequal motion* (in speed or impulse) of the earth and the waters, there results a *violent compression* of the waters upward, which constitutes the *flood*, and a *relaxation* of the same, when they can no longer rise, which constitutes the *ebb*. Yet this must be inquired into separately. Nevertheless, even granting this supposition, it remains equally fixed that *somewhere or*

other there must occur *reflux of the sea at the same times* that *floods occur in other regions*.

[3] Bacon's proviso "on the supposition that the earth stands immobile" revealed his reluctance to accept the Copernican system. Though he entertained the possibility of terrestrial rotation as an hypothesis, he withheld assent on both theological and empirical grounds. His neutrality contrasts with Galileo's open advocacy and Kepler's mathematical conviction. Historically, this hesitation limited Bacon's cosmological insight but did not diminish the logical value of his method.

Similarly, if the nature under inquiry be that latter motion of the sea which we have supposed—namely, the *rising and subsiding of the waters*—if (after diligent examination) the other motion, that of *progression*, be rejected, then the *trilemma* concerning this nature will be as follows. It must needs be that the motion whereby the waters rise and fall in the tides, *without any accession of other waters flowing in*, proceeds by one of these three ways: Eeither that this quantity of waters *issues from the interior of the earth* and returns into it again; or that there is *no increase of bulk*, but the same waters, without augmentation of quantity, *expand or rarefy themselves*, so as to occupy greater space and dimension, and then *contract* again; or that neither the bulk be increased nor the extension enlarged, but that the same waters—remaining as to their mass and rarity the same—be *attracted upward by some magnetic power from above* and, by sympathy, *rise and fall* accordingly. Let the inquiry, then (omitting the two former motions), be reduced to this last: whether such a *magnetic elevation* by consent or attraction from above takes place. Now, in the first place, it is evident that all the waters contained in the basin or hollow of the sea cannot *rise together*, since there would then be *no substance to succeed beneath*; so that, even if there were in the waters some such *appetence of elevation*, it would yet be broken and restrained by the *cohesion of things*—or, as men commonly say, *lest a vacuum should occur*. It remains, therefore, that the waters are *raised in some part*, and thereby *diminished and withdrawn from another*. And again, it

necessarily follows that the *magnetic force*, since it cannot operate upon the whole equally, *acts most strongly about the middle*; so that it *lifts the waters in the centre*, while those thus elevated *leave and forsake the sides* in succession.

We have therefore now at length arrived at the Instance of the Cross concerning this subject. It is as follows: If it be found that, during the ebb of the sea, the *surface of the waters* in the open ocean is *more curved and rounded*—the waters being thereby *raised in the middle* and *lowered toward the sides*, that is, the shores—while during the flow of the tide the same surface becomes *flatter and more even*, the waters returning to their former position; then, by this *decisive instance*, the *elevation of the waters through a magnetic force* may be accepted; otherwise, it must wholly be rejected.

This, moreover, may not be difficult to test in straits, by means of *nautical soundings*—namely, whether during the ebb the sea be *higher and deeper toward its middle* than during the flow. It should also be noted that, if this be so, then (contrary to common belief) the waters *rise during the ebb* and only *subside during the flow*, so that the shores are *clothed and inundated* by their descent.

In like manner, let the nature in question be Spontaneous Rotatory Motion—and, in particular, whether the diurnal motion, by which the sun and stars appear to rise and set before our eyes, be a *true motion of rotation in the heavens*, or rather an *apparent motion in the heavens but a real motion of the earth*. An *Instance of the Cross* on this subject might be as follows. If it be found that there exists in the ocean a movement from *east to west*, however faint and languid; that a *similar motion* is found in the *air*, somewhat more active—especially within the *tropics*, where, because of the larger circles, it is more perceptible; that the *same motion* is observed in the *lower comets*, now become lively and vigorous; that it is also seen in the *planets*, yet so ordered

and graduated that the *nearer they are to the earth the slower they move*, and the *more distant the swifter*, and that in the *firmament of the fixed stars* it is *most rapid of all*—then certainly the *diurnal motion* must be accepted as *true and proper to the heavens*, and the *motion of the earth* must be denied. For it will then be manifest that the motion from *east to west* is altogether *cosmic*, arising from the *consent and harmony of the universe*—which, being *most rapid in the heights of heaven*, gradually *slackens* and at last *ceases and dies away* in that which is *immobile*, namely, the *earth*.

In like manner, let the nature in question be that *other Rotatory Motion*, celebrated among astronomers and contrary to the diurnal—namely, that from *west to east*; which the ancient astronomers ascribed to the *planets* and even to the *firmament of the fixed stars*, but *Copernicus* and his followers also to the *earth itself*. The question is, whether there be in nature any such motion, or whether it be a *fiction and assumption* introduced for the *convenience of computation* and for the sake of that beauty—the explanation of celestial motions by *perfect circles*. For this motion is in no wise proved to be *real and existent in the heavens*—neither by the *failure of the planets to return* to the same point of the starry sphere in their diurnal motion, nor by the *obliquity of the zodiac* in relation to the poles of the world; for these two phenomena, which gave rise to the hypothesis, may be *otherwise and better explained*—the former by *anticipation and lagging*, the latter by *spiral lines*. Thus the inequality of restitution and the declination toward the tropics may be regarded as *modifications of the single diurnal motion*, rather than as *motions resisting or about different poles*. And it is most certain that, if we for a time behave as lay observers—setting aside the commentaries of the astronomers and the schools, whose habit it is to do violence to sense in many things, and to prefer what is obscure—the motion is, *to sense*, just such as we have described; of which we have sometimes caused a *representation to be made by means of iron wires*, as in a machine.

Nevertheless, an *Instance of the Cross* concerning this matter might be such as follows: If in any trustworthy history it be found that there has appeared some comet, whether *higher* or *lower*, which has not revolved in manifest accordance (however irregularly) with the *diurnal motion*, but rather has *moved contrariwise to the heavens*, then we must conclude that such a motion may indeed exist in nature. But if nothing of the kind be found, the hypothesis must be regarded as *suspect*, and recourse must be had to *other Instances of the Cross* on the subject.

Likewise, let the nature under inquiry be Weight, or Gravity. The bifurcation here is as follows. It must needs be that heavy and ponderous bodies either *tend of their own nature* toward the *centre of the earth*, by reason of their *peculiar configuration*; or else that they are *attracted and drawn* by the *mass of the earth itself*, as by an *assemblage of bodies of like nature*, and are borne toward it by *sympathy*. But if this latter be the true cause, it will follow that the *closer heavy bodies approach the earth*, the *more strongly and swiftly* they are borne toward it; the *further they are removed*, the *weaker and slower* the attraction—just as in *magnetic* operations. And this effect must occur within *certain limits*; so that if the bodies be carried so far from the earth that the earth's virtue can no longer act upon them, they will remain *suspended*, like the earth itself, and will not fall at all. An *Instance of the Cross* on this subject may therefore be as follows: Take a *clock* which is moved by *lead weights* [4], and another which is moved by the *tension of a steel spring*; and let both be accurately tested, that one shall not go faster or slower than the other. Then place the *clock moved by weights* on the *summit of some very high building*, keeping the other below; and carefully observe whether the clock at the higher elevation *goes more slowly* than before, owing to the *diminished power of the weights*. Let the same experiment be made in *deep mines*, far below the surface of the earth—whether the same

clock shall *move more quickly* than usual, by reason of the *increased power of the weights*. If it be found that the *force of the weights* diminishes aloft and increases in subterranean places, then the *attraction of the mass of the earth* may be accepted as the cause of *gravity*.

[4] Bacon's proposal to test gravity by comparing clocks raised and lowered in altitude anticipated later gravitational experiments, including Pascal's barometric test (1648) and Airy's pendulum measurements in the nineteenth century. The idea of testing whether attraction varied with distance was brilliant, though Bacon's expectation that gravity increased below ground was mistaken. Modern physics shows that gravitational force decreases both above and below the surface, reaching a maximum at the Earth's surface.

In like manner, let the nature under inquiry be the Verticity of an Iron Needle [5] which has been touched by the magnet. Concerning this nature, the *bifurcation* is as follows. It must needs be that the *touch of the magnet* either of itself imparts to the iron its verticity toward *north and south*; or else merely *excites and prepares* the iron, while the motion itself is imparted through the *presence of the earth*—as *Gilbert* supposes, and strives to prove with great effort. To this point belong those observations which he, with shrewd diligence, has collected: namely, that an *iron nail*, which has long remained fixed in a position north and south, acquires verticity with the mere passage of time, *without contact with a magnet*—as if the earth itself, which acts only weakly at a distance (for the surface or outer crust of the earth, as he thinks, is devoid of magnetic virtue), nevertheless by long continuance *supplied the touch of the magnet*, *excited the iron*, and then, being excited, *conformed and turned it*. Again, that *iron when heated and then allowed to fall*, if it be *laid out north and south at the moment of cooling*, likewise acquires verticity without contact with the magnet—as if the particles of the iron, being loosened by heat and then coming to rest, were at the instant of cooling rendered more *susceptible* and, as it were, *sensitive* to the virtue that emanates from the earth, and

thus become excited by it. Yet, although these things are well observed, they do not *wholly prove* that which he asserts.

[5] The discussion of the "Verticity of an Iron Needle" derived directly from William Gilbert's *De Magnete* (1600), which Bacon admired but criticized. Bacon accepted the Earth's magnetic influence but doubted Gilbert's conclusion that the Earth itself was a magnet. His proposed *terrella* experiment (a small magnetic globe) was sound in principle yet redundant; modern magnetism confirms Gilbert's view that terrestrial magnetism imparts the needle's polarity.

An *Instance of the Cross* on this subject may therefore be as follows. Let there be taken a *terrella* (that is, a small globe of magnet), and let its poles be noted; and let the poles of the terrella be placed toward *east and west*, not toward *north and south*, and so left lying. Then let an *iron needle*, not yet magnetized, be laid upon it and allowed to remain for six or seven days.

Now it is certain (for of this there is no doubt) that while the needle rests upon the magnet, it will, forsaking the poles of the world, turn toward the poles of the magnet; and thus, while it lies there, it will be directed *toward the east and west of the world*.

If, then, when removed from the magnet and placed on a compass, that same needle immediately *turns itself toward the north and south*, or even *gradually settles* into that direction, then the *presence of the earth* must be received as the cause. But if, on the contrary, it *continues to point east and west*, as before, or *loses its verticity altogether*, then that cause must be *held suspect*, and further inquiry made.

In like manner, let the nature under inquiry be the Material Substance of the Moon [6]—whether it be *tenuous, fiery, or aerial*, as most of the ancient philosophers held; or *solid and dense*, as *Gilbert* and many of the moderns, together with certain of the ancients, have maintained. The arguments for this latter opinion rest chiefly upon the fact that the

moon *reflects the rays of the sun*; and it seems that *reflection of light* can take place only from *solid bodies*. Hence, the *Instances of the Cross* on this subject (if any such exist) would be those which *show reflection from a tenuous body*, such as *flame*, provided it possess sufficient thickness. Certainly, one of the causes of *twilight* is the *reflection of the sun's rays* from the upper region of the air. Likewise, we sometimes see, in calm evenings, the *rays of the sun reflected* from the *edges of moist clouds*—not with less brightness, but even with *greater splendor and glory* than that which is rendered from the body of the moon; though it does not appear that those clouds have condensed into a dense body of water. We also observe that the *dark air behind windows at night* reflects the *light of a candle* no less than a solid body does. It might also be tried by experiment whether the *rays of the sun*, admitted through a small aperture, when they fall upon a *flame somewhat dim or bluish*, are reflected. Indeed, the open rays of the sun, when they strike *obscurer flames*, seem, as it were, to *dead them*, so that they appear rather like *white smoke* than *flame*. These are, for the present, the considerations that occur which partake of the nature of *Instances of the Cross* upon this subject; better perhaps may be found hereafter. But it must always be noted that *reflection from flame* is not to be expected except from a flame of some *depth or thickness*; otherwise, it inclines toward *transparency*. This, however, may be taken as certain: that *light*, in any homogeneous body, is *either received and transmitted*, or *reflected back*.

[6] Bacon argued that the moon's reflection of sunlight implied a solid body, yet he admitted uncertainty. His suggestion that reflection might occur from "thick flame" shows the pre-telescopic limits of seventeenth-century optics. After Galileo's *Sidereus Nuncius* (1610) revealed lunar mountains and shadows, the moon's solidity became certain. Modern astrophysics confirms it as a dense, rocky satellite, and the phenomenon of reflection is explained by surface scattering, not by tenuous vapors.

Likewise, let the nature under inquiry be the Motion of Projectiles [7]—such as darts, arrows, or bullets, through the air. The *Schoolmen* (as is

their custom) dispose of this matter with great negligence, being content merely to distinguish it from *natural motion* by the name of *violent motion*; and as for the first percussion or impulse, they think it sufficiently explained by saying that two bodies cannot occupy one place at the same time, lest the dimensions should interpenetrate; but concerning the continued progress of the motion, they take no care at all. Now concerning this nature the bifurcation is as follows: Either this motion proceeds from the *air carrying* the body forward and closing in behind it, as a river carries a boat or the wind drives straws; or else it proceeds from the *parts of the body itself*, which, not being able to sustain the impression, *move successively forward to relieve the pressure*. The former explanation is adopted by *Fracastorius* and by nearly all who have examined this motion with any subtlety; nor is there doubt that the *air* has *some share* in the effect. But the latter motion is *without question the true one*, as is proved by innumerable experiments. Among others, there may be an *Instance of the Cross* on this subject such as this: A *steel spring or wire*, somewhat stiff, or even a *reed or quill split in the middle*, being *bent* between the thumb and finger, will *spring forth* when released. It is manifest that this cannot be ascribed to the *air closing in behind the body*; for the *source of motion* lies in the *middle* of the spring or quill, not in its extremities.

[7] Bacon's treatment of projectile motion, in rejecting Aristotelian "violent motion," represented a genuine advance, but he erred in supposing that propulsion came from successive motions of the body's parts rather than persistence of momentum. Galileo, writing almost simultaneously, identified inertia and parabolic trajectories. Bacon's "Instance of the Cross" with a spring or quill demonstrated internal elasticity, not the general law of motion; scientifically it was misconceived though methodologically well-aimed.

Likewise, let the nature under inquiry be that swift and powerful motion of the expansion of gunpowder into flame [8], whereby such vast masses are overthrown and such heavy weights are projected, as we see in great mines and cannons. The *bifurcation* concerning this nature is as follows. Either this motion is *excited by the mere appetite*

of the body to expand itself when it has been inflamed; or it arises from a *compound appetite*, namely, of the *crude spirit* which *rapidly flees the fire* and bursts forth violently from the fiery matter surrounding it, as from a prison. Now the *School* and common opinion dwell only upon the first of these appetites. Men think they have philosophized excellently when they assert that flame, by the necessity of its elemental form, is endowed with the property of occupying more space than the same body filled when it assumed the form of powder, and that hence this motion follows. Meanwhile they fail to observe that, although this would indeed be true *if flame be generated*, yet the generation of flame may be *prevented* by the *mass of matter* compressing and stifling it, so that the event is never reduced to that necessity of which they speak. For it is rightly thought that, *if flame be generated*, an *expansion* must needs occur, and thence the *expulsion or displacement* of whatever resists. But this necessity is wholly avoided if the solid mass *suppresses the flame before it is generated*. Indeed, we see that flame, especially in its first generation, is *soft and gentle*, and requires *space* wherein it may *try and play*. Therefore, so great a violence as this cannot be ascribed to it of itself. But this is the truth: the generation of such fiery and windy flames proceeds from the *conflict of two bodies* whose natures are utterly contrary—one *highly inflammable*, as in *sulphur*; the other *abhorring flame*, as the *crude spirit* in *nitre*. Hence arises that marvelous contention: the sulphur striving to inflame itself as much as possible (for the *third substance*, namely *charcoal of willow*, contributes little else than to unite and incorporate the other two conveniently); while the spirit of nitre, as much as it can, *bursts forth*, and in bursting *expands itself* (for air and all crude and watery substances do this when heated); and by this flight and eruption meanwhile *drives out* the flame of the sulphur, as with hidden bellows, on every side.

[8] Bacon's account of gunpowder's explosive force as a conflict between sulphur and nitre, one seeking flame and the other fleeing it, typified alchemical

explanation. He correctly recognized that the effect involved rapid expansion of confined vapor, but he lacked chemical knowledge of gaseous production. Modern chemistry shows that combustion of nitre, sulphur, and carbon produces gases—mainly nitrogen and carbon dioxide—whose thermal expansion drives the explosion. His "Instances of the Cross" here were descriptive rather than quantitative.

Now there may be *Instances of the Cross* concerning this subject of two kinds. The first, among those bodies which are *most inflammable*—such as *sulphur, camphor, naphtha,* and the like, together with their mixtures—which take fire *more quickly and easily than gunpowder*, if they are not hindered. Whence it is clear that the mere *appetite of inflammation* does not produce that astonishing effect. The second, among those bodies which *flee and abhor flame*—as do *all salts*. For we see, if they be cast into the fire, that their *watery spirit bursts forth with a crack* before the flame is conceived; which also happens gently in leaves that are somewhat tough, the *watery part* escaping before the *oily* part takes fire. But it is most clearly seen in *quicksilver* (which is not ill called *the mineral water*); for this, *without inflammation*, by mere *eruption and simple expansion*, almost *equals the force of gunpowder*, and when mixed with gunpowder, is said even to *multiply its power*.

Likewise, let the nature under inquiry be the transitory nature of flame [9], and its *momentary extinction*. For it seems that the *flame-like nature* among us *does not become fixed or permanent*, but is generated, as it were, *from moment to moment*, and as quickly *vanishes*. It is manifest, indeed, in flames which here appear to continue and last, that their *continuance* is not of the *same identical flame*, but occurs by the *succession* of *new flame* perpetually generated; not by the persistence of *one and the same flame in number*. This is easily perceived from the fact that, *when the aliment or fuel of the flame is withdrawn*, the flame immediately *perishes*. The *bifurcation* concerning this nature is as follows. This momentary being

may arise either from the *relaxation of the cause* which first produced it—as in light, sounds, and violent motions (as they are called)—or else because flame, though in its nature able to subsist here, yet suffers and is destroyed by *contrary natures* surrounding it.

[9] Bacon's analysis of flame as a continually generated and extinguished phenomenon revealed his acute empirical eye but an incomplete grasp of combustion. He rightly noted that flame depended on fuel and air, yet he imagined its "extinction" to result from external enmity of the air rather than from chemical depletion of reactants. Later work by Boyle, Lavoisier, and Priestley established the role of oxygen. His suggested experiment using dual-colored flames was inventive but physically misconceived.

Hence an *Instance of the Cross* concerning this subject may be as follows. We observe in great fires how *high the flames ascend*. For the *broader the base* of the flame, the *higher its apex*. Hence it appears that the *beginning of extinction* occurs *around the sides*, where the flame is *compressed and disturbed by the air*. But the *midst* of the flame, which the air does not touch, being surrounded on all sides by other flame, *remains the same in number* and is not extinguished until it is gradually *narrowed* by the air pressing in from the sides. Thus every *pyramidal flame* is *broad at the base* around its fuel, but *sharp at the top*—because of the *enmity of the air* and the *failure of fuel*. Smoke, on the other hand, being *narrower at the base*, *expands in ascending*, and becomes as it were an *inverted pyramid*; since air *receives smoke* but *compresses flame*. (For let no man dream that air itself is *flame unkindled*; they are bodies wholly heterogeneous.)

A more exact *Instance of the Cross* adapted to this subject may be had, if perhaps the thing can be made manifest, through *flames of two colors*. Let a small *metal vessel* be taken, and within it a *small wax candle* fixed and lighted. Let the vessel be placed in a *dish*, and around it pour a small quantity of *spirit of wine*, not reaching to the brim of the vessel. Then set fire to the *spirit of wine*. The *flame of the spirit of wine* will appear *more bluish*, the *flame of the candle more yellow*. Let

it then be observed whether the *flame of the candle* (which is easily distinguished from the other by its color, for flames, unlike liquids, do not readily mingle) *remains pyramidal*, or rather *tends toward a globular form*, since there is nothing present that destroys or compresses it. If the latter occurs, it must be taken as certain that a flame can *remain numerically the same* so long as it is *enclosed within another flame* and experiences no *hostile force of the air*.

Thus much concerning the Instances of the Cross. We have been the more extended in our treatment of them for this reason—that men may *gradually learn and accustom themselves* to *judge of nature* by means of *Instances of the Cross* [10] and *experiments of light-giving* (*lucifera*), and not by *probable reasoning*.

[10] This aphorism has enduring philosophical importance as the first explicit statement of the logic of the decisive experiment. The *Instantiae Crucis* embody what later thinkers—Boyle, Newton, Herschel, Mill, and Popper—called the method of difference or falsification. Bacon's insistence that such instances must sometimes be "devised by design and forethought" anticipates modern experimental design and the role of critical testing in theory choice. Though his natural philosophy was pre-Newtonian, his epistemology remains foundational.

II-XXXVII (2:37).

Among the prerogative instances we place, in the **fifteenth position**, the Instances of Divorce (*Instantiae Divortii*) [1]; which indicate the *separations of natures* that for the most part are found united. They differ from those *instances which are subjoined to Instances of Companionship* (*Instantiae Comitatus*), because those show the *separation of some nature from a concrete body* with which it commonly associates; whereas *Instances of Divorce* exhibit the *separation of one nature from another nature*. They differ also from *Instances of the Cross* (*Instantiae Crucis*), since they do not *determine* anything, but merely *warn* that one nature can be *separated from*

another. Their use is to *expose false forms* and to *dispel superficial reflections* arising from common appearances—so that, as it were, they *add weight and ballast to the intellect*.

[1] Bacon placed in the fifteenth position of his prerogative instances the *Instantiae Divortii*, or "Instances of Divorce," by which he meant cases in which two qualities normally found together might appear apart. He used them to test habitual assumptions of inseparability among phenomena, and thereby to discipline the intellect against hasty generalization. The Latin *divortii* referred not to moral separation but to the logical disjunction of natures, revealing Bacon's concern to refine classification by the evidence of exceptions rather than by the comfort of general rules.

For example, let the natures under inquiry be those four *Contubernal Natures* ("natures that dwell together") which *Telesius* desired to hold as being of one household [2] and chamber, namely: heat, light, tenuity, and mobility (or readiness to motion). Yet many *Instances of Divorce* are found among them. For air is *tenuous* and *apt to motion*, but *neither hot nor luminous* [3]; the moon is *luminous* without *heat*; boiling water is *hot* without *light*; the *motion of the magnetic needle* upon its pivot is *quick and nimble*, yet in a body that is *cold, dense,* and *opaque*; and many other such examples may be observed.

[2] Bernardino Telesius (1509–1588) had maintained that heat and cold were the two living forces of the universe and that the other properties of bodies derived from their influence. He held that heat, light, tenuity, and mobility belonged together as properties of the Sun, while cold, darkness, density, and immobility characterized the Earth. Bacon cited this doctrine to illustrate a received dogma of natural conjunctions that his "Instances of Divorce" were meant to dissolve. His criticism thus placed him in opposition to the vitalistic cosmology of Telesius, which he regarded as speculative rather than experimental.

[3] When Bacon observed that air was tenuous and apt to motion but neither hot nor luminous, he meant to show that tenuity and mobility did not entail either heat or light. This was sound methodologically, since it urged the separation of correlated properties before asserting their dependence. Yet his physical description was only partially correct: air may be cold or warm depending on energy transfer, and it does not lack heat intrinsically but simply lacks visible luminosity. The later distinction between heat as molecular motion and light as

electromagnetic radiation clarified what Bacon could only conjecture through sensory contrast.

In like manner, let the natures under inquiry be Corporeal Substance and Natural Action. For it seems that no *natural action* is found except as *subsisting in some body*. Yet there may perhaps be an *Instance of Divorce* in this matter. Such is the magnetic action, by which *iron is drawn to the magnet*, or *heavy bodies toward the globe of the earth* [4]. To these may be added certain other operations at a distance. For this kind of action proceeds *in time*, through successive *moments* (not in a mathematical instant), and *in space*, through successive *degrees and intervals*. Therefore there must be some *moment of time* and some *interval of space* in which this power or action *rests midway* between the two bodies that excite motion. Hence the inquiry is reduced to this question [5]: whether the *bodies which are the termini of motion* dispose or alter the *intermediate bodies*, so that the virtue may pass gradually from one to the other through true contact and succession, subsisting meanwhile in the intermediate body; or whether there is nothing of the kind, but only *the bodies themselves, the virtue, and the space* between them. Now, in optical rays, sounds, heat, and certain other effects that operate at a distance, it is probable that the *intermediate bodies* are indeed *disposed and altered*—the more so because a *qualified medium* is required to carry on such operation. But the magnetic or attractive virtue admits *all media indifferently* (*tanquam adiaphora*), and its power is *not hindered by any kind of medium*. If, therefore, that virtue or action has *nothing to do with the intermediate body*, it follows that there exists a *natural power or action* which for some time and in some space *subsists without a body* [6]; since it subsists neither in the *terminating bodies* nor in the *intermediate*. Therefore, magnetic action may serve as an *Instance of Divorce* concerning *Corporeal Substance* and *Natural Action*. To this may be added, as a *corollary* or *gain not to be omitted*, that even according to the sense of philosophy there may hence be taken a

certain *probation or evidence* that *there exist substances separate and incorporeal* [7]. For if a *natural power or action*, emanating from a body, can *subsist for a time and in a place entirely without a body*, it is not far from possible that it might also *emanate originally from an incorporeal substance*. It seems, indeed, that a *corporeal nature* is required no less for *sustaining and transmitting* a natural action than for *exciting or generating* it.

[4] In speaking of "the magnetic action, by which iron is drawn to the magnet, or heavy bodies toward the globe of the earth," Bacon used the term "magnetic" broadly to include both magnetism and gravity. He thereby conflated two phenomena later shown to arise from distinct forces, though the analogy served his purpose of illustrating attraction without visible contact. His suggestion that such action might exist in time and space without a body prefigured the conceptual structure of field theory, in which forces are understood as properties of space itself. Scientifically, his example was unsound in detail but strikingly prescient in form: he perceived the puzzle of non-contact interaction long before it could be mathematically expressed.

[5] When Bacon reduced the inquiry to the question whether the acting bodies altered the intermediate medium or whether the effect passed without mediation, he entered a dispute that divided late scholastic and early mechanical philosophy. The Aristotelians had taught that effects such as sound and light required a modified medium through which the species of the agent passed; mechanical philosophers after Bacon denied the need for such alteration and sought instead to explain transmission by local motion. Bacon's hesitation between the two shows how transitional his thought was, poised between the language of qualities and the coming language of mechanism.

[6] Bacon concluded that if such attraction subsisted for a time and in a place without a body, there must exist a natural power detached from matter. This reasoning marked a bold step from physical speculation toward metaphysics. Though the idea anticipated modern field theory in form, Bacon expressed it as a conjecture about the autonomy of natural "virtues" rather than about the structure of space. Modern physics treats fields as physical continua governed by measurable laws, whereas Bacon imagined an incorporeal force resting between bodies. His inference was therefore unsound as physics but valuable as an early intuition of an immaterial medium of interaction.

[7] When Bacon added that from such an instance one might take evidence for "substances separate and incorporeal," he moved beyond experiment to a

philosophical inference consonant with the theology of his age. He reasoned that if a natural virtue could exist without a body, then it was not impossible that purely immaterial agents might also exist. This move from physics to metaphysics no longer stands as science, yet it illuminates Bacon's intellectual world, in which empirical discovery still served the broader aim of confirming a rational and divinely ordered universe.

II-XXXVIII (2:38).

There follow five classes of instances which are especially useful for the use of the intellect, and also immediately for the senses. We are accustomed to call them *Instances of the Lamp*, or *of First Information* [1]. Their function is to warn the understanding in advance [2], and to provide, as it were, early and preliminary assistance in its operations, and also to place the senses themselves, to some extent, under direction. For the interpretation of nature is accomplished through the senses as by a close and necessary foundation [3]; but in order for this interpretation to be made properly, it is necessary that both the information of the senses be rendered more trustworthy [4], and the guidance of the intellect more cautious.

[1] The Latin phrase *instantiae luciferae sive de prima informatione* literally meant "light-bringing instances or those concerning first instruction." Bacon used the image of light in contrast to heat, to distinguish knowledge that *illuminated* the intellect from that which merely *generated effects*. He had already employed the same metaphor in the *Distributio Operis* and in *Parasceve ad Historiam Naturalem et Experimentalem* to differentiate *experimenta lucifera* (experiments of light) from *experimenta fructifera* (experiments of fruit). Earlier translators tended to flatten the metaphor into "Instances which aid the senses," but here we preserve the philosophical resonance of "Lamp," which evokes the inner illumination of method rather than the external brilliance of discovery.

[2] Bacon wrote that the *Idols*—habitual errors of perception and reasoning—had to be cleared before any true induction could begin. The "Instances of the Lamp" thus functioned as prophylactic instruments for the intellect, providing what he called *praemunitio intellectus*, a fortification against prejudice. Whereas the *Idols* diagnosed cognitive corruption, the "Lamp" prescribed its remedy: cautious advance of understanding through methodical restraint. The

aim was not to distrust reason, but to discipline it through a preparatory "lighting" of its path.

[3] Bacon's statement that the interpretation of nature proceeds "through the senses as by a close and necessary foundation" reflected his epistemological materialism—his insistence that all knowledge must begin in perception. Yet he knew that perception was not passive. His program for "aiding the senses" anticipated the later development of experimental instruments: the telescope (Galileo), the air pump (Boyle), and the microscope (Hooke). Historically, this aphorism sits on the threshold of what has been called *instrumental empiricism*: the conviction that empirical knowledge depends on artfully constructed means of observation.

[4] When Bacon demanded that the senses be "rendered more trustworthy," he was referring to what modern philosophy of science calls *calibration*. In contemporary laboratories, the reliability of instruments is secured by replication, standardization, and statistical control—all direct descendants of Bacon's insistence that perception must be rectified before it can serve as a foundation for reasoning. His "Lamp" metaphor, therefore, may be read as an early intuition of what later became the epistemology of measurement and verification.

Now these five classes of *Instances of the Lamp* do not seek the form of the thing, nor do they touch upon the deeper and more inward physical cause; rather, they provide information only, as it were, by way of the first presentation of the sense, and thus also dispose the intellect accordingly [5]. Neither is it customary for such instances to be investigated with a view to experiment or practice, but only for the correction and improvement of both sense and intellect. Nevertheless, they are of great benefit in the discovery of causes and axioms, even though they may not seem to go beyond common observation [6].

[5] The phrase "dispose the intellect accordingly" recalled Bacon's long-standing division between light-bearing and fruit-bearing inquiry. The "Instances of the Lamp" were *lucifera*, because they refined judgment and extended conceptual understanding without immediate practical yield. In this sense, Bacon anticipated the modern distinction between basic and applied science. The "Lamp" illuminated inquiry itself rather than the world's material transformation, showing that theoretical clarity is often the first condition of experimental success.

[6] Bacon offered no natural examples here, and thus his "Instances of the Lamp" are scientifically sound insofar as they propose a methodological rather than empirical claim. Their enduring strength lies in their recognition that perception and understanding must co-evolve. Yet Bacon's view remained incomplete, since he treated sense correction as an external act rather than as an internal, theory-laden process. Modern epistemology and cognitive science have shown that all observation is conditioned by conceptual frameworks—an insight Bacon only approached metaphorically through the language of illumination. Nevertheless, this aphorism correctly foresaw that scientific progress depends not only on discovery but on the *refinement of the means of discovering*.

II-XXXIX (2:39).

Among the prerogative instances we place, in the **sixteenth position**, the Instances of the Door or of the Gate (*Instantiae Januae sive Portae*) [1]: for by that name we designate those which assist the *immediate actions of the senses*. Now among the senses it is manifest that sight holds the chief place for the purposes of information; wherefore *aids for this sense* are chiefly to be sought. These aids appear to be of three kinds: either (1) that the sense *perceive what is invisible*; or (2) that it *perceive at a greater distance*; or (3) that it *perceive more exactly and distinctly*.

[1] The phrase *Instantiae Januae sive Portae* literally meant "Instances of the Door or Gate." Bacon employed the metaphor to indicate that such cases open nature to perception, functioning as thresholds through which sensory information enters the intellect. He had earlier used related imagery in *Novum Organum* I.106, where the mind's "entrance" to nature required cleansing from habitual error. The metaphor of the gate therefore conveys both an epistemic passage and a moral discipline of perception.

Of the first kind are (passing over spectacles and similar devices, which serve only to *correct and relieve the infirmity of the visual organ* when ill disposed, and therefore give *no new information*) those instruments lately invented, called perspicilla (magnifying glasses) [2]. These reveal the *hidden and invisible minutiæ of bodies*, and their *concealed*

textures and motions, by *greatly enlarging their species* (that is, their visible images). By their aid the *accurate structure and delineation* of the body of a flea, a fly, or a small worm, together with their *colours and motions* hitherto unseen, may be discerned—and not without admiration. They even report that a line drawn with a pen or brush, when viewed through such a glass, appears *very uneven and tortuous*; because neither the motion of the hand, though guided by a rule, nor the impression of ink or colour, is in truth perfectly even—although the inequalities are so minute that without the help of such glasses they cannot be perceived. Some, as often happens in new and marvellous matters, have added a certain *superstitious observation* to this effect: namely, that such glasses *illustrate the works of nature*, but *dishonour those of art*. But that means nothing more than this—that the *textures of nature are far more subtle* than those of art. Indeed, the glass is of use only for *minute objects*: and if Democritus had seen such a glass, he might perhaps have *leaped for joy* and thought that the *mode of seeing the atom* (which he held to be altogether invisible) had at last been discovered. But the inadequacy of such instruments, except for very small objects (and not even for all such, if they be parts of larger bodies), destroys much of their usefulness. For if the invention could be extended to *larger bodies* or to the *minute parts of larger bodies*—so that, for instance, the texture of a linen cloth might appear as a mesh or net, and thus the hidden minutiæ and inequalities of gems, liquids, urine, blood, wounds, and many other things might be seen—doubtless *great advantages* would arise from this invention.

[2] Bacon referred to the *perspicilla* or "magnifying glasses," by which he evidently meant early microscopes rather than spectacles. At the time of writing (c. 1620), compound microscopes had recently been constructed, probably by Zacharias Jansen in Middelburg around 1590, though their use was still confined to a few experimental circles. Bacon most likely knew of them only by report and had not seen one himself. His remark that they disclosed "the hidden and invisible minutiæ of bodies" was accurate in spirit, though their resolving power was still rudimentary. The example of seeing the roughness of

a pen-line is scientifically sound, reflecting genuine optical magnification, even if Bacon overstated the precision attainable by contemporary lenses.

Of the second kind are those other *perspicilla* which Galileo with memorable effort invented [3] [4]—by the help of which, as through little skiffs or vessels, we may open and maintain closer commerce with the heavenly bodies. Hence it has been ascertained that the *Milky Way* is a *cluster or knot of small stars*, clearly numbered and distinct—a matter concerning which the ancients had only a suspicion. Hence it appears that the *spaces of the planetary orbits* (as they are called) are *not entirely void of other stars*, but that the heavens begin to be *stellated* before one reaches the firmament itself, though with stars too small to be seen without such instruments. Hence may be observed those *little dances of stars about the planet Jupiter*, from which it may be conjectured that in the motions of the stars there are *many centres*. Hence also the *inequalities of brightness and shadow* in the moon are seen more distinctly and located more precisely—so that there might almost be framed a certain Selenography (a mapping of the moon) [5]. Hence, too, the *spots in the sun*, and others of that kind—all certainly *noble discoveries*, so far as confidence may safely be given to such demonstrations [6]. Yet these are somewhat *suspect to us*, because *experiment stops with a few instances*, and *many other things* equally worthy of investigation have *not yet been discovered by the same method*.

[3] Bacon credited *Galileo Galilei* (1564–1642) with inventing telescopes that "opened commerce with the heavenly bodies." Historically, Galileo adapted and refined the Dutch refracting telescope in 1609, rather than inventing it, but he was the first to employ it systematically for astronomy. Bacon's tone of reserve—acknowledging "noble discoveries" yet warning that "experiment stops with a few instances"—revealed his mistrust of single-observer data and speculative enthusiasm. This caution was characteristic of his program to separate empirical observation from premature cosmological theory.

[4] **Excursus – On the Hazards of Too Much Detailed Data**

Some historians have since argued that the imperfections of Galileo's telescopes, rather than hindering discovery, were in fact instrumental to his success. The blurred and edge-distorted images forced him to interpret what he saw conceptually, using geometry and analogy rather than photographic realism. Because the indistinctness of the observations left room for inference, Galileo could reconcile them with pre-Newtonian physics, constructing an idealized and intelligible cosmos without the need for a complete dynamical theory. In this sense, the very fuzziness that troubled Bacon's empiricism may have been what allowed Galileo's imagination to transform imperfect visual data into coherent astronomical knowledge. Another echo of this epistemic concern was expressed by the Russian biophysicist P. P. Lazarev, who observed that if Kepler had possessed highly precise astronomical data, the complexity of planetary motion might have prevented him from discerning simple empirical laws—thus depriving Newton of the foundation for the theory of universal gravitation. Like Bacon, Lazarev emphasized that the true test of an axiom lies not in fitting known particulars but in enabling fruitful extensions.

[5] The term "Selenography" referred to the first attempts to chart the lunar surface, a practice begun by Galileo and continued by Hevelius later in the century. Bacon's remark that "the inequalities of brightness and shadow in the moon are seen more distinctly" captured the initial state of telescopic astronomy. His skepticism about these observations, however, arose from the limited reliability of early optics and from the controversy surrounding the Copernican system, which he never accepted.

[6] Bacon's qualification "so far as confidence may safely be given to such demonstrations" typified his broader insistence on *iterative verification*. He demanded repeated trials and independent confirmation before admitting empirical results into the structure of induction. In modern scientific terms, this reflects the principle of replication and instrumental calibration. His caution was justified: early telescopes and microscopes suffered from spherical and chromatic aberration, so that many apparent details were indeed optical artifacts.

Of the third kind are the measuring rods, astrolabes, and similar instruments [7]; which do not *enlarge* the sense of sight, but *rectify and guide it*. If there be also other instances which assist the *remaining senses* in their *immediate and particular actions*, yet if such instruments *add no new information* to that which is already possessed, they *contribute nothing* to the present purpose. Therefore we have made *no mention* of them here.

[7] Bacon placed measuring rods and astrolabes among aids that "rectify and guide" rather than extend vision. His distinction between amplification and correction corresponds to modern differentiation between detection and measurement instruments. Whereas telescopes and microscopes multiply sensory reach, devices such as the astrolabe standardize and stabilize observation. Bacon's insight here remains methodologically sound: the reliability of data depends as much on precision tools as on magnifying ones.

II-XL (2:40).

Among the prerogative instances, we shall place in the **seventeenth position** the *Citing Instances* [1], a term borrowed from civil law, because they summon things to appear which previously did not appear; we have also been accustomed to call them *Evoking Instances*. These bring the non-sensible down to the sensible [2].

[1] *Instantiae citantes* (also *evocativae*) were named from legal procedure, since Bacon likened experiment to a trial in which hidden causes were summoned to appear before the senses. This metaphor reflected his background as Lord Chancellor and expressed his belief that nature could be compelled to "testify" through experiment.

[2] The phrase *deductio non-sensibilis ad sensibile* described Bacon's method of translating imperceptible phenomena into sensible signs. In modern terms, it anticipates the logic of instrumental mediation, where instruments now render the invisible measurable.

Things escape the senses either because of the distance of the object's location, or because the sense is obstructed by intervening bodies, or because the object is not fit to make an impression upon the sense, or because the quantity in the object is insufficient to strike the sense, or because the time is not proportioned to actuate the sense, or because the impact of the object is not tolerated by the sense, or because the object has already filled and occupied the sense, leaving no room for a new motion. These matters pertain chiefly to vision, and next to touch. For these two senses are informative in a broad sense and concerning common objects, whereas the remaining three almost

never inform except immediately and concerning their proper objects [3].

[3] Bacon classified seven reasons why things escaped sense—distance, obstruction, faintness, insufficiency, disproportion of time, excess of force, and sensory saturation. His classification belonged to early modern psychology of perception but corresponds today to categories such as signal strength, occlusion, and temporal resolution.

(1) In the first kind, reduction to the sensible does not occur unless to the thing which cannot be perceived because of distance, there is added or substituted another thing which is more capable of stimulating and striking the sense from afar—as in the signaling of things by fires, bells, and the like.

(2) In the second kind, a reduction to the sensible occurs when those things which lie hidden internally due to the interposition of bodies and cannot conveniently be exposed, are brought to the senses through those things that are on the surface or that flow out from the internal parts—as the condition of human bodies is inferred through the pulse, urine, and the like.

(3, 4) But the reductions of the third and fourth kinds pertain to many things, and must be sought from all directions in the investigation of nature. Examples of this matter are the following: It is evident that air, spirit, and similar things, which are subtle and diffuse throughout the entire body, can neither be seen nor touched. Therefore, in inquiries concerning such bodies, reduction to the sensible is absolutely necessary.

Let, then, the nature under investigation be the action and motion of the spirit that is enclosed within tangible bodies. For every tangible thing among us contains an invisible and intangible spirit, which is enclosed by it and, as it were, clothed by it. Hence arises the powerful and wondrous threefold source of the spirit's process within the

tangible body. For the spirit in a tangible body, when emitted, contracts and dries the body; when retained, softens and melts the body [4]; when neither fully emitted nor fully retained, it shapes, gives structure, assimilates, expels, organizes, and the like. And all these are brought down to the sensible through their visible effects.

[4] Bacon explained the opposite effects of heat—hardening in some bodies and softening in others—by the emission or retention of *spiritus*. When spirit escaped, he said, bodies dried and contracted; when retained and stirred, they melted or flowed. Present physics attributes both outcomes to microstructural and chemical differences. The observation was sound; the mechanism was pre-chemical.

Indeed, in every inanimate tangible body, the enclosed spirit first multiplies itself [5], and as it were, feeds upon the tangible parts—those which are most susceptible and best prepared for this—and digests and processes them, converting them into spirit, and then both go forth together. And this digestion and multiplication of the spirit is reduced to the sensible through the loss of weight [6]. For in every drying process, something is lost from the quantity of the body; and this not merely from the pre-existing spirit, but from the body itself which was formerly tangible and has now been converted; for spirit has no weight. Now the escape or emission of spirit is brought to the senses in the rusting of metals [7], and in other corruptions of that kind which arrest themselves before reaching the beginnings of life; for those [that reach such beginnings] pertain to the third kind of process. Indeed, in more compact bodies, the spirit finds no pores or passages through which it might escape; therefore it is compelled to drive out the tangible parts themselves and force them forward, so that they depart together; and from this results rust and similar phenomena. But the contraction of the tangible parts, after some of the spirit has been emitted (from which drying results), is brought to the senses both by the increased hardness of the substance, and even more clearly by the fissures, narrowings, wrinkles, and folds of bodies which follow.

[5] Bacon held that every tangible body contained an enclosed *spiritus*—a subtle, pneumatic substance responsible for change, fermentation, and life. The idea descended from Stoic and Paracelsian theories of *pneuma*. Although the concept has no empirical basis, it illustrates how seventeenth-century thinkers unified physical and vital processes under a single principle.

[6] Bacon believed that drying caused a body to lose weight because the departing *spiritus* was weightless. Modern chemistry shows that desiccation reduces mass through evaporation or decomposition, not through conversion of matter into spirit. The phenomenon was real; the explanation was mistaken.

[7] He interpreted rusting as the escape of *spiritus* that carried portions of the body outward, producing decay. Modern chemistry demonstrates that rusting adds oxygen and increases weight. The example shows how Bacon misread a true observation through an erroneous causal model.

For the parts of wood shrink and become narrower; skins wrinkle; and not only this, but (if the emission of the spirit is sudden by the heat of fire) they contract so violently that they fold and curl up upon themselves.

But on the contrary, when the spirit is retained, yet nonetheless is expanded and stimulated by heat or its analogues—which happens in bodies that are more solid or tenacious—then indeed the bodies become softened, as in red-hot iron; they begin to flow, as in metals; they liquefy, as in gum, wax, and the like. Therefore, those contrary operations of heat (whereby from the same cause some things harden and others melt) are easily reconciled: for in the former, the spirit is emitted; in the latter, it is stirred and retained. Of these, the latter is the proper action of heat and spirit; the former is merely the action of the tangible parts, occasioned by the emission of spirit.

But when the spirit is neither entirely retained nor entirely emitted, but merely stirs and tests its bounds, and finds tangible parts that are compliant and yielding at hand, so that wherever the spirit moves, they follow along—then there results the shaping of an organic body, the formation of members, and the other vital operations, both in plants

and in animals. And these are especially brought to the senses through careful observation of the earliest beginnings and rudimentary stirrings of life in small creatures born from putrefaction: as in ant eggs, worms, flies, frogs after rain, etc.

Now, for vivification, both a mild degree of heat and a certain softness of body are required, so that the spirit does not burst forth through too much haste, nor be suppressed by the stubbornness of the parts, but rather, as with wax, can bend and shape them.

Again, that distinction of spirit—most noble and relevant to many matters (namely: the spirit that is cut off, the simply branched spirit, and the branched and also cellular spirit—of which the first is the spirit of all inanimate bodies, the second of plants, and the third of animals)—is brought, as it were, before the eyes through many *deductive instances*.

In like manner, it is evident that the subtler textures and configurations of things (even though they extend throughout the whole body of visible or tangible objects) can neither be seen nor touched. Therefore, in these cases too, information proceeds by way of deduction. Now, the most fundamental and primary difference in configurations is taken from the abundance or scarcity of matter occupying the same space or dimension. For the remaining configurations—which relate to the dissimilarities among parts contained in the same body, and to their arrangements and positions—are secondary in comparison to that former one.

Let, then, the nature under investigation be the *Expansion or Contraction of Matter* within bodies respectively—that is, how much matter occupies how much space in each case. For nothing is more certain in nature than the twin proposition: *from nothing, nothing comes,* and *nothing is reduced to nothing*; rather, the quantity of

matter itself—the total sum—remains constant, and is neither increased nor diminished [8]. It is no less true that, within the same spatial dimensions, more or less matter is contained depending on the nature of the body: as, for example, more in water, less in air. So much so, that if someone were to claim that a given volume of water could be transformed into the same volume of air, it would be the same as saying that something can be reduced to nothing. Conversely, if one were to say that a given volume of air could be transformed into the same volume of water, it would be equivalent to claiming that something can come from nothing. And from this abundance or scarcity of matter, those notions of the *dense* and the *rare*, which are often used loosely and nterchangeably, are properly derived. We must also accept this third proposition, which is sufficiently reliable: that the greater or lesser amount of matter in this or that body can be reduced to calculation—by means of comparison and to exact or near-exact proportions. For example, if someone says that in a given volume of gold there is such a concentration of matter that to equal it in amount, a volume of alcohol would be required which is twenty-one times as large, he would not be mistaken.

[8] Bacon asserted that "the total quantity of matter remains constant," restating the ancient maxim *ex nihilo nihil fit, nec in nihilum redigitur*. Though qualitative and theological in his day, this claim anticipated the modern law of conservation of mass, later confirmed experimentally by Lavoisier.

The accumulation of matter and its ratios are brought to the senses through weight. For weight corresponds to the quantity of matter, as far as the tangible parts of a thing are concerned; but the spirit, and that portion of matter which constitutes it, is not accounted for by weight—for it rather lightens than increases weight. Now, we have compiled a fairly accurate table on this matter, in which we recorded the weights and volumes of individual metals, principal stones, woods, liquids, oils, and many other substances, both natural and artificial—a resource of multiple uses, both for the illumination of understanding

and the guidance of practice; and one that reveals many things altogether unexpected. Nor should this be considered a small matter: that it shows all the variation found among tangible bodies known to us (by which we mean well-compacted bodies, not entirely spongy, hollow, or largely filled with air) does not exceed the ratio of 21 to 1; so limited is nature—or at least that portion of it which most directly concerns us.

We also considered it part of our diligence to investigate whether, perhaps, the proportions of non-tangible or pneumatic bodies could be grasped in relation to tangible bodies.

This we undertook by the following experiment. We took a glass vial that could hold, perhaps, a single ounce—we used a small vessel so that the subsequent evaporation could occur with less heat. We filled this vial nearly to the neck with spirit of wine, choosing spirit of wine because, as shown in the previous table, it is among the rarest of angible bodies (that are well compacted and not hollow), and contains the least amount of matter within a given dimension. Then we carefully recorded the weight of the water [note: meaning the liquid, i.e., spirit of wine] together with the vial. Next, we took a bladder that could hold about two pints. From it we expelled all the air as far as possible, so that the two sides of the bladder were touching.

Before that, we had rubbed the bladder with oil and gently massaged it, so that the bladder would be more tightly sealed—any porosity being blocked by the oil. We then tied this bladder securely around the mouth of the vial, inserting the vial's neck into the bladder's opening, and using lightly waxed thread to make it adhere better and bind more tightly. At last, we placed the vial over hot coals in a small furnace. Soon, the vapor or vaporous breath of the spirit of wine, expanded by heat and transformed into a pneumatic body, gradually inflated the bladder and expanded it fully in all directions like a sail. After this was

done, we immediately removed the glass from the fire and placed it on a carpet so that it would not shatter from the cold. We also immediately pierced a small hole in the top of the bladder, so that the vapor, when no longer heated and converted back to liquid, would not settle and thereby distort the results. Then we removed the bladder and again measured the weight of the spirit of wine that remained. From this, we calculated how much had been consumed and converted into vapor or pneumatic body. By comparing the volume that the liquid occupied when it was still spirit of wine in the vial with the volume it occupied after being transformed into vapor in the bladder, we drew our ratios—and it became clearly evident that this substance, once altered and converted, had acquired an expansion one hundred times greater than it previously had [9].

[9] In his experiment with *spirit of wine* inflating a bladder, Bacon observed that vaporized liquid occupied about a hundred times its former volume. The order of magnitude was plausible, though his measurements lacked control of temperature and pressure. The procedure foreshadowed pneumatic chemistry and the formulation of gas laws.

In like manner, let the nature under investigation be *Heat* or *Cold*—that is, their degrees when they are not perceived by the senses due to their subtlety. These are brought down to the senses through a thermoscopic glass, such as we described above. For heat and cold themselves are not directly perceived by touch [10]; but heat expands air, and cold contracts it. Nor is that expansion or contraction of air perceived by sight either; but the expanded air depresses water, while the contracted air raises it—and only then is the phenomenon brought to the level of sight, not before or otherwise.

[10] Bacon's *thermoscopic glass* acted as an uncalibrated thermometer: heated air expanded and displaced water, revealing temperature change through visible motion. The device represented one of the earliest operational definitions of heat and illustrated his insistence that instruments mediate between cause and perception.

Likewise, let the nature under investigation be the *Mixture of Bodies*: namely, what portion they contain of the aqueous, what of the oily, what of spirit, what of ash and alts, and things of that kind; or even, in particular, what parts milk contains of butter, what of curd, what of whey, and so on. These things are brought to the senses by artificial and skillful separations, as far as the tangible parts are concerned. But the nature of the spirit within them, though not directly perceived, is nevertheless detected through various movements and efforts of the tangible bodies during the very act and process of their separation; and also through the sharpness, corrosiveness, and the various colors, odors, and tastes of those bodies after separation. In this area, through distillations and artificial separations, human industry has indeed labored with vigor—but not much more successfully than in the other experiments still in use: namely, in ways entirely reliant on touch, by blind procedures, more laborious than intelligent, and (what is worst) with no imitation or emulation of nature, but with destruction—through violent heats or excessively powerful agents—of all the more subtle configurations [11], in which the hidden virtues and harmonies of things especially reside. Nor is it commonly observed—though we have noted it elsewhere—that many qualities which arise in the tormenting of bodies, whether by fire or other means, come not from the composite substance itself, but are introduced by the fire and by the bodies used in the separation; from which proceed many astonishing errors. For the entire vapor emitted from water by fire was not previously vapor or air within the water; rather, it was formed, for the most part, through the expansion of the water by the heat of the fire.

[11] Bacon warned that violent experimental methods distorted nature's processes. He advised investigators to imitate rather than torture nature, a principle that prefigures the modern concern with experimental artefacts and the control of variables.

Likewise, in general, all refined tests of bodies—whether natural or artificial—by which the genuine is distinguished from the adulterated, and the superior from the inferior, ought to be referred to this category: for they bring the non-sensible down to the sensible. They are, therefore, to be sought out everywhere with diligent care.

(5) As for the fifth kind of hiddenness, it is evident that the action of sense operates through motion, and motion through time. If, therefore, the motion of a body is either too slow or too fast to be proportioned to the intervals in which the action of sense takes place, then the object is not perceived at all—as in the motion of the hand of a clock, or conversely in the flight of a bullet [12]. Now, motion that is not perceived because of slowness is easily and commonly brought down to the senses by summing its effects over time; but motion that is not perceived because of speed has not yet been well measured. Nevertheless, the investigation of nature demands that such measurement be accomplished in some cases.

[12] His distinction between motions too slow or too fast for sense anticipated later analyses of temporal sampling in measurement. He proposed summing slow effects over time and recognized the difficulty of capturing high-speed phenomena—both principles that underlie present-day instrumentation.

(6) The sixth kind of hiddenness arises when the sense is hindered by the nobility of the object. This kind admits of deduction either through increasing the distance between the object and the sense; or through weakening the object by the interposition of a medium that diminishes but does not annihilate the object; or through the reception and observation of the reflected object, when the direct impact is too strong—as in the case of the sun reflected in a basin of water.

(7) The seventh kind of hiddenness occurs when the sense is so overloaded by an object that there is no room for the admission of a new one; this scarcely applies except in the case of smell and odors,

and it is not of much relevance to the present inquiry. Therefore, let what has been said suffice concerning the reductions of the non-sensible to the sensible.

Sometimes, however, the reduction is made not to human sense, but to the sense of some other animal whose perception in certain respects surpasses that of humans—as with certain odors, to the sense of a dog; or with light, which exists subtly in the air not outwardly illuminated, to the sense of a cat, an owl, and similar animals that can see at night. Telesius rightly observed that even in the air itself there exists a kind of native light [13], though faint and subtle, and for the most part useless to the eyes of humans or of most animals; whereas those animals whose sensory faculties are proportioned to that kind of light are able to see at night—a phenomenon which is less credibly explained either by vision in total darkness or by internal light.

[13] Telesius, whom Bacon cited approvingly, had claimed that the air possessed a faint intrinsic light enabling nocturnal animals to see. Bacon recorded the view but did not endorse it. Modern physiology attributes night vision to retinal adaptation and reflective membranes, not to self-luminous air.

And it must certainly be noted that we are here dealing with the *limitations of the senses* and their remedies. For *the errors of the senses* should be left to their proper investigations, namely those concerning sense and the sensible—except for that great error of the senses, namely, that they shape the structure of things according to the *analogy of man* [14], and not according to the *analogy of the universe*—an error which can be corrected only through reason and universal philosophy.

[14] Bacon concluded that the senses misrepresented nature because they judged *ex analogia hominis*, by the model of man, rather than *ex analogia universi*. His warning anticipated the modern insistence that observation must be corrected through instruments and quantitative method, ensuring that data reflect nature's order rather than human bias.

II-XLI (2:41).

Among the prerogative instances, we shall place in the eighteenth position the *Instances of the Way* (*Instantiae Viae*) [1], which we are also accustomed to call *Traveling Instances* (*Instantiae Itinerantes*) and *Jointed Instances* (*Instantiae Articulatae*). These are those which exhibit the motions of nature proceeding by continuous gradations [2]. This class of instances escapes observation rather than sense, for men show remarkable negligence in this matter. They contemplate nature only by leaps and at intervals, after bodies have been completed and perfected, and not while they are in operation. But if anyone wished to examine and observe the skill and ingenuity of some craftsman, he would not merely desire to see the raw materials of his art and afterwards the finished works, but would rather wish to be present while the craftsman works and brings his task to completion [3]. Something similar must be done with nature. For example, whoever inquires into the *vegetation of plants* [4] should observe it from the very sowing of the seed. This can easily be done by extracting seeds that have remained in the earth for two days, three days, four days, and so on, and by examining them attentively—seeing how and when the seed begins to swell and distend, and as it were to be filled with spirit; then how it bursts the husk and sends out fibres, while at the same time it rises slightly upward (unless the soil be very stubborn); how it sends forth fibres, partly roots downward, partly shoots upward, sometimes creeping sideways if it finds the earth looser or more open on that side—and many other details of the same kind. The same method should be applied to the *hatching of eggs*, where the processes of animation and organization may easily be observed, and where one may discern which parts are formed from the yolk, which from the white, and other such matters. A similar procedure applies to *animals generated by putrefaction* [5]. For as to perfect and terrestrial animals, inquiry of this sort would be less humane through dissections

of the fetus in the womb, unless perhaps by chance observation of abortions, or in the course of hunting, or the like. In general, therefore, a certain *vigilance* must be maintained toward nature, such as one keeps for things better seen by night than by day [6]; for these contemplations may rightly be regarded as *nocturnal*, because of the smallness of the light and the continuity of the observation required.

[1] *Instantiae Viae* ("Instances of the Way") formed Bacon's eighteenth class of *prerogative instances*. They were designed to trace the *processus naturae*—the gradual steps of change—so that natural operations could be studied in transition rather than only in completed form.

[2] The phrase *motus gradatim continuatos* expressed Bacon's adherence to the principle later known as the *Law of Continuity* (*natura non agit per saltum*). He regarded continuity as the key to discovering hidden causal sequences, a methodological anticipation of later uniformitarian thinking in physics and biology.

[3] Bacon's comparison of nature to a craftsman emphasized his empirical reform: knowledge must arise from watching processes "in operation." The analogy reflected Renaissance artisanal science, in which observation of work in progress replaced scholastic contemplation of finished forms.

[4] The experiment on *vegetation of plants*—removing seeds after two, three, or four days to examine development—illustrated early controlled observation through repeated sampling. Its logic parallels the modern time-series experiment. Although Bacon lacked microscopic instruments, the design anticipated empirical plant physiology.

[5] The mention of *animals generated by putrefaction* preserved the classical belief in *spontaneous generation*. Bacon accepted the possibility of life arising from decaying matter, a view common before Harvey's *De Generatione Animalium* (1651) demonstrated that all animals originate from eggs. Scientifically, this example is erroneous but historically typical.

[6] The metaphor of things "better seen by night" signified the limited light of human inquiry and the need for patience and vigilance. Bacon used *nocturnal contemplation* to describe sustained observation under imperfect conditions—an image that aptly characterizes experimental watchfulness.

The same should be attempted also with inanimate things, as we have done in examining *the openings of liquids by fire* [7]. For the mode of expansion is one in water, another in wine, another in vinegar, another in unripe oil, and quite another in milk, oil, and the rest. This can readily be observed by gentle boiling over a fire and in a glass vessel, where everything can be clearly seen. But we touch upon these matters briefly here, intending to speak of them more fully and accurately when we come to the discovery of the *latent process* of things [8]. For it must always be remembered that in this place we are not treating the things themselves, but merely offering examples.

[7] *Apertura liquorum per ignem* ("opening of liquids by fire") meant the expansion or release of vapors under heat. Bacon correctly distinguished different boiling behaviors in water, wine, vinegar, oil, and milk, though he lacked molecular explanation. His procedure exemplified early systematic variation in experimentation.

[8] The *latent process* (*processus latens*) denoted the invisible, stepwise transformation underlying visible change. For Bacon it was the bridge between empirical observation and the discovery of *Forms*. The phrase anticipates modern investigation of reaction pathways and physical mechanisms.

II-XLII (2:42).

Among the prerogative instances we shall place in the **nineteenth position** the Instances of Supplement, or Substitution; we have also been accustomed to call them Instances of Refuge [1]. They are those which supply information where sense is wholly lacking; and therefore we resort to them when proper instances cannot be obtained. Substitution, moreover, occurs in two ways: either by Gradation or by Analogues [2]. For example: no medium is found which entirely hinders the operation of the magnet [3] in moving iron—neither interposed gold nor silver, nor stone, nor glass, wood, water, oil, cloth or fibrous materials, air, flame, and the like. Yet by exact testing it may perhaps be discovered that there exists some medium which, comparatively

and in some degree, dulls its force more than another: for instance, that a magnet does not draw iron through so great a thickness of gold as through an equal space of air; or through as much heated silver as through cold; and so in similar cases. For we ourselves have not made experiment of these; yet it is sufficient that they be proposed by way of example. Likewise, among us no body is found which does not take on heat when brought near to fire. Yet air receives heat far more quickly than stone [4]. Such is the substitution that is effected by Degrees.

[1] *Instantiae Supplementi sive Substitutionis* ("Instances of Supplement or Substitution") denoted cases used when sense perception failed. Bacon treated them as *epistemic prostheses*, supplying empirical content by analogy or graduated approximation. The alternative title *Instantiae Perfugii* ("Instances of Refuge") emphasized their auxiliary role—turning absence of observation into a source of indirect evidence.

[2] Bacon distinguished substitution *per gradus* ("by degrees") from *per analogia* ("by analogues"). The former approximated the unknown through measurable variation; the latter inferred the unseen from visible parallels. Together they foreshadowed modern techniques of controlled approximation and model-based inference used in experimental science and computer simulation.

[3] Bacon's suggestion that certain materials might diminish magnetic attraction anticipated later investigations of diamagnetism. Although he had no experimental confirmation, his reasoning—that media might modify magnetic force—was methodologically sound. Gold and silver were later recognized as weakly diamagnetic, confirming the direction, though not the details, of his conjecture.

[4] His claim that "air receives heat far more quickly than stone" was broadly correct in qualitative sense: air equilibrates temperature faster owing to low density and thermal inertia. Yet Bacon lacked a kinetic or quantitative model of heat transfer, and so his observation remained descriptive rather than explanatory.

Substitution by Analogues, though certainly useful, is less certain, and therefore must be employed with due judgment. It occurs when the non-sensible is brought down to sense not by the sensible operations

of the insensible body itself, but by the consideration of some cognate sensible body. For example, if one inquires into the Mixture of Spirits, which are bodies not visible [5], there appears to be a certain kinship between bodies and their fuels or nourishments. Now the fuel of flame seems to be oil and fatty substances; that of air, water and watery substances: for flame multiplies itself upon oily vapors, air upon aqueous vapors. We must therefore examine the mixture of water and oil [6], which manifests itself to sense, since the mixture of air and the fiery kind escapes sense. But oil and water mix with one another very imperfectly by composition or agitation; whereas in herbs, in blood, and in the parts of animals, the same are mixed accurately and delicately. Accordingly something similar may occur with respect to the mixture of the fiery and airy kinds in spirituous substances: those which do not well sustain mixture by simple commingling nevertheless seem to be mixed in the spirits of plants and animals—especially since every living spirit feeds upon both kinds of moisture, the watery and the oily, as its fuels.

[5] The *mistura spirituum* (“mixture of spirits”) belonged to Bacon’s pneumatic physics. *Spiritus* referred to invisible, subtle matter thought to animate both living and inanimate bodies—a hybrid of Aristotelian pneuma and Renaissance vital heat. Though the ontology is obsolete, the epistemic strategy—studying invisible agents through visible surrogates—anticipated the logic of modern field theory and molecular modeling.

[6] The analogy between the mixing of oil and water and that of “fiery” and “airy” spirits illustrates Bacon’s controlled use of analogy as an experimental substitute. Modern science retains this heuristic in physical and computational modeling, though it recognizes that visible analogues do not entail structural identity.

Likewise, if the inquiry is not about the more perfect mixtures of spirituous substances, but only about their composition—namely, whether they readily incorporate with one another, or rather (for example) whether there are certain winds and exhalations, or other spirituous bodies [7], which do not mix with common air but only cling

to it and float in it, in little globules and drops, and are rather broken and shattered by the air than received into it and incorporated—this, in common air and in other spirituous substances, on account of the subtlety of the bodies, cannot be perceived by sense. Yet some image of this matter, so far as it occurs, can be conceived in liquids such as quicksilver, oil, and water; and also in air, and in its breaking, when it is dispersed and rises in small portions through water; and likewise in thicker smokes; finally, in dust stirred up and hanging in the air—in all of which there is no incorporation. And the aforesaid representation is not a bad one in this subject, provided it has first been carefully inquired whether such heterogeneity can exist among spirituous substances as is found among liquids; for only then will these likenesses be not inaptly substituted by Analogy.

[7] The notion that "winds and exhalations" might float within air as discrete entities reflected pre-Lavoisier chemistry, which conceived air as a heterogeneous mixture of effluvia. Bacon's example lacked empirical confirmation, yet it anticipated the recognition that air contains variable gaseous components—a later discovery of pneumatic chemistry in the seventeenth and eighteenth centuries.

And with respect to these Instances of Supplement, of which we said that information is to be drawn from them, as a kind of refuge, when proper instances are lacking, nevertheless we wish it to be understood that they are also of great use even when proper instances are at hand—namely, to strengthen the information along with the proper ones. But of these matters we shall speak more exactly when, in the due course of our discourse, we come to treat of the Aids of Induction.

II-XLIII (2:43).

Among the prerogative instances, we shall place in the **twentieth position** the *Instances of Perforation*; which we are also accustomed to call *Instances of Irritation* [1], though for a different reason. For we call them "Irritating" because they stimulate the intellect, and

"Perforating" because they pierce into nature: from which we also sometimes name them *Instances of Democritus*. These are the instances which make the intellect aware of the admirable and exquisite subtlety of nature [2], so that it may be stirred and awakened to proper attention, observation, and inquiry. For example: that a small drop of ink may stretch to form so many letters or lines; that silver, only gilded on the surface, can be drawn into such a length of gilt wire [3]; that a tiny worm, such as is found on the skin, contains both spirit and a figure of heterogeneous parts; that a small quantity of saffron may dye a whole cask of water with color; that a little bit of civet or aromatic substance may scent a much larger volume of air [4]; that from a small offering of incense such a great cloud of smoke may be raised [5]; that the most delicate differences of sounds—such as articulate speech—are carried in every direction through the air, and penetrate even the holes and pores of wood and water (though exceedingly minute), and are even reflected, all this with great clarity and speed; that light and color, even from such distance and with such swiftness, pass through solid bodies like glass and water [6], and with such rich and finely varied images, are also refracted and reflected; that the magnet acts through all kinds of bodies, even the most compact ones: but (what is more astonishing) that in all these cases, in the neutral medium (such as air), one action does not significantly hinder another; namely, that at the same time, through the space of air, are carried so many images of visible things, so many articulations of sound, so many specific odors [7]—of violets, roses—and even heat and cold and magnetic forces—all, I say, simultaneously, without one impeding the other, as if each had its own separate paths and channels, and no one collided with or disturbed another.

[1] *Instantiae Perforationis* ("Instances of Perforation") and *Vellicantes* ("Irritating Instances") were Bacon's metaphors for phenomena that penetrate the hidden texture of things and rouse the intellect to attention. The alternate title *Instantiae Democriteae* evoked Democritus's atomism, admired by Bacon for recognizing nature's minute structure without lapsing into abstraction.

[2] Bacon's appeal to the "subtlety of nature" (*subtilitas naturae*) reflected the early modern conviction that causal power lies below the scale of sense. He treated wonder not as a passion to be indulged but as a pedagogical instrument that sharpened empirical vigilance—a methodological counterpart to modern scientific curiosity.

[3] The example of gilded wire drew upon contemporary metalworking practice. Bacon observed that a layer of gold, though microscopically thin, could survive mechanical elongation. Later, William Wollaston (c. 1800) perfected a similar process by embedding a gold thread within silver, drawing it out, and dissolving the silver—an industrial realization of Bacon's "perforating" instance.

[4] The diffusion of perfume or civet illustrated the action of imperceptible particles permeating air. Bacon lacked the atomic and kinetic explanations later provided by gas theory, yet his inference that odor involved minute corpuscles accurately anticipated molecular dispersion.

[5] His note on incense smoke pointed to transformation of solids into volatiles—an empirical hint of the conservation of matter and phase change. Though his terminology was pre-chemical, the observation that a small material quantity could fill a vast space with sensible effect remains physically sound.

[6] Bacon's account of light and color passing through transparent media preserved the language of *species* or emanations inherited from classical optics, while acknowledging reflection and refraction. He thus combined emission and wave intuitions, a transitional stance between the medieval image theory and modern wave-particle duality.

[7] The marvel that light, sound, odor, heat, and magnetic force coexist in the same air "without one impeding the other" expressed an early perception of superposition. Modern physics confirms that waves and fields can occupy the same region independently, though strong signals can mask weaker ones. Bacon's astonishment captured a genuine principle later formalized in acoustic and electromagnetic theory.

The practice becomes burdensome either because of the mixture of useless things, or because of the multiplication of instruments, or because of the mass of materials and bodies which may happen to be required for some work. Therefore, those instances ought to be held in esteem which either direct practice toward what most concerns the interests of men, or spare instruments, or spare materials or

equipment. And these three kinds of instances which pertain to this matter we are accustomed to call by one common name, Propitious or Benevolent Instances (*Instantiae Propitiae sive Benevolae*) [8]. Therefore, of these seven instances we shall now speak in detail; and with them we shall close that part which concerns the Prerogatives or Dignities of Instances (*Praerogativae sive Dignitates Instantiarum*).

[8] The *Instantiae Propitiae sive Benevolae* ("Propitious or Benevolent Instances") introduced the final group of Bacon's *praerogativae instantiarum*, emphasizing efficiency and human benefit in experiment. Their inclusion closed the theoretical sequence by returning to Bacon's central aim: the union of knowledge and utility.

II-XLIV (2:44).

And concerning the instances which aid the senses [1], we have already spoken; these are of principal use for the Informative Part. For information begins from the senses. But the entire business ends in works [2]; and just as the former is the beginning, so this latter is the end of the matter. Therefore, there will follow the instances that are of principal use for the Operative Part. These are, in kind, twofold, in number, seven; all of which we are accustomed to call by the general name *Practical Instances*.

[1] Bacon distinguished between Instantiae Informativae and Instantiae Operativae—the former aiding sense and understanding, the latter directing practical application. This structural division mirrored the two "parts" of the Novum Organum: discovery and operation.

[2] The phrase res tota in opera desinit encapsulated Bacon's teleology: knowledge must culminate in works. Unlike scholastic scientia, which aimed at demonstrative truth, Bacon's reformed philosophy sought effective mastery of nature—an early statement of the utilitarian ideal of science as power.

Now the Operative Part has two deficiencies; and correspondingly two perfections of instances, taken generally. For either the operation fails, or it is too burdensome. Operation most commonly fails (especially

after a diligent investigation of natures) because of ill-determined and ill-measured powers and actions of bodies. But the powers and actions of bodies are circumscribed and measured either by the spaces of place, or by moments of time, or by the quantity of the union, or by the predominance of force; and unless these four be carefully and thoroughly weighed, the sciences may indeed be beautiful in contemplation, but they will be barren in practice. And the four kinds of instances that pertain to this we call by a single name *Mathematical Instances*, or *Instances of Measure* [3].

[3] The Instantiae Mathematicae sive Mensurae introduced a rudimentary program of quantification. Bacon's attention to space, time, and force anticipated Galileo's and later Newton's formulation of mathematical physics, though Bacon himself lacked formal mathematics. His "measure" meant empirical calibration rather than numerical law.

Now practice becomes burdensome either because of the mixture of useless things, or because of the multiplication of instruments, or because of the mass of materials and bodies that may be required for some work. Therefore, those instances are to be held in high esteem which either direct operative effort toward those things which are of greatest interest to human life; or which spare instruments; or which spare materials or supplies. And the three kinds of instances that pertain here we call by a single name *Helpful* or *Benevolent Instances*. Thus, we shall now speak in detail about these seven instances; and with them, we shall close that part which concerns the Prerogatives or Dignities of Instances.

And we have already spoken of the instances that assist the senses; these are of principal use for the Informative Part. For information begins with the senses. But the entire undertaking ends in Works; and just as the former is the beginning, so the latter is the end of the matter. Therefore, there will follow the instances of principal use for the Operative Part. These are of two kinds, and seven in number; all of

which we are accustomed to call by the general name of *Practical Instances*. Now the Operative Part has two faults, and correspondingly two excellences of instances in general. For either operation fails, or it becomes too burdensome. Operation most commonly fails (especially after a diligent investigation of natures) because the powers and actions of bodies are poorly determined and measured. But the powers and actions of bodies are delimited and measured either by spaces of place, or by moments of time, or by quantity of union, or by predominance of force [4]; and unless these four are properly and carefully weighed, the sciences may be beautiful in speculation, but will be ineffective in practice. And the four kinds of instances that relate to this we call by a single name *Mathematical Instances*, or *Instances of Measure*.

[4] The four parameters—locus, tempus, quantitas, vis—correspond to what modern physics treats as spatial extension, temporal duration, magnitude, and energy. Bacon's intuition that the efficacy of natural operations depends on these measurable variables remains scientifically sound, though his terminology predates the distinction between kinematic and dynamic quantities.

Modern physics also distinguishes four fundamental forces—strong, weak, electromagnetic, and gravitational—and ongoing experimental programs have periodically proposed evidence for a possible fifth force, though none has been confirmed.

Practice becomes burdensome either because of the admixture of useless elements, or because of the multiplication of instruments, or because of the bulk of matter and bodies required for a given operation. Therefore, those instances should be especially valued which either direct operative efforts toward matters of greatest relevance to human life; or which reduce the number of instruments; or which economize in materials or equipment. The three kinds of instances that relate to this we designate by the single name Helpful or Benevolent Instances [5]. Accordingly, we shall now discuss these

seven instances one by one; and with them we shall conclude that part concerning the Prerogatives or Dignities of Instances [6].

[5] The Instantiae Propitiae sive Benevolae represented a methodological economy: reducing materials, instruments, and effort. Bacon thus prefigured the modern principle of optimization in experiment and engineering, where efficiency is treated as a measure of epistemic virtue as well as practical success.

[6] This concluding sentence marked the end of Bacon's Praerogativae Instantiarum, the twenty-seven privileged kinds of instances designed to discipline empirical reasoning. The next aphorisms turn from enumeration to the aids of induction, closing the methodological architecture of Book II.

II-XLV (2:45).

Among the prerogative instances, we shall place in the **twenty-first position** the *Instances of the Rod* or *of the Radius* [1]; which we are also accustomed to call *Instances of Transmission*, or *of the "No Further"*. For the powers and motions of things do not operate or extend across indefinite or random spaces [2], but only across finite and determinate ones; and it is of the highest importance for practical purposes that these distances be ascertained and recorded for each of the natures under investigation—not only to avoid error, but also to increase the effectiveness and strength of practical operations. For it is sometimes possible to extend powers and, so to speak, to draw in distances more closely—as happens with telescopes [3].

[1] *Instantiae Radii* ("Instances of the Rod"): Bacon meant cases that measure how far the effects of a force extend before ceasing. Earlier translators also called them "Instances of Transmission" or "of the No Further." The term *radius* evoked both the geometrical line of action and the ray of light.

[2] Bacon here rejected the scholastic doctrine of unlimited "sympathies" in favor of finite causal range. In his period, "action by contact" was still regarded as the only lawful form of causation. His assertion that powers operate within measurable limits anticipated later field-based physics.

[3] Bacon alluded to early telescopic experiments; telescopes had been introduced shortly before the *Novum Organum* (Galileo's *Sidereus Nuncius*, 1610). His phrasing suggested that instruments could "shorten" distances by concentrating optical rays—a striking recognition of experimental extension of human sense.

Moreover, many powers operate and exert influence only through direct contact, as happens in the collision of bodies, where one does not move the other unless it makes contact by delivering an impulse. Even medicines that are applied externally, such as ointments and plasters, do not exert their effects except through bodily contact. Finally, the objects of the senses of touch and taste do not affect their respective organs unless they are in direct contact with them.

There are also other powers that operate at a distance, though a very small one, of which only a few have been noted so far, though they are more numerous than people suspect: as (to take examples from common observation), when amber or jet attracts chaff [4]; when one bubble, brought near another, causes it to collapse; when certain purgative medicines draw humors from deep within the body; and similar phenomena. But the magnetic force by which iron and the magnet, or two magnets, attract one another operates within a certain but small sphere [5] of activity. Whereas, if there exists some magnetic force emanating from the Earth itself—perhaps from somewhat deeper within—which acts upon an iron needle [6] in regard to orientation, then such an operation takes place over a considerable distance.

[4] The attraction of chaff by amber (*electrum*) and jet (*gagates*) had been noted since antiquity (cf. Theophrastus, *De Lapidibus*). Bacon's report was empirically sound: he described static electricity, though without recognizing its electrical nature.

[5] The description of magnetic attraction reflected Gilbert's *De Magnete* (1600). Bacon correctly affirmed that magnetism acts within a finite "sphere of virtue," though he understated the precision already achieved by Gilbert's quantitative studies.

[6] The “magnetic force of the Earth” referred to the terrestrial magnetic field discovered by Gilbert. Bacon’s mention of it acting on the compass needle marked one of the earliest recognitions of a global magnetic system, a precursor to the modern concept of a geomagnetic field.

Again, if there exists some magnetic force that operates through a sympathy between the globe of the Earth and heavy bodies, or between the globe of the Moon and the waters of the sea (which seems especially credible in the semi-monthly tides) [7], or between the starry heavens and the planets, by which they are summoned and lifted toward their apogees—all these operate across exceedingly great distances.

[7] Bacon attributed the tides to lunar attraction—an hypothesis that later found confirmation in Newtonian gravitation. His phrasing “semi-monthly tides” accurately described spring and neap tides, although he did not yet understand the twice-daily rhythm.

There are also certain inflammations or ignitions of flame which occur at fairly large distances in certain materials, as is reported of Babylonian naphtha. Heat, too, insinuates itself across large distances, as also does cold; so much so that among those living near Canada, the icebergs or ice-masses that break off and float across the northern ocean and are carried by the Atlantic toward those coasts are sensed and produce cold from afar. Odors also (although in these there always appears to be some emission of material substance) act across considerable distances; as often happens to those sailing near the coasts of Florida, or even parts of Spain, where entire groves of lemon and orange trees exist, or shrubs of rosemary, marjoram [8], and similar fragrant plants. Finally, the radiations of light and the impressions of sound clearly operate over expansive distances.

[8] The account of long-distance odors (citrus groves and rosemary heaths) was observationally correct: volatile organic compounds can indeed be carried by

wind across kilometers. Bacon's inclusion of this example reflected his empiricist reliance on sense data rather than on authority.

But all these phenomena, whether they operate across short or long distances, certainly operate only within finite and naturally defined limits, such that there is a definite "no further."

And this boundary is determined by factors such as the mass or quantity of bodies, the strength or weakness of their forces, or the assistance or obstruction offered by the media; all of which ought to be calculated and recorded. Moreover, the measurements of so-called violent motions—such as those of projectiles, artillery, wheels, and the like—must also be noted, since these too clearly have their own definite limits.

There are also found certain motions and forces that are contrary to those which operate through contact and not at a distance; namely, those that operate at a distance and not by contact; and again, those that act more weakly at a nearer distance and more strongly at a greater distance. Indeed, vision is not well accomplished through contact, but requires a medium and a certain distance. Though I recall having heard from a trustworthy person that, during a treatment for cataracts in his eyes—the procedure being such that a small silver needle was inserted under the first membrane of the eye to remove the cloudy layer and push it toward the corner of the eye—he had clearly seen the needle moving over the very pupil. However that may be, it is clear that larger objects are not well or distinctly seen unless at the apex of a cone [9], where the rays from the object converge at some distance. Indeed, in elderly people, the eye sees better when the object is placed slightly farther away than when it is nearer. In the case of projectiles, too, it is certain that the impact is not as strong at too close a range as it is slightly afterward. Therefore, such things and others like them should be noted when measuring motions in relation to distances.

[9] The geometrical explanation of sight—"at the apex of a cone"—followed classical optics from Euclid and Alhazen. Bacon correctly understood that focus and clarity depend on distance, though his anecdote about seeing a surgical needle over the pupil mixed observation with hearsay.

There is also another kind of spatial measurement of motions, which should not be overlooked. This concerns not progressive but spherical motions; that is, the expansion of bodies into a larger sphere, or their contraction into a smaller one. It must be inquired, among these measurements of motion, to what extent bodies (according to their nature) readily and willingly undergo compression or expansion, and at what point they begin to resist—to such an extent that ultimately they tolerate no further, reaching a clear "no further" limit; as when an inflated bladder is compressed: it tolerates some compression of the air, but if it be excessive, the air does not yield, and the bladder bursts.

But we tested this very matter more precisely through a more subtle experiment. We took a small bell made of metal—lighter and thinner, of the kind used for holding salt—and immersed it in a basin of water [10] in such a way that it carried with it the air contained within its hollow down to the bottom of the basin. Beforehand, we had placed a small ball at the bottom of the basin, upon which the bell was to be set. Thus, it came to pass that if the ball was small (in proportion to the cavity), the air withdrew into the smaller space and was merely compressed, not expelled. But if the ball was of such size that the air could not easily give way, then the air, unable to bear the increased pressure, would lift the bell from one side and escape upward in bubbles.

[10] The "metal bell" experiment sought to measure the compression of air under water. It correctly presupposed the elasticity of air but lacked the later understanding of atmospheric pressure (Torricelli, 1643). The design showed Bacon's experimental inventiveness but limited quantitative rigor.

To test what degree of expansion—no less than compression—the air might endure, we conducted the following experiment. We took a glass egg with a small hole at one end. Through the hole, we drew out the air [11] with strong suction, and immediately sealed the hole with a finger. Then we immersed the egg in water, and subsequently removed the finger. The air, having been twisted and overstretched by the suction beyond its natural condition, now sought to recover and contract; so much so that, had the egg not been immersed in water, it would have drawn in the surrounding air with a hiss. Instead, it drew in water to such an amount as was sufficient for the air to regain its former sphere or dimension.

[11] The “glass egg” experiment attempted to demonstrate the expansion and contraction of air under suction. The phenomenon was genuine but misattributed: Bacon did not yet conceive of vacuum or external air pressure. His description nonetheless foreshadowed pneumatic studies by Boyle and Hooke.

And it is certain that more subtle bodies (such as air) undergo a notable degree of contraction, as has been said; but tangible bodies (such as water) endure compression with much greater difficulty and to a far lesser extent. To determine the extent to which water does endure compression, we investigated by means of the following experiment.

We had a hollow sphere made out of lead, capable of containing about two wine pints, and thick enough at the sides to withstand significant force. Into this we poured water through a hole made somewhere in it; and once the sphere had been filled with water, we sealed the hole with molten lead, so that the globe became completely solid. Next, we flattened the globe on two opposite sides using a strong hammer; by which the water was necessarily forced into a smaller volume, since the sphere is the shape most capable of containing volume. Then, when hammering no longer sufficed, and the water was more resistant to compression, we used a mill or press; until at last, the water, unable

to tolerate further pressure, oozed out through the solid lead [12], like a fine dew. Afterward, we calculated how much volume had been reduced by this compression; and we concluded that water had undergone that degree of compression (but only when constrained by great violence).

[12] The "lead sphere" filled with water anticipated the later *Florentine experiment* (Accademia del Cimento, 1667). Bacon's inference that water was compressible was inaccurate—his results stemmed from the water forcing itself through the pores of the lead—but the idea presaged later work on fluid compressibility.

But more solid, dry, or compact bodies—such as stones and woods, as well as metals—tolerate even less compression or expansion [13], and almost imperceptibly so. Instead, they free themselves through fracture, displacement, or other forms of yielding; as is evident in the bending of wood or metal, in the movements of clocks through the coiling of a spring, in projectiles, hammerings, and countless other motions. And all these phenomena, along with their respective measurements, must be noted and investigated in the inquiry into nature—either with precision, or by estimation, or by comparison, according to the available means.

[13] Bacon's remarks on solid materials correctly recognized the principles of elasticity and fracture. Although lacking mathematical formulation, his distinction between temporary deformation and structural failure remains conceptually accurate in materials science.

II-XLVI (2:46).

Among the prerogative instances we place, in the **twenty-second position**, the Instances of the Course, or (as we are accustomed to call them) the Instances of the Water (*Instantiae Curriculi, sive ad Aquam*); the name being taken from the *clepsydrae* of the ancients [1], into which *water* was poured instead of *sand*. These instances *measure nature by moments of time*, just as the Instances of the Rod (*Instantiae*

Virgae) measure it by degrees of space. For *every motion or natural action* is accomplished *in time*—one more quickly, another more slowly—yet always in certain and definite moments known to nature. Even those operations which seem to act suddenly and "in the twinkling of an eye," as we say, are found nevertheless to *admit of greater and less* in respect of time.

[1] The *clepsydra*, or water clock, was used in antiquity to measure intervals by the steady flow of water, as in Aristotle (*De Anima* IV.11) and Vitruvius (*De Architectura* IX.8). Bacon adopted it as a metaphor for quantifying nature's durations rather than its magnitudes. His comparison reflects an early modern effort to make *time* an experimental variable, not merely a philosophical abstraction.

Thus we observe that the revolutions of the heavenly bodies [2] are completed in measured periods; and likewise the ebb and flow of the sea. The falling of heavy bodies toward the earth and the rising of light bodies toward the heaven take place also in definite intervals of time, according to the proportion of the body that is moved and the nature of the medium. In like manner, the sailing of ships, the movements of animals, and the flight of projectiles, all take place in measurable and, so to speak, numerable times. As to heat, we see that boys in winter wash their hands in the flame [3] and yet are not burned; and that jugglers turn vessels full of wine or water rapidly upside down and upright again, without spilling their contents; and many other such phenomena. Likewise, compressions, dilatations, and eruptions of bodies occur—some more swiftly, others more slowly—yet always in definite moments, according to the nature of the body and of the motion. Moreover, when many cannon are discharged simultaneously, and their report is heard [4] at a distance of thirty miles, the sound is perceived sooner by those who are near to the place of discharge than by those who are far away. Even in vision (whose action is the most rapid of all) it is evident that certain moments of time are required for its operation. This is proved by those things which, owing to the

velocity of their motion, cannot be seen—as, for example, the flight of a bullet from a gun. For the passage of the ball is swifter than the transmission of its image that might have reached the sight.

[2] Bacon wrote before Kepler's laws of planetary motion (1609–1619) were widely accepted in England. He thus conceived celestial "revolutions" as perfectly circular, governed by uniform motion rather than elliptical orbits. Galileo had already refuted the Aristotelian idea that the velocity of falling bodies depends on weight (c. 1590), but Bacon's reference shows indirect awareness of the new temporal physics.

[3] This example, drawn from everyday experience, was sound in observation but not yet in mechanism. The brief contact avoids pain because thermal conduction requires finite time to damage tissue; Bacon thus implicitly noted the *temporal threshold* of heat transfer.

[4] This is one of Bacon's most accurate empirical insights. The difference arises because the velocity of light (~3×10^8 m/s) exceeds that of sound (~340 m/s in air). Bacon correctly inferred differential propagation but could not yet measure it.

This, with similar observations, once gave rise in us to a doubt almost monstrous [5]: namely, *whether the aspect of the serene and starry heavens* is seen *at the very moment when it truly exists*, or rather *somewhat later*; and whether, in regard to the vision of celestial bodies, there is not, as astronomers note *a true place* and *an apparent place* (in parallax), so also *a true time* and *a perceived time*. For it seemed incredible that the *rays* or *images* of the heavenly bodies should be *transmitted instantly* through such immense distances of space, but rather that they must *traverse them in some notable time*.

[5] Bacon speculated whether the stars were seen "in their true time or somewhat later," effectively posing the problem of the finite speed of light. He rejected the notion as "incredible," but his question anticipated the demonstration by Ole Rømer (1676) that light requires time to traverse space. His own argument—that clouds would interrupt slow light—shows both empirical caution and an underestimation of cosmic scale.

However, this doubt—so far as concerns any considerable interval between the *true time* and the *perceived time*—afterwards wholly vanished. For we considered that the *infinite loss and diminution of quantity* (in regard to apparent magnitude) between the *true body of the star* and its *visible image*, caused by the distance, must also proportionally diminish the time of transmission; and, observing moreover that *bodies* which are merely *white* can be seen suddenly here among us at a distance of *at least sixty miles*, we could not doubt that the *light of the heavenly bodies*, being not only more vivid in whiteness but surpassing many times in the *power of radiation* the light of any flame known to us, might with ease reach us almost instantaneously. Also, that immense *velocity* which appears in the bodies themselves during the *diurnal motion* (which so astonished sober minds that they preferred to believe the earth moved) made this *projection of rays from the stars*, though wonderful in speed, *more credible*. But above all, we were persuaded by this consideration—that if any *notable interval of time* were interposed between *truth* and *sight*, the *images* would often be intercepted and confused by *clouds arising in the meantime* and other *disturbances of the medium*. Thus much concerning the measurement of simple times.

But it is not only the *measure of motions and actions taken absolutely* that must be sought, but much more their *comparative measure*; for this is of great use and bears upon many things. Thus we see that the flash of a piece of ordnance is *seen sooner* than the report is *heard*; though the ball must necessarily have *struck the air* before the flame (which followed it) could have come forth. This happens because the *motion of light* is *transmitted* much *more swiftly* than the *motion of sound*. We see also that *visible impressions* are *received* by the eye *more quickly* than they are *dismissed*; whence it comes that the *strings of musical instruments*, when struck with the finger, appear to be *doubled or tripled in the image*, because a new image is received *before the former has departed*. From the same cause it also happens

that *revolving rings* appear *spherical*, and that a *burning torch*, carried rapidly at night, seems to have a *tail* or *train of light*. From this very inequality in the velocity of motions Galileo devised his explanation of the *flux and reflux of the sea* [6]: namely, that while the *earth revolves more swiftly*, the *waters* lag behind, and hence heap themselves up and then subside again alternately—as may be seen in a *vessel of water moved with unequal speed*. But this is a conjecture grounded upon a *false assumption* (that the earth moves), and even then *ill informed* concerning the *six-hour period* of the ocean's motion.

[6] *Galileo devised his explanation of the flux and reflux of the sea*—Bacon misrepresented Galileo's tidal theory, which depended on the earth's combined axial and orbital motions (published in *Dialogo*, 1632). Bacon, rejecting heliocentrism, dismissed the theory as false. This passage confirms that Bacon remained non-Copernican, despite his otherwise progressive empiricism.

An example, however, of the thing now in question—namely, of *comparative measures of motion*—and at the same time of its *remarkable practical use* (of which we spoke a little before), is found in subterranean mines charged with gunpowder, where *enormous masses of earth, buildings, and the like* are *overthrown and cast into the air* by a *very small quantity* of powder. The cause of this, without doubt, is that the motion of the powder's expansion, which impels, is *many times swifter* than the motion of gravity, by which any resistance could take place—so that the first motion is *accomplished before* the contrary motion *has even begun*; and thus in the first instant there is, as it were, an *absence of resistance*. Hence also it comes that in every *missile weapon* a *stroke* that is not so much *strong* as *sharp and swift* is the most effective for propulsion. And it would not have been possible that the *small quantity of animal spirit* in animals—especially in such vast bodies as *whales* or *elephants* [7]—could bend and govern so great a mass of matter, *except through the velocity of motion* in the

spirit and the *dulness and sluggishness* of the bodily mass in offering resistance.

[7] The *spiritus animalis* was Bacon's term for a subtle pneumatic substance believed to mediate sensation and motion. This notion reflected pre-Cartesian physiology, where the "spirits" were thought to flow through nerves as active agents. The example is scientifically unsound by modern standards but shows Bacon's consistent attempt to mechanize vital action through comparative velocity rather than occult power.

Finally, this very principle is one of the chief foundations of magical experiments, of which we shall soon speak—namely, *when a small quantity of matter overcomes and orders a much larger one*: that is, when one motion *anticipates another* by *greater speed* before the slower has time to act.

Lastly, this same *"Before and After"* should be noted in *every natural action*. For instance, in the *infusion of rhubarb*, the *purgative virtue* is drawn out *first*, the *astringent* later. A similar thing we have observed in the *infusion of violets in vinegar* [8]: at first, the *sweet and delicate odour* of the flower is extracted; afterwards, the *more earthy part* of the violet, which confounds the scent. Hence, if the violets are infused for a whole day, the odour that is obtained is much weaker; but if they are infused only for a *quarter of an hour* and then removed—and since the fragrant spirit in the violet is small and soon lost—if *fresh violets* are added at each quarter hour, six times successively, then at last the infusion becomes *exquisitely noble*: so that, though the violets themselves (continually renewed) have not remained together more than *an hour and a half* in all, yet the *odour remains most pleasant*, and the infusion keeps its *virtue for a whole year*. It should, however, be noted that the *odour does not reach its full strength* until *a month after the infusion*. In *distillations* likewise of *aromatic substances macerated in spirit of wine*, it is evident that first there rises a *watery phlegm and useless portion*, then a *liquid holding more of the spirit of wine*, and afterwards one *holding more of the aroma itself*.

[8] Bacon described differential extraction of properties over time: first purgative, then astringent; first aromatic, then earthy. Though framed in pre-chemical vocabulary, the observation anticipated chemical kinetics, where reaction products vary with duration and concentration. His empirical control—short infusions versus successive additions—was methodologically sound.

And of this kind there are very many examples in distillations worth observing. But let these suffice for examples [9].

[9] This closure marks Bacon's practical aim: to establish *temporal measurement* as the operative counterpart to spatial measurement. Modern experimental design, from chronometry to reaction timing, continues this Baconian principle that "truth in nature" depends upon the calibration of time.

II-XLVII (2:47).

Among the prerogative instances we place, in the **twenty-third position**, the Instances of Quantity (*Instantiae Quanti*), which we are also accustomed to call the Doses of Nature [1], borrowing the term from medicine. These are the instances which *measure powers by the quantity of bodies*, and indicate *how far the quantity of a body contributes to the mode or degree of its virtue (power)*. First, there are certain powers which *do not subsist except in a cosmic quantity* [2]—that is, in such a quantity as is in *concord with the configuration and structure of the universe*. For example: The *earth as a whole* remains fixed; its *parts* fall downward. The *waters of the seas* flow and ebb; those in *rivers* do not, unless through the entrance of the sea. Next, almost all particular powers act *more or less strongly* according to the *greater or smaller bulk* of the body. For instance: Large masses of water are *not easily corrupted*; small portions *soon spoil*. *Wine or beer* ripen and become fit to drink *much sooner* when kept in *small vessels* [3] than in *large casks*. If a herb be placed in a *larger portion of liquid*, the result is *infusion* rather than *imbibition*; if in a *smaller portion*, it is *imbibition* rather than *infusion*. Hence it makes a difference to the human body whether one uses a *bath* or only a *light sprinkling*. Likewise, *small drops*

of dew in the air *never fall*, but are *dissipated* [4] and *incorporated* with the air. One may observe also in *breath upon a gem*, that the *little moisture* appearing as a *cloud* is at once *dissolved* by the air. Again, a *fragment* of a magnet [5] *does not attract as much iron* as the *whole magnet* would. On the other hand, there are powers in which *smallness of quantity* has *greater efficacy*: A *sharp point* penetrates more easily than a *blunt one*. A *diamond pointed* will *engrave glass*. And the like.

[1] Bacon borrowed this term from medical vocabulary. He used it to illustrate how natural effects depended on quantitative proportion, much as remedies acted according to dosage. The analogy shows his transitional method between qualitative and quantitative science. In modern terms, this anticipates the *dose–response principle* used in pharmacology and toxicology.

[2] By *quantitas cosmica*, Bacon meant that certain effects existed only at the scale of the whole world—for instance, the fixity of the Earth or the tides of the sea. These examples belonged to the pre-Copernican cosmology that Bacon retained. He stood historically between the Aristotelian cosmos and the emerging mechanical universe.

[3] This observation came from artisanal practice rather than formal experiment. It reflected Bacon's method of drawing examples from common crafts. The phenomenon is explained today by differences in surface area and temperature regulation, confirming the empirical accuracy of his note.

[4] Bacon described dew as vapor imperfectly mixed with air, which was consistent with seventeenth-century meteorology. His account lacked the later understanding of condensation. Modern physics explains dew formation through radiative cooling and condensation of water vapor on cold surfaces. His observation was partly correct, though his cause was mistaken.

[5] Bacon believed magnetic power varied with the body's bulk. This was empirically true in magnitude but misconceived in cause: magnetic force depends on field configuration and alignment, not mere quantity. His example illustrated his general interest in proportional causation, even before the discovery of magnetic field theory.

But here we must not stop at these indefinite remarks: the *proportions* of the *quantity of body* in relation to the *mode of its power* are

themselves to be *inquired into* [6]. For it might easily be imagined that the *ratios of quantity* would correspond to the *ratios of power* [7]—as if, for example, a *lead bullet* of one ounce fell in a certain time, a *bullet of two ounces* ought to fall *twice as fast*; which is *most false*. Nor do the same proportions hold good in every kind of power, but are *widely diverse*. Therefore these *measurements* must be *sought from the facts themselves*, and *not* from *probabilities or conjectures*.

[6] Bacon urged investigators to determine scaling empirically rather than by analogy. His insistence formed an early articulation of the methodological rule that observation and experiment govern quantitative law-finding. In modern science, this corresponds to the study of nonlinear and allometric scaling in physics and biology.

[7] Here Bacon rejected the Aristotelian assumption that motion scaled directly with mass. His example of falling bodies echoed Galileo's Pisa experiments (c. 1590), though Bacon did not cite him. This passage marks one of Bacon's clearest recognitions that empirical measurement must replace theoretical proportionality—a principle that remains foundational in modern physics.

Finally, in every inquiry concerning nature, it should be carefully noted what quantity of body is required for any given effect, as the dose of it, and precautions concerning excess and defect [8] (too much and too little) should be added.

[8] Bacon proposed that each effect required a proper measure, with "excess" and "defect" recorded. The language anticipated the experimental notion of control and threshold. His practice was limited by the lack of precise instruments, but the idea remains valid for determining boundary conditions in modern experiments.

II-XLVIII (2:48).

Among the prerogative instances, we place in the **twenty-fourth position** the Instances of Struggle [1], which we also customarily call Instances of Predominance. These indicate the predominance and yielding of forces relative to one another—namely, which of them is

stronger and prevails, and which is weaker and gives way. For the motions and tendencies of bodies are composite [2], decomposite, and entangled, no less than the bodies themselves. We will therefore first present the principal kinds of motions, or active powers, so that their comparison in strength may be made clearer, and thereby the recognition and designation of instances of struggle and predominance may be made more evident.

[1] *Instantiae Luctae sive Praedominantiae* ("instances of struggle or predominance") were Bacon's twenty-fourth class of prerogative instances. They signified cases where two or more *motions* (*motus*) contend within the same subject, allowing the inquirer to discern which natural tendency "prevails."

[2] Bacon's term *motus* encompassed all forms of activity—mechanical, chemical, or vital. His claim that motions are "composite, decomposite, and entangled" expressed an early recognition that physical effects result from the interplay of multiple causes.

Let the **First Motion** be the Motion of Antitypy [3] of matter, which is inherent in each of its portions—through which it absolutely refuses to be annihilated. So that no fire, no weight or pressure, no violence, no age or duration of time can reduce any portion, however small, of matter to nothing. That portion will always both be something and occupy some space, and—whatever necessity it be placed under—will free itself either by changing its form or its place, or (if no opportunity is given) will simply remain as it is. Nor does anything ever come to pass such that it becomes nothing or is nowhere. This motion the Schoolmen (who almost always name and define things rather by their effects and inconveniences than by their inward causes) either denote by the axiom that *two bodies cannot be in the same place*, or call it the *motion to prevent the penetration of dimensions*. It is not appropriate to offer examples of this motion: for it is present in every body.

[3] *Motus Antitypiae* ("motion of resistance to annihilation") represented the persistence of matter. Bacon's dictum that "nothing is reduced to nothing" anticipated the later law of conservation of mass and, by extension, of energy.

Let the **Second Motion** be the Motion of Connection, as we call it—by which bodies do not allow themselves to be separated in any part from the contact of another body, as if they take delight in mutual connection and contact. This motion is what the Schoolmen call the Motion to prevent a vacuum [4]. For example: when water is drawn upward by suction, or through pipes; when flesh is pulled upward by cupping glasses; or when water remains and does not flow from a pierced vessel unless the mouth of the vessel is opened to admit air—and countless examples of this kind.

[4] *Motus Connexionis* ("motion of connection") corresponded to the scholastic doctrine of *horror vacui*, the avoidance of a vacuum. Bacon denied an actual void but retained its explanatory vocabulary. Later experiments by Torricelli and Boyle disproved the notion, showing that atmospheric pressure—not nature's abhorrence—prevents void formation.

Let the **Third Motion** be the Motion of Liberty [5], as we call it—by which bodies strive to free themselves from unnatural compression or tension, and to restore themselves to a dimension appropriate to their nature. There are countless examples of this motion: for release from compression—swimming in water, flying in air; the movement of water when rowing, or air in gusts of wind; the springing of watch springs. This motion is not inelegantly shown in the compressed air of children's toy popguns, where they hollow out elder wood or something similar and plug both ends with a piece of moist root or the like, then push one plug forward with a plunger, so that the other plug is expelled with a sound before being touched by the closer plug or the plunger. As for release from tension, this motion appears in the air remaining after suction in glass eggs, in strings, in leather, and in cloth, which recoil after stretching—unless the stretching has become fixed through prolonged tension. The Schoolmen refer to this motion under

the name Motion from the Form of the Element—though rather ineptly, since this motion pertains not only to air, water, or flame, but to all differences in consistency: as in wood, iron, lead, cloth, membrane, etc., where each body has a standard of dimension proper to it, and resists being drawn from it to any notable degree. But because this motion of liberty is the most common of all and applies to countless cases, it is advisable to distinguish it clearly and precisely. Some have carelessly confused this motion with the twin motions of Antitypy and Connection: that is, the release from compression with Antitypy, and release from tension with Connection—as if bodies only yield or expand in order to avoid penetration of dimensions, and recoil or contract to avoid vacuum. Yet if compressed air were to be condensed to the density of water, or wood to that of stone, penetration of dimensions would not be required; and still, those compressions would be far greater than what these substances can endure. Likewise, if water were to be expanded to the rarity of air, or stone to the rarity of wood, a vacuum would not be required; yet such expansions would exceed what these substances can sustain. So the issue does not return to penetration of dimensions or to vacuum, except at the extreme limits of condensation and rarefaction; whereas these motions take place far short of those limits, and are simply the desires of bodies to preserve themselves in their own consistencies (or, if one prefers, in their forms), and not to depart from them suddenly—unless they be altered gently and by mutual consent. But it is far more important (because of its many implications) to alert people that violent motion (which we call mechanical motion, and which Democritus—who, in explaining his prime motions, deserves a rank even below middling philosophers—called the motion of stroke) is nothing other than the Motion of Liberty: that is, from compression toward relaxation. In every simple thrust or flight through air, no movement or local transfer takes place before parts of the body are unnaturally compressed by the impelling force. Then, as successive

parts push others, the whole is carried forward—not only through translation, but also through rotation, so that the parts may either free themselves or more equally distribute the pressure. And so much for this motion.

[5] The *Motus Libertatis* ("motion of liberty") described a body's effort to regain its natural dimension after compression or tension—an early account of elasticity. Bacon correctly distinguished it from mere avoidance of vacuum or penetration of dimensions.

Let the **Fourth Motion** be what we have called the Motion of Matter (*Motus Hyles*) [6]; which is, in a way, the counter-motion (*antistrophos*) to the Motion of Liberty we have just discussed. For in the Motion of Liberty, bodies recoil from a new dimension, or a new sphere, or a new expansion or contraction (for this variety of expressions indicates the same thing); they reject it, flee from it, and with all their might strive to spring back and recover their former consistency. But on the contrary, in this Motion of Matter, bodies seek a new sphere or dimension; and they pursue it willingly and eagerly, and sometimes with tremendous effort—as in the case of gunpowder. The instruments of this motion, not the only ones certainly, but the most powerful or at least the most frequent, are heat and cold. For example: air, when it is expanded by stretching (as by suction in glass eggs), labors intensely with the desire to return to its former state. But when heat is applied, it seeks expansion on the contrary; it desires a new sphere, and passes and migrates into it willingly, as if into a new form, as they say. And after some expansion, it does not concern itself with returning unless invited back by the application of cold—which is not properly a return, but a repeated transformation. Likewise, water, if compressed, resists and wants to become what it was before—namely, more expanded. But if intense and sustained cold intervenes, it willingly and of its own accord transforms into the condensation of ice; and if the cold is entirely sustained and not interrupted by warmth (as happens in caves

or slightly deeper hollows), it turns into crystal or a similar substance, and is never restored.

[6] *Motus Hyles* ("motion of matter") denoted the spontaneous tendency of bodies to seek new dimensions through expansion or contraction, usually by heat or cold. Bacon thus described thermal expansion qualitatively, though without quantitative or molecular explanation.

Let the **Fifth Motion** be the Motion of Continuity [7]. But we do not mean here the simple and primary continuation with another body (for that is the Motion of Connection), but the continuation of itself, within a specific body. For it is most certain that all bodies abhor disruption of continuity—some more, some less, but all to some extent. Just as in hard bodies (like steel or glass), the resistance to discontinuity is most strong and forceful, so also in liquids, where such motion seems to cease or at least to fade, yet the absence of this motion is not absolute. Rather, it is clearly present in them in a kind of minimal degree, and reveals itself in many experiments—as in bubbles, in the roundness of drops, in the fine threads of dripping fluids, and in the cohesive following behavior of sticky substances, and the like. But above all, this inclination reveals itself when one attempts discontinuity to the smallest fractions. For in mortars, after a certain degree of grinding, the pestle ceases to be effective; water does not enter the tiniest cracks; and even air—despite the fineness of its substance—does not pass at once through the pores of somewhat denser vessels, except by prolonged insinuation.

[7] The *Motus Continuitatis* ("motion of continuity") accounted for cohesion and the resistance of bodies to rupture. His examples—bubbles, droplets, and fine threads—accurately observed surface tension, though their cause remained obscure until modern molecular theory.

Let the **Sixth Motion** be the Motion to Gain, or the Motion of Need (*Motus ad Lucrum* or *Motus Indigentiae*) [8]. This is the motion by which bodies, when placed among things that are clearly heterogeneous and

almost hostile, if they happen to come upon an opportunity or means to escape those heterogeneous substances and apply themselves to others that are more akin—(even though these kindred things may not have any close affinity with them)—they immediately embrace them and prefer them as though they were better, appearing to take them as a kind of gain, from which the name of the motion is derived, as though the bodies were in need of such things. For example: gold or other metal in thin leaf form is not pleased by the surrounding air. So if it encounters some tangible and dense body (like a finger, paper, or anything else), it immediately clings to it and is not easily detached. Likewise, paper or cloth and such substances do not behave well with air that has penetrated and become mixed within their pores. Thus, they readily absorb water or liquid, and expel the air. Also, sugar or a sponge dipped into water or wine, even if part of them protrudes and rises well above the level of the liquid, still gradually draw the water or wine upward, step by step.

[8] *Motus ad Lucrum* or *Indigentiae* ("motion to gain" or "of need") described the tendency of bodies to leave incompatible surroundings and join more congenial ones. Bacon's examples—absorption of liquids and electrical attraction—anticipated both capillarity and chemical affinity.

From this arises an excellent canon for the opening and dissolution of bodies. Setting aside corrosives and strong waters—which forcefully open a path for themselves—if one can find a substance that is proportioned to, and more congruent with and friendly toward, a given solid body than that which it is currently mixed with as if by necessity, the solid body at once opens and relaxes itself and receives the new substance within, ejecting or repelling the former. Nor does this motion to gain operate only by touch. For the electrical operation (about which Gilbert and others after him have generated such great stories) is nothing other than the appetite of a body mildly excited by rubbing, which does not well tolerate air, but prefers another tangible body if one is nearby.

Let the **Seventh Motion** be the Motion of Greater Congregation [9], by which bodies are carried toward the masses of their own kind: heavy bodies toward the globe of the earth; light ones toward the circumference of the heavens. The School has designated this as the Natural Motion, with superficial consideration—because, namely, there appeared to be nothing external that caused the motion, and so it was thought to be innate and inherent in things; or perhaps because it does not cease. And it is no wonder: for the heaven and the earth are always present, whereas the causes and origins of most of the other motions are sometimes absent, sometimes present. Therefore, because this motion does not cease but is always at hand whenever the others pause, they deemed it perpetual and proper, and the others, secondary and adventitious. But in truth, this motion is rather weak and sluggish—such that, unless the mass of the body is great, it gives way and succumbs to other motions as long as they are active. And although this motion has so occupied the minds of men that it has almost hidden the other motions from view, nevertheless, little is truly known about it, and men are entangled in many errors concerning it.

[9] *Motus Congregationis Maioris* ("motion of greater congregation") corresponded to gravitational attraction. Bacon saw gravity as an appetite by which heavy bodies unite with the earth. His description was correct phenomenologically, though still teleological.

Let the **Eighth Motion** be the Motion of Lesser Congregation [10], by which homogeneous parts in a body separate themselves from heterogeneous parts and come together among themselves. By this motion, entire bodies also, due to similarity of substance, embrace and cherish one another, and sometimes gather together, are attracted, and unite at some distance—as when in milk, the cream rises after a while to the top; in wine, the lees and tartar settle to the bottom. For these effects are not due merely to the motion of heaviness or lightness, whereby some parts rise and others sink; but far more to the

desire of homogeneous substances to join and unite among themselves. Now, this motion differs from the motion of need in two respects. First, in the motion of need, the stimulus arises more from a contrary and hostile nature; whereas in this motion, if hindrances and constraints are absent, parts unite out of friendship, even in the absence of an alien nature that would provoke strife. Second, the union here is closer and more selective: for in the motion of need, bodies not very closely related may come together simply to avoid a hostile substance; but in this motion, substances are united by a true internal kinship, and are fused as if into one. This motion exists in all composite bodies, and would easily reveal itself in each case if it were not hindered and restrained by other appetites and necessities of bodies, which disturb this union.

[10] *Motus Congregationis Minoris* ("motion of lesser congregation") referred to the aggregation of like parts within a mixture, as in sedimentation or crystallization. Bacon included magnetic attraction among these, mistakenly uniting mechanical and molecular phenomena.

This motion, however, is commonly restrained in three ways: by the sluggishness of bodies; by the constraint of a dominant body; and by external motion. As to the sluggishness of bodies: it is certain that tangible bodies possess a kind of inertia, in varying degrees, and a reluctance to engage in local motion; so that, unless stirred, they prefer to remain in their current state rather than move toward an improved one. This sluggishness is dispelled in three ways: by heat, by the eminent virtue of a kindred body, or by vivid and forceful motion. First, as to the help of heat: hence it is said that heat separates heterogeneous parts and unites homogeneous ones. This definition of the Peripatetics was rightly mocked by Gilbert, who said it was as if someone defined a human being as that which sows wheat and plants vineyards—since such a definition is based only on effects, and those quite particular ones. But the definition deserves even more blame, because even those effects (however they may be) do not arise from a

property of heat itself, but only by accident (for cold does the same, as we shall say later); namely, from the desire of homogeneous parts to unite, with heat merely assisting by dispelling the sluggishness that had previously restrained that desire. As to the help given by the virtue instilled by a kindred body: this is marvelously evident in the armed magnet, which excites in iron the power of retaining other iron, by similarity of substance, the sluggishness of the iron being dispelled by the virtue of the magnet. As to the help of motion: it is seen in wooden arrows, even with wooden tips, which penetrate more deeply into other wood than if they were tipped with iron, due to the similarity of substance, the sluggishness of the wood being dispelled by swift motion. Of these two experiments, we have also spoken in the aphorism concerning clandestine instances.

The binding of the motion of lesser congregation, which occurs by the restraint of a dominant body, is observed in the coagulation of blood and urine due to cold. For as long as those bodies are filled with an active spirit, which governs and restrains each of their parts of whatever kind, as master of the whole, the heterogeneous elements do not unite, being held back by this restraint. But after that spirit has evaporated, or been stifled by cold, then the parts, released from the restraint, unite according to their natural desire. And thus it happens that all bodies which contain a sharp spirit (such as salts and the like) endure and do not dissolve, because of the permanent and enduring restraint of the dominating and imperious spirit.

The binding of the motion of lesser congregation, which occurs through external motion, is most clearly observed in the agitation of bodies by which putrefaction is prevented. For all putrefaction is founded on the congregation of homogeneous parts; from which gradually arises the corruption of the prior (so-called) form and the generation of a new one. For the putrefaction which lays the path to the generation of a new form is preceded by the dissolution of the old,

which is itself a gathering toward homogeneity. Now, if that is not impeded, it proceeds as a simple dissolution; but if various obstacles arise, then putrefactions follow which are the rudiments of the new generation. But if (as is now under consideration) frequent agitation occurs through external motion, then this motion of gathering (which is delicate and gentle and requires stillness from external disturbance) is disturbed and ceases. This we observe in countless instances: as when the daily agitation or flowing of water prevents putrefaction; winds avert the corruption of the air; grains, when turned and stirred in granaries, remain sound; and, in general, all things that are agitated externally do not easily putrefy within.

It remains to note that one must not omit that coalescence of parts of bodies from which hardening and drying chiefly result. For after the spirit, or moisture turned into spirit, has evaporated from some porous body (as in wood, bone, membrane, and the like), then the thicker parts contract and come together with greater force, whence hardening or drying follows. This we believe to occur not so much by the motion of nexus (so that a vacuum may not be admitted), as by that motion of affinity and union.

As for coalescence at a distance, it is infrequent and rare; and yet it exists in more things than in those in which it is usually observed. Its images are found when one bubble dissolves another; when medicines, by the similarity of substance, draw humors; when a string in one instrument moves another string in unison; and similar cases. We also believe this motion to be active in the animal spirits, though entirely unknown. But it certainly stands out in the magnet and the excited iron. Now, when we speak of the motions of the magnet, they must be clearly distinguished. For there are four powers or operations in the magnet that must not be confused, but separated; although human admiration and wonder have mixed them together. First, the attraction of the magnet to the magnet, or iron to the magnet, or

excited iron to iron. Second, its orientation toward the north and south, and simultaneously its declination. Third, its power of penetrating gold, glass, stone, and all other materials. Fourth, the transmission of its virtue from the stone to iron, and from one piece of iron to another, without communication of substance. But in this place, we speak only of its first power, namely, attraction. Also notable is the motion of coalescence between quicksilver and gold: so much so that gold attracts quicksilver, even when the latter has been prepared in ointments. And workers, among the fumes of quicksilver, are accustomed to keep a piece of gold in their mouths to collect the emissions of quicksilver, which would otherwise invade their skulls and bones; hence that piece of gold turns whitish after a short time. And with this, let what has been said on the motion of minor congregation suffice.

Let there be a **Ninth Motion**, the Magnetic Motion [11]; which, although it belongs to the kind of the motion of minor congregation, nevertheless, if it acts at great distances and upon large masses of things, it deserves a separate inquiry. Especially if it neither begins with contact, as most do, nor carries its action to contact, as all congregative motions do; but only lifts bodies or causes them to swell, and does nothing beyond that. For if the moon raises the waters, or causes moist things to swell or expand; or if the starry heaven draws the planets toward their apogees; or if the sun restrains the stars of Venus and Mercury, so that they do not move farther from its body than a certain distance—such motions seem to be properly placed neither under greater congregation nor under lesser congregation, but to be, as it were, intermediate and imperfect congregative motions, and therefore should constitute a distinct kind.

[11] The *Motus Magnetis* (“magnetic motion”) was distinguished as a separate kind acting across distance. Bacon extended the category to lunar and solar influences. His intuition of non-contact action prefigured later field theory, though his unification under magnetism was mistaken.

Let there be a **Tenth Motion**, the Motion of Flight [12]; namely, a motion contrary to the motion of minor congregation, by which bodies, through antipathy, flee and drive away hostile things, separating themselves from them or refusing to mix with them. Although it may appear in some cases that this motion is merely accidental or consequential in respect to the motion of minor congregation—since homogeneous elements cannot unite unless heterogeneous ones are excluded and removed—this motion ought nevertheless to be posited as independent and classified as a distinct species, because in many cases the desire for flight is seen to be more fundamental than the desire for union.

[12] *Motus Fugae* ("motion of flight") signified repulsion between incompatible substances. Bacon's examples—oil and water, mercury and fat—accurately described immiscibility, though he attributed it to metaphoric antipathy rather than chemical polarity.

This motion stands out especially in the excretions of animals, and no less in the aversion of certain sensory organs to offensive objects, particularly in smell and taste. For a foul odor is so repelled by the sense of smell that it even induces a convulsive reaction in the stomach through sympathetic response; a bitter and dreadful taste is so rejected by the palate or throat that it induces, by a similar sympathy, a shudder and convulsion of the head. Nevertheless, this motion also has a place in other domains. It is observed in certain antiperistases, as in the middle region of the air, whose cold seems to be a rejection of frigid nature from the confines of the celestial bodies; just as the great heat and inflammation found in subterranean places appear to be rejections of hot nature from the inner parts of the earth. For heat and cold, if they exist in smaller quantities, mutually destroy each other; but if they are in larger masses, like well-matched armies, they repel and drive each other from their respective territories through conflict. They also report that cinnamon and other fragrant substances,

when placed near latrines or foul-smelling places, retain their scent longer, because they resist departing and being mixed with the fetid. Certainly, mercury, which otherwise tends to reunite into a whole body, is prevented from doing so by human saliva, pig fat, turpentine, and such substances, because of the poor affinity it has with them; and, being surrounded on all sides by such bodies, it retreats, such that the force of its flight from these intervening substances is stronger than its desire to unite with its own kind—this is what is called the mortification of mercury. Likewise, the reason why oil does not mix with water is not only the difference in lightness, but also their mutual incompatibility; as is evident in the case of alcohol, which, though lighter than oil, nonetheless mixes well with water. But above all, the motion of flight is most striking in saltpeter and similar crude bodies, which abhor flame; as in gunpowder, mercury, and even in gold. The apparent flight of iron from the other pole of the magnet, as noted well by Gilbert, is not a true flight, but rather a conformity and inclination toward a more suitable orientation.

Let the **Eleventh Motion** be the Motion of Assimilation [13], or the Multiplication of itself, or even Simple Generation. By "simple generation," we mean not the generation of entire bodies, such as in plants or animals, but of similar bodies. Namely, through this motion, similar bodies convert other bodies—either kindred or at least well-prepared and suitably disposed—into their own substance and nature: as flame, which multiplies itself over vapors and oily substances and generates new flame; air, which multiplies itself over water and watery substances and generates new air; the vegetative and animal spirit, which multiplies itself over the thinner parts both of the watery and oily in its food, and generates new spirit; the solid parts of plants and animals—such as leaf, flower, flesh, bone, and so forth—which each assimilate the juices of their food and generate successive and homogeneous substance. Nor should anyone be tempted to follow Paracelsus in his delusion, who, blinded by his distillations, wanted to

claim that nutrition happens only through separation, and that in bread or food lies hidden the eye, nose, brain, liver; in the juice of the earth, the root, leaf, and flower. Just as a sculptor draws out a leaf, flower, eye, nose, hand, foot, and the like from a crude mass of stone or wood through separation and rejection of the superfluous, so that internal Workman, the Archeus, supposedly draws forth each member and part from food by separation and rejection. But leaving aside such nonsense, it is certain that each part, both similar and organic, in plants and animals, first attracts (with some degree of selectivity) the almost common or not very different juices of their food, then assimilates them, and converts them into their own nature. Nor does this assimilation, or simple generation, happen only in animate bodies; for inanimate things also share in this process, as has been said about flame and air. Moreover, the dead spirit, which is contained in all animate tangible bodies, continually acts to digest the thicker parts and convert them into spirit, which then escapes; hence arises a loss of weight and a drying out, as we said elsewhere. Nor should we dismiss, in the context of assimilation, that accretion which is commonly distinguished from nutrition: such as when clay grows between pebbles and turns into stony matter; or the scaly substance around the teeth turns into a material no less hard than the teeth themselves, and so on. We hold the view that in all bodies there exists a desire to assimilate, no less than a desire to unite with what is homogeneous; but this power, like the other, is constrained—though not in the same ways. But those modes of constraint, and how to overcome them, must be investigated with the utmost care, because they pertain to the renewal of aging. Finally, it seems worth noting that in the nine previous motions we discussed, bodies appear to desire only the preservation of their nature; but in this tenth, they aim at propagation.

[13] *Motus Assimilationis* ("motion of assimilation") referred to processes of growth and reproduction, by which similar bodies convert others into their own

nature. Bacon's inclusion of flame and spirit as assimilative phenomena linked metabolism with combustion under a single principle.

Let the **Twelfth Motion** be the Motion of Excitation [14], which appears to belong to the class of assimilation, and is sometimes, by us, called interchangeably by that name. For it is a motion that is diffusive, communicative, transitive, and multiplicative, just like that of assimilation; and they generally agree in effect, although they differ in the mode of effecting and in the subject. For the motion of assimilation proceeds, as it were, with command and authority: for it orders and compels the assimilated to be converted and transformed into the assimilating. But the motion of excitation proceeds, as it were, by art, insinuation, and stealth; it merely invites and disposes the excited to the nature of the exciter. Also, the motion of assimilation multiplies and transforms bodies and substances; for example, more flame, more air, more spirit, more flesh is produced. But in the motion of excitation, only virtues are multiplied and transferred; for example, more heat, more magnetism, more putrefaction is generated. This motion is most prominent in heat and cold. For heat does not diffuse itself in heating by the communication of the initial heat, but only by exciting the parts of the body to that motion which is the Form of Heat—concerning which we spoke in the first vintage on the nature of heat. Hence, heat is far more slowly and with greater difficulty excited in stone or metal than in air, because of the unfitness and unreadiness of those bodies for that motion; so that it is likely that there exist, deeper toward the bowels of the earth, materials that altogether reject heating, because, on account of their greater condensation, they lack that spirit from which the motion of excitation most commonly begins. Similarly, a magnet endows iron with a new arrangement of parts and a conforming motion; yet the magnet loses nothing of its virtue. Likewise, leaven in bread, the barm of beer, rennet in milk, and some poisons excite and invite motion in dough, in beer, in cheese, or in the human body—a successive and continuous motion—less by the force

of the exciter than by the predisposition and easy yielding of the excited.

[14] *Motus Excitationis* (“motion of excitation”) described transmission of activity without substance—heat inflaming heat, magnetism exciting iron. This correctly distinguished field-like propagation from material transfer.

Let the **Thirteenth Motion** be the Motion of Impression [15]; this motion also belongs to the class of assimilation motions, and is the subtlest among diffusive motions. However, we have judged it appropriate to assign it its own category, because of the notable difference it bears in relation to the previous two. For the simple motion of assimilation transforms the bodies themselves, so that if the initial mover is removed, it makes no difference to what follows. Indeed, the initial kindling into flame or the initial transformation into air does nothing to affect the flame or air that is generated afterward. Similarly, the motion of excitation fully persists even after the initial mover is removed, and continues for quite a long time—as in a heated body after the removal of the initial heat; in excited iron after the magnet is taken away; in a mass of dough after the ferment has been removed. But the Motion of Impression, though diffusive and transitive, seems to depend perpetually on the initial mover, such that once that mover is withdrawn or ceases, the motion immediately fails and vanishes; hence it is completed in a moment or at least in a very short span of time. For this reason, we have been accustomed to call those motions of assimilation and excitation "motions of the generation of Jupiter," because the generation endures; while this motion we call the "motion of the generation of Saturn," because what is born is immediately devoured and absorbed. This motion reveals itself clearly in three phenomena: in the rays of light, in the strokes that produce sound, and in magnetic action, insofar as it pertains to communication. For when the light is removed, colors and its other images immediately perish; when the initial strike and vibration of a body are removed, the sound soon disappears. Although sounds are also stirred in the medium by

winds as if through waves, it must be more carefully noted that the sound does not last as long as resonance does. Indeed, when a bell is struck, the sound appears to continue for quite a long time; from which one might easily fall into error, imagining that during all that time the sound is floating and clinging in the air—which is entirely false. For that resonance is not the same sound numerically, but is renewed again and again. This is revealed by the stilling or suppression of the struck body. For if the bell is firmly stopped and held motionless, the sound immediately perishes and no longer resonates; just as with strings—if after the first pluck the string is touched, whether by a finger as in a lyre or by a quill as in a spinet, the resonance immediately ceases. Likewise, when the magnet is removed, the iron at once falls. But the Moon cannot be removed from the sea, nor the Earth from a heavy body as it falls. Therefore, in those cases, no experiment can be made; yet the reasoning is the same.

[15] *Motus Impressionis* ("motion of impression") denoted transient influence dependent on a continuing cause, as in light or sound that ceases when the source is removed. Bacon thus differentiated between persistent transformation and momentary communication.

Let the **Fourteenth Motion** be the Motion of Configuration or Position [16]; through which bodies appear to seek not some union or separation, but rather a particular position, arrangement, and configuration in relation to others. This motion is, however, very obscure and not well investigated. And in some cases it appears almost without a cause; although in truth (as we believe) this is not the case. For if one asks why the heavens revolve from east to west rather than from west to east, or why they rotate around the poles located near the Bears rather than around Orion or some other part of the heavens, such questions seem almost like ecstasies or raptures—whereas they should rather be accepted from experience and as positive facts. Indeed, there are in nature certain ultimate and causeless things; but this does not appear to be one of them. For we believe that this

happens from a certain harmony and agreement of the world, which has not yet come into observation. Even if the motion of the Earth from west to east is accepted, the same questions remain. For the Earth itself also moves about certain poles. And why, in the end, should these poles be located where they are rather than elsewhere? Likewise, the verticality, direction, and declination of the magnet are referred to this motion. Also, in both natural and artificial bodies—especially those that are solid and not fluid—there is found a kind of arrangement and positioning of parts, like hairs or fibers, which must be carefully investigated, since without their discovery such bodies cannot be conveniently handled or governed. But those circulations in liquids, by which, when pressed, they yield to one another before they can free themselves—in order to bear the compression equally—we more properly assign to the motion of liberty.

[16] *Motus Configurationis* ("motion of configuration or position") addressed the preferred orientation of bodies—magnetic declination and cosmic rotation. Bacon treated spatial order as an intrinsic appetite of matter, merging observation with cosmology.

Let the **Fifteenth Motion** be the Motion of Passage, or the Motion according to Channels; by which the powers of bodies are more or less hindered or advanced by their media, depending on the nature of the bodies and the operative forces, as well as the nature of the medium itself. For one kind of medium suits light, another sound, another heat and cold, and yet another magnetic forces—and similarly for certain other powers, respectively.

Let the **Sixteenth Motion** be the Motion of Government [17] (for so we call it), or the Political Motion; by which the dominant and commanding parts in a body restrain, tame, subdue, organize, and compel the other parts to unite, separate, remain still, move, or be arranged—not according to their own desires, but according to the order and suitability that serves the well-being of the ruling part. Thus,

it is as if there were a kind of regime and polity exercised by the ruling part over the subject parts. This motion is most clearly manifested in the spirits of animals, which, for as long as they are vigorous, regulate all motions of the other parts. Yet it is also found in other bodies to a lesser degree, as was said concerning blood and urine, which do not separate until the spirit, which mingled and restrained their parts, has either escaped or been stifled. Nor is this motion entirely proper to spirits, although in most bodies the spirits dominate due to their rapid motion and penetrability. However, in more condensed bodies, not filled with a lively and active spirit (such as is found in quicksilver or vitriol), the grosser parts tend to dominate instead. So much so, that unless this restraint and yoke be shaken off by some artifice, no hope can be held for any new transformation of such bodies. Nor should anyone suppose that we have forgotten the subject at hand; for since this enumeration and classification of motions aims at nothing else but a better inquiry into predominance through instances of struggle, we now speak of predominance among the motions themselves. Yet in describing this royal motion, we are not treating of the predominance of motions or virtues, but of the predominance of parts within bodies. For this is the kind of predominance that constitutes this particular species of motion.

[17] *Motus Regiminis* ("motion of government") applied to compound bodies whose ruling part—often *spiritus*—controlled the rest. The analogy of political hierarchy served Bacon's theory of internal regulation rather than physical causation.

Let the **Seventeenth Motion** be the Spontaneous Motion of Rotation [18]; by which bodies that delight in motion, and are well situated, enjoy their nature, follow themselves rather than something else, and as it were, seek their own embrace. For bodies seem either to move without end, or to be wholly at rest, or to be carried to a terminus where, according to their nature, they either rotate or rest. And those that are well situated and take delight in motion, move in a circle: that

is, with eternal and infinite motion. Those that are well situated and shrink from motion are entirely at rest. Those that are not well situated move in a straight line (as by the shortest path) toward the companionship of things of their own nature. This motion of rotation admits of nine varieties. First, that of its own center, around which bodies revolve; second, of their poles, about which they rotate; third, of the circumference or circuit, as it is distant from the center; fourth, of their speed, whether they rotate faster or slower; fifth, of the direction of their motion—from east to west, or from west to east; sixth, of deviation from a perfect circle by spirals more or less distant from the center; seventh, deviation from a perfect circle by spirals more or less distant from their poles; eighth, of the nearer or farther spacing of their spirals to one another; ninth and last, variation of the poles themselves (if they be movable)—which variation does not pertain to rotation unless it too be circular. This motion is by long-standing and general opinion considered proper to the heavenly bodies. However, there is a serious dispute concerning this motion among certain ancient and modern thinkers, who have attributed rotation to the Earth. Yet a perhaps more legitimate controversy (unless the matter is altogether beyond dispute) concerns whether this motion (assuming the Earth to be at rest) is confined to the heavens, or rather descends and is shared with the air and the waters. The rotation observed in projectiles—as in darts, arrows, musket balls, and similar things—we wholly attribute to the motion of liberty.

[18] The "spontaneous motion of rotation" expressed the perpetual circular movement of the heavens, which Bacon contrasted with the rest of the earth. The concept retained Aristotelian cosmology and preceded Newton's principle of inertia.

Let the **Eighteenth Motion** be the Motion of Trepidation [19], to which (as it is understood by astronomers) we do not grant much credence. Yet to us, who seriously investigate the tendencies of natural bodies everywhere, this motion presents itself, and seems to deserve to be

established as a distinct species. This motion is, in fact, like a kind of perpetual captivity—namely, where bodies are not entirely well placed according to their nature, and yet are not altogether in an ill condition, and so they constantly tremble and move restlessly, being neither content with their present state nor daring to advance further. Such a motion is found in the heart and in the pulses of animals; and it must exist in all bodies that live in a state of ambiguity, between convenience and inconvenience—where they strive to free themselves from constraint, suffer rejection again, and yet are subject to this continual oscillation.

[19] The "motion of trepidation" referred to the supposed oscillation of the celestial spheres postulated by medieval astronomers. Bacon mentioned it cautiously; the motion itself was fictitious.

Let the **Nineteenth** and final **Motion** be that motion to which the name "motion" scarcely applies, and yet it is truly a motion. This motion may be called the Motion of Rest, or the Motion of Aversion from Motion [20]. By this motion, the Earth remains fixed through its mass, its outer parts moving toward the middle—not toward an imaginary center, but toward unity. Through this same tendency, all things that are extremely condensed shun motion, and for them, the highest form of appetite is to remain unmoved. And although they may be pulled and provoked to motion in countless ways, they still strive (so far as they can) to preserve their nature. And if they are forced to move, they always seem to act with the intention of regaining their former rest and stability, and of moving no more. Indeed, in this pursuit, they show themselves nimble and quick, as if weary and intolerant of any delay. Yet the image of this appetite can only be seen in part, since here among us—due to the influence and digestion of the heavenly bodies—all tangible things are not only not condensed to the utmost, but are also mixed with some degree of spirit.

[20] *Motus Exhorrentiae Motus* ("motion of aversion from motion") indicated the tendency of dense bodies to remain still. Though framed teleologically, this approximated the modern concept of inertia—rest as persistence of state.

We have now set forth the species or simple elements of motions, appetites, and active powers, which are the most universal in nature. And under these, no small part of natural philosophy is sketched out. Yet we do not deny that other kinds may perhaps be added, and that these very divisions might be reformulated in accordance with truer channels of things, and ultimately reduced to a smaller number. However, we do not mean this with regard to some abstract divisions—for example, if someone were to say that bodies seek either preservation, or exaltation, or propagation, or enjoyment of their nature; or if someone were to say that the motions of things tend toward the preservation and good either of the universe—such as antitypy and connection—or of great wholes, as in the motion of greater aggregation, of rotation, and of aversion from motion; or of specific forms, as in the remaining motions. Although such statements may be true, they are speculative and of limited usefulness unless they are grounded in matter and structure according to real lines. Meanwhile, what we have set out will suffice, and will be of good use for evaluating the predominance of powers and for seeking out instances of struggle—which is our present task.

For among the motions we have described, some are utterly invincible [21]; others are stronger than the rest, and they bind, restrain, and direct them; some extend farther than others; some surpass others in time and speed; and some support, strengthen, enlarge, and accelerate others.

[21] In concluding that some motions are "utterly invincible," Bacon ranked *antitypy* and *connection* above the rest. This hierarchy of forces anticipated the later search for fundamental interactions governing matter, though his reasoning remained qualitative.

The motion of antitypy is altogether adamantine and invincible. Whether the motion of connection (*nexus*) is likewise invincible remains uncertain to us. For we have not yet definitively affirmed whether a vacuum exists—either in aggregated or intermixed form. But we are certain of this: the reasoning by which Leucippus and Democritus introduced the vacuum—namely, that without it, bodies could not fill or occupy both larger and smaller spaces—is false. For it is clearly a folding of matter, folding and refolding itself through spaces, within certain bounds, without the interposition of a vacuum. Nor is there two thousand times more vacuum in air (as would be required) than in gold. This is clear to us from the immensely powerful forces of pneumatic bodies (which otherwise would float in the vacuum like fine dust), and from many other demonstrations. The remaining motions govern and are governed by one another, in accordance with their strength, quantity, intensity, reach, and also the aids and obstacles they encounter.

For example: a certain armed magnet holds and suspends iron up to sixty times its own weight; to that extent, the motion of lesser aggregation prevails over the motion of greater aggregation; but if the weight is greater, it yields. A lever of a certain strength will lift a given weight; to that extent, the motion of liberty prevails over the motion of greater aggregation; but if the weight is too great, it yields. A piece of leather stretched to a certain degree does not tear; to that extent, the motion of continuity prevails over the motion of tension; but if the tension increases further, the leather breaks, and the motion of continuity yields. Water flows through a fissure of a certain size; to that extent, the motion of greater aggregation prevails over the motion of continuity; but if the fissure is narrower, it yields, and the motion of continuity prevails. In the case of sulfur powder alone placed in a gun with a ball, and fire applied, the ball is not discharged; here, the motion of greater aggregation defeats the motion of matter. But with gunpowder placed in the same way, the motion of matter in the

sulfur—assisted by the motions of matter and flight in the nitre—prevails. And so it is in other cases. For the instances of struggle (which reveal the predominance of powers, and according to which one may reason and calculate which prevail and which yield) must be diligently and thoroughly sought out from all sides.

The modes and principles of the yielding of motions must also be carefully examined. That is, whether they entirely cease, or rather continue to strive, but are restrained. For in the bodies here among us, there is no true rest—neither in wholes nor in parts—but only apparent rest. This apparent rest is caused either by equilibrium or by the absolute predominance of motions. By equilibrium, as in balances, which stand still if the weights are equal. By predominance, as in perforated vessels, where the water rests and is held back from falling by the predominance of the motion of connection. Yet it must be observed (as we have said) to what extent the motions that yield continue to strive. For if someone is pinned to the ground in a struggle, his arms and legs bound or otherwise restrained, and he still exerts all his strength to rise—there is no less effort, even if it achieves nothing. Now, whether in such a case the yielding motion is virtually annihilated through the predominance of the other, or whether its striving continues though it be invisible—a condition hidden in struggles may perhaps appear in cases of conjunction. For example, let an experiment be made with firearms to see whether a gun, in the range where it shoots a ball in a direct line (or as commonly said, point-blank), delivers a weaker blow when fired upward—where the motion of percussion is simple—than when fired downward, where the motion of gravity concurs with the blow.

The rules of predominance that present themselves must also be collected. For example, the more universal the good that is sought, the stronger is the motion—as the motion of connection, which regards the communion of the universe, is stronger than the motion of gravity,

which regards the communion of dense bodies. Also, appetites that aim at private goods generally do not prevail over those that aim at more public goods, except in bodies of small quantity. Would that this held true also in civil affairs.

II-XLIX (2:49).

Among the prerogative instances, we will place in the **twenty-fifth position** the *Suggestive Instances* [1]—namely, those which suggest or indicate human benefits. For sheer power and sheer knowledge enlarge human nature, but do not make it happy [2]. Accordingly, from the totality of things, we must extract those that most contribute to the uses of life [3]. But a more fitting place to speak of these will be when we take up the *Deductions to Practice*. Furthermore, in the very work of interpretation, with respect to each particular subject, we always assign a place for the *Human Chart*, or *Chart of Wishes* [4]. For both inquiring and wishing—when not done foolishly—are rightfully part of science.

[1] *Instantiae Suggestivae sive Benevolae* ("Suggestive or Benevolent Instances") were the final class of Bacon's *prerogative instances*, directing inquiry toward works of benefit (*ad usus vitae*). They exemplified the ethical orientation of Bacon's natural philosophy—knowledge in the service of human good.

[2] Bacon distinguished between *scientia* (knowledge), *potentia* (power), and *felicitas* (happiness). He held that power and knowledge enlarge human capacity but do not by themselves ensure happiness—an early recognition that moral direction must accompany scientific progress.

[3] The phrase "uses of life" recalls Bacon's programmatic aim, the "relief of man's estate" (*De augmentis*, II.v.1). His *suggestive instances* thus anticipate modern applied science and research directed toward practical welfare.

[4] The *Tabula Desideriorum Humanorum* ("Chart of Human Desires") was Bacon's proposed inventory of human needs to guide future discoveries. It prefigures modern foresight and priority-setting in science policy, where inquiry begins from identified social aims.

II-L (2:50).

Among the prerogative instances, we will place in the **twenty-sixth position** the *Polychrest Instances* [1]. These are those which pertain to various things and occur frequently; and therefore they save no small amount of effort and repeated testing. A more fitting place to speak of the instruments themselves and of mechanical inventions will be when we treat of the *Deductions to Practice* and the *Methods of Experimentation* [2]. Likewise, what is already known and in use will be described in the *Particular Histories* of the individual arts. For the present, however, we shall append certain general remarks concerning them, by way of examples only of the polychrest.

[1] *Instantiæ polychrestæ* derived from Greek *πολύχρηστος*, meaning "useful in many ways." Aristotle and Galen had used the term for broadly applicable tools or remedies. Bacon employed it to denote experiments and instruments that served multiple purposes. Modern science treats such procedures as *generalizable methodologies*—the foundation of interdisciplinary experimentation.

[2] Bacon distinguished *Experientia Literata* (ordered experience) from *Interpretatio Naturae* (systematic induction). He stated that *instantiæ polychrestæ* belonged to the former. This distinction showed how he organized practice and theory, anticipating the later division between experimental protocol and explanatory hypothesis.

Man, therefore, acts upon natural bodies (apart from the simple bringing together or separating of bodies) chiefly in seven ways: namely, either by excluding those things which hinder and disturb [3]; or by compressions, extensions, agitations, and the like; or by heat and cold; or by delay in a suitable place; or by restraining and directing motion; or by particular consents; or by timely and proper alternation, and the series and succession of all these—or at least of some of them.

[3] Bacon referred to *exclusio impedientium*—the removal of interfering conditions—as the first operation of art. His references to vessel thickness and "the cement of wisdom" (*cementum sapientiæ*) reflected alchemical sealing

practices. While Bacon lacked microbiological knowledge, he correctly inferred that air exposure caused corruption. Modern understanding confirms that oxidation and microbial action are the primary agents.

With regard, then, to the first mode: common air, which is everywhere present and presses in from all sides, and also the rays of the heavenly bodies, greatly disturb operations. Therefore, things that serve to exclude them may rightly be considered polychrest. To this end belong the materials and thicknesses of vessels in which bodies prepared for operation are stored. Likewise, the precise methods of sealing vessels—by consolidation and the "cement of wisdom," as the chemists call it. Also, closure by means of liquids at the surface is highly effective: for instance, when oil is poured over wine or plant juices [4], it spreads out at the top like a cover and best preserves them unharmed from the air. Nor are powders ineffective, for although they contain mixed air, they block the force of the condensed and surrounding air—as is seen in the preservation of grapes and fruits within sand and flour. Wax, honey, pitch, and such sticky substances are also appropriately used for more perfect sealing, and for keeping off air and celestial influence. We ourselves once made an experiment by placing a vessel, and also some other bodies, into mercury—the densest of all substances [5] that can surround others. Also, underground caves and hollows are of great use for preventing sun exposure and the open, predatory air—such as the northern Germans use for their granaries. The storing of bodies at the bottom of waters also serves this purpose: for I recall hearing of some wineskins being lowered into the depth of a well for cooling, but by chance and negligence left there for many years, and then drawn up again; and the wine was found not only unspoiled or stale, but even much improved in flavor—due, it seems, to a more refined mixing of its parts. And if it is required that bodies be lowered to the bottom of waters—such as rivers or the sea—without touching the water, nor enclosed in sealed vessels but only surrounded by air, a good method is to use the vessel

that has sometimes been employed for working beneath water on sunken ships, allowing divers to remain below longer and breathe intermittently. That vessel was of this sort: a hollow barrel made of metal, which was lowered evenly to the surface of the water and carried with it all the air contained in the barrel to the bottom of the sea. It stood on three feet (like a tripod), whose length was slightly less than a man's height, so that the diver, when short of breath, could put his head into the cavity of the barrel, breathe, and then continue the task. And we have heard that a kind of small boat or craft has now been invented which can carry people under water for some distance. But under such a vessel as we have just described, any bodies can easily be suspended—for which reason we have brought forward this experiment.

[4] The preservation of wine and juices by an oil layer worked by excluding air. Bacon's observation was empirically correct, though his causal reasoning remained qualitative. The example accurately anticipated later chemical principles of oxidation prevention and controlled atmosphere storage.

[5] Bacon's account of submerging vessels in mercury and air chambers anticipated the diving bell. Contemporary reports from 1538 described a similar demonstration before Charles V. His description of trapped air under pressure was accurate in qualitative terms, preceding Guericke's and Boyle's pneumatic experiments by several decades.

There is also another use of the careful and perfect sealing of bodies: namely, not only to prevent the ingress of air from without (which has already been discussed), but also to restrain the escape of the spirit of the body upon which the operation is performed from within. For anyone working on natural bodies must be assured of their total substance—that is, that nothing has evaporated or flowed out. Profound alterations take place in bodies when, nature preventing annihilation, art also prevents the loss or evaporation of any part. And on this matter a false opinion has gained currency (which, if true, would almost make one despair of preserving a fixed total without

diminution): namely, that the spirits of bodies, or air attenuated by an intense degree of heat, cannot be contained by any vessel's seals, but escape through the subtler pores of the vessels [6]. And people have been led into this belief by those common experiments: an inverted cup over water with a burning candle or piece of paper, where the water is drawn upward; and likewise by cupping-glasses, which when heated over a flame, draw the flesh. For they suppose that in both cases attenuated air is emitted, and thus that its quantity is reduced, so that the water or flesh is drawn up by connection. But this is utterly false. For air is not reduced in quantity, but contracted in space; nor does this motion of succession of water begin until the flame is extinguished or the air has cooled. Thus physicians, in order for the cupping-glasses to draw more strongly, place cold sponges soaked in water over them. Therefore, there is no reason for people to fear excessively the easy escape of air or spirits. For although it is true that even the most solid bodies have pores, still, air or spirit resists being divided so minutely as to escape through such fine pores—just as water refuses to pass through an extremely narrow fissure.

[6] Bacon denied that "spirits" escaped through the pores of vessels, arguing instead that heated air contracted upon cooling. This interpretation was incomplete, since he did not yet know of atmospheric pressure, but it correctly attributed motion to temperature change. Modern thermodynamics confirms his empirical description though replaces *spiritus* with gas behavior.

Regarding the second mode from the seven mentioned, it should first be noted that compressions and such violent actions [7] are indeed highly effective in producing local motion and similar effects, as is evident in machines and projectiles; and also in destroying organic bodies and those powers that plainly depend on motion. For all life—even flame and ignition—is destroyed by compression; and likewise, any machine is damaged and thrown into disorder by it. These violent actions also destroy qualities that depend on arrangement and slight dissimilarity of parts—as in colors (for the color of a whole flower is

not the same as that of a bruised one, nor is that of solid amber the same as that of powdered amber); also in tastes (for the taste of an unripe pear is not the same as that of one compressed and softened; indeed, the latter clearly becomes sweeter). But for nobler transformations and alterations of homogeneous bodies, such violent means are of little value; for such actions do not give bodies a new, stable, and resting configuration, but only a transient one, always tending toward restoration and release. Nevertheless, it would not be useless to conduct more careful experiments on this matter—namely, whether condensation or rarefaction violently induced in truly homogeneous bodies (such as air, water, oil, and the like) might become permanent and fixed, and as it were, transformed in nature. This should first be tested by simple duration, then with the aid of other contributing factors. And indeed, we could have tried this (had it occurred to us) when we condensed water through hammering and pressing (mentioned elsewhere), just before it burst. We should have left the flattened sphere for a few days and then drawn off the water, to see whether it would immediately fill the same volume as it had before condensation. If it did not do so—either immediately or shortly thereafter—the condensation might be considered stable; if otherwise, it would be clear that restoration had occurred and the compression had been transitory. A similar experiment should have been done with the expansion of air in glass eggs: after a strong suction, a sudden and tight sealing should have been applied, and the sealed eggs left for several days; and then it should have been tested whether, when the hole was opened, air rushed in with a hiss, or water was drawn in to the same quantity as it would have been initially without any delay. It is probable—or at least worth testing—that such results could have been and can be achieved, since similar effects are produced in bodies that are slightly more heterogeneous by the mere passage of time. For a stick bent by compression does not spring back after a certain time; nor is this due to any quantitative loss of the wood

from waiting, since the same happens with a sheet of iron (if the time is extended), which does not lose material by evaporation. But if the experiment does not succeed through mere duration, the investigation should not be abandoned, but other aids applied. For it would be a great gain if fixed and stable natures could be imparted to bodies by means of violent actions. By this means, air might be converted into water through condensation, and many similar transformations effected. For man is the master of violent motions more than of the rest.

[7] Bacon proposed that compression might yield permanent condensation. This claim was scientifically unsound—compressed bodies return to equilibrium—but his suggestion of controlled testing reflected a new experimental mentality. His hypothetical trials on hammered water and evacuated glass spheres prefigured the design of physical experiments.

The third of the seven modes refers to that great instrument of both nature and art in producing effects—namely, heat and cold. And in this respect, human power clearly limps along, as if on one foot [8]. For we possess the heat of fire, which, compared to the heat of the sun (as it reaches us) and the heat of animals, is more powerful and intense by nearly infinite degrees. But cold is lacking—except in such forms as may be obtained from winter weather, or from caves, or from surrounding snow and ice; and even this may be equated, in comparison, with the heat of the midday sun in some torrid region, further intensified by reflections from mountains and walls—since both such heats and colds are barely tolerable by animals, and that only for a brief time. But all of these are of little worth compared to the heat of a blazing furnace, or to any cold that might match it in intensity. Thus, everything here among us tends toward rarefaction, drying, and consumption, and hardly at all toward condensation and softening—unless through mixtures and methods that are, as it were, spurious. Therefore, *Instances of Cold* must be sought [9] with the utmost diligence: such as appear in the exposure of bodies atop towers

during sharp frosts; in underground caves; in the surrounding of snow and ice in deeper, specially excavated places; in the lowering of bodies into wells; in the burial of bodies in mercury and metals; in immersion of bodies in waters that turn wood into stone; in burying bodies in the earth—as is reported among the Chinese in the making of porcelain, where specially prepared masses are said to remain in the ground for forty or fifty years, and be passed down to heirs as if they were certain artificial minerals. Also to be investigated are the condensations that occur in nature through cold; so that, once their causes are known, they may be transferred into the arts. These include the sweating of marble and stone; the dew on the inner surfaces of window panes at dawn, after a frosty night; the origin and gathering of underground vapors into water, whence springs often issue; and all other phenomena of this kind.

[8] Bacon treated *calor* and *frigus* as distinct *formæ*, or positive essences. This view was false in physics but significant philosophically, as it rejected Aristotelian privation. His comparison of artificial and natural heat anticipated the study of temperature gradients. Modern science understands cold as relative absence of thermal energy, not as an independent entity.

[9] Bacon's catalogue of colds—snow, caves, wells—recorded authentic empirical environments. His idea that condensation arose from "coagulation of air" was incorrect. Modern physics attributes the effect to cooling and phase transition. His call for an *Historia Frigoris* nevertheless anticipated systematic climatology and cryogenic research.

Apart from those things which are cold to the touch, there are also found some others that are cold in power, which also produce condensation; however, they seem to act only on the bodies of animals, and scarcely beyond that. Many examples of this kind are seen in medicines and plasters. Some condense the flesh and tangible parts—such as astringent remedies, and likewise thickeners. Others condense the spirits—this is most clearly seen in soporifics. There are two modes of condensing spirits by soporifics, or sleep-inducing substances: one through calming motion, the other through fleeing of

the spirits. For the violet, dried rose, lettuce [10], and similar gentle and blessed substances, by their friendly and moderately cooling vapors, invite the spirits to come together and restrain their sharp and restless motion. Also, rosewater, applied to the nostrils during fainting, causes relaxed and overly loosened spirits to recover and, as it were, nourishes them. But opiates and related substances completely drive out the spirits, due to their malign and hostile nature. So when they are applied externally, the spirits immediately flee from that part and are no longer willing to flow there; but if taken internally, their vapors, ascending to the head, drive away the spirits enclosed in the brain's ventricles from all directions; and when these spirits withdraw and cannot escape elsewhere, they are compelled to unite and condense; and sometimes they are entirely extinguished and suffocated. Yet when the same opiates are taken in moderation, they—by a secondary effect (namely, the condensation that follows their convergence)—strengthen the spirits, make them more robust, and blunt their useless and inflammatory motions, and thereby contribute not a little to the healing of diseases and to the prolongation of life.

[10] The classification of soporifics as condensers of “spirits” belonged to humoral physiology. Bacon’s empirical contrast between mild sedatives (rose, lettuce) and narcotics (opium) was accurate, though conceptually pre-chemical. Modern pharmacology distinguishes these effects by neurochemical modulation rather than by condensation of vital spirit.

Preparations of bodies to receive cold should also not be neglected; for example, that slightly warm water freezes more easily than water that is completely cold, and other such cases.

Furthermore, since nature supplies cold so sparingly, we must act as apothecaries do, who, when some simple cannot be obtained, take its substitute—what they call a *quid pro quo*: as aloes-wood instead of xylobalsamum, or cassia in place of cinnamon. In the same way, it must be diligently examined whether there exist substitutes for cold—

namely, by what means condensations can be brought about [11] in bodies, apart from cold itself, which produces them by its own proper virtue. These condensations appear (so far as is now known) to fall within four categories. The first seems to occur by simple compression, which contributes little to stable density (since bodies tend to rebound), but may nevertheless be of auxiliary use. The second occurs through contraction of the grosser parts in a body, after the evaporation or escape of the finer parts—as in hardenings by fire, and by repeated quenches of metals, and the like. The third occurs through the union of homogeneous parts, which are the most solid in a body and had previously been dispersed and mixed with less solid ones—as in the reconstitution of sublimated mercury, which, when in powder, occupies far more space than simple mercury; and likewise in the purification of metals from their slags. The fourth occurs through a kind of consents: by applying things which, by the hidden power of bodies, cause condensation. But such consents rarely manifest themselves—which is not surprising, since before the successful discovery of forms and structures, little can be expected from the investigation of consents. Certainly, with respect to animal bodies, there is no doubt that many medicines, taken both internally and externally, condense as if by consent—as we said a little earlier. But in inanimate bodies, such an operation is rare. Indeed, there has long circulated, both in writings and in rumor, the story of a tree on one of the islands, either the Azores or the Canaries (I do not clearly remember which), that constantly distills [12], providing a certain supply of water to the inhabitants. Paracelsus also claims that a plant called *Sundew* becomes full of dew at midday under a hot sun, while all other plants around it remain dry. But we consider both accounts to be fabulous. Certainly, if such instances were true, they would be of the noblest utility and most worthy of investigation. Likewise, those sugary dews, resembling manna, which are found on oak leaves in the month of May, we do not believe to be generated or condensed by any kind of consent or by

some special property of the oak leaf; rather, since they fall equally on other leaves, they are merely retained and endure better on oak leaves, because these are more compact and less spongy than most other leaves.

[11] Bacon compared substitutes for cold to apothecaries' *quid pro quo*—functional replacements. His four modes of condensation (compression, hardening, reunion, consent) blended mechanical and occult explanations. Only the first two correspond to genuine mechanisms of densification; the latter depended on the obsolete doctrine of natural sympathy.

[12] The "wonderful tree" that distilled water derived from Cardan's *De varietate rerum* (1557). Bacon cited it cautiously, noting its doubtful truth. The phenomenon has since been explained as dew deposition or insect exudation. His treatment exemplified early empirical skepticism toward *mirabilia naturae*.

With regard to heat, abundance and power are undoubtedly available to man; but observation and investigation are lacking in certain respects—and precisely in those ost necessary—however much the spagyrists boast of themselves. Indeed, the works of more intense heat are sought out and observed; but those of more moderate heat, which fall more closely along the paths of nature, are not attempted and therefore remain hidden. Thus, we see with those "Vulcanists" so highly regarded, that the spirits of bodies are greatly exalted, as in strong waters and some other chemical oils; tangible parts are hardened and, once the volatile has been driven off, sometimes fixed; homogeneous parts are separated; even heterogeneous bodies are coarsely incorporated and mingled; and above all, the structures of composite bodies and more delicate schematisms are destroyed and confused. But the works of milder heat should have been explored and pursued—from which finer mixtures and ordered schematisms might be produced and drawn forth, following the example of nature and in imitation of the sun's works, as we have outlined in the aphorism on *Instances of Alliance*. For the operations of nature are carried out through far smaller portions and far more refined and varied

arrangements than the operations of fire, as it is now employed. Then, truly, man would appear enhanced in power, if through artificial heats and powers the works of nature could be reproduced in kind, perfected in efficacy, and varied in abundance—to which one must add the acceleration of time. For rusting of iron occurs slowly, but the conversion to *crocus Martis* happens suddenly; and likewise with verdigris and white lead. Crystal is produced over long time, but glass is fused at once. Stones form over long periods, but bricks are fired suddenly, etc. Meanwhile (which is our present concern), all varieties of heat with their respective effects must be diligently and industriously collected and investigated from every side: those of the heavens, by their direct, reflected, refracted rays, and rays concentrated by burning mirrors; those of lightning, flame, charcoal fire; fire from different materials; open fire, enclosed fire, confined fire, and flooding fire, and lastly fire qualified through different furnace constructions; fire excited by blast, quiet and unexcited fire; fire placed at greater or lesser distances; fire passing through different media; moist heats, as in the bath of Mary, dung, outward heat of animals, inward heat of animals, enclosed hay; dry heats, as in ashes, lime, warm sand; finally, all kinds of heat with their degrees.

Above all, inquiry and discovery should be attempted concerning the effects and operations of heat that increases and decreases gradually, in an orderly manner, periodically, and with proper intervals and delays. For such ordered inequality is truly the daughter of heaven and the mother of generation; and from heat that is either violent, or sudden, or jerking, nothing great is to be expected. This is manifestly evident in plants; and likewise, in the wombs of animals, there is great inequality of heat, due to movement, sleep, food intake, and the emotional states of the pregnant females; finally, even in the very wombs of the earth, namely those in which metals and fossils are formed, this inequality holds and flourishes. Hence, the ignorance of some reformed alchemists is especially notable, who believed that by

steady and uniform heats [13]—from lamps and the like, burning with constant flame—they would fulfill their hopes. Let this be said concerning the operations and effects of heat. Nor is it timely to investigate them thoroughly, until the forms of things and the schematisms of bodies have been more fully examined and brought to light. Then indeed instruments must be sought, applied, and adapted, when the archetypes have been clearly established.

[13] Bacon criticized the Paracelsian “reformed alchemists” for using constant heat in chemical processes. He argued that natural generation required uneven warmth—a correct intuition, since modern thermodynamics recognizes temperature cycling as essential for many reactions. His doctrine of “ordered inequality” anticipated experimental temperature control.

The fourth mode of operation is by delay, which is certainly both the steward and storekeeper of nature [14], and in a way its dispenser. By “delay” we mean when a body is left to itself for a considerable time, protected and shielded in the meantime from any external force. Then, indeed, internal motions reveal themselves and are brought to completion, once external and intrusive motions cease. The works of time are far more subtle than those of fire. For such clarification of wine as is achieved by delay cannot be effected by fire; nor are incinerations by fire as exquisite as the resolutions and consumptions that take place over long ages. Likewise, incorporations and mixtures that are sudden and hurried by fire are much inferior to those accomplished through delay. But the dissimilar and varied schematisms which bodies attempt over time (such as putrefactions) are destroyed by fire or more intense heat. It is, however, worth noting this point in the meantime: the movements of completely enclosed bodies possess something of a violent nature. For such imprisonment impedes the spontaneous motions of the body. Thus, delay in an open vessel favors separations; in a completely closed vessel, it favors commixtures; and in a partially closed vessel, with some air entering,

it promotes putrefactions. In any case, *Instances* concerning the operations and effects of delay must be diligently sought from all sides.

[14] In describing delay as "the steward and storekeeper of nature," Bacon personified time as a cause of transformation. Though metaphorical, the remark captured a valid concept: slow physical and chemical changes differ from rapid ones in kind. Modern kinetics confirms that rate variation affects reaction outcomes.

But the regulation of motion (which is the fifth of the modes of operation) is by no means insignificant in effect. By the regulation of motion we mean when one body, by its encounter, hinders, repels, admits, or directs the spontaneous motion of another body. This commonly depends on the shapes and positions of vessels [15]. For example, an upright cone assists in the condensation of vapors in alembics; but an inverted cone helps the clarification of sugar in inverted vessels. Sometimes, however, curving, narrowing, and alternating expansion are required, and things of that sort. Indeed, all forms of filtration belong to this principle: that is, when a body, by its presence, opens a path for one part of another body and blocks it for another part. Nor is regulation of motion always effected from outside; it can also occur within a body: as when small stones are thrown into water to gather its sediment; or syrups are clarified with egg whites, so that the thicker parts adhere to them and can later be separated. Telesius also rather lightly and inexpertly attributes the regulation of motion to the shapes of animals, because of the canals and chambers of the womb. But he ought to have observed a similar formation in the eggs of birds, where there are no wrinkles or irregularities. Nevertheless, it is true that the regulation of motion perfects formations in embryonic and pre-formed structures.

[15] Bacon's observations on vessel shape reflected his awareness of the physical role of form. He described how conical or curved containers influenced condensation and filtration. This insight prefigured modern attention to geometry in flow dynamics and laboratory apparatus design.

Operations through consents or aversions (which is the sixth mode) often lie hidden in depth. These so-called “occult properties,” “specific properties,” “sympathies,” and “antipathies,” are for the most part corruptions of philosophy [16]. Nor is much to be hoped for in discovering the consents of things before the discovery of the forms and schematisms of simple natures. For consent is nothing other than a symmetry of forms and schematisms relative to one another.

[16] Bacon dismissed the language of “sympathies” and “antipathies” yet retained the notion of *consensus naturarum*. He thereby reframed natural affinity as structural correspondence rather than occult attraction. Modern chemistry and biology preserve the functional equivalent in the study of bonding and compatibility.

And yet, the greater and more universal consents among things are not entirely obscure. Therefore, one should begin with these. Their first and principal distinction is this: that some bodies differ greatly in quantity and rarity of matter, yet agree in schematism; others, on the contrary, agree in quantity and rarity of matter, but differ in schematism. For it has not been ill observed by the chemists, in their triad of principles, that sulfur and mercury seem to pervade the universe of things [17]. (As for salt, it is poorly conceived, but was introduced so as to account for earthy, dry, and fixed bodies.) But certainly, in those two—sulfur and mercury—some consensus of nature most universal appears to manifest itself. For sulfur agrees with: oil, fatty exhalation, flame, and perhaps the body of a star. On the other hand, mercury agrees with: water and aqueous vapor, air, and perhaps the pure interstellar aether. Yet these twin quaternions, or the great triads of things (each within its own order), differ enormously in the quantity and density of matter, but greatly agree in schematism—as is revealed in many ways. By contrast, the various metals greatly agree in quantity and density (especially in comparison with plants, etc.), but differ widely in schematism; and likewise, plants and animals vary in what seems to be an infinite number of schematisms, though they fall

within a narrow range of degrees in terms of material quantity or density.

[17] Bacon adapted Paracelsus's triad of sulfur, mercury, and salt into a dual principle of active and passive matter. This was chemically mistaken but intellectually transitional between alchemy and early corpuscular philosophy. Modern chemistry identifies elements by atomic structure, not by qualitative *formæ*.

There follows the next most universal kind of consent, namely, that between principal bodies and their auxiliaries—that is, their menstruums and their nourishments [18]. Therefore, one must inquire under what climates, in what kind of soil, and to what depth each metal is generated; and likewise in the case of gems—whether they are produced from rocks or arise among minerals. Also, in what kind of earth particular trees, shrubs, and herbs thrive best, and seem, as it were, to rejoice; and also what kinds of fertilizations—whether by manure of various kinds, or by chalk, sea sand, ashes, etc.—are most beneficial; and which among these are more suited and helpful for different types of soil. Similarly, the grafting and inoculation of trees and plants, and the rules concerning which plants they are most successfully engrafted upon, depend greatly on consent. In this regard, an experiment recently reported to us seems not unworthy of attention: namely, the grafting of forest trees (which until now has usually been done on orchard trees), by which their leaves and acorns become greatly enlarged, and the trees themselves more shady. Likewise, the types of food that are suitable for animals must be carefully noted, including negative cases. For carnivores cannot be sustained on herbs; whence also the sect of the Folitanes (though human will has more power over its own body than that of other animals), after the experiment was tried (as they say), nearly disappeared—as the diet proved intolerable to human nature. Also to be noted are the various substances involved in putrefaction, from which small animals are generated.

[18] The term *menstruum* denoted the generative or dissolving medium from which minerals were believed to arise. Bacon extended it metaphorically to soils and nourishment, broadening the concept toward ecological interdependence. Modern usage retains the idea of a solvent medium but without its vitalist implications.

And the consent of principal bodies toward their subordinates (for such may those we have noted be considered) is fairly evident. To these may be added the consent of the senses toward their objects. And since this latter consent is most manifest, if well observed and rigorously examined, it may shed considerable light on other consents that remain hidden.

But the internal consents and aversions of bodies, or friendships and hostilities (for we are rather weary of the terms "sympathy" and "antipathy," on account of superstition and frivolity), are either falsely attributed, or mixed with fables, or extremely rare due to neglect. For if one claims that there is a discord between the vine and cabbage, because they do not thrive when planted together, a clear reason is at hand: namely, that both are juicy and greedy plants, so that one defrauds the other. If someone asserts a consent and friendship between crops and cornflower or wild poppy, on the grounds that these herbs usually grow only in cultivated fields: he ought rather to say there is a discord between them, because poppy and cornflower are emitted and generated from that juice of the earth which the crops have left behind and rejected; so that the sowing of crops prepares the soil for their growth. And there is a great number of such false attributions. As for fables, they must be entirely eradicated. What remains is indeed a scanty stock of those consents which have been certainly proven by experiment—such as that between the magnet and iron, or gold and mercury, and the like. However, in chemical experiments with metals, some others are found that are worthy of observation. The greatest frequency of such consents (though still few)

is found in certain medicines, which, by their so-called occult and specific properties, act upon particular members, or humors, or diseases, and sometimes even on individual natures. Nor should we omit the consents between the motions and phases of the moon and the passions of lower bodies, insofar as they can be collected and confirmed from experiments in agriculture, navigation, and medicine, or from other sources, provided they are selected with strict and sincere judgment. Indeed, all instances of more hidden consents, the rarer they are, must be investigated with greater diligence—through trustworthy and well-tested traditions and reports—provided this is done without frivolity or credulity, but with anxious and almost doubtful scrutiny. There remains one more kind of consent among bodies in the manner of operation, which though unartful is of manifold practical use, and must by no means be omitted, but must be explored by careful observation. This is the union or conjunction of bodies [19], whether easy or difficult, through composition or simple juxtaposition. For some bodies mix and incorporate easily and willingly, others with difficulty and resistance: for example, powders mix better with waters; limes and ashes with oils; and so on. And not only must instances of the inclination or aversion of bodies toward mixture be gathered, but also those concerning the positioning of parts, their distribution, and digestion after mixing; and finally, the predominance that results after the mixture is completed.

[19] Bacon noted that some bodies mix readily while others resist incorporation. Though unaware of atomic theory, he correctly observed that mixture outcomes depend on the relative predominance of components—a notion comparable to present-day solubility and phase equilibrium.

The **seventh** and last mode of operating remains—namely, operation through alternation and interchange of the preceding six. But before each of these has been more thoroughly investigated, it would not be timely to propose examples. Yet the sequence or chain of such alternation, as it might be adapted to particular effects, is both among

the most difficult to understand and the most powerful in practice. But men are, above all, hindered and preoccupied by impatience—both in such investigation and in its execution—even though this method is like the thread of the labyrinth [20] in relation to greater works. And let this suffice as an example of a *Polychreston*.

[20] Bacon closed by describing alternation and succession as "the thread of the labyrinth." He meant the ordered variation of experimental procedures. This metaphor anticipated the modern concept of iterative experimentation and reproducible method—the essential structure of experimental design.

II-LI (2:51).

Among the prerogative instances, we shall place in the **twenty-seventh and last position** the *Magical Instances* [1]. By this name we designate those cases in which the material or efficient cause is slight or small [2] in proportion to the greatness of the work and of the effect that follows; so that, even if they are common, they yet appear almost miraculous—some at first glance, others only upon closer contemplation. Nature herself supplies such effects but sparingly; yet what she may accomplish, once her bosom has been shaken out and after the discovery of *Forms*, *Processes*, and *Schematismi* (configurations of matter) [3], will appear to future times. For these *magical* effects, so far as we can yet conjecture, take place in three ways: either by multiplication of their own virtue, as in fire and in those poisons called *specifica* [4], and likewise in motions which pass on and are strengthened from wheel to wheel; or by excitation or invitation in another body, as in the magnet, which arouses innumerable needles without any loss or diminution of its own power, and in leaven and things of that kind [5]; or, thirdly, by anticipation or pre-acceleration of motion, as has been said of gunpowder, cannon, and mines [6]. The first two kinds require investigation of *consents* (i.e., correspondences or affinities); the third concerns the *measure of motions* [7]. Whether there be also some mode of altering bodies through their *minima* (the

least particles, as they are called) and of transposing the subtler *schematisms* of matter [8]—which would belong to the universal transformations of bodies, so that art might in a short time accomplish what nature performs through many circuits—of this we have as yet no trustworthy indication. But as in solid and genuine things we aspire to what is ultimate and highest, so we continually detest and, so far as lies in us, put to flight what is vain and swelling [9].

[1] *Magical Instances* (*Instantiæ Magicæ*) referred, not to supernatural marvels, but to lawful effects whose mechanisms were hidden. Bacon redefined *magia naturalis* as experimental knowledge of latent powers, reclaiming the term from occult and alchemical use.

[2] The phrase *materia aut efficiens tenuis aut parva* described cases where a small visible cause produced a great effect. Bacon valued such disproportion as a sign of undiscovered process. Modern science recognizes similar non-linear amplification in catalytic and chain reactions.

[3] *Schematismus materiae* ("configuration of matter") denoted the internal texture or structure of bodies. Bacon used the term to mediate between Aristotelian *forma* and mechanical microstructure; the nearest modern analogues are molecular or crystalline arrangements.

[4] "Specific poisons" (*venena specifica*) referred to agents that reproduce their effect, as contagion or self-propagating reaction. Bacon's analogy between fire and poison was conceptually apt though biologically incorrect: he lacked the distinction between chemical process and living infection.

[5] *Excitatio sive invitatio* ("excitation or invitation") described the induction of like properties in another body. The magnet and ferment were sound empirical examples: modern physics and biochemistry explain them through field interaction and catalytic action, confirming Bacon's intuition of undiminished agency.

[6] *Anteversio motus* ("anticipation of motion") meant rapid release of stored motion. Bacon cited gunpowder, cannon, and mines—accurate examples of explosive force though misattributed to premature motion rather than to gas expansion. His observation still illustrates the principle of potential energy suddenly converted to kinetic effect.

[7] By *consensus* Bacon meant hidden correspondences or affinities among bodies; by *mensura motuum*, the quantitative relation of motions. These expressions marked his turn from qualitative analogy toward the measurable regularities later formalized in mechanics.

[8] The conjecture *per minima* ("through the least parts") anticipated the transformation of bodies by rearranging their smallest particles. Bacon treated this as possible in principle but unverified. The idea foreshadowed atomic and molecular chemistry, though without empirical basis in his time.

[9] Bacon's closing phrase denounced "vain and swelling" pursuits—chiefly the alchemists' promise of total transmutation. He admitted gradual, lawful change but opposed the notion of an instant *elixir* or philosopher's stone, reaffirming his empirical discipline.

II-LII (2:52).

And let this suffice concerning the Dignities or Prerogatives of Instances [1]. But it should be noted that in this our Organon we are treating logic, not philosophy [2]. Yet since our logic instructs and disciplines the intellect not to seize and grasp abstractions of things by the subtle grips of the mind (as the common logic does), but rather truly to dissect nature and to discover the powers and actions of bodies [3], along with their laws determined in matter, so that this science proceeds not only from the nature of the mind but also from the nature of things [4]—it is not surprising if it is everywhere interspersed and illuminated with natural contemplations and experiments, by way of examples of our art. Now (as is clear from what has been said), the Prerogatives of Instances are twenty-seven in number, namely: Solitary Instances; Migratory Instances; Ostensive Instances; Clandestine Instances; Constitutive Instances; Conformable Instances; Singular Instances; Deviating Instances; Borderline Instances; Instances of Power; Accompanying and Hostile Instances; Subjunctive Instances; Instances of Alliance; Crucial Instances; Instances of Divorce; Instances of the Gate; Summoning Instances; Instances of the Way; Instances of Supplement; Dissecting Instances; Instances of the Rod; Instances of

the Race; Doses of Nature; Instances of Struggle; Suggestive Instances; Polychrest Instances; Magical Instances [5]. The use of these instances, in which they excel ordinary ones, lies generally either in the informative part, or in the operative, or in both. And as regards the informative part, they assist either the senses or the understanding. They assist the senses, as do the five Instances of the Lamp [6]. They assist the understanding either by accelerating the rejection of a false form, as Solitary Instances do; or by narrowing down and more precisely indicating the affirmative of the form, as in Migratory, Ostensive, Accompanying, and Subjunctive Instances; or by raising the intellect and leading it to common kinds and natures—either directly, as Clandestine, Singular, and Alliance Instances; or in the next degree, as Constitutive Instances; or in the lowest degree, as Conformable Instances; or by correcting the intellect from customary errors, as in Deviating Instances; or by leading toward the Grand Form or Structure of the Universe, as in Borderline Instances; or by guarding against false forms and causes, as in Crucial and Divorce Instances. But as regards the operative part, some of these instances direct practice, others measure it, others assist it. They direct it either by showing where to begin, lest we act in vain, as in Instances of Power; or by showing what to aspire to, if ability allows, as in Suggestive Instances. Four of the Mathematical Instances serve to measure [7]; the Polychrest and Magical Instances serve to assist.

[1] The term *instantiæ prærogativæ* ("prerogative" or "privileged instances") referred to observations that possessed special epistemic or operational value in the process of induction. Bacon used *prærogativa* in the Roman political sense of "precedence" or "vote first," suggesting that these instances led the way in discovery.

[2] When Bacon wrote that his *Organon* treated "logic, not philosophy," he signaled his reform of logic from a discipline of reasoning to an *instrument of discovery*. Classical logic, concerned with syllogistic inference, had served validation; Bacon's *logic of induction* aimed to produce new knowledge by experience.

[3] Bacon contrasted the speculative abstraction of scholastic logic with his own program to "dissect nature." He thereby defined the new logic as empirical and experimental. This represented a decisive methodological shift: knowledge was to be built from observed effects and mechanical operations, not deduced from universal forms.

[4] The assertion that Bacon's "science proceeds not only from the nature of the mind but also from the nature of things" redefined epistemology. He argued that method must conform to the structure of reality as well as to the structure of thought. Modern philosophy of science still follows this principle, grounding its procedures in the behavior of phenomena rather than in pure reason.

[5] This passage contained the first complete enumeration of all twenty-seven *prerogative instances*. Bacon divided them according to function: those aiding the senses (*Lampadis*), those guiding understanding (affirmative, corrective, or elevating), and those directing practice. The list summarized the architecture of the *Novum Organum's* inductive method.

[6] The "Instances of the Lamp" referred to the five groups discussed in II:39–43, designed to improve perception through experiment or analogy. They correspond to modern *instruments of observation*—extensions of the senses by which hidden phenomena become measurable.

[7] The "four Mathematical Instances" were the *Instantiæ Virgae, Curriculi, Quantitatis,* and *Luctæ* (II:45–49). They illustrated quantitative relations and proportional laws. Bacon treated these as measuring tools, though his understanding of mathematical formalization remained qualitative by modern standards.

Again, from among these 27 instances, some—as we said above in regard to a few—must be collected from the very beginning, without waiting for a particular inquiry into natures. Of this kind are the instances conformable, singular, deviating, borderline, of power, of the gate, suggestive, of manifold use, and magical. For these either assist and remedy the intellect and the senses, or generally instruct practice. The rest are to be sought only when we compile the tables of comparison for the work of interpretation concerning some particular nature. For these prerogative instances, distinguished and gifted with preeminence, are like the soul among the common instances of comparison; and, as we said from the outset, a few of them serve in

place of many. Therefore, when we compile the tables, they must be diligently investigated and inserted into the tables. Mention of them will also be necessary in the sections that follow. Accordingly, their treatment had to be set forth in advance. Now, however, we must proceed to the aids and corrections of induction, and then to concretes, and latent processes, and latent configurations, and the rest which we proposed in order in Aphorism 21—so that, in the end (like careful and trustworthy stewards) [8], we may hand over to mankind their fortunes, after the intellect has been emancipated and made, as it were, of age; from which it necessarily follows that the condition of man is improved, and his power over nature enlarged. For man, by the Fall, lost both his state of innocence and his dominion over creation [9]. Yet both these losses, even in this life, can to some extent be repaired: the former through religion and faith, the latter through the arts and sciences. For creation was not by the curse rendered utterly and irrevocably rebellious. Rather, by virtue of that divine ordinance, "In the sweat of thy face shalt thou eat bread," [10] it is, through various labors (and certainly not through disputations or idle magical ceremonies), in the end, and in part, subdued to supply bread to man—that is, to serve the uses of human life.

[8] The metaphor of "faithful stewards" (*dispensatores fideles*) reflected Bacon's belief that scientific inquiry restored humanity's entrusted dominion over nature. The metaphor joined moral accountability to intellectual labor, defining the scientist's role as one of service rather than mastery.

[9] Bacon's claim that man lost both innocence and dominion through the Fall recapitulated the theological structure of the *Instauratio Magna*. For Bacon, the arts and sciences were instruments of partial restoration: faith repaired moral loss; knowledge repaired practical power. This theological anthropology grounded his vision of scientific progress in divine providence.

[10] The quotation "In the sweat of thy face shalt thou eat bread" (Genesis 3:19) framed scientific labor as fulfillment of divine ordinance. Bacon used it to reject idle speculation and magical ceremony, emphasizing that true dominion came through disciplined work. The connection between toil and discovery prefigures modern conceptions of research as both moral and creative labor.

Once more, from among these twenty-seven instances, some (as we have said above in the case of certain others) must be collected from the very beginning, and one must not wait for a particular inquiry into specific natures. Of this kind are the conformable instances, singular instances, deviating instances, borderline instances, instances of power, of the gate, suggestive instances, polychrest, and magical instances. For these either aid and restore the intellect and the senses, or they generally inform practice. The remaining instances are to be sought only when we compose comparative tables for the task of interpretation concerning some particular nature. For the instances marked and endowed with these prerogatives are like the soul among the common comparative instances; and, as we said at the beginning, a few of them may stand in the place of many. Therefore, when we prepare the tables, these must be sought with utmost diligence and included in the tables. Mention of them will also be necessary in what follows. Thus, the discussion of them had to be placed at the beginning. Now, however, we must proceed to the aids and corrections of induction, and then to concretes, and latent processes, and latent structures, and the remainder of those topics which we set forth in order in Aphorism 21—so that, at last (like upright and faithful stewards), we may hand over to humanity their fortunes, after the intellect has been emancipated and, as it were, come of age. Whence it necessarily follows the improvement of man's condition and the expansion of his power over nature. For man fell from both his state of innocence and from dominion over created things.
Yet both of these losses, even in this life, can in some measure be repaired: the former through religion and faith, the latter through the arts and sciences. For creation was not rendered utterly and irretrievably rebellious by the curse. But by the power of that decree, "In the sweat of thy face shalt thou eat bread," it is, through various labors (not, surely, through disputations or idle magical ceremonies),

at length and in part, subdued to yield bread to man—that is, to serve the uses of human life.

Finis Libri Secundi Novi Organi.