

Three essays on

Dialectic

One Word, Many Meanings, Thousands of Misunderstandings

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<https://hosseinjorjani.com/dialectic/>

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Preface

I have read many short, politically motivated essays about Iran on various websites. One recurrent observation was the remarkable diversity of meanings attached to the term *dialectic*. In the vast majority of cases, authors who used the term did not define it. The word seemed to possess explanatory power in its own right, yet, as a reader, I could extract no coherent meaning from its varied uses. In some cases, *dialectic* even appeared in the title of an essay without being used or explained in the text itself.

Nor did the authors who employed the term belong to a single school of thought. Some were recognizably Marxists of one kind or another; others wrote from within an explicitly religious system of belief. *Dialectic* appeared able to travel between otherwise incompatible intellectual traditions, acquiring a different meaning—or merely a different suggestion of meaning—in each of them.

Eventually, I encountered an essay in which *dialectic* was explicitly defined, immediately after its first occurrence, as the reciprocal effects of theory and praxis. I could not clearly relate this definition to the forms of dialectic with which I had some familiarity. At the time, I was translating Bacon's *Novum Organum* into English and Farsi (Persian), and Bacon's treatment of dialectic offered no obvious home for this definition. Nor did this usage have much in common with what I could remember of Georges Politzer's *Elementary Principles of Philosophy*, which I had read some fifty years earlier.

After reading that essay, I wrote a short note about it. In a deliberately polemical manner, I argued that *dialectic* had no obvious or generally accepted meaning and that its use was more likely to confuse than to inform.

Two friends read the first draft. Each pointed to several passages and said that a particular claim required further explanation or expansion. As I tried to answer their questions, my short note of two or three pages gradually grew into the three essays presented here.

This book does not attempt to provide an exhaustive history of dialectic. It makes only brief reference to a selection of thinkers, from Zeno to Žižek. Both the choice of thinkers and the aspects of their work discussed here were governed largely by the Hegel–Marx–Engels axis. These three figures played a major role in carrying dialectic beyond specialist philosophical works and into political argument and ordinary intellectual language.

I have therefore restricted my inquiry mainly to those elements in the history of *dialectic* that contributed to, influenced, or help illuminate that tradition. Other histories could be written, following different lines of descent and arriving at different selections. The present book has a narrower purpose: to determine what *dialectic* has meant within the tradition most responsible for its modern prominence, whether its principal examples withstand examination, and how much explanatory work the concept can reasonably be expected to perform.

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Chapter 1: What Is Dialectic?

1.1 — Abstract

This chapter examines the shifting meanings of dialectic across philosophical traditions. Today the term is used ambiguously and often stretched beyond clarity. Rather than fixing a single definition, the study traces how successive thinkers introduced, expanded, or dismantled key “building blocks” of dialectic—for example, from Zeno’s paradoxes to Socratic questioning, from Hegel’s logic of development to Marx’s historical materialism, and from Engels’s naturalization to Adorno’s negative dialectics and beyond. By mapping these transformations, the chapter shows both the constructive power of dialectic and the fragmentation that undermined its coherence in the twentieth century. Its constructive aim is to identify minimal conditions for keeping “dialectic” meaningful as a philosophical method. Chapter 2 investigates claims about dialectic in nature and the sciences; Chapter 3 considers alternative approaches.

1.2 — Introduction

Dialectic is commonly described as a method of reasoning that advances understanding through the confrontation of opposites (Ollman, 1993; Rescher, 2006).¹ Deduction draws necessary conclusions from fixed premises, induction generalizes from repeated observations, and inference to the best explanation (IBE) selects the most plausible hypothesis among competing ones (Lipton, 2004). Dialectic, by contrast, proceeds by exposing tensions or contradictions within a given idea or framework and then confronting them through resolution, transformation, or sustained tension (Hegel, [1807] 1977).²

The historical overview presented in the Introduction may at first appear sprawling; that is intentional. Its purpose is to display how differently dialectic has been understood, and why a systematic framework is required. In the final part of this Introduction, I present such a framework by identifying the “building blocks” of dialectic that various thinkers added, removed, or transformed.

The roots of dialectic lie in ancient Greek philosophy. In Plato’s dialogues, it appears as the Socratic method of cross-examination designed to reveal contradictions and stimulate insight (Vlastos, 1994; Plato, 1997).³ Aristotle then distinguishes dialectical reasoning

¹ One might expect a study on dialectic to begin with a fixed definition. This article does not, because the term has undergone so many revisions and appropriations that its continued use requires justification. The task here is to track its transformations first, before asking whether a viable definition is still possible.

² Hegel’s *Phenomenology of Spirit* was first published in 1807. References are to the Oxford University Press translation (1977).

³ I see a formal resemblance between Plato’s description of the soul’s ascent (Republic VI–VII) and Hegel’s notion of sublation: both emphasize overcoming lower forms through a process of development. I have not seen this similarity discussed explicitly in secondary literature; it is my interpretive observation.

from demonstration. Both can take syllogistic form, but whereas demonstration proceeds from true and primary premises, dialectical syllogism proceeds from widely accepted opinions (*endoxa*) (Smith, 1997a). In late antiquity, Neoplatonists such as Plotinus and Proclus reinterpreted dialectic as an ascent through layers of reality, stressing unity through negation (Armstrong et al., 2012).

During the Islamic Golden Age, Avicenna integrated Aristotelian dialectic into a broader system of logic, while Averroes transmitted it back to the Latin West through his commentaries (Gutas, 2001; Butterworth, 2007). In medieval Europe, scholastic thinkers such as Abelard and Aquinas developed dialectic into a structured practice of disputation (Marenbon, 1997; Stump, 2003). Renaissance humanist Peter Ramus attempted to simplify Aristotelian dialectic into a pedagogical tool (Ong, 1958).

In the early modern period, Descartes questioned its epistemic value and instead advocated the analytic method (Gaukroger, 1995). Kant, in the *Critique of Pure Reason* ([1781/1787] 1998), diagnosed dialectic as reason's tendency to generate antinomies when it exceeds its legitimate bounds (Allison, 2004).⁴ Hegel reimaged dialectic as a generative logic in which concepts develop through self-negation and transformation (Houlgate, 2005). Marx adapted this framework to historical materialism, emphasizing conflict within social relations (Marx [1867] 1999; Ollman, 1993).

In the twentieth century, dialectic was reinterpreted by critical theorists. Adorno developed a “negative dialectics” that rejected synthesis and emphasized non-identity and contradiction (Adorno, [1966] 1973; Jarvis, 1998). Horkheimer and Adorno retained it as a method of critique in *Dialectic of Enlightenment* ([1947] 2002). Later, thinkers such as Žižek (1989, 2012) revived Hegelian dialectic through a psychoanalytic lens, while Jameson (2009) employed it as a hermeneutic strategy for interpreting culture and history. Beyond these figures, dialectical motifs also appear in critical realism (Bhaskar, 1993) and elements of post-structuralism.

Across this history, dialectic has never been static. It has been reshaped as method, metaphysics, pedagogy, critique, and cultural interpretation. These changes raise the central problem: has the concept become too fragmented to retain meaning?

To address this, the chapter proceeds by identifying what I call the “building blocks” of dialectic. Each philosopher introduces or removes structural elements that redefine its function. By tracing these pivotal shifts, we can evaluate whether the concept still names a viable philosophical method or whether it has dissolved into metaphor.

1.3 — Aim: Conceptual Mapping of Dialectic

The aim of this chapter is to systematically compare and categorize the different meanings that philosophers have assigned to the term “dialectic” throughout its history. This

⁴ Kant's *Critique of Pure Reason* appeared in two editions (1781 and 1787). References here are to the Cambridge University Press translation (1998). Some scholars note that in the Prefaces, Kant already gestures toward shifts that resemble later dialectical transformations. A fuller treatment of this issue is deferred to section 4 (Kant → Hegel transition).

conceptual mapping will provide the foundation for the subsequent analyses, which will focus on identifying inconsistencies within the concept, the undue extension of the term to domains beyond its original scope, and the confusion of dialectic with other ideas on the basis of superficial resemblance.

This mapping also requires a distinction between what a thinker noticed and what an argument depends upon. A passing observation, an illustration, and a proposition that organises an explanation do not carry equal theoretical weight. Finding a statement in an author's writings establishes its presence; it does not establish that the author developed its consequences or assigned it a structural role. I use the term "mumble" for an observation whose role remains peripheral or undeveloped, not for one that is necessarily foolish or worthless.⁵

This distinction constrains criticism as well as defence. An unsuccessful example may weaken a particular inference without bringing down the entire system. Conversely, a defender cannot answer a criticism of explanatory priority merely by showing that the author mentioned the neglected phenomenon somewhere. We must ask what work a proposition performs, which conclusions depend upon it, and what would remain if it were removed. In the chapters that follow, the crucial question is whether contradiction explains the transformation under investigation or merely supplies language in which that transformation can be redescribed.

1.4 — Building Blocks of Dialectic

Given the historical background of dialectic, one can identify many building blocks. Some of these are relatively simple strands in which dialectic is treated as a method or logical technique (*simplicis*), while others are more complex system-building enterprises where dialectic becomes embedded in a comprehensive philosophical framework (*compositum*).⁶ These can be listed and grouped as follows:^{7 8}

⁵ The fuller distinction is discussed in the [Excursus 140 – On Mumbles and Structural Arguments](#).

⁶ *Simplicis* is a coined technical term (from *simplex*, *simplicis*), used here to denote a non-composite theoretical structure. *Compositum* is the classical Latin term for a compound or composite structure. For consistency with certain English and Latin nouns (e.g., *species*, *series*), both *simplicis* and *compositum* are treated as invariant in plural form.

⁷ In this article, contemporary traditions such as phenomenology (e.g., Merleau-Ponty), structuralism, and post-structuralism (e.g., Derrida and Deleuze) have not been examined directly. The reason is that these traditions cannot be regarded as internal continuations of the Hegelian–Marxian dialectical tradition; rather, they should be treated as parallel, and at times incompatible, lines of thought. Moreover, most of these perspectives do not claim validity or applicability within the domain of nature and the natural sciences, and therefore do not find a place within the analytical framework of this article series, which seeks to reconsider the relationship between dialectic and science.

⁸ Certain late 20th-century thinkers — such as Roy Bhaskar, Margaret Archer, Andrew Sayer, and others in the critical realist tradition — do incorporate dialectical reasoning while departing from the Hegelian–Marxian paradigm. Their approach reconfigures dialectic around concepts such as ontological stratification, emergence, and emancipatory critique, often with a view to integrating scientific realism and social theory. Likewise, figures such as Jürgen Habermas and Alain Badiou offer alternative reconstructions of dialectic: the former grounds it in communicative rationality and discourse ethics, while the latter formalizes it

A. Classical and Early Traditions

1. Socratic Dialectic (simple method of questioning)
2. Platonic Dialectic (structured ascent toward truth)
3. Aristotelian Dialectic (formalized debate and logical testing)
4. Buddhist Dialectic (logical analysis and debate traditions)
5. Neoplatonic Dialectic (metaphysical systematization)
6. Islamic Dialectic (kalam and philosophical disputation)

B. Medieval and Renaissance Traditions

1. Scholastic Dialectic (disputation in medieval universities)
2. Ramist Dialectic (humanist simplification of dialectical method)

C. Early Modern Transformations

1. 9. Pre-Kantian Critique (dialectic as critique of metaphysics)
2. 10. Kantian Dialectic (transcendental critique of reason)
3. 11. The Modern Redefinition of Dialectic: Kant or Hegel? (*transition point, highlighting tensions before Hegel*)

D. Hegelian Break and Aftermath

1. 12. Hegelian Dialectic (systematic unfolding of Spirit)
2. 13. The rupture introduced by Hegel
3. 14. Marxian Dialectic (*historical materialism*)
4. 15. Engelsian Dialectic (*dialectics of nature*)

E. Contemporary Reinterpretations

1. 16. Transformative Reinterpretations outside System-Building
2. 17. Adorno's Critical-Theoretical Dialectic (Frankfurt School)
3. 18. Jameson's Attempt to Modernize Dialectic
4. 19. Žižek's Attempt to Modernize Dialectic

A. Classical and Early Traditions

1.4.1 — Socratic Dialectic

Socratic dialectic builds upon earlier philosophical inquiry by introducing the methodical questioning approach of *elenchus* (refutation), which challenges assumptions and exposes contradictions. This building block enables rigorous examination of prevailing wisdom, fostering intellectual humility and encouraging critical evaluation of thoughts and values. By acknowledging the limitations of human knowledge, Socratic dialectic promotes self-reflection and recognizes that true wisdom lies in admitting one's own ignorance.

through set theory and the logic of the event. Some of these perspectives, while distinct from both classical dialectics and post-structuralist critique, fall outside the scope of this section.

According to Plato's dialogues, especially *Apology* and *Gorgias* (Plato [c. 427–347 BCE] 1997), this method is central to Socratic philosophy. Scholars such as Robinson ([1941] 1953) and Brickhouse & Smith (1994) analyze the function of the *elenchus*, while Vlastos (1991) explores its implications for moral philosophy. Importantly, Socratic dialectic introduces contradiction not in order to resolve or synthesize it, but to destabilize premature certainty and open the path for deeper inquiry.

Socratic dialectic marks the shift from assertion to questioning, destabilizing certainty through contradiction and opening the way for deeper inquiry.

1.4.2 — Platonic Dialectic

Plato builds upon the Socratic method by adding a metaphysical dimension that explores the nature of reality and the Forms. For Plato, dialectic is the process of philosophical inquiry that seeks to ascend to the highest level of understanding, grasping the eternal and immutable Forms that underlie the world of sensory experience⁹ (Plato [c. 427–347 BCE] 1997, *Republic*; Cornford, 1941).

Plato's dialectic involves a method of collection and division, where concepts are analyzed and categorized to reveal their essential nature (Plato [c. 427–347 BCE] 1997, *Phaedrus*; Robinson [1941] 1953). In addition to the Socratic elements of questioning, dialogue, critical thinking, *elenchus*, intellectual humility, and self-reflection, Plato's dialectic adds the crucial element of hypothesis and theory development. Abstract concepts are systematically examined and refined through dialectical reasoning (Vlastos, 1991).

In this way, Plato moves dialectic from ethical dialogue toward a metaphysical ascent. Contradiction is not merely exposed in interpersonal debate but embedded within an ontological hierarchy,¹⁰ where the movement from the world of appearances toward the Forms structures the inquiry. Through this process, Platonic dialectic aims to provide a more comprehensive understanding of reality, knowledge, and the human condition.

Platonic dialectic transforms Socratic questioning into a metaphysical ascent, embedding contradiction within a hierarchy of Forms.

1.4.3 — Aristotelian Dialectic

Aristotle develops dialectic into a systematic method distinct from both rhetoric and demonstration. In the *Topics* and *Sophistical Refutations*, he uses *endoxa*—reputable

⁹ In later discussions, we will see that Hegel views the world as dynamic, in contrast to the Platonic emphasis on eternity and immutability. The question arises whether any philosophers before Hegel also conceived the world in dynamic terms. I maintain that Hegel was not the first to do so. It is also worth noting that Plato's notion of eternity and immutability carries an additional dimension—namely, essentialism.

¹⁰ The idea of the “internality of contradiction,” however one defines “internal” and “external,” can already be found in Plato.

opinions—as the starting point for constructing arguments and testing prevailing views¹¹ (Aristotle, [384–322 BCE] 1984, *Topics*; Smith, 1997b). Unlike demonstration (*apodeixis*), which proceeds from true and primary premises, dialectic begins from *endoxa* and tests competing positions through structured questioning and syllogistic reasoning.

Aristotle’s dialectic contributes key building blocks such as categorization and syllogistic reasoning, where concepts are classified and arguments are systematically constructed to test validity (Aristotle, [384–322 BCE] 1984, *Prior Analytics*; Striker, 2009). In this way, dialectic becomes not merely a tool of disputation but also a means of cultivating critical reasoning and systematic inquiry into philosophical problems.¹²

Placed between Plato’s metaphysical ascent and later scholastic and modern reinterpretations, Aristotle’s approach represents a decisive shift: he anchors dialectic in logical structure and argumentative practice, laying groundwork that subsequent traditions would either refine or react against.

Aristotle redirects dialectic from metaphysical ascent toward structured reasoning with *endoxa*, categorization, and syllogism, grounding it in plausibility rather than transcendence.

1.4.4 — Buddhist Dialectic (e.g., Nāgārjuna)

Buddhist dialectic, particularly as developed in the Madhyamaka tradition of Nāgārjuna, approaches contradiction not as a problem to be overcome but as a tool for undermining false certainties. The method of *prasaṅga* (reductio ad absurdum) exposes the untenability of opposing positions without supplying a final resolution, emphasizing instead the emptiness (*śūnyatā*) and dependent origination of all phenomena¹³ (Garfield, 1995). This refusal to close debate stands in marked contrast to the dominant Western trajectory from Socrates through Engels, where contradiction is typically directed toward resolution, whether in the form of clarified concepts, logical consistency, or dialectical “laws of nature.”

Yet, while distant in historical and cultural context, the Buddhist refusal of closure bears a structural resemblance to certain modern Western reconfigurations of dialectic. From

¹¹ Aristotle did not oppose dialectical reasoning to formal logic as such. Both dialectic and demonstration can take syllogistic form. His innovation lay partly in distinguishing different kinds of reasoning according to their premises and purposes: demonstration proceeds from true and primary premises, dialectic from reputable or widely accepted opinions (*endoxa*), and sophistical reasoning from premises that merely appear reputable. The works later collected under the title *Organon* include both the *Topics* and *Sophistical Refutations*.

¹² By integrating dialectic into his wider philosophical framework, Aristotle elevated it beyond an exercise in disputation, giving it a constructive role in philosophical inquiry and education.

¹³ Nāgārjuna’s *Mūlamadhyamakakārikā* (c. 2nd–3rd century CE) is the classical text of Madhyamaka dialectics. Its method of *prasaṅga* avoids proposing positive theses, instead showing that any fixed position collapses under analysis. See Garfield (1995).

Adorno's *negative dialectics* to Žižek's revival of Hegelian contradictions within psychoanalytic materialism, we find a common insistence that contradiction should remain open-ended, destabilizing premature syntheses and exposing the incompleteness of thought.¹⁴ Unlike these Western approaches, however, the Buddhist project is soteriological: its dialectical method aims not at system-building or social critique, but at liberation from attachment to views.

Buddhist dialectic thus introduces a unique twist in the history of dialectical thought: it demonstrates that contradiction can be mobilized not to reconcile or systematize, but to unsettle, dissolve, and transform perspectives. In this sense, it shifts dialectic away from resolution toward deliberate non-closure, a stance later echoed—though with different aims—by critical theorists from Adorno to Žižek.

1.4.5 — Neoplatonic Dialectic

Neoplatonists, such as Plotinus and Proclus, developed a dialectical method that extended and transformed Plato's ideas, emphasizing ascent to the ultimate reality, the "One." In Neoplatonic dialectic, the process of abstraction and negation aims to transcend the multiplicity of the sensible world and grasp the unity and simplicity of the divine (Plotinus, [250] 1966; Proclus, [440] 1970).

Whereas Plato directed dialectic toward the realm of eternal Forms, Neoplatonism radicalizes this movement by positing a principle beyond being itself. Negation thus becomes the highest mode of intelligibility, guiding the soul toward a reality that cannot be positively defined but only approached through withdrawal and abstraction.¹⁵

To their predecessors' dialectic, Neoplatonists added the building blocks of negative theology and hierarchical emanation, conceiving reality as structured by successive levels flowing from the One (Dillon, [1977] 1996; Gersh, 1978). In this way, Neoplatonic dialectic functions less as logical inquiry than as spiritual ascent, aiming at union with the One rather than conceptual clarification.

Neoplatonic dialectic thus marks a decisive turn: it relocates the goal of dialectic from metaphysical knowledge of Forms to mystical union with a transcendent principle beyond being.

¹⁴ While Buddhist dialectic and modern Western traditions such as Adorno's *negative dialectics* or Žižek's Lacanian-Hegelian approach share a formal emphasis on non-closure, their aims diverge. In Buddhism, dialectic serves a soteriological purpose (liberation from suffering and attachment), whereas in Western critical theory it functions as a tool of philosophical critique and social analysis.

¹⁵ In Neoplatonism, the "One" is conceived as ineffable, transcending even being and thought. The method of negation (*aphairesis*) and negative theology reflect this stance: the divine cannot be described by affirmations, only by stripping away determinations. This contrasts with Plato, for whom dialectic culminates in grasping the highest Form (the Good), still within the domain of being.

1.4.6 — Islamic Dialectic

Islamic dialectic, as developed by thinkers such as Al-Farabi, Ibn Sina (Avicenna), Ibn Rushd (Averroes), and Mulla Sadra, integrated Aristotelian logic with Islamic theology and philosophy. Across these traditions, dialectic was used both defensively, to articulate and safeguard Islamic theology, and constructively, to explore philosophical questions (Al-Farabi [c. 950] 1985; Ibn Sina [1027] 2005).

Distinct emphases emerged within this tradition. Rationalist thinkers such as Averroes stressed logical precision and Aristotelian commentary, while Mulla Sadra introduced more mystical elements through his doctrine of “trans-substantial motion” (*al-ḥarakat al-jawhariyah*), which posits that reality is in a state of continual dynamic transformation (Mulla Sadra, [1630] 1981; Kalin, 2003).

To their predecessors’ dialectic, Islamic thinkers added the building blocks of *dalāla* (indication) and *taklīf al-bayān* (burden of proof),¹⁶ which placed emphasis on the responsibility of the claimant to provide evidence and on the precise analysis of language in argumentation (Wolfson, 1976; Ibn Rushd [12th century] 2001). This enriched the dialectical method with features drawn from theology, law, and philosophy, producing a tradition that fused rational demonstration with the possibility of mystical ascent.

Islamic dialectic thus represents a distinctive turn in the history of dialectical thought: it hybridized Aristotelian logic with theological debate and, in some strands, extended dialectic into metaphysical and mystical dimensions.

B. Medieval and Renaissance Traditions

1.4.7 — Scholastic Dialectic

Thomas Aquinas and other medieval scholastics developed a dialectical method that combined Aristotelian logic with Christian theology. While diverse in style and emphasis, scholastic dialectic generally employed formal disputation—through methods such as *quaestiones disputatae* (disputed questions) and *quodlibetal* debates—to clarify doctrine and resolve objections (Aschbach, 1860; Thomas Aquinas, [1265–1274] 1920). To their predecessors’ dialectic, medieval scholastics added the building blocks of authoritative citation and the synthesis of faith and reason, where arguments were constructed through close engagement with sources such as Scripture and Aristotle.¹⁷ Scholastic disputation

¹⁶ In Islamic theology and jurisprudence, *dalāla* refers to the way in which a statement indicates or implies meaning, while *taklīf al-bayān* assigns the burden of proof to the one making a claim. These concepts shaped dialectical practice by linking argumentation not only to logical validity but also to linguistic precision and responsibility in debate.

¹⁷ Scholastic dialectic tended to subordinate reasoning to authoritative sources such as Scripture, the Church Fathers, papal decrees, and established dogma. Early modern and modern critics frequently highlighted this reliance. Francis Bacon ([1620] 2025) faulted the Scholastics for building knowledge on received authorities and verbal disputation rather than empirical investigation (*Novum Organum*, I.63–65). Ramus (1543) denounced their appeal to *auctoritas* as a corruption of dialectic. Descartes (1637) rejected dependence on external authorities in favor of self-evident reason. Bertrand Russell (1945) summarized Scholasticism as “essentially based upon authority — Aristotle, the Bible, and the Fathers of the Church.” For detailed historical analyses, see Gilson (1955) and Pieper (1964).

thus formalized contradiction as a pedagogical exercise for doctrinal clarification rather than as a means of transformative discovery.

Scholastic dialectic represents a decisive moment in the history of dialectical thought: it institutionalized reason in the service of authority, producing a rigorous but bounded intellectual system that would later face sharp criticism for contributing to Europe's intellectual stagnation.

Scholastic dialectic systematized contradiction within a framework bound by authority, shaping medieval thought but also contributing to Europe's intellectual stagnation.

1.4.8 — Ramist Dialectic

Petrus Ramus and certain Renaissance humanists critiqued and reformed Aristotelian dialectic, promoting a more practical and pedagogical approach. Ramus argued that dialectic should focus on natural reasoning and everyday experience rather than abstract logic (Ramus 1543; cf. Ong 1958). To their predecessors' dialectic, Ramus and his followers added the building blocks of methodus and simplification, treating dialectic as a structured tool for communication, persuasion, and education¹⁸ (Ramus 1543; cf. Ong, 1958).

Ramus's reforms transformed dialectic into a didactic method that emphasized clarity and binary structure, prioritizing accessibility and pedagogy over metaphysical depth.

Ramist dialectic redefined dialectic as method, emphasizing binary structure, pedagogy, and accessibility over speculative or metaphysical concerns.

C. Early Modern Transformations

1.4.9 — Pre-Kantian Critique

René Descartes, John Locke, and David Hume, prominent philosophers of the 17th and 18th centuries, reshaped the intellectual environment in which dialectic would later be redefined. Rather than developing dialectic directly, each introduced methodological critiques that undermined traditional metaphysics and logic. Descartes emphasized methodic doubt, using systematic skepticism to establish a firm foundation for knowledge, in deliberate contrast to Scholastic disputation (Descartes, [1641] 1984).

¹⁸ Ramus critiqued the complexity of Aristotelian classification and advocated strict dichotomous division as a pedagogical method. His methodus simplified conceptual organization by reducing categories to binary branching structures, enhancing clarity and memorization (Ong, 1958). A historical complication arises from Aristotle's own examples, many of which appear in binary form (e.g., animate–inanimate, cold-blooded–warm-blooded). Over time, some readers confused Aristotle's examples with his method, reinforcing dualistic schemes that persisted for centuries. Binary classification continued well beyond Ramus, especially in biology, until Carl von Linné (Linnaeus) introduced more complex taxonomies in the mid-18th century.

Locke stressed empirical observation and the limits of human knowledge, challenging speculative dialectic and insisting that inquiry be grounded in experience and sensory data (Locke, [1689] 1975).¹⁹ Hume extended this critique by exposing the limits of both rationalist deduction and inductive generalization, arguing that human knowledge is inherently probabilistic and that reason itself confronts irresolvable limits (Hume, [1748] 2000).²⁰

Although they did not employ dialectic as a method of conceptual inquiry or system-building, Descartes, Locke, and Hume cleared crucial ground for Kant's later re-envisioning of dialectic. Their work destabilized inherited assumptions and shifted philosophy toward questions of epistemic foundation and limitation, thereby shaping the context in which dialectic could be transformed.

Descartes, Locke, and Hume did not practice dialectic directly, but their critiques of knowledge laid the groundwork for Kant's redefinition of it.

1.4.10 — Kantian Dialectic

Immanuel Kant's views on dialectic are primarily outlined in his *Critique of Pure Reason*, where he developed a distinctive approach to dialectic as a critique of metaphysics. In the *Transcendental Dialectic*, Kant analyzes reason's tendency to generate *paralogisms* (false inferences in rational psychology) and *antinomies* (contradictions in rational cosmology),²¹ as well as its reliance on Ideas such as God, freedom, and immortality. These Ideas, while lacking constitutive validity, retain a regulative function in guiding inquiry (Kant, [1781/1787] 1998).

To his predecessors' dialectic, Kant added the building blocks of transcendental critique and the delimitation of reason's legitimate use. Dialectic, for Kant, is not a constructive method for producing knowledge, but a diagnostic framework for exposing the inevitable illusions of reason when it exceeds possible experience. By redefining dialectic in this

¹⁹ Although Bacon sharply criticized traditional dialectic as practiced by the Scholastics, he may be seen as reformulating aspects of dialectical inquiry within his new empirical method. His systematic elimination of prejudices ("idola"), reliance on structured observation, and method of gradual induction parallel certain dialectical aims of confronting error and refining knowledge, even though he explicitly opposed Scholastic disputation. In this sense, Bacon's *Novum Organum* contributed decisively to the transformation of scientific reasoning in early modernity. See Bacon ([1620] 2025); Gaukroger (2001).

²⁰ Hume's *An Enquiry Concerning Human Understanding* was first published in 1748 under the title *Philosophical Essays Concerning Human Understanding*. While it revises material from his earlier *Treatise of Human Nature* (1739–1740), the *Enquiry* stands as an independent and more accessible work, and is usually cited by its 1748 publication date. Noting these dates matters for intellectual history: Hume had already rejected induction in 1739–1740, yet Europe continued to follow Bacon's inductive method from 1620 well into the mid-20th century.

²¹ Rational cosmology (Vernunft-Kosmologie) is, for Kant, the branch of metaphysics that deals with the world as a whole, distinct from the empirical science of astronomy.

way, Kant established a more modest and rigorous understanding of the relationship between the human mind and reality (Kant, [1781/1787] 1998; see also Allison, 2004).²²

Through this process, Kant's dialectic aimed to provide a nuanced account of knowledge and reality — one that treats contradiction not as an engine of development but as a structural illusion, signaling the necessary limits of speculative reason.

Kant redefined dialectic as a critique of reason's illusions, exposing its limits rather than constructing new knowledge.²³

1.4.11 — The Modern Redefinition of Dialectic: Kant or Hegel?

If dialectic underwent a decisive transformation in modern philosophy, the question arises: who should be credited with redefining it — Kant or Hegel? Kant, in the *Critique of Pure Reason*, confined dialectic to a diagnostic role within epistemology (Kant, [1781/1787] 1998; see also Allison, 2004). In the *Transcendental Dialectic*, he treated it not as a method for constructing knowledge but as a systematic illusion: reason overreaches itself, producing paralogisms and antinomies when it attempts to transcend empirical boundaries (Kant, [1781/1787] 1998; see also Guyer, 1987). For Kant, dialectic thus functioned to expose failure and clarify the limits of rational inquiry.

Hegel, by contrast, redefined dialectic by introducing its generative dimension. Contradiction, rather than a mere boundary signal, became the engine of development: concepts unfold by negating and preserving themselves in a process of sublation (*Aufhebung*). Dialectic thereby became the logic of “becoming” itself — capable of generating knowledge, concepts, and even history through the dynamic interplay of negation and transformation (Hegel, [1807] 1977; [1812–1816] 2010; see also Pippin, 1989; Ollman, 1993).

This shift marks a fundamental break. Whereas for Kant and his predecessors dialectic remained diagnostic, clarifying or limiting thought, with Hegel it becomes constitutive: a principle that produces the movement of thought and reality. Many interpreters therefore regard Hegel, not Kant, as the architect of dialectic in its fully modern sense (Taylor, 1975).²⁴

²² Kant's *Critique of Pure Reason* appeared in two editions (1781 and 1787), often referred to as the A and B editions. The *Transcendental Dialectic* treats three major topics: paralogisms, antinomies, and the Ideal of Pure Reason. These distinctions are important: while the antinomies illustrate contradiction, the paralogisms expose false self-inference about the soul, and the Ideas of reason function regulatively rather than constitutively. Together, these analyses show that dialectic, for Kant, is not a method of discovery but a critique of reason's inherent illusions.

²³ This describes the role Kant himself assigned to dialectic. We should distinguish a thinker's intention from the intellectual consequences of that thinker's work. In Gurvitch's interpretation, Kant's critical philosophy, despite restricting the use of dialectic, also gave later thinkers resources for reconstructing it on new foundations. See [“On Authorial Intention and Intellectual Consequence”](#).

²⁴ Some scholars note continuity between Kant and Hegel: Kant's recognition that reason necessarily generates contradictions already suggests a dynamic model of thought. But the decisive innovation lies in Hegel's claim that contradiction is not an error to be corrected but a productive force, driving conceptual, historical, and ontological development.

With Hegel, dialectic was redefined from a diagnostic tool into a generative logic, transforming its very meaning compared to Kant and all predecessors.

D. Hegelian Break and Aftermath

1.4.12 — Hegelian Dialectic

Georg Wilhelm Friedrich Hegel's views on dialectic are central to his philosophical system. He developed a distinctive approach that emphasizes the dynamic and historical nature of reality and knowledge. Hegel's dialectic is characterized by the unity of opposites, where contradictions are not anomalies but necessary moments in the unfolding of being and thought. For Hegel, contradiction is ontologically constitutive: it is the very essence of determinate being, and thus the principle through which reality develops (Hegel, [1812–1816] 2010).

A crucial aspect of Hegel's dialectic is his emphasis on immanence, where development is driven by internal contradictions and negations rather than by external causes (Hegel, [1807] 1977). The self-undoing of each stage compels its transformation, leading to more comprehensive and self-aware forms of knowledge and reality. This immanent logic demonstrates how reality and thought move forward not by resolution from outside but by necessity from within.

Another important aspect is the transition between quantity and quality.²⁵ Hegel illustrated this relation through the changes of state of water as its temperature altered (Hegel, [1812–1816] 2010). He recognised that a gradual alteration in a measurable condition can reach a point at which another determinate state appears. The observation deserves consideration: the phases differ genuinely, and the progress of a phase transition is not simply an uninterrupted rise or fall in temperature. But the observation and the philosophical inference must be distinguished. A threshold-dependent change does not by itself demonstrate that an internal contradiction produced it.²⁶ The water example, together with the incandescence example used by Engels, is examined in greater detail in Sections 2.5.1 and 2.5.2.

²⁵ Hegel introduces the transition from quantity to quality (*Der Übergang der Quantität in Qualität*) in his *Science of Logic* (Hegel, [1812–1816] 2010), e.g., through water changing state (ice $\rightleftharpoons$ water $\rightleftharpoons$ steam). A more precise framing understands the principle as one of threshold effects or scale-dependent transformation: when quantitative variables cross certain critical points, qualitative outcomes emerge. This interpretive reconceptualization offers clearer analytic traction than Hegel's metaphoric analogies.

²⁶ The thresholds-dependent phenomena belong to the concept of "non-linearity", disproportionate or threshold-driven effects, where small causes can trigger major shifts. Hegel's treatment of quantity and quality clearly illustrates non-linearity (thresholds and qualitative leaps). It also suggests a form of logical dynamism, though his physical examples fail to establish any genuine internal drive in nature. In other words, Hegel's dynamism differs from the modern concept. What he presents as an immanent drive is, in fact, externally mediated threshold behavior, not the kind of self-organizing change we now call dynamism.

At this point in the *Science of Logic*, Hegel introduces the notion of the “thing with its measure” (ein Ding mit seinem Maß). This is not a “system” or “phenomenon” in the modern sense but a logical unity of quality and quantity. A thing is what it is by virtue of its measure: its quality is sustained only within a determinate quantitative range. Once this measure is exceeded, the thing ceases to be what it is and becomes something else. For Hegel, this illustrates the dialectical necessity of transformation: a “thing with its measure” embodies the interpenetration of quantitative and qualitative determination. Importantly, this category is still situated within the *Logic*; Hegel is not yet speaking of empirical systems with complex internal mechanisms but of the logical form that empirical examples are meant to illustrate.²⁷

This distinction matters for assessing the scope of Hegel’s dialectic. Within his idealism, logical categories were intended to express the intelligible structure of reality, not merely conventions of description (Hegel, [1812–1816] 2010). His argument therefore cannot be assessed as though its entire ontological claim rested on an experiment with water. Nevertheless, an empirical illustration does not independently demonstrate the generative power attributed to contradiction. The occurrence of a phase transition establishes a difference between material states; the claim that this difference expresses immanent dialectical development requires a further argument. When that claim is transferred into a materialist account, the connection between logical determination and material causation must be justified rather than assumed. Identifying an internal organisation, an external condition, or a threshold does not by itself supply that justification.²⁸

Hegel also added the building blocks of historical and contextual unfolding, treating dialectic as a process inseparable from concrete cultural and temporal conditions (Hegel, [1807] 1977). His method of negation — including the “negation of the negation” — reveals contradiction as the constitutive engine of development. It is within this framework of German Idealism that Hegel’s dialectic achieves coherence, even if his terminology and examples sometimes remain open to charges of looseness or overextension.

Only after outlining these features should we note the familiar tripartite formula of “thesis–antithesis–synthesis”.²⁹ Though widely used as a heuristic shorthand, it was not Hegel’s systematic terminology, but rather a later interpretive simplification.

²⁷ In Hegel’s *Science of Logic* (1812–1816), the “thing with its measure” (Ding mit seinem Maß) represents the culmination of the section on Measure. It signifies a logically simple unity of quality and quantity: a thing is defined by the quantitative relations that sustain its quality. Once those relations shift beyond a limit, the thing becomes qualitatively other. This is not a “system” in the modern scientific sense but a category of thought/being.

²⁸ This helps explain why later extensions, such as in Engels’ *Dialectics of Nature* or in Levins & Lewontin’s *The Dialectical Biologist*, encounter difficulties. Engels universalized the quantity–quality transition into a natural law, while Levins & Lewontin expanded “system” to such breadth that everything could be redescribed as “internal.” Both moves risk collapsing the boundary between logical categories and empirical processes, thereby weakening the analytic clarity of dialectic.

²⁹ The familiar “thesis–antithesis–synthesis” formula is often used to simplify explanations of Hegel’s method. Hegel himself rarely, if ever, used these terms systematically. Three-part formulations appear in the work of Fichte, who wrote before Hegel; the application of this particular formula to Hegel’s logic is largely a reconstruction by later interpreters and does not accurately represent that logic. See Taylor (1975).

Through this dialectical method, Hegel sought to provide a comprehensive and systematic understanding of reality, knowledge, and history. In redefining contradiction as a generative principle, Hegel transformed dialectic into a logic of development — a break from all previous traditions that had treated contradiction as an error, a limit, or a rhetorical device.

Hegel redefined dialectic as a generative and ontological principle, turning contradiction into the engine of reality itself. This redefinition had divergent consequences. By treating conceptual development as expressive of the structure of reality, he prepared the way for Marx and Engels to extend dialectic to material and natural processes. At the same time, it provoked an opposing tendency in modern logic, represented by Frege and Russell, which sought rigor precisely through the exclusion of contradiction. The first of these paths leads to Marx, to whom we now turn.

1.4.13 — Marxian Dialectic

Karl Marx’s use of dialectic is rooted in his critique of capitalism³⁰ and his attempt to analyze the dynamics of historical change. Marx’s approach is deeply indebted to Hegel, but reoriented through Feuerbach’s materialism³¹ and through engagement with British political economy. Instead of centering on abstract philosophical concepts, Marx’s dialectic emphasizes the material conditions of society, particularly the structures of production and class relations. In this sense, his work redirected the dialectical tradition toward the analysis of concrete social realities (Marx, [1867] 1999).

A central feature of Marx’s method is immanence: the contradictions that drive historical change are not imposed externally, but arise within the capitalist system itself.³² The exploitation of labor, the concentration of wealth, and recurrent crises are not anomalies but structural contradictions. Marx argued that these contradictions generate both the instability of capitalism and the possibility of its transformation through class struggle, where the working class becomes the agent of its own emancipation.

Marx also employed Hegel’s notion of the transition from quantity to quality, transferring it from the domain of logic and metaphysics³³ to political economy. Gradual quantitative

³⁰ Marx’s dialectical method provided a systematic framework for analyzing capitalism, its internal contradictions, and its historical development. Its influence extended well beyond philosophy into economics, political science, sociology, historiography, and critical theory.

³¹ Feuerbach’s critique of Hegelian idealism — particularly his emphasis on sensuous human existence and species-being — served as a transitional influence. Marx radicalized these themes, but Feuerbach’s role highlights that Marx’s materialism was not without precedent.

³² The emphasis on immanence — contradictions arising within a system rather than from external pressures — marks continuity with Hegel, but redirected toward economic and social structures.

³³ Here, “metaphysics” refers to philosophical inquiry into the most general structure and categories of reality—such as being, identity, causation, and change. It does not refer specifically to immaterial, supernatural, or otherworldly entities. In Hegel’s system, the transition from quantity to quality belongs primarily to his logic and ontology.

changes in capital accumulation, he argued, can culminate in qualitative shifts — such as intensified exploitation, crises of overproduction, or revolutionary transformations (Marx, [1867] 1999).³⁴ By extending this principle to the dynamics of capitalism, Marx sought to capture its non-linear and crisis-prone character.

Marx thus assembled several building blocks already present in earlier thought: from Hegel, the emphasis on contradiction and development; from Feuerbach, the primacy of material conditions; from classical economists, insights into labor, value, and capital. His distinctive move was to fuse these elements into historical materialism, a framework in which social change is understood as the outcome of material production, class conflict, and systemic contradiction (Marx, [1845–1846] 1970; [1867] 1999).

The reassembly, however, introduced a burden of justification. Once the material world was no longer treated as the manifestation of the Idea, a movement among concepts could not automatically count as the process generating a material event. A materialist account could reconstruct dialectic on different foundations, but it had to establish what contradiction meant within the phenomenon itself and how it produced the proposed transformation. Removing the idealist premises did not prove the inherited categories false; it removed the warrant for transferring their explanatory force without further examination.

Marx’s own methodological statement makes this question unavoidable. In the 1873 afterword to *Capital* he distinguished inquiry from presentation and insisted that the material be investigated in detail before its movement could be adequately represented. He also presented his method as the opposite of Hegel’s while maintaining that Hegel’s dialectic contained a rational kernel. The issue is therefore not whether Marx undertook empirical investigation. It is whether, in a particular argument, that investigation established the causal claim assigned to dialectic. His express endorsement of Hegel’s quantity and quality principle in the minimum-capital discussion provides a case for examination, not a warrant for treating all of his economic analysis as dependent upon the principle.³⁵

Marx managed to reassemble existing strands — Hegelian contradiction, Feuerbachian materialism, and classical economics — into a new and effective materialist framework for analyzing “capitalism and class struggle”.

1.4.14 — Engelsian Dialectic

Frederick Engels’ views on dialectic emphasized the objective presence of contradictions in nature and society, arguing that contradictions are inherent to things and processes themselves (Engels, [1878] 1969). For Engels, dialectic was not simply a method of thought but a reflection of real structures of change and development. A key principle in

³⁴ Marx’s use of the quantity–quality transition illustrates his adaptation of Hegelian categories to political economy, rather than an innovation of his own.

³⁵ The distinction is developed in the [Excursus 141 — On the Materialization of Hegelian Dialectic](#).

his account was the transition from quantity to quality, where gradual quantitative changes culminate in sudden qualitative transformations (Engels, [1878] 1969; see also Ilyenkov, 1977).

Unlike Hegel, who illustrated this principle largely through logical and conceptual examples, Engels grounded it in the natural sciences.³⁶ He cited the phase transitions of water, magnetic polarity reversals, the existence of allotropes (different structural forms of the same element), hydrocarbon addition reactions, and the systematic relations expressed in the periodic table as empirical instances of dialectical transformation. Marx applied the same principle to society, arguing that a sum of money must exceed a certain minimum before it can function as capital; Engels later cited and defended this example as an instance of quantity becoming quality (Marx, [1867] 1999; Engels, [1878] 1969).

Through such examples, Engels sought to establish dialectic as a general account of development in nature as well as society and thought. He presented the laws as abstracted from material processes, rather than imposed upon them by speculative philosophy. His formulation of quantity and quality also admitted the addition or subtraction of matter or energy, including energy communicated to a body (Engels, [1883] 1976). It should therefore not be confused with a simple claim that every object transforms independently of its surroundings. The difficulty is more precise: do the diverse examples establish a universal explanatory law, and do they demonstrate a generative contradiction? A formulation broad enough to include externally induced changes may accommodate the examples while leaving the stronger causal claim unproved.

Engels' work in *Anti-Dühring* exemplified this extension, critiquing static and metaphysical modes of thought while emphasizing the dynamic, contradictory, and transformative character of reality (Engels, [1878] 1969). Yet this very extension raises enduring philosophical questions: does invoking contradiction in physical processes amount to dialectic in any meaningful sense, or are such analogies metaphorical? Can quantity–quality transformations in chemistry or physics truly be considered dialectical if they lack the immanent conceptual development central to Hegel's method? And if dialectical laws operate in nature independently of human cognition or society, what ontological status should be ascribed to them?

Engels' distinctive contribution was to universalize dialectic as an ontological law of nature, grounding it in natural science as well as society. But this move left unresolved whether contradiction in nature is literal or metaphorical, how it could function as a material cause, and what distinguishes a dialectical law empirically from ordinary physical mechanisms.

³⁶ A vast body of literature within orthodox Marxism, especially in Soviet philosophy, emphasized Engels' extension of dialectic to nature. Here, dialectic was interpreted not only as a logical or critical method but as an objective law governing matter itself. Thinkers such as Joseph Dietzgen, Georgi Plekhanov, and Evald Ilyenkov advanced this view, and many Soviet scientific works were framed as validations of dialectics in nature. This essay, however, does not pursue that line, since its focus is on the epistemological and logical status of dialectic within the history of thought.

E. Contemporary Reinterpretations

1.4.15 — Transformative Reinterpretations outside System-Building

Although many contributions to dialectic aim at major systematic transformations, others introduce more localized but influential modifications. The following three figures represent distinct modes of reinterpretation — existential, methodological-political, and cultural — that expanded the reach of dialectical thought beyond system-building.

1.4.15.1 — *Kierkegaard: Dialectic and the Leap of Subjectivity*

Søren Kierkegaard critiques Hegelian dialectics for neglecting individual subjectivity and existential experience. While Hegel's dialectic unfolds impersonally through conceptual necessity, Kierkegaard emphasizes the unique and irreducible experience of the individual before God. For Kierkegaard, the “leap of faith” confronts paradoxes that cannot be mediated or synthesized rationally but must be endured existentially (Kierkegaard, [1849] 1980).

It is important to note that Kierkegaard himself did not describe the leap of faith as dialectical. The reinterpretation came later: thinkers such as Jean Wahl, Karl Jaspers, and Paul Tillich characterized Kierkegaard's paradoxical leap as a form of “existential dialectic.” In their usage, “dialectic” no longer meant a logical resolution but rather the lived confrontation with irreducible contradiction.

1.4.15.2 — *Lukács: Reification and Totality in Marxist Dialectic*

Georg Lukács extends Marxian dialectics by introducing the concept of “reification”: the process by which human social relations under capitalism take on the character of things, appearing autonomous and unchangeable. In *History and Class Consciousness* ([1923] 1971), Lukács argues that reification conceals the historical construction of reality and that dialectic must recover the *totality* behind these frozen appearances.

Here, “totality” is not a restatement of Hegelian synthesis. For Hegel, synthesis was the logical resolution of contradictions within conceptual development. For Lukács, by contrast, totality is a methodological principle: every social phenomenon can only be understood within the historical whole of capitalist society. Rather than dissolving contradictions, totality situates them within a broader structural horizon, enabling both critique and revolutionary praxis. This methodological move has had wide influence, though not without problems.³⁷

³⁷ The concepts of *reification*, *totality*, and *non-closure* each grapple with the problem of how societies obscure or reveal their own structures. For Lukács, reification is the process by which relations between people appear as relations between things under capitalism, making human activity seem fixed and unchangeable. His methodological response is “totality”: understanding each phenomenon only within the horizon of the whole. In contrast to Hegelian synthesis, totality does not resolve contradictions but situates them in a determinate historical context. The poststructuralist idea of “non-closure” resonates here: both reject the fantasy of ultimate reconciliation. But there is an important difference—non-closure stresses openness and contingency, while Lukács insists on historical determinacy, locating contradictions in the capitalist mode of production.

1.4.15.3 — Gramsci: Cultural Hegemony as Dialectical Struggle

Antonio Gramsci expands Marxian dialectic through his analysis of hegemony: the process by which a social class seeks intellectual and moral leadership by securing consent, forming alliances, and articulating its interests as a broader social project, while political rule may also involve coercion. Hegemony is therefore not restricted to an already dominant class; subordinate classes may struggle to construct an alternative hegemony and become capable of political leadership. In *Prison Notebooks* ([1929–1935] 1971), Gramsci integrates dialectic with cultural analysis, showing how class struggle operates not only at the level of material production but also through struggles over cultural meanings, institutions, and intellectual authority.

For Gramsci, hegemony is dialectical because it is a struggle of contradictions within the cultural and institutional superstructure. This broadens the scope of dialectic beyond economics into culture, highlighting the contested and dynamic nature of ideology.

Kierkegaard, Lukács, and Gramsci each reinterpreted dialectic outside system-building: Kierkegaard existentially, Lukács methodologically and politically, Gramsci culturally. Their contributions illustrate the adaptability of dialectic as a tool for addressing paradox, social structures, and cultural struggles.

1.4.16 — Adorno's Negative Dialectic

Theodor Adorno's dialectic is defined by its negative orientation and its emphasis on the non-identity between concepts and their objects. Concepts are indispensable to thought, but no concept exhausts the particular reality to which it refers; something in the object always escapes complete conceptual subsumption (Adorno, [1966] 1973). Dialectic thus becomes a method for exposing the inadequacy of rigid conceptual classifications and the contradictions of modern capitalist society, particularly the ways dominant ideologies legitimize oppression and domination.³⁸

Reification, however, is not unique to capitalism but only one form of the universal tendency of societies to naturalize their structures, whether through tradition, religion, or status. The concept of the commodity should remain strictly within economics, not be elevated into a metaphysical master key for culture, politics, or consciousness. Lukács and Adorno overextend the term, and in doing so commit a kind of conceptual imperialism: they universalize a historically bounded category to explain everything. This overreach produces distortions, such as the claim that Enlightenment rationality is inherently totalitarian or that reproduction itself is reducible to economic calculation. These are not genuine insights but artifacts of a flawed conceptual inflation.

³⁸ Non-identity does not mean that concepts and measurements are necessarily false, arbitrary, or equally unreliable. It means that a representation is not identical with the reality it represents and may capture it only partially. The extent and significance of this incompleteness vary across domains. See [Excursus 070 — On the Distinction Between Epistemological and Ontological Claims](#); [Excursus 073 — On Four Sources of Epistemic Incompleteness](#); [Excursus 074 — On the Uneven Distribution of Human Knowledge](#); [Excursus 094 — On Formal Logic and Changing Reality](#); and [Excursus 109 — Reality, Knowledge, and Epistemic Mediation](#). The epistemological implications of this distinction are examined further in Section 3.7.5.

Theodor Adorno's dialectic is defined by its negative orientation, emphasizing the non-identity between concepts and reality. For Adorno, thought and language inevitably fail to capture the complexity of the world (Adorno, [1966] 1973). Dialectic thus becomes a method for exposing contradictions in modern capitalist society, particularly the ways dominant ideologies legitimize oppression and domination.

Unlike earlier philosophers who sought to build dialectic into positive systems, Adorno's project is marked by systematic withdrawals. His *negative dialectics* rejects three classical features:

1. Synthesis — contradictions must not be reconciled into a higher unity.
2. Totality — coherent systems of thought are treated as ideological masks of domination.
3. Historical-teleology — dialectic is stripped of the belief in progressive development.³⁹

Through these withdrawals, Adorno redefines dialectic not as a path to reconciliation but as a practice of permanent critique, keeping contradiction alive as resistance against the violence of conceptual closure.

This stands in stark contrast to his predecessors. Kant deployed dialectic as a *critical boundary-policing tool* to clarify the limits of reason. Hegel reconceived dialectic as a *generative logic*, capable of building systems and tracing the development of thought and reality. Marx transformed dialectic into a *historical-materialist method*, linking contradiction to social and economic structures, particularly class struggle.

Adorno, however, offers neither clarification, nor system-building, nor historical grounding. Instead, he strips dialectic of constructive orientation and leaves it as pure negativity, a refusal to reconcile, progress, or redeem.

This orientation becomes explicit in *Dialectic of Enlightenment* (with Max Horkheimer), where dialectic is no longer about epistemology or "truth",⁴⁰ but about diagnosing reason itself as a historical disaster. They argue that Enlightenment rationality inevitably degenerates into instrumental reason, a form of calculation serving domination rather than liberation. Their infamous thesis that "Enlightenment is totalitarian" pushes this claim to the extreme: rationality itself is treated as complicit in oppression, culminating in fascism, capitalism, and technocratic control.

This move amounts to an intellectual declaration of war on science. By collapsing distinctions between emancipatory uses of science (medicine, democratic institutions, human rights discourse) and its abuses, Horkheimer and Adorno conflate method with

³⁹ The term "historical-teleological" is warranted because Adorno's negative dialectics rejects both (1) the historical unfolding of reason or class struggle as intrinsically progressive, and (2) the teleological belief in a final synthesis or redemption. His is a dialectic without a destination — aimed at sustained negativity rather than resolution.

⁴⁰ The word "truth" here is used in its broad philosophical sense. I do not provide my own definition in this essay.

misuse. Worse still, their argument is self-undermining: they deploy rational critique to argue against rationality, relying on the very Enlightenment tools they seek to delegitimize. In doing so, they risk turning dialectic into a rhetoric of suspicion without constructive resources, leaving only despair in place of critical progress. Yet precisely in its negativity, Adorno's project inspired whole fields of cultural critique, from postwar aesthetics to media studies, where dialectic was retooled less as a path to "truth" than as a lens for diagnosing domination.

Adorno's negative dialectic has undoubtedly influenced philosophy, cultural theory, and political critique. But it also represents a decisive rupture: the abandonment of dialectic as a vehicle of knowledge or emancipation, and its recasting as a mode of relentless negation. Whether this transformation should be seen as philosophical depth or as a dead end remains one of the sharpest debates about his legacy.

In contrast to Kant's delimitation of reason, Hegel's system-building, and Marx's historical materialism, Adorno and Horkheimer recast dialectic as an instrument of sustained negation: contradiction was no longer overcome in synthesis but preserved as a means of criticizing identity, domination, and the totalizing claims of Enlightenment reason.

1.4.17 — From Political Economy to Culture, Language, and Power

During the twentieth century, the centre of critical thought gradually shifted away from Marx's original project of the critique of political economy. Questions of production, value, exploitation, and class did not disappear, but they increasingly shared their explanatory role with analyses of culture, psychology, language, sexuality, knowledge, and power. This was not a single intellectual movement, nor did it amount in every case to a rejection of Marx. It was a redistribution of attention from the economic structure of "capitalism" toward the processes through which subjects are formed, domination is normalized, and social arrangements acquire meaning and legitimacy.⁴¹

This shift was already visible in Erich Fromm and Herbert Marcuse, who combined Marxian social criticism with psychoanalysis. Fromm examined how social conditions shape character, desire, conformity, and the fear of freedom (Fromm, 1941). Marcuse likewise drew upon Freud to investigate repression, sexuality, technology, consumption, and the production of socially compliant needs (Marcuse, 1955; 1964). Neither thinker simply abandoned "capitalism" as an object of criticism. Rather, both expanded the inquiry by asking how "capitalist society" reproduces itself psychologically and culturally as well as economically. The critique of political economy was thereby supplemented—and sometimes displaced—by a critique of personality, desire, and everyday life.

Jacques Lacan carried the analysis further into language and subjectivity. Lacan was not primarily a Marxist theorist and did not offer a critique of political economy. His concern was the divided subject constituted through language, desire, and the unconscious (Lacan,

⁴¹ This chapter does not extend the discussion to later post-Marxist and identity-centred political theories, in which class loses its status as the primary or privileged source of political conflict and becomes one identity or antagonism among others. These developments belong to a subsequent stage in the history of political theory and fall outside the present account of dialectic.

[1966] 1977). Yet his reinterpretation of Freud provided concepts that were subsequently incorporated into Marxist and post-Marxist theory. Contradiction increasingly appeared not as a conflict within the mode of production but as a division within the subject itself. Through later thinkers, especially Althusser and Žižek, Lacanian psychoanalysis became one of the principal means by which questions of ideology and political identification were detached from a narrowly economic framework.

With Jacques Derrida and Michel Foucault, the departure from classical dialectic became more explicit.⁴² Derrida's deconstruction retained an interest in opposition, negation, and conceptual instability, but resisted the Hegelian expectation that oppositions would be resolved or preserved within a higher synthesis. *Différance* names a process in which meaning arises through differences and deferrals that do not culminate in final conceptual closure (Derrida, [1967] 1976; [1967] 1978; [1972] 1982). Deconstruction may therefore resemble negative dialectic, but it lacks sublation, determinate resolution, and a necessary direction of development. Under the criteria adopted in Chapter 3, it is better understood as quasi-dialectical than as a continuation of Hegelian dialectic.

Foucault moved still further from dialectical explanation. His archaeological and genealogical studies rejected histories organized around a single contradiction, a unified historical subject, or a necessary progression from one social form to another. Historical transformations instead arose through contingent changes in discourse, institutions, disciplinary practices, and relations of power (Foucault, [1969] 1972; [1975] 1977). Although his later work examined governmentality, liberalism, neoliberalism, and economic rationality (Foucault, 2008), it did not restore the Marxian categories of value, surplus value, accumulation, and class contradiction as the organizing principles of analysis. Power was treated as dispersed through practices and institutions rather than derived from one fundamental economic relation.

These developments expanded the range of critical inquiry, but they also altered the meaning of dialectic. Contradiction was increasingly replaced by difference, instability, psychic division, discursive conflict, or dispersed power; synthesis and historical necessity receded still further. The result was not merely a new form of dialectic but, in many cases, the emergence of alternative modes of criticism that preserved certain dialectical motifs while abandoning dialectic's systematic structure. Jameson would subsequently attempt to reconnect cultural interpretation with the historical logic of "capitalism," while Žižek would bring Lacanian psychoanalysis back into conjunction with Hegel and Marx. Their projects can therefore be read as partial attempts to return cultural and psychoanalytic criticism to the orbit of Marxist political critique, though not necessarily to Marx's critique of political economy in its strict sense.

The twentieth-century turn toward psychology, culture, language, and power broadened social criticism, but it also loosened its connection to the economic categories and systematic structure of classical Marxian dialectic.

⁴² Derrida and Foucault differed substantially in subject matter, method, and philosophical orientation, and neither can be adequately reduced to this label. They are considered together here because both challenged unified structures, teleological histories, and totalizing forms of explanation, thereby contributing to the fragmentation of the classical dialectical model.

1.4.18 — Jameson's Attempt to Modernize Dialectic

Fredric Jameson, in *Valences of the Dialectic* (2009), seeks to adapt dialectic to the complexities of late capitalism and postmodernity. He argues that dialectic must function both analytically and narratively, helping us grasp the totality of social contradictions that define contemporary life. Central to this project is his notion of cognitive mapping — a mode of interpretation designed to orient individuals within the vast and often opaque networks of global capitalism, allowing them to perceive their own position within larger economic, cultural, and geopolitical structures (Jameson, 2009).

In addition, Jameson introduces the building block of utopian critique,⁴³ the search for latent utopian impulses embedded in cultural forms. Unlike Adorno's emphasis on negation, Jameson reads even mass culture as unconsciously expressing longings for alternative social arrangements. These "utopian traces" reveal both the constraints of the present and its unrealized possibilities (Jameson, 2005).

By combining cognitive mapping with utopian critique, Jameson retools dialectic into a cultural hermeneutics suited to the opacity of globalization. He inherits Adorno's suspicion of totality but turns it toward interpretive and narrative practices that emphasize historical possibility rather than despair.

Yet, this adaptation raises questions. Unlike the canonical developments from Kant through Engels, which progressively added epistemological, ontological, historical, and material dimensions to dialectic, Jameson introduces no comparable conceptual innovation. Instead, his use of the term "dialectic" may serve more as a gesture of affiliation within the tradition of critical theory than as a rigorous philosophical extension.

Jameson reinterprets dialectic as a narrative and cultural hermeneutics for late capitalism, drawing on cognitive mapping and utopian critique. Whether this constitutes a genuine philosophical development or primarily a rhetorical continuation of the tradition remains an open question.

1.4.19 — Žižek's Attempt to Modernize Dialectic

Slavoj Žižek attempts to revitalize dialectic by integrating Lacanian psychoanalysis, Hegelian logic, and Marxist critique. For Žižek, contradiction is not a moment to be sublated into unity but an ontological constant: reality itself is structured by incompleteness, impossibility, and antagonism (Žižek, 1989; Žižek, 2012).

Drawing on Lacan's concept of the *Real*, Žižek introduces structural impossibility as the core of dialectic: closure is always blocked, synthesis forever deferred. His dialectic centers on how subjectivity and ideology emerge from failed symbolizations, gaps, and trauma rather than from progressive conceptual reconciliation. He further develops the

⁴³ Here *utopian* does not mean detached from reality or a detailed blueprint for an ideal society. Jameson uses it to describe the search for desires and possibilities for different social arrangements within existing cultural works.

idea of the *parallax view*⁴⁴ — the irreducible gap between perspectives that cannot be unified into a higher synthesis. For Žižek, reality is constituted by oscillation between incompatible viewpoints, not by their eventual resolution (Žižek, 2006).

To clarify this departure, one can compare Žižek’s notion of “failed symbolization” with Gestalt psychology’s concept of the “unfinished gestalt.” Both begin from psychic tension in the face of incompleteness. Yet Gestalt assumes closure is possible: the mind seeks and often achieves the integration of fragments into coherent wholes. Žižek, in contrast, radicalizes incompletion, claiming the Real ensures that closure is impossible in principle. The comparison reveals a crucial point: if dialectic is stripped of synthesis, then Žižek’s method resembles psychology rather than philosophy. His framework, however provocative, risks ceasing to be a dialectical logic and instead becomes a psychoanalytic model of subjectivity.

This commitment to structural incompletion aligns Žižek, perhaps unintentionally, with Adorno’s negative dialectic and Jameson’s cultural hermeneutics. All three reject the classical dialectical trajectory of reconciliation, replacing it with open-ended contradiction, unresolved negativity, or symbolic opacity. But this trajectory raises a decisive question: at what point does the rejection of synthesis amount to the rejection of dialectic itself?

Žižek’s defenders argue that his work preserves the “spirit of contradiction” central to dialectic, even if it abandons its logical form. His critics counter that what remains is not dialectic but a rhetoric of paradox and incompletion — an intellectually fertile psychology, perhaps, but no longer a philosophy of dialectic.

1.5 — Twists and Turns in the Concept of Dialectics

To synthesize the foregoing discussion, we may briefly track the key conceptual transitions that transformed the notion of dialectic across philosophical history. Each philosopher introduces or removes structural elements that redefine its function.

Zeno of Elea to Plato: Dialectic moves from paradoxical critique of motion and plurality toward a more systematic method, combining Socratic questioning with the theory of Forms to create a constructive ascent.

Plato to Aristotle: Dialectic shifts from metaphysical idealism to empirical and syllogistic reasoning, grounding itself in endoxa and structured disputation while preserving its dialogical core.

⁴⁴ Parallax originally denotes the apparent displacement of an object when it is observed from different positions. A simple example is holding one finger in front of the face and looking at it first with one eye and then with the other: the finger appears to move relative to the background, although it has not changed position. In Žižek’s philosophical usage, the “parallax view” refers to an irreducible gap between two perspectives that cannot be combined into a single neutral or higher viewpoint. The gap is not merely an error of observation; it is treated as constitutive of how the object itself appears and is understood. See Žižek (2006).

Aristotle to Neoplatonism: Logical inquiry becomes mystical ascent, adding hierarchical emanation, negative theology, and the vision of unity beyond being.

Neoplatonism to Islamic and Scholastic Dialectics: Dialectic is merged with theology, producing systematic traditions of disputation through figures such as Al-Farabi, Avicenna, Averroes, and Aquinas, where Aristotelian logic serves theological and philosophical ends.

Medieval Scholastics to Renaissance Humanism and Ramism: Dialectic is simplified into methodical and pedagogical tools, replacing dense metaphysical argumentation with binary clarity and didactic utility.

Pre-Kantian Critiques (Descartes, Locke, Hume): Dialectic is displaced by skepticism and methodological caution, undermining speculative metaphysics and preparing the ground for Kant's redefinition.

Kant to Hegel: A decisive redefinition occurs: Kant restricts dialectic to exposing reason's illusions, while Hegel transforms contradiction into the generative motor of thought, history, and reality itself.

Hegel to Marx: Dialectic is inverted from idealism to materialism, applied to class struggle and historical change as a critique of capitalism.

Marx to Engels: Dialectic is extended into nature itself, proposed as an objective set of laws governing physical and social transformation.

Engels to Frankfurt School (Adorno, Horkheimer): Dialectic is no longer a constructive method but becomes "negative dialectics," a critique of identity, domination, and false totality, where contradiction persists without resolution.

Kierkegaard, Lukács, and Gramsci: Outside system-building, Kierkegaard introduces existential paradox, Lukács develops reification and totality within Marxist dialectics, and Gramsci extends it into cultural hegemony and ideological struggle.

Frankfurt School to Jameson and Žižek: Dialectic drifts further from its classical function, reinterpreted as cultural mapping (Jameson) or ontological impossibility (Žižek). In both cases, it risks becoming a flexible rhetorical label, detached from its epistemological roots.

The history of dialectic resembles the construction of a grand building for reason: erected and expanded up to Hegel, redirected by Marx and Engels toward its surrounding grounds, and eventually dismantled by Adorno and later thinkers, leaving the concept fragmented and unstable.

1.6 — Conclusions

The concept of dialectic has undergone a series of deep and uneven transformations, stretching from ancient Greek philosophy to contemporary theory. Its early core lay in the rational examination of contradiction and the pursuit of conceptual clarity. Up to the Kant–Hegel transition, dialectic largely preserved its epistemological integrity, evolving from a method of inquiry and dialogue into a generative logic of thought and self-critique. From Hegel onward — particularly with Marx, Engels, and the Frankfurt School — this integrity fractured: dialectic was repurposed for historical materialism, social critique, or cultural analysis, often at the cost of its methodological and epistemological coherence. In more recent thinkers such as Jameson and Žižek, the term “dialectic” persists, but often as a flexible metaphor rather than a rigorously defined method.

This chapter has avoided offering a single formal definition of dialectic. Instead, it proposes minimal conditions for meaningful use. The historical trajectory shows both expansion and fragmentation, but against this background, certain conditions can be set for any contemporary use of the term. These conditions concern the cause, outcome, and structure of dialectical transformation:

1. **Generative contradiction (cause)** — internal contradictions must be the source of transformation, rather than external triggers or simple juxtaposition.
2. **Transformative discontinuity (outcome)** — the process must yield qualitative novelty, not just gradual modification or rhetorical contrast.
3. **Systematic method (structure)** — the transformation must follow a logic or procedure that develops concepts, rather than collapsing into metaphor or open-ended fragmentation.

Dialectic remains meaningful only when it entails contradiction as cause, discontinuity as outcome, and method as structure; without these, it dissolves into metaphor or ideological gesture.

1.7 — Postscript

The historical development of dialectic can be divided into three broad stages.

First (Zeno to Kant): Dialectic functioned as a simple tool for understanding phenomena and clarifying concepts. It remained largely uncontroversial, and in this chapter I have described its stages with minimal judgment.

Second (Hegel to Engels): Dialectic was expanded into a multi-purpose system. New structural components were added, and the tool was applied to increasingly broad domains. While its extension to new areas was not controversial, stronger claims — that all of nature and society must operate according to dialectical laws — provoked opposition. In this chapter I traced this development in detail but left its evaluation for the next two parts of the series.

Third (20th century, Horkheimer to Žižek): Dialectic underwent rapid transformation, often through the removal of components. This produced both creative reinterpretations

and conceptual confusions. For this stage I provided not only description but also critical assessment.

The trajectory of dialectic may be summarized as *tool* → *system* → *fragmentation*, a pattern that frames both the historical overview of Chapter 1 and the analyses that follow in Chapters 2 and 3.

1.8 — Overview of Chapters 2 and 3

Part 2 of this article series offers a critical examination of the dialectical principle that quantitative accumulation leads to qualitative transformation — a core tenet of Hegelian dialectics — and evaluates its scientific validity. By analyzing seven widely cited examples from physics, chemistry, and biology, including phase transitions, incandescence, magnetic polarity reversal, allotropy, hydrocarbon series, the periodic table, and punctuated equilibrium, the next article argues that these phenomena are more accurately explained through continuous, externally mediated processes rather than through internal contradiction or ontological leaps. The analysis reveals that the “quantity-to-quality” transition, often invoked as a universal law, lacks empirical substantiation and methodological coherence when subjected to modern scientific scrutiny. The article concludes that while dialectic may retain heuristic or rhetorical value in certain domains, its extension into natural sciences (and most likely social sciences) as a lawlike explanatory framework is unwarranted and should be reconsidered.

Part 3 of this chapter series maintains that not all systemic transformations are dialectical, and many that appear so are quasi-dialectical transformations, better explained by several other concepts, one of which is scale-dependent thresholds. To untrained eyes, quasi-dialectical transformations have a rudimentary resemblance to the Hegel-Engels dialectic, while they do not fulfil its requirements. Drawing from domains as varied as urban design, biological stability, artificial intelligence, and enzymatic systems, the article presents six cases of quasi-dialectical transformation. These transitions exhibit sharp discontinuities and systemic reorganization, yet remain intelligible without resorting to dialectical metaphysics. The article concludes by exploring the role of Inference to the Best Explanation (IBE) as a model for evaluating competing frameworks, and argues for a rethinking of dialectic not as a universal method but as one explanatory strategy among others.

Chapter 2: Re-visiting Dialectic

2.1 — Abstract

This chapter offers a critical examination of the dialectical principle that quantitative accumulation leads to qualitative transformation — a core tenet of Hegelian dialectics — and evaluates its scientific validity. Using explicit methodological criteria (continuity vs. discontinuity, internal vs. external causation, novelty, predictive adequacy, and conceptual coherence), the article tests seven widely cited examples from physics, chemistry, and biology, including phase transitions, incandescence, magnetic polarity reversal, allotropy, the hydrocarbon series, the periodic table, and punctuated equilibrium. Each case is shown to be more accurately explained through continuous, externally mediated, or probabilistic processes rather than through internal contradiction or ontological leaps. The analysis reveals that the “quantity-to-quality” transition, often invoked as a universal law, lacks empirical substantiation and methodological coherence when subjected to modern scientific scrutiny. The article concludes that while dialectic may retain heuristic or rhetorical value, its extension into natural sciences (and, by analogy, social sciences) as a lawlike explanatory framework is unwarranted. More broadly, the attempt to legislate nature by contradiction risks collapsing into metaphor, obscuring rather than clarifying the causal diversity of natural processes.

2.2 — Introduction

In the first chapter, the history of the concept of dialectic was reviewed. It was shown that dialectic began as a relatively simple tool (*simplicus*), used for inquiry and conceptual clarification (e.g., in Socratic dialogue), and gradually acquired additional “building blocks” (further *simplicus*) until it became a complex system (*compositum*) embedded in broader philosophical frameworks.⁴⁵

Before Hegel, dialectic functioned mainly as a methodological instrument within epistemology and rhetoric — a way of engaging contradiction to test positions and clarify concepts (Rescher, 2006). With Hegel, however, dialectic was redefined as the immanent logic of thought and reality: contradiction became constitutive of motion itself, not merely a feature of discourse (Houlgate, 2005). This marked a decisive break, expanding dialectic from a method into a comprehensive logic of becoming.

From Hegel to Marx and Engels, dialectic underwent both inversion and extension: it was turned toward materialism and applied beyond logic to history and nature (Ollman, 1993). Engels, in particular, argued that one of Hegel’s key claims — the transformation from quantity to quality — could be treated as a universal law of motion in nature (Engels

⁴⁵ *Simplicus* is a coined technical term (from *simplex*, *simplicis*), used here to denote a non-composite theoretical structure. *Compositum* is the classical Latin term for a compound or composite structure. For consistency with certain English and Latin nouns (e.g., *species*, *series*), both *simplicus* and *compositum* are treated as invariant in plural form. For further discussion, see [“On the Typology of Theoretical Structure: Simplicus vs. Compositum”](#) and [“On Simplicus and Compositum”](#).

[1878] 1969; Engels [1883] 1976). The idea is that accumulation of quantitative change produces qualitative novelty, as when “more of the same” eventually yields something categorically different. This formulation has been especially influential in Marxist traditions, where it is often treated not as a heuristic but as a law of nature — a usage more characteristic of nineteenth-century science than of today.⁴⁶

The central question of this chapter is whether such a claim is scientifically tenable. To clarify, by a “dialectical leap” we mean three interrelated criteria:

- (1) **Ontological discontinuity**, irreducible to a continuous gradient;
- (2) **Qualitative novelty**, the emergence of a new kind rather than a mere modification; and
- (3) **Internal causation**, arising from contradictions within the system rather than external triggers.

These criteria distinguish dialectical leaps from threshold phenomena already known in science.

It is important to note that the critique developed here does not apply to dialectic as a method of inquiry, argumentation, or conceptual clarification, from Socratic dialogue to Kantian critique, nor even to many aspects of Hegel’s philosophical system. Instead, the focus is precisely on the strong-form claim — articulated by Hegel and codified by Engels in *Dialectics of Nature* — that dialectic, through the “quantity-to-quality” transformation, constitutes a universal law governing natural processes.

This chapter evaluates whether the Hegel–Engels claim that quantitative accumulation generates qualitative transformation through internal contradiction is supported by empirical evidence in nature.

2.3 — Framing the Problem

In Chapter 1, I examined how various 20th-century thinkers — notably Adorno and Žižek — transformed or removed essential building blocks of dialectic, including contradiction, immanence, and ontological necessity. As a result, their use of the term “dialectic” becomes increasingly metaphorical and conceptually unmoored. Likewise, some thinkers (e.g., Levins & Lewontin, 1985; Sheehan, 2018) invoke dialectical-sounding language such as reciprocity or dynamic interdependence, but without the presence of internal contradiction or endogenous causality. These uses may have rhetorical or heuristic appeal, but they fall outside the strict dialectical framework under scrutiny here. What follows,

⁴⁶ The concept of a “law of nature” carried different connotations across historical periods. In the seventeenth and eighteenth centuries, laws were often conceived as universal, even divine, prescriptions governing reality, as in Galileo and Newton. By the nineteenth century, this metaphysical sense persisted, which helps explain Engels’s confidence in formulating “laws of dialectics” as natural-scientific principles. In the twentieth century, however, the term came under greater scrutiny: philosophy of science increasingly treated laws as descriptive regularities rather than necessary structures (see van Fraassen, 1989; Carroll, 1994), and scientific practice shifted toward models, mechanisms, and statistical descriptions (Cartwright, 1983). This broader decline in the invocation of “laws” partly reflects the move away from deterministic worldviews.

then, is a critique not of dialectic in the loose or metaphorical sense, but of a strong-form claim: that internal contradiction drives qualitative transformation in nature. It is this claim, not its diluted variants, that I examine on scientific grounds.

The principle of quantitative-to-qualitative transformation originates most explicitly in Hegel's *Science of Logic* (1812–1816), where he asserts that “quantity is sublated in quality”⁴⁷ when an accumulation results in a fundamental change of kind.⁴⁸ This idea was later reformulated by Friedrich Engels in *Dialectics of Nature* (1883), where it appears as one of the three “laws of dialectics.” Engels presented these laws not merely as philosophical insights but as laws of development in nature itself, valid for theoretical natural science as well as thought. To illustrate, he used examples from physics and chemistry, such as the boiling and freezing of water or the magnetization of iron, treating these transitions as paradigmatic cases of dialectical leaps (Engels [1883] 1976).

Reversibility must be distinguished from the reciprocal determination of quantity and quality. Hegel described transitions between quality and quantity in both directions; Engels subsequently formulated this relation as a law of nature, “the transformation of quantity into quality and vice versa.” Neither formulation establishes that every material process is physically reversible or follows the same temporal direction. Water can return to an earlier phase, and a heated wire can cease to glow as it cools. Such examples may illustrate differences of state without demonstrating irreversible historical advance. Conversely, Hegel's discussion of coming-to-be and passing-away does not imply that a dead organism can return to life.⁴⁹ The relevant objection is that common dialectical terminology does not establish a common temporal direction or mechanism across these different processes.

⁴⁷ Hegel redefines dialectic as a generative principle operative both in the foundation of philosophical systems and in the unfolding of actual historical reality. In his *Science of Logic*, dialectic is no longer merely a method of reasoning; it becomes the internal structure of the very process through which concepts develop. This development occurs through contradiction, negation, and sublation (*Aufhebung* = [negation + preservation + elevation]) (Hegel [1812–1816] 2010).

⁴⁸ Two short passages from Hegel illustrate the framework for the “shift from quantity to quality.” *The Science of Logic*:

1. §367: “As it alters in temperature, it does not become just more or less warm, but passes through the states of solid, liquid, and vapor; and these different states do not occur gradually, but, on the contrary, even the otherwise merely gradual increase in temperature is interrupted and inhibited at these points: the irruption of another state is a leap. – Every birth and every death, far from being a protracted gradualness, is rather its breaking off and a leap from quantitative into qualitative alteration.”
2. §368: “*Natura non facit saltum*, as the saying goes; and ordinary thinking, when confronted by a coming-to-be or a passing-away, believes that it has comprehended it conceptually by representing it, as we said, as a gradual emerging or vanishing. But we have seen that the alterations of being in general are not only the passing over of a magnitude into another magnitude, but the transition from the qualitative into the quantitative and contrariwise, a becoming-other that interrupts gradualness and stands over against the preceding existence as something qualitatively other.”

⁴⁹ Hegel's discussion of coming-to-be and passing-away concerns logical determinations as well as the examples through which he illustrates them. The transition from quality to quantity and conversely must not be read as a claim that every material process is physically reversible. Reversibility, recovery of an earlier state, and historical direction require separate examination in each case.

Can we infer from the return of vapour to liquid water that capitalism can likewise return to feudalism? Clearly not. But neither can the historical succession of feudalism and capitalism confer irreversibility upon water's phase transitions. If these examples are offered as manifestations of one universal law, their differences demand examination. Calling them all "quantity becoming quality" does not discharge that obligation; it merely gives unlike processes the same name.

The rules governing water's phase transitions are not the rules governing changes in modes of production. Calling both "quantity becoming quality" does not demonstrate otherwise. If dialectic claims scientific authority as a universal law, it must establish the connection. Without that demonstration, the analogy borrows the authority of physics without earning it.

Though grounded in metaphysical reflection, Engels explicitly framed the principle as a scientific law, generalizing it beyond philosophy to natural processes. It has since been invoked in Marxist theory (Ollman, 1993) to explain revolutionary breaks in social development, and more recently linked to complexity theory or systems transitions. This universal ambition makes the principle vulnerable to empirical scrutiny.

The key issue is this: Does a transition in behavior or structure — whether physical, chemical, or social — necessarily imply a dialectical leap caused by an internal contradiction? Or can all such transformations be described in terms of continuous, quantifiable processes already modeled by modern science? To evaluate the validity of dialectical leaps, we must examine not only the occurrence of qualitative transformations but also the causal mechanisms driving them.

The question of internal contradiction leads us to a second core feature of dialectical transformation: immanence. In dialectical logic, especially as developed by Hegel and extended by Marx (Engels [1878] 1969; Ollman, 1993; Houlgate, 2005), the transformation from one state to another must arise from within — from a contradiction inherent to the structure of the system itself. It is not enough for change to occur; the cause must be endogenous, driven by contradictions internal to the object under consideration.

This raises a methodological challenge: What would count as a genuinely immanent transformation in the natural world? The subsequent sections (2.5.1–2.5.7) test this claim across notable examples. If all known transformations can be explained through external inputs, stochastic fluctuations, or structural thresholds without appeal to contradiction, then immanence as a scientific category is undermined.

The problem under investigation is whether natural transformations genuinely arise from internal contradictions (immanence) and thus warrant dialectical interpretation, or whether they can be fully explained without recourse to dialectical leaps.

2.4 — Methodological Standards

In assessing dialectical claims against scientific phenomena, we employ the following methodological criteria. These standards refine the three criteria of a dialectical leap (discontinuity, novelty, immanence) into operational tests suitable for scientific evaluation:

- **Continuity vs. Discontinuity** — Is the transformation smooth and gradual, or abrupt and ruptural?
- **Internal vs. External Causation** — Does the system change because of internal contradiction, or due to external influences?
- **Novelty** — Does the transformation yield a qualitatively new state, irreducible to prior states?
- **Predictive Models** — Can the process be accounted for by established scientific models (quantitative or mechanistic)?
- **Conceptual Coherence** — Does the description rely on clearly defined, testable concepts rather than vague metaphor?

These criteria allow us to test whether dialectical principles add genuine explanatory value, or whether observed transformations can be fully captured within existing scientific frameworks.⁵⁰

⁵⁰ The methodological standards used here are not philosophically neutral. They reflect an empirically oriented conception of scientific explanation that emphasizes testability, causal specification, predictive and explanatory adequacy, and conceptual clarity. Their use is justified not because they exhaust the philosophy of science, but because the claim under examination presents dialectic as a scientifically valid law of nature. A framework claiming scientific authority may reasonably be evaluated by standards used in the assessment of scientific explanations.

The relevant philosophers nevertheless emphasize different aspects of scientific inquiry. Popper concentrates primarily on the logical exposure of theoretical claims to possible falsification; Hempel on the structure of scientific explanation; Cartwright on models, causal capacities, and the limited applicability of universal laws; Lakatos on the development of composite research programmes; and Kuhn on the historically situated communities, practices, and paradigms within which theories are constructed and assessed. These approaches should not be treated as neutral or interchangeable, but neither must one be selected as an exclusive authority. As argued in [Excursus 064 — On Viewing the Same Problem from Different Perspectives](#), they may be understood as viewing different aspects and levels of the same scientific activity.

The distinction between *simplicus* and *compositum* further qualifies the use of these standards. A comparatively isolated *simplicus* may expose a relatively determinate claim to testing, although even such a test depends on measurement procedures, statistical assumptions, and background knowledge. A *compositum*, by contrast, integrates several theoretical components, auxiliary assumptions, and relations among them. When its prediction fails, the failure does not by itself identify which component or connection is responsible. Falsification therefore functions more sharply as a diagnostic instrument for *simplicus* than for *compositum*, where evaluation requires component testing, comparison of alternative specifications, and cumulative evidence. See [Excursus 013 — On the Typology of Theoretical Structure: Simplicus vs. Compositum](#) and [Excursus 090 — On Simplicus and Compositum](#).

The natural-scientific examples examined in Section 2.5 are therefore assessed case by case. The question is not whether one philosophical programme can provide a final tribunal for every scientific claim, but whether dialectical contradiction supplies identifiable causal or predictive content beyond the physical, chemical, and biological mechanisms already available. Kuhnian and sociological accounts remain relevant to the formation and historical alteration of scientific standards, but they do not replace the empirical

2.5 — Refutations of notable examples

In this section, seven prominent examples often cited to support the dialectical transition from quantity to quality are examined. The analysis draws from the works of Hegel, Engels, and the paleobiologists Gould and Eldredge.

The cases fall into three groups:

- **Hegel's examples:** phase transitions of water.
- **Engels' examples:** incandescence in metals; magnetic polarity reversal; allotropy; hydrocarbon chain extension; the periodic table.
- **Evolutionary biology (20th century):** punctuated equilibrium, as proposed by Gould and Eldredge.

These cases are shown to be either illusory, externally mediated, or reducible to continuous, mechanistic processes that undermine the dialectical model.

The classic examples used to defend the dialectical leap fail to meet scientific scrutiny and instead reveal continuous, externally mediated processes.

2.5.1 — Water Phase Transition

The phase transitions of water provide a stronger example of qualitative change than many criticisms of Hegel allow. Ice, liquid water, and water vapour have genuinely different macroscopic properties. Hegel also noticed that the otherwise gradual alteration of temperature is interrupted during the transition. Under approximately constant pressure and equilibrium conditions, energy can continue to enter or leave a sample while its temperature remains approximately constant and the proportions of the coexisting phases change. We should concede the observation before examining what Hegel made of it.

The relevant quantity is not simply the mass of water. Heating the same sample can alter its phase without adding water, and Engels explicitly included the addition or subtraction of energy in his formulation. Asking why the removal of some water does not automatically freeze the remainder therefore does not answer his actual claim. Nevertheless, the choice of quantity matters. Increasing mass, supplying energy, and changing pressure are different interventions. A general formula about quantitative change cannot replace an account of which intervention produces which outcome and under what conditions.⁵¹

evaluation of the particular claims at issue. Gould's punctuated equilibrium is accordingly examined as a biological hypothesis about patterns and rates of evolutionary change, not accepted or rejected merely because its formulation has sometimes been associated with Kuhnian or dialectical imagery.

⁵¹ The aggregation of water molecules offers a separate question about quantity. One cannot infer the temperature or phase of an aggregate from its mass alone. A physical account must specify the initial conditions, interactions, and exchanges of energy. Nor should gravity automatically be classified as external: mutual gravitational attraction among the bodies included in a system belongs to their internal interaction. If aggregation or compression changes temperature, the relevant explanation concerns the redistribution and dissipation of energy under specified conditions. Calling the process quantity becoming quality does not identify those conditions or establish a contradiction as its cause.

The familiar heating experiment also raises a question about immanence. The water has internal properties that determine its response, but energy is supplied through interaction with its surroundings. Its capacity to respond belongs to the material; the occurrence of the particular transition depends on the conditions imposed upon it. Internal organisation and external induction are compatible. Neither of them, however, identifies an internal contradiction that generates the transformation. External heating therefore challenges a claim of strictly self-generated development, while the stronger question remains unanswered even if externally supplied energy is admitted: what causal work is performed by the alleged contradiction?

A further difficulty concerns the level at which the new quality appears. A single water molecule is not a miniature solid, liquid, or vapour sample. These phase distinctions concern collective organisation. Water normally remains chemically water as it freezes, melts, boils, or condenses; the molecular identities are not replaced by a new chemical species. This does not make the macroscopic differences unreal. It does require the dialectical argument to specify what has changed, at which level, and why that change should count as the resolution of a contradiction rather than a reorganisation of interacting molecules.

The transition is also conditional. Pressure helps determine the phase boundary, and the liquid–vapour coexistence boundary terminates at a critical point (Flowers et al., 2026). The familiar boiling threshold is therefore not an unconditional property of water taken in isolation. Nor does an entire finite sample necessarily change phase at one instant: different phases can coexist while their relative amounts change (Flowers et al., 2026). The distinction between an equilibrium discontinuity and the progress of an actual transformation matters. A genuine phase transition need not be denied in order to question the inference from it to a universal dialectical leap.

Finally, the phases can be recovered by suitable changes in conditions. Vapour can condense and water can freeze again. This does not mean that every practical cycle is thermodynamically reversible or that no energy has been dissipated. It means that the succession of phases does not by itself establish an irreversible ascent towards a higher form. Any analogy with birth, death, or historical development must account for their different mechanisms and temporal directions rather than conceal those differences under a shared vocabulary.

The water example thus establishes a real qualitative difference and a condition-dependent transition. It does not establish that contradiction caused the transition. If quantity becoming quality means only that measurable changes can accompany differences of state, the example is persuasive but the principle is weak. If it means that an internal contradiction necessarily produces a qualitatively new form, the additional causal claim still requires evidence.⁵²

⁵² The materialist transfer of this inference is examined further in the [Excursus 141 — On the Materialization of Hegelian Dialectic](#).

2.5.2 — Incandescence in Metals

Incandescence offers a different problem from the phase transitions of water. Engels cited the minimum current needed to make the platinum wire of an electric lamp glow, treating the appearance of visible luminosity as a case of quantity becoming quality. The example belongs to the reception of Hegel's principle, but its evidential force must be examined separately from that of melting or boiling. A wire becoming visibly luminous and a substance crossing a phase boundary need not undergo the same kind of transformation.

For an ideal blackbody, Planck's law describes a spectrum that varies smoothly with temperature. As a body becomes hotter, its thermal radiation grows more intense and its spectral distribution changes. A real metal is not a perfect blackbody: its emissivity and surface condition affect what it emits. Nevertheless, the onset of a visible glow does not itself establish a discontinuity in the material. Radiation that was too weak for an observer to detect can become visible without a new radiative mechanism suddenly coming into existence.

The distinction between dark and glowing therefore involves an observer or a detector as well as the heated object. A detector sensitive to infrared radiation can register emissions while the wire still appears dark to the eye. The practical point at which a glow becomes detectable depends upon the sensitivity of the detector and the conditions of observation. The radiation is real; the error would be to treat its entry into our range of detection as proof of an ontological rupture in the wire.

The same caution applies to the succession of colour descriptions. Red-hot, orange-hot, and white-hot name perceptible differences within a changing spectrum. The names do not establish separate material stages divided by dialectical leaps. A change can matter greatly to an observer or an engineering application without constituting a discontinuity in the physical process producing it.⁵³

As with water, externally supplied energy also matters, but this objection must be used precisely. Engels allowed energy communicated to a body. The mere presence of an electric supply is therefore no refutation of his stated formulation. It does show why a claim of strictly self-generated transformation cannot be read directly from this experiment. More importantly, neither the supply of energy nor the changing spectrum identifies an internal contradiction whose resolution explains the glow.

Heating can also produce genuine structural changes, melting, or chemical reactions in a particular specimen. Those possibilities do not rescue the incandescence argument automatically. Each is a distinct event that must be identified and explained. We cannot infer a phase transition merely because a metal glows, or infer that the mechanism of a coincident phase transition is the mechanism of visible radiation.

⁵³ The physiology of vision reinforces this point. Human eyes perceive color categorically, distinguishing "red" from "orange" even though the underlying radiation spectrum varies smoothly (Wakui et al., 2025). This categorical perception creates the illusion of abrupt transitions. Blackbody radiation curves demonstrate that the shift is in fact continuous across wavelengths.

The contrast with water is instructive. Water supplies a genuine phase distinction that does not demonstrate dialectical causation; incandescence supplies a detection threshold that need not involve a phase distinction at all. Grouping the two as quantity becoming quality obscures a difference that an explanatory theory should preserve. Engels's examples support the modest observation that quantitative variation can change what a body does or what we can detect. They do not, by themselves, establish that these outcomes express a common generative contradiction.

2.5.3 — Magnetic Polarity Reversal

Engels pointed to the phenomenon of magnetic polarity reversal as a case of “quantity becoming quality.” When temperature or magnetic field strength increases beyond a certain point, the magnet's orientation appears to flip suddenly. This, he argued, demonstrated a dialectical leap: an accumulation of quantitative change producing a qualitative transformation.

Yet the decisive factor here is again external. Heat from the environment or an imposed magnetic field drives the change; nothing in the magnet itself accumulates an internal contradiction that erupts spontaneously. What looks like a leap is simply the system's response to external conditions, finely tuned by experimental parameters. Engels overlooked the inconsistency in treating such externally mediated behavior as an immanent dialectical necessity.⁵⁴

Modern physics confirms this. Near the Curie temperature, increasing thermal energy gradually disrupts spin alignment until ferromagnetism vanishes (Kittel, 2005; Ashcroft & Mermin, 1976). Likewise, in applied fields, domain walls shift incrementally, with reorientation proceeding by nucleation and propagation (Bertotti, 1998). The apparently abrupt reversal is the macroscopic outcome of many microscopic adjustments, fully described by models such as the Ising framework and the Landau–Lifshitz–Gilbert equations (Brush, 1967; Landau & Lifshitz, 1935; Gilbert, 2004).

Magnetic polarity reversal only appears abrupt; in reality it is a continuous, externally mediated process, and thus fails as an example of a dialectical leap.

2.5.4 — Allotropes

Engels cited allotropes as an example of “quantity becoming quality.” Carbon, for instance, appears in strikingly different forms — graphite, diamond, graphene — and Engels interpreted these transformations as evidence that mere variation in structure yields a new qualitative kind of matter.

Yet this example suffers from the same inconsistency as the earlier cases. The decisive factor is not any internal contradiction within carbon, but external conditions such as pressure, temperature, and chemical environment. A diamond does not emerge from

⁵⁴ A second way to refute the dialectical reading is to note the probabilistic nature of domain reorientation. Microscopic domains respond stochastically to external influences; only when aggregated at scale do they produce the impression of a sudden flip. The “leap” is therefore a perceptual artifact of collective behavior, not the eruption of internal contradiction.

graphite by internal necessity; it requires extreme pressures and temperatures, whether in the Earth's mantle or in controlled laboratory conditions. Engels overlooked the fact that these transformations depend entirely on external mediation, not on the immanent unfolding of quantity into quality.

Modern chemistry confirms this. The conversion from graphite to diamond involves a reconfiguration of bonding geometries, from planar sp^2 to tetrahedral sp^3 hybridization.⁵⁵ This shift demands external intervention to overcome large activation energy barriers and is fully explained by molecular orbital and crystal field theory (Atkins & Friedman, 2010; Ballhausen, 1962). Moreover, many allotropic transformations are reversible — as in the case of ozone and dioxygen — which undermines the idea of a one-directional dialectical leap toward a “higher” stage.

Allotropy demonstrates externally conditioned structural variation, not a dialectical leap arising from internal contradiction.

2.5.5 — Hydrocarbon Addition

Engels cited the hydrocarbon series as an empirical illustration of “quantity becoming quality.” By gradually adding CH_2 groups, hydrocarbons progress from gases (methane, ethane) to liquids (pentane, hexane) to waxy solids (paraffins). Engels treated this as a clear case of molecular quantity producing a qualitative shift in phase.

But the logic here does not hold. The decisive factor in these transitions is not an internal contradiction within the hydrocarbon molecule but external conditions of temperature and pressure. A molecule does not become a liquid or solid simply by virtue of “adding more of the same.” Rather, whether methane, pentane, or paraffin, the phase depends on surrounding environmental parameters. Engels overlooked the fact that what appears as a leap is in fact a gradual adjustment governed by external mediation.

Contemporary chemistry confirms this. The transition from gas to liquid to solid in homologous hydrocarbon series is explained by London dispersion forces,⁵⁶ which scale smoothly with molecular size and surface area (Israelachvili, 2011). As CH_2 units accumulate, boiling and melting points rise incrementally, producing different observable phases under standard conditions. What seems to be an abrupt transformation is simply the outcome of continuous variation in intermolecular interactions, fully accounted for by statistical mechanics and thermodynamics (McQuarrie & Simon, 1997).

⁵⁵ The notations “ sp^2 ” and “ sp^3 ” refer to the hybridization of s and p orbitals in a carbon atom. Orbitals are cloud-like regions surrounding atoms where the probability of finding electrons is highest. (See also the personal note on orbitals in Section 2.5.6.)

⁵⁶ London dispersion forces are weak intermolecular attractions caused by correlated fluctuations in electron distributions. They grow with molecular surface area and polarizability, explaining why larger hydrocarbons condense more readily than smaller ones. A supplementary perspective comes from nucleation theory: in hydrocarbon condensation (e.g., in hydrocarbon clouds), phase change begins in localized microdomains, not in a single abrupt shift. Tiny molecular clusters form gradually, stabilized by ambient pressure or cooling, and only become macroscopically visible once they coalesce. This illustrates how the supposed “leap” is actually a threshold effect of aggregation.

Hydrocarbon phase changes result from continuous intermolecular scaling under external conditions, not from an intrinsic dialectical leap.

2.5.6 — Periodic Table

Engels treated the periodic table as a demonstration of quantity turning into quality. As atomic weights increase, he argued, new chemical properties emerge, and Mendeleev's successful prediction of undiscovered elements seemed to confirm the dialectical principle of nodal transformation.

But this interpretation overlooks the decisive point: the emergence of chemical properties is not an immanent leap within matter but the outcome of external structural constraints. Each element differs from the previous one by exactly one proton and one electron, and their behavior is determined by how electrons occupy available orbitals. The periodic table thus reflects a mathematical ordering, not the eruption of internal contradiction. Engels misread what is, in fact, a systematic quantum pattern as a dialectical rupture.

Modern science makes this plain. The properties of the elements arise from electron configuration governed by the Pauli exclusion principle⁵⁷ (Pauli, 1925), Hund's rule (Hund, 1927), and the Schrödinger equation (Schrödinger, 1926). Periodicity in reactivity, ionization energy, and bonding is a consequence of orbital filling, a smoothly scaling process with no sudden break. On the cosmic scale, the origin of the elements reinforces the same point: after the Big Bang produced hydrogen and helium, heavier nuclei were synthesized gradually in stars through fusion, up to iron (Burbidge et al., 1957), and beyond iron through supernovae and neutron-star collisions, where extreme conditions enabled rapid neutron capture (Kratz et al., 2007). These processes depend entirely on external astrophysical environments — gravity, pressure, temperature — not on any self-contradictory drive within hydrogen or helium atoms.

The periodic “law” and the cosmic origin of elements are fully explained by quantum mechanics and astrophysics; they reveal patterned continuity shaped by external conditions, not dialectical leaps from quantity into quality.

2.5.7 — Bridge: From Classical Examples to a New Example

Given the evident failure of the classical examples (Sections 2.5.1–2.5.6), one might expect the idea of a dialectical leap or rupture to have long been abandoned as

⁵⁷ There are certain things which, once they settle in the mind, never leave it. In high school chemistry, our teacher explained how electrons occupy orbitals. What he told us—it must have been around 1969 or 1970—was that, among orbitals of equal energy, each receives one electron before any receives a second. At that instant, I realized I was a socialist. I had remembered this classroom example as an explanation of the Pauli exclusion principle; more precisely, the order of filling described here is Hund's rule. The Pauli exclusion principle states that no two electrons in an atom can occupy the same quantum state. One can even draw from these ideas a metaphor of diversity leading toward democracy. A second time I realized I was a socialist was when our geology teacher said: “The ultimate goal of all flowing water is the complete leveling of the Earth's surface.” Honor to all teachers! Of course, scientific laws are not political doctrines, but they can serve as metaphors that illuminate ethical intuitions..

unsubstantiated, surviving only in the most traditional Marxist circles. Yet the notion has retained a curious charm. In fact, some contemporary thinkers have continued to fashion new theories upon the model of the dialectical leap.

Even more strikingly, the imagery of sudden rupture has traveled well beyond philosophy and natural science. Variants of the model appear in social theory and public policy (e.g., accounts of long stasis interrupted by sudden reform), in evolutionary economics (where equilibria and discontinuities are used to frame market dynamics), and in theoretical modeling more broadly, where complex systems are sometimes described in terms borrowed from dialectical or quasi-dialectical imagery.⁵⁸

Something that should never have inspired new theoretical constructions — given its lack of rigor and repeated refutations — has nevertheless generated further attempts to recast the dialectical leap. The most notable of these is the twentieth-century theory of punctuated equilibrium, to which we now turn.

2.5.8 — Punctuated equilibrium

The theory of punctuated equilibrium, introduced by Stephen Jay Gould and Niles Eldredge in the 1970s, challenged the Darwinian picture of slow, gradual change. According to their model, species persist in long periods of relative stasis, interrupted by comparatively brief episodes of rapid change during which new species appear (Eldredge & Gould, 1972). The fossil record, with its frequent gaps and abrupt transitions, was taken as evidence in support of this view. Gould later framed this explicitly in dialectical terms, treating the “punctuations” as evolutionary leaps (Gould, 2002).

Yet this interpretation misrepresents the processes at work. From a philosophical standpoint, punctuated equilibrium does not involve an internal contradiction within species that suddenly erupts into novelty. Rather, it depends on external and contingent conditions: small, isolated populations, specific ecological pressures, and the probabilistic accumulation of genetic changes. What looks like a rupture in the fossil record is an artifact of scale and resolution, not a dialectical leap.⁵⁹

Modern genetics and systems biology confirm this. Mutations accumulate gradually across many loci, most having little effect in isolation. Only in rare cases does a further mutation tip the balance, producing a visible trait that may spread if environmental

⁵⁸ For example, in political science, Baumgartner and Jones (1993) introduced a “punctuated equilibrium” model of public policy, emphasizing long periods of stability disrupted by sudden bursts of change. Similar formulations appear in evolutionary economics, where concepts such as multiple equilibria and discontinuous shifts are invoked to describe market dynamics.

⁵⁹ The temporal resolution of the fossil record is much coarser than the physical proximity of fossils may suggest. A sedimentary layer only a few centimetres thick may contain material accumulated over thousands or hundreds of thousands of years. Moreover, bioturbation, reworking, uneven sedimentation, and limited sampling may bring fossils from different times into the same apparent stratigraphic interval. Consequently, the last observed fossil of one species and the first observed fossil of another may appear adjacent—or may even be assigned to the same layer—although a very large number of generations separates them. The “sudden appearance” of a new species therefore means that intermediate stages have not been resolved in the available record, not necessarily that the biological transformation occurred instantaneously.

conditions allow. In small populations, such changes can rise to prominence through genetic drift and natural selection, but this remains a cumulative process unfolding over time. The fossil record, with its gaps, makes such gradual origins invisible and creates the illusion of suddenness. Detailed accounts from metabolic control analysis (Kacser & Burns, 1973; Heinrich & Rapoport, 1974) reinforce this probabilistic and distributed character of biological change.⁶⁰

Thus, punctuated equilibrium does not vindicate the Hegelian or Engelsian principle of quantity transforming into quality. It exemplifies how changes occurring across many generations can appear instantaneous when represented at the coarse temporal resolution of the fossil record. Even where comparatively rapid morphological change is attributed to mutations or regulatory genes with large effects, the proposed explanation remains genetic and population-based, not dialectical. The “punctuations” are therefore not eruptions of internal contradiction.

2.5.9 — Pseudo-dialectical examples

A final category concerns thinkers who invoke the language of dialectic but use it in ways that no longer meet the conceptual criteria under discussion here. Among these are Richard Levins and Richard Lewontin, whose *Dialectical Biology* (1985) became the cornerstone of “dialectical biology,” and more recent authors such as Sheehan (2018), who link dialectical motifs with complexity science. While these contributions have been influential in their own domains, they rely on a broadened and metaphorical sense of dialectic that diverges from the standards of contradiction, immanence, and qualitative leap that guide the present critique.

Levins and Lewontin’s definition of “system” is so expansive that virtually every process can be treated as “internal” to it. This rhetorical move renders the notion of *internal contradiction* analytically empty: if all external influences can be redescribed as internal relations, the distinction between inner dynamic and outer mediation collapses. Similarly, by equating any dynamic or reciprocal process with dialectics, they effectively conflate *dialectic* with *systems theory* or *cybernetic feedback*. While such models are useful, they are not dialectical in the Hegelian or Engelsian sense.⁶¹

Further, their framework does not provide an account of *qualitative leaps* in the strict sense. Their treatment of biological change emphasizes co-determination, mutual interaction, and historical contingency — all valid scientific concepts — but none of these amount to the dialectical principle of quantity turning into quality through contradiction.

⁶⁰ For an extended discussion of how Metabolic Control Analysis (MCA) illustrates the distributed, gradual character of biological change — including analogies and experimental evidence — see Appendix 2.

⁶¹ Some Marxist commentators defend this broadened usage by arguing that “dialectic” should be understood as a general ontology of relationality or process. From this perspective, Levins and Lewontin’s assimilation of external factors into “internal” relations is not a distortion but an expansion. The difficulty with this defense, however, is that it erases the specificity of dialectical contradiction. If everything dynamic is dialectical, then the term becomes indistinguishable from “systemic” or “interactive,” losing its philosophical edge.

Instead, what we find are continuous adaptive processes that can be adequately explained without recourse to dialectical categories.

Sheehan (2018)⁶² takes this trend further by aligning dialectic with complexity science. Here, “dialectic” becomes a synonym for emergence, nonlinearity, or multi-level causation. These notions, though valuable in their own right, are fully explicable within the methodological frameworks of systems biology, network theory, and nonlinear dynamics. They neither require nor exemplify the dialectical logic of contradiction and leap.

The point is not to diminish the intellectual contributions of these thinkers. Levins and Lewontin, for example, provided enduring insights into ecological modeling, the critique of reductionism, and the role of reciprocal causation in evolution. But these insights are better understood as developments in systems theory and evolutionary biology than as instances of dialectical logic. To conflate the two is to blur categorical distinctions and to misrepresent both traditions.

In short, these “pseudo-dialectical” approaches fall outside the scope of this critique — not because they are dialectical, but precisely because they are not. They exemplify the tendency to expand “dialectic” into a metaphor for dynamism or complexity, thereby losing the conceptual rigor that makes dialectical logic a distinct philosophical position.

Approaches such as dialectical biology and complexity-based “dialectics” are scientifically valuable but philosophically misleading; they mistake systemic dynamics for dialectical contradiction, and thus do not qualify as genuine dialectical models.

2.5.10 — Comparative analysis: patterns and divergences

Having reviewed seven prominent examples traditionally cited in support of the dialectical transition from quantity to quality, we can now identify broader patterns in how each fails to meet the dialectical criteria.

In physical systems (e.g., water phase transitions, incandescence, magnetism), transformations are fully governed by external parameters such as pressure, temperature, or field strength. Threshold behavior is real, but it reflects statistical aggregation or perceptual limits rather than contradiction or immanent rupture.

In chemical systems (e.g., allotropy, hydrocarbon chains), changes in structure and properties result from reconfigurations of bonding geometries and intermolecular forces, themselves dependent on environmental conditions. These processes follow clear energetic principles and require external intervention. They exhibit reversibility and continuity, not one-directional dialectical leaps.

⁶² Sheehan’s discussion of complexity theory often emphasizes features such as emergence, multi-level causation, and sensitivity to initial conditions. While these are genuine properties of nonlinear systems, they can be adequately modeled by existing mathematical and computational tools without invoking dialectics. In this sense, “dialectic” functions more as a metaphorical flourish than as a necessary explanatory principle.

In biological systems, especially in the case of punctuated equilibrium, apparent discontinuities in the fossil record emerge from incomplete sampling and resolution limits. The underlying mechanisms — mutation, genetic drift, and natural selection — operate gradually and probabilistically within ecological contexts. What looks like sudden transformation is the delayed manifestation of cumulative processes in small populations, not an internal contradiction.

Taken together, these cases reveal not a shared dialectical principle but a striking diversity of mechanisms. No single law unites phase transitions, domain wall propagation, atomic reconfigurations, or population genetics. The supposed commonality is imposed retrospectively as a metaphor.⁶³ If “quantity turning into quality” can be stretched to cover phenomena so heterogeneous, it loses explanatory power and collapses into tautology.

The diversity of physical, chemical, and biological transformations shows that apparent leaps are the outcome of external mediation, gradual accumulation, and probabilistic thresholds — not dialectical contradictions — and thus the principle of “quantity into quality” fails as a general law of nature.

2.6 — Philosophical Consequences

Across the examined domains, the supposed “dialectical leaps” turn out, under closer analysis, to be continuous, multivariable processes. Whether in phase transitions, incandescence, magnetic reversals, allotropy, hydrocarbon chains, the periodic table, or speciation, the transformations arise from external mediation, probabilistic aggregation, or thresholds of detectability — not from internal contradiction or logical necessity. The dialectical narrative thus overlays a metaphysical interpretation onto processes that science can already explain in mechanistic and heterogeneous terms.

This cumulative failure has consequences that extend beyond the individual examples. If the most frequently cited illustrations collapse under contemporary scrutiny, the credibility of the *quantity-to-quality* principle itself is undermined. The issue is not that Engels or Hegel chose the wrong cases; rather, the principle lacks explanatory precision. Natural systems show distributed causation, gradual transitions, and external constraints — not abrupt ruptures generated by immanent contradiction.

At the same time, one might argue that dialectical categories are not meant to compete with scientific mechanisms, but to serve as heuristic metaphors for complexity and change. This softer reading preserves dialectic as a rhetorical or pedagogical device, but at the cost of abandoning its claim to identify “universal laws of motion.” If dialectic is to retain philosophical value, it must be acknowledged as a style of thought rather than as a binding ontology.

⁶³ Over-extension of dialectical categories risks dissolving them into metaphorical language. By treating any change as a “leap,” dialectics ceases to function as an explanatory framework and becomes an interpretive overlay, applicable everywhere but illuminating little.

From the perspective of the philosophy of science,⁶⁴ this aligns more with critical rationalism (Popper, 1959; 1963) and research-program methodologies (Lakatos, 1978), where explanatory frameworks stand or fall by empirical resilience and coherence, not metaphysical resonance. On this view, the dialectical leap adds little to scientific explanation: it overstates the role of contradiction and understates the roles of contingency, environment, and probability. The burden rests not on those who deny the leap, but on those who continue to assert it.

2.7 — Conclusion

The cumulative failure of the examined cases reveals a deeper flaw in the dialectical framework itself. Its central claim — that quantitative accumulation yields qualitative transformation through internal contradiction — collapses under scrutiny not simply because Engels or Hegel chose weak examples, but because no consistent mechanism unites them. What the dialectical narrative treats as logical necessity is, in scientific terms, nothing more than threshold effects, contextual shifts, or perceptual limits.

The supposed “leap” obscures rather than illuminates. Physical, chemical, and biological systems display reorganization, thresholds, and discontinuities, but these emerge from external mediation, probabilistic causation, and distributed interactions. The dialectical interpretation misrepresents this complexity by collapsing causal diversity into a single metaphysical template. It offers narrative unity where science requires explanatory precision.

This failure has broader implications. Defenses of dialectic in philosophy, politics, or social theory often lean on analogies with nature: dialectic is said to mirror reality because

⁶⁴ My broader position on the philosophy of science is elaborated in a collection of [philosophical excursions](#). In brief, I distinguish between scientific theories that are *simplicus* and those that are *compositum*: *simplicus* denotes a non-composite theoretical structure and *compositum* a composite one, with both terms treated as invariant in the plural.

In evaluating *simplicus*, my position is closest to a family of approaches broadly associated with critical scrutiny, testability, and comparative assessment. These include Popper’s critical rationalism as well as related, though distinct, approaches represented by thinkers such as David Hull and Elliott Sober, who emphasize selection among competing theories, evidential comparison, and the fallibility and revisability of scientific claims. These thinkers do not constitute a single school, but their approaches share a concern with exposing relatively determinate claims or models to empirical criticism.

The evaluation of *compositum* requires a broader range of considerations. Here, my position is closer to a family of historical, programmatic, and sociological approaches represented, in different ways, by Kuhn, Lakatos, Bourdieu, and others. These approaches draw attention to paradigm-dependence, the organization of research programmes, historical contingency, scientific communities, institutional structures, and the social conditions under which composite theoretical frameworks are maintained, revised, or replaced. Once a theory consists of several interdependent components, an empirical failure does not by itself determine which component, auxiliary assumption, or relation among components should be rejected.

These families of thought are neither internally homogeneous nor mutually exclusive. They examine different aspects and levels of scientific inquiry. The common thread in my use of them is that explanatory value derives not from metaphysical necessity, but from empirical resilience, coherence, comparative success, and openness to criticism and revision.

reality itself is dialectical. But if the natural world provides no genuine examples of dialectical leaps, then this foundational analogy collapses. Worse, the argument often turns circular: nature is read as dialectical to validate dialectic, and dialectic is then applied to interpret nature and society, which in turn supposedly confirms the method. Once this loop is broken, dialectic loses its evidentiary footing.

Rejecting the leap does not mean rejecting development, contradiction, or systemic analysis. It means rejecting the claim that change is driven by immanent negation rather than by mechanisms, conditions, and contingencies. Scientific explanation today requires fine-grained models supported by evidence, not metaphysical imperatives imposed in advance.

If dialectic is to remain relevant, it must renounce its ambition to legislate nature from within and accept a humbler role: not as a law of transformation, but as a metaphor among others — a perspective open to revision like everything else. Nature does not obey contradiction; it obeys mechanisms.

2.8 — Overview of Chapter 3

Part 3 of this chapter series maintains that not all systemic transformations are dialectical, and many that appear so are quasi-dialectical transformations, better explained by several other concepts, one of which is scale-dependent thresholds. To untrained eyes, quasi-dialectical transformations have a rudimentary resemblance to the Hegel-Engels dialectic, while they do not fulfil its requirements. Drawing from domains as varied as urban design, biological stability, artificial intelligence, and enzymatic systems, the article presents six cases of quasi-dialectical transformation. These transitions exhibit sharp discontinuities and systemic reorganization, yet remain intelligible without resorting to dialectical metaphysics. The article concludes by exploring the role of Inference to the Best Explanation (IBE) as a model for evaluating competing frameworks, and argues for a rethinking of dialectic not as a universal method but as one explanatory strategy among others.

Chapter 3: Alternatives to Dialectic

3.1 — Abstract

Many transformations that seem dialectical are in fact quasi-dialectical—better explained by mechanisms such as scale-dependent thresholds. To the untrained eye, such transformations bear a superficial resemblance to the Hegelian–Marxist–Engelsian dialectic, yet they do not meet its conditions. Drawing on domains as varied as urban design, biological stability, artificial intelligence, and enzymatic systems, the article presents six cases of quasi-dialectical transformation. These transitions involve sharp discontinuities and systemic reorganization, yet can be understood without invoking dialectical metaphysics. Alongside these cases, the article takes a philosophical detour through critical theory, examining how suspicion of science in Adorno and Horkheimer shaped debates on dialectic, and contrasting their stance with a more pluralist, explanatory framework. The article concludes by examining the role of Inference to the Best Explanation (IBE) as a model for evaluating competing frameworks, and argues for

treating dialectic not as a universal method but as one explanatory strategy among others within a pluralist framework.

3.2 — Introduction

Before introducing alternatives to dialectic, it is useful to briefly summarize the two preceding chapters.

3.2.1 — Summary of Chapter 1

On dialectic (1): What is dialectic. In Chapter 1, we traced the development of dialectic from Socratic dialogue to Žižekian paradox. What began as a modest epistemological technique in Socrates — dialogical testing — gradually accumulated further building blocks. Kant introduced formal constraints and transcendental tensions, turning dialectic into a regulative boundary for reason. With Hegel, and later Marx and Engels, the concept reached its architectural peak: dialectic became a metaphysical program,⁶⁵ complete with internal contradiction, historical necessity, and the triadic movement of thesis–antithesis–synthesis. At this stage, dialectic claimed not only to organize knowledge, but also to explain nature and reality itself.

In more recent developments — from Adorno’s negative dialectics to Žižek’s ontological detours⁶⁶ — this grand structure has undergone partial dismantling. The most significant shift has been the abandonment of synthesis, especially among Frankfurt School thinkers, who often rejected closure as politically and morally suspect (partly because of suspicion of totalizing solutions)⁶⁷. For them, contradiction was not something to resolve but something to sustain. As a result, dialectic has been stripped of structural rigidity and now floats more freely as a metaphorical stance, invoked for rhetorical force rather than methodological precision. Whether this counts as development or erosion remains an open (and uncomfortable) question.

3.2.2 — Summary of Chapter 2

On dialectic (2): Re-visiting dialectic. In Chapter 2, we examined two of Hegel’s core building blocks and assessed their scientific validity. The first is the claim that contradictions are strictly internal. The second is the claim that quantitative accumulation leads to qualitative transformation.

⁶⁵ Here, “metaphysics” and “metaphysical” are used in the sense of philosophy dealing with the structure of reality.

⁶⁶ Žižek occupies a unique position in contemporary thought: he has revived Hegelian and Lacanian perspectives, but his philosophical rigor is contested, with divided reception among Marxists and critical theorists.

⁶⁷ Here, “totalizing solutions” means proposed resolutions that claim to reconcile all tensions within a single framework, at the risk of suppressing unresolved conflicts, contingencies, or particular experiences.

By analyzing examples from physics, chemistry, and biology — such as phase transitions, incandescence, magnetic polarity reversal, allotropy, hydrocarbon series, the periodic table, and punctuated equilibrium — we argued that these phenomena are better explained through continuous, externally mediated processes rather than through internal contradiction or ontological leaps.⁶⁸ Our analysis showed that the so-called “quantity-to-quality” transition, often invoked as a universal law, lacks empirical support and methodological coherence. While dialectic may retain heuristic or rhetorical value, its extension into natural science — and likely into the social sciences as well — is unwarranted and should be reconsidered.

The first two parts traced the historical rise of dialectic and showed that its scientific claims, when tested, often collapse into more ordinary explanatory models.

3.3 — Aim of this chapter

We must clarify what is meant by a “dialectical leap.” In dialectical terms, a leap is not merely a threshold-crossing or a nonlinear response to cumulative input.⁶⁹ Rather, it implies three interrelated criteria:

1. **Ontological discontinuity** — a transformation that cannot be reduced to a continuous gradient.
2. **Qualitative novelty** — the emergence of a new kind of entity or state, not just a quantitative modification.
3. **Internal causation** — the transformation must arise from contradictions or tensions within the system itself, rather than from external inputs or environmental triggers.

Together, these criteria — discontinuity, novelty, and immanence — distinguish the dialectical leap from the kinds of quasi-dialectical transitions we will examine: transitions that may appear dialectical but operate through different mechanisms.

A true dialectical leap requires internal contradiction, whereas quasi-dialectical transitions are better explained by external thresholds and mechanistic processes.

3.4 — Quasi-dialectical processes

3.4.1 — False Dialectical Attributions

Not all processes that appear dialectical are in fact governed by dialectical logic. In many fields of inquiry, one encounters transformations or oppositional dynamics that resemble dialectical movement — shifts in form, breaks in continuity, or apparent contradictions. Yet these arise from fundamentally different mechanisms.

⁶⁸ By “ontological leaps” we mean claims of sudden, irreducible transformation not reducible to continuous processes.

⁶⁹ Some repetitions of the terms, such as “dialectical leap”, are deliberate, used to reinforce key distinctions across contexts. Here, redundancy has been minimized while retaining emphasis where pedagogically useful.

Such phenomena may display the external resemblance of dialectical reasoning without involving internal contradiction, determinate negation, or sublation.⁷⁰ I refer to such phenomena as **quasi-dialectical**.

Many processes may look dialectical, but without contradiction, negation, or sublation they are only quasi-dialectical.

3.4.2 — Quasi-Dialectical Phenomena: Definition and Scope

Quasi-dialectical phenomena must be distinguished from other relational systems that are often mislabeled as dialectical. In contemporary discourse, it is common to hear systems described as “dialectical” merely because they involve change, feedback, or interaction. Yet such features, while essential to many systems, do not by themselves constitute dialectic in any rigorous sense.

Examples include:

- A thermostat, which has a feedback loop but no contradiction.
- Predator–prey cycles, which oscillate but do not have sublation.⁷¹
- A conversation, which may be interactive but lacks immanent necessity.

Such systems are best understood as cybernetic (feedback-driven), reciprocal (mutually dependent), or adaptive (responsive to environment), not dialectical in any meaningful philosophical sense. They lack the structural tensions, determinate negations, or conceptual mediation required by dialectical reasoning. To call any dynamic or interactive process “dialectical” is to make the term so broad that it loses philosophical specificity. Recognizing this distinction helps maintain clarity between genuine dialectical models, quasi-dialectical models, and merely interactive systems.

Dynamism, feedback, or interaction alone does not make a system dialectical.

3.4.3 — Examples Across Domains

Quasi-dialectical models span a wide conceptual range. Examples include:

- Debate and adversarial reasoning, which replicate dialectic’s confrontational format but aim at persuasion or victory, not synthesis.
- Trial-and-error methods, which evolve through successive approximations rather than contradiction.
- Systems thinking, which in organizational sociology highlights feedback, emergence, and interdependence rather than contradiction and negation.

⁷⁰ Sublation (*Aufhebung*) in Hegelian dialectic refers to contradiction being both negated and preserved within a higher synthesis.

⁷¹ For example, in fox–rabbit population cycles, each species’ numbers rise and fall with a temporal lag relative to the other. This interaction shows fluctuation but no internal contradiction or synthesis.

- Thermodynamic phase transitions and evolutionary models, which show discontinuities and tension but lack the logical mediation central to dialectic.⁷²
- Inference to the Best Explanation (IBE), which reconciles competing hypotheses without contradiction.
- Dialogical logic, which formalizes reasoning as structured dialogue, and polyphonic theory, which hosts conflicting voices without requiring resolution.
- Policy-making through critical systems heuristics or boundary critique, often applied to organizations and institutions, which interrogates assumptions without requiring dialectical development.

This distinction is crucial for identifying the real sources of systemic change in science, society, and technology — and for avoiding the mystification of transformation through dialectical mislabeling.

The concept of quasi-dialectical processes is offered here as one explanatory model among many. By situating it alongside other approaches — such as classical mechanism, Aristotelian teleology, rationalist idealism, empiricist inductivism, probabilistic modeling, systems theory, and pragmatist analysis — we highlight the diversity of explanatory strategies available for understanding complex phenomena. Quasi-dialectical reasoning shares with systems theory, evolutionary naturalism, and process philosophy a focus on transformation, interaction, and emergent structure, but without positing internal contradiction as the universal engine of change.

Quasi-dialectical models show that systemic change often follows diverse mechanisms — not the contradictions required by dialectic.

3.5 — Scale-dependent transformation

A particularly instructive quasi-dialectical model is scale-dependent transformation. In such cases, systems undergo qualitative shifts in structure, behavior, or strategy once certain quantitative thresholds are crossed. These transformations may appear to be dialectical leaps, but they are better explained by structural saturation, nonlinear dynamics, or resource constraints. Their prevalence cautions against interpreting discontinuity or transformation too quickly as evidence of dialectic. Instead, they invite a more precise analysis of what actually drives systemic change, and whether contradiction is genuinely at its core.

Scale-dependent transformation is notable because of its ubiquity across scientific domains. In the physical and biological sciences, systems exhibit abrupt changes of state once parameters exceed critical values. Physics provides examples such as phase transitions or symmetry breaking. In biology and ecology, population growth or increased

⁷² Logical mediation means that transitions between stages follow necessarily from inner contradiction, not from external imposition.

ecosystem density can trigger new organizational regimes, including trophic cascades or shifts in metabolic demands described by allometric scaling laws.⁷³

Comparable dynamics occur in engineering, urban systems, and computational fields. Scaling up infrastructure or population leads to qualitative redesigns, such as the move from local provisioning to industrial supply chains or from informal traffic flow to structured multi-modal transit systems. In computational statistics, high-dimensional matrix operations or the breakdown of Markov Chain Monte Carlo (MCMC) methods illustrate how problem spaces can demand fundamentally new algorithms once they surpass hardware or numerical thresholds. In general systems theory, metasystem transitions demonstrate how increasing complexity requires the emergence of higher-order control mechanisms. Across these examples, transformation is real and qualitative, but it stems from external structural constraints, scaling limits, or resource saturation—not from internal contradictions or dialectical tension.

To ground this argument in concrete terms, we turn to six representative examples drawn from different domains. First, the shift in bridge design from stone arches to suspension structures as span length increases. Second, the transformation of urban food provisioning from local farms to industrial supply chains in response to population growth. Third, the evolution of traffic and governance mechanisms in large cities, requiring layered infrastructure and institutional adaptation. Fourth, the redesign of genetic structures based on increased enzyme activity. Fifth, the emergence of metasystem transitions in organizational growth, where informal coordination gives way to hierarchical management. Sixth, the shift in artificial intelligence problem-solving strategies from brute-force search to heuristic and learned approaches as the search space grows. Together, these six cases illustrate how scale alone can compel qualitative redesign without invoking dialectical contradiction.

Scale-dependent transformations look dialectical in form, but they are driven by thresholds, saturation, and structural constraints rather than contradiction.

3.5.1 — From Arch to Suspension

Bridge design illustrates a general structural principle: size, material, and design must remain compatible with one another. A structure that is stable at one scale cannot necessarily be enlarged without changing its materials, its design, or both. In short-span bridges, such as Roman aqueducts and medieval stone bridges, span length, the compressive properties of stone, and the arch design formed a stable triad. The arch transferred loads through compression, allowing stone to carry them efficiently within a limited range of spans.

As span length increased, the compatibility among size, material, and design began to break down. Wider arches generated greater lateral thrust, and the structure risked

⁷³ Allometric scaling is a branch of biology concerned with how growth and function vary with body size. Its origins date to the late nineteenth century, but interpretations have shifted from deterministic to probabilistic frameworks. It can be captured with formulas of the type $y = k \cdot x^a$, which reveal regularities across diverse domains of life. See Peters (1983); Schmidt-Nielsen (1984).

collapsing under its own weight. Engineers had to introduce new solutions: a change in material (from stone to wood, iron, or steel), a change in design (from arch to truss or suspension), or both. What results is not a simple enlargement of the earlier design but a qualitative shift in structural logic. Compression is replaced by tension, and rigid mass by flexible distribution.

This is a clear case of scale-dependent transformation. Growth in span length forces a redefinition of both material and design, producing a new kind of structure. Crucially, the change does not emerge from internal contradiction but from external constraints of scale.

As bridges grow larger, scale itself forces a change in material and design, showing how structural transformation can occur without dialectic.

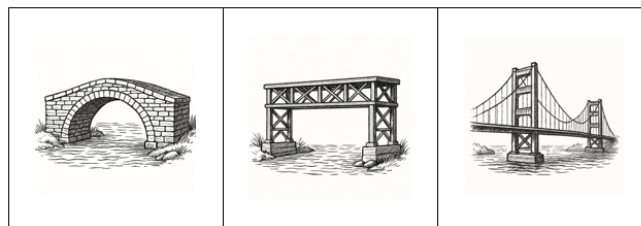


Figure 1. Illustrative progression in bridge design: from stone arch (compression-based), to truss (rigid distribution), to suspension (tension-based). Each transition reflects a scale-dependent transformation, where increasing span length compels qualitative redesign through external constraints rather than dialectical contradiction.

3.5.2 — From Local Farms to Agro-Industry

In a small town, food provisioning can be sustained through direct links with nearby villages. Fresh produce, dairy, and meat are transported over short distances with minimal infrastructure. In this setting, the system rests on a stable triad: limited population, perishable goods, and localized logistics. Size, material, and design are naturally aligned.

Once the urban population surpasses a certain threshold, this arrangement becomes untenable. Larger daily food volumes shorten the viable time window for perishables, overburden local transport routes, and render informal supply chains increasingly unreliable. At this point, the system requires a fundamental redesign. Industrial agriculture, long-distance logistics, and centralized distribution begin to replace village delivery. Refrigeration and cold-chain transport allow goods to travel greater distances, while processed and preserved products extend shelf life and buffer seasonal variability. Wholesale markets, refrigerated storage, and coordinated scheduling become essential to maintaining supply.

This transformation is not a linear scaling-up of the original system. It is a qualitative change in how city planners and institutions organize provisioning, one compelled by thresholds of spoilage, transport, and coordination. The redesign emerges not from internal contradictions but from external constraints imposed by scale.

Urban growth forces food provisioning to shift from local immediacy to cold-chain logistics and industrial coordination, a structural transformation driven by scale rather than dialectic.

3.5.3 — From Street Grids to Institutional Overhaul

In a small town or village, traffic can be managed with minimal infrastructure. Shared roads, a few signs, and informal social coordination are enough to maintain order. In this setting, the triad of scale, material, and design is aligned: a small population, simple routes, and cooperative norms sustain mobility.

As the city grows, however, this arrangement quickly reaches its limits. Increased traffic volume and route complexity overwhelm informal regulation. One-way streets, traffic lights, and simple bridges are added to preserve flow, but these measures soon prove insufficient once density passes a critical threshold. At that point, the system must undergo a deeper redesign. Elevated highways and subways appear, accompanied by new technological layers such as digital traffic management, surveillance, and road pricing.

Eventually, the pressure of scale extends beyond infrastructure into institutional arrangements. Large cities often require the decentralization of administrative services, the introduction of remote access to government functions, and in some cases, national-level coordination to manage congestion and service delivery.

What begins as a local problem of traffic engineering therefore becomes a challenge of metropolitan governance and national infrastructure planning. The prior framework no longer holds at larger scales, leading to new material and institutional arrangements.

As cities grow, mobility shifts from informal coordination to infrastructure and finally to institutional governance, a transformation driven by scale rather than dialectical contradiction.

3.5.4 — From Distributed Control to Constraint

Metabolic Control Analysis (MCA) provides a clear mechanistic example of how systemic transformation emerges through scale, not through dialectical contradiction, but through resource saturation and redistribution.⁷⁴ In an unbranched enzymatic pathway at steady state, the same flux passes through each successive step, although the magnitude

⁷⁴ Philosophical discussions of nature have traditionally drawn many of their principal examples from physics—including mechanics, thermodynamics, and astronomy—and from general chemistry. Biology has, of course, generated its own extensive philosophy, but detailed biological mechanisms are less commonly used to test general philosophical claims about transformation, causation, and systemic organization. Chapters 2 and 3 deliberately broaden the evidential field by drawing on evolutionary biology, genetics, and metabolic control. These examples are not introduced merely as analogies: they are used to examine whether claims presented as general laws of nature remain defensible when applied to complex biological systems.

of that flux may change when enzyme activities or external conditions change.⁷⁵ The summation theorem of metabolic control states that the flux control coefficients of all enzymes in the pathway sum to one.⁷⁶ Control is therefore distributed across the pathway: increasing the control exercised by one component must be accompanied, in aggregate, by reduced control elsewhere, although the redistribution need not be proportional among individual enzymes. This is a constraint on the distribution of control, not an internal contradiction.

When a mutation produces a new enzyme variant, its effect on pathway flux depends on the existing distribution of control across the pathway. The variant may have little or no detectable effect under the prevailing conditions because control lies largely elsewhere. If its effect changes when the genetic background at another locus changes, the resulting non-additive dependence is described genetically as epistasis.⁷⁷ Mutations that spread through a population may therefore alter both pathway flux and the distribution of control, but neither outcome follows automatically from any single mutation.⁷⁸

Branching enzymatic pathways add further constraints. Downstream enzymes often compete for a common substrate. At first glance, this might resemble a contradiction, since one branch limits the other. But closer inspection shows that the limiting factor is external: resource scarcity. What looks like dialectical opposition is better described as allocation under constraint.

These biochemical dynamics also bear on quantitative genetics. The effects of enzymatic branching may be reflected in patterns of genetic correlation among traits, often summarized in the genetic variance–covariance matrix (the G-matrix). When enzymes influence different traits, a change that benefits one trait may be neutral or harmful to another, depending on the conditions and available resources. Such effects may produce a trade-off, though a trade-off need not appear as a negative genetic correlation; the sign of the estimated correlation also depends on how the traits are defined and measured. Trade-offs of this kind arise from structural or resource constraints, not from logical contradiction.

⁷⁵ The overall flux of a system can be considered equivalent to the rate of production of the final product in a linear enzymatic chain. As in the earlier metaphor of a car factory, the flux corresponds to the number of cars leaving the assembly line per unit of time.

⁷⁶ The summation theorem in Metabolic Control Analysis (MCA) states that the sum of all flux control coefficients equals one, creating a principle of distributed or “democratic” control. See Kacser & Burns (1979).

⁷⁷ “Epistasis” refers to interactions in which the effect of one genetic locus depends on another. Originally phenotype-masking in classical genetics, it now covers non-additive interactions in systems biology, reflecting structural interdependence.

⁷⁸ This permits a limited analogy with social and political systems: concentrated intervention in one component may fail or produce destabilizing effects when other interdependent components do not change correspondingly. The analogy does not imply that biological and social systems operate by identical mechanisms, or that unilateral change necessarily causes collapse.

As more traits or populations are included in a G-matrix analysis, the number of variances and covariances to estimate grows. The difficulty depends not only on that number but also on the information linking the traits or populations. Weak connectedness can leave particular covariances poorly estimated or unestimable; including additional, well-connected data can instead strengthen those estimates. When separately estimated correlations are assembled into one matrix, the result may fail to be positive-definite and require adjustment.⁷⁹ These are limits of the data, model, and computation. They should not be mistaken for a loss of positive-definiteness in the underlying genetic covariance structure, still less for a logical contradiction in the biological system.

The same difficulty has a computational consequence. An estimated genetic correlation matrix assembled from separately estimated components may not be positive-definite, preventing calculations that require its inverse or Cholesky decomposition. Weighted bending adjusts the matrix while seeking to change its more reliable estimates less than its less reliable ones.⁸⁰ The adjustment makes the calculation possible; it does not recover information absent from poorly connected data. Here, increasing scale creates a problem of estimation and computation, not an internal contradiction demanding a biological transformation.⁸¹

Metabolic and genetic systems show that scale-dependent transformation arises through allocation and constraint, not through dialectical contradiction—nature does not work dialectically.

3.5.5 — From Informal Coordination to Hierarchical Control

In a small organization—a startup, a local cooperative, or a project team whose members can remain directly aware of one another’s roles and activities—coordination can be managed informally. Verbal agreements, mutual awareness, and flexible task assignment are sufficient, because the triad of scale, material, and design is aligned: few people, social trust and memory as the material of coordination, and a flat, non-hierarchical design.

As headcount grows into the dozens, then hundreds and beyond, this arrangement becomes less effective. Message volume rises faster than headcount, since each additional member increases the number of potential interactions with all others. Tasks begin to overlap; responsibility becomes diffuse; spans of control widen; and handoffs multiply.

⁷⁹ A covariance matrix is positive-semidefinite: none of its eigenvalues can be negative. Some analyses require a *positive-definite* matrix, whose eigenvalues are all positive, so that it can be inverted or decomposed as required by the calculation. Combining correlation estimates obtained separately can yield a matrix with negative eigenvalues. “Bending” adjusts such an estimated matrix; weighted bending aims to preserve its more reliable entries more closely. This is an estimation problem, not a biological transformation.

⁸⁰ Jorjani et al. (2003) explain why a matrix assembled from separately estimated correlations may fail to be positive-definite. Their weighted bending method adjusts the matrix while seeking to change its more reliable estimates less than its less reliable ones.

⁸¹ For the specific problem discussed here, Jorjani et al. (2005) is the more relevant reference: it examines how weak connectedness between populations complicates the estimation of genetic correlations. Turchin (1977) would be relevant only if the discussion were extended to a broader theory of systemic transitions.

Informal regulation proves unsustainable, not because of contradiction but because coordination costs rise with organizational size and the interactions that must be managed.

At this threshold, organizations often undergo a metasystem transition, in which a higher-level layer emerges to coordinate lower-level units and their interactions (Turchin, 1977).⁸² Middle management, formal reporting lines, and specialized departments tend to appear; enterprise software, shared databases, workflow systems, and dashboards often provide the necessary material supports. The design commonly shifts toward division of labor, bounded authority, standardized interfaces, and schedule discipline.

With further growth, demands spill beyond infrastructure into institutional arrangements. Functions are decentralized; shared-service or platform teams consolidate expertise; remote and automated channels provide access; and city-, sector-, or national-level coordination may be required for compliance, risk, and service continuity. What begins as a local problem of team coordination becomes a problem of organizational governance.

The driver throughout is external constraint: communication complexity, interdependence, and reliability requirements rise with scale, forcing a redesign of both material infrastructure and organizational architecture. The transformation is qualitative, but it is induced by scale and coordination burdens, not by dialectical contradiction.

3.5.6 — From Brute Force to Learned Heuristics

In small or well-bounded problems, trying every option can work. With three guests, seating them around a dinner table is simple—there are only a handful of possible arrangements. With ten guests, the number of distinct arrangements around a round table rises to hundreds of thousands. Testing them all soon becomes impractical: much of the effort would go into arrangements that are plainly unsuitable, such as placing two feuding relatives side by side. The example illustrates a general constraint: the number of possibilities can grow much faster than the resources available to examine them.

When this happens, a search strategy has to change. In artificial intelligence, a program may shift from checking every possibility to using heuristics—rules that direct attention toward promising options. A scheduling program, for example, might begin with the people whose availability is hardest to accommodate. A host, too, remembers which seating arrangements caused trouble.

The mesenteric vascular network does not remember in that sense. Across generations, natural selection acts on organisms bearing heritable differences that affect vascular development. Differences associated with successful reproduction can become more common in subsequent generations. Within each organism, vascular development also responds to local conditions. Neither natural selection across generations nor vascular development within an organism tests every possible branching arrangement. The resemblance to a search algorithm lies in the restricted range of variants that arise,

⁸² “Metasystem transition” denotes the formation of a higher-level control system that integrates and regulates interacting subsystems. For the original formulation, see Turchin, V. (1977).

followed by differential reproduction at the evolutionary level and stabilization or pruning at the developmental level—not in foresight or literal learning by the vessels.

The computational scaling problem becomes clear in games such as chess and Go. Their possible sequences of moves far exceed what a computer can evaluate exhaustively. Heuristics, lookahead guided by estimates, and learned strategies help programs concentrate on useful lines of play. These methods can find good moves without exploring every continuation. The shift is from exhaustive enumeration to selective search.

The biological comparison has limits, but it reinforces the central point: a workable outcome need not result from testing every possibility. In computation, limited time and processing power favor selective search. In vascular development and evolution, physical conditions and heritable variation limit which arrangements arise and persist. These processes differ in mechanism; none requires an inherent dialectical contradiction to explain the constraint.

As problems scale, exhaustive search becomes impractical, and selective methods become more valuable.

Across the six cases, changes in scale or in the conditions under which a system operates create constraints that may call for changes in components, coordination mechanisms, and sometimes the basic design itself. Where human agents are involved, they may respond by deliberately redesigning the system. Materials and load logic shift (stone arches to steel suspension; compression to tension). Provisioning moves from local supply to cold-chain industry, and mobility evolves from informal street norms to layered infrastructure and governance. In biochemical systems, heritable changes in enzyme activity can redistribute control over pathway flux and, as the variants spread through a population, reveal allocation constraints and possible trade-offs.⁸³ Organizations develop hierarchical management over flat coordination, and AI transitions from exhaustive enumeration to heuristic and learned guidance. These changes are better explained by the particular constraints and mechanisms at work in each case than by immanent dialectical opposition. This sets up the philosophical question taken up next: by the standards of Inference to the Best Explanation, which framework most economically accounts for such changes?

Across these domains, qualitative change occurs when shifts in scale or operating conditions disturb the compatibility among size, material conditions, and design or organization. The resulting reconfigurations are better explained by specific constraints and mechanisms than by dialectical contradiction.

⁸³ A mutation that alters an enzyme can change how control over a biochemical pathway is distributed. If the resulting effects on the organism are heritable and affect reproductive success, natural selection can change the variant's frequency across generations. Competition for shared resources may produce trade-offs, but neither a change in control nor a trade-off follows automatically from the mutation.

3.6 — Philosophical Consequences

The six cases above show that many striking transformations are better explained by scale, thresholds, and constraints than by contradiction. This matters because calling any phenomenon with tension, feedback, discontinuity, or complexity “dialectical” risks conceptual inflation: the term loses specificity, and explanatory credit is misassigned. For example, phase transitions or policy oscillations are sometimes read as contradictions unfolding dialectically, when they are more parsimoniously treated as threshold or control phenomena. The aim is not polemic but diagnostic: to separate formal resemblance from causal structure.

Acknowledging quasi-dialectical phenomena clarifies a practical distinction. Some systems transform because external saturation and resource limits force redesign; others change because of internal conceptual or normative conflict. The difference is consequential. In the first case, interventions reorganize resources, architectures, and coordination mechanisms; in the second, they address values, meanings, and rules. Not all change demands sublation, and not all progress follows a dialectical arc.

This discipline of use also reframes dialectic itself. Rather than a ubiquitous pattern, the Hegel–Marx–Engels tradition functions as a metaphysical program: a framework that posits necessary development driven by contradiction across thought, nature, and society. That thesis is powerful, rhetorically and psychologically, yet it is often overextended as an ontological claim. A more precise application treats dialectic as one explanatory strategy among others.

Placed alongside alternatives, the landscape becomes clearer. Mechanistic and naturalist programs explain change through forces on parts and contingent regularities; teleological and idealist programs appeal to ends or rational orders; evolutionary, systems, and process views emphasize adaptation, emergence, and becoming; analytic modal/structural approaches model necessity, possibility, and dependence without historical inevitability. These families often account for discontinuity and novelty without invoking internal contradiction as the universal engine.

When frameworks compete, Inference to the Best Explanation (IBE) becomes the appropriate filter: which account explains the patterns with greatest power and economy, best fits independent evidence, and integrates with background knowledge?⁸⁴ On the evidence of our six cases, constraint- and scale-based accounts typically outperform dialectical necessity on these criteria. Yet IBE is not a cudgel. It coexists with deduction and induction, guiding model choice under theoretical plurality; and it should be applied with awareness of its limits—subjectivity in weighting criteria, incommensurable virtues, and underdetermination—mitigated by pluralism and case-by-case comparison.⁸⁵

⁸⁴ Foundational discussions include Harman (1965) and Lipton (2004); for critique, see van Fraassen (1980); for an accessible overview, see Walton (2016). Working IBE criteria commonly include explanatory power, consilience with independent evidence, parsimony, predictive/explanatory success, and coherence with background theory.

⁸⁵ Methodological note: adopting IBE here signals disciplined pluralism rather than allegiance to a single program; competing frameworks should be assessed comparatively, case by case, with criteria made explicit.

On IBE grounds, scale- and constraint-based explanations often outmatch dialectical necessity; dialectic remains a selective tool, not a universal key.

3.7 — A Philosophical Detour

3.7.1 — Enlightenment as Myth — Or Political Allegory?

Horkheimer and Adorno's *Dialectic of Enlightenment* famously opens with the provocation that "Enlightenment is totalitarian,"⁸⁶ a thesis that casts reason's emancipatory promise as complicit in domination (Horkheimer & Adorno, [1944/1947] 2002). Their argument is powerful and historically situated: written in exile and in the shadow of fascism, it bears the imprint of its moment. The book's sweeping claims about reason and history sometimes read less as neutral analysis than as a politically charged narrative of catastrophe, an allegorical retelling of modernity's descent into administered life.

3.7.2 — The Irony of Social Embeddedness

The authors themselves supply the materials for reassessment. If, as they insist, knowledge is produced within concrete historical, economic, and ideological conditions, then their own critique must also be read as a product of such conditions. The deep ambivalence toward reason, progress, and science reflects moral and political disillusionment as much as philosophical judgment. Without careful qualification, the critique risks functioning as a mirror image of the totalities it opposes—rhetorically potent, yet prone to overgeneralization where more discriminating analysis is possible.⁸⁷

3.7.3 — From Caution to Closure: When Critique Becomes Myth

A cautionary stance toward reason can harden into its own metaphysical narrative. Just as Bacon diagnosed pervasive cognitive "idols," Horkheimer and Adorno portray scientific reason as pervasively instrumental. In both cases, structural pessimism threatens to eclipse critical discrimination, yielding a generalized suspicion that can become paralyzing. The issue is not whether abuses of reason occur—they do—but whether a wholesale indictment clarifies more than it obscures, especially in contexts where stable measurement and effective inquiry are demonstrable.

⁸⁶ Horkheimer and Adorno introduce this claim as the conclusion of an argument about Enlightenment's capacity to absorb even the myths invoked against it: "No matter which myths are invoked against it, by being used as arguments they are made to acknowledge the very principle of corrosive rationality of which enlightenment stands accused. Enlightenment is totalitarian" (Horkheimer & Adorno, [1944/1947] 2002, p. 4). Here, "totalitarian" refers primarily to Enlightenment's alleged tendency to subject everything to a single order of calculability, utility, and systematic unity, although the term's political resonance is plainly deliberate.

⁸⁷ This assessment does not deny the work's historical and political force. Composed in exile, forced abroad by Nazi atrocities and in the midst of World War II's catastrophes, *Dialectic of Enlightenment* offered a penetrating diagnosis of modernity's entanglement with domination and technocracy. The claim here is narrower: its epistemological pessimism is often overextended relative to the evidence.

3.7.4 — IBE as a Response: From Suspicion to Explanation

As argued in Section 3.6, Inference to the Best Explanation (IBE) offers a comparative standard: competing narratives are judged by explanatory power, economy, consistency with independent evidence, and coherence with background knowledge. From this angle, *Dialectic of Enlightenment* retains enduring value in diagnosing technocratic and capitalist pathologies, but its claim that science is inherently mythic reads less as discovery than as a historically shaped suspicion. IBE does not dismiss the suspicion; it treats it as one explanation among others and asks whether alternative frameworks—resource constraints, feedback, evolutionary adaptation—organize the same evidence more effectively.

3.7.5 — A Thermometer in a Room: The Limits of Social Embedding

Consider a simple but telling case: a calibrated thermometer placed in a room registers 21 °C. Under ordinary conditions of calibration and measurement error, its reading does not change with the class position, ideological commitments, or personal histories of those who look at it. The instrument has a social history — like all technologies — and its readings can certainly be misused. Yet in cases such as this, the act of measurement itself is remarkably robust: it yields the same result across political regimes, cultures, and beliefs. To collapse such reliability into “domination” risks confusing the instrument’s embeddedness with its invalidity, and in doing so undermines the very empirical inquiry that critical reflection ought to enrich.⁸⁸

The thermometer’s reading is not identical with the room or even with the physical state it represents. In that limited sense, Adorno’s principle of non-identity remains valid. But non-identity does not entail unreliability: a representation need not be identical with its object in order to describe one of its properties accurately. The relevant question is therefore not whether knowledge and reality are identical, but how adequately and reliably a particular representation captures the aspect of reality under investigation.

Adorno and Horkheimer’s reframing of Enlightenment reason also reshapes dialectic’s status. In their hands, dialectic no longer functions primarily as an epistemological method aimed at reconciliation or understanding; it marks an impasse of reason. This is not a neutral redefinition but an intellectual declaration of war on science itself, collapsing empirical inquiry into domination and treating Enlightenment’s very tools of progress as instruments of totalitarianism. In this respect, they radicalize a trajectory already present in Hegel, Marx, and Engels, where dialectic increasingly bears metaphysical weight

⁸⁸ Of course, a thermometer can be manipulated, miscalibrated, or placed in an unrepresentative spot. But such cases are failures of application, not proof that measurement itself is reducible to ideology or power. The very possibility of identifying a “bad reading” presupposes that better, more reliable readings are available. Physical instruments can be calibrated against external natural phenomena — for example, the freezing and boiling points of water at sea level — which shows that science is not wholly dependent on social factors but can anchor its practices in reproducible features of the natural world.

rather than methodological discipline—a shift that demands critical resistance as much as historical parsing.⁸⁹

In much of the humanities and social sciences, “positivism” has become less a description of a philosophical position than a curse word, sometimes used to dismiss quantitative or empirical research wholesale. This usage confuses two different claims. One may insist that empirical assertions be tested against evidence without claiming that the methods of the empirical sciences determine what counts as knowledge in every discipline. The latter is a philosophical position worth debating; the former is a condition of empirical inquiry. Criticism of positivism therefore cannot, by itself, discredit measurement or statistical modelling. Models may begin with severe simplifications and later be criticized, revised, or replaced by approaches that handle more variables, interactions, or changing conditions. Such revision does not guarantee progress in every case, but dismissing a model merely because an earlier version was crude mistakes its history for a verdict on its present use. To collapse every form of measurement into domination is to throw out the child with the bathwater.⁹⁰

This overreaction has been fed, admittedly, by scientistic overreach of the opposite kind.

From Auguste Comte’s vision of sociology (1830–42) as a ‘social physics’ to E. O. Wilson’s call for consilience (1998), there has been a recurring impatience to subsume the humanities under a single scientific framework. Such sweeping universalism provoked defensiveness, but Adorno and Horkheimer’s reply went further: rather than criticizing scientism’s excesses, they demonized science itself, conflating the abuse of empirical tools with their very possibility. In doing so, they helped institutionalize a stance of suspicion that discourages methodological pluralism and undermines the careful, incremental work by which models improve. A more constructive path would be to recognize both dangers — the arrogance of impatient universalists, and the despair of wholesale rejection — while continuing to refine empirical methods as one vital strand in the broader tapestry of knowledge.

Read through IBE, the critical insights of *Dialectic of Enlightenment* can be preserved while resisting totalizing suspicion: not all inquiry is domination, just as not every thermometer is propaganda. Dialectic is best treated as a selective instrument of critique — a scalpel rather than a sledgehammer.

⁸⁹ For contrastive contemporary rearticulations of “dialectic” that foreground epistemic method rather than totalizing critique, compare Brandom’s inferentialism (dialectical progression recast as the social articulation of commitments and entitlements) and Bhaskar’s dialectical realism (retaining ontological contradiction while rejecting idealism). On the classical side, see Bacon’s *Novum Organum* (1620), where “dialectica” functions as an instrument of inquiry rather than a metaphysical scheme (passim).

⁹⁰ See [Excursus 057 – On Positivism](#) for the distinction between empirical method and positivism as an epistemological doctrine. See [Excursus 065 – On the Ripley Principle: The Evolution of Ideas](#) on criticism and reformulation across successive versions of an idea.

3.8 — Conclusion

Across physical, biological, and social domains, we explain change with models; the question is whether one model can account for all transformation. The argument of this series—especially in this third chapter—is that no such overarching model exists. A pluralistic approach is preferable: compare frameworks case by case and keep what works.

Here we developed one such lens—scale-dependent transformation—and examined six domains: bridge design, urban food provisioning, urban mobility and governance, metabolic and genetic systems, organizational structure, and artificial intelligence. Across these cases, changes in scale or operating conditions bring particular thresholds, resource limits, and coordination problems into view. Their consequences depend on the mechanisms at work in each case, rather than on contradiction and sublation. These cases are therefore best treated as quasi-dialectical in appearance, not as evidence of dialectical necessity.

To adjudicate among competing accounts, we relied on Inference to the Best Explanation (IBE): prefer the framework with greater explanatory power, parsimony, consistency with independent evidence, and coherence with background knowledge. Used this way, IBE supports a disciplined pluralism—room for empirical inquiry and theoretical critique without the temptations of a single key to all change.

This stance is revisable. It would be weakened by reproducible cases in which internal contradiction, independent of threshold or resource constraints, uniquely drives development and yields superior predictions to constraint-based models; or by formal results showing that contradiction-based dynamics outperform scaling explanations across multiple domains with clear empirical tests.

Rather than seek universality, the better task is to sharpen our comparative tools and determine, case by case, which model best illuminates the phenomenon at hand.

The evidence favors explanations grounded in the particular constraints and mechanisms of each case over a universal appeal to contradiction. IBE helps us compare those explanations without assuming in advance that one framework must prevail everywhere.

3.9 — Postscript

Two contemporary approaches help clarify what remains at issue. Robert Brandom's inferentialism examines the norms that govern what speakers are entitled or committed to claim, and how those commitments may be revised. Roy Bhaskar's critical realism begins elsewhere: with a reality structured in levels whose causal powers cannot always be explained by describing their lower-level components alone.⁹¹

⁹¹ Brandom (1994; 2000); Bhaskar (1975; 1979).

Bhaskar's account of stratification supports a plurality of explanations. Even if the emergence of living things could be explained in physical and chemical terms, biology would retain its subject matter if living things had causal effects of their own. On this point, his realism is compatible with the argument of this chapter: different phenomena may require explanations at different levels. Stratification, however, does not by itself show that contradiction causes change at any of those levels.⁹²

Bhaskar's later dialectical realism makes that further ontological claim. It deserves examination rather than dismissal, but it must show what contradiction explains in a particular case beyond the identified mechanisms and conditions. Brandom raises a different question: whether revisions within a practice of giving and asking for reasons are usefully called *dialectical* without making dialectic a law of nature.⁹³

Neither question is settled by the six cases examined here. They mark the boundary of this chapter's conclusion: explanatory plurality can be defended without deciding in advance that every transformation—or no transformation—is dialectical.

⁹² Bhaskar, *A Realist Theory of Science* (1975), on the causal powers of higher-level entities.

⁹³ Bhaskar (1993), *Dialectic: The Pulse of Freedom*. The distinction between accepting stratification and questioning dialectical causation is the assessment made in this chapter, not a position attributed to Bhaskar.

Appendix 1: Birth and Death Years of the Main Philosophers

Birth and death years of the main philosophers mentioned in this chapter.

Name	Birth/death year
Zeno of Elea	-490 — -430
Plato	-427 — -347
Aristotle	-384 — -322
Plotinus	204 — 270
Al-Farabi	872 — 950
Avicenna	980 — 1037
Averroes	1126 — 1198
Thomas Aquinas	1225 — 1274
Ramus, Peter	1515 — 1572
Bacon, Francis	1561 — 1626
Descartes, René	1596 — 1650
Locke, John	1632 — 1704
Hume, David	1711 — 1776
Kant, Immanuel	1724 — 1804
Hegel, Georg Wilhelm Friedrich	1770 — 1831
Marx, Karl	1818 — 1883
Engels, Friedrich	1820 — 1895
Kierkegaard, Søren	1813 — 1855
Lukács, György	1885 — 1971
Gramsci, Antonio	1891 — 1937
Horkheimer, Max	1895 — 1973
Adorno, Theodor W.	1903 — 1969
Jameson, Fredric	1934 — 2024
Žižek, Slavoj	1949 —

Appendix 2: Metabolic Control and the Illusion of Evolutionary Leaps

A more precise explanation of this phenomenon, which emerges from the framework of Metabolic Control Analysis (MCA), is that in a saturated system with a large number of enzymes, the effect of each enzyme on the system's final flux generally follows a hyperbolic curve. This means that increasing the activity of a single enzyme, on its own, in most cases cannot lead to a significant increase in final output—unless similar changes occur in the activity of other enzymes as well.

Of course, in classical MCA models, the control coefficient of any given enzyme may be small or large at a particular point in time; but over a long timescale, under conditions of weak selection and environmental stability, these coefficients tend to converge toward relatively stable average values, and nearly all enzymes come to play a role in determining system behavior across generations.

This long-term stability of the averages is, in fact, one of the foundations for the development of stable and “modified” dominance structures in biological systems. As it happens, Wikipedia has a good article on this topic (in this [link](#)). Even if the reader is not in a position to read the entire article, examining the illustrations provided in the Wikipedia entry can still be beneficial.

To offer an intuitive illustration of this phenomenon, one may refer to a simple example from an automobile factory: increasing the power of a single engine—for instance, doubling its output—does not imply that the number of cars produced will also double. This example, although it involves a logical inconsistency in the type of quantities being compared (power versus count), intentionally introduces that asymmetry in order to highlight an important systemic principle: enhancing the capacity or efficiency of a single component in a complex system does not necessarily lead to a proportional increase in total system output. To double the final output, even components such as mirrors or turn signals must also be scaled up accordingly.

This principle is observable not only in mechanical systems but also in empirical biology: in one of the earliest transgenic experiments, reported in 1982 (Palmiter et al., 1982), the production of growth hormone in mice increased dramatically, yet the final body weight of the mice rose by only about 1.5 times. These findings suggest that in biological systems, the effectiveness of individual components is governed by multivariate control—regulated through internal interactions, external biological constraints, and structural limitations.

On a personal level, until 1991, influenced by my earlier understanding of dialectic, I believed in “revolution” as a theoretical framework. However, in 1991, after reading the article by Kacser and Burns (1979) titled “*Molecular Democracy: Who Shares the Controls?*”, which concerns the functional role of enzymes, I began to question the theory of revolution. I ultimately came to the conclusion that a unilateral and abrupt change in one part of a system quickly leads to the breakdown of that system. Conversely, if a small change in one part of a system is gradually accompanied by small changes in its other

parts, one may reasonably hope for a transformation of the system as a whole. In the next article in this series, I will refer to “molecular democracy” using the insights of Kacser and Burns (1979).

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