Commentary on Wikipedia article on Evolution

- For some reasons that are not important at this stage, I decided to find a short text about evolution in Persian. There were many, but none was to my satisfaction, and many of them were biased! The Persian Wikipedia had also an article on evolution, but I thought it contained too many misunderstandings. I tried to edit the worst of misunderstandings, but it was protected by some "gate keepers" who obviously were the source of misunderstandings. In order to become "eligible" for making changes to that article, I had to go through some hurdles, which I thought was not worth the effort!
- So, I decided to find a short English text about evolution and translate it to Persian. The shortest text that I could find was Wikipedia's article entitled "Evolution". The article "seemed" to cover enough number of subjects to give a fair overall view. I started to translate it right away without reading it first! Soon after the start of translation, I realized that even the Wikipedia's English article on evolution was not balanced, had many misunderstandings and misconceptions, and outright mistakes.
- I did not want to leave it there, so I started adding comments to it. I only commented the parts that I thought it necessary to comment. I just ignored minor issues.
- In other words, I did not attempt to do a thorough review of the Wikipedia article on "Evolution". Therefore, there aws also no need to check the correspondence between the text and references. However, some of the statements in the text were so much off the scale, that I checked some of the references. In majority of cases, I thought the Wiki writers had done a poor job.
- **What you see below in is the Wikipedia text (in black font color) paragraph by paragraph, and my comments to them (in blue font color). My comments are not "systematic", and on occasions reflect the emotions that the orginal text invoked in me.**
- Formatting of the original Wikipedia text was mainly dictated by Wikipedia's conversion of the original HTML text to PDF, and how the PDF version was converted to Microsoft Word. However, I made some minor formatting adjustments to make the text more visually pleasing.
- The references and other stuff are reproduced afer the main text, without any check or modification.

Wikipedia

Evolution

https://en.wikipedia.org/wiki/Evolution
Accessed 2021-03-17

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Evolution is change in the heritable characteristics of biological populations over successive generations.[1][2] These characteristics are the expressions of genes that are passed on from parent to offspring during reproduction. Different characteristics tend to exist within any given population as a result of mutation, genetic recombination and other sources of genetic variation.[3] Evolution occurs when evolutionary processes such as natural selection (including sexual selection) and genetic drift act on this variation, resulting in certain characteristics becoming more common or rare within a population.[4] It is this process of evolution that has given rise to biodiversity at every level of biological organisation, including the levels of species, individual organisms and molecules.[5][6]

1- The definition put forward here is one of the best definition that I have seen. However, my own definition is "Evolution is the study of biological variation". The reasons for suggesting my own definition for evolution is beyond the scope of this commentary.
2- Wiki writers have conditioned the evolution on natural selection and genetic drift. My guess is that they

thought these two processes are more important. In addition to these two, there are three other processes that have not been mentioned, or have been mentioned in passing. These are mutation, migration and mating systems.

3- Each of these processes alone, or in combination with others, can lead to evolution.

4- There are many definitions for sexual selection, according to some of which sexual selection is not a part of natural selection.

5- The number of biological structure levels, that Wiki writers have mentioned three of them, can easily be extended. For example, cellular organelles, tissues, organs, populations, multi-species habitats. This is an important issue because levels and targets of selection is an important subject in evolution.

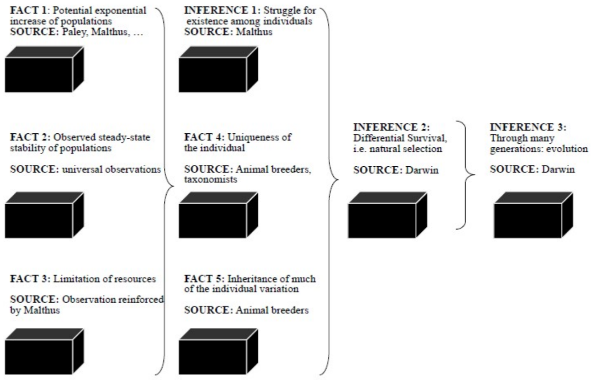
6- Unfortunately, the word "gene" has so many definitions, that it has been many years since I used it. However, here I have to use it because the Wiki article has used it. One of the most obvious misconceptions about "gene" is that it is sometimes interchangeably used as "locus" and "allele", which leads to lower clarity of the text. Locus and allele will be defines later.

7- In the philosophy of biology, there is this extensive discussion about the definition of "individual". David Hull as argued that "species" is an individual. Irrespective of what any person might think of Hull's ideas, this discussion has forced others to be more careful in using the words "individual" and "organism". It is important not to use any of these words to mean "species". Unfortunately, it seems that Wiki writers are not careful enough and on occasions have used "organism" as "individual" and on occasions as "species".

The scientific theory of evolution by natural selection was conceived independently by Charles Darwin and Alfred Russel Wallace in the mid-19th century and was set out in detail in Darwin's book *On the Origin of Species*.[7] Evolution by natural selection was first demonstrated by the observation that more offspring are often produced than can possibly survive. This is followed by three observable facts about living organisms:

(1) traits vary among individuals with respect to their morphology, physiology and behaviour (phenotypic variation), (2) different traits confer different rates of survival and reproduction (differential fitness) and (3) traits can be passed from generation to generation (heritability of fitness).[8] Thus, in successive generations members of a population are more likely to be replaced by the progenies of parents with favourable characteristics that have enabled them to survive and reproduce in their respective environments. In the early20th century, other competing ideas of evolution such as mutationism and orthogenesis were refuted as the modern synthesis reconciled Darwinian evolution with classical genetics, which established adaptive evolutionas being caused by natural selection acting on Mendelian genetic variation.[9]

1. Ernst Mayr believes that despite Darwin's frequent usage of "my theory", the Darwinian evolution has five inter-related theories: (1) Evolution as such; (2) Common descent; (3) origin of variation; (4) gradualness; and (5) natural selection. Further, with a lucid picture, Mayr has shown how Darwin might have possibly arrived at his conclusions (see the picture below).
2. Wiki writers have decided to explain the evolutionary process in three steps. It is a sensible and common way, but it is not the most complete way.
3. Competing theories to the Darwinian evolution theory are not restricted to the two mentioned by Wiki writers. The most important of them are probably Kimura's "Neutral Mutation Theory", and Eldredge & Gould's "Punctuated Equilibrium". In my opinion, Kimura's theory is, more or less, useful for explanation of variation at the DNA level. It basically claims that the Darwinian theory of evolution is concerned with the phenotypic level, while at the molecular level genetic drift and neutral mutations are more important. In my opinion, the theory of Punctuated Equilibrium is more or less wrong, and has some limited explanatory power for fossil records. Gould's insistence (Reference number 168) on the correctness of his theory, in my opinion, is due to his shortage of knowledge in genetics and its relationship with biochemistry.



4. The detailed explanation of this picture and my reasons for changing Mayr's "text boxes" to "black boxes" is beyond the scope of this commentary. [I have no idea if reproducing a modified version of Mayr's picture is lawful or not!]

All life on Earth shares a last universal common ancestor (LUCA)[10][11][12] that lived approximately 3.5 billion years ago.[13] The fossil record includes a progression from early biogenic graphite,[14] to microbial mat fossils,[15][16][17] to fossilised multicellular organisms. Existing patterns of biodiversity have been shaped by repeated formations of new species (speciation), changes within species (anagenesis) and loss of species (extinction) throughout the evolutionary history of life on Earth.[18] Morphological and biochemical traits are more similar among species that share a more recent common ancestor, and can be used to reconstruct phylogenetic trees.[19][20]

1. The choice of a point in time to call "start of life" is not easy. Because, we do not know how long after the formation of the first biomolecules the first cellular structures appeared. Further, because of the erosions of the Earth's layers, many of the old evidence has disappeared. In any case, 3.5 to 3.8 billion years is the minimum.

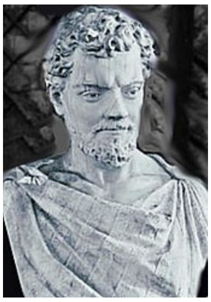
Evolutionary biologists have continued to study various aspects of evolution by forming and testing hypotheses as well as constructing theories based on evidence from the field or laboratory and on data generated by the methods of mathematical and theoretical biology. Their discoveries have influenced not justthe development of biology but numerous other scientific and industrial fields, including agriculture, medicine and computer science.[21]

Contents

History of evolutionary thought

Classical times

The proposal that one type of organism could descend from another type goesback to some of the first pre-Socratic Greek philosophers, such as Anaximander and Empedocles.[23] Such proposals survived into Roman times. The poet and philosopher Lucretius followed Empedocles in his masterwork *De rerum natura* (*On the Nature of Things*).[24][25]


Lucretius

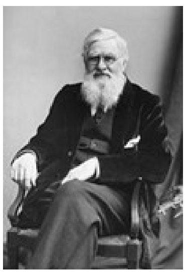
Medieval

In contrast to these materialistic views, Aristotelianism considered all naturalthings as actualisations of fixed natural possibilities, known as forms.[26][27] This was part of a medieval teleological understanding of nature in which allthings have an intended role to play in a divine cosmic order. Variations of thisidea became the standard understanding of the Middle Ages and were integrated into Christian learning, but Aristotle did not demand that real types of organisms always correspond one-for-one with exact metaphysical forms and specifically gave examples of how new types of living things could cometo be.[28]

1. “Type” is also a philosophical concept, and should be used with some care.
2. If I were in the place of Wiki writers, I would have not explained the useless theories of Aristotle. Instead, I would have explained the main difference between Darwin and his predecessors (and even many of his contemporaries). The most important philosophical rival of Darwin is the Platonic Essentialism. Even today, many of the misconception about the theory of evolution is rooted in Essentialism. Darwin’s theory is, in fact, the death of Essentialism. The thing that all Essentialist, from Plato to today, called “Essence” and considered to be “immutable”, Darwin considered to be “changeable”.

Pre-Darwinian

In the 17th century, the new method of modern science rejected the Aristotelian approach. It sought explanations of natural phenomena in terms of physical laws that were the same for all visible things and that did not require the existence of any fixed natural categories or divine cosmic order. However, this new approach was slow to take root in the biological sciences,the last bastion of the concept of fixed natural types. John Ray applied one ofthe previously more general terms for fixed natural types, "species", to plant and animal types, but he strictly identified each type of living thing as a species and proposed that each species could be defined by the features that perpetuated themselves generation after generation.[29] The biological classification introduced by Carl Linnaeus in 1735 explicitly recognised the hierarchical nature of species relationships, but still viewed species as fixed according to a divine plan.[30]


Alfred Russel Wallace

Other naturalists of this time speculated on the evolutionary change of speciesover time according to natural laws. In 1751, Pierre Louis Maupertuis wrote of natural modifications occurring during reproduction and accumulating overmany generations to produce new species.[31] Georges-Louis Leclerc, Comte de Buffon suggested that species could degenerate into different organisms, and Erasmus Darwin proposed that all warm-blooded animals could have descended from a single microorganism (or "filament").[32] The first full- fledged evolutionary scheme was Jean-Baptiste Lamarck's "transmutation" theory of 1809,[33] which envisaged spontaneous generation continually producing simple forms of life that developed greater complexity in parallel lineages with an inherent progressive tendency, and postulated that on a local level, these lineages adapted to the environment by inheriting changes caused by their use or disuse in parents.[34] (The latter process was later called Lamarckism.)[34][35][36] These ideas were condemned by established naturalists as speculation lacking empirical support. In particular, Georges Cuvier insisted that species were unrelated and fixed, their similarities reflecting divine design for functional needs. In the meantime, Ray's ideas of benevolent design had been developed by William Paley into the *Natural Theology or Evidences of the Existence and Attributes of the Deity* (1802), which proposed complex adaptations as evidence of divine design and which was admired by Charles Darwin.[37][38]

1. I don't think the word "law" should be used in science, and especially not in biology. This word gives a deterministic worldview, which was common in 15th to 19th centuries. Nowadays, it is better to limit the use "law" to matters of legislation.
2. It seems that the Wiki writers are not careful in using the words that might have specific philosophical and especially biological philosophy, and mix them with colloquial words. The use of the word "scheme" is just one example.
3. I do not understand why a theory (e.g. Lamarckism), that has been proven wrong by so much evidence, should be mentioned in here. Explanation of refuted theories created confusion in non-experts. Worse than that is explaining the wrong reasons (such as is mentioned of Cuvier's views) that had been offered against the wrong theories. To understand why Lamarck was wrong needs the understanding of the experiments performed by Weismann in 1880's and Waddington in 1950's.
4. Chronologically it is not correct to put the picture of an old Wallace before the picture of a young Darwin. Wallace was born 14 years after Darwin.
5. Of course, "Deeds of fathers is no service of the sons!" but Erasmus Darwin was Charles Darwin's grandfather.
6. The theory of Spontaneous Generation encompassed production of any animate substance from inanimate material. Louis Pasteur had a famous experiment from which he drew a correct and a wrongful conclusion. In his experiment from 1859, he boiled broth for some minutes, and then limited the access of air to the broth after the boiling. The result was that the broth as not spoiled as fast as it usually does. However, exposing the broth to air caused the broth to spoil. The correct conclusion was that the bacteria and other contaminants present in air are responsible for food spoilage. The wrong conclusion was that Spontaneous Generation could have not been responsible for the start of life on Earth. Therefore, with this wrongful conclusion he joined Darwin's and evolution's opponents. For me, this experiment has many lessons, the most important of which is that each experiment has an aim and a scope. Extending the results to other domains that the experiment was not designed to answer, is erroneous. In my opinion, Pasteur with this wrongful conclusion caused a delay in understanding of origin of life on Earth. Humanity had to wait for 93 years, until Miller-Urey experiment could show that start of life on Earth from inanimate material was very plausible.

In 1842, Charles Darwin penned his first sketch of *On the Origin of Species*.[22]

Darwinian revolution

The crucial break from the concept of constant typological classes or types inbiology came with the theory of evolution through natural selection, which was formulated by Charles Darwin in terms of variable populations. Darwin used the expression "**descent with modification**" rather than "evolution".[39] Partly influenced by *An Essay on the Principle of Population* (1798) by Thomas Robert Malthus, Darwin noted that population growth would lead to a "struggle for existence" in which favourable variations prevailed as others perished. In each generation, many offspring fail to survive to an age of reproduction because of limited resources. This could explain the diversity ofplants and animals from a common ancestry through the working of natural laws in the same way for all types of organism.[40][41][42][43] Darwin developed his theory of "natural selection" from 1838 onwards and was writing up his "big book" on the subject when Alfred Russel Wallace sent him a version of virtually the same theory in 1858. Their separate papers were presented together at an 1858 meeting of the Linnean Society of London.[44] At the end of 1859, Darwin's publication of his "abstract"as *On the Origin of Species* explained natural selection in detail and in a way that led to an increasingly wide acceptance of Darwin's concepts of evolution at the expense of alternative theories. Thomas Henry Huxley applied Darwin's ideas to humans, using paleontology and comparative anatomy to provide strong evidence that humans and apes shared a common ancestry. Some were disturbed by this since it implied that humans did not have a special place in the universe.[45]

1. "Descent with modification" is still one of the shortest and best definitions.
2. The word "Evolution" is not free from problems. It contains some of the misconceptions that towards end of 19th and beginning of 20th centuries were common.
3. According Darwin's notes, he started to read Malthus' book on September 28, 1838 and finished it seven days later on October 4th 1838. Sometime during these seven days, he conceived the idea of "descent with modification".
4. Those editions of Malthus's book that I have seen, depending of the size of the font and the paper, are between 80 and 130 pages. The fact that Darwin has taken seven days to read it means he has spent some time to elaborate on the content, and let the ideas sink in him.
5. Using the word "favourable" alone in this paragraph is inappropriate for two reasons. First, there is a kind of "value judgment" in this word, as if there is an external being that judges what is "favourable" and what is "unfavorable". Second, every word that is used in this context should be considered as temporary and transitional. A trait that leads to a higher frequency in this environment and in this generation, may lead to lower frequency in a different environment and a diffent generation.
6. The word "prevailed" means that its frequency was described (avoid value judgments!)
7. The term "struggle for existence" may be interpreted as "being forced to fight or nake war"! However, we now know that the argest bulk of single individuals "disappear" not because of fights, but because of scarcity of resources.
8. Huxley (who "incidentally" was the gradfather of Julian and Aldus Huxley) was lated called Darwin's bulldog, because of his heated and sometimes furious efence of Darwin.
9. The statement that "humans did not have a special place in the universe" was not something that Darwin would have said with clarity. However, all who could see Darwin's "mechanistic and dynamic" explanation, would have reached this conclusion by themselves. There was another conclusion that everyone could draw: In Darwin's world everything was in a stated od being random, and there was no "devine order" anywhere.

Pangenesis and heredity

The mechanisms of reproductive heritability and the origin of new traits remained a mystery. Towards this end, Darwin developed his provisional theory of pangenesis.[46] In 1865, Gregor Mendel reported that traits were inherited in a predictable manner through the independent assortment and segregation of elements (later known as genes). Mendel's laws of inheritance eventually supplanted most of Darwin's pangenesis theory.[47] August Weismann made the important distinction between germ cells that give rise to gametes (such as sperm and egg cells) and the somatic cells of the body, demonstrating that heredity passes through the germ line only. Hugo de Vries connected Darwin's pangenesis theory to Weismann's germ/soma cell distinction and proposed that Darwin's pangenes were concentrated in the cell nucleus and when expressed they could move into the cytoplasm to change the cell's structure. De Vries was also one of the researchers who made Mendel's work well known, believing that Mendelian traits corresponded to the transfer of heritable variations along the germline.[48] To explain how new variants originate, de Vries developed a mutation theory that led to a temporary rift between those who accepted Darwinian evolution and biometricians who allied with de Vries.[49][50] In the 1930s, pioneers in the field of population genetics, such as Ronald Fisher, Sewall Wright and J. B. S. Haldane set the foundations of evolution onto a robust statistical philosophy. The false contradiction between Darwin's theory, genetic mutations, and Mendelian inheritance was thus reconciled.[51]

1. Using the word "heritability" in this paragraph shows that Wiki writers do not know that this word has a profound meaning in quantitative genetics, and have used it in a colloquial manner. Quantitative genetics term "heritability" is a complex concept with one conceptual definitions, and at least four operational definition. Its conceptual definition is "the regression of additive genetic value on the phenotypic value (in a population)". For the moment, for the sake of brevity, I refrain from presenting any operational definition.
2. Hugo de Vries who claimed to be an ardent Darwinian honored Darwin by abbreviating Darwin's pangenesis to pangene and later to gene.
3. In my opinion a Wikipedia article about evolution does not need to describe obsolete genetic theories.
4. Indicating that Biometricians have been supporting views of De Vries is a misunderstanding, and Wiki writers' misunderstanding. Additionally, reference number 50 has nothing about this subject. However, reference number 49 (chapters 2 and 3) clearly states that the two sides of the evolutionary conflict between 1900 and 1918 were Mendelians and Biometricians, and de Vries was certainly one of the Mendelians.
5. The first publications of these three mental giants in this field were Fisher in 1918, Wright in 1921, and in Haldane 1924. Therefore, it is better to say in "1920s" (and not 1930s). However, it is possible that the Wiki writers are not aware of these papers ☹.

The 'modern synthesis'

In the 1920s and 1930s, the so-called modern synthesis connected natural selection and population genetics, based on Mendelian inheritance, into a unified theory that applied generally to any branch of biology. The modern synthesis explained patterns observed across species in populations, through fossil transitions in palaeontology.[51]

1. It is funny that Wiki writers have written only these few lines about the "Modern Synthesis". A sign of their ignorance?

Further syntheses

Since then, the modern synthesis has been further extended in the light of numerous discoveries, to explain biological phenomena across the full and integrative scale of the biological hierarchy, from genes to populations.[52]

The publication of the structure of DNA by James Watson and Francis Crick with contribution of Rosalind Franklin in 1953 demonstrated a physical mechanism for inheritance.[53] Molecular biology improved understanding of the relationship between genotype and phenotype. Advances were also made in phylogenetic systematics, mapping the transition of traits into a comparative and testable framework through the publication and use of evolutionary trees.[54] In 1973, evolutionary biologist Theodosius Dobzhansky penned that "nothing in biology makes sense except in the light of evolution," because it has brought to light the relations of what first seemed disjointed facts in natural history into a coherent explanatory body of knowledge that describes and predicts many observable facts about life on this planet.[55]

1. Quite the contrary! If there has been any "contribution" to someone else's work, it was Watson and Crick who "contributed" to the work of Franklin. First, the graduate students did the work in the laboratory. Second, it was one of Rosalind Franklin students / assistants who took that famous picture of the DNA

molecule. The patriarchal system existed and still exists in science, and many women's achievements have been ignored through years. Rosalind Franklin is just one of them.
2. Discoverers of the DNA structure did not demonstrate "a physical mechanism for inheritance"! This had been known for several decades. They just showed the molecular structure whose chemical properties had been known from before.
3. A simple check of the references shows that Dobzhansky has stated this famous sentence in a biology teachers' journal.

One extension, known as evolutionary developmental biology and informally called "evo-devo," emphasizes how changes between generations (evolution) acts on patterns of change within individual organisms (development).[56][57] Since the beginning of the 21st century and in light of discoveries made in recent decades, some biologists have argued for an extended evolutionary synthesis, which would account for the effects of non-genetic inheritance modes, such as epigenetics, parental effects, ecological inheritance and cultural inheritance, and evolvability.[58][59]

1. The term "evo-devo" is not as informal as it is claimed here, and can be observed in scientific literature abundantly. Now, in the reference number 57, there is no mentioning of "evo-devo". Generally, scientists may have different definitions of "evo-devo", and some definitions might be "extreme". In any case, I am not sure if Avise and Ayala, just like myself, are too thrilled about extreme forms of evo-devo.
2. In my opinion, for many things mentioned at the end of this paragraph, there is not enough evidence. Further, many of the so-called evidence may turn out to be artefacts.

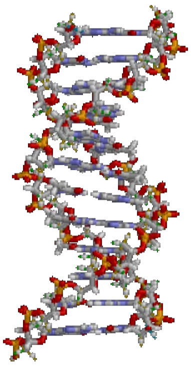
Heredity

Evolution in organisms occurs through changes in heritable traits—the inherited characteristics of an organism. In humans, for example, eye colour is an inheritedcharacteristic and an individual might inherit the "brown-eye trait" from one of their parents.[60] Inherited traits are controlled by genes and the complete set of genes within an organism's genome (genetic material) is called its genotype.[61]

1. The definition in the first sentence of this paragraph has slight difference with the definition presented in the beginning of this article. There the word "characteristics" could be interpreted to include means and variances as well. Further, using the word "population" has emphasized the population-based nature of evolution. Here, dropping the word "population" may increase the likelihood of misunderstanding. In any case, I emphasize that evolution does not occur in an individual organism. Individual organisms do not "evolve". "Population" do!
2. From my point of view, which is a quantitative genetics point of view, there is no biological trait that is under the control of a single locus. Single locus model is only, and only a "pedagogical and model-building" tool, and is not anchored in any reality. In order to disprove the "single locus model" do as follows: Try to identify the enzyme (or enzymes) of any trait that you think is controlled by a single locus. Then, try to find that enzyme on a biochemical chart and show that that enzyme (or enzymes) is not related to any other enzyme. I guarantee that even if you stare at the biochemical chart for three days, you will not find such an enzyme. So, why such a misunderstanding is so prevalent? Because for showing the effect of other loci involved would require much larger and more expensive experiments. Therefore, "single locus model" is an adequate approximation of reality with useful applications in some areas. ((In a way, like the Newtonian mechanics, which works for average velocities, average distances, and average masses. It works approximately. However, if you increase the velocity or the mass (like movement of photons of light across galaxies), or if you reduce the mass to very small particles (like quarks in the nucleus of an atom), then the Newtonian mechanics, does not work, even approximately.))
3. The word "genotype" is a flexible (!) word and encompasses one locus or the entire genome.

The complete set of observable traits that make up the structure and behaviour ofan organism is called its phenotype. These traits come from the interaction of itsgenotype with the environment.[62] As a result, many aspects of an organism's phenotype are not inherited. For example, sun tanned skin comes from the interaction between a person's genotype and sunlight; thus, suntans are not passed on to people's children. However, some people tan more easily than others, due todifferences in genotypic variation; a striking example are people with the inherited trait of albinism, who do not tan at all and are very sensitive to sunburn.[63]

1. The word phenotype, just like the word genotype, is flexible (!) and can be used for a trait of an individual organism or for the individual in its entirety.
2. It is not clear for me if the word "behavior" in the first sentence of this paragraph also included "function" or not. In any case, function is also a phenotype.
3. Concepts like phenotype and genotype have gradually (at least in quantitative genetics) have become mathematical-statistical concepts, and are "model based". For example, the phenotype of an individual, depending on the model, be different from the "observation" value of that trait.
4. The statement that the "sun tanned" person does not pass on the tanned skin to his/her children, but the ability to get sun tanned is passed on.



DNA structure. Bases are in the centre, surrounded by phosphate–sugar chainsin a double helix.

Heritable traits are passed from one generation to the next via DNA, a molecule that encodes genetic information.[61] DNA is a long biopolymer composed of four types of bases. The sequence of bases along a particular DNA molecule specify the genetic information, in a manner similar to a sequence of letters spelling out a sentence. Before a cell divides, the DNA is copied, so that each ofthe resulting two cells will inherit the DNA sequence. Portions of a DNA molecule that specify a single functional unit are called genes; different genes have different sequences of bases. Within cells, the long strands of DNA form condensed structures called chromosomes. The specific location of a DNA sequence within a chromosome is known as a locus. If the DNA sequence at a locus varies between individuals, the different forms of this sequence are called alleles. DNA sequences can change through mutations, producing new alleles. If a mutation occurs within a gene, the new allele may affect the trait that the gene controls, altering the phenotype of the organism.[64] However, while this simple correspondence between an allele and a trait works in some cases, most traits are more complex and are controlled by quantitative trait loci (multiple interacting genes).[65][66]

1. My reluctance to use the word "gene", and of the most important problems of definition of "gene" lies in the phrase "single functional unit". The root of this definition goes to 1950s and 1960s, when the "genetics central dogma" was popular. Today, we know that not all "genes" have functional roles. Even, sequences that were called "junk" until a few years ago, seems to have some role today, but not protein coding role.
2. It has been many years that I think "locus" is a better word than "gene".

Sources of variation

Evolution can occur if there is enough genetic variation within a population. Variation comes from mutations in the genome, reshuffling of genes through sexual reproduction and migration between populations (gene flow). Despite the constant introduction of new variation through mutation and gene flow, most of the genome of a species is identical in all individuals of that species.[73] However, even relatively small differences in genotype can lead to dramatic differences in phenotype: for example, chimpanzees and humans differ in only about 5% of their genomes.[74]

1. If I were going to write this section, I would have not put the mutation, recombination (= "reshuffling of genes"), migration, and gene flow together in this manner. In my mind, there is only one source of variation, and that id mutation. Any "mistake" in duplicating of DNA, or repairing a damage in the DNA, is a mutation. In addition, mutation can happen at any level of complexity of the DNA molecule. When mutation happens, there are different mechanisms for putting it in a new combination (crossover, recombination, reshuffling), spread it within a population (reproduction), or move it across populations (migration). There are different methods the measure the spread of a new mutation, one of which is "gene flow".
2. The 5% difference mentioned here is a bit larger than the numbers I usually encounter (around 1%). The number 5%mentioned in reference number 72 is related to a specific class of DNA sequences, and cannot be extrapolated to the whole genome. Human reference genome has about 3 billion nucleotides. Any human, from any part of the world, has about 4.1 to 5.0 difference from the reference genome. That is about 0.16% ($(5*10^6)/(3*10^9)$), or approximately one sixth of a one percent.

White peppered moth

Black morph in peppered moth evolution

1. The above two figures are related to an example of rapid evolution. I do not know how these two picture have ended up here in Wikipedia's pagination! The explanation that has been given under "Mechanisms" is also inadequate. The summary of this example is as follows. Before the industrial revolution in England, most of the pepper moth were white, and the black ones were rare, presumably because birds ate the black ones. After the industrial revolution, and in the areas that were close to factories, the pollutants started to change the color of trees to darker shades. Simultaneously, the frequency of the black pepper moth started to rise. This phenomenon is called "Industrial melanism", and is explained by how easy or how difficult different variants of the pepper moth become visible to the predators.

An individual organism's phenotype results from both its genotype and the influence of the environment it has lived in. A substantial part of the phenotypic variation in a population is caused by genotypic variation.[66]The modern evolutionary synthesis defines evolution as the change overtime in this genetic variation. The frequency of one particular allele willbecome more or less prevalent relative to other forms of that gene. Variation disappears when a new allele reaches the point of fixation— when it either disappears from the population or replaces the ancestral allele entirely.[75]

1. Please pay special attention to the second sentence, because it is a very important one. It says: "A substantial part of the phenotypic variation in a population is caused by genotypic variation". First, the phrase "substantial part" is not precise. It is better to say "A variable part". Second, this sentence relates to "variations" to each other: "phenotypic variation" and "genotypic variation". What it does not say is also important, among other things; it does not say "phenotypic variation" is due to "genetics". In addition, it does not say "phenotype" is due to "genetic variation". From the two times that the word "variation" has been used, if you remove any of them, you have opened up the possibility of

misunderstanding.

2. Now that these two "variations" have been mentioned, I can present one of the operational definitions of the term heritability. If we show the genotypic variance by V_G and the phenotypic variance by V_P, then the "broad sense heritability", symbolized by H^2, will be obtained from equation "$H^2 = V_G / V_P$". Further, if we show that part of the genotypic variance that is caused by additive action of alleles by V_A, then the "narrow sense heritability", symbolized by h^2, will be obtained from the equation "$H^2 = V_A / V_P$". Please notice that this is only one of the operational definitions of the concept of heritability.
3. One more point is that the modern science of evolution is not just a verbal description of natural changes. It used much mathematical and statistical models and equations.
4. Definition of evolution as "the change overtime in this genetic variation" for people like me with a background in genetics seems obvious. However, I am certain that many of my colleagues from other biological disciplines would consider this definition as "reductionistic".
5. This definition has also another problem, and that is ignoring the geographical variation. Before Darwin, there were many naturalists who had studied variation either during "time", as in paleontology, or through "space", as in the study of geographical variation. One of Darwin's strong points was to study variation "in space and time" simultaneously.

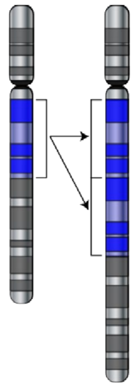
Before the discovery of Mendelian genetics, one common hypothesis was blending inheritance. But with blending inheritance, genetic variation would be rapidly lost, making evolution by natural selection implausible. The Hardy–Weinberg principle provides the solution to how variation is maintained in a population with Mendelian inheritance. The frequencies of alleles (variations in a gene) will remain constant inthe absence of selection, mutation, migration and genetic drift.[76]

1. Again, here, I do not understand why is it necessary to present the refuted theory of "blending inheritance"?
2. The Hardy-Weinberg principle (which, in addition to the word "principle" has been described by many other words) has many more complex pre-requisites, among others, random mating. Strictly speaking, Hardy-Weinberg principle applies to diploid species (but has some approximate generalities).

Mutation

Mutations are changes in the DNA sequence of a cell's genome. When mutations occur, they may alter the product of a gene, or prevent the gene from functioning, or have no effect. Based on studies in the fly *Drosophila melanogaster*, it has been suggested that if a mutation changes a protein produced by a gene, this will probably be harmful, with about 70% of these mutations having damaging effects, and the remainder being either neutral or weakly beneficial.[77]

1. I emphasize again that some sentences of this Wikipedia article have the "smell of misunderstanding"! Not all "genes" lead to protein coding. One sort of DNA sequence with no apparent function or coding role is the Copy Number Variation (CNV). Interestingly, it has been shown that they have rather high correlations with some diseases!



Duplication of part of a chromosome

Mutations can involve large sections of a chromosome becoming duplicated (usually by genetic recombination), which can introduce extra copies of a gene into a genome.[78] Extra copies of genes are a major source of the raw material needed for new genes to evolve.[79] This is important because most new genes evolve within gene families from pre-existing genes that share common ancestors.[80] For example, the human eye uses four genes to make structures that sense light: three for colour vision and one for night vision; allfour are descended from a single ancestral gene.[81]

New genes can be generated from an ancestral gene when a duplicate copy mutates and acquires a new function. This process is easier once a gene has been duplicated because it increases the redundancy of the system; one gene in the pair can acquire a new function while the other copy continues to perform its original function.[82][83] Other types of mutations can even generate entirely new genes from previously noncoding DNA.[84][85]

The generation of new genes can also involve small parts of several genes being duplicated, with these fragments then recombining to form new combinations with new functions.[86][87] When new genes are assembled from shuffling pre-existing parts, domains act as modules with simple independent functions, which can be mixed together to produce new combinations with new and complex functions.[88] For example, polyketide synthases are large enzymes thatmake antibiotics; they contain up to one hundred independent domains that each catalyse one step in the overall process, like a step in an assembly line.[89]

1. Again, I am unable to understand the role of this paragraph with its technical jargon. Do we expect the Wikipedia reader to know all about the biochemistry of DNA-Protein axis? I guess the Wiki writers wanted to generalize their writings and have entangled themselves in a web of details, as is evident from referring to domains and modules. If I were to write this paragraph, I would have written it as follows. Proteins are made of one or more chains of amino acids. Usually those parts of chromosome that are responsible for coding different chains of a complex protein sit together in a “gene” or “gene complex”. A new “gene” can be formed by putting together different DNA sequences that formerly were parts of different “genes” that now exist in duplicate copies. Thus, the assembly of amino acid chains that existed before are now part of a new combination, with a new function”.
2. Now, I am thinking that the Wiki writers should have painted a simple picture of evolution, and then tried to fill the possible gaps. Finally, if necessary, more technical explanations of intricate problems could have been offered.

Sex and recombination

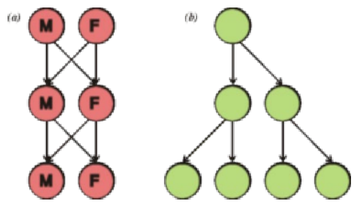
In asexual organisms, genes are inherited together, or *linked*, as they cannot mix with genes of other organisms during reproduction. In contrast, the offspring of sexual organisms contain random mixtures of their parents' chromosomes that are produced through independent assortment. In a related process called homologous recombination, sexual organisms exchange DNA between two matching chromosomes.[90] Recombination and reassortment do not alter allele frequencies, but instead change which alleles are associated with each other, producing offspring with new combinations of alleles.[91] Sex usually increases genetic variation and may increase the rate of evolution.[92][93]

The two-fold cost of sex was first described by John Maynard Smith.[94] The first cost is that in sexually dimorphic species only one of the two sexes can bear young. This cost does not apply to hermaphroditic species, like most plants and many invertebrates. The second cost is that any individual who reproduces sexually can only pass on 50% of its genes to any individual offspring, with even less passed on as each new generation passes [50.0% to the 1st generation, 25.0% to the 2nd generation, 12.% to the 3rd generation, and so on].[95] Yet sexual reproduction is the more common means of reproduction among eukaryotes and multicellular organisms. The Red Queen hypothesis has been used to explain the significance of sexual reproduction as a means to enable continual evolution and adaptation in response to coevolution with other species in an ever-changing environment.[95][96][97][98]

1. The “Red Queen” refers to a part of “Through the Looking Glass” by Lewis Carroll. In that part of the story, there is a conversation between Alice and the Red Queen as follows.
2. `Well, in our country,' said Alice, still panting a little, `you'd generally get to somewhere else -- if you ran very fast for a long time, as we've been doing.' `A slow sort of country!' said the Queen. `Now, here, you see, it takes all the running you can do, to keep in the same place. The “Red Queen” hypothesis refers to the rapid environmental changes and the corresponding genetic changes.
3. In population genetics, especially among those who work more with evolution, and some neighboring fields, it is customary to use such names as “Red Queen” for models and hypotheses. I think such names are uninformative, silly, and childish.

Gene flow

Gene flow is the exchange of genes between populations and between species.[99] It can therefore be a source of variation that is new to a population or to a species. Gene flow can be caused by the movement of individuals between separate populations oforganisms, as might be caused by the movement of mice betweeninland and coastal populations, or the movement of pollen between heavy-metal-tolerant and heavy-metal-sensitive populations of grasses.



This diagram illustrates the *twofold cost ofsex*. If each individual were to contribute to the same number of offspring (two), *(a)* the sexual population remains the same size each generation, where the *(b)* Asexual reproduction population doubles in size each generation.

Gene transfer between species includes the formation of hybrid organisms and horizontal gene transfer. Horizontal gene transferis the transfer of genetic material from one organism to another organism that is not its offspring; this is most common among bacteria.[100] In medicine, this contributes to the spread of antibiotic resistance, as when one bacteria acquires resistance genes it can rapidly transfer them to other species.[101] Horizontal transfer of genes from bacteria to eukaryotes such as the yeast *Saccharomyces cerevisiae* and the adzuki bean weevil *Callosobruchus chinensis* has occurred.[102][103] An example of larger-scale transfers are the eukaryotic bdelloid rotifers, which have received a range of genes from bacteria, fungi and plants.[104] Viruses can also carry DNA between organisms, allowing transfer of genes even across biological domains.[105]

1. These obscure examples will not help non-expert readers. If a person has a full understanding of a subject, he/she should be able to explain it to non-experts. If it is not possible to do so, then try to avoid creating confusion.

2. There are many phenomena in nature, some with high frequency and some with low frequency. Some of the events are rules, and some are exceptions. Theories and hypotheses have a corresponding situation. Some explain many phenomena, and some only a few. In a Wikipedia article, or even in a general book, the presentation should be proportional to the frequency of events and phenomena. For example, if horizontal transfer of genes is constitute only 0.1% of all gene transfers, it should not be discussed here. Unquantified reference to such phenomena create confusion in non-expert readers and leads them to assume that such phenomena are frequent. It is not so.

Large-scale gene transfer has also occurred between the ancestors of eukaryotic cells and bacteria, during the acquisition of chloroplasts and mitochondria. It is possible that eukaryotes themselves originated from horizontal gene transfers between bacteria and archaea.[106]

Mechanisms

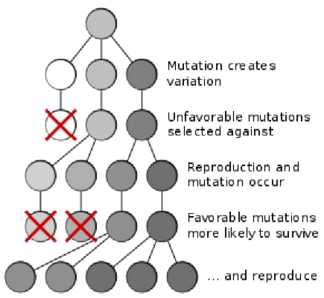
From a neo-Darwinian perspective, evolution occurs when there are changes in the frequencies of alleleswithin a population of interbreeding organisms,[76] for example, the allele for black colour in a population of moths becoming more common. Mechanisms that can lead to changes in allele frequencies include naturalselection, genetic drift, gene flow and mutation bias.

1. Neo-Darwinism is yet another name for the “Modern synthesis”.
2. Here, as in some other places. The Wiki writers have forgotten to mention genotype frequencies alongside allele frequencies.
3. I repeat: evolutionary forces are selection, mutation, migration, random drift, and mating systems.

Natural selection

Evolution by means of natural selection is the process bywhich traits that enhance survival and reproduction become more common in successive generations of a population. It has often been called a "self-evident" mechanism because it necessarily follows from three simple facts:[8]

- Variation exists within populations of organisms with respect to morphology, physiology, and behaviour (phenotypic variation).
- Different traits confer different rates of survival and reproduction (differential fitness).
- These traits can be passed from generation to generation (heritability of fitness).



Mutation followed by natural selection results in apopulation with darker colouration.

More offspring are produced than can possibly survive, and these conditions produce competition between organisms for survival and reproduction. Consequently, organisms with traits that give them an advantage over their competitors are more likely to pass on their traits to the next generation than those with traits that do not confer an advantage.[107] This teleonomy is the quality whereby the process of natural selection creates and preserves traits that are seemingly fitted for the functional roles they perform.[108] Consequences of selection include nonrandom mating[109] and genetic hitchhiking.

1. In this paragraph there is a logical-linguistic issue related to the word “trait”. Everyone makes this

common mistake. This is my attempt to clarify the situation. First, we must distinguish between the colloquial and evolutionary-genetic sense of the word “trait”. For example, when we say “organisms with traits that give them an advantage overtheir competitors”, it does not mean that an organism has that trait, and another organism does not have it. The meaning is that the “size of the trait” is different in the two organisms. As an example, when we discuss stature in the evolutionary-genetic sense of the word, we do not mean that one “has stature”, and the other “doesn’t have stature”. What we mean is that they have different stature, one is taller and the other is shorter.

2. Please also notice that in a specific organism, generation, and environment being tall might has “adaptive” advantage, and in some other organism, generation, and environment being short has “adaptive advantage”. The thing that is advantageous for one organism, is not necessarily advantageous for another organism,
3. Now that I have said this, I should say another thing too. In evolutionary discussions, we should avoid using words that contain “value judgment”. Advantage and disadvantage are not appropriate words. Think that we have measured a trait, and we get different values for different individuals.
4. I am opposed, strongly, to the sentence that comes before reference 108, and I consider it a misconception. First, reference 108 is Darwin’s book, and it is not clear to me where in that book I will find the sentences that support such a statement. I argue that the expression “economy of nature” is completely different from “teleonomy”. Second, even if Darwin himself meant such a thing, he has made a mistake; current science does not support such a statement. Third, teleological language and words of Aristotelian understanding, might be use sloppily even today, but neither Darwin, nor modern science are teleological. Fourth, natural selection acts on temporary needs and has no long-term aim or purpose. If temporarily a “direction” is observed in natural selection, it is just temporary, an artifact. With the slightest change in environment, the direction will change. Fifth, and allusion to the evolution being progressive or upward, is just fairy tale.
5. Natural selection by itself is a kind of non-random mating. In any case, in the classic texts non-random matings are discussed separately from selection.
6. For those interested (!) I should say my PhD thesis from 1995 was about non-random matings.

The central concept of natural selection is the evolutionary fitness of an organism.[110] Fitness is measured byan organism's ability to survive and reproduce, which determines the size of its genetic contribution to the next generation.[110] However, fitness is not the same as the total number of offspring: instead fitness is indicated by the proportion of subsequent generations that carry an organism's genes.[111] For example, if an organism could survive well and reproduce rapidly, but its offspring were all too small and weak to survive, this organism would make little genetic contribution to future generations and would thus have low fitness.[110]

If an allele increases fitness more than the other alleles of that gene, then with each generation this allele will become more common within the population. These traits are said to be "selected *for*." Examples of traits that can increase fitness are enhanced survival and increased fecundity. Conversely, the lower fitness caused by having a less beneficial or deleterious allele results in this allele becoming rarer—they are "selected *against*."[112] Importantly, the fitness of an allele is not a fixed characteristic; if the environment changes, previously neutral or harmful traits may become beneficial and previously beneficial traits become harmful.[64] However, even if the direction of selection does reverse in this way, traits that were lost in the past may not re-evolve in an identical form (see Dollo's law).[113][114] However, a re-activation of dormant genes, as long as they have not been eliminated from the genome and were only suppressed perhaps for hundreds of generations, can lead to the re-occurrence of traits thought to be lost like hind legs in dolphins, teeth in chickens, wings in wingless stick insects, tails and additional nipples in humans etc.[115] "Throwbacks" such as these are known as atavisms.

1. In this article, the fitness of “one” allele has been mentioned several times. However, the example of “one” allele must be extended to a large number of alleles and loci. Please remember that Darwinian-evolutionary “fitness” is the product of survival and fertility, each of which has many components, and each component is under the influence of many loci.

Natural selection within a population for a trait that can vary across a range of values, such as height, can be categorised into three different types. The first is directional selection, which is a shift in the average value of a trait over time—for example, organisms slowly getting taller.[116] Secondly, disruptive selection is selection for extreme trait values and often results in two different values becoming most common, with selection against the average value. This would be when either short or tall organisms had an advantage, but not those of medium height. Finally, in stabilising selection there is selection against extreme trait values on both ends, which causes a decrease in variance around the average value and less diversity.[107][117] This would, for example, cause organisms to eventually have a similar height.

1. To visualize different kinds of selection, consider distribution of a trait as in a bell-shaped normal distribution. With the right definition, and with the right statistical transformation, almost any trait can be shown with a normal distribution curve.
2. In evolutionary jargon "over time" means "over many generations".
3. Directional selection is the selection of individuals that form one (or the other) end of the distribution.
4. Disruptive selection the selection of individuals that form both ends of the distribution.
5. Stabilizing selection is the selection of individuals that form the middle of distribution.

Natural selection most generally makes nature the measure against which individuals and individual traits, are more or less likely to survive. "Nature" in this sense refers to an ecosystem, that is, a system in which organisms interact with every other element, physical as well as biological, in their local environment. Eugene Odum, a founder of ecology, defined an ecosystem as: "Any unit that includes all of the organisms in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles (i.e., exchange of materials between living and nonliving parts)within the system."[118] Each population within an ecosystem occupies a distinct niche, or position, with distinct relationships to other parts of the system. These relationships involve the life history of the organism,its position in the food chain and its geographic range. This broad understanding of nature enables scientists to delineate specific forces which, together, comprise natural selection.

1. This paragraph increases the likelihood of the Wiki writers to have ecology background. Consequently, their genetical inaccuracies becomes more understandable. Please notice that geneticists do not have monopoly over evolution and evolution can be studied from many scientific perspectives.
2. The word "niche" is a habitat that has been "empty", and then becomes "occupied". Consider a river with a depth of two meters, with a variety of plants and animals living in it. Then because a natural event (such as a landslide) or an unnatural event (such as humans building a dam) a lake is created with a depth of 100 meters. The depth of this newly formed lake are at first empty. Those plant and animal species that can adapt to the empty spaces have occupied it. Therefore, "niche" is an empty habitat that becomes populated very quickly. This also happens in human society. For example, soon after "mobile phone" was invented, many individuals moved their businesses to this new niche.
3. "Life history" is a central concept in ecology.

Natural selection can act at different levels of organisation, such as genes, cells, individual organisms, groups of organisms and species.[119][120][121] Selection can act at multiple levels simultaneously.[122] An example of selection occurring below the level of the individual organism are genes called transposons, which can replicate and spread throughout a genome.[123] Selection at a level above the individual, such as group selection, may allow the evolution of cooperation.[124]

Genetic hitchhiking

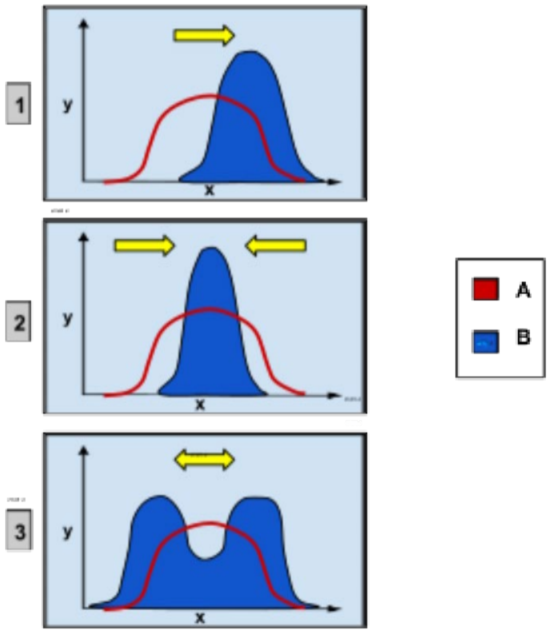
Recombination allows alleles on the same strand of DNA to become separated. However, the rate of recombination is low (approximately two events per chromosome per generation). As a result, genes close together on a chromosome may not always be shuffled away from each other and genes that are close together tend to be inherited together, a phenomenon known as linkage.[125] This tendency is measured by finding how often two alleles occurtogether on a single chromosome compared to expectations, which is called their linkage disequilibrium. A set of alleles that is usually inheritedin a group is called a haplotype. This can be important when one allele in a particular haplotype is strongly beneficial: natural selection can drive a selective sweep that will also cause the other alleles in the haplotype to become more common in the population;this effect is called genetic hitchhiking or genetic draft.[126] Genetic draft caused by the fact that some neutral genes are genetically linked to others that are under selection can be partially captured by an appropriate effective population size.[127]

1. Sometimes nagging is good for your mental health. If I were going to write about genetic linkage, I would probably would not go back in time further than 1920s (!) and the works of people like Morgan. Referring to reference number 125, published in 2000, whose main subject is not linkage, is a bit strange. Is this the publication that the Wiki writer first learned about linkage?
2. To consider genetic hitchhiking and genetic drift as one concept, as has been mentioned here is wrong, definitely wrong. In reference number 126, the size of their effects have been compared, but they are not considered the same concept. This is just a misunderstanding. You can compare the effect of tens of processes on allele And genotype frequencies, and it does not mean that those processes are the same.
3. The last sentence of this paragraph is in conflict with the claim that genetic hitchhiking and genetic drift are the same. Reference number 127 also disagrees with the Wiki writers claim. In the abstract of reference 127 you can read: "Moreover, these rates are only weakly dependent on population size, again contrary to the strong dependency of drift-based dynamics."
4. General conclusion is that Wiki writers have misunderstood these concepts.
5. The difference of opinion between Wiki writers and myself is a natural part of scientific discussions. If we were going to conduct this discussion outside of Wikipedia, we would have referred to more experiments, equations, numbers, and statistical analyses. In any case, science is about building theories, refuting them, and building better theories. Each new theory reduces our ignorance a little bit, and adds a lot to our questions.

Sexual selection

A special case of natural selection is sexual selection,which is selection for any trait that increases mating success by increasing the attractiveness of an organism to potential mates.[128] Traits that evolved through sexual selection are particularly prominent among males of several animal species. Although sexually favoured, traits such as cumbersome antlers, mating calls, large body size and bright colours often attract predation, which compromises the survival of individual males.[129][130] This survival disadvantage is balanced by higher reproductive success in males that show these hard-to-fake, sexually selected traits.[131]

1. Darwin's definition of sexual selection was selection for traits that were supposed to be unrelated to fitness. Of course, later it was shown that the examples used by him or others could have been fitness related, though a more elaborate mechanism. To use sexual selection for fitness related traits or not may be considered a matter of taste!



These charts depict the different types of genetic selection. On each graph, the x-axis variable is the type of phenotypic trait and the y-axis variable is thenumber of organisms. Group A is the original population and Group B is the population after selection.
Graph 1 shows directional selection, in which asingle extreme phenotype is favoured.
Graph 2 depicts stabilizing selection, where the intermediate phenotype is favoured over the extremetraits.
Graph 3 shows disruptive selection, in which theextreme phenotypes are favoured over the intermediate.

Genetic drift

Genetic drift is the random fluctuations of allele frequencies within a population from one generation to the next.[132] When selective forces are absent or relatively weak, allele frequencies are equally likely to *drift* upward or downward at each successive generation because the alleles are subject to sampling error.[133] This drift halts when an allele eventually becomes fixed, either by disappearing from the population or replacing the other alleles entirely. Genetic drift may therefore eliminate some alleles from a population due to chance alone. Even in the absence of selective forces, genetic drift can cause two separate populations that began with the same genetic structure to drift apart into two divergent populations with different sets of alleles.[134]

1. Definition of genetic drift has been referred to Chapter 3 of reference number 132. The right chapter is actually Chapter 7.
2. It now seems to me that "genotype frequency" has been totally ignored in this article. My recommendation is for you to think also about "genotype frequency" very time "allele frequency" is mentioned.

The neutral theory of molecular evolution proposed that most evolutionary changes are the result of the fixation of neutral mutations by genetic drift.[135] Hence, in this model, most genetic changes in a population are the result of constant mutation pressure and genetic drift.[136] This form of the neutral theory is now largely abandoned, since it does not seem to fit the genetic variation seen in nature.[137][138] However, a more recent and better-supported version of this model is the nearly neutral theory,where a mutation that would be effectively neutral in a small population is not necessarily neutral in a large population.[107] Other alternative theories propose that genetic drift is dwarfed by other stochastic forces in evolution, such as genetic hitchhiking, also known as genetic draft.[133][127][139]

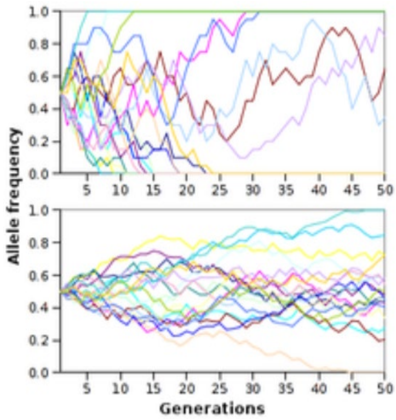
1. With all due respect, I must say there are so many confusions in this paragraph that I do not know how to start!
2. First a linguistic comment: Playing with the words "drift" and "draft", is as silly as it can get. It reminds me of something that Ernst Mayr had said once. In my wording it was: "If we were to invent a new term

for any slight modification in a concept, we would be flooded by new terms".

3. My opinion about Neutral Mutation Theory is what I have said before. Here, I should say that the findings in one branch of science might take many years to reach scientists in other branches! I will explain this in more detail in Point 7 below.
4. To misunderstand other scientist's findings and writings is also common, not to mention the occasions that views of other scientists are misrepresented so that they can be refuted more easily!
5. We should not forget that scientists are also humans, with all the flaws that all humans have. A scientist may think he/she can achieve prominence if he/she can refute the theories of another (great) scientist. Just like the fame that Darwin achieved after refuting the theories of his predecessors, or Kimura that put limit to the extension of Darwin's theories to molecular evolution. Therefore, it is natural that many claims about refuting previous theories may be made. The fate of most of such claims is similar to what Kimura has predicted for alleles (!): most of such claims have no effect (are neutral), some are slightly deleterious, and occasionally they might improve our understanding.
6. The above point is the key success factor for "science". No one achieves prominence by just approving previous scientists' theories. However, doubting previous theories, and attempt to refute them leads to continuous scientific progress. Here lies the wisdom in knowing that "all scientific theories are wrong", but it takes time to refute them. In addition, here is wisdom in knowing that "all scientific theories are useful for a short time or a few phenomena".
7. In any case, here the Neutral Mutation Theory is the victim of a misunderstanding. Another Japanese scientist, Ohta, who has had a lot of cooperation with Kimura, has maintained from 1971 that nearly neutral mutations or slightly deleterious mutations can be included in the Kimura's original Neutral Mutation Theory from 1968. Kimura's book from 1983 includes discussions about this. It seems that Wiki writers are not so familiar with Ohta's views. [Is it because Ohta is a woman? Do not be a chauvinist pig!]
8. In my opinion, the concept of "genetic hitchhiking" can easily be explained by the old quantitative genetic concept of genetic correlation and correlated response to selection. It can also be easily handled with the old population concept of linkage disequilibrium. There is no need for so much acrobatics that Wiki writers are using. In any case, genetic hitchhiking is not genetic drift, and there is no other random process than genetic drift.

The time for a neutral allele to become fixed by genetic drift dependson population size, with fixation occurring more rapidly in smaller populations.[140] The number of individuals in a population is not critical, but instead a measure known as the effective population size.[141] The effective population is usually smaller than the total population since it takes into account factors such as the level of inbreeding and the stage of the lifecycle in which the population is thesmallest.[141] The effective population size may not be the same for every gene in the same population.[142]

1. Effective population size is a key and important concept in both population and quantitative genetics. In the same way that heritability had one conceptual definitions and four operational definitions, effective population size has one conceptual definition, and probably tens of operational definitions. The conceptual definition can be seen in the following funny sentence: "Effective population size of a real population is the number of individuals in an idealized population that leads to the same inbreeding coefficient as in the real population"! Opening up this definition and explaining all the operational definition needs hundreds (if not thousands) of pages.
2. In the above paragraph, the Wiki writers wanted to say is that, one of the operational definitions of effective population size depends on the mating structure and family size variance in a generation. In addition, the effective population size across generations depends on the geometric mean of effective population size in different generation.



Simulation of genetic drift of 20 unlinked alleles in populations of 10(top) and 100 (bottom). Drift to fixation is more rapid in the smallerpopulation.

It is usually difficult to measure the relative importance of selection and neutral processes, including drift.[143] The comparative importance of adaptive and non-adaptive forces in driving evolutionary change is an area of current research.[144]

1. Being neutral and being subjected to genetic drift are partially independent. Any allele, irrespective of its effect being positive or negative, is subject to genetic drift in small populations.
2. First, please notice that reference number 144 was published in 2005, and cannot indicate the trends in 2021. Second, comparison of different evolutionary forces has been a hot research topic in the last 160 years!!

Gene flow

Gene flow involves the exchange of genes between populations and between species.[99] The presence or absence of gene flow fundamentally changes the course of evolution. Due to the complexity of organisms, anytwo completely isolated populations will eventually evolve genetic incompatibilities through neutral processes,as in the Bateson-Dobzhansky-Muller model, even if both populations remain essentially identical in terms of their adaptation to the environment.

If genetic differentiation between populations develops, gene flow between populations can introduce traits or alleles which are disadvantageous in the local population and this may lead to organisms within these populations evolving mechanisms that prevent mating with genetically distant populations, eventually resulting in the appearance of new species. Thus, exchange of genetic information between individuals is fundamentallyimportant for the development of the *Biological Species Concept* (BSC).

During the development of the modern synthesis, Sewall Wright developed his shifting balance theory, which regarded gene flow between partially isolated populations as an important aspect of adaptive evolution.[145] However, recently there has been substantial criticism of the importance of the shifting balance theory.[146]

1. Wright's first publication in this area is from 1932.
2. Reference number 146 which has been branded as "recently" was published in 1997 (23-24 years ago?).

Mutation bias

Mutation bias is usually conceived as a difference in expected rates for two different kinds of mutation, e.g., transition-transversion bias, GC-AT bias, deletion-insertion bias. This is related to the idea of developmental bias.

1. Again, Wiki writers have gone into details without explaining the basics.
2. There are four types of nucleobases in DNA. Two of them have a single cycle Cytosine (C), and Thymine (T), and are among Pyrimidine bases. The other two are Adenine (A), and Guanine (G) and are among

Purine bases.

3. The “transition-transversion bias” is the difference between mutations within the Pyrimidine and within the Purine groups, or mutations from one group to the other.
4. The “GC-AT bias” is related to the difference in the content of G and C bases, compared to the A and T bases.
5. The “deletion-insertion bias”, probably more commonly written as “insertion-deletion bias”, is the addition or deletion of a segment of chromosome. The length of chromosome segment can be from one nucleotide and up to millions of them.
6. In my opinion, discussing the subject of mutation bias is to go into unnecessary and unimportant subjects. If all subjects of equal relevance were going to be included, then this article should be thousands of pages. As an example, reference number 3, which is a book of more than 700 pages, does not mention mutation bias at all.

Haldane[147] and Fisher[148] argued that, because mutation is a weak pressure easily overcome by selection, tendencies of mutation would be ineffectual except under conditions of neutral evolution or extra ordinarily high mutation rates. This opposing-pressures argument was long used to dismiss the possibility of internal tendencies in evolution,[149] until the molecular era prompted renewed interest in neutral evolution.

1. This paragraph is in disagreement with some previous paragraphs, and is problematic from another point of view.
2. Wiki writers have rejected two versions of evolution by neutral mutations before (Wright, 1932; and Kimura, 1968). Now, they are re-introducing it in a vague form.
3. More importantly, up to here nothing about “internal tendencies in evolution” had been mentioned. It is not clear what, or who, the sources of these internal tendencies are. Are these at the locus, individual, or population level? How do they work? Are they teleological? A problem of such claims is that those who make these claims do not have a clear stance against Lamarck, or the tendencies that Lamarck’s God has placed in the essence every living being! In my ears and eyes, the claims of “internal tendencies” is very similar to the “natural theology” of 17th, 18th, and the first half of 19th centuries.
4. The other problem of this paragraph is that it tries to explain variation at levels of biological complexity with one theory. In some levels, for some traits (in the widest meaning of the word) and some tempo-spatial conditions one theory is useful, and at others conditions other theories are useful.
5. May I remind that in modern physics we still do not have a theory that can explain all four forces of the nature (weak, strong, electromagnetism, and gravity). Not to mention the possibility of the yet unknown fifth force). The equivalent of such theory does not exist in biology or evolution.

Noboru Sueoka[150] and Ernst Freese[151] proposed that systematic biases in mutation might be responsible for systematic differences in genomic GC composition between species. The identification of a GC-biased *E.coli* mutator strain in 1967,[152] along with the proposal of the neutral theory, established the plausibility of mutational explanations for molecular patterns, which are now common in the molecular evolution literature.

For instance, mutation biases are frequently invoked in models of codon usage.[153] Such models also include effects of selection, following the mutation-selection-drift model,[154] which allows both for mutation biases and differential selection based on effects on translation. Hypotheses of mutation bias have played an important role in the development of thinking about the evolution of genome composition, including isochores.[155] Different insertion vs. deletion biases in different taxa can lead to the evolution of different genome sizes.[156][157] The hypothesis of Lynch regarding genome size relies on mutational biases toward increase or decrease in genome size.

1. In my opinion, the Wiki writers have lost the “red thread” in the last few paragraphs.

However, mutational hypotheses for the evolution of composition suffered a reduction in scope when it was discovered that (1) GC-biased gene conversion makes an important contribution to composition in diploid organisms such as mammals[158] and (2) bacterial genomes frequently have AT-biased mutation.[159]

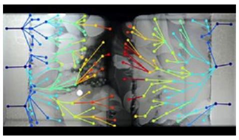
Contemporary thinking about the role of mutation biases reflects a different theory from that of Haldane and Fisher. More recent work[149] showed that the original "pressures" theory assumes that evolution is based on standing variation: when evolution depends on the introduction of new alleles, mutational and developmental biases in the introduction can impose biases on evolution *without requiring neutral evolution or high mutation rates*.

1. I am remembering some important points!
2. Bengt Molander, a Swedish philosopher of science says [in my words] “scientists use the methods that they want”. What he means that the scientists are not usually too concerned about the opinions of philosophers about how the research should be conducted. I agree with Molander. It is good if scientists are aware of what philosophers say about philosophy of science, but they do not need to be so fussy about it. After all, the tradition is that the scientists do what they do, and then philosophers of science “theorize” what scientists have done.
3. However, it is absolutely necessary that scientist, as soon as possible, learn about “argumentation analysis”, which might be considered a part of logic. Otherwise, they will misunderstand other scientists’ writings, misrepresent them, and attack them in a wrong way. They even will defend their own views in a wrong way, if they are weak in understanding of “argumentation analysis”.
4. Referring to Fisher and Haldane reminded me that natural selection is a two-step process. In the first step, because of mutation and its spread, a standing phenotypic variation becomes available in the population. In the second step, the degree of adaptation of these phenotypes with their immediate environment, leads to different values of fitness (survival x fertility). Any scientist, Darwin, Fisher, or Haldane, may be wrong about one of these two steps, without being wrong about the other step. It is not necessary that explanations of the different components of a complex process should be dependent on each other. For example, Darwin had a wrong view on formation of genetic variation. Did his wrong view on genetics any relationship with his views on adaptation to environment or fitness? No! It did not!
5. Therefore, my recommendation to you is to stop whatever you are doing, and learn “argumentation analysis”.
6. Many of the paragraphs of this Wikipedia article and full of arguments that the deductions / conclusions have very weak connections to the premises.
7. What Fisher and Haldane have said about “formation of standing variation” has nothing to do with their views on the “effect of standing variation” or “selection on standing variation”.

Several recent studies report that the mutations implicated in adaptation reflect common mutation biases[160][161][162] though others dispute this interpretation.[163]

Outcomes

Evolution influences every aspect of the form and behaviour of organisms. Most prominent are the specific behavioural and physical adaptations that are the outcome of natural selection. These adaptations increase fitness by aiding activities suchas finding food, avoiding predators or attractingmates. Organisms can also respond to selection by cooperating with each other, usually by aiding theirrelatives or engaging in mutually beneficial symbiosis. In the longer term, evolution produces new species through splitting ancestral populations of organisms into new groups that cannot or will not interbreed.



A visual demonstration of rapid antibiotic resistanceevolution by *E. coli* growing across a plate with increasing concentrations of trimethoprim.[164]

These outcomes of evolution are distinguished basedon time scale as macroevolution versus microevolution. Macroevolution refers to evolution that occurs at or above the level of species, in particular speciation and extinction; whereas microevolution refers to smaller evolutionary changes within a species orpopulation, in particular shifts in allele frequency and adaptation.[165] In general, macroevolution is regardedas the outcome of long periods of microevolution.[166] Thus, the distinction between micro- and macroevolution is not a fundamental one—the difference is simply the time involved.[167] However, in macroevolution, the traits of the entire species may be important. For instance, a large amount of variation among individuals allows a species to rapidly adapt to new habitats, lessening the chance of it going extinct, while a wide geographic range increases the chance of speciation, by making it more likely that part of the population will become isolated. In this sense, microevolution and macroevolution might involve selection atdifferent levels—with microevolution acting on genes and organisms, versus macroevolutionary processes such as species selection acting on entire species and affecting their rates of speciation and extinction.[168][169][170]

1. Not writing a comment is a sign of agreement with the text!
2. Referring to reference 168 reminded me that I have been regretful while reading only one book, and half-regretful while reading only one book. The book that I read half-regretfully was reference number 168, Gould's approximately 1500-page book!

A common misconception is that evolution has goals, long-term plans, or an innate tendency for "progress", as expressed in beliefs such as orthogenesis and evolutionism; realistically however, evolution has no long-termgoal and does not necessarily produce greater complexity.[171][172][173] Although complex species have evolved, they occur as a side effect of the overall number of organisms increasing and simple forms of life stillremain more common in the biosphere.[174] For example, the overwhelming majority of species are microscopic prokaryotes, which form about half the world's biomass despite their small size,[175] and constitute the vast majority of Earth's biodiversity.[176] Simple organisms have therefore been the dominant form of life on Earth throughout its history and continue to be the main form of life up to the present day, withcomplex life only appearing more diverse because it is more noticeable.[177] Indeed, the evolution of microorganisms is particularly important to modern evolutionary research, since their rapid reproduction allowsthe study of experimental evolution and the observation of evolution and adaptation in real time.[178][179]

1. Evolutionism refers to some ideas from 18th and 19th centuries that considered living beings capable of changing by will!
2. Understanding the phrase "side effect of the overall number of organisms increasing" is not easy. However, I hope you do your best to understand it.

Adaptation

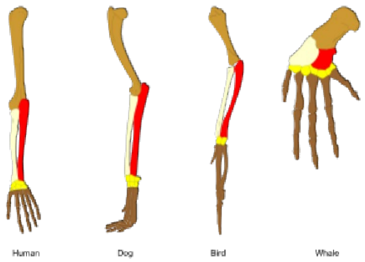
Adaptation is the process that makes organisms better suited to their habitat.[180][181] Also, the term adaptationmay refer to a trait that is important for an organism's survival. For example, the adaptation of horses' teeth to the grinding of grass. By using the term *adaptation* for the evolutionary process and *adaptive trait* for the product (the bodily part or function), the two senses of the word may be distinguished. Adaptations are produced by natural selection.[182] The following definitions are due to Theodosius Dobzhansky

1. Let me do a little bit of hair-splitting, and say that the first sentence is about change in the constitution and composition of populations over many generations, i.e. the frequency of different alleles, genotypes, and frequencies change. An individual organism has the same alleles and genotypes throughout its life, which does not change.

- *Adaptation* is the evolutionary process where by an organism becomes better able to live in its habitat or habitats.[183]
- *Adaptedness* is the state of being adapted: thedegree to which an organism is able to live andreproduce

in a given set of habitats.[184]

- An *adaptive trait* is an aspect of the developmental pattern of the organism which enables orenhances the probability of that organism surviving and reproducing.[185]

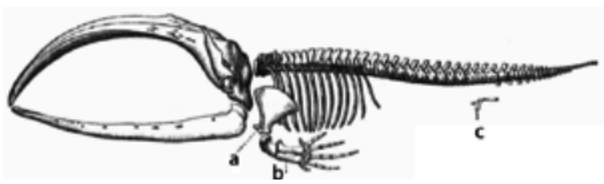


Homologous bones in the limbs of tetrapods. The bones of these animals have the same basic structure, but have been adapted for specific uses.

Adaptation may cause either the gain of a new feature, or the loss of an ancestral feature. An example that shows both types of change is bacterial adaptation to antibiotic selection, with genetic changes causing antibiotic resistance by both modifying the target of the drug, or increasing the activity of transporters that pump the drug out of the cell.[186] Other striking examples are the bacteria *Escherichia coli* evolving the ability to use citric acid as a nutrient in a long-term experiment,[187] *Flavobacterium* evolving a novel enzyme that allows these bacteria to grow on the by-products of nylon manufacturing,[188][189] and thesoil bacterium *Sphingobium* evolving an entirely new metabolic pathway that degrades the synthetic pesticide pentachlorophenol.[190][191] An interesting but still controversial idea is that some adaptations might increasethe ability of organisms to generate genetic diversity and adapt by natural selection (increasing organisms' evolvability).[192][193][194][195][196]

1. For the people working with plant and animal breeding the subject of evolvability is quite understandable, because the genetic coefficient of variation varies quite a lot across families.
2. In the last phrase "increasing organisms' evolvability", using the word organism is not appropriate, and should be changed to species.

Adaptation occurs through the gradual modification of existing structures. Consequently, structures with similar internal organisation may have different functions inrelated organisms. This is the result of a single ancestral structure being adapted to function in different ways. Thebones within bat wings, for example, are very similar to those in mice feet and primate hands, due to the descent of all these structures from a common mammalian ancestor.[198] However, since all living organisms are related to some extent,[199] even organs that appear to have little or no structural similarity, such as arthropod, squid and vertebrate eyes, or the limbs and wings of arthropods and vertebrates, can depend on a common setof homologous genes that control their assembly and function; this is called deep homology.[200][201]



A baleen whale skeleton. Letters *a* and *b* label flipper bones, which were adapted from front legbones, while *c* indicates vestigial leg bones, bothsuggesting an adaptation from land to sea.[197]

During evolution, some structures may lose their original function and become vestigial structures.[202] Such structures may have little or no function in a current species, yet have a clear function in ancestral species, or other closely related species. Examples include pseudogenes,[203] the non-functional remains of eyes in blind cave-dwelling fish,[204] wings in flightless birds,[205] the presence of hip bones in whales and snakes,[197] and sexual traits in organisms that reproduce via asexual reproduction.[206] Examples of vestigial structures in humans include wisdom teeth,[207] the coccyx,[202] the vermiform appendix,[202] and other behavioural vestiges such as goose bumps[208][209] and primitive reflexes.[210][211][212]

However, many traits that appear to be simple adaptations are in fact exaptations: structures originally adapted for one function, but which coincidentally became somewhat useful for some other function in the process.[213] One example is the African lizard *Holaspis guentheri*, which developed an extremely flat head for hiding in crevices, as can be seen by looking at its near relatives. However, in this species, the head has become so flattened that it assists in gliding from tree to tree—an exaptation.[213] Within cells, molecular machines such as the bacterial flagella[214] and protein sorting machinery[215] evolved by the recruitment of several pre-existing proteins that previously had different functions.[165] Another example is the recruitment ofenzymes from glycolysis and xenobiotic metabolism to serve as structural proteins called crystallins within the lenses of organisms' eyes.[216][217]

1. The word "exaptation" is the short for "ex adaptation".
2. Even this paragraph is probably going into unimportant details.

An area of current investigation in evolutionary developmental biology is the developmental basis of adaptations and exaptations.[218] This research addresses the origin and evolution of embryonic developmentand how modifications of development and developmental processes produce novel features.[219] These studies have shown that evolution can alter development to produce new structures, such as embryonic bone structures that develop into the jaw in other animals instead forming part of the middle ear in mammals.[220] It is also possible for structures that have been lost in evolution to reappear due to changes in developmental genes, such as a mutation in chickens causing embryos to grow teeth similar to those of crocodiles.[221] It is now becoming clear that most alterations in the form of organisms are due to changes in a small set of conserved genes.[222]

Coevolution

Interactions between organisms can produce both conflict and cooperation. When the interaction is between pairs of species, such as a pathogen and a host, or a predator and its prey, these species can develop matched sets of adaptations. Here, the evolution of one species causes adaptations in a second species. These changesin the second species then, in turn, cause new adaptations in the first species. This cycle of selection and response is called coevolution.[223] An example is the production of tetrodotoxin in the rough-skinned newt and the evolution of tetrodotoxin resistance in its predator, the common garter snake. In this predator-prey pair, an evolutionary arms race has produced high levels of toxin in the newt and correspondingly high levels of toxin resistance in the snake.[224]

Common garter snake (*Thamnophissirtalis sirtalis*) has evolved resistance to the defensive substance tetrodotoxin in its amphibian prey.

Cooperation

Not all co-evolved interactions between species involve conflict.[225] Many cases of mutually beneficial interactions have evolved. For instance, an extreme cooperation exists between plants and the mycorrhizal fungi that grow on their roots and aid the plant inabsorbing nutrients from the soil.[226] This is a reciprocal relationship as the plants provide the fungi with sugars from photosynthesis. Here,the fungi actually grow inside plant cells, allowing them to exchange nutrients with their hosts, while sending signals that suppress the plant immune system.[227]

Coalitions between organisms of the same species have also evolved. An extreme case is the eusociality foundin social insects, such as bees, termites and ants, where sterile insects feed and guard the small number of organisms in a colony that are able to reproduce. On an even smaller scale, the somatic cells that make up the body of an animal limit their reproduction so they can maintain a stable organism, which then supports a small number of the animal's germ cells to produce offspring. Here, somatic cells respond to specific signals that instruct them whether to grow, remain as they are, or die. If cells ignore these signals and multiply inappropriately, their uncontrolled growth causes cancer.[228]

Such cooperation within species may have evolved through the process of kin selection, which is where one organism acts to help raise a relative's offspring.[229] This activity is selected for because if the *helping* individual contains alleles which promote the helping activity, it is likely that its kin will *also* contain these alleles and thus those alleles will be passed on.[230] Other processes that may promote cooperation include group selection, where cooperation provides benefits to a group of organisms.[231]

1. A simpler explanation of kin selection, which also applies to altruism, is that if an individual sacrifices itself to ensure the survival of appropriate number of relatives, then its inclusive fitness (its contribution to future generations) increases.
2. Such models, first presented by Hamilton (1964), can also be used to explain the start and evolution of morality.

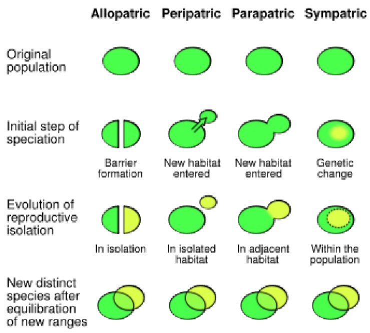
Speciation

Speciation is the process where a species diverges into two or more descendant species.[232]

There are multiple ways to define the concept of "species." The choice of definition is dependent on the particularities of the species concerned.[233] For example, some species concepts apply more readily toward sexually reproducing organisms while others lend themselves better toward asexual organisms. Despite the diversity of various species concepts, these various concepts can be placed into one of three broad philosophical approaches: interbreeding, ecological and phylogenetic.[234] The *Biological Species Concept* (BSC) is a classic example of the interbreeding approach. Defined by evolutionary biologist Ernst Mayr in 1942, the BSC states that "species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups."[235] Despite its wide and long-term use, the BSC like others is not without controversy, for example because these concepts cannot be applied to prokaryotes,[236] and this is called the species problem.[233] Some researchers have attempted a unifying monistic definition of species, while others adopt a pluralistic approach and suggest that there may be different ways to logically interpret the definition of a species.[233][234]

1. As it has been mentioned above, the “biological species concept” is the most common definition. However, it can sometimes encounter funny problems. For example, in the modern industrial populations of turkey the body size sexual dimorphism has become so large that natural mating is almost impossible, and the mode of reproduction is through artificial insemination. Should we consider the two sexes as to different species?!

Barriers to reproduction between two diverging sexual populations are required for the populations to become new species. Gene flow may slow this process by spreading the new genetic variants also to the other populations. Depending on how far two species have diverged since their most recent common ancestor, it may still be possible for them to produce offspring, as with horses and donkeys mating to produce mules.[237] Such hybrids are generally infertile. In this case, closely related species may regularly interbreed, but hybrids will be selectedagainst and the species will remain distinct. However, viable hybrids are occasionally formedand these new species can either have propertiesintermediate between their parent species, or possess a totally new phenotype.[238] The importance of hybridisation in producing new species of animals is unclear, although cases have been seen in many types of animals,[239] with the gray tree frog being a particularly well-studied example.[240]



The four geographic modes of speciation

1. Please notice that the word "mode", after a book called "Tempo and Mode in Evolution" by G. G. Simpson (1944) has its special connotation in evolutionary studies.

peciation has been observed multiple times under both controlled laboratory conditions (see laboratory experiments of speciation) and in nature.[241] In sexually reproducing organisms, speciation results from reproductive isolation followed by genealogical divergence. There are four primary geographic modes of speciation. The most common in animals is allopatric speciation, which occurs in populations initially isolated geographically, such as by habitat fragmentation or migration. Selection under these conditions can produce very rapid changes in the appearance and behaviour of organisms.[242][243] As selection and drift act independently on populations isolated from the rest of their species, separation may eventually produce organisms that cannot interbreed.[244]

The second mode of speciation is peripatric speciation, which occurs when small populations of organisms become isolated in a new environment. This differs from allopatric speciation in that the isolated populationsare numerically much smaller than the parental population. Here, the founder effect causes rapid speciation after an increase in inbreeding increases selection on homozygotes, leading to rapid genetic change.[245]

1. There is a little bit of inaccuracy and mixing up in this paragraph.
2. "Inbreeding" should be considered a process. Unfortunately, the pattern caused by the process of inbreeding is also called "inbreeding"! To distinguish between these two, it is better to use the term "inbreeding coefficient" for the pattern.
3. The "founder effect" is the direct effect of small size of population that leads to increase homozygosity. However, this has no relationship to selection. Even in this paragraph, no reason for the necessity of selection has been presented.
4. The start of peripatric speciation does not need selection, even though selection would increase the speed of divergence
5. Now, I do not remember where I have read something to the following effect: "Evolution is all about patterns and processes, and processes and patterns". [Could it be from Simpson?]

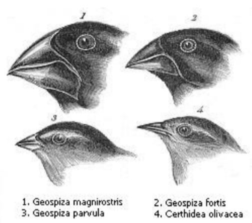
The third mode is parapatric speciation. This is similar to peripatric speciation in that a small population entersa new habitat, but differs in that there is no physical separation between these two populations. Instead, speciation results from the evolution of mechanisms that reduce gene flow between the two populations.[232] Generally this occurs when there has been a drastic change in the environment within the parental species' habitat. One example is the grass *Anthoxanthum odoratum*, which can undergo parapatric speciation in response to localised metal pollution from mines.[246] Here, plants evolve that have resistance to high levels ofmetals in the soil. Selection against interbreeding with the metal-sensitive parental population produced a gradual change in the flowering time of the metal-resistant plants, which eventually produced complete reproductive isolation. Selection against hybrids between the two populations may cause reinforcement, whichis the evolution of traits that promote mating within a species, as well as character displacement, which is whentwo species become more distinct in appearance.[247]

Finally, in sympatric speciation species diverge without geographic isolation or changes in habitat. This form israre since even a small amount of gene flow may remove genetic differences between parts of a population.[248] Generally, sympatric speciation in animals requires the evolution of both genetic differencesand nonrandom mating, to allow reproductive isolation to evolve.[249]

1. The claim that sympatric speciation is not common is not necessarily entirely accurate. I do not want to go into the details, but one sort of non-random mating called assortative mating can quickly lead to divergence in a population. A simple example of assortative mating is mating in the flowering plants, i.e. those flowering in the early season mate with each other, and those flowering in late season mate with each other. In this example, the "flowering time" is the trait the primary reason of assortative mating. In other species and populations, it could be other traits. The trait under assortative mating can be stature, weight, color, or any other trait.
2. Dobzhansky has argued that in Wright's shifting balance theory, and in a fitness landscape, assortative mating would allow a population in a local fitness peak to pass through a fitness valley, to reach another local or global fitness peak.
3. In my own simulation studies from mid-1990s, positive assortative mating could lead to a divergence of 4.5 standard deviation in 25 generation. Such a difference is enough to cause pre-mating isolation in a population.

One type of sympatric speciation involves crossbreeding of two related species to produce a new hybrid species. This is not common in animals as animal hybrids are usually sterile. This is because during meiosis the homologous chromosomes from each parent are from different species and cannot successfully pair. However, it is more common in plants because plants often double their number of chromosomes, to form polyploids.[250] This allows the chromosomes from each parental species to form matching pairs during meiosis, since each parent's chromosomes are represented by a pair already.[251] An example of such a speciation event is when the plant species *Arabidopsis thaliana* and *Arabidopsis arenosa* crossbred to give the new species*Arabidopsis suecica*.[252] This happened about 20,000 years ago,[253] and the speciation process has been repeated in the laboratory, which allows the study of the genetic mechanisms involved in this process.[254] Indeed, chromosome doubling within a species may be a common cause of reproductive isolation, as half the doubled chromosomes will be unmatched when breeding with undoubled organisms.[255]

1. Explaining these points, without first explaining the cell division processes, and the polyploidy phenomena, can be confusing.
2. Arabidopsis thaliana is used in genetics and evolution as an experimental species like fruit fly, and mice.



Finches from Galapagos Archipelago

Geographical isolation of finches on the Galápagos Islands produced over a dozennew species.

1. Finches from Galapagos Islands could be considered the facto triggering Darwin's thoughts on evolution. After his return from his 5-year journey aboard H. M. S. Beagle, Darwin learned from his ornithologist fried, Hooker, that his finches were different species. Darwin started to wonder how an ancestral population from mainland South America could have become several species.

Speciation events are important in the theory of punctuated equilibrium, which accounts for the pattern in the fossil record ofshort "bursts" of evolution interspersed with relatively long periods of stasis, where species remain relatively unchanged.[256] In this theory, speciation and rapid evolutionare linked, with natural selection and genetic drift acting most strongly on organisms undergoing speciation in novel habitats or small populations. As a result, the periods of stasis in the fossil record correspond to the parental population and the organisms undergoing speciation and rapid evolution are found in small populations or geographically restricted habitats and therefore rarely being preserved as fossils.[169]

1. The description of the "punctuated equilibrium" is this paragraph is a so "mild" version that even I can accept it! As mentioned before, this theory was first presented by Eldredge and Gould (1972) in a version that was not much stronger than the one presented here.
2. The evidence behind this theory, briefly described, is as follows: If we look at the fissile records of a species, we will observe that the species does not change significantly over long periods, and "suddenly" fossils of a new species appear.
3. So far so good. The problem started when Gould started to extend his ideas to the genetic changes of the living populations of those fossil records, and claimed that their evolution has been in "jumps", and not gradual (which had been claimed to be by the modern synthesis). Gradually some people started to believe Gould's views to the point that Gould and some of his followers claimed that a new paradigm had been formed. Unfortunately, some of the philosophers of science (e.g. Michael Ruse) agreed that punctuated equilibrium fulfils the requirements of being a new paradigm. I must say that I disagree with Gould and with Ruse. I expressed my disagreement in a short message to Ruse some years ago (his response to me can be discussed on a different occasion). Unfortunately, Gould passed away in 2002, before his 62nd birthday, and I lost the opportunity of discussion this matter with him.
4. I am opposed to many of Gould's views, and believe his misunderstandings are rooted in his weak knowledge of population, quantitative, and biochemical genetics. Nevertheless, and but, Gould must have been of the greatest minds of all times. The breadth of his knowledge and the spread of his study material are unparalleled. It was a pity that he left us so soon.

Extinction

Extinction is the disappearance of an entire species. Extinction is not an unusual event, as species regularly appear through speciation and disappear through extinction.[257] Nearly all animal and plant speciesthat have lived on Earth are now extinct,[258] and extinction appears to be the ultimate fate of all species.[259] These extinctions have happened continuously throughout the history of life, although the rate of extinction spikes in occasional mass extinction events.[260] TheCretaceous–Paleogene extinction event, during which the non-avian dinosaurs became extinct, is the most well-known, but the earlier Permian–Triassic extinction event was even more severe, with approximately 96% of all marine species driven to extinction.[260] The Holocene extinction event is an ongoing mass extinction associated with humanity's expansion across the globe over the past few thousand years. Present-day extinction rates are 100–1000 times greater than the background rate and up to 30% of current species may be extinct by the mid 21st century.[261]Human activities are now the primary cause of the ongoing extinction event;[262] [263] global warming may further accelerate it in the future.[264] Despite the estimated extinction of more than 99 percent of all species that ever lived on Earth,[265][266] about 1 trillion species are estimated to be on Earth currently with only one-thousandth of one percent described.[267]

1. The number "1 trillion" that has been mentioned here is much larger than the numbers that I have usually encountered (about 5-50 million).

Tyrannosaurus rex. Non-avian dinosaurs died out in the Cretaceous–Paleogene extinction event at the end of the Cretaceous period.

The role of extinction in evolution is not very well understood and may depend on which type of extinction is considered.[260] The causes of the continuous "low-level" extinction events, which form the majority of extinctions, may be the result of competition between species for limited resources (the competitive exclusion principle).[56] If one species can out-compete another, this could produce species selection, with the fitter species surviving and the other species being driven to extinction.[120] The intermittent mass extinctions are also important, but instead of acting as a selective force, they drastically reduce diversity in a nonspecific manner and promote bursts of rapid evolution and speciation in survivors.[268]

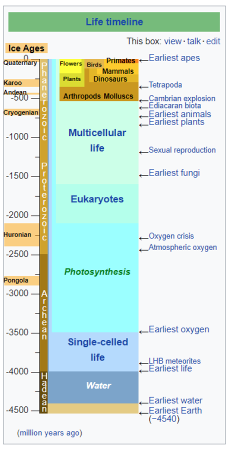
1. Please notice that "competition between species for limited resources" does not mean that members of one species are killed by members of another species. In such cases, death or infertility because of food shortage and starvation is more important than being hunted.

Evolutionary history of life

Origin of life

Further information: Abiogenesis, Earliest known life forms, Panspermia, and RNA world hypothesis

The Earth is about 4.54 billion years old.[269][270][271] The earliest undisputed evidence of life on Earth dates from at least 3.5 billion years ago,[13][272] during the Eoarchean Era after a geological crust started to solidify following the earlier molten Hadean Eon. Microbial mat fossils have been found in 3.48 billion-year-old sandstone in Western Australia.[15][16][17] Other early physical evidence of a biogenic substance is graphite in 3.7 billion-year-old metasedimentary rocks discovered in Western Greenland[14] as well as "remains of biotic life" found in 4.1 billion-year-old rocks in Western Australia.[273][274] Commenting on the Australian findings, Stephen Blair Hedges wrote, "If life arose relatively quickly on Earth, then it could be common in the universe."[273][275] In July 2016, scientists reported identifying a set of 355 genes from the last universal common ancestor (LUCA) of all organisms living on Earth.[276]



More than 99 percent of all species, amounting to over five billion species,[277] that ever lived on Earth are estimated to be extinct.[265][266] Estimates on the number of Earth's current species range from 10 million to

14 million,[278][279] of which about 1.9 million are estimated to have been named[280] and 1.6 million documented in a central database to date,[281] leaving at least 80 percent not yet described.

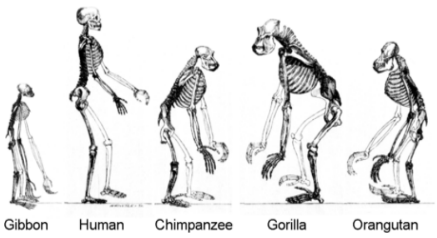
1. You realize that the number of species in this paragraph is different from had been said above.
2. This show the Wiki writers have been more than one person and each one of them has written a part, without paying attention to other parts!

Highly energetic chemistry is thought to have produced a self-replicating molecule around 4 billion years ago, and half a billion years later the last common ancestor of all life existed.[11] The current scientific consensus is that the complex biochemistry that makes up life came from simpler chemical reactions.[282][283] The beginning of life may have included self-replicating molecules such as RNA[284] and the assembly of simple cells.[285]

Common descent

All organisms on Earth are descended from a common ancestor or ancestral gene pool.[199][286] Current species are a stage in the process of evolution, with their diversity the product of a long series of speciation andextinction events.[287] The common descent of organisms was first deduced from four simple facts about organisms: First, they have geographic distributions that cannot be explained by local adaptation. Second, thediversity of life is not a set of completely unique organisms, but organisms that share morphological similarities. Third, vestigial traits with no clear purpose resemble functional ancestral traits. Fourth, organisms can be classified using these similarities into a hierarchy of nested groups, similar to a family tree.[288]

Modern research has suggested that, due to horizontal gene transfer, this "tree of life" may be more complicated than a simple branching tree since some genes have spread independently between distantly related species.[289][290] To solve this problem and others, some authors prefer to use the "Coral of life" as a metaphor or a mathematical model to illustrate theevolution of life. This view dates back to an idea briefly mentioned by Darwin but later abandoned. [291]



The hominoids are descendants of a commonancestor.

Past species have also left records of their evolutionary history. Fossils, along with thecomparative anatomy of present-day organisms, constitute the morphological, or anatomical, record.[292] By comparing the anatomies of both modern and extinct species, palaeontologists can infer the lineages of those species. However, this approach is most successful for organisms that had hard body parts, such as shells, bones or teeth. Further, as prokaryotes suchas bacteria and archaea share a limited set of common morphologies, their fossils do not provide informationon their ancestry.

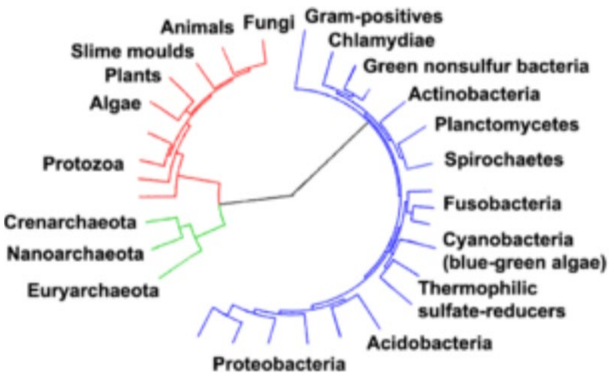
More recently, evidence for common descent has come from the study of biochemical similarities between organisms. For example, all living cells use the same basic set of nucleotides and amino acids.[293] The development of molecular genetics has revealed the record of evolution left in organisms' genomes: dating when species diverged through the molecular clock produced by mutations.[294] For example, these DNA sequence comparisons have revealed that humans and chimpanzees share 98% of their genomes and analyzing the few areas where they differ helps shed light on when the common ancestor of these species existed.[295]

Evolution of life

Prokaryotes inhabited the Earth from approximately 3–4 billion years ago.[297][298] No obvious changes in morphology or cellular organisation occurred in these organisms over the next few billion years.[299] The eukaryotic cells emerged between 1.6 and 2.7 billion years ago. The next major change in cell structure came when bacteria were engulfed by eukaryotic cells, in a cooperative association called endosymbiosis.[300][301] The engulfed bacteria and the host cell then underwent coevolution, with the bacteria evolving into either mitochondria or hydrogenosomes.[302] Another engulfment of cyanobacterial-like organisms led to the formation of chloroplasts in algae and plants.[303]

The history of life was that of the unicellular eukaryotes, prokaryotes and archaea until about 610 million yearsago when multicellular organisms began to appear in the oceans in the Ediacaran period.[297][304] The evolution of multicellularity occurred in multiple independent events, in organisms as diverse as sponges, brown algae, cyanobacteria, slime moulds and myxobacteria.[305] In January 2016, scientists reported that, about 800 million years ago, a minor genetic change in a single molecule called GK-PID may have allowed organisms to go from a single cell organism to one of many cells.[306]

Soon after the emergence of these first multicellular organisms, a remarkable amount of biological diversity appeared over approximately 10 million years, in an event called the Cambrian explosion. Here, the majority of types of modern animals appeared in the fossil record, as well as unique lineages that subsequently became extinct.[307] Various triggers for the Cambrian explosion havebeen proposed, including the accumulation of oxygenin the atmosphere from photosynthesis.[308]



Evolutionary tree showing the divergence of modern species from their common ancestor in the centre.[296]The three domains are coloured, with bacteria blue, archaea green and eukaryotes red.

About 500 million years ago, plants and fungi colonised the land and were soon followed by arthropods and other animals.[309] Insects were particularly successful and even today make up the majority of animal species.[310] Amphibians first appeared around 364 million years ago, followed by early amniotes and birds around 155 million years ago (both from "reptile"-like lineages), mammals around 129 million years ago, homininae around 10 million yearsago and modern humans around 250,000 years ago.[311][312][313] However, despite the evolution of these large animals, smaller organisms similar to the types that evolved early in this process continue to be highly successful and dominate the Earth, with the majority of both biomass and species being prokaryotes.[176]

Application

Concepts and models used in evolutionary biology, such as natural selection, have many applications.[314]

Artificial selection is the intentional selection of traits in a population of organisms. This has been used for thousands of years in the domestication of plants and animals.[315] More recently, such selection has become a vital part of genetic engineering, with selectable markers such as antibiotic resistance genes being used to manipulate DNA. Proteins with valuable properties have evolved by repeated rounds of mutation and selection(for example modified enzymes and new antibodies) in a process called directed evolution.[316]

1. I had mentioned before that “Sometimes nagging is good for your mental health”! Now, I should add, “sometimes cursing and calling names is good for indigestion!” The above paragraph that starts with the two words “artificial selection” shows the depth of Wiki writers’ ignorance. 15000 years of artificial selection in domestication of animals and plants, and 270 years of scientific animal and plant breeding has been reduced to the gibberish written in the above paragraph.
2. The above paragraph also shows that Wiki writers have not read Darwin’s book to learn how much value had Darwin given to the work of breeders. Wiki writers also do not know that Fisher was employed in an agricultural research station (Rothamsted), and Wright worked until his first retirement in USDA. It is a shame that such ignorant people dare to write in Wikipedia.

Understanding the changes that have occurred during an organism's evolution can reveal the genes needed to construct parts of the body, genes which may be involved in human genetic disorders.[317] For example, the Mexican tetra is an albino cavefish that lost its eyesight during evolution. Breeding together different populations of this blind fish produced some offspring with functional eyes, since different mutations had occurred in the isolated populations that had evolved in different caves.[318] This helped identify genes required for vision and pigmentation.[319]

1. I repeat again: if “organism” in the first sentence is referring to one single individual, then that sentence is wrong. Evolution does not occur in one specimen! Evolution happens in populations through many generations.

Evolutionary theory has many applications in medicine. Many human diseases are not static phenomena, but capable of evolution. Viruses, bacteria, fungi and cancers evolve to be resistant to host immune defences, as well as pharmaceutical drugs.[320][321][322] These same problems occur in agriculture with pesticide[323] and herbicide[324] resistance. It is possible that we are facing the end of the effective life of most of available antibiotics[325] and predicting the evolution and evolvability[326] of our pathogens and devising strategies to slow or circumvent it is requiring deeper knowledge of the complex forces driving evolution at the molecular level.[327]

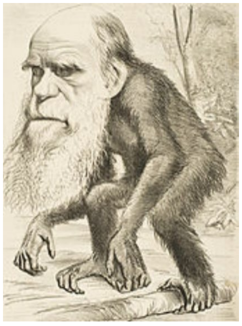
In computer science, simulations of evolution using evolutionary algorithms and artificial life started in the 1960s and were extended with simulation of artificial selection.[328] Artificial evolution became a widely recognised optimisation method as a result of the work of Ingo Rechenberg in the 1960s. He used evolution strategies to solve complex engineering problems.[329] Genetic algorithms in particular became popular through the writing of John Henry Holland.[330] Practical applications also include automatic evolution of computer programmes.[331] Evolutionary algorithms are now used to solve multi-dimensional problems more efficiently than software produced by human designers and also to optimise the design of systems.[332]

1. If the above paragraph were written now, it would have contained machine learning and artificial intelligence.

Social and cultural responses

In the 19th century, particularly after the publication of *On the Origin of Species* in 1859, the idea that life had evolved was an active source of academic debate centred on the philosophical, social and religious implications of evolution. Today, the modern evolutionary synthesis is accepted by a vast majority of scientists.[56] However, evolution remains a contentious concept for some theists.[334]

While various religions and denominations have reconciled their beliefs withevolution through concepts such as theistic evolution, there are creationists who believe that evolution is contradicted by the creation myths found in theirreligions and who raise various objections to evolution.[165][335][336] As had been demonstrated by responses to the publication of *Vestiges of the NaturalHistory of Creation* in 1844, the most controversial aspect of evolutionary biology is the implication of human evolution that humans share common ancestry with apes and that the mental and moral faculties of humanity have the same types of natural causes as other inherited traits in animals.[337] In some countries, notably the United States, these tensions between science andreligion have fuelled the current creation–evolution controversy, a religious conflict focusing on politics and public education.[338] While other scientificfields such as cosmology[339] and Earth science[340] also conflict with literal interpretations of many religious texts, evolutionary biology experiences significantly more opposition from religious literalists.



As evolution became widelyaccepted in the 1870s, caricatures of Charles Darwin with an ape or monkey body symbolised evolution.[333]

The teaching of evolution in American secondary school biology classes was uncommon in most of the first half of the 20th century. The Scopes Trial decision of 1925 caused the subject to become very rare in American secondary biology textbooks for a generation, but it was gradually re-introduced later and became legally protected with the 1968 *Epperson v. Arkansas* decision. Since then, the competing religious belief of creationism was legally disallowed in secondary school curricula in various decisions in the 1970s and 1980s,but it returned in pseudoscientific form as intelligent design (ID), to be excluded once again in the 2005 *Kitzmiller v. Dover Area School District* case.[341] The debate over Darwin's ideas did not generate significant controversy in China.[342]

1. I Have made no attempt to go through the following parts of the Wikipedia article on evolution.
2. Neither have I tried to make the formatting more pleasing to the eye.

See Also

Argument from poor design
Biological classification
Evidence of common descent
Evolution in Variable Environment
Evolutionary anthropology
Evolutionary ecology
Evolutionary epistemology
Evolutionary neuroscience
Evolution of biological complexity
Evolution of plants
Project Steve
Timeline of the evolutionary history of life
Universal Darwinism

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