

19th Century Ideas about Evolution

Various theories of evolution, and a growing
consensus on the facts of evolution

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Various theories of evolution

By Darwin's time, most naturalists accepted that there had been some changes in biological species. However, even if we accept that there has been change in species throughout the history of the earth, we might have several different theories about how this change occurred.

All of the theories advanced before Darwin argued for some kind of **directed change**, in some sense *responding to* and hence *directly influenced by* the environment and the actions of organisms.

Darwin tried to distinguish his theories from these by arguing that evolutionary changes was based only on **naturally occurring processes** – processes that are still occurring around us now. In fact, however, by the end of the 19th century, most naturalists still thought of evolution as an essentially directed process.

The theory of evolution by *natural selection*

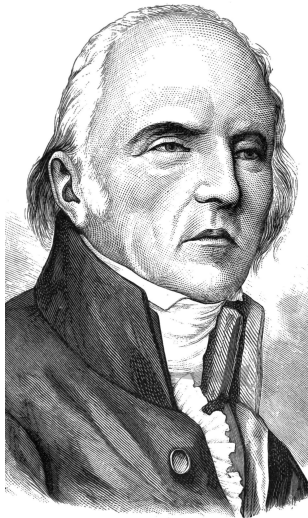
The theory of evolution by natural selection is a **theory** about the *mechanism by which* evolution occurred in the past, and is still occurring now. The basic theory was developed by both Darwin and Wallace, however, Darwin gave a much fuller **argument**.

The Theory of Evolution by *Natural Selection*

The theory states that biological change takes place with two basic characteristics:

- 1) **Variation:** *Random variations* occur in the traits of individual organisms and are passed on to their offspring.
- 2) **Struggle for existence:** There is an existential competition that insures *advantageous traits are preserved* and *disadvantageous traits are eliminated*.

Jean-Baptiste Lamarck (1744–1829)



- Born to an impoverished aristocratic family with a military history.
- Had a brief military career before taking up medicine and natural history.
- Worked at the Jardin du Roi (Jardin des Plantes).
- Developed a theory of evolution, with which we now generally disagree, called *Lamarckian evolution*.
- Until the 1930s, Lamarckian views of evolution were more common among biologists than Darwinian views.

Lamarck, The complexifying force

Lamarck believed that all organisms have a *natural tendency* towards greater **complexity** – a sort of directed progress. He held that spontaneous generation is always producing simple organisms, which then naturally become gradually more complex, through the action of a natural force.

Lamarck, *Histoire naturelle des animaux sans vertebres*, 1815

“The rapid motion of fluids will etch canals between delicate tissues. Soon their flow will begin to vary, leading to the emergence of distinct organs. The fluids themselves, now more elaborate, will become more complex, engendering a greater variety of secretions and substances composing the organs.”

That is, there is an *internal force*, active in the organism, that interacts with the environment to produce more complex forms.

Lamarck, The adaptive force

Lamarck, *Philosophie Zoologique*, 1809

“First Law: In every animal which has not passed the limit of its development, a more frequent and continuous use of any organ gradually strengthens, develops and enlarges that organ, and gives it a power proportional to the length of time it has been so used; while the permanent disuse of any organ imperceptibly weakens and deteriorates it, and progressively diminishes its functional capacity, until it finally disappears.

Second Law: All the acquisitions or losses wrought by nature on individuals, through the influence of the environment in which their race has long been placed, and hence through the influence of the predominant use or permanent disuse of any organ; all these are preserved by reproduction to the new individuals which arise, provided that the acquired modifications are common to both sexes, or at least to the individuals which produce the young.”

Lamarck, force of habit and acquired characteristics

Lamarck argued that an individual organism's habits throughout its life produced changes in its physical structure, which it then passed on to its offspring.

Lamarck, *Philosophie Zoologique*, 1809

"It is interesting to observe the result of habit in the peculiar shape and size of the giraffe: This animal, the largest of the mammals, is known to live in the interior of Africa in places where the soil is nearly always arid and barren, so that it is obliged to browse on the leaves of trees and to make constant efforts to reach them. From this habit long maintained in all its race, it has resulted that the animal's front legs have become longer than its hind legs, and that its neck is lengthened to such a degree that the giraffe, without standing up on its hind legs, attains a height of six meters..."

Comparative anatomy

The great comparative anatomists of the 19th century generally did not believe in evolution – instead arguing that there had been successive periods of creation. They produced the field known as **descriptive morphology**, which greatly expanded the evidential basis of the debate.

Georges Cuvier (1769–1832), at the Musée d'Histoire Naturelle de Paris, organized the animal kingdom into four phyla – *vertebrata*, *mollusca*, *articulata*, and *radiata* – and argued that each had their own hierarchies from simple to more complex. He worked to complete Linnaeus' project of filling in the taxonomy of living things, and – having proven that certain fossils belonged to extinct species – he included these in his organization. His work was continued by naturalists such as Louis Agassiz (1807–1873) and Richard Owen (1804–1892), who carried out meticulous dissection and extended this type of analysis-by-form to many species.

The *Vestiges of the Natural History of Creation* was first published anonymously in 1844, although it eventually became clear that the author was Robert Chambers, a Scottish bookseller and publisher. *Vestiges* was very popular, and went through 12 editions.

The book proposes a cosmic theory of *transformation*: the solar system, earth, rocks, plants and corals, fish, land plants, reptiles and birds, mammals and finally human beings are all the result of natural processes according to *internal forces* ordained by God – but not continuously acted upon and maintained by God.

Vestiges, 1844–1884

“To a reasonable mind the Divine attributes must appear, not diminished or reduced in some way, by supposing a creation by law, but infinitely exalted.”

Malthus's social ideas



From the end of the 18th century, the rising industrialism in Britain created a massive growth of urban poor. This led to the rise of poverty as a social problem and to various attempts to address it. In 1798, Thomas Malthus (1766–1834) published his *Essay on the Principle of Population*.

Malthus argued that human population increases **geometrically**, while food supplies increase **arithmetically**. This means that at some point, population growth will always outstrip food supplies and there will be a **struggle for existence**, especially among the poor. Thus, Malthus saw the conditions of poverty, *which had been created by the Industrial Revolution*, as a necessary fact of the human condition.

Charles Darwin (1809–1882)

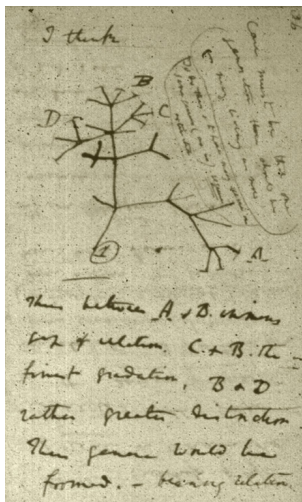
- 5th child of a wealthy, agnostic doctor.
- Started in medicine, then graduated from Cambridge to be a pastor, but felt no sense of vocation.
- Took the opportunity to pay his own way as a naturalist on a surveying expedition: 5 years on *HMS Beagle*.
- Became a respected member of the British scientific elite.
- After 20 years, published his ideas about transformation (evolution).
- Was almost always sick with various psychosomatic disorders.
- Worked endlessly on scientific projects until the day he died.



The voyage of the *Beagle*

- While on the voyage of the *Beagle*, Darwin read the three volumes of Lyell's *Principles of Geology*.
- He collected thousands of specimens of plants and animals and carried out extensive studies of the geography of South America and various Pacific islands.
 - He came to believe that the Andes were formed over long periods of time, by the landmass slowly rising and the seas receding.
 - He became convinced that the atolls of Pacific islands were produced by the coral growing as the mountains sank.
- In Tierra Del Fuego, he observed native people living in the wild and became convinced that humans are not so far removed from animals and show great diversity amongst themselves.
- In the Galapagos Islands, he observed considerable diversity but he collected erratically and did not consistently tag by island.

Secret notebooks



Darwin's first sketch of his concept of speciation

When he returned to England, he sent out all of his specimens to be cataloged by experts.

- John Gould, ornithologist, realized that all of the different types of birds that Darwin had collected on the Galapagos were different species of finches.

Darwin began to keep a series of *secret notebooks* in which he wrote his ideas about the “**transmutation**” of species. From the beginning, he was interested in the origin of life and the human species.

During this time, he read Malthus' *Essay* – which provided a key idea for the mechanism for evolution.

Becoming respectable

After returning from the voyage of the Beagle, Darwin began to publish his ideas about the geography of South America, handbooks of the flora and fauna of the places he visited and an account of his travels. He wrote a definitive work on barnacles.

He made a name for himself as a naturalist and became a friend and colleague of many of the most important naturalists in England.

Occasionally, he would try to interest someone in his ideas about **transmutation**, but few were convinced.

Because Darwin was himself a member of the social elite, he tried to distance himself from other evolutionists, such as Lamarck and Chambers. Also, his wife was very religious.

- At this time, in Britain, evolution was regarded as a dangerous idea, associated with France, the revolution, and social and political unrest.

Alfred Russel Wallace (1823–1913)

A.R. Wallace was a British naturalist, explorer, geographer, anthropologist, and biologist, best known for having proposed, independently from Darwin, a theory of evolution by natural selection. He was from a poor middle-class family and struggled financially most of his life. He worked as a carpenter, a teacher and surveyor. He went on a number of long expeditions as a naturalist, supporting himself by selling the specimens he collected.

He read avidly, including Lyell, Malthus, *Vestiges* and Darwin's early works. Wallace already believed in the transmutation of species when he traveled as a naturalist – he was simply trying to work out the mechanism by which it functioned. Indeed, Wallace was interested in many non-conventional ideas and wrote about life on other planets, spiritualism, and a non-material origin of mental faculties.

Wallace and natural selection

By the late 1850s, Wallace was convinced of the reality of evolution, and he was looking for a mechanism. According to his autobiography, while he was in bed with a fever on a South East Asian island, he began to think about Malthus's essay, and he came up with the idea of natural selection – although he did not use that expression.

In the late 1850s, he started a correspondence with Darwin, and in the course of this he sent Darwin a draft of his paper titled "On the Tendency of Varieties to Depart Indefinitely From the Original Type," 1858. Darwin forwarded this paper to Lyell and Joseph Hooker (1817–1911), who decided that it should be published with some of Darwin's writings in the journal of the Linnean Society of London. No one took any notice of this publication.

The Origin of Species, 1859–1872

When Darwin had realized that the established scientists were not interested in his ideas, he began to cultivate the friendship of younger men who were on the rise such as Thomas Huxley (1825–1895) and J. Hooker. Over a period of many years, through correspondence, he tried to convince them of his ideas.

In the 1850s, after a short correspondence with Wallace, Darwin mentioned some of his ideas about natural selection. This led to Wallace sending Darwin a short paper in which he had independently described a theory of evolution by natural selection.

After they both published their ideas in the journal of the Linnean Society, 1858, Darwin went on to spend over a year developing a full argument for his position, which was published as *On the Origin of Species*, 1859.

The Origin of Species: Variation (Chaps. 1 & 2)

Chap. 1: Darwin pointed out that animal breeders artificially select preferred characteristics from domestic populations (pigeons, cows, dogs, etc.) in which there is a lot of random variation.

Over many generation these small differences produce very different types of animals (varieties of the same species).

Chap. 2: Darwin argued that a similar *selection occurs* in nature.

He then began to discuss the **nature of species**. He pointed out that it is often hard to demarcate between species – it is hard to decide what are different *species* as opposed to different *varieties*.

He argued that we could think of well-marked varieties as “incipient species” – that is, newly forming, or emerging.

The Origin of Species: Struggle for existence (Chap. 3)

Chap. 3: Darwin argued that individual organisms and species are all in a **struggle for existence**.

- This was contrary to the prevailing view of natural theology – that nature was harmonious and showed evidence of a beneficent creator.

Instead, Darwin claimed that life is a complex struggle – not always dramatically violent, as in predators and prey, but usually more subtle, as a plant struggling against drought, or the introduction of new species into a habitat, etc.

He argued that this struggle then resulted in what he called “natural selection.” In the 6th edition of the book, he adopted the terminology of Herbert Spencer and referred to the “survival of the fittest.”

The struggle for existence

The Origin of Species, 1872 (6th edition)

“A **struggle for existence** inevitably follows from the high rate at which all organic beings tend to increase. Every being...must suffer destruction during some period of its life...otherwise, on the principle of geometrical increase, its numbers would quickly become so inordinately great that no country could support the product. Hence, as more individuals are produced than can possibly survive, there must in every case be a **struggle for existence**, either one individual with another of the same species, or with the individuals of distinct species, or with the physical conditions of life. It is the **doctrine of Malthus** applied with manifold force to the whole animal and vegetable kingdoms; for in this case there can be no artificial increase of food...”

The Origin of Species: Natural selection (Chap. 4)

Chap. 4: In this chapter, Darwin explains the core of his theory:

- Nature varies, randomly.
- Some of variations are more advantageous than others.
- Because there is a struggle for existence, any advantage will be important, *however slight*.
- In the long run, those organisms that have a slight innate advantage will survive more often than those who do not, passing on their advantages to their offspring.

Through this mechanism, Darwin argued that a **population** will change by the accumulation of small, but favorable advantages, over *vast periods of time*.

Again, he referred to artificial selection, calling natural selection “unconscious artificial selection.” But notice that nature does **not** chose preferred traits in the way that a breeder does.

Natural selection

The Origin of Species, 1868 (5th edition), Introduction

“Owing to this struggle [for existence], variations, however slight and from whatever cause proceeding, if they be in any degree profitable to the individuals of a species, in their infinitely complex relations to other organic beings and to the physical conditions of life, will tend to the preservation of such individuals, and will generally be inherited by the offspring. The offspring, also, will thus have a better chance of surviving, for, of the many individuals of any species which are periodically born, but a small number can survive. I have called this principle, by which each slight variation, if useful, is preserved, by the term **Natural Selection**, in order to mark its relation to man’s power of selection. But the expression often used by Mr. Herbert Spencer of the **Survival of the Fittest** is more accurate, and is sometimes equally convenient.”

The Origin of Species: Natural selection (Chap. 4), II

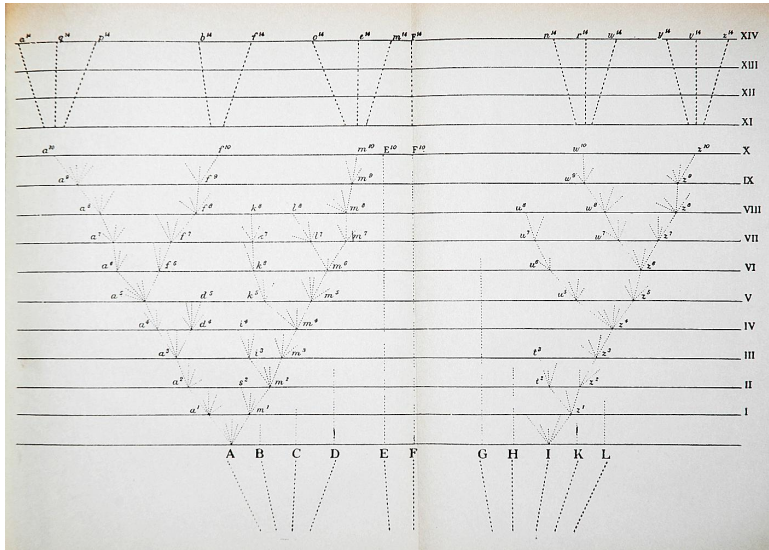
Darwin also introduced another selection process, which he called **sexual selection**. This is the long term result of individuals of the same sex competing against one another for sexual partners. Darwin emphasized the role of males competing and females choosing.

- For example, the bright plumage of a male bird seems to be non-adaptive, but it is adapted to sexual competition.

Finally, he discusses how natural selection explains the evolution from a common ancestor by divergence. This discussion includes the only diagram in the book.

- The extremes of a varying population are selected for, because they have a greater chance of finding a new niche to exploit.
- The more similar organisms are to each other, the greater the competition and the struggle, because they typically occupy the same niche.

Darwin's concept of divergence



The diagram represents divergence against time, as earth strata

The initial reaction

The *Origin* was a very popular book, and went through six editions from 1859 to 1872. Darwin tapped into the thinking of the time and pitched evolution as a form of progress similar to the progress of the English nation that his contemporaries perceived. England was no longer as conservative as it had been when he was young and a belief in social progress using science and industry fit well with the evolutionary idea of biological progress.

Literal interpretations of the Bible were coming under increasing criticism and many were prepared to be convinced of the *fact of biological evolution*.

Darwin's close supporters, such as Huxley, Hooker and Lyell, were influential and helped Darwin carry out the social aspect of the argument for evolution.

The reaction to natural selection

Although the *Origin* convinced many naturalists of the fact of evolution, most remained skeptical about the theory of **natural selection**. People raised the following objections:

- It is random and open-ended.
- Is not a goal directed process.
 - Where the goal was *implicitly* understood as white, Victorian, upper-class males.
- It does not imply directed progress.
 - This was a challenge to the establishment and to the mercantile values of the rising middle class.
- Is not an open system, as in Lamarck's theory. That is, individuals cannot improve themselves throughout the course of their lives and pass on these improvements.

Most naturalists of the 1870s and 80s became evolutionists, and even called themselves Darwinists, but did not accept **natural selection**, which was the core of Darwin's theory.

The religious reaction

Darwin's ideas gave a profound shock to the religious establishment, and to the naturalists who supported it with the theory of **natural theology**. Darwin's theory was perceived as being much more difficult to reconcile with a creative, all powerful god, than those of Copernicus, Galileo or Newton.

If we take natural selection seriously it is difficult to see how a god could have created *us*, and hence it is difficult to see how we could have any special place in god's creation.

There were a number of public disputes between religious authorities, older naturalists and the Darwinists.

- Bishop Wilberforce and Huxley at the British Association for the Advancement of Science (BAAS) meeting.
- There was an ongoing debate in newspapers and journals.

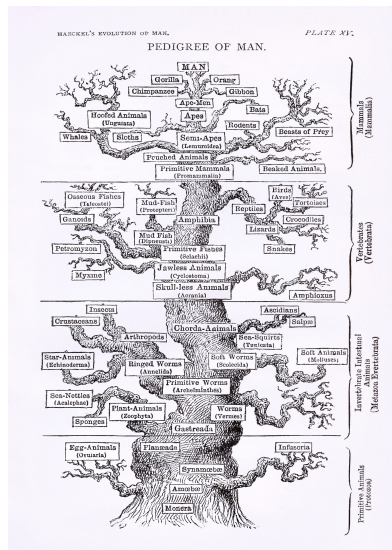
A number of naturalists argued for "theistic evolution," and even many of Darwin's friends, such as Lyell and Wallace, could not fully accept the natural selection of human beings.

Darwinists without natural selection

Even many people who supported Darwin, did not accept, or understand, natural selection.

For example, Herbert Spencer (1820–1903), used Darwin's ideas to explain human progress towards fitter individuals – a very progressivist view of evolution.

Ernst Haeckel (1834–1919), an avid Darwinist, thought that evolution unfolded according to a plan, like embryonic development (“ontogeny recapitulates phylogeny”).



Haeckel's "Tree of Life"

Evolutionists but not Darwinists

From the end of the 19th century, until the 1930s or 40s, the majority of naturalists believed in a guided, or progressive evolution. There were good reasons for this. At the time, physical scientists did not believe that the earth could be old enough to support the kind of time that natural selection required.

Biologists developed ideas of evolution that incorporated various aspects of Lamarckism with directed evolution – what was called **orthogenesis**. In general, these naturalists believed that the natural world, and the fossil record, revealed a trend that was too regular to be compatible with a mechanism based on random variation. They also pointed to various non-adaptive characteristics as evidence that there was some sort of guiding principle underlying evolutionary variation, as evidenced by the tendency of an organ to develop in a certain way even when it was no longer adaptive.

Lamarckian Darwinists

In the minds of the general educated public, Lamarckism and Darwinism were the same, and we often read expressions like the “Lamarckian-Darwinian theory.”

For example, in the philosophical work of Ernst Kapp (1808–1996), we read the following passage:

Kapp, *Elements of a Philosophy of Technology* (1877)

“The Lamarckian theory of descent, revived and adapted by Darwin, is *the* scientific issue of the day.”

It would only be in retrospect after the modern synthesis of the 1930s and 40s, that it would become clear to a broader public that there are great differences between these two theories.

- Throughout the 19th century, there were a number of theories of evolution that were advanced.
- The theory of evolution by natural selection was advanced by both Wallace and Darwin, but Darwin's argument was much more developed, and he was seen as the primary exponent.
- Although there was considerable debate, by the end of the century most naturalists were convinced of the empirical fact of evolution.
- Nevertheless, most naturalists were non-Darwinists about the mechanisms of evolution, focusing on theories that combined Lamarckism and orthogenesis.