

Evolution: The Darwinian Revolutions

BIOEE 2070 / HIST 2870 / STS 2871

DAY & DATE: Thursday 5 July 2012

READINGS:

- Darwin/*Origin of Species*, chapters 11 through 14
- MacNeill/*Evolution: The Darwinian Revolutions* chapters 1-4
- Ruse/*Darwin and Design: Does Evolution Have a Purpose?* chapters 5 & 6

Lecture 6:00-7:50: Conclusion and Summary of the *Origin of Species*

Section 8:00-9:00: Discussion of reactions to Darwin's theory

Announcements:

- **The Course Packet is currently available at the course website.**

Just point your web browser to <http://evolution.freehostia.com> and check it out. The “Course Packet” section of the website requires a password to access the documents. The password is:

evolutioncp

- **ESSAY #1 IS DUE MONDAY (Monday 9 July 2012)!**

You may submit your essay via email up to 6 PM next Monday without penalty. Please submit your essay via email to me or your TA in MicroSoft Word .doc format, and for safety's sake paste a copy of your paper into the body of your email. If you can't submit via email or you want an extension, just talk to me or your TA this evening.

Darwin on Variation

Darwin begins his presentation of his views on variation with this statement:

- "Our ignorance of the laws of variation is profound." ([*Origin of Species*, 1st ed., pg 167/Wilson, pg 557](#))

Neither Darwin nor any of his contemporaries (that he knew of) had a coherent theory of heredity or variation. In a coincidence of history, [Gregor Mendel](#) had published his [theory of heredity](#) at about the same time, but Darwin either never read it (the journal in which it was published was available only in German, and was of limited distribution) or didn't understand its importance to his own work. Consequently Darwin could propose no theory of heredity or variation, nor could he suggest how it might affect his conclusions.

However, this was not an insuperable obstacle to Darwin. Instead of giving up his argument, he simply accepted as a given that many important traits of animals and plants *are* heritable (pointing again to the observable facts of inheritance in domesticated animals and plants). He also proposed that, although he had no explanation of how they arose, **variations among the members of a species do indeed occur**, and can provide the raw material for natural selection.

- Darwin pointed out on pages [134 to 139 of the *Origin*](#) that although use and disuse could produce characteristics that were inherited (an assertion that later geneticists disproved), such changes do **not** account for most of the variation we observe among the members of most species.

Darwin also stressed that "**correlation of growth**" ([pages 143-150](#)) **could produce peculiar side-effects when only certain traits were subjected to selection:**

- "Hence we see that modifications of structure, viewed by systematists as of high value, may be wholly due to unknown laws of correlated growth, and without being, as far as we can see, of the slightest service to the species. ([*Origin of Species*, 1st ed., pg 146/Wilson, pg 543](#))

In other words, selection for traits controlled by genes that have more than one phenotypic effect can produce considerable variation between the individuals in populations, which may serve as raw material for selection.

Difficulties with Darwin's Theories

The Problem of Convergent Characters

Darwin pointed out that [convergent evolution](#) (i.e. adaptation to similar environmental pressures) could result in traits that appeared very similar in unrelated organisms. This could lead observers to false assumptions about common ancestry and phylogenetic lineages. He suggested that **it would be more useful to focus attention on non-adaptive characteristics, especially when determining phylogenetic relationships** (i.e. constructing evolutionary "family trees").

- This was a foresighted suggestion on Darwin's part. Ever since Darwin, [taxonomists](#) have concentrated on non-adaptive characters to classify organisms. This is especially true today; [molecular taxonomy](#) (based on DNA and other nucleic acid sequences) is based primarily on [non-coding nucleotide sequences and satellite DNA](#). This is because [coding sequences](#) tend to be conserved over time, whereas non-coding sequences tend to diverge randomly at predictable rates.

Darwin Answers His Critics

As he states in both the *Origin of Species* and his autobiography, Darwin used a very powerful technique to deal with his critics: **he listened very carefully to their criticisms and objections, and addressed these directly in his presentations of his theories.** In so doing, he forestalled many criticisms, and kept his critics on the defensive.

- For example, he anticipates that some readers of the *Origin* will disbelieve his assertion that the wings of bats are descended from a common ancestor of the hands of humans. He counters this by pointing out that it is possible to imagine how bats might have evolved from something like a flying squirrel, and how whales might have evolved from something like a bear.
- In so doing, Darwin committed a serious fallacy: implying that an organism living today is descended from another organism living today (*i.e.* whales descendant from bears). Creationists gleefully (and rightly) jump on such assertions, because they are in nearly all cases egregiously false. What Darwin should have said is that whales and bears are both descended from a bear-like common ancestor.

Organs of Extreme Perfection

Many of Darwin's critics pointed out the inconceivability of the idea that an organ such as the vertebrate eye, so complex and well-adapted, could have arisen without some kind of design or purpose in mind. Darwin counters this argument by pointing out that **it is possible to imagine how such an organ arose, not from a sudden creation, but rather from a series of gradual steps**, in which structures of increasing usefulness were selected for until something as complex and highly adaptive as the vertebrate eye existed.

Darwin points out a potential fatal argument against his theory: if any species could be shown to have evolved a trait exclusively for the benefit of another species, it could not have done so by natural selection. The only logical alternative is design by a benevolent deity. Darwin points out that in many cases, what seem to be adaptations that benefit other species (such as the flowers that provide nectar and excess pollen to pollinating insects) actually benefit as well, and so natural selection is not undermined.

Indeed, Darwin takes pains several times in the *Origin* to point out that **natural selection generally results in adaptations that are far less than perfect.** His point in doing so is to imply that an omnipotent supernatural creator would not have created such "imperfect adaptations." Ergo, such a deity probably doesn't exist.

Darwin on Hybridization

Darwin wrote an entire chapter on hybridization in the *Origin*. This is because **the theory of special creation**, which Darwin directly opposed, **implies that species are created separately, and that there are "unbreakable barriers" between species that prevent real hybridization**. Darwin attacked this idea on two fronts: he pointed out that there are viable hybrids between many species in nature, thereby undermining the "unbreakable barrier" argument. He also pointed out that natural selection itself could not erect any such barriers, because natural selection cannot possibly select for any form of sterility (*i.e.* how can a tendency toward sterility possibly be inherited?)

Darwin asserted that hybrid sterility and/or inviability must be side-effects of the divergence of species. Essentially, **once a species has diverged into two separate species and have remained separate for a sufficiently long time, random changes in the hereditary makeup of the separate species will eventually result in their being unable to interbreed and form viable offspring**. This assertion is essentially the same one made by current evolutionary biologists, including Ernst Mayr. In essence, "hybrid sterility" is a side-effect of speciation, not a cause.

- "On the theory of natural selection the case is especially important, inasmuch as the sterility of hybrids could not possibly be of any advantage to them, and therefore could not have been acquired by the continued preservation of successive profitable degrees of sterility." (*Origin of Species* 1st ed., pg 245 / Wilson, pg 606)

He then goes on to assert that **sterility is not a biological absolute**. On the contrary, **there are variable degrees of sterility**:

- "It is certain, on the one hand, that the sterility of various species when crossed is so different in degree and graduates away so insensibly, and on the other hand, that the fertility of pure species is so easily affected by various circumstances, that for all practical purposes it is most difficult to say where perfect fertility ends and sterility begins." (*Origin of Species*, 1st ed., pg 248 / Wilson, pg 608)

For example, orchids (a special favorite of Darwin, who cultivated them at his home at Down House) can easily be hybridized across species, genera, and in some cases, even families. Yet, among other types of plants (and most species of animals), hybridization between recognized species is difficult. Darwin concluded that, as in the case of the laws of variation (*i.e.* genetics), **the scientists of his day were almost completely in the dark as to the causes and degree of sterility among hybridized organisms**.

Darwin on Instincts

Darwin was very interested in the behaviors of non-human animals, especially those that were commonly referred to as "instincts." In particular, Darwin pointed out that **the existence of sterile castes (such as the worker castes in honeybees) could present a "fatal flaw to the theory" of evolution** if he could not explain them as just another case of natural selection in action:

- **"I...will confine myself to one special difficulty, which at first appeared to me insuperable, and actually fatal to my whole theory. I allude to the neuters or sterile females in insect-communities: for these neuters often differ widely in instinct and in structure from both the males and fertile females, and yet, form being sterile, they cannot propagate their kind."** (*Origin of Species*, 1st ed., pg 236 / Wilson, pg 600)

Members of neuter castes (such as "worker bees") have instincts and anatomical features that are different from those of reproductive individuals (such as "queen bees"). The question Darwin confronted was, how can a characteristic of a neuter (*i.e.* sterile) individual be passed on?

Darwin answered that **"This difficulty, though appearing insuperable, is lessened, or, as I believe, disappears, when it is remembered that selection may be applied to the family, as well as to the individual, and may thus gain the desired end."** (*Origin of Species*, 1st ed., pg 237 / Wilson, pg 601), **emphasis** added). This is natural selection at the level of the family, rather than at the level of the individual. Darwin's argument is this:

- **neuter castes show adaptive variation, just like individual organisms**
- **neuter caste members are directly (and closely) related to reproductive individuals**
- **therefore, selection acting on fertile individuals can produce adaptations in their closely related sterile "family members"**

This idea languished for over a century, then suddenly became controversial in the 1950s and 1960s. At that time, several biologists proposed competing theories of "group selection," in which natural selection was hypothesized to operate at the level of groups, rather than individuals. Principle among these was Vero C. Wynne-Edwards, whose monumental book, *Animal Dispersal in Relation to Social Behaviour*, published in 1962, made the strongest case yet for group selection.

These theories were opposed (and eventually replaced) by the theory of "**kin selection**," first proposed by W. D. Hamilton. According to Hamilton's theory, **selection happens at the level of genes, rather than individuals**. This means that individuals that share the same genes can undergo selection in such a way that their genes increase in frequency in populations even when they forego reproduction themselves.

- This is essentially the same argument made by Darwin, but updated to include genetics. Darwin's assessment that the existence of neuter castes and his idea of "family selection" didn't necessarily strengthen his overall theory, but neither did it fatally undermine it.

The concept of group selection, while mostly discredited, still has supporters. In particular, David Sloan Wilson of Binghamton University has written extensively on the subject, especially as it relates to human behavior.

Darwin on Deficiencies in the Fossil Record

Consider a squirrel that dies on the Cornell campus - will it fossilize? No; in virtually all cases, it will entirely decompose in a matter of only a few weeks. The reason for this is that **fossilization requires very specific conditions, which are not often found in most ecosystems.**

- Only resistant body parts (like bones and teeth) fossilize. Even these do not persist in their original form; instead, they become mineralized, as rock minerals replace the original remains of the organism.

In general, fossilization only occurs under circumstances in which the organism is very quickly buried (*i.e.* before it can decay and its remains become dispersed), either in mud or sand. This generally doesn't happen in open, dry-land ecosystems. For this reason, most fossils are formed in shallow aquatic ecosystems, which eliminates most of the animals and plants on Earth as candidates for frequent fossilization.

The geological column (that is, the "pile" of sediments deposited on the ground, which eventually form the layers of sedimentary rocks in most locales) had been investigated, and its overall outlines determined and named before Darwin published the Origin of Species. The order of layers in this column (which are generally named after the geographical region from which they were first described) are the same the world over, although the entire column is not known from any single location. There are very large gaps in most of these layers, and in many places whole layers are entirely missing.

Darwin described this situation by saying that **the fossil record** (that is, the collection of fossils that might confirm the theory of evolution) **is everywhere incomplete**. We do not have a continuous, unbroken fossil record of the evolution of any living thing, and certainly not for life on Earth as a whole. Instead, we have bits and pieces of this record, which must be assembled and related to each other by means of inference.

- In particular, Darwin pointed out that intermediate forms are almost entirely missing from the fossil record (Origin of Species, 1st ed., pg 280-290 / Wilson, pg 628-638). He points out that this is to be expected, given the very low probability of finding a complete record, plus the difficulty of finding a transitional form among all of the other forms in the geological column.

Another problem is the tremendous volume of fossil material available. The Smithsonian has analyzed less than 10% of all of the fossils in its collection. There are literally millions of fossils in collections around the world, most of which have never been analyzed.

- However, there are only a few hundred fossils of human ancestors. The reason for this is that humans have not existed for very long, and so have not left as many fossils. Furthermore, the kinds of habitats where the ancestors of humans lived were not generally conducive to fossil formation.

Comparative Biogeography

The distribution of animals and plants around the world provided Darwin with a powerful argument against the theory of special creation: Why would a deity create **unrelated organisms at the same latitude but on different continents**, when they had the same climate, geography, etc., but create very similar, yet **related, organisms at the same latitude on the same continents?**

For example, if one compares the animals and plants found at similar latitudes around the world, one finds that they are totally unrelated to each other, yet remarkably similar in adaptation. This is very strong evidence for the idea that they had independently evolved in place, rather than being independently created world-wide.

- "In the southern hemisphere, if we compare large tracts of land in Australia, South Africa, and western South America...we shall find parts extremely similar in all their conditions, yet it would not be possible to point out three faunas and floras more utterly dissimilar." ([*Origin of Species*, 1st ed., pg 347 / Wilson, pg 671](#))

Darwin points out that if one travels up or down the coast of nearly any continent (which he did several times while on the voyage of HMS Beagle), one "...never fails to be struck by the manner in which successive groups of beings, specifically distinct, yet clearly related, replace each other." ([*Origin of Species*, 1st ed., pg 349 / Wilson, pg 672](#))

Finally, Darwin pointed out that the inhabitants of islands lying at about the same latitudes world-wide (such as the Galapagos and islands in the tropical Atlantic) were also populated by animals and plants that were not related to each other. Instead, they were closely related to organisms located on the nearby mainland, providing strong evidence that they had been derived from those organisms, rather than having been created in place.

Taken together, these correlations present some of the strongest evidence for descent with modification, and were crucial to Darwin's eventual success in convincing most biologists that evolution had happened.

Biogeographic Distribution and Continental Drift

The distribution of several species of fossil animals and plants at the end of the Permian Period (approximately 245 million years ago) was puzzling to Darwin. Fossils of extinct animals and plants (such as *Cynagnathus*, *Lystrosaurus*, and *Glossopteris*) from South America, Africa, India, and Australia were similar enough to be classified in the same species (or at least genus), yet were so widely separated as to require Darwin to propose complex explanations, such as land bridges and transoceanic floating mats of vegetation.

In some of these cases, Darwin was simply misled by a problem he had warned about elsewhere in the *Origin*: convergent adaptations.

- For example, [freshwater mussels](#) are distributed world-wide, and appear very closely related. Darwin was misled into believing that they were closely related because of their very similar appearance. However, recent genetic and taxonomic work on freshwater mussels by [Arthur J. Cain](#) has indicated that they are not, in fact, closely related. Instead, they have all evolved very similar appearances as a result of [convergent adaptation](#) to very similar environments.

In the case of other fossils, however, Darwin resorted to complex and rather implausible explanations. Now we know that these fossils are explainable with reference to a much broader (and in many ways simpler) explanation. These continents (and Antarctica) were once all connected in a giant continent, which later split apart into five pieces and "drifted" to their current locations.

[Click here to watch online](#)

- This video clip that shows the movement of the continents from about 750 million years ago until the present. Most striking in this video is the relatively sudden and rapid movement of India, which split from Africa about 65 million years ago and eventually rammed southeast Asia (about 35 million years ago). This collision, which continues to the present day, is what raised the Himalaya Mountains. It also explains the striking similarity in species distributions in Africa and India (elephants, lions, etc.) It has been estimated that India is still moving northward into the south of Asia at a rate of about two meters per century.

The theory of continental drift (with its underlying geological theory, called [plate tectonics](#)) provides the explanation that Darwin missed. This theory wasn't recognized or accepted until the mid-20th century, so Darwin couldn't have incorporated it into his theory.

Ironically, Darwin's belief in the unchanging arrangement of the continents was mirrored in the attitude of most geologists and paleontologists until the 1960s. As the result of reading Lyell's [Principles of Geology](#), Darwin had come to believe in the doctrine of [uniformitarianism](#), according to which all geological processes happening at the present time have been happening forever. These processes, such as erosion, subsidence, uplift, volcanism, and so forth, must account for the various geological features we see today: mountains, valleys, shorelines, etc. The idea of uniformitarianism was an important piece of evidence for evolution, as it implied an immense age for the Earth. It also countered theories of [catastrophism](#), such as those proposed by [Georges Cuvier](#), who believed that God had periodically wiped out the animals and plants on Earth, replacing them with newly created versions following each catastrophe.



However, belief in uniformitarianism was an impediment to belief in plate tectonics and continental drift. Darwin and other uniformitarians believed that the Earth and its continents and oceans had always had the conditions and arrangement that it has now. More recent discoveries in geology have indicated otherwise.

- As discussed earlier, **there is very strong evidence that the continents have drifted across the Earth's surface over the past few billion years**, thereby explaining the distribution of closely related but widely separated species that puzzled Darwin.

According to most measurements, the continents are drifting at about the same rate that your fingernails grow: a few millimeters per year. However, over many millions of years, even such a low rate of speed can cause the continents to drift about the surface of the Earth like ice cakes on a windy pond.

There is also very strong evidence that sudden drastic changes can alter not only the course of evolution, but the geological features of the Earth itself. For example, there is increasing evidence that the [extinction of the dinosaurs at the end of the Cretaceous period](#) was caused by an [asteroid collision](#), most likely at the [northern coast of the Yucatan peninsula](#).

Evolution and the Classification of Organisms

Darwin completely overturned the previous system of taxonomy, which was based on the underlying assumption that all living things had been created by God in essentially their present form, and that species boundaries were fixed and unbreakable:

- "...many naturalists think that something more is meant by the Natural System; they believe that it reveals the plan of the Creator; but unless it be specified whether order in time or space, or what else is meant by the plan of the Creator, it seems to me that nothing is thus added to our knowledge." ([Origin of Species, 1st ed., pg 413 / Wilson, pg 712](#))

Darwin proposed descent as the basis for the only "true" systematic classification, and pointed out that basing a new system of classification on descent (*i.e.* evolution) was prone to error in the case of convergent organisms (that is, organisms that appear superficially similar as the result of adaptation to similar environmental conditions).

This caveat has caused problems for systematists right up to the present day. An important point to note in this context is that acceptance of natural selection as the primary "engine" of evolutionary descent is not necessary for the construction of a taxonomy based on descent. On the contrary, evolutionary systematics is concerned only with the outcome of evolution, not with its mechanism.

For this reason, and to compensate for the pitfalls of convergent adaptations, **systematists have generally followed Darwin's lead and used non-adaptive characters as the basis for taxonomic groupings:**

- "...no one will say that rudimentary or atrophied organs are of high physiological or vital importance, yet...organs in this condition are often of high value in classification." ([Origin of Species, 1st ed., pg 416 / Wilson, pg 714](#))

- "On my view of characters being of real importance for classification...we can clearly understand why analogical or adaptive character, although of the utmost importance to the welfare of the being, are almost valueless to the systematist." ([*Origin of Species*, 1st ed., pg 427/Wilson, pg 721](#))

In other words, "don't mistake a horned toad for a toad" - they're not even in the same class ([horned toads](#) are reptiles, [toads](#) are amphibians)!



Homology versus Analogy

Systems of evolutionary classification are often confounded because of confusion between homology and analogy.

Homology (in evolutionary biology) is the existence of similar (or modified) characteristics as the result of descent from a common ancestor.

- An example of [homology](#) is the wings of bats and the hands of humans. Although these structures appear quite different at first glance, a more detailed examination of the bone structure of both indicates that the same bones are located in the same relationships with each other. Therefore, the two structures are homologous; bats and humans share a common ancestor that had the same bone structure (although not modified into either wings or hands).

Analogy (in evolutionary biology) is the existence of similar characteristics as the result of convergent evolution.

- An example of [analogy](#) is the wings of insects and the wings of birds. They both appear superficially similar in some respects, and both perform the same functions for the animals that have them (i.e. flight), but they are not derived from a common ancestor. That is, the common ancestor of insects and birds (a very primitive animal indeed!) did not have wings, which evolved independently in insects and birds).

Recent genetic analysis of many structures in many species of animals has indicated that what were once thought to be the result of homology actually are not; in many cases, structures that appear to have been derived from a common ancestor actually evolved independently in separate lines of descent, a process called [convergent evolution](#).

Objections to the Use of Descent as the Basis for Taxonomic Classification

There are several objections that have been raised to the use of evolutionary descent as the basis for a comprehensive system of taxonomic classification. Beside the obvious objections of creationists, there are some problems with descent, even for scientists:

- The prevailing "[biological species concept](#)" (which is based on the ability of members of the same species to interbreed and produce fertile offspring under natural conditions) is not applicable in several important groups of organisms: (1) extinct organisms (known only from fossils or preserved specimens); (2) organisms whose reproductive capacity in the wild is unknown; (3) organisms that can be forced to hybridize under laboratory conditions, but do not do so under natural conditions; and (most importantly) (3) asexually reproducing organisms.
- Knowledge (or inference) of descent is not necessary to construct the currently most favored kind of classification scheme, called a [clade](#) (from the Greek word *klados*, meaning "branch", and "cladism," a system of classification based on shared derived characteristics, which has been used to classify such unlikely entities as office furniture).
- **A system of taxonomic classification based on descent is only as good as the data from which descent can be inferred.** Even with molecular genetics, such data is sometimes difficult to come by, and sometimes adds to confusion rather than eliminating it.
- **Classification systems can be based on an almost infinite variety of criteria.** That such a system based on evolutionary descent is the "best" is more or less a matter of preference, rather than necessity.

Darwin on [Embryology](#) and Evolution

The remarkable complexity and similarity of the embryos of widely separated vertebrate groups (such as fish, amphibians, reptiles, birds, and mammals), plus the tendency of developing embryos to survive rather drastic shocks without lasting damage has often been cited as evidence of intelligent design. However, Darwin pointed out that these same similarities could be viewed as evidence for descent with modification from common ancestors sharing similar early embryonic stages.

- This idea was championed by [Ernst Haeckel](#), whose well-known aphorism "**ontogeny recapitulates phylogeny**" was based on Darwin's idea. However, more recent research indicates that the situation, while bearing some relationship to Haeckel's principle, is more complex.

Darwin also pointed to the existence of rudimentary and atrophied organs as evidence for descent with modification, and therefore as useful criteria for taxonomic classification (see above).

The relationships between evolution and development (especially in animals) has undergone a tremendous resurgence during the last decade. In particular, an entirely new field of evolutionary biology, [evolutionary developmental biology](#) (popularly called "[evo-devo](#)") has made great strides in exploring the many connections between developmental processes and evolutionary diversification and adaptation.

- As we have already seen, **variation between individuals in populations** (and between lower taxa, such as species, within higher taxa, such as genera, families, etc.) **is essential for evolution**, especially evolution by natural selection. Researchers into evo-devo have shown that there are multiple mechanisms by which developmental processes can produce extraordinary amounts of variation, and can do so in a surprisingly short time, compared with the very long periods of time that Darwin and early population geneticists believed was required for such changes to occur.

Furthermore, there is increasing evidence that some evo-devo processes can invert the “classical” sequence of evolutionary adaptation. According to the “classical” view, the characteristics of organisms (i.e. their **phenotypes**) can change only as a result of changes in their underlying genetic code (i.e. their **genotypes**). Recent research in evo-devo has show that, on the contrary, **it is possible for phenotypic changes to precede changes in the controlling genes**, a process now known as **genetic assimilation**. We will be taking a closer look at evo-devo and genetic assimilation later in this course.

An Overview of Darwin's *Origin of Species*

Darwin's view of the evolution, as expressed in the *Origin of Species* was very comprehensive and synthetic, combining information from animal and plant breeding, natural selection, animal behavior, paleontology, biogeography, comparative morphology, classification and taxonomy, and embryology. Several qualities of the *Origin* made its reception by scientists and lay people alike very controversial:

- Only blind and purposeless natural forces (*i.e.* heredity, variation, and natural selection) were needed to explain the extraordinary diversity and adaptive perfection of living systems.
- There was no reference to supernatural forces whatsoever, especially in the first edition.
- Darwin implied (but did not explicitly state) that humans had evolved from lower forms of life: **"Light will be thrown on the origin of man and his history."** ([*Origin of Species*, 1st ed., pg 488/Wilson, pg 759](#))
- The diversity of living organisms was explained as the result of descent with modification (Darwin's term for "evolution"), which Darwin suggested could be used to extensively revise the taxonomy of life on Earth.
- Natural selection doesn't, and almost certainly *can't*, produce perfect adaptations. All adaptations are, of necessity, compromises.
- Natural selection, in the long run, virtually guarantees extinction. Indeed, the more "perfectly adapted" a species is to its environment, the more likely it is to go extinct if that environment changes significantly.
- Life almost certainly arose on Earth only once; since then, all living organisms are the descendents of that most ancient of ancestors.

In the first edition of the *Origin*, Darwin never once mentions God or a "Creator." However, in later editions of the *Origin*, Darwin waffled on the subject of a Creator (this sentence was changed to include "...having been originally breathed by the Creator into a few forms or into one..." ([*Origin of Species* 1st ed., pg 490 / Wilson, pg 760](#))).

Some creationists have pounced on this line, suggesting that Darwin believed in theistic evolution. However, from his correspondence and autobiography it is clear that this modification was essentially a "sop" to his wife, Emma, who was a devout Christian. However, as the historical record shows, Darwin himself did not; his last words (to his wife Emma) were "I am not in the least afraid to die."

Darwin concluded the *Origin* with this paragraph:

"It is interesting to contemplate an entangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us. ...

"Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows. There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, *evolved*." ([*Origin of Species* 1st ed., pg 490 / Wilson, pg 760](#)).