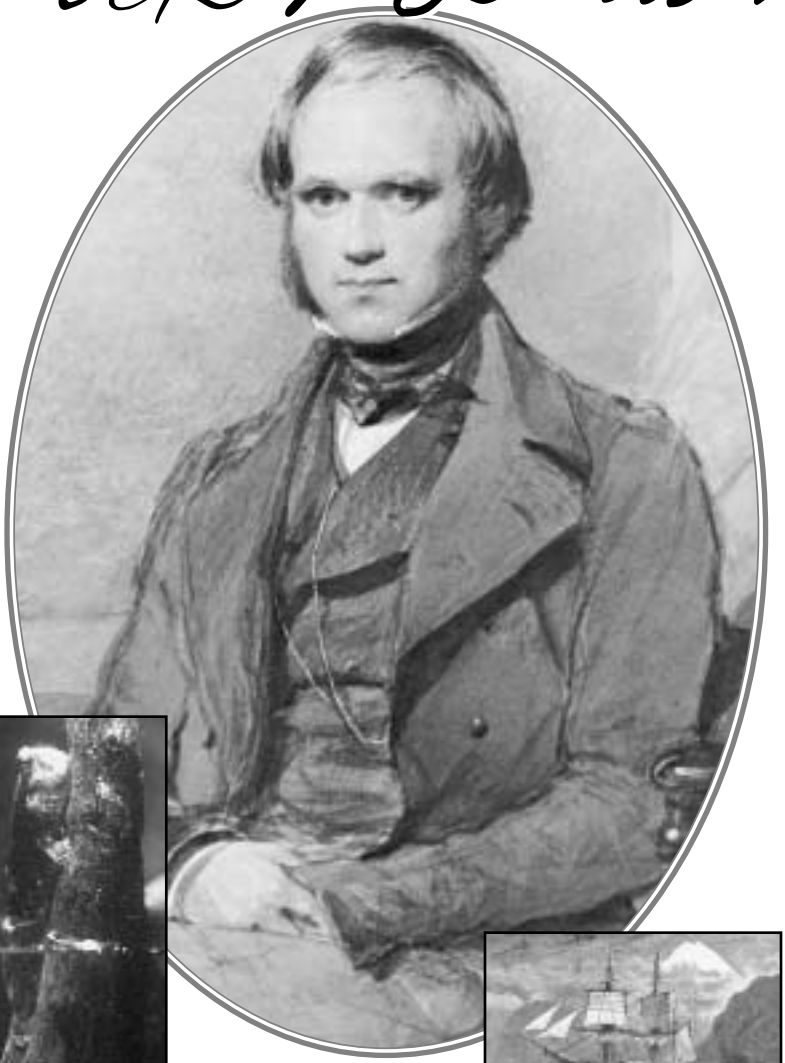
The Pocket Darwin



by
Susan Brassfield Cogan

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The Pocket Darwin

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On the Cover:

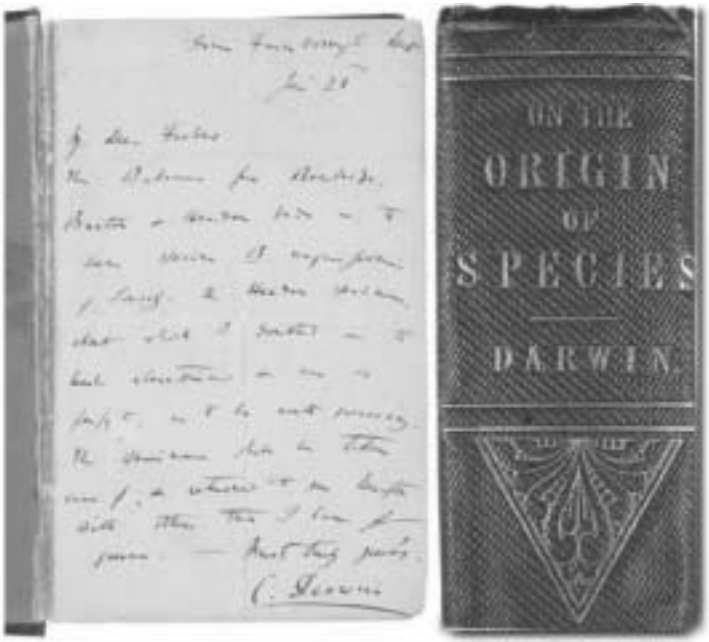
Charles Darwin at the age of 31, four years after his famous voyage on the H.M.S. Beagle, which is shown in the lower right inset. The little creature on the left is a mudskipper, *Periophthalmus agentilineatus*, an Indonesian fish that uses its fins to crawl out of the water onto shore. Mudskipper photo courtesy Richard Mleczko, http://members.ozemail.com.au/~thebobo/goby.htm .

Introduction

Few people know what evolution is all about.

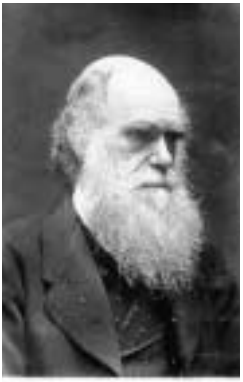
Some people think it is a progression to a higher and higher spiritual plane or a fight to become a “higher” animal and if you work really hard to improve yourself, you will become a more “evolved” human being. Some people think it is “survival of the fittest,” so only the meanest, most selfish people or animals survive. Still others think it is just an excuse for atheists to ignore the Bible, that evolution is not based on science, and nobody with any honesty or character would or should believe in it.

I hope to clear up all these confusing ideas about evolution with this little booklet. What is evolution? Is it scientific? What, exactly, did Charles Darwin give to the world? It would take more than a human lifetime to examine in detail all the evidence supporting the Theory of Evolution. This booklet will cover some of the main ideas of the theory and give pointers and references to find out more.



Charles Darwin

(1809-1882)



Charles Darwin was born in Shrewsbury, Shropshire. He was the son of Robert Waring Darwin and his wife Susannah, the grandson of the scientist Erasmus Darwin and of the potter Josiah Wedgwood. His mother died when he was eight years old and he was brought up by his sister. He was taught classics at Shrewsbury, then sent to Edinburgh to study medicine, which he hated, and a final attempt at educating him was made by sending him to Christ's College, Cambridge, to study theology (1827). During that period he loved to collect plants, insects, and geological specimens, guided by his cousin William Darwin Fox, an entomologist. His scientific inclinations were encouraged by his botany professor, John Stevens Henslow, who was instrumental, despite heavy paternal opposition, in securing a place for Darwin as a naturalist on the surveying expedition of HMS Beagle to Patagonia (1831-6).

Under Captain Robert Fitzroy he visited the Cape Verde Islands, Brazil, Tierra del Fuego, Chile, the Galapagos Islands, Tahiti, New Zealand and Tasmania. In the Keeling Islands he devised his theory of coral reefs. During this five-year expedition he obtained intimate knowledge of the fauna, flora and the geology of many lands, which equipped him for his later investigations. By 1846 he had published several works on the geological and zoological discoveries of his voyage—works that placed him at once in the front rank of scientists. He developed a friendship with Sir Charles Lyell, became secretary of the Geological Society (1838-41) and in 1839 married his cousin Emma Wedgewood (1808-96).

From 1842 he lived at Down House, Downe, Kent, a country gentleman among his gardens, conservatories, pigeons and fowls. The practical knowledge he gained there, especially in variation and interbreeding, proved invaluable. Private means enabled him to devote himself to science, in spite of continuous ill-health: it was not realised until after his death that he had suffered from Chagas' disease, which he had contracted from an insect bite while in South America.

At Down House he addressed himself to the great work of his life—the problem of the origin of species. After five years of collecting the evidence he

began to speculate on the subject. In 1842 he drew up his observations in some short notes, expanded in 1844 into a sketch of conclusions for his own use. These embodied the principle of natural selection, the germ of the Darwinian Theory, but with typical caution he delayed publication of his hypothesis.

However, in 1858 Alfred Russel Wallace sent him a memoir of the Malay Archipelago, which, to Darwin's surprise, contained in essence the main ideas of his own theory of natural selection. Lyell and Joseph Hooker persuaded him to submit a paper of his own, based on his 1844 sketch, which was read simultaneously with Wallace's before the Linnean Society in 1858. Neither Darwin nor Wallace was present on that historic occasion.

Darwin then set to work to condense his vast mass of notes and put into shape his great work, *The Origin of Species by Means of Natural Selection,* published in 1859. This epoch-making work, received throughout Europe with the deepest interest, was violently attacked because it did not agree with the account of creation given in the Book of Genesis. But eventually it succeeded in obtaining recognition from almost all biologists.

Darwin continued to work at a series of supplemental treatises: *The Fertilisation of Orchids* (1862), *The Variation of Plants and Animals under Domestication* (1867), and *The Descent of Man and Selection in Relation to Sex* (1871), which postulated that the human race was derived from a hairy animal belonging to the great anthropoid group and was related to the progenitors of the orang-utan, chimpanzee and gorilla. In his 1871 work he also developed his important supplementary theory of sexual selection.

Later works include *The Expression of Emotions in Man and Animals* (1872), *Insectivorous Plants* (1875), *The Effects of Cross and Self Fertilisation in the Vegetable Kingdom* (1876), *Different Forms of Flowers in Plants of the Same Species* (1877), and *The Formations of Vegetable Mould through the Action of Worms* (1881).

Darwin died after a long illness, leaving eight children, several of whom achieved great distinction. Though not the sole originator of the evolution hypothesis, nor even the first to apply the concept of descent to plants and animals, he was the first thinker to gain for that theory a wide acceptance among biological experts. By adding to the crude evolutionism of Erasmus Darwin, Lamarck and others, his own specific idea of natural selection, Darwin supplied a sufficient cause, which raised it from an hypothesis to a verifiable theory.

Source: http://home.austarnet.com.au/stear/charles_darwin.htm, author unknown

CAROLI LINNÆI

Naturæ Curioſorum *Dioſcoridis Secundi*

SYSTEMA NATURÆ

IN QUO

NATURÆ REGNA TRIA,

SECUNDUM.

CLASSES, ORDINES, GENERA, SPECIES,

SYSTEMATICE PROPONUNTUR.

Editio Secunda, Auctior.

STOCKHOLMIÆ

Apud GOTTFR. KIESEWETTER.

1740.

The Scientific Method

The scientific method is the best way developed thus far for discovering and exploring practical truth usable in the everyday world. Understanding the scientific method is very important to understanding evolution or any other branch of science. This is a very simple statement of the Scientific Method:

1. Make some observations about the world
2. Make an hypothesis, a tentative explanation, that is consistent with what you have observed and which can, at least in theory, be proved wrong.
3. Use the hypothesis to make predictions.
4. Test those predictions by experiments or further observations.
5. If necessary, adjust your hypothesis to fit the new observations you have made.
6. Go back to step 3.

As more and more evidence accumulates to support a hypothesis and as it is refined to fit with observations, gradually the hypothesis can begin to be fleshed out into a theory. However, the relationship between hypothesis, theory and "law" is not as linear or quite as simple as can be presented here in this brief summary.

The simple outline of the scientific method above, leaves out peer review. Peer review is an important part of the scientific method, because it is a way to detect and correct mistakes. When a scientist is beginning to be confident that her hypothesis is true, she will submit a paper for publication describing it and all the relevant observations, and the methods used to make those observations. Other scientists review the paper and decide if the methods used to collect the data were valid and if the conclusions made in the paper are warranted by the evidence. If the paper meets that standard, then it is published.

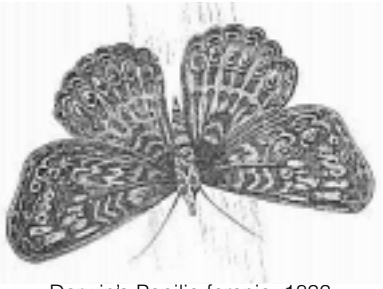
It is impossible for every scientist to do every experiment independently to confirm every theory. Because life is short, scientists must trust each other. A scientist who claims to have done an experiment and obtained certain results will usually be believed, and most people will not bother to repeat the experiment. However, experiments do get repeated as part of other experiments. Most scientific papers contain suggestions for other scientists to follow up. Usually the first step in doing this is to repeat the earlier work. So if a hypothesis is the starting point for a significant amount of work then the initial experiments will get repeated many times.

Fact, Hypothesis, Theory

In science a theory is a conceptual framework that explains existing facts and predicts new ones. In popular usage, a theory is a guess. Perry Mason will say he has a theory about who committed the murder. What Perry Mason has is a hypothesis. He has a possible explanation that will need to be supported by further investigation. The murder itself is a fact. Perry will have to make many observations about that fact to remove reasonable doubt about his hypothesis.

An hypothesis is a tentative theory that can be tested and possibly be proved false. Scientists will devise an hypothesis and then test it against available data. The idea that an hypothesis must be able to be proved false is very, very important. You could have an hypothesis that gravity is caused by invisible pink unicorns holding us down on the ground, but how would you test it? How would you prove it true or false?

It is a fact that atoms exist and behave in certain ways. Atomic Theory predicts that certain kinds of atoms will be radioactive. Nuclear power plants are designed on the basis of Atomic Theory; let us hope it is not "only" a theory!



Darwin's Papilio feronia, 1833
Now called Ageronia feronia, 1889

Evolution is a fact. The Theory of Evolution is a system of ideas explaining all the many observations science has made about evolution. The Theory of Evolution has had a powerful impact on all the biological sciences, including agriculture and medicine, and yet it is still "only" a theory.

When Darwin first wrote about evolution, many scientists had already accepted that evolution was a fact. What Darwin proposed was a Theory of Evolution. In the beginning, while he was still collecting data to support his theory, his ideas really only amounted to an hypothesis, an hypothesis that could have been proved false if the data had not been available to support it. Over the last 144 years, some of the details of Darwin's theory have been refined and augmented with new information, but generally, Darwin was correct in nearly every respect. So far the data have always supported the Theory of Evolution, even data that were discovered long after Darwin lived.

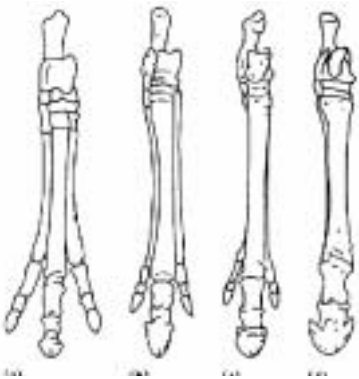
Proof, Truth and Certainty

Though "proof" is a word scientists will sometimes use when speaking informally, it is not something that scientists talk about when they are speaking formally of the evidence supporting any scientific theory. Theories are not proved. They are supported by the preponderance of the evidence—or not. This provisional attitude allows scientists to refine and expand our knowledge. Science always assumes that there is more to know and more to understand, that we can never know and understand it all. Therefore, all of scientific knowledge is held provisionally and can be discarded if new data shows that old ideas and theories are wrong.

What Science Is

"Science is the search for the widest possible consensus among competent researchers."—John Ziman quoted by Cromer in *Uncommon Sense: The Heretical Nature of Science*.

"Science is a social activity that studies those things for which a universal consensus is possible. Its methods are experimentation and mathematics because it is possible to obtain general agreement using them. They are, to use Ziman's term, *consensible*. This isn't because these methods are unambiguous—the case of cold fusion shows just how ambiguous experiments can be—but because their ambiguities are capable of resolution."—Alan Cromer, a physicist from Northeastern University, in *Uncommon Sense: The Heretical Nature of Science*



Evolution of the horse hoof

ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNEAN, ETC., SOCIETIES;

AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:

JOHN MURRAY, ALBEMARLE STREET.

1859.

The Theory of Evolution

What is Evolution?

Darwin only used the word "evolution" once in the 6th edition of *The Origin of Species.* He called his theory "descent with modification." Modern population geneticists define evolution is a change in the gene pool of a population over time. It is a simple, yet powerful idea. The Theory of Evolution seeks to explain how gene pools change and why they change.

A gene is a unit of hereditary that passes from generation to generation. The gene pool is the set of all genes in a species or a population. It is populations that evolve, not individuals.

Darwin did not know about genes. He could see that offspring inherited physical traits from their parents, but he did not know how. During Darwin's lifetime, Gregor Mendel was doing important research into inheritance, but Darwin never knew about it. After Darwin died, Mendel's paper was discovered in Darwin's study, still unopened. In 1900, 18 years later, Mendel's work and the mechanism for inheritance that had always eluded Darwin, was rediscovered by Carl Correns, Hugo de Vries, and Erich von Tschermak.

Variation

When you look at a litter of puppies, one of the first things you notice is how different they are from each other in size, color and personality. Variation was the first thing Darwin noticed when he began observing plants and animals in domestication and in the wild:

"When we look to the individuals of the same variety or sub-variety of our older cultivated plants and animals, one of the first points which strikes us, is, that they generally differ much more from each other, than do the individuals of any one species or variety in a state of nature."—*Origin of Species,* Ch. 1

Genetic variation is the raw material of evolution. Some puppies in the litter are larger, some smaller, some fatter, some thinner, some lighter, some darker. Most of these variations are neutral and will have no effect on the puppies' survival. However, if external conditions change, if there is a food shortage, for example, the fatter ones will survive better. If the puppies find themselves in snowy conditions, lighter fur might help them hide from predators better. Whether or not a variation is an advantage depends, for the most part, on the environment.

Mutations

When a cell divides, the genes duplicate themselves so that each cell will have an identical copy of all the information it needs to perform whatever function it has in the body. That duplication is almost always perfect. But, sometimes, for many reasons, including many that are unknown, the gene will not be copied perfectly. This non-exact copy is called a mutation. Most mutations are neutral and will not harm the organism at all. They can "drift" through a population. Some mutations are harmful, and death or impaired function results. Some mutations are beneficial and provide enhanced reproductive success for an organism. Whether a mutation is beneficial or not depends on environmental conditions.

Natural Selection

The main mechanism Darwin hypothesized for evolution was natural selection. The environment "selects" organisms that have everything they need to survive, or at least enough advantages to pass their genes on to the next generation. Less fit organisms die off or leave few, if any, offspring. The more fit an organism is the more offspring it leaves behind. What "fit" means changes as the environment changes.

Finches from
Galapagos Archipelago

It is easy to see how much change can be brought about when humans are doing the selecting. Darwin studied animal and plant breeding techniques when he was gathering evidence for his evolutionary hypothesis. Broccoli, cauliflower, cabbage, kale, and Brussels sprouts all came from one species of a wild mustard through the efforts of human selection. This is an example of extremely rapid evolution. Natural selection sometimes works this quickly, but is usually much slower and more gradual.

"Can it, then, be thought improbable, seeing that variations useful to man have undoubtedly occurred, that other variations useful in some way to each being in the great and complex battle of life, should sometimes occur in the course of thousands of generations? If such do occur, can we doubt (remembering that many more individuals are born than can possibly survive) that individuals having any advantage, however slight, over others, would have the best chance of surviving and of procreating their kind?"—*Origin of Species*, Ch. 4.

Sexual Selection

Males of many species develop very distinct secondary sexual characteristics. Some examples are the peacock's tail, the horns of sheep and cattle, bird calls, and flashes in fireflies. Many of these traits are actually a liability from the standpoint of survival for the individual organism, because in come cases it takes a great deal of additional energy to produce and use these attraction techniques and in other cases the strategy which attracts the attention of a female will also attract the attention of a predator. Nevertheless the advantages to the male's genes outweighs the disadvantages. A male who lives a short time, but produces many offspring is much more successful than a male who lives a long time, but leaves few offspring. The genes of successful males will eventually spread throughout the gene pool of that particular population.

Genetic Drift

Since Darwin did not know about genes, he could not know about genetic drift. That is a modern refinement to his theory. Darwin assumed that natural selection acted upon every detail of an organism's anatomy. However, some features of an organism clearly do not have either positive or negative survival value. A population appears to change gradually over time even without evolutionary pressure "selecting" for or against specific traits. The frequency of neutral genes may change purely by chance, eventually becoming either zero or 100%.

Punctuated Equilibrium

This theory, proposed by Niles Eldredge and Stephen Jay Gould, attempts to explain the pattern of fossilization that has been observed. Though they acknowledged that there are many transitional fossils, they noticed that there are fewer than might be expected, especially at the species level. Often a species will persist in the fossil record with little or no change for a very long time and then suddenly a new species will replace the old one—suddenly in geological terms, which can be a very long time compared to a human life.

Eldredge and Gould's explanation is based on allopatric speciation, meaning "from another place." If a population becomes isolated from the parent species, say in a very different habitat, since they are a small population they will evolve very rapidly. When they return to the main population, they seem to appear suddenly, with no local transitional fossils, completely changed from their ancestors.

Common Descent

Darwin's most important idea was that all living organisms on this planet descended from a common ancestor. We know today that we share morphology (physical structures) and genetic similarity with all other animals and even all plants. We share about 33% of our genetic material with *Arabidopsis* the tiny mustard plant. The relatedness all living things is one of the the most profound implications of evolution, and is very well supported by the evidence.

A lot of medical research is conducted on mice. All of that research would be useless if mice and men did not have a very great similarity. The recent publication of the mouse genome by Waterstone et al. in *Nature* reveals that the base sequences of the human and mouse genomes are 90.2% similar. Our common ancestor was not recent—75 million years ago—and today the differences between humans and mice are obviously very great. But just as obviously, the strong genetic similarities clearly show the existence of our common ancestor.

Taxonomy

Carolus Linnaeus (1707-78) died 31 years before Darwin was born. He was the first to attempt to classify plants and animals and place them into related groups called taxons. His system is still used today with only minor modifications. Without DNA evidence, using morphology alone, he was able to classify living things in a nested hierarchy that is sometimes referred to as the "tree of life" by evolutionists. Early on, Linnaeus believed that every single animal and plant was specially created by God. Later he concluded that every genus was specially created. Nevertheless, his tree of life is considered the first major evidence for evolution and common descent.

The Tree of Life from Darwin's 1837 notebook

DNA

Arabidopsis

As you see from the discussion of the mouse genome, DNA evidence of common ancestry is especially compelling. Everything that is alive shares some DNA similarity. The DNA evidence tracks very closely with the morphological evidence Linnaeus used to make his taxonomy. Not only do we share some of our genes with everything that is alive, but even so-called "junk" DNA—DNA that is not currently in use by an organism—have similarities and differences.

For example, we humans cannot manufacture vitamin C in our bodies and neither can many other primates. When the DNA of vertebrates is compared, we find that both humans and primates possess genes for making vitamin C, but the genes for it are non-functional. A mutation destroyed that particular gene some time in our history. This mutation which blocks the production of vitamin C in our bodies is identical to the mutation in apes. It's very unlikely that the same mutation occurred independently in both apes and humans. It is clear that this mutation occurred at some time in our past in an ancestor common to us both.

Human Races

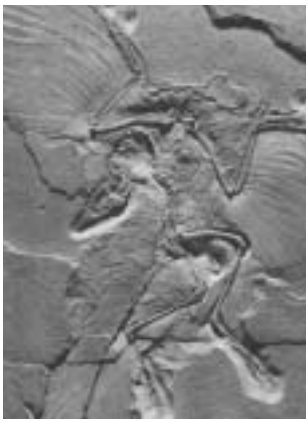
The concept of a human "race" has no validity in biology. Originally the word "race" referred to a sub-species. Now the word is almost never used in that sense. The human species has no sub-species variants.

More than 98% of chimpanzee genes are also present in humans, which shows that we have a much more recent common ancestor with chimpanzees than with mice. Even with that much greater similarity we still think of chimps as distant cousins. From that standpoint, though, all human beings are brothers and sisters. Humans evolved from *Homo heidelbergensis* only about 120,000 years ago. That is so recently in geological time, that there has not been enough time for much variation to accumulate. In fact, all human beings are 99.9% genetically identical to each other. Most genetic variation does not occur between "races" but between individuals within a population. That tiny .01% arose because human populations around the globe were isolated for much of our history. However, in modern times humans are so mobile it is unlikely the variation will ever increase enough to allow the evolution of a new species in the genus *Homo.*

The Fossil Record

Though it is far from complete, the fossil record is one of the most powerful and persuasive ways we can examine the history of life on earth, investigate the details of the "tree of life" and trace the ancestry of any currently living organism, including human beings.

"Only a small portion of the world has been geologically explored. Only organic beings of certain classes can be preserved in a fossil condition, at least in any great number. Widely ranging species vary most, and varieties are often at first local, — both causes rendering the discovery of intermediate links less likely. Local varieties will not spread into other and distant regions until they are considerably modified and improved; and when they do spread, if discovered in a geological formation, they will appear as if suddenly created there, and will be simply classed as new species."—*Origin of Species*, Ch. 14



In Darwin's time the fossil record was very poor. The dinosaur-bird transitional fossil *Archaeopteryx* was not discovered until two years after the publication of the *Origin of Species*. *Archaeopteryx* has the skeleton of a small dinosaur with none of the speicializations characteristic of birds, yet it possesses fairly modern looking feathers. It was small, about the size of a pigeon, and probably flew badly, perhaps no better than a modern chicken.

The General Trend

In the 1700s and early 1800s, geologists and engineers observed in rocks exposed in natural outcrops or in quaries and mines, that rock and soil are arranged in layers. They assumed, as we do now, that deeper meant older. They also noticed that fossils were distributed in the layers in a way that was not random. Some kinds of fossils were always found above or below other kinds. They eventually saw that this order was consistent everywhere in the world. This order has an undeniable general trend. As the fossils become more recent in time, the more they resemble modern forms. Also, simpler organisms such as bacteria appear long before protists (more complex single-celled forms) which in turn appear long before multicellular plants and ani-

mals. Each group of multicellular organisms also appear in a definite general order. Thus within the vertebrates, fishes appear first, then amphibians, reptiles, mammals and then birds. Within the mammals, apes appear before hominids and hominids before modern humans.

Transitional Fossils

"The supposed lack of intermediary forms in the fossil record remains the fundamental canard of current antievolutionists. Such transitional forms are scarce, to be sure, and for two sets of reasons—geological (the gappiness of the fossil record) and biological (the episodic nature of evolutionary change, including patterns of punctuated equilibrium and transition within small populations of limited geological extent). But paleontologists have discovered several superb examples of intermediary forms and sequences, more than enough to convince any fair-minded skeptic about the reality of life's physical geneology."— Stephen Jay Gould, "Hooking Leviathan by Its Past," 1994; In *Dinosaur in a Haystack: Reflections in Natural History*.

Strictly speaking, every fossil is a transitional form, since every fossil organism has an ancestry and every fossil has descendants unless it is the last in an extinct line. There are many nicely filled-in series of transitional forms from a sea shore predator that gradually turns into a whale to a tiny, many-toed horse that gradually turns into the large hoofed horse of today. One of the most interesting series of transitional forms is the hominids, which make up our own ancestry. Humans and chimpanzees are the last remaining twigs of a once-bushy family tree. Therefore we can never be completely certain if the array of ancestors are truly ancestral to humans or representatives of side branches that died off. Nevertheless, the general progression of human ancestry is toward larger brains and upright walking, and, as the fossils become more recent in time, the more they resemble modern forms.

Human Fossil Ancestry

The hominid fossil record documents the evolution of humans from an ape-like ancestor through a series of stages involving the acquisition of bipedal walking, smaller teeth, enlarged brain capacity, tool making capabilities and various aspects of culture. The most recent common ancestor of modern apes

and human beings lived some time between 5 and 10 million years ago. This information is deduced from molecular data, but the fossils bear out that deduction.

- The earliest fossil hominid or near-hominid, *Sahelanthropus tchadensis*, lived between 6 and 7 million years ago. It was discovered very recently and only named in July 2002. Its cranial capacity was very small, only about 350 cc. It is not known whether it was bipedal.
- *Ardipithecus ramidus* is between 5 and 6 million years old.
- *Australopithecus afarensis*. Though there are many examples of this species, the first discovered and most famous is called "Lucy." *A. afarensis* lived between 3 and 4 million years ago, was bipedal, though it walked a little stooped over, and had a cranial capacity from about 375 to 550 cc.
- *Kenyanthropus platyops* is about 3.5 million years old.
- *Australopithecus africanus* is between 2 and 3 million years old. Their teeth are very similar to those of humans but their cranial capacity is between 420 and 500 cc, which is a little larger than chimp brains.
- *Australopithecus aethiopicus* which is not directly ancestral to humans, lived between 2.6 and 2.3 million years ago and had a cranial capacity of about 410 cc.
- *Australopithecus robustus* is also not directly ancestral to humans and lived between 2 and 1.5 million years ago. It may have used digging tools and had a cranial capacity of about 530 cc.
- *Homo habilis* is so called because of evidence that they made and used stone tools. Their cranial capacity was between 500 and 800 cc and there is some evidence that they were capable of rudimentary speech.
- *Homo ergaster* is an early *erectus*-like hominid which lived about 1.8 million years ago. Its cranial capacity varied from 600 to 680 cc.
- *Homo erectus* lived 1.8 million to 300,000 years ago. Its cranial capacity was about 750 to 1225 cc. *H. erectus* made sophisticated stone tools and probably used fire.
- *Homo heidelbergensis* first appeared about 500,000 years ago. The brain size is larger than *H. erectus* but smaller than modern humans, averaging about 1200 cc.
- *Homo neanderthalensis* existed between 230,000 and 30,000 years ago. Their brain size was slightly larger than that of modern humans at about 1450 cc. They made sophisticated stone tools, were formidable hunters and are the first people known to have buried their dead.
- *Homo sapiens*, modern humans, appear about 120,000 years ago. Modern humans have an average brain size of about 1350 cc.

The Age of the Earth

The universe is about 12-15 billion years old. The earth is about 4.5 billion years old. There are now many methods for establishing those ages, but that was not always the case.

". . . we find oysters together in very large families, among which some may be seen with their shells still joined together, indicating that they were left there by the sea and that they were still living when the strait of Gibraltar was cut through. In the mountains of Parma and Piacenza multitudes of shells and corals with holes may be seen still sticking to the rocks . . ."—Leonardo Da Vinci: *Selections from the Notebooks of Leonardo Da Vinci*, written in the year 1510.

Long before Darwin, geologists and perceptive observers knew that the earth was ancient. How ancient was very much in doubt. In the 1700s, early geologists were estimating the age of the earth from 75,000 years to several billion years, and a century later estimates were not much more accurate.

In 1862 Kelvin estimated the age of the earth at 98 million years, based on a model of the rate of cooling from its initial heat of formation. In 1897 he revised his estimate downwards to 20-40 million years. This was too little time for uniformitarian geological processes to work and much too little time for life on earth to have evolved as Darwin proposed. If his estimates had held true, Darwinian evolution would have been disproved.

The first radiometric dating was done in 1905; it and subsequent measurements confirmed that the earth was several billion years old.

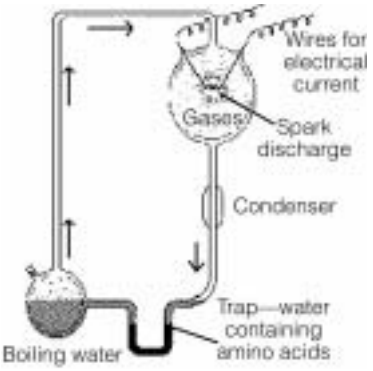
It should be understood that estimating the ages of rocks using radiometric dating is an entirely separate technique from the radiocarbon (C-14) method for dating organic remains. Radiometric dating of rocks is based on the decay of long-lived isotopes of Potassium, Thorium, and Uranium. Radiocarbon dating is based on the decay of the short-lived C-14 isotope and is irrelevant to determining the age of the earth.

Much of this is from "Changing Views of the History of the Earth" by Richard Harter, used with permission http://www.talkorigins.org/faqs/geohist.html

The Beginning of Life

Abiogenesis is the study of how life might have arisen for the first time on earth. It is a young science, barely 50 years old. Most ideas about abiogenesis are still in the realm of hypothesis, and much research is still ongoing. However, fossil evidence indicates that living cells were thriving 3.5 billion years ago, soon after the earth's crust cooled.

The Miller-Urey Experiment



In the 1920s it was hypothesized by Aleksandr Oparin and J. B. S. Haldane that simple organic molecules like sugars and amino acids could form spontaneously under certain circumstances. In the 1950s that hypothesis was tested by Stanley Miller and Harold Urey, who designed an apparatus that simulated what they thought might be atmospheric conditions on early earth. They shot electricity through the apparatus to simulate lightning. A week later they found that amino acids and other organic molecules had formed. Since that time, many similar experiments using different combinations of gases have produced a wide variety of organic molecules, including the nucleotide bases of RNA and DNA.

The Primordial Organic Soup

Oparin, in the 1930s, envisioned that the organic molecules would, over vast spans of time, accumulate in the shallow seas to form a "sea of organic soup." Under such conditions he thought that smaller organic molecules (monomers) would combine to form larger ones (polymers). Based on evidence gathered since Oparin's time, most scientists think it more likely that organic polymers formed and accumulated on rock or clay surfaces rather than in the primordial seas.

Hydrothermal Vents

Another hypothesis is that the origin of life occurred around hydrothermal vents, cracks in the deep ocean floor where hot water and minerals such as sulfur spew forth. These hot springs produce precursors of biological molecules and are an interesting area of ongoing research.

After the first organic molecules form, how could they have assembled spontaneously into more complex structures? That is still unknown, but scientists have synthesized several different molecules, precursors to life, which are called “protobionts.” They have been able to make protobionts that resemble living cells in several ways, helping us to figure out how aggregations of complex nonliving molecules became living cells.

Abiogenesis and Evolution

Abiogenesis is not actually a part of the Theory of Evolution. Though it is clear that life must have begun some way, exactly how life began is still unknown. Evolution did not begin until life existed and could replicate itself. Furthermore evolution could not begin until molecules could replicate themselves *imperfectly*, creating variation upon which natural selection could act.

Alfred Russel Wallace

"*...every species comes into existence coincident in time and space with a pre-existing closely allied species.*" (1855)

Born 1823 in Wales, Wallace was co-discoverer of the theory of national selection. A self-taught professional natural history collector who had spent years in South America and Asia, he began work on the species problem in the mid-1850's while in the field, publishing little-noticed papers that argued for the fact of evolution on the basis of geographical distributions. In 1858 he suddenly intuited the selection theory. He wrote a paper "On the Tendency of Varieties to Depart Indefinitely From the Original Type" which he sent to Darwin asking for help to get it published. Darwin, who for the most part had completed his research into natural selection 15 years earlier, shared credit for the idea with Wallace and they read a joint paper before the Linnean Society and published it that year. Darwin then hurried *Origin* into print.

Throughout the rest of his life Wallace graciously gave as much credit as possible to Darwin, and the Darwin circle reciprocated by arranging a government pension and assorted honors for Wallace. Unlike Darwin, however, Wallace later argued that the theory of evolution did not apply to man.

Wallace contributed greatly to the scientific foundations of zoogeography and some of his many publications include *Contributions to the Theory of Natural Selection* in 1870, *The Geographical Distribution of Animals* in 1876, *Darwinism* in 1889 and the *World of Life* in 1910.

In 1893 Wallace was elected Fellow of the Royal Society, and in 1908 he received the Copley Medal from the Royal Society and the Order of Merit from the Crown. Alfred Russel Wallace died in 1913. In 1915 a medallion bearing Wallace's name was placed in Westminster Abbey.

God and Darwin

It is often said that you can't believe in evolution and believe in God at the same time, or that you can't be a Christian and believe in evolution. Nothing could be further from the truth. You can't be a Biblical literalist and believe in evolution, but only a minority of Christians believe that the Bible is literal history. All you have to believe is that God is in charge of evolution, that God made the universe and everything in it and evolution is how he created life on earth. The essential message in Genesis is "I made you." Shepherds of 3000 years ago did not need to know the details of biochemistry or fossilization. What would they have done with such knowledge?

An omnipotent God could have created the raw material of the Big Bang and touched it off. An eternal God would not have considered 14 billion years to be a long time. Such a time-span would be a mere eye-blink. An omniscient God would have known in advance that a creature—perhaps many creatures on many planets—would eventually evolve that could detect his presence and form relationships with him. Such a God would have built randomness into the system to ensure that all created beings would have true free will and could make true moral choices.

Evolution does not speak to any of these issues. It does not contradict the existence of a God or preclude a belief in creation. For Christians and other religious people who believe the evidence for Darwin's theory is compelling, the study of evolution and the natural sciences is a study of God's handiwork.

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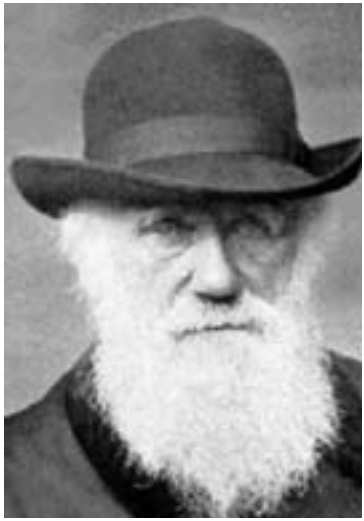

International Darwin Day
February 12