(I) DEVELOPMENT OF EVOLUTIONARY THEORY

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I. Pre-Renissance Thought | Back to Top

The Ancient Greek philosopher Anaxiamander (611-547 B.C.) and the Roman philosopher Lucretius (99-55 B.C.) coined the concept that all living things were related and that they had changed over time. The classical science of their time was observational rather than experimental. Another ancient Greek philosopher, Aristotle developed his Scala Naturae, or Ladder of Life, to explain his concept of the advancement of living things from inanimate matter to plants, then animals and finally man. This concept of man as the "crown of creation" still plagues modern evolutionary biologists (See Gould, S.J., Wonderful Life, 1989, for a more detailed discussion).

Post-Aristotlean "scientists" were constrained by the prevailing thought patterns of the Middle Ages -- the inerrancy of the biblical book of Genesis and the special creation of the world in a literal six days of the 24-hour variety. Archbishop James Ussher of Ireland, in the mid 1600's, calculated the age of the earth based on the geneologies from Adam and Eve listed in the biblical book of Genesis, working backward from the crucificxion. According to Ussher's calculations, the earth was formed on October 22, 4004 B.C. These calculations were part of Ussher's History of the World, and the chronology he developed was taken as factual, even being printed in the front pages of bibles. Ussher's ideas were readily accepted, in part because they posed no threat to the social order of the times; comfortable ideas that would not upset the linked applecarts of church and state.

Geologists had for some time doubted the "truth" of a 5,000 year old earth. Leonardo da Vinci (painter of the Last Supper, and the Mona Lisa, architect and engineer) calculated the sedimentation rates in the Po River of Italy, and concluded it took 200,000 years to form some nearby rock deposits. Galileo, convicted heretic for his contention that the earth was not the center of the Universe, studied fossils (evidence of past life) and concluded that they were real and not inanimate artifacts. James Hutton, regarded as the Father of modern Geology, developed (in 1795) the Theory of Uniformitarianism, the basis of modern geology and paleontology. According to Hutton's work, certain geological processes operated in the past in much the same fashion as they do today, with minor exceptions of rates, etc. Thus many geological structures and processes cannot be explained if the earth is only 5000 years old. British geologist Charles Lyell refined Hutton's ideas during the 1800s to include slow change over long periods of time; his book Principles of Geology had profound effects on Charles Darwin and Alfred Wallace.

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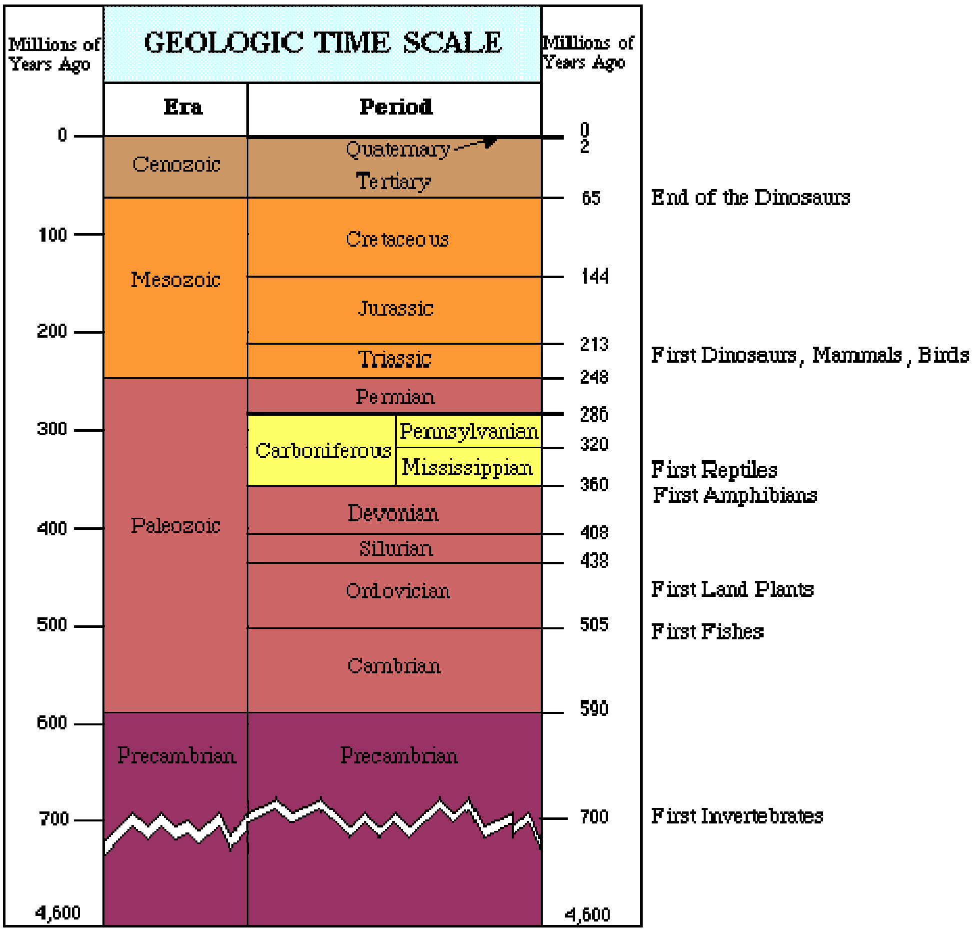
Radiometric age assignments based on the rates of decay of radioactive isotopes, not discovered until the late 19th century, suggest the earth is over 4.5 billion years old. The Earth is thought older than 4.5 billion years, with the oldest known rocks being 3.96 billion years old. Geologic time divides into eons, eroas, and smaller units. An overview of geologic time may be obtained at http://www.ucmp.berkeley.edu/help/timeform.html.



The geologic time scale. Image is from http://www.clearlight.com/~mhieb/WVFossils/GeolTimeScale.html.

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Swedish botanist **Carl Linne** (more popularly known as **Linneus**, after the common practice of the day which was to latinize names of learned men), attempted to pigeon-hole all known species of his time (1753) into immutable categories. Many of these categories are still used in biology, although the underlying thought concept is now evolution and not immutability of species. Linnean hierarchical classification was based on the premise that the species was the smallest unit, and that each species (or taxon) belonged to a higher category.

Georges-Louis Leclerc, Comte de Buffon (pronounced Bu-fone; 1707-1788) in the middle to late 1700's proposed that species could change, in a forty-four volume natural history of all (then) known plants and animals. This was a major break from earlier concepts that species were created by a perfect creator and therefore could not change because they were perfect, etc. Buffon also provided evidence of descent with modification and speculated on various causative mechanisms. In his written work, Buffon mentioned several factors could influence evolutionary change: influences of the environment, migration, geographical isolation, overcrowding, and the struggle for existence. However, Buffon vacillated as to whether or not he believed in evolutionary descent, and professed to believe in special creation and the fixity of species.

Erasmus Darwin (1731-1802; grandfather of Charles Darwin) a British physician and poet in the late 1700's, proposed that life had changed over time. His writings on both botany and zoology contained many comments that suggested the possibility of common descent based on changes undergone by animals during development, artificial selection by humans, and the presence of vestigial organs. However, this Darwin offered no mechanism to explain evolutionary descent.

William "Strata" Smith (1769-1839), employed by the English coal mining industry, developed the first accurate geologic map of England. He also, from his extensive travels, developed that Principle of Biological Succession. This idea states that each period of earth history has its own unique assemblages of fossils. In essence Smith fathered the science of stratigraphy, the correlation of rock layers based on (among other things) their fossil contents.
Abraham Gottlob Werner and Baron Georges Cuvier (1769-1832) were among the foremost proponents of catastrophism, the theory that the earth and geological events had formed suddenly, as a result of some great catastrophe (such as Noah's flood). This view was a comfortable one for the times and thus was widely accepted. Cuvier eventually proposed that there had been several creations that occurred after catastrophies. Louis Agassiz (1807-1873) proposed 50-80 catastrophies and creations.
Jean Baptiste de Lamarck (1744-1829) developed one of the first theories on how species changed. Lamarck, in 1809, concluded that organisms of higher complexity had evolved from preexisting, less complex organisms. He proposed the inheritance of acquired characteristics to explain, among other things, the length of the giraffe neck. The Lamarckian view is that today's giraffe's have long necks because their ancestors progressively gained longer necks due to stretching to reach food higher and higher in trees. According to the 19th century of use and disuse the stretching of necks resulted in their development, which was somehow passed on to their progeny. Today we realize that only bacteria are able to incorporate non-genetic (aka nonheritable) traits. Lamarck's work was a theory that plainly stated that life had changed over time and provided (albeit an erroneous) mechanism of change. Additional information about the biological thoughts of Lamarck is available by clicking here. Although Charles Darwin and Alfred Wallace's theory of natural selection supplanted Lamarckianism, sporadic efforts to revive it continued into this century, most notably in the Soviet Union under the guidance of Troffim Lysenko.

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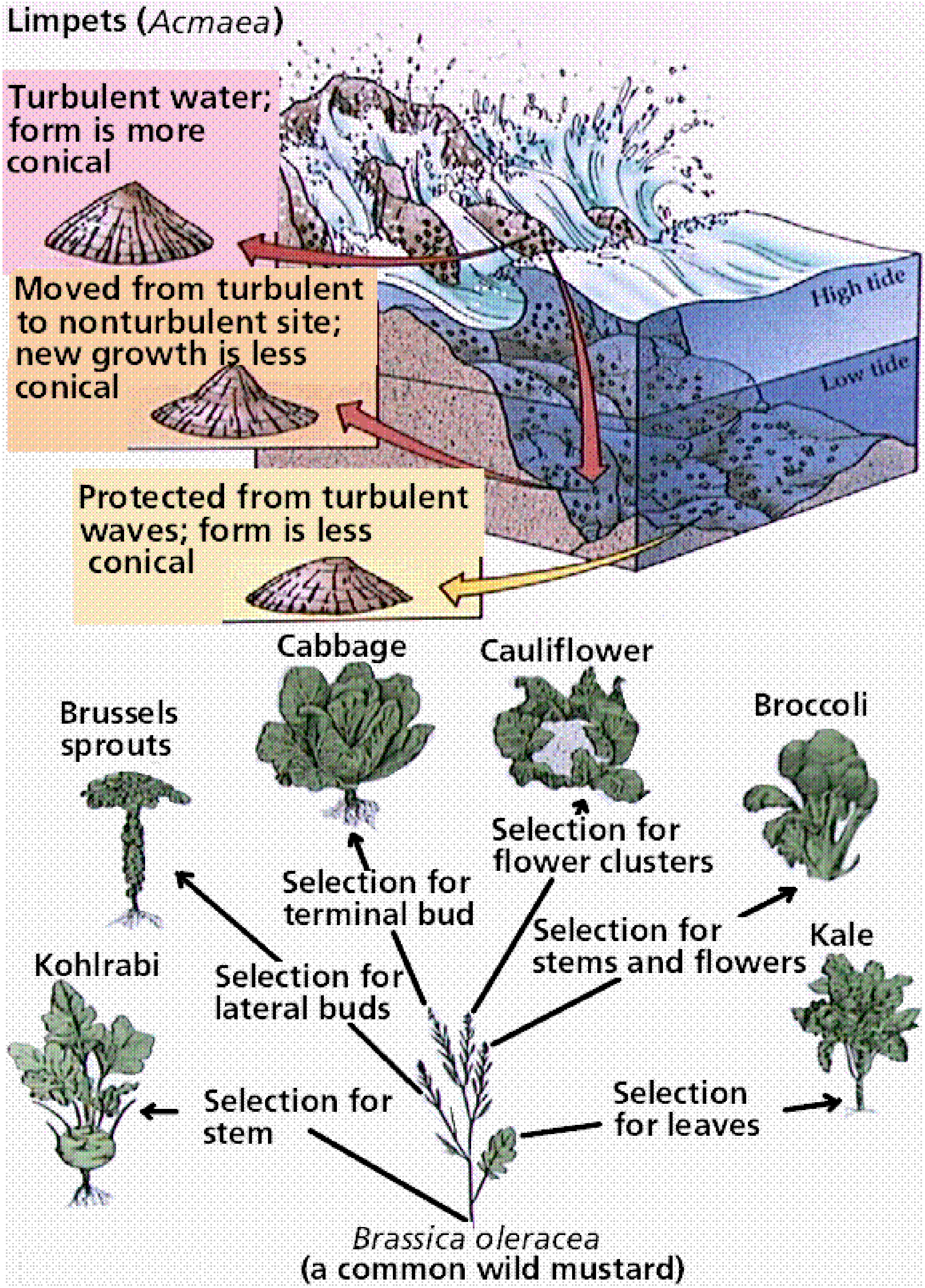
The idea (given voice by **Lamarck**) that species could change over time was not immediately acceptable to many: the lack of a mechanism hampered the acceptance of the idea as did its implications regarding the biblical views of creation. Charles Darwin and Alfred Wallace both worked independently of each other, traveled extensively, and eventually developed similar ideas about the change in life over time as well as a mechanism for that change: natural selection.

Charles Darwin, former divinity student, former medical student, secured (through the intercession of his professor) an unpaid position as ship's naturalist on the **H.M.S. Beagle**. The voyage would provide Darwin a unique opportunity to study adaptation and gather a great deal of proof he would later incorporate into the theory of evolution. Darwin spent much time ashore collecting plant, animal and fossil specimens, as well as making extensive geological observations. On his return to England in 1836, Darwin began (with the assistance of numerous specialists) to catalog his collections and ponder the seeming "fit" of organisms to their mode of existence. He eventually settled on four main points of the theory.
Adaptation: all organisms adapt to their environments.
Variation: all organisms are variable in their traits.
Over-reproduction: all organisms tend to reproduce beyond their environment's capacity to support them (this is based on the work of **Thomas Malthus**, who studied how populations of

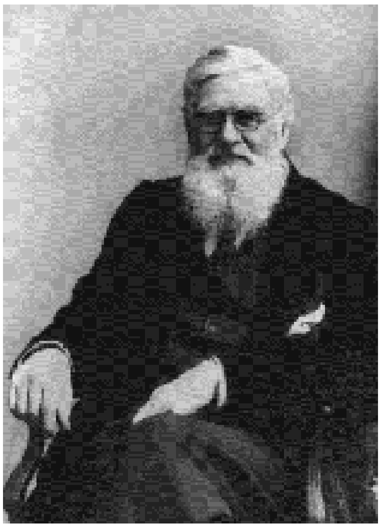
organisms tended to grow geometrically until they encountered a limit on their population size).

Since not all organisms are equally well adapted to their environment, some will survive and reproduce better than others -- this is known as natural selection. Sometimes this is also referred to as "survival of the fittest". In reality this merely deals with the reproductive success of the organisms, not solely their relative strength or speed.

Adaptations of various organisms to their environments:



Selection of a wild mustard to produce some food crops. Image from Purves et al., Life: The Science of Biology, 4th Edition, by Sinauer Associates (www.sinauer.com) and WH Freeman (www.whfreeman.com), used with permission.
Unlike the upper-class Darwin, **Alfred Russel Wallace** (1823-1913) came from a different social class. Wallace spent many years in South America, publishing salvaged notes in Travels on the Amazon and Rio Negro in 1853. In 1854, Wallace left England to study the natural history of Indonesia, where he contracted Malaria. During a fever Wallace managed to write down his ideas on natural selection.



Alfred Russel Wallace, codeveloper of the theory of evolution. The image is modified from http://www.prs.k12.nj.us/schools/phs/science_Dept/APBio/Natural_Selection.html
In 1858, Charles Darwin received a letter from Wallace, in which Darwin's as-yet-unpublished theory of evolution and adaptation was precisely detailed. Darwin and his colleagues arranged for Wallace's paper to be read at the July 1, 1858 meeting of the Linnean Society, along with a letter on the same subject by Darwin. (Click here for an excellent site covering Darwin and Wallace's paper). Wallace's paper, published in 1858, was the first to define the role of natural selection in species formation. Darwin rushed to finish his major treatise, On the Origin of Species by Means of Natural Selection, which remains one of the most influential books ever written. To be correct, we need to mention that both Darwin and Wallace developed the theory, although Darwin's major work was not published until 1859. While there have been some changes to the theory since 1859, most notably the incorporation of genetics and DNA into what is termed the "Modern Synthesis" during the 1940's, most scientists today accept evolution as the guiding theory on which modern biology is based.
Careful field observations of organisms and their environment led both Darwin and Wallace to the role of natural selection in formation of species. They also utilized the works of Charles Lyell (geology) and Thomas Malthus. Malthus' ideas were first published in 1798, and noted that the human population was capable of doubling every 25 years. Population would soon outstrip the food supply, leading to starvation, famine and war, which would reduce the population. Wallace and Darwin adapted Malthus' ideas about how scarce resources could affect populations.

The Wallace-Darwin Theory
Individuals in a population have variable levels of agility, size, ability to obtain food, and different siccesses in reproducting.
Left unchecked, populations tend to expand exponentially, leading to a scarcity of resources.
In the struggle for existence, some individuals are more successful than others, allowing them to survive and reproduce.

Those organisms best able to survive and reproduce will leave more offspring than those unsuccessful individuals.
Over time there will be heritable changes in phenotype (and genotype) of a species, resulting in a transformation of the original species into a new species similar to, but distinct from, its parent species.

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Neither Darwin nor Wallace could explain how evolution occurred: how were these inheritable traits (variations) passed on to the next generation? (Recall that Gregor Mendel had yet to publish his ideas about genetics). During the 20th century, genetics provided that answer, and was linked to evolution in neoDarwinism, also known as the Modern Synthesis.
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Enter Evolution UCMP Berkeley presents a site detaining the basics of Darwin and Wallace's idea.
Darwin's Origin of Species Available to cure all insomniacs!
The Darwin-Wallace 1858 Evolution Paper Prepared by James L. Reveal, Paul J. Bottino and Charles F. Delwiche (U. of Maryland). An excellent site to discover the origins of one of biology's major theories.
Geologic Timeline This site, developed by the Fossil Company, offers an image map that can be used to access data about the various units of geologic time.
Science and Creationism: A View from the National Academy of Sciences The National Academy of Science weighs in on the still raging debate between scientists and creationists. Nothing is more needed that scientific literacy, or at least the ability to distinguish between science and nonsense.

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