THE EVOLUTION OF EVOLUTION
(Adapted from various sources)

INTRODUCTION
The idea of evolution is simple enough: Species of living things change over time in response to changing environments. Under continued *selective pressures* and *adaptations*, eventually, new species may develop. Many people have contemplated the origins of living things. The modern story of evolutionary theory began in 17th century Europe. For the preceding 1700 years, the ancient Judeo-Christian-Islamic creation story was generally considered to be literally true—a factual recounting of the origin of all things. It was thought that the earth and its inhabitants were pretty much the same now as they were when created, some 6,000 years ago (according to this view/belief). Religious texts, including the Bible, were the primary source of information about the world, but dependence upon *non-empirical* sources for knowledge of the natural world was not to last.

Scientists (termed "naturalists" or "natural scientists") began to seek knowledge about the earth and the living things it contains from the earth itself. What they saw forced them to begin to change their minds about what seemed to be the obvious lessons from the Book of Genesis. Long held beliefs about the world, such as an earth-centered universe, were challenged by the discoveries of scientists such as the mathematicians/astronomers, Copernicus and Galileo, who demonstrated through their meticulous *empirical* observations and calculations that the earth revolved around the sun (helio-centric). The discoveries of science began to change the way people thought about the world, and a realization that the Bible did not provide sufficient explanations for how all things in the natural world arose.

For example, fossils of plants and animals—once believed to be "quirks" of nature—were beginning to be recognized as the remains of creatures that had become extinct or were the ancestors of modern day forms. Living things, in other words, had changed—they had evolved. And this change required scientific investigation and explanation.

There were many "natural scientists" that addressed this issue. One of the most influential pre-Darwinian scientists was the French naturalist Jean-Baptiste Lamarck (1744-1829). He emphasized that plants and animals are adapted to their environments; i.e., each kind of living organism has physical traits and behaviors that allow it to survive under a given set of natural conditions. When environments change—as the geological stratigraphic record shows they do—organisms must change if they are to continue to exist.

Lamarck proposed a mechanism for biological change and called it **the inheritance of acquired characteristics**. According to Lamarck, the traits acquired during an organism's lifetime could be passed on to its offspring. For example, he explained the long necks and legs of giraffes in the following way: In the past, giraffes were short, but an environmental change altered their food source, making the foliage they ate higher up in the trees. Confronted with this problem, each giraffe was able to stretch itself enough to reach the leaves. This greater height was automatically passed on to the giraffes' offspring, who had to make themselves even taller.

Clearly, specific characteristics do not appear in living things just because they want or need them to, nor are physical changes acquired during an organism's lifetime inherited by its offspring. For example, a bodybuilder's children will not automatically be born with bulging muscles just as the offspring of an individual who had braces to straighten their teeth will not automatically be born with straight teeth.

It should be noted, however, that our understanding of inheritance has changed dramatically as our knowledge of the structure and function of genes has expanded. For instance, geneticists have discovered that some genetic changes that occur within an organism's cells during its lifetime (due to life experiences such as chronic stress, trauma, poor nutrition, or exposure to toxins/chemicals that alter the function or expression of genes), can in fact be passed down to one's offspring and future generations as well. This is a fascinating and burgeoning field of research with very profound implications, which will be discussing in greater detail later.

Now, back in the 19th century, Charles Darwin was born into a world that accepted the FACT of biological evolution but was still in search of a *mechanism* (or process) that *explained* that change. It was Darwin (along with Alfred Russell Wallace) who provided the mechanism that has withstood over a century and a half of scientific examination. In fact, their *explanation (i.e. theory)* for how evolution occurs has been and continues

to be supported by a wide body of evidence from molecular biology/genetics, animal behavior and comparative anatomy, geology, and paleontology.

Darwin recognized an important fact not fully appreciated by many of his predecessors or contemporaries. He realized the incredible degree of ***VARIATION*** that exists within each living species and reasoned that some of the natural variation within a species would make a difference in the success, or *fitness*, of individuals. The better adapted individuals would tend to be more *reproductively successful* (the definition of fitness). Their traits would be passed on to more offspring than would those of the less well adapted. Over time, then, some traits would accumulate while others would decrease in frequency or even be eliminated. If the environment to which a species is adapted changes, it stands to reason that the fitness value of certain traits might also change—what was once adapted might now be neutral or perhaps even poorly adapted or disadvantageous.

Although Darwin didn't know where the variation (differences between individuals) came from, his observations showed it was a fact; and he realized that nature, like a human plant or animal breeder, "selects" better-adapted individuals for more successful reproduction. Darwin called this process ***NATURAL SELECTION***.

For Darwin, the explanation of evolution was simple. The basic processes, as he observed and explained them, are as follows:

1. All species are capable of producing offspring at a faster rate than food supplies increase.
2. There is biological variation within all species; no two individuals are exactly alike.
3. Because in each generation more individuals are produced than can survive due to limited resources, some individuals will survive, and others will perish.
4. It is those individuals who possess favorable variations or traits (for example, speed, resistance to disease, protective coloration, ability to cooperate with others, etc.) that have an advantage over individuals that do not possess them. By virtue of the favorable trait, these individuals are more likely to survive to produce offspring than are others.
5. Since those individuals with the favorable traits contribute more offspring to the next generation than do others, over time, such traits (and the genes that cause those traits) become more common in the population; less favorable traits are not passed on as frequently and become less common. Those individuals who produce more offspring, compared to others, are said to have greater ***reproductive success*** (i.e. fitness - which is where "survival of the fittest" comes from)
6. Over long periods of geological time, successful variations accumulate in a population, so that later generations may be distinct from ancestral ones (meaning, they could not/would not interbreed with one another due to physical or behavioral changes/adaptations). Thus, in time, a new species may appear. It is important to note, however, that natural selection does not ALWAYS lead to the production of new species. Rather, it leads to the ADAPTATION of species to their environment, which, if barriers to reproduction arise (as discussed below), then similar species could eventually become genetically distinct.
7. Geographical isolation may also lead to the formation of new species. As populations become separated from each other, through time, they begin to adapt to different environmental circumstances such that the genes that come to predominate in one population are incompatible with those in the other, making the groups distinct species. The thirteen species of Galapagos finches studied by Darwin, and later by other biologists, all descended from a common ancestor on the South American mainland, and provide an example of the role of geographical isolation.
8. In natural selection, the environmental context determines whether or not a trait is beneficial. That is, what is favorable in one setting, may be a liability in another. In this way, which traits become most advantageous is the result of a natural process.

Darwin saw that *variation* among individuals could explain how selection occurred. Favorable variations were selected for survival by nature; unfavorable ones were eliminated. This emphasis on the uniqueness of the individual led Darwin to natural selection as the mechanism that made evolution work. ***Natural selection operates on individuals*****,** favorably or unfavorably, ***but it is the population that evolves***. In other words, the unit or level of natural selection is the individual; the unit or level of evolution is the population. Individuals pass on or contribute their genes to the population at large (reproductive fitness through natural selection), while the cumulative effects of this differential reproductive success leads to changes in the population, which is, evolution.