**Chapter 2**

**Biology: from natural philosophy to Darwin to Modern Times**

In historical perspective, explanations for the origin and diversity of life are not new and probably began when humans first began asking questions about the natural world. By the time of the Greeks, individuals such as Thales (624 to 548 B.C.) and Anaximander (611 to 547 B.C.) proposed explanations for life's origins and gradual changes.

* During the Dark Ages we regressed to believing that organisms have never changed since creation.
* The Renaissance bought about a period of when that thought process changed, old theories were challenged.

Early naturalists classified life’s diversity

Early ideas about evolution

* Earth formed according to laws of physics and chemistry
  + Older than previously thought
* Life emerged as distinct types
  + Transformed when environment changed
  + Life has changed since creation

Paleontology provided evidence that life changed

* Georges Cuvier (1769-1832)
  + Fossils resemble but are not exactly the same as modern species
  + Many past species are **extinct**

Geologists recognized that change was gradual

* James Hutton
  + Observable processes produce small changes that accumulate over time
  + The earth must be old
* William Smith
  + Different rock layers contain distinct fossils
* By the end of the 1700s, paleontologists had swelled the fossil collections of Europe, offering a picture of the past at odds with an unchanging natural world. And in 1801, a French naturalist named Jean Baptiste Pierre Antoine de Monet, Chevalier de Lamarck took a great conceptual step and proposed a full-blown theory of evolution.
  + Life driven from simple to complex
  + Complex species descended from microbes
  + Microbes continually generated spontaneously
  + Adaptation occurs through inheritance of acquired changes

In the 1800s three individuals proposed explanations for biological evolution—Jean Lamarck, Charles Darwin, and Alfred Russel Wallace.

* Lamarck started his scientific career as a botanist, but in 1793 he became one of the founding professors of the Musee National d'Histoire Naturelle as an expert on invertebrates. His work on classifying worms, spiders, molluscs, and other boneless creatures was far ahead of his time.
* Jean Lamarck (1744 - 1829), a French biologist, proposed a view of evolution that questioned the then popular idea that species did not change.
* Lamarck proposed the idea that changes do take place in animals over long periods of time, specifically through the use of organs and appendages.
* The popular example of Lamarck's idea is the long necks of giraffes that helped them feed higher in trees. Based on the extension and use of the neck, one generation of giraffes passed the longer neck to the next generation.
* Charles Darwin (1809 to 1882), studied medical school in Edinburgh
  + Preferred to study nature
* Studied diversity of organisms at Cambridge
* Invited to serve as unofficial naturalist for HMS *Beagle* in 1831
  + Collected many fossils and living organisms
  + Studied geology while reading *Principles of Geology* by Lyell
  + **Uniformitarianism:** observable natural processes responsible for events in the past

Of particular note in history is Darwin's observations on the Galapagos Islands located off the coast of Ecuador. Darwin's curiosity and insight led him to observe both similarities and differences among organisms and compare them on the mainland and the islands 600 miles offshore.

* Darwin began formulating his theory of natural selection in the late 1830s but he went on working quietly on it for twenty years. He wanted to amass a wealth of evidence before publicly presenting his idea.

Alfred Russel Wallace (1823 - 1913) was also born in England. He became a teacher of English. He later developed an interest in collecting plants and insects.

* In 1848 he made an expedition to the Amazon River in Brazil to collect scientific materials. On a later expedition to the Malay Islands, Wallace observed some variations in organisms that engaged the same questions that Darwin posed—why did each island have different species?
* Darwin corresponded briefly with Wallace, while Wallace supplied Darwin with birds for his studies and decided to seek Darwin's help in publishing his own ideas on evolution. He sent Darwin his theory in 1858, which, to Darwin's shock, nearly replicated Darwin's own.
* In 1858, Darwin reported his and Wallace's work in a joint presentation to the Scientific Society in London. One year later, in 1859, Darwin published *On the Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life*
* Descent with modification
* All species share common ancestry
* Changes occur through natural selection
* Darwin’s 5 week visit in 1835 to the Galapagos provided the starting point for his theory of natural selection.
* Darwin did not understand most of what he saw.
* It wasn’t until he got back to England and conferred with ornithologist John Gould that he realized that he had discovered something big.
* Dozens of species, both plants and animals found nowhere else in the world
  + Giant tortoises
  + A comorant that has lost the ability to fly
  + The only lizard that feeds in the sea
  + The only equatorial penguin in the world
* The Galapagos finches are a textbook example of adaptive Around 10,000 years ago, the finches made their way across the Pacific Ocean (~1000km)
* The islands are relatively free of competitors and because of the isolation, new species arrived infrequently.
* The finches underwent adaptive radiation producing a range of finches occupying a variety of niches
  + adaptive radiation: the evolutionary diversification of a single lineage with adaptive properties.
  + There are 13 species of these little songbirds.
    - The diversity of beak structure and feeding habitats is remarkable
    - Some eat seeds
    - Some eat flowers
    - Some eat leaves
    - Some eat insects
    - Some remove ticks from tortoises
    - Some drink blood from seabirds
    - Some use twigs to extract insect larvae
    - The different species probably evolved due to the water gaps between the numerous islands
    - Genetic analysis shows that all 13 species evolved from a flock of birds arriving a million years ago!

Darwin interests were initially geological. He discovered a fossilized forest in the Andes that was overlain by sedimentary deposits laid down by the sea (proves occurrence of earlier movements of the earth). In 1856 he started to write his paper about his discoveries and his thought on natural selection.

Common descent makes sense of puzzling patterns in nature

* **Homologous trait:** similar because of inheritance from a common ancestor

Summary of Statements from Origin of Species

* Statement 1: Organisms produce far more offspring than ever give rise to adult individuals.
* Statement 2: The number of individuals of a species remain, more or less, the same in a particular ecosystem.
* Statement 3: Natural Resources are limited

Deduction 1

Therefore, there must be a high death rate, resulting from the constant struggle taking place between all organisms for food, in avoiding predators and disease, and in coping with climatic conditions.

Deduction 2

In the competition for survival, variations allow some individuals to adapt, survive and reproduce better than others, so passing on these “successful” traits to offspring.

* Statement 4: The individuals in a species are not all identical, but show variation in their characteristics that have arisen through sexual reproduction and mutation.
* Statement 5: Much of this variation is inherited

Deduction 3

Over many generations, these small changes accumulate until two groupings within the population can no longer interbreed and a new species is formed.

Darwin’s theory has been expanded

* Sexual selection
  + Selection for traits that provide a mating advantage
* Genetic drift
  + Change in frequency of traits due to chance events

Ironically, it was just as Darwin was publishing the *Origin of Species* that someone got the first real glimpse of the biological machinery behind heredity.

* In a secluded monastery in what is now the Czech Republic, a monk named Gregor Mendel was studying heredity in a garden of peas.
* Mendel, the son of a farmer, had always been interested in plants, and while at the University of Vienna he had been trained in mathematics and learned how to design experiments and analyze data. In the 1850s, he decided to run an experiment to better understand what kept species distinct and what made it possible for hybrids to form.
* Mendel abandoned his experiments in the 1860s and turned his attentions to running his monastery. When he died in 1884, he was remembered as a puttering monk with a skill for breeding plants. It was only some 15 years after his death that scientists realized that Mendel had revealed the answer to one of life's greatest mysteries.

Many of these first geneticists who rediscovered Mendel's insights around 1900 also opposed natural selection. After all, Darwin had talked of natural selection gradually altering a species by working on tiny variations.

* But the Mendelists found major differences between traits encoded by alleles. A pea was smooth or wrinkled, and nothing in between. In order to jump from one allele to another, evolution must make giant jumps—an idea that seemed to clash with Darwin.
* But in the 1920s geneticists began to recognize that natural selection could indeed act on genes. It became clear that any given trait was usually the product of many genes rather than a single one. A mutation to any one of the genes involved could create small changes to the trait rather than some drastic transformation.

Just as importantly, several scientists — foremost among them Ronald Fisher, JBS Haldane, and Sewall Wright— showed how natural selection could operate in a Mendelian world. They carried out breeding experiments like previous geneticists, but they also did something new: they built sophisticated mathematical models of evolution.

Fisher, Haldane and Wright left an equally major project open for later biologists: to explain in the language of genes, what species are and how they originate.

* The answer only began to emerge in the 1930s, thanks in large part to the work of a Soviet-born geneticist named Theodosius Dobzhansky.

Dobzhansky, who emigrated to the United States in 1928, worked in Thomas Hunt Morgan's "Fly Room," where mutations were being studied closely for the first time. He also paid careful attention to the work of population geneticists such as Sewall Wright, who were showing how the size of a population affects the rate at which a mutation can spread. Dobzhansky was interested in discovering the genetics that determined the differences between populations of a species.

* Dobzhansky's ability to combine genetics and natural history attracted many other biologists to join him in the effort to find a unified explanation of how evolution happens. Their combined work, known as "The Modern Synthesis," brought together genetics, paleontology, systematics, and many other sciences into one powerful explanation of evolution, showing how mutations and natural selection could produce large-scale evolutionary change.

Evolutionary biology was revolutionized by the discovery of DNA. Mutations, researchers realized, change the spelling of the cookbook. A single base pair may change, or a set of genes may be duplicated. Those mutations that confer a selective advantage to an individual become more common over time, and ultimately these mutant genes may drive the older versions out of existence.

Thanks to the discovery of DNA, it is now possible for scientists to identify not just the genes, but the individual bases. Before the discovery of DNA, scientists could only uncover the evolutionary tree of life by comparing the bodies and cells of different species. Now they can compare their genetic codes, working their way down to the deepest branches of life dating back billions of years.