

Chapter for today: Chap. XVII**Major points for the day:**

1. The concept of the Great Chain of Being
2. Evidence that species are altered over time
3. Darwin's theory of evolution

Genetics describes how traits are passed on, and how those traits are expressed

We have looked at the mechanisms of genetics for the last two weeks

- We began by considering cell division (both mitotic and meiotic) as mechanical processes
 - Understanding the way chromosomes are transmitted helps to explain inheritance
- We looked at the data generated by Mendel which explained how traits segregate in crosses
 - This underscored how genetic traits are systematically transmitted to succeeding generations
 - It emphasized the importance of probability--the chance that a particular progeny individual would express a phenotype characteristic of the parent can be precisely quantitated, depending on certain simple rules of inheritance
- We saw how we as humans are the expression of our genes
 - It is surprising, perhaps, that something as simple as the way we fold our hands could be caused by a genetic difference
- Finally, we saw the chemical nature of this inheritance
 - DNA as the genetic material
 - The "central dogma" explained how this genetic inheritance is expressed in cells
 - Regulatory processes determine when, where and how these genes are expressed

Now we move on to ask how simple processes can explain how the genetic makeup of organisms can change over time. The theory to explain the mechanics of this process is called **evolution**. Today we will consider how the concept of evolution, or "changes in lines of descent", became the accepted explanation of biodiversity.

The "Great Chain of Being"

Most of the concepts about the nature of living things derive from the writings of Aristotle (a Greek philosopher of the Fourth Century, B.C.)

- From Aristotle we derive the concept of distinct types of organisms which could each be distinguished from all the rest
- Aristotle was interested in much more than the biological world, and attempted to build a theory of the world as a whole
- As part of this theory, he believed that all of nature could be seen as a continuum of organization from lifeless matter (e.g., water, Earth, fire and air) to the most complex forms of life

He thought of humans as different from the rest of animals because of their capacity for reason or thought

- In fact reason is the capacity which differentiates man from animals, but Aristotle proposed a rank ordering of all living things, from the least to the highest (humans)

This idea developed, during the later centuries, into the concept of the “**Great Chain of Being**”

- The idea had become rigidly codified by the 14th century (preceeding the Renaissance)
- All living things were seen as members of unchanging types, called **species**, which could be ordered from the least to the highest
- The metaphor of the “chain” of being suggested that these species were linked to each other by a logical progression
- This concept, in the Western tradition, is the result of the attempt to combine the Aristotelian philosophy and Christian theology

This concept of reality was modified by the Renaissance, which broke with the medieval tradition of reliance on authority (for example, on Aristotle), and emphasized the importance of reliance on direct observation (science) or pure reason (philosophy)

(You’ll have to pardon me for bringing in so much philosophy, but it was my Minor subject in College, and has interested me ever since)

Creation of a system of classification of living things

Scientists during the 18th century believed, based on this Aristotelian concept, that the Earth was populated with a set of organisms, as distinct species, which had always existed, since their creation, in the same form

- They felt that if they could catalog all of the forms of life, and understand the relationships among them, that they would understand the meaning of life
- Species were termed “natural species”, with the understanding that they were unchangeable units of living things

The most successful of the 18th century systematists was Carl von Linné, also known as Linnaeus

- From detailed observance of living things he created a system of classification which related each living thing to all others
- It is important to remember that Linnaeus understood that the relation among these species was based on the Great Chain of Being, and not on any relation of descent between the species (which is an evolutionary idea)

Evidence that species were not unchanging

During the 18th century, however, naturalists began to find evidence of relations among species which defied explanation under the prevailing theory

- **Biogeographers** studied the way that species were distributed on the Earth
 - They found odd instances of very similar animals separated across seemingly impenetrable barriers
 - They also found unique species in abundance in places of isolation, like islands (note the bizarre fauna of Australia and New Zealand)
 - They couldn’t explain how these came to be
- **Comparative Anatomists** compared the structures of various species
 - They found unexpected similarities in structure which had no purpose, such as the pelvic bones in snakes, or the similarity of structure of human hands, bat wings, and whale flippers
 - If the similarity in organization of these structures could not be explained by the prevailing theory then what would explain them?

- Finally **geologists** began to find evidence of a progression in complexity of organisms across layers of sedimentary rocks
 - Toward the bottom of such a bed were fossils of simple organisms, while layers above them contained those of more complex organisms, with the fossils at the highest levels most resembling existing organisms
 - Were these sequences of fossils, that is, did the more complex organisms derive from the less complex?

Gradually, a few scientists started to consider an alternative explanation:

- If species did not seem to originate in a single act of creation, and disperse throughout the world, then perhaps they originated in more than one place
- And, perhaps species could be modified over time, as suggested by the comparative anatomy and the fossil record
- These are **evolutionary ideas** and they were prevalent well before Darwin

Theories to explain the apparent evolution of living things

Two theories were proposed which we can now see are attempts to evade the available evidence—**Catastrophism** and **Lamarckianism**

- **Catastrophism** suggested that species were indeed immutable (unchanging), but that they many species have been lost over the history of the Earth
 - Catastrophes which happened during that history at certain times eliminated large numbers of species, which appear in the fossil record to be succeeded by new species
 - **Catastrophism** suggests that this is not the case, and that instead pre-existing organisms which survived the catastrophe simply populated the world afterward

The fossil record refutes this theory since it is quite clear that fossil forms from more recent layers are utterly absent from earlier layers, despite the vast amount of material available from each layer

- **Lamarckianism** attempts a different explanation for change over time, that individual organisms adapt to their environment, and that the changes made are then passed on to their descendants
 - There is in fact no evidence for this theory
 - Neo-Lamarckianism in the Soviet Union during the 1930s essentially destroyed Soviet genetics, and helped to destroy Soviet agriculture

Darwinism

Charles Darwin was a trained minister of the Church of England, who was an avid naturalist. His observations of nature during a five year voyage on H.M.S. *Beagle* led him to propose the theory which continues to define biological thought in the 20th century.

Darwin was heavily influenced by those naturalists who had preceded him, and certainly had absorbed the ideas of the changing nature of species on earth

- His contribution to biology boils down to his proposing a mechanism which could explain this evolution, not the process of evolution itself
- He was also strongly influenced by the writings of Thomas Malthus who wrote that human populations tend to grow exponentially, and to outstrip the available food resources--this leads to crises in which individuals compete strongly for the limiting supply of food
- Darwin generalized this theory to all populations

- Darwin's insight was that variations in the hereditary traits of the members of these populations might affect their ability to compete for resources

Darwin found evidence for the effects of competition driving evolution of animals in the Galapagos Islands off Ecuador

- As is often the case on islands, the Galapagos have a unique population of animals and plants
- Darwin argued that the availability of food would "select" for adaptive changes in populations
- For example, in a population of birds presented only with very hard seeds those with the strongest bills will tend to be able to survive and reproduce best since they will be able to forage better than those with weaker bills

Darwin, and later Alfred Wallace, described a theory which explained the changing nature of species:

Given the Malthusian tendency to outstrip resources

- Individuals in a population must compete for those resources

Since the individuals differ in their "form and function", and these differences can affect the ability of the individuals to compete for the resources

- Adaptive traits (traits which confer a greater ability to compete) must increase in frequency over successive generations
- Therefore, populations can evolve because of this **natural selection** the traits which characterize the population can change over time when heritable traits are responsible for differences in survival and reproduction

Darwin and religion

Though the response of established religion in the 19th century was strongly antagonistic to Darwinism, he felt that there was not a necessary conflict

- As a trained minister, he had Christian convictions and beliefs
- His scientific theories were based on his observation, and did not conflict with his religious convictions
- Importantly, his theory does not deal with **why** changes should occur over time.

The theory of natural selection, or Darwinian evolution, has been characterized as a secular humanist theory

Stephen Jay Gould has written extensively on this subject, and in "Non-moral nature" he objects to creationists who "accuse evolutionists of preaching a specific ethical doctrine called secular humanism and thereby demand equal time for their unscientific and discredited views....[E]volution can not teach any ethical theory at all....Not only did Darwin eschew any attempt to discover an antireligious ethic in nature, he also expressly stated his personal bewilderment about such deep [religious] issues as the problem of evil....Darwin wrote..."I feel most deeply that whole subject is too profound for the human intellect. A dog might as well speculate on the mind of Newton. Let each man hope and believe what he can"