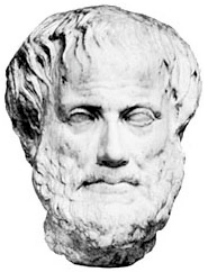
History of Evolutionary Thought

Learning objectives:

1. To describe major historical events and key contributors to the development of the theory of evolution.
2. To outline the key components of Darwin's theory of evolution by natural selection.

Readings: Your text does not cover this topic (except for box 2.1 and scattered parts of Ch. 2). However, the people and events mentioned have Wikipedia entries.

The roots of evolutionary thinking



Aristotle
384–322 BC

2008 will mark the 150th anniversary of the reading of addresses on the theory of evolution by natural selection by Wallace and Darwin, but the roots of evolutionary thinking are usually traced back to the Greek philosopher Aristotle.

Aristotle developed the idea of a natural order "Scala naturae", in which all forms of life were linked in a "chain of being".

Aristotle thought of species as unchanging and reflecting a divine order.

Carl Linnaeus: father of modern taxonomy

Linnaeus
1707–1778

Linnaeus is credited with developing the binomial nomenclature system, in which each species name has two parts

Genus name + specific epithet = species name

Cucurbita pepo = *cultivated pumpkin*

Homo sapiens = *modern human*

Linnaeus also saw species as nested within broader groups, e.g. families include many genera, genera include many species, etc.

Carl Linnaeus: father of modern taxonomy

Linnaeus
1707–1778

Linnaeus recognized that individuals within a species are capable of interbreeding, while individuals in different species could not interbreed.

Linnaeus believed in the 'balance of nature', with each species having a place in the divine plan. Species do not change or go extinct.

Later in life, Linnaeus acknowledged that new species could be formed by hybridization (by crossing different species)

Linnaeus the famous professor

Linnaeus was an interesting and somewhat eccentric man.

He spent his academic career in at the University of Uppsala, but as time went on, he spent most of his time at Hammarby (his summer cottage 16 km outside Uppsala). There he taught classes and led walks through the surrounding natural areas.

George Louis Leclerc, Compte de Buffon

Buffon

1707-1788

Buffon was a French mathematician and naturalist who influenced Lamarck and Darwin.

Buffon believed that biological diversity could be accounted for by material processes operating in nature.

He believed the Linnaean hierarchy reflected common descent, with change over time.

His process:

new species form when animals migrate

new environments then cause changes to the species

Erasmus Darwin: organisms adapt to their environment

E. Darwin

1731-1802

"Organic life beneath the shoreless waves
Was born and nurs'd in ocean's pearly caves;
First forms minute, unseen by spheric glass,
Move on the mud, or pierce the watery mass;
These, as successive generations bloom,
New powers acquire and larger limbs assume;
Whence countless groups of vegetation spring,
And breathing realms of fin and feet and wing."

The Temple of Nature (1802)

Jean-Baptiste Lamarck: a mechanism of evolutionary change

Lamarck

1744-1829

Lamarck was a French naturalist

He believed that organisms progress from simple through more complicated forms. Simple forms of life were seen as constantly originating through spontaneous generation

Lamarck suggested a mechanism (2 'laws')for evolutionary change:

1. Use or disuse of a structure leads to its development or diminishment (within the lifespan of an individual)
2. These acquired characters could then be passed on to offspring.

(from Philosophie Zoologique, 1809)

Thomas Malthus: Principle of Overproduction

Malthus
1766–1834

Malthus was an English clergyman, demographer and political economist who had a major influence on both Darwin and Wallace.

He wrote an essay on the Principle of Population in 1797:

- Most organisms (including humans) produce more offspring than can possibly survive
- Even when resources are plentiful, populations tend to continue growing until they outstrip their food supply
- Once resources become scarce, populations experience a struggle for existence, in which (for humans) poverty, disease and famine ensue.

Charles Lyell: Geologist and Supporter of Darwin

Lyell
1797–1875

Lyell was an English geologist and contemporary o Charles Darwin and Alfred Russell Wallace. Both were heavily influenced by Lyell's "Principles of Geology".

Lyell visited Mount Etna in Sicily. He saw the crater had been built up by numerous small eruptions, and understood that geological events were always changing the shape of the Earth. Lyell also observed fossil mollusks, similar to modern species, and in noting the number of layers in sedimentary rock, he inferred that the Earth must be very old.

Charles Lyell: Geologist and Supporter of Darwin

The idea that the Earth was constantly changing, but without progress or development.

This idea of constant change, the constant action of natural forces (uniformitarianism), influenced many naturalists and was important to the development of Darwin's thinking about how the mechanism of evolution might work.

However, Lyall initially thought of the living world as created, though he later became a strong proponent of evolution (after reading Darwin's book).

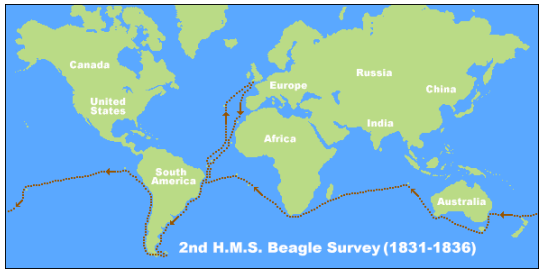
Charles Darwin

Darwin
1809–1882

Darwin was a man of independent means, who was able to devote himself to his passion: natural history.

His father wanted him to be a doctor, then a clergyman, but eventually allowed young Charles to participate in an expedition as a ship's naturalist.

The voyage of the Beagle, 1831–1836



Charles Darwin

The voyage of the Beagle, 1831-1836.

Many observations lead Darwin to pose challenging questions:
Why are Rheas so similar to ostriches?

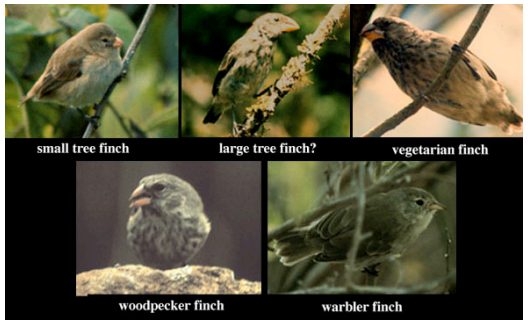
Charles Darwin

The voyage of the Beagle, 1831-1836.

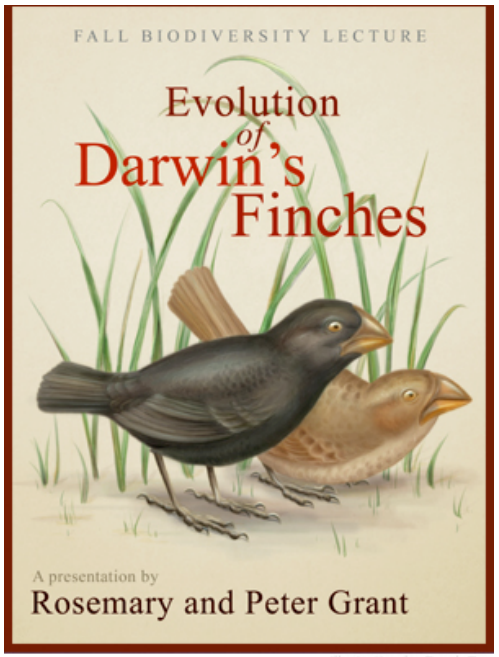
Galapagos Islands

Why do different species tend to occur in areas separated by boundaries (e.g. oceans)?

e.g. Galapagos finches: a group of 14 species that differ in habitat and food choice.



"When I see these Islands in sight of each other, and possessed of but a scanty stock on animals, tenanted by these birds, but slightly differing in structure and filling the same place in Nature, I must suspect they are only varieties....If there is the slightest foundation for these remarks the zoology of Archipelagoes - will be well worth examining; for such facts would undermine the stability of Species." (1836)



Work on the Galapagos finches continues to the present day - as you will see in a few weeks through your tutorial reading of a paper by P. and R. Grant.

Charles Darwin

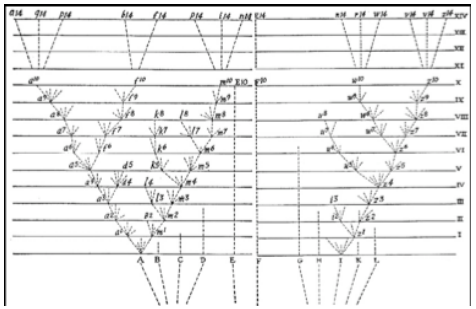
Back in Britain, Darwin developed his theory of natural selection.

Darwin recognized several critical facts:
Variability exists within species
Variant traits may be inherited (Darwin didn't know how)
Malthus's Principle of Overproduction implies that many individuals must die or fail to reproduce.
Individuals slightly better suited to their environment must be more likely to survive.
Therefore, some variants will be preserved over time more than others.
The composition of populations must change over time.
☛*Evolution by natural selection.*

Charles Darwin

Darwin on the origin of species

As natural selection acts on geographically isolated populations, they become increasingly different from each other. This leads to the formation of first varieties within a species, then separate species, then genera, etc., in an ever-branching process.



Alfred Russell Wallace

Wallace
1823-1913

Wallace was a working naturalist.
In 1858, sent a letter to Darwin describing his independent discovery of natural selection.

Like Darwin, Wallace traveled around the world observing biodiversity and biogeography. Like Darwin, he'd read Lyell and Malthus, and eventually realized that:
"[the] self-acting process [of natural selection] would necessarily improve the race, because in every generation the inferior would inevitably be killed off and the superior would remain - that is, the fittest would survive."

Evolution Made Public

Charles Lyell and Joseph Hooker quickly arranged for Darwin's and Wallace's views to be co-presented at the meetings of the Linnaean Society in London in 1858.

The next year (1859), Darwin published The Origin of Species by Means of Natural Selection. The depth and breadth of Darwin's book, developed over twenty years of thought and research, revolutionized science.

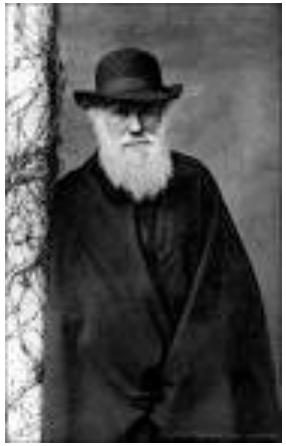
Major contributions of Darwin's work:

1. Populations change over time = evolution happens.
2. All species are related through common ancestry = the tree of life connects living and extinct species.
3. Evolution happens through the action of natural selection.

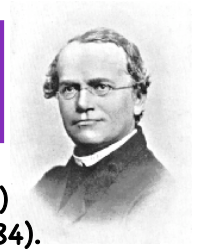
Darwin the man

Darwin continued to work on natural history and evolution in groups from pigeons to orchids. He wrote many books and articles.

He shunned the public eye and continued to work quietly on his estate outside London until his death in 1882, at the age of 73.

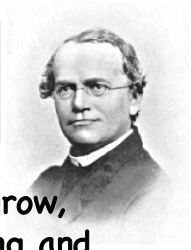


Gregor Mendel



- Austrian scientists and a Catholic (Augustinian) priest, born near Vienna in July 1822 (died 1884).
- Educated in physics and math at the University of Vienna
- Lived and worked in Brno, at the abbey of St. Thomas.
- Studied patterns of inheritance using garden peas and other plants.
- Was a contemporary of Charles Darwin (1809-1882).
- The significance of Mendel's work was not recognized by the scientific community until after his death and the rediscovery of his work in 1900 by Correns and DeVries.

Mendel's Experimental System: Garden peas, *Pisum sativum*



Annual plants, easy to grow, capable of self-fertilizing and cross-fertilizing, variable in a number of traits.

Mendel's experiments yielded the principles of inheritance: Segregation, and independent assortment.

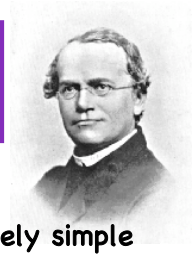
Mendel's unique contributions

- The study of large numbers of progeny (allows the effects of chance to be minimized).
- The use of more than one generation of crosses to understand patterns.
- The use of reciprocal crosses to see if the sex of the parent affects patterns of inheritance.
- The use of test crosses to determine the genotype of a parent in a cross.

Linking Mendelian Genetics and Meiosis

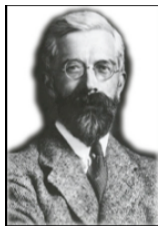
Mendel's work was not appreciated until its rediscovery in 1900. Three years later, in 1903, Sutton and Boveri linked Mendel's results to the behaviour of chromosomes in meiosis, formulating the chromosome theory of inheritance.

When traits don't behave according to Mendel's laws

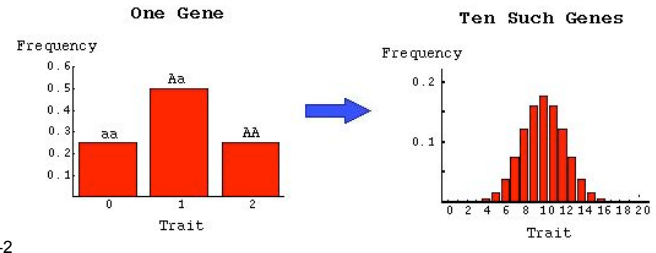


- Mendel's studies focused on traits with relatively simple patterns of inheritance. This was critical to establishing the fundamental rules of particulate inheritance.
- There are many other traits that could have been measured on Mendel's plants. Some of these would not have yielded clearly interpretable patterns.
- For example, leaf length, total plant mass, number of hairs on the stems... These traits don't fall into clear categories. Instead they show continuous variation and are called quantitative traits.

Sir Ronald Fisher (1890-1962): Linking quantitative traits variation and mendelian genetics



- In 1918, Fisher showed that a large number of Mendelian factors (genes) influencing a trait would cause a nearly continuous distribution of trait values. Therefore, mendelian genetics can lead to an approximately normal distribution



Conclusions

- Scientific inquiry occurs in a particular social/ historical context. The formulation of the theory of evolution by natural selection by Darwin and Wallace represented a natural progression from the ideas and foundations of their predecessors.