GAME PLAN

1. Discuss the intellectual climate leading to the Development of Darwin's Theory.

A. Age of the earth?

B. Origins of Species

C. Adaptation

Thesis: Darwin was one of a long line of thinkers to approach the topic of evolution.

His theory was radical, but not because it predicted change.

The age of the earth?

1. The Pre-History Conundrum.
2. Creation myths.
3. Cycles and Philosophy.
4. Stratigraphy.

Nicolaus Steno (1638-1680) – Principle of superposition

Comte de Buffon (Georges Louis Leclerc) (1707-1788)

James Hutton (1726-1797), – erosion, uplift, and buckling.

"no vestige of a beginning,--no prospect of an end."

Georges Cuvier (1769-1832) Catastrophes

Charles Lyell (1797-1875) – gradualism and Uniformitarianism.

Darwin (1809-1882) Most important publication in 1859

Origin of Species

Special Creation

Jean Baptiste Lemarck (1744-1829)

Buffon -- believed there was no real differences between animal, mineral or vegetable, under proper conditions new species could arise spontaneously.

Erasmus Darwin (1731-1802)

Étienne Geoffroy St. Hilaire (1772-1844) Variation of species within limits of body plan. (formalist)

Cuvier – Multiple creations and progress

Erasmus Darwin

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.

Erasmus Darwin. The Temple of Nature. 1802.

Adaptation

Étienne Geoffroy St. Hilaire (1772-1844)

Lamarck Acquired traits, Vitalism, Scala Nature

Natural Theology (John Ray 1628-1705, William Paley 1743-1805)

Study organisms to understand god, Adaptation is interpreted as the wisdom of a creator.

Others

Cuvier and Darwin Two Examples of Good Science

Cuvier is sometimes portrayed as a unempirical theorist who always supported the orthodox interpretation of nature.

Cuvier's actual contributions and writings are not consistent with this portrait.

Cuvier

- Cuvier and anatomy
  - Founded modern Comparative Anatomy.
  - Based a classification system on detailed knowledge of shared common characters.
  - Functionalist interpretation of adaptation
- Cuvier and Fossils
  - Cuvier conducted some of the most extensive studies of fossils ever done.
  - He used knowledge of anatomy to compare fossil forms to current forms and show they were different
  - He is often credited with "proving" that species could and did go extinct.

Cuvier

Cuvier and Catastrophism

Studied not only isolated fossil but also studied the location of fossil within the geological strata.

Observed that frequently species found in one layer would be not be found in the layer above it. The layer above would contain new and different species.

Seldom observed intermediate forms and never observed long sequences of intermediates leading to modern forms.

Observed that older layers contained "simpler" species and the younger layers contained "more complex" species

Concluded:

1. Periodic catastrophes had destroyed species and then new species replaced them.
2. That this replacement resulted in the creation of more and more advanced species leading eventual to humans one of the most recent species to appear.

Was vague on time scales, but did not argue for truly young earth.

Rarely equated his catastrophes with literal biblical events

Used other creation myths as well as biblical events to argue for worldwide catastrophes

Quick Summary

- The Concepts of old earth and mutable species were common before Darwin
- Good Scientists Interpreted the Fossil record in a number of different ways.

Robert Chambers

Interpreted the fossil record as evidence of eveolution. i.e. he recognized that species changed.

Interpreted evolutions as the unfolding of God's plan

The term "evolution" is derived from the latin *evolutio* meaning unrolling or unfolding

Published a best selling book England 5-10 years before Darwin published his theory.

GAME PLAN

- Introduce my concepts of why Darwin's Theory were radical
- Review Darwin's Life
- Summarize Darwin's Theory of Natural Selection

Importance of Charles Darwin's Theories

1. Darwin's theory provided a compelling argument of **how** evolution might occur.
2. Darwin provided the most extensive review of the evidence for evolution to that date (1859).
3. Darwin's theory did not predict progress only change.

Ernst Mayr's List of "Darwin's Five Theories"

- "Evolution as such" (= Transmutationism)
- Common Descent
- Gradualness
- Populational speciation
- Natural Selection.

Timeline of Events in Darwin's Life

1831 Graduated from Cambridge with a degree in theology

1832 Begins circumnavigation of globe.

1836 returns from Beagle Voyage

1837 First scientific articles published

begins notebooks on transmutation

1842 Writes essay on "Origin of Species" distributes it only to few close friends

1858 Wallace proposes an identical theory to Darwin's

1858 Wallace and Darwin's papers are presented back to back at a scientific conference

1859 Publishes 600 page "abstract" of detailing and defending his theory

1872 Published 6th Edition Of Origin of Species

1882 Dies.

Outline of Darwin's Theory

Postulate 1.

There is variation within species.

Postulate 2.

There is some form inheritance such that offspring are likely to share common traits with their parents

Postulate 3.

All species have the biotic potential to produce more offspring than the environment can support. Meaning there is a struggle for survival.

Postulate 4.

A very old earth.

Outline of Darwin's Theory

Logical construction

Theorem 1:

If postulate 1 is true and postulate 3 is true then it follows that some individuals will have variations that make them more likely to survive in a given environment.

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Outline of Darwin's Theory

Theorem 2:

If theorem 1 is true and postulate 2 is true it follows that those individuals with traits that allow them to survive more frequently will produce offspring that share those traits and therefore over time those traits will become more common in the population.

Outline of Darwin's Theory

Theorem 3:

If theorem 2 is true and postulate 4 is true over a long period time small variations could gradually lead to large changes in species.

Quick Summary

- Darwin really proposed at least five theories the most important being Natural Selection
- Darwin's Theory of Natural Selection develops logically from a relatively few postulates.
- Those being
  - There is variation within species
  - There is inheritance of variable traits
  - Every species has the ability to grow exponentially
  - The earth is very old.

Game Plan

- Discuss some critically misunderstood terms related to Darwin's Theory
- The Radical Ideas embedded in Darwin's Theory of Evolution.

Darwin's Theory and Catch Phrases

- **Natural Selection**
- **Survival of the fittest**
- **Nature red in tooth and fang**
- **Descent with modification**
- **Local Adaptation**

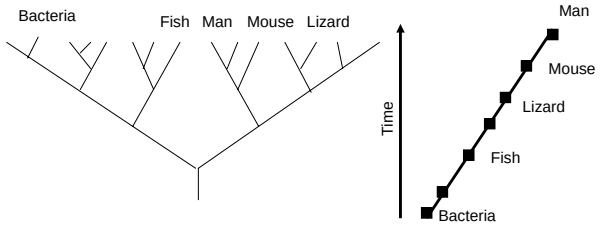
The Origin of Species

Original Title – *On The Origin Of Species By Means Of Natural Selection, Or The Preservation Of Favoured Races In The Struggle For Life.*

The word *"evolution"* does not appear in text. The word "*evolved"* occurs only once as the last word in the text.

Radical Ideas Embedded in Darwin's Theory

- Non-directional selection
  - Tree of life vs. Ladder of progress
  - Selection only favors adaptation to local conditions, Not progressive improvement!



Vitalism Materialism and Natural Theology

- Vitalism – a doctrine that life is endowed with a “vital” force independent of physical and chemical processes.
- Materialism – a doctrine that all phenomena can be explained in their entiity based only on physical and chemical principles.
- Darwin’s theory was materialistic and undermined the central tenants of natural theology.

Radical Ideas Embedded in Darwin’s Theory

- Thinking about Populations not Individuals
  - Populations evolve, individuals do not
  - Probability and chance play a major role.

QUICK SUMMARY

Darwin’s theory were radical because –

- They challenged the idea of progress and direction in evolution.
- They were materialistic
- They required thinking about statistical changes in populations rather than understanding individuals.

Darwin’s Luck

- “Chance favors the prepared mind” -Pasteur
- Darwin assumed many things that in retrospect there was only marginal evidence or understanding of at the time.
- In the 140 years since Darwin’s theory was published, the physical and chemical principles of those assumptions have become more fully understood.
- Darwin’s crucial assumptions have all been supported by subsequent developments.

Darwin's Luck

- Darwin assumed that there was variation within all species.
- Darwin based this assumption on a lifetime of experience of collecting and measuring organisms.
- He used inductive reasoning to generalize that because the species and specimens he studied varied, all species varied.

Darwin's Luck

- Darwin did not know –
  - Why variation occurred.
  - Whether there were limits on the variation,
  - Whether the variation was caused by environment or genetics
- Subsequently, the discovery of DNA and the chemical and physical principles involved in mutation allow modern scientist to confirm –
  - Individuals vary, in part, because their DNA has different nucleotide sequences.
  - Mutation alters the nucleotide sequence and will provide a nearly limitless source of variation.
  - Variation is caused by both genetics (inherited nucleotide sequences) and environment.

Darwin's Luck

- Darwin assumed that traits were inherited from parents, that individuals would tend to resemble their parents and that individuals did not acquire new traits during their lifetime.
- He based this assumption largely on the limited knowledge of inheritance that practical plant and animal breeders had developed over the centuries

Darwin's Luck

- Darwin did not know –
  - The chemical of physical principles of inheritance.
  - Why offspring resembled their parents.
  - Why offspring are not identical to their parents.
  - Whether traits were inherited as discrete units or whether their was a blending the two parent's traits
- Subsequently the discovery of chromosomes, meiosis, genes and DNA confirmed –
  - A well understood chemical and physicals process will result in children inheriting discrete genes from each parent.
  - It is likely that offspring will share many traits with their parents.
  - In sexually reproducing species it is unlikely that the offspring will be identical to their parents
  - The units of inheritance are discrete, but the resulting offspring will have some traits that are characteristic of only one parent and other traits that will be intermediate between the two parents.
  - That traits acquired during life an individual are unlikely to be transmitted to their offspring.

Darwin's Luck

- Darwin assumed that every species had the potential for its populations to grow exponentially.
- Darwin based this on inductive reasoning, the species studied up to that time had demonstrated this ability. So he generalized that all species have that ability.
- Subsequent observation have yet to find a viable population that does not show this ability. Since it is impossible to study all species we still use inductive reasoning to make this generality, but it is supported by another 140 years of data.

Darwin's Luck

- Darwin assumed that the earth was very old.
- He based this on the accepted geological theories of the time. Many of those theories were based on arguments about how and why geological strata were formed.

Darwin's Luck

- The geological theories of Darwin's day were often based on analogies to how and how fast sediments are formed today. There was no independent way of dating when or how a sediment was formed.
- Subsequently
  - Knowledge of radioactivity and other physical and chemical principles have allowed the development a number of techniques to assign dates to the formation of geological strata.
  - These independent dating techniques are consistent with a very old earth.

Chapter 2 – Evolution

Key Concepts Section 2.1-2.3

- Prior to Darwin there were many views about the mutability of species.
  - Immutable – unchanging
  - Mutable – changing
  - Transmutation – process of change
- Prior to Darwin there were many views about the nature of change if it occurred
  - No change
  - Extinction occurs but no speciation
  - Extinction with new creations but no change
  - Extinction with progressive (goal oriented change)

Key Concepts Section 2.1-2.3

- Darwin's model predicted
  - Extinctions
  - Evolution of new species
  - Analogy – was a tree of life
    - Branches represent the formation of new species
    - Short branches indicate that line went extinct before now
    - Longest branches represent extant groups

Parsimony

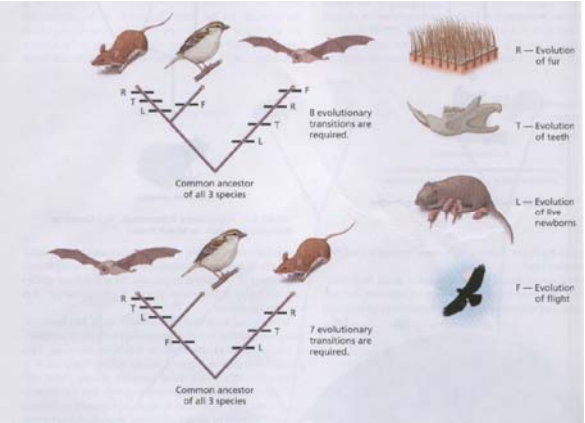
- The Principle of Parsimony – states all else being equal, the better explanation is the one that has the fewest assumptions.
- Occam's Razor – William of Occam (1285-1345) – "do not multiply entities unecesarily"
- Crude modern equivalent – "Keep it simple stupid"

Mathematical Justification of Parsimony

- Consider two events (event A and event B) each with a fixed low probability of occuring.
- Assume the probability that Event A will occur is 1 in 100 (0.01).
- Assume the probability that Event B will occur is 2 in 100 (0.02).
- The probability that Event A **and** Event B will both occur is Probability of Event A times the Probability of Event B. In our example (0.01*0.02=0.0002 or 2/10,000)
- If your explanation assumes that both event A and Event B occurs it is much less likely than if it assumes only one of the events occurs.

Parsimony and Creation of Cladograms

- A cladogram is a stick figure representing a ancestral tree of a group of organisms
- The evolution of adaptations (wings, furs etc) can be viewed as rare but finitely possible events
- The probability of the same adaptations evolving multiples times would be unlikely.
- If a number of adaptations are shared between species, minimizing the total number of times that rare evolution events occurred can create a most parsimonious cladogram.



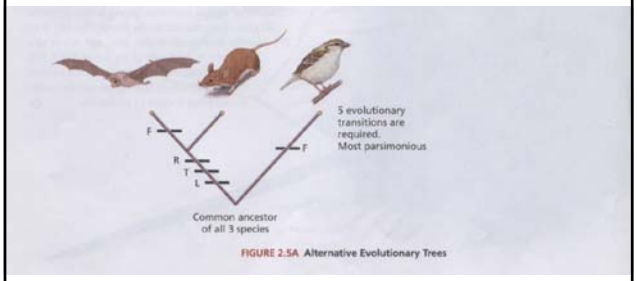


FIGURE 2.5A Alternative Evolutionary Trees

Parsimony

- Mutations as a source variation
- DNA sequences as adaptations
- Neutral and Selectively
- Conserved and Variable Sequences
- Equally parsimonius trees