EVOLUTION

The Principle of Evolution

- Living things have evolved through time in an orderly fashion, without repetition and without reversal, to produce modern life. OR
- All existing life has its origins in pre-existing life and has changed to its present state through successive generations.
Contributing Concepts to Evolution

- Lucretius 96-55 BC
  - Universe-shower of atoms with eddies
  - Nature in a constant state of change, growth, death…species change with time
- Read by scholars in spite of conflict with Bible
- Note conflict with Creationists – universe made all at once then decay

Concepts Contributing to Darwin’s Evolution

- Exploration of the world in 1700’s
  - World too large for biblical accounts
  - Too many animals for the ark
  - Animals (and plants) differ markedly in different parts of the world
- Linneus’s books
  - Huge number of living things
  - Living things are naturally related to one another
Contributing Concepts to Evolution

- Geology
  - William Smith
    - Studied fossils of England
    - Developed the Law of Fossil Succession
      "Fossils succeed one another in an orderly fashion through time"
      New forms appear as time passes – not all at once
      Flood(s) don’t explain it

Concepts Contributing to Darwin's Evolution

- Geology
  - James Hutton and Charles Lyell
  - Geologic Time and Uniformitarianism
    - The earth is very, very old (more than 6000 yrs.)
    - Present day processes explain past changes in rocks (and fossils)
Concepts Contributing to Darwin's Evolution

- Count Buffon (1707-1788)
- “The Ladder of Creation” Theorized the “transmutation” of species into one another
  - Simple to complex with man at top but below angels and God.
  - Still accepted by some; was accepted by Thomas Jefferson

“Ladder of Creation”

- Depends on spontaneous generation
- Each group evolves parallel to others
- Problems:
  - Fossil record not a picture of simple to complex
  - “Cambrian Explosion”
  - Spontaneous generation disproved by Louis Pasteur
Concepts Contributing to Darwin's Evolution

- Jean Baptiste Lamark (1744-1829) – Inheritance of acquired characteristics
  - Characteristics acquired during organism’s lifetime can be passed on, inherited.
  - Life evolved by accumulation of acquired characters

Inheritance of Acquired Characteristics

- Problems
  - August Weismann (1834-1914 experiments proved it isn’t so with mice
  - James Watson (1928-)– described a “one-way” relationship between DNA and RNA
Concepts Contributing to Darwin's Evolution

- Georges Cuvier (1769-1832)
- Catastrophism: Catastrophies explained extinctions and new creations
- Unconformities were evidence of catastrophies
- Problems:
  - Extinctions didn’t always correspond to unconformities
  - New forms arose between unconformities

Concepts Contributing to Darwin's Evolution

- Erasmus Darwin (1731-1802)
- Poem on Evolution
  - Evolution of all life from a single ancestor
  - Like a branching tree
- Problem
  - Lacking a mechanism for speciation
Concepts Contributing to Darwin’s Evolution

- Thomas Malthus (1766-1834)
  - Many more are born than survive
  - Individuals in a population compete for limited resources

Evolution by Means of Natural Selection

- Alfred Russel Wallace (1823-1913)
- Charles Darwin (1809-1882)
Darwin’s Evidence in Origin of Species

- Domestic selective breeding
- Natural adaptation to the environment
- Natural variation within populations
- Malthusian population and competition
- Fossils
- Geographic distribution of species
- Linnaeus’s taxonomy

Darwin’s Evidence

- Domestic animals and selective breeding
  - Produces new forms like new varieties
  - The boundaries between varieties and species are blurred.
Darwin’s Evidence

- Adaptation to the environment
  - Animals are physically and behaviorally adapted to their immediate environments
  - Darwin’s finches
  - Diversification of island life

Darwin’s evidence

- Variation within Populations
  - Variations occur in all species
  - The boundary between species, sub-species and varieties is blurred
  - Variations can be selected for (as in domestic selective breeding)
  - Variations become species in islands by diversification into different environments
  - Variations can become new species characters
Darwin’s Evidence

- Many more are born than survive
  - Competition must determine which survive
- Fossil Records show species arising and becoming extinct (although imperfect record of gradual change)

Darwin’s Evidence

- Geographic distribution
  - Species in proximity show closer relationships to each other than to more geographically distant relatives.
  - Islands near continents are populated with species closely related to those on the adjacent continent
  - Species are not randomly distributed around the world as a creator would have made them
Darwin’s Evidence

- The natural system of classification (Linnean taxonomy) reflects a belief in descent.
  - Genera and Families imply that their members are descended from common ancestors (a common ancestor)
  - Evolution is an underlying principle of taxonomy

Darwin’s Conclusions

- Natural Selection
- Evolution
- Phyletic Gradualism
- Cladism
- Competition
Darwin’s Conclusions

- Natural Selection – Organisms that inherit favorable variations for their immediate environment will tend to survive more often than others (and reproduce).
  - Traits appear in a population
  - Nature selectively acts on individuals with that trait to destroy or perpetuate
  - If favorable, trait spreads to whole population making a change toward new variety or species
  - Traits add up

Darwin’s Conclusions

- Evolution
  - Life has changed constantly through time
  - New species have arisen and species have become extinct
  - This occurs because of natural selection acting on variations within populations
Darwin’s Conclusions

- Phyletic Gradualism
  - The change from one species to another is a gradual process
  - If change in the fossil record seems abrupt it is because the record is so imperfect.

- Cladism
  - Similar organisms are descended from a single ancestor
  - Evolution is like a branching tree
Darwin’s Conclusions

- Competition (ala Malthus)
  - Many more are born than survive
  - Individuals compete for limited resources
  - Only the best adapted survive
  - “Survival of the fittest”
- Natural selection is the means of Evolution

Neodarwinism

- “The great synthesis” of Darwin and modern genetics
  - Mendel (rediscovered about 1900)
    - Got past the “blending inheritance problem”
    - 7 characters in 28,000 pea plants
    - Discovered discreet inheritance and dominance
    - Rare traits can re-appear
    - Not all traits blend but offspring are in ratios
Neodarwinism

- **Mutation**
  - Changes in the genotype that produce changes in the phenotype
  - Most mutations are detrimental to the phenotype, but not all.

- **Population Genetics**
  - Mathematics show natural selection could make major changes in the gene pool even with low rates of mutation.

The 4 “ISM’s of Neodarwinism

- **Reductionism**
- **Panselectionism**
- **Extrapolationism**
- **Gradualism**
Reductionism

- An attempt or tendency to explain a complex set of facts, entities, phenomena, or structures by another, simpler set:

  Decartes argued that all non-human animals can be reduced to automata 1629

Reductionism

- Organisms can be reduced to their genes
  - Genotype to Phenotype – Phenotype is just a reflection of genotype – same thing
  - Many Phenotypes in a population – a pool of genes for natural selection to work on

Gene in relation to double-helix DNA
While recognizing the importance of random drift for silent mutations, selectionists hypotheses argue that balancing and positive selection are the driving forces of molecular evolution. Those hypotheses are often based on the broader view called panselectionism, the idea that selection is the only force strong enough to explain evolution, relaying random drift and mutations to minor roles.

Panselectionism

- Natural selection is a continuously operating force that acts on all traits of the phenotype (hence all genes)
Panselectionism

- All changes in the population are adaptive in some way
- All traits of the species are adaptive in some way

Panselectionism

- Nothing is neutral or wasted

The lion’s archetypal roar is used to communicate with other group members and warn intruders of territorial boundaries.
Long, retractable claws help the lion to grab and hold prey.
The species’ rough tongue helps it to peel the skin of prey animals away from flesh and flesh away from bone.
Loose belly skin allows the African lion to be kicked by prey with little chance of injury.
Extrapolationism

- Part of Microevolution
  - Small changes seen in modern populations (such as fruit flies) can be extrapolated to explain all major evolutionary change
  - Small changes add up to create larger changes

Microevolution is evolution on a small scale—within a single population. That means narrowing our focus to one branch of the tree of life.
Phyletic Gradualism

- Phyletic gradualism is a speciation hypothesis rooted in uniformitarianism. The hypothesis states that species continue to adapt to new environmental and biological selection pressures over the course of their history, gradually becoming new species.

Gradualism

- Part of Microevolution
  - Evolution takes place gradually by the accumulation of small steps that add up to larger changes.
  - Numerous transitional stages should be observable in evolution from one species to another.
Gradualism: A long time ago, there were a lot of tiger-like animals, but without stripes. Most of them were unmarked, but a few had light markings and color variation in their fur. These few blended in with the tall grasses a little bit better, so they were generally able to catch more food, and fewer of the marked than unmarked ones died of hunger, so more of them were able to reproduce. In the next generation, more animals were marked than in the previous generation. Of those that were marked, some had more, some less, and some the same amount of marks than in the previous generation. Also, the marks were more, less, or the same amount clearly defined. Again, the ones with marks did better than the ones without, and the ones with more, clearly defined marks did better than the ones with fewer or fainter marks. Very gradually, over many, many generations, stripes over the tigers' whole bodies formed and appeared in the whole population, because the tigers that survived in each generation were those whose marks were most clear and contrasted most with the rest of the fur, and those that covered the most area on the bodies of the tigers.

Challenges to Neodarwinism

- New Lanarkian Ideas
- Neutralism
- Types of Strange Genes
- Macroevolution
- Evolution and Paleontology
- “New Theory of Evolution” – Punctuated Equilibrium
New Lamarkian Ideas

- Genetic assimilation – shock or environmental stimulus seems to cause genetic change
- “Experiential genes” – immunity inheritance
- Jumping genes and viruses

Jumping genes

- **Transposons** are sequences of DNA that can move around to different positions within the genome of a single cell, a process called **transposition**. In the process, they can cause mutations and change the amount of DNA in the genome. Transposons were also once called **jumping genes**, and are examples of mobile genetic elements. They were discovered by **Barbara McClintock** early in her career, for which she was awarded a **Nobel prize** in 1983.
Neutralism

- The **neutral theory of molecular evolution** was introduced by Motoo Kimura in the late 1960s and early 1970s. The theory states that the vast majority of evolutionary changes at the molecular level are caused by random drift of selectively neutral mutants.

Neutralism

- Many genes never used (can’t be subject to selection)
- Both genes and mutations (selectively neutral) can accumulate for large changes
- Pleiotropy – Genes that code for multiple features- some features carried along
Types of Strange Genes

- Quantitative Inheritance
  - Eg. Weight/height depends on several Genes

  AABBCDDD-biggest
  aabbcddd- smallest
  AAbbCCdd – in between

Types of Strange Genes

- Structural genes and regulatory genes
- Regulatory genes control many structural genes so change in reg. means many changes in structure.

- Junk genes – don’t seem to do anything

- Homeotic genes – make major changes – limb in wrong place
Macroevolution

- Robert Goldschmidt
  - Structural and regulatory genes
  - Macroevolution and the hopeful monster - the problem of a mate
  - Breakthroughs in embryology – change can take place in several individuals

Evolution and Paleontology

- G. G. Simpson – gradualism in the fossil record
- Biostratigraphy – Practitioners used stasis in the fossil record
  Eldrich and Gould – Species are inflexible and non-responsive to the environment
  Sewall Wright – Species are a hierarchical level above individuals and populations.
Evolution and Paleontology

- “Species Sorting”
  - Does natural selection work on species?
  - Competition is between species (not individuals?)
  - Extinction
  - Species speciate, not organisms

A “new theory of evolution”

- Macroevolution
- Allopatric Speciation
- Punctuated Equilibrium
- Species sorting
Answers to the isms

- Reductionism – neither the individual nor the species is merely the sum of its genes
- Panselectionism – some changes are neutral to selection; many of such changes are pre-adaptive

Answers to isms

- Extrapolationism – small changes do not add up. Small changes are irrelevant; speciation requires large changes
- Gradualism – Species are static. They do not change gradually. New species appear fully formed, abruptly.