

The background of the slide features a dense pattern of vibrant green leaves, likely from a tree or shrub, with prominent veins. Below the leaves, there are soft, circular ripples in a light blue-green hue, suggesting water. The entire scene is overlaid with a semi-transparent white rounded rectangle that serves as a backdrop for the text.

Chapter 4

Mechanisms of Population Change

Adaptations

- Organisms that live long enough to reproduce will pass on their traits to the next generation
- Those organisms that are best adapted to their environments will be most likely to survive
- Adaptations can be either structural, behavioural, or physiological

Structural Adaptations

- Adaptations that come from a change in DNA of the organism and result in a physical change to their anatomy
 - Ex: webbed feet, camouflage, opposable thumbs, mimicry

Behavioural Adaptations

- Adaptation that results from a combination of experience and instinct. It is a change in the way an organism acts in response to an environmental stimulus.
 - Ex: hibernation, migration, mimicry

Physiological Adaptations

- Adaptations that result from changes to internal body systems of an organism.
 - Ex: most mammals make similar hormones, counter-current exchange, cows have 4 stomachs

The Source of Adaptations

- Adaptations are due to the gradual change in the characteristics of a population over time
- Although variations (DNA) can result in adaptations, not all variations are beneficial

Variation Within Species


- Variation is the result of genetic changes (mutations) and recombinations
- The recombination of genes can occur during sexual reproduction

Mutations and Variation

- However, ultimately, all variation is due to mutations
- Changes in the genetic code result in slightly different genes than the genes present in other organisms
- DNA mutations can occur from errors in copying the DNA, and damage from radiation or mutagens

The Effect of Mutations

- Genes code for proteins
- A change in the genetic code will alter the sequence of amino acids that forms a protein
- This change in the amino acid sequence will change the shape of the protein, which changes its action

- 
- Some mutations occur in somatic cells (the cells that make up body tissues)
 - These mutations will disappear when the organism dies
 - However, if mutations occur in germ line cells (those that produce sperm or eggs), the mutations will be passed on to the next generation



Mutations and Selective Advantage

- Some mutations produce a change in an individual that is beneficial
- These mutations increase the individual's chance of survival and will most likely be passed on to the next generation

Case Study: Venom-Resistant Squirrels

- In California, some ground squirrels have developed a mutation that makes them more resistant to rattlesnake venom
- Therefore, the ground squirrels with the mutation have a greater chance of survival and therefore will pass on their traits to the next generation
- Ultimately, the majority of the squirrel population will have this beneficial adaptation because they are more likely to survive to reproduce



Case Study: Pesticide Resistance

- In 1955, the World Health Organization initiated a widespread program to kill malaria-carrying mosquitoes using DDT
- This program was initially very successful in decreasing mosquito populations, but they quickly reappeared
- Because of the reduced effectiveness of DDT and its negative environmental effects, the spraying program was discontinued



Case Study: Pesticide Resistance

- Why did DDT lose its effectiveness?

Case Study: “Superbugs”

- In 1928, Sir Alexander Fleming discovered that penicillin could be used to kill bacteria
- Penicillin was first used as a medicine in 1941
- By 1945, there were already reports of penicillin-resistant strains of bacteria
- There are now bacterial strains that are resistant to all known antibiotics




Case Study: “Superbugs”

- What factors contributed to the development of antibiotic-resistant bacteria?



Natural Selection

- Individuals that have beneficial adaptations that are passed on to their offspring will change the population as those traits are passed on to the next generation
- For natural selection to occur, there must be variation within the species

- 
- In a population, individuals are selected for by their environment
 - It is important to consider that individuals do not change during their lifetime – rather, the population changes over time
 - The environment will exert a selective pressure on a population


Example: Selective Pressure

- In a population of grasses, some of the grasses are better adapted to survive drought conditions
- If a drought occurs, it exerts a selective pressure that favours those plants that are drought-resistant
- This causes a change in the makeup of the population



Natural Selection & the Environment

- Natural selection does not anticipate changes in the environment
- Instead, random changes occur and produce traits that may be beneficial in the future
- When the environment changes, then those variations that have been produced increase the ability of some organisms to survive

- 
- Variations that are not beneficial in a certain environment may not be harmful, they may simply be useless
 - If a variation is detrimental, it is unlikely that it will be passed on until the environment changes to select for that variation



Developing a Theory to Explain Change


- People have been asking questions for centuries regarding how life developed on Earth
- Theories have developed through observations, analysis of data and the formulation of hypotheses

Historical Theories

- The most important Greek philosophers (Plato and Aristotle) believed that life existed on Earth in a perfected and unchanged form

Creationist Theories

- Creationists believe that God created all organisms in their original state during a period of creation
- This particular period can vary, depending on literal interpretation (a 6-day creation followed by a day of rest) or more figurative interpretations (each day corresponding to a longer period of time)

- 
- Literal creationists believe that the Earth is between 5000 and 6000 years old
 - They attribute massive geological changes to cataclysmic events, such as the biblical flood (found in Genesis, chapters 6 – 9)
 - However, there is a diverse range of creationist views



Developing the Theory of Natural Selection

- The theory of natural selection has developed over many centuries
- Because of the influence of the Roman Catholic Church in Europe, few evolutionary theories appeared until the 1700s

Georges-Louis Leclerc, Comte de Buffon

- One of the first people to challenge the idea that life forms do not change



<http://content.answers.com>

Georges Cuvier

- Largely credited with developing the science of paleontology



<http://content.answers.com>

Charles Lyell

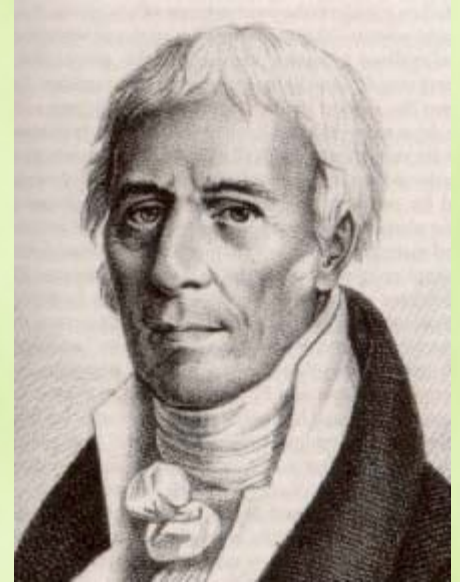
- Suggested, unlike Cuvier, that the geological processes that occur on Earth take long times, meaning the Earth was quite old



<http://io.uwinnipeg.ca>

Jean-Baptiste Lamarck

- Developed an early idea regarding how animals change over time
- Proposed that animals evolved through continued use of and organ or limb. Disuse of organs/limbs resulted in “de-evolution” of them...until they disappeared entirely.
- Basically proposed that acquired characteristics could be passed on to the next generation



<http://www.nndb.com>

Charles Darwin

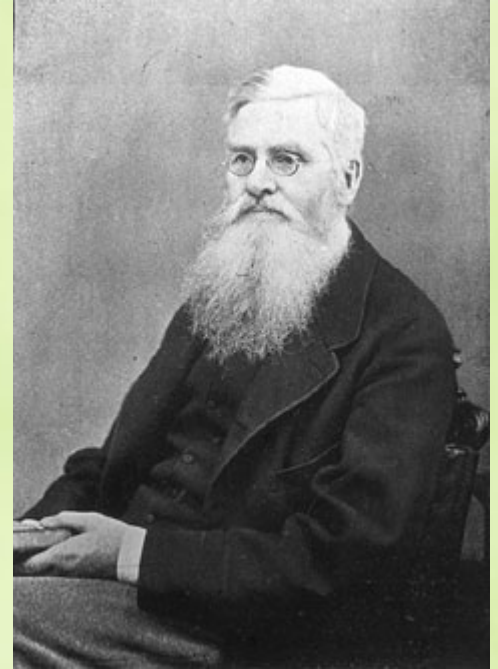
- Traveled aboard the HMS *Beagle* on a voyage to survey the coast of South America
- He made numerous observations regarding the organisms that he saw along the way



<http://www.don-lindsay-archive.org>

Alfred Russel Wallace


- At the same time that Darwin was studying his observations made on the Beagle voyage, Wallace was studying organisms in South America and Malaysia



<http://www.nndb.com>

The Theory of Evolution by Natural Selection

- Both Darwin and Wallace were influenced by Thomas Malthus' *Essay on the Principles of Population* that stated that populations produced more offspring than an environment could support
- Darwin and Wallace reasoned that competition for limited resources would select for favorable traits

- 
- Therefore, a proportion of the population would have these traits
 - As time passed, a greater proportion of the population would have these beneficial traits as they improved their chances of surviving and reproducing



Darwin's *On the Origin of Species*

- Darwin's book proposed two main ideas based on his observations:
 1. Present forms of life have descended from ancestral species
 2. The mechanism for modification is natural selection that takes place over a long period of time

Mechanism of Change

- According to Darwin, there are five major events that lead to evolution:
 1. **Overproduction** – organisms generally produce more offspring than will survive (their environment has limited resources)
 2. **Struggle for Existence** – overproduction leads to competition for resources
 3. **Variation** – members of a species are not identical; some will have more favourable traits than others
 4. **Natural Selection** – aka survival of the fittest; those with favourable traits will likely out-compete those with environmentally unfavourable traits and pass these traits on to the next generation
 5. **Speciation** – after many generations of accumulated variations being passed down, eventually the newest generation is too different from its ancestors and is classified as a new species



Further Evidence for Evolution

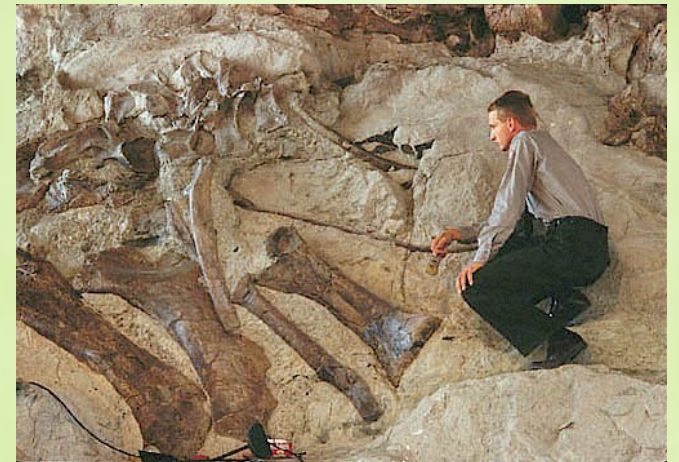
- Since Darwin's publishing of *On the Origin of Species* a significant amount of evidence has been collected to support his theories
- Biologists, geologists, geographers, and paleontologists have all contributed evidence supporting evolution

Fossils

- Fossils are formed within sedimentary rock
- The layer in which a fossil is found often is indicative of the age of that particular specimen



<http://www.field.ca>



<http://www.cpluhna.nau.edu>

Fossils as Evidence

- Fossils found in layers of rock near the surface appear to be much more closely related to modern species than fossils found in older layers
- Fossils appear in chronological layers, so probable ancestors of a particular species would lie beneath the rock layers in which the more current species is found
- Not all organisms appear in the fossil record at the same time, which indicates that different species evolved at different times

Transitional Fossils

- Often there were apparent gaps in the fossil record
- Over time, transitional fossils are found that fill the gaps and link different species together

Patterns of Distribution

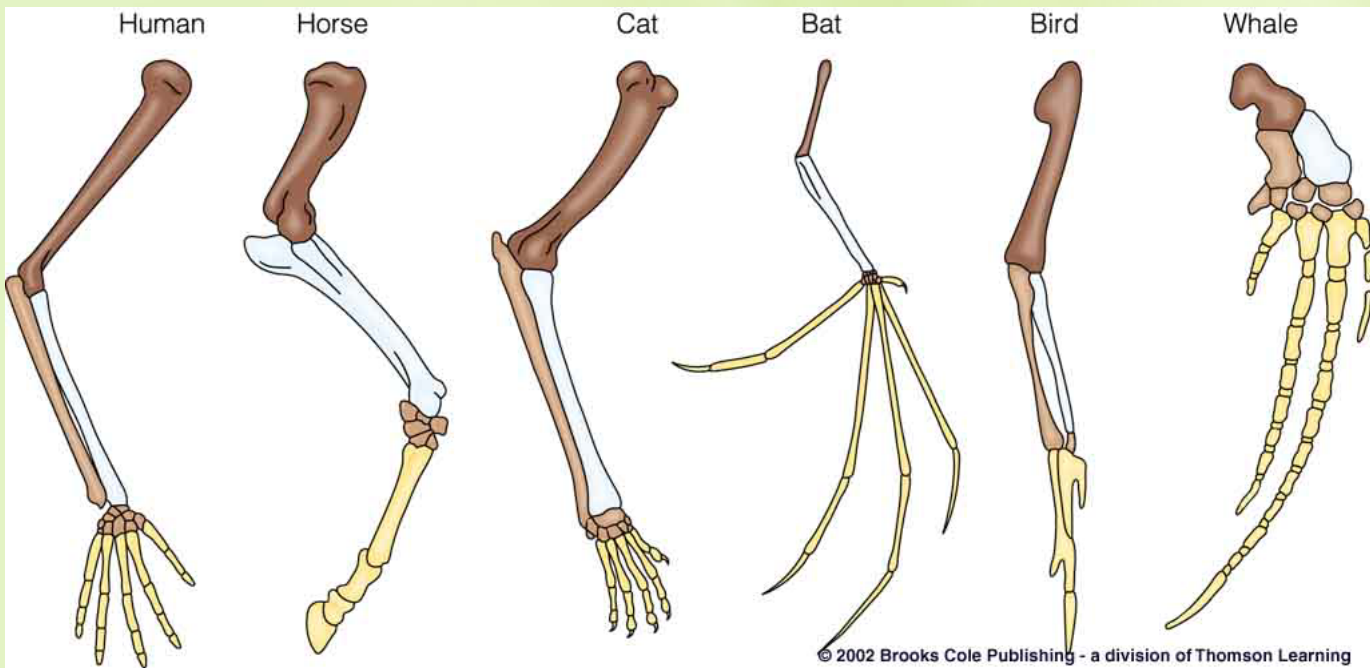
- Biogeography is the study of the past and present geographical distribution of organisms
- Many of the observations used by Wallace and Darwin were based on biogeography

Examples of Biogeographical Evidence

- Darwin studied finches in the Galapagos Islands. Different islands had different finches, each with unique forms of their beaks.
- He attributed this to the food found in the environment on different islands.
- Variations in beaks that were beneficial on their island would result in more success, and be more likely passed on

Anatomy

- Many closely related organisms have homologous structures (structures that have the same origin and general elements, but different functions)






Homologous Structures and Evolution

- Homologous structures point to a common ancestor
- Variations in the structure over time made the homologous structures useful adaptations for different environments
- Analogous structures (those with a similar function, but different origins) do not lend evidence to evolution
 - Ex: convergent evolution in species (ie: pandas / human opposable digits)



Molecular Biology

- Evolutionary relationships can be studied and traced using DNA
- We have learned that some traits are shared by all organisms:

- 
- **Cell Design:** all eukaryotic cells contain a nucleus, cell membranes made of similar material, and mitochondria
 - **Proteins:** many organisms contain the same or similar proteins and enzymes that perform similar functions in their bodies. (ex: insulin)
 - **Genetic Material:** many organisms share a significant portion of DNA. This points to a common ancestor.

Genetics

- When Darwin proposed his theory of evolution, very little was understood regarding genetics
- We now know the following:
 1. Species pass on their traits to offspring using genetic material
 2. The genetic material can randomly change (mutations), leading to variation in traits

The Scopes Trial

- In 1925, John Scopes was arrested and put on trial for teaching Darwin's evolutionary theory in his High School Biology class in Dayton, Tennessee
- He was convicted and fined \$100

[Scopes Trial Newsreel](#)

How Species Form

- Two species may appear very similar, but be considered different species
- This is because of the definition of a species:
 - organisms that share very similar DNA, can successfully reproduce with each other, and are reproductively isolated from other groups of organisms (other species)

Reproductive Isolation

- Therefore, different species are reproductively isolated from other species
- This can be due to a number of different factors:
 1. **Habitat Isolation** – includes geographical barriers that prevent physical contact
 2. **Temporal Isolation** – some species are fertile at different times of the year
 3. **Behavioural Isolation** – some species require a mating ritual in order to recognize as a suitable partner
 4. **Physiological Isolation** – some species' anatomy are not compatible or may require a certain pheromone to attract mates. Even if offspring were conceived, they are often sterile.

Isolation of Populations

- For speciation to occur, species must be prevented from breeding
- Therefore, there must be biological or geographical barriers that prevent breeding
- If the populations are separated for a long enough time, changes occur in the populations through natural selection

Geographical Barriers

- These keep populations physically separated
- These physical barriers only need to be present long enough for speciation to occur
- Examples of geographical barriers:
 - islands, mountain ranges, continent separation, removal/destruction of land bridges, new river formation

Biological Barriers

- Biological barriers occur between species that share the same geographical ranges
- Examples may include:
 - physical incompatibility
 - structural or molecular blockage of the formation of a zygote

Forming New Species

- There are two general pathways that can lead to the creation of a new species

1. Transformation

- over many generations, genetic variations accumulate and the ancestral species is replaced by the emergence of a “better version”, a descendent that outcompetes its ancestors.

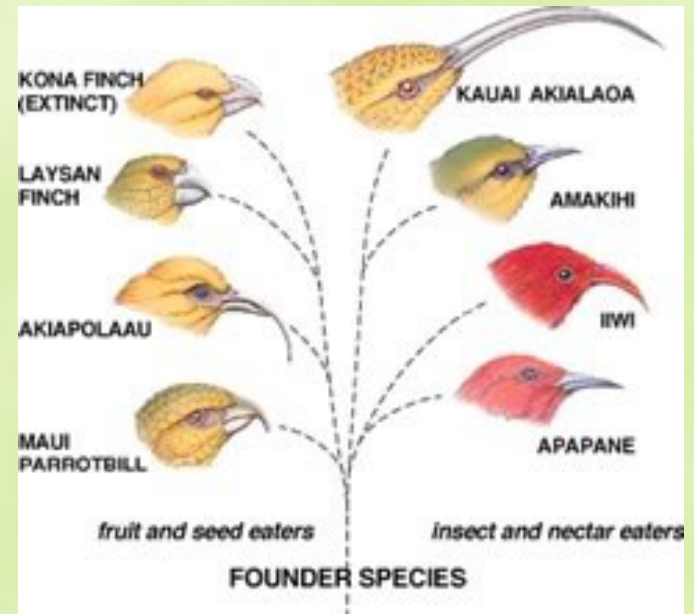
Species Formation

2. Divergence

- when a species undergoes evolutionary changes through reproductive isolation, resulting in 2 (or more) different species coexisting at the same time. They both experience different natural selections and both replace their ancestor species.
- Divergence increases biological diversity because it increases the number of species

Speciation in Reproductively Isolated Populations

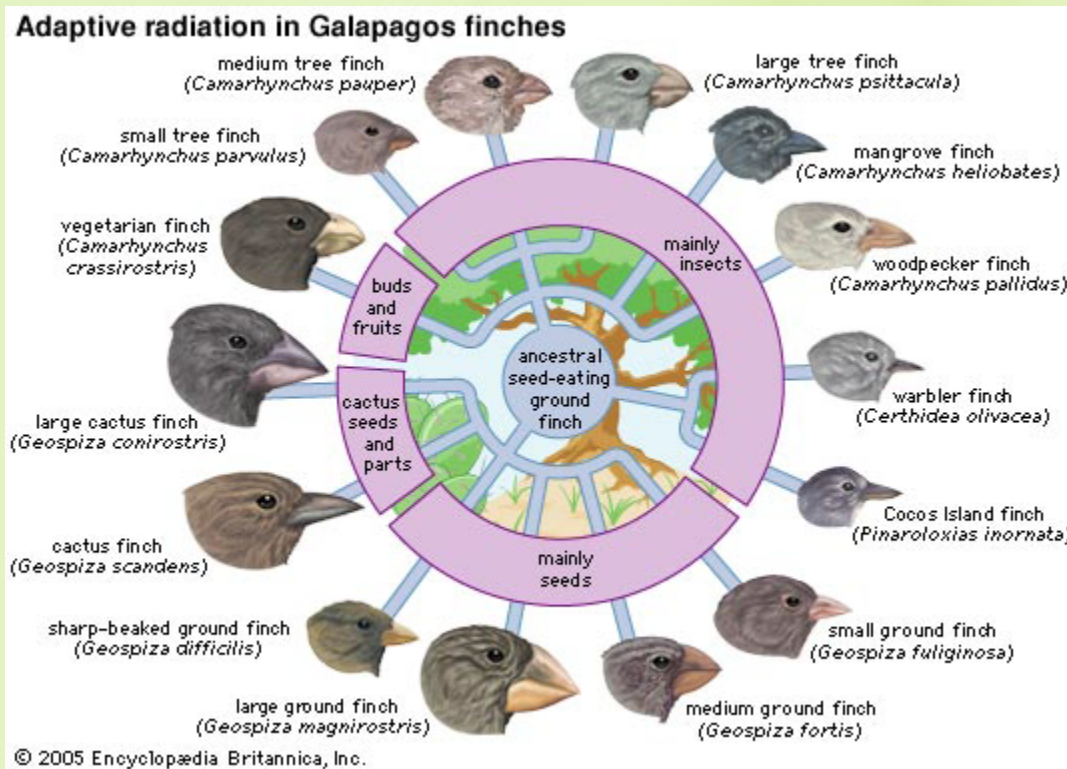
- A single founder species can produce a number of different new species
- This occurs when the offspring are reproductively isolated and develop variations



<http://www.virtuallaboratory.net>

Adaptive Radiation

- Adaptive radiation is the diversification of a common ancestral species into a variety of differently adapted species






Why Does Adaptive Radiation Occur?

- As the offspring of the original ancestor disperse, they encounter new environments with slightly different selection pressures
- The adaptations that allow the organisms to survive in these new habitats eventually result in new species


The Speed of Evolution

- Since Darwin's time, evolutionary biologists have suggested that evolution is very slow
- This would indicate that the large differences we see between species now are the sum of all of the small changes over a long period of time
- However, sudden changes seen in the fossil record do not support this in some cases

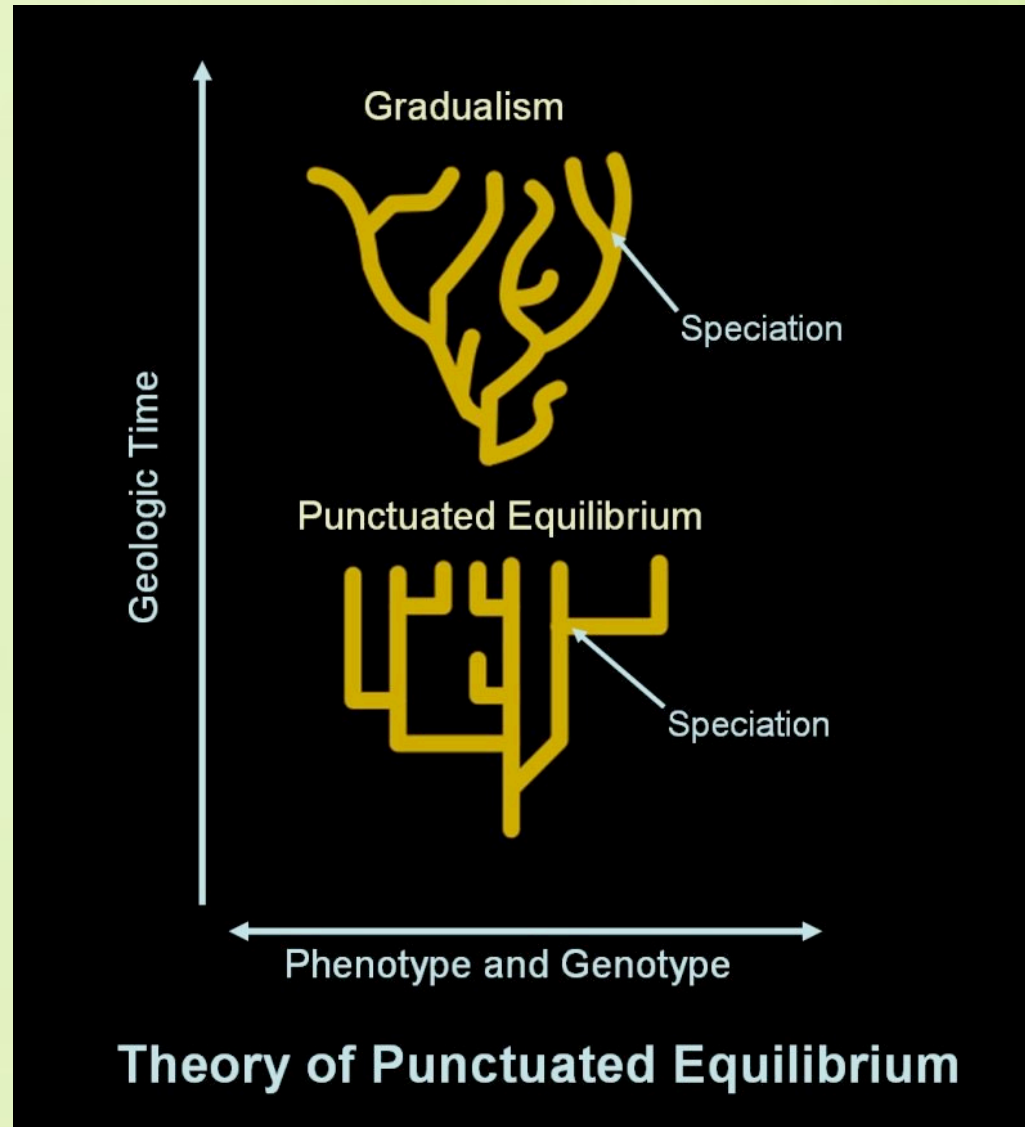


A New Idea - Punctuated Equilibrium

- Punctuated equilibrium proposes that evolutionary history consists of long periods where very little changes that is broken up by rapid periods of change
- This theory proposes that when a species first diverges from a parent species, major morphological changes occur

- 
- This can occur when a species enters a new area
 - When this occurs, new selection pressures will select for different adaptations, resulting in the next generation being quite different from the parent generation

Gradualism vs. Punctuated Equilibrium





Summary - The Theory of Evolution by Natural Selection

1. Life forms have developed from ancestral species.
2. All living things are related to one another by varying degrees through common descent.
3. All living things on Earth share a common origin (or ancestor)



Summary - The Theory of Evolution by Natural Selection (Continued)

4. The mechanism by which one species evolves into another involves random heritable genetic mutations. Mutations that increase the survival advantage of an individual will most likely be passed on to offspring. Over time the successful mutation spreads throughout the population and causes a change in the population

Where Do We Go From Here?

- There is still wide debate over evolutionary theories
- Much research is being carried out to refine these hypotheses, and new discoveries will further the development of these theories over time