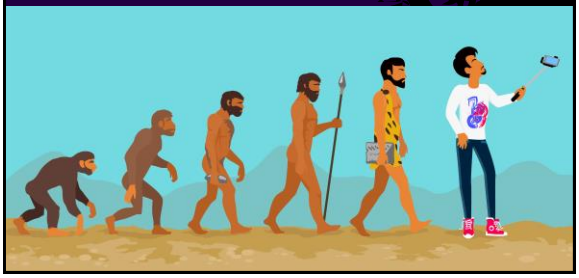
Principles of Evolution

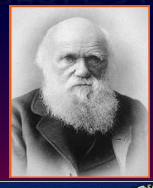


Evolution- Hypothesis or Theory?

- Hypothesis- a specific, testable prediction
- Theory- a general explanation for a broad range of data
- **Evolution**- *Change over time*; modern organisms have descended with modification from ancient organisms.
- Because it is supported by so many lines of evidence, evolution is no longer considered a hypothesis. Evolution is one of the great unifying theories of Biology.

What was Charles Darwin's contribution to science?

CHARLES DARWIN



- At 22, sailed on the "HMS Beagle" to the Galapagos Islands.
- Was going to school to be a minister-believed God created each species to match its habitat and they never changed.
- Thought Earth was about 6,000 years old and didn't change.

CHARLES DARWIN

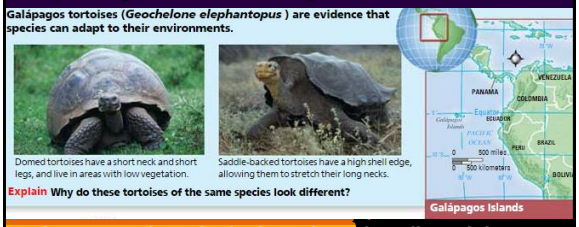
- During journey, he made observations and recorded them in a journal.
- Darwin began to doubt that species remained "constant."

Darwin's Background Voyage

- Darwin's many observations led him to the idea that species slowly **change** over time
- Darwin's comparison of the animals of South America and the Galapagos Islands caused him to conclude that adaptation to the environment can cause **diversification**, including origin of new species
- Examples: Patagonian hares replaced rabbits in the South American grasslands

The Galapagos Islands

- Island species varied from the mainland species, and from island-to-island
- Each island had either long or short necked tortoises depending on the island's vegetation



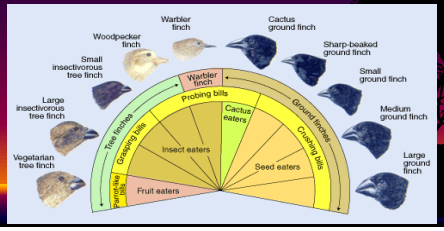
- These organisms had adaptations that allowed them to better survive in their environment

Darwin's Observations Contd.

- Finches found only on the Galapagos Islands- resembled a mainland finch, but there were more types
- Beak shapes are adaptations to different means of gathering food (what the finches eat)
- Galapagos finch species varied by:
  - nesting site
  - beak size
  - eating habits

The Galapagos Islands

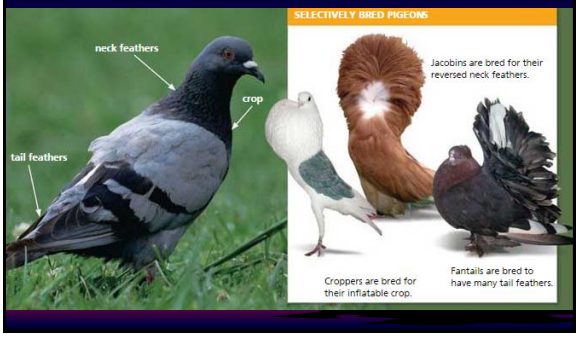
- The diagram below presents 10 species of finches on the Galapagos Islands, each filling a different niche on various islands.
- All of them evolved from one ancestral species
  - Each species evolved from the same ancestor through process of geographic isolation



Darwin's Observations

- Darwin noticed a lot of variation in domesticated plants & animals
- Artificial selection- selection by humans for breeding of useful traits from the natural variation among different organisms
  - ❖ Artificial selection is used to breed animals with the trait of interest (selective breeding)
  - ❖ In artificial selection, nature provided the variation, and humans selected those variations that they found useful
    - ❖ Lots of change can be achieved in a relatively short time

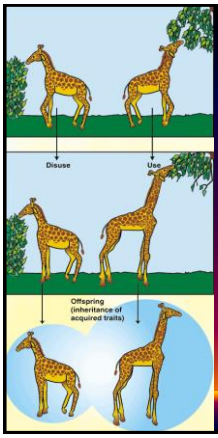
Artificial Selection/ Selective Breeding



What ideas shaped Darwin's thinking?

Charles Darwin wasn't the only person to develop a theory to explain evolution

- Hutton and Lyell helped scientists recognize that Earth is many millions of years old, and the processes that changed Earth in the past are the same processes that operate in the present
  - Hutton and Lyell proposed that geological processes have shaped the Earth, ex. Rain



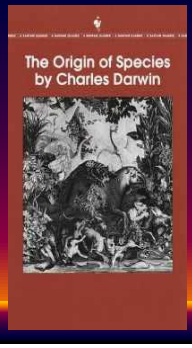
LaMarck's Theory

- **Jean Baptiste LaMarck: 1800's**
  - Believed:
    - Change Occurs Over **Time**
    - Inheritance of acquired characteristics
      - **acquired** changes were passed to offspring
    - Law of Use and Disuse
      - If a body part were used, it got stronger
      - If body part NOT used, it deteriorated
    - Examples: Body builders or pierced ears

Thomas Malthus

- 19th century English economist
- Malthus proposed that resources such as food, water and shelter were natural limits to population growth.
- Things like disease and limited food supply keep the population smaller.

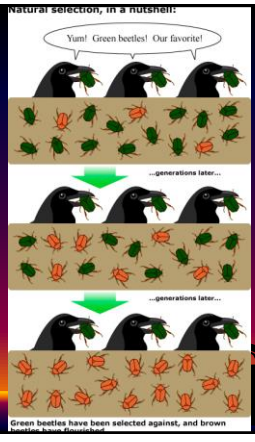
CHARLES DARWIN'S BOOK



- In 1859, Darwin published "The Origin of Species."
- His book stirred up controversy.
- **Proposed that Evolution occurred by Natural Selection**

Natural Selection

- Natural selection is the process by which organisms with beneficial adaptations/variations survive and leave more offspring because they are better suited for their environment.
  - These traits are **inherited**, *not acquired (learned/developed).*
  - These traits are passed on to future generations.
  - If the environment changes, different traits may become beneficial
- Natural selection acts on phenotypes, or physical traits, rather than on genetic material itself.



Natural Selection Example

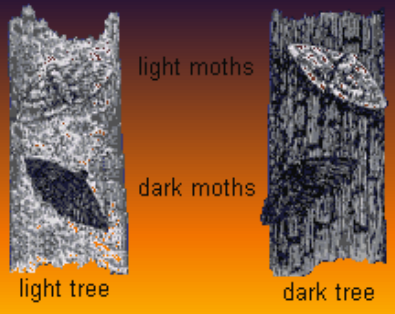
The Industrial Revolution

- In England in the early 1800's industry boomed
- Factories, trains, smoke and smog
- Peppered moths were dark or light colored, and the dark ones that were once rare became more common.
- Hypothesis?

The Peppered Moth

- Kettlewell tested this hypothesis
  - Released equal numbers of moths in polluted AND clean forests.
  - In industrialized areas, dark gray moth was better camouflaged.
  - They survived, had more offspring
- The population *as a whole* evolved to be better suited to the environment→ more gray and camouflaged → ADAPTATION!

The Peppered Moth



Adaptations

3 Types of Adaptations:

1. Structural
2. Physiological
3. Behavioral

1. Structural Adaptations

- Changes in the **structure** of organism's body parts
- Ex: thorns, spines, disruptive coloration (zebra/killer whale), eyespots, camouflage, mimicry

Camouflage

- A species **blends** in with environment
- Ex. Walking stick

Mimicry

- One species **copies** another species
- Ex: bee orchid- the orchid has evolved to resemble a female bee, the male unsuccessfully tries to mate with the flower, collects and spreads the orchid's pollen

2. Physiological Adaptations

- Changes in an organism's **metabolic processes**
  - jobs of body parts
- Ex:
  - drug resistant bacteria
  - pesticide resistant insects
  - poison glands in snakes
  - Desert animals with kidneys that are super efficient at reabsorbing water

Bacterial Resistance to Antibiotics

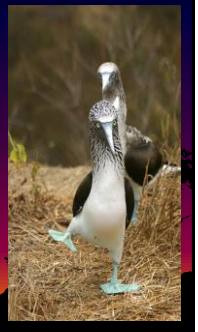
- **Bacterial resistance to antibiotics**- if the same antibiotic is used too many times it can become less effective against a certain type of bacteria
  - Survival and reproduction of unaffected (**resistant**) bacteria
    - These bacteria are resistant because they have **inherited**, *not acquired*, a **gene** that codes for resistance .
- Penicillin (a mold that frequently grows on fruit) is widely used to kill bacteria which cause disease
  - This drug does not affect as many species of bacteria today as it did when it was first discovered
    - Ability of bacteria to resist penicillin varies within a population
    - Bacteria which are resistance to penicillin survive exposure to drug
    - Bacteria which are resistant to penicillin will produce penicillin-resistant offspring

Insect Resistance to Insecticides

- When the insecticide known as DDT was first introduced, it was highly effective
- Over time, DDT became less effective (didn't kill insects as well)
  - This is because the insects became resistant to DDT
    - These insects **inherited** a gene that coded for resistance to DDT.
  - The insects that were resistant to DDT survived and reproduced successfully

3. Behavioral Adaptations

- Changes in organism's **response to environment**
  - Can be learned behaviors (taught) or instinctual (inherited)
- Ex:
  - Spinning webs- spiders
  - Danger signals- bird calls
  - Mating rituals- mating dances
  - Hibernation



4 MAIN PRINCIPLES OF NATURAL SELECTION

- **Overproduction**- having many offspring results in competition for resources, therefore not all will survive
- **Variation**- the differences in individuals result from differences in genetic material ***(this is inherited, not acquired)***
- **Competition**- some variations allow individuals to survive because they have adaptations better suited for the environment
- **Differential reproduction or Descent with modification**- over time, natural selection will result in species with adaptation better "fit" to their environment and those traits will get passed down to further generation
  - ***Fitness*** *is a measure of the ability to survive and produce more offspring than other members of the population*

Evidence for Evolution

Evidence of Evolution

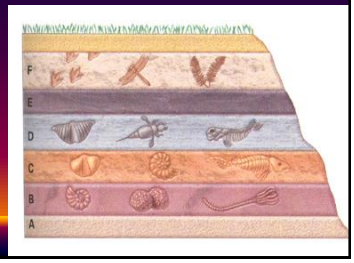
1. The Fossil Record
2. Geographic Distribution (Biogeography)
3. Embryology (Developmental Similarities)
4. Anatomy
   a. Homologous structures
   b. Analogous structures
   c. Vestigial structures
5. DNA (Molecular)

1. Fossils

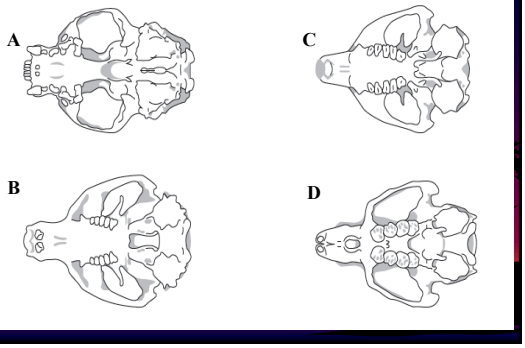
- **Fossils** are preserved remains of traces of ancient organisms
- Examples of fossils include: impressions of leaves in rocks, mineralized bones of ancient fish and mosquitoes trapped in amber
- After extinction- fossil layers contain evidence of the disappearance of old, dominant species and the appearance of new species
- The fossil record also shows that some organisms haven't changed morphologically over time
  - These organisms are at stasis= a period of inactivity or equilibrium

A look at fossils…

- Fossil organisms in the bottom, or older, layers are more primitive than those in the upper, or newer, layers.

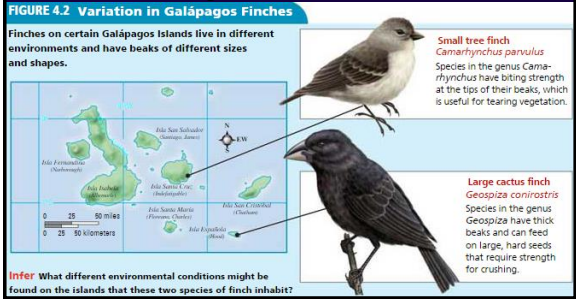


Which skull represents an animal that is ***most distantly*** related to the other three?



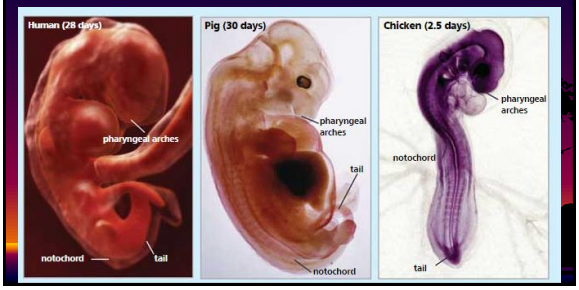
2. Geographic Distribution (Biogeography)

- Darwin hypothesized that at some point in the past, some individuals from the South American mainland had migrated to the islands.



3. Embryology

- Although humans, pigs and chickens appear different from each other as adults, several of the same structures can be seen at various stages in their developing embryos



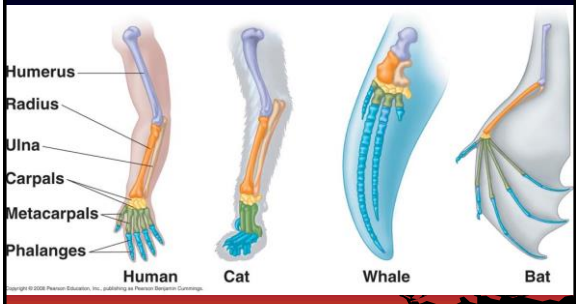
3. Embryology

- Scientists have shown that all vertebrates have a set of very similar genes & gene expression that direct the development of body structures from a basic body plan
- This suggests that vertebrates and other organisms evolved from distant common ancestors

4a. Anatomy- Homologous Structures

- Some of Darwin's best evidence came from comparing the body parts of different species.
- Homologous structures- features that are similar in structure but appear in different organisms and have different function
  - These organisms share a common ancestor
- Example: Vertebrate forelimbs contain the same sets of bones organized in similar ways, despite their dissimilar functions
- **Same structure, different function!**

Homologous Structures

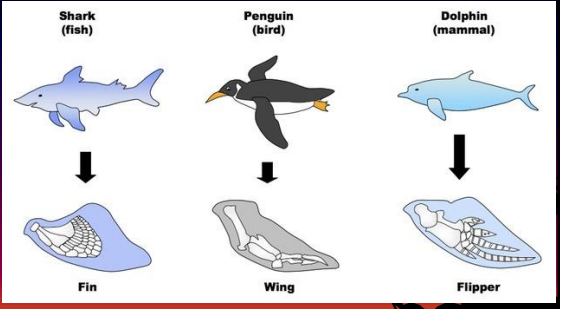


•Notice that each of these organisms contain the same set of bones (anatomy) even though the structure is used for different functions

4b. Anatomy- Analogous Structures

- Having similar structures doesn't always mean two species are closely related
- Analogous structures – structures that perform similar functions but are not similar in origin
  - These organisms do not come from a closely related organism
  - Their ancestors faced similar environmental challenges and evolved similar adaptations
    - Ex: wings of birds vs. wings of insects
    - Ex: fins of fish vs. flippers of whales

Analogous Structures



- Fins, wings and flippers perform the same function (swimming) but are not similar in origin
- These organisms do not share a closely related ancestor

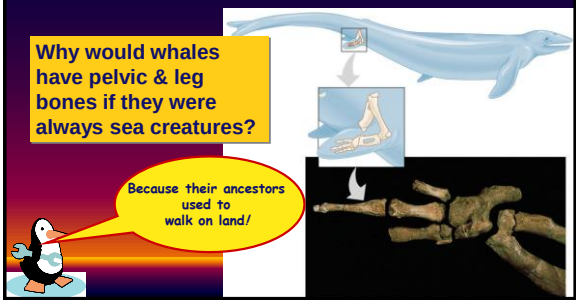
4c. Vestigial Structures

- Some organisms have structures or organs that seem to lack any useful function, or at least no loner used for their original purpose.
  - Ex: Wings of an ostrich are used for balance, not to fly. Over generations, their large bodies and powerful legs may have been enough to escape predators, making wings not essential. Therefore, the genes coding for large wings weren't preserved over generations.
  - Ex: The **appendix** is a remnant of an organ (the cecum) that was important in our leaf-eating ancestors in order to digest cellulose in plants.

4c. Vestigial Structures

- Many modern whales have vestigial pelvic and leg bones.

Why would whales have pelvic & leg bones if they were always sea creatures?



5. DNA (Molecular)

- DNA or protein sequence comparisons can be used to show probable evolutionary relationships between species
  - The more DNA two organisms have in common, the more related those organisms are.
  - Because all living organisms share the same genetic code and use the same 20 amino acids, it has been possible to determine that organisms share a remarkable number of proteins that are similar to one another.
  - Due to mutations, the sequences of nucleotides change over time.

Comparing DNA Sequences

- The data below shows the order of a part of the DNA sequence of several organisms. This data shows that the ***greatest difference*** is between which two groups of organisms: (count differences)
  - A. Mammals and non mammals
  - B. Plants and animals
  - C. Warm blooded and cold blooded animals
  - D. Reptiles and insects

Partial DNA Sequence in Cytochrome-C Protein

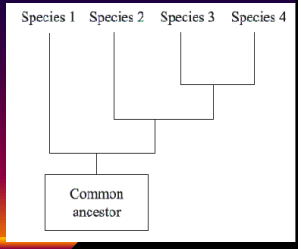
HUMAN	GGU	GAU	GUC	GAG	AAG	GGU	AAG	AAG
CHIMPANZEE	GGU	GAU	GUC	GAG	AAG	GGU	AAG	AAG
HORSE	GGU	GAU	GUC	GAG	AAG	GGU	AAG	AAG
RATTLESNAKE	GGU	GAU	GUC	GAG	AAG	GGU	AAG	AAG
FRUIT FLY	GGU	GAU	GUC	GAG	AAG	GGU	AAG	AAG
SUNFLOWER	GGU	GAU	GCC	ACG	ACG	GGU	GCG	GCG

Common Ancestry- Phylogenetic Trees

- A **phylogeny (evolutionary tree)** shows the evolutionary history for a group of species.
  - Phylogenies can be shown as branching tree diagrams.
- The branches of an evolutionary tree show how different groups of species are related to each other.
- The most common method used to make evolutionary trees is called cladistics.
  - This places species in the order in which they descended from a common ancestor.

Common Ancestry- Cladograms

- A cladogram is a diagram based on patterns of shared, derived traits that shows evolutionary relationships between a group of organisms.



- Species 3 is more genetically similar to which species than the others?

Common Ancestry- Cladograms