Evolution Notes

What is Evolution?

- Evolution = change in species over time
  - Most changes occur gradually, but can happen on a shorter time scale
  - Variations in populations come from RANDOM MUTATIONS

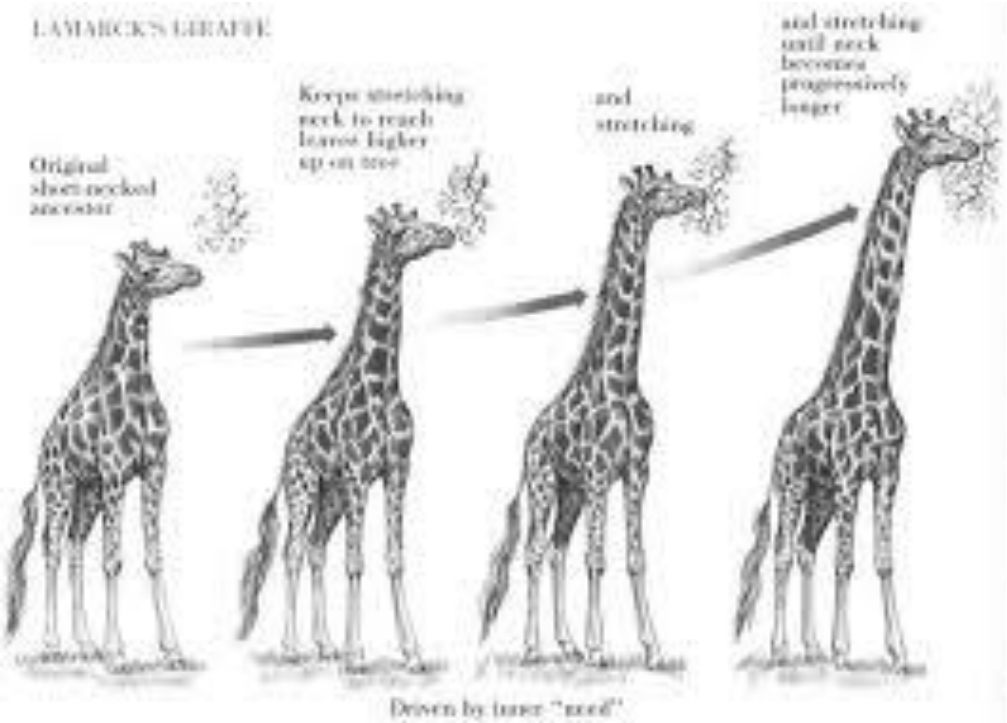
Time Line of Scientists

- 1785 – Hutton proposes that the Earth is shaped by geologic forces that occurred over millions of years

- 1798 – Malthus predicts that human population will grow faster than the space and food supplies needed to sustain it

Time Line of Scientists

- 1809 – Lamarck hypothesized that acquired traits could be passed to offspring
  - Was found to NOT be correct; behavior can't determine the traits that are passed to offspring
- 1831 – Darwin sails around the world
- 1833 – Lyell explains that geologic processes observed today have always been occurring…Earth is very old

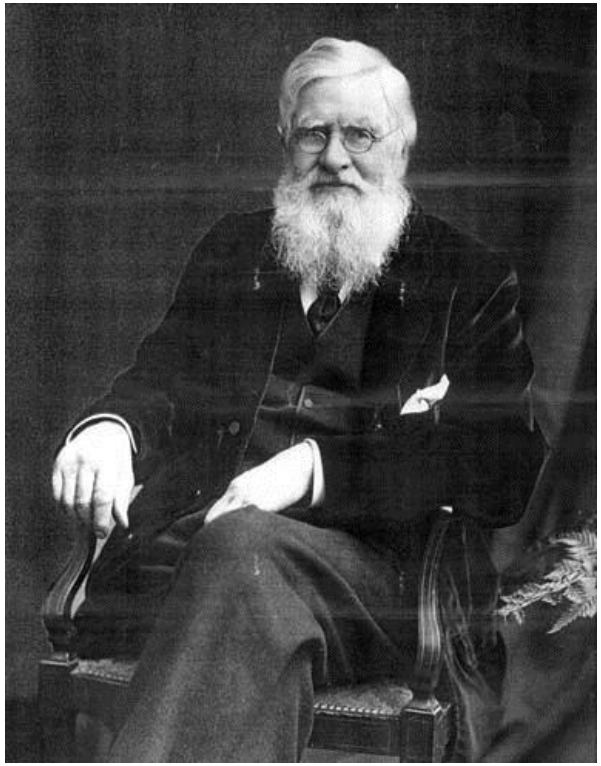

LAMARCK'S GIRAFFE
Original short-necked ancestor
Keeps stretching neck to reach leaves higher up on tree
and stretching
and stretching until neck becomes progressively longer
Driven by inner "need"

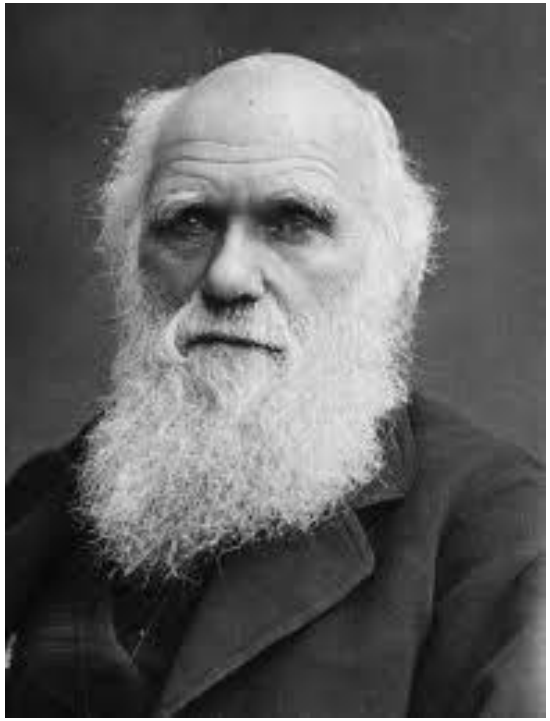
Time Line of Scientists

- 1858 – Wallace discusses the idea of evolution by natural selection

- 1859 – Darwin publishes his book *On the Origin of Species*

- 1866 – Mendel does experiment with pea plants and starts to determine the role of genes in an organism's appearance





Darwin's Voyage

- At age 22, Darwin joined a voyage around the world on the H.M.S. Beagle
- He made observations and collected fossils that helped shape his hypothesis about the way life changes over time
- He saw great diversity from one island to the next in the Galapagos islands
  - Organisms shared similarities with those on the mainland
- He compared fossils to living organisms – they resembled living organisms

Darwin's Ideas

- Descent with Modification – over generations populations change
  - Newer forms appearing in the fossil record are modified descendants of older species
  - All species came from a few original types of life

- Modification by Natural Selection – populations change by having good traits for an environment, survive, and pass on genes
  - Explains HOW evolution occurs

Darwin's Ideas

- Reproductive Isolation – when species are not able to interbreed because they are geographically separated (different islands) **OR** other barriers prevent mating
  - This causes the appearance of different adaptations to the environment and over time it would cause big differences between species on different islands

- Geographic isolation = physical separation of species that can lead to reproductive isolation

Darwin's 4 Observations

- Populations overproduce offspring
- Variation exists among those offspring
- Having a particular trait makes individuals more or less likely to survive in an environment
- Over time, those traits become adaptations
  - Adaptation = inherited trait that is present in a population because the trait helps individuals survive and reproduce in an environment

Strengths and Weaknesses of Darwin's Theory

- Strengths
  - Many types of evidence
  - Logical and testable mechanism for how evolution occurs: natural selection
  - Variation in individuals is important

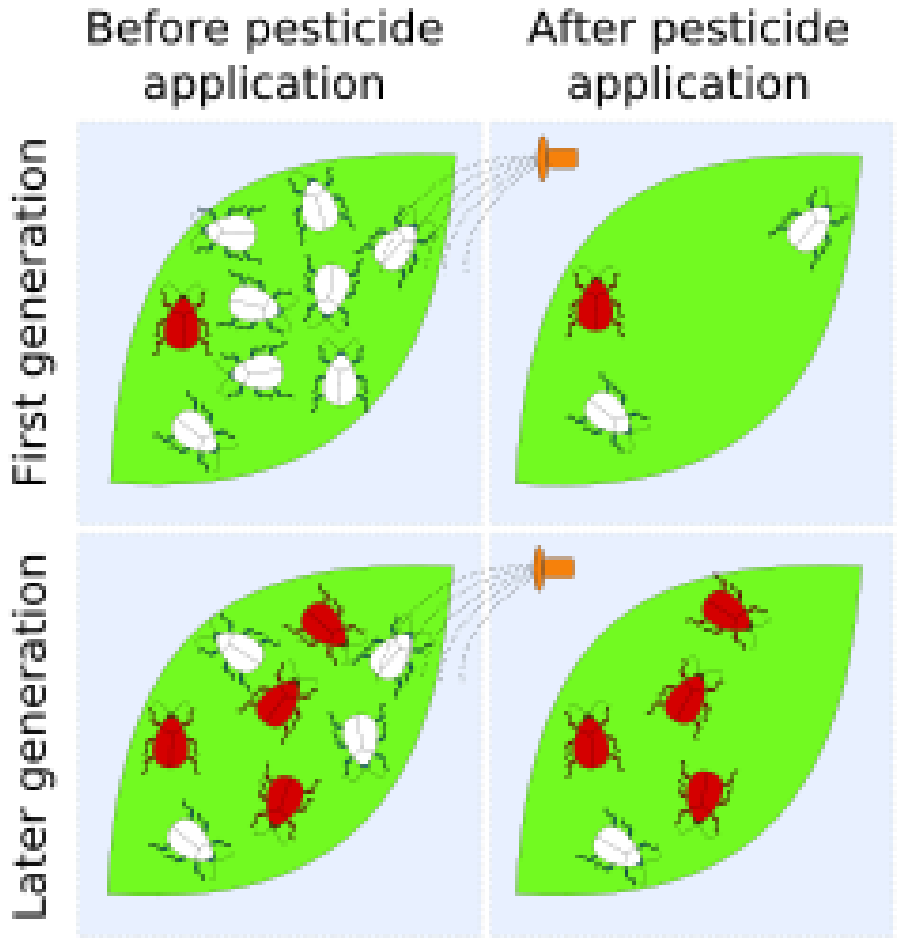
- Weaknesses
  - Darwin didn't know very much about genetics

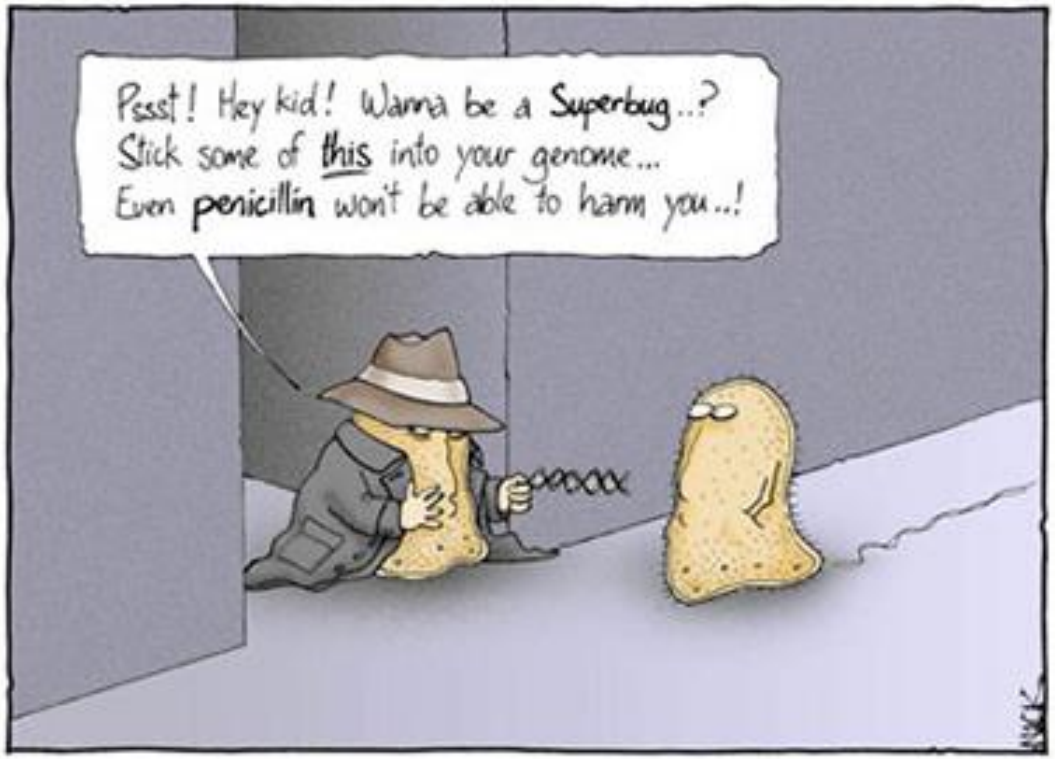
Types of Evolution

- Macroevolution – over long periods of time that results in a new species
  - Helps to create higher order organisms

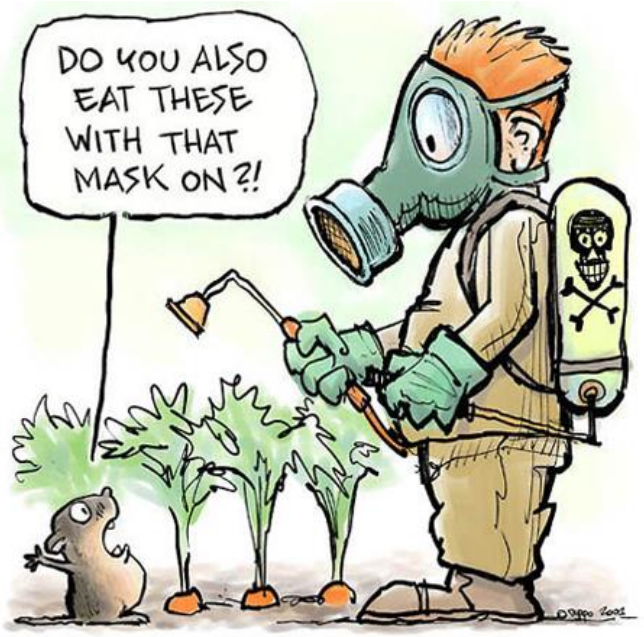
- Microevolution – over a shorter period of time and occurs within a population
  - Antibiotic resistance bacteria and insects that are resistant to pesticides

Antibiotic Resistance or Pesticide Resistance





It was on a short-cut through the hospital kitchens that Albert was first approached by a member of the Antibiotic Resistance.



Natural Selection

- Organisms with traits that are beneficial in the environment will survive to pass on their traits
- Organisms with traits that are not beneficial in the environment will die off
- Individuals DO NOT evolve; Populations evolve

Types of Natural Selection

- Stabilizing Selection – maintaining an organisms normal genetic makeup in an environment
  - Occurs when environment has not changed much or if species are very well adapted
  - Ex) If everyone's grades in the class stayed the same as the first progress report all semester

- Directional Selection – change from one phenotype to another within an environment
  - Ex) If everyone in the class starting with F's, then the grades would shift to A's

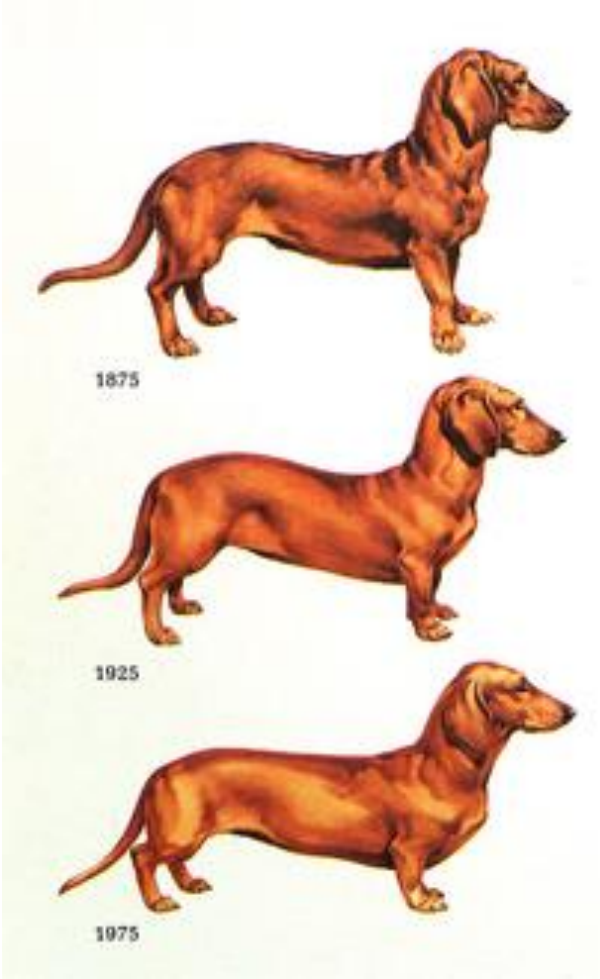
- Disruptive Selection – when intermediate phenotypes disappear and extreme phenotypes remain
  - Ex) If the C grades dropped out, and there was only A's and F's

- Diversifying Selection – when no single phenotype is better than another
  - Ex) If we had an equal number of A's, B's, C's, and F's

- Draw a graph to present the first 3 types of natural selection

- 3 graphs are on p. 409 in your book

Artificial Selection



- Intentional reproduction of organisms in a population that have desirable traits

Labradoddle puppies



















~10,000 years of evolution by artifical selection

LBR 10/2002

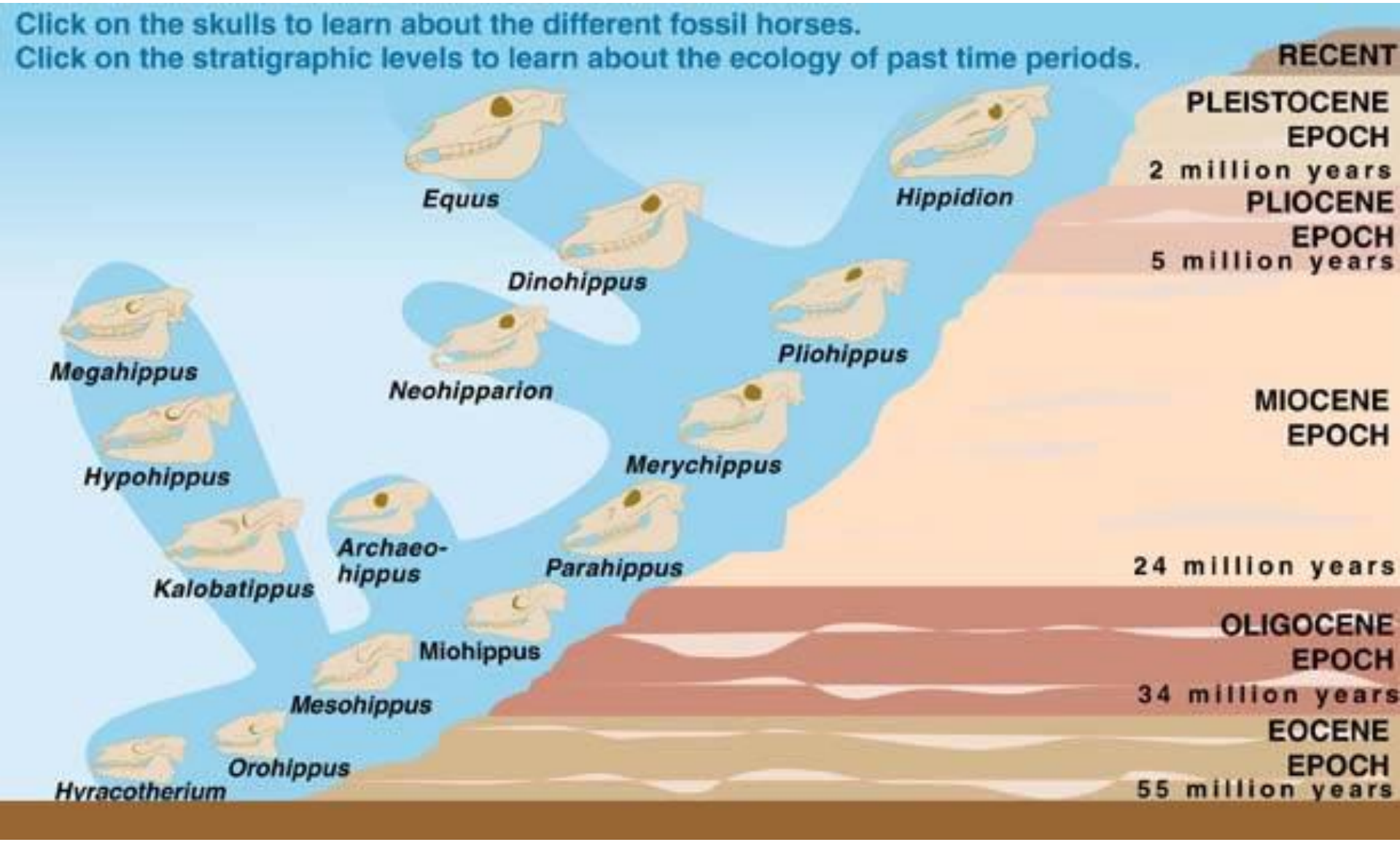
Evidence - Fossils

- **Fossil Record**
  - The age of fossils is determined by radioactive (radioisotope) dating and relative dating
    - **Radioactive dating** = uses an element's half-life to determine the **exact** age
    - Half-life = the amount of time for **half** of an unstable element to break down into a stable one
    - Ex: Carbon-14 is radioactive

Evidence - Fossils

- **Fossil Record**
  - **Relative dating** = determining age of fossils based on rock layers they are found in
  - Fossils in rock layers near the surface are younger than fossils found in rock layers deeper down

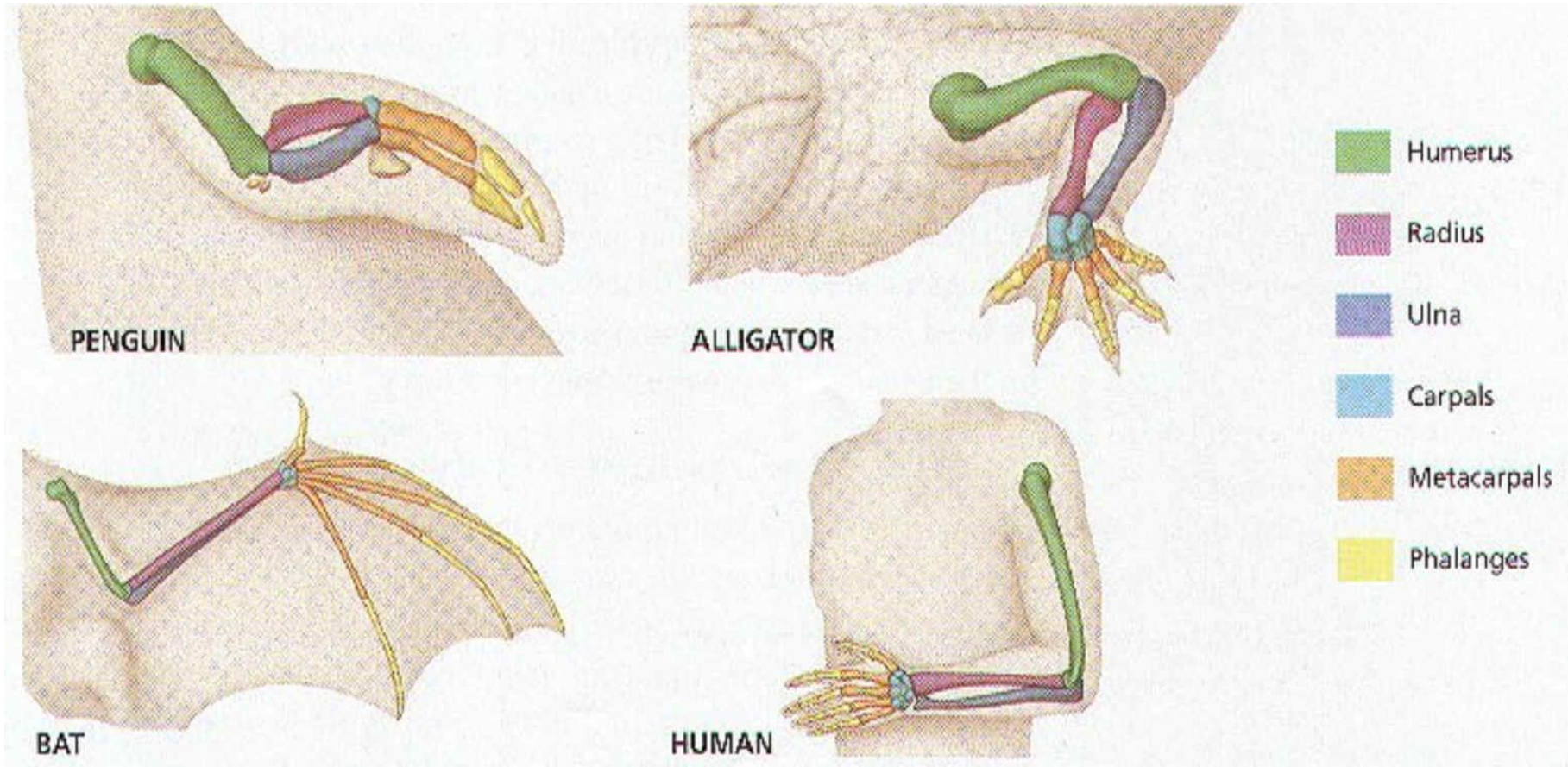
- Incomplete record – not all animals will leave fossils and not all fossils have been found


Click on the skulls to learn about the different fossil horses.
Click on the stratigraphic levels to learn about the ecology of past time periods.
RECENT
PLEISTOCENE EPOCH
2 million years
PLIOCENE EPOCH
5 million years
MIOCENE EPOCH
24 million years
OLIGOCENE EPOCH
34 million years
EOCENE EPOCH
55 million years
Equus
Hippidion
Dinohippus
Pliohippus
Megahippus
Neohipparion
Merychippus
Hypohippus
Archaeo-hippus
Parahippus
Kalobatippus
Miohippus
Mesohippus
Orohippus
Hyracotherium

Evidence - Anatomy

- **Homologous structures** – same internal structures (bones) which are shared by related species because they have been inherited from a common ancestor
  - Ex) bat wing, dog leg, and human arm all have similar bone structure

- **Vestigial organs** – organs that had a function in the past but serves no function in the current organism
  - Ex) appendix and wisdom teeth in humans; pelvic bone in whales


PENGUIN
ALLIGATOR
Humerus
Radius
Ulna
Carpals
Metacarpals
Phalanges
BAT
HUMAN

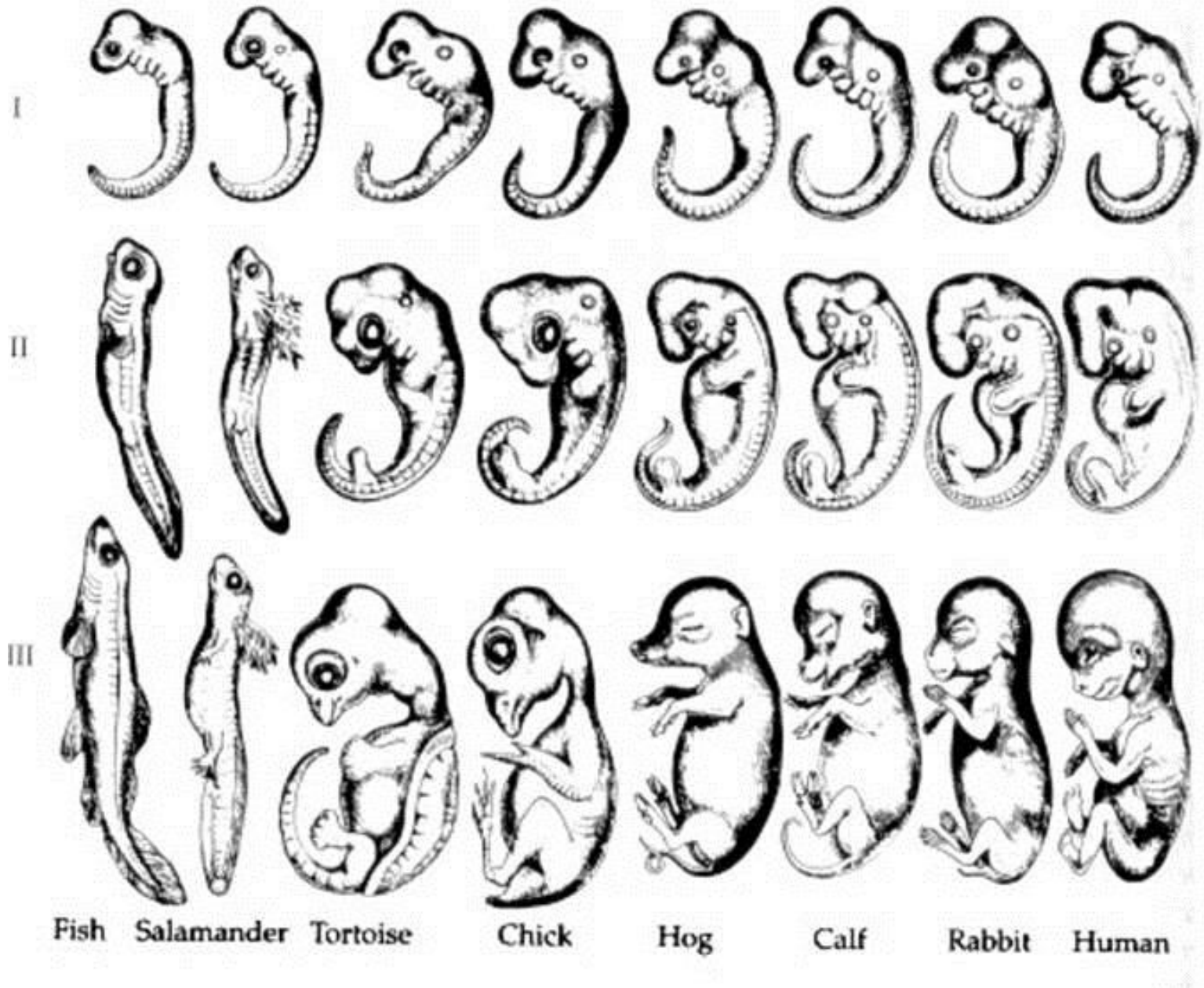
Evidence – Development

- **Embryology** –organisms appear very similar in their embryo stages of development
  - Many animals have backbones
  - Same group of embryonic cells develop in the same order and in similar patterns in all vertebrates
  - Similar homeotic genes – genes that control the structures that form in the adult form of an organism

Evidence - Development

- However, now know that the artist took some artistic liberties when drawing the embryos

- Embryos really look a little less similar than previously thought


I
II
III
Fish
Salamander
Tortoise
Chick
Hog
Calf
Rabbit
Human

Evidence - Molecular

- Comparison of **DNA and amino acid sequences** can be used to determine relationships between organisms
  - The more similarities between organisms, the more closely they are related
  - The more differences, the less closely they are related
  - Ex: hemoglobin (protein) is the same in mammals

Evidence - Biogeography

- Distribution of organisms across different areas of land
  - Can see similar characteristics of organisms that live in similar environments on different continents
  - Ex: sugar glider and the flying squirrel
  - Ex: muskrat and carybara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Patterns of Macroevolution

- **Convergent evolution** – unrelated species become more and more similar to each other
  - Occurs because they are under the same selective pressures
  - Ex) sharks (fish) and dolphins (mammals)

- Convergent evolution can lead to the appearance of analogous structures

- **Analogous structures** = similar structures that have the same function but organisms are not closely related
  - Structures appeared because organisms live in similar environments with the same selective pressures
  - Ex) Wings of a bat versus wings of a bird

Patterns of Macroevolution

- **Divergent evolution** – related species become more and more dissimilar
  - Under go **adaptive radiation** = split of species into 2 or more lines of descent when species enter a new environment and begin to fill a large variety of ecological niches
  - Leads to biodiversity
  - Ex) finches or orchids

Patterns in Evolution

- **Co-evolution** – species that share close ecological interactions can influence each others evolution – can evolve in response to each other
  - Ecological relationships include: Predator/prey and parasite/host, competitive species, mutualistic species
  - Ex) flowers and bats that feed off of the nectar

Patterns of Macroevolution

Patterns of Macroevolution

- Extinction – permanent loss of a species
  - Endangered species

- Scientist use fossils to construct the Geologic Time Scale
  - Shows when each type of organisms first appeared on Earth and in what order they appeared

Microevolution Processes

- Natural selection
- Migration = movement of individuals into, out of, or between populations
- Mate choice = random mating creates random arrangement of traits
- Mutation = changes the # of alleles in the population
- **Genetic Drift** = random change in alleles in a population due to differences in survival and reproduction

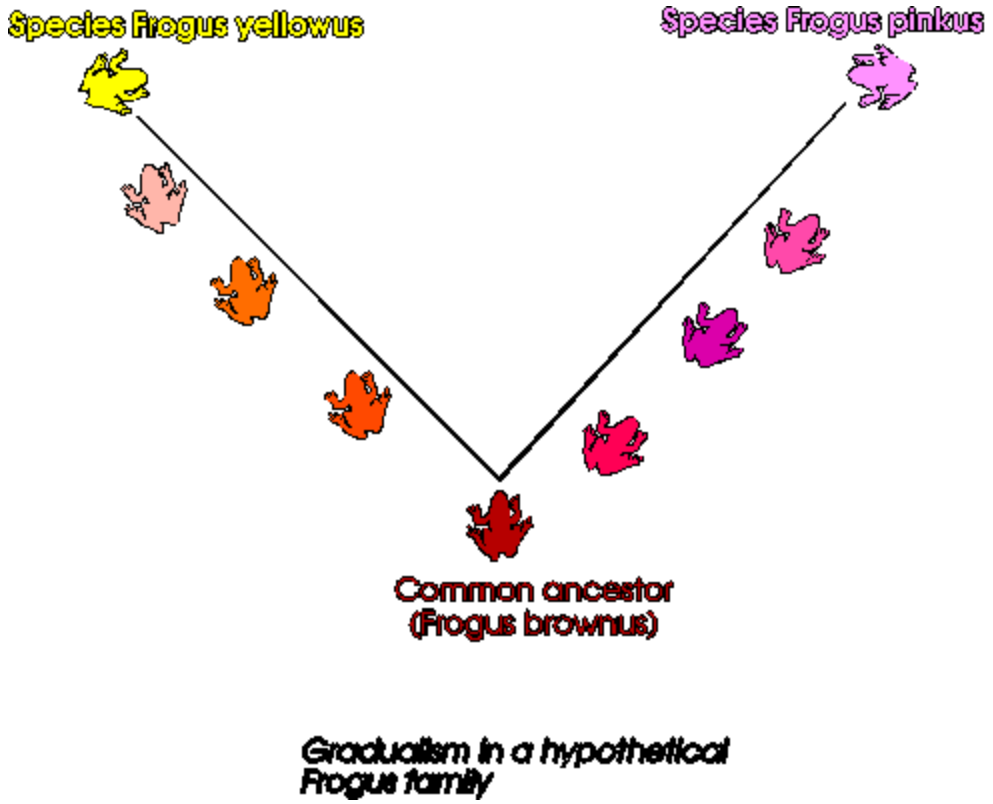
Speciation

- Formation of a new species
  - Occurs because of geographic or reproductive isolation

- 2 Rates that speciation can occur:
  - Gradualism = slow
  - Punctuated Equilibrium = fast

Rate of Speciation

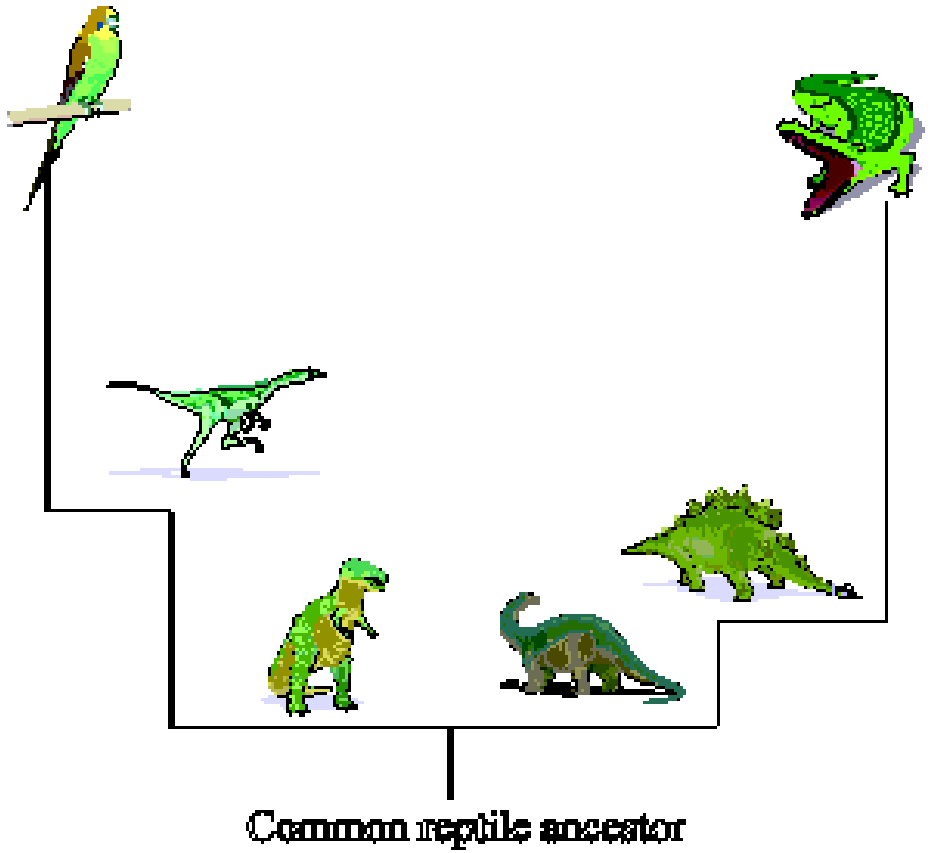
- **Gradualism** – gradual adaptive changes over time in a population



Gradualism in a hypothetical Frogus family

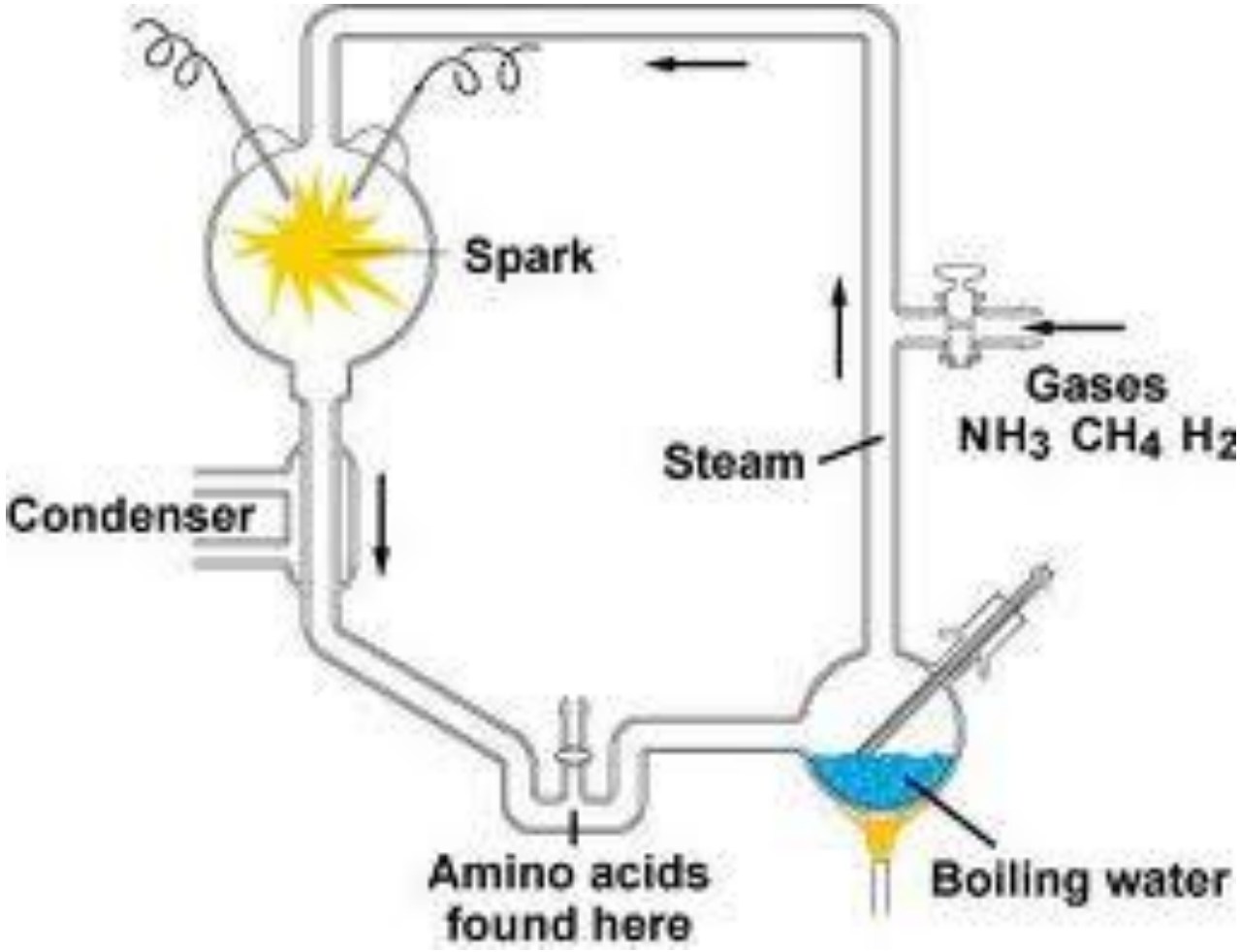
Rate of Speciation

- **Punctuated equilibrium** – changes occur quickly in rapid bursts with long periods of stability in between



History of Life on Earth

- Earth formed 4.5 billion years ago
- As the Earth grew, pools of water started to form and the atmosphere lacked oxygen
  - Miller/Urey experiment tested whether macromolecule could be formed in the lab from molecules that were present in the Earth's early atmosphere
  - Many other scientists have tested this and have formed: monomers, macromolecules, RNA, and pre-cell structures
  - No one has been able to create a functioning cell in the lab

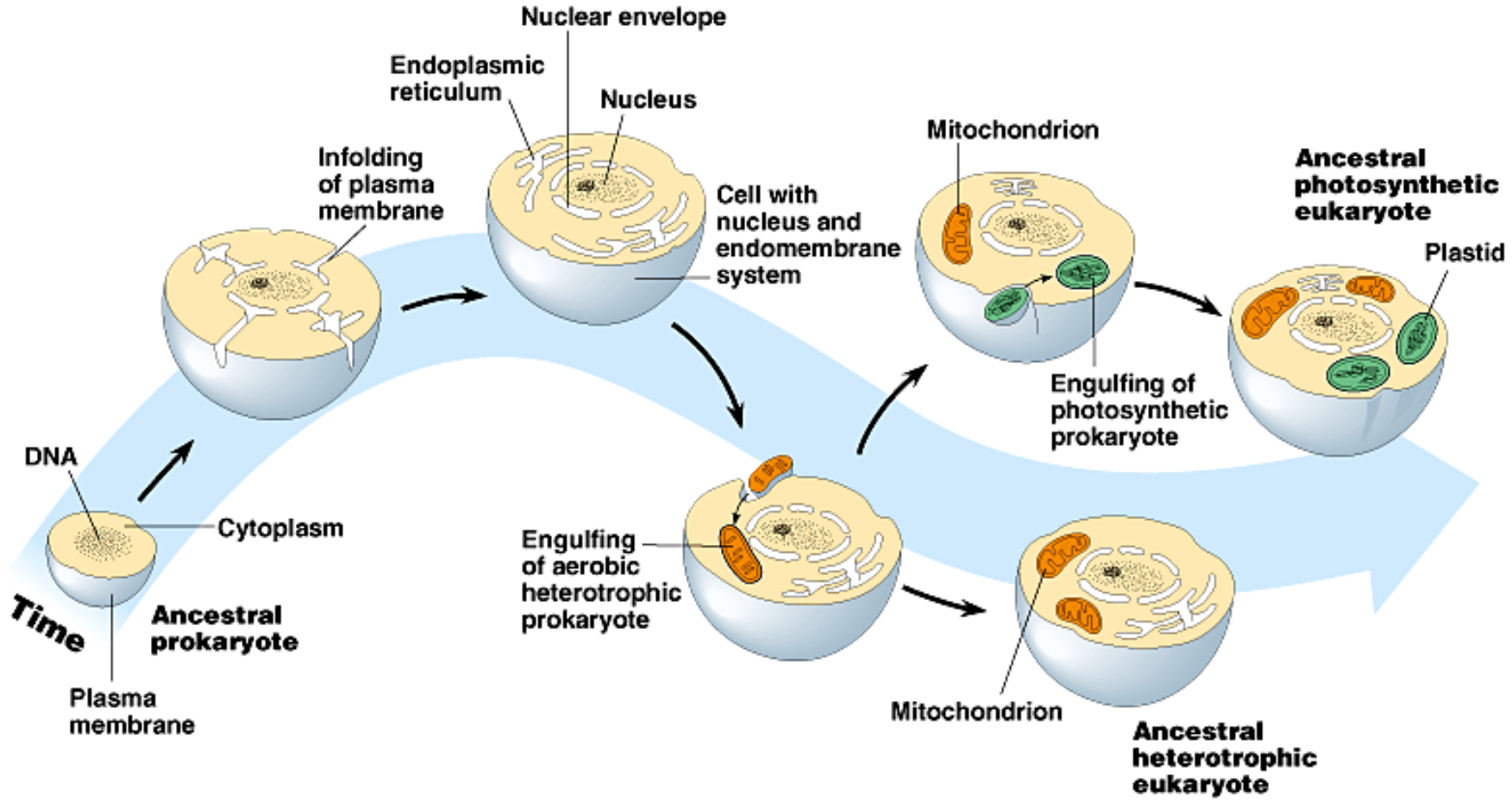

Spark
Gases
NH_3 CH_4 H_2
Steam
Condenser
Amino acids
found here
Boiling water

History of Life on Earth

- Prokaryotic cells were believed to be the first life to evolve on Earth
  - Bacteria started producing oxygen through photosynthesis which added O2 to the atmosphere
- Then, eukaryotic cells arose in the geologic time scale
  - Lots of fossils of marine organisms
- Then, multicellular eukaryotic organisms started to show up in the fossil record

History of Life on Earth

- Photosynthetic prokaryotes eventually increased the oxygen levels and other prokaryotes evolve to do respiration
- **Endosymbiotic theory** = one bacteria cell was taken up by another cell and the result was a mitochondria and chloroplast
  - Explains how eukaryotic cells developed from prokaryotic cells
  - Evidence: DNA in mitochondria and chloroplasts, both can reproduce independently of the cell, and both have ribosomes



Kingdom Review

- Archaebacteria
  - Prokaryotic, cell wall, unicellular, both heterotroph and autotroph
- Eubacteria
  - Prokaryotic, cell wall, unicellular, both heterotroph and autotroph
- Protista
  - Eukaryotic, some have cell walls, unicellular and multicellular, both heterotroph and autotroph

Kingdom Review

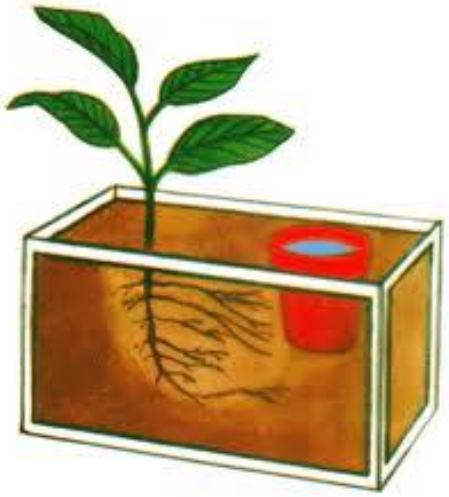
- Fungi
  - Eukaryotic, cell wall (chitin), unicellular and multicellular, heterotroph
- Plantae
  - Eukaryotic, cell wall (cellulose), multicellular, autotroph
- Animalia
  - Eukaryotic, no cell wall, multicellular, heterotroph

Plant Adaptations

- **Tropisms =** plant's response to a stimulus
  - Phototropism = response to light
  - Hydrotropism = response to water
  - Thigmotropism = response to touch
  - Gravitropism = response to gravity
- Plants close stomata (holes in leaves) when it is dry
- Plants produce chemicals to keep predators from eating them

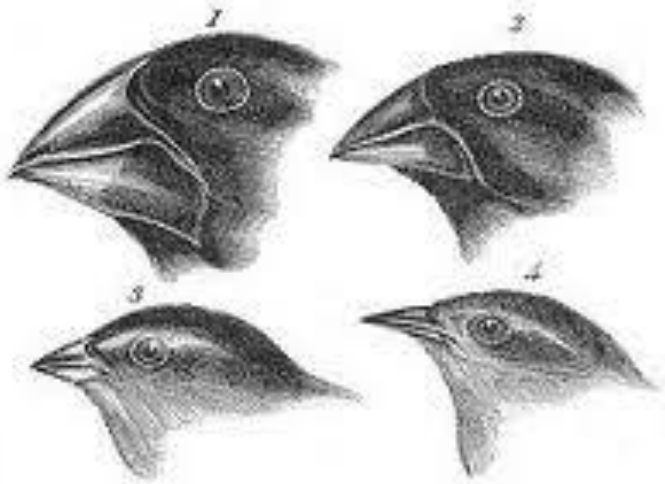

SUN
I love
the light!


SCIENCEphotoLIBRARY



Animal Adaptations

- Size of beak (birds) or neck (giraffes or Galapagos tortoise) determines food source
- Thick fur to live in cold biomes
- Mimic another toxic animal to get protection from predators
- Hibernation and migration
- Adaptive behaviors to enhance survival
  - Pill bugs roll up when you touch them
  - Porcupines puff out quills when in danger
  - Courtship behaviors



1. Geospiza magnirostris
2. Geospiza fortis
3. Geospiza parvula
4. Certhidea olivacea

Finches from Galapagos Archipelago