Magnet Biology: Unit 6

1) Concepts of Evolution
2) Classification of Organisms

Mader Text:

Evolution: Ch 17-19

Classification: Ch 20 (with brief parts from Ch 21-23

Online Text: OpenStax

Part 1-EVOLUTION
Basic Vocabulary

- **Natural Selection-**a population of organisms can change over generations if individuals having certain heritable traits leave more offspring than others
- **Adaptation-** trait shaped by natural selection that increases an organism's reproductive success ("fitness"). Ex- camouflage, mimicry
- **Evolution-** change in the genetic composition of a population over time


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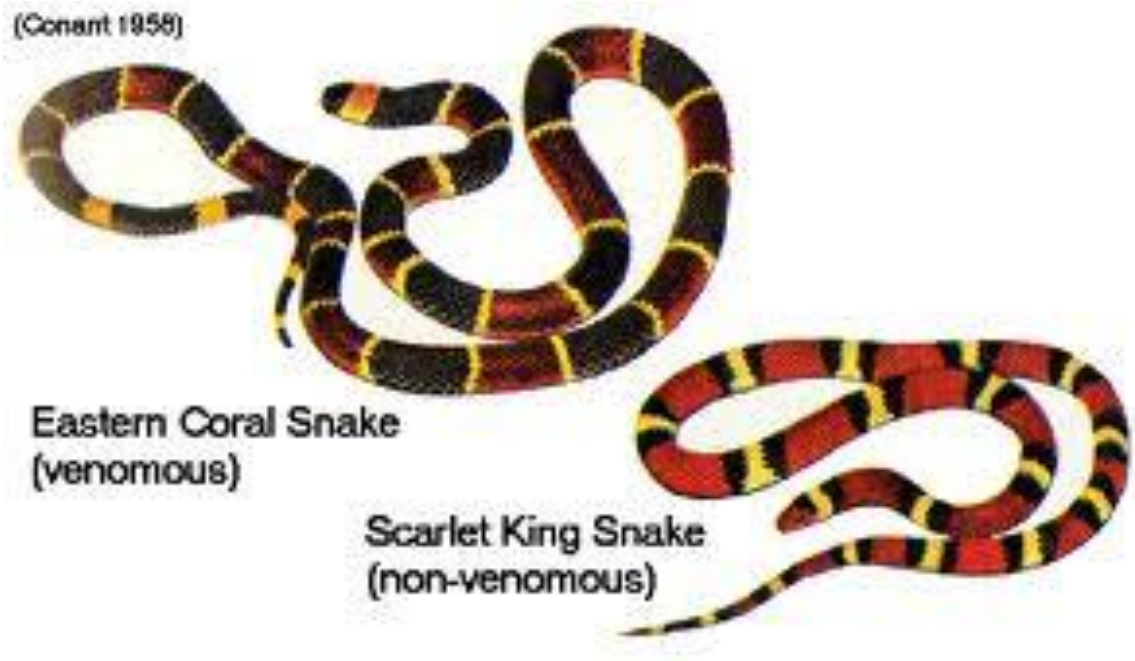
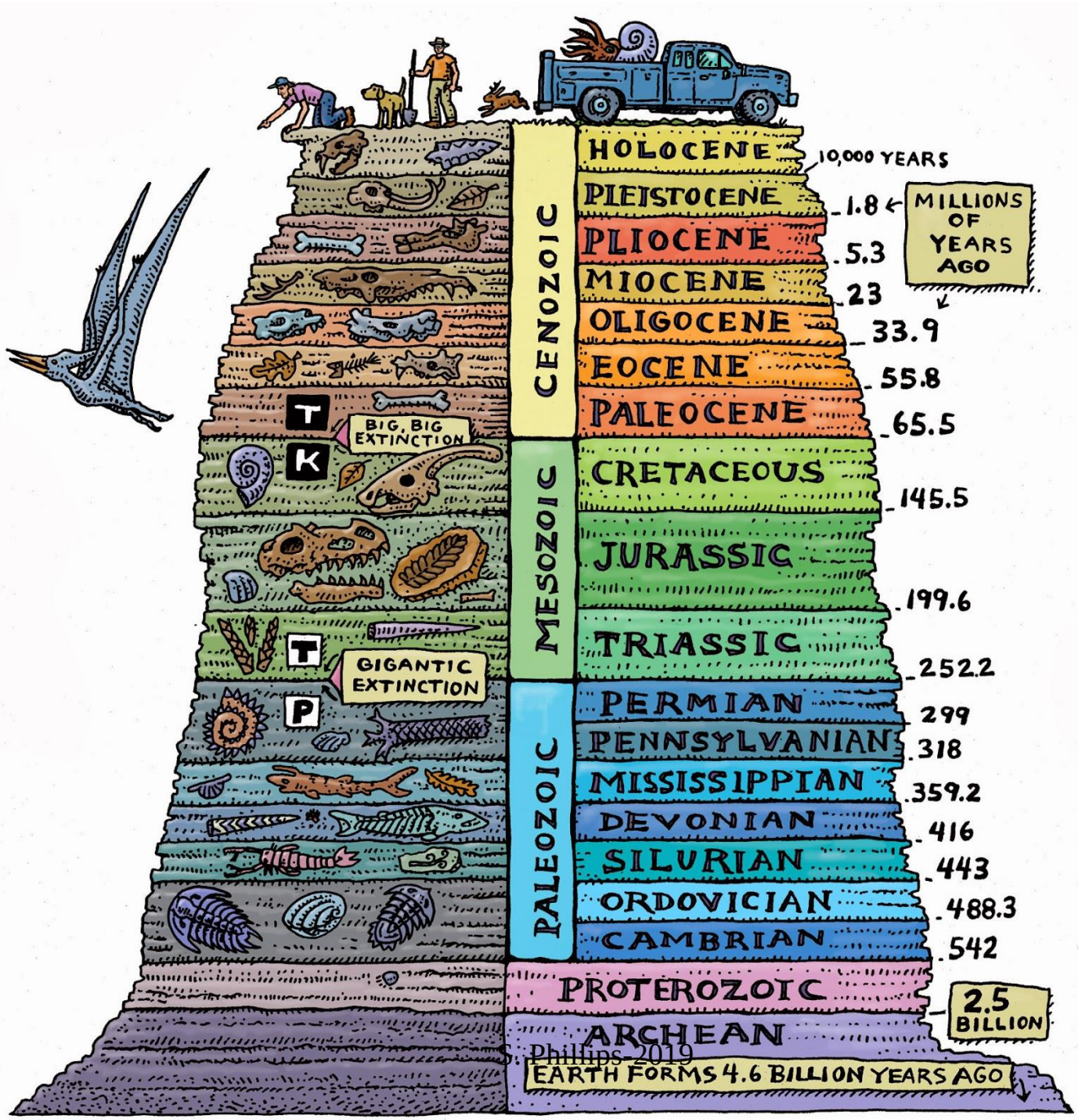

(Conant 1958)
Eastern Coral Snake
(venomous)
Scarlet King Snake
(non-venomous)

Paleontology & Evolution

- Older layers of sedimentary rock (the layers on the bottom) contain fossil species very dissimilar from modern
- Each layer (stratum) is characterized by a unique group of fossil species
- As you move upward through the layers, you find species more and more similar to modern life


CENOZOIC
MESOZOIC
PALEOZOIC
HOLOCENE
10,000 YEARS
PLEISTOCENE
1.8
PLIOCENE
5.3
MIOCENE
23
OLIGOCENE
33.9
EOCENE
55.8
PALEOCENE
65.5
CRETACEOUS
145.5
JURASSIC
199.6
TRIASSIC
252.2
PERMIAN
299
PENNSYLVANIAN
318
MISSISSIPPIAN
359.2
DEVONIAN
416
SILURIAN
443
ORDOVICIAN
488.3
CAMBRIAN
542
PROTEROZOIC
2.5 BILLION
ARCHEAN
EARTH FORMS 4.6 BILLION YEARS AGO
MILLIONS OF YEARS AGO
T
K
BIG, BIG EXTINCTION
T
P
GIGANTIC EXTINCTION
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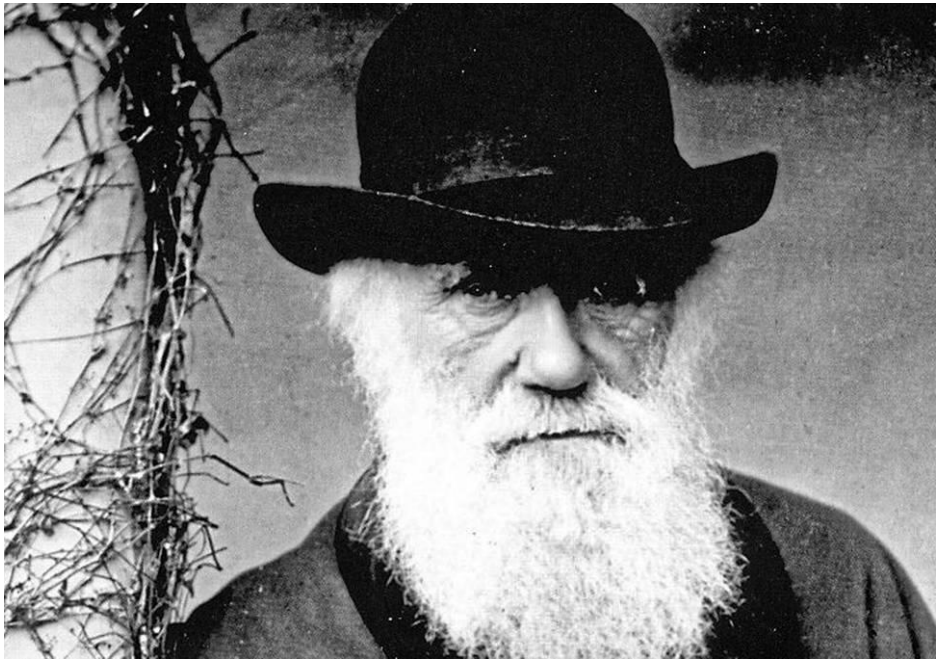
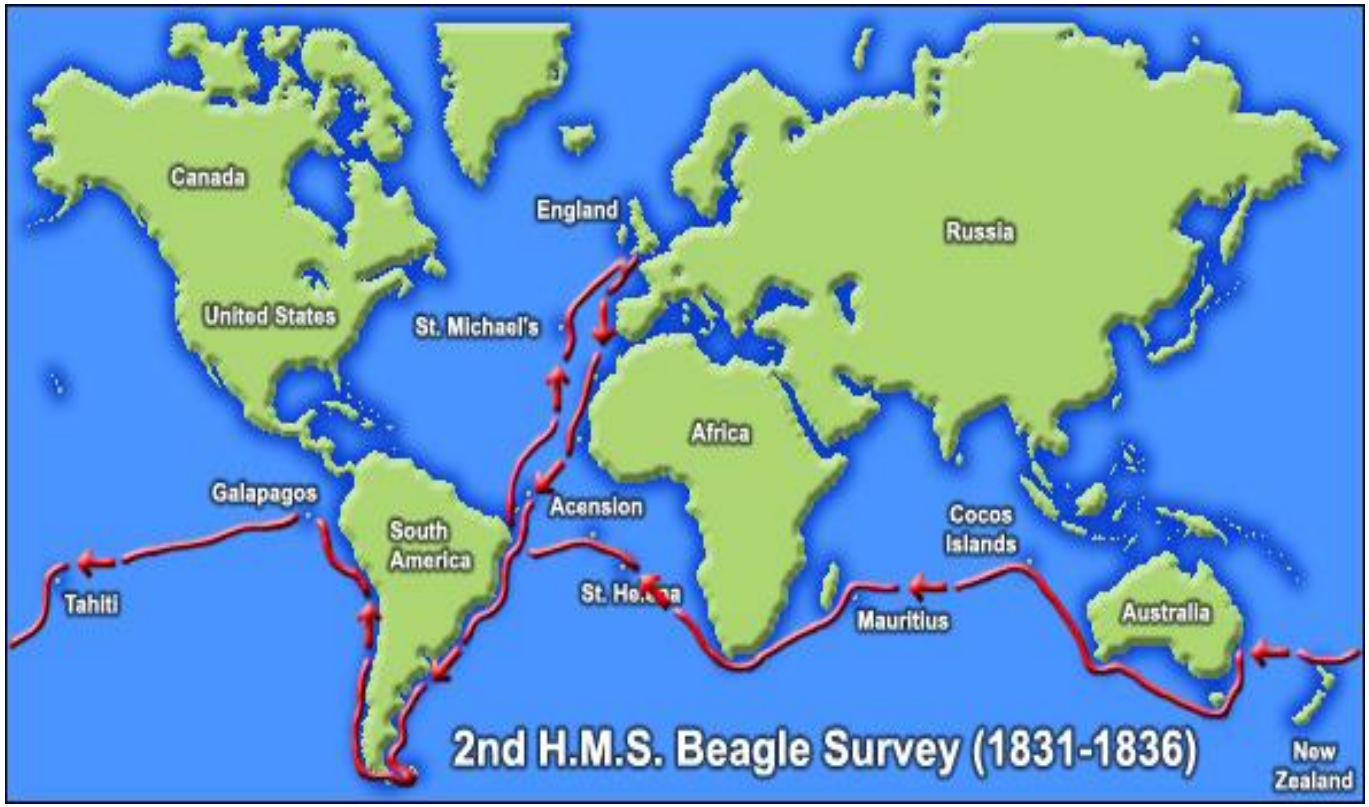
Based on paleontology, Lamarck proposed a theory of evolution

- Based on 2 mechanisms (1809)
  - Use and disuse: the idea that parts used the most grow stronger; the parts that don't get used deteriorate
  - Inheritance of acquired characteristics: the modification that an organism acquires during its lifetime can be passed along to its offspring
  - Helped set stage for Darwin by proposing that species evolve as a result of interaction with environment

Charles Darwin (1809-1882)

- Born in England, he had a consuming interest in nature that his dad did not like
- His dad sent him to medical school (at 16). Charles was bored and left
- He then enrolled at Christ College at Cambridge with the intent to become a clergyman
- He was invited along on a voyage to chart the South American coastline on board the HMS Beagle that lasted 5 years





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The Origin of Species (1859) developed 2 main points

- Descent with modification
  - The history of life is like a tree, with multiple branching and re-branching from a common trunk all the way to the tips of it youngest twigs; most branches are dead ends
- Natural selection and adaptation
  - The concept of natural election is based on 5 observations made by Darwin and can be summarized in 3 inferences made from those observations

Natural Selection

- Obs. 1: all species have the reproductive potential for the population size to grow exponentially
- Obs. 2: Populations do not tend to grow exponentially, but tend to remain stable in size
- Obs. 3: Environmental resources are limited

Natural Selection

- Based on those 3 observations, the following inference was made:
- **Inference #1**: Production of more individuals than the environment can support leads to a struggle for existence among individuals of a population, with only a fraction of offspring surviving

Natural Selection

- Obs. 4: Individuals of a population vary phenotypically; no 2 are exactly alike
- Obs. 5: Much of this variation is heritable
- **Inference #2**: Those individuals whose heritable traits best fit them for the environment are likely to leave more offspring than less fit individuals
- **Inference#3**: This differential reproductive success will lead to a gradual change in a population

Summary of Darwin's ideas

- Natural selection is differential success in reproduction
- It occurs through an interaction between the environment and the variability among individuals within a population
- The product of natural selection is the adaptation of populations of organisms to their environment
  - Watch: "Stated Clearly" https://www.youtube.com/watch?v=0SCjhI86grU

Natural Selection in Action

- The evolution of insecticide-resistant insects
- Evolution of antibiotic-resistant strains of bacteria
- Industrial melanism in the peppered moth

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Evidence for Evolution

- **Biogeography-** Darwin first noticed on his voyage
- **Comparative Anatomy-** homologous structures function differently but have similar structures because of common ancestry
- **Comparative embryology-** similarities sometimes only seen in early embryological development
- **Molecular biology-**similarities in genes and proteins (*this is BIG now)
  - Watch: https://www.youtube.com/watch?v=ooGKYediys8&t=2s

The Fossil Record

- Fossil fishes predate all other vertebrates, with amphibians next, followed by reptiles, then mammals and birds---consistent with what Darwin predicted
- All vertebrate fossils are NOT found in rocks of the same age

Reminder

- **INDIVIDUAL ORGANISMS DO NOT EVOLVE!**
- Natural selection does not act on individuals, but only in the sense that it affects one individual's ability to survive and reproduce
- **The smallest unit that can evolve is a population**, a collection of individuals of the same species living in an area together

Microevolution

- Pertains to evolutionary change within a **population**, which is all the members of a single species occupying a particular area.
- Changes in allele frequencies in a gene pool of a population signifies microevolution has occurred.

Hardy- Weinberg

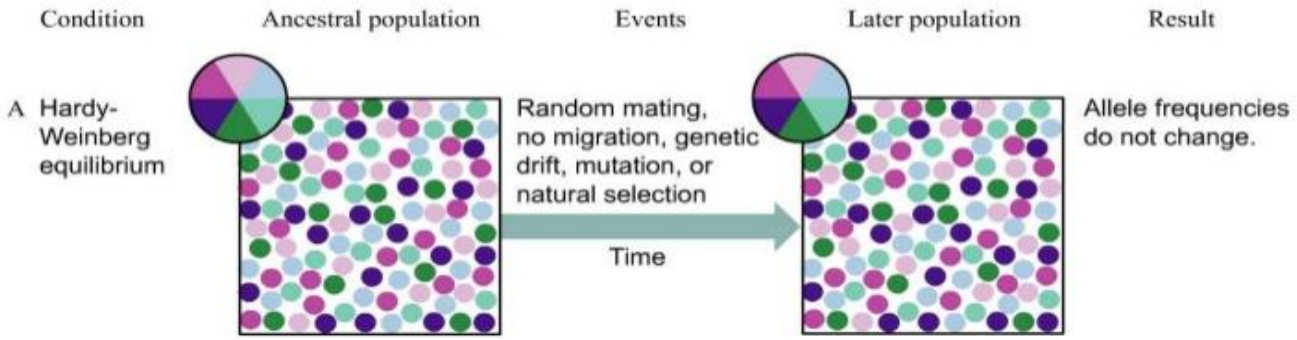
- The **Hardy Weinberg Equation** can be used to determine that evolution is occurring. ***If there is no change in allele frequency from generation to generation, the population is in H-W equilibrium and no evolution is occurring.***
- Showed mathematically that microevolution will not occur in a population unless allele frequencies are acted on by a force that causes the change. In the absences of these forces, the allele frequencies will remain the same, and no evolution occurs.
- *Recommended (1st) video:* https://www.youtube.com/watch?v=oEBNom3K9cQ

Example of a Population in Hardy-Weinberg Equilibrium (**no evolution is occurring)*

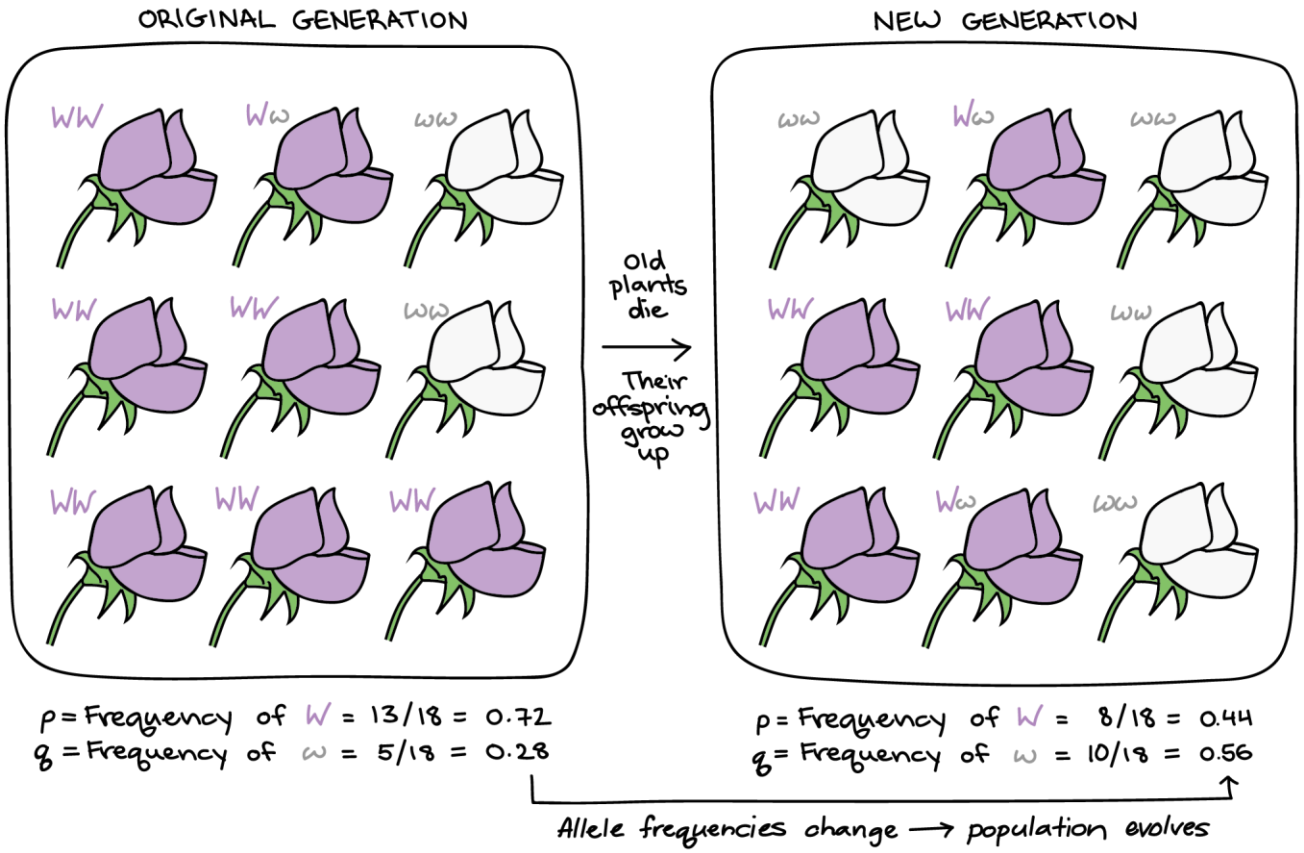
Basic Assumptions of the Hardy-Weinberg Principle

- All phenotypes equal fitness, no natural selection
- No mutation
- No immigration or emigration
- No genetic drift (infinitely large population)
- No assortative mating

Of course, at least one of these factors will be acting on a population in the wild



Is this New Population in H-W Equilibrium?



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Answer?

- No, it is not in H-W equilibrium because the allele frequencies have changed. That means evolution is occurring. The most likely reason is natural selection, but other reasons for microevolution are: gene flow, genetic drift, mutation, non-random mating

What is microevolution & what causes it to occur?

- **Genetic drift-** change in the gene pool of a small population due to chance
  - Watch: https://www.youtube.com/watch?v=mjQ_yN5znyk&t=12s
- **Gene flow** gain or loss of alleles due to immigration or emigration
- **Mutation-** the ONLY way to get a new allele
- **Non random mating-** if certain individuals are preferred by the opposite sex
- **Natural selection-** results in adaptation
  - Watch: https://www.youtube.com/watch?v=R6La6_kIr9g

HARDY - WEINBERG

- A population that is not changing genetically is said to be at **Hardy–Weinberg equilibrium**
- The assumptions that underlie the Hardy–Weinberg equilibrium are (*make sure you know these!)
  - population is large
  - mating is random
  - no migration
  - mutation can be ignored
  - natural selection is not acting on the population.
- Sets up a reference point at equilibrium
- Watch: https://www.youtube.com/watch?v=XlrhCRfkn1c

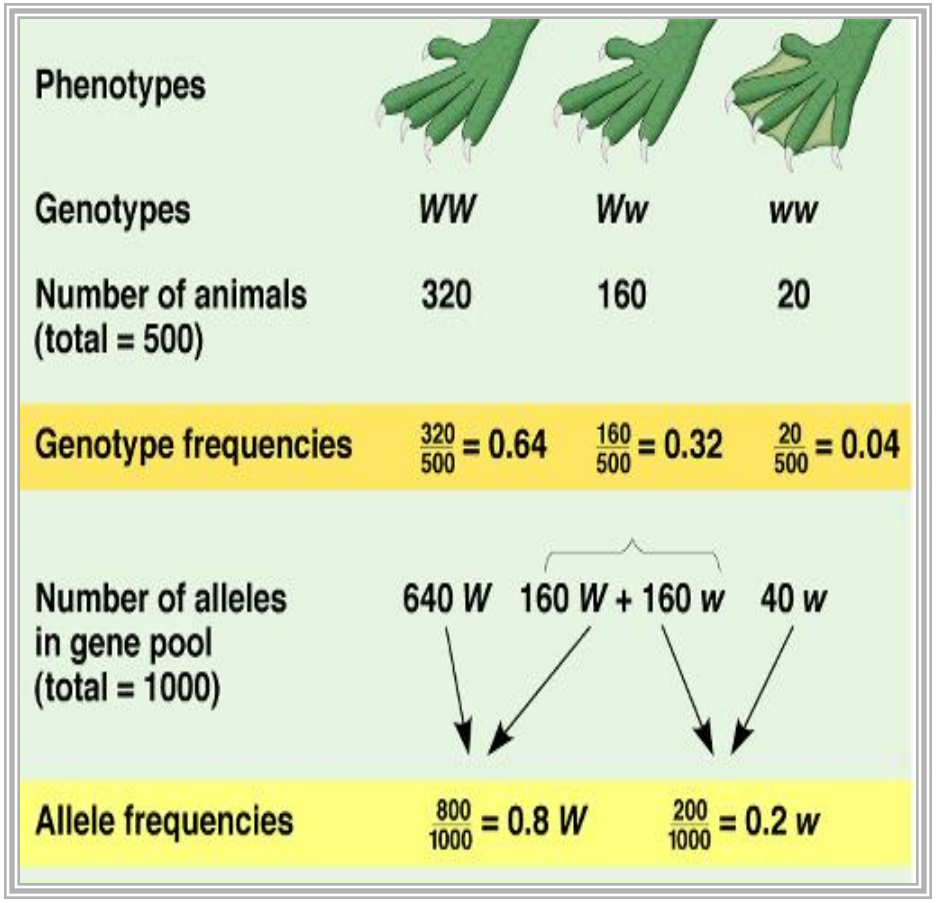
HARDY-WEINBERG & EVOLUTION

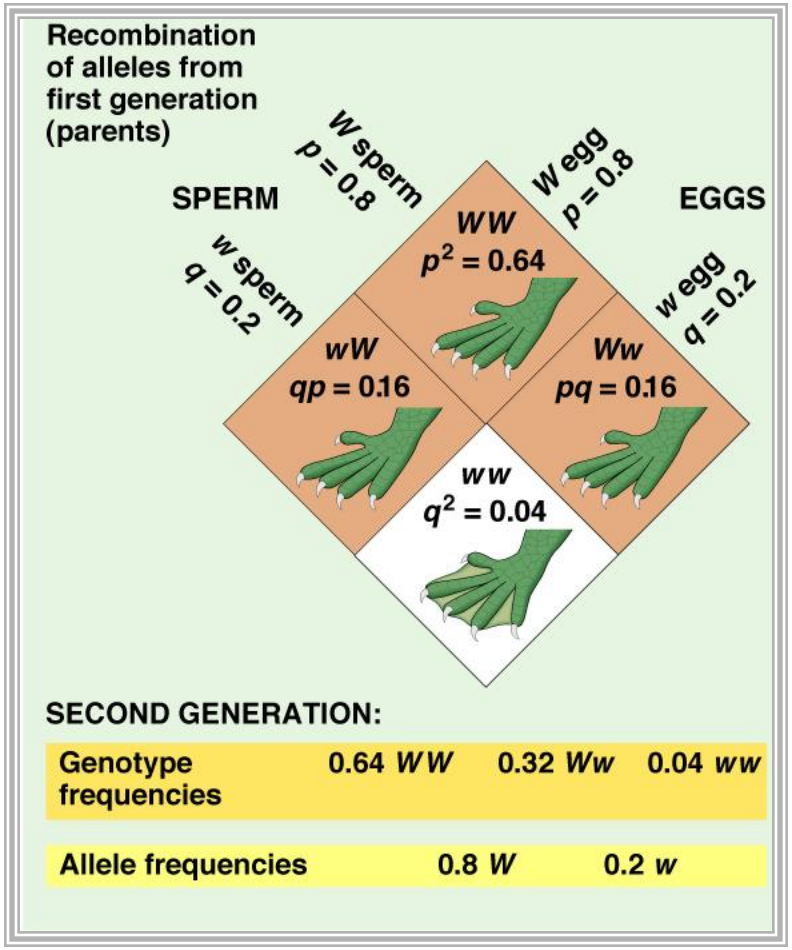
- Biologists can determine whether an agent of evolution is acting on a population by comparing the population's genotype frequencies with Hardy–Weinberg equilibrium frequencies.
- If there is no change in frequencies, there is no evolution
- Conversely, if there have been changes in the frequencies, then evolution has occurred.
- **Evolution is the change of allelic frequencies**
- Let's try a problem…

HARDY - WEINBERG

- In a population at Hardy–Weinberg equilibrium, allele frequencies remain the same from generation to generation, and genotype frequencies remain in the proportions $\mathbf{p^2 + 2pq + q^2 = 1}$.
- Two equations
  - **p + q = 1**
    - A + a = 1, where A and a equal gene percentages
    - All dominant alleles plus all recessive alleles add up to all of the alleles for a particular gene in a population
    - **Allele frequencies**
  - $\mathbf{p^2 + 2pq + q^2 = 1}$
    - AA + 2Aa + aa = 1
    - For a particular gene, all homozygous dominant individuals plus all heterozygous individuals plus all homozygous recess individuals add up to all of the individuals in the population
    - **Genotype frequencies**

HARDY-WEINBERG





HARDY-WEINBERG PROBLEM

- Given: In a population of 100 individuals (200 alleles), sixteen exhibit a recessive trait.
- Problem:
  - Find the allele frequencies for A and a.
  - Find the genotypic frequencies of AA, Aa, and aa.
- Allele frequency
  - $p + q = 1$ or $A + a = 1$
  - Equation for genotype freq: $p^2+2pq+q^2=1$
  - ?% + 16% = 100% or 16% = aa and 84% = AA +Aa
  - aa = qq or $q^2 = .16$ or $q = .4$
  - $1 - q = p$ $1 - .4 = .6$ or A = **.6** and a = **.4**

HARDY - WEINBERG PROBLEM

- Phenotypic frequencies
  - If: p = .6 and q = .4, then
    - p^2 = (.6)(.6) = .36
    - q^2 = (.4)(.4) = .16
    - 2pq = 2(.6)(.4) = .48
- Therefore, in the population:
  - Homozygous dominant = 36/100 or 36%
  - Heterozygous dominant = 48/100 or 48%
  - Recessive = 16/100 or 16%

ALLELE FREQUENCY VARIATIONS

- Hardy-Weinberg applies only if there is genetic equilibrium or NO allele frequency changes
- How often in nature does this occur?
  - Rarely, if ever.

Causes of (micro)evolution

- **Genetic drift-** change in the gene pool of a small population due to chance
- **Gene flow** gain or loss of alleles due to immigration or emigration
- **Mutation**
- **Non random mating-** if certain individuals are preferred by the opposite sex
- **Natural selection-** results in adaptation
- Watch: https://www.youtube.com/watch?v=XlrhCRfkn1c

Genetic Drift

- **Bottleneck effect-** a change in a populations allele frequencies due to a substantial reduction in population size ex-earthquake
- **Founder effect**-Colonization of a new location by a small number of individuals and the random change that occurs in a small colony. Ex- Amish population and polydactylism; species in Galapagos islands
- **Genetic drift** is due to **chance**, and not due to natural selection

Gene Flow

- Gain or loss of alleles from a population by the movement (migration) of individuals or gametes. Tends to reduce genetic differences between populations

Mutation

- Vital to evolution because it is the only force that actually generates new alleles

Non random mating

- The rule in most populations
- Tendency to mate with individuals of similar phenotype
- Tendency promotes in breeding

Natural selection

Factor most likely to result in adaptive changes in gene pool

Polymorphism

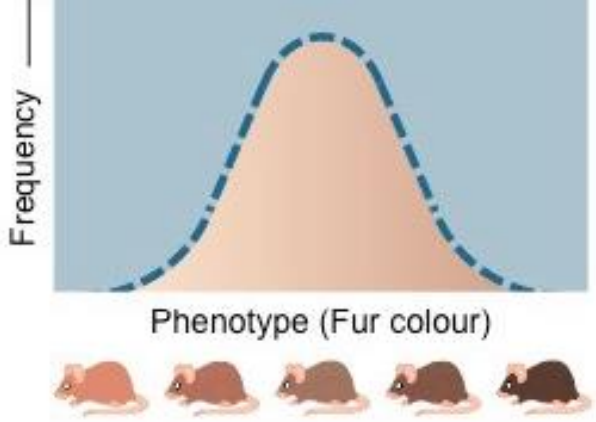
- **Morph**-2 or more contrasting phenotypic alleles for a trait. Population is poly -morphic if morphs are present in population in noticeable numbers-Ex-King snakes; blood types
- **Cline**-graded change in inherited traits in geographic continuum

More info

- **Heterozygote advantage-**promotes variability and larger gene pool
- **Endangered species-**generally, low variability. Danger of extinction.
- **Vestigial Structure-** structures that evolved and no longer have function. (Ex- appendix; pelvic bones in snakes)
- **Neutral variability-** No apparent selective advantage for reproductive success; not subject to natural selection. Ex- fingerprints
  - *Some scientists say there's no such thing as neutral variation

Types of natural selection

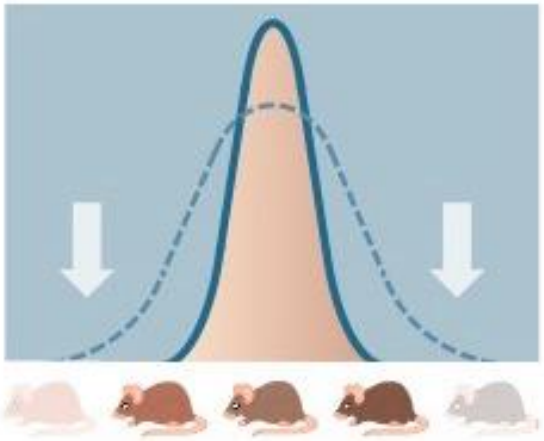
- **Stabilizing**-favors intermediate variants
- **Directional**- shifts the phenotype frequency in one direction or another. Acts against one phenotypic extreme. Common during environmental change. Ex- peppered moths
- **Diversifying (disruptive**) -favors both extremes over intermediates
  - **Watch: https://www.youtube.com/watch?v=64JUJdZdDQo
  - Also, go over the graphs given in class & complete WS



Normal Distribution

Gaussian (bell-shaped) trend

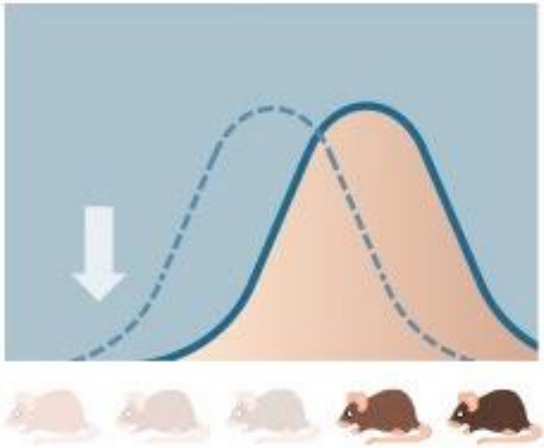
*Note-'**disruptive**' is also called '**diversifying**'. *Know both!*



Stabilising Selection

Culls extreme variations

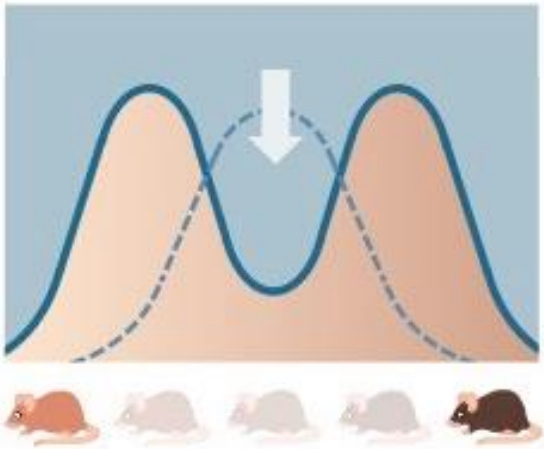
Narrows width of distribution



Directional Selection

Favours one extreme

Shifts distribution left / right



Disruptive Selection

Favours both extremes

Creates bimodal distribution

Macroevolution

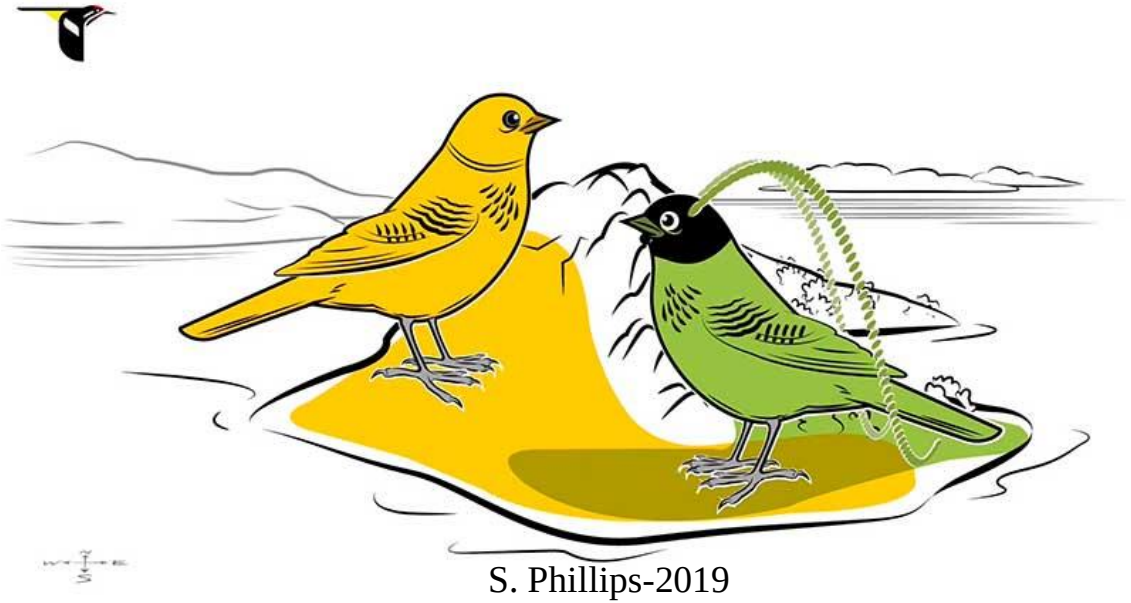
- **Macroevolution-** any evolutionary change *at or above the level of species*. It means *at least* the splitting of a species into two (**speciation**, or *cladogenesis*) or the change of a species over time into another. ***Speciation is the final result of changes in gene pool alleles and genotypic frequencies***
- ***Watch:***

More Macroevolution

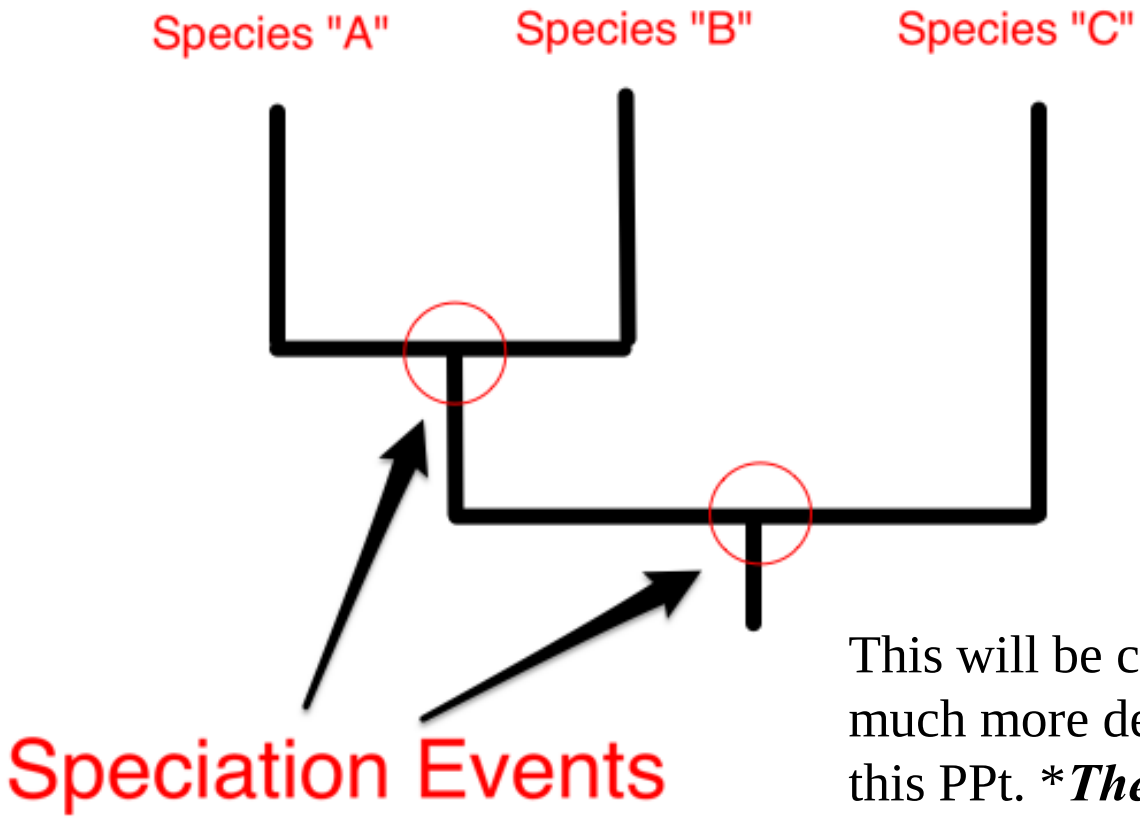
- **Macroevolution**: Mainly studied in the fossil record. It is contrasted with **microevolution**, (study of evolution over short time periods). Microevolution refers to changes in gene frequency within a population. Macroevolutionary events are likely to take millions of years. Speciation is the traditional dividing line between micro-and macroevolution.
- **Speciation** is the final result of changes in the gene pool and genotypic frequencies.

Speciation

- Some members of a sexually reproducing population change so much that they can no longer produce fertile offspring with members of the original population



Phylogenetic Trees & Cladograms



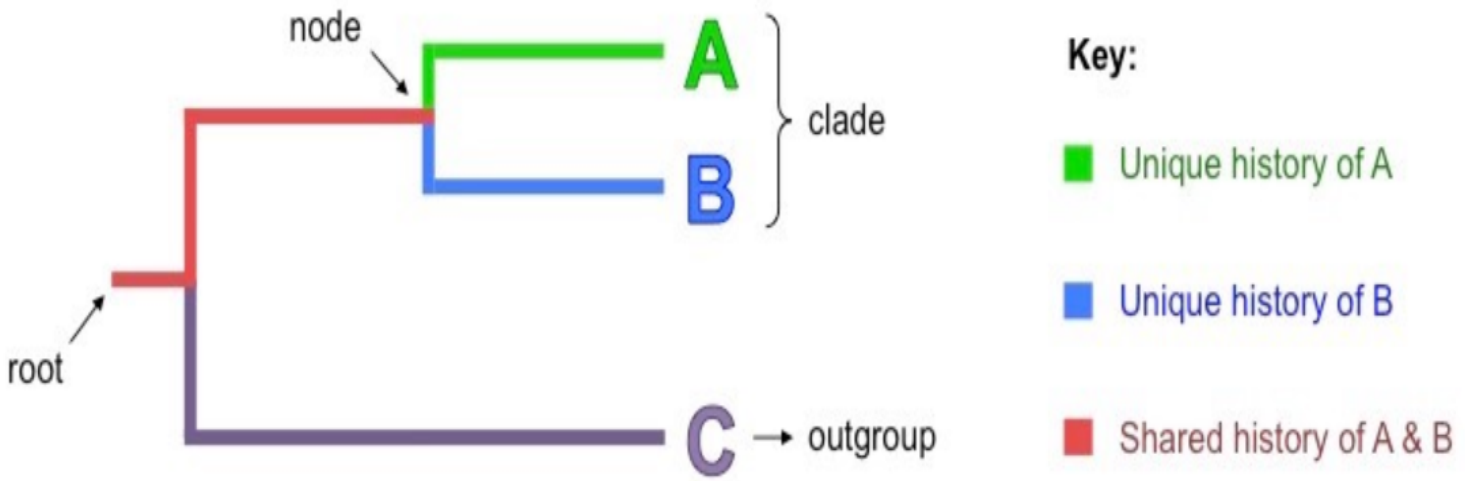
This will be covered in much more depth later in this PPt. ***There's also another PPT on blog, if needed***

Cladograms-Intro (more depth after Evol Quiz)

Constructed cladograms all typically share certain key features:

- *Root* – The initial ancestor common to all organisms within the cladogram (incoming line shows it originates from a larger clade)
- *Nodes* – Each node corresponds to a hypothetical common ancestor that speciated to give rise to two (or more) daughter taxa
- *Outgroup* – The most distantly related species in the cladogram which functions as a point of comparison and reference group
- *Clades* – A common ancestor and all of its descendants (i.e. a node and all of its connected branches)

Key Features of a Cladogram



What is a Species?

- Usually defined as a group of populations that can breed among themselves to produce fertile offspring. Further, the members of a species are reproductively isolated and unable to reproduce with members of another species (no gene flow)
- Watch: https://www.youtube.com/watch?v=rlfNvoyijmo&t=195s

What are Reproductive Isolating Mechanisms?

- **Prezygotic** (before the formation of a zygote) isolating mechanisms, are those that prevent reproduction attempts and make it unlikely that fertilization will be successful if mating is attempted.
- **Examples:**
- **Habitat isolation** (ex- garter snake. One lives on land; one in water);
- **Behavioral isolation** (certain species secrete their own pheromones; birds have distinctive mating songs);
- **Mechanical isolation-** sex organs are incompatible;
- **Temporal isolation-** species reproduce during different seasons or times of day (pollen released at different times; fireflies mate at different times of night)

Reproductive Isolating Mechanisms

- **Postzygotic** (after formation of zygote)- fert. has occurred, but hybrid offspring can't develop or reproduce.
- Ex- lion and tiger produce sterile liger; donkey and horse make mule *(*FYI- a few mules have been known to reproduce with each other, but their offspring are sterile)*

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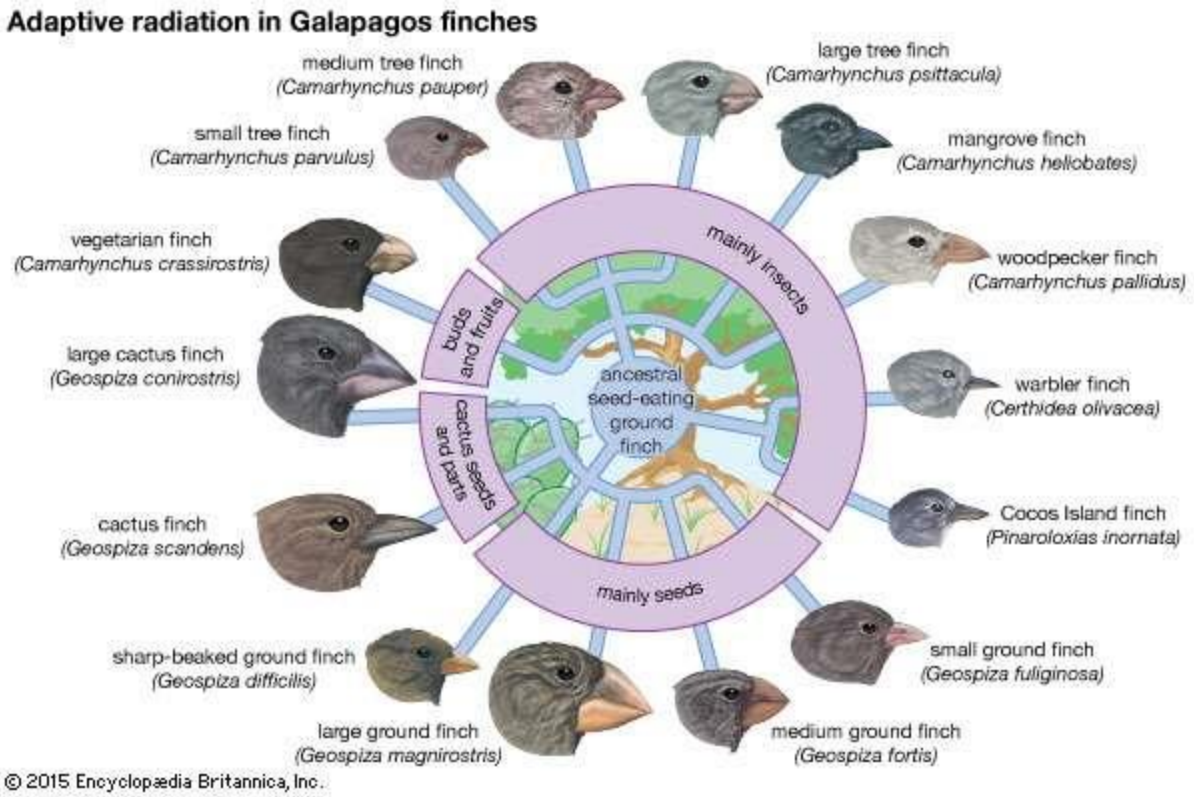
Modes of Speciation

- For speciation to occur, population must diverge and become reproductively isolated. Most common cause is **allopatric** speciation: populations are separated by a geographic barrier (mountain range emerges and splits population; canyons and rivers emerge or widen, etc.)
  - **Adaptive radiation** is divergent & here's a good example: the finches on Galapagos. There were many unoccupied niches, thus many species resulted that were able to adapt to different environments (little, if any, competition)

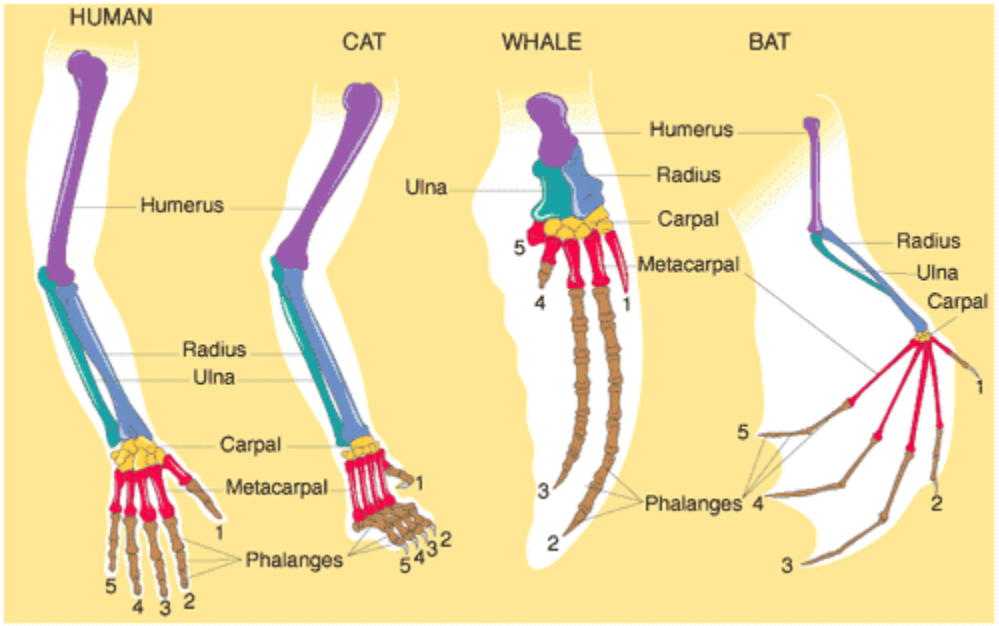

Adaptive radiation in Galapagos finches
medium tree finch
(Camarhynchus pauper)
large tree finch
(Camarhynchus psittacula)
small tree finch
(Camarhynchus parvulus)
mangrove finch
(Camarhynchus heliobates)
vegetarian finch
(Camarhynchus crassirostris)
woodpecker finch
(Camarhynchus pallidus)
large cactus finch
(Geospiza conirostris)
warbler finch
(Certhidea olivacea)
cactus finch
(Geospiza scandens)
Cocos Island finch
(Pinaroloxias inornata)
sharp-beaked ground finch
(Geospiza difficilis)
small ground finch
(Geospiza fuliginosa)
large ground finch
(Geospiza magnirostris)
medium ground finch
(Geospiza fortis)
mainly insects
buds and fruits
cactus seeds and parts
mainly seeds
ancestral seed-eating ground finch
© 2015 Encyclopædia Britannica, Inc.

More Evo

- **Divergent** evolution- formation of new species. Adaptive radiation (resulting in many different species) is one example of divergent evolution.
- **Convergent** evolution- 2 unrelated species that are in similar niches develop similar adaptations due to similar environmental pressures.
- ****Homologous** structure (species are more closely related, but adapted for a different function. Ex: our arm and a bat's wing…both species are mammals) vs. **Analogous** structure (less related species, but adapted with a similar function: Ex- bee's wing and bird's wing…one species is an invertebrate, the other is a vertebrate…so not very related)
- Videos: 1) https://www.youtube.com/watch?v=X-XtZyHcck4;
- 2) https://www.youtube.com/watch?v=4-QL-4z0y1U (he explains it really well)

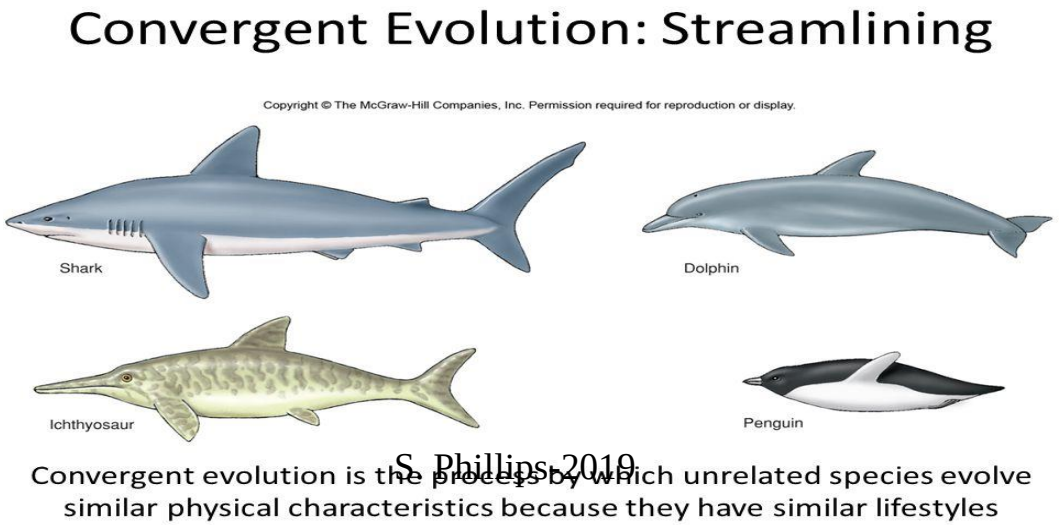
Divergent Evolution

- **Divergent evolution-** Species that share a recent common ancestor and are thus more related. Ex- humans and whales are both mammals.
  - **<u>Homologous</u>** <u>structure-</u> have a different function, but similar structure and are thus more related. (Ex: human arm and whale's fin- both are mammals)



Convergent Evolution

- **Convergent evolution-** 2 'unrelated' species that occupy similar type niches and therefore have similar adaptations. Many times the species are geographically far apart. Ex- 2 different plant species that are in similar climates with similar environmental pressures. Thus they have evolved similarly, yet they could be thousands of miles apart!
  - **Analogous** structure- have a similar function, but are less related. (Ex: whale and shark can both swim, but one is a mammal & the other's a bony fish)



Only one is a cactus…this occurred because of convergent evolution

More on Speciation

- **<u>Coevolution</u>-** Mutualistic relationship between 2 species. Evolution of one affects the other. Ex- Flower and pollinator (like a bee)
- **<u>Artificial Selection</u>-** nature doesn't select…'Man' does! Ex – Dog Breeds. Is picking & choosing 'desirable' phenotypes always best for the species? Why or why not?

Co-evolution

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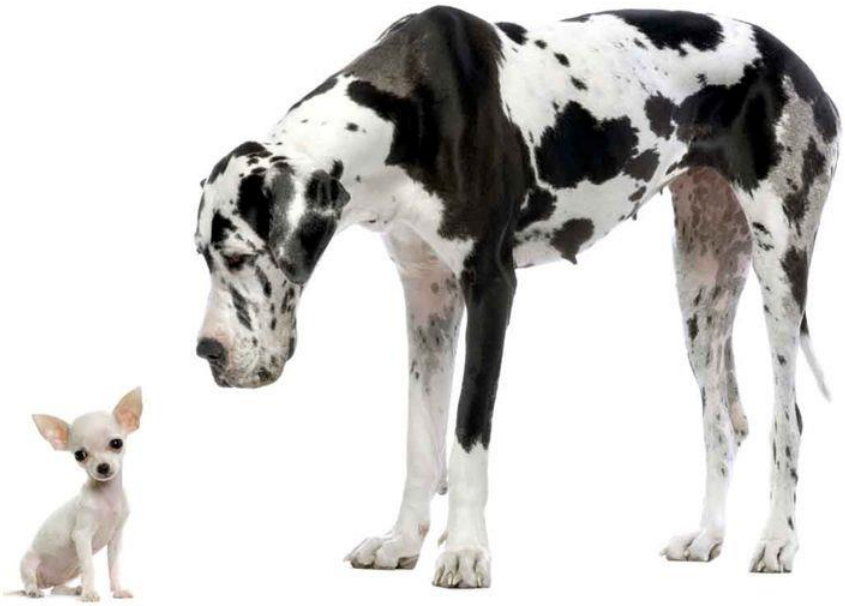
Artificial selection



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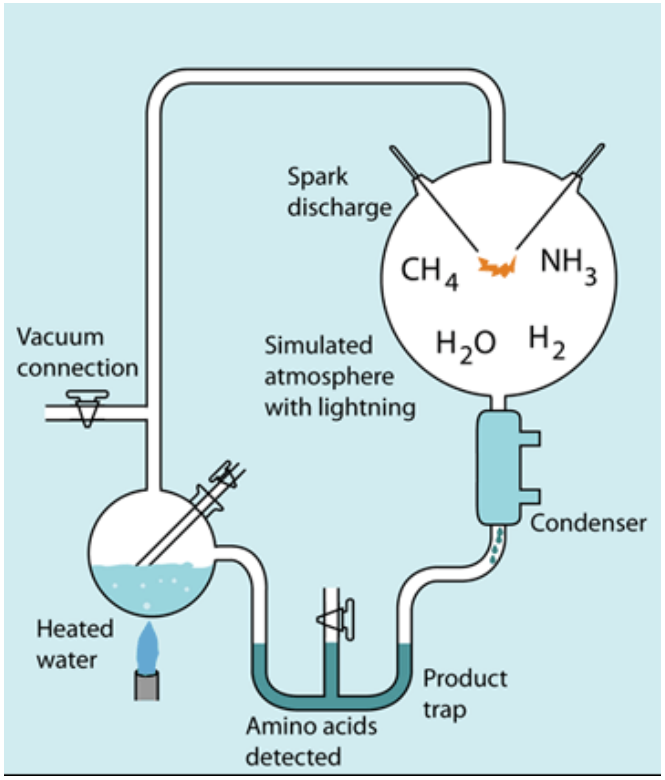
Rate of Speciation

- **Rate of speciation-** Most evolution is believed to proceed very slowly- **gradualism** (*Darwinian idea)
- Sometimes a dramatic event occurs abruptly and speciation occurs ‘faster’**- punctuated equilibrium**. Ex: after extinction of dinosaurs, mammals began to prevail (think of the newly available unoccupied niches!).
  - Scientists use fossil evidence, as well as genetic sequencing, to try and determine this.

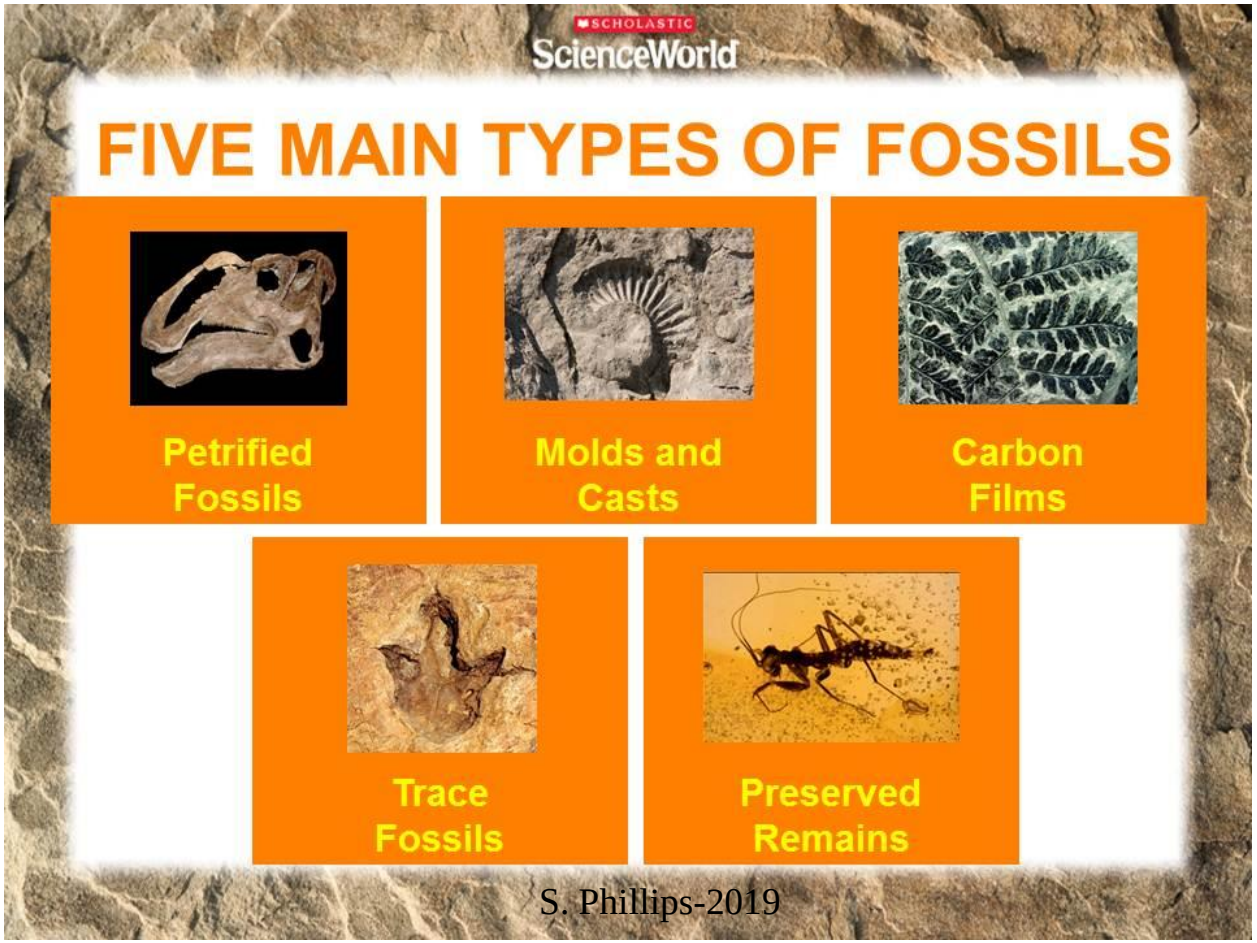
Theories Regarding Life's Origin:

- **Oparin and Haldane** (1920)- suggested first organic molecules came from early atmospheric gases (abiotic synthesis)
- **Miller and Urey** (1950)- Confirmed above theory by transforming small reduced particles (NH3, H2, CH4, H20, etc) to amino acids with electric spark (simulating lightning)
- *What does reduced mean again??
  - *Think back to Respiration (NADH)*



Early Life: Fossil Evidence

- **Paleontologist- Studies Fossils**
- **Types of fossils:**



FOSSIL DATING

Relative Dating

- Uses order of rock strata to determine relative age of fossils

Radiometric Dating

- Measure decay of radioactive isotopes present in layers where fossils are found
  - Aka ‘Absolute Dating’
- Half-life: # of years for 50% of original sample to decay

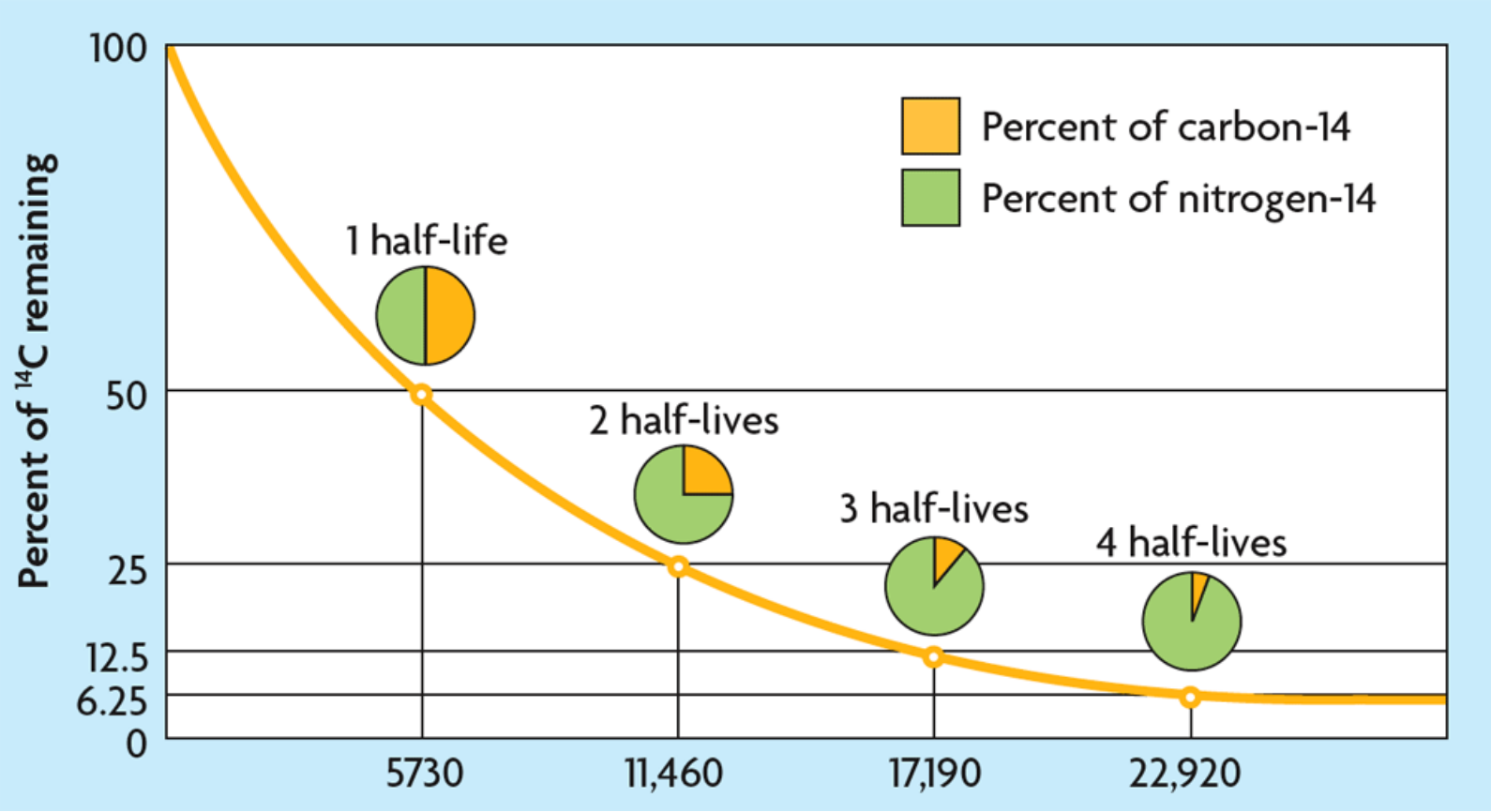
Both are used to date fossils and determine age

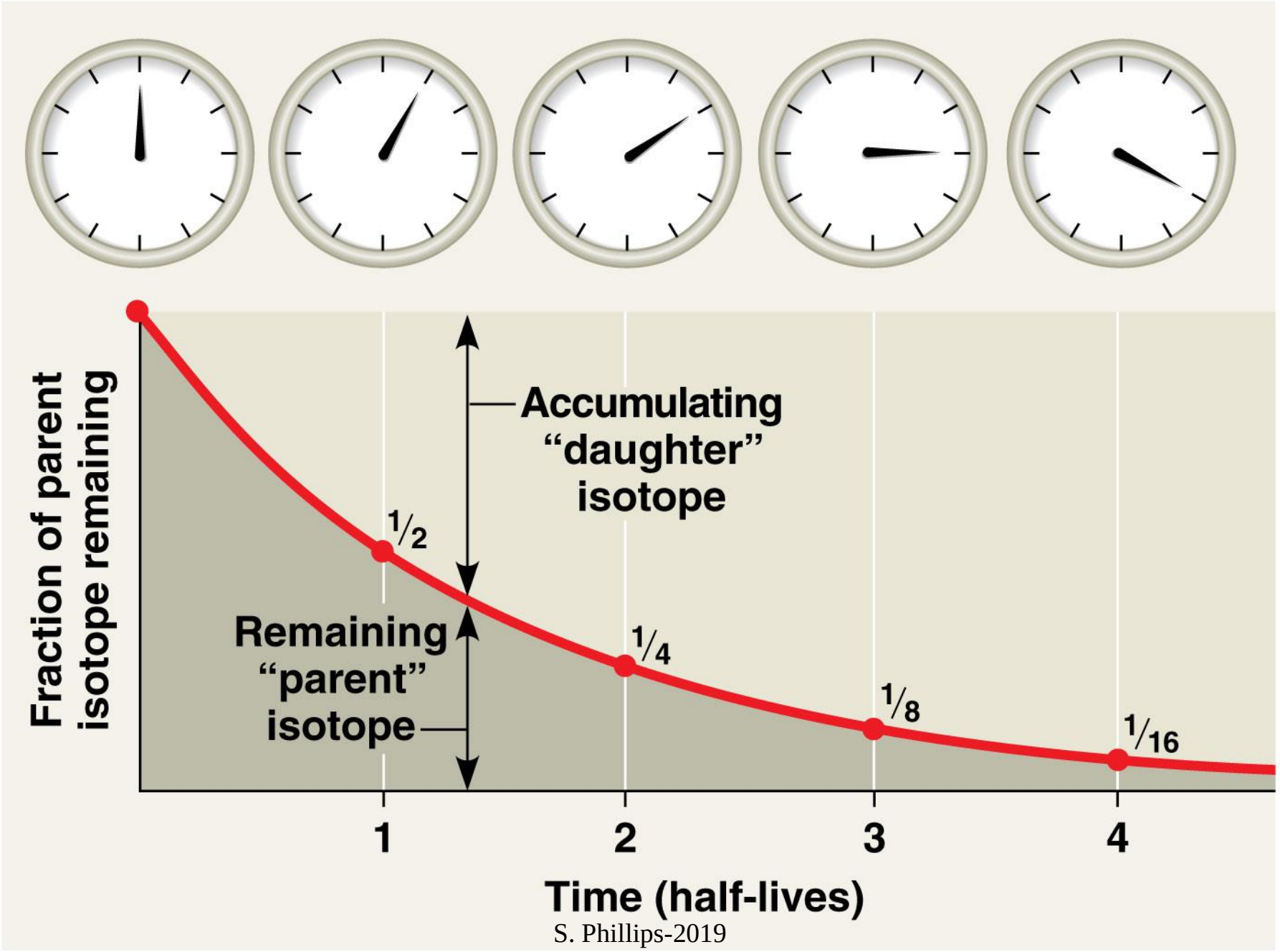
Radiometric Fossil Dating

- Radiometric Dating (Absolute Dating): Half-lives are used to determine a fossils age. The half life of an isotope is the time it takes for ½ of an isotope to decay (break down). Carbon-14 is used to date fossils.
- Ex. of Radiometric Dating: The half life of Carbon-14 is 5730 years. In 2 half-lives, how much C-14 would remain? How old would the fossil be? *Interpret the graph on next page.*
  - *This was also taught in Magnet Chemistry-Unit 1

Radiometric Dating of Fossils

(*this one's easy…just read the graph)





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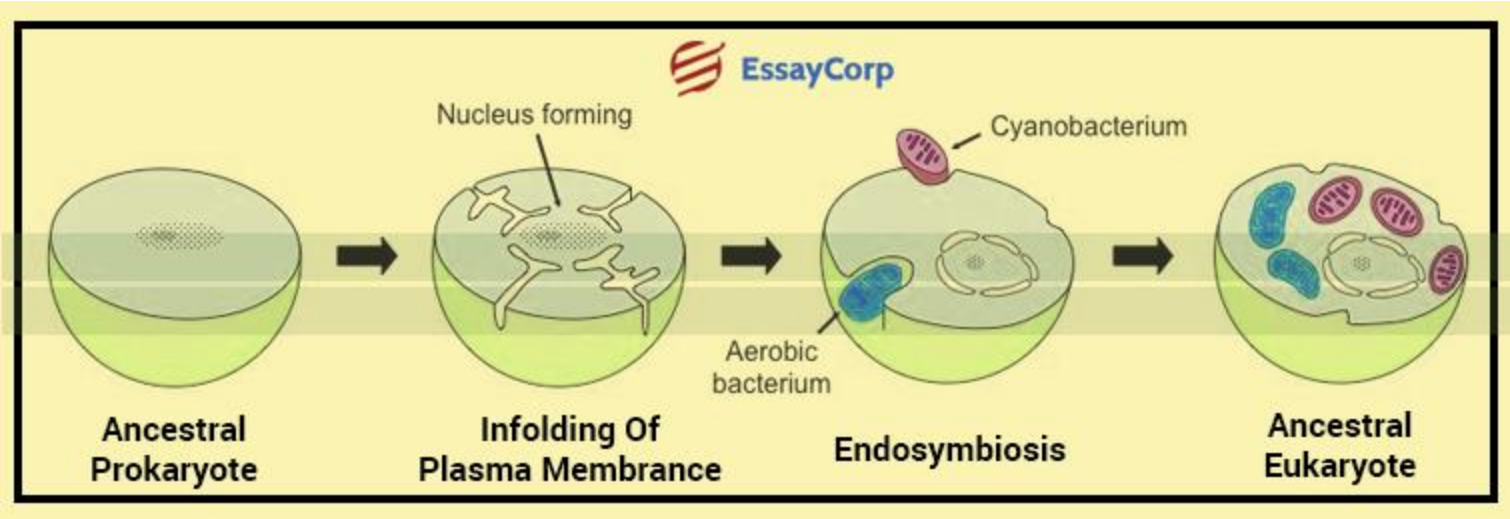
More Theories of Life

- Theories of how life began:
  - Spontaneous Generation- life from nonlife
  - Theory of Biogenesis- life from life
  - **<u>Endosymbiotic theory-</u>** A **theory** stating that the eukaryotes evolved through a process whereby different types of free-living prokaryotes became incorporated inside larger prokaryotic cells and eventually developed into mitochondria, chloroplasts, and possibly other organelles.**BE SURE YOU KNOW THIS ONE*!
  - See next slide

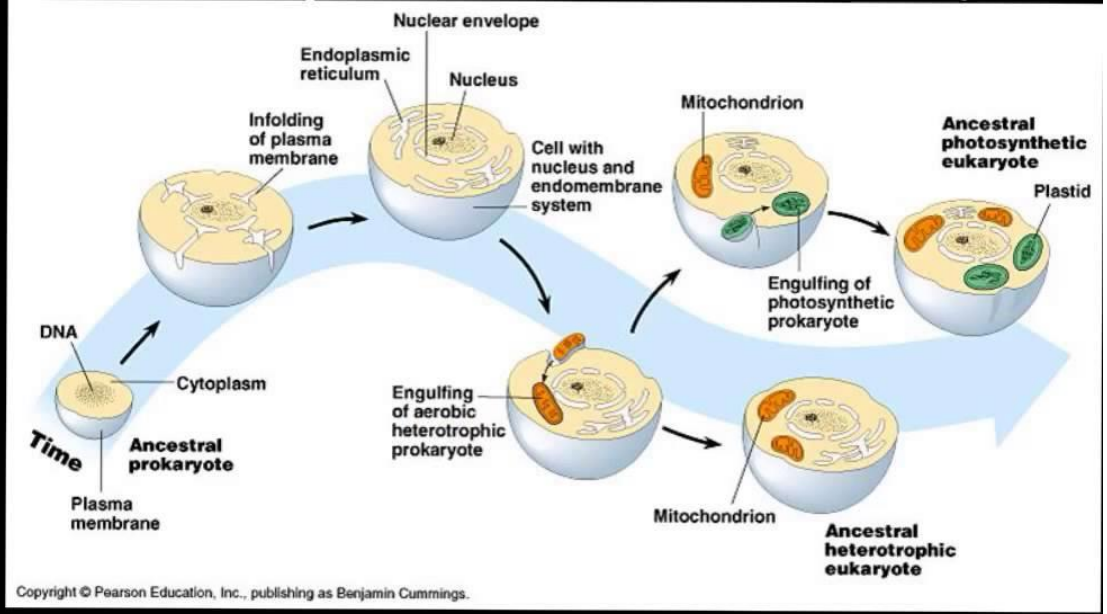
Endosymbiotic Theory



Formation of ER

Became mitochondria & chloroplasts- both have their own DNA, plus double membranes

Endosymbiotic Theory



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For more detail and information:

Go to my blog, Power Point Section, click "Phylogeny"

Also posted: "Evidence for Evolution"

Make sure to check out the numerous **linked videos** on my blog. They are **NOT** all linked in this PPt

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Part 2: The Diversity of Life

Classification of Organisms

Viruses, Prokaryotes, Protists and Fungi

****SEE NEXT PPT!**

Magnet: Mader Text- Parts of 20-23; OpenStax online Text

So what exactly is Classification?

- Life on Earth is constantly changing (evolving)
- Scientists have currently identified around 1.5 million species (and estimate another 2-100 million species yet to be discovered)
  - Remember: A species is a population of organisms that share similar characteristics and can breed with one another and produce fertile offspring.
- This diversity creates an organizational challenge.
  - To deal with this, biologists name each organism and attempt to organize living things into groups that have biological meaning.
    - Watch:

1.5 - 2 million known species…

Bacteria	**4,000**
Protozoa, algae, etc.	**80,000**
Fungi	**70,000**
Plants	**321,000**
Animals	**1,320,000**
•insects	**1,000,000**
•vertebrates	**62,000**

Taxonomy

- Scientists classify organisms and assign each organism a universally accepted name based on a common criteria - taxonomy
- Science requires both general and very specific categories to properly categorize all organisms.
- Organisms placed into a particular group are more similar to each other that they are to organisms in other groups.

- ***Systematics*** *is a broader science that deals with both taxonomy and evolutionary history* ***(phylogeny)***

Scientific Names

- There was confusion among scientists when they used common names.
- In the eighteenth century, scientists created a scientific name for each species using Latin and Greek languages.
  - Originally, scientists named organisms according to their physical characteristics, but names were long and inefficient.
  - Then, **Carolus Linnaeus**, a Swedish botanist known as the 'Father of Taxonomy', developed a system of assigning each species a two-part scientific name = binomial nomenclature (*Genus and species*).
- Today, scientists still use this binomial nomenclature based on Latin and Greek to name newly discovered species.

Binomial Nomenclature

- 2 part scientific name
  - Genus — larger group to which organism belongs
    - always capitalized
  - species — specific name for that organism
    - always lowercase
  - example: Linnaeus named humans *Homo sapiens*
    - means “wise man” — perhaps in a show of hope & optimism

Genus groupings

- Classify organisms into broader groups
- Species that are closely related are grouped into the same genus
  - Leopard *Panthera pardus*
  - African lion *Panthera leo*
  - Tiger *Panthera tigris*

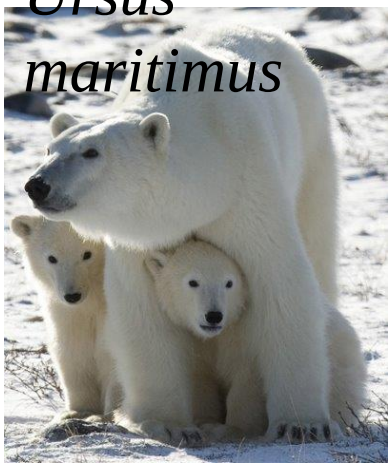


Grizzly Bear and Polar Bear

- The genus *Ursus* indicates that it is a bear, but the species name describes either where the species lives or characteristics of the species.
- What do you think maritimus means?
- *maritimus* refers to the sea in Latin
- How does this relate to polar bears?

Ursus arctos

Ursus maritimus

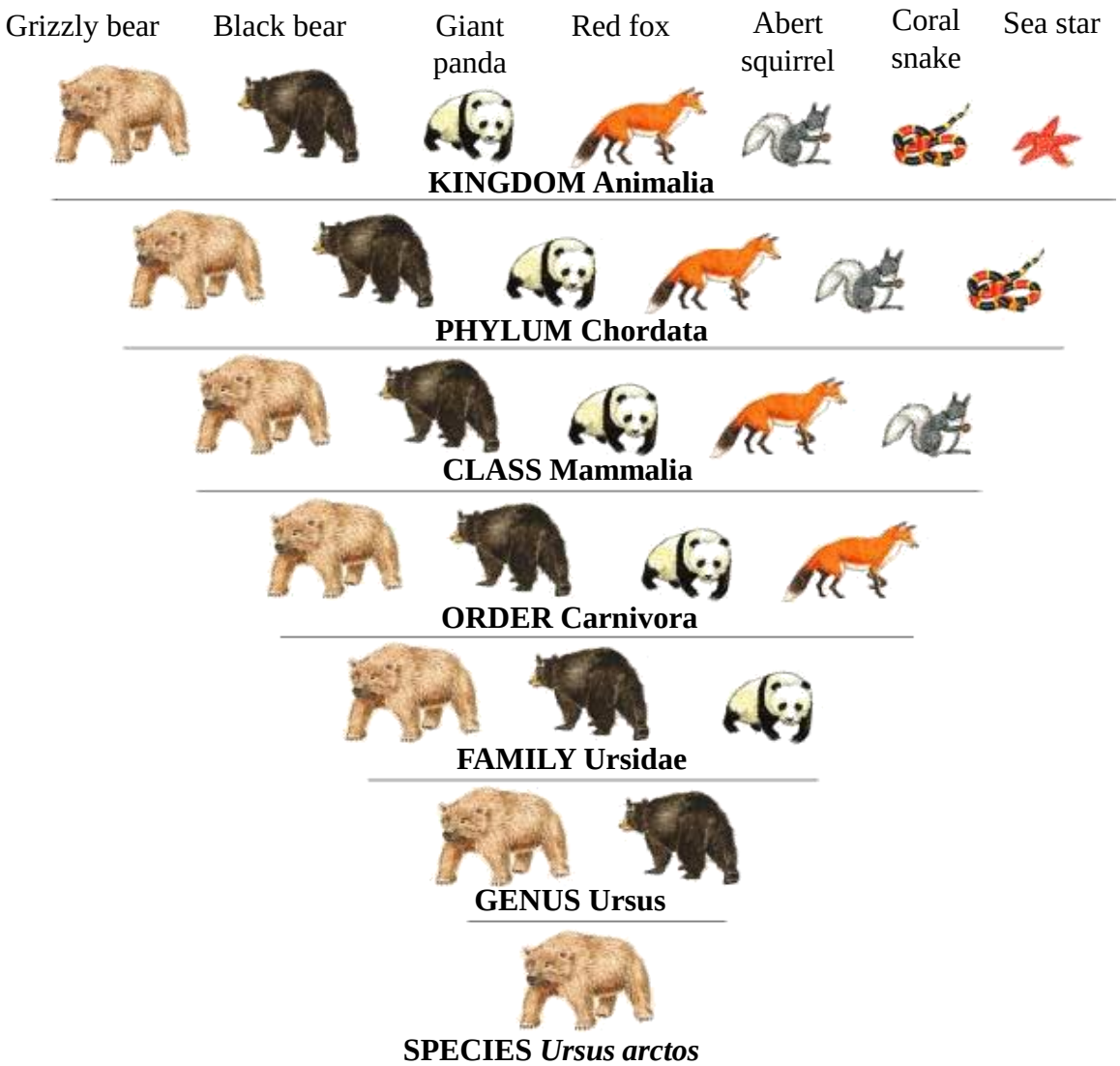


Linnaeus's System of Classification

- Uses seven **taxon**omic categories (largest to smallest):
  - Kingdom
  - Phylum
  - Class
  - Order
  - Family
  - Genus
  - species

"King Philip Came Over For Grape Soda"

Figure 18-5 Classification of *Ursus arctos*



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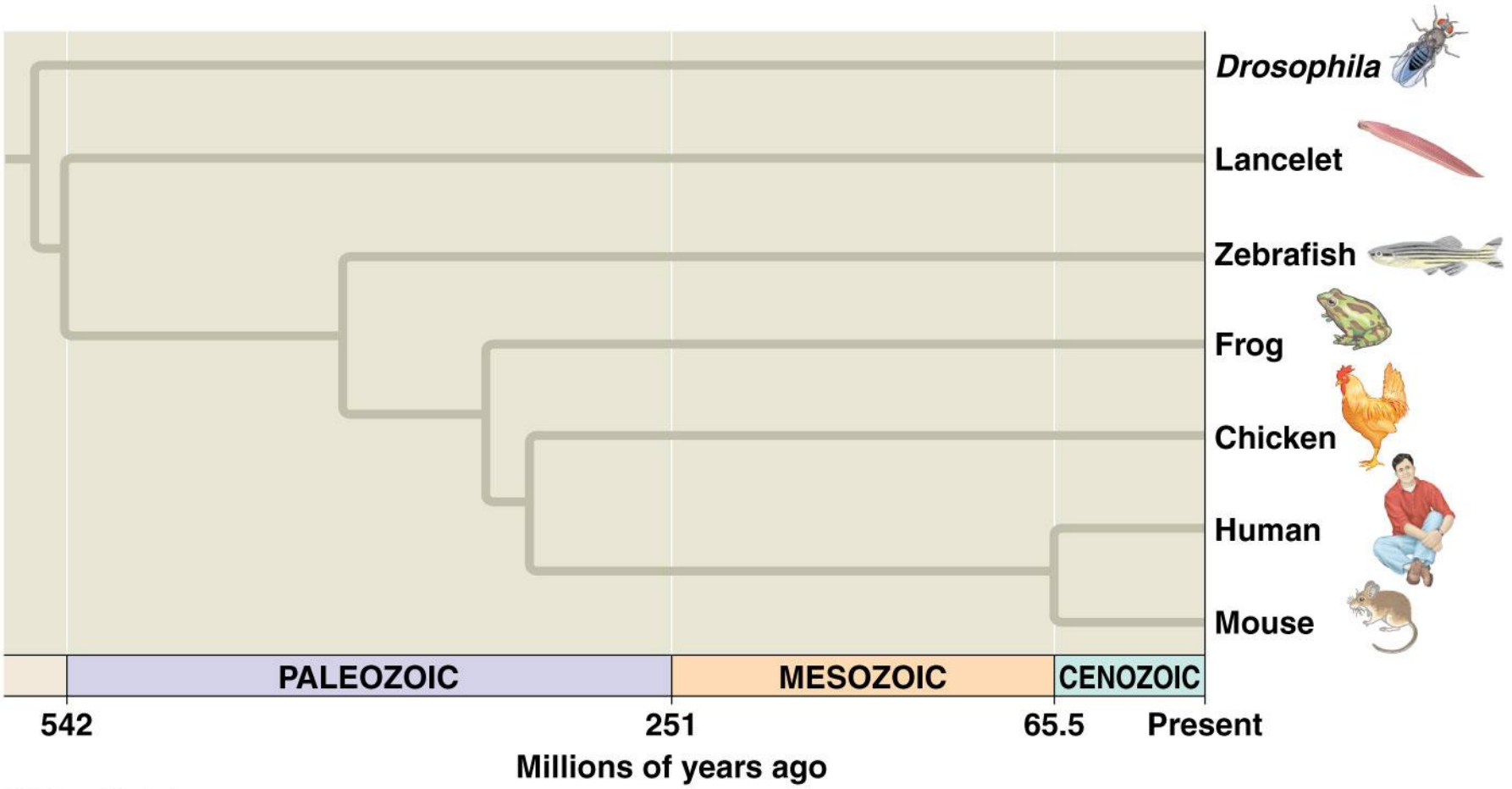
Modern Evolutionary Classification

- Linnaeus focused on structures and anatomy.
  - Due to convergent ("coming together") evolution, organisms that were quite different evolved similar analogous adaptations because of selective environmental pressures.
    - Bat and Bird wings
    - Whale and fish fins
- Darwin's theory of evolution changed how biologists classify organisms.
- Biologists now group organisms into categories that represent lines of evolutionary descent (the evolutionary history they share), not just similar traits = Evolutionary Classification.

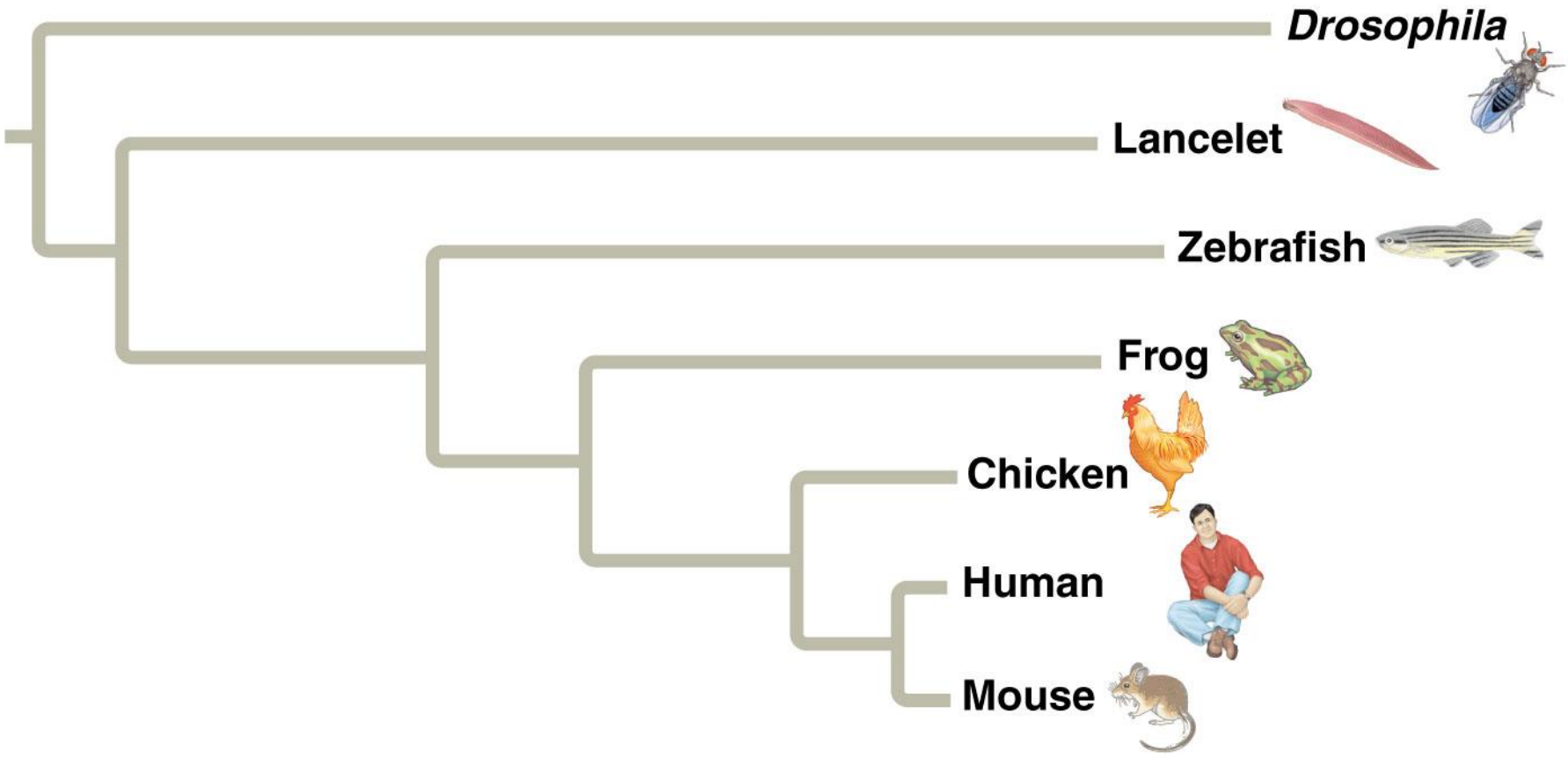
Cladograms

- **Cladogram** = a diagram that shows the evolutionary relationships among a group of organisms ("evolution family tree")
- Cladistic analysis = using cladograms to map out evolutionary history
- Based on derived characters = new characteristics that appear in recent parts of a lineage arising as lineages evolve over time
- *FYI- although a **phylogenetic tree** is similar, the length of the branches correspond to time (or genetic differences), whereas a cladogram does not
  - **VIDEOS**: Here's one of many: https://www.youtube.com/watch?v=ouZ9zEkxGWg
  - Go to my blog. There are many other linked videos & it's vital you learn how to construct & analyze these!

Phylogenetic Trees: Branch lengths can indicate time

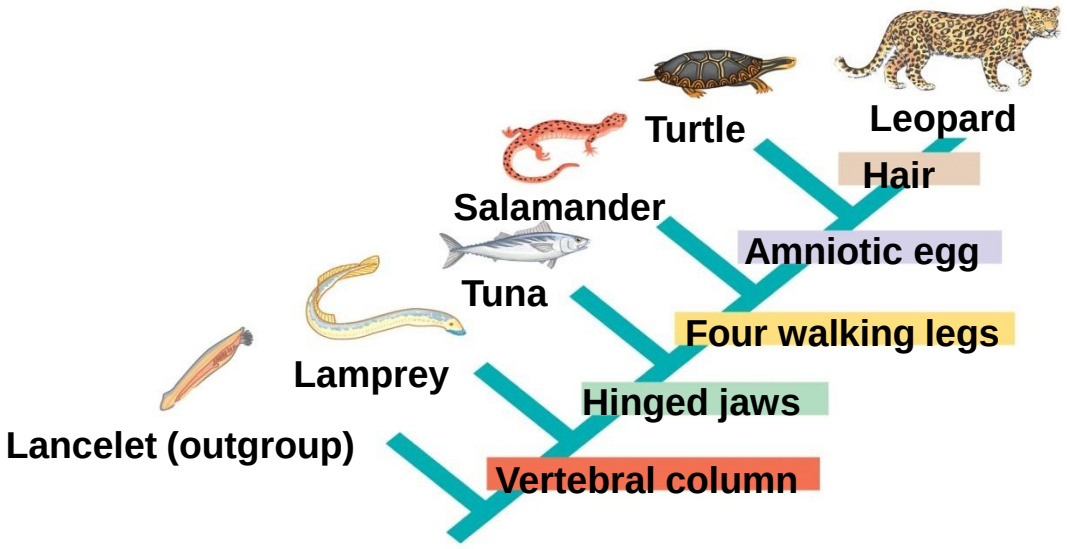


Branch lengths can also represent genetic change



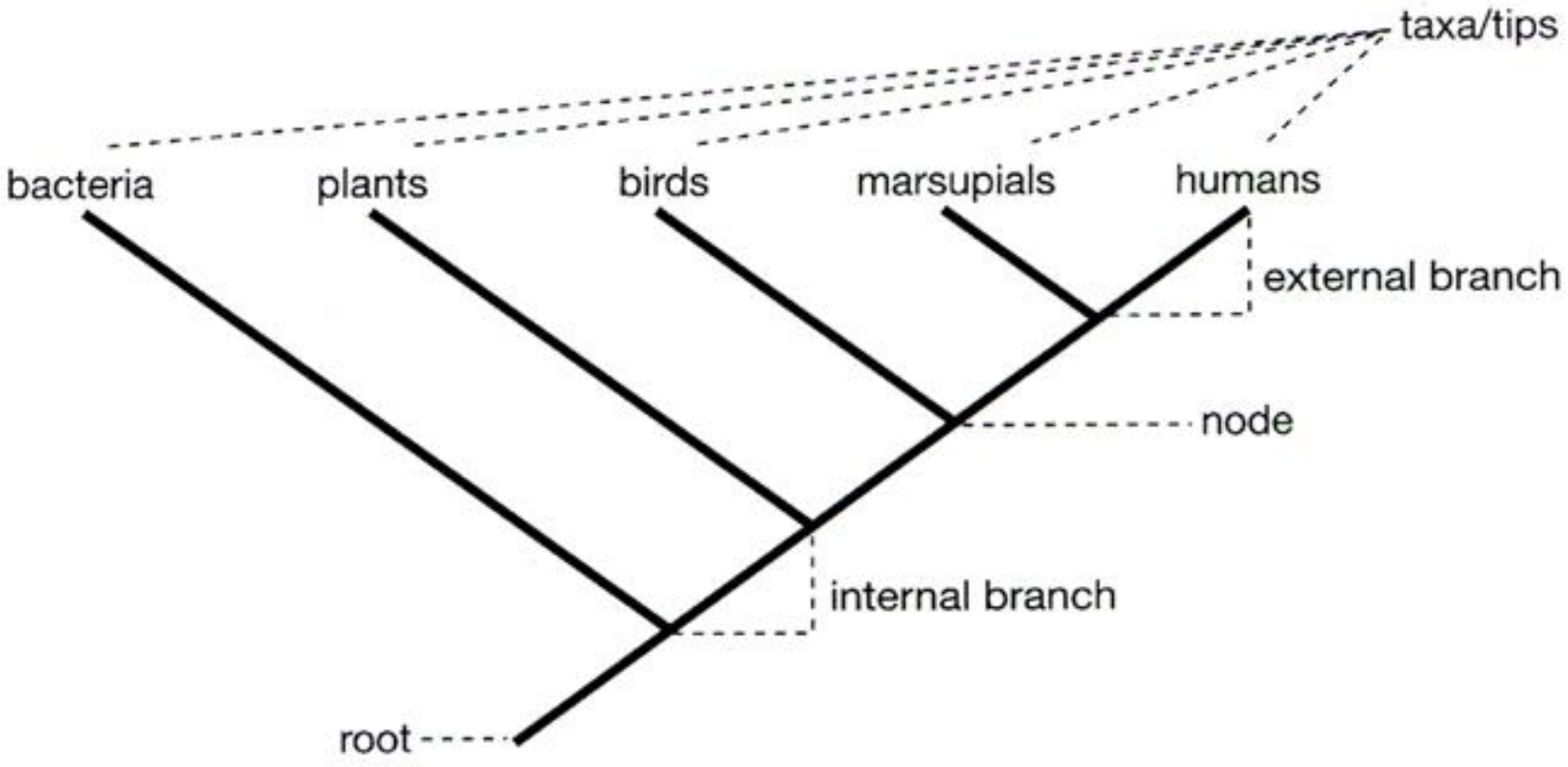
Cladogram: diagram that depicts patterns of shared characteristics among taxa

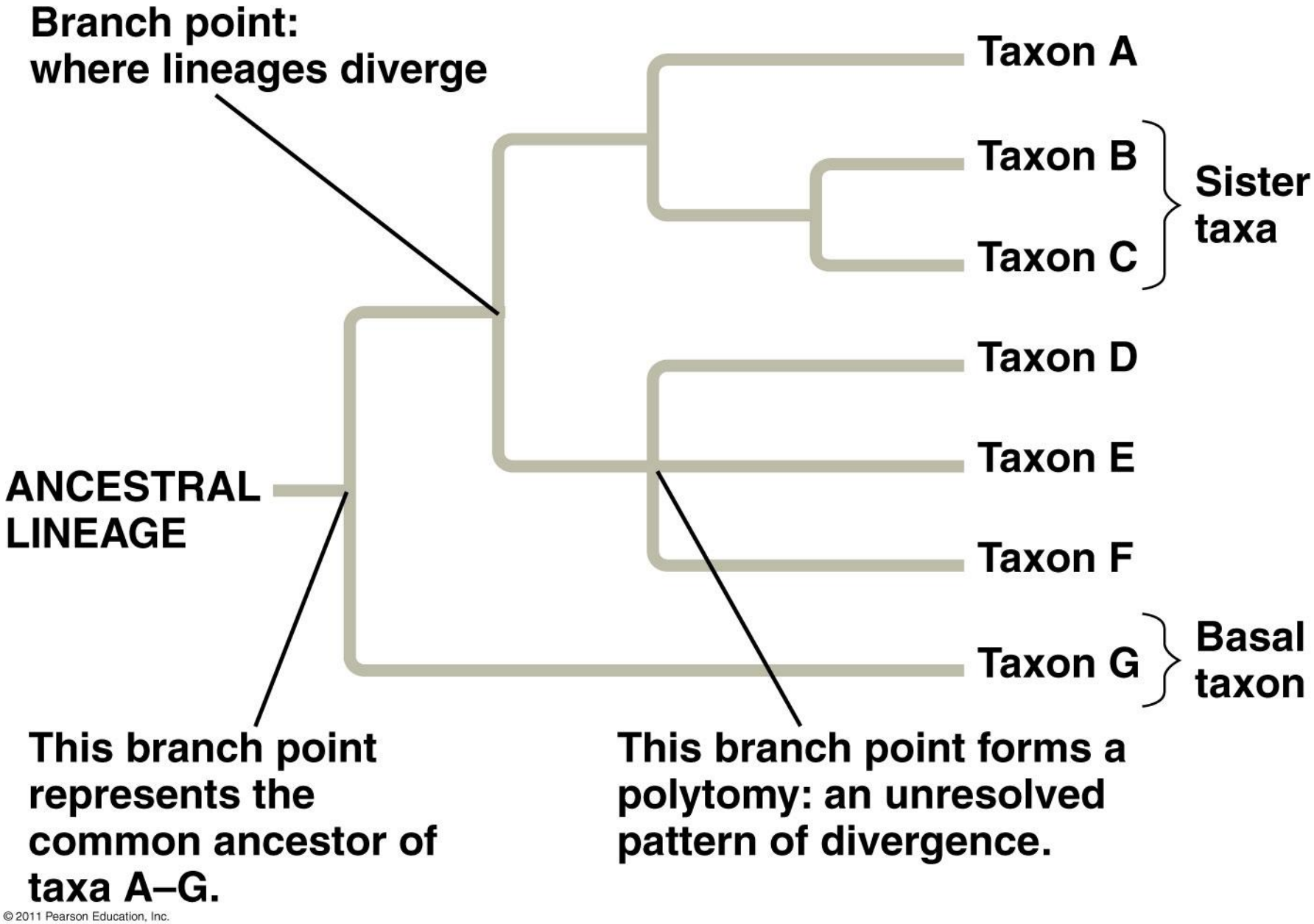
- Clade = group of species that includes an ancestral species + all descendents. (*Lines do not = time)
- Shared derived characteristics are used to construct cladograms

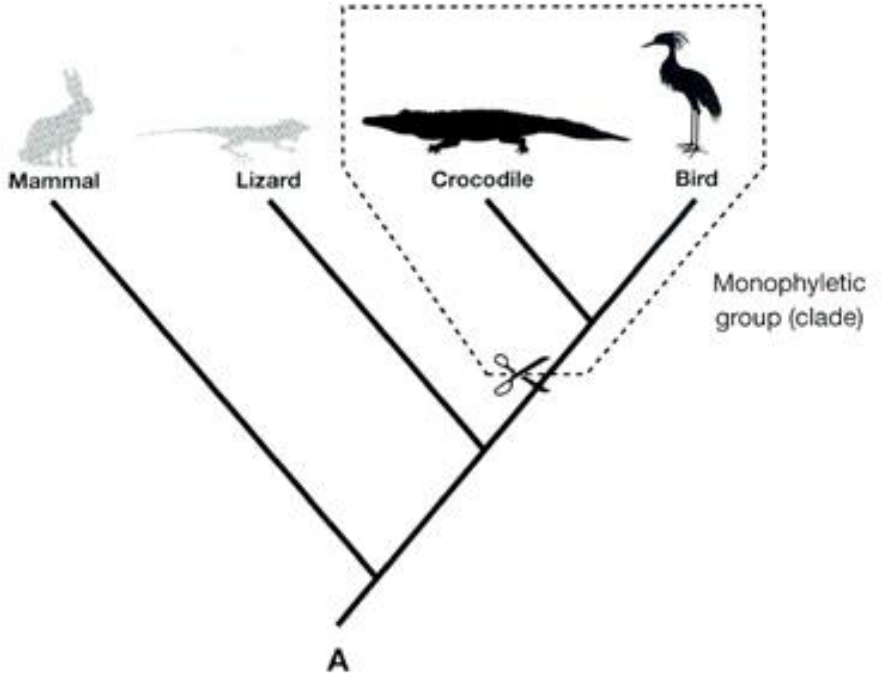


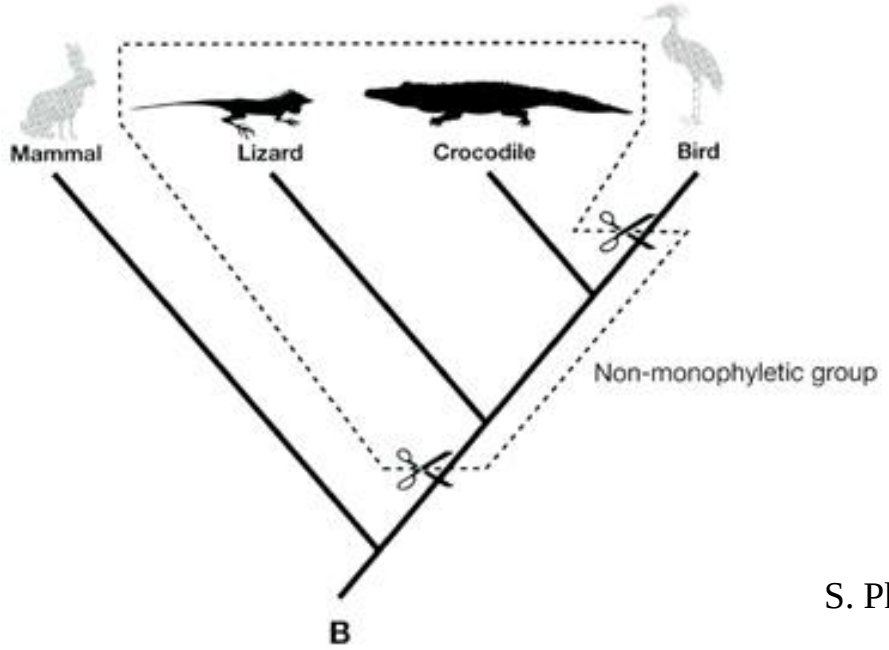
(b) Cladogram

Some important terms used to describe phylogenetic trees and cladograms



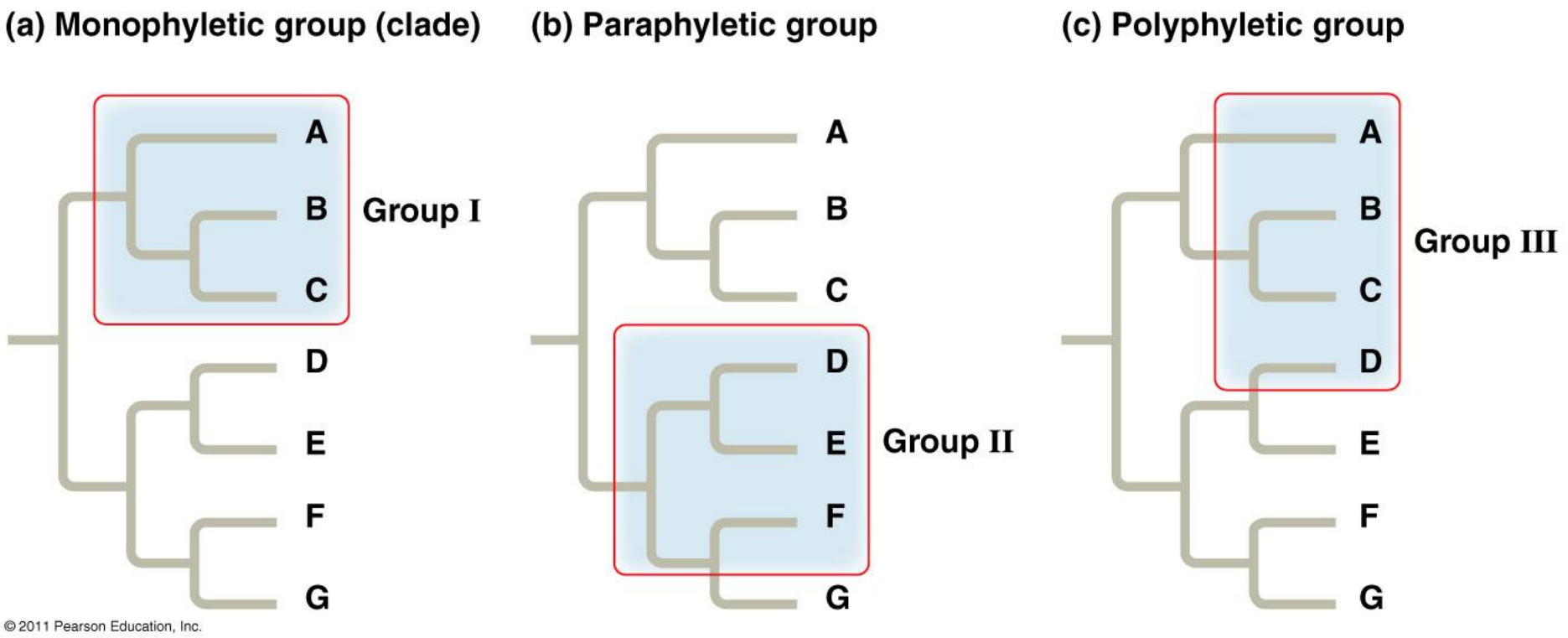






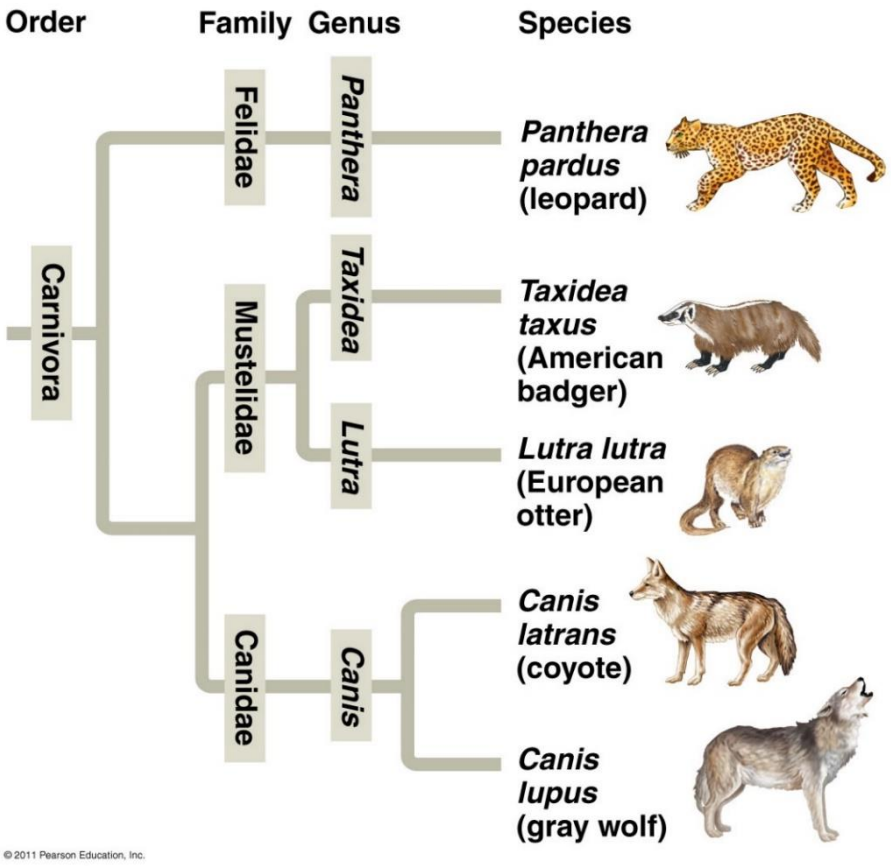
Cladogram: A **clade** includes *all* and *only* the descendants of a particular ancestor

Monophyletic, paraphyletic, and polyphyletic groups



Monophyletic- includes all members of a clade; FYI: Paraphyletic- excludes 1 or more members of clade; Polyphyletic- includes 1 or more from a different clade (but not all)

Find All of the Monophyletic Groups on this Tree:



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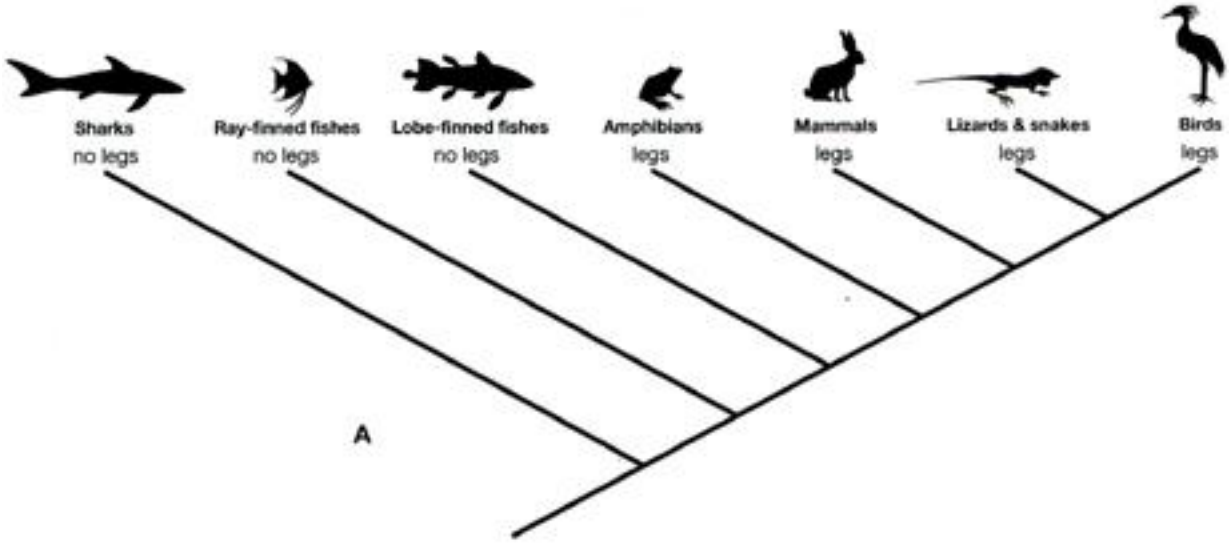
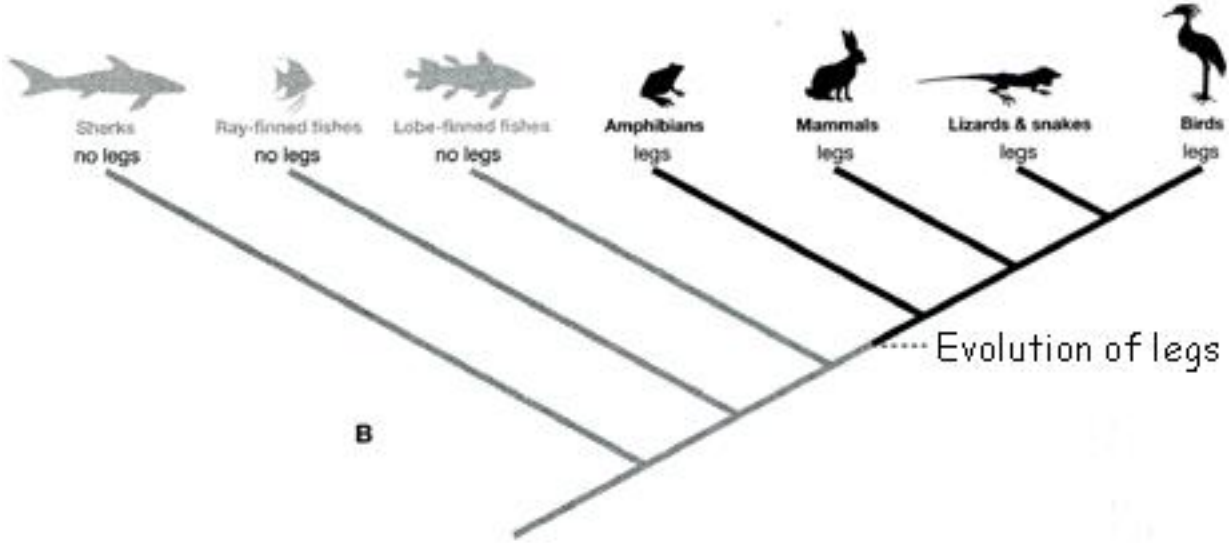
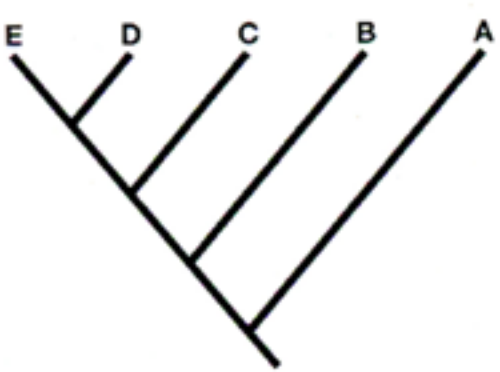


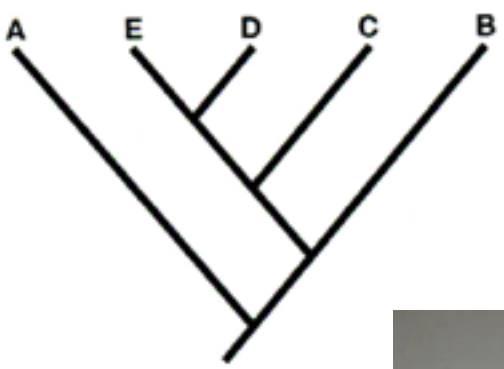
So…what's a derived character?

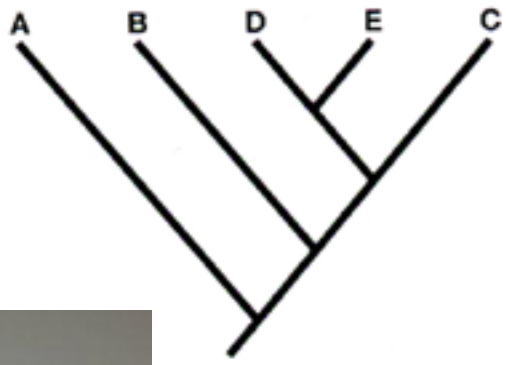


←Derived character

Three trees, all depict the same evolutionary history *(the nodes can 'rotate'…kind of like a baby's mobile works)*







If you can't picture this in your head, or don't know what the heck a baby's mobile even is: https://www.youtube.com/watch?v=VeGf-BlaoDQ

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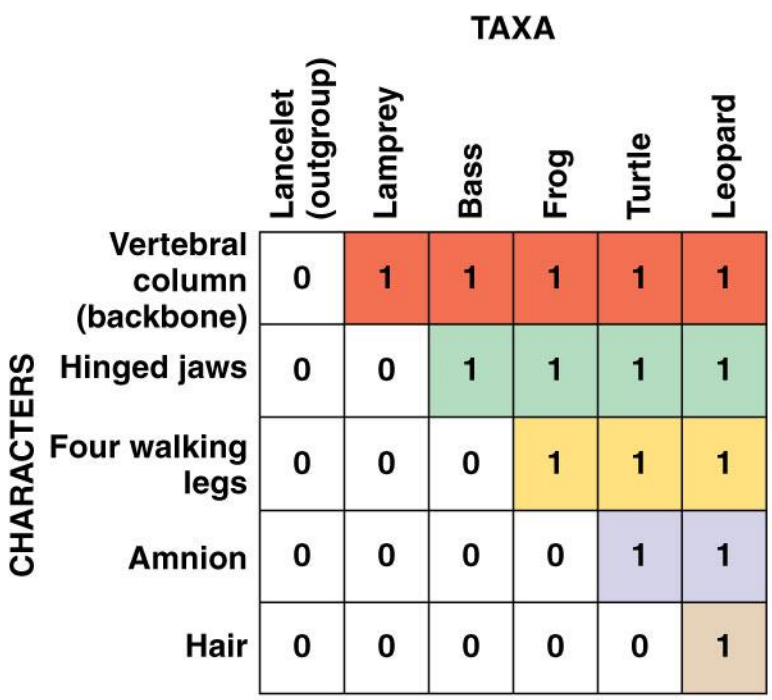
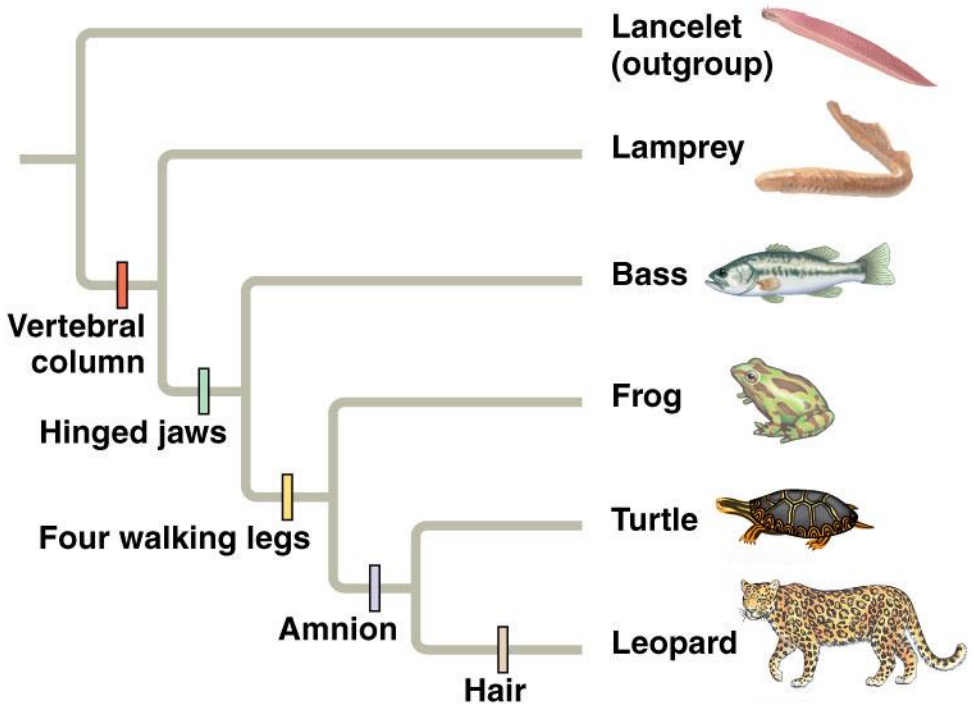
Constructing a Tree

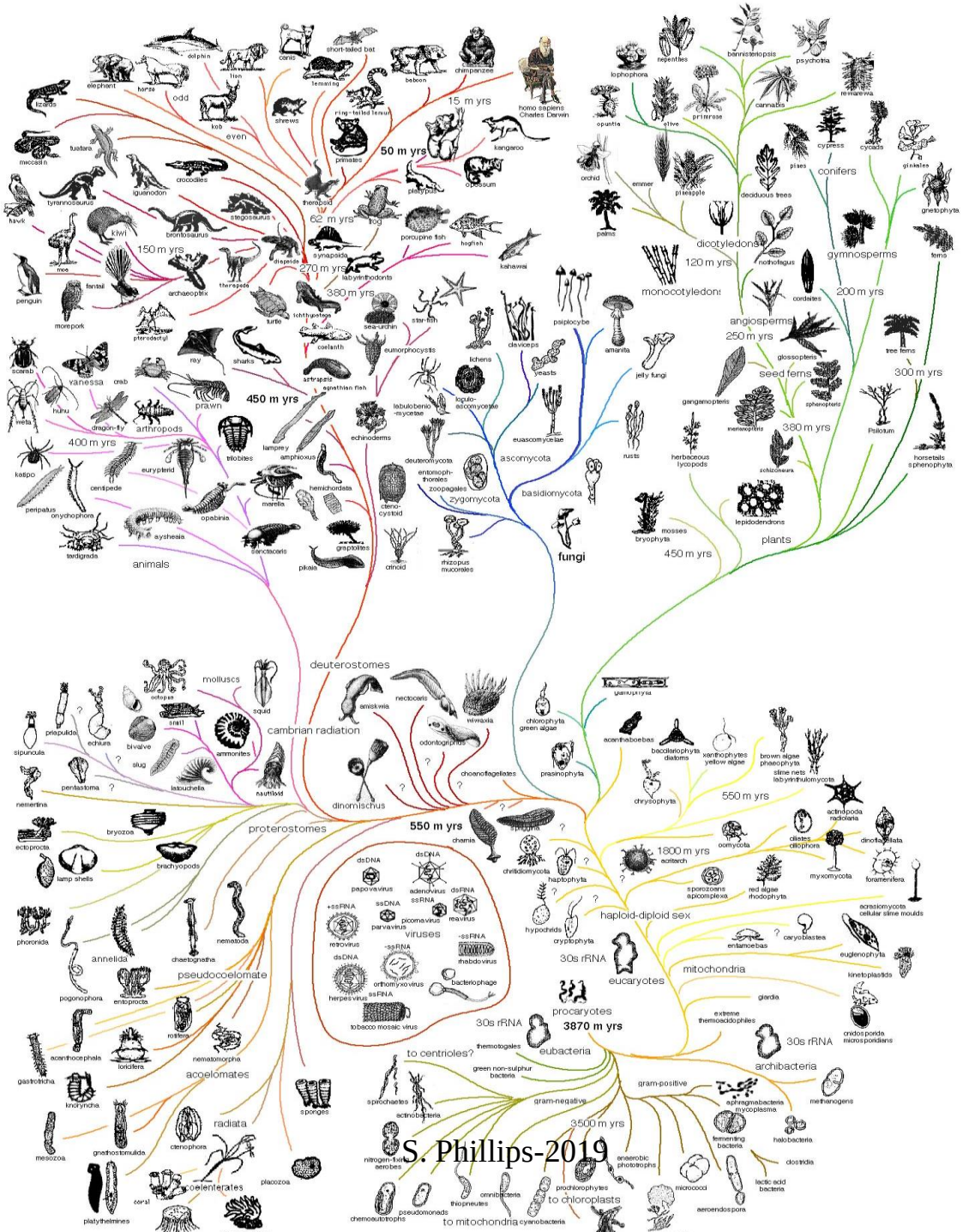


(a) Character table



(b) Phylogenetic tree

A 0 indicates a character is absent; a 1 indicates that a character is present.
What is the Outgroup?



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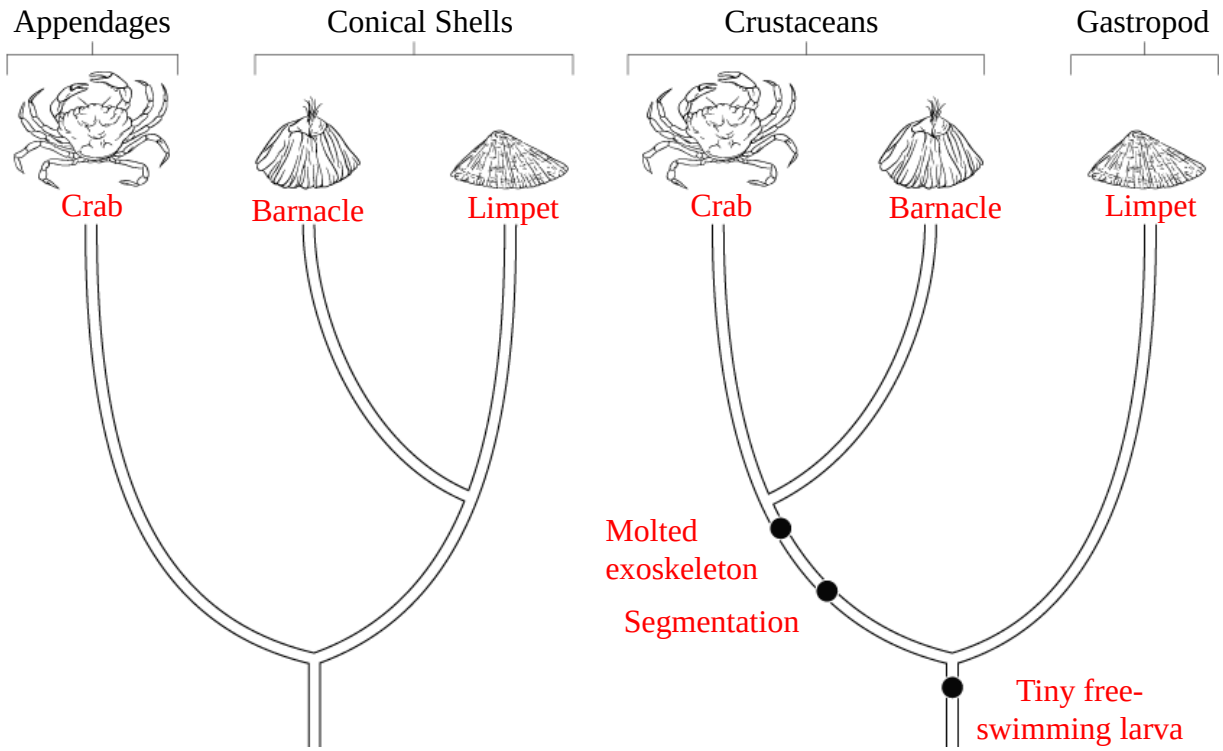
How would you group these organisms?



TRADITIONAL CLASSIFICATION

CLADOGRAM

* Taxonomic affinities based on measurable similarities (morphology or structural similarities)

* Branch points defined by novel (derived) characteristics. Includes systematics (which takes into account the molecular similarities, as well as DNA/protein sequencing)

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If needed, be sure to….

- Review the other PPt on my blog regarding Phylogeny (and watch the linked videos on my blog)

Similarities in DNA & RNA

- Other classification systems are based on anatomical similarities and differences, but how would you compare very different organisms?
- All organisms use DNA & RNA to pass on information and control growth and development.
- Since there are many similar genes in all forms of life suggesting a common ancestry, these molecules are an excellent way to compare organisms.
- The genes of many organisms show important similarities at the molecular level. These molecular similarities can be used as criteria to help determine classification.

Vultures and Storks?

American vulture

African vulture

Stork

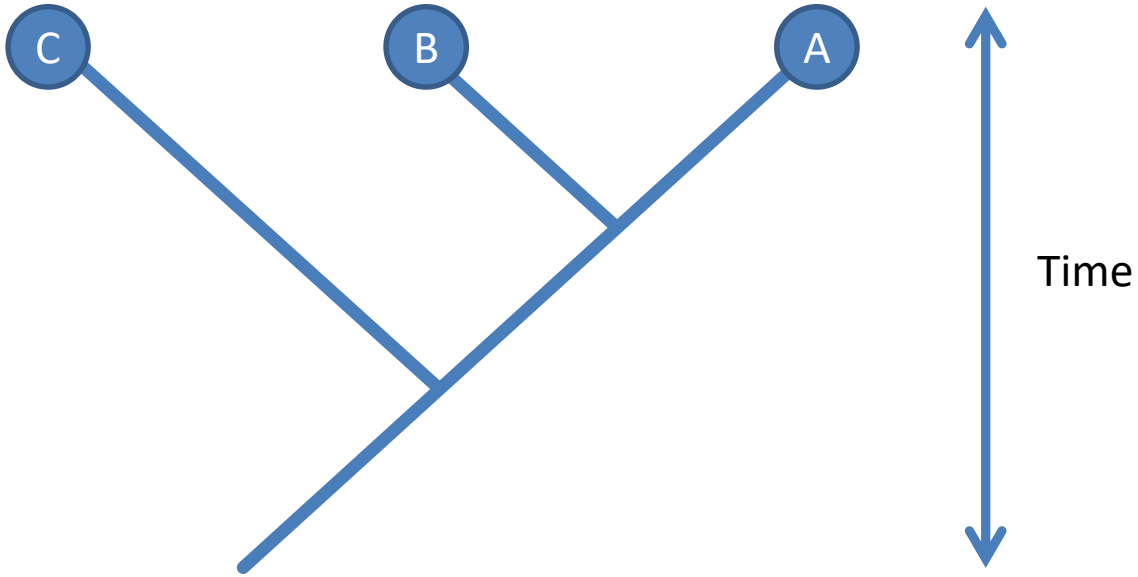
Traditionally, American vultures and African vultures were classified together in the falcon family. Recently, because the American vulture and stork share a common cooling behavior, scientists compared their DNA, and discovered that the American vulture and stork are more closely related than the American vulture and African vulture.

Molecular Clocks

- Uses DNA comparisons to estimate the length of time that two species have been evolving independently.
- Mutations occur all the time, causing slight changes in DNA.
- Mutations build up with time and the more difference in mutations of specific genes, the less related they are with a common ancestor further back in history.

The assumption is that these changes occur at a ‘regular’ rate. (**which may not always be the case, as mutations are random*)

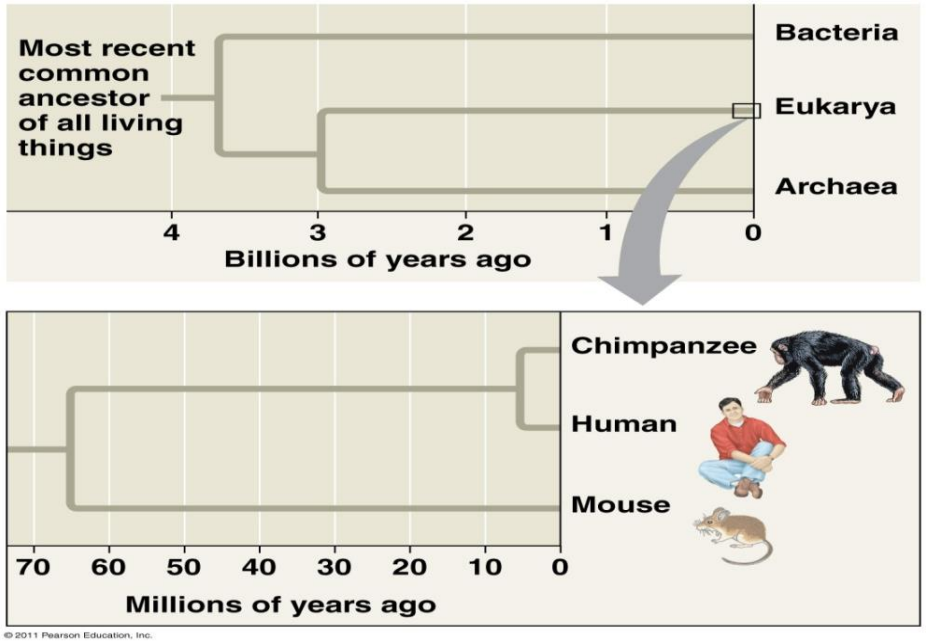
Therefore if species A had 5 differences from species B and 10 differences from species C, then the lineages for A and C must have split twice as long ago as for A and B



Evolutionary Development Biology: Evo-Devo

("hot topic" in biology)*

- Discipline concerned with discovering and understanding the role of changes in developmental mechanisms
- Compares developmental processes to understand how changes can lead to evolution of organisms



Evolutionary Development Biology

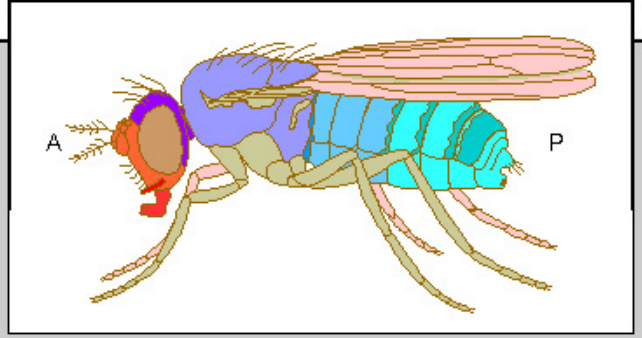
- So what exactly is it?
- Evolutionary developmental biology (Evo-Devo) is a discipline concerned with discovering and understanding the role of changes in developmental mechanisms in the evolutionary origin of aspects of the phenotype. In a very real sense, Evo-Devo “opens the black box” between genotype and phenotype.

Remember all that 'junk' DNA (over 98% of genome)? Here's (just) one example of it's function:

Homeotic (Hox) genes: master regulatory genes

- Act as master 'switches' which control placement and spatial organization of body parts. It's like the 'architect'…
- Highly conserved between species. Found in many groups (fungi, animals, plants)
- Hints at relatedness between all life forms
- Note the similarities on the next slide

- https://www.youtube.com/watch?v=14yxfot5sq8
- https://www.youtube.com/watch?v=9sjwlxQ_6LI
- https://www.youtube.com/watch?v=ydqReeTV_vk



Drosophila

3′ — lab — pb — (Zen) — Dfd — Scr — Antp — // — Ubx — abd-A — Abd-B — 5′

Antennapedia complex — bithorax complex

Mouse

Hoxa, chromosome 6

3′ — a1 — a2 — a3 — a4 — a5 — a6 — a7 — a9 — a10 — a11 — a13 — 5′

Hoxb, chromosome 11

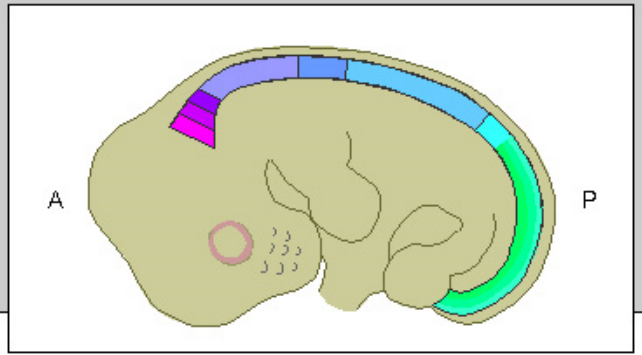
b1 — b2 — b3 — b4 — b5 — b6 — b7 — b8 — b9

Hoxc, chromosome 15

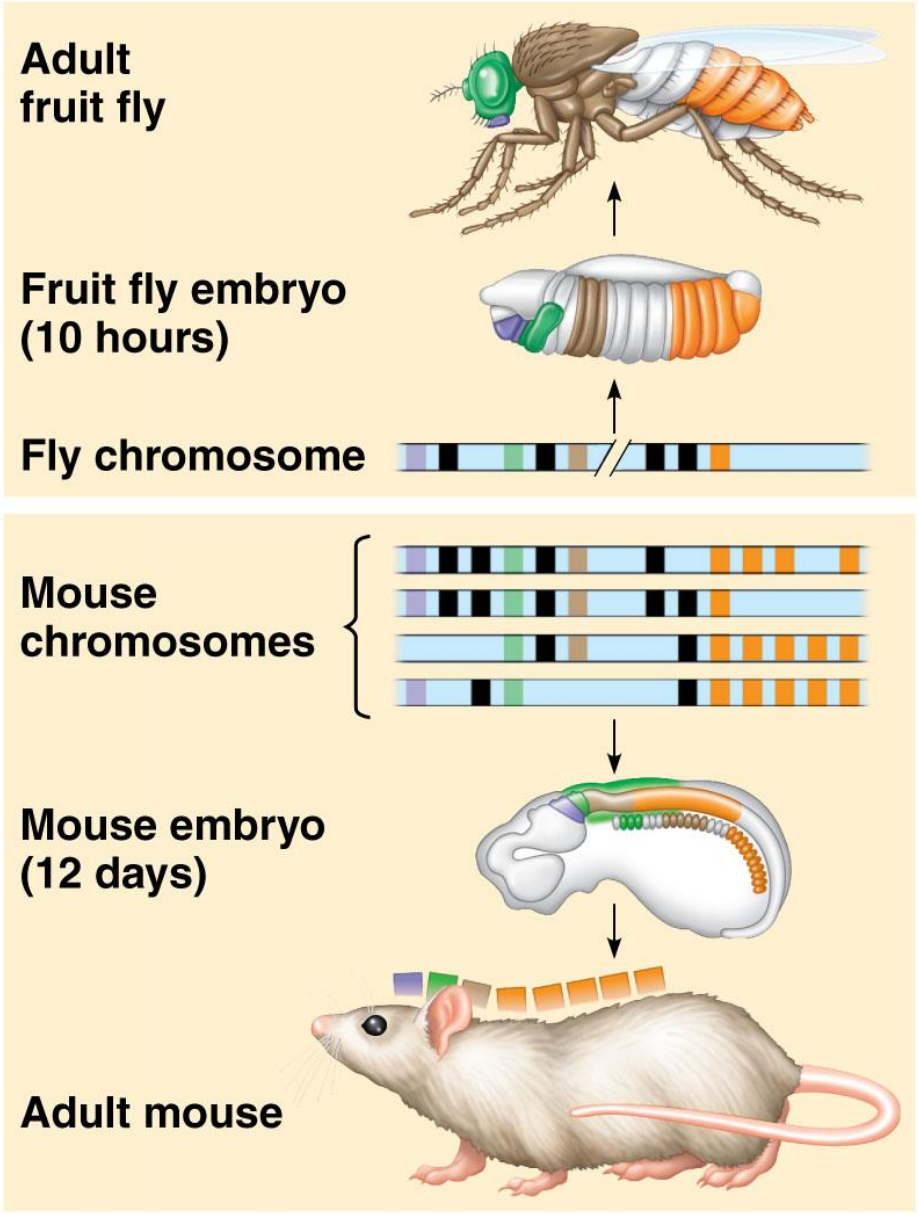
c4 — c5 — c6 — c8 — c9 — c10 — c11 — c12 — c13

Hoxd, chromosome 2

d1 — d3 — d4 — d8 — d9 — d10 — d11 — d12 — d13



Conservation of homeotic genes



New Kingdoms

- As evidence about different organisms continues to accumulate, biologists adjust the classification system.
- The current classification system includes six kingdoms:
  - Eubacteria
  - Archaebacteria
  - Protista
  - Fungi
  - Plantae
  - Animalia

Formerly together in K. Monera

The Tree of Life Evolves

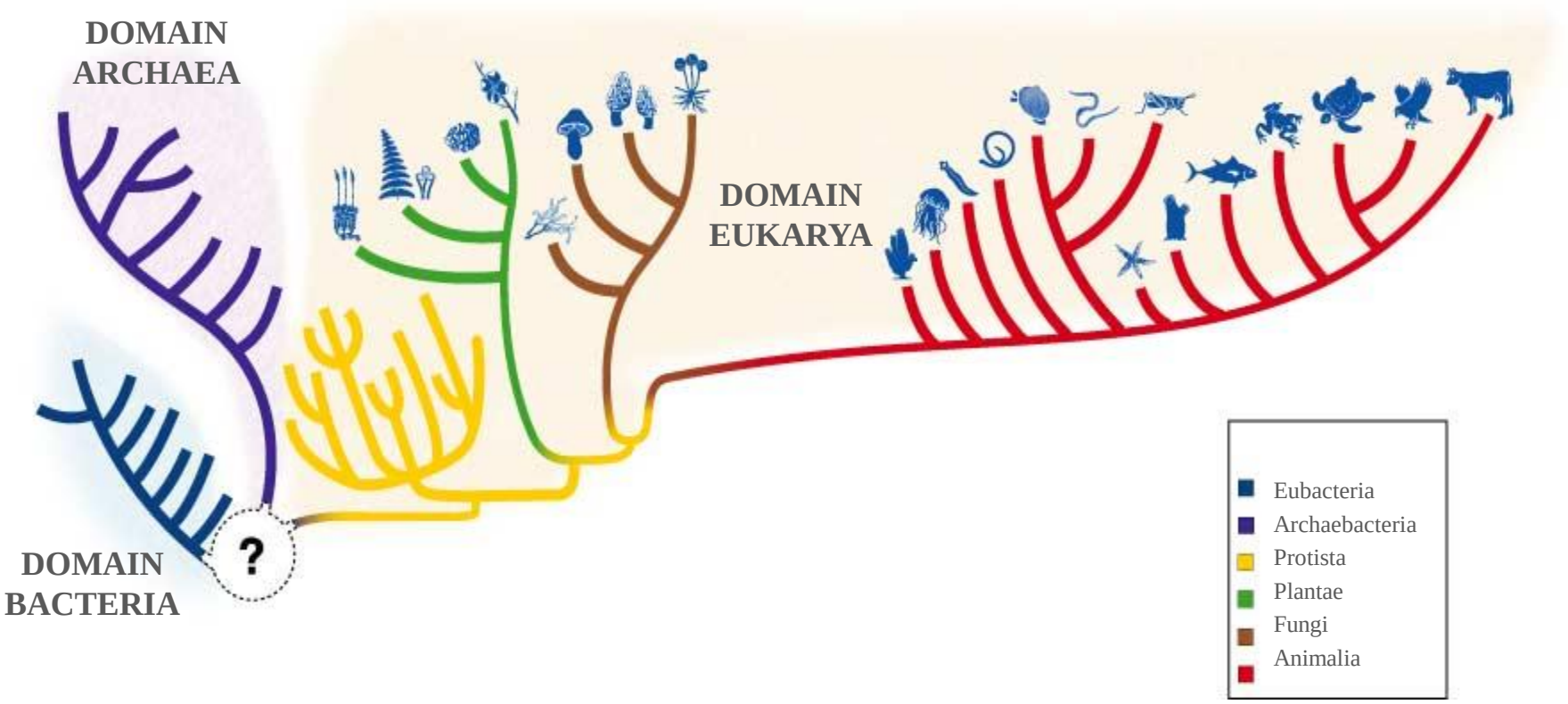
Changing Number of Kingdoms						
Introduced	Names of Kingdoms					
1700's	Plantae					Animalia
Late 1800's	Protista			Plantae		Animalia
1950's	Monera		Protista	Fungi	Plantae	Animalia
1990's	Eubacteria	Archaea-bacteria	Protista	Fungi	Plantae	Animalia

Review the Domains Chart I gave you in Unit 1.

*Watch: https://www.youtube.com/watch?v=wGVgIcTpZkk

Three-Domain System

- Using molecular analyses, scientists group modern organisms into three, more general categories (domains) according to how long they have been evolving independently.
- The three domains are:
  - Bacteria
  - Archaea
  - Eukarya



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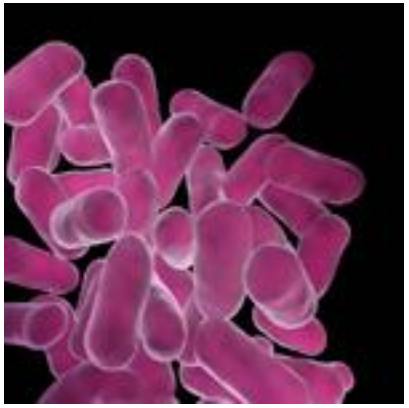
Domain Bacteria

- Kingdom: Eubacteria
- Unicellular
- Prokaryotic
- Cell walls with peptidoglycan
- Range from free-living soil organisms to deadly parasites.

E. coli

lactobacillus

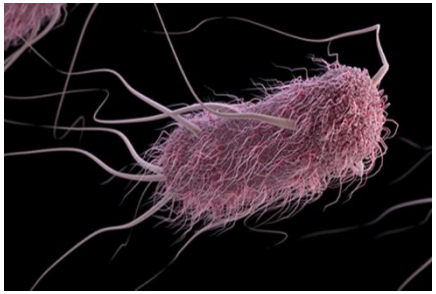


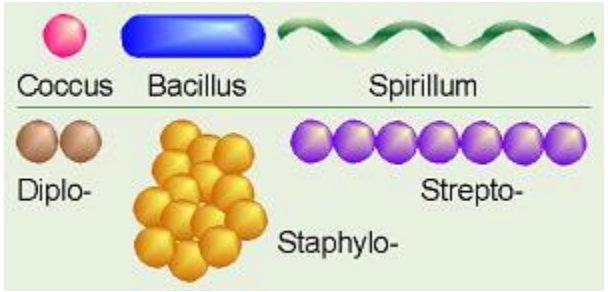
Bacteria

- Have nucleoid region (NO nuclear membrane)
  - Large circular chromosome; also has plasmids
- Bacteria- Usually 1-10 um long
- Many secrete sticky substance that forms **capsule** outside wall.
- Cell wall prevents osmotic rupture.
- Penicillin, the first successful antibiotic, was derived from the *Penicillium* mold. It is able to break down cell wall and allows osmotic rupture

Bacteria

- Some use O_2—others are anaerobes (may be obligate or falcultative)
- Some are flagellated (why? where?)
- Fimbriae (extensions) help bacteria to adhere to surfaces.
- Pili used for conjugation (sexual reproduction)
- Reproduce asexually by binary fission
- Shapes:
  - Cocci-spheres
  - Spirillum (spirochete)-spiral (helical)
  - Bacillus-rod shaped





‘Typical’ Bacterial Cell

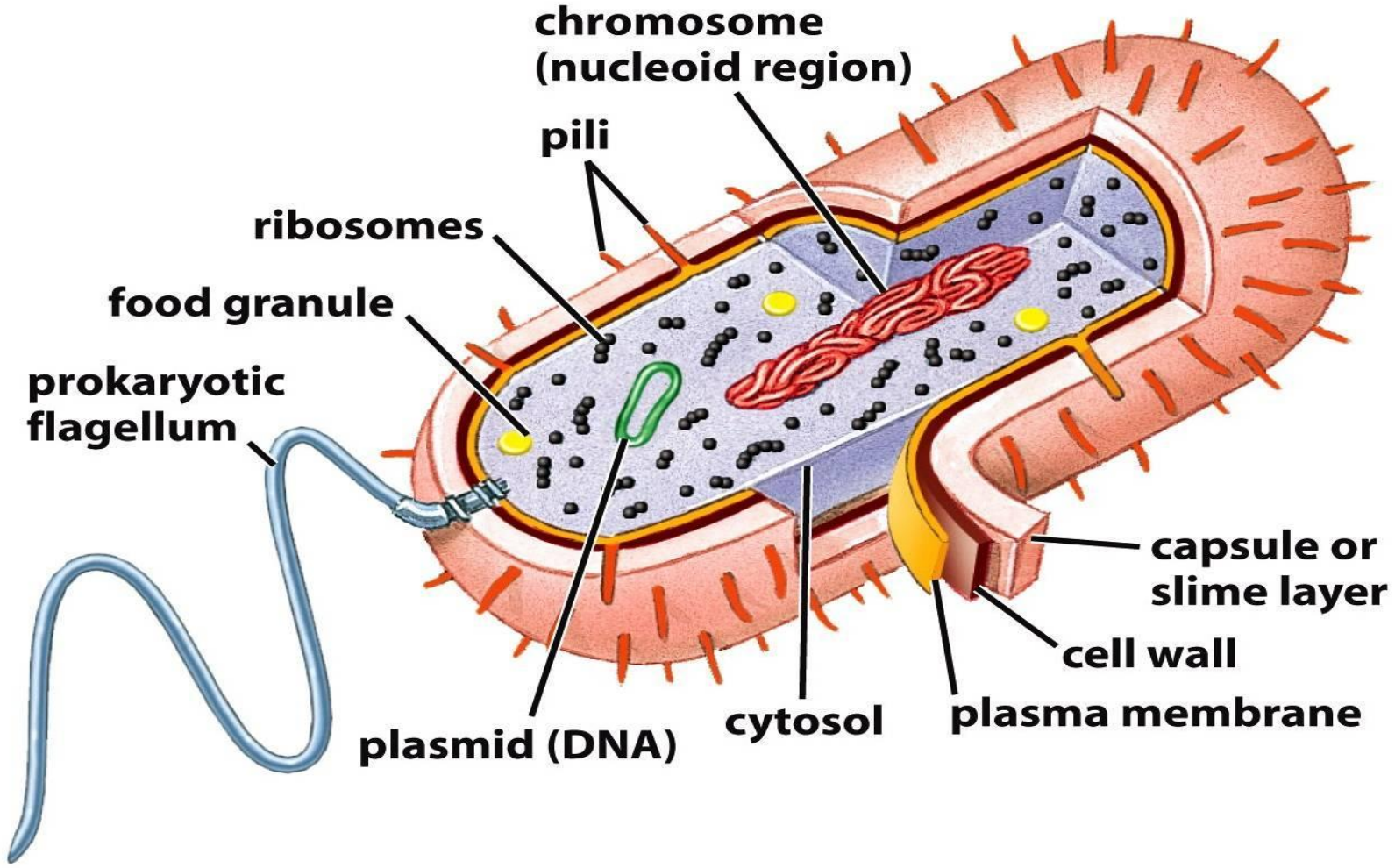


Figure 4-20a Biology: Life on Earth, 8/e
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Prokaryotes are the foundation of life on earth

- Most bacteria are VERY beneficial
- Decompose dead organisms
  - Decomposers, saprobes, saprophytes
- Perform nitrogen fixation
- Live in our digestive system and are also used in the food industry
  - Cheese, yogurt, etc
- Used to decompose waste in sewage
- However, some bacteria cause disease – Usually produce toxins. Ex- bacteria that causes botulism (paralyzes nerve cells). Other diseases: Lyme disease; strep throat; syphilis; gonorrhea

Some Prokaryotes Cause Disease

- Usually produce toxins. Ex- bacteria that causes botulism (paralyzes nerve cells).
  - Ever heard of an endospore? 1g of botulism toxin can kill 10^6 people!
- Other diseases: Lyme disease; strep throat; syphilis; gonorrhea
- Antibiotics are currently the most effective means of fighting bacterial infections
- **No known Archaea cause disease

Domain Bacteria

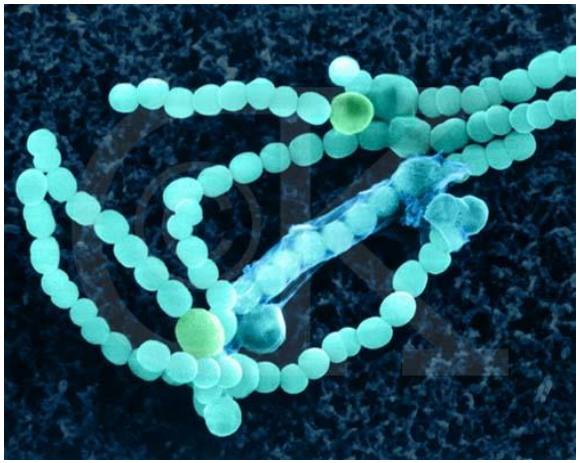
- The domain Bacteria corresponds to the kingdom **Eubacteria**.
- Be sure and review Bacteria info studied in both the Cell & DNA units!
- *Ex- Think back & connect to a previous unit…what is transformation?*

Classification of Living Things	
DOMAIN	Bacteria
KINGDOM	Eubacteria
CELL TYPE	Prokaryote
CELL STRUCTURES	Cell walls with peptidoglycan
NUMBER OF CELLS	Unicellular
MODE OF NUTRITION	Autotroph or heterotroph
EXAMPLES	*Streptococcus, Escherichia coli*

Domain Archaea

- Kingdom: Archaebacteria
- Unicellular
- Prokaryotic
- Live in the most extreme environments (volcanic hot springs, brine pools, black organic mud without oxygen)
- Live in absence of oxygen
- Cell wall lacks peptidoglycan
- Cell membranes contain unusual lipids not found in any other organism
- No known archaea cause disease

Archaea in Anaerobic Environment

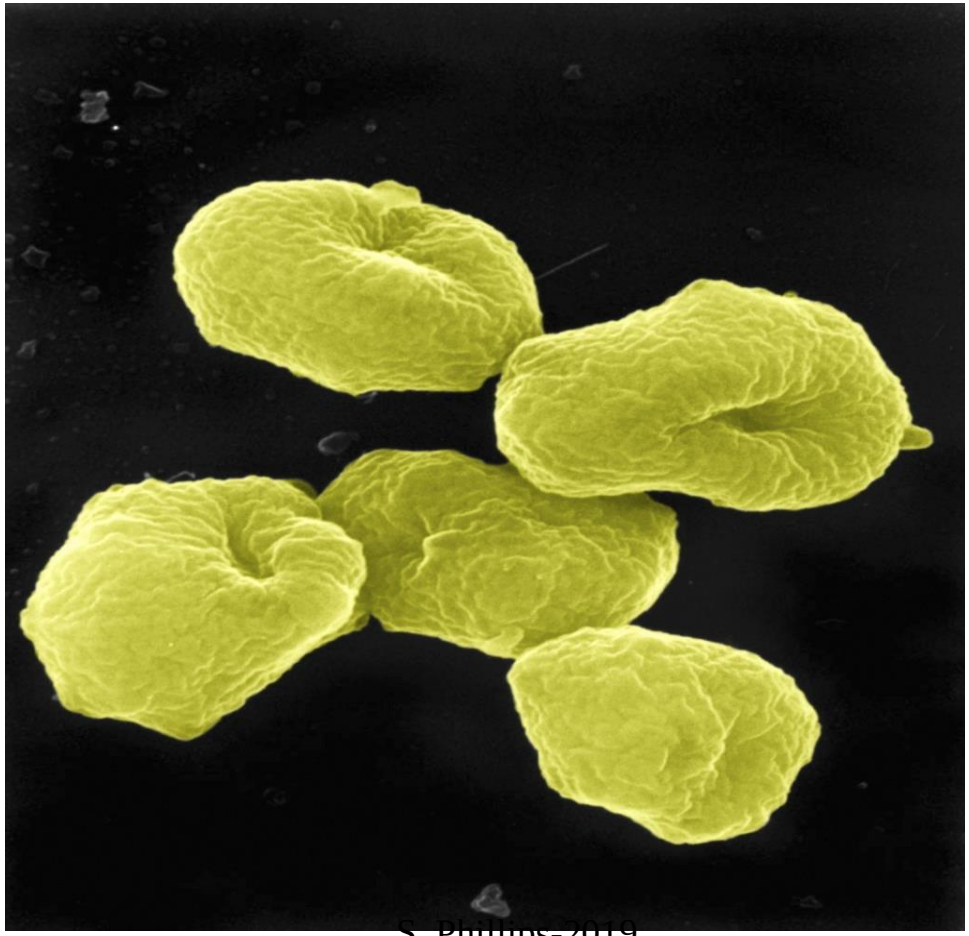


Archaea in Hot Spring

Major Groups of **Archaea**

- Extremophiles-3 types
  - Methanogens- are poisoned by oxygen; use CO_2 as the electron acceptor in respiration; produces methane as a waste product
    - Ex: Swamps! Think about the 'bubbling'. What causes it?
  - Halophiles- live in places with high salinity
    - Ex: Great Salt Lake; Dead Sea
  - Thermophiles (aka hyperthermophiles)
    - Ex: "Old Faithful" – Yellowstone Park

Archaea



Archaebacteria

- Used to be grouped with bacteria and called monerans
- Now believed eukaryotes evolved from archaeal line of descent
- Archaea and Eukarya share some of the same rRNA sequences and ribosomal proteins; also, similar tRNA
- Archaea have “unusual” diverse lipids in membrane that allow them to live under extreme conditions
- Cell walls are not peptidoglycan
- **Some Archaea have introns; bacteria do not

Domain Archaea

- The domain Archaea corresponds to the kingdom **Archaebacteria**

Classification of Living Things	
DOMAIN	Archaea
KINGDOM	Archaebacteria
CELL TYPE	Prokaryote
CELL STRUCTURES	Cell walls without peptidoglycan
NUMBER OF CELLS	Unicellular
MODE OF NUTRITION	Autotroph or heterotroph
EXAMPLES	Methanogens, halophiles

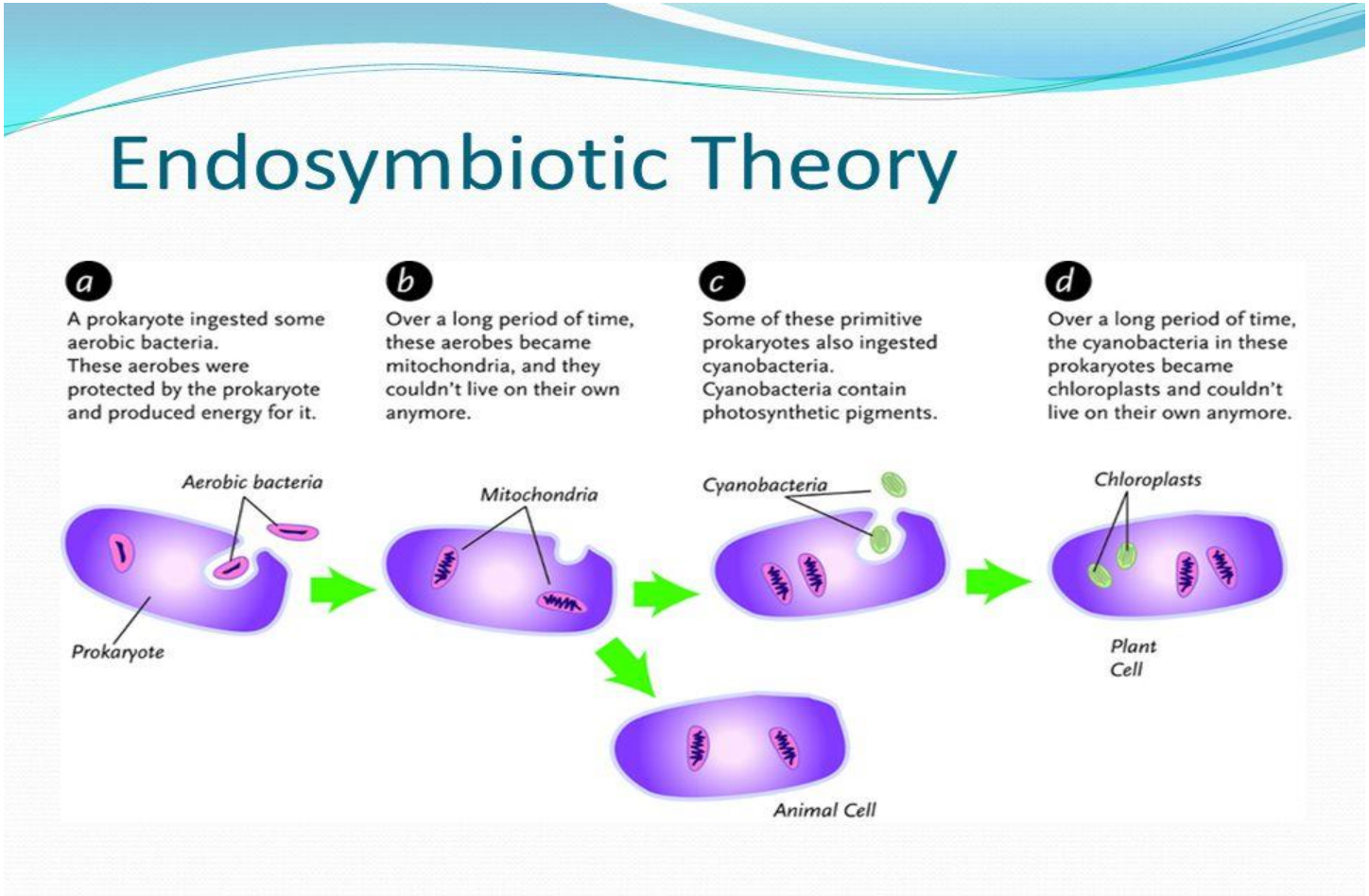
The Origin of the Eukaryotic Cell

- Eukaryotic cells arose through a combination of 2 processes:

  - membrane infolding- produce all the membrane-bound organelles (Ex: ER) except the mitochondrion and the choloroplasts.

  – **Endosymbiosis-**Mitochondria and chloroplasts believed to once be prokaryotic cells that were ingested or absorbed by another prokaryotic cell.

Endosymbiotic Theory



Domain Eukarya

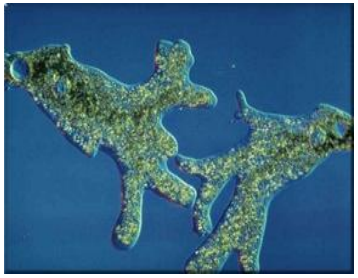
- All of the organisms that have a true nucleus (nuclear envelope/ membrane)
- **Kingdoms**:
  - Protista *(*the 'junk drawer'. It's under 'revision'…but that shouldn't be a factor for EOC*)
  - Fungi
  - Plantae
  - Animalia

Classification of Living Things

DOMAIN	Eukarya			
KINGDOM	**Protista**	**Fungi**	**Plantae**	**Animalia**
CELL TYPE	Eukaryote	Eukaryote	Eukaryote	Eukaryote
CELL STRUCTURES	Cell walls of cellulose in some; some have chloroplasts	Cell walls of chitin	Cell walls of cellulose; chloroplasts	No cell walls or chloroplasts
NUMBER OF CELLS	Most unicellular; some colonial; some multicellular	Most multicellular; some unicellular	Multicellular	Multicellular
MODE OF NUTRITION	Autotroph or heterotroph	Heterotroph	Autotroph	Heterotroph
EXAMPLES	*Amoeba*, *Paramecium*, slime molds, giant kelp	Mushrooms, yeasts	Mosses, ferns, flowering plants	Sponges, worms, insects, fishes, mammals

Domain Eukarya

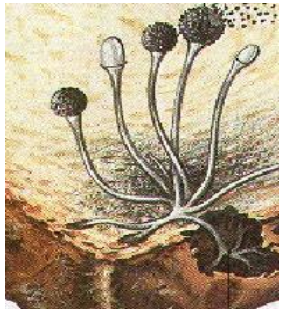
- **Kingdom Protista**
  - Most diverse kingdom
  - Most are unicellular, but some are multicellular
  - Some are autotrophic (Algae), others are ingestive heterotrophs (Protozoans), others are absorptive heterotrophs (Slime Molds)
  - Some share characteristics with plants, others with fungi, and others with animals
  - Ex:Amoeba



Diatoms

- **Kingdom Fungi**
  - Heterotrophs (digest food extracellularly & then absorbs the smaller molecules)
  - Composed of thread-like hyphae (mass of hyphae called mycelium)
  - Multicellular (except yeast)
  - **Important decomposers!**
  - Cell walls: made of chitin
  - some cause disease (ex-athlete's foot)
  - Ex:mushroom

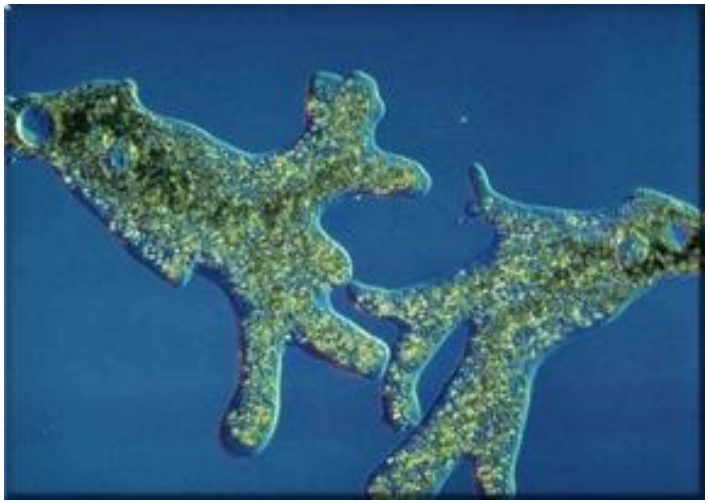
mold



K. Protista

Protozoans- classified by how they move

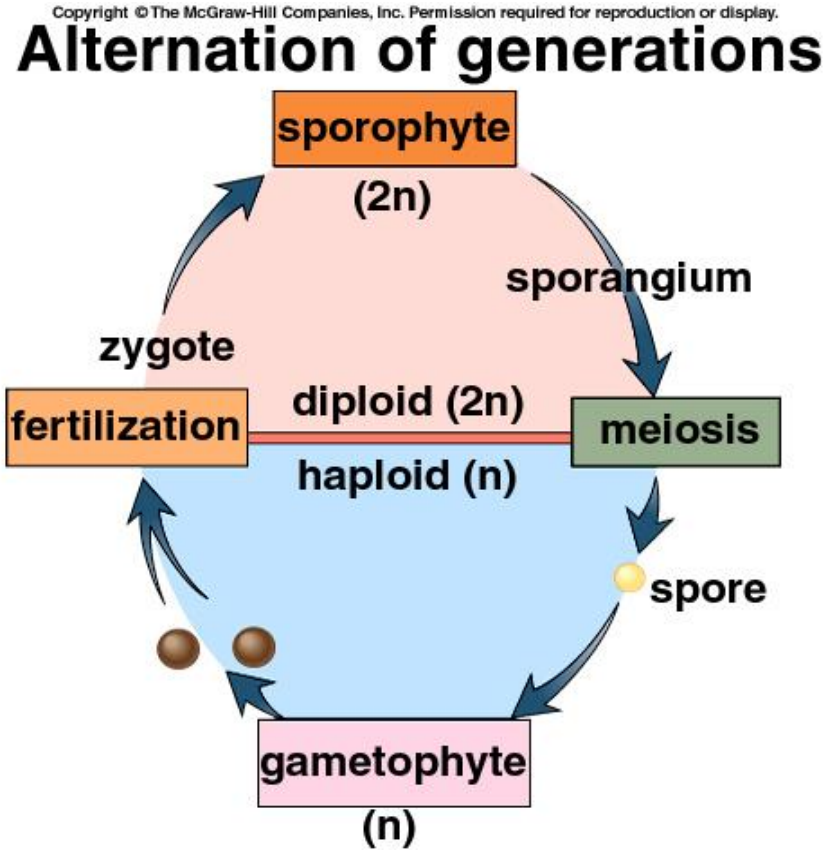
- Amoeba-pseudopodia



Paramecium (cilia)

K. Protista: Alternation of Generations (Algae: general life cycle)

(Mader p. 386)

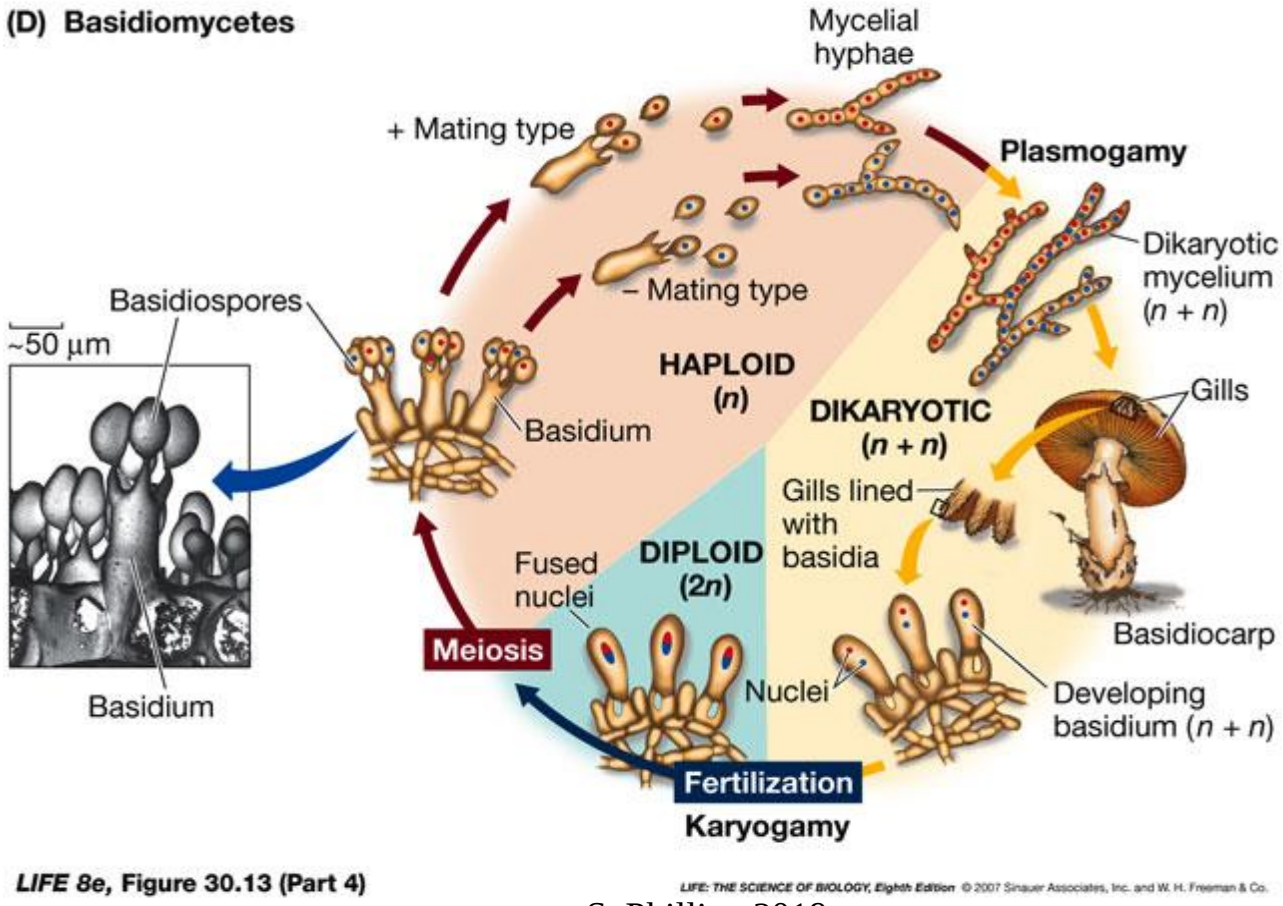


- the haploid stage is the main vegetative stage of most protists; only the zygote is diploid. Zygotes undergo meiosis and become haploid (spores). *Why do they need spores??*

K. Fungi
General Life cycle

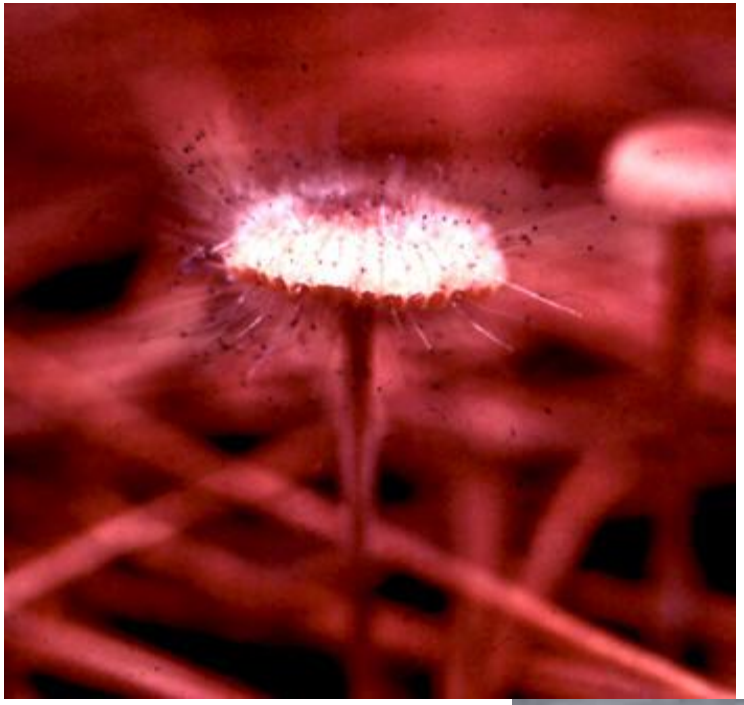
- See next slide for life cycle of mushroom
- Stages of a mushroom:
  - **Dikaryotic-** cytoplasm merges between the 2 mating types, but nuclei do not (contains 2 haploid nuclei/cell)
  - **Diploid-** Haploid nuclei fuse in fruiting body of mushroom forming diploid zygote
  - **Haploid-**Zygote undergoes meiosis and forms haploid spores. Spores then germinate and fuse.

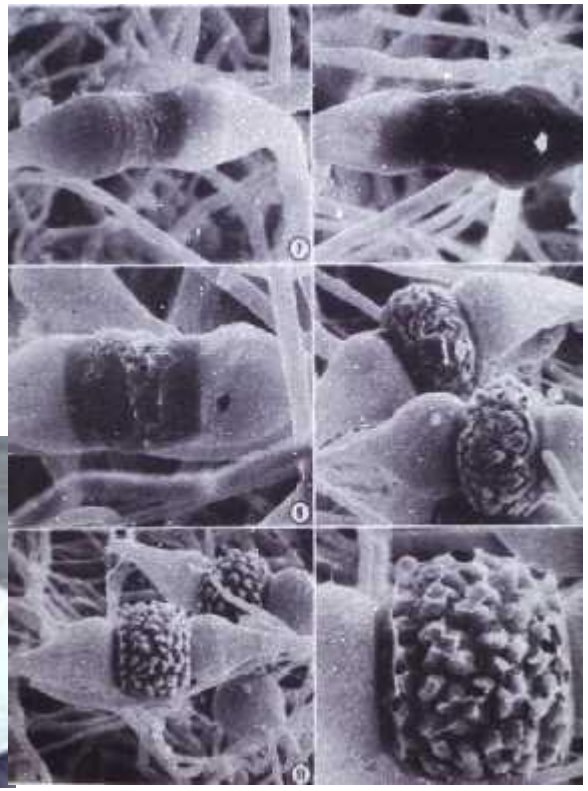
Mushroom Life Cycle- *Do not need to know specific life cycles (only a general one). This is just one example of many. FYI- Spores are produced by meiosis in the sporangium (basidium is just a more specific name for one in a mushroom)



Zygomycota (bread mold)-

*<u>These slides are just for viewing.</u> **<u>Don't memorize phyla names</u>!**

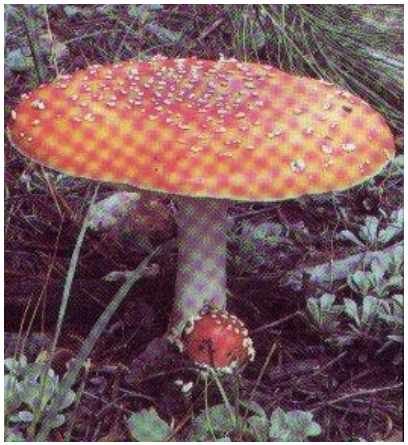


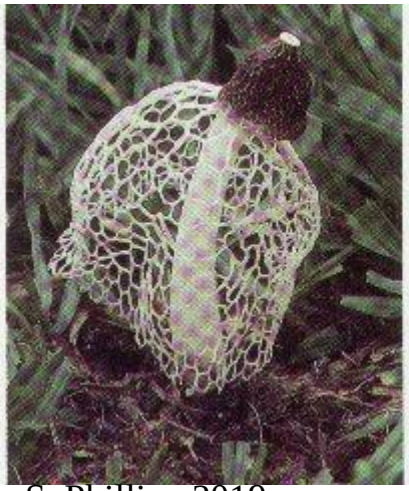


Can you find which pic is dikaryotic?

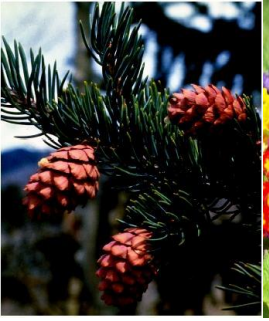
Ascomycota- sac fungi

Basidiomycota- club fungi



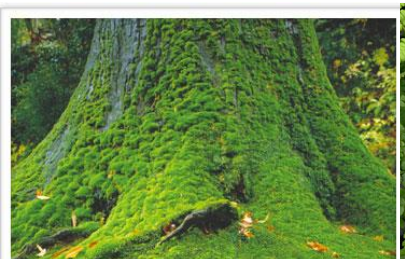


Deuteromycota- ‘imperfect’ fungi

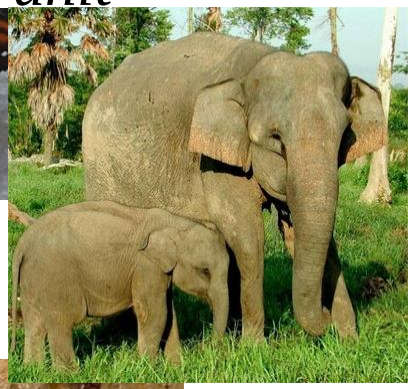



Domain Eukarya- con't

- **Kingdom Plantae**
  - Multicellular
  - Photosynthetic autotrophs (make food; produce O2)
  - Non-motile (can't move from place to place)
  - Cell walls with cellulose
  - Cone-bearing, flowering-plants, mosses, & ferns
  - **More in next unit*

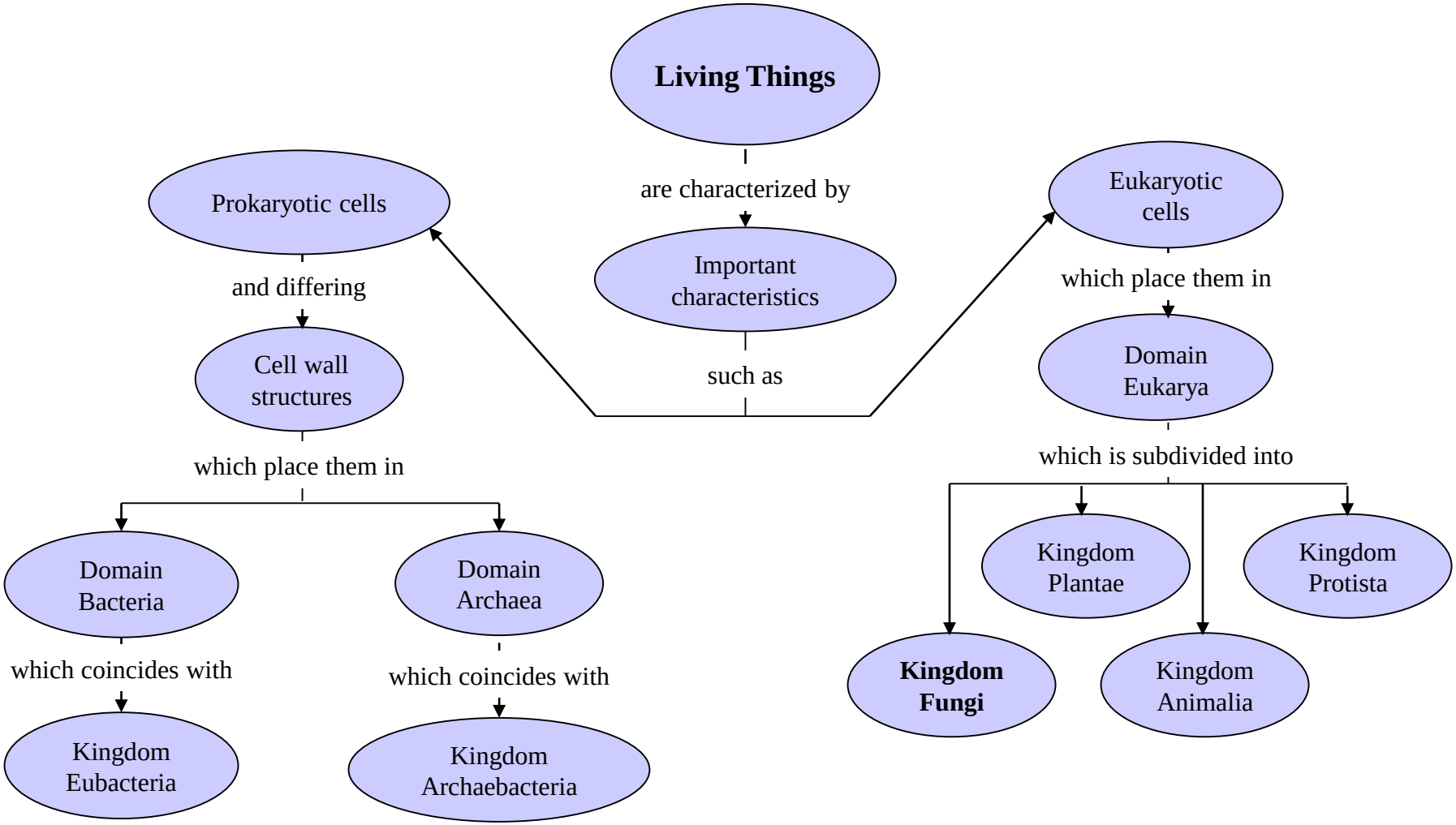



- **Kingdom Animalia**
  - Multicellular
  - Heterotrophic (consume/ingest food)
  - No cell walls
  - Motile (can move)
  - **More in next unit*


Kingdoms and Domains

DOMAIN	Bacteria	Archaea	Eukarya			
KINGDOM	**Eubacteria**	**Archaebacteria**	**Protista**	**Fungi**	**Plantae**	**Animalia**
CELL TYPE	Prokaryote	Prokaryote	Eukaryote	Eukaryote	Eukaryote	Eukaryote
CELL STRUCTURES	Cell walls with peptidoglycan	Cell walls without peptidoglycan	Cell walls of cellulose in some; some have chloroplasts	Cell walls of chitin	Cell walls of cellulose; chloroplasts	No cell walls or chloroplasts
NUMBER OF CELLS	Unicellular	Unicellular	Most unicellular; some colonial; some multicellular	Most multicellular; some unicellular	Multicellular	Multicellular
MODE OF NUTRITION	Autotroph or heterotroph	Autotroph or heterotroph	Autotroph or heterotroph	Heterotroph	Autotroph	Heterotroph
EXAMPLES	*Streptococcus, Escherichia coli*	Methanogens, halophiles	*Amoeba, Paramecium,* slime molds, giant kelp	Mushrooms, yeasts	Mosses, ferns, flowering plants	Sponges, worms, insects, fishes, mammals


Living Things
are characterized by
Important characteristics
such as
Prokaryotic cells
and differing
Cell wall structures
which place them in
Domain Bacteria
which coincides with
Kingdom Eubacteria
Domain Archaea
which coincides with
Kingdom Archaebacteria
Eukaryotic cells
which place them in
Domain Eukarya
which is subdivided into
Kingdom Plantae
Kingdom Protista
Kingdom Fungi
Kingdom Animalia

Dichotomous Keys

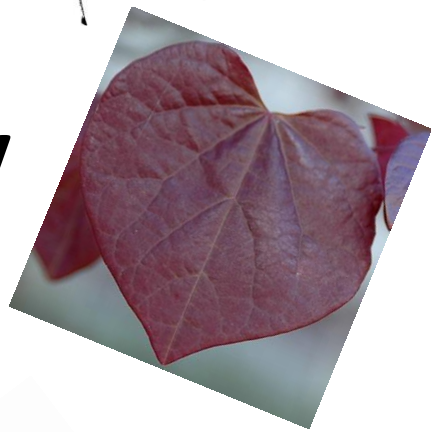
- Dichotomous keys are tools used to identify organisms.
- Dichotomous means “divided into two parts”
- It includes a series of paired statements based on physical characteristics that are chosen and lead the user to the correct name of the organism.
- Let’s try one together!

I

II

IV

V



III

Can you make a key?

VI

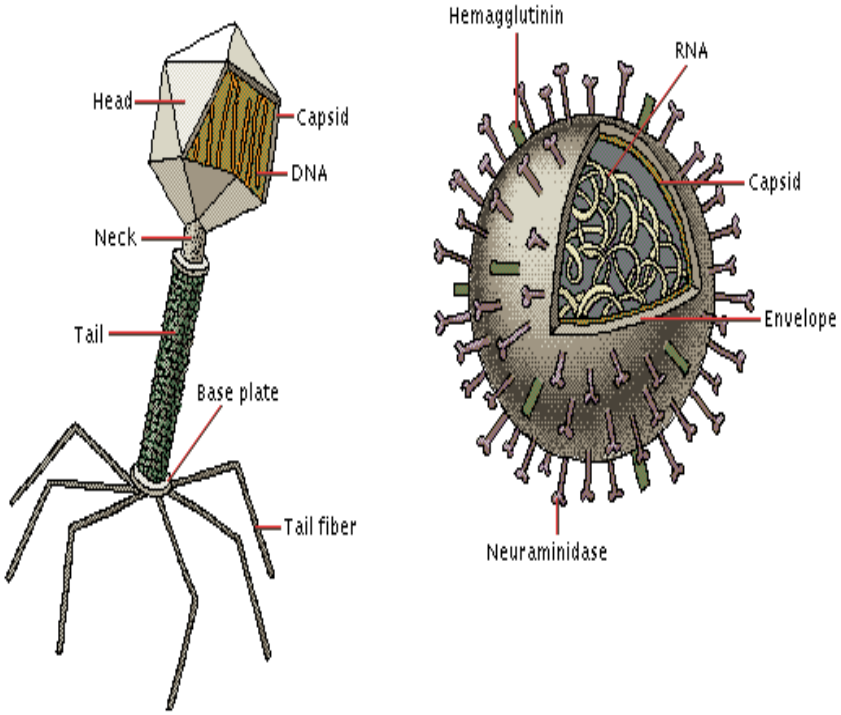
VII

The Tree of Life Evolves

Changing Number of Kingdoms						
Introduced	Names of Kingdoms					
1700's	Plantae					Animalia
Late 1800's	Protista			Plantae		Animalia
1950's	Monera		Protista	Fungi	Plantae	Animalia
1990's	Eubacteria	Archae-bacteria	Protista	Fungi	Plantae	Animalia

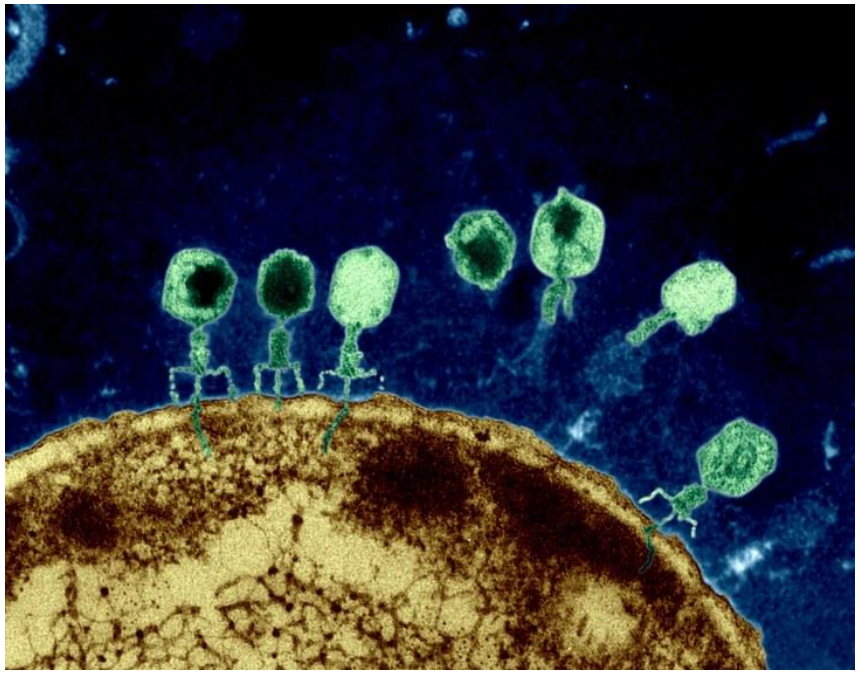
Viruses

- **<u>Not classified. Why aren't they considered "living</u>**"?
- Made of protein coat (capsid) and nucleic acid
- 5-300 nm (nm is a billionth of a meter)
- No "cure". Some can be prevented by vaccination (NOT antibiotics!)
- Ex- influenza, cold, measles, mumps, HIV, hepatitis, chicken pox, herpes
  - **WATCH THIS** (2020)!
    https://www.youtube.com/watch?v=NJLXdsO1GBI



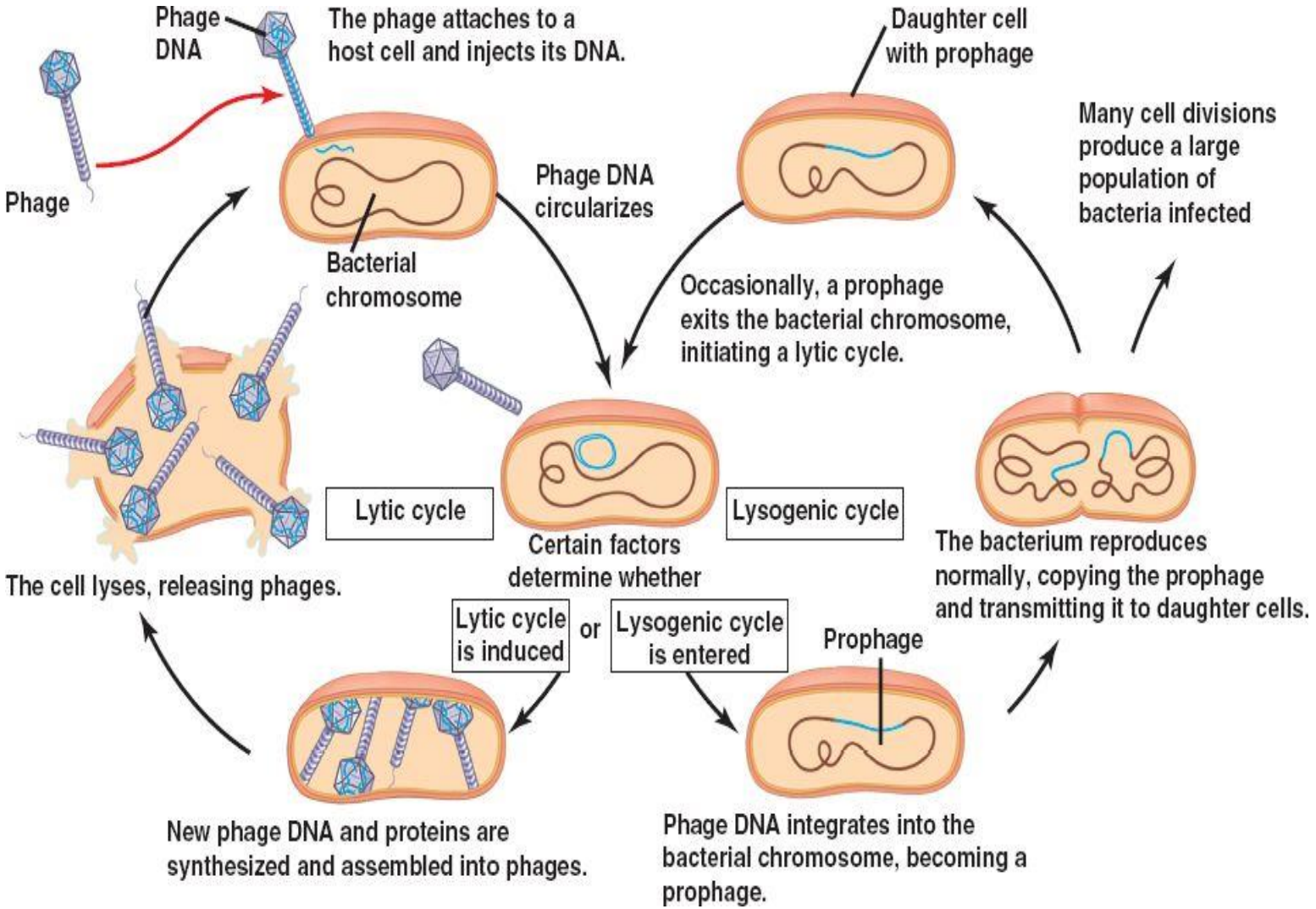
Viral Structure

Bacteriophage infecting E. coli



Viral Reproduction

- Intracellular parasites
- Virus attaches to host cell using their coat's proteins and the host's cell membrane receptors. Viral genome then enters host cell
- Viruses can be made of DNA or RNA---HIV is a retrovirus made of RNA (*Does not follow 'Central Dogma': instead RNA→DNA). So what's the big deal? No proof-reading enzyme (polymerase), so mutates OFTEN
- **Lytic cycle** (active-lysis) vs. **Lysogenic** (inactive-virus 'hides' in host's DNA as a prophage. Ex: both Herpes Simplex types I & II).
- **See next page*


Phage DNA
The phage attaches to a host cell and injects its DNA.
Phage
Bacterial chromosome
Phage DNA circularizes
Daughter cell with prophage
Many cell divisions produce a large population of bacteria infected
Occasionally, a prophage exits the bacterial chromosome, initiating a lytic cycle.
Lytic cycle
Lysogenic cycle
Certain factors determine whether
The cell lyses, releasing phages.
The bacterium reproduces normally, copying the prophage and transmitting it to daughter cells.
Lytic cycle is induced
or
Lysogenic cycle is entered
Prophage
New phage DNA and proteins are synthesized and assembled into phages.
Phage DNA integrates into the bacterial chromosome, becoming a prophage.

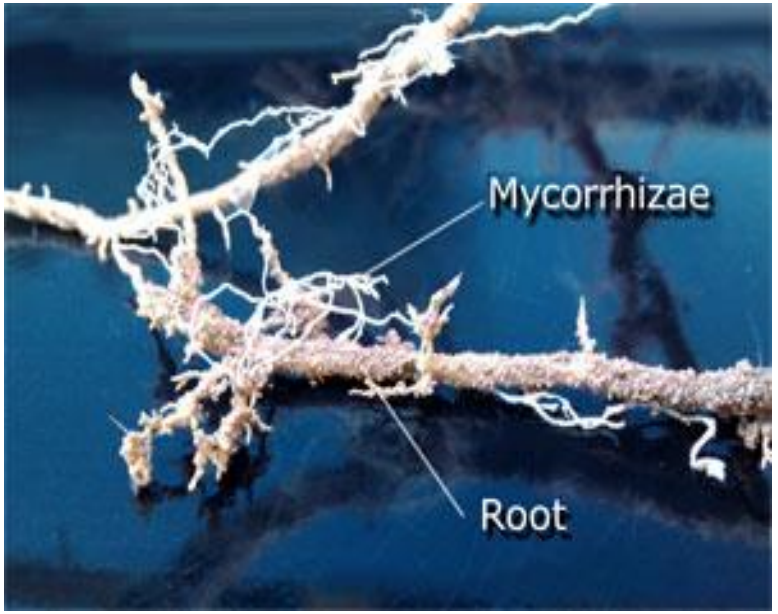
Important Symbiotic Relationships between Organisms of Different Kingdoms:

Lichens- (Know!)

- Look similar to some species of moss, but are not!
- Lichens are **symbiotic** associations between a **fungus (often an ascomycete) and green algae or cyanobacteria**
- The fungus usually give lichens “shelter” (optimal environment) which gives rise to their shape
- Alga provides the fungus with food
- Fungus provides a suitable physical environment for growth

Mycorrhizae ("fungus roots")- Know!

- Mutualistic associations of plant roots and fungi
- Almost all vascular plants have mycorrhizae



Review:

- Organisms whose cell walls contain peptidoglycan belong in the kingdom
  - Fungi.
  - Eubacteria.
  - Plantae.
  - Archaebacteria.

#2

– Multicellular organisms with no cell walls or chloroplasts are members of the kingdom
  - Animalia.
  - Protista.
  - Plantae.
  - Fungi.

#3

– Organisms that have cell walls containing cellulose are found in
  - Eubacteria and Plantae.
  - Fungi and Plantae.
  - Plantae and Protista.
  - Plantae only.

#4

– Which of the following contain more than one kingdom?
  - only Archaea
  - only Bacteria
  - only Eukarya
  - both Eukarya and Archaea

#5

– Molecular analyses have given rise to a new taxonomic classification that currently includes
  - three domains.
  - seven kingdoms.
  - two domains.
  - five kingdoms.

  - *But not for long! ***Someone tell me why….**