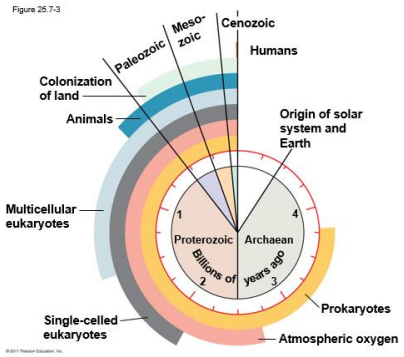
OPHS Biology Name: _____

Unit 8 (evolution & classification)

Topic 1: History of Life

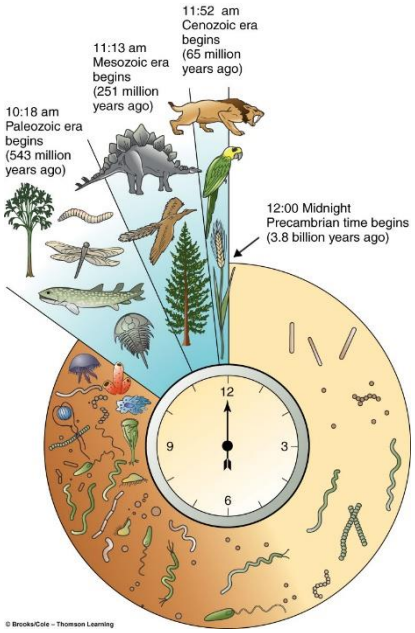
By the end of this topic, I will be able to…

- *Match the origin of life experiments to the person that conducted them*
- *Explain the various origin of life experiments*
- *Sequence the order of life on earth*
- *Explain how eukaryotic cells evolved from prokaryotic cells*



The History of Life

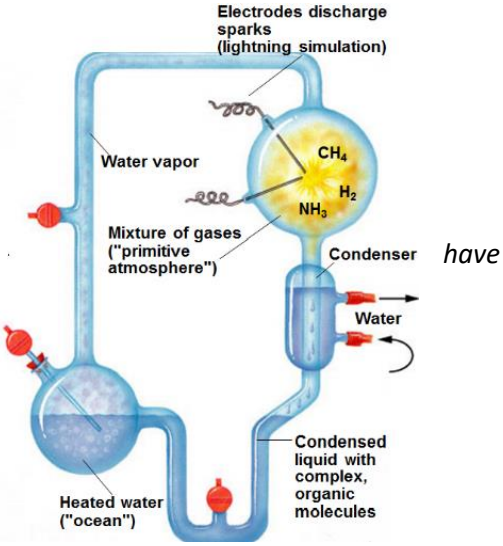
- Earth + solar system formed about _____
- Bombardment of Earth by rocks and ice likely vaporized water and prevented seas from forming before 4.2 to 3.9 BYA
- Earth's early atmosphere likely contained: _____ and chemicals released by volcanic eruptions like _____, nitrogen oxides, _____, methane, ammonia, hydrogen, hydrogen sulfide.



- NO _____ in atmosphere!
  - _____ evolution occurred prior to _____ evolution
    - *Energy from sun, volcanoes and lightning combined w/ gases to form chemical substances (Sugars, nucleotides, amino acids) which then combine to form all life on Earth*

Origin of Life Experiment #1: Miller-Urey

- In the 1950s, scientists Miller & Urey set out to demonstrate that it was possible for _____ to appear on earth, given the early atmospheric conditions, without organisms actually present yet
  - *Recreate earth's early atmosphere (H, CH4, NH3, H2)*
  - *Add electric sparks (simulate _____)*
  - *Gasses cooled, leaving _____*
    - Water droplets contained _____ and _____!
      - *Yes, amino acids and nucleotides could have formed under early conditions on earth*



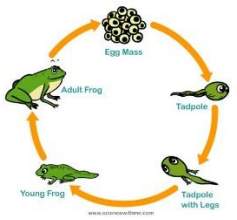
- Bottom line: Organic molecules CAN form from inorganic molecules
  - RNA evolved before DNA. Why does this make sense?
    - *RNA codes _____ (makes inheritance possible)*
    - _____
    - *First step of evolution in the Central Dogma*
      - _____→RNA→_____

OPHS Biology Name: _____

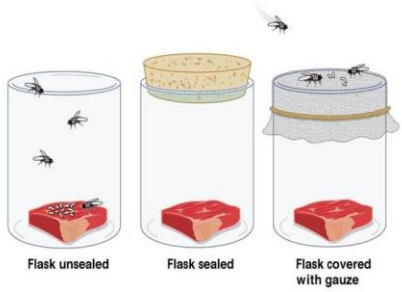
Unit 8 (evolution & classification)

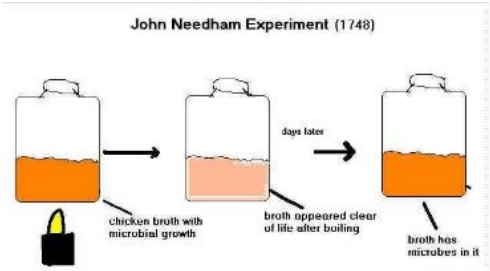
Spontaneous Generation v. Biogenesis

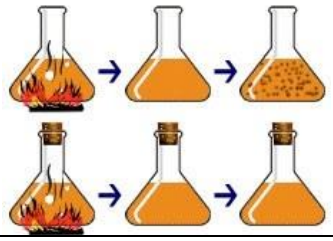
Spontaneous Generation
 
 	
	■ Until about _____, many people believed life could arise from _____ matter.
	■ Spon.Gen.: the belief that life can arise from nonliving things
	  ■ *Frogs arise from mud*
	  ■ *Flies arise from rotting meat*
	  ■ *Mice arise from dirty underwear*
	■ _____ approved this belief – people trust the church, this must be right
	■ Francesco Redi is the first big name to say something different (_____)
	■ Battle of experiments to determine how life actually comes to be

Biogenesis
 
 	
	■ The belief that life can only come from _____ matter
	  – _____
	■ Now widely accepted, but was not until about _____
	  ■ In the life cycle of a frog, tadpoles hatch from eggs, eventually are frogs
	  ■ Flies were previously larvae, which hatched from eggs (deposited on the meat)
	  ■ Mice are born from other mice

Origin of Life Experiments

Francesco Redi (1668)
 
 	
	■ Designed an experiment to test spontaneous generation
	  – *In support of:* _____
	***Setup**: three jars, each holding meat*
	■ **Control**: _____
	  – *Flies and air have access to meat*
	■ **Experimental setup 1**: _____ lid
	  – *Neither flies nor air can access meat*
	■ **Experimental setup 2**: _____ lid (cheesecloth)
	  – *Flies cannot access meat, air can*
	***Findings**: the only jar with flies was the control!*

John Needham (1748)
 
 	
	■ John Needham, an Englishman, wanted to prove Redi wrong
	  – *In support of:* _____
	  – ***Experiment**: heat broth to remove _____; seal and let sit… check for life*
	***Findings**: there is bacteria in the broth! Spontaneous generation must be right.*
	***Problem**: did not _____ _____ to remove all microbes*

Lazzaro Spallanzani (1770)
 
	■ Lazzaro Spallanzani, an Italian doctor, was sure Needham made a mistake when attempting to remove all microbes and repeated his experiment
	  – *In support of:* _____
	  – ***Experiment**: pour broth in two flasks; heat broth (kill microbes); seal one flask and leave the other open*
	***Findings**: only the _____ contained microbes*

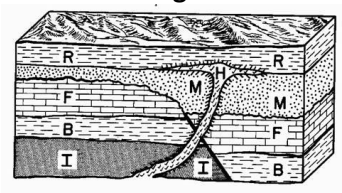
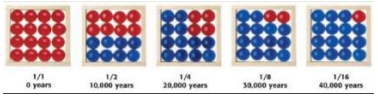
OPHS Biology Name: _____

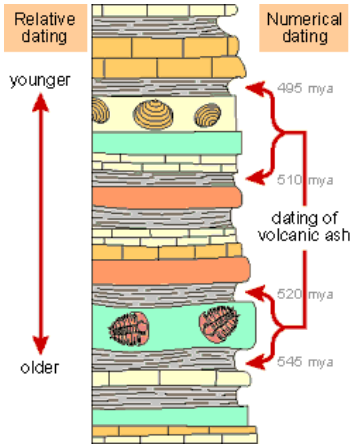
Unit 8 (evolution & classification)

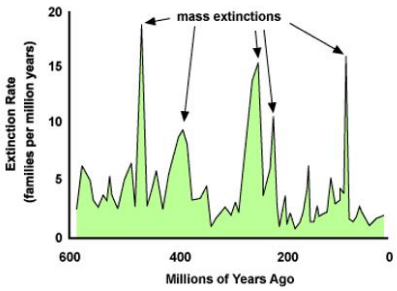
Louis Pasteur (1864)	■ French scientist that ended the debate – *In support of:* _____ – ***Setup**: built upon the work of Needham and Spallanzani, but with a twist* ■ **Control**: flask with broth that had been heated to kill microbes ■ **Experimental setup**: _____ _____ with broth heated to kill microbes – *Air has access to the broth!* ***Findings**: swan-neck flask remained microbe-free until tilting the flask, allowing the broth to pick up microbes from the bend… spontaneous generation is not real!*

Sequencing Life on Earth

- Earth: 4.6 billion years old
- Method of aging: radioactive/absolute dating v. relative dating
- Early atmosphere: CO_2, SO_2, Methane, ammonia… no free O_2
  - *RNA, amino acids form and lead to first cells*

Relative Dating  Oldest to youngest: _____	■ _____ age based on the position in the _____ of the sedimentary rock ■ _____ form when fine sediment buries organisms, but if they are not buried, it is possible to decay before fossilizing ■ Areas with wet lowlands or slow moving water are excellent for fossil formation
Absolute (Radioactive) Dating 	■ _____ based on _____ of remaining fossil using radioactive dating (carbon-14) ■ Half-life: amount of time it takes for ½ of the radioisotope to decay ■ Remember: isotopes are the same _____ with different numbers of _____ ■ Carbon Dating: You want to determine how long it is taking for half of the sample of the isotope to decay.





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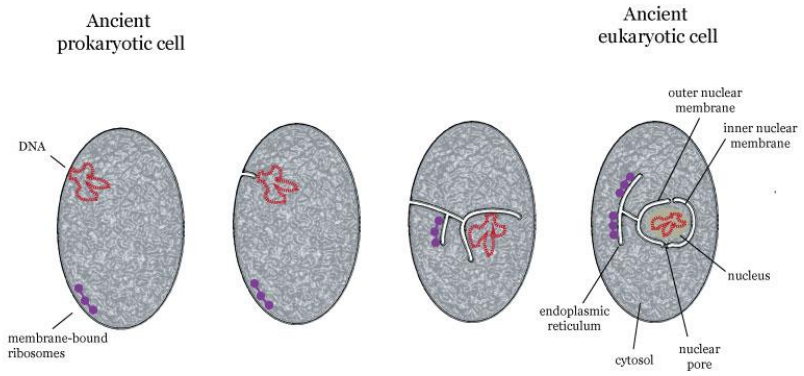
Precambrian Era (3.5 billion years ago- oldest life)

Prokaryotes

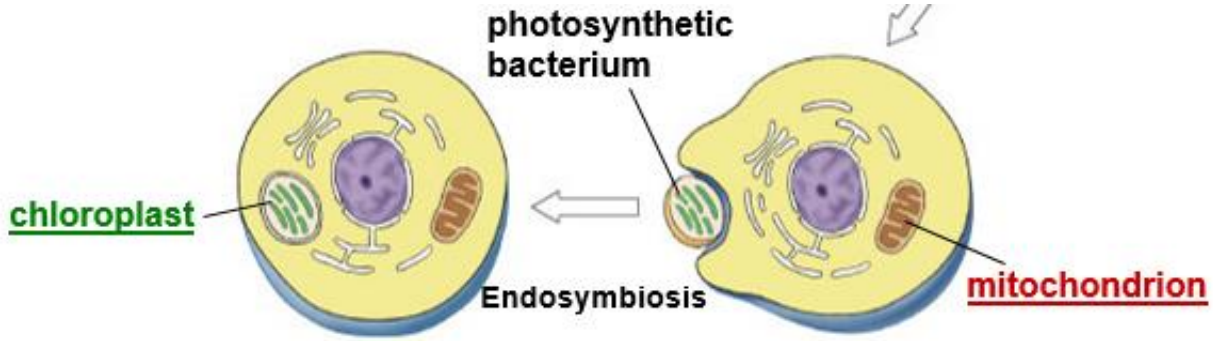
- Atmosphere lacked _____ _____
  - Organisms had to be _____
- First cells were archaebacteria (_____)
  - Cell walls lack peptidoglycan
  - Methanogens, halophiles, thermophiles



- First cells were _____
  - There were autotrophic archaebacteria (chemosynthesis, not photosynthesis)
    - As autotrophs began living, they put oxygen into the environment (produce ozone layer)
    - Oxygen began accumulating 2.7 BYA (banded iron/rust in rocks)
- Blue green algae, _____, were the first photosynthetic organisms
  - Produce: _____, a carbohydrate (and _____)
  - Require: _____
  - Significant oxygen in the atmosphere _____ years ago

Eukaryotes Evolve (2.7 BYA)

- _____, more _____ than prokaryotes
  - Can reproduce sexually, increasing _____
- Contain a nucleus and other membrane-bound organelles (golgi, lysosomes) for specific jobs in the cell
  - Internal membranes increase _____
- Process of evolution: _____
  - Ancestral cell _____ smaller cell (_____ bacteria or _____ bacteria), but did not _____
  - Origin of the _____ and _____
    - Mitochondria and chloroplast contain their own (circular) _____; have bacterial shape/structure
  - Formed a _____ relationship



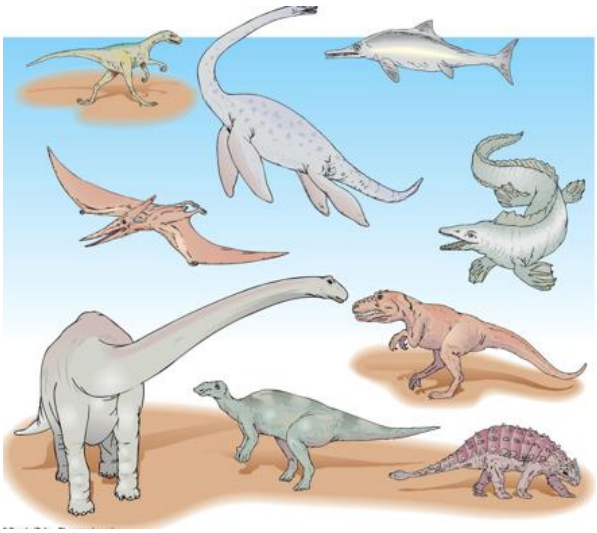
Paleozoic Era (245-542 MYA)

- The first _____ organisms evolve: _____!
  - *Fish are vertebrate (have a _____)*
- First plants evolve from seaweed and move to land
- Traces of complex burrows have been found- _____
- **Dominant animal life**: _____

- *Vertebrate that spends half its life in the water, the other half on land*
- *Certain fish evolved limbs and lungs for land life around 380 MYA*

- Conifer, a type of plant, evolves
  - *Better adapted to drier climates*
  - *Flowering plants not yet established (all other major plant groups are)*
- Mass extinction to close this period ended _____ on earth

Mesozoic Era (65-245 MYA)



- _____ breaks and _____ begin forming
- _____ begin to **dominate**
- _____ roamed in this period
  - *First 150 MY of period is ruled by dinosaurs*
- Birds evolve from _____ about 155 MYA
- Mammals evolve at the same time as dinosaurs, but do not dominate
  - *Many were very small, nocturnal insect eaters*
    - Nocturnal: _____ _____ (warm-blooded)
- Flowering plants and insects _____
  - *When two organisms evolve at the same rate, same time*
- Leafy trees and shrubs also evolve

Cenozoic Era (present/current)

- Comparatively short when compared to other eras, but full of fossils! (deep record)
- _____ replace reptiles as the **dominating** group
  - *Mammals: fur, fat, mammary glands, vertebrates*
  - *Angiosperm dominance (_____) influenced faster evolution of birds and mammals*
- ~35 MYA– climate became cooler/drier
  - *Remember, mammals are warm-blooded*
- ~2 MYA, _____ evolved
  - *Use of fire*
  - *Society and culture*
  - *Tools to control world*

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Unit 8 (evolution & classification)

Topic 2: Evolution

By the end of this topic, I will be able to…

- *Compare and contrast the theories of Darwin and Lamarck*
- *Explain the evidence for and of evolution*
- *Describe the process of speciation*

Key Vocabulary:

- Inference: interpretation based on _____
- Hypothesis: a scientific explanation that can be _____ (research based, written _____)
- Theory: a well-tested explanation that unifies a _____ of observations and hypotheses
  - *About the* _____
  - *Lots of* _____ *in support*
- Law: a statement based on repeated experimental observations
  - _____
- Evolution is a _____ in a _____ [of species] over a period of time
  - *Genotypic v. phenotypic changes*
- Evolution acts on populations, **not** _____
  - *A population is a group of individuals of the same species in an area (can interbreed)*
- Populations share a _____
  - *Gene pool: all of the genes (_____) for all of the traits in a given population at any time*
  - *If all members of a population are homozygous for a particular allele, then the allele is _____ in the gene pool*
- Microevolution: _____ scale (molecular)
  - *Seen in* _____ *populations*
- Macroevolution: _____ scale (speciation)
  - *Seen in the* _____ *record*

Scientists

Jean Baptiste Lamarck (1744-1829)	**Acquired Traits** ■ Theory of _____ – *If an organ is used, it becomes stronger and better developed* – *If an organ is not used, it becomes weaker and withers away* ■ Believed an organism acquires traits based on _____, not from genes
Charles Darwin (1809-1882)	**Natural Selection** **Descent by Modification** ■ Nature will select the organisms that have _____ that allow them to better survive (survival of the fittest) ■ Found that species vary locally/globally/over time ■ Studied finches and other animals in the Galapagos while on board the HMS Beagle (naturalist on voyage)

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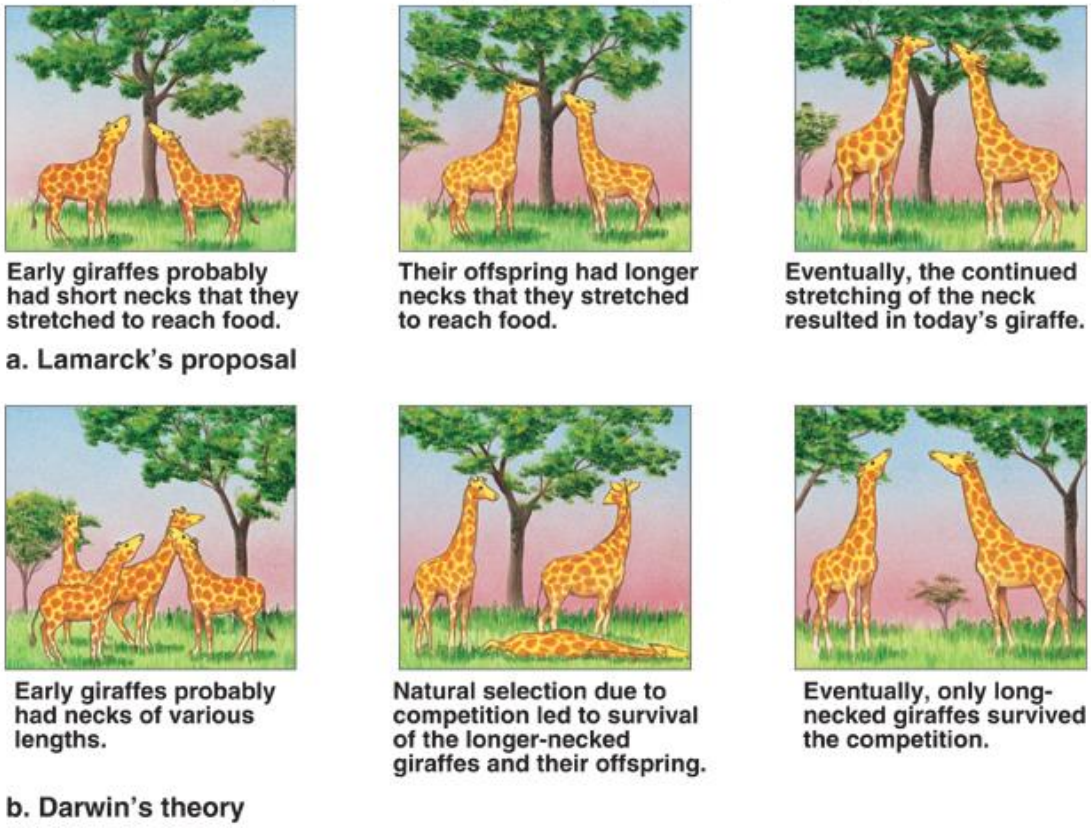
Unit 8 (evolution & classification)



Natural Selection

1) There is _____ in every population
2) Some variations are _____ *(these organisms live and can reproduce, the others die)*
3) More young are produced in each generation than can survive *(_____)*
4) There is _____ for resources (food, water, shelter, space) *(struggle for existence)*
5) Those that are successful go on to reproduce
6) Overtime, small changes accumulate in a population because the best traits continue to be passed on

- **What leads to these changes?**
  - *Random* _____
    - Organisms w/ shorter generation times have higher mutation rates & so evolve quicker than animals w/ longer generation times

Examples:

- Industrial Revolution vs. Peppered Moth
  - Explain: _____
    _____
    _____
    _____

OPHS Biology Name: _____

Unit 8 (evolution & classification)

- Darwin's Finches
  - Explain:

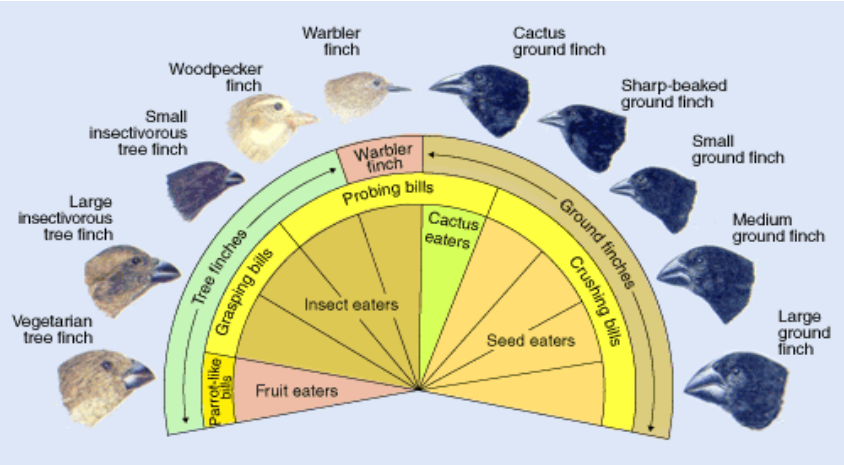
    _____

    _____

    _____

    _____

    _____



Evidence of Evolution

- Fossils
  - *Trace of long-dead organism found in layers of _____ rock; _____ _____*
- Comparative anatomy
  - *Compare _____ in modern organisms with ancient organisms (homologous, analogous, and vestigial structures)*
- Comparative embryology
  - *Finding similarities in embryos; organisms with a _____ _____*
- Comparative biochemistry
  - *Finding similarities in protein and DNA sequences (the _____ differences, the _____ related two organisms are)*

FAME summarizes the evidence that evolution has occurred:

- F – **fossil** evidence (remains of ancient organisms)
- A – **anatomical** structures (body parts)
- M – **molecular** evidence (DNA/RNA/ATP)
- E – **embryological** (embryos look similar from one species to the next)

Fossils

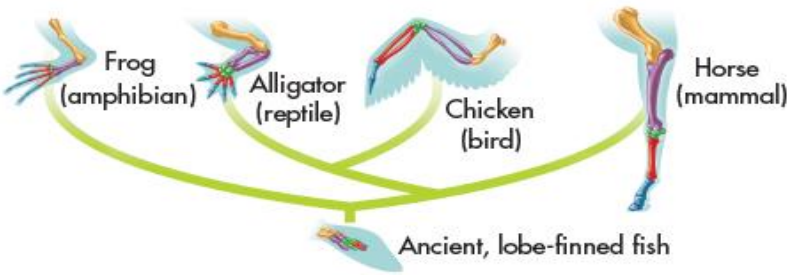
(tell us age, diet, habitat, lifestyle)

Types of Fossils

- Mold = _____ in rock
- Cast = a _____ filled with _____
- Trace Fossils = _____ (footprints, burrowing, etc.)
- Resin Fossils = organisms that have been _____ nearly perfectly in plant resin (amber)
- "Living Fossils" = any living species that is _____ to species previously known only from fossils

Anatomy: HOMOLOGOUS Structures

- Darwin proposed that animals with similar structures evolved from a _____ with a basic version of that structure.
- Structures that are shared by related species and that have been inherited from a common ancestor are called *homologous structures*.



- *Homologous structures* are similar in structure because they develop from same tissues early in development

- *may or may not have different functions.*

Anatomy: ANALOGOUS Structures

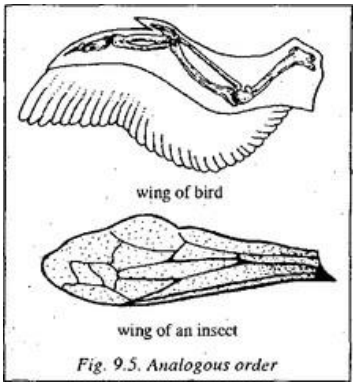
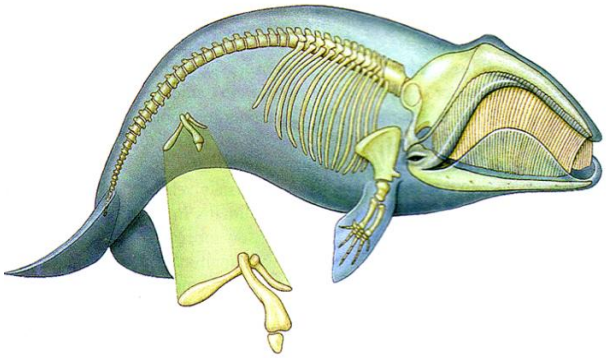


Fig. 9.5. Analogous order

- The clue to common descent is common structure, not common function. A bird's wing and a horse's front limb have different functions but similar structures (homologous structures).
- Body parts that share a common function, but not structure, are called <u>analogous structures</u>. Analogous structures are used for the same purpose but are _____ _____. The wing of a bee and the wing of a bird are analogous structures.

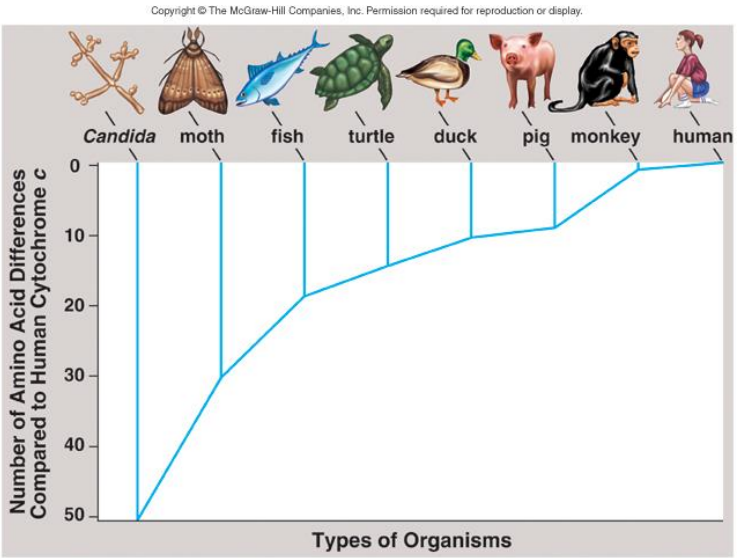
Anatomy: Vestigial Structures

- Not all homologous structures have important functions.
- Vestigial structures are _____ from ancestors, but have lost much or all of their original function due to different selection pressures acting on the descendant.
  - *The hipbones of bottlenose dolphins are vestigial structures. In their ancestors, hipbones played a role in terrestrial locomotion. However, as the dolphin lineage adapted to life at sea, this function was lost.*
  - *The human tailbone and appendix are vestigial structures.*



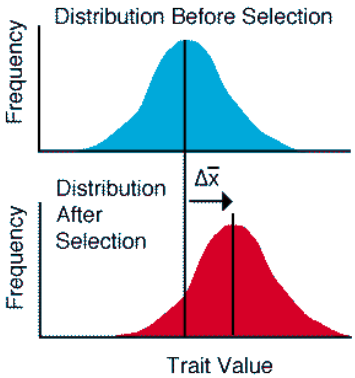
Biochemistry

- Universal genetic code – organisms use the same triplet code and the same 20 amino acids in proteins
- All organisms have certain organic molecules in common.
  1. *Hemoglobin - carries oxygen in blood*
  2. *Cytochrome c - protein for cell respiration found in almost all living cells*
  3. *HOX genes – control development*



Types of Natural Selection

- Stabilizing
- Directional
- Disruptive
  - *Aka diversifying*
- Sexual



Directional Selection: Individuals at one end of the curve have higher fitness than those in the middle or at the other end.

- *(Example: Large beak size in finches.)*

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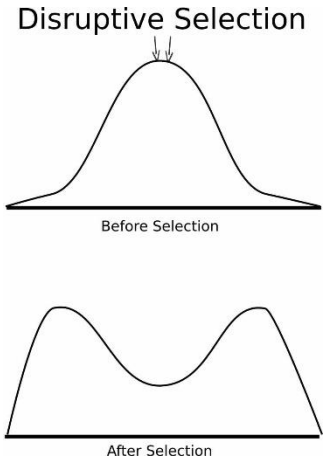
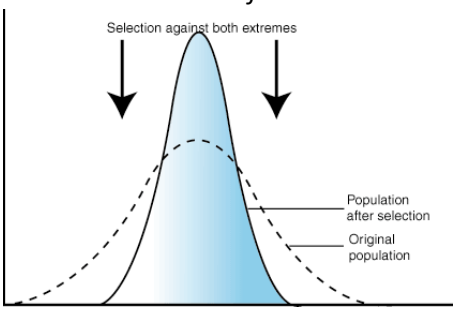
Unit 8 (evolution & classification)

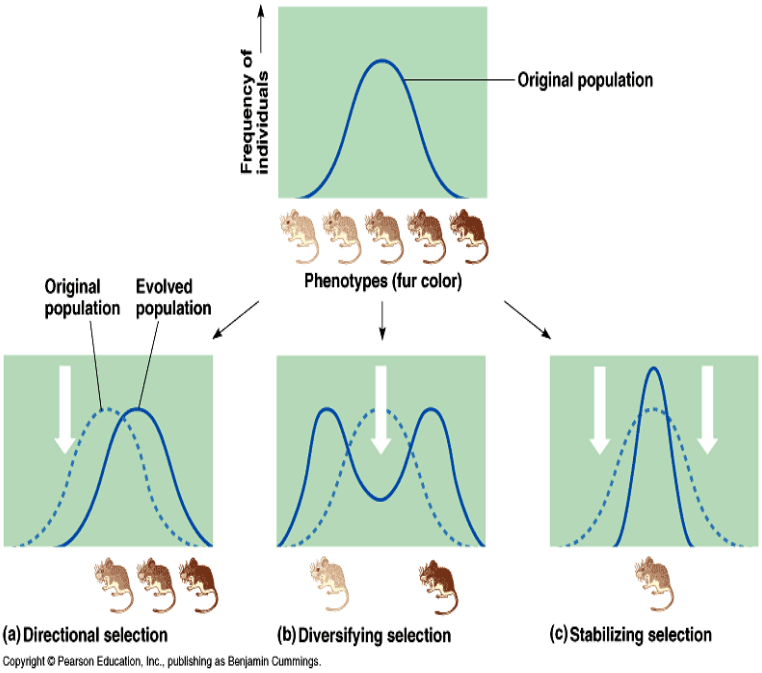
Disruptive Selection: Individuals at the upper and lower ends of the curve have higher fitness than those near the middle.

- *Creates two different* _____ .



Stabilizing Selection: Individuals near the center of the curve have higher fitness than those at either end of the curve.





Which type of selection could lead to one species splitting up into 2 separate species?

_____

_____

Why?

_____

_____

_____

Sexual Selection: Females choose males based on certain traits

- *Males with these traits have higher fitness*
  - *Reproductive success*

Artificial Selection:

- To find an explanation for change in nature, Darwin studied change produced by **plant and animal breeders**.
- Breeders knew that individual organisms vary, and that some of this variation could be passed from parents to offspring and used to improve crops and livestock – _____.
  - For example, farmers would select for breeding only trees that produced the largest fruit or cows that produced the most milk.
- Over time, this **selective breeding** would produce trees with even bigger fruit and cows that gave even more milk.
- **Artificial Selection** = humans "_____" certain characteristics in plants, dogs, etc., that they find favorable

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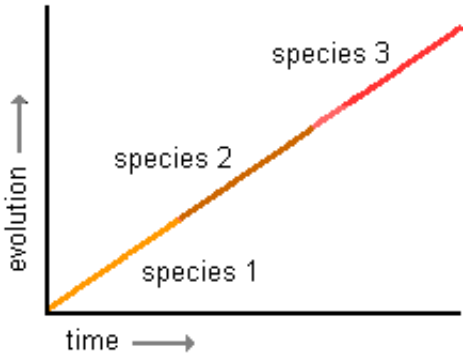
Unit 8 (evolution & classification)

Speciation

First off, how do we define a species?

- **Morphological Species Concept** – _____ and _____ structures are used to group organisms into species
- **Biological Species Concept**– defines a species as a population of organisms that can successfully _____
- **Speciation =** formation of a new species
- **Reasons for Speciation**
  1) Geographic Isolation
  2) Reproductive Isolation
  -prezygotic (before fertilization)
  -postzygotic (after fertilization)

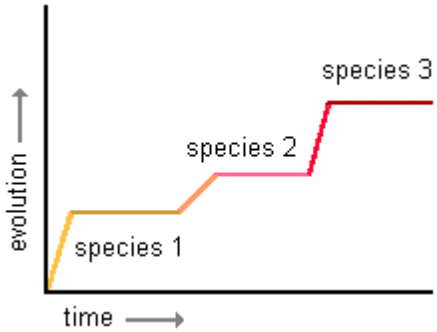


There are two models of speciation, or how populations change over time:

Model #1: Gradualism (change happens _____, and new species are made at a _____)

Model #2: Punctuated Equilibrium (there are times of little or no change followed by times of rapid change – often due to major changes in the environment)

Stephen Jay Gould came up with this model!



Patterns of Evolution:

- **Co-evolution**: change of two or more _____ in response to one another
- **Convergent**: organisms with _____ ancestors become very _____ due to environment
- **Divergent**: two or more _____ populations/species become _____
  - **Adaptive Radiation**: an _____ form of _____ evolution where many related species evolve from a single ancestor species (Darwin's finches)

OPHS Biology Name: _____

Unit 8 (evolution & classification)

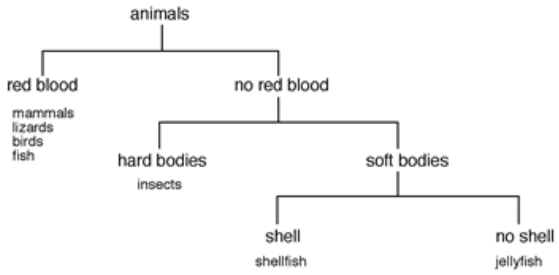
Topic 3: Classification

By the end of this topic, I will be able to…

- *Name the three domains and describe common characteristics for each*
- *Identify the kingdom an organism belongs to when provided characteristics*
- *Interpret a cladogram*
- *Use a dichotomous key to name an organism*

What is Classification?

- Putting organisms into groups based on their similarities
- How? – Using _____. When comparing the anatomies of different organisms, researchers look at:
  - Homologous structures: common _____; different environments + functions
  - Analogous structures: different ancestors; same _____ + functions
  - Vestigial structures/organs: organs that were useful in an ancestor, but are _____
- The science of classifying organisms is called _____
- First scientist to use modern system of taxonomy = _____
  - He is called the Father of _____
- 2000 years ago, Aristotle was the first taxonomist
  - Aristotle divided organisms into plants & animals
  - He subdivided them by their habitat ---
    _____
    _____



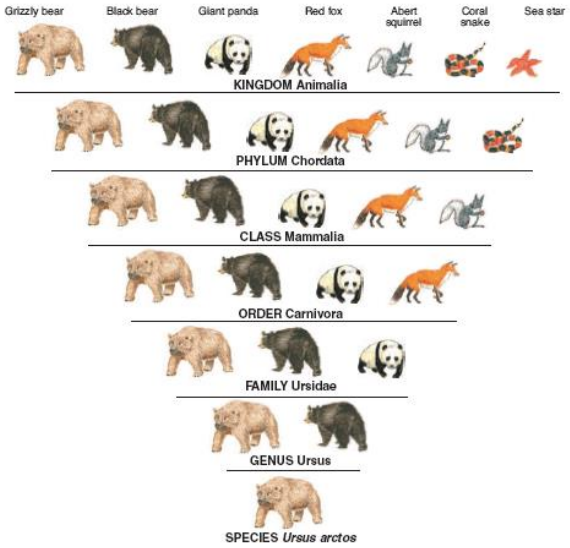
- Linnaeus developed a naming system using the following:
  - levels of _____
  - Based groupings on morphological (_____) differences of organisms
  - Divided organisms into two groups: _____
- Today, scientists use Linnaeus's system – the binomial system of nomenclature.
  - *Nomenclature* = _____ *(putting organisms into named groups!)*
- This system is based on a ranking system or hierarchy
  - Modern system is called the binomial system (bi = _____ ; nom = _____)
  - These names include the _____ and the _____
- When writing the scientific name of an organism, both words must be <u>underlined</u> or *italicized*. The genus is always _____, and the species always begins with a _____ case letter.
  - *Homo sapiens* = _____
  - *Felis domesticus* = _____
- Scientific names are always written in _____ or ancient _____ so that they have the same name everywhere!
  - Can abbreviate the genus with one letter (ex: *H. sapiens)*
- Genus = a group of _____
  - How did we define a species in our evolution notes? (*organisms able to interbreed)*
- Scientific names may _____ the organism (Ex: *Chaos chaos)*
- They may also honor a _____ or suggest the _____ of the organism (*(Linnaea borealis)*
- Accurately & uniformly names organisms
- Prevents misnomers such as starfish & jellyfish that aren't really fish

OPHS Biology Name: _____

Unit 8 (evolution & classification)

Classification Groups

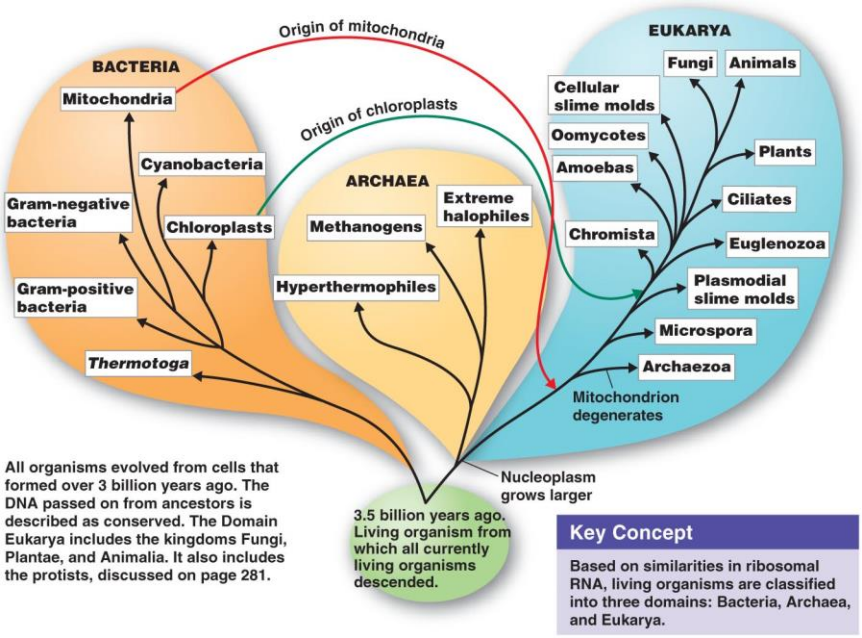
- Taxon (taxa-plural) is a category into which _____ organisms are placed
- There is a hierarchy of groups (taxa) from broadest to most specific
  - Domain, Kingdom, Phylum, Class, Order, Family, *Genus, species*
    - The largest group is the _____, and the smallest group is the _____
      - *Each kingdom (plant and animal) was divided into a phylum* (division for plants)*
      - *Each phylum into a smaller groups called class.*
      - *Each class was divided into an order.*
      - *Each order was divided into family (families).*
      - *Each family was divided into a genus (plural-genera)*
      - *Each genus was divided into a species. (scientific name)*



Memory Trick: **K**ing **P**hillip **C**ame **O**ver **F**or **G**ood **S**oup

Domains

- _____, most inclusive taxon
- _____ domains
- Archaea and Bacteria are unicellular _____ (no nucleus or membrane-bound organelles)
- Eukarya are more complex and have a nucleus and membrane-bound organelles



All organisms evolved from cells that formed over 3 billion years ago. The DNA passed on from ancestors is described as conserved. The Domain Eukarya includes the kingdoms Fungi, Plantae, and Animalia. It also includes the protists, discussed on page 281.

The Kingdoms

- Archaebacteria
  - Probably the 1st cells to evolve
  - Live in _____ environments
  - Found in:
    - Sewage Treatment Plants (Methanogens)
    - Thermal or Volcanic Vents (Thermophiles)
    - Hot Springs or Geysers that are acid
    - Very salty water (Dead Sea; Great Salt Lake) - Halophiles
- Eubacteria
  - Some may cause _____
  - Found in ALL HABITATS except harsh ones
  - Are both _____

- Important _____ for environment
- Commercially important in making cottage cheese, yogurt, buttermilk, etc.

- Protista
  - Most are _____
  - Some are _____
  - Some are autotrophic, while others are heterotrophic
  - Aquatic
- Fungi
  - _____, except yeast
  - Absorptive _____ (digest food outside their body & then absorb it)
    - obtain their nutrients by releasing digestive enzymes into a food source.
    - They absorb their food after it has been digested by the enzymes.
  - Cell walls made of _____
- Plantae
  - _____
  - _____
    - Absorb sunlight to make glucose – Photosynthesis
  - Cell walls made of _____
  - Kingdom Plantae includes mosses, ferns, cone-bearing plants (_____), and flowering plants (_____).
- Animalia
  - _____
  - Ingestive _____ (consume food & digest it inside their bodies)
    - Feed on plants or animals
  - Most members of the Animal Kingdom can move from place to place.
    - Some are permanently attached to surfaces such as sponges and barnacles.
  - Fish, Birds, Reptiles, Amphibians, and mammals-including humans belong to the Kingdom Animalia.
  - This Kingdom also includes sponges, jellyfish, worms, sea stars, and insects.

Kingdom	Organization	Type of Nutrition	Representative Organisms				
Protista	Complex single cell, some multicellular	Absorb, photo-synthesize, or ingest food	 paramecium	 euglenoid	 slime mold	 dino-flagellate	Protozoans, algae, water molds, and slime mold
Fungi	Some unicellular, most multicellular filamentous forms with specialized complex cells	Absorb food	 black bread mold	 yeast	 mushroom	 bracket fungus	Molds, yeast, and mushrooms
Plantae	Multi-cellular form with specialized complex cells	Photo-synthesize food	 moss	 fern	 pine tree	 nonwoody flowering plant	Mosses, ferns, nonwoody and woody flowering plants
Animalia	Multi-cellular form with specialized complex cells	Ingest food	 coral	 earthworm	 blue jay	 squirrel	Invertebr-ates, fishes, reptiles, amphibians, birds, and mammals

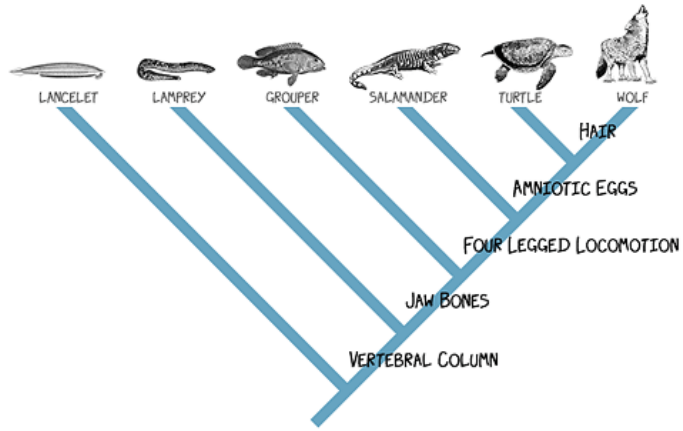
c. Domain Eukarya
Eukaryotes, structurally diverse and organized into the four kingdoms depicted here.

OPHS Biology Name: _____

Unit 8 (evolution & classification)

Cladogram

- Diagram showing how organisms are related based on shared, derived characteristics such as feathers, hair, or scales



Using the cladogram to the left…

1. Which organisms have jaw bones?

_____

2. Which organisms have amniotic eggs?

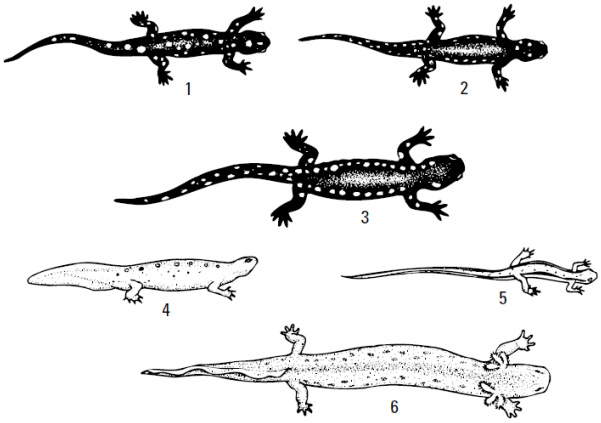
_____

3. What organism is most closely related to the wolf?

_____

Dichotomous Key

- Used to _____ organisms
- Characteristics given in _____ (di = 2)
- Read both characteristics and either go to another set of characteristics OR identify the organism



#1: _____

#2: _____

#3: _____

#4: _____

#5: _____

#6: _____

1	a	Hind limbs absent	*Siren intermedia*, siren
	b	Hind limbs present	Go to 2
2	a	External gills present in adults	*Necturus maculosus*, mud puppy
	b	External gills absent in adults	Go to 3
3	a	Large size (over 7 cm long in Figure 1)	Go to 4
	b	Small size (under 7 cm long in Figure 1)	Go to 5
4	a	Body background black, large white spots variable in size completely covering body and tail	*Ambystoma tigrinum*, tiger salamander
	b	Body background black, small round white spots in a row along each side from eye to tip of tail	*Ambystoma maculatum*, spotted salamander
5	a	Body background black with white spots	Go to 6
	b	Body background light color with dark spots and/or lines on body	Go to 7
6	a	Small white spots on black background in a row along each side from head to tip of tail	*Ambystoma jeffersonianum*, Jefferson salamander
	b	Small white spots scattered throughout a black background from head to tip of tail	*Plethodon glutinosus*, slimy salamander
7	a	Large irregular white spots on a black background extending from head to tip of tail	*Ambystoma opacum*, marbled salamander
	b	No large irregular black spots on a light background	Go to 8
8	a	Round spots scattered along back and sides of body, tail flattened like a tadpole	*Triturus viridescens*, newt
	b	Without round spots and tail not flattened like a tadpole	Go to 9
9	a	Two dark lines bordering a broad light middorsal stripe with a narrow median dark line extending from the head onto the tail	*Eurycea bislineata*, two-lined salamander
	b	Without two dark lines running the length of the body	Go to 10
10	a	A light stripe running the length of the body and bordered by dark pigment extending downward on the sides	*Plethodon cinereus*, red-backed salamander
	b	A light stripe extending the length of the body without dark pigment on the sides	*Hemidactylium scutatum*, four-toed salamander