5.1 Evidence for evolution **Name:** _____

Essential idea: There is overwhelming evidence for the evolution of life on Earth.

Nature of science:

Looking for patterns, trends and discrepancies—there are common features in the bone structure of vertebrate limbs despite their varied use. (3.1)

Understandings:

∑ **- Evolution occurs when heritable characteristics of a species change.**

- When heritable characteristics of a species or a biological population change over successive generations
- These traits cannot be acquired over a lifetime, they are heritable traits or alleles in an organism's DNA

∑ **- The fossil record provides evidence for evolution.**

Fossil Record

- Fossils are the preserved remains of animals, plants, and other organisms from the past.
- The fossil record shows the gradual change of species over time.
- The timeline in which fossils appear are what scientists would expect, with bacteria and algae being the oldest in the fossil record. Followed later by shelled animals and trilobites, then dinosaurs and early reptiles, birds and mammals later still.

Trilobite: http://burgess-shale.rom.on.ca/en/fossil-gallery/view-species.php?id=11&m=1&&ref=a

- Many fossil sequences link together present day organisms with their likely ancestors. For example present day horses and zebras are closely related to tapirs and rhinos, which are all linked back to the Hyracotherium, an animal similar to the rhinoceros

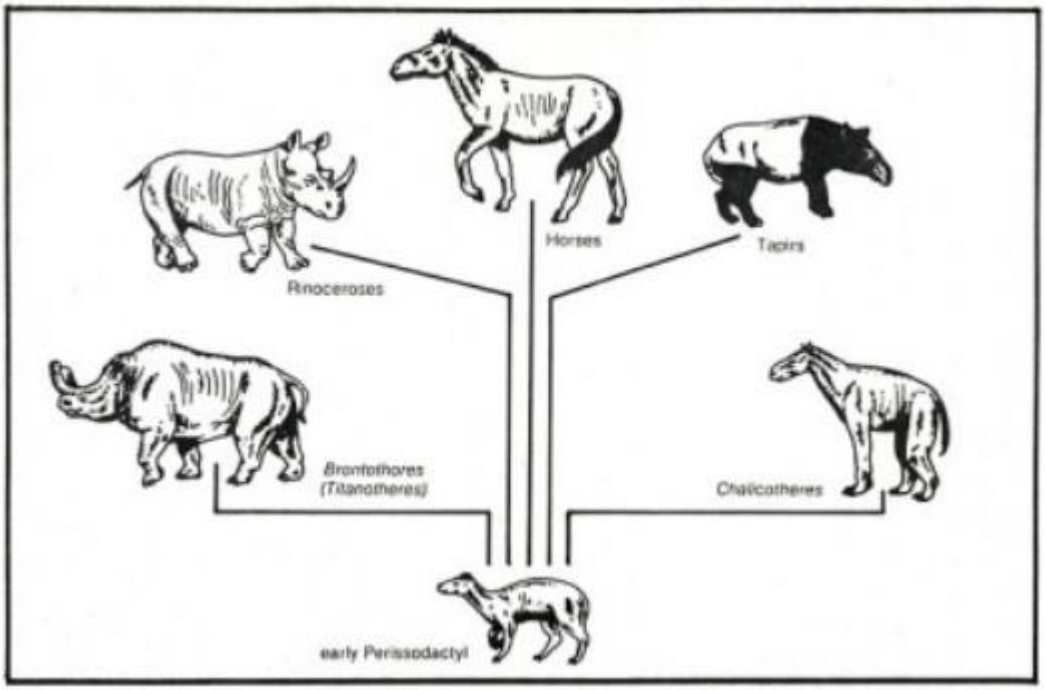
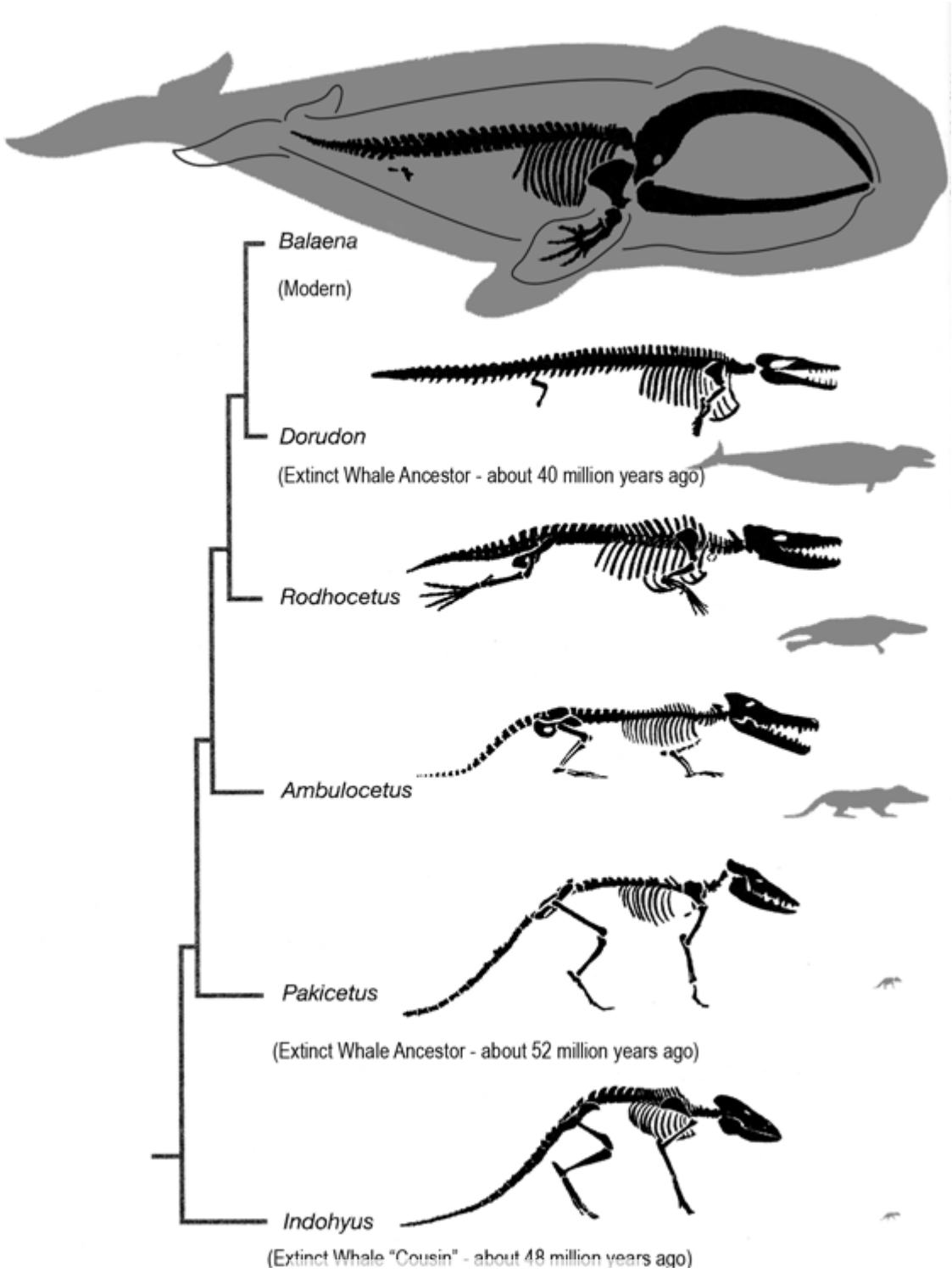


FIGURE 3: Simplified chart showing Perissodactyl "kind" evolving from early common ancestor.



- **Whale evolution fossil record is also whale documented**

***** Do data based questions on page 243*****

∑ - Selective breeding of domesticated animals shows that artificial selection can cause evolution.

<u>Selective Breeding</u>

- Breeding plants and animals for specific genetic traits.
- Shows a good record of recent changes in genetic characteristics over a few dozens of generations that man has selected to breed.
- For example, chickens that produce more eggs or cows that produce more milk are selected to breed, hopefully passing these traits onto next generations.
- Plants can be bred in a similar manner based on useful or beneficial characteristics breeders would like to see in the next generation of plants.
- The evolution of domesticated dogs has produced many different breeds through artificial selection

Some good videos on artificial selection

Belgium Blue cow https://www.youtube.com/watch?v=Nmkj5gq1cQU

Russian domesticated foxes https://www.youtube.com/watch?v=-L58NPPQ5eI

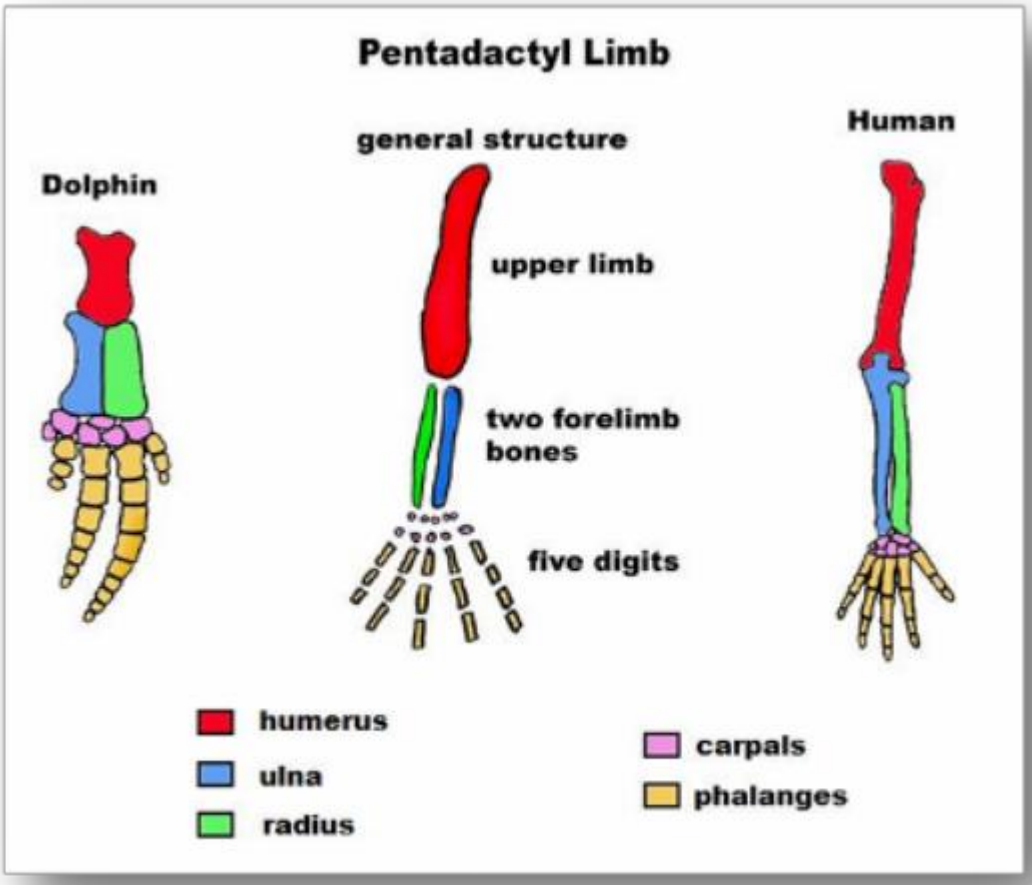
https://www.youtube.com/watch?v=ipSTntA_Znw

∑ - Evolution of homologous structures by adaptive radiation explains similarities in structure when there are differences in function.

Homologous Structures

- Common internal structures that are similar in seemingly dissimilar animals that have evolved from a common ancestor.
- The standard example of homologous structures is the “Pentadactyl limb” which is the five digit limb found in animals such as humans, dolphins, bats, and dogs.
- Even though the shape, size and function of this structure vary between species, the general structure and position of the bones in these limbs are the same.

***** Do data-based questions on page 244*****



Woolly Mammoth Cloned? http://dailym.ai/1GQ7hWR

β - Application: Comparison of the pentadactyl limb of mammals, birds, amphibians and reptiles with different methods of locomotion.

Draw and compare the pentadactyl limb for a mammal, bird, amphibian, and a reptile.

Mammal	Bird	Amphibian	Reptile

∑ - **Populations of a species can gradually diverge into separate species by evolution.**

- Within a population there is genetic variation
- If two populations of the same species become separated so that they do not reproduce or interbreed because they become separated by geographical boundaries; for example one group migrates to an island or they became separated by a mountain range, then natural selection will act differently on those two separate populations
- Over time, these populations change so that they are recognizably different and can or do not interbreed if they were to merge together again
- This process is called speciation

∑ **- Continuous variation across the geographical range of related populations matches the concept of gradual divergence.**

- When populations diverge over time and are separated, one would expect these populations to be in different stages of variation or divergence and not all separate distinct organisms right away or all the same unchanged species
- Darwin gave many of these examples that showed populations that are slightly different, but are not clearly separate species
- Examples of this are the Lava lizards and finches of Galapagos, and the Spiny Sticklebacks of BC

β - Application: Development of melanistic insects in polluted areas.

Do the peppered moth simulationhttp://biologycorner.com/worksheets/pepperedmoth.html

*****Do data-based questions on page 248-249*****

Theory of knowledge:

• Evolutionary history is an especially challenging area of science because experiments cannot be performed to establish past events or their causes.

There are nonetheless scientific methods of establishing beyond reasonable doubt what happened in some cases. How do these methods compare to those used by historians to reconstruct the past?

5.2 Natural selection

Essential idea: The diversity of life has evolved and continues to evolve by natural selection.

Nature of science:

Use theories to explain natural phenomena—the theory of evolution by natural selection can explain the development of antibiotic resistance in bacteria. (2.1)

Understandings:

∑ - Natural selection can only occur if there is variation among members of the same species.

- Within a species, different individuals of that species show genetic variation.

- Individuals that are best suited for their environment will survive and reproduce.
- If there was no variation within a species, then all individuals would be the same and no individual would be favoured over the other and natural selection would not take place

∑ - Mutation, meiosis and sexual reproduction cause variation between individuals in a species.

- Sexual reproduction can produce variation in a species through fertilization and meiosis.
- Sexual reproduction occurs when two different members of a species create offspring that have a combination of genetic material contributed from both parents.
- During **meiosis** 50% of the females chromosomes will end up in the egg(haploid gamete) and 50% of the male's chromosomes will end up in the sperm (haploid gamete).
- **During meiosis chromosomes *will line up or assort independently*** of each other creating ($2^{n)}$ possible variations of chromosomes in the sex cells.
- During meiosis, specifically prophase 1, crossing over might occur in homologous chromosomes where parts of each chromosome are exchanged.
- **Random fertilization** through sexual reproduction gives millions of sperms a chance at fertilizing the egg. This allows mutations that have occurred in different individuals to come together in their offspring.
- Lastly, **genetic mutations** might occur where new alleles are produced. Genetic mutations are the original source of variation within a species.

∑ - Adaptations are characteristics that make an individual suited to itsenvironment and way of life.

- Where and how an organism lives is largely due to its specific adaptations that allow it to survive and reproduce in a particular area or habitat
- In other words their structure allows them to function in that environment

- Polar bears are well adapted to life in the Arctic. They have a large layer of blubber to keep them warm. They are strong swimmers, aided by their strong forearms and layer of blubber for buoyancy. They have hollow fur to aid in insulation as well. For plants, cacti have water storage tissue and spines (prevent water loss) because of the infrequent rainfall in the desert.
- Adaptations develop over time through natural selection

25 cool adaptations https://www.youtube.com/watch?v=wNqiclBUxdY

Animals in extremes - Mimic Octopus https://www.youtube.com/watch?v=H8oQBYw6xxc

∑ - Species tend to produce more offspring than the environment can support.

- Populations tend to produce more offspring than the environment can supportor that could survive in a particular community or ecosystem.
- For example, fish produce thousands of eggs but only few make it to adulthood.
- Plants also can produce hundreds or thousands of seeds to be released into the environment.
- When parents don't spend a lot or even any time caring for their young, they produce many offspring. This is a reproductive method used to make sure some offspring make it to the next generation.
- Parents that put a lot of time and energy protecting and raising their young tend to have far smaller litters, i.e. most mammals.
- The population density that the environment can support is called the carrying capacity.
- If there are too many organisms, the demand for resources increases.
- However, there is a limited supply of resources in an ecosystem.
- Overpopulation and a limited amount of resources creates competition within a population.

∑ - Individuals that are better adapted tend to survive and produce more offspring while the less well adapted tend to die or produce fewer offspring.

- Within a population, there is genetic variation between the individuals in the population.

- The organisms with the beneficial characteristics will be able to out-compete the other individuals with the less beneficial or harmful genetic traits for limited resources and mates.
- Therefore, these individuals will survive and reproduce and pass these genetic traits onto the next generation of offspring.
- Organisms with less desirable traits will die or produce less offspring

∑ - Individuals that reproduce pass on characteristics to their offspring.

- These organisms that survive and reproduce, pass these beneficial traits on to their offspring
- Over many generations the accumulation of these beneficial genetic traits mayresult in a change in the population known as evolution.
- For another species to develop, these genetically different individuals eventually have to become reproductively isolated (separated from the general population) where they will only reproduce with individuals with similar genetic traits.
- Acquired characteristics of an individual such as large muscles are not passed on to an organism's offspring

∑ - Natural selection increases the frequency of characteristics that make individuals better adapted and decreases the frequency of other characteristics leading to changes within the species.

- Since the better adapted individuals of a species are the ones that survive, reproduce and pass their genes on to the next generation, these alleles will become more frequent within the population
- The same would hold true for individuals that are less suited to an environment. These individuals will reproduce less frequently and die more often, thus decreasing the frequency of their alleles within a population
- These changes happen over many generations

Video on natural selection https://www.youtube.com/watch?v=aTftyFboC_M

Watch episode 2 of The Cosmos on Natural Selection

*****Do the data-based questions on page 253*****

Applications and skills:

β - Application: Changes in beaks of finches on Daphne Major.

Watch the short film on changes in beak size of the Galapagos finches

http://www.hhmi.org/biointeractive/origin-species-beak-finch

Do the evolution in action data analysis and graphinghttp://www.hhmi.org/biointeractive/evolution-action-data-analysis from the HHMI

The handout for the data analysis will be handed out in class.

β - Application: Evolution of antibiotic resistance in bacteria.

Antibiotic Resistance in Bacteria

- Antibiotics kill bacteria directly or weaken the bacteria so your immune system can fight and destroy the invading pathogen.
- If a patient has a bacterial infection, when antibiotics are given to fight the infection the majority of the original population of bacteria will be destroyed.
- However, some of these bacteria might not die because of changes within their DNA. These changes could be caused by mutations within their genome or the transfer of an antibiotic resistant gene from another bacterium.
- Resistance is more likely to occur if the proper amounts of antibiotics aren't taken or if a patient doesn't finish the prescription.
- These resistant bacteria will survive and reproduce, creating more identical resistant bacteria.
- These resistant bacteria will make the person sick again in the future.
- However if given the same antibiotic, these bacteria will no longer be destroyed.
- Another antibiotic can be prescribed to kill these new resistant bacteria.
- Resistance can be passed onto other pathogenic bacteria, creating more species of resistant bacteria.
- Some examples of bacteria known to develop resistance are Treponema pallidum which causes syphilis and the bacteria that causes tuberculosis (Mycobacterium tuberculosis)

- ***Also do the data-based question on page 255***

Guidance:

• Students should be clear that characteristics acquired during the lifetime of an individual are not heritable. The term Lamarckism is not required.

Theory of knowledge:

• Natural Selection is a theory. How much evidence is required to support a theory and what sort of counter evidence is required to refute it?

5.3 Classification of biodiversity

Nature of science:

Cooperation and collaboration between groups of scientists—scientists use the binomial system to identify a species rather than the many different local names. (4.3)

Understandings:

∑ **- The binomial system of names for species is universal among biologists and has been agreed and developed at a series of congresses**.

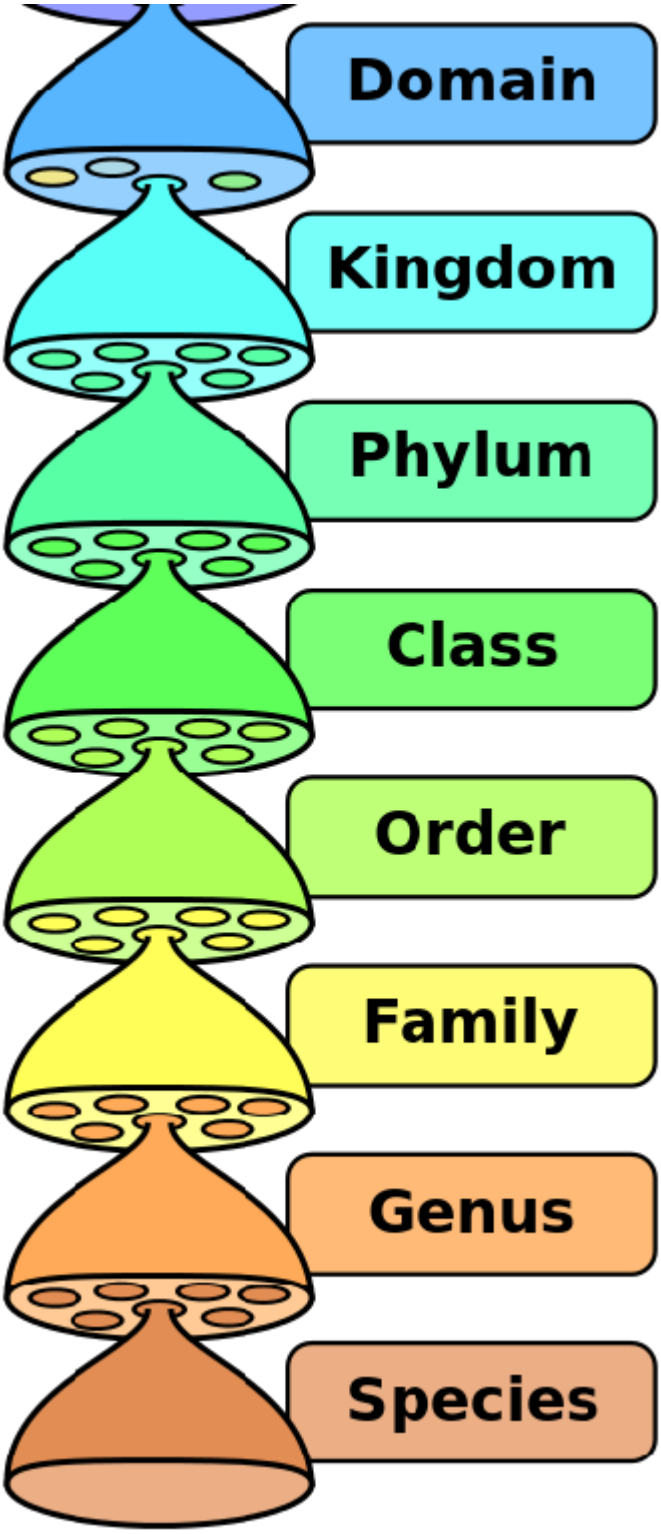
- Formal two naming system of classifying species.
- Originally developed by Swedish naturalist Carolus Linnaeus.
- Currently, many scientists and specialists meet in a series of International Congresses of Zoology which meet in different cities every 4 years
- They meet to discuss their findings regarding genetics, animal behaviour and classification
- A main topic is the binomial nomenclature system and decisions regarding the classification of new organisms or the reclassification of old ones because of new evidence regarding ancestry.
- The main objectives with regards to using the binomial nomenclature system developed are to
    -
        - Make sure each organism has a unique name that cannot be confused with another organism
        - The name can be universally understood regardless of the nationality or culture that is using the name
        - Stability exists within the system by not allowing people to change the name without valid scientific reasons

∑ - When species are discovered they are given scientific names using the binomial system.

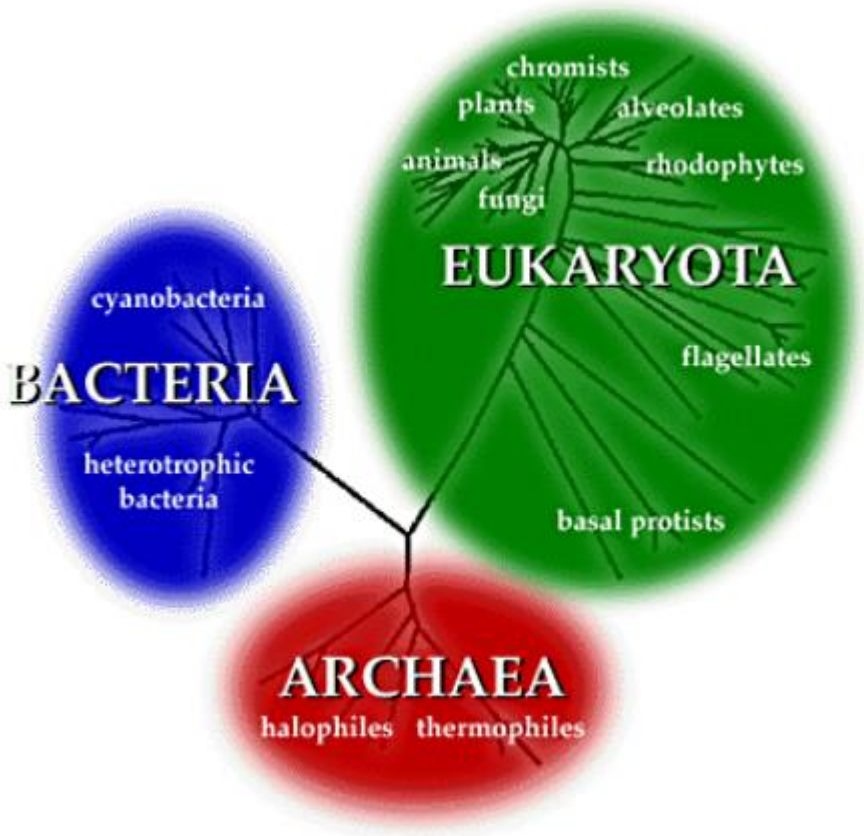
- Formal two naming system of classifying species.
- Originally developed by Swedish naturalist Carolus Linnaeus.
- The first name in the binomial naming system is called the genus and is always capitalized.
- The second name starts with a small letter and is called the species.
- The binomial system allows for scientists across cultures, regions and languages to communicate effectively with regards to specific organisms.
    -
    - **Taxonomy - https://www.youtube.com/watch?v=F38BmgPcZ_I**

∑ - Taxonomists classify species using a hierarchy of taxa.

- A taxon means a group of something
- Scientists arrange or organize species in to a hierarchical set of groups in order to organize organisms into specific similar groups based on similar characteristics
- As one goes higher up on a classification chart, the greater the number of species are included into the group



∑ - **All organisms are classified into three domains.**



http://www.ucmp.berkeley.edu/alllife/threedomains.gif

- The Archaea and Bacteria domains are prokaryotes. These are organisms that do not have a membrane bound nucleus and their DNA is not associated with proteins.
- The Bacteria domain consists of Eubacteria and archaebacteria are classified as Archaeans.
- The Eukarya domain includes eukaryotes, or organisms that have a membrane bound nucleus. This domain is further subdivided into the kingdoms Protista, Fungi, Plantae, and Animalia
- Groups organisms primarily based on differences in ribosomal RNA structure. Ribosomal RNA is a molecular building block for ribosomes.

∑ - The principal taxa for classifying eukaryotes are kingdom, phylum, class, order, family, genus and species.

Taxa	**Human**	**Gray Wolf**
Kingdom	Animalia	Animalia
Phylum	Chordata	Chordata
Class	Mammalia	Mammalia

Order	Primate	Carnivora
Family	Hominidae	Canidae
Genus	Homo	Canus
Species	sapiens	lupus

∑ - In a natural classification, the genus and accompanying higher taxa consist of all the species that have evolved from one common ancestral species.

For natural classification, it is assumed that all members of that group shared a common ancestor at some point in their history. This can be seen in their structure. Unnatural or artificial classification for example would be birds and flies. They both can fly; however flight evolved separately, and they are classified separately

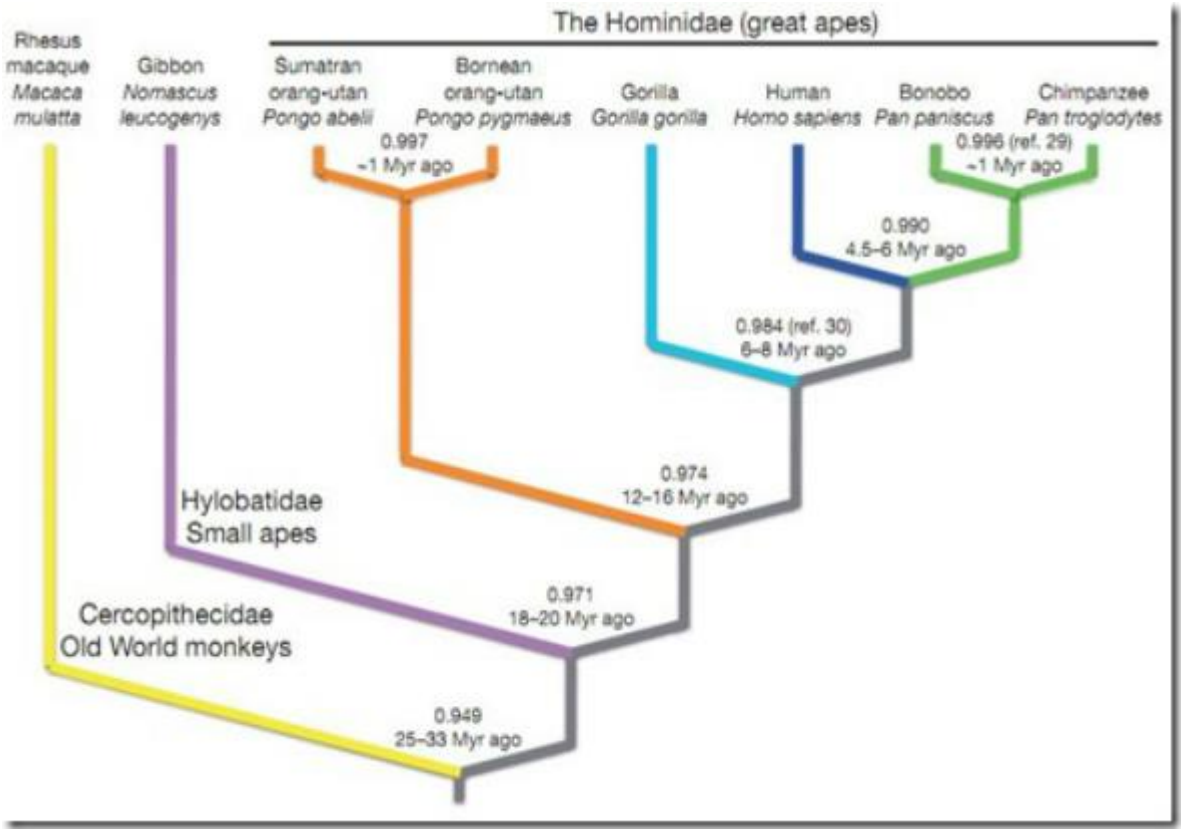
β - Application: Classification of one plant and one animal species from domain to species level.

- **Research one plant and one animal example and fill out the table below.**

Taxa	**Plant example (_____)**	**Animal example (_____)**
Domain		
Kingdom		
Phylum		
Class		
Order		
Family		
Genus		
Species		

∑ - Taxonomists sometimes reclassify groups of species when new evidence shows that a previous taxon contains species that have evolved from different ancestral species.

- Sometimes new evidence is found that shows scientists that members of a particular group do not share a common ancestor as once originally thought
- Sometimes other species that were once thought to be a lot different, are found to be more similar; sharing a common ancestor
- This switching of classification is an ongoing process as new discoveries or better methods of classification are found.
- Putting apes together with humans in Hominidae was one of these cases



Orangutan as seen in this classification chart on the left are now in a sub family of Pongidae. All apes used to belong to the family Pongidae

∑ - Natural classifications help in identification of species and allow the prediction of characteristics shared by species within a group.

- Natural classification is very useful for research into biodiversity
- Easier identification for new species that do not obviously fit into a specific classification (Kingdom à Phylum à Class à etc.)
- A dichotomous key could be used to put an organism into a classification that fits that organism the best
- This would not work as well for artificial classification (eg. Colour of flower petals)
- Since organism evolved from a common ancestor, new species would share similar characteristics (likely internal), allowing for easier identification and classification. For example the pentadactyl limb, or mammary glands in mammals

Applications and skills:

β - Application: Recognition features of bryophyta, filicinophyta, coniferophyta and angiospermophyta.

Plant Phyla			
Bryophyta	Mosses/small soft plants/no roots/simple stems and leaves	Non-vascular/no flowers or seeds/produce spores	
Filicinophyta	Ferns and horsetails/large flat leaves/have stems and roots	Seedlessvascular plant/produce spores	
Coniferophyta	Conifers/leaves are needles or scale-like leaves/woody stems	Vascular plants/produceseed cones and seed scales	
Angiospermophyta	Flowering plants, flowers and fruits with seeds have roots/stems and leaves	Vascular plants/developovaries (eggs) and anthers (pollen)	

β - Application: Recognition features of porifera, cnidaria, platylhelmintha, annelida, mollusca, arthropoda and chordata.

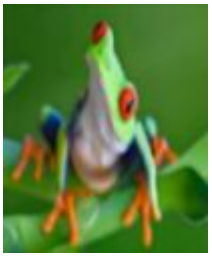
Animal Phyla			
Porifera	Sponges/no mouth or anus	Pores on the surface that suck in water for filter feeding/ no symmetry	
Cnidaria	Corals, Sea anemones, hydra and jellyfish/ One opening for food and waste	Generally soft accept species of hard corals/ radial symmetry/Tentaclesarranged around the mouth (some with stinging cells)	
Platyhelminthes	Flatworms/ one opening for food and waste/lack body cavity except a gut/no circulatory or respiratory system	Soft/no skeleton/flat thin ribbon-like shape/ bilateral symmetry	
Annelida	Segmented worms such as earthworms and leeches/ segmented internal cavity with the same organs in each segment/mouth and anus	Ringed shaped segments withbristles/ bilateral symmetry	

Mollusca	Snails, bivalves and squid/most have calcium carbonate ($CaCO_3$) shell	Mantle secretesshell/bilateral symmetry/most have radula (hard rasping tongue-like structure) for feeding	
Arthropoda	Insects and crustaceans/mouth and anus/have head, thorax and abdomen	Hard exoskeletonmade of chitin/bilateral symmetry/ segmented bodies withjointed appendages	
Chordata	All the vertebrates and a few non-vertebrate (such as the tunicates - sea squirts) groups, have a mouth and an anus and have a dorsal strengthening structure called a notochord for at least some stage of their lives.	Have a nerve cord lying above the notochord and have a series of pharyngeal slits that open up between the mouth and esophagus	

**Please note that Chordata has a sub-phylum called vertebrata (have a vertebral column) **

β - Application: Recognition of features of birds, mammals, amphibians, reptiles and fish.

Birds (aves)	Mammals (Mammalia)	Amphibians (Amphibia)	Reptiles (Reptilia)	Fish (Osteichthyes)

				
Skin covered in feathers made out of Keratin	Skin has follicles with hair made out of Keratin	Moist skin, permeable to water	Impermeable skin covered in scales of keratin	Scales made out of bony plates in the skin
Lungs ventilated using air sacs, with para-bronchial tubes	Lungs with alveoli, ventilated with ribs and a diaphragm	Simple lungs and moist skin for gas exchange	Lungs with extensive folding (increase SA)	Gills covered by an operculum
Pentadactyl Limbs				No limbs
Two wings and two legs	Four legs for many, some have two arms/wings and two legs	Adults have four legs	Four legs in most species (some have none)	Fins
Internal fertilisation (sperm and egg)	Internal fertilisation (sperm and egg)	External fertilisation with sperm and eggs	Internal fertilisation (sperm and egg)	External fertilisation with sperm and eggs
Females lay eggs with hard shells	Most have live birth and feed young with milk from mammary glands	Larval stage in water, adult usually on land	Females lays eggs with soft shells	Remain in water throughout their lives
Beak and no teeth	Different types of teeth, living core	Eggs coated in protective jelly	Same type of teeth with no living parts	Swim bladder for buoyancy
Maintain constant internal temperature (warm blooded)		Do not maintain an internal body temperature (cold blooded)		

β - Skill: Construction of dichotomous keys for use in identifying specimens.

- A dichotomous key is a key constructed from a series of statements arranged into pairs.
- The two descriptions should represent separate choices or characteristics that determine the difference between two organisms.
- Both choices are read and compared with the organism to be identified.

- If the first characteristic is present in the organism to be identified follow the instructions at the end of the statement. If the characteristic is not present go to the second statement as this should be true.
- Once a choice is made, that selection directs you to another pair of descriptive statements.
- One statement might identify the organism or lead you further on in the key.
- This process is repeated until a successful identification is obtained.

Example for the Kingdom Animalia (using some of the characteristics from the above table)

1. Symmetry

- Has bilateral symmetry go to 2
- Has radial symmetry go to 3

2. Digestive

- Has mouth and anus go to 4
- Has only one opening for mouth and anus go to 5

3. Exoskeleton

- Secretes hard exoskeleton made from $CaCO_3$ Stony corals
- Soft exoskeleton go to 6

4. Body structure

- Has segmented body go to 7
- No segmentation with mantle Octopus

5. Mouth

- Has suckers and hooks for attachment Tapeworm
- No suckers or hooks Planaria

6. Locomotion

- Move on surface beneath it by an adhesive foot Sea Anemone
- Move by propulsion of water Jellyfish

7. Exoskeleton

- Hard exoskeleton with jointed appendages — Scorpion
- Soft outer skeleton with bristles — Earthworm

Guidance:

• Archaea, eubacteria and eukaryote should be used for the three domains.

• Members of these domains should be referred to as archaeans, bacteria and eukaryotes.

• Students should know which plant phyla have vascular tissue, but other internal details are not required.

• Recognition features expected for the selected animal phyla are those that are most useful in distinguishing the groups from each other and full descriptions of the characteristics of each phylum are not needed.

• Viruses are not classified as living organisms.

International-mindedness:

• There are international codes of nomenclature and agreements as to the principles to be followed in the classification of living organisms.

Theory of knowledge:

• The adoption of a system of binomial nomenclature is largely due to Swedish botanist and physician Carolus Linnaeus (1707–1778). Linnaeus also defined four groups of humans, and the divisions were based on both physical and social traits. By 21st-century standards, his descriptions can be regarded as racist. How does the social context of scientific work affect the methods and findings of research? Is it necessary to consider the social context when evaluating ethical aspects of knowledge claims?

Topic 5.4 – Cladistics

Essential idea: The ancestry of groups of species can be deduced by comparing their base or amino acid sequences.

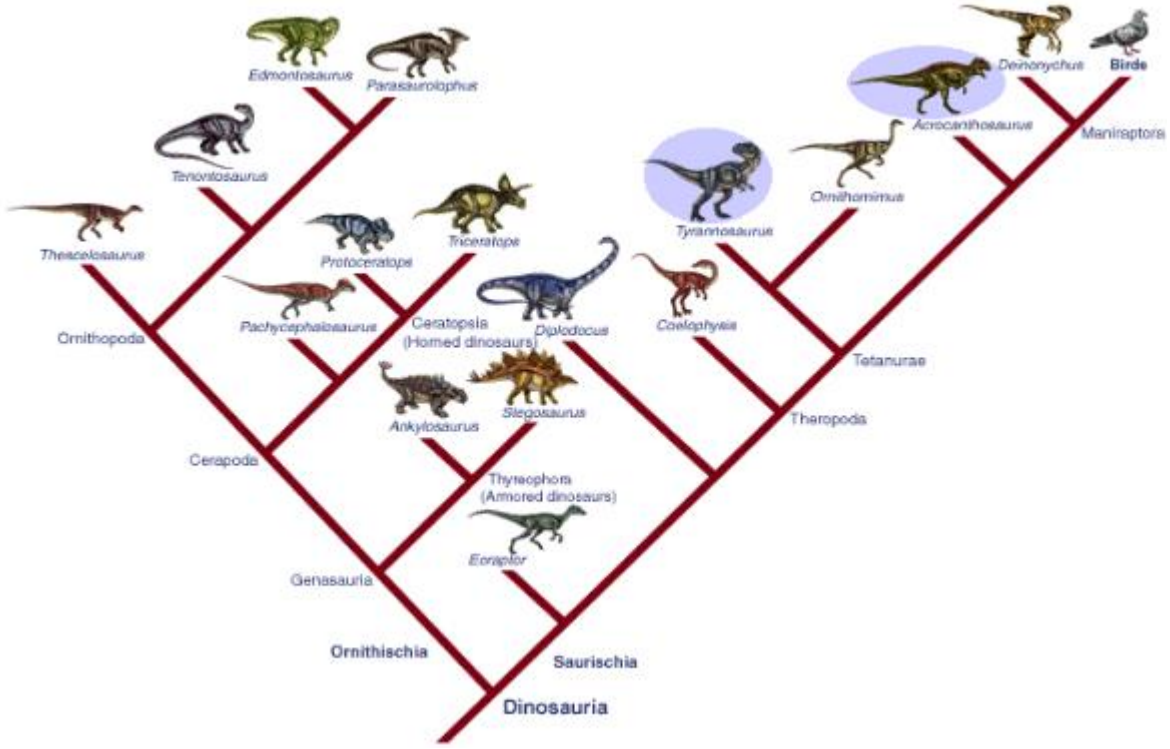
Nature of science:

Falsification of theories with one theory being superseded by another—plant families have been reclassified as a result of evidence from cladistics. (1.9)

Understandings:

∑ - A clade is a group of organisms that have evolved from a common ancestor.

- Over time species evolve and split to form new species
- This process can occur repeatedly with some highly successful species leading to a large group of organisms that share a common ancestor
- These groups of species evolved from a common ancestor, that have shared characteristics is called a clade



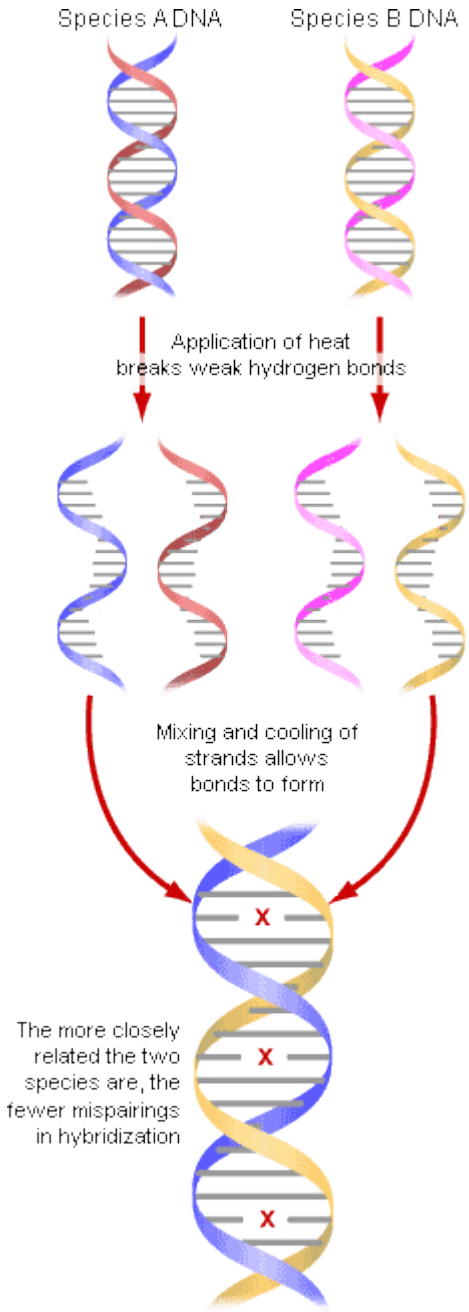
- Branch points in the tree represent the time at which the two taxa spilt from each other
- The degree of divergence between branches represent the differences that have developed between the two taxa since they diverged

∑ - Evidence for which species are part of a clade can be obtained from the base sequences of a gene or the corresponding amino acid sequence of a protein.

- Sometimes determining which species are part of a certain clade is difficult
- The most accurate evidence is derived from amino acid sequences of certain proteins, such as *Hemoglobin and Cytochrome C* and from base sequences of genes

DNA Base sequences

- DNA hybridization is performed with the DNA from other animal species to discover how closely they are related to humans



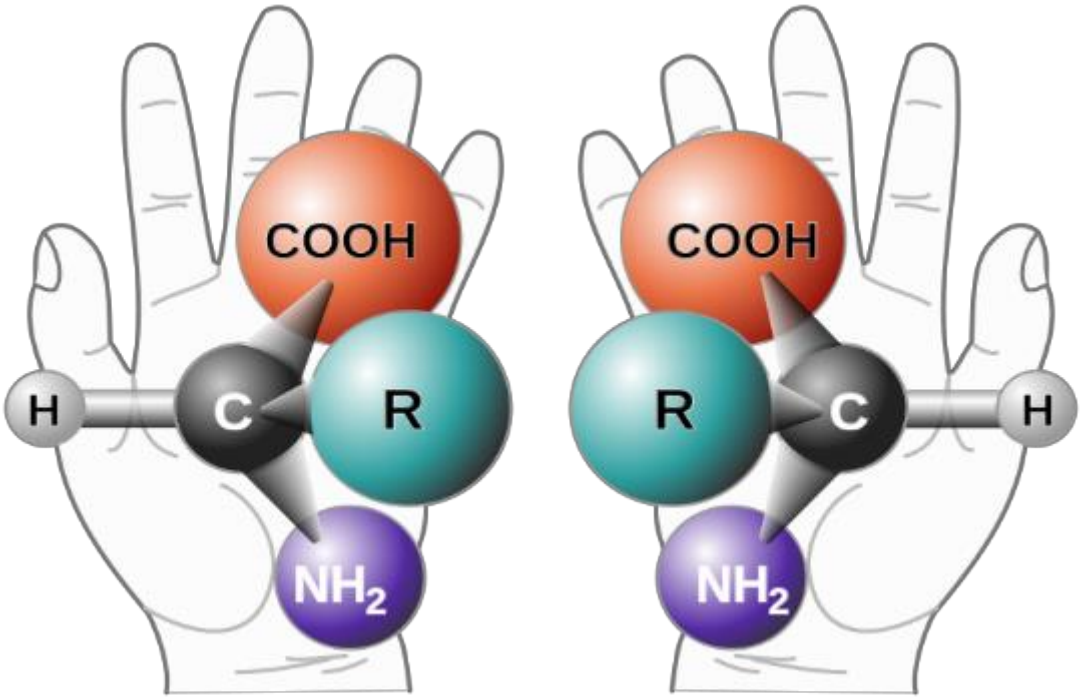
Amino Acid Sequence of Certain Proteins

- The sequences for alpha and beta hemoglobin are known for humans, chimpanzees, and gorillas. Humans and chimpanzees have identical alpha and beta sequences from which gorillas differ by only one residue in each chain.
- On position 23 on the alpha hemoglobin, for example, gorillas have the amino acid aspartic acid instead of glutamic acid and at position 104 on beta hemoglobin gorillas have lysine instead of arginine.

Link on similarities between human and chimpanzee **DNA** http://bit.ly/1DXeU0N

Scientific American Article http://bit.ly/1HkmRwt

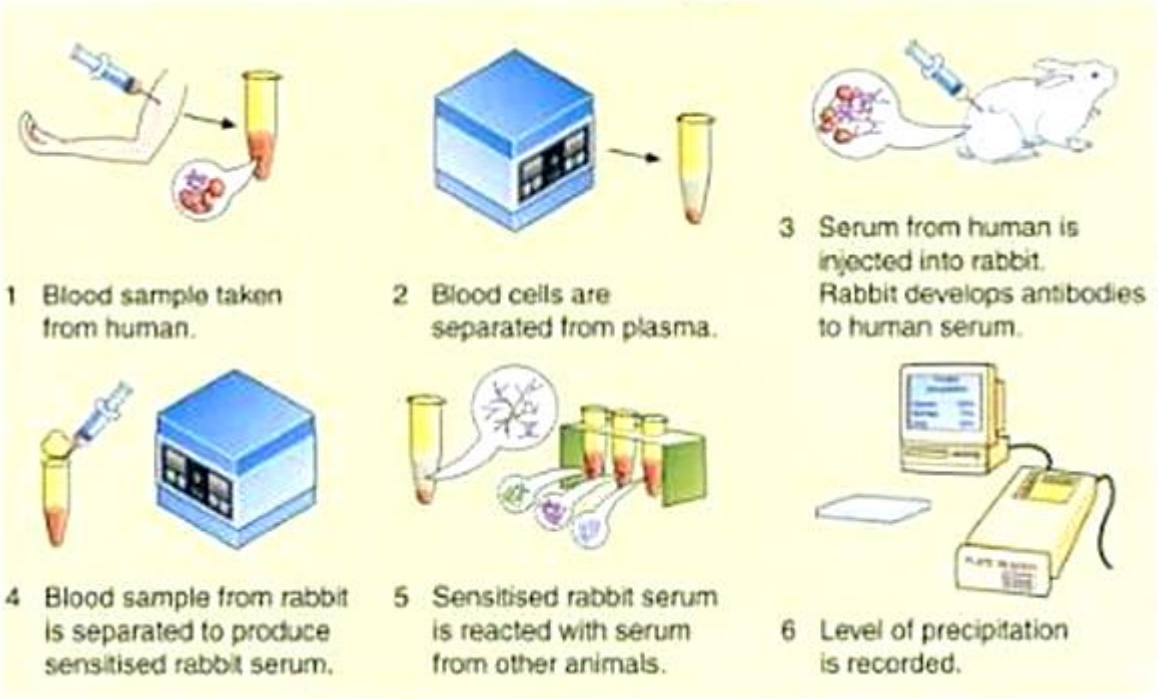
- Amino acids also have either right-handed or left-handed orientation
- The majority of organisms on earth use left-handed amino acids to build their proteins and only a small number use right-handed amino acids (mostly certain bacteria). This implies common ancestry for these life forms with the same amino acid orientation



- **Another example comes from immunological studies,** which is an way to detect differences in specific proteins of species, indirectly showing how closely two species are related
- Human blood serum (blood minus cells and fibrinogens) is obtained and injected into a rabbit
- Later a sample of the rabbits blood that contains anti-human antibodies to human proteins is taken
- Serum from other mammals is mixed with the anti-human antibodies
- The more the precipitation the more closely the animal is related to humans

Species	% Precipitation with human serum	% Difference from human
Human	100	-
Chimpanzee	95	5
Gorilla	95	5
Orangutan	85	15
Gibbon	82	18
Baboon	73	27

Spider Monkey	60	40



∑ - Sequence differences accumulate gradually so there is a positive correlation between the number of differences between two species and the time since they diverged from a common ancestor.

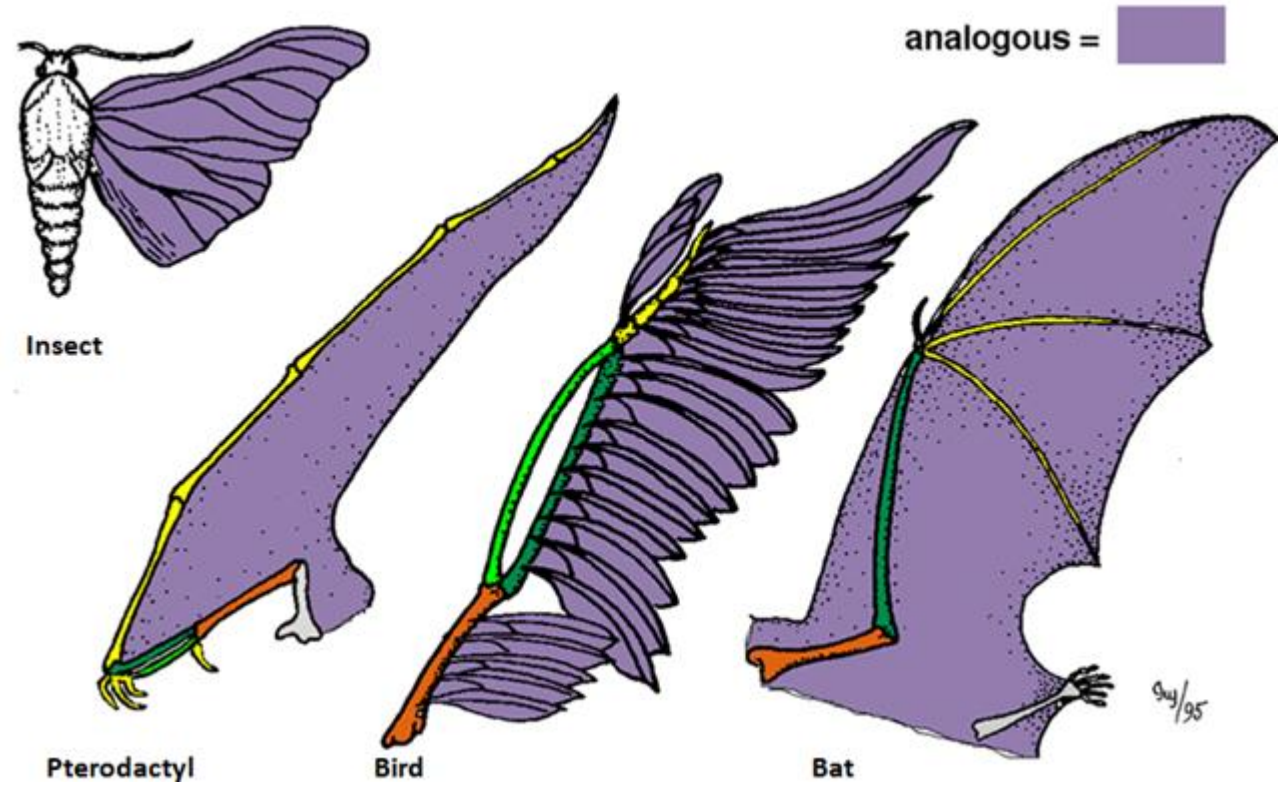
- Differences in the base sequence of DNA are caused by mutations. These gradually accumulate over time.
- By sequencing nuclear DNA and mitochondrial DNA, we can establish a biochemical phylogeny between species to show common ancestry
- The difference in the sequences can be used to deduce when a certain species split from a common ancestor

∑ - Traits can be analogous or homologous.

Analogous Structures

- Some animals belonging to different groups live in the same or similar habitat
- This can lead to development of similar superficial structures for organisms that live in a similar manner
- The structures look comparable anatomically from the outside; however, are not alike on the inside (do not share a common ancestor)

Example different types of wings or the fins between sharks and dolphins

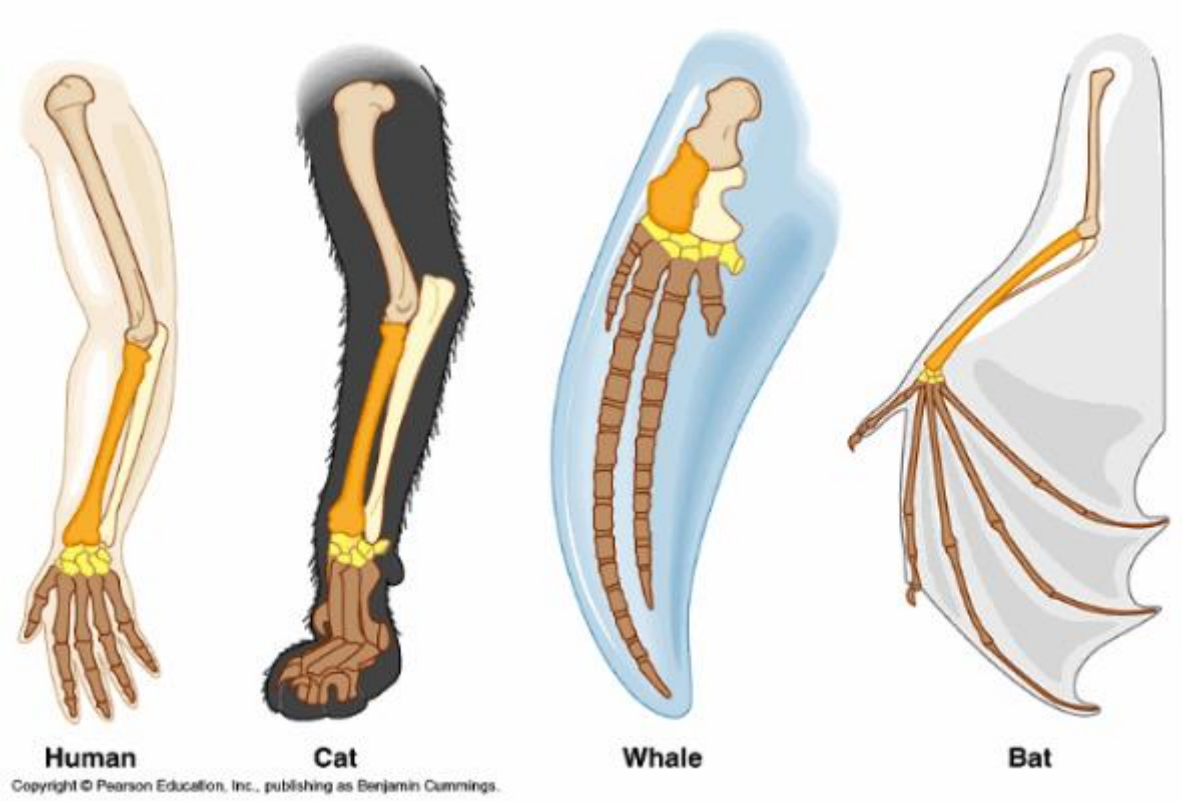


http://bit.ly/1CVSqcS

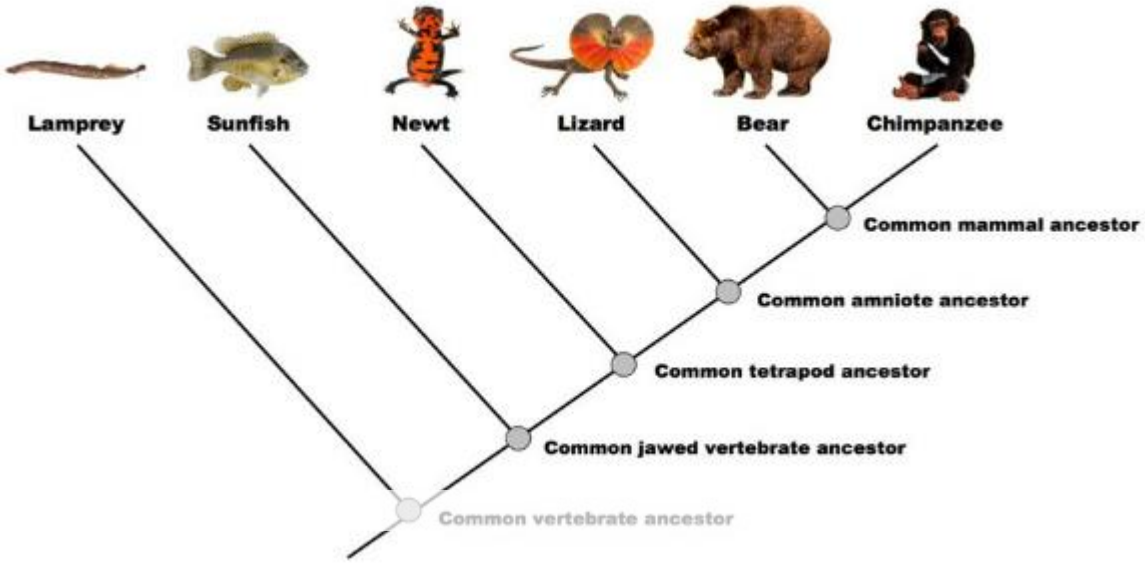
Homologous Structures

- Common internal structures that are similar in seemingly dissimilar animals that have evolved from a common ancestor.
- The standard example of homologous structures is the “pentadactyl limb” which is the five digit limb found in animals such as humans, dolphins, bats, and dogs.

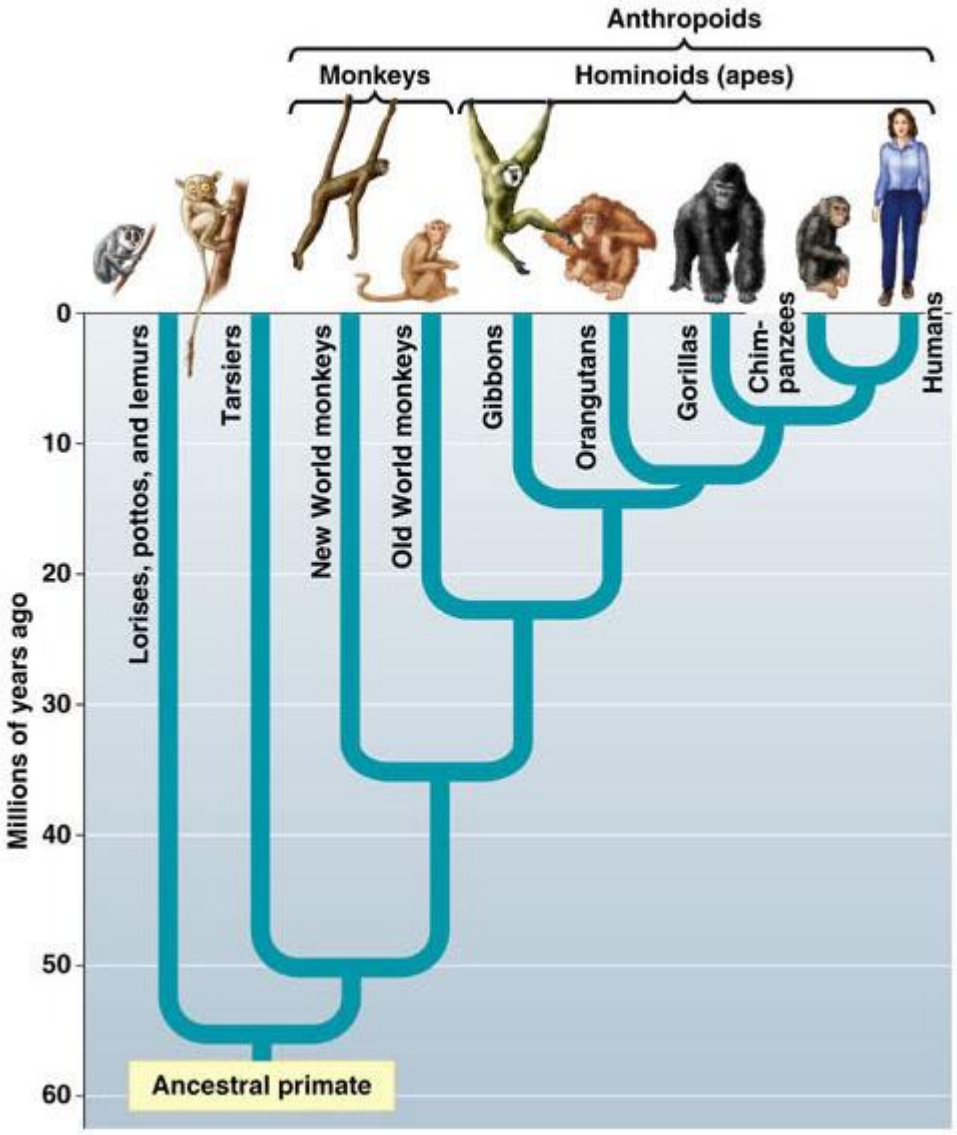
Even though the shape, size and function of this structure vary between species, the general structure and position of the bones in these limbs are the same.



∑ - Cladograms are tree diagrams that show the most probable sequence of divergence in clades.



β - Application: Cladograms including humans and other primates.



Draw a cladogram containing humans and other primates based on the order listed in the immunological study table above in the previous understanding

∑ - Evidence from cladistics has shown that classifications of some groups

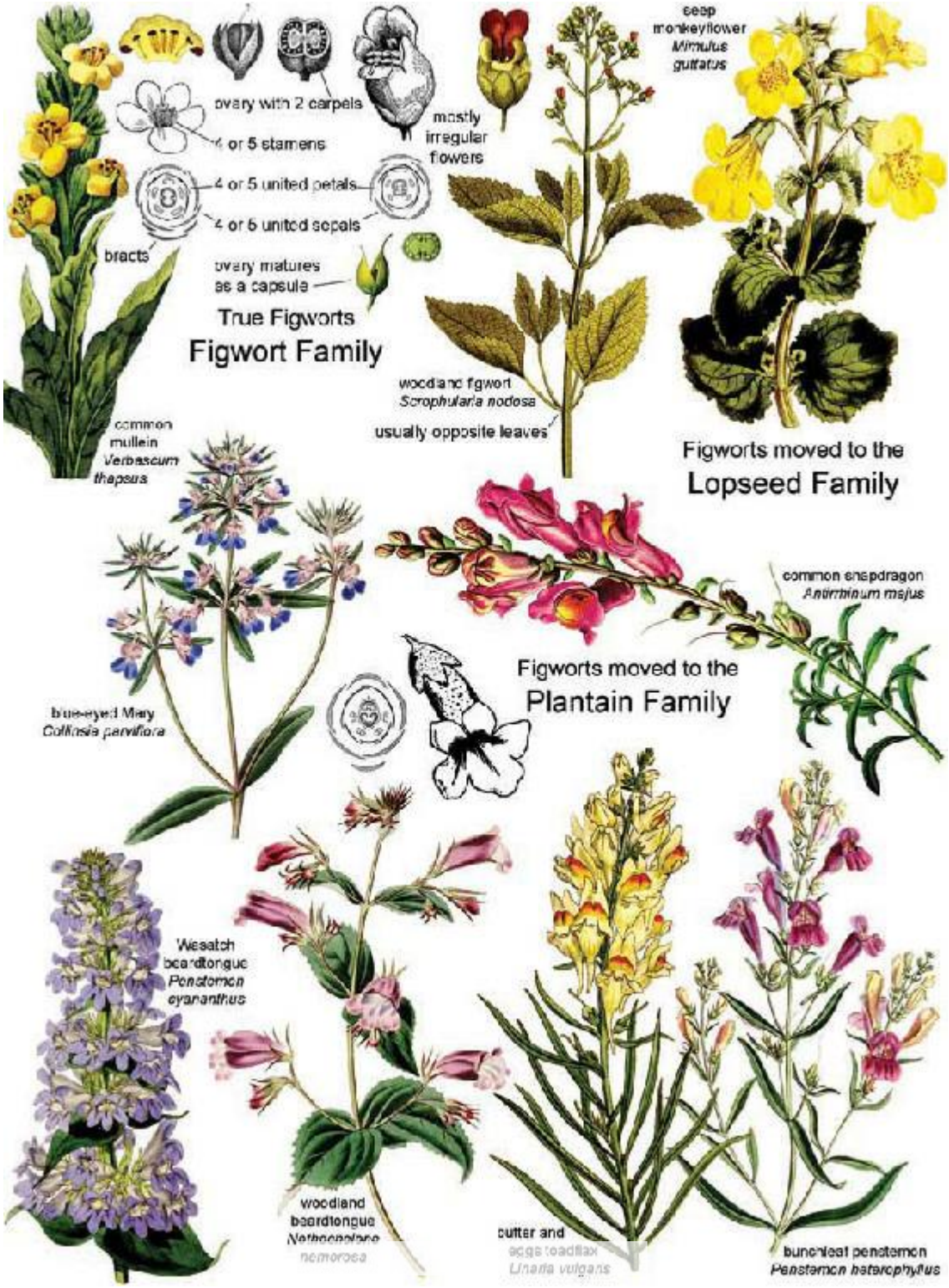
based on structure did not correspond with the evolutionary origins of a group or species.

- Since evidence from base and amino acid sequences only became possible in the mid to late 1900's, some changes have occurred in traditional classifications of certain plants and animals based solely on morphology
- Cladistics has provided evidence that shows some morphologies do not match the evolutionary origins of the groups of organisms they were put in to
- As a result some groups have been reclassified, some groups have merged or divided, and in some cases, some species have been moved to another group
- This process is time consuming; however, the new classifications based on cladistics, give a clear and more concise view of an organism's true natural classification

β - Application: Reclassification of the figwort family using evidence from cladistics.

- An example of the reclassification of an organism is the Family Scrophlahulariaceae
- At one point this family consisted of over 275 genera and 5000 species
- Scientists recently used cladistics to reclassify the Figworts family
- They focused on the base sequences of three chloroplast genes and discovered that the species in the Figwort family were not one clade but five clades and had been incorrectly grouped together into one family

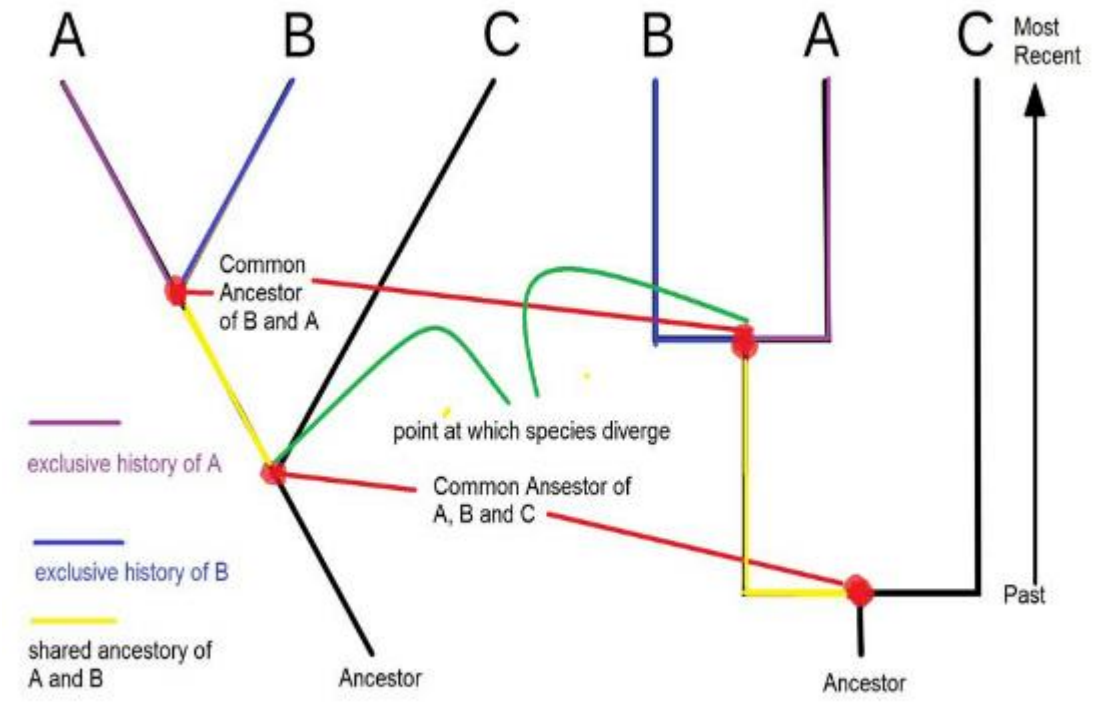
Below is a picture of some of the groupings now

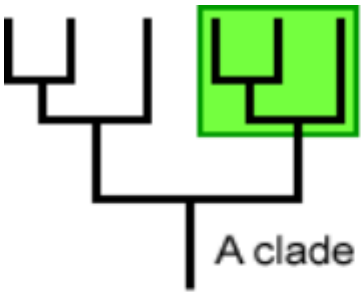


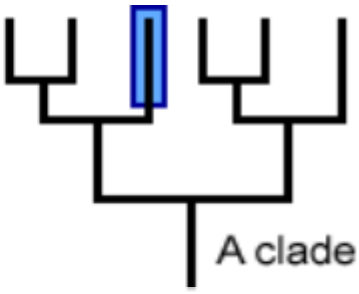
β - Skill: Analysis of cladograms to deduce evolutionary relationships.

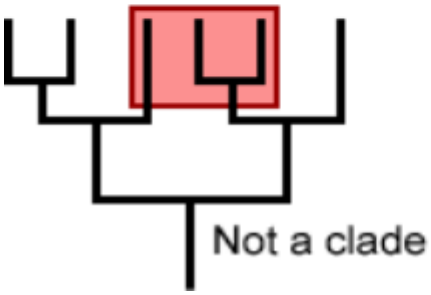
These are some pictures outlining which part of a cladogram is a clade and another picture I created on ancestry using a cladogram. The red dots are called nodes, and represent the time when two species are estimated to have split.

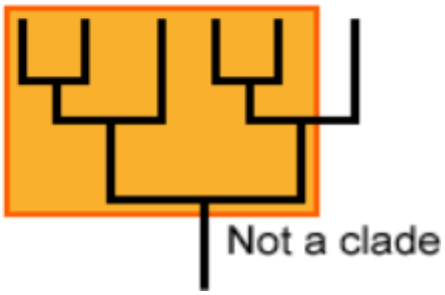
One thing to note, just because a species like C split earlier than from B, it does not mean that B has evolved more. All the species at the top are present D species. The ones that have died out or changed would be at the nodes.

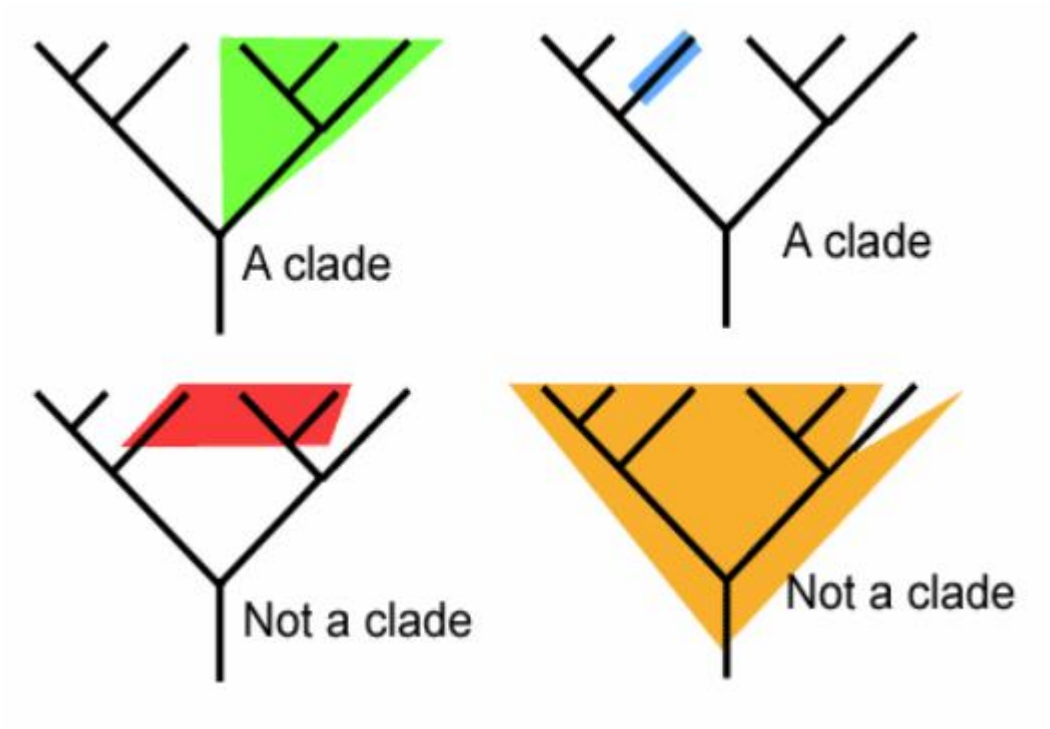












******Create your own cladogram that contains at least 8 organisms using biochemical evidence such as DNA, Protein similarities or immunological studies. ******

Topic 1 - Cells
Topic 2 - Molecular Biology
Topic 3 - Genetics
Topic 4 - Ecology
Topic 5 - Evolution & Biodiversity
Topic 5.1 - Evidence for Evolution
Topic 5.2 - Natural Selection
Topic 5.3 - Classification of Biodiversity
Topic 5.4 - Cladistics
Topic 6- Human Health and Physiology
Topic 7 - Nucleic Acids (AHL)
Topic 8 - Respiration and Photosynthesis (AHL)
Topic 9 - Plant Biology (AHL)
Topic 10 - Genetics and Evolution (AHL)
Topic 11 - Physiology (AHL)