Name:____Period:______Date:______
Ms. Randall LE
Unit 7 Evolution and Classification

Unit Objectives:

- Explain what organism classification is and the purpose of this.
- List the six major kingdoms of living things and state some basic characteristics and examples of these.
- Define the term evolution and recognize that current life forms have evolved from earlier life forms.
- Define the term adaptation.
- State Darwin's theory of natural selection and explain the following features in his theory; overproduction, competition, variations, survival of the fittest, reproduction, and speciation.
- Compare the modern natural selection theory to that of Darwin.
- Explain why increased genetic diversity tends to enhance the survival of a species.
- Recognize that organisms are classified based on structural similarities and evolutionary relationships.
- Realize that small differences between parents and offspring can accumulate over successive generations so that descendants become very different from their ancestors.
- Explain the heterotroph hypothesis.

Focus Questions for the Unit:
How can we tell how closely related organisms are?
How are living things classified?

Define the following vocabulary:

genus
species
dichotomous key
cladogram
evolution
meiosis
fossil
evolution
speciation
natural selection

adaptation
gene pool
mutation
classification
phylogeny
descent with modification
homologous structure
analogous structure
vestigial organ
embryology

Lesson 1: Evolution and phylogeny

Date:______

Objective: To define the central ideas of evolution and apply them to a phylogeny tree

Biological evolution, simply put, is descent with modification. This definition encompasses small-scale evolution (changes in gene frequency in a population from one generation to the next) and large-scale evolution (the descent of different species from a common ancestor over many generations). Evolution helps us to understand the history of life. Biological evolution is not simply a matter of change over time. Lots of things change over time: trees lose their leaves, mountain ranges rise and erode, but they aren't examples of biological evolution because they don't involve descent through genetic inheritance.

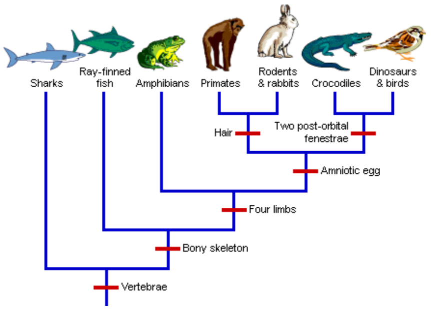
The central idea of biological evolution is that all life on Earth shares a common ancestor, just as you and your cousins share a common grandmother.

Through the process of descent with modification, the common ancestor of life on Earth gave rise to the fantastic diversity that we see documented in the fossil record and around us today. Evolution means that we're all distant cousins: humans and oak trees, hummingbirds and whales.

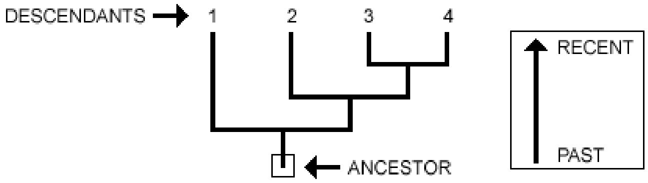
The central ideas of evolution are that life has a history — it has changed over time — and that different species share common ancestors.

We can explore how evolutionary change and evolutionary relationships are represented in "family trees," how these trees are constructed, and how this knowledge affects biological classification. The process of evolution produces a pattern of relationships between species. As lineages evolve and split and modifications are inherited, their evolutionary paths diverge. This produces a branching pattern of evolutionary relationships.

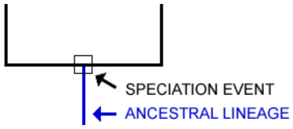
By studying inherited species' characteristics and other historical evidence, we can reconstruct evolutionary relationships and represent them on a "family tree," called a phylogeny. The phylogeny you see below represents the basic relationships that tie all life on Earth together.



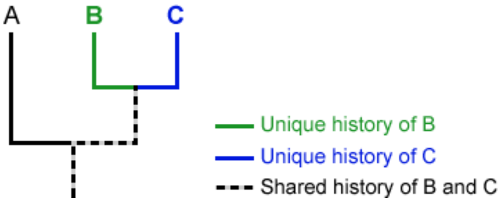
Understanding a phylogeny is a lot like reading a family tree. The root of the tree represents the ancestral lineage, and the tips of the branches represent the descendants of that ancestor. As you move from the root to the tips, you are moving forward in time. Cladograms are diagrams which depict the relationships between different groups of taxa called "clades". By depicting these relationships, *cladograms* reconstruct the evolutionary history (phylogeny) of the taxa. Cladograms can also be called "phylogenies" or "trees".



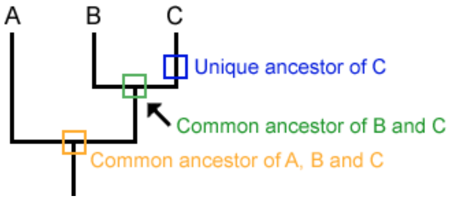
When a lineage splits (speciation), it is represented as branching on a phylogeny. When a speciation event occurs, a single ancestral lineage gives rise to two or more daughter lineages.



Phylogenies trace patterns of shared ancestry between lineages. Each lineage has a part of its history that is unique to it alone and parts that are shared with other lineages.

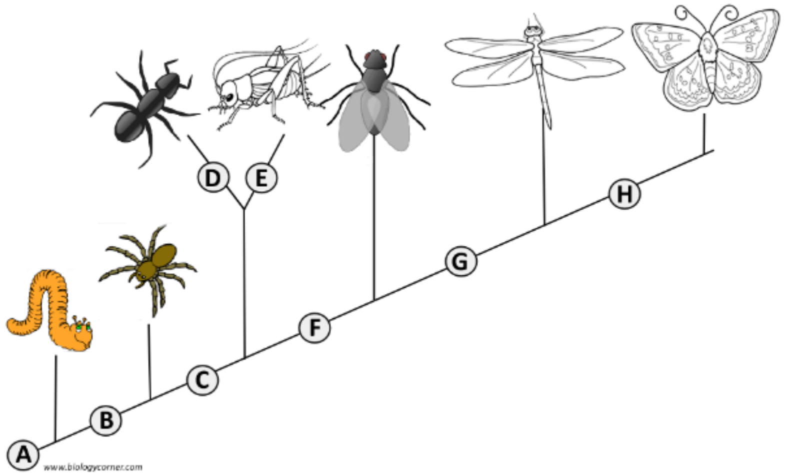


Similarly, each lineage has ancestors that are unique to that lineage and ancestors that are shared with other lineages — <u>common ancestors</u>.



<u>Check your understanding:</u>

Examine the sample cladogram, each letter on the diagram points to a derived character, or something different (or newer) than what was seen in previous groups. Match the letter to its character. Note: this cladogram was created for simplicity and understanding, it does not represent the established phylogeny for insects and their relatives



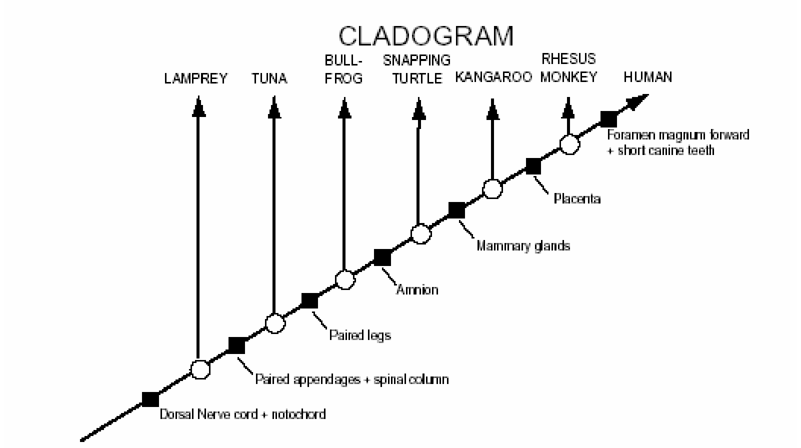
1. _____ Wings
2. _____ 6 Legs
3. _____ Segmented Body
4. _____ Double set of wings
5. . _____ Jumping legs
6 . _____ Crushing mouthparts
7. _____ Legs
8. Curly antennae

Practice:

Introduction:

Technology today allows scientist to compare organisms at the molecular level. By comparing characteristics such as DNA fragments and amino acid sequences in specific proteins, scientists are looking at the evolutionary relationships between organisms in ways Darwin and Wallace; two scientists whose work defined the science of evolution could not. In this activity, you are going to compare the amino acids sequences for a protein known as Cytochrome C of 5 different species or animals. Cytochrome-C is a protein that helps cells produce energy and, therefore, it is found in the mitochondria of cells.

1. The cladogram diagram below shows the relationship of selected animals based on their shared anatomical features. For example, out of seven key traits, all of these animals have a dorsal nerve cord but only humans, monkeys and kangaroos have mammary glands.



2. What trait is shared by all organisms in the cladogram?

____

3. What organisms possess mammary glands?

____

4. Based on the cladogram, which species is most closely related to a human. Explain

____

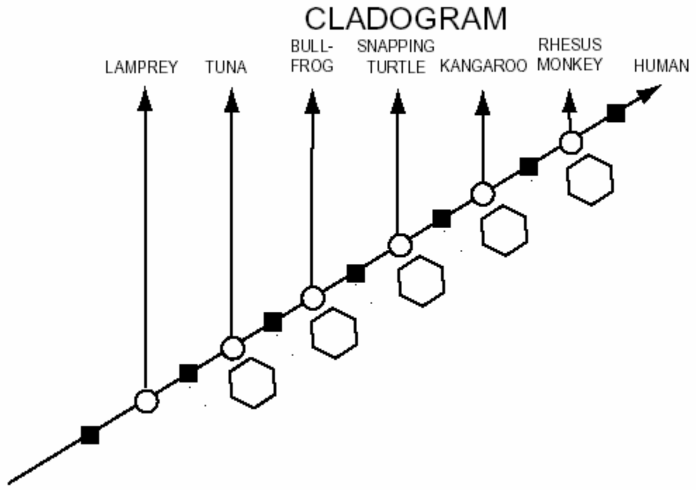
____

5. Find the human, rhesus monkey, kangaroo, snapping turtle, bullfrog, and tuna on the "Amino Acid Sequences in Cytochrome-C Proteins from 20 Different Species" chart provided and underline their names. Compare the human amino acid sequence with each of these five animals by counting the number of times an amino acid in that animal's cytochrome c is different from the amino acid in that same position of the human sequence. For example, the number of differences between human and dog=10.

6. Write that information below:

Number of amino acid differences between human and
Rhesus monkey= __________ Snapping turtle= __________ Tuna=__________
Kangaroo= __________ Bullfrog=__________

Record the total number of amino acid differences between humans and each animal shown below. Write your answer in the hexagon below the arrow pointing to the name of that animal.



7. Does the data from the amino acid sequence generally agree with the anatomical data that was used to make the cladogram? Use specific examples from the cladogram.

____

____

____

8. Do organisms with fewer shared anatomical traits also have more amino acid differences? Use specific examples from the cladogram.

____

____

____

9. Based on the molecular data, how does the "human-monkey" relationship compare to the "duck chicken" relationship (which shows three amino acid differences)? Be sure to state which pairing is more closely related and why.

____

____

____

10. Which two species, a dog and a gray whale or a snapping turtle and a bullfrog, do you think are more closely related? Explain your reasoning.

____

____

____

11. Based on the molecular data, which two species, dogs and gray whales or snapping turtles and bullfrogs, are more closely related. Use specific data to support your answer.

____

____

____

How did this compare to your prediction in question 10?

____

____

____

12. Chickens and turkeys are both birds and have the same sequence of amino acids in their cytochrome-c protein. Explain how two species can have identical cytochrome-c and still be different species.

____

____

____

AMINO ACID SEQUENCES IN CYTOCHROME-C PROTEINS FROM 20 DIFFERENT SPECIES

	10 20 30 40 50
Amino Acid Number----->	1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9
Human	- - - - - - - - G D V E K G K K I F I M K C S Q C H T V E K G G K H K T G P N L H G L F G R K T G Q A P G Y S Y T A A
Rhesus monkey.....	- - - - - - - - G D V E K G K K I F I M K C S Q C H T V E K G G K H K T G P N L H G L F G R K T G Q A P G Y S Y T A A
Horse	- - - - - - - - G D V E K G K K I F V Q K C A Q C H T V E K G G K H K T G P N L H G L F G R K T G Q A P G F T Y T D A
Pig, cow, sheep...	- - - - - - - - G D V E K G K K I F V Q K C A Q C H T V E K G G K H K T G P N L H G L F G R K T G Q A P G F S Y T D A
Dog..............	- - - - - - - - G D V E K G K K I F V Q K C A Q C H T V E K G G K H K T G P N L H G L F G R K T G Q A P G F S Y T D A
Gray whale	- - - - - - - - G D V E K G K K I F V Q K C A Q C H T V E K G G K H K T G P N L H G L F G R K T G Q A V G F S Y T D A
Rabbit...........	- - - - - - - - G D V E K G K K I F V Q K C A Q C H T V E K G G K H K T G P N L H G L F G R K T G Q A V G F S Y T D A
Kangaroo..........	- - - - - - - - G D V E K G K K I F V Q K C A Q C H T V E K G G K H K T G P N L N G I F G R K T G Q A P G F T Y T D A
Chicken, Turkey...	- - - - - - - - G D I E K G K K I F V Q K C S Q C H T V E K G G K H K T G P N L H G L F G R K T G Q A E G F S Y T D A
Penguin...........	- - - - - - - - G D I E K G K K I F V Q K C S Q C H T V E K G G K H K T G P N L H G I F G R K T G Q A E G F S Y T D A
Pekin duck........	- - - - - - - - G D V E K G K K I F V Q K C S Q C H T V E K G G K H K T G P N L H G L F G R K T G Q A E G F S Y T D A
Snapping turtle...	- - - - - - - - G D V E K G K K I F V Q K C A Q C H T V E K G G K H K T G P N L N G L I G R K T G Q A E G F S Y T E A
Bullfrog..........	- - - - - - - - G D V E K G K K I F V Q K C A Q C H T C E K G G K H K V G P N L Y G L I G R K T G Q A A G F S Y T D A
Tuna..............	- - - - - - - - G D V A K G K K T F V Q K C A Q C H T V E N G G K H K V G P N L W G L F G R K T G Q A E G Y S Y T D A
Screwworm fly.....	- - - - G V P A G D V E K G K K I F V Q R C A Q C H T V E A G G K H K V G P N L H G L F G R K T G Q A A G F A Y T N A
Silkworm moth.....	- - - - G V P A G N A E N G K K I F V Q R C A Q C H T V E A G G K H K V G P N L H G F Y G R K T G Q A P G F S Y S N A
Wheat	A S F S E A P P G N P D A G A K I F K T K C A Q C H T V D A G A G H K Q G P N L H G L F G R Q S G T T A G Y S Y S A A
Fungus (*Neurospora*)	- - - - G F S A G D S K K G A N L F K T R C A E C H G E G G N L T Q K I G P A L H G L F G R K T G S V D G Y A Y T D A
Fungus (baker's yeast)	- - - T E F K A G S A K K G A T L F K T R C E L C H T V E K G G P H K V G P N L H G I F G R H S G Q A Q G Y S Y T D A
Fungus (*Candida*)	- - P A P F E O G S A K K G A T L F K T R C A E C H T I E A G G P H K V G P N L H G I F S R H S G Q A Q G Y S Y T D A

[CONTINUED FROM ABOVE]

	60 70 80 90 100 110
Amino Acid Number----->	0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2
Human	N K N K G I I W G E D T L M E Y L E N P K K Y I P G T K M I F V G I K K K E E R A D L I A Y L K K A T N E
Rhesus monkey.....	N K N K G I T W G E D T L M E Y L E N P K K Y I P G T K M I F V G I K K K E E R A D L I A Y L K K A T N E
Horse	N K N K G I T W K E E T L M E Y L E N P K K Y I P G T K M I F A G I K K K T E R E D L I A Y L K K A T N E
Pig, cow, sheep...	N K N K G I T W G E E T L M E Y L E N P K K Y I P G T K M I F A G I K K K G E R E D L I A Y L K K A T N E
Dog...............	N K N K G I T W G E E T L M E Y L E N P K K Y I P G T K M I F A G I K K T G E R A D L I A Y L K K A T K E
Gray whale........	N K N K G I T W G E E T L M E Y L E N P K K Y I P G T K M I F A G I K K K G E R A D L I A Y L K K A T N E
Rabbit............	N K N K G I T W G E D T L M E Y L E N P K K Y I P G T K M I F A G I K K K D E R A D L I A Y L K K A T N E
Kangaroo..........	N K N K G I I W G E D T L M E Y L E N P K K Y I P G T K M I F A G I K K K G E R A D L I A Y L K K A T N E
Chicken, Turkey...	N K N K G I T W G E D T L M E Y L E N P K K Y I P G T K M I F A G I K K K S E R V D L I A Y L K D A T S K
Penguin...........	N K N K G I T W G E D T L M E Y L E N P K K Y I P G T K M I F A G I K K K S E R A D L I A Y L K D A T S K
Pekin duck........	N K N K G I T W G E D T L M E Y L E N P K K Y I P G T K M I F A G I K K K S E R A D L I A Y L K D A T A K
Snapping turtle...	N K N K G I T W G E E T L M E Y L E N P K K Y I P G T K M I F A G I K K K A E R A D L I A Y L K D A T S K
Bullfrog..........	N K N K G I T W G E D T L M E Y L E N P K K Y I P G T K M I F A G I K K K G E R Q D L I A Y L K S A C S K
Tuna..............	N K S K G I V W N N D T L M E Y L E N P K K Y I P G T K M I F A G I K K K G E R Q D L V A Y L K S A T S -
Screwworm fly.....	N K A K G I T W Q D D T L F E Y L E N P K K Y I P G T K M I F A G L K K P N E R G D L I A Y L K S A T K -
Silkworm moth.....	N K A K G I T W G D D T L F E Y L E N P K K Y I P G T K M V F A G L K K A N E R A D L I A Y L K E S T K -
Wheat	N K N K A V E W E E N T L Y D Y L L N P K K Y I P G T K M V F P G L K K P Q D R A D L I A Y L K K A T S S
Fungus 1 (*Neurospora*)	N K Q K G I T W D E N T L F E Y L E N P K K Y I P G T K M A F G G L K K D K D R N D I I T F M K E A T A -
Fungus 2 (bkrs yeast)	N I K K N V L W D E N N M S E Y L T N P K K Y I P G T K M A F G G L K K E K D R N D L I T Y L K K A C E -
Fungus 3 (*Candida*)	N K R A G V E W A E P T M S D Y L E N P K K Y I P G T K M A F G G L K K A K D R N D L V T Y M L E A S K -

AMINO ACID SYMBOLS

A - Alanine
C - Cysteine
D - Aspartic acid
E - Glutamic acid
F - Phenylalanine
G - Glycine
H - Histidine
I - Isoleucine
K - Lysine
L - Leucine
M - Methionine
N - Asparagine
P - Proline
Q - Glutamine
R - Arginine
S - Serine
T - Threonine
V - Valine
W - Tryptohpan
Y - Tyrosine

Symbols in light blue or gray represent amino acids which show NO differences in any organism on the list, so you can ignore them.
(adapted from Strahler, Arthur, *Science & Earth History*, 1987, p. 348)

Lesson 2: Classification Date:_____________

Objective: To classifiy organisms using a dichotomous key

Before the advent of modern, genetically based evolutionary studies, European and American biology consisted primarily of **taxonomy**, or classification of organisms into different categories based on their physical characteristics and presumed natural relationship. The leading naturalists of the 18th and 19th centuries spent their lives identifying and naming newly discovered plants and animals. However, few of them asked what accounted for the patterns of similarities and differences between the organisms. This basically nonspeculative approach is not surprising since most naturalists two centuries ago held the view that plants and animals (including humans) had been created in their present form and that they have remained unchanged. As a result, it made no sense to ask how organisms have evolved through time. Similarly, it was inconceivable that two animals or plants may have had a common ancestor or that extinct species may have been ancestors of modern ones.

One of the most important 18th century naturalists was a Swedish botanist and medical doctor named Karl von Linné. He wrote 180 books mainly describing plant species in extreme detail. Since his published writings were mostly in Latin, he is known to the scientific world today as **Carolus Linnaeus**

Carolus Linnaeus
1707-1778

Classification of living things is called "Taxonomy." This is when scientists put organisms into groups when they have things in common. The first groups they use are the Kingdoms. There are five kingdoms:

- **Animal Kingdom:** organisms that usually move around and find their own food.
- **Plant Kingdom:** organisms that make their own food and do not actively move around.
- **Fungi Kingdom:** organisms that absorb food from living and non-living things.
- **Protist Kingdom:** organisms that have single, complex cells.
- **Moneran Kingdom:** organisms that have single, simple cells.

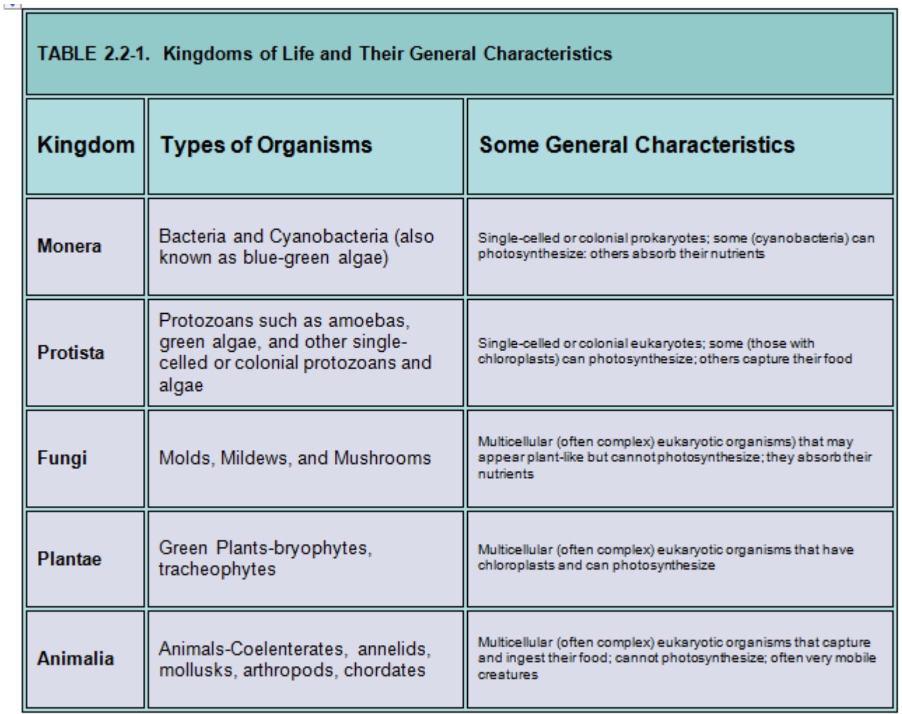


TABLE 2.2-1. Kingdoms of Life and Their General Characteristics		
Kingdom	**Types of Organisms**	**Some General Characteristics**
Monera	Bacteria and Cyanobacteria (also known as blue-green algae)	Single-celled or colonial prokaryotes; some (cyanobacteria) can photosynthesize: others absorb their nutrients
Protista	Protozoans such as amoebas, green algae, and other single-celled or colonial protozoans and algae	Single-celled or colonial eukaryotes; some (those with chloroplasts) can photosynthesize; others capture their food
Fungi	Molds, Mildews, and Mushrooms	Multicellular (often complex) eukaryotic organisms) that may appear plant-like but cannot photosynthesize; they absorb their nutrients
Plantae	Green Plants-bryophytes, tracheophytes	Multicellular (often complex) eukaryotic organisms that have chloroplasts and can photosynthesize
Animalia	Animals-Coelenterates, annelids, mollusks, arthropods, chordates	Multicellular (often complex) eukaryotic organisms that capture and ingest their food; cannot photosynthesize; often very mobile creatures

Each **Kingdom** is then split into smaller groups, called Phyla. Each **Phylum** is split into smaller groups called Classes, each **Class** is split into Orders, each **Order** is split into Families, each **Family** is split into Genera, and each **Genus** is split into **Species**. A Species is a single organism, not a group. Some examples of species would be Southern Leopard Frog, Honey Mushroom, or White Oak. All seven types of groups go in order from largest to smallest, like this:

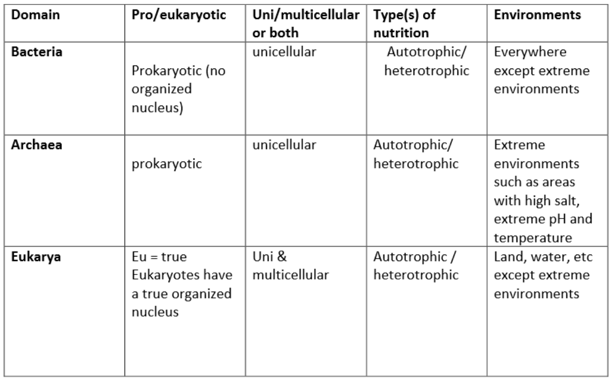
- Kingdom
- Phylum
- Class
- Order
- Family
- Genus
- Species

As each group is split into smaller groups, the organisms are more and more alike. For instance, a White-tailed Deer, an Eastern Gray Squirrel, and an Eastern Chipmunk are all in the Mammal Class together. This is because they have more in common with each other than with other animals, such as turtles, birds, or insects. However, it is easy to notice that there are some big differences between a deer and squirrels and chipmunks. The White-tailed Deer is in the Aritiodactyla Order (Even-toed Hoofed Mammals), while squirrels and chipmunks are both in the Rodentia Order (Rodents). In fact, squirrels and chipmunks have so much in common; they are also in the same Family, the Sciuridae Family. However, even though squirrels and chipmunks are very much alike, they still have differences. The Eastern Gray Squirrel is in the Sciurus Genus, while the Eastern Chipmunk is in the Tamias Genus.

Did you notice that these groups have funny names? Scientists from around the world agreed to use the ancient language of Latin to give organisms, and their groups, names. Sometimes a group will have a "Common Name" and a fancy, scientific Latin name. For example, there is a Family of frogs called "Ranidae" (Scientific Latin name). This Family's common English name is "True Frogs." Sometimes this gets confusing. Every Species gets a fancy scientific Latin name. A Bullfrog is also known as "*Rana catesbeiana.*" A White-tailed Deer is known as "*Odocoileus virginianus*." A Monarch butterfly is known as "*Danaus plexipus*." We are *"Homo sapiens."*

- One thing that makes it easier to understand all these names is to know that a Species always has a first and a last name; and that the first name is also the name of the Genus group that Species is in. So the Monarch butterfly is known as *Danaus plexipus* and it is in the *Danaus* genus. Notice that the first name of a Species is always capitalized, while the second name is not. A Species is a group of organisms that are similar in structure and can mate to produce fertile offspring.

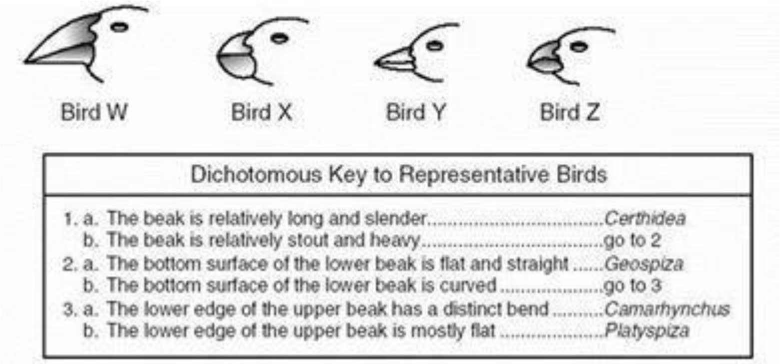
This is known as the Linnaean system of classification. It assigns every organism a kingdom, phylum, class, order, family, genus, and species, which, among other possibilities, has the handy mnemonic **K**ing **P**hilip **C**ame **O**ver **F**or **G**ood **S**oup. This system was created long before scientists understood that organisms evolved. Because the Linnaean system is not based on evolution, most biologists are switching to a classification system that reflects the organisms' evolutionary history. Recent evidence provided by rRNA (ribosomal RNA, a form of genetic material) has suggested that a broader grouping is necessary above kingdom. This grouping is referred to as a domain. All life as we know it now can be grouped into three distinct domains: Bacteria, Archaea and Eukarya



Domain	**Pro/eukaryotic**	**Uni/multicellular or both**	**Type(s) of nutrition**	**Environments**
Bacteria	Prokaryotic (no organized nucleus)	unicellular	Autotrophic/ heterotrophic	Everywhere except extreme environments
Archaea	prokaryotic	unicellular	Autotrophic/ heterotrophic	Extreme environments such as areas with high salt, extreme pH and temperature
Eukarya	Eu = true Eukaryotes have a true organized nucleus	Uni & multicellular	Autotrophic / heterotrophic	Land, water, etc except extreme environments

We can find the name of a species by using a tool called a dichotomous key. A dichotomous key is a tool that allows the user to determine the identity of items in the natural world, such as trees, wildflowers, mammals, reptiles, rocks, and fish. Keys consist of a series of choices that lead the user to the correct name of a given item. "Dichotomous" means "divided into two parts". Therefore, dichotomous keys always give two choices in each step.

A Dichotomous Key is a series of branching, two-part statements used to identify organisms or objects. Organisms are classified into various taxa with defined criteria which provide a framework for identifying organisms. Dichotomous Keys are basically a structure in which a large set of items is broken down into smaller subsets, ultimately leading to the smallest available classification level.



Dichotomous Key to Representative Birds

1. a. The beak is relatively long and slender.................................*Certhidea*
   b. The beak is relatively stout and heavy...................................go to 2
2. a. The bottom surface of the lower beak is flat and straight ......*Geospiza*
   b. The bottom surface of the lower beak is curved ....go to 3
3. a. The lower edge of the upper beak has a distinct bend ....*Camarhynchus*
   b. The lower edge of the upper beak is mostly flat ....*Platyspiza*

If we pick a bird in the above image, we can follow the dichotomous key to figure out which species it is. For example, if we choose Bird X: 1b to 2b to 3a (*Camarthyncus*)

A key challenge that traditional taxonomists face is deciding and agreeing on what criteria to use to define each taxon. The choice of criteria is often hotly debated but most modern taxonomists no longer use similarity as the basis for grouping organisms. Now, biologists use the principle of relatedness to classify organisms and this is based on the evolutionary history of a species. This new approach has significant advantages but many biologists still us the traditional and familiar classification system.

Check your understanding:

1. Why do scientists classify living things?

2. Organisms that below to the same class, must belong to the same : (check)
   ____ Order _____Phylum ____Kingdom ___ Family

3. Fill in the blanks:

   Kingdom --> ______________ --> Class --> _______________
   --> _________________ --> Genus --> _______________

4. How does a dichotomous key work?

<u>Practice:</u>

Five-Kingdom System

Animal Kingdom – Invertebrates (without backbones) and vertebrates (with backbones), multicellular, no cell walls, obtain energy through respiration.
Plant Kingdom – multicellular, have cell walls, obtain energy through photosynthesis. Ex. mosses, ferns, flowering and seed plants
Fungi Kingdom – cells with cell walls but not green and do not carry out photosynthesis, break down other organic materials to obtain food. Ex. mushrooms, molds, and yeasts.
Protist Kingdom – come in a wide variety of forms, some are animal-like, such as amoeba, paramecium and protozoan. Some are plant-like such as algae and others are fungi-like. Many are single-celled and others are multicellular.
Monera Kingdom – some photosynthesize while others respire. The nuclei of Moneran cells are not bounded by nuclear membranes like cells in the other kingdoms. Ex. bacteria and blue-green algae.

The classification of humans –
Homo sapiens

The two part naming system is called Binomial nomenclature (consists of genus and species.).

Kingdom:
Animalia
Phylum:
Chordata
Class:
Mammalia
Order:
Primata
Family:
Hominadae
Genus:
Homo
Species: sapiens (note: species is not capitalized.

Using the information above, answer the following questions.

1. What is the next smallest classification group after Order? ______________
2. What is the smallest classification group? ______________
3. Every living organism has what classification groups as its name? _________ and ________
4. The first letter of every genus name is ______________.
5. The first letter of every species name is _______________.
6. What is binomial nomenclature? ____.
7. Give one example of how you classification is used at school.

8. Why is the understanding of classification an important life skill?

<u>Lesson 3: Charles Darwin and Evolution</u> Date:________

Objective: To describe the process of evolution as defined by Darwin

Evolution is defined as the study of how a species changes over time. Changes occur more rapidly for organisms with shorter reproductive cycles. Many different scientists contributed to the modern day theory of evolution.

Biodiversity – total of the variety of organisms in the biosphere (part of Earth in which life exists including land, water, and air)

Patterns of Biodiversity

1. Species vary globally
2. Species vary locally
3. Species vary over time

Charles Darwin

Darwin was a naturalist that traveled the world making observations about the world around him. He developed a theory of evolution that explains how organisms have evolved through the descent from common ancestors. As Darwin made his observations he noted specific patterns of biodiversity.

Science that Influenced Darwin

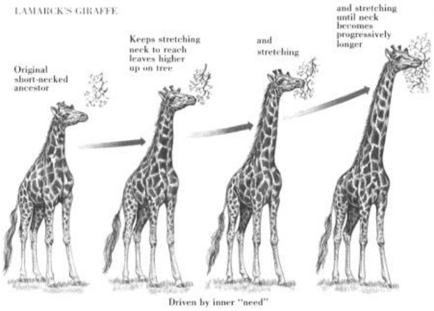
Darwin used information that geologist had collected to help him build the foundation for evolution.

Hutton and Lyell

Many people in Darwin's time believed that Earth was only a few thousand years old (actual age 4.54 billion years) and that it hadn't undergone many changes. Geologists James Hutton and Charles Lyell studied various geological processes. Their studies allowed them to conclude that Earth is extremely old and that processes that changed the planet in the past are the same processes that are operating today. Hutton and Lyell's work helped explain to Darwin how fossils of rocks and animals that were once beneath the sea could be pushed to the surface.

Lamarck

Jean-Baptiste Lamarck was a French naturalist. He suggested ways that organisms could change over time before Darwin proposed his theory of evolution. Lamarck suggested that organisms could change during their lifetimes by selectively using or not using various parts of their bodies. Then he suggested that these organisms could then pass these traits on to their offspring.



Was Lamarck's theory of evolution correct? Even though Lamarck was wrong with his theory he helped Darwin make the connection between an organism's body and its environment.

Malthus

Thomas Malthus was an English economist whose work also influenced Darwin. Malthus noticed that people were being morn faster than people were dying. This population increase lead to overcrowding. Malthus thought that overcrowding would lead to conditions that would slow down population growth.

Darwin took Malthus's ideas and saw that it was true for all organisms, from maple trees to oysters. If all of the offspring of a single species would survive than that species would soon cover the Earth…and this doesn't happen.

Darwin didn't just study the work of scientists; he also researched things that farmers were doing. He noticed that farmers were able to breed organisms that had the best traits. Darwin called this selecting of desired traits artificial selection.

Artificial selection – the selective breeding of plants and animals to promote desirable traits in offspring
After researching and gathering a lot of different information on evolution, Darwin developed his theory of natural selection.

Natural selection – the process by which organisms that are most suited to their environment survive and reproduce most successfully; also called survival of the fittest.

Darwin did not share his theory with the public for over 20 years! Why would Darwin wait that long to share his theory? He didn't want to be criticized for his theory like the other scientists were In 1858, Darwin shared his ideas with another scientist named Alfred Russel Wallace. Darwin then learned that his thoughts on evolution were very similar to Wallace's theory. Within a year Darwin published his book on evolution called *On the Origin of Species.*

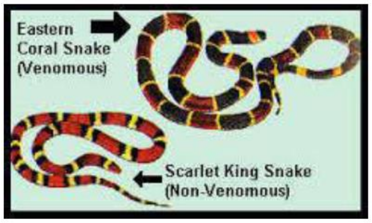
Natural Selection

Basic Steps in Natural Selection:

1. Overproduction of Offspring
2. Competition for Limited Resources
3. Survival and Reproduction or Death

Survival of the Fittest = Organisms that are better adapted to their environment and able to reproduce successfully are considered "fit". Unfit organisms die, and their traits are eventually removed from the gene pool.

Adaptation – a heritable characteristic that increases an organism's ability to survive and reproduce in an environment.



Fitness – How well an organism can survive and reproduce in its environment

According to Darwin's theory, individuals that are better adapted to their environment survive and reproduce. This leads to Darwin's principle of common descent. According to the principle of common descent, all species – living and extinct – are descended from ancient common ancestors.

Speciation-over time, variations lead to evolution into new species.

Check your understanding:

1. How would you define evolution? ____

____

2. What makes evolution possible? ____

____

3. What is natural selection? Can you give an example? _____________________________________

____

4. How would selective breeding play a role in evolution? ____________________________________

____

Practice: Read this passage and answer the questions that follow.

The Voyage of the Beagle

In 1831, when Darwin was just 22 years old, he set sail on a scientific expedition on a ship called the HMS Beagle. He was the naturalist on the voyage. As a naturalist, it was his job to observe and collect specimens of plants, animals, rocks, and fossils wherever the expedition went ashore.

Darwin was fascinated by nature, so he loved his job on the Beagle. He spent more than 3 years of the 5-year trip exploring nature on distant continents and islands. While he was away, a former teacher published Darwin's accounts of his observations. By the time Darwin finally returned to England, he had become famous as a naturalist.

Darwin's Observations

During the long voyage, Darwin made many observations that helped him form his theory of evolution.

For example:

•He visited tropical rainforests and other new habitats where he saw many plants and animals he had never seen before. This impressed him with the great diversity of life.

- He experienced an earthquake that lifted the ocean floor 2.7 meters (9 feet) above sea level. He also found rocks containing fossil sea shells in mountains high above sea level. These observations suggested that continents and oceans had changed dramatically over time and continue to change in dramatic ways.
- He visited rock ledges that had clearly once been beaches that had gradually built up overtime. This suggested that slow, steady processes also change Earth's surface.
- He dug up fossils of gigantic extinct mammals, such as the ground sloth. This was hard evidence that organisms looked very different in the past. It suggested that living things — like Earth's surface —change over time.

The Galápagos Islands

Darwin's most important observations were made on the Galápagos Islands. This is a group of 16 small volcanic islands 966 kilometers (600 miles) off the west coast of South America.
Individual Galápagos Islands differ from one another in important ways. Some are rocky and dry. Others have better soil and more rainfall. Darwin noticed that the plants and animals on the different islands also differed. For example, the giant tortoises on one island had saddle-shaped shells, while those on another island had dome-shaped shells. People who lived on the islands could even tell the island a turtle came from by its shell. This started Darwin thinking about the origin of species. He wondered how each island came to have its own type of tortoise.

Questions

1. What was Darwin's role on the Beagle?

2. What was significant about the new habitats Darwin visited?

3. What was significant about the rocks Darwin found in the mountains?

4. What was significant about the fossils Darwin found?

5. What did Darwin notice about life on the Galápagos Islands?

Lesson 4: Evidence of Evolution Date:_________

Objective: To compare and contrast the evidence used to support the evolution

Evidence of Evolution

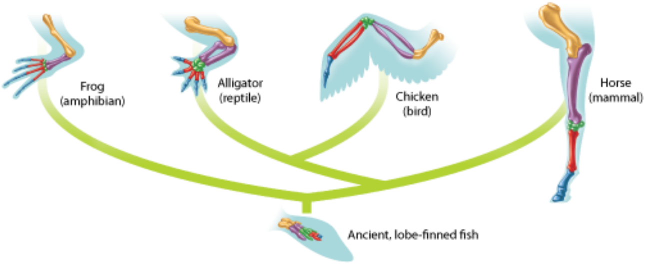
When Darwin’s book was published scientists were not able to test all of his ideas. Since then a lot of evidence has been found. This evidence comes from many sciences – biogeography, anatomy, geology, chemistry, genetics, and molecular biology.

Biogeography – the study of past and present distribution of organisms

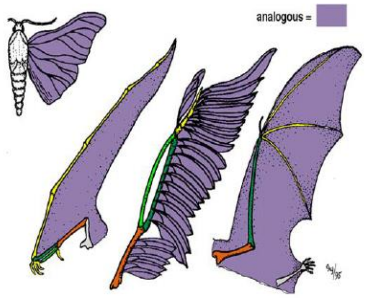
1. Closely related organisms that live in different environments often show great differences.

2. Distantly related organisms that live in similar organisms that live in similar environments are often similar.

Homologous structures – structures that are similar in different species of common ancestry



Analogous structures – structures that are similar in function but not structure, they do NOT suggest common ancestry



Vestigial structure – a structure that is reduced in size and has little or no function
Ex – Hipbones of dolphins

Embryology also suggests common ancestry. Similar patterns of embryo development provide evidence that organisms have descended from a common ancestor.

Evidence from Fossils:
Many recently discovered fossils form series that trace the evolution of modern species from extinct ancestors.

Genetics and Molecular Biology:
All living things use DNA and RNA to make proteins to pass on their genetic material. There are also many homologous molecules found in all living organisms. The universal genetic code and homologous molecules provide molecular evidence of evolution.
In order for a theory to be valid it must be testable and Darwin's theory of evolution is. Some scientists have designed experiments using bacteria, others have used guppies. Rosemary and Peter Grant studied the finches on the Galapagos Islands and observed natural selection in action.

<u>**Check your understanding:**</u> Circle the letter of the correct choice.

1. Evidence of evolution includes

(a)DNA sequence analysis.
(b)the fossil record.
(c)anatomical evidence.
(d)all of the above

2. Examples of analogous structures are

(a)the tails of mice and rats.
(b)the limbs of humans and apes.
(c)the wings of bats and birds.
(d)all of the above

3. An example of a vestigial structure is the

(a)kangaroo pouch.
(b)human tail bone.
(c)cat forelimb.
(d)all of the above

4. The strongest evidence for evolution from a common ancestor is

(a)similar DNA sequences.
(b)similar body structures.
(c)similar embryological structures.
(d)similar fossils.

Practice: Read these passages from the text and answer the questions that follow.

Evidence from Biogeography

Biogeography is the study of how and why plants and animals live where they do. It provides more evidence for evolution. Let’s consider the camel family as an example.

Biogeography of Camels: An Example

Today, the camel family includes different types of camels. All of today's camels are descended from the same camel ancestors. These ancestors lived in North America about a million years ago. Early North American camels migrated to other places. Some went to East Asia. They crossed a land bridge during the last ice age. A few of them made it all the way to Africa. Others went to South America. They crossed the Isthmus of Panama. Once camels reached these different places, they evolved independently. They evolved adaptations that suited them for the particular environment where they lived. Through natural selection, descendants of the original camel ancestors evolved the diversity they have today.

Island Biogeography

The biogeography of islands yields some of the best evidence for evolution. Consider the birds called finches that Darwin studied on the Galápagos Islands. All of the finches probably descended from one bird that arrived on the islands from South America. Until the first bird arrived, there had never been birds on the islands. The first bird was a seed eater. It evolved into many finch species. Each species was adapted fora different type of food. This is an example of adaptive radiation. This is the process by which a single species evolves into many new species to fill available niches.

Eyewitness to Evolution

In the 1970s, biologists Peter and Rosemary Grant went to the Galápagos Islands. They wanted to re-study Darwin's finches. They spent more than 30 years on the project. Their efforts paid off. They were able to observe evolution by natural selection actually taking place. While the Grants were on the Galápagos, a drought occurred. As a result, fewer seeds were available for finches to eat. Birds with smaller beaks could crack open and eat only the smaller seeds. Birds with bigger beaks could crack and eat seeds of all sizes. As a result, many of the small-beaked birds died in the drought. Birds with bigger beaks survived and reproduced. Within 2 years, the average beak size in the finch population increased. Evolution by natural selection had occurred.

Questions

1. What is biogeography and what does it provide?

2. Where do all camels come from?

2. Why did camels evolve?

3. What is adaptative radiation? Give an example.

4. What did the Grants study? What did they observe?

Lesson 5: Mechanisms of Evolution

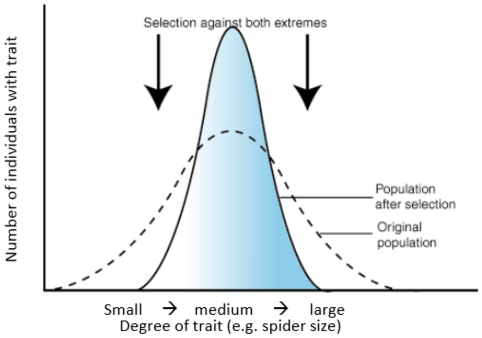
Date:___________

Natural selection is a mechanism of evolution.

Different types of natural selection act over the range of a trait's variation. In the following graphs, the dotted, bell -shaped curve indicates a trait's variation in a population. The solid blue, bell-shaped curve indicates the effect of a natural selection.

Stabilizing Selection

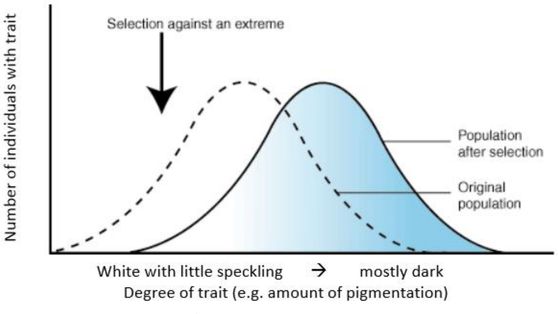
The intermediate phenotype is favored and becomes more common in the population.
Example: Consider a population of spiders in which the average size is a survival advantage: larger spiders are easily spotted and preyed upon by birds and smaller spiders have more difficulty located resources. Therefore, the average sized spider has a selective advantage---and is "selected for", while the extremes are "selected against".



To interpret this graph, you should be able to say that the majority of individuals have approximately the mean (i.e. average) trait (i.e. intermediate spider size). There are few individuals at the "tails" of the curve representing small or large spiders.

Divergent or Directional Selection

One extreme variation of a trait is favored and becomes more common in the population.
Example:
The peppered moth is a good example of directional selection as the changing environment selected for a relatively rare trait (conversely selecting against the more common trait) causing that trait to increase within the population

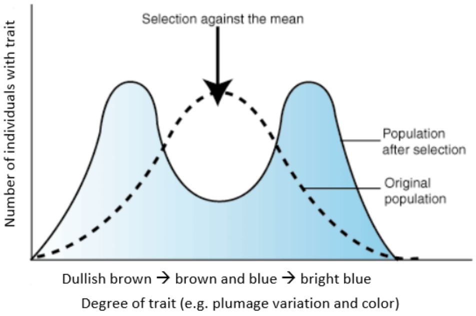


To interpret this graph, you could say the majority of the population has had an increase in the mean amount of pigmentation.

Disruptive Selection

Both extreme variations of a trait are favored and become more common in a population.
Example: Consider a population of lazuli buntings. Male's plumage ranges from bright blue, to a mix of blue and brown, to dullish brown. Adult dominant males are those with the brightest blue feathers on their heads and backs. These birds

are more attractive to potential mates and therefore are typically more reproductively successful than say a male with a combination of brown and blue plumage(intermediate).The dominant males are very aggressive towards the intermediate plumage type, but not so of the dullish brown plumage type. Therefore, the dullish brown plumage birds can affectively attract a mate due to less competition and harassment. In this example, the intermediate plumage type is selected against, favoring individuals with either the brightest blue or the dullest brown plumage.
This is also an example of sexual selection, where one sex favors a specific phenotype/trait in the other sex, leading to differential reproductive success



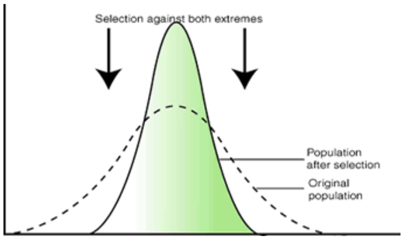
Other mechanisms of evolution are mutations, migration, and genetic drift. A population without selection pressure of a changing environment, no mutations, a gene pool that does not change due to movement of genes into or out of the population and not experiencing genetic drift due to changes in allelic frequency are said to be in genetic equilibrium. These populations are not undergoing any form of evolution.

Check your understanding:

1. In a certain population, disruptive selection is occurring. In this population, which is most likely to survive?

   a) organisms with average traits
   b) organisms with extreme traits
   c) organisms that sexually select
   d) organisms that are small

2 . This picture illustrates what type of selection?



a) sexual
b) disruptive
c) directional
d) stabilizing

3. Any characteristic that can help an organism survive and/or reproduce can be called a(n):

   a) Gene

b) Species
c) Adaptation
d) specialization

Practice: Read these passages from the text and answer the questions that follow.

Forces of Evolution

The Hardy-Weinberg equilibrium is a principle stating that the genetic variation in a population will remain constant from one generation to the next in the absence of disturbing factors. When mating is random in a large population with no disruptive circumstances, the law predicts that both genotype and allele frequencies will remain constant because they are in equilibrium. The conditions for Hardy-Weinberg equilibrium are unlikely to be met in real populations. The Hardy-Weinberg theorem describes populations in which allele frequencies are not changing. By definition, such populations are not evolving. How does the theorem help us understand evolution in the real world? From the theorem, we can infer factors that cause allele frequencies to change. These factors are the forces of evolution. There are four such forces: mutation, gene flow, genetic drift, and natural selection.

Mutation

Mutation creates new genetic variation in a gene pool. It is how all new alleles first arise. In sexually reproducing species, the mutations that matter for evolution are those that occur in gametes. Only these mutations can be passed to offspring. For any given gene, the chance of a mutation occurring in a given gamete is very low. Thus, mutations alone do not have much effect on allele frequencies. However, mutations provide the genetic variation needed for other forces of evolution to act.

Gene Flow

Gene flow occurs when people move into or out of a population. If the rate of migration is high, this can have a significant effect on allele frequencies. Both the population they leave and the population they enter may change. During the Vietnam War in the 1960s and 1970s, many American servicemen had children with Vietnamese women. Most of the servicemen returned to the United States after the war. However, they left copies of their genes behind in their offspring. In this way, they changed the allele frequencies in the Vietnamese gene pool. Was the gene pool of the American population also affected? Why or why not?

Genetic Drift

Genetic drift is a random change in allele frequencies that occurs in a small population. When a small number of parents produce just a few offspring, allele frequencies in the offspring may differ, by chance, from allele frequencies in the parents. This is like tossing a coin. If you toss a coin just a few times, you may by chance get more or less than the expected 50 percent heads or tails. In a small population, you may also by chance get different allele frequencies than expected in the next generation. In this way, allele frequencies may drift over time. Genetic drift occurs under two special conditions. They are called bottleneck effect and founder effect.

1. Bottleneck effect occurs when a population suddenly gets much smaller. This might happen because of a natural disaster, such as a forest fire. By chance, allele frequencies of the survivors may be different from those of the original population.
2. Founder effect occurs when a few individuals start, or found, a new population. By chance, allele frequencies of the founders may be different from allele frequencies of the population they left.

Questions

1. What are the forces of evolution?
2. Describe the type of mutations that affect evolution. Why?
3. Was the gene pool of the American population also affected by the gene flow described above? Why or
4. What is genetic drift?
5. Describe one special condition under which genetic drift occurs

Lesson 6: Evolution and Mankind Date:____________________

Objective: To relate human influence on evolution of various species

Almost daily, evolution-related stories are reported in the press. Some of these reports, like the stories about antibiotic-resistant strains of TB, depict serious problems that need to be understood and solved. Clearly, the ubiquitous presence of antibiotics in our environment—antibiotics in animal feed, over-prescribing by doctors, and rampant use in hospitals—has created a crisis in the evolution of drug-resistant pathogens. In addition, our bacteria-phobic society has created a potpourri of new antibacterial products from soaps to toys—without considering the possible consequences for bacterial evolution. The presence of substances that select against certain microorganisms will most certainly have an effect on future populations. At the same time, we regularly see how knowledge gleaned from evolution is providing very practical applications to real-world concerns: finding oil fields by analyzing fossils or understanding how coevolution of organisms and their natural parasites contribute to disease and recovery. But sciences such as geology and medicine are not the only arenas where an under- standing of evolutionary processes is valuable. Selective breeding of food crops and domesticated animals has created many valuable new varieties and breeds: “burpless” cucumbers, larger tomatoes with fewer seeds, cows that produce ten times more milk than cows of a century ago, and hens that lay four times as many eggs. All have been bred by the process of artificial selection, which is evolution guided by humans. Perhaps the reports we remember most are those that are controversial. They often deal with biotechnology or conservation and environmental management. For example, effort to avert plant and wildlife extinction through controls on over-cutting of timber or over-fishing often place conservationists at odds with the lumber or fishing industries. Genetically engineered foods are another controversial issue. In this case, genes of a desirable trait in one organism are introduced into another organism. There are already many bioengineered food crops in the market- place, many designed to resist pests. Today we have biotech corn that has been engineered to produce a pesticide that kills the corn-borer larvae. These so-called biopesticides are used to improve our food supply and to reduce our dependence on commonly used chemical pesticides. No one knows yet what the long-term consequences of bioengineered foods, both positive and negative, will be. But, we’ve already seen genetic drift of corn pollen from biotech corn to other corn crops. Once the genes are released into the environment via wind and pollinators, there is no getting them back. Human activities influence evolution in many other ways. During the last 50 years, over 500 species of insects and mites have become resistant to pesticides. Scientists are now using evolutionary principles to slow down the evolution of pesticide-resistant insects and to develop alternative methods of pest control. Our destruction of habitats has endangered species and reduced populations so that their genetic diversity has decreased, and so too their ability to adapt to environmental changes. The list goes on and on. Our use of technology is allowing us to alter the evolution of many species besides our own. We have a responsibility to continue to learn how to use our knowledge of evolution wisely to minimize the deleterious effects we have on the biosphere.

Check your understanding:

1. How does an understanding of evolution help doctors manage infectious diseases?

2. How have disease organisms coevolved with humans?

Practice: Read the following article and answer the questions.

Fossil skull sheds new light on transition from water to land ***Date:*** March 11, 2015 ***Source:*** University of Bristol

The first 3D reconstruction of the skull of a 360 million-year-old near-ancestor of land vertebrates has been created by scientists from the Universities of Bristol and Cambridge, UK. The 3D skull, which differs from earlier 2D reconstructions, suggests such creatures, which lived their lives primarily in shallow water environments, were more like modern crocodiles than previously thought. The researchers applied high-resolution X-ray computed tomography (CT) scanning to several specimens of *Acanthostega* gunnari, one of the 'four-footed' vertebrates known as tetrapods which invaded the land during one of the great evolutionary transitions in Earth's history, 380-360 million years ago. Tetrapods evolved from lobe-finned fishes and display a number of adaptations to help them survive on land.

An iconic fossil species, *Acanthostega* gunnari is crucial for understanding the anatomy and ecology of the earliest tetrapods. However, after hundreds of millions of years in the ground fossils are often damaged and deformed. No single specimen of *Acanthostega* preserves a skull that is complete and three-dimensional which has limited scientists' understanding of how this key animal fed and breathed -- until now. Using special software, the Bristol and Cambridge researchers 'digitally prepared' a number of *Acanthostega* specimens from East Greenland, stripping away layers of rock to reveal the underlying bones. They uncovered a number of bones deep within the skull, including some that had never before been seen or described, resulting in a detailed anatomical description of the *Acanthostega* skull.

Once all of the bones and teeth were digitally separated from each other, cracks were repaired and missing elements duplicated. Bones could then be manipulated individually in 3D space. Using information from other specimens, the bones were fitted together like puzzle pieces to produce the first 3D reconstruction of the skull of *Acanthostega*, with surprising results. Lead author, Dr Laura Porro, formerly of Bristol's School of Earth Sciences and now at the Royal Veterinary College, said: "Because early tetrapods skulls are often 'pancaked' during the fossilization process, these animals are usually reconstructed having very flat heads. Our new reconstruction suggests the skull of *Acanthostega* was taller and somewhat narrower than previously interpreted, more similar to the skull of a modern crocodile."

The researchers also found clues to how *Acanthostega* fed. The size and distribution of its teeth and the shape of contacts between individual bones of the skull (called sutures) suggest *Acanthostega* may have initially seized prey at the front of its jaws using its large front teeth and hook-shaped lower jaw. Co-author, Professor Emily Rayfield, also from Bristol's School of Earth Sciences, said: "These new analyses provide fresh clues about the evolution of the jaws and feeding system as the earliest animals with limbs and digits began to conquer the land." The researchers plan to apply these methods to other flattened fossils of the earliest tetrapods to better understand how these early animals modified their bones and teeth to meet the challenges of living on land. Digital models of the original fossils and the 3D reconstruction are also useful in scientific research and education. They can be accessed by researchers around the world, without risking damage to fragile original fossils and without scientists having to travel thousands of miles to see original specimens. Furthermore, digital models and 3D printouts can be easily and safely handled by students taking courses and by the public during outreach events.

Here are the articulated cranium and lower jaws shown in oblique right lateral view (A). Right facial skeleton and skull roof shown in "exploded" view to illustrate the nature of sutural contacts (B); the left side of the cranium (braincase omitted) is shown in internal view (C). The right lower jaw in "exploded" view to illustrate sutural morphology. Individual bones shown in various colors. *Credit: Porro et al.; CC-BY*

Do you think it is important for scientists to study the relationships of fossils to modern organism? Why or why not?

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