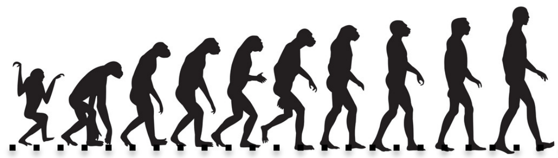
Topic 1.1- Evidence Of Evolution:



EVOLUTION: A change in the *frequency* of an ______________________________

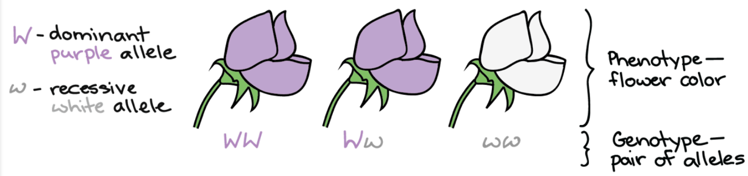
trait within a ____________________ across generations. (*change over time)*

Refresher:

____________________: observable characteristics

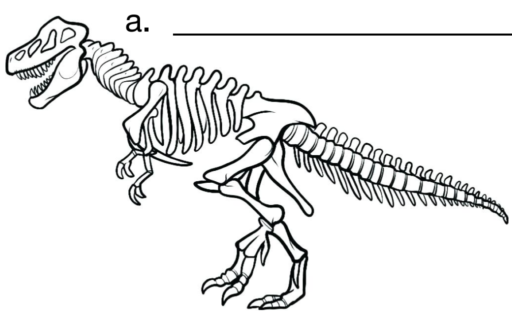
____________________: genetic characteristics (alleles)

____________________: a variant form of a given gene



Evidence:

1. ____________________________: The scientific study of prehistoric life



   a. ____________________: **ANY** trace or remains of an organism (tissue, bones, imprints or footprints). Formed in ______________________ rock or preserved in tar, ice, or amber.

   Transitional Fossils: intermediate evolutionary forms of life, ____________________ or a "common ancestor"

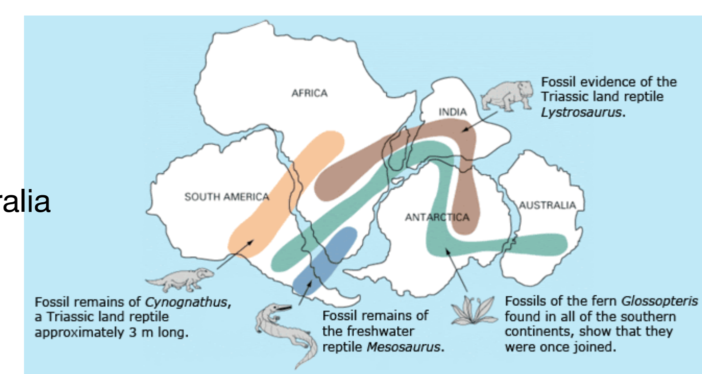
   b. Law of ___________________________: Undisturbed sedimentary layers are deposited with the ______________ on the bottom and _______________ on the top.

2. _______________________________: studies the geographic patterns of species distribution and the processes that result in such patterns.

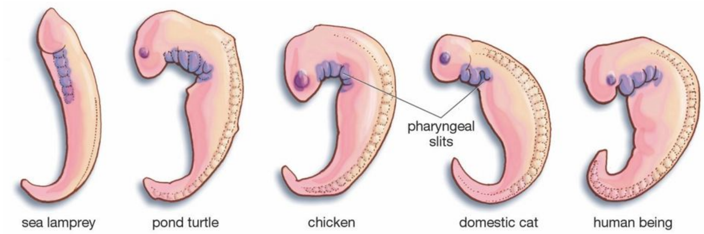
   a. Isolated Island populations are very useful in studying evolution.
      i. Darwin in the **Galapagos**
      ii. **Lake Baikal** in Siberia

   b. Supports the Pangea hypothesis

   c. Example: The large native mammals in Australia are all marsupials, whereas almost all large mammals on other continents are placental.

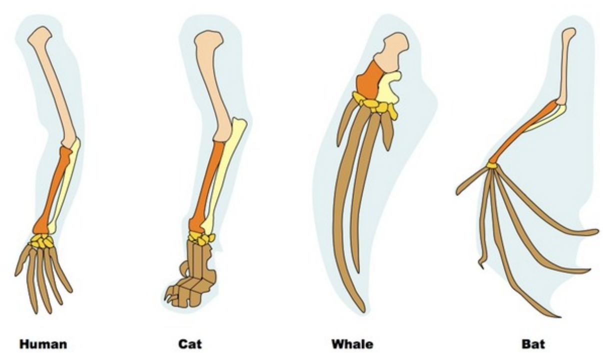


3. Comparative ____________________________ & Developmental Biology: the study of similarities between organisms during embryonic & fetal development

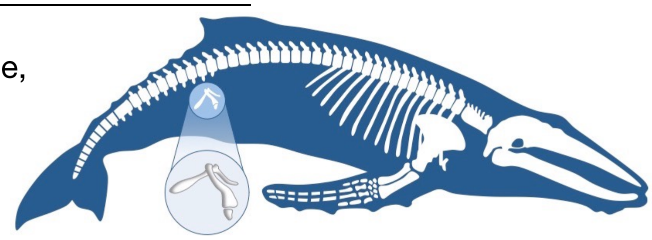


   a. Similarities during developmental stages suggests common ancestry
   b. *Hox* or ______________________ genes are regulatory genes that orchestrate the body plan development in ALL animals (from sea anemones to fruit flies to humans)
      i. Example: Changing the timing and duration of a *Hox* gene controlling vertebrae development causes the difference in the number of bones in a chicken's neck compared to a snake.

4. Comparative ____________________________ : the study of structural similarities and differences among species.
   a. ________________________________ structures : similar internal structures but different functions (the bones inside are similar but the function is very different)
      i. evidence of a ____
      ii. examples:



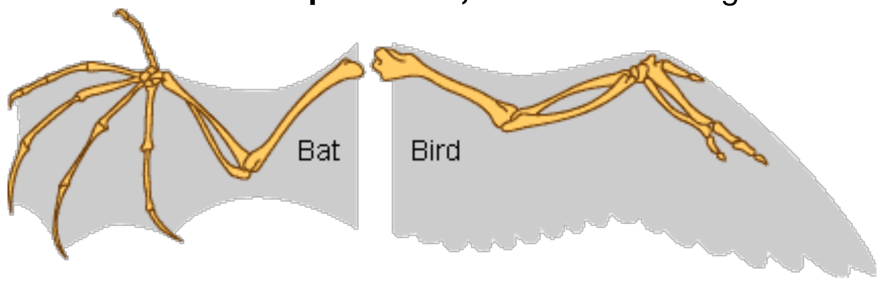
   b. ________________________________ structures : remnants or non-functional organs or body structures that are functional in ancestral species
      i. evidence of a ____
      ii. examples: wisdom teeth, appendix, tail bone, and hip bones in whales and snakes



c. ________________________________ structures : difference internal structures but similar external shape and function (example: shark fin, dolphin flipper, penguin wing)

i. NOT evidence of a ____

ii. Evidence of **similar environmental selective pressures,** known as convergent evolution



5. Comparative __________________________ (molecular biology): studies the similarities and differences in biological processes, proteins, enzymes, and DNA between all living things.

a. ALL life contains the same basic biochemical molecules (________________________)

b. DNA & RNA generally function the same across all species, this allows a human gene to be placed into the genome of a bacterium, and the desired protein will be produced

Below are similar sections of the hemoglobin gene for 3 species, circle the differences

DNA sequence:									
Human	TTG	GTC	AAC	GGC	TAA	TAT	CAT	TGG	TCG
Chimp	TTG	GTT	AAC	GGC	TAA	TAA	CAT	TGG	TGG
Gorilla	TTG	GTC	AAC	GAC	TAG	CGA	CAT	TGG	TCA
Amino Acid Sequence:									
Human	ASN	GLN	LEU	PRO	ILE	ILE	VAL	THR	SER
Chimp	ASN	GLN	LEU	PRO	ILE	ILE	VAL	THR	THR
Gorilla	ASN	GLN	LEU	LEU	ILE	ALA	VAL	THR	SER

Why does DNA analysis show more differences than protein analysis?

____

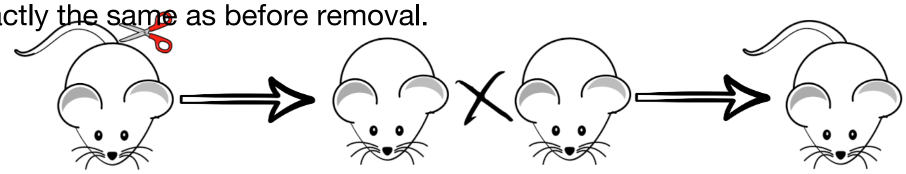
Topic 1.2- Natural Selection

Early contributions: to the theory of evolution

Jean Baptiste Lamarck

1. **NEED**: Organisms strive to better themselves and are capable of developing new traits to do so
2. **USE & DISUSE**: The more an organism uses a structure or trait, the more advanced it becomes, unused structures or traits will slowly disappear
3. **INHERITANCE OF ACQUIRED TRAITS**: Once a structure or trait is modified by use or disuse, the trait is passed down to the offspring

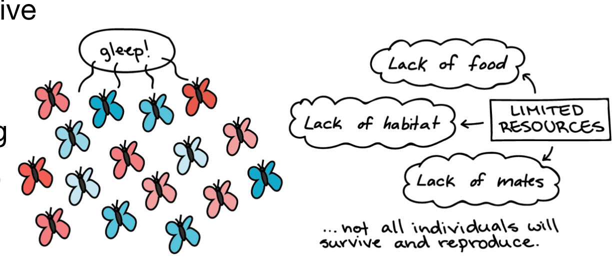
August Weismann: Experimented on mice to show only germ line cells (gametes/sex cells) function as agents of heredity, disproving Lamarck's Theory of "inheritance of acquired traits". He removed the tails of over 68 mice across 5 generations (over 900 mice were produced). He found the average tail length of all generations to be exactly the same as before removal.



Charles Darwin: (Alfred Wallace)

Described how all species of organisms arise and develop through the natural selection of small, inherited variations that increase the individual's ability to compete, survive, & reproduce.

1. **Overproduction**: more offspring are produced than can survive (carrying capacity)



2. **Variation:** for sexually reproducing organisms, each offspring is a unique combination of the parents genes. (crossing over, independent assortment, random mating/fertilization and mutations.)
    a. **Adaptation**: the specific variation BEST suited for the given environment, increasing survivability and reproductive success.

3. **Competition** organisms fight for limited resources (one species per niche)

4. **Differential Reproductive Success**: organisms born with the most favorable traits outcompete others and are able to have more offspring and pass their traits along to the next generation. This is often described as "*survival of the fittest*"
    a. **fitness** is determined by the number of offspring produced.

5. **Speciation**: Over many generations, favorable adaptations accumulate and unfavorable ones disappear from a population. They eventually become so different that they are considered a new species (if two variations exist they must no longer mate or produce *fertile* offspring)

Evolution Practice

1. Within a population there are 2 types of worms: worms that eat at night (nocturnal) and worms that eat during the day (diurnal). The birds eat during the day and seem to be eating ONLY the diurnal worms. The nocturnal worms are in their burrows during this time. Each spring when the worms reproduce, they have about 500 babies but only 100 of these 500 ever become old enough to reproduce. Using the brief reading above to support the following statements

    a. What worm has natural selection selected AGAINST? ____________________ FOR? _________________

    b. Populations have variations. ____

    c. Some variations are favorable. ____

    d. More offspring are produced than survive. ____

    e. Those that survive have favorable traits. ____

    f. A population will change over time. ____

2. Richard believes that giraffes have long necks because they have stretched their necks to try and reach food that is high in trees. Since the parent had stretched its neck, it passed the long neck on to its offspring. Ryan believes that giraffes have long necks because the ones with long necks were able to reach the food, and those with short necks could not and died. The long necked giraffes reproduced, and soon all of the giraffes had long necks.

    a. Who thinks like Lamarck? _____________________________________

    b. Who thinks like Darwin? ______________________________________

3. The common ancestor to all living bears today was believed to be dark brown in color. According to natural selection describe how polar bears became white

    ____

    ____

    ____

    ____

    ____

    ____

    ____

Name:____ Date:____________ Period:____________

Rock Pocket Mouse Evolution

INTRODUCTION

A typical rock pocket mouse is about 170 millimeters long from its nose to the end of its tail, shorter than an average pencil. And at just 15 grams, this tiny mouse weighs about as much as a handful of paper clips. Rock pocket mice, however, have had an enormous impact on science. What's so special about them?

You can find populations of rock pocket mice all over the Sonoran Desert in the southwestern United States. There are two common varieties of these mice — a light-colored variety and a dark-colored variety. There are also two major colors of substrate, or surface materials, that make up the desert floor. Most of the desert is covered in light-colored sand and rock. However, there are also patches of dark volcanic rocks that formed from cooling lava flows. These patches of dark-colored substrate are often separated by several kilometers of light- colored substrate.

MATERIALS

- Rock Pocket Mouse Illustrations (provided by your teacher)
- *The Making of the Fittest: Natural Selection and Adaptation* video
- Supplies for creating bar graphs (e.g. computer graphing software or graph paper and colored pencils)

PROCEDURE

1. The four illustrations provided by your teacher represent snapshots of rock pocket mouse populations. Each illustration shows the color variation at two different locations, A and B, at a particular moment in time. The illustrations may be out of order. Count the number of light-colored and dark-colored mice present at each location at each moment in time. Record your counts in the table below.

		Illustration Number			
		1	2	3	4
Location A	Number of Light-Colored Mice				
	Number of Dark-Colored Mice				
Location B	Number of Light-Colored Mice				
	Number of Dark-Colored Mice				

2. Place the illustrations in what you think is the correct order from oldest to most recent. In the space below, write the numbers of the illustrations in the order you decided.

_____ _____ _____ _____

3. Explain how you decided which illustration represents the most recent rock pocket mouse population and why you positioned the others in the order that you did.

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4. Watch the BioInteractive short film *The Making of the Fittest: Natural Selection and Adaptation*. As you watch, think about the following:

- Why are some mice light colored and some mice dark colored?

  ____

  ____

- Does fur color provide any selective advantage or disadvantage?

  ____

  ____

- What role does the rock pocket mouse play in the desert food web?

  ____

  ____

- What explains the differences among the four illustrations? Is there anything that confirms or contradicts the order in which you arranged the illustrations?

  ____

  ____

  ____

5. Using what you learned by watching the film, confirm or change the order in which you arranged the illustrations. Once you are satisfied that the order is correct, fill out the data table below using the counts you recorded for the illustrations.

Number of Mice at Different Locations

		Illustration Order			
		Oldest (First)	**Second Oldest (Second)**	**Third Oldest (Third)**	**Most Recent (Fourth)**
Location A	**Number of Light-Colored Mice**				
	Number of Dark-Colored Mice				
Location B	**Number of Light-Colored Mice**				
	Number of Dark-Colored Mice				

12. Create a bar graph based on the data that shows the numbers of the mice at locations A and B through time. Be sure to provide an appropriate title for the graph, and titles and labels for the *x*- and *y*-axes. You should plot all of your data for both A and B on one bar graph.

13. Explain why a rock pocket mouse's color influences its overall fitness. Remember that "fitness" is defined by an organism's ability to survive and produce offspring in its environment.

14. Explain the presence of dark-colored mice at location A. Why didn't this phenotype become more common in the population?

____

____

15. Write a scientific summary that describes changes in the rock pocket mouse populations at location B. Your summary should include:
    - a description of how the population has changed over time
    - an explanation of what caused the changes
    - a prediction that describes what the population will look like 100 years in the future
        - *Base your prediction on trends in the data you have organized. You can assume that environmental conditions do not change over the 100 years.*

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16. Use the data and what you have learned about evolution to explain how mutation is a random process, but natural selection is not random.

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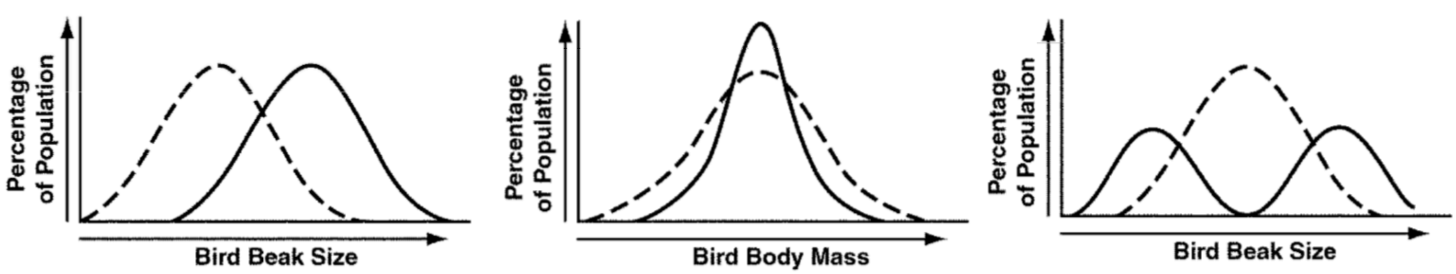
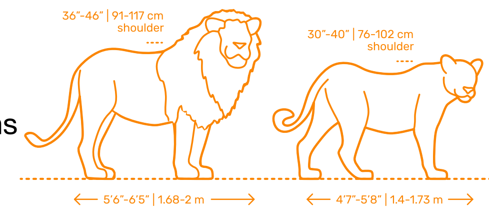
Types of Selection



Topic 1.3- Other Types of Selection

Sexual Selection (not focused on enough!)

1. Caused by ____________________________________ of males and/or females within a population
    a. ______________________________ mating – preference for similar phenotypes
    b. ______________________________ mating – preference for different phenotypes
2. Can result in ______________________________________
    a. the condition where the two sexes of the same species exhibit different characteristics **beyond** the differences in their sexual organs



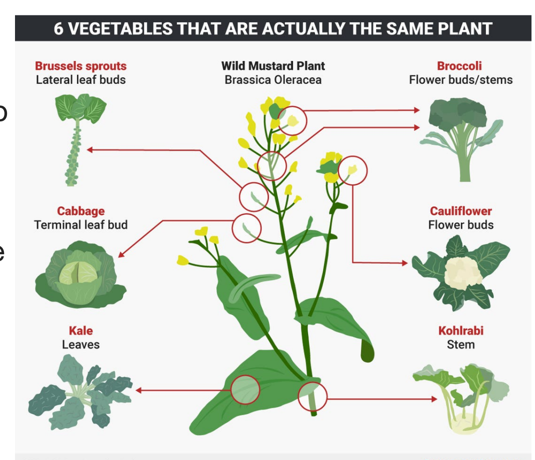
3. How selection affects the sexes
    a. Females produce relatively few, highly nutritious sessile gametes
    b. Males produce abundant, smaller motile gametes
    c. As a result, males typically compete among themselves for females and females are usually choosy with whom they mate.
4. _________sexual selection occurs between members of the same sex (usually males) for access to mates
5. _________sexual selection occurs between individuals of different sexes, when one sex (usually females) picks the member of the other sex they want to mate with.

Kin/Group Selection

1. Traits that benefit the family/group over the individual are selected for
    a. **Altruism**- behavior by an individual that increases the fitness of another individual while possibly decreasing the fitness of the actor
2. This accounts for species who survive well past reproductive age
    a. A female human survives far past reproductive age and becomes a grandmother. The traits that allowed her to survive to this age had no effect on her ability to reproduce so why/how would old age in humans be selected for? Grandparents often care for their grandkids, and this care increases the survival and thus the fitness of their grandkids. This helps the group (specific family) as a whole and those traits that allow for survive until old age are indirectly being selected for. (*natural selection acts on traits before reproduction, group selection works on traits effecting the individual after reproduction)*

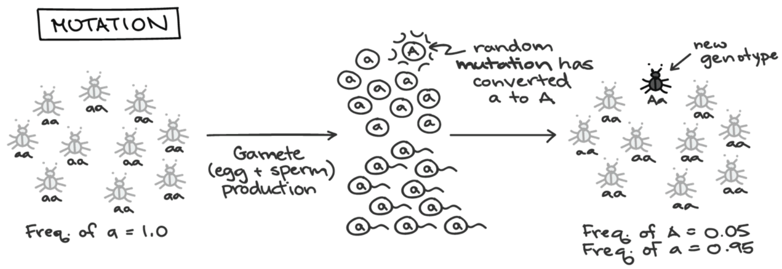
Artificial Selection

1. Also called "___________________________" is the process by which humans use animal breeding and plant breeding to selectively develop particular phenotypic traits (characteristics) by choosing which males and females will sexually reproduce and have offspring together.
2. Examples:
    a. Brussel sprouts, broccoli, cabbage, kale, and cauliflower all came from a single species of wild mustard
    b. all domestic dog breeds are the result of selective breeding.

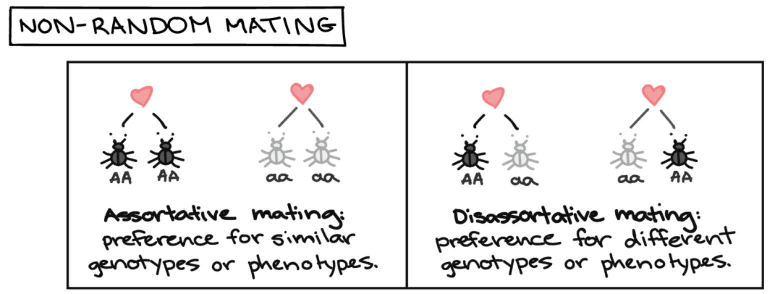


Topic 1.4 - 5 Agents of Evolution

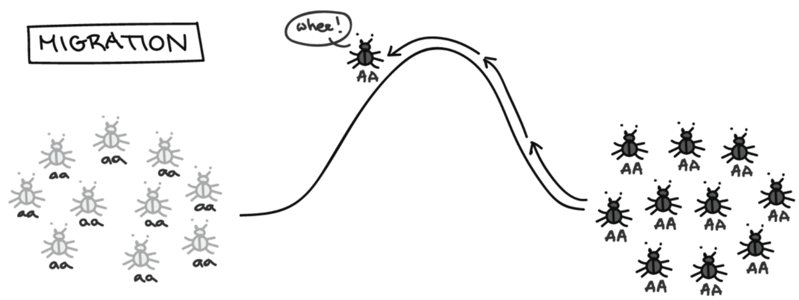
Mutations. Although mutation is the original source of all genetic variation, mutation rate for most organisms is pretty low. So, the impact of brand-new mutations on allele frequencies from one generation to the next is usually not large. (However, natural selection acting on the results of a mutation can be a powerful mechanism of evolution!)



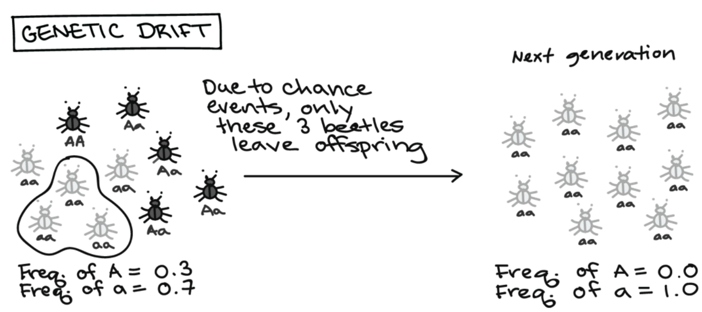
Non-random mating. In non-random mating, organisms may prefer to mate with others of the same genotype or of different genotypes. Non-random mating won't make allele frequencies in the population change by itself, though it can alter genotype frequencies. This keeps the population from being in Hardy-Weinberg equilibrium, but it's debatable whether it counts as evolution, since the allele frequencies are staying the same.



Gene flow. Gene flow involves the movement of genes into or out of a population, due to either the movement of individual organisms or their gametes (eggs and sperm, e.g., through pollen dispersal by a plant). Organisms and gametes that enter a population may have new alleles, or may bring in existing alleles but in different proportions than those already in the population. Gene flow can be a strong agent of evolution.

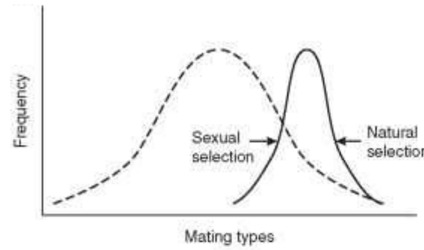


Non-infinite population size (genetic drift). Genetic drift involves changes in allele frequency due to chance events – literally, "sampling error" in selecting alleles for the next generation. Drift can occur in any population of non-infinite size, but it has a stronger effect on small populations. We will look in detail at genetic drift and the effects of population size on the next page.



Natural selection. Finally, the most famous mechanism of evolution! Natural selection occurs when one allele (or combination of alleles of different genes) makes an organism more or less fit, that is, able to survive and reproduce in a given environment. If an allele reduces fitness, its frequency will tend to drop from one generation to the next. We will look in detail at different forms of natural selection that occur in populations.

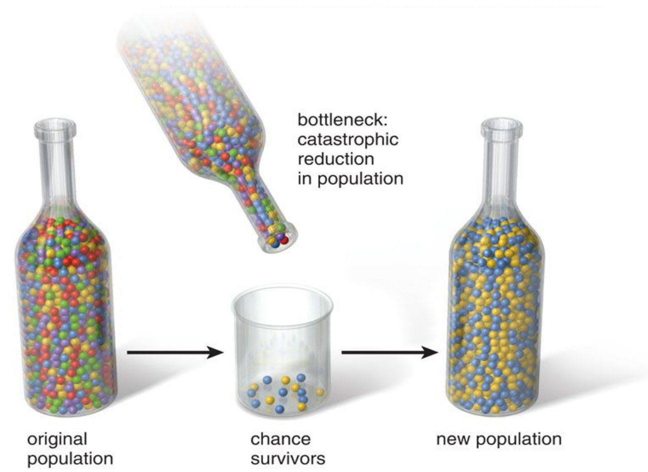
All five of the above mechanisms of evolution may act to some extent in any natural population. In fact, the evolutionary trajectory of a given gene (that is, how its alleles change in frequency in the population across generations) may result from several evolutionary mechanisms acting at once. For instance, one gene's allele frequencies might be modified by both gene flow and genetic drift. For another gene, mutation may produce a new allele, which is then favored (or disfavored) by natural selection.



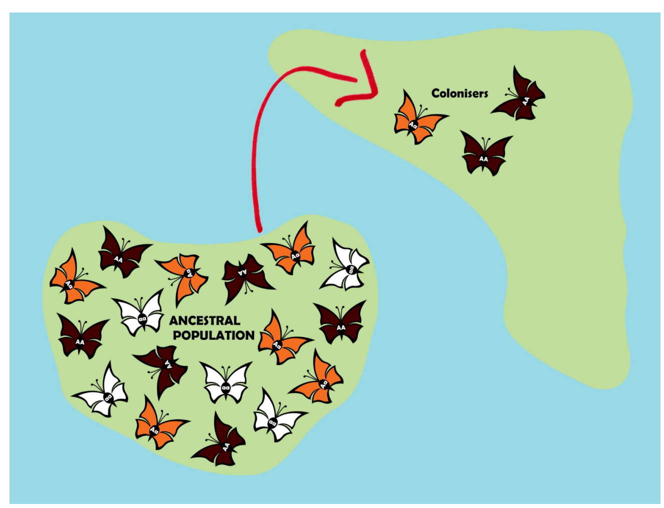
Deeper look into **Genetic Drift**

Genetic drift is change in allele frequencies in a population from generation to generation that occurs due to chance events. To be more exact, genetic drift is change due to "sampling error" in selecting the alleles for the next generation from the gene pool of the current generation. Although genetic drift happens in populations of all sizes, its effects tend to be stronger in small populations. This is a lot like flipping a coin a small vs. a large number of times. If you flip a coin just a few times, you might easily get a heads-tails ratio that's different from 50/50. If you flip a coin a few hundred times, on the other hand, you had better get something quite close to 50/50

The __________________ **effect** is an extreme example of genetic drift that happens when the size of a population is severely reduced. Events like natural disasters (earthquakes, floods, fires) can decimate a population, killing most individuals and leaving behind a small, random assortment of survivors. The allele frequencies in this group may be very different from those of the population prior to the event, and some alleles may be missing entirely. The smaller population will also be more susceptible to the effects of genetic drift for generations (until its numbers return to normal), potentially causing even more alleles to be lost.



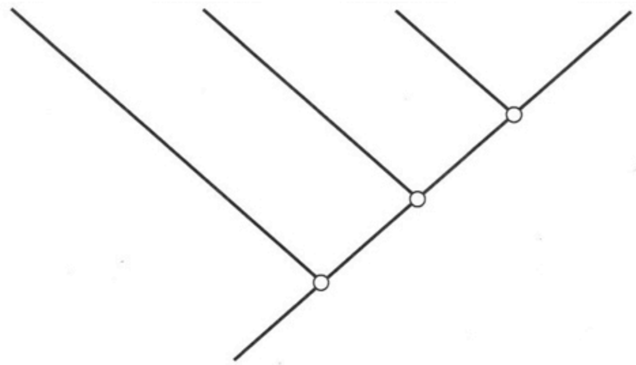
The __________________ **effect** is another extreme example of drift, one that occurs when a small group of individuals breaks off from a larger population to establish a colony. The new colony is isolated from the original population, and the founding individuals may not represent the full genetic diversity of the original population. That is, alleles in the founding population may be present at different frequencies than in the original population, and some alleles may be missing altogether. The founder effect is similar in concept to the bottleneck effect, but it occurs via a different mechanism (colonization rather than catastrophe).



Topic 1.5- Phylogeny

1. **Cladograms & Phylogenetic Trees**: are branching diagrams showing the evolutionary relationships among various biological species based upon similarities and differences in their physical and/or genetic characteristics. *(difference between them is phylogenic trees typically include a time scale to show the rate of change)*

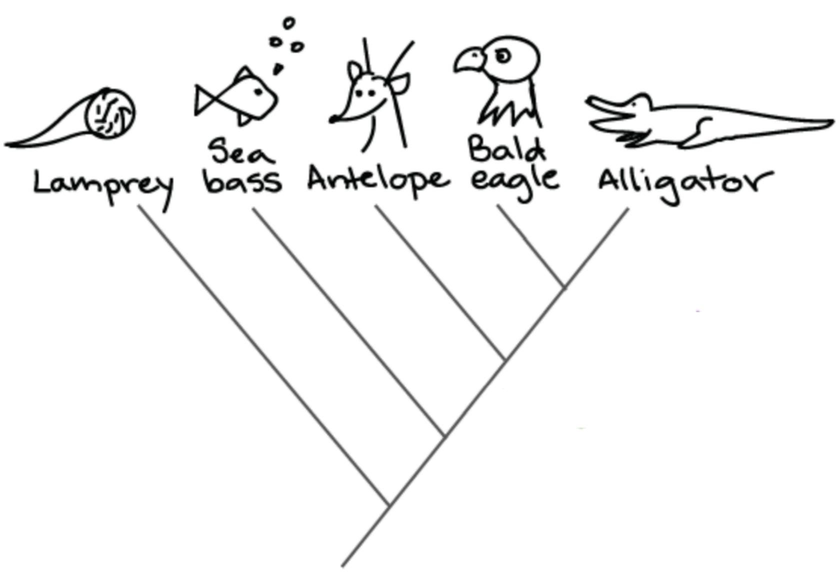
Organism	Vascular Tissue	Flowers	Seeds
Mosses	0	0	0
Pine trees	+	0	+
Flowering plants	+	+	+
Ferns	+	0	0



a. ____________________ data typically provides the most accurate & reliable evidence.
Example: placment of a hippopotomus based on physcial vs molecular evidence.
Using morphological traits, next to ______________________________
Using molecular data, next to ______________________________

b. Different cladograms can also be constructed based on whether a trait is believed to be _____________________ or _____________________.

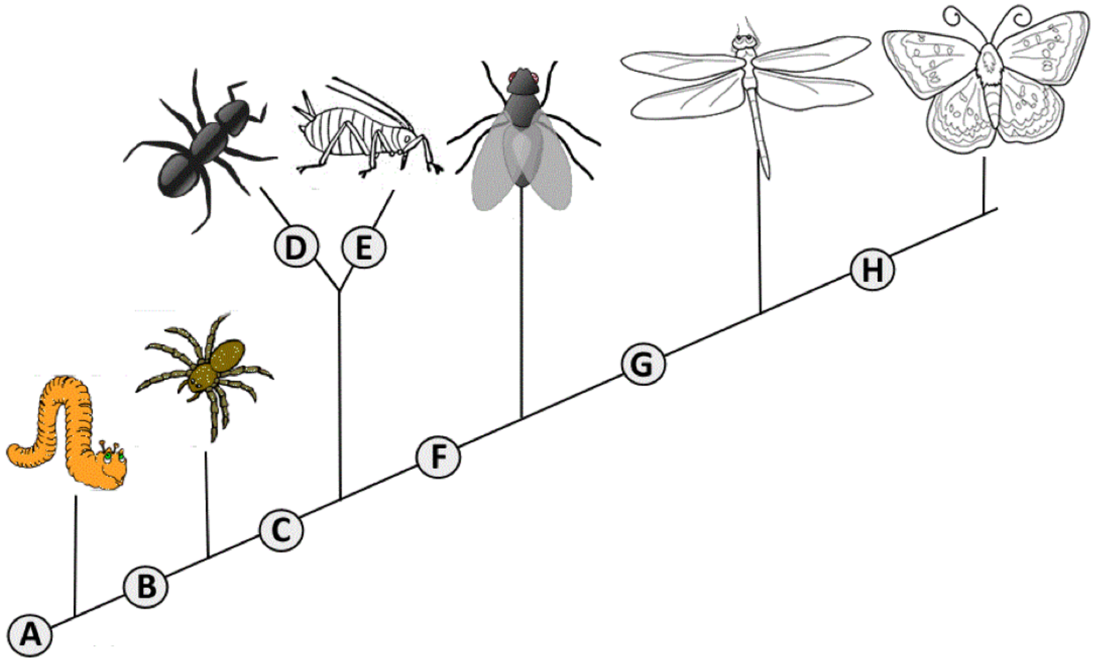
c. _______________________: (Occam's razor) the principle that the simplest explanation that can explain the data is to be preferred (least number of changes)



Feature	Lamprey	Antelope	Bald eagle	Alligator	Sea bass
Lungs	0	+	+	+	0
Jaws	0	+	+	+	+
Feathers	0	0	+	0	0
Gizzard	0	0	+	+	0
Fur	0	+	0	0	0

PART I - Analyze a Cladogram

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. ______ Double set of wings
3. ______ Curly Antennae
4. ______ 6 Legs
5. ______ Legs
6. ______ Cerci (abdominal appendages)
7. ______ Segmented Body
8. ______ Crushing mouthparts

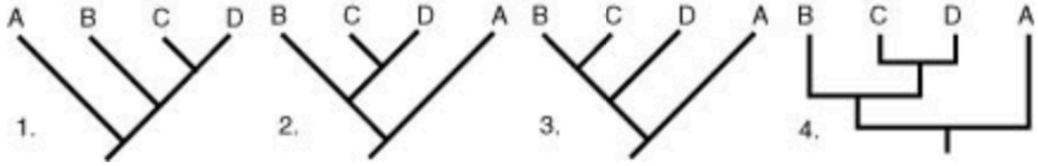
PART II - Create Your Own Cladogram

To make a cladogram, you must first look at the animals you are studying and establish characteristics that they share and ones that are unique to each group. For the animals on the table, indicate whether the characteristic is present or not (+ or ✓). Based on that chart, create a cladogram like the one pictured above.

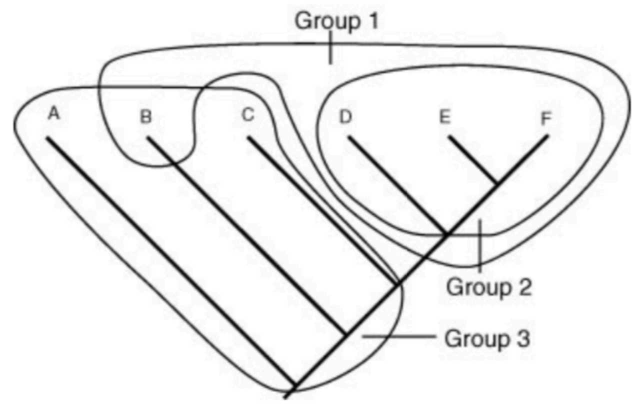
	Cells	Backbone	Legs	Hair	Opposable Thumbs
Slug					
Tiger					
Frog					
Catfish					
Human					

DRAWING OF YOUR CLADOGRAM:

1. Circle the cladogram that shows different relationships across the 4 species.

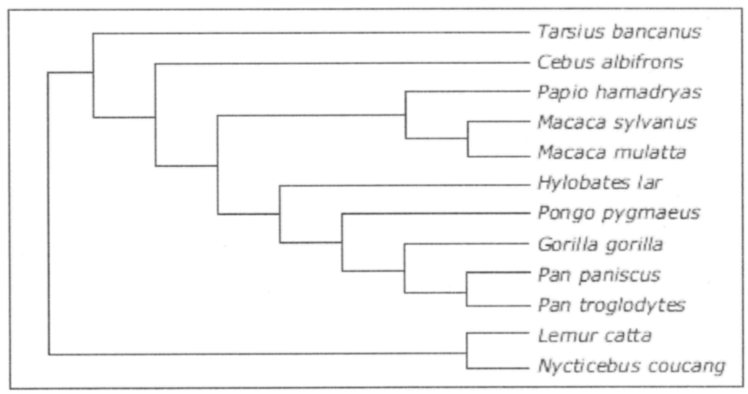


2. Three taxonomic groups are circled on the cladogram below. Indicated what type of group they represent using the following terms:



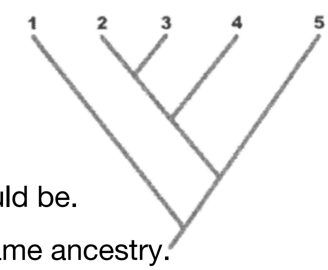
   a. Monophyletic = Group ___
   b. Polyphyletic = Group ___
   c. Paraphyletic = Group ___

3. The diagram below shows a model of species divergence among some primates. If the model is correct the greatest difference would be found in the DNA sequences of which two species?



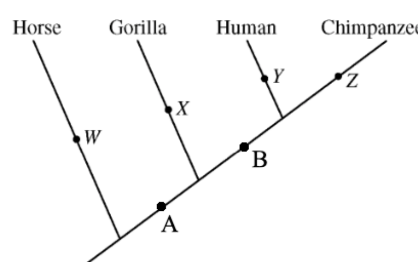
   a. *Macaca sylvanus* & *Macaca mulatta*
   b. *Hylobates lar* & *Pongo pygmaeus*
   c. *Tarsius bancanus* & *Cebus albifron*
   d. *Pan troglodytes* & *Lemur catta*

4. Based on the phylogeny shown to the right



   a. Species 2 is most closely related to species ____
   b. The outgroup would be ____
   c. Draw a **circle** where the common ancestor of 2 and 5 would be.
   d. Draw a different version of this cladogram, showing the same ancestry.

5. The cladogram shown below depicts an accepted model of the evolutionary relationships among selected species. The amino acid at position 34 of Type 1 collagen protein for each of these four organisms is listed below. The validity of the cladogram is best supported by molecular evidence for which of the following changes in the amino acid composition of the Type 1 collagen protein during the evolution of these species?

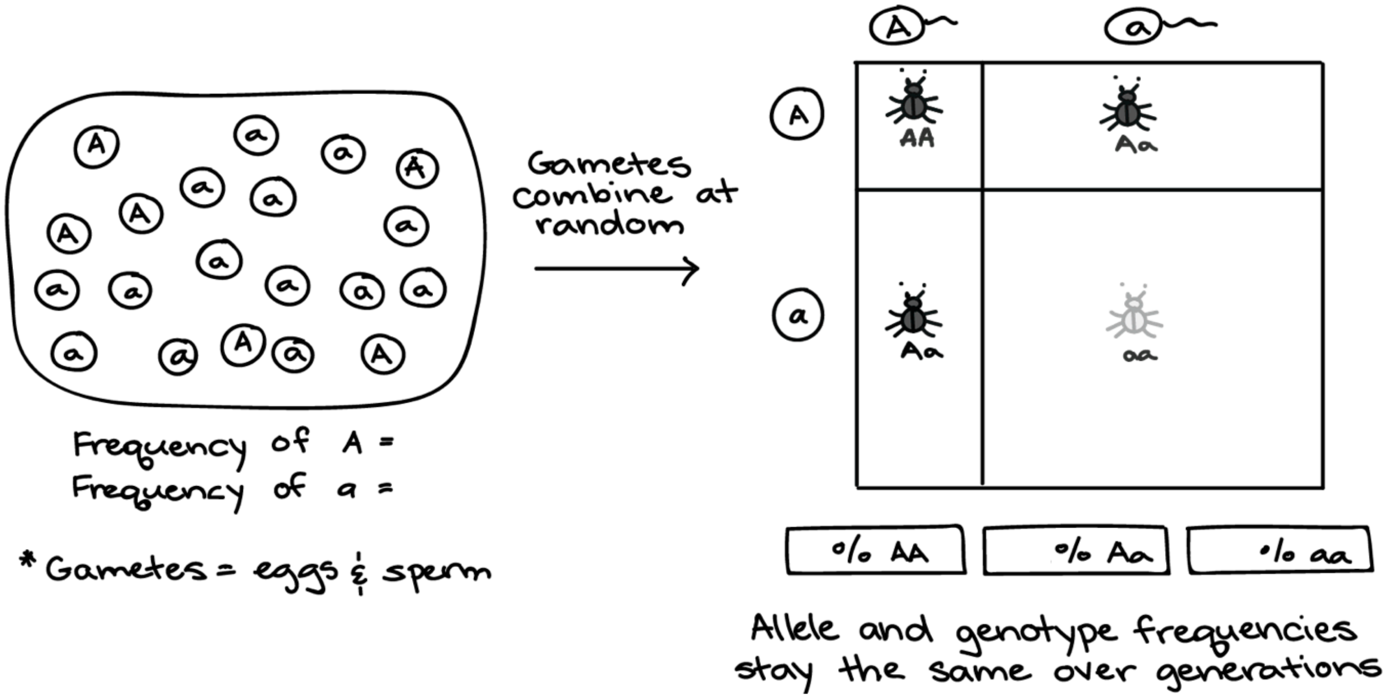


Species	Amino Acid 34
Horse	proline
Gorilla	proline
Human	valine
Chimpanzee	proline

   a. Proline to valine at position B
   b. Valine to proline at position B
   c. Proline to valine at position Y
   d. Valine to proline at position Y
   e. Proline to valine at position X

Topic 1.6 Hardy-Weinberg Equilibrium

In nature populations are usually evolving, meaning the gene/allele frequencies are changing from one generation to the next. In the **rare** instance that there is no change, the population is said to be in **HARDY-WEINBERG EQUILIBRIUM**



Hardy-Weinberg Principle

There are 5 conditions that can disrupt genetic equilibrium and “cause” evolution to occur, in order for a population to be in a “non-evolving” state these 5 assumptions must be met:

1. ________________________________ there are no new traits / alleles entering the gene pool, genes are also not being duplicated or deleted.
2. ________________________________ Organisms mate randomly, there is no sexual selection or mate preference based on any phenotypic condition
3. ________________________________ individuals nor their gametes (windborne pollen) are immigrating or emigrating from the population
4. ________________________________ Since there are so many individuals, random events / genetic drift have no impact on allele frequencies
5. ________________________________ all phenotypes have equal fitness / reproductive success

Hardy-Weinberg Equations

$$p + q = 1 \qquad\qquad p^2 + 2pq + q^2 = 1$$

QUESTION: When & why do we use these equations if populations are almost never “in equilibrium”?

____

____

Practice with square roots and squaring: *(change to decimals)*

1. The Square root of 81 is ____________
2. The Square root of 64 is ____________
3. The Square of 60 is ____________
4. The Square of 30 is ____________
5. The Square root of 81% is ____________
6. The Square root of 64% is ____________
7. The Square of 60% is ____________
8. The Square of 30% is ____________

Note: You must ask yourself “what are they giving me, alleles or individuals?”

Identify the variable: (p, q, q^2, etc.) *In this example black is dominant, red is recessive*

1. _______ This represents heterozygote frequency
2. _______ This represents homozygous red frequency
3. _______ This represents homozygous black frequency
4. _______ This represents the red allele frequency _________ This represents red individual frequency
5. _______ This represents the black allele frequency _________ This represents black individual frequency
6. _______ 45% of the alleles in the gene pool are for black fur
7. _______ 24% of the population has red fur _________ 86% of the population has black fur

EQUATIONS: $p^2 + 2pq + q^2 = 1$ $p + q = 1$

1. What is the Hardy-Weinberg symbol for the frequency of the **dominant allele**? _____
2. What is the Hardy-Weinberg symbol for the frequency of the **recessive allele**? _____
3. What is the symbol for the frequency of the homozygous dominant genotype? _____
4. What is the symbol for the frequency of the heterozygous genotype? _____
5. What is the symbol for the frequency of the homozygous recessive genotype? _____
6. If the allele frequency of “r” is 0.75, what is the allele frequency of “R”? _____
7. If the allele frequency of “R” is 0.15, what is the allele frequency of “r”? _____
8. In a population the homozygous dominant individuals make up 81% of the population, heterozygous individuals make up 18%. What is the frequency of the “p” allele?
9. Tay-Sachs disease is caused by a recessive allele. The frequency of this allele is 0.1 in a population of 3,600.

   a. What is the frequency of the dominant allele? _____
   b. How many people in this population will have Tay-Sachs? _____
   c. How many people do not have Tay-Sachs? _____
   d. How many of these people are Tay-Sachs carriers? (heterozygous) _____
10. Researchers observing a large population of Blue-Footed Boobies, easily recognizable by its distinctive bright blue feet, recorded the following data about beak shape. Assuming the bird population is in Hardy-Weinberg equilibrium what proportion of future populations is expected to be round beaked heterozygous for the allele controlling beak shape?

Beak phenotypes in Blue-Footed Booby population	
Phenotype	Number of individuals
Round beak	8,956
Pointed beak	1,128

11. Cystic fibrosis is caused by a recessive allele. The frequency of this allele is 0.2 in a population of 2,500.

a. What is the frequency of the dominant allele? _____

b. How many people in this population will have cystic fibrosis? _____

c. How many people in this population are cystic fibrosis carriers (heterozygous)? _____

12. Huntington's disease is a dominant allele disorder. While looking at his family's pedigree, Parker noticed that 49 out of his 100 relatives were affected by this disorder.

a. What is the value of "q"? _____

b. What is the value of "2pq"? _____

c. How many people are homozygous dominant in Parker's family pedigree? _____

d. How many people are heterozygous in Parker's family pedigree? _____

12. What does the Hardy-Weinberg model show?

____

13. What conditions are required for populations to stay in Hardy-Weinberg equilibrium?

____

____

____

14. What can be predicted by the Hardy-Weinberg equilibrium?

____

15. Why do real populations rarely reach Hardy-Weinberg equilibrium?

____

MORE HARDY-WEINBERG PRACTICE

1. If 9% of the population has blue eyes, what percent of the population is hybrid for brown eyes? Homozygous for brown eyes?

2. Determine the percent of the population that is homozygous dominant if the percent of the population that is homozygous recessive is 16%

3. A plant population consists of 84% plants with red flowers (dominant) and 16% with white flowers (recessive). Determine the percent with the homozygous dominant and heterozygous condition.

4. If 64% of the population has brown eyes, and 36% of the population has blue, what percentage of the population is homozygous or heterozygous brown?

5. In *Drosophilia*, the allele for normal-length wings is dominant over the allele for vestigial wings. In a population of 1000 individuals, 360 show the recessive phenotype. How many individuals would you expect to be homozygous dominant and heterozygous dominant for this trait?

6. The allele for unattached earlobes is dominant over the allele for attached earlobes. In a population of 500 individuals, 25% show the recessive phenotype. How many individuals would you expect to be homozygous dominant for this trait?

7. The allele for the hair pattern called "widow's peak" is dominant over the allele for no "widow's peak". In a population of 1000 individuals, 510 show the dominant phenotype. How many individuals would you expect of each of the possible three genotypes for this trait?

8. In the United States about 16% of the population is Rh negative (recessive). If the population of a high school in the U.S. is 2000, how many students would you expect for each of the three possible genotypes?

9. In certain African countries, 4% of the newborn babies have sickle-cell anemia, which is a recessive trait. Out of a random population of 1000 newborn babies, how many would you expect for each of the three possible genotypes?

10. In a certain population, the dominant phenotype of a certain trait occurs 91% of the time. What is the frequency of the dominant allele?

EVEN MORE HARDY-WEINBERG PRACTICE

1. There are two equations necessary to solve a Hardy-Weinberg Equilibrium question:

2a. A population of cats can be either black or white; the black allele (B) has complete dominance over the white allele (b). Given a population of 1,000 cats, 840 black and 160 white, determine the allele frequency, the frequency of individuals per genotype, and number of individuals per genotype.

Comparing Generations

To know if a population is in Hardy-Weinberg Equilibrium scientists must observe at least two generations. If the allele frequencies are the same for both generations then the population is in Hardy-Weinberg Equilibrium.

2b. The next generation of cats has a total population of 800 cats, 672 black and 128 white. Is the population in Hardy-Weinberg Equilibrium?

3a. The beak color of finches has a complete dominance relationship where black beaks are dominant over yellow beaks. There are 210 individuals with the genotype DD, 245 individuals with the genotype Dd and 45 individuals with the genotype dd. Find: the frequency of the dominant and recessive alleles and the frequency of individuals with dominant, heterozygous, and recessive traits.

3b. The next generation of finches has a population of 400. There are 336 with black beaks and 64 with yellow beaks. Is this population in Hardy-Weinberg Equilibrium?

4a. Scale coloration of lizards has a complete dominance relationship where green scales are dominant over blue scales. There are 1,024 individuals with the genotype GG, 512 individuals with the genotype Gg, and 64 individuals with the genotype gg. Find: the frequency of the dominant and recessive alleles and the frequency of individuals with dominant, heterozygous, and recessive genotype.

4b. The next generation of lizards has 1092 individuals with green scales and 108 individuals with blue scales. Is the population in Hardy-Weinberg Equilibrium? Solve for p and q

5a. Rabbits ears can be either short or floppy, where short ears are dominant over floppy ears. There are 653 individuals in a population. 104 rabbits have floppy ears and 549 have short ears. Find: the frequency of the dominant and recessive alleles and the frequency of individuals with dominant, heterozygous, and recessive genotypes.

5b. The next generation of rabbits has 560 individuals with short ears and 840 individuals with floppy ears. Is the population in Hardy-Weinberg Equilibrium? Solve for p and q.

6a. Petal coloration of pea plants has a complete dominance relationship where purple petals are dominant over white petals. There are 276 plants, 273 have purple petals. Find: the frequency of the dominant and recessive alleles and the frequency of individuals with the dominant, heterozygous, and recessive genotype.

6b. The next generation of pea plants has 552 plants, 546 have purple petals. Is the population in Hardy-Weinberg Equilibrium? Solve for p and q.

Topic 1.7- Mechanisms of Reproductive Isolation

According to the biological species concept, organisms belong to the same **species** if they can interbreed to produce viable, fertile offspring.

What keeps species from interbreeding are called **mechanisms of reproductive isolation**.

Prezygotic barriers

1. ______________________________ Two species might prefer different habitats and thus be unlikely to encounter one another

2. ______________________________ Two species might be active or fertile during different times of the day or months of the year and are unlikely to mate

3. ______________________________ Two species have bodies or reproductive structures that don't allow for copulation

4. ______________________________ Two species might have different courtship behaviors (songs / dances) and mate preference finding one another "unattractive"

5. ______________________________ Two species might produce egg and sperm cells that can't combine in fertilization, even if they meet up through mating.

6. ______________________________ Two species might have different courtship behaviors (songs / dances) or have different mate preference finding one another "unattractive"

Pre-zygotic Isolating Mechanisms		Example	
Temporal	Occurs when two species mate at different times of year	Frogs live in same pond but breed during different seasons (summer vs spring)	
Ecological	Occurs when two species occupy different habitats	Lions and tigers can potentially interbreed, but usually occupy different habitats	
Behavioural	Occurs when two species have different courtship behaviours	Certain groups of birds will only respond to species-specific mating calls	
Mechanical	Occurs when physical differences prevent copulation / pollination	Certain breeds of dog are morphologically incapable of mating due to size	

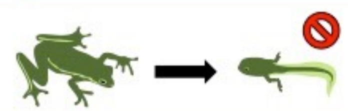
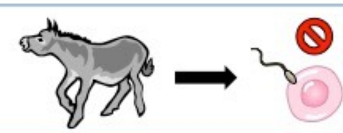
Postzygotic barriers

1. ________________________________ Egg is fertilized, but zygote does not develop.

2. ________________________________ Hybrid embryo forms, but of reduced viability (doesn't survive to reproductive age)

3. ________________________________ Hybrid is viable, but resulting adult is sterile. (mule)

4. ________________________________ First generation (F1) hybrids are viable and fertile, but further hybrid generations (F2 and backcrosses) may be inviable or sterile.

Post-zygotic Isolating Mechanisms		Examples	
Hybrid Inviability	Hybrids are produced but fail to develop to reproductive maturity	Certain types of frogs form hybrid tadpoles that die before they can become a frog	
Hybrid Infertility	Hybrids fail to produce functional gametes (sterility)	Mules are sterile hybrids resulting from mating between a horse and a donkey	
Hybrid Breakdown	F_1 hybrids are fertile, but F_2 generation fails to develop properly	The offspring of hybrid copepods have less potential for survival or reproduction	

Practice:

1. Two populations of birds have overlapping geographic ranges. Birds in the two populations look similar, having only small differences in their feather coloring. The populations are classified as being part of a single species. A scientist claims that, according to the biological species concept, the two populations are actually separate species. Which of the following observations would provide the most direct evidence in support of the scientist's claim?

   a. Birds from each population fight only with birds from the other population while defending their breeding territory.
   b. Birds in one population have a distinct song pattern that is more complex than that of the other population.
   c. Birds from each population mate only with birds from their own population.
   d. Birds in one population eat mostly berries, while birds in the other population eat mostly insects.

2. Which of the following describes a postzygotic mechanism of reproductive isolation?
   a. The sea urchin species *Strongylocentrotus franciscanus* and *S. purpuratus* have incompatible gametes, preventing cross-species fertilization in the water.
   b. The orchid species *Chiloglottis grammata* and *C. triceratops* have overlapping geographic ranges, but the chemicals they produce attract different types of pollinators.
   c. Female *Pundamilia pundamilia* and *P. nyererei* fish choose mates based on scale color: breeding *P. pundamilia* males have blue scales on their back, while *P. nyererei* males have red scales.
   d. Two species of *Ensatina* salamanders that occur together in the California foothills can mate and form hybrids, but most of the hybrids die before reaching maturity.

Topic 1.8- Speciation

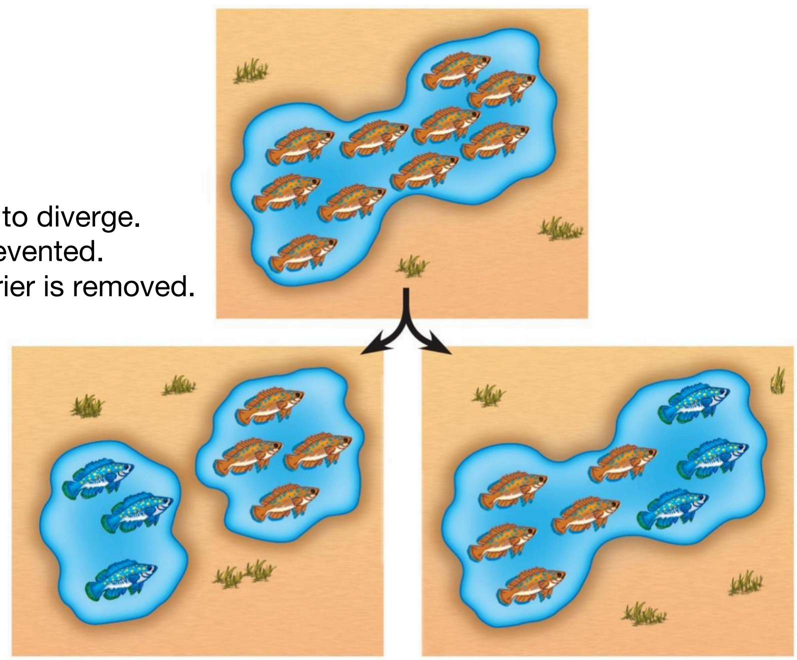
Evolution: A change in the frequency of an inheritable phenotypic trait within a population across generations

- ______________________________ : which refers to large-scale changes that occur over extended time periods, such as the formation of new species and groups.
- ___________________________ : which refers to small-scale changes that affect just one or a few genes and happen in populations over shorter timescales.

A **species** contains organisms that can interbreed to produce viable, fertile offspring.

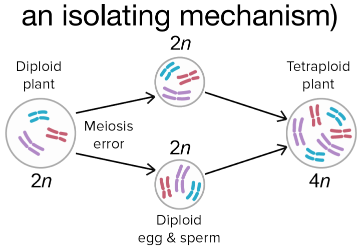
Types of speciation:

1. _____________________ **Speciation**:
A population is divided by a geographic barrier.
Natural selection occurs causing the gene pools to diverge.
Interbreeding between the two populations is prevented.
Populations can no longer interbreed even if barrier is removed.
New species have formed

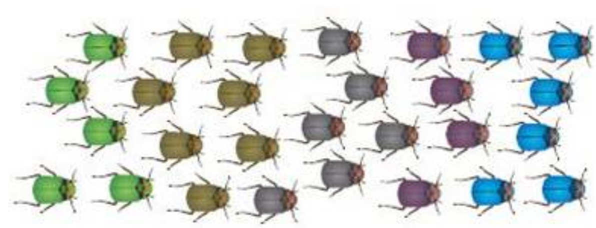


(a) Allopatric speciation **(b) Sympatric speciation**

2. _____________________ **Speciation**:
The formation of new species without the presence of a geographic barrier.
(usually results from polyploidy or an isolating mechanism)



3. _____________________ **Speciation**: (Extremely RARE)
There is no specific physical barrier to prevent gene flow.
The population is continuous but does not mate randomly.
Individuals mate with their geographic neighbors rather than individuals in different parts of the range. This reduces gene flow and divergence can occur.



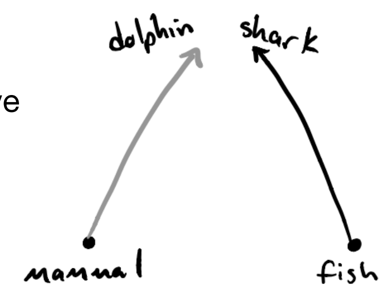
Topic 1.9- Patterns of Evolution

1. ________________________ **evolution:** occurs when a population becomes isolated (for any reason) from the rest of the species and are exposed to different/new selective pressures causing it to evolve into a new species.

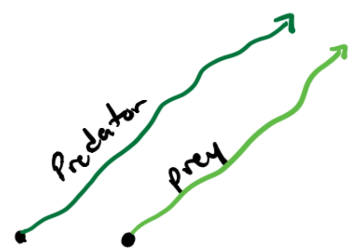
    ________________________ structures are evidence of this

2. _________________________ **evolution:** occurs when unrelated species occupy the same or similar environments and are under similar selective pressures and show similar adaptations.

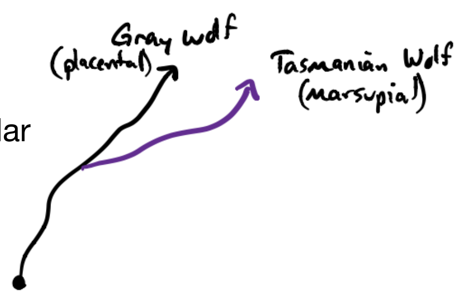
    _______________________ structures are evidence of this



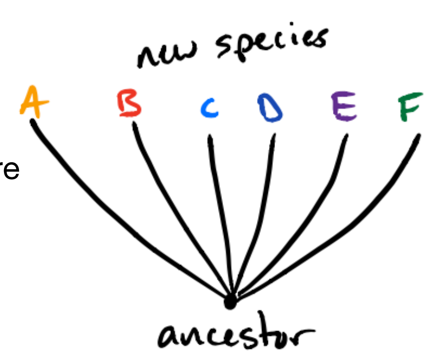
3. ____**evolution:** occurs when two species interact heavily, either mutualistically or in spite of one another (predator-prey). Their adaptations mimic one another.



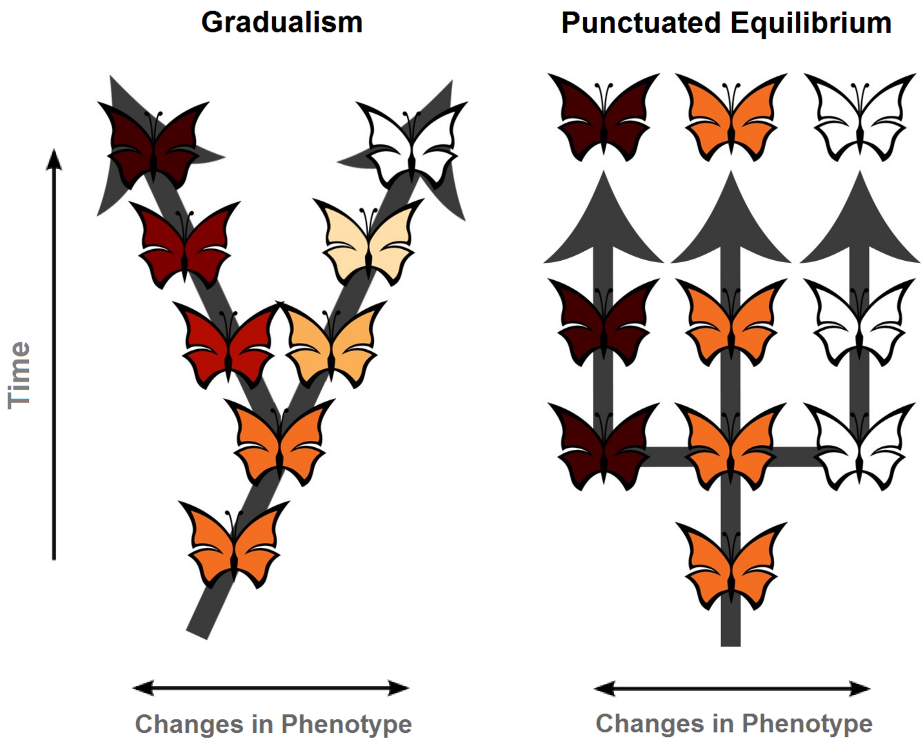
4. _____________________ **evolution:** two related species have made similar evolutionary adaptations after their divergence due to similar selective pressures.



5. ______________________________________**:** Rapid evolution of many species from a single ancestor. It occurs when the population colonizes an area where diverse conditions are available. Niches are exploited. Variants of the ancestor diverge as natural selection occurs. (Darwin's finches are example of adaptive radiation)



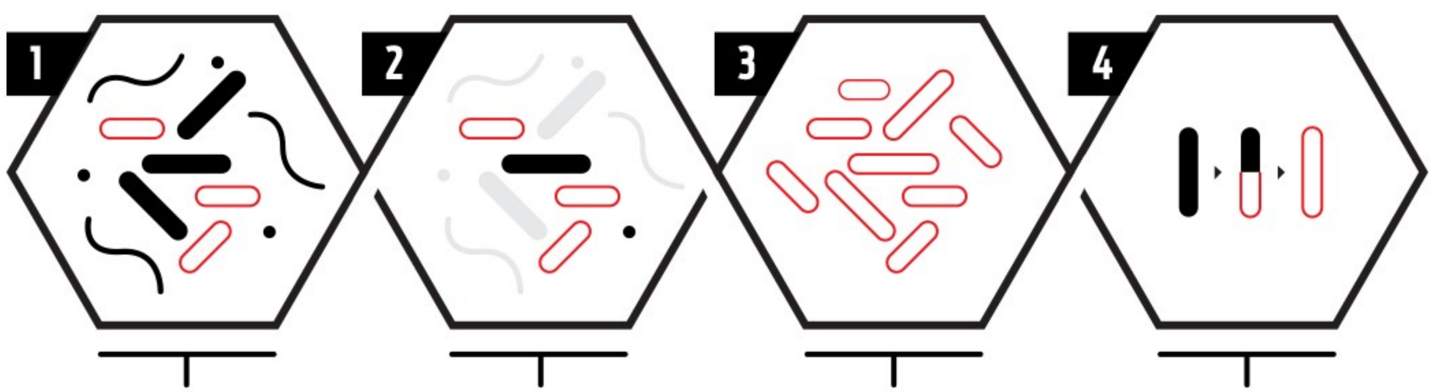
Rate of Evolution/Speciation:



Gradualism
evolution occurs at a slow-but-steady pace with many intermediate species

Punctuated Equilibrium
Every once in a while, due to an environmental change or mutation, a drastic abrupt change occurs, with few or no intermediate species

How Antibiotic Resistance Happens



Topic 1.10- Heterotroph Hypothesis

Introduction:

In the 1920s, Russian scientist Aleksandr Oparin and English scientist J. B. S. Haldane both separately proposed what's now called the **Oparin-Haldane hypothesis**: that life on Earth could have arisen step-by-step from non-living matter through a process of "gradual chemical evolution." Oparin and Haldane thought that the early Earth had an oxygen-poor atmosphere in which simple inorganic molecules could have reacted (with energy from lightning or the sun) to form building blocks like amino acids and nucleotides, which could have accumulated in the oceans, making a "primordial soup."

STAGE 1

Hydrogen is the most abundant element. Hydrogen combined with the other available elements to form various gases:

$\mathbf{CH_4}$ (methane) $\mathbf{NH_3}$ (ammonia) $\mathbf{H_2O}$ (water) $\mathbf{H_2}$ (hydrogen gas)

The primitive atmosphere contained **no free oxygen**. The gasses dissolved in heavy rains and were carried down to form the first oceans. The oceans of this time were described as a "**hot thin soup**" where chemical reactions were likely occurring rapidly

STAGE 2

Lightning, **cosmic rays** and **ultraviolet light** from the sun supplied the **energy** for the breakdown and formation of chemical bonds. Many simple organic compounds, like amino acids, glycerol, fatty acids and simple monosaccharides were being formed and broken down constantly.

STAGE 3

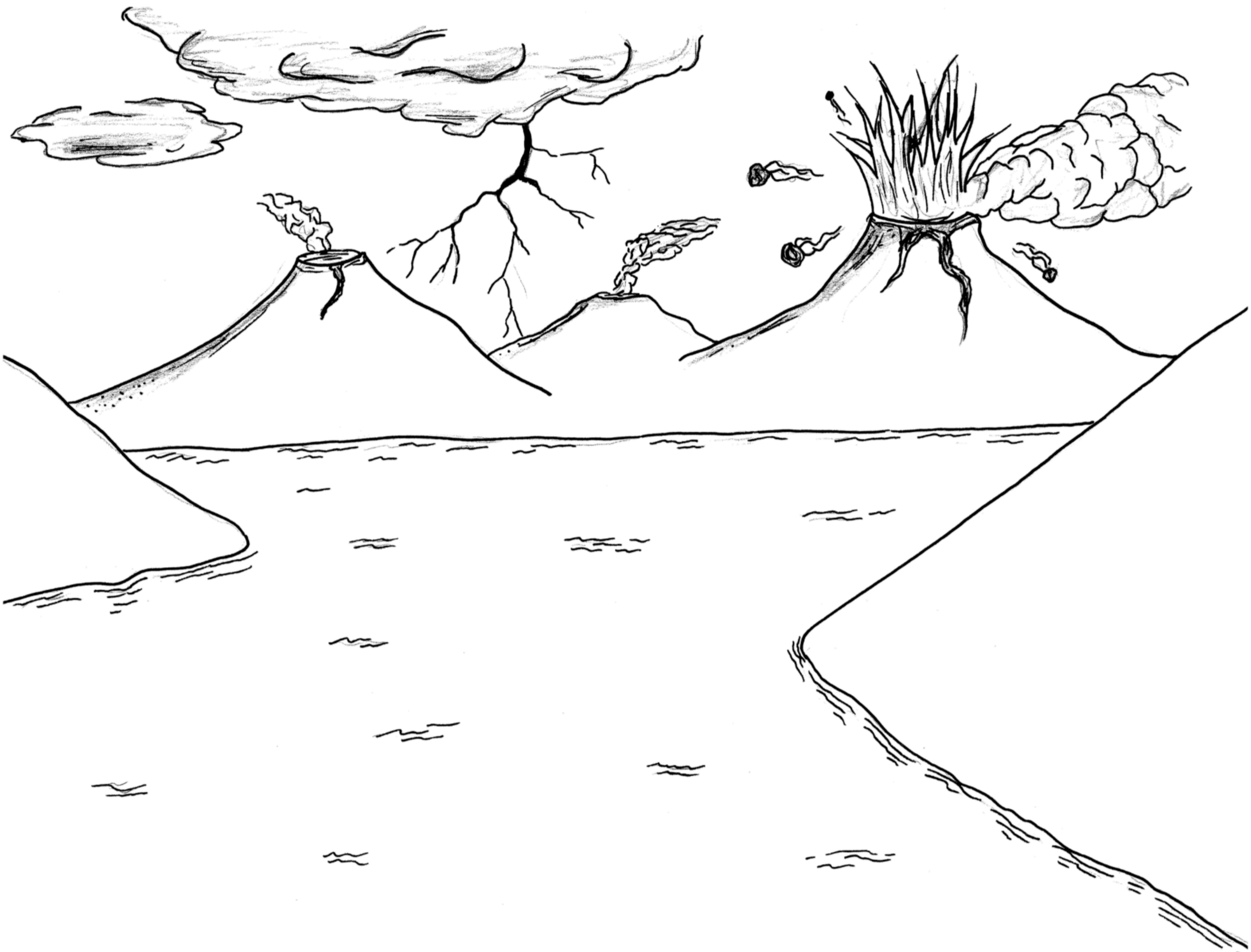
In the rock crevices of the shorelines, where evaporation could occur, the simple organic compounds joined together to from larger macromolecules through dehydration synthesis.

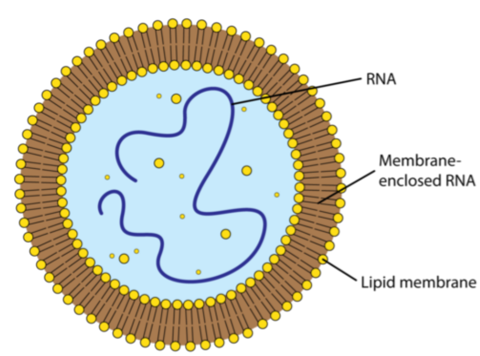
STAGE 4

The protein molecules formed aggregates, or clusters and catalyzed further reactions. The aggregates became surrounded by clusters of droplets of lipids called **Coacervates.** These Coacervates formed a "membrane like" barrier between the organic molecules and their watery environment

STAGE 5

The coacervates absorbed nutrients from the "hot thin soup" and increased in size. Eventually, they would split in half and each would grow in size again. Oparin called these primitive living things **heterotrophs** because they obtained nutrients from the environment.

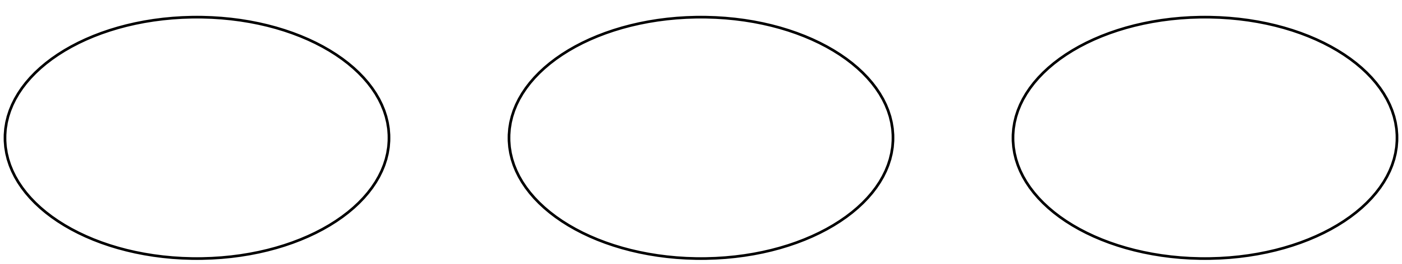



RNA
Membrane-
enclosed RNA
Lipid membrane

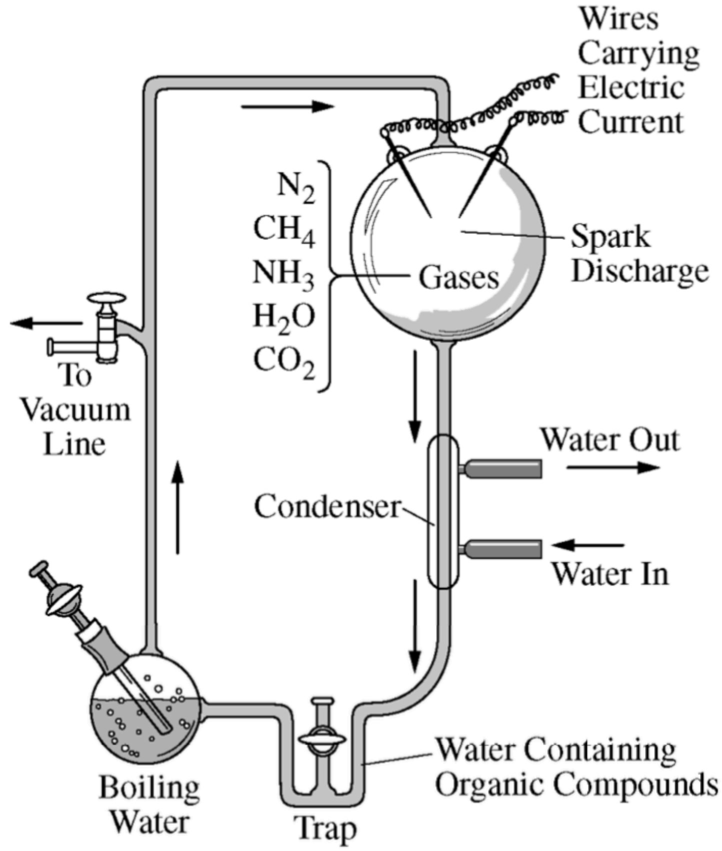
What happened next?

***Remember* there was no free oxygen gas in the primitive earth's atmosphere**

1. Those very first heterotrophs therefore had to be ____________________, organisms that do not use oxygen, but do give off **CO_2**
2. Once there was CO_2 in the atmosphere, it was possible for **autotrophic** organisms to evolve. Autotrophs are organisms that use photosynthesis to convert energy from the sun into a more usable form, sugar. When autotrophs conduct photosynthesis, __________ and _________ are combined to produce ________________ and _______ is released into the air.
3. The presence of O_2 led to the formation of the ozone and also to the development of organisms with the capacity to carry out __________________ respiration. **Aerobes** are organisms that use O_2 to convert food into usable energy and release CO_2 into the air.

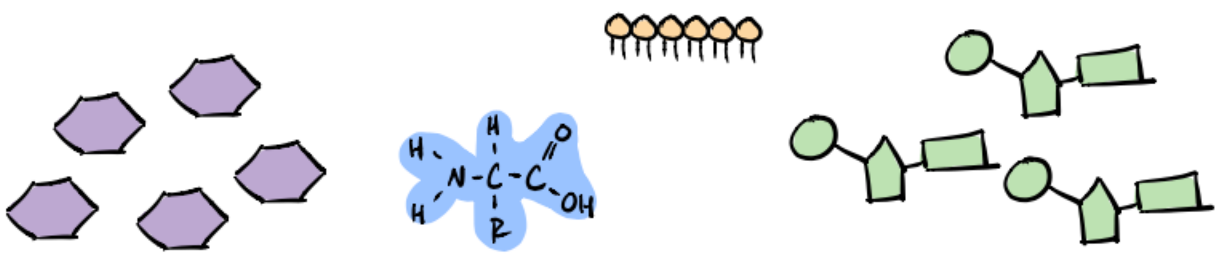


Topic 1.11- Miller-Urey Experiment

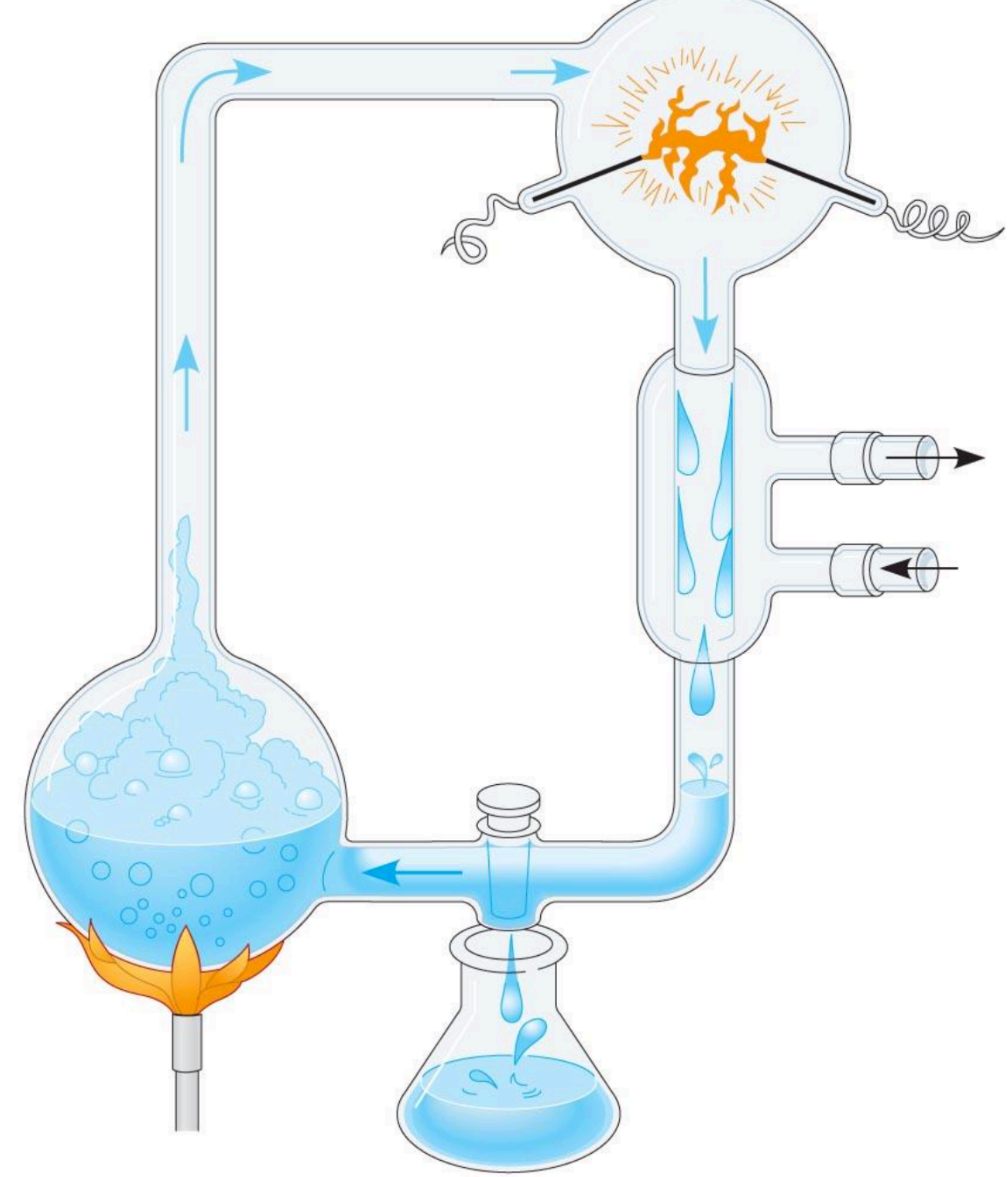


Miller and Urey built a closed system containing a heated pool of water and a mixture of gases that were thought to be abundant in the atmosphere of early earth (H_2O, NH_3, CH_4, and H_2). To simulate the lightning that might have provided energy for chemical reactions in Earth's early atmosphere, they sent sparks of electricity through their experimental system.

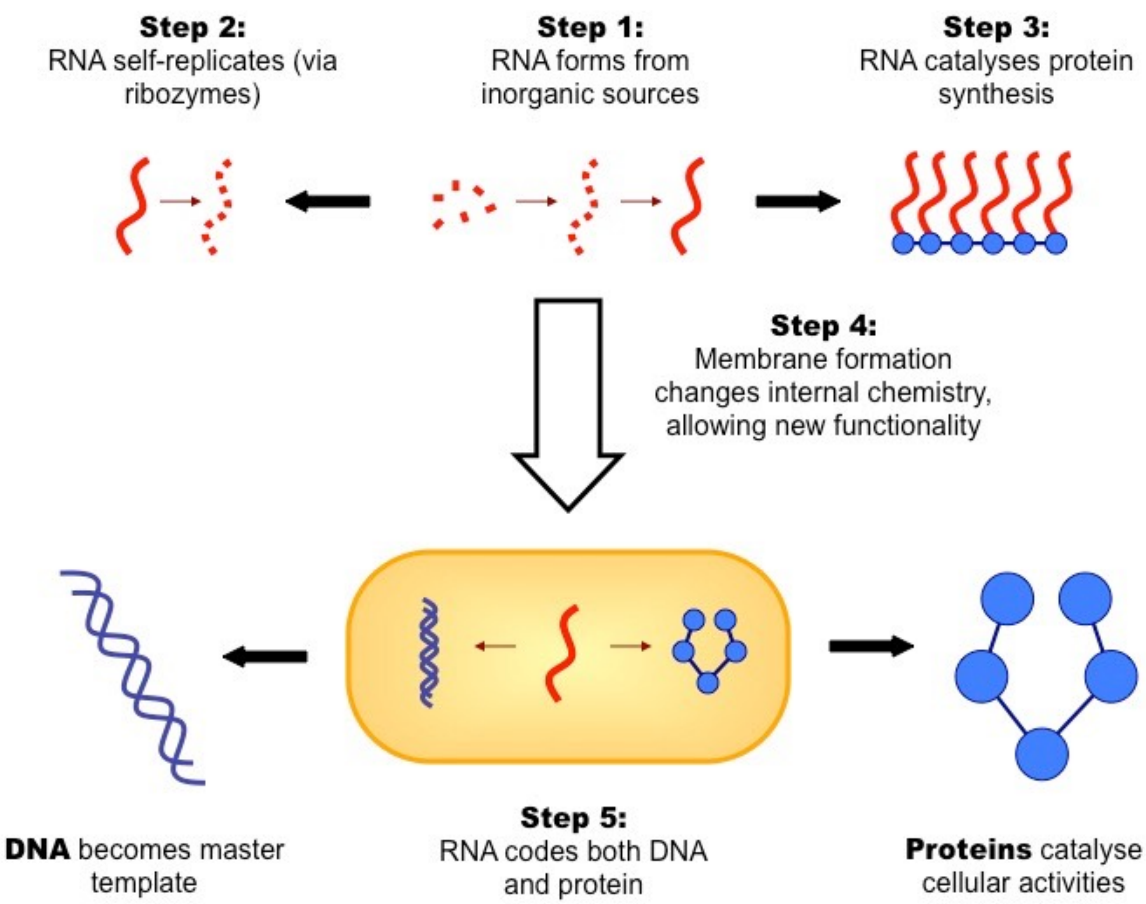
After letting the experiment run for a week, Miller and Urey found that various types of amino acids, sugars, lipids and other organic molecules had formed. Large, complex molecules like DNA and protein were missing, but the Miller-Urey experiment showed that at least *some* of the building blocks for these molecules could form spontaneously from simple compounds.



One more recent study using a different approach found that **RNA nucleotides** could be formed from inorganic components under conditions thought to resemble those of early Earth. **Cytosine** was the nucleotide in particular synthesized, and when light was applied the cytosine was converted into **uracil**. This finding helps support the RNA world hypothesis and also includes the missing components from Miller-Urey. The key difference in this experiment is that phosphorus was included, which was excluded from Miller-Urey's experiment and an essential part of nucleic acids.



Topic 1.12- RNA World Hypothesis



Evidence:

1. RNA is an unstable molecule that undergoes frequent mutations. These mutations allow for more variety, this variety is acted upon by natural selection.
2. Certain RNA molecules (ribozymes) can catalyze reactions, including RNA replication.
3. RNA codes for proteins which can carry out cellular processes
4. RNA can store, replicate, and pass on hereditary information.
5. Scientists have synthesized RNA nucleotides under early earth conditions (Cytosine & Uracil)

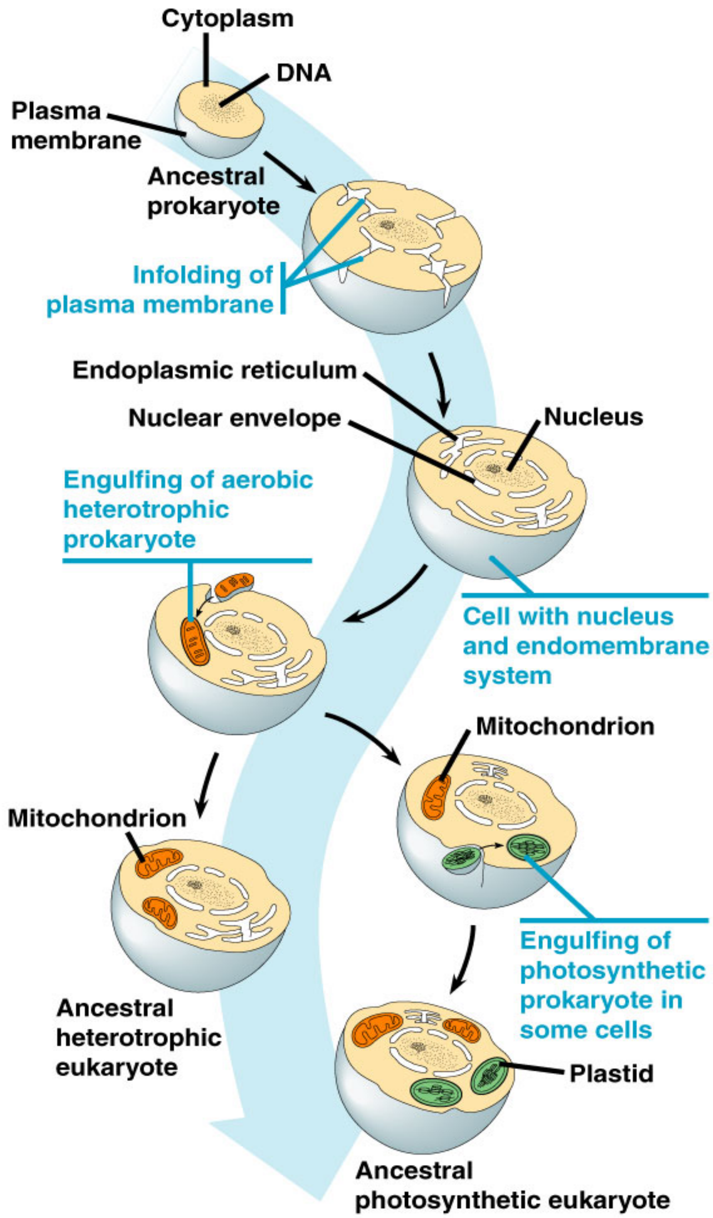
Odds & Ends:

Heterozygote advantage:
Sickle cell and malaria
Tay-Sachs & Tuberculosis (TB)
Cystic Fibrosis & Cholera

Darwin couldn't explain the "Sources of Variation":

- Mutations
- Sexual Reproduction: Independent Assortment, Crossing Over, Random Fertilization

Topic 1.13- Endosymbiotic Theory



Evidence:

1. Mitochondrion and chloroplast **contain their own DNA** that is **circular** like prokaryotes not linear like eukaryotes
2. They have a **double membrane**, with the inner membrane resembling that of bacteria and the outer a eukaryote
3. They can **self-replicate by binary fission** (like prokaryotes)
4. They contain their **own ribosomes** that are more like prokaryotic ribosomes (smaller)
5. They synthesize their own unique proteins not found elsewhere in the cell
6. Because chloroplast and mitochondrion are so similar to prokaryotes (bacteria) they are sensitive to antibiotics which act on the difference between prokaryotic and eukaryotic cells (like the protein synthesis process)