Name: _____ **Unit 7: Evolution Study Guide**

Topic 7.1: Introduction to Natural Selection

Learning Objective

EVO-1.C.1 Natural selection is a major mechanism of evolution.

I can…

- □ I can describe how competition for limited resources results in differential survival.
- □ I can describe how individuals with more favorable phenotypes are more likely to survive and produce more offspring
- □ I can describe how evolutionary fitness is measured by reproductive success.
- □ I can describe how environments can be more or less stable/fluctuating, and this affects the rate and direction of evolution

1. Define the following evolution terms:
   a. natural selection
   b. fitness
   c. selective pressure
   d. reproductive success
   e. differential survival

2. How is fitness measured?

3. African elephants, Loxodonta africana, are often hunted illegally for their tusks. Both male and female elephants have tusks, although the tusks are much larger in the males. Researchers have followed the elephant population in Gorongosa National Park in Mozambique for many years. Figure 1 shows the percent of tuskless female elephants expected in wild populations throughout the species' range, as well as the percent of tuskless females that survived the hunting between 1977 and 1992 (those over 25 years old) and the percent of female elephants born after 1992 without tusks in the park. The data are based on 200 known female elephants in the park.

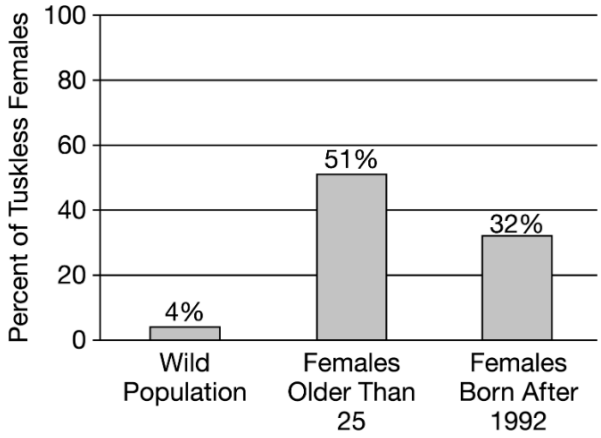


Figure 1. Comparison of the frequency of tuskless females by age cohort

Which of the following best describes the process responsible for the change in the percent of tuskless female elephants in the Gorongosa National Park population shown in Figure 1?

A. Human hunting of elephants with tusks between 1977 and 1992.

B. Sexual selection for females without tusks between 1977 and 1992.

C. Tusklessness in female elephants is a dominant trait that is only expressed in females.

D. After 1992, female elephants from neighboring populations merged, with the population in the park adding more tuskless individuals to the population.

4. Scientists investigated the role that beak depth plays in the ability of one species of seed-eating finch to reproduce. The scientists calculated the average beak depth of finches in mating pairs and then observed whether or not the pairs produced at least one offspring that survived to the next season. The data are represented in Figure 1.

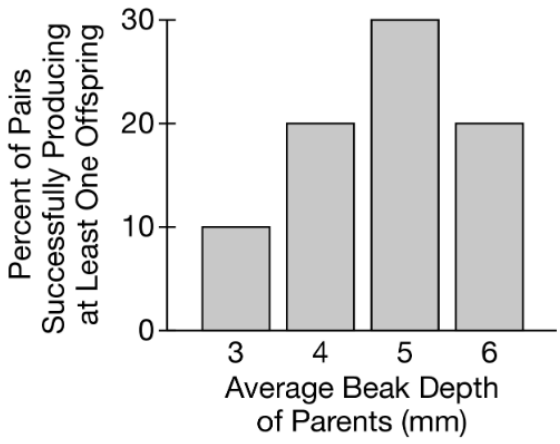


Figure 1. Beak depth and offspring survival in a species of finch

Based on the data in Figure 1, which of the following best describes the concept illustrated?

A. Parental pairs with a specific beak depth had the highest reproductive fitness.
B. Parental pairs with a specific beak depth ate the most nutritious seeds.
C. Finches with a certain beak depth rarely find mates.
D. Increasing average beak depth results in increasing finch fitness.

Topic 7.2: Natural Selection

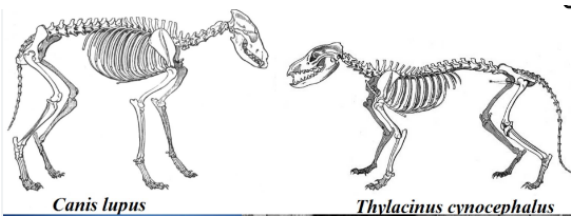
Learning Objective	**EVO-1 Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.**
I can…	□ I can describe how natural selection acts on phenotypic variations in populations.
	□ I can describe how environments change and apply selective pressures to populations
	□ I can describe how some phenotypic variations significantly increase or decrease fitness of the organism in particular environments

1. Define the following evolution terms:
    a. homologous structures
    b. analogous structures
    c. vestigial structure
    d. molecular homology
    e. convergent evolution
    f. divergent evolution
    g. sexual selection
    h. kin selection
    i. coevolution

2. How does an environment apply a selective pressure to a population? Give an example.

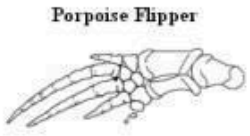
3. Bats are the only mammals that are capable of powered flight. Bats are traditionally divided into two subgroups — microbats and megabats. Microbats are generally smaller, have poor vision, and use sonar emitted by the larynx. Megabats have large brains, good vision, and either no sonar, or sonar that involves tongue clicks. Megabats' brains and vision are more like those in primates than like those in microbats. DNA (molecular) homology has shown that megabats are more closely related to microbats than to any other type of mammal.
   a. That megabats and primates share several similarities (large brains, good vision) is a result of **convergent** or **divergent** evolution?
   b. These traits then, are examples of **homologous** or **analogous** structures?

4. The gray wolf and the Tasmanian wolf (extinct) looked very much alike. The Tasmanian wolf is a marsupial mammal, like kangaroos, and lived in Australia. The gray wolf is a placental mammal (like us) and is native to North America, Europe and Asia.



   a. Are the similarities in these animals the result of **convergent** or **divergent** evolution?
   b. Are similarities in their body shapes **homologous** or **analogous** structures?

5. The bone structures of a porpoise flipper and a bat wing are shown.
   a. Are the similarities in these animals the result of **convergent** or **divergent** evolution?
   b. Are similarities in their body shapes **homologous** or **analogous** structures?



6. Prairie dogs are small mammals that live in large colonies in burrows in the ground. Prairie dogs that are near their own relatives when a predator approaches are much more likely to issue a warning bark than those that are near unrelated prairie dogs. The prairie dogs that hear a warning bark are more likely to hide in their burrows than to remain above ground. However, the prairie dog that gives the warning bark is putting itself at increased risk of being identified and killed by the predator.
Which of the following presents the most likely evolutionary explanation for the behaviors described?
A. The warning bark changes the behavior of the related prairie dogs nearby, allowing the prairie dog's family to have increased survival and reproductive success.
B. The barking prairie dog chooses to warn other prairie dogs, leading to more prairie dogs living above ground.
C. The barking prairie dog is alerting unrelated prairie dogs to the predator, so it is not giving any advantage to its own relatives.
D. The failure of the individual to bark when surrounded by unrelated prairie dogs ensures survival of the individual.

7. Staphylococcus aureus is a pathogenic bacterium that can infect a wide range of host species, including humans. S. aureus has a particular protein that binds with hemoglobin from the host organism. Hemoglobin is the iron-containing protein used to transport oxygen in the blood. Since iron is important for growth, S. aureus have evolved the ability to absorb the iron from the host's hemoglobin.

Table 1. Selected amino acid sequences and preferred host for four strains of *S. aureus*

S. aureus Strain	Amino Acid Sequence	Host Species
1	Q Q F Y H Y A R S	Species A
2	R Q A Y H Y A R T	Species B
3	Q Q A Y H Y A R T	Macaque
4	R Q A A H Y Q L T	Species C

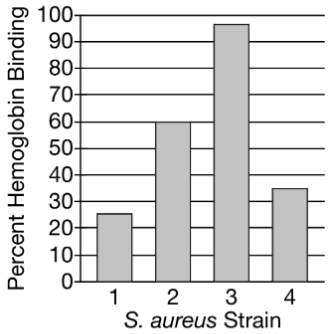


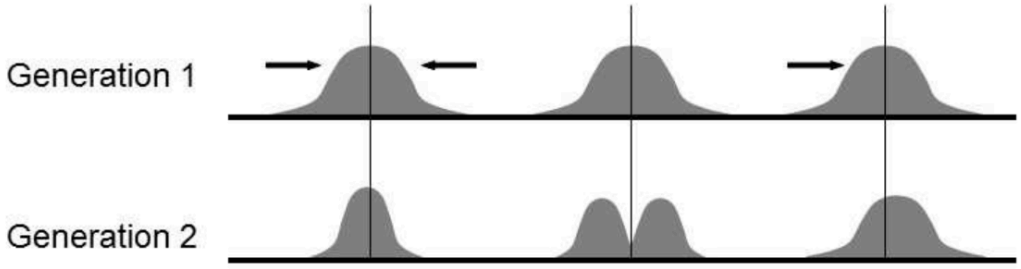
Figure 1. Macaque hemoglobin binding ability of different strains of *S. aureus*

Different S. aureus strains preferentially infect different hosts and have different amino acid sequences at their hemoglobin-binding domains (Table 1; letters indicate different amino acids). In an experiment, different S. aureus strains were mixed with hemoglobin from macaque monkeys and their binding ability was measured (Figure 1). The differences in amino acid sequences contributed to the differential binding abilities observed.
Which of the following processes is most consistent with the differences in the amino acid sequences listed in Table1?
A. Each host transcribes and translates this gene differently.
B. S. aureus develops a mutualistic relationship with each host species.
C. Changes in amino acid sequence are unrelated to protein function.
D. Each strain is best adapted to a specific host species.

8. Which of the following is probably the best explanation for the fact that Antarctic penguins cannot fly, although there is evidence that millions of years ago their ancestors could do so?
A. Penguins live on land and feed in the water; therefore they have no need to fly.
B. The Antarctic home of penguins is flat and barren; therefore there is no place to fly.
C. Ancestral penguins without large wings were better able to swim and feed in the water; therefore they passed their genes for shorter wing structure on to their offspring.
D. Ancestral penguins did not use their wings for long periods of time; therefore today's penguins have only tiny, nonfunctional wings.
E. The cold and wind of Antarctica make flight impossible; therefore penguins that live there have lost the ability to fly.

9. Climate change is disrupting the length of winter in various ecosystems, resulting in less snowfall and milder winters. Scientists in Finland have been observing the tawny owl, a fairly large owl species that is commonly found in woodlands across much of Europe and Asia. Typically, the feathers of the upper body are either brown (BB) or gray (bb). Scientists studying tawny owls in Finland have found that the percentage of tawny owls that have brown feathers has increased over the past 28 years.
Which of the following best explains why the brown-feathered phenotype in tawny owls has increased over the past 28 years?
A. Since the brown genotype is dominant, it will eventually eliminate the recessive gray genotype from the population.
B. Darker feather color in tawny owls makes them less visible to predators as they sit in the trees.
C. With milder winters, the advantage of gray feathers that blend into a snowy environment has decreased.
D. The directional selection toward a darker phenotype is random and likely due to a bottleneck event.

10. Identify the type of selection (directional, stabilizing, and disruptive) shown in each diagram below.



11. Two species of fish that live in extremely cold environments produce near-identical antifreeze glycoproteins, called AFGPs. Scientists have determined the origins of the AFGPs gene in both species. Selected characteristics of the two fish species are provided in Table 1.

Table 1. Characteristics of two fish species producing nearly identical antifreeze glycoproteins

Fish Species	Order	Location	Evolutionary origin of the $AFGP$ Gene
Boreogadus saida	Gadiformes	Arctic	No sequence identity with trypsinogen
Dissostichus mawsoni	Perciformes	Antarctic	Pancreatic trypsinogen

Based on the information in Table 1, which of the following statements best describes the production of nearly identical AFGPs in these two species of fish?
A. The fish eat the same type of food, which resulted in the evolution of similar digestive proteins.
B. The fish live in environments with similar selective pressures, and those that produce AFGPs are better able to survive.
C. The Antarctic fish species evolved into a separate species after being geographically isolated from the Arctic population because of commercial fishing.
D. The production of similar AFGPs was due to random splicing of exons in both species.

12. Which of the following best explains why the brown-feathered phenotype in tawny owls has increased over the past 28 years?
A. Since the brown genotype is dominant, it will eventually eliminate the recessive gray genotype from the population.
B. Darker feather color in tawny owls makes them less visible to predators as they sit in the trees.
C. With milder winters, the advantage of gray feathers that blend into a snowy environment has decreased.
D. The directional selection toward a darker phenotype is random and likely due to a bottleneck event.

Topic 7.3: Artificial Selection

Learning Objective

EVO-1-F Explain how humans can affect diversity within a population.

I can…

- □ I can describe how humans affect variation in other species.
- □ I can describe how similar selective pressures result in similar phenotypic adaptations in different populations or species through convergent evolution.

1. Explain the difference between natural selection and artificial selection.

2. Table 1 shows a trend of increasing milk yield for cows. Part of the increase in milk production can be attributed to improved nutrition and health protocols for dairy cows.
Based on the information provided, which of the following best describes the source of the rapid increase in milk production from 1976 to 2015?
A. From the 1970s to the early 2000s, dairy cows were not used for beef production.
B. Starting in the 1970s, farmers increased the selective breeding of cows and bulls for offspring that produced more milk.
C. Reproduction rates in cows and bulls increased significantly in the 1970s.
D. Cows were healthier after the 1970s, so they lived longer and produced more milk during their lifetime.

Year	Average Annual Milk Production($\frac{Kg}{Cow}$)
1924	2,300
1937	2,300
1950	2,600
1963	3,400
1976	4,800
1989	6,400
2002	8,400
2015	10,000

3. Malaria is caused by several different species of Plasmodium, a protozoan parasite. Plasmodium resistance to the common drugs used to treat malaria has increased in recent years.
In a scientific study, Plasmodium samples were analyzed in blood drawn from a large number of infected patients before drug treatment and subsequently from the subset of infected patients with drug-resistant Plasmodium. DNA sequences of four different Plasmodium genes thought to be involved in resistance were compared between samples from patients with drug-sensitive Plasmodium and patients with drug-resistant Plasmodium.
Which of the following best supports the hypothesis that preexisting mutations confer drug resistance?
A. Drug resistance can sometimes be reversed by simultaneous treatment with a drug that inhibits the drug-pumping mechanism of Plasmodium.
B. Some of the mutations that occur most frequently in samples from patients treated with antimalarial drugs are detectable in Plasmodium samples collected prior to use of antimalarial drugs.
C. Continued use of the same antimalarial drugs leads to increased Plasmodium resistance.
D. The same mechanism of drug resistance in Plasmodia isolated from separate populations of patients resulted from an accumulation of new genetic mutations.

4. Over many years of a breeding program, a zoo has an established population of foxes that is well adapted for living in captivity. A representative sample of wild foxes from the neighboring forest was used to start the zoo population. A study was conducted to compare the behavior of the zoo fox population with the wild fox population in the neighboring forest. The behaviors of equal numbers of foxes from each population were assessed. Each fox's behavior was scored on a continuum from docile to aggressive based on its interaction with a trained behaviorist. The data is shown in Figure 1.

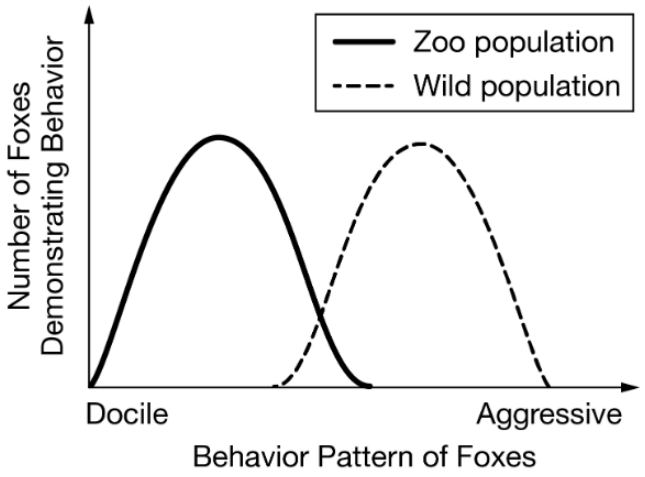


Figure 1. Aggressive behavior in zoo and wild fox populations

The phenotypic variation in behavior between the two populations can best be described as resulting from
A. sexual selection
B. natural selection
C. artificial selection
D. genetic drift

Topic 7.4: Population Genetics

Learning Objective	**EVO-1.H Explain how random occurrences affect the genetic makeup of a population.**
I can…	□ I can describe how evolution is driven by random occurrences, including mutation, genetic drift, bottlenecks, founder effect, and gene flow. □ I can describe how reduction of genetic variation within a given population can increase the differences between populations of the same species. □ I can describe how mutation results in genetic variation, which provides phenotypes on which natural selection acts.

1. A tiny population of beautiful mice exists in my barn. The mice have either purple hair (autosomal dominant), or pink hair. I happen to know the genotypes of each mouse because I have been charting their families for generations! Currently, there are 4 homozygous dominant purple mice, 5 heterozygous mice, and 1 homozygous recessive pink mouse. Please list the frequencies of the P allele, the *p* allele, the purple phenotype, and the pink phenotype. Do the allele frequencies match the phenotypic frequencies? Why or why not?

2. Why is genetic variation important to the survival of a species?

3. The following processes can change allele frequency in a population, thereby causing evolution. Define each term.

gene flow

genetic drift

bottleneck

founder effect

mutation

natural selection

4. Fill in the chart for each process.

	The process is selective or nonselective?	Makes the population more fit for its current environment?	Population must be small?	Tends to increase or decrease the genetic diversity of the population?	Tends to increase the likelihood of local extinction?	Tends to increase the likelihood of a new speciation event?
Natural selection						
Gene flow						
Genetic drift						
Bottle neck						
Founder effect						
Mutation						

5. Why is the bottleneck effect a problem for endangered species?

6. In humans, one allele of the APOE gene, called APOE-ε2, can result in a high tolerance of cholesterol. Cholesterol is a vital substance for humans but may lead to heart disease in an older adult with a history of high cholesterol diets. High cholesterol diets are becoming more prevalent in the United States. Currently only about 2% of humans carry the APOE-ε2 allele.
Which of the following states a valid null hypothesis about the future distribution of APOE-ε2 alleles in future generations in the United States?
A. The APOE-ε2 allele was the result of chance mutations so it is not possible to predict how its frequency will change in the future.
B. As high cholesterol diets become more common in the United States, individuals with the APOE-ε2 allele will have a better survival rate from heart disease than those without the allele, so the allele will increase in frequency.
C. The low frequency of the APOE-ε2 allele indicates it is probably a recessive allele, so it will become less frequent as the dominant allele becomes more frequent.
D. The variant protects an individual from a condition that is only common among humans beyond reproductive age, so the frequency of the allele will likely not change much in the future because it is not influenced by natural selection.

Topic 7.5: Hardy-Weinberg Equilibrium

Learning Objective	**EVO-1.K Describe the conditions under which allele and genotype frequencies will change in populations.**
I can…	□ I can describe how Hardy-Weinberg is a model for describing and predicting allele frequencies in a non-evolving population □ I can describe the five conditions that must be met to be in Hardy-Weinberg equilibrium, which serves as a null hypothesis for non-evolving populations. □ I can describe how changes in allele frequencies provide evidence for the occurrence of evolution in a population

1. Hardy-Weinberg conditions:
   a. What are the five conditions that must be met for a population or allele to be in Hardy-Weinberg equilibrium?

   b. Are these five conditions usually met?

   c. What does it mean for the evolution of this population if all of the conditions have been met?

   d. What is the null hypothesis in a Hardy-Weinberg problem?

2. Sickle-cell anemia is a genetic blood disorder that protects heterozygous individuals from the infectious malaria parasite. Homozygous individuals (SS) have normal blood cells that are easily infected with the malarial parasite. Thus, many of these individuals become very ill from the parasite and many die. Individuals homozygous for the sickle-cell trait (ss) have red blood cells that readily collapse when deoxygenated due to a difference in the hemoglobin protein. Although malaria cannot grow in these red blood cells, individuals often die because of the hemoglobin difference. However, individuals with the heterozygous condition (Ss) have some sickling of red blood cells, but generally not enough to cause mortality. In addition, malaria cannot survive well within these red blood cells. The presence of the different hemoglobin causes the cells to sickle when the parasite is present. Thus, heterozygous people tend to survive better than either of the homozygous conditions if malaria is present in the environment.

If 9% of an African population is born with a severe form of sickle-cell anemia (ss), what percentage of the population will be more resistant to malaria because they are heterozygous (Ss) for the sickle-cell gene?

3. Within a population of butterflies, the color brown (B) is dominant over the color white (b). And, 40% of all butterflies are white. Given this simple information, calculate the following:

A. The percentage of butterflies in the population that are heterozygous.
B. The frequency of homozygous dominant individuals.

4. A very large population of randomly-mating laboratory mice contains 35% white mice. White coloring is caused by the double recessive genotype, "aa". Calculate allelic and genotypic frequencies for this population. Assume complete dominance.

5. A rather large population of frogs have 396 red-skinned individuals and 557 blue-skinned individuals. Assume that red is totally recessive. Calculate the following:

a. The allele frequencies of each allele._____
b. The expected genotype frequencies._____
c. The number of heterozygous individuals that you would predict to be in this population._____
d. The expected phenotype frequencies._____
e. Conditions happen to be really good this year for breeding and next year there are 1,245 young frogs. Assuming that all of the Hardy-Weinberg conditions are met, how many of these would you expect to be red-skinned and how many blue-skinned?_____

6. Cystic fibrosis is a recessive condition that affects about 1 in 2,500 Caucasian babies in the United States. Please calculate the following:

The frequency of the recessive allele in the Caucasian population.
The frequency of the dominant allele in the Caucasian population.
The percentage of heterozygous individuals (carriers) in the Caucasian population.

7. The ability to taste PTC is due to a single dominate allele "T". You sampled 215 individuals, and determined that only 150 individuals could detect the bitter taste of PTC. Calculate all of the potential frequencies and label each with genotype or allele.

8. In alpacas, a gene controlling fur color is determined by three alleles of a single gene: F^B, F^W, f. The F^B and F^W alleles are codominant, and both are completely dominant to the f allele. The three alleles and the phenotypes they produce are listed in the table below, with the frequency of the phenotypes in a large population of alpacas.

Phenotype	Genotype	Frequency
Black fur	F^BF^B or F^Bf	0.14
White fur	F^WF^W or F^Wf	0.45
Himalayan: white fur with black tipped ears, nose, tail	F^BF^W	0.06
Chinchilla: light gray fur on entire body	ff	0.35

The Hardy-Weinberg principle can be applied to a genetic locus with three alleles by using the following equations.

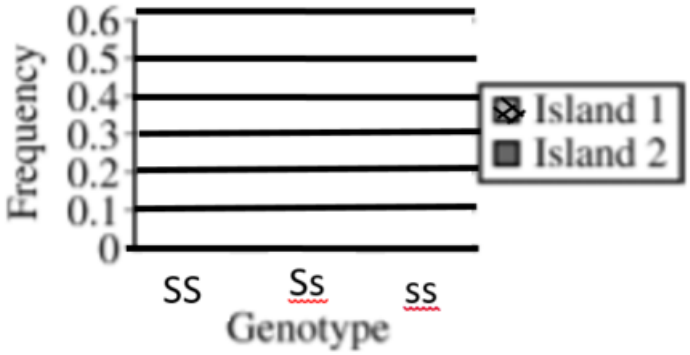
$$p^2 + q^2 + r^2 + 2pq + 2pr + 2qr = 1$$
$$p + q + r = 1$$

Assuming that the population is in Hardy-Weinberg equilibrium with respect to fur color, what is the frequency **of the chinchilla allele?**

9. Scientists are studying several populations of wild alpacas on the Elizabeth Islands. Previous genetic analysis has shown that a single gene controls hair texture and that the allele for soft fur (S) is dominant to the allele for rough fur (s). On two separate islands, the scientists recorded the number of alpacas with soft fur and the number of alpacas with rough fur. The results are shown in the table below.

Location	Phenotype	Number of Individuals
Island 1	soft fur	3,150
	rough fur	1,009
	Total count	4,159
Island 2	soft fur	4,914
	rough fur	890
	Total count	5,804

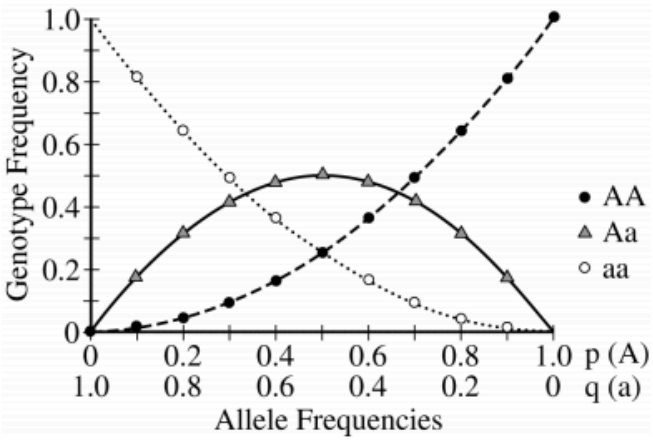
Assume that the two wild alpaca populations are each in Hardy-Weinberg equilibrium and are isolated from each other. Determine the genotype frequencies of each population and plot them on the graph below.



10. Hereditary hemochromatosis is a recessive genetic disorder that often causes increased iron absorption and storage. The extra iron is often stored in the liver and pancreas, causing diabetes or cancer. Approximately 1 in 200 Europeans have hereditary hemochromatosis, but 1 in 83 Irish people have the disease[1]. Assume that both of the populations are in Hardy-Weinberg equilibrium with respect to this disease.

a. What is the difference in allele frequency in the European population, and the Irish population?
b. Describe a possible difference in selective pressure between these populations.

11. Using the graph, determine the frequency of the recessive allele in the population if the frequency of heterozygous individuals in the population is 0.3.



12. Using the graph, determine the frequency of homozygous dominant individuals if the frequency of the recessive allele is 0.5

13. Using the graph, determine the frequency of homozygous recessive individuals if the frequency of the recessive allele is 0.8

Genotype	Phenotype	Number of Individuals in Original Population	Number of Individuals in New Population
RR	Red	953	0
Rr	Pink	1,467	1,467
rr	White	332	332

14. The genetic makeup of rose plants in a greenhouse is provided in the table above. At the start of prom season, love struck teenagers removed all of the red roses, resulting in a population that was not in Hardy-Weinberg equilibrium. Thankfully, none were stung by the greenhouse pollinators! Calculate the frequency of the dominant allele **in the remaining population** of roses.

15. A single gene controls stripes in spider plants and the allele for white stripes (W) is dominant to the allele for no stripes (w). Scientists recorded the number of spider plants with stripes and the number of spider plants without stripes in a particular population. The results are shown in the table below. Determine the **genotype frequencies** of this population.

Phenotype	Number of Individuals
stripes	109
no stripes	150
total count	259

16. A single gene controls coloration of leaves in clover plants. The allele for solid pattern (S) is dominant to the allele for swirly pattern (***s***). Scientists recorded the number of clover plants with solid pattern leaves and the number of clover plants with swirly pattern leaves in a particular population. The results are shown in the table below. Determine the **allele frequencies** of this population.

Phenotype	Number of Individuals
solid	345
swirly	150
total count	495

17. What does it mean if the allele frequency changes from one generation to the next?

18. Why are small populations more susceptible to changes in allele frequency?

Topic 7.6: Evidence of Evolution

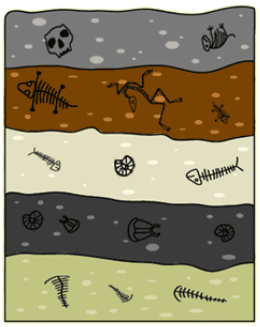
Learning Objective

EVO-1.M Describe the types of data that provide evidence for evolution.

I can…

- □ I can describe how molecular evidence (DNA nucleotide sequences and protein amino acid sequences) provide evidence of common ancestry.
- □ I can describe how conserved cellular features and processes provide evidence for common ancestry.
- □ I can describe how morphological or fossilized evidence (from extant and extinct organisms) provides evidence of evolution
- □ I can describe how morphological homologies, including vestigial structures, represent features shared by common ancestry.
- □ I can describe how fossils can be dated by the age of the rocks, the rate of isotope decay, and geographical data

1. Fossil questions:



   a. In what kind of rock would you find fossils?

   b. Which layers in the diagram are oldest?

   c. How are rock layers dated?

   d. Why are there different fossils in different rock layers?

   e. What signs might be present between rock layers to suggest a catastrophic event, like a meteorite crash?

   f. What kinds of organisms fossilize more easily? (Why is the fossil record incomplete?)

2. Describe how each of the following can be considered evidence for evolution.

   a. Molecular homology (in DNA, RNA or proteins)

   b. Conservation in cellular features and processes (ex. bacteria and mitochondria use proton pumps; eukaryotes have many membrane-bound organelles in common; eukaryotes have linear chromosomes and genes that contain introns (more on this later)).

   c. Similarity in early development (especially embryos). Why are embryo structures often highly conserved? What does “highly conserved” mean?

   d. Homology in structures, including bones, limbs, exoskeletons, etc.

e. Vestigial structures

f. Convergent evolution

g. The fossil record

3. Spines and thorns on plants look similar, and both provide protection from herbivores. However, not all plants with spines or thorns have descended from a recent common ancestor. Spines are modified leaves, and thorns are modified stems. Which of the following statements best describes how this information provides evidence for evolution?
A. It shows that different organisms sometimes look alike.
B. It shows that herbivores are the strongest selection force on organisms.
C. It shows that a variety of structures can be effective in protecting an organism from herbivores.
D. It shows that environmental pressures can cause unrelated organisms to change in similar ways.

4. Some cells release active signaling proteins when membrane-bound precursor proteins are cleaved by proteolytic enzymes. The signaling proteins can then bind to receptors on the surface of a target cell, thereby activating an intracellular signaling pathway and eliciting a response from the target cell. This mechanism of activating receptor-binding signaling proteins has been observed in a variety of organisms from bacteria to humans. Many of the enzymes responsible for proteolysis of membrane-bound precursor proteins have been isolated and characterized.
Which of the following questions would be most appropriate to investigate whether the proteolytic enzymes are evolutionarily conserved among species?
A. Are the genes encoding the proteolytic enzymes expressed in the same cell types in all species?
B. Once the precursor proteins of different species are cleaved, do the active signaling proteins bind to the same receptors on different target cells?
C. If a proteolytic enzyme from one species is incubated with a precursor protein from another species, does correct cleavage occur?
D. Are the proteolytic enzymes synthesized in the rough endoplasmic reticulum of all species?

5. Which of the following statements best supports the claim that organisms share fundamental processes as a result of evolution?
A. All organisms that are introduced into new environments have the capacity to fill vacant ecological roles.
B. All organisms have the ability to utilize oxygen to harness energy from the chemical breakdown of organic compounds.
C.All organisms share a genetic code organized into triplet codons, making it possible for one organism to express a gene from another organism.
D. All organisms possess structures such as chloroplasts and mitochondria within their cells that reflect past symbiotic relationships between prokaryotic precursors.

Topic 7.7: Common Ancestor

Learning Objective	**EVO-2.C Describe structural and functional evidence on cellular and molecular levels that provides evidence for the common ancestry of all eukaryotes.**
I can…	□ I can describe how structural evidence (membrane bound organelles, linear chromosomes, genes that contain introns) indicates common ancestry of all eukaryotes.

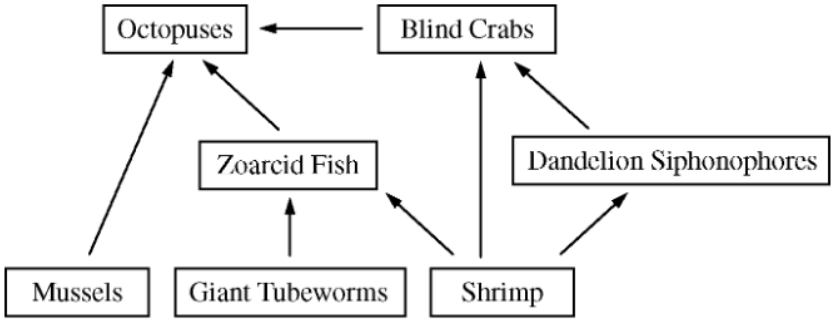
1. What is a membrane bound organelle?

2. How did membrane bound organelles, such as chloroplasts, originate?

3. How do membrane-bound organelles support common ancestry for eukaryotes?

4. How do linear chromosomes indicate common ancestry for all eukaryotes?

5. How do genes containing introns indicate common ancestry for all eukaryotes?



6. The food web represents feeding relationships in a biological community near a deep-sea hydrothermal vent. Hydrothermal vents are geysers on the seafloor that gush super-heated, mineral-rich water. The seawater surrounding hydrothermal vents typically contains carbon dioxide (CO_2), molecular hydrogen (H_2), hydrogen sulfide (H_2S), and methane (CH_4). Sunlight, however, fails to reach the seafloor where deep-sea hydrothermal vents are located.
As part of an investigation, researchers collected living specimens from an area near a deep-sea hydrothermal vent. Mussels in the collection were found to be dependent on molecular hydrogen in seawater. Also, the researchers discovered multiple species of bacteria living in the gills of the mussels. Mussels use gills for filter-feeding and gas exchange with the surrounding seawater. On the basis of their experimental results, the researchers hypothesized that some bacteria living in the gills of the mussels are capable of chemosynthesis.
Researchers are investigating the evolutionary relationships among organisms found near deep-sea hydrothermal vents and similar organisms found closer to the ocean surface. Which of the following scientific questions is most relevant to the investigation?
A. What are the nucleotide sequences of ribosomal RNA genes that are found in the genomes of the different species?
B. What large-scale geological events have occurred recently in the Mid-Atlantic Ocean?
C. Does water temperature at different ocean depths affect the relative levels of dissolved oxygen?
D. Do species found near deep-sea hydrothermal vents all have the same haploid number of chromosomes?

7. Researchers observed selected internal structures of four different microscopic organisms as part of a larger study on the divergence between eukaryotes and prokaryotes. Their observations are recorded in Figure 1.
Which organism in figure 1 would the researchers most likely predict to be the most distantly related to eukaryotes?

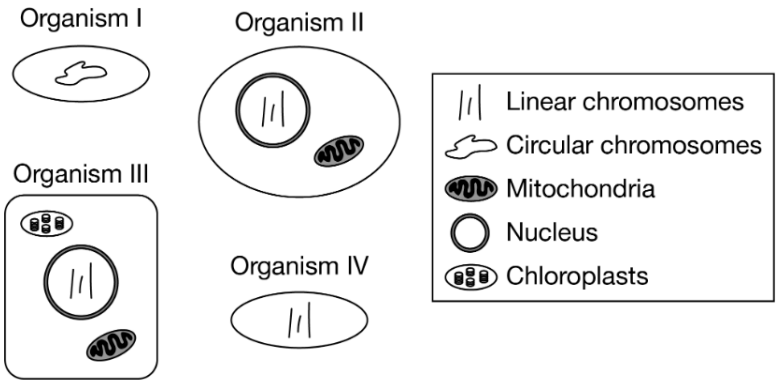


Figure 1. Selected cellular structures in four organisms

Topic 7.8: Continuing Evolution

Learning Objective

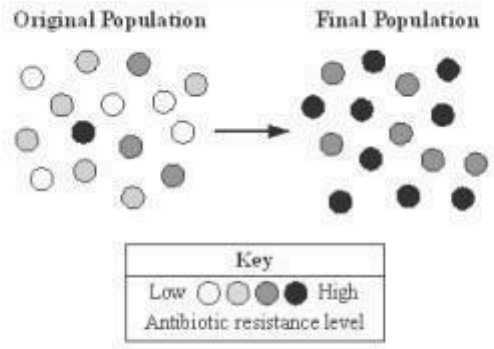
EVO-3.A Explain how evolution is an ongoing process in all living organisms.

I can…

- □ I can describe how All species have evolved and continue to evolve—
  - Genomic changes over time.
  - Continuous change in the fossil record.
  - Evolution of resistance to antibiotics, pesticides, herbicides, or chemotherapy drugs.
  - Pathogens evolve and cause emergent diseases

1. Antibiotic resistance

a. What is antibiotic resistance? Explain using this diagram.



b. How can horizontal gene transfer speed up this process?

c. Why do bacterial populations evolve quickly?

2. How has malaria changed the frequency of the sickle cell allele in humans?

3. A protein called CCR5 is found on the surface of human white blood cells. A mutation in a gene coding for the protein CCR5 prevents HIV from entering these cells. This mutation likely arose in Europe about 2,500 years ago, long before HIV became a virus that infects humans. Other viruses (like small pox and bubonic plague) are thought to also use the CCR5 to enter cells.

a. Why do humans make a protein that viruses can use to enter our cells?

b. How can exposure to past diseases affect the human population today?

4. Which of the following experiments would be most appropriate to determine whether populations of S. aureus are continuously adapting in order to obtain iron from hosts more effectively?
A. Grow S. aureus in media with macaque hemoglobin and abundant free iron. Record bacterial growth over time and compare it to growth of the original population.
B. Culture S. aureus bacteria with hemoglobin from a mixture of host species. Then transfer the bacteria to media with a known effective antibiotic and record bacterial growth.
C. Sequence the genes of different S. aureus strains and construct a cladogram representing their relatedness.
D. Culture S. aureus bacteria with hemoglobin from a novel host species as the only source of iron for many generations, then compare protein structure from bacteria in this culture with bacteria from the original culture.

5. The pesticide DDT was widely used in the 1940s as a method of insect control. In the late 1950s the first DDT-resistant mosquitoes were discovered, and eventually DDT-resistant mosquitoes were found globally. When DDT is used now, the development of DDT resistance in mosquito populations occurs in months rather than years.
Which of the following best explains the observations concerning DDT resistance in mosquitoes?
A. Competition for limited resources causes mosquitoes to migrate to geographical areas that have richer supplies of DDT.
B. The proportion of DDT-resistant mosquitoes in a population remains constant due to the metabolic costs of DDT utilization
C. Natural selection favors DDT-resistant mosquitoes that are already present in a population when DDT exposure occurs.
D. DDT is a chemical signal that delays normal reproductive cycles in many mosquito populations.

6. The bird, *Parus major*, is commonly found in man-made habitats. During the summer these birds primarily feed on insects, and in the winter, when insects are scarce, they forage in gardens and bird feeders for seeds, nuts, and berries. Recently, climate change has led to a decrease in food available from gardens, and scientists have observed that the average beak length of the birds has increased.
Which of the following best explains the directional shift in beak length in these birds?
A. Longer beaks allow the birds to better fend off predators.
B. Longer beaks increase the fitness of the birds in wild habitats.
C. Longer beaks allow the birds to better access seeds in bird feeders.
D. Longer beaks decrease the fitness of the birds in wild habitats.

7. MRSA is the acronym for methicillin-resistant Staphylococcus aureus. Many of the strains of the common bacterium are also resistant to other antibiotics in use today. The resistance is linked to a collection of genes carried on plasmids that are passed from one bacterium to another by conjugation. Suppose a newly discovered, chemically different antibiotic is used in place of methicillin. Which of the following would be the most likely effect on Staphylococcus aureus antibiotic resistance?
A. The gene for methicillin resistance, no longer needed, would disappear entirely from Staphylococcus aureus populations within a few generations.
B. Transmission of the methicillin-resistance plasmid by conjugation would increase among the Staphylococcus aureus population as the genes would confer resistance to the new antibiotic.
C. Transmission of the methicillin-resistance plasmid would gradually decrease but the plasmid would not entirely disappear from the Staphylococcus aureus population.
D. Transmission of the methicillin-resistance plasmid by conjugation would increase among the Staphylococcus aureus population due to destruction of bacteria without the plasmid through use of the new antibiotic.

8. Over many years of a breeding program, a zoo has an established population of foxes that is well adapted for living in captivity. A representative sample of wild foxes from the neighboring forest was used to start the zoo population. A study was conducted to compare the behavior of the zoo fox population with the wild fox population in the neighboring forest. The behaviors of equal numbers of foxes from each population were assessed. Each fox's behavior was scored on a continuum from docile to aggressive based on its interaction with a trained behaviorist. The data is shown in Figure 1.

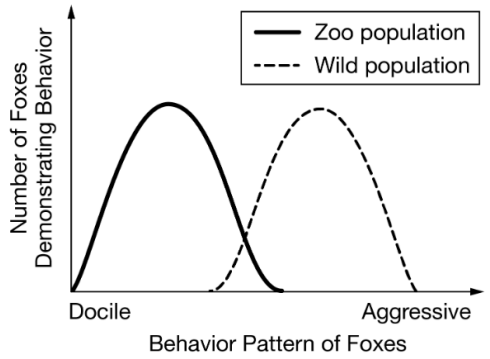


Figure 1. Aggressive behavior in zoo and wild fox populations

The phenotypic variation in behavior between the two populations can best be described as resulting from
A. sexual selection
B. natural selection
C. artificial selection
D. genetic drift

Topic 7.9: Phylogeny

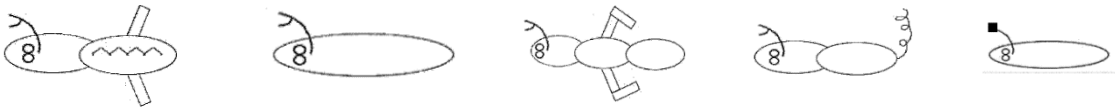
Learning Objective

EVO-3.B Describe the types of evidence that can be used to infer an evolutionary relationship.

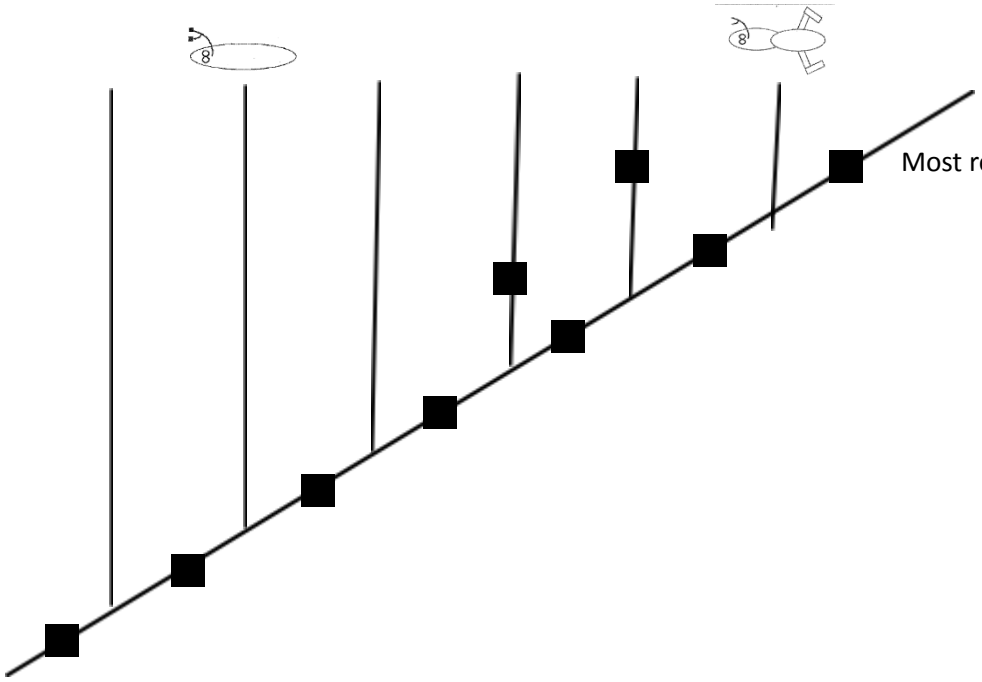
I can…

- □ I can describe how phylogenetic trees and cladograms show evolutionary relationships among lineages, but that phylogenetic trees are calibrated by fossils or a molecular clock.
- □ I can describe how traits that are either gained or lost during evolution can be used to construct phylogenetic trees and cladograms.
  - Shared, derived characters indicate common ancestry.
  - The out-group represents the lineage that is least closely related to the remainder of the organisms in the phylogenetic tree.
  - The nodes on a tree represent the most recent common ancestor of any two groups
- □ I can describe why molecular data typically provides more accurate and reliable evidence than morphological traits

1. Below are diagrams of some related insect species alive today (in no particular order).



a. Arrange the present day insects on the phylogenetic tree below by drawing a sketch of each insect at the top of each line. Two have already been added to the phylogenetic tree and are not pictured above.
b. Write in a derived characteristic at each solid square.



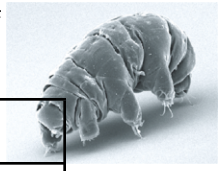
Oldest common ancestor (all present day insects on this model are descended from this ancestor)

2. What is phylogeny?

3. If two different species share a derived characteristic, what does that imply?

4. Which species is the outgroup in the tree above?

5. Draw a phylogenetic tree showing the relationships of the following organisms, given the chart of derived characteristics below. Label the derived characteristics locations on the phylogenetic tree.



Organism	Derived Characters (+ indicates the character is present)					
	Outer shell and mantle	Mouth develops from first opening in embryo	At least three layers of cuticle and molting (shed exoskeleton)	Four layers of cuticle	onycho phoran-like claws	Ventral nervous system
Tardigrades		+	+	+	+	+
Nematodes		+	+			
Arthropods		+	+		+	+
Molluscs	+	+				
Onychophorans		+	+			+

6. Students analyzed several photosynthetic eukaryotic organisms in the laboratory to determine their phylogenetic relationships. The organisms were Spirogyra (a green alga), a moss, a spruce tree, and an apple tree. Table 1 compares several characteristics in the organisms (+ indicates the trait is present, − indicates the trait is absent). Which of the following rows of data listed in table 1 best supports the possibility of a common ancestor for the organisms listed there?

Table 1. Characteristics present in four photosynthetic species

	Green Alga	Moss	Spruce Tree	Apple Tree
Cell wall composed of cellulose	+	+	+	+
Vascular tissue	−	−	+	+
Roots	−	−	+	+
Seeds enclosed in fruit	−	−	−	+
Flagellated sperm cells	−	+	−	−

A. Vascular tissue
B. Seeds enclosed in fruit
C. Cell wall composed of cellulose
D. Flagellated sperm cells

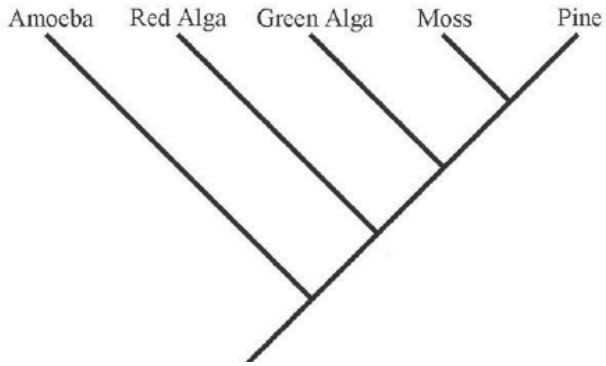
7. By reference to the tree shown, which of the following is an accurate statement of relationships in the phylogenic tree shown?

a) A green alga is more closely related to a red alga than to a moss

b) A green alga is more closely related to a moss than to a red alga

c) A green alga is equally related to a red alga and a moss

d) A green alga is related to a red alga, but is not related to a moss



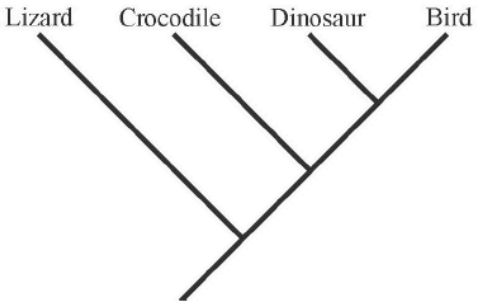
8. By reference to the tree shown, which of the following is an accurate statement of relationships?

a) A crocodile is more closely related to a lizard than to a bird

b) A crocodile is more closely related to a bird than to a lizard

c) A crocodile is equally related to a lizard and a bird

d) A crocodile is related to a lizard, but is not related to a bird



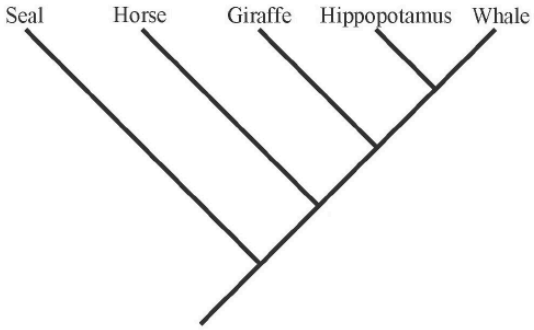
9. By reference to the tree shown, which of the following is an accurate statement of relationships?

a) A seal is more closely related to a horse than to a whale

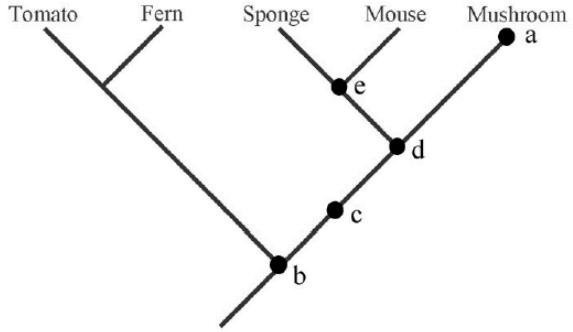
b) A seal is more closely related to a whale than to a horse

c) A seal is equally related to a horse and a whale

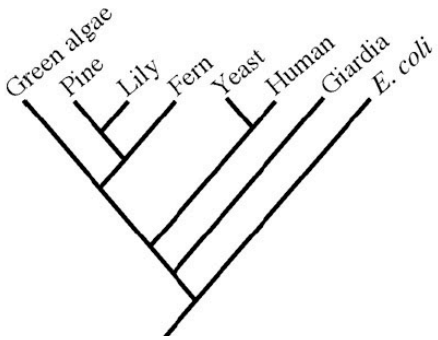
d) A seal is related to a whale, but is not related to a horse

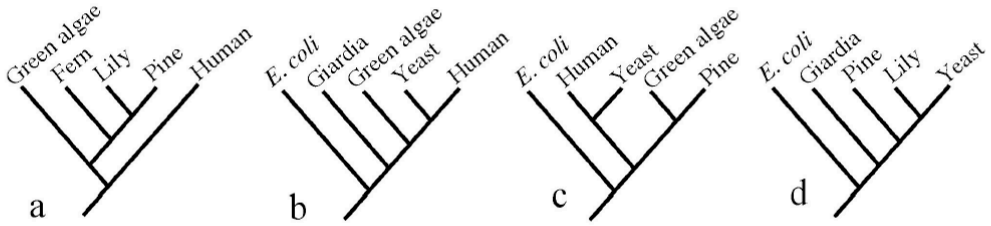


10. Which of the five marks in the tree shown corresponds to the most recent common ancestor of a mushroom and a sponge?

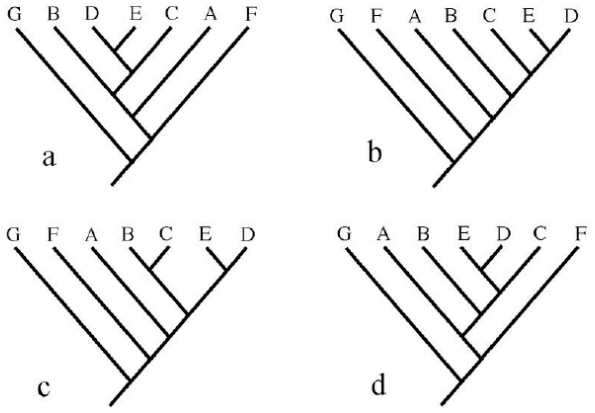


11. Which of the trees below is false given the larger phylogeny to the right?

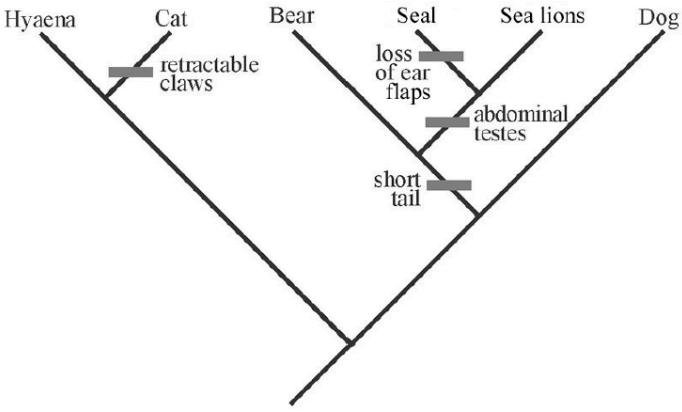




12. Which of the four trees here depicts a different pattern of relationships than the others?



13. In the tree below, assume that the ancestor had a long tail, ear flaps, external testes, and fixed claws.



What traits does a sea lion have?

a) long tail, ear flaps, external testes, fixed claws

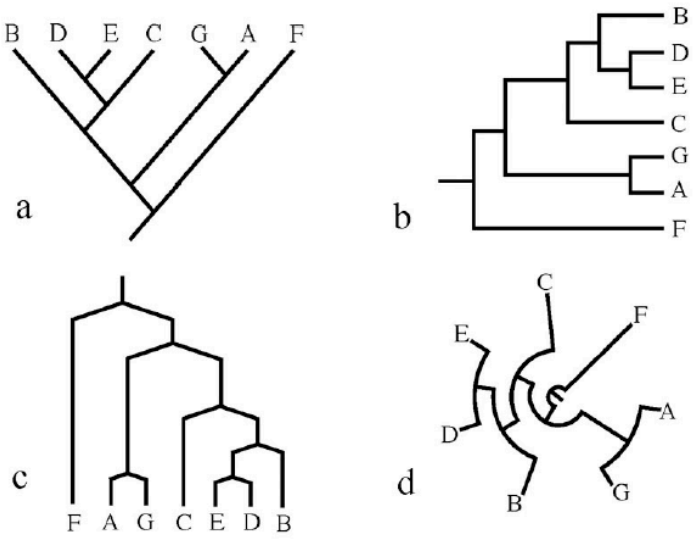
b) short tail, no ear flaps, external testes, fixed claws

c) short tail, no ear flaps, abdominal testes, fixed claws

d) short tail, ear flaps, abdominal testes, fixed claws

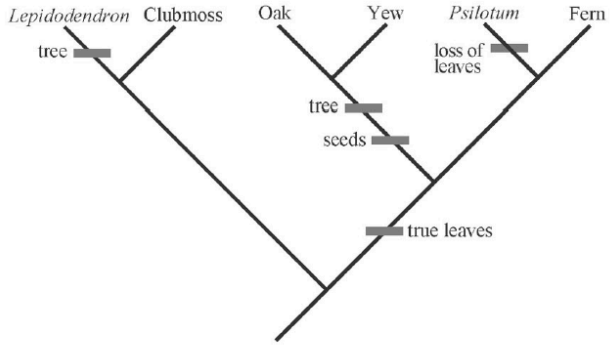
e) long tail, ear flaps, abdominal testes, retractable claws

14. Which of the four trees depicts a different pattern of relationships than the others?

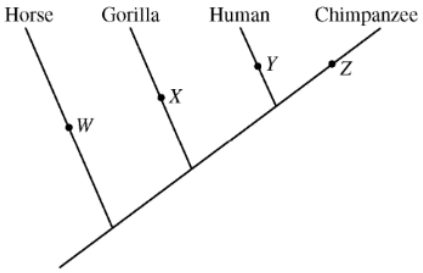


15. In the tree, assume that the ancestor was a herb (not a tree) without leaves or seeds. Based on the tree and assuming that all evolutionary changes in these traits are shown, which of the tips has a tree habit and lacks true leaves?

a) Lepidodendron
b) Clubmoss
c) Oak
d) Psilotum
e) Fern



16. The cladogram depicts an accepted model of the evolutionary relationships among selected species.



The amino acid at position 104 in the beta-hemoglobin protein for each of these four organisms is listed in the chart.

Species	Amino Acid 104
Horse	Arginine
Gorilla	Leucine
Human	Arginine
Chimpanzee	Arginine

The validity of the cladogram is best supported by molecular evidence for which of the following changes in the amino acid composition of the beta-hemoglobin protein during the evolution of these species?

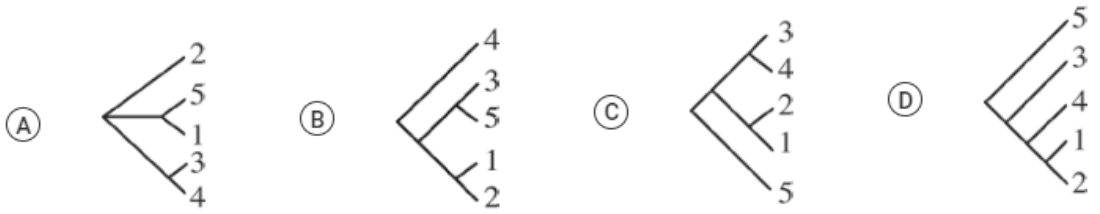
A. Arginine to leucine at position X on the cladogram
B. Arginine to leucine at position Y on the cladogram
C. Leucine to arginine at position W on the cladogram
D. Leucine to arginine at position Z on the cladogram

17. Five new species of bacteria were discovered in Antarctic ice core samples. The nucleotide (base) sequences of rRNA subunits were determined for the new species. The table below shows the number of nucleotide differences between the species.

NUCLEOTIDE DIFFERENCES

Species	1	2	3	4	5
1	-	3	19	18	27
2		-	19	18	26
3			-	1	27
4				-	27
5					-

Which of the following phylogenetic trees is most consistent with the data?



18. The amino acid sequence of cytochrome c is exactly the same in humans and chimpanzees. There is a difference of 13 amino acids between the cytochrome c of humans and dogs, and a difference of 20 amino acids between the cytochrome c of humans and rattlesnakes.
Which of the following statements is best supported by these data?
A. Rattlesnakes apparently gave rise evolutionarily to the dog, chimpanzee, and human.
B. Cytochrome c apparently has an entirely different function in rattlesnakes than in mammals, which explains the difference in the number of amino acids.
C. Cytochrome c is not found universally in animals.
D. Cytochrome c from a rattlesnake could function in a dog, but not in a chimpanzee.
E. The human is apparently more closely related to the chimpanzee than to the dog or rattlesnake.

19. The hormone prolactin has varying effects in many different animal species. All vertebrates produce prolactin, which is involved in signal transduction pathways. In mammals, prolactin stimulates the production of milk in mammary glands. In fish, prolactin plays an important role in osmoregulation. In birds, prolactin is involved in lipid metabolism.
Which of the following best explains the presence of prolactin in various vertebrate species?
A. Though all vertebrates produce prolactin, its varied uses indicate it arose as a result of convergent evolution and not as a result of common ancestry.
B. Prolactin is a homologous hormone because it has a common origin but different functions in various species.
C. Prolactin will bind only to intracellular receptors in animal species with phospholipid bilayers, so its effects are varied in different species.
D. Because of different receptors activating different signal transduction pathways within the same species, it is likely that prolactin production is a trait with highly selective pressure.

20. Researchers studying the evolutionary relationships of three species of snails collected the data shown in Table 1.

Table 1. Comparison of selected characteristics of three snail species

	Species A	Species B	Species C
Location of Fossils	North America	North America	Europe
Shell Orientation	Counterclockwise	Counterclockwise	Clockwise
Shell Composition	Calcium Carbonate	Calcium Carbonate	Calcium Carbonate
Trophic Level	Carnivore	Carnivore	Detritivore
DNA Analysis	$\%\ \mathrm{A{+}T} = 43.2$	$\%\ \mathrm{A{+}T} = 43.4$	$\%\ \mathrm{A{+}T} = 43.0$
	$\%\ \mathrm{G{+}C} = 56.8$	$\%\ \mathrm{G{+}C} = 56.6$	$\%\ \mathrm{G{+}C} = 57.0$

Which of the following data sets is most likely to provide reliable information about the evolutionary relationships among these three snail species?

A. Shell composition and shell orientation
B. Trophic level and DNA analysis
C. Location of fossils and shell orientation
D. Shell composition and location of fossils

21. Hemoglobin is a highly conserved protein used by all mammals to transport oxygen. Table 1 was constructed by comparing the amino acid sequence in the hemoglobin molecules from five different mammal species.

Table 1. Hemoglobin amino acid differences among five different mammal species

	Species 1	Species 2	Species 3	Species 4	Species 5
Species 1	–	21	11	13	5
Species 2		–	18	17	20
Species 3			–	3	10
Species 4				–	12
Species 5					–

Which of the following best describes the importance of the number of amino acid differences indicated in Table 1?

A. They reflect the different environments where the organisms were captured.
B. They reflect the number of base pair changes in the DNA
C. They reflect random changes due to translation errors.
D. They reflect the number of oxygen molecules each hemoglobin molecule carries.

22. Different photosynthetic organisms have different types of chlorophyll molecules. The distribution of chlorophylls in several different groups of organisms is shown in Table 1. A plus sign (+) in the table indicates the presence of a chlorophyll, while a minus sign (−) indicates its absence.

Table 1. The distribution of chlorophylls in several groups of organisms

	Chlorophyll *a*	Chlorophyll *b*	Chlorophyll *c*	Chlorophyll *d*
Flowering plants	+	+	−	−
Green algae	+	+	−	−
Brown algae	+	−	+	−
Red algae	+	−	−	+
Cyanobacteria	+	−	−	−

Based on the data, which of the following most likely describes the evolutionary relationship among the organisms?

A. Because brown algae, red algae, and cyanobacteria lack chlorophyll b, they evolved before green algae and flowering plants did.

B. Because green algae and flowering plants contain chloroplasts, they evolved more recently than brown algae, red algae, and cyanobacteria did.

C. Because increasingly complex forms of chlorophyll are found in red algae, brown algae, green algae, and flowering plants, respectively, this reflects the order of their appearance.

D. Because all of the organisms contain chlorophyll a, the organisms share a common ancestor.

Table 1. Presence or absence of 5 transposons in primate species

Species	1	2	3	4	5
Human	−	+	+	+	+
Bonobo	+	+	+	+	+
Chimpanzee	+	+	+	+	+
Gorilla	−	−	+	+	+
Orangutan	−	−	−	+	+
Gibbon	−	−	−	−	−

23. Transposable elements are significant features in the genomes of almost all eukaryotic organisms. The accumulation of these elements in various species can help determine their relatedness. Table 1 indicates the presence (+) or absence (−) of 5 segments of DNA that have been moved by transposition (transposons) in 6 primate species.

Which of the following best predicts how phylogenetic relationships might be revised if transposon 1 was not found in chimpanzees?

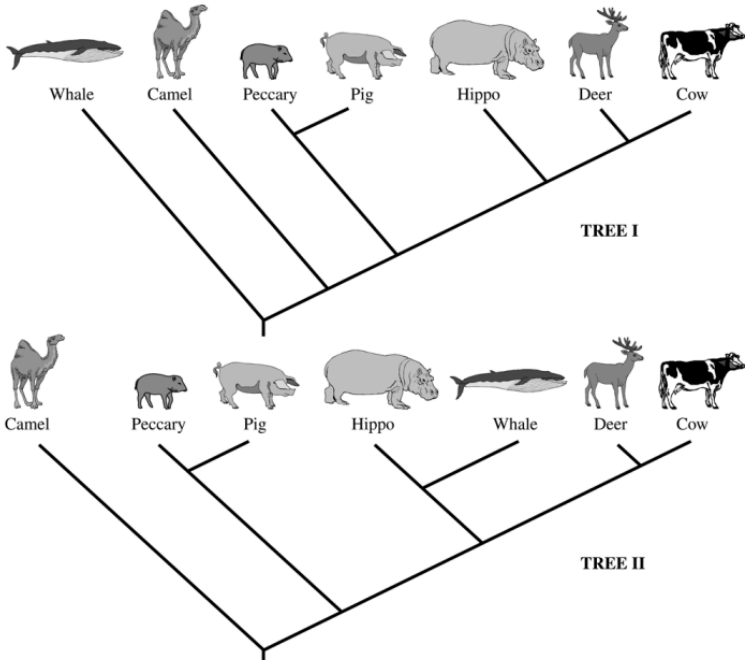
A. Bonobos would be more closely related to humans than to chimpanzees.

B. Chimpanzees would be more closely related to humans than to bonobos.

C. Orangutans would be more closely related to humans than to chimpanzees.

D. Chimpanzees would be more closely related to gibbons than to gorillas.

24. The two phylogenetic trees represent the relationship of whales to six other mammals. All of the organisms shown have a pulley-shaped astragalus bone in the ankle except for the whale.
For each tree, describe a monophyletic group, the closest relative to the whale, and the point at which the pulley astragalus was lost or gained.



Based on the principle of parsimony (the simplest explanation is the best) and the genomic information in the table shown, identify which tree is the best representation of the evolutionary relationship of these animals, and justify your answer.

DATA ON PRESENCE OF SPECIFIC DNA SEQUENCES

+ sequence present
– sequence absent
? undetermined

Locus	1	2	3	4	5	6	7	8	9	10	11	12	13
Cow	–	–	–	–	–	+	+	+	+	+	+	+	–
Deer	–	–	–	–	–	+	?	+	+	+	+	+	–
Whale	+	+	+	+	+	–	?	+	+	–	?	+	–
Hippo	?	–	+	+	+	–	+	+	+	–	?	+	–
Pig	–	–	?	–	–	–	?	–	?	–	–	+	+
Peccary	?	?	?	?	?	?	?	?	?	?	?	?	+
Camel	–	–	–	–	–	–	–	–	–	–	–	–	–

Topic 7.10: Speciation

Learning Objective

EVO-3.D Describe the conditions under which new species may arise.

I can…

- □ I can describe how speciation may occur when two populations become reproductively isolated from each other.
- □ I can state the definition of a species (a group of organisms capable of interbreeding and producing viable, fertile offspring)
- □ I can describe the rate of speciation in terms of punctuated equilibrium and gradualism
- □ I can describe how divergent evolution occurs when adaptation to new habitats results in phenotypic diversification.
- □ I can describe how speciation rates are high during times of adaptive radiation.
- □ I can describe both sympatric and allopatric speciation.
- □ I can describe various prezygotic and postzygotic mechanisms that can maintain reproductive isolation and prevent gene flow between populations.

1. How can you determine if two organisms are part of the same species?

2. Define:

allopatric speciation -

parapatric speciation -

sympatric speciation -

3. What is a reproductive isolating mechanism?

4. Using the following chart, describe the types of pre- and post- zygotic reproductive barriers with examples.

Prezygotic Reproductive Barriers		
Reproductive Isolation Type	Description	Example
Habitat/Ecological Isolation		
Temporal Isolation		
Behavioral Isolation		
Gametic Isolation		
Geographical Isolation		
Postzygotic Reproductive Barriers		
Reproductive Isolation Type	Description	Example
Hybrid Breakdown		
Reduced Hybrid Viability		
Reduced Hybrid Fertility		

5. How does reproductive isolation lead to speciation?

6. What two potential results occur when two species come in contact in the hybrid zone?

7. What reproductive isolating mechanisms lead to speciation in sympatric speciation?

8. What reproductive isolating mechanisms lead to speciation in allopatric speciation?

9. Distinguish between punctuated equilibrium and gradualism.

10. What is adaptive radiation? How does it affect speciation rate?

11. Two species of fish that live in extremely cold environments produce near-identical antifreeze glycoproteins, called AFGPs. Scientists have determined the origins of the AFGP gene in both species. Selected characteristics of the two fish species are provided in Table 1.

Table 1. Characteristics of two fish species producing nearly identical antifreeze glycoproteins

Fish Species	Order	Location	Evolutionary origin of the $AFGP$ Gene
Boreogadus saida	Gadiformes	Arctic	No sequence identity with trypsinogen
Dissostichus mawsoni	Perciformes	Antarctic	Pancreatic trypsinogen

Based on the information in Table 1, which of the following statements best describes the production of nearly identical AFGPs in these two species of fish?
A. The fish eat the same type of food, which resulted in the evolution of similar digestive proteins.
B. The fish live in environments with similar selective pressures, and those that produce AFGPs are better able to survive.
C. The Antarctic fish species evolved into a separate species after being geographically isolated from the Arctic population because of commercial fishing.
D. The production of similar AFGPs was due to random splicing of exons in both species.

Topic 7.11: Extinction

Learning Objective

EVO-3.G Describe factors that lead to the extinction of a population.

I can…

- □ I can describe how extinctions have occurred throughout Earth's history and how extinction rates can be rapid during times of ecological stress.
- □ I can describe how human activity can drive changes in ecosystems that cause extinctions.
- □ I can describe how the amount of diversity in an ecosystem can be determined by the rate of speciation and the rate of extinction.
- □ I can describe how extinction provides newly available niches that can then be exploited by different species.

1. Do humans have any impact on the extinction of other organisms? What is the number one cause of extinction today?

2. Do organisms mutate in order to evolve, or do organisms mutate randomly and those random mutations are sometimes helpful?

3. Which populations are more likely to adapt to a sudden environmental change, those with slow or fast generation times?

4. Which populations are more likely to adapt to a sudden environmental change, those with high or low genetic diversity?

5. How do extinctions affect available niches in an ecosystem?

6. How do changes in available niches affect organisms in an ecosystem?

7. Some scientists claim that amphibians are currently experiencing a period of mass extinction. Which of the following should be included in an alternative hypothesis that would best support this claim?
A. The current extinction rate of amphibians compared with the background rate of extinction as determined by the fossil record
B. The extinction rate of amphibians in the 21st century compared with the extinction rate of amphibians during the 20th century
C. The number of species of amphibians currently alive compared with the number of amphibian species known to be extinct
D. The number of new amphibian species being discovered per year compared with the number of amphibian species becoming extinct during the same time period

8. A group of students summarized information on five great extinction events. The students are sampling a site in search of fossils from the Devonian period. Based on the chart, which of the following would be the most reasonable plan for the students to follow?

Mass Extinction	Time of Extinction	Organisms Greatly Reduced or Made Extinct
End of the Ordovician period	443 million years ago	Trilobites, brachiopods, echinoderms, and corals
End of the Devonian period	354 million years ago	Marine families on tropical reefs, corals, brachiopods, and bivalves
End of the Permian period	248 million years ago	Trilobites, mollusks, brachiopods, and many vertebrates
End of the Triassic period	206 million years ago	Mollusks, sponges, marine vertebrates, and large amphibians
End of the Cretaceous period	65 million years ago	Ammonites, dinosaurs, brachiopods, bivalves, and echinoderms

A. Searching horizontal rock layers in any class of rock and trying to find those that contain the greatest number of fossils
B. Collecting fossils from rock layers deposited prior to the Permian period that contain some early vertebrate bones
C. Looking in sedimentary layers next to bodies of water in order to find marine fossils of bivalves and trilobites
D. Using relative dating techniques to determine the geological ages of the fossils found so they can calculate the rate of speciation of early organisms

9. Which of the following observations best supports the hypothesis that a large object collided with Earth in a period of time associated with a mass extinction?
A. A species found only in Australia resembles a species found only in North America.
B. An analysis of radiation reaching Earth from outer space suggests that water might have existed on distant planets.
C. A fossil of an extinct species of mammal is found to have morphological characteristics that are similar to those of a living nocturnal mammal.
D. Iridium, which is common in meteorites but rare on Earth, is found in sedimentary rock that contains the last appearance of many species in the fossil record.

Topic 7.12: Variations in Populations

Learning Objective	**SYI-3.D Explain how the genetic diversity of a population affects its ability to withstand environmental pressures.**
I can…	□ I can describe how the level of variation in a population affects population dynamics— ○ Species and populations with little genetic diversity are at risk of extinction. ○ Genetically diverse populations are more resilient to environmental perturbation because they are more likely to contain individuals who can withstand the environmental pressure. ○ Alleles that are adaptive in one environmental condition may be deleterious in another because of different selective pressures

1. Commercial bananas are grown as a monoculture, with all banana plants cloned from one original banana plant. The commercial strains of bananas are seedless, so each new banana plant has to be manually planted from a cutting of an existing banana root. In the 1950s, the Gros Michel banana strain, the dominant export banana at that time, was destroyed by the fungus Fusarium oxysporum. A new Fusarium resistant variety, the Cavendish banana, was developed and is currently the banana strain grown for export. Recently, a Fusarium strain that successfully attacks the Cavendish strain has been documented.
Which of the following best provides reasoning supporting a method that would help protect commercial banana crops from infection by pathogenic organisms such as Fusarium fungi?
A. The commercial banana strains should be exposed to X-rays to encourage random mutations that will then be passed to offspring, producing resistance to pathogenic organisms.
B. The Cavendish banana plants should be exposed to pathogenic organisms under controlled conditions, so the plants can be encouraged to mutate and develop resistance to the pathogens.
C. The commercial banana strains should not be grown in monocultures, since many pathogenic organisms are able to evolve rapidly in response to a single selective pressure.
D. Growing the Cavendish strain under different conditions will allow natural selection to produce the variation needed to resist infection by pathogenic organisms.

2. Modern bananas originated from a cross between a tetraploid banana species and a diploid banana species. The product of this cross was the triploid Cavendish banana strain, a sterile hybrid that is only grown asexually. Recently, the Panama fungus has been observed more frequently parasitizing the Cavendish banana, and scientists claim that this type of banana is on the brink of extinction.
Which of the following provides the best explanation of the scientists' claim regarding the threat to the Cavendish banana?
A. The triploid genome of the Cavendish banana makes it susceptible to the negative impact of recessive alleles.
B. Having three of each chromosome interferes with normal function of the cells and increases the likelihood of contracting a disease.
C. The lack of genetic diversity of the Cavendish banana decreases the chance that a variation exists in the population that is immune to the fungus.
D. Asexual reproduction increases the mutation rate during replication, resulting in a greater chance that the offspring have a dysfunctional immune system.

3. Finch beak depth was measured before and after a severe drought in 1977. The averaged results are shown in Figure 1. After the drought, there were fewer seeds available for the finches to eat and the seeds that did remain were larger and harder to crack open. Researchers claim that when large, hard seeds are the predominate food source, the average beak depth of these finches tends to increase in subsequent generations. Using the evidence provided, which of the following best justifies the researchers' claim?

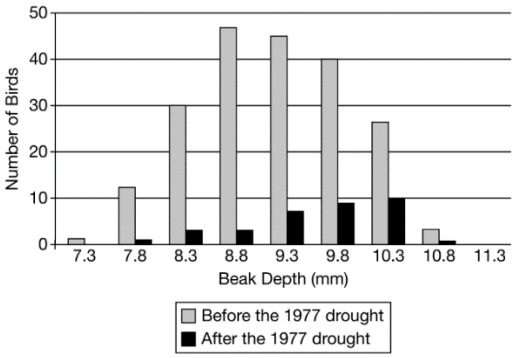


Figure 1. Finch beak depth before and after the 1977 drought

A. Finch beak depth increased after the drought because the overall numbers of finches decreased, reducing competition for resources.

B. Finch beak depth increased as a consequence of selective pressure after the drought because the remaining seeds were larger and harder.

C. Finch beak depth increased after the drought due to intraspecific competition since finches with deeper beaks attract more mates.

D. Finch beak depth increased after the drought due to increased predation since finches with deeper beaks can fight off predators more effectively.

Topic 7.13: Origins

Learning Objective

SYI-3.E Describe the scientific evidence that supports models of the origin of life on Earth.

I can…

- □ I can describe the model that states Earth formed approximately 4.6 billion years ago (bya). The environment was too hostile for life until 3.9 bya.
- □ I can describe the model that states that primitive Earth provided inorganic precursors from which organic molecules could have been synthesized because of the presence of available free energy and the absence of a significant quantity of atmospheric oxygen (O_2).
- □ I can describe the model that states that organic molecules could have been transported to Earth by a meteorite or other celestial event.
- □ I can describe the RNA World Hypothesis which proposes that RNA could have been the earliest genetic material.

1. What were the characteristics of primitive Earth?

2. What occurred in Stanley Miller’s experiment regarding primitive Earth and what did it indicate?

3. What is the RNA World Hypothesis and what evidence supports it?