

Biology EOC Study Guide: Part 3, Evolution

Content Standard “A” (9-11 LS3A)	Student Performance Expectation
Students know that: Biological <i>evolution</i> is due to: (1) <i>genetic variability</i> of offspring due to <i>mutations</i> and <i>genetic recombination</i> , (2) the potential for a <i>species</i> to increase its numbers, (3) a finite supply of resources, and (4) <i>natural selection</i> by the <i>environment</i> for those offspring better able to survive and produce offspring.	Students are expected to: <i>Explain</i> biological <i>evolution</i> as the consequence of the <i>interactions</i> of four <i>factors</i> : <i>population growth</i> , <i>inherited variability</i> of offspring, a <i>finite supply</i> of resources, and <i>natural selection</i> by the <i>environment</i> of offspring better able to survive and reproduce. <i>Predict</i> the <i>effect</i> on a <i>species</i> if one of these <i>factors</i> should change.*a
<p>In other words:</p> <ul style="list-style-type: none"> Because organisms over-reproduce, there is competition for resources (like food, water, mates). Since organisms of the same species are all slightly different, those individuals that have inherited variations that are favorable in the given environment will survive to reproduce. <p>Important notes:</p> <ul style="list-style-type: none"> Don’t forget the importance of over-reproduction. Without that, competition would not occur. Those “inherited variations” are due to two things (1) mutations in genes (changes in the As, Gs, Cs, and Ts of the DNA molecule), and (2) rearrangement of existing genes during the process of meiosis, crossing over, and fertilization. To review meiosis, revisit the <i>Meiosis Square Dance</i>. http://www.youtube.com/watch?v=eaf4j19_3Zg. Recall that when chromosomes line up in their pairs during meiosis, how they line up is random (on one side it could be mom, mom, dad...or dad, mom, dad, etc.) Also, the chromatid tips can exchange, making new combinations of genes in a chromosome. Natural selection does not select the biggest, strongest, etc. Although those factors may play a role, natural selection selects the successful individuals. Successful individuals are those that reproduce healthy offspring. The “environment” does the selection, but the most important “parts” of the environment are the predators, especially the little ones: bacteria, viruses, and protozoans (unicellular organisms that live in water). Recall that only species evolve. Evolution is something that happens to a population, not to an individual. It is the individual that may have a mutation, but that has to be passed on to many in the population for the species to evolve. Two organisms are of the same species if they breed and produce fertile offspring under natural conditions (e.g., not in a zoo). <p>What to look out for:</p> <ul style="list-style-type: none"> If you have to explain anything (“<i>Predict the effect on a species if one of these factors should change.</i>”) what they are going to be looking for is if you mess up by writing a teleological statement: saying that an organism changes because it needs to in order to keep up with a changing environment. NO NO NO. This is the red flag that shows them that you do not know how evolution works. You MUST say that a given mutation gives the organism an advantage over others that do not have the mutation (and give some sort of logical reason why). Because they have this advantage, they will pass it on to their offspring and that mutation will become more prevalent in the population. TALK OF EVERYTHING IN BIOLOGY IN TERMS OF “WHAT IS THE ADVANTAGE OF ___?” <p>Vocabulary</p> <p>Adaptation: Any change in the structure or functioning of an organism that is favored by natural selection and makes the organism better suited to its environment.</p> <p>Evolution: A series of gradual or rapid changes, some regular, some random, that account for the present form and function of phenomena both living and nonliving.</p> <p>Generation: A generation is defined as —the average interval of time between the birth of parents and the birth of their offspring.</p> <p>Genetic information: A set of instructions coded in DNA molecules that specifies the traits of an organism.</p>	

Genetic recombination: The regrouping of genes in an offspring caused by the crossing over of chromosomes during meiosis.

Genetic variation: A measure of the tendency of individual genotypes in a population to vary from one to another.

Mutation: Change to the nucleotide sequence of the genetic material of an organism.

Natural selection: The process by which heritable traits that are favored by environmental conditions become more common in successive generations, and heritable traits that are less favored by environmental conditions become less common. Over time, this process may result in the emergence of new species.

Species: A group of organisms capable of interbreeding and producing fertile offspring.

Variation: A measure of the tendency of individuals in a population to differ from one another.

Content Standard “B” (9-11 LS3B)	Student Performance Expectation
Students know that:	Students are expected to:
Random changes in the <i>genetic</i> makeup of cells and <i>organisms (mutations)</i> can cause changes in their physical <i>characteristics</i> or behaviors. If the <i>genetic mutations</i> occur in eggs or sperm cells, the changes will be inherited by offspring. While many of these changes will be harmful, a small minority may allow the offspring to better survive and reproduce.	<i>Describe</i> the molecular process by which <i>organisms</i> pass on physical and behavioral traits to offspring, as well as the <i>environmental</i> and <i>genetic factors</i> that cause minor differences (<i>variations</i>) in offspring or occasional mistakes in the copying of <i>genetic</i> material that can be inherited by future <i>generations (mutations)</i> . <i>Explain</i> how a <i>genetic mutation</i> may or may not allow a <i>species</i> to survive and reproduce in a given <i>environment</i> .
<p><i>In other words:</i></p> <ul style="list-style-type: none"> • Meiosis creates sperm and egg. It is because of meiosis that offspring are different from their parents. Each human parent has 23 PAIRS of chromosomes. They randomly “give” one of each pair to their offspring through the process of meiosis and then fertilization, thus mixing up which chromosomes the offspring get. So variation is caused by (a) how the chromosome line up in meiosis, (b) crossing over during meiosis, and (c) fertilization [which sperm gets to the egg first!]. • Mutations (as far as we know) in the DNA or sperm and eggs (and all other cells) are random, and can be caused by environmental factors as well as copying mistakes when DNA gets duplicated. • Most mutations are harmful. But some are advantageous. • Mutations have to occur in sperm or in eggs in order for those mutations to be passed on to the next generation. Mutations in other cells (somatic cells) may harm the individual, but they won’t affect the offspring. <p><i>Important notes:</i></p> <ul style="list-style-type: none"> • The process of meiosis creates sperm and egg. In humans, the 46 chromosomes line up in their pairs along the equator of a cell (forming two rows of 23 chromosomes). Each of these chromosomes has already duplicated, but the two parts (chromatids) are held together in the middle (by a centromere). The spindle fibers pull one of each duplicated chromosome to each side of the cell and then the cell splits. This reduces the chromosome number from 46 to 23. But those 23 chromosomes are still duplicated. So each cell goes through a process just like mitosis where the duplicated chromosomes line up. THIS time the spindle fibers pull then centrioles apart, and the chromatids now separate to the two sides of each cell. You end up with four new cells, each with 23 chromosomes (each chromatid became a chromosome). In males, all 4 cells grow a tail and become sperm. In females, one cell hogs all the cytoplasm and the other three die. • NOTE: Crossing over occurs in meiosis. This mixes the DNA up even more. Once again, review the <i>Meiosis Square Dance!</i> 	

- Mutations are changes in the bases (As. Cs. G. and Ts) of DNA molecules. Mutations can be caused by
 - Environment, such as physical damage to DNA (e.g., from ultraviolet light), or chemical damage from all sorts of carcinogens (cancer causing chemicals).
 - “Reading errors” when DNA duplicates. The wrong bases (A, T, C, or G) may be added. Although eukaryotic cells have a “checking” mechanism to be sure all the bases are correct, occasionally it fails. Bacteria have no such checking mechanism, which is why they mutate so fast. They just make lots of errors when copying themselves!
- Genes are segments of DNA that tell the cell what protein to make.
- Mutations can cause a physical characteristic to change or a behavioral characteristic to change, such as a “fixed action pattern.” (E.g., give a mommy duck an egg-like object and it will always tuck it in under its feathers and sit on it.)

What to look out for:

- **AGAIN: Talk about everything in terms of the advantage trait/mutation/whatever will have for an organism.**
- What they want you to know is that the genetic change has to occur in the egg or sperm in order for it to be of any consequence for future generations (for evolution).
- Focus on the big idea that meiosis reduces the number of chromosomes by $\frac{1}{2}$ so that when sperm meets egg, the original number of chromosomes are present in the fertilized egg.

Vocabulary

Anatomical feature: A structure found in a living thing (e.g., heart, lung, liver, backbone).

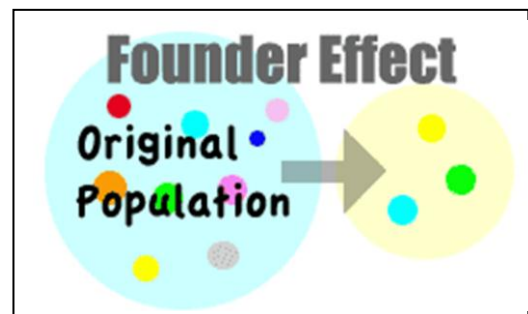
Content Standard “C” (9-11 LS3C)	Student Performance Expectation
Students know that:	Students are expected to:
The great <i>diversity</i> of <i>organisms</i> is the result of more than 3.5 billion years of <i>evolution</i> that has filled available <i>ecosystem niches</i> on Earth with life <i>forms</i> .	<i>Explain how</i> the millions of different <i>species</i> alive today are related by descent from a <i>common ancestor</i> . <i>Explain that genes</i> in <i>organisms</i> that are very different (e.g., yeast, flies, and mammals) can be very similar because these <i>organisms</i> all share a <i>common ancestor</i> .

In other words:

- None. The Standards and Expectations are very clear. But read the notes below .

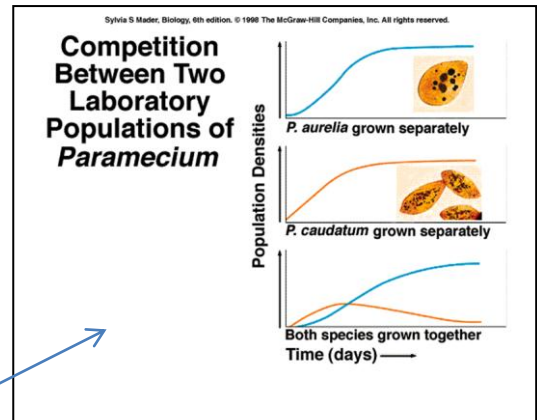
Important notes:

- If I were writing this test (which I am not), I might make a question that incorporates the first standard (“A”) with this standard. Here’s what I would be looking for: It is over-reproduction that makes organisms compete for resources. And if the Earth were not totally populated with plants and animals, any unpopulated or under-populated area would be prime for an invasion of anything that had genes that would allow it to live there. It could take advantage of new land (or water), new food sources (if you weren’t the first one there!), new water sources, etc. The genes that would allow it to live there wouldn’t necessarily be all the genes from the parent population. The new population would have a different gene pool. This is called the “Founder Effect.” A new population would be working with a different mixture of genes.

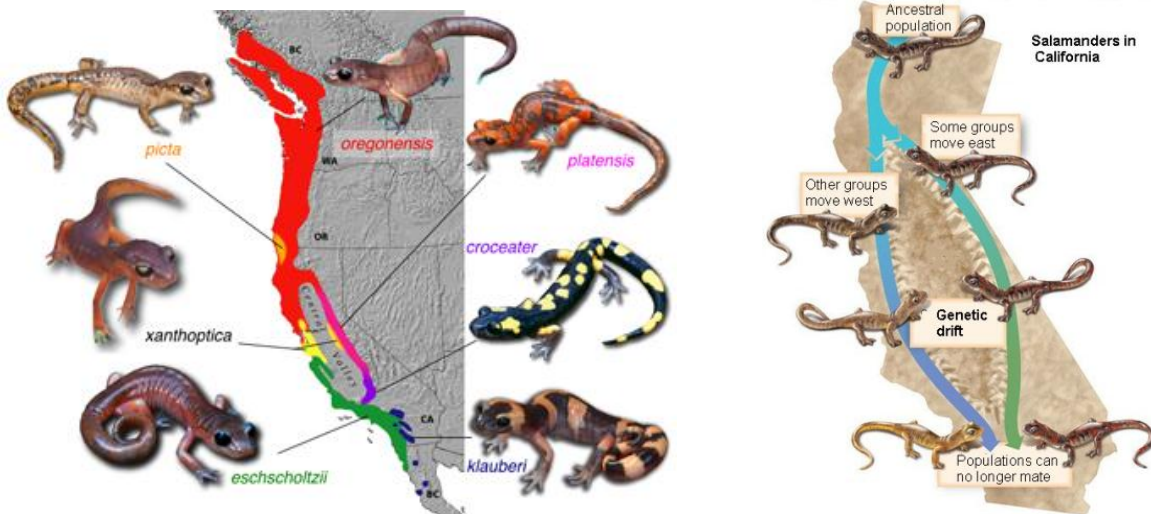


- Note that different environments and different niches require different sets of both physical and behavioral genes to allow organisms to survive. **Again**, those organisms with mutations that give them an advantage and allow them to reproduce will survive and pass those mutations on to the next generation. The mutations will spread in the population. And then the environment (both predators and climate) will change, and the process of accumulating advantageous mutations continues.

- A niche is how a population responds to the abundance of its resources and enemies.
 - the competitive exclusion principle states that no two species can occupy the same niche in the same environment for a long time



- As change spreads, organisms become more and more different from each other. Eventually they may be so different that they can no longer mate and produce fertile offspring. They then would be considered two different species.
 - How do we know if a population is changing? We monitor the gene pool (the percentage of one gene versus its allele [e.g., brown eyes vs blue eyes]) over a period of time. If it changes, the population is evolving. **Evolution is the change in gene frequencies of a population over time.**
 - The process of speciation means the making of two or more species from one. They will probably not ask you the specifics on this, but be aware that a common example is when a species grows and migrates it may get separated into two groups. Each group accumulates different mutations over a period of time and eventually cannot mate. They have become two species. Common example in the west: one species of salamanders in California have migrated to either side of the Sierra Nevada Range and can no longer interbreed (see diagram on next page). This is also called adaptive radiation; the critters are going in different directions (radiating) and accumulating different adaptations that suit those two different environments (adaptive).



- Going backwards, we can see that the genetic make-up of present day organisms originally came from a much smaller pool of genes. They could have come from one single organism. Which begs the question, where did that cell come from, but that is another field of investigation.

What to look for:

- Use of the words “**descent from a common ancestor**” is what they are probably going to look for, even if it is in the stem of the question. You will need to explain it, however. I think a good tactic would be to say something about following an organism’s history backwards and reversing any mutations that took place would end us up with one or a few common ancestral cells. Maybe you can come up with a good analogy. Think of a family genealogy chart. What are some other analogies?

Vocabulary

Common ancestors: A group of organisms is said to have common descent if they have a common ancestor. In modern biology, it is generally accepted that all living organisms on Earth are descended from a common ancestor or ancestral gene pool.

Extinction: The death of all members of a species of plant or animal. The moment of extinction is generally considered to be the death of the last individual of that species, although the capacity to breed and recover may have been lost before this point.

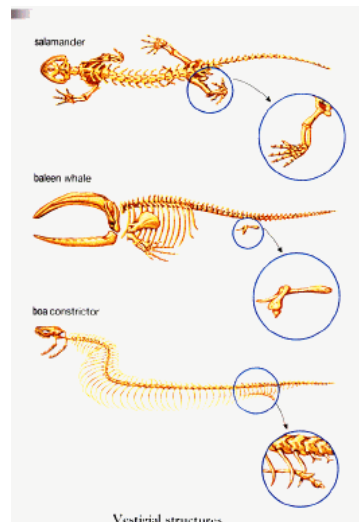
Content Standard “D” (9-11 LS3D)	Student Performance Expectation
Students know that:	Students are expected to:
The <i>fossil</i> record and anatomical and molecular similarities observed among diverse <i>species</i> of living <i>organisms</i> provide <i>evidence</i> of biological <i>evolution</i> .	Using the <i>fossil</i> record and anatomical and/or molecular (DNA) similarities as <i>evidence</i> , formulate a <i>logical argument</i> for biological <i>evolution</i> as an explanation for the development of a representative <i>species</i> (e.g., birds, horses, elephants, whales).

In other words:

- The “Students know that” says it all. What you are expected to know is addressed in “What to look for.”

Important notes:

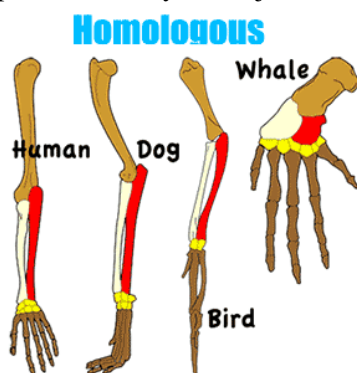
- What the fossil record shows:
 - Most important are transitional forms: fossils that are intermediate in form between species. The classic example is *Archaeopteryx*, an animal like a dinosaur, with teeth, bony tail, and scales on most of its body, and yet like a bird with modern feathers.
- What comparative anatomy shows:
 - Vestigial structures: Structures in common to similar groups of organisms, but useless in some (remnants, or left-overs, of evolution). Examples: hips and legs in snakes and whales, appendix in humans and carnivores.
 - Homologous structures: Look at the arm (or leg, or skull, or...) bones of a human, horse, porpoise, and bat, and they all have the same parts in the same positions. They differ just in length, girth, and proportion.



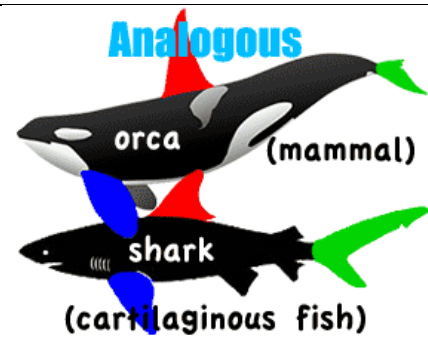
Leg bones in salamander

Leg bones in whale

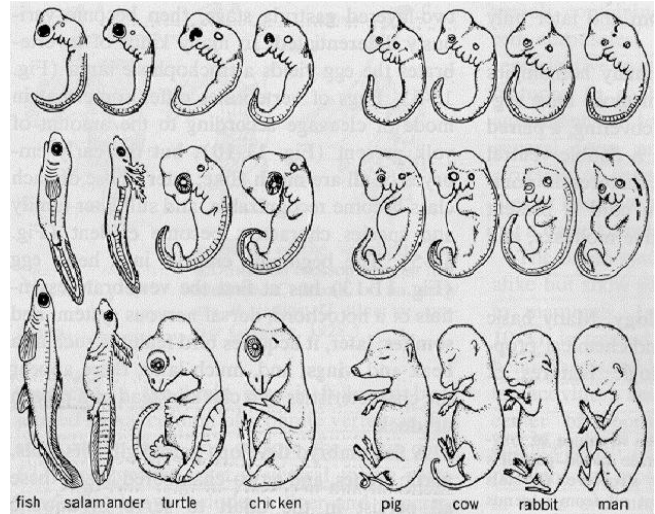
Leg bone in boa constrictor



- Analogous structures: Structures that evolved independently but are used for the same function and are at least superficially similar in structure. Usually, because organisms live in similar environments, even if those are on different continents, they form similar adaptations for the same purposes. Examples: Wings of birds vs wings of insects. Eyes of octopuses and eyes of humans (they are not structurally the same; the octopus eye is much more logical!)



- What comparative embryology shows:
 - Example: The embryos of fish, reptiles, amphibians, birds, and mammals all look very similar when they are young. All have tails. All have pharyngeal gill slits. Their head, spinal column, eyes, and limb buds look the same. You and I could not tell them apart. But as they mature, they begin to develop differently due to different genes being turned on and off. In reptiles, birds, and mammals, the pharyngeal gill slits turn into ears, jaws, and throat. In fish, they turn into gills!



- Comparative biochemistry
 - The more closely related two species are, the greater the number of chemical similarities they share.
 - Compare amino acid sequences. Commonly compared are the amino acid sequences in a protein that all eukaryotes have: cytochrome c. It is a carrier in the electron transport system of cellular respiration.
 - DNA sequences are compared, as are RNA sequences.

What to look for:

- Here I am only guessing. Evolution is a good topic to give students a set of data or a set of pictures to look at. The student is then expected to play the game “Which one of these is most like another one” to figure out which organisms are either most closely related and most distantly related. I would be familiar with all the lines of evidence listed above. Do not necessarily memorize them, but understand the concepts so that, given a data set, you know what to do with it! The data set would most likely show homologous structures, or amino acid sequences, or DNA/RNA sequences. I doubt they would give you vestigial structures, analogous structures, and probably not embryological sketches.
- I would guess you might be asked about what transitional forms show, and why analogous structures form.

Vocabulary

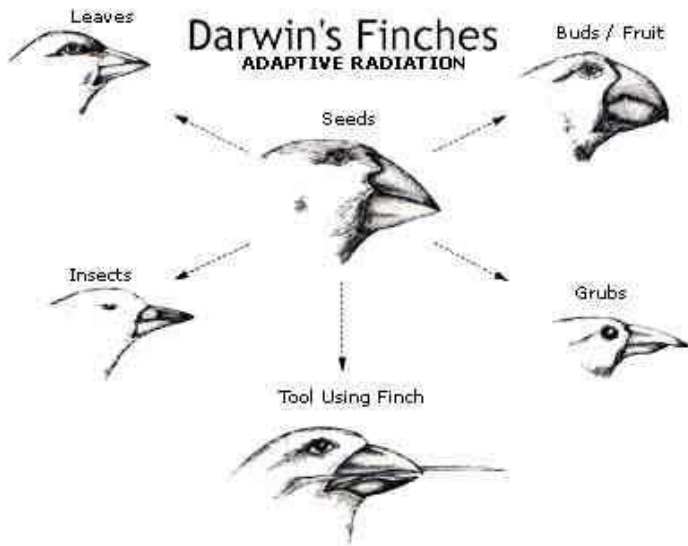
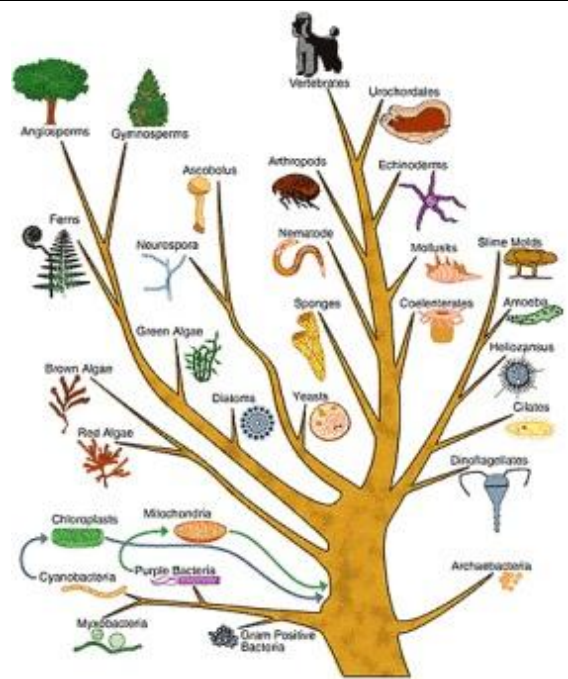
Fossil: The preserved remains or traces of animals, plants, and other organisms from the remote past.

Index fossil: Fossil that is used to determine relative age of layer of sedimentary rock.

Content Standard “E” (9-11 LS3E)	Student Performance Expectation
Students know that: Biological classifications are based on how organisms are related, reflecting their evolutionary history. Scientists infer relationships from physiological traits, genetic information, and the ability of two organisms to produce fertile offspring.	Students are expected to: Classify organisms, using similarities and differences in physical and functional characteristics. Explain similarities and differences among closely related organisms in terms of biological evolution (e.g., Darwin’s finches had different beaks due to food sources on the islands where they evolved).

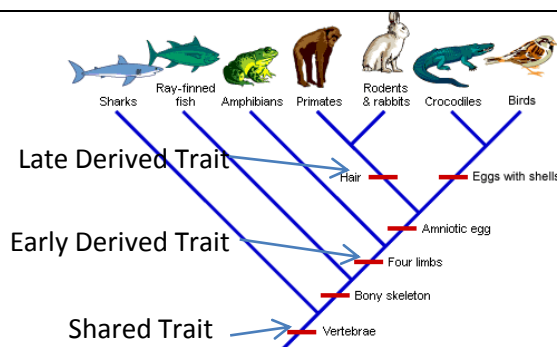
In other words:

- We group organisms into kingdoms, phyla, classes, orders, families, genera, and species by how closely related they are to each other. We use physical characteristics, amino acid sequences, DNA, and even behavior. By grouping organisms this way, we can deduce an evolutionary history...an evolutionary tree.
- Closely related organisms may show variation. This typically is a result of adapting to slightly different environments. The classic example are the finches that Darwin cataloged on the Galapagos Islands. The shape of their beak was adapted to their food source: strong beaks for nuts, sharp pointy beaks for insects, hooked beaks for grubs, etc.



Important notes:

- We call traits that we can trace back to ancient ancestors “ancestral traits”. Or, because all their descendants have those traits, we also call them “shared traits.”
- We call traits that have evolved more recently “derived traits.”
- By comparing shared with derived traits, we can build an evolutionary tree (called a cladogram, because organisms with similar traits at some level, e.g., an order, belong to the same “clad.”)



What to look for:

- I will guess they won't have you create a cladogram. Instead, they will have to look at a data chart and, once again, play the game of “Which one of these is most like the other one?” The closer they are alike, the more closely related they are.
- They will probably also ask you to “Explain similarities and differences among closely related organisms in terms of biological evolution.” Here you just need to use common sense. Look at the information they give you and decide which features would give an organism a selective advantage (that is, assure them reproductive success). **Again!** Be sure you talk about **advantages**. No organism changes “in order to adapt.” **RECALL, AN ORGANISM DOES NOT CHANGE OR ADAPT OR EVOLVE; A POPULATION DOES! ORGANISMS CAN HAVE MUTATIONS, AND IF THOSE MUTATIONS AFFECT THEIR SEX CELLS, THEY WILL PASS THEM ON TO THEIR OFFSPRING. A SINGLE ORGANISM DOES NOT ADAPT TO ITS ENVIRONMENT! A POPULATION DOES.** Organisms pass on variations (mutations) because those variations were helpful in terms of reproductive success. Organisms **don't** pass on variations because they “know” the next generation will be better adapted!

Vocabulary

Biological classification: A method by which biologists group and categorize species of organisms. Biological classification is a form of scientific taxonomy.

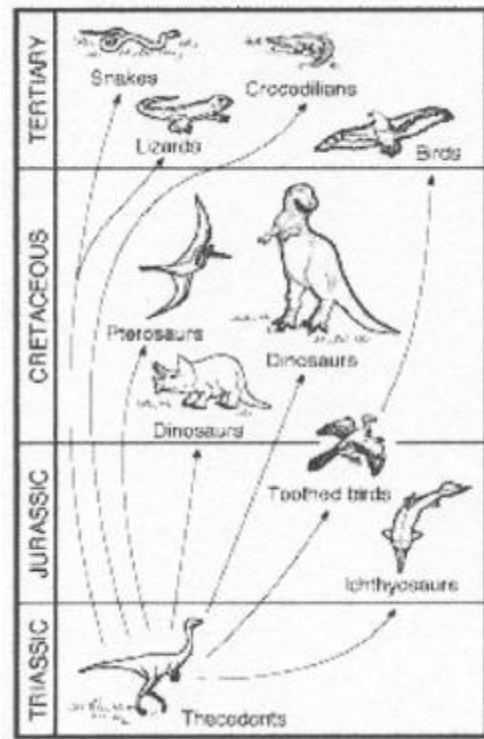
Classify: To arrange in some sort of order by categories or groupings

This is critical to this portion of the test, so I will say it again” **AN ORGANISM DOES NOT EVOLVE; A POPULATION DOES. ORGANISMS CAN HAVE MUTATIONS (ADAPTATIONS), AND IF THOSE AFFECT THEIR SEX CELLS, THE MUTATIONS WILL PASS TO THEIR OFFSPRING.**

***Be uber careful with the word “change.” SUGGESTION: Never use the word “change” when talking about evolution. In evolution, “change” can mean a change in a genetic code in one organism (aka, a mutation/adaptation) OR change in a population through time (evolution). If you mean a change in an individual's genetic make-up, use the word “mutation”. If you mean a change in a population through time, use the word “evolution.” If you simply say “change,” test graders may think you are saying that individuals evolve. Individuals do not. Populations do.**

EVOLUTION TEST EXAMPLES

1. Which of these *best* illustrates natural selection?
 - a. ☐ An organism with favorable genetic variations will tend to survive and breed successfully.
 - b. ☐ A population monopolizes all of the resources in its habitat, forcing other species to migrate.
 - c. ☐ A community whose members work together utilizes all existing resources and migratory routes.
 - d. ☐ The largest organisms in a species receive the only breeding opportunities.
2. A small population of chimpanzees lives in a habitat that undergoes no changes for a long period. How will genetic drift probably affect this population?
 - a. ☐ It will accelerate the appearance of new traits.
 - b. ☐ It will promote the survival of chimpanzees with beneficial traits.
 - c. ☐ It will increase the number of alleles for specific traits.
 - d. ☐ It will reduce genetic diversity.
3. In carrier pigeons there is a rare inherited condition that causes the death of the chicks before hatching. In order for this disease to be passed from generation to generation there must be parent birds that
 - a. ☐ are heterozygous for the disease.
 - b. ☐ have the disease themselves.
 - c. ☐ produce new mutations for this disease.
 - d. ☐ are closely interbred.
4. A single species of squirrel evolved over time into two species, each on opposite sides of the Grand Canyon. This change was *most* likely due to
 - a. ☐ higher mutation rates on one side.
 - b. ☐ low genetic diversity in the initial population.
 - c. ☐ the isolation of the two groups.
 - d. ☐ differences in reproductive rates.
5. A species of finch has been studied on one of the geographically isolated Galapagos Islands for many years. Since the island is small, the lineage of every bird for several generations is known. This allows a family tree of each bird to be developed. Some family groups have survived and other have died out. The groups that survive *probably* have
 - a. ☐ interbred with other species.
 - b. ☐ inherited some advantageous variations.
 - c. ☐ found new places on the island to live.
 - d. ☐ been attacked by more predators.
6. The diagram below shows a possible evolutionary sequence for some vertebrates. Which of the following statements is best supported by the diagram?



- a. ☐ Lizards and birds are both reptiles.
- b. ☐ Pterosaurs and ichthyosaurs became extinct at the same time.
- c. ☐ Pterosaurs evolved into birds.
- d. ☐ Thecodonts were ancestors of several different types of animals.

7. Mutations within a DNA sequence are

- a. ☐ natural processes that produce genetic diversity.
- b. ☐ natural processes that always affect the phenotype.
- c. ☐ unnatural processes that always affect the phenotype.
- d. ☐ unnatural processes that are harmful to genetic diversity.

8. Earth has undergone some catastrophic changes from time to time. Which of these *most* likely explains why life on Earth continued following these catastrophes?

- a. ☐ Dominant species had a slow mutation rate.
- b. ☐ Many species filled the same niche.
- c. ☐ A strong species had many different characteristics.
- d. ☐ A wide diversity of species existed.

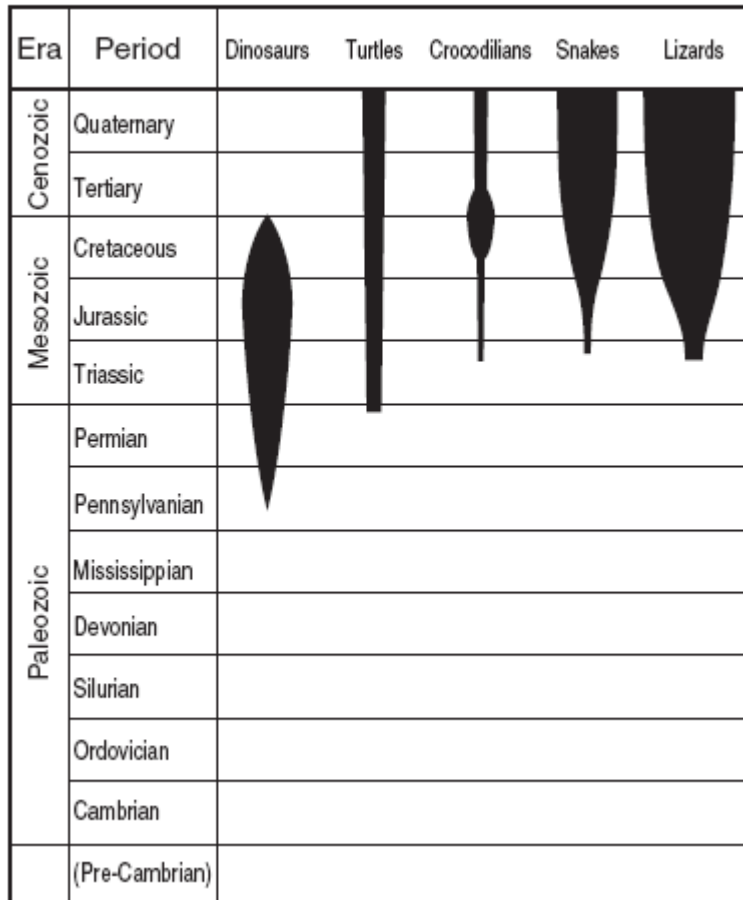
9. 5' G T A _ _ _ A A 3'

3' C A T G C A T T 5'

This segment of DNA has undergone a mutation in which three nucleotides have been deleted. A repair enzyme would replace them with

- a. ☐ CGT.
- b. ☐ GCA.
- c. ☐ CTG.
- d. ☐ GTA.

Numbers of Representative Species



10. According to this information, which group demonstrated the greatest biodiversity during the Cretaceous period?

- a. ☐ dinosaurs
- b. ☐ crocodilians
- c. ☐ snakes
- d. ☐ lizards

11. Which of these would *most* likely cause a mutation?

- a. ☐ the placement of ribosomes on the endoplasmic reticulum
- b. ☐ the insertion of a nucleotide into DNA
- c. ☐ the movement of transfer RNA out of the nucleus
- d. ☐ the release of messenger RNA from DNA

12. Fossil evidence suggests that a number of members of one fish species from an ancient lake in Death Valley, California, became several isolated species. Each of these new species lived in a different pond. Which of the following *best* explains the cause of this speciation?
- a. ☐ episodic isolation
 - b. ☐ temporal isolation
 - c. ☐ geographic isolation
 - d. ☐ behavioral isolation
13. If a paleontologist finds fossils of many different species existing in the same area at approximately the same time, the paleontologist can conclude that the ecosystem in this area had a high degree of
- a. ☐ climatic variation.
 - b. ☐ episodic speciation.
 - c. ☐ biological diversity.
 - d. ☐ geographic isolation.
14. Genetic engineering has produced goats whose milk contains proteins that can be used as medicines. This effect was produced by
- a. ☐ mixing foreign genes into the milk.
 - b. ☐ injecting foreign genes into the goats' udders.
 - c. ☐ inserting foreign genes into fertilized goat eggs.
 - d. ☐ genetically modifying the nutritional needs of the goats' offspring.
15. How can radiation produce mutations in the offspring of an exposed organism?
- a. ☐ It doubles the amount of DNA within egg or sperm cells.
 - b. ☐ It changes recessive traits to dominant traits and vice versa.
 - c. ☐ It allows non-DNA proteins to control the expression of various traits.
 - d. ☐ It rearranges the genetic information in the DNA of an egg or sperm cell.