

**STUDY GUIDE - Ch. 22.1 - The Darwinian revolution challenged traditional views of a young Earth inhabited by unchanging species.**  
**- Ch. 22.2 - Descent with modification by natural selection explains the adaptations of organisms and the unity and diversity of life.**

NAME: \_\_\_\_\_

- **PHYSICALLY PRINT OUT this PDF and HANDWRITE (with a black or blue pen) your answers directly on this PDF.** Typed or digitally-written work is not accepted. Do not answer questions on separate paper.
- **Importantly, study guides are NOT GROUP PROJECTS!!!** You, and you alone, are to answer the questions as you read your assigned textbook. You are not to share answers with other students. You are not to copy any answers from any other source, including the internet.
- **Get in the habit of writing LEGIBLY, neatly, and in a medium-sized font.** AP essay readers and I will skip grading anything that cannot be easily read so start perfecting your handwriting, and don't write so large you can't add all the relevant details and key elaborations in the space provided.
- **SCAN physical documents in color and with good resolution. Then, upload your final work as PDFs to Archie.** Avoid uploading dark, shaded, washed-out, sideways, or upside-down scans of homework. Keep completed physical study guides organized in your biology binder to use as future study and review tools.
- **READ FOR UNDERSTANDING and not merely to complete an assignment.** *First*, read a section quickly to get an overview of the topic covered. Then, read it a second time slowly, paraphrasing each paragraph out loud and analyzing every figure. Finally, read it a third time as you answer the study guide questions if assigned and start building your memory. Try to write answers out in your own words, when possible, and try to purposefully and accurately use all new terminology introduced.

*"As you study this chapter, read several paragraphs at a time to catch the flow of ideas and understand the reasoning being described. In some places, the text describes a narrative or story of events that led to Darwin's theory of evolution. Therefore, first read the narrative to absorb the big picture and then return to answer the questions related to the material."*

1. **Do Memorize** = Though Darwin referred to evolution as "descent with modification" and defined evolution as the process by which species accumulate difference from their ancestors as they adapt to different environments over time. However, today, we define evolution as a change in the frequency of alleles for one or more genes in a population of organisms (or a change in the genetic composition of a population over time).
  - \* **Note that evolution happens at the population level, not the individual organism or species level.** Remember, population = a group of organisms of the same species living in a particular region.
2. a. What are fossils?  
  
b. Fossils are often found in Sedimentary Rock, which forms from deposits of eroded pre-existing rocks (like mud) or pieces of once-living organism that accumulate on the Earth's surface and then solidifies as these sediments settle (often at the bottom of seas, lakes, and swamps). What are strata?  
  
c. How do fossils form in sedimentary rock?
3. a. George Cuvier is known as the "father of paleontology" or the study of fossils. What did two observations did he make about the fossils he found in various strata?
  - 1.
  - 2.  
b. What did he believe were the reasons for the change in fossils from an older strata below to a newer one above the older one?

4. In Europe in the 1800s, Christian scholars and religious leaders interpreted the age of the Earth to be a few thousand years old. Certain scientists, however, began to question such a young age through their research and observations, these individuals influencing Charles Darwin's thinking as well about the length of time organisms had existed and the potential cumulative effects of small change in organisms over long period on time. What were the **proposals made by the following two geologists** of the 18<sup>th</sup> and 19<sup>th</sup> centuries?

1. **James Hutton** (1726–1797) =

2. **Charles Lyell** (1797–1875) =

5. Darwin was not the first to theorize that life evolves. **Jean Baptiste de Lamarck** proposed his own theory for evolution along with **a mechanism for how life changes**. Though Lamarck was incorrect about the mechanism, he can be considered a visionary for recognizing that *the observation that organisms are well-suited to their environments can be explained by gradual evolutionary change* and for *proposing a testable hypothesis (explanation) for how such evolutionary change occurs*.

Explain the **two principles Lamarck proposed as mechanisms of evolution**.

1. **The Principal of Use and Disuse** =

2. **The Principal of the Inheritance of ACQUIRED Characteristics** =

6. **Darwin's Voyage on the HMS Beagle had a great impact on Darwin's research.** Darwin embarked from England on the HMS Beagle in December 1831. As the crew surveyed the coastline of South America and traveled around the world, Darwin observed and collected thousands of plants and animals, especially in South America. He noticed marine fossils high in the Andes and hypothesized that they had reached such heights by being thrust up after many earthquakes and geological processes. Overall, he realized that the physical evidence did not support the traditional view of a static Earth only a few thousand years old.

He noticed that characteristics of *plants and animals were very well suited to each distinct environment*. He noted that plants and animals in temperate regions of South America were more similar to those species living in South American tropics than species living in European temperate regions. *Fossils also resembled living species in the same area*. He further *hypothesized that animals that colonized the Galapagos originated from South America and diversified upon reaching the different islands after noting that although the animals on the Galápagos resembled species living on the South American mainland, most of the Galápagos species were not known anywhere else in the world*.

- a. Darwin observed many examples of adaptations and eventually **proposed an explanation for how adaptations arise**, namely **through natural selection**. What is an **evolutionary adaptation**?

- b. Explain the **process of Natural Selection** Darwin felt was the cause of evolutionary change.

- c. Give an example of an adaptation you've learned about so far in AP Biology (that is not presented in this chapter) and **explain why it is an adaptation**. WHEN ASKED THIS ON THE AP EXAM, BE SURE TO CLEARLY ARTICULATE HOW THIS TRAIT HELPS THE ORGANISM **1. SURVIVE** and, therefore, **2. REPRODUCE**! If you do not explain how it helps in these two processes, then, you have failed to explain why that version of a characteristic is an adaptation.

Example of Adaptation:

Reason this is an Adaptation - how does it help the organism survive?

Reason this is an Adaptation - why does it help the organism reproduce?

7. Before you continue, **watch the 30-minute documentary** The Origin of Species: The Making of a Theory by navigating to <https://www.biointeractive.org/classroom-resources/origin-species-making-theory>
8. a. In his publication, "On The Origin of Species by Means of Natural Selection", what did **Darwin attribute the unity** (the similarities in characteristics) **seen across life to?**
- b. **What did Darwin attribute the diversity** (differences in characteristics) **seen across life to?**
9. a. Study and **UNDERSTAND** how to read the evolutionary tree in figure 22.8. Based on this tree, around what time did the most recent ancestor of the Mammuthus, Asian elephants, and African elephants live? **Explain** your reasoning. (Check your answer by going to the Ch.22 **Figure Questions** for **Figure 22.8** in Appendix A of your textbook)
- b. How many lineages related to elephants are still alive today? **Explain** your reasoning.
- c. Which species are more closely related: the Stegodon and the Mammuthus **or** the Stegodon and the Platybeledon? **Explain** your reasoning.

**TIP:** You will share the most similar DNA (nucleotide sequences) with those species with whom you share a more recent common ancestor!!! This is because the DNA that gets copied and passed down through each generation to become the DNA of two different, but closely related species' gene pools has NOT had as much time to accumulate different mutations (genetic differences) in each of these two species' gene pools since the DNA was part of the gene pool of the more recent shared common ancestor while the DNA that has been copied and passed down through many more generations since it was part of the gene pool of a more distant shared common ancestor has had more chances of accumulating different mutations (genetic differences) in the two lineages that led two less closely related species of organisms.

10. a. Define the term artificial selection?

b. Elaborate on how did the concept of artificial selection impacted Darwin's ideas?

11. a. What were the two natural observations Darwin described that helped shape his ideas on natural selection?

1.

2.

b. What were the two inferences Darwin drew from these four observations?

1.

2.

12. Summarize the key features of Natural Selection?

1.

2.

3.

13. Take note of **how evolution by natural selection occurs** and also **how to properly explain the process** with the biological terminology you need to use accurately yourself:

**Evolution happens at the level of the population (*not the individual*)!!! It is the **population** that changes in an **average** phenotype over **MULTIPLE GENERATIONS**, *not* an individual that changes its phenotype in some **inheritable way in its lifetime**. After all, an individual is born with the versions of genes - alleles of genes - that it inherited from its parents and this individual cannot change its DNA because a different phenotype would be more useful in the current environment.**

The **HERITABLE VARIATION** in a characteristic (the genetic variation that causes phenotypic variation in a characteristic) **has to already be present in the population for evolution by means of natural selection to occur as a consequence of these variations causing individuals to experience DIFFERENTIAL REPRODUCTIVE SUCCESS within the environment**. If an environment changes and no phenotype that allows any of the organisms to survive exists in the population because the variation in the DNA leading to such a phenotype is absent, no individual could decide to suddenly change their phenotype to a more beneficial version for this new environment. These organisms with disadvantaged phenotypes may not survive and thus not be able to reproduce in the environment and so may **disappear** from that habitat. If these organisms were the last of its kind on Earth (the last of that species), then that species would go **extinct**.

Thankfully, **genetic mutations**, though a **random process**, do occur over time introducing genetic variation into gene pools of populations. If a new, useful version of a gene exists or later arises that alters an organism's characteristic in such a way that it now survives better, then this organism has a better chance of reaching reproductive age and passing this genetic variation on to its offspring. In sexual reproducer, the process of meiosis and fertilization brings together different alleles for the different genes in different organisms, leading to multiple variations in phenotypes.

Because the phenotypes of organisms influence the probability that they survive or not and, thus, get to reproduce or not, we say **each individual (each phenotype) is acted on by Natural Selection**. Each individual will have more or less success in reproducing compared to others with differing versions of a phenotype in the environment they are living in. So, **while evolution happens at the population level, natural selection happens at the individual organismal level!**

Over time, individuals with beneficial phenotype are more successful in surviving and go on to reproduce more often than those that don't survive as often. **The beneficial phenotype is being SELECTED FOR by natural selection while the less beneficial phenotype is being SELECTED AGAINST by natural selection.**

**Over many generations, as a consequence of this differential survival and reproductive success, the descendant's population will exhibit, on average, a phenotype more similar to the more beneficial phenotype in its ancestors. This feature (which is now more prevalent in the descendant population) is beneficial as it helps the organisms in the descendant population survive and reproduce.** This feature is referred to, therefore, as an **ADAPTATION**.

Now, let's learn about the evolution of sample adaptations seen in nature by watching the following two short videos:

1. <https://www.biointeractive.org/classroom-resources/science-extreme-animal-athlete>
2. <https://www.biointeractive.org/classroom-resources/biology-skin-color>

14. Let's practice explaining accurately certain aspects of Evolution by means of Natural Selection. Justify why the entirety of the following statements are valid.
- a. **"Individuals do NOT evolve, populations do"**

b. "Natural selection acts only on heritable traits"

c. "Even if a trait is heritable, if all the individuals in a population are genetically identical for that trait, evolution by natural selection cannot occur."

d. "Which traits are favored depends on the environmental context"

15. *Think* - If you discovered a fossil of an extinct mammal that lived high in the Andes, would you predict that it would more closely resemble present-day mammals from South American jungles or present-day mammals that live high in Asian mountains? **Explain.**

(Check your answers to #15 by going to the [Ch.22.2 Concept Check Question #2](#) answers in Appendix A)