Chapter 9

Life: From the First Organism Onward Worksheets

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- **Lesson 9.1: Earth Forms and Life Begins**
- **Lesson 9.2: The Evolution of Multicellular Life**
- **Lesson 9.3: Classification**

9.1 Earth Forms and Life Begins

Lesson 9.1: True or False

Name_____ **Class**_____ **Date**_____

Write true if the statement is true or false if the statement is false.

_____ 1. Life first appeared on Earth about 4 million years ago.

_____ 2. Much of what we know about the history of life on Earth is based on the fossil record.

_____ 3. Absolute dating is often based on the amount of radioactive carbon-12.

_____ 4. The geologic time scale is based on major changes in biology, chemistry, and the evolution of life.

_____ 5. In the early Earth, the oceans formed first, followed by the atmosphere.

_____ 6. Did DNA or proteins evolve first? Scientists believe proteins evolved first.

_____ 7. The oxygen catastrophe killed off many early cells.

_____ 8. The earliest cells were probably autotrophs – that is, they made their own food through photosynthesis.

_____ 9. A digital clock uses DNA sequences to estimate how long ago related species diverged from a common ancestor.

_____ 10. As organic molecules evolved before cells, the molecules must have evolved about 4.5 billion years ago.

_____ 11. The earliest cells may have been just nucleic acid inside a lipid membrane.

_____ 12. Did DNA or RNA evolve first? Some scientists believe RNA evolved first.

_____ 13. The solar system evolved from stardust.

_____ 14. Species with few differences in their DNA sequences are closely related.

_____ 15. In order for fossils to provide useful information, they must be dated.

Lesson 9.1: Critical Reading

Name_____ **Class**_____ **Date**_____

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

The First Cells

How organic molecules such as RNA developed into cells is not known for certain. Scientists speculate that lipid membranes grew around the organic molecules. The membranes prevented the molecules from reacting with other molecules, so they did not form new compounds. In this way, the organic molecules persisted, and the first cells may have formed.

LUCA

No doubt there were many early cells of this type. However, scientists think that only one early cell (or group of cells) eventually gave rise to all subsequent life on Earth. That one cell is called the **Last Universal Common Ancestor (LUCA).** It probably existed around 3.5 billion years ago. LUCA was one of the earliest prokaryotic cells. It would have lacked a nucleus and other membrane-bound organelles.

Photosynthesis and Cellular Respiration

The earliest cells were probably heterotrophs. Most likely they got their energy from other molecules in the organic "soup." However, by about 3 billion years ago, a new way of obtaining energy evolved. This new way was photosynthesis. Through photosynthesis, organisms could use sunlight to make food from carbon dioxide and water. These organisms were the first autotrophs. They provided food for themselves and for other organisms that began to consume them. After photosynthesis evolved, oxygen started to accumulate in the atmosphere. This has been dubbed the "oxygen catastrophe." Why? Oxygen was toxic to most early cells because they had evolved in its absence. As a result, many of them died out. The few that survived evolved a new way to take advantage of the oxygen. This second major innovation was cellular respiration. It allowed cells to use oxygen to obtain more energy from organic molecules.

Questions

1. Describe the first cells.

2. What was LUCA?

3. Why were the first cells heterotrophs?

4. How long did it take for photosynthesis to evolve?

5. What was the oxygen catastrophe?

Lesson 9.1: Multiple Choice

Name_____ **Class**_____ **Date**_____

Circle the letter of the correct choice.

1. Place the following in the order in which they evolved: eukaryotic cell, prokaryotic cell, photosynthesis, organic molecules.
   (a) eukaryotic cell - prokaryotic cell - photosynthesis - organic molecules
   (b) prokaryotic cell - eukaryotic cell - photosynthesis - organic molecules
   (c) organic molecules - prokaryotic cell - photosynthesis - eukaryotic cell
   (d) organic molecules - photosynthesis - prokaryotic cell - eukaryotic cell
2. Which of the following statements is true concerning LUCA? (1) LUCA was a cell. (2) All life on Earth evolved from LUCA. (3) LUCA probably existed probably around 4.5 billion years ago.
   (a) 1 only
   (b) 2 and 2
   (c) 1 and 2
   (d) 1, 2, and 3
3. The RNA world hypothesis states that
   (a) early life was based on RNA as the first organic molecule.
   (b) RNA evolved soon after the formation of the world.
   (c) the first cells were made of RNA and lipids.
   (d) all of the above
4. The "soup" of molecules refers to
   (a) an ocean full of a mixture of many different substances.
   (b) organic molecules created from inorganic chemicals in Earth's early atmosphere.
   (c) a Earth full of volcanic eruptions, thunder, and lightning.
   (d) the classic evolution experiments of Campbell and Chunky.
5. Early Earth
   (a) had a primitive atmosphere of ammonia, methane, water vapor, and carbon dioxide.
   (b) lacked much oxygen gas.
   (c) probably had a very hot environment.
   (d) all of the above
6. Which of the following can be considered fossils?
   (a) a 1 billion year-old rock.
   (b) a 1 billion year-old piece of amber.
   (c) a 1 billion year-old piece of amber with a primitive insect inside.
   (d) all of the above
7. "We are made of stardust" refers to
   (a) the dust of dead skin cells we shed every day.
   (b) the rotating cloud of stardust that formed the planets.
   (c) the gases in the stars that formed the gases in the atmosphere.
   (d) the rotating cloud of stardust that formed LUCA and all the organisms that evolved later.
8. Place the mouse, fruit fly, duck, and gorilla in order of their relatedness to humans, from least related to most related.
   (a) mouse - fruit fly - duck - gorilla

(b) fruit fly - mouse - duck - gorilla
(c) gorilla - mouse - duck - fruit fly
(d) fruit fly - duck - mouse - gorilla

Lesson 9.1: Vocabulary I

Name_____ **Class**_____ **Date**_____

Match the vocabulary word with the proper definition.

Definitions

_____ 1. the preserved remains or traces of organisms that lived in the past

_____ 2. divides Earth's history into divisions that are based on major changes in geology, climate, and the evolution of life

_____ 3. uses DNA sequences to estimate how long it has been since related species diverged

_____ 4. explains how the first eukaryotic cells probably evolved

_____ 5. says that early life was based solely on RNA

_____ 6. occurs when a species completely dies out

_____ 7. process in which organisms could use sunlight to make food from carbon dioxide and water

_____ 8. determines about how long ago a fossil organism lived

_____ 9. when oxygen started to accumulate in the atmosphere

_____ 10. has provided lots of information about the history of life on Earth

_____ 11. determines which of two fossils is older or younger than the other

_____ 12. the one early cell that eventually gave rise to all subsequent life on Earth

Terms

a. absolute dating

b. endosymbiotic theory

c. extinction

d. fossil

e. fossil record

f. geologic time scale

g. Last Universal Common Ancestor

h. molecular clock

i. oxygen catastrophe

j. photosynthesis

k. relative dating

l. RNA world hypothesis

Lesson 9.1: Vocabulary II

Name_____ **Class**_____ **Date**_____

Fill in the blank with the appropriate term.

1. Life first appeared on Earth about _____ billion years ago.

2. A _____ clock uses DNA sequences to estimate how long ago related species diverged from a common ancestor.

3. It is likely that organic molecules evolved before _____.

4. Fossils are the _____ remains or traces of organisms that lived in the past.

5. Scientists think that one early cell gave rise to all subsequent life on Earth. That one cell is called the _____.

6. Absolute dating determines about how long ago a fossil organism _____.

7. Human DNA is most similar to _____ DNA.

8. Some scientists speculate that _____ may have been the first organic molecule to evolve.

9. _____ dating determines which of two fossils is older or younger than the other.

10. The _____ theory explains how eukaryotic cells evolved.

11. _____ and Urey demonstrated that organic molecules could form under simulated conditions on early Earth.

12. If we think of Earth's history as a 24-hour day, humans would have appeared only during the last _____ of that day.

Lesson 9.1: Critical Writing

Name_____ **Class**_____ **Date**_____

Thoroughly answer the question below. Use appropriate academic vocabulary and clear and complete sentences.

Describe how the first organic molecules arose.

9.2 The Evolution of Multicellular Life

Lesson 9.2: True or False

Name_____ **Class**_____ **Date**_____

Write true if the statement is true or false if the statement is false.

_____ 1. Most of Earth's history passed before multicellular life evolved.

_____ 2. Dinosaurs went extinct just 65 thousand years ago.

_____ 3. Continental drift caused intense volcanic activity.

_____ 4. The disaster called the Cambrian explosion resulted in a tremendous mass extinction.

_____ 5. Birds evolved from reptile ancestors.

_____ 6. The Permian extinction was the biggest mass extinction the world had ever seen.

_____ 7. Sexual reproduction resulted in less variety among offspring.

_____ 8. Sexual reproduction slowed the rate of evolution.

_____ 9. *Homo sapiens* are primates.

_____ 10. The supercontinent called Pangaea formed during the Permian Period, just under 300 million years ago.

_____ 11. By 2 billion years ago, the first multicellular organisms had evolved.

_____ 12. Birds and insects filled the niches left by the dinosaurs.

_____ 13. The Triassic Period was the golden age of dinosaurs.

_____ 14. The Jurassic Period ended with the extinction of the dinosaurs.

_____ 15. During one ice age, snow and ice completely covered the planet.

Lesson 9.2: Critical Reading

Name_____ **Class**_____ **Date**_____

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

Setting the Stage: The Late Precambrian

The late Precambrian is the time from about 2 billion to half a billion years ago. During this long span of time, Earth experienced many dramatic geologic and climatic changes.

- Continents drifted. They collided to form a gigantic supercontinent and then broke up again and moved apart. Continental drift changed climates worldwide and caused intense volcanic activity.
- Carbon dioxide levels in the atmosphere rose and fell. This was due to volcanic activity and other factors. When the levels were high, they created a greenhouse effect. More heat was trapped on Earth's surface, and the climate became warmer. When the levels were low, less heat was trapped and the planet cooled. Several times, cooling was severe enough to plunge Earth into an ice age. One ice age was so cold that snow and ice completely covered the planet.

Life During the Late Precambrian

The dramatic changes of the late Precambrian had a major impact on Earth's life forms. Living things that could not adapt died out. They were replaced by organisms that evolved new adaptations. These adaptations included sexual reproduction, specialization of cells, and multicellularity.

- Sexual reproduction created much more variety among offspring. This increased the chances that at least some of them would survive when the environment changed. It also increased the speed at which evolution could occur.
- Some cells started to live together in colonies. In some colonies, cells started to specialize in doing different jobs. This made the cells more efficient as a colony than as individual cells.
- By 1 billion years ago, the first multicellular organisms had evolved. They may have developed from colonies of specialized cells. Their cells were so specialized they could no longer survive independently. However, together they were mighty. They formed an organism that was bigger, more efficient, and able to do much more than any single-celled organism ever could.

The Precambrian Extinction

At the close of the Precambrian 544 million years ago, a mass extinction occurred. In a **mass extinction**, many or even most species abruptly disappear from Earth. There have been five mass extinctions in Earth's history. Many scientists think we are currently going through a sixth mass extinction. What caused the Precambrian mass extinction? A combination of climatic and geologic events was probably responsible. No matter what the cause, the extinction paved the way for a burst of new life during the following Paleozoic Era.

Questions

1. Name two major events of the late Precambrian.

2. Name three major adaptations for life during the late Precambrian.

3. Explain the major benefits of the evolution of sexual reproduction.

4. How did the first multicellular organisms evolve? What were the benefits of being multicellular?

5. What is a mass extinction?

Lesson 9.2: Multiple Choice

Name_____ **Class**_____ **Date**_____

Circle the letter of the correct choice.

1. Which division of time during Earth's history came first?
   (a) The Paleozoic Era
   (b) The Cenozoic Era
   (c) The Late Precambrian
   (d) The Mesozoic Era
2. Which period was the "golden age of dinosaurs"?
   (a) the Triassic Period
   (b) the Jurassic Period
   (c) the Cretaceous Period
   (d) the Tyrannosaurus Period
3. Pangaea
   (a) is a supercontinent of all the major landmasses.
   (b) formed during the Mesozoic Era.
   (c) allowed dinosaurs to roam all over the planet.
   (d) all of the above
4. The Permian extinction probably
   (a) occurred because photosynthesis stopped and the planet cooled.
   (b) occurred at the beginning of the Mesozoic Era, allowing the dinosaurs to evolve.
   (c) killed most life on Earth except for small reptiles and mammals.
   (d) all of the above
5. The dinosaurs disappeared at the end of the
   (a) Triassic Period.
   (b) Jurassic Period.
   (c) Cretaceous Period.
   (d) Mesozoic Period.
6. Which of the following did not occur during the Carboniferous Period?
   (a) The first amphibians left the water to live on land, but they had to return to the water to reproduce.
   (b) Plants and animals evolved adaptations to dryness.
   (c) Widespread forests of huge plants left massive piles of carbon that eventually turned to coal.
   (d) The first reptiles evolved.
7. When the dinosaurs went extinct _____ million years ago, the _____-took over.
   (a) 65, reptiles
   (b) 65, mammals
   (c) 145, mammals
   (d) 65, birds
8. Which of the following is not true about the Jurassic Period?
   (a) The earliest birds evolved from reptile ancestors during this time.
   (b) The major groups of mammals evolved during this time.

(c) Flowering plants appeared for the first time.
(d) The period ended with the dramatic extinction of small lizards, an important food for the large dinosaurs.

Lesson 9.2: Vocabulary I

Name_____ **Class**_____ **Date**_____

Match the vocabulary word with the proper definition.

Definitions

_____ 1. when many or even most species abruptly disappear from Earth

_____ 2. the era of "old life"

_____ 3. the era of "middle life"

_____ 4. the era of "modern life"

_____ 5. Earth during the ice age of the late Precambrian

_____ 6. the biggest mass extinction the world had ever seen

_____ 7. adaptation that created much more variety among offspring

_____ 8. spectacular burst of new life that began the Palezoic Era

_____ 9. when first dinosaurs branched off from the reptiles

_____ 10. the golden age of dinosaurs

_____ 11. when dinosaurs reached their peak in size and distribution

Terms

a. Cambrian explosion

b. Cenozoic Era

c. Cretaceous Period

d. Jurassic Period

e. mass extinction

f. Mesozoic Era

g. Palezoic Era

h. Permian extinction

i. sexual reproduction

j. snowball Earth

k. Triassic Period

Lesson 9.2: Vocabulary II

Name_____ **Class**_____ **Date**_____

Fill in the blank with the appropriate term.

1. During the late Precambrian, continents drifted. They collided to form a gigantic _____.
2. During the late Precambrian, sexual _____ created much more variety among offspring.
3. During the late Precambrian, the first multicellular organisms had _____.
4. In a _____, many or even most species abruptly disappear from Earth.
5. The Paleozoic Era began with a spectacular burst of new life, called the Cambrian _____.
6. The Paleozoic Era ended with the biggest mass extinction the world had ever seen, known as the Permian _____.
7. The Mesozoic Era is known as the age of _____.
8. During the Triassic Period, the first dinosaurs branched off from _____.
9. Dinosaurs flourished during the _____ period.
10. The Cretaceous Period ended with the dramatic extinction of the _____.
11. The Cenozoic Era is known as the age of _____.
12. The last ice age ended about _____ years ago.

Lesson 9.2: Critical Writing

Name_____ **Class**_____ **Date**_____

Thoroughly answer the question below. Use appropriate academic vocabulary and clear and complete sentences.

Describe three major events of life that occurred during the "age of dinosaurs."

9.3 Classification

Lesson 9.3: True or False

Name_____ **Class**_____ **Date**_____

Write true if the statement is true or false if the statement is false.

_____ 1. Classification helps understand the present diversity and past evolutionary history of life on Earth.

_____ 2. Linnaeus grouped together organisms that shared obvious physical traits, such as number of heads or shape of toes.

_____ 3. Binomial nomenclature gives each species a unique, two-word Latin name.

_____ 4. Eukaryota consists of four kingdoms: Animalia, Plantae, Fungi, and Protista.

_____ 5. Phylogeny is the evolutionary history of a group of related organisms.

_____ 6. Organisms are currently grouped together if they look alike.

_____ 7. The Linnaean system of classification consists of a hierarchy of groupings, called domains.

_____ 8. The domain is a grouping that is larger and more inclusive than the kingdom.

_____ 9. *Homo sapiens* means "ape (primate) with big brain."

_____ 10. Most biologists agree there are four domains of life on Earth: Bacteria, Archaea, Prokaryota, and Eukaryota.

_____ 11. The evolution of life on Earth is ongoing for over 4 billion years.

_____ 12. Closely related species are grouped together in a family.

_____ 13. The kingdom is the largest and most inclusive grouping.

_____ 14. The genus is the smallest and most exclusive grouping.

_____ 15. Carolus Linnaeus developed his classification system in the early 1800s.

Lesson 9.3: Critical Reading

Name_____ **Class**_____ **Date**_____

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

Linnaean Classification

All modern classification systems have their roots in the **Linnaean classification system.** It was developed by Swedish botanist Carolus Linnaeus in the 1700s. He tried to classify all living things that were known at his time. He grouped together organisms that shared obvious physical traits, such as number of legs or shape of leaves. For his contribution, Linnaeus is known as the "father of taxonomy." The Linnaean system of classification consists of a hierarchy of groupings, called **taxa** (singular, taxon). Taxa range from the kingdom to the species. The **kingdom** is the largest and most inclusive grouping. It consists of organisms that share just a few basic similarities. Examples are the plant and animal kingdoms. The **species** is the smallest and most exclusive grouping. It consists of organisms that are similar enough to produce fertile offspring together. Closely related species are grouped together in a **genus.**

Binomial Nomenclature

Perhaps the single greatest contribution Linnaeus made to science was his method of naming species. This method, called **binomial nomenclature**, gives each species a unique, two-word Latin name consisting of the genus name and the species name. An example is *Homo sapiens*, the two-word Latin name for humans. It literally means "wise human." This is a reference to our big brains. Why is having two names so important? It is similar to people having a first and a last name. You may know several people with the first name Michael, but adding Michael's last name usually pins down exactly whom you mean. In the same way, having two names uniquely identifies a species.

Revisions in Linnaean Classification

Linnaeus published his classification system in the 1700s. Since then, many new species have been discovered. The biochemistry of organisms has also become known. Eventually, scientists realized that Linnaeus's system of classification needed revision. A major change to the Linnaean system was the addition of a new taxon called the domain. A **domain** is a taxon that is larger and more inclusive than the kingdom. Most biologists agree there are three domains of life on Earth: Bacteria, Archaea, and Eukaryota. Both Bacteria and Archaea consist of single-celled prokaryotes. Eukaryota consists of all eukaryotes, from single-celled protists to humans. This domain includes the Animalia (animals), Plantae (plants), Fungi (fungi), and Protista (protists) kingdoms.

Questions

1. What is Linnaeus known for?

2. What is binomial nomenclature?

3. What is a major difference between a kingdom and a species?

4. What is a domain? What are the three domains?

5. List the members of the domain Eukaryota.

Lesson 9.3: Multiple Choice

Name_____ **Class**_____ **Date**_____

Circle the letter of the correct choice.

1. Who is considered the "father of taxonomy?"
   (a) Charles Darwin
   (b) Carolus Linnaeus
   (c) Gregor Mendel
   (d) Francis Crick
2. Which of the following is in the correct order, from most inclusive to most exclusive?
   (a) kingdom - family - order - species
   (b) kingdom - phylum - family - species
   (c) phylum - class - species - genus
   (d) order - class - genus - species
3. The three domains of life include
   (a) Prokaryota
   (b) Eukaryota
   (c) Bacteriota
   (d) all of the above
4. Phylogeny refers to
   (a) the evolutionary history of a group of related organisms.
   (b) a group of organisms that includes an ancestor and all of its descendants.
   (c) Darwin's method to classify organisms.
   (d) all of the above
5. Eukaryotic organisms that are neither fungi, plants, nor animals are members of which kingdom?
   (a) Animalia
   (b) Plantae
   (c) Fungi
   (d) Protista
6. An example of binomial nomenclature would be
   (a) *Homo sapiens*
   (b) *Panthera tigris*
   (c) *Tyrannosaurus rex*
   (d) all of the above
7. Revisions in Linnaean classification were made, in part, because
   (a) many species went extinct.
   (b) many organisms were found to be members of the same species.
   (c) of an understanding of the biochemistry of many organisms.
   (d) all of the above
8. Which two domains consist only of single-celled prokaryotes?
   (a) Bacteria and Archaea
   (b) Bacteria and Eukaryota
   (c) Archaea and Eukaryota
   (d) Prokaryota and Bacteria

Lesson 9.3: Vocabulary I

Name_____ **Class**_____ **Date**_____

Match the vocabulary word with the proper definition.

Definitions

_____ 1. the science of classifying organisms

_____ 2. groupings

_____ 3. a taxon that is larger and more inclusive than the kingdom

_____ 4. grouping of closely related species

_____ 5. represents a phylogeny

_____ 6. developed classification system in the 1700s

_____ 7. the largest and most inclusive grouping

_____ 8. the smallest and most exclusive grouping

_____ 9. a group of organisms that includes an ancestor and all of its descendants

_____ 10. the evolutionary history of a group of related organisms

_____ 11. system in which modern classification systems are based

_____ 12. gives each species a unique, two-word Latin name

Terms

a. binomial nomenclature

b. Carolus Linnaeus

c. clade

d. domain

e. genus

f. kingdom

g. Linnaean classification system

h. phylogenetic tree

i. phylogeny

j. species

k. taxa

l. taxonomy

Lesson 9.3: Vocabulary II

Name_____ **Class**_____ **Date**_____

Fill in the blank with the appropriate term.

1. The science of _____ organisms is called taxonomy.
2. A hierarchy of groupings is known as a _____.
3. _____ nomenclature gives each species a unique, two-word Latin name.
4. A _____ is a new taxon that is larger and more inclusive than the kingdom.
5. The _____ is the smallest and most exclusive grouping.
6. The Bacteria and Archaea domains both consist of single-celled _____.
7. Phylogeny is the _____ history of a group of related organisms.
8. Eukaryota consists of the _____, Plantae, Fungi, and Protista kingdoms.
9. The reptile clade shows that _____ evolved from reptiles.
10. A _____ is a group of organisms that includes an ancestor and all of its descendants.
11. Bacteria, Archaea, and Eukaryota are the three _____ of life.
12. All modern classification systems have their roots in the _____ classification system.

Lesson 9.3: Critical Writing

Name_____ **Class**_____ **Date**_____

Thoroughly answer the question below. Use appropriate academic vocabulary and clear and complete sentences.

Describe the Linnaean classification, and define binomial nomenclature.