**Chapter 1—The Origin of the Ocean**

**MULTIPLE CHOICE**

1. How much of the Earth's water is found in the ocean?

|  |  |
| --- | --- |
| a. | 3% |
| b. | 67% |
| c. | 71% |
| d. | 97% |

ANS: D

Approximately 97% of the Earth's water is contained in the ocean. An ocean, in general, is a term used to describe a vast body of saline water that occupies depressions on Earth's surface. Information can be found in the section *Earth is an Ocean World*.

PTS: 1 DIF: Knowledge

2. There were multiple sources of water that contributed to the ocean. How was the majority of the ocean's water formed?

|  |  |
| --- | --- |
| a. | The condensation of a cloud composed of dust and gas from exploded stars |
| b. | The condensation and cooling of water vapor |
| c. | The infiltration of comets |
| d. | Run-off from continental land masses |

ANS: B

Although the Earth (and other planets in our solar system) was formed via the condensation of a dust and gas ridden cloud, this was not the direct cause of the formation of the ocean. Water vapor began escaping from Earth's interior. Over time this vapor condensed and cooled. Additional water was brought to Earth by comets. Information can be found in the section *Stars and Seas*.

PTS: 1 DIF: Knowledge

3. What key characteristic marks the beginning stages of the collapse of a star?

|  |  |
| --- | --- |
| a. | The increase in temperature |
| b. | The depletion of carbon and oxygen |
| c. | The depletion of hydrogen |
| d. | The expulsion of energy |

ANS: C

The lack of hydrogen in a star marks its death. The rapid compression of the core then causes the internal temperature to increase. In turn, this allows for the formation of heavy metal atoms. Information can be found in the section *Stars and Seas*.

PTS: 1 DIF: Knowledge

4. What caused Earth to partially melt when being formed?

|  |  |
| --- | --- |
| a. | Impact of asteroids, comets, and debris |
| b. | Gravitational compression |
| c. | Accumulation of decaying radioactive elements |
| d. | A combination of all of these choices |

ANS: D

Asteroids, comets, and debris heated the surface of Earth. Combined with gravitational compression and decaying radioactive elements, this caused Earth to partially melt. Information can be found in the section *Earth, Ocean, and Atmosphere Accumulated in Layers Sorted by Density*.

PTS: 1

5. What was the main requirement for the development of life on Earth?

|  |  |
| --- | --- |
| a. | Exposure to sunlight |
| b. | Absence of free oxygen |
| c. | Simple sugars |
| d. | Energization from electrical sparks |

ANS: B

In laboratory experiments, gases and compounds thought to be similar to Earth's early atmosphere were exposed to light, heat, and electrical sparks; the result was the production of simple sugars, small proteins, and nucleotides. The absence of free oxygen seemed to be the key factor. Information can be found in the section *Life Probably Originated in the Ocean*.

PTS: 1

6. What created Earth's moon?

|  |  |
| --- | --- |
| a. | The expulsion of rocky mantle after a collision with a planetary body |
| b. | The initial big bang expansion event |
| c. | The formation of a new star |
| d. | The collision between two older moons |

ANS: A

The moon orbiting Earth resulted from the initial collision with another planetary body about the size of Mars. The collision ejected some rocky mantle while the metallic core of that body fell into Earth's core. The rocky mantle began to condense to form the moon we know today. Information can be found in the section *Earth, Ocean, and Atmosphere Accumulated in Layers Sorted by Density*.

PTS: 1 DIF: Knowledge

7. Why is biosynthesis unlikely to occur today as it did in Earth's youth?

|  |  |
| --- | --- |
| a. | Living organisms have altered oceanic and atmospheric conditions |
| b. | There is less available oxygen in the atmosphere |
| c. | Ozone is less protective from the sun's influence |
| d. | The ocean’s do not contain enough free iron |

ANS: A

Living organisms have altered the ocean and atmosphere, and those changes are not consistent with any new origin of life. Plants are now producing oxygen which is then added to the atmosphere. Oxygen, in the form of Ozone, also blocks the most dangerous wavelengths of light from reaching the surface of the ocean. Additionally, the many tiny organisms present today would gladly scavenge on any large organic molecules. Information can be found in the section *Life Probably Originated in the Ocean*.

PTS: 1 DIF: Knowledge, Evaluation

8. A marine scientist is studying the amount of dissolved oxygen in a particular area. They are attempting to connect the data with the type of organisms found in that area. What kind of marine scientist might they be classified as?

|  |  |
| --- | --- |
| a. | Physical oceanographer |
| b. | Chemical oceanographer |
| c. | Marine biologist |
| d. | Marine geologist |

ANS: B

Chemical oceanographers study dissolved gases and solids in the ocean. They then apply these measurements to the geology and biology of the ocean as a whole. Information can be found in the section *Marine Scientists Use the Logic of Science to Study the Ocean*.

PTS: 1

9. The composition of the Milky Way does not include:

|  |  |
| --- | --- |
| a. | stars |
| b. | gases |
| c. | dust |
| d. | galaktos |

ANS: D

The Milky Way galaxy is made up of stars, gas, dust, and debris. As with any galaxy, it is held in place by gravity. The Milky Way galaxy is named after the Greek *galaktos*, which means "milk". Information can be found in the section *Stars and Seas*.

PTS: 1

10. What process accounts for the layers found in Earth?

|  |  |
| --- | --- |
| a. | Plate tectonics |
| b. | Accretion |
| c. | Density stratification |
| d. | Subduction |

ANS: C

Heavy elements like iron and nickel pulled inward towards the core while lighter materials like oxygen and silicon rose toward the surface. The Earth now has distinct interior layers separated by their density. Information can be found in the section *Earth, Ocean, and Atmosphere Accumulated in Layers Sorted by Density*.

PTS: 1 DIF: Knowledge

11. How old are fossils that indicate the first life forms on Earth?

|  |  |
| --- | --- |
| a. | Between 1.2 and 1.5 billion years old |
| b. | Between 2.6 and 2.7 billion years old |
| c. | Between 3.4 and 3.5 billion years old |
| d. | Between 4 and 4.2 billion years old |

ANS: C

Bacteria-like fossils have been found in northwest Australia. These are the oldest fossils found to date. There is additional evidence found near Greenland in the form of carbon residue in some of the rocks which could represent life as far back as 3.85 billion years ago. Information can be found in the section *Life Probably Originated in the Ocean*.

PTS: 1

12. \_\_\_\_ is a critical aspect of science.

|  |  |
| --- | --- |
| a. | The ability to operate in reverse |
| b. | The ability to be refined with new information |
| c. | Looking at data rather than being told |
| d. | All of these choices are critical aspects of science |

ANS: D

Science is a dynamic process. Scientific theories have the ability to change or be refined as new information is obtained. Science can even operate in reverse by using laws and theories to predict what *could* happen. Information can be found in the section *Marine Scientists Use the Logic of Science to Study the Ocean*.

PTS: 1

13. Since the formation of our ocean, Earth has made approximately \_\_\_\_ orbits around the galaxy.

|  |  |
| --- | --- |
| a. | 20 |
| b. | 42 |
| c. | 230 |
| d. | 280 |

ANS: A

The Earth has only made about 20 orbits around the galaxy since the ocean's formation. One orbit takes approximately 230 million years, despite our speed of 200 kilometers per second. This puts into perspective the sheer magnitude of our galaxy. Information can be found in the section *Stars and Seas*.

PTS: 1 DIF: Knowledge

14. What had the most influence in irreversibly changing the Earth's atmosphere?

|  |  |
| --- | --- |
| a. | Formation of carbonic acid in the ocean |
| b. | Production of oxygen from photosynthesis |
| c. | Chemical breakup of water vapor by sunlight |
| d. | Fluctuation in the atmospheric composition |

ANS: B

Although all these factors did occur, the addition of oxygen to the atmosphere changed the atmosphere forever. It was called the oxygen revolution. As more and more photosynthetic organisms evolved, more oxygen was added into the atmosphere. Information can be found in the section *Earth, Ocean, and Atmosphere Accumulated in Layers Sorted by Density*.

PTS: 1

15. A(n) \_\_\_\_ is a test involving manipulations made on conditions of a particular observation.

|  |  |
| --- | --- |
| a. | hypothesis |
| b. | experiment |
| c. | theory |
| d. | scientific method |

ANS: B

The simplification of an observation in nature or in a laboratory is conducted by manipulating conditions. Often times, one aspect is manipulated at a time to narrow possible reasons for an observation. Information can be found in the section *Marine Scientists Use the Logic of Science to Study the Ocean*.

PTS: 1

16. Which is not necessarily a characteristic of a red giant?

|  |  |
| --- | --- |
| a. | The engulfing of inner planets |
| b. | The expansion of atmosphere |
| c. | Becoming a supernova |
| d. | Materials sent into space from shattering |

ANS: C

Not all red giants are large enough to become a supernova. When our sun begins to die, it likely will not become a supernova. It will engulf planets and expand its radius. The pieces sent into space are to be recycled. Information can be found in the section *What Will be the Future of Earth*.

PTS: 1

17. The life history of a star is dependent upon what?

|  |  |
| --- | --- |
| a. | The amount of helium present |
| b. | The speed of conversion of hydrogen to carbon or oxygen |
| c. | The initial mass |
| d. | The amount of energy output |

ANS: C

The life history of a star is based on its initial mass. Stars convert hydrogen atoms into larger carbon and oxygen atoms. Once the star begins to consume the carbon and oxygen it produced, it increases its energy output. The rate of this is determined by temperature and size. Information can be found in the section *Stars and Seas*.

PTS: 1

18. What planet is an example that others planets besides Earth have a plethora of water?

|  |  |
| --- | --- |
| a. | Mars |
| b. | Jupiter |
| c. | Saturn |
| d. | Neptune |

ANS: B

Water is a common resource throughout our solar system. Although Jupiter has hundreds of times more water than Earth, it is in a solid state of ice. Information can be found in the section *Are There Other Ocean Worlds*.

PTS: 1

19. How long did the process of density stratification of Earth last?

|  |  |
| --- | --- |
| a. | 100 million years |
| b. | 100 thousand years |
| c. | 10 billion years |
| d. | 1 billion years |

ANS: A

The density stratification of Earth lasted approximately 100 million years. Then the Earth began to cool down. Information can be found in the section *Earth, Ocean, and Atmosphere Accumulated in Layers Sorted by Density*.

PTS: 1

20. A(n) \_\_\_\_ is an explanation that can be tested by additional observations or controlled experiments.

|  |  |
| --- | --- |
| a. | question |
| b. | science |
| c. | hypothesis |
| d. | scientific method |

ANS: C

In general, a hypothesis is a tentative explanation for a particular observation or measurement. It can be supported or refuted based on further observations and controlled experiments. Information can be found in the section *Marine Scientists Use the Logic of Science to Study the Ocean*.

PTS: 1

21. What type of marine scientist studies the Earth's ocean, continents, and climate?

|  |  |
| --- | --- |
| a. | Physical oceanographer |
| b. | Marine climatologist |
| c. | Chemical oceanographer |
| d. | Marine geologist |

ANS: D

Marine geologists study many abiotic factors associated with the Earth and its ocean. They also study the composition of inner Earth, the mobility of the crust, characteristics of sediments, and geological activity such as earthquakes. Information can be found in the section *Marine Scientists Use the Logic of Science to Study the Ocean*.

PTS: 1

22. What process involves the clumping of small particles into larger masses?

|  |  |
| --- | --- |
| a. | Condensation |
| b. | Coagulation |
| c. | Secretion |
| d. | Accretion |

ANS: D

Accretion clumps small particles together into larger masses. This process formed new planets, including our own, from the dust and debris surrounding the sun. Information can be found in the section *Stars and Seas*.

PTS: 1

23. Although it currently does not have an ocean, \_\_\_\_ is thought to have had one in the distant past.

|  |  |
| --- | --- |
| a. | Europa |
| b. | Saturn |
| c. | Jupiter |
| d. | Mars |

ANS: D

Mars shows signs there might have been an ocean on its surface. It is possible this ocean occupied low areas of the planet's northern hemisphere. This would have existed as much as 3.2 billion years ago when conditions were warmer. The red planet might have even had as much carbon dioxide in its atmosphere as early Earth. Information can be found in the section *Are There Other Ocean Worlds*.

PTS: 1

24. High levels of \_\_\_\_ could indicate life on other planets.

|  |  |
| --- | --- |
| a. | free nitrogen |
| b. | carbon dioxide |
| c. | free oxygen |
| d. | bound nitrogen |

ANS: C

Oxygen in itself is a very reactive element. It binds quickly to other materials. Remember, free oxygen only became abundant in our atmosphere when photosynthetic organisms began producing more. Thus, if there is a large amount of free oxygen, then there is something present that is replacing it in the atmosphere. This is likely to be a life-form of some sort. Information can be found in the section *Are There Other Ocean Worlds*.

PTS: 1

25. What forms heavy elements such as gold, mercury, and uranium?

|  |  |
| --- | --- |
| a. | A protostar |
| b. | Condensation |
| c. | A supernova |
| d. | A solar nebula |

ANS: C

A supernova is a shattering expansion in which there is an explosive release of energy. This explosion, lasting only thirty seconds, can demolish a star. Information can be found in the section *Stars and Seas*.

PTS: 1

26. Which does not describe a law?

|  |  |
| --- | --- |
| a. | A law summarizes observations. |
| b. | A law explains observations. |
| c. | A law is the largest construct to summarize experimental observations |
| d. | A law explains unvarying uniformity under the same conditions. |

ANS: B

Laws provide explanations to events that occur in nature which are uniform when tested under the same conditional parameters. Therefore, a law is able to summarize observations. A theory is actually responsible for supplying explanations for those observations. Information can be found in the section *Marine Scientists Use the Logic of Science to Study the Ocean*.

PTS: 1

27. In the Insight into National Geographic Explorer, Dr. Hand suggests that studying life in extreme environments is important for what reason?

|  |  |
| --- | --- |
| a. | It can improve our understanding of earth’s early evolution |
| b. | Extreme environments have highly adapted organisms |
| c. | These environments could mimic conditions on other planets |
| d. | New species of organisms are being discovered |

ANS: C

It was thought that life could not exist in these harsh, dry, cold, environments but in the 70’s rocks from Antarctica had complex microbial communities of lichens and cyanobacteria. Dr. Hand explains that studying microbes is tricky because if you bring the rocks up from the extreme environments they often change what they’re doing. Information can be found in the section *Insight from a National Geographic Explorer.*

PTS: 1

28. What could ultimately be linked to the lack of water on Mars?

|  |  |
| --- | --- |
| a. | The large decrease in carbon dioxide. |
| b. | The proximity to the sun. |
| c. | The lack of free oxygen in the atmosphere. |
| d. | The lack of outgassing from the interior of the planet |

ANS: A

The large decrease in carbon dioxide could explain why there is currently no water found on Mars. Carbon dioxide is a greenhouse gas which can insulate a planet. As the carbon dioxide began to be absorbed by rocks, the atmosphere became thin. This made the surface very cold. The ocean disappeared because the water either bound to rocks or froze beneath the surface. Information can be found in the section *Are There Other Ocean Worlds*.

PTS: 1 DIF: Knowledge

29. How long ago did the big bang catalyze the beginning of the universe?

|  |  |
| --- | --- |
| a. | 13.7 billion years ago |
| b. | 1.37 billion years ago |
| c. | 4 billion years ago |
| d. | 40 billion years ago |

ANS: A

The "big bang" was the catalyst for the formation of the universe. It is thought to have occurred approximately 13.7 billion years ago at a concentrated geometric point. Information can be found in the section *Stars and Seas*.

PTS: 1

30. The scientific method is characterized as:

|  |  |
| --- | --- |
| a. | an orderly process in which theories are proved to be absolutely true. |
| b. | an orderly process in which a test simplifies an observation in nature by controlling the conditions in which they are made. |
| c. | an orderly process in which theories are verified or rejected. |
| d. | a testable speculation or explanation of a theory. |

ANS: C

The scientific method is an orderly process in which theories are verified or rejected. The scientific method can be conducted in many forms, but can never absolutely prove a hypothesis or theory. Information can be found in the section *Marine Scientists Use the Logic of Science to Study the Ocean*.

PTS: 1

**TRUE/FALSE**

1. The spinning of a shrinking nebula marks the transition from a protostar to a star.

ANS: F

A spinning nebula begins to shrink over time. As the gases of the sphere flatten and condense at the center, it becomes a protostar. Hydrogen atoms eventually begin to fuse into helium which releases a great amount of energy. The rapid release of energy marks the transition to a star. Information can be found in the section *Stars and Seas*.

PTS: 1

2. Despite a multitude of names given to describe portions of the ocean, it is more accurate to call it a single dynamic world ocean.

ANS: T

Humans have created many names to describe a portion of the ocean, but all these bodies interact with each other. Thus, the world ocean is better described as a single entity which has different characteristics depending on locale. Information can be found in the section *Earth is an Ocean World*.

PTS: 1

3. Amino acids, sugars, proteins, and nucleotides are considered the building blocks of life.

ANS: T

In lab experiments that simulated early Earth's atmosphere, these components were formed. The real atmosphere conditions allowed these building blocks to progress into life on Earth. Information can be found in the section *Life Probably Originated in the Ocean*.

PTS: 1

4. Water in its liquid state is common in our solar system.

ANS: F

Although water itself is a common resource in our solar system, it is not commonly found in liquid form as it is on Earth. It is usually found in solid states on other planets and moons. Information can be found in the section *Are There Other Ocean Worlds*.

PTS: 1

5. Scientists believe that some answers to proposed question will ultimately never be known.

ANS: F

Scientists truly believe that the answers to questions are all ultimately knowable. The answers themselves are sought out using the scientific method. Information can be found in the section *Marine Scientists Use the Logic of Science to Study the Ocean*.

PTS: 1

6. The outermost gases of early Earth were initially destroyed by radiation from the sun, but the underlying atmosphere remained intact.

ANS: F

The layer of gases that the sun stripped was Earth's first atmosphere. There were other gases which were released from the interior of the planet to form a secondary atmosphere. Information can be found in the section *Earth, Ocean, and Atmosphere Accumulated in Layers Sorted by Density*.

PTS: 1

7. The expansion of the universe that began during the big bang event continues to this day.

ANS: T

It is hard to say how long this expansion might continue, but it could last for billions of years. Information can be found in the section *Stars and Seas*.

PTS: 1

8. The scientific method is a useful tool beyond the confines of science fields. It can be used in everyday life, by any person.

ANS: T

The scientific method is absolutely applicable to everyday life. Recall the example given in the book that references how to determine why a person's car will not start. Information can be found in the section *Marine Scientists Use the Logic of Science to Study the Ocean*.

PTS: 1

9. Earth was most likely chemically homogenous when it was young.

ANS: T

The young Earth, formed by the accretion of cold particles, was probably chemically homogeneous throughout. Then, in the midst of the accretion phase, Earth's surface was heated by the impact of asteroids, comets, and other falling debris. Information can be found in the section *Earth, Ocean, and Atmosphere Accumulated in Layers Sorted by Density*.

PTS: 1

10. Oceanography encompasses aspects of many other science fields such as geology, physics, biology, and chemistry.

ANS: T

Marine science, or oceanography, uses other science fields to better understand life-forms, processes, and the composition of the oceanic realm. Information can be found in the section *Marine Scientists Use the Logic of Science to Study the Ocean*.

PTS: 1

11. Experiments involving early atmospheric conditions were able to produce amino acids, sugars, and even microscopic bacteria.

ANS: T

In laboratory experiments, mixtures of dissolved compounds and gases thought to be similar to Earth's early atmosphere have been exposed to light, heat, and electrical sparks. These energized mixtures produce simple sugars and a few of the biologically important amino acids. They even produce small proteins and nucleotides (components of the molecules that transmit genetic information between generations). Information can be found in the section *Life Probably Originated in the Ocean*.

PTS: 1

12. The ocean was mostly in place by 4 billion years ago.

ANS: T

The ocean continues to form to this day. This is on a very small level, about 0.1 cubic kilometers per year. Information can be found in the section *Earth, Ocean, and Atmosphere Accumulated in Layers Sorted by Density*.

PTS: 1

13. Studying microbes in extreme environments is tricky because when you retrieve the rocks they often change what they are doing.

ANS: T

Studying life from extreme environments is tricky because if you change their environment they often change what they were doing. Studying life in the lab often tells you one thing while in reality the little buggers may be doing something quite different in their home environments. Information can be found in the *Insight from National Geographic Explorer section*.

PTS: 1 DIF: Comprehension

14. The only aspect of science is the gathering of information and the studying of that information.

ANS: F

Science is the process of asking questions by gathering information and studying information, but it also has a very distinguishing characteristic, the interpretation of raw data. Information can be found in the section *Marine Scientists Use the Logic of Science to Study the Ocean*.

PTS: 1

15. The Earth was formed by the condensation of a cloud comprised of dust and gas.

ANS: T

The dust and gas that formed Earth came from remnants of exploded stars. The gases and dust were enriched by the very recycled stars which they came from. Information can be found in the section *Stars and Seas*.

PTS: 1

**ESSAY**

1. How did the Earth form? How did the ocean form? Include relevant terminology, dates, and processes.

ANS:

Answer should include:

|  |  |
| --- | --- |
|  | The Big Bang Theory was an event in which the universe began expanding from a geometric point. |
|  | The Big Bang happened approximately 13.7 billion years ago. |
|  | Stars began condensing via accretion about 1 billion years ago. |
|  | Accretion is a process that brings smaller particles together into larger masses. |
|  | The Earth began to form as elements condensed from a cloud of dust and gas. |
|  | Ocean formation begins when the Earth's surface is extremely hot. Water vapor began escaping to the surface through volcanic activity and outgassing. The vapor eventually cooled and condensed to form the ocean approximately 4 billion years ago. |

Information can be found in the section *Stars and Seas*.

PTS: 1

2. Eventually our sun will become a red giant. Explain what this means. What would happen to Earth and our universe if this were to happen?

ANS:

Answer should include:

|  |  |
| --- | --- |
|  | A red giant refers to the stage when a star begins to swell after its energy output increases. The path to becoming a red giant starts with a star consuming carbon and oxygen. This marks the death of a star. |
|  | If the red giant is large enough, it can become a supernova. |
|  | Eventually, our sun will become a red giant. It will engulf the inner planets of the universe, including Earth. |
|  | The materials that shatter into space will be recycled in the universe. |
|  | The sun's explosion could trigger a new solar system. Accretion is likely to start, and the creation of new planets could occur. |

Information can be found in the section *What Will be the Future of Earth*.

PTS: 1

3. Describe how the Earth's ocean accumulated. What aspects of the initial atmospheric conditions prohibited the formation of liquid water? Once in place, how did the water become saline?

ANS:

Answer should include:

|  |  |
| --- | --- |
|  | Early atmospheric conditions prohibited the collection of water. Water vapor was unable to cool enough to form into liquid form due to the extreme surface temperature of Earth. The sun was also unable to penetrate the atmosphere due to thick clouds in the early atmosphere. |
|  | As the upper layer of clouds began to cool, droplets of water were able to form. Eventually, hot rain began to fall toward Earth. The rain that fell boiled once it came in contact with the surface of Earth. The water then evaporated and cycled back into clouds. |
|  | The cycling of water from the atmosphere to the Earth's surface and back again helped cool the surface of the Earth. |
|  | Once the surface of Earth cooled, water began to collect in basins. |
|  | As the water collected in basins, minerals began to dissolve. This created the saline conditions of the ocean. |
|  | The whole process of the formation of the ocean lasted approximately 20 million years. |
|  | The ocean was mostly in place by 4 billion years ago. |

Information can be found in the section *Earth, Ocean, and Atmosphere Accumulated in Layers Sorted by Density*.

PTS: 1

4. What conditions are necessary to maintain an ocean of liquid water permanently? Why is having a liquid ocean so important?

ANS:

Answer should include:

|  |  |
| --- | --- |
|  | The movement in a nearly circular orbit around a stable star is needed. |
|  | The distance from the star is important. It has an effect on the temperature. If a planet is too close to a star, it may only be able to sustain water vapor. On the other hand, a planet that is too far away from the star will only be able to sustain solid ice. |
|  | There can only be a single star that it is orbiting to ensure the consistency of the temperature. Multiple stars could cause intense periods of heat or cold. |
|  | Materials on the planet must be present to form a solid crust in addition to water. |
|  | The planet must be large enough to ensure its gravity will keep the ocean and atmosphere from meandering into space. |
|  | The presence of an ocean is vital for the formation of life. This is likely the place on Earth where life began. |

Information can be found in the section *Are There Other Ocean Worlds*.

PTS: 1

5. What was the composition of the early atmosphere of Earth? What changes occurred to the early atmosphere? What was the key factor in creating an atmosphere similar to today?

ANS:

Answer should include:

|  |  |
| --- | --- |
|  | The early atmosphere was rich in nitrogen, carbon dioxide, and water vapor. There were also traces of methane and ammonium. |
|  | Changes in the atmosphere began 3.5 billion years ago. The composition changed into nitrogen and oxygen. |
|  | Carbon dioxide that was once abundant in the atmosphere began to get absorbed into seawater attributed to the changes in composition 3.5 billion years ago. |
|  | The change in atmosphere allowed sunlight to penetrate the Earth's surface which was able to break up the water vapor. |
|  | Photosynthetic organisms were key in changing the atmosphere approximately 1.5 billion years ago. These photosynthetic organisms produced large amounts of oxygen and are what caused our atmosphere to look similar to what it does today. |
|  | The oxygen began oxidizing minerals in the sediments. Eventually, the oxygen began accumulating in the atmosphere. |
|  | This increase in oxygen to the atmosphere is often called the oxygen revolution. |

Information can be found in the section *Earth, Ocean, and Atmosphere Accumulated in Layers Sorted by Density*.

PTS: 1