Chapter 1—Understanding Earth: A Dynamic and Evolving Planet

ESSAY

1. What is the definition of the word theory as used in science? How is the word misused in day-to-day language?
   ANS:
   A theory in science is a coherent explanation for one or several related natural phenomena that is supported by a large body of objective evidence. Colloquially, theory is used to mean an idea; the better term for that would be hypothesis.
   PTS: 1 REF: LO2 Geology and the Formulation of Theories
2. What distinguishes science from other forms of human inquiry?
   ANS:
   Scientific ideas are based on data and observation. They are testable. Other forms of inquiry are based on faith, emotion, or something else that is nontestable.
   PTS: 1 REF: LO2 Geology and the Formulation of Theories
3. What is the scientific method?
   ANS:
   The scientific method is an orderly, logical approach to understanding our world that involves gathering and analyzing data about a natural phenomenon, formulating hypotheses to explain the phenomenon, testing the hypotheses, which, if one survives, is put forth as a theory.
   PTS: 1 REF: LO2 Geology and the Formulation of Theories
4. How is a theory formulated?
   ANS:
   Theories are formulated using the scientific method. Observations and data are gathered to test the problem. Tentative explanations, also called hypotheses, are then formulated to explain the observations and data. More tests are done and the data are analyzed. If the data show that the hypothesis is not correct, it is tossed out. If the data all support the hypothesis, there are no significant data refuting it, and it is accepted by scientists, it becomes a theory.
   PTS: 1 REF: LO2 Geology and the Formulation of Theories
5. How have natural resources been important in history? Provide an example of a situation in which natural resources have altered the course of history.
   ANS:
   States, nations, and empires have risen and fallen, and they have fought for control of, or sometimes lost, natural resources. There are many examples available.
   PTS: 1 REF: LO3 How Does Geology Relate to the Human Experience?
6. Describe the ways in which geology affects our everyday lives.
   ANS:
   Natural disasters profoundly affect the regions and nations that they strike. Many of the resources that we depend on for our lives in modern society are located and made useful by geologists. These resources include minerals and fuels. Many environmental problems are due to the affects of human activities on Earth systems.
   PTS: 1
   REF: LO4 How Does Geology Affect Our Everyday Lives?| LO5 Global Geologic and Environmental Issues Facing Humankind
7. What is the greenhouse effect, and how does it work? What happens when greenhouse gas levels in the atmosphere increase?
   ANS:

Carbon dioxide and other greenhouse gases are natural components of the atmosphere. These gases allow sunlight to pass through the atmosphere but trap some of the heat that radiates outward from Earth's surface. This is the greenhouse effect. If the mount of greenhouse gases in the atmosphere increases, they can trap more heat, and the atmosphere warms.
PTS: 1 REF: LO5 Global Geologic and Environmental Issues Facing Humankind

8. What are some of the consequences of global warming predicted to be?
ANS:
Warmer temperatures overall; melting glaciers, ice caps, and sea ice; increased drought in some locations, increased precipitation in other locations; difficulty growing food in some agricultural areas; and spread of tropical diseases into areas that have traditionally been too cold for them.
PTS: 1 REF: LO5 Global Geologic and Environmental Issues Facing Humankind

9. What are two examples of geology-related environmental concerns? Briefly explain why geology holds an important position in environmental science.
ANS:
Water quality and distribution, soil formation and erosion, monitoring pollution, finding suitable locations for power plants and other potentially dangerous buildings, climate change, and so on—there are many to choose from. Geology is concerned with all aspects of the physical Earth and their interactions with the biosphere.
PTS: 1 REF: LO5 Global Geologic and Environmental Issues Facing Humankind

10. Why is overpopulation a geologic issue?
ANS:
Additional people must be provided with food, water, clothing, and housing at a minimum. Obtaining these things puts a strain on the available resources, such as the soil needed to grow food. Since many of the desirable and safe areas of the planet are already developed, future development is more likely to be in locations that are at risk for natural disasters. More people also produce more wastes so pollutants must be dealt with.
PTS: 1 REF: LO5 Global Geologic and Environmental Issues Facing Humankind

11. Describe how the universe, galaxies, stars, and chemical elements formed.
ANS:
Scientists believe that the universe originated with the Big Bang approximately 14 billion years ago. At the moment of the Big Bang, there was only energy, no matter. In the first second following the Big Bang, the four basic forces separated, and the universe experienced enormous expansion. Galaxies and stars came together, and the chemical makeup of the universe changed. In the early universe, the only chemical elements were hydrogen and helium, but now 2% of the universe is all other elements by weight.
PTS: 1 REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them

12. Briefly explain the current theory of Earth's origin, including how and why it came to be differentiated by composition.
ANS:
In the solar nebula, gases and solid particles condensed in localized eddies and then accreted into planetesimals. These bodies collided and grew until they became planets. The planets nearer the Sun were small and composed of rock and metallic elements. One of these was Earth. Heat was generated by meteorite impacts, gravitational compression, and nuclear reactions. The heat caused the material to melt. Since it could now move, dense metals sank to the core and denser silicates to the mantle. Lighter silicates rose to form the crust.
PTS: 1 REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them

13. Name, locate, and describe Earth’s three concentric layers. What are these divisions based on and what volume does each layer take up?
ANS:

The three concentric layers are determined by density. At Earth's center is the most dense layer, the core, with a calculated density of 10-13 grams per cubic centimeter. At 16% of the total volume, the core is mostly iron with a small amount of nickel. There are two layers, a solid interior and a liquid outer layer. The mantle makes up most of the planet's volume, 83%. The mantle is much less dense than the core, 3.3-5.7 grams per centimeter cubed. It is composed mostly of dark, dense peridotite. The outermost layer is the least dense layer, the crust. There are two major types, continental crust, which is thick and has an average density of 2.7 grams per cubic centimeter and oceanic crust, which is thinner and density at 3.0 grams per cubic centimeter.

PTS: 1 REF: LO7 Why Earth is a Dynamic and Evolving Planet

14. How are the rock cycle and plate tectonics related?

ANS:

Interactions between plates determine, to some extent, which of the three rock groups will form. Plates may melt to form igneous rocks, be altered to form metamorphic, or sink to allow sediments to become sedimentary rocks.

PTS: 1 REF: LO8 The Rock Cycle

15. What is the basic tenet of the theory of organic evolution? What is the mechanism for organic evolution called, and how does it work?

ANS:

All living things are related and have descended with modification from organisms that lived in the past. The mechanism is called natural selection, which states that the organisms that are best adapted to their environment are the most likely to survive to reproduce, causing species to evolve with time.

PTS: 1 REF: LO9 Organic Evolution and the History of Life

16. Briefly explain how the themes of plate tectonics, organic evolution, and geologic time provide a cohesive story of the history of Earth.

ANS:

Earth has evolved internally and externally. As internal processes were established, they played a role in what was happening on the surface of Earth as the atmosphere, hydrosphere, and landmasses developed. Organic evolution was directly dependent on development of favorable conditions for different life forms. The net result of the physical, chemical, and biological evolution of Earth has been profound, particularly, in light of the amount of time necessary for those changes to take place (synthesis).

PTS: 1 REF: various

17. Briefly explain how geologists can formulate theories about events that occurred on Earth before humans were here to make observations.

ANS:

Geologists base their theories on two assumptions. First, that rocks record the processes that were involved in formation of those rocks. Second, that uniformitarianism is true, and the present is the key to the past. This means that basic physical, chemical, and biological processes have not changed, and that if we study and understand them today, we can apply what we learn to conditions in the past.

PTS: 1 REF: LO10 Geologic Time and Uniformitarianism

18. Briefly explain the importance of the geologic time scale.

ANS:

The geologic time scale is the result of work by many geologists worldwide who used fossils, the rock record, and radiometric dating techniques to determine a chronology for the evolution of Earth and its life through time.

PTS: 1 REF: LO10 Geologic Time and Uniformitarianism

19. Briefly explain the importance of the principle of uniformitarianism to the study of historical geology.

ANS:

Uniformitarianism provides the basis for interpreting the geologic history of Earth because geologists cannot travel back in time to study events. By using modern analogies, geologists can make reasonable interpretations about past events.

PTS: 1 REF: LO10 Geologic Time and Uniformitarianism

SHORT ANSWER

1. What is a system? What are four Earth systems?
   ANS:
   A system is a combination of related parts that interact in an organized fashion. Earth systems include the atmopshere, biosphere, hydrosphere and solid Earth.
   PTS: 1 REF: Introduction
2. Why is Earth considered to be a dynamic (as opposed to static) planet?
   ANS:
   Earth has been continuously changed through its 4.6 billion year existence.
   PTS: 1 REF: Introduction
3. What does geology have to do with the standard of living that societies have?
   ANS:
   Geologists locate and help extract the mineral and petroleum resources that societies use.
   PTS: 1 REF: LO4 How Does Geology Affect Our Everyday Lives?
4. What is one way in which geologic knowledge is used to help humans?
   ANS:
   There are several possible answers to this, including finding mineral or energy resources, helping solve environmental problems, or predicting natural hazards.
   PTS: 1 REF: various
5. What are the characteristics of the terrestrial planets?
   ANS:
   The terrestrial planets—Mercury, Venus, Earth, and Mars—are all small and are composed of rock and metallic elements that condensed at the high temperatures of the inner solar nebula.
   PTS: 1 REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
6. What are the characteristics of the Jovian planets?
   ANS:
   The Jovian planets—Jupiter, Saturn, Uranus, and Neptune—are all large, gaseous bodies with rings and heavy atmospheres.
   PTS: 1 REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
7. What is Pluto now that it is no longer a planet, and what are the characteristics of that type of body?
   ANS:
   Pluto is now a dwarf planet. These bodies are similar to planets, but they have not cleared their portion of space of debris. Pluto is found within the Kuiper Belt of comets and other icy debris.
   PTS: 1 REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
8. Describe how temperature increases will occur in all global warming scenarios.
   ANS:
   Average global temperature will rise everywhere but the greatest warming will be in the higher latitudes of the Northern Hemisphere. This is already being seen.
   PTS: 1 REF: LO6 Global Geologic and Environmental Issues Facing Humankind
9. What is Doppler effect?
   ANS:
   Doppler effect is a change in the frequency of a sound, light or other wave caused by the movement of the wave’s source relative to the observer.
   PTS: 1 REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
10. What are the three types of tectonic plate boundaries?
    ANS:
    Divergent, convergent, and transform.
    PTS: 1 REF: LO7 Why Earth is a Dynamic and Evolving Planet

11. What extremely important theory is as foundational and unifying to geology as the theory of evolution is to biology?
    ANS:
    plate tectonis theory
    PTS: 1 REF: LO7 Why Earth is a Dynamic and Evolving Planet
12. What is the difference between a rock and a mineral?
    ANS:
    A rock is an aggregate of minerals. Minerals are naturally occurring, inorganic, crystalline solids that have definite physical and chemical properties.
    PTS: 1 REF: LO8 The Rock Cycle
13. What are the three ways sedimentary rocks can form?
    ANS:
    (1) Consolidation of mineral or rock fragments, (2) precipitation of mineral matter from solutions, or (3) compaction of plant or animal remains.
    PTS: 1 REF: LO8 The Rock Cycle
14. How do igneous rocks form?
    ANS:
    Magma crystallizes or volcanic ejecta accumulates and consolidates.
    PTS: 1 REF: LO8 The Rock Cycle
15. How do metamorphic rocks form?
    ANS:
    The alteration of existing rocks s a result of heat, pressure, and chemical activity.
    PTS: 1 REF: LO8 The Rock Cycle
16. What is the central thesis of the theory of organic evolution?
    ANS:
    All present day organisms are related and have descended with modifications from organisms that lived in the past.
    PTS: 1 REF: LO9 Organic Evolution and the History of Life
17. What is natural selection?
    ANS:
    Natural selection is the mechanism that drives organic evolution. Organisms that are best adapted to their environment are more likely to survive to have offspring and pass their genes on to the next generation.
    PTS: 1 REF: LO9 Organic Evolution and the History of Life
18. What is the basic premise of the principle of uniformitarianism?
    ANS:
    Present-day processes have operated throughout geologic time.
    PTS: 1 REF: LO10 Geologic Time and Uniformitarianism
19. State the principle of uniformitarianism.
    ANS:
    The physical and chemical laws of nature have remained the same over time and cannot be violated.
    PTS: 1 REF: LO10 Geologic Time and Uniformitarianism
20. What is the name of the method that is used to determine the absolute age of a rock body?
    ANS:
    Radiometric dating.
    PTS: 1 REF: LO10 Geologic Time and Uniformitarianism
21. The three major groups of rocks are _____, _____, and _____.
    ANS:
    igneous, sedimentary, metamorphic
    PTS: 1 REF: LO8 The Rock Cycle

22. Earth's solid portion is divided into concentric layers of rock and other materials that may be solid, liquid, or partially molten. From the center to the surface, these are known as the inner _____, outer _____, _____, and _____.
ANS:
core, core, mantle, crust
PTS: 1 REF: LO7 Why Earth is a Dynamic and Evolving Planet
23. Planetesimals are _____.
ANS:
Accreting masses of gases, liquids, and solids that may eventually become true planets
PTS: 1 REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
24. The four basic forces are _____, _____, _____, and _____.
ANS:
gravity, electromagnetic, strong nuclear, weak nuclear
PTS: 1 REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
25. Historical geology is the study of _____.
ANS:
the origin and evolution of Earth and its continents, oceans, atmosphere, and life
PTS: 1 REF: LO1 What is Geology?
26. Physical geology is the study of _____.
ANS:
Earth materials, such as rocks and minerals, as well as the processes operating within Earth and on its surface
PTS: 1 REF: LO1 What is Geology?
27. Earth's six principal subsystems are _____, _____, _____, _____, _____, and _____.
ANS:
atmosphere, hydrosphere, biosphere, lithosphere, mantle, core
PTS: 1 REF: Introduction

COMPLETION

1. Earth formed _____ billion years ago.
ANS: 4.6
PTS: 1 REF: Introduction
2. Anthropology is the study of human beings. Therefore, the name of the system that refers to humans on Earth is the _____.
ANS: anthrosphere
PTS: 1 REF: Introduction
3. A combination of related parts that interact in an organized fashion is a(n) _____.
ANS: system
PTS: 1 REF: Introduction
4. Theories are formulated through the process known as _____.
ANS: scientific method
PTS: 1 REF: LO2 Geology and the Formulation of Theories
5. Earth’s human population reached _____ in 2011 and is prjected to be _____ in 2045.
ANS: 7 billion, 9 billion
PTS: 1 REF: LO5 Global Geologic and Environmental Issues Facing Humankind

6. Global warming is caused by increased concentrations of _____ in the atmosphere.
   ANS: greenhouse gases
   PTS: 1 REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
7. When the universe originated, it was composed of 100% _____ and _____, but now consists of _____% hydrogen and 2% _____ elements.
   ANS: hydrogen, helium, 98, other
   PTS: 1 REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
8. The scientific theory for the origin of our solar system, involving the condensation and collapse of interstellar material in a spiral arm of the Milky Way galaxy, is the _____ theory.
   ANS: solar nebula
   PTS: 1 REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
9. The material in Earth's inner core is _____, while the outer core is _____.
   ANS: solid, liquid
   PTS: 1 REF: LO7 Why Earth is a Dynamic and Evolving Planet
10. The crust and the underlying uppermost mantle make up the _____.
    ANS: lithosphere
    PTS: 1 REF: LO7 Why Earth is a Dynamic and Evolving Planet
11. The two types of crust are _____ and _____.
    ANS:
    oceanic, continental
    continental, oceanic
    PTS: 1 REF: LO7 Why Earth is a Dynamic and Evolving Planet
12. The two primary materials that geologists use as clues to understand Earth's past are _____ and _____.
    ANS:
    rocks, fossils
    fossils, rocks
    PTS: 1 REF: LO9 Organic Evolution and the History of Life
13. The three eras that have taken place since the end of the Precambrian from oldest to youngest are the _____, _____, and _____.
    ANS: Paleozoic, Mesozoic, Cenozoic
    PTS: 1 REF: LO10 Geologic Time and Uniformitarianism

MULTIPLE CHOICE

1. Which of the following statements about a scientific theory is *not* true?
   a. It is an explanation for some natural phenomena.
   b. It has a large body of supporting knowledge.
   c. It is testable.
   d. It is conjecture or guess.
   e. none of the above

   ANS: D PTS: 1 REF: LO1 What is Geology?
2. A hypothesis is
   a. thought to be the truth by most scientists.
   b. a tentative explanation.
   c. a description of something that happens without fail.
   d. a guess.

   ANS: B PTS: 1 REF: LO2 Geology and the Formulation of Theories

3. Science does not utilize beliefs or supernatural explanations because they
   a. have been proven to be true and so science isn't needed.
   b. none of these.
   c. have been proven to be untrue.
   d. cannot be tested.

   ANS: D PTS: 1 REF: LO2 Geology and the Formulation of Theories
4. Most scientists argue that the greatest environmental problem facing the world today is:
   a. climate change.
   b. the ozone hole.
   c. water pollution.
   d. overpopulation.
   e. overfishing.

   ANS: D PTS: 1
   REF: LO5 Global Geologic and Environmental Issues Facing Humankind
5. The Big Bang took place approximately ____ years ago.
   a. 140 billion
   b. 40 billion
   c. 14 billion
   d. 14 million
   e. 4,000

   ANS: C PTS: 1
   REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
6. The age of the universe is estimated by the:
   a. temperature of the universal background radiation.
   b. age of comets formed in interstellar space.
   c. rate at which galaxies are moving away from one another.
   d. age of subatomic particles as determined by radioactive decay.
   e. age of the sun.

   ANS: C PTS: 1
   REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
7. At the moment of the Big Bang, both ____ and ____ were compressed into an infinitely small high-temperature and high-density state.
   a. matter, energy
   b. gravity, energy
   c. nuclear power, matter
   d. energy, matter
   e. matter, weak nuclear forces

   ANS: A PTS: 1
   REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
8. At the moment of the Big Bang, both ____ and ____ were set at zero.
   a. matter, energy
   b. time, space
   c. nuclear power, weak nuclear forces
   d. gravity, chemistry
   e. matter, weak nuclear forces

   ANS: B PTS: 1
   REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
9. The Jovian planets are:
   a. Jupiter, Saturn, Uranus, and Neptune.

b. Mercury, Venus, Earth, and Mars.
c. Earth, Mars, and Jupiter.
d. Uranus, Neptune, and Pluto.
e. Mercury, Earth, Mars, and Pluto.

ANS: A PTS: 1
REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them

10. The zone between the core and the crust is the:
a. innersphere.
b. lithosphere.
c. mantle.
d. convection center.
e. molten zone.

ANS: C PTS: 1 REF: LO7 Why Earth is a Dynamic and Evolving Planet

11. Earth's core is probably:
a. composed of rock with high silica content.
b. hollow.
c. molten throughout.
d. composed of potassium and aluminum rich silicates.
e. composed mostly of iron and nickel.

ANS: E PTS: 1 REF: LO7 Why Earth is a Dynamic and Evolving Planet

12. Which of the following statements about the asthenosphere is *not* true?
a. It lies beneath the lithosphere.
b. It is a rigid rock layer.
c. It behaves plastically.
d. Partial melting within it generates magma.
e. It is surrounded by the upper mantle.

ANS: B PTS: 1 REF: LO7 Why Earth is a Dynamic and Evolving Planet

13. The theory that all living organisms are descendants of different life forms that existed in the past is called:
a. organic evolution.
b. astrology.
c. paleontology.
d. plate tectonics.
e. natural selection.

ANS: A PTS: 1 REF: LO9 Organic Evolution and the History of Life

14. Fossils are:
a. useful for reconstructing past environmental conditions.
b. evidence that evolution has occurred.
c. evidence that Earth has a long history predating humans.
d. the remains or traces of once-living organisms.
e. all of these

ANS: E PTS: 1 REF: LO9 Organic Evolution and the History of Life

15. In 19th century, geologists developed the geologic time scale using
a. fossils.
b. radiometric dating techniques.
c. absolute ages.
d. the principle of uniformitarianism.

ANS: D PTS: 1 REF: LO10 Geologic Time and Uniformitarianism

TRUE/FALSE

1. Historical geology is the study of how geology is related to human history.
   ANS: F PTS: 1 REF: LO1 What is Geology?
2. Historical geology is concerned only with the sequence of events in Earth history, and not with processes that caused the events.
   ANS: F PTS: 1 REF: LO1 What is Geology?
3. Scientists have proven that there is no supernatural or spiritual realm.
   ANS: F PTS: 1 REF: LO2 Geology and the Formulation of Theories
4. A theory - such as the theory of plate tectonics or the theory of evolution - is not accepted by a large number of scientists.
   ANS: F PTS: 1 REF: LO2 Geology and the Formulation of Theories
5. Many wars are fought over natural resources.
   ANS: T PTS: 1
   REF: LO3 How Does Geology Relate to the Human Experience?
6. Overpopulation will affect many Earth systems, but there is enough fresh water for many billions of people.
   ANS: F PTS: 1
   REF: LO5 Global Geologic and Environmental Issues Facing Humankind
7. The solar nebula theory of the formation of the solar system accounts for the differences in composition between the terrestrial and Jovian planets.
   ANS: T PTS: 1
   REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
8. Pluto is the planet with the most ellipitcal orbit.
   ANS: F PTS: 1
   REF: LO6 Origin of the Universe and Solar System, and Earth's Place in Them
9. The two types of crust are continental and lithospheric.
   ANS: F PTS: 1 REF: LO7 Why Earth is a Dynamic and Evolving Planet
10. According to the theory of organic evolution, all living organisms are related, and they descended with some modifications from organisms that lived in the past.
    ANS: T PTS: 1 REF: LO9 Organic Evolution and the History of Life
11. The central thesis of the theory of organic evolution is that there has always been the same diversity of species on Earth in the past as today.
    ANS: F PTS: 1 REF: LO9 Organic Evolution and the History of Life
12. Natural selection refers to survival of organisms that are best adapted to their environment.
    ANS: T PTS: 1 REF: LO9 Organic Evolution and the History of Life
13. In the 19th century, the geologic time scale was first developed using radiometric age dating techniques.
    ANS: F PTS: 1 REF: LO10 Geologic Time and Uniformitarianism
14. According to the principle of uniformitarianism, processes have occurred at the same rates throughout geologic time.
    ANS: F PTS: 1 REF: LO10 Geologic Time and Uniformitarianism
15. In order for geologists to use the principle of uniformitarianism to interpret the geologic record, they do not need to study modern geologic processes.
    ANS: F PTS: 1 REF: LO10 Geologic Time and Uniformitarianism