The Earth

CHAPTER 1

The poetry of the earth is never dead.

—John Keats

GEOLOGIC TIME SCALE

Two time scales are used to measure the age of Earth. One is a relative time scale based on the sequence of layering of the rocks and the evolution of life. The other is the radiometric time scale, based on the natural radioactivity of chemical elements in rocks. Earth's past has been organized into various units according to events that took place in each period. Different spans of time on the time scale are usually separated by major geologic or paleontological events, such as mass extinctions. For example, the boundary between the Cretaceous period and the Paleogene period is defined by the extinction of the dinosaurs and many marine species. The largest defined unit of time is the eon. Eons are dived into eras, which are in turn divided into periods, epochs, and stages (Eon → Eras → Periods → Epochs → Stages). Key principles of the geological time scale:

1. Rock layers (strata) are laid down in succession with each strata representing a "slice" of time.
2. The principle of superposition—any given stratum is probably older than those above it and younger than those below it.

Several factors complicate the geologic time scale:

1. Sequences of strata are often eroded, distorted, tilted, or even inverted after deposition.
2. Strata laid down at the same time in different areas can have entirely different appearances.
3. Strata of any given area represent only part of Earth's history.

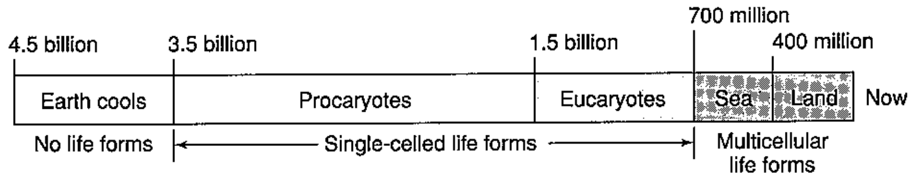


Figure 1.1 Timeline of life development

THE GEOLOGIC TIME SCALE

Era	When period began (millions of years ago)	Period	Animal life	Plant life	Major geologic events
Cenozoic		Neogene	Rise of civilizations	Increase in number of herbs and grasses	Ice Age
	2	Paleogene	Appearance of first men; dominance on land of mammals, birds, and insects	Dominance of land by flowering plants	
Mesozoic	65	Cretaceous	Age of dinosaurs	Dominance of land by conifers; first flowering plants appear	Building of the Rocky Mountains
	135	Jurassic			
	180	Triassic	First birds		
Paleozoic	225	Permian	Expansion of reptiles		Building of the Appalachian Mountains
	275	Carboniferous	Age of amphibians	Formation of great coal swamps	
	350	Devonian	Age of fishes		
	413	Silurian	Invasion of land by invertebrates	Invasion of land by primitive plants	
	430	Ordovician	Appearance of first vertebrates (fish)	Abundant marine algae	
	500	Cambrian	Abundant marine invertebrates	Appearance of primitive marine algae	
Precambrian	570	—	Primitive marine life		

Figure 1.2 Geologic time scale

TIP

When writing your FRQ essays, a picture is worth a thousand words! If you can sketch out a labeled diagram of what you are describing it will go a long way in improving your score.

EARTH STRUCTURE

Earth, which formed about 4.6 billion years ago, is the third planet away from the sun in the solar system and is the only planet known to support life. Earth can be divided into three sections: the biosphere, the hydrosphere, and the internal structure. The biosphere includes all forms of life (plants and animals) both on land and in the sea. The hydrosphere includes all forms of water (fresh and saltwater, snow, and ice). The internal structure of Earth is divided into the crust, mantle, and core.

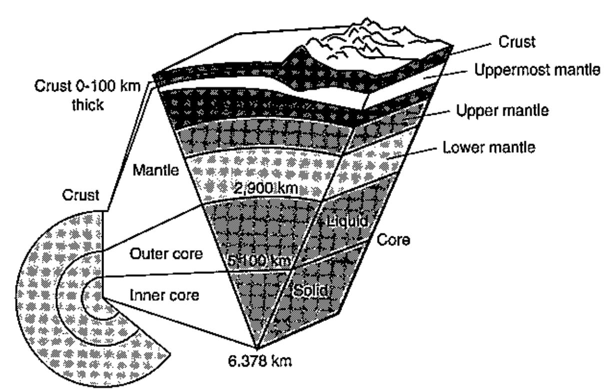


Figure 1.3 Layers of the Earth

Crust

The crust makes up only 0.5% of Earth's total mass and can be subdivided into two main parts: basalt-rich oceanic crust and granite-rich continental crust. The crust floats on top of the mantle. Oceanic crust covers about two-thirds of Earth's surface but comprises about only one-third of the crustal mass, as the continental crust is much thicker. Being relatively cold, the crust is rocky and brittle, so it can fracture in earthquakes.

CONTINENTAL CRUST

The continental crust extends from the surface of Earth down to 20–30 miles (30–50 km). The exposed parts of the continental crust are less dense than oceanic crust. This is because oceanic crust contains minerals rich in heavier elements such as iron and magnesium. However, continental crust appears to be stratified (layered) and becomes denser with depth. It is largely composed of volcanic, sedimentary, and granite-type rocks, although the older areas are dominated by metamorphic rocks.

OCEANIC CRUST

From the surface of Earth down to about 7 miles (11 km) is the oceanic crust. The oceanic crust can be divided into ocean basins where water depth exceeds 2 miles (3 km), and the crust is layered and very uniform.

MOHO

The Mohorovicic discontinuity, usually referred to as the Moho, is the boundary between the Earth's crust and the mantle. The Moho serves to separate both oceanic crust and continental crust from underlying mantle. It lies 3 miles (5 km) below the ocean floor and 19–31 miles (30 to 50 km) beneath the continents. It was first identified in 1909, when abrupt increases in the velocity of earthquake waves (specifically P-waves) occurred in this area. During the late 1950s, Project Mohole was proposed to drill a hole through the ocean floor to reach this boundary, but the project was cancelled in 1967.

MANTLE

Most of Earth's mass is in the mantle, which is composed of iron, magnesium, aluminum, and silicon-oxygen compounds. At over 1800°F (1000°C), most of the mantle is solid. However, the upper third (known as the asthenosphere) is more plastic-like in nature.

CORE

The core is composed mostly of iron and is so hot that the outer core is molten. The inner core is under such extreme pressure that it remains solid.

PLATE TECTONICS

Plate tectonic theory arose out of two separate geological observations: continental drift and seafloor spreading.

The Continental Drift Theory

In 1915, Alfred Wegener proposed that all present-day continents originally formed one landmass (Pangaea). Wegener believed that this supercontinent began to break up into smaller continents around 200 million years ago. He based his theory on five factors:

1. Fossilized tropical plants were discovered beneath Greenland's icecaps.
2. Glaciated landscapes occurred in the tropics of Africa and South America.
3. Tropical regions on some continents had polar climates in the past, based on paleoclimatic data.
4. The continents fit together like pieces of a puzzle.
5. Similarities existed in rocks between the east coasts of North and South America and the west coasts of Africa and Europe.

Continental drift gained acceptance in the 1960s when the theory of plate tectonics provided a mechanism that would account for the movement of the continents.

The Seafloor Spreading Theory

During the 1960s, alternating patterns of magnetic properties were discovered in rocks found on the seafloor. Similar patterns were discovered on either side of mid-oceanic ridges found near the center of the oceanic basins. Dating of the rocks indicated that as one moved away from the ridge, the rocks became older. This suggested that new crust was being created at volcanic rift zones.

The lithosphere (crust and upper mantle, approximately 62 miles (100 km) thick) is divided into massive sections known as plates. These float and move on the viscous asthenosphere. Subduction zones are areas on the Earth where two tectonic plates meet and move toward each other, with one sliding underneath the other and moving down into the mantle.

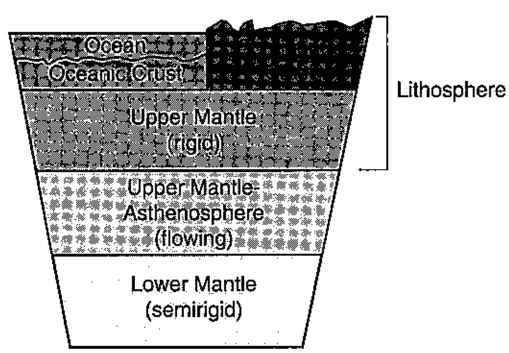


Figure 1.4 The outer layers of Earth

The plates move slowly over time. They sink in areas of volcanic island chains, folded mountain belts, and trenches. They rise up from ridges and rift valleys. These plates move in relation to one another at one of three types of plate boundaries: transform, divergent, and convergent.

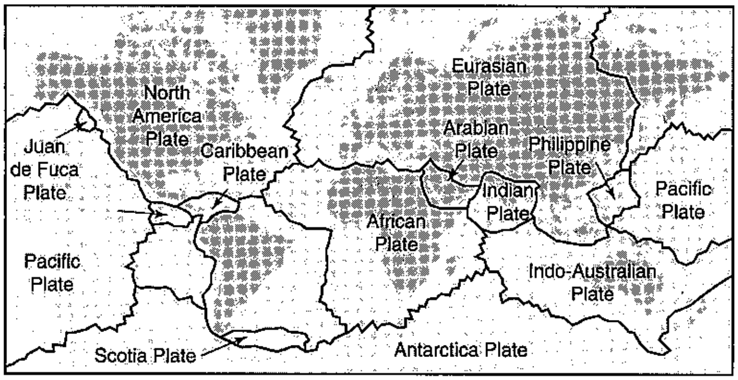
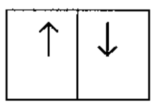


Figure 1.5 Earth's major plates

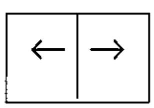
TRANSFORM BOUNDARIES

Transform boundaries occur where plates slide *past* each other. The friction and the stress buildup from the sliding plates frequently cause earthquakes—a common feature along transform boundaries. The San Andreas Fault, which is found near the western coast of North America, is where the Pacific and North American plates move relative to each other such that the Pacific plate is moving northwest with respect to North America. In about 50 million years, the part of California that is west of the San Andreas Fault will be a separate island near Alaska.



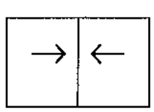
DIVERGENT BOUNDARIES

Divergent boundaries occur where two plates slide *apart* from each other with the space that was created being filled with molten magma from below. Examples of areas of oceanic divergent boundaries include the Mid-Atlantic Ridge and the East Pacific Rise. Examples of areas of continental divergent boundaries include the East African Great Rift Valley. Divergent boundaries can create massive fault zones in the oceanic ridge system and are areas of frequent oceanic earthquakes.



CONVERGENT BOUNDARIES

Convergent boundaries occur where two plates slide *toward* each other, commonly forming either a subduction zone (if one plate moves underneath the other) or an orogonic belt (if the two plates collide and compress). When a denser oceanic plate moves underneath (subducts) a less-dense continental plate, an oceanic trench is produced on the ocean side and a mountain range on the continental side. One example is the Cascade Mountain range. It extends north from California's Sierra Nevada Mountains and includes Mount Saint Helens.



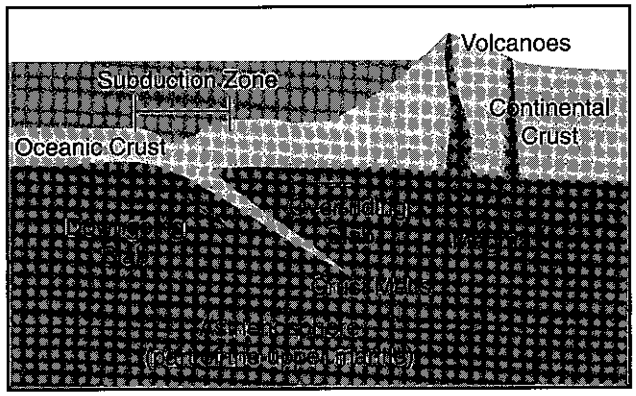


Figure 1.6 Subduction

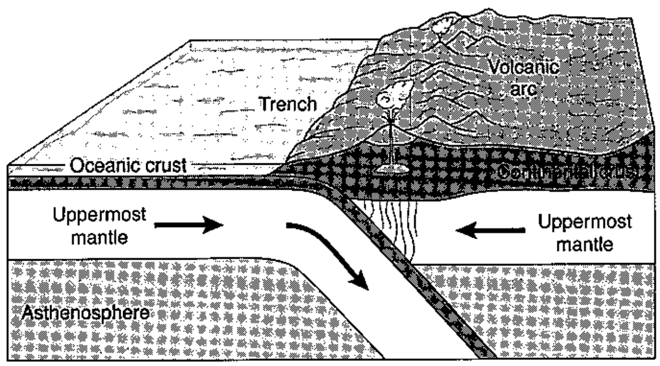


Figure 1.7 Oceanic-continental convergence

When *two oceanic plates converge*, they create an island arc—a curved chain of volcanic islands rising from the deep seafloor and near a continent. They are created by subduction processes and occur on the continent side of the subduction zone. Their curve is generally convex toward the open ocean. A deep undersea trench is located in front of such arcs where the descending plate dips downward. Examples include Japan and the Aleutian Islands in Alaska.

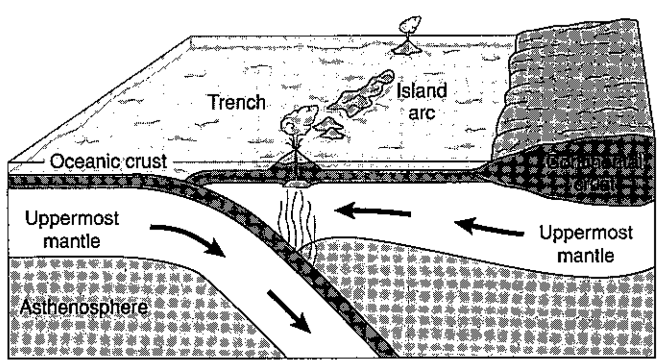


Figure 1.8 Oceanic-oceanic convergence

When *two continental plates collide*, mountain ranges are created as the colliding crust is compressed and pushed upward. An example is the northern margins of the Indian subcontinental plate being thrust under a portion of the Eurasian plate, lifting it and creating the Himalayas.

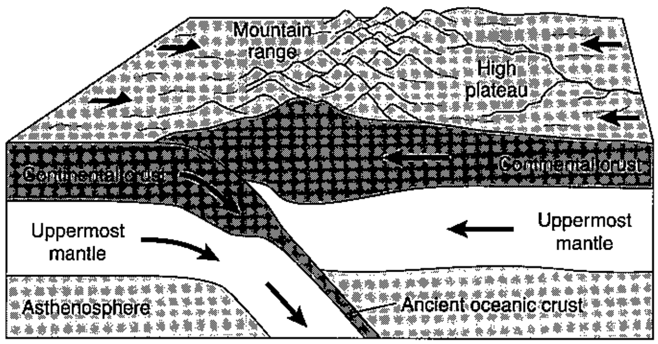


Figure 1.9 Continental-continental convergence

EARTHQUAKES

Earthquakes occur during abrupt movement on an existing fault, along tectonic plate boundary zones or along mid-oceanic ridges. A massive amount of stored energy, held in place by friction, is released in a very short period of time. The area where the energy is released is called the focus. From the focus, seismic waves travel outward in all directions. Directly above the focus, on Earth's surface, is the epicenter.

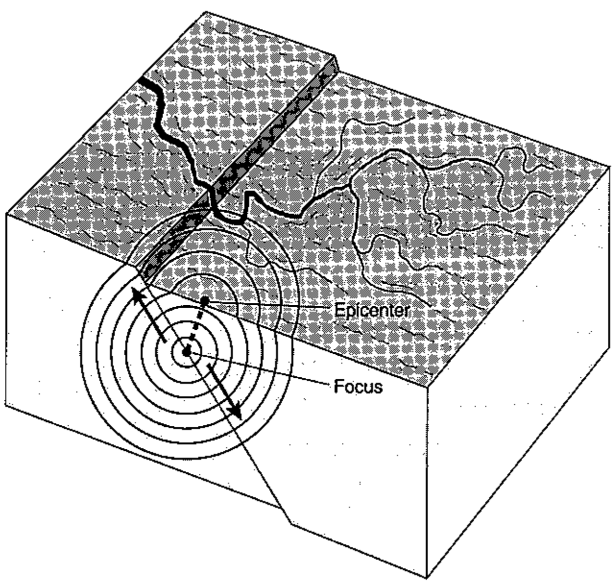


Figure 1.10 Relationship of an epicenter to a focus

The strength or magnitude of an earthquake is commonly measured by the logarithmic Richter scale and is recorded by a seismograph onto a seismogram.

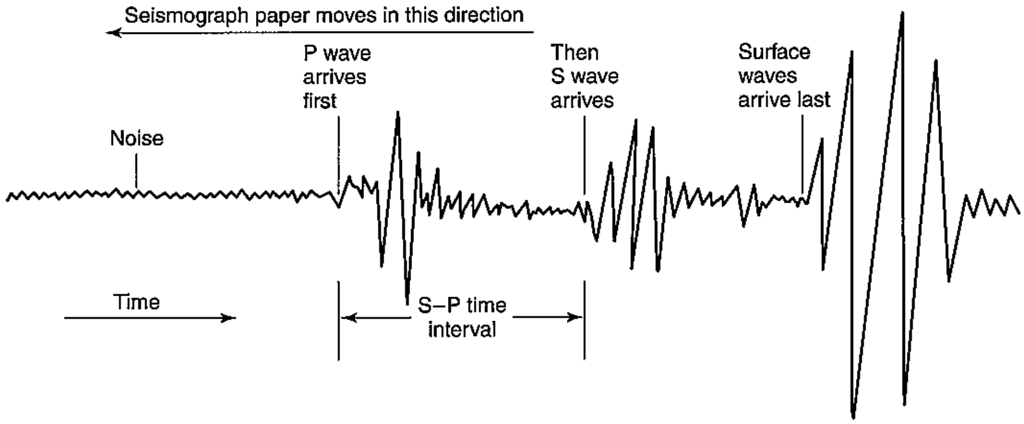


Figure 1.11 Seismogram

However, the Richter magnitude scale is really comparing amplitudes of waves on a seismogram, not the strength (energy) of the quakes. Because of the logarithmic basis of the scale, each whole number increase in magnitude on the Richter scale represents a tenfold increase in measured amplitude. In terms of energy, each whole number increase corresponds to an increase of about 32 times the amount of energy released. It is the energy or strength of the earthquake that knocks down buildings and causes damage.

The Richter Scale

Severity	Richter scale	Description	Occurrence (per year)
Minor	3.0–3.9	Rarely causes damage.	~ 50,000
Light	4.0–4.9	Shaking of indoor items. No significant damage.	~ 6,000
Moderate	5.0–5.9	Major damage to poorly constructed buildings.	~ 800
Strong	6.0–6.9	Destructive up to 100 miles.	~ 120
Major	7.0–7.9	Serious damage over large areas.	~ 18
Great	8.0–8.9	Serious damage over several thousand miles.	~ 1
Extreme	9.0+	Devastating for thousands of miles.	1 in 20 years

There are two classes of seismic waves: body waves and surface waves. Body waves travel through the interior of Earth. There are two types of body waves: P waves and S waves. P waves travel through Earth and are caused by expansion and contraction of bedrock. S waves are produced when material moves either vertically or horizontally and travel only within the uppermost layers of Earth (along its surface). Surface waves produce rolling and/or swaying motion and are slower than P or S waves. Surface waves cause ground motion and damage.

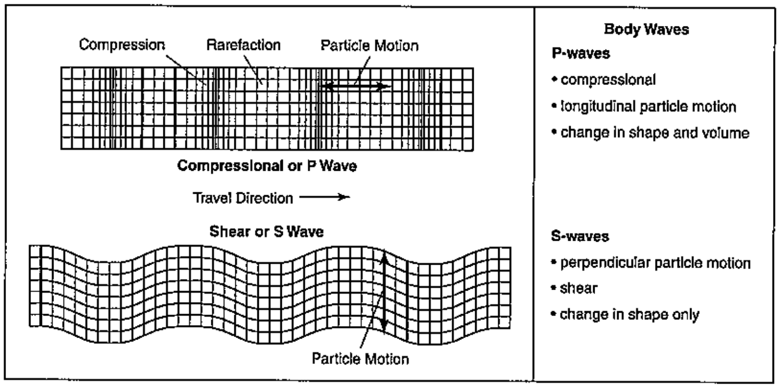


Figure 1.12 P waves and S waves

The severity of an earthquake depends upon:

1. The amount of potential energy that had been stored
2. The distance the rock mass moved when the energy was released
3. How far below the surface the movement occurred
4. The makeup of the rock material

Primary effects are due to the shaking and resulting damage to buildings and infrastructure and due to the loss of life or injury. Secondary effects include rock slides, flooding due to subsidence (sinking) of land, liquefaction of recent sediments, fires, and tsunamis. Damage due to earthquakes can be reduced through mapping of faults, preparing computer models and simulations, strengthening building codes, preparing emergency teams with adequate training, upgrading communication technology and availability, storing emergency supplies, and educating the public.

CASE STUDIES

- **Haiti, 2010:** The January 2010 earthquake in Haiti was a catastrophic, magnitude 7.0 quake that occurred at a depth of 8 miles (13 km) below the surface. The International Red Cross estimates that about 3 million people were affected by the quake, with close to 200,000 people killed directly and more than 250,000 severely injured. The capital of Port-au-Prince and surrounding cities were entirely destroyed primarily due to inadequate building codes, making rescue attempts extremely difficult. The quake occurred in the vicinity of the northern boundary of the Caribbean tectonic plate, where it shifts eastward by about 0.79 inches (20 mm) per year in relation to the North American plate.
- **San Andreas Fault:** The San Andreas Fault, first discovered in 1895, is a continental transform fault that extends 800 miles (1,300 km) through California to Baja California in Mexico, forming the tectonic boundary between the Pacific plate and the North American plate. All land west of the fault on the Pacific plate is moving slowly to the northwest, while all land east of the fault is moving southwest. The rate of slippage averages about 1.5 inches (38 mm) per year. In 1906 a portion of the fault ruptured near San Francisco; the earthquake (estimated at 7.8) caused 3,000 deaths, many due to the resulting fires.

TSUNAMIS

Tsunamis are a series of waves created when a body of water is rapidly displaced usually by an earthquake. The effects of a tsunami can be devastating due to the immense volumes of water and energy involved. A tsunami can be generated when plate boundaries abruptly move and vertically displace the overlying water. Subduction-zone-related earthquakes generate the majority of all tsunamis. Tsunamis formed at divergent plate boundaries are rare since they do not generally disturb the vertical displacement of the water column. Tsunamis have a small wave height offshore, very long wavelength, and generally pass unnoticed at sea. Most tsunamis are generated in the Pacific and Indian Ocean basins. In 2004, the Indian Ocean 9.3 earthquake created tsunamis that killed ~300,000 people—one of the deadliest natural disasters in recorded history.

VOLCANOES

Active volcanoes produce magma (melted rock) at the surface. Other types of volcanoes are classified as intermittent, dormant, or extinct. The majority of volcanoes—95%—occur at subduction zones and mid-oceanic ridges. The remaining 5% occur at hot spots, areas where plumes of magma come close to the surface. Volcanoes may produce ejecta (lava rock and/or ash), molten lava, and/or toxic gases. The most common gases released by volcanoes are steam, carbon dioxide, sulfur dioxide, and hydrogen chloride. Volcanoes affect the climate by introducing large quantities of sulfur dioxide (SO_2) into the atmosphere that is later converted to sulfate ions (SO_4^{2-}) in the stratosphere. The sulfate particles reflect shorter wavelengths of solar radiation and serve as condensation nuclei for high clouds. In 1992, the year after the Mt. Pinatubo eruption, the effect of stratospheric sulfate particles decreased the average global temperature by as much as 1°F (0.5°C) by decreasing the amount of sunlight reaching Earth. The particles settle out of the atmosphere usually within two years and contribute to acid rain.

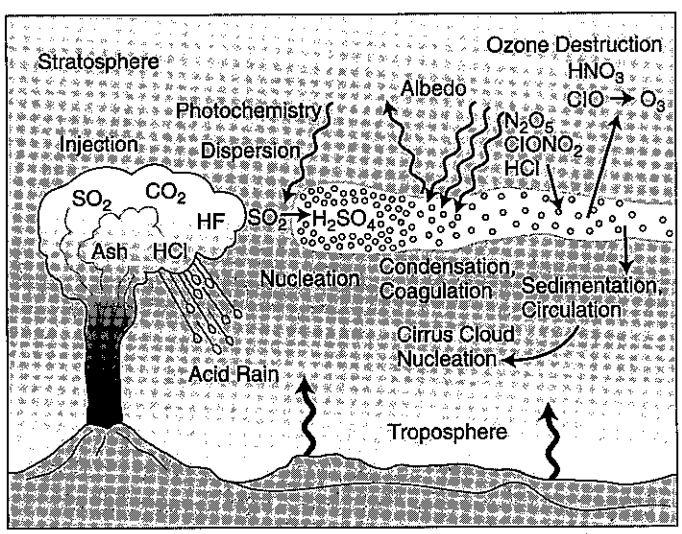


Figure 1.13 Atmospheric effects of volcanoes

Eruptions occur when pressure within a magma chamber forces molten magma up through a conduit (pipe) and out a vent at the top of the volcano. The type of eruption depends on the gases, the amount of silica in the magma (which determines viscosity), and how free the conduit is (whether the volcano flows or explodes). Correlation exists between seismic and volcanic activity. Benefits of volcanic eruptions include producing new landforms as seen in the Hawaiian Islands and increased soil nutrient levels produced from erosion of lava rock. Methods of dealing with volcanoes include:

1. Modeling and data analysis for better volcanic activity prediction
2. Better evacuation plans
3. Study of precursors such as changes in the cone
4. Measuring changes in temperature and gas composition
5. Magnetic changes
6. Changes in seismic activity.

Volcano Structure

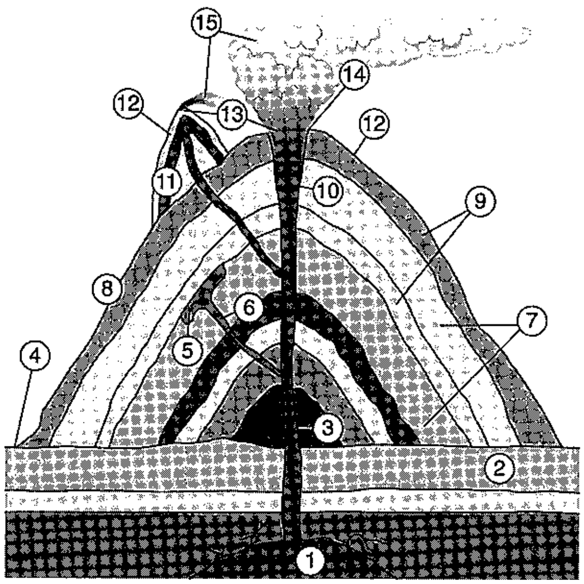


Figure 1.14 General volcano structure

CASE STUDIES

- **Mount Saint Helens:** Located in Washington State, Mount Saint Helens erupted in 1980. The earthquake removed trees, increased soil erosion, destroyed wildlife, and polluted the air with gases and ash. Other effects included mudflows, melting of glacial ice and snow, and clogged rivers that caused flooding. Fifty-seven people were killed.
- **Mount Pinatubo:** Mount Pinatubo is part of a chain of composite volcanoes on the west coast of the island of Luzon in the Philippines. In June 1991, Mount Pinatubo erupted for 9 hours, disgorged a cubic mile of volcanic debris, and vented 18 million metric tons of sulfur dioxide into the atmosphere which encircled Earth in three weeks after reaching the stratosphere. This was the largest sulfur dioxide cloud ever detected to date. The sulfate aerosols formed in the stratosphere increased reflection of solar radiation and within 3 years caused over a 2°F (1°C) overall cooling of Earth.

SEASONS, SOLAR INTENSITY, AND LATITUDE

Factors that affect the amount of solar energy at the surface of Earth (which is directly correlated with plant productivity) include Earth's rotation (once every 24 hours), Earth's revolution around the sun (once per year), tilt of Earth's axis (23.5°), and atmospheric conditions. Summer (the period of greatest solar radiation) occurs in the Northern Hemisphere when the Northern Hemisphere is tilted toward the sun. The sun rises higher in the sky and stays above the horizon longer, with the rays of the sun striking the ground more directly (at less of an angle). Likewise, in the Northern Hemisphere winter, the hemisphere is tilted away from the sun. The Sun rises lower in the sky and stays above the horizon for a shorter period, with the rays of the sun striking the ground more obliquely (at a greater angle).

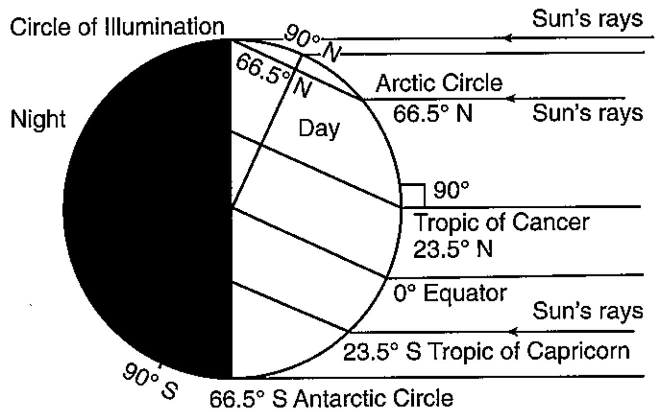


Figure 1.15 Summer solstice

Earth is actually closer to the sun in the Northern Hemisphere during the winter than in the summer. Earth is at its closest approach to the sun (perihelion) in January of each year (the middle of the Northern Hemisphere winter) and the farthest away in July (aphelion) during the middle of the Northern Hemisphere summer. Seasons are NOT caused by Earth's distance from the sun.

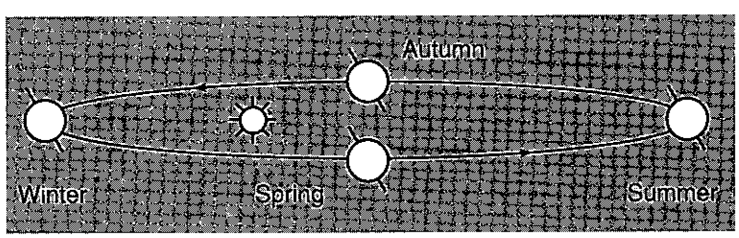


Figure 1.16 Seasons in the Northern Hemisphere

SOIL

Soils are a thin layer on top of most of Earth's land surface. This thin layer is a basic natural resource and deeply affects every other part of the ecosystem. For example, soils hold nutrients and water for plants and animals; water is filtered and cleansed as it flows through soils; and soils affect the chemistry of water and the amount of water that returns to the atmosphere to form rain. Soils are composed of three main ingredients: minerals of different sizes, organic materials from the remains of dead plants and animals, and open space that can be filled with water or air. A good soil for growing most plants should have about 45% minerals (with a mixture of sand, silt, and clay), 5% organic matter, 25% air, and 25% water.

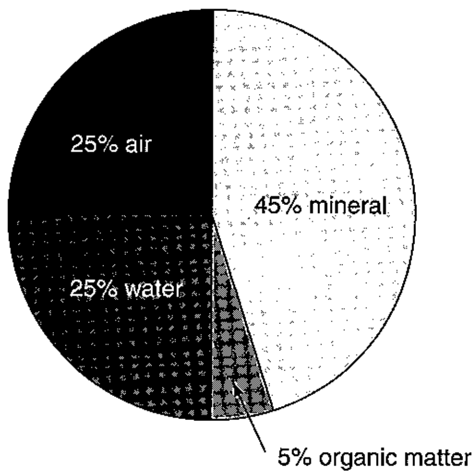


Figure 1.17 Soil components

Soils develop in response to several factors:

1. **Parent material.** This refers to the rock and minerals from which the soil derives. The nature of the parent rock, which can be either native to the area or transported to the area by wind, water, or glacier, has a direct effect on the ultimate soil profile.
2. **Climate.** This is measured by precipitation and temperature. It results in partial weathering of the parent material, which forms the substrate for soil.
3. **Living organisms.** These include the nitrogen-fixing bacteria *Rhizobium*, fungi, insects, worms, snails, etc. that help to decompose litter and recycle nutrients.
4. **Topography.** This refers to the physical characteristics of the location where the soil is formed. Topographic factors that affect a soil's profile include drainage, slope direction, elevation, and wind exposure.

With sufficient time, a mature soil profile reaches a state of equilibrium. Feedback mechanisms involving both abiotic and biotic factors work to preserve the mature soil profile. The relative abundance of sand, silt, and clay is called the soil texture.

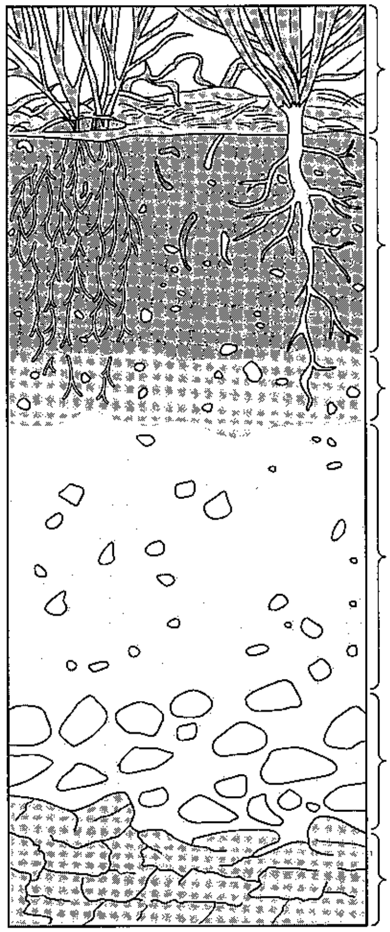


Figure 1.18 Soil profile

Soil Components

Component	Description
Clay	Very fine particles. Compacts easily. Forms large, dense clumps when wet. Low permeability to water; therefore, upper layers become waterlogged.
Gravel	Coarse particles. Consists of rock fragments.
Loam	About equal mixtures of clay, sand, silt, and humus. Rich in nutrients. Holds water but does not become waterlogged.
Sand	Sedimentary material coarser than silt. Water flows through too quickly for most crops. Good for crops and plants requiring low amounts of water.
Silt	Sedimentary material consisting of very fine particles between the size of sand and clay. Easily transported by water.

Organic vs. Inorganic Fertilizers

Organic Fertilizer	Inorganic Fertilizer
Three common forms: animal manure, green manure, and compost. Improves soil texture, adds organic nitrogen, and stimulates beneficial bacteria and fungi. Improves water-holding capacity of soil. Helps to prevent erosion.	Does not add humus to the soil, resulting in less ability to hold water and support living organisms (earthworms, beneficial bacteria, and fungi, etc.). Lowers oxygen content of the soil thereby keeping fertilizer from being taken up efficiently. Supplies only a limited number of nutrients (usually nitrogen and phosphorus). Requires large amounts of energy to produce, transport, and apply. Releases nitrous oxide (N_2O)—a greenhouse gas.

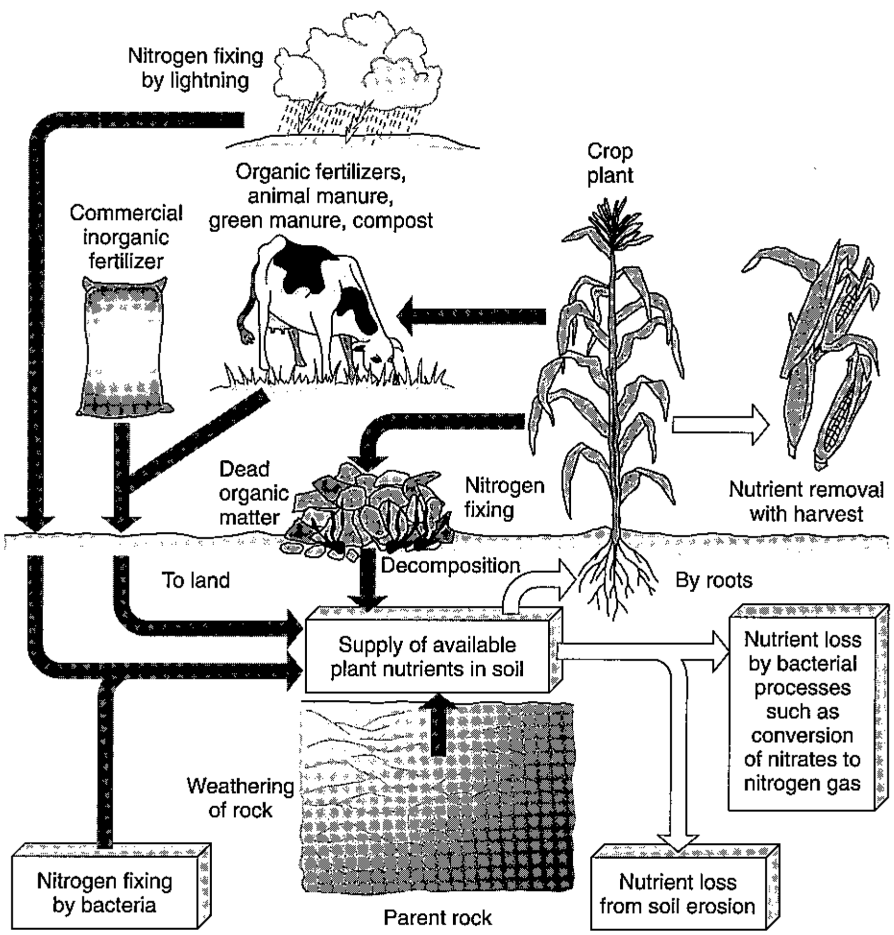


Figure 1.19 Plant nutrient pathways

SOIL FOOD WEB

The soil food web is the community of organisms living all or part of their lives in the soil. It describes a complex living system in the soil and how it interacts with the environments, plants, and animals.

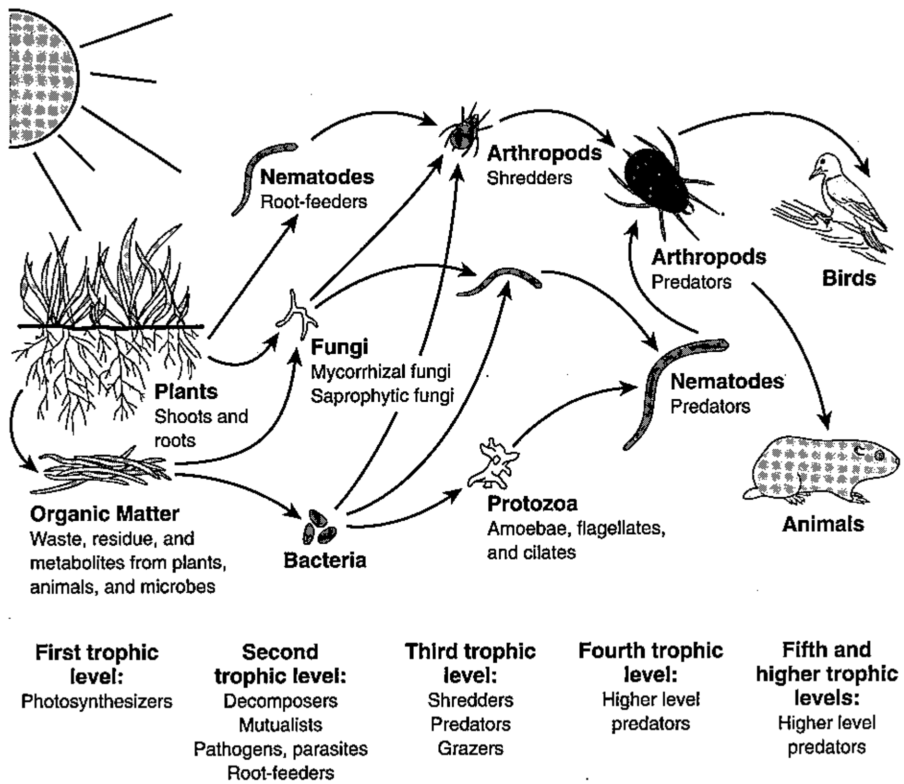


Figure 1.20 Soil food web

EROSION

Soil erosion is the movement of weathered rock or soil components from one place to another. It is caused by flowing water, wind, and human activity such as cultivating inappropriate land, burning of native vegetation, deforestation, and construction. Soil erosion destroys the soil profile, decreases the water-holding capacity of the soil, and increases soil compaction. Because water cannot percolate through the soil, it runs off the land, taking more soil with it (positive feedback loop). Because the soil cannot hold water, crops grown in areas of soil erosion frequently suffer from water shortage. In areas of low precipitation, erosion leads to significant droughts. Poor agricultural techniques that lead to soil erosion include monoculture, row cropping, overgrazing, improper plowing of the soil, and removing crop wastes instead of plowing the organic material back into the soil. There are three common types of soil erosion:

1. **Sheet erosion**—soil moves off as a horizontal layer
2. **Rill erosion**—fast-flowing water cuts small channels in the soil
3. **Gully erosion**—extreme case of rill erosion, where over time, channels increase in size and depth.

Soil erosion causes damage to agriculture, waterways (canals), and infrastructures (dams). It interferes with wetland ecosystems, reproductive cycles (as in salmon), oxygen capacity, and the pH of the water.

Soil Erosion

Desertification	Salinization	Waterlogging
Definition: Productive potential of arid or semiarid land falls by at least 10% due to human activity and/or climate change.	**Definition:** Water that is not absorbed into the soil and evaporates leaves behind dissolved salts in topsoil.	**Definition:** Saturation of soil with water resulting in a rise in the water table.
Symptoms: Loss of native vegetation; increased wind erosion; salinization; drop in water table; reduced surface water supply.	**Symptoms:** Stunted crop growth; lower yield; eventual destruction of plant life.	**Symptoms:** Saline water envelops deep roots killing plants; lowers productivity; eventual destruction of plant life.
Remediation: Reduce overgrazing; reduce deforestation; reduce destructive forms of planting, irrigation, and mining. Plant trees and grasses to hold soil.	**Remediation:** Take land out of production for 2–5 years; install underground perforated drainage pipes; flush soil with freshwater into separate lined evaporation ponds; plant halophytes (salt-loving plants) such as barley, cotton, sugar beet and/or semi-dwarf wheat.	**Remediation:** Switch to less water-demanding plants in areas susceptible to waterlogging; utilize conservation-tillage farming; plant waterlogging-resistant trees with deep roots; take land out of production for a while; and/or install pumping stations with drainage pipes that lead to catchment-evaporation basins.

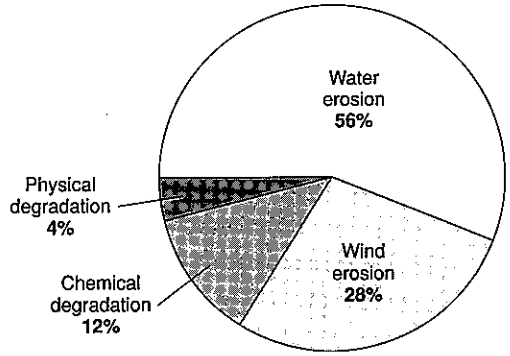


Figure 1.21 Soil degredation by type

CASE STUDY

Dust Bowl: The Dust Bowl occurred during the 1930s in Oklahoma, Texas, and Kansas. It was caused by plowing the prairies and resulted in the loss of natural grasses that rooted the soil. Drought and winds that occurred blew most of the topsoil away, causing people to leave the area.

LANDSLIDES AND MUDSLIDES

Landslides occur when masses of rock, earth, or debris move down a slope. Mudslides, also known as debris flows or mudflows, are a common type of fast-moving landslide that tends to flow in channels. Landslides are caused by disturbances in the natural stability of a slope. They can happen after heavy rains, droughts, earthquakes, or volcanic eruptions. Mudslides develop when water rapidly collects in the ground and results in a surge of water-soaked rock, earth, and debris. Mudslides usually begin on steep slopes and can be triggered by natural disasters. Areas where wildfires or construction have destroyed vegetation on slopes are at high risk for landslides during and after heavy rains. Some areas are more likely to experience landslides or mudslides, including:

- Areas where wildfires or construction have destroyed vegetation
- Areas where landslides have occurred before
- Steep slopes and areas at the bottom of slopes or canyons
- Slopes that have been altered for construction of buildings and roads
- Channels along a stream or river
- Areas where surface runoff is directed

RELEVANT LAW

1935 Soil Erosion Act: Established the Soil Conservation Service. Mandates the protection of the nation's soil reserves. Deals with soil erosion problems, carries out soil surveys, and does research on soil salinity. Provides computer databases for scientific research.

1977 Soil and Water Conservation Act: Provides for a continuing appraisal of U.S. soil, water, and related resources, including fish and wildlife habitats, and a soil and water conservation program to assist landowners and land users in furthering soil and water conservation.

THE ROCK CYCLE

There are three main categories of rocks: metamorphic, igneous, and sedimentary.

1. **Igneous**—formed by cooling and classified by their silica content. Intrusive igneous rocks solidify deep underground, cool slowly and have a large-grained texture (e.g., granite). Extrusive igneous rocks solidify on or near the surface, cool quickly, and have a fine-grained smooth texture (e.g., basalt). Igneous rocks are broken down by weathering and water transport. Most soils come from igneous rocks.

2. **Metamorphic**—formed by intense heat and pressure. Those with high quartz content form sandy soil (e.g., gneiss). Slate forms silty soil. Marble forms limestone clay. Common examples: diamond, marble, asbestos, slate, anthracite coal.

3. **Sedimentary**—formed by piling and cementing of various materials (diatoms, weathered chemical precipitates, fragments of older rocks) over time in low-lying areas. Fossils form only in sedimentary rock.

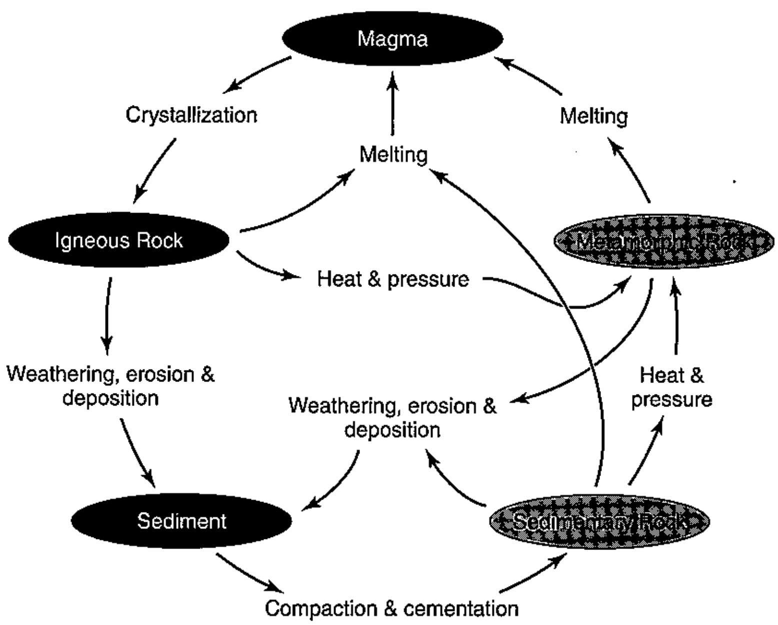


Figure 1.22 The rock cycle

QUICK REVIEW CHECKLIST

- ☐ **Geologic Time Scale**
  - ☐ eon, era, periods, epochs, stages
  - ☐ timeline of development
- ☐ **Earth Structure**
  - ☐ layers of the Earth (crust-oceanic-continental, mantle, and core)
  - ☐ Continental Drift Theory
  - ☐ seafloor spreading
  - ☐ plate tectonics
  - ☐ boundaries (differences between transform, divergent, and convergent)
- ☐ **Earthquakes**
  - ☐ epicenter, focus
  - ☐ Richter scale vs. magnitude
  - ☐ P wave vs. S wave
  - ☐ primary vs. secondary effects
  - ☐ mitigation
  - ☐ tsunamis
- ☐ **Volcanoes**
  - ☐ cinder cones—what they are and examples
  - ☐ composite (strato)—what they are and examples
  - ☐ spatter cones—what they are and examples
  - ☐ shield—what they are and examples
  - ☐ mitigation
- ☐ **Seasons**
  - ☐ angle of sun and how it affects season
- ☐ **Soil**
  - ☐ components
  - ☐ factors that affect soil development
  - ☐ horizons (O, A, E, B, C)
  - ☐ types (clay, gravel, loam, sand, silt)
  - ☐ organic vs. inorganic fertilizers
  - ☐ disadvantages of inorganic fertilizers
  - ☐ soil cycle
- ☐ **Erosion**
  - ☐ types (sheet, rill, and gully)
- ☐ **Rock Cycle**
  - ☐ metamorphic—how it is formed and examples
  - ☐ igneous—how it is formed and examples
  - ☐ sedimentary—how it is formed and examples