Chapter 8
Earth Systems and Resources

Earth's resources were determined when the planet formed.

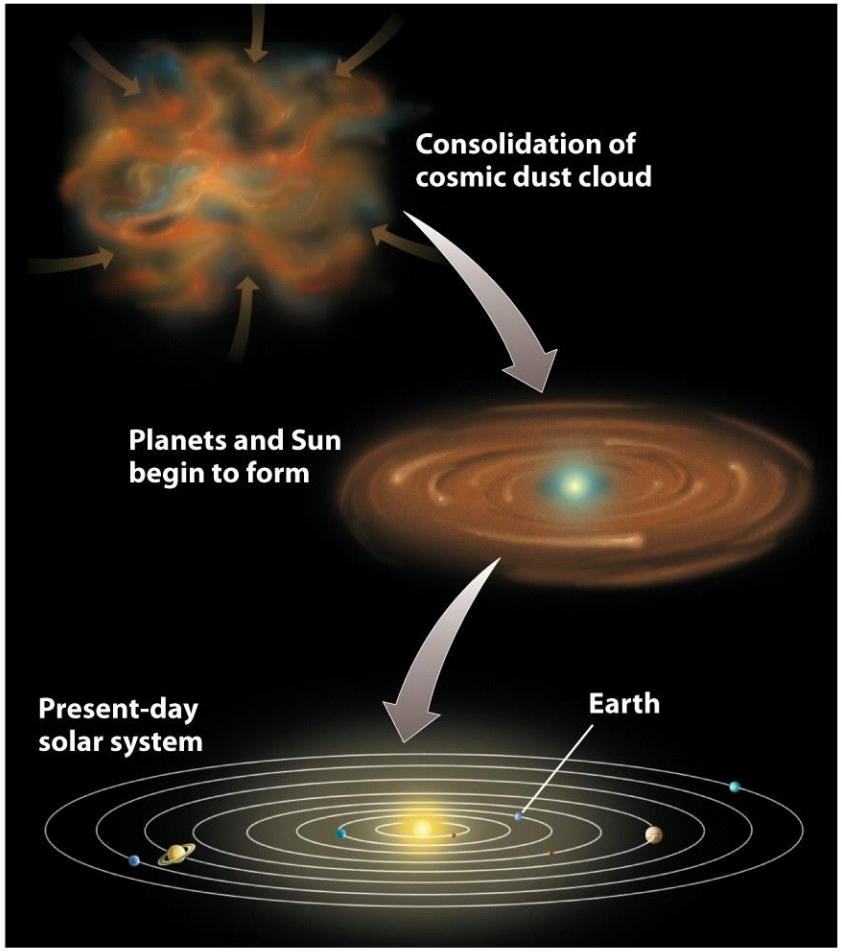
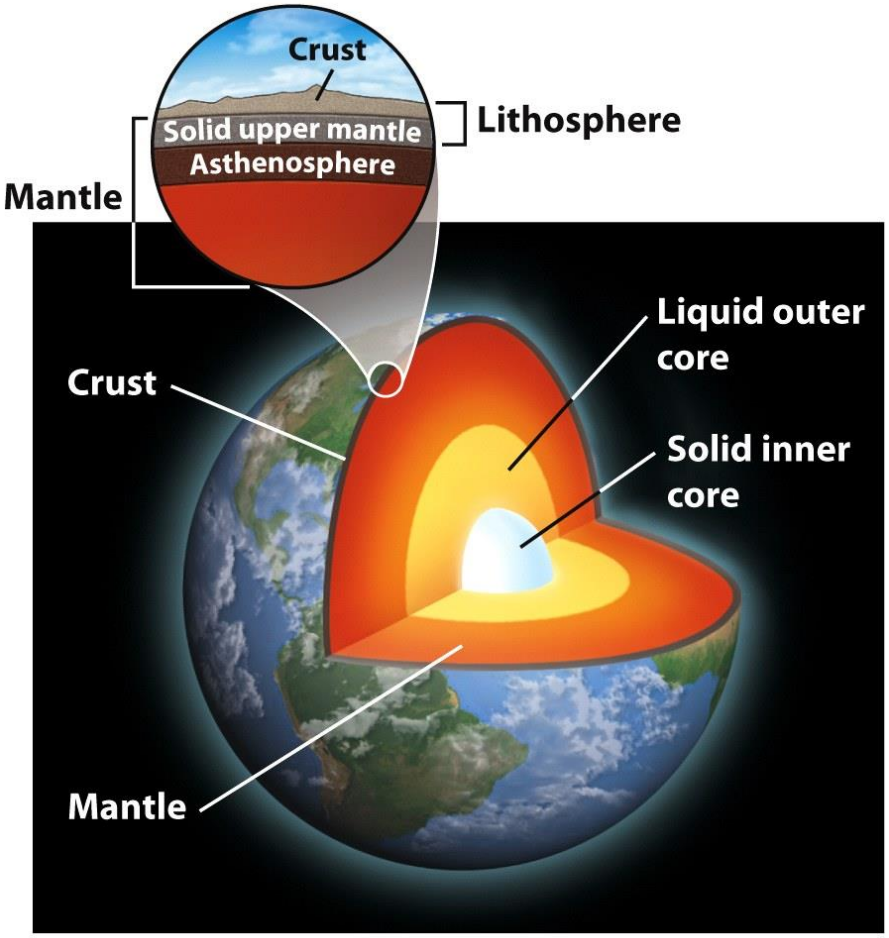


Figure 8.1
Environmental Science

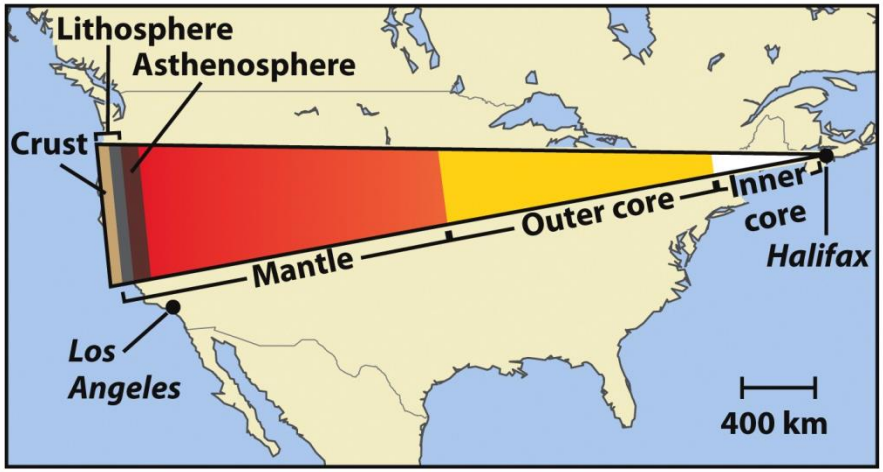
The Earth's Crust Layers

- ***Core:*** innermost zone of the planet, largely nickel and iron.
- ***Mantle:*** above the core, contains magma (molten rock).
- ***Crust:*** the outermost layer of the planet.



Earth's vertical zonation

Figure 8.2a
Environmental Science



Scale of Earth's layers

Figure 8.2b
Environmental Science

The Earth's Layers

- ***Asthenosphere:*** the outer part of the mantle, composed of semi-molten rock.
- ***Lithosphere:*** the brittle outermost layer of the planet, approximately 100 km thick.

Earth is dynamic and constantly changing

- The Earth's geologic cycle consists of three cycles: the *tectonic cycle*, the *rock cycle*, and *soil formation*.

Convection and Hot Spots

- The Earth is very hot at the center.
- This heat causes plumes of hot magma to well rise upward from the mantle.
- ***Hotspots:*** intra-place locations where molten material from the mantle reach the *lithosphere*.

Convection and Hot Spots

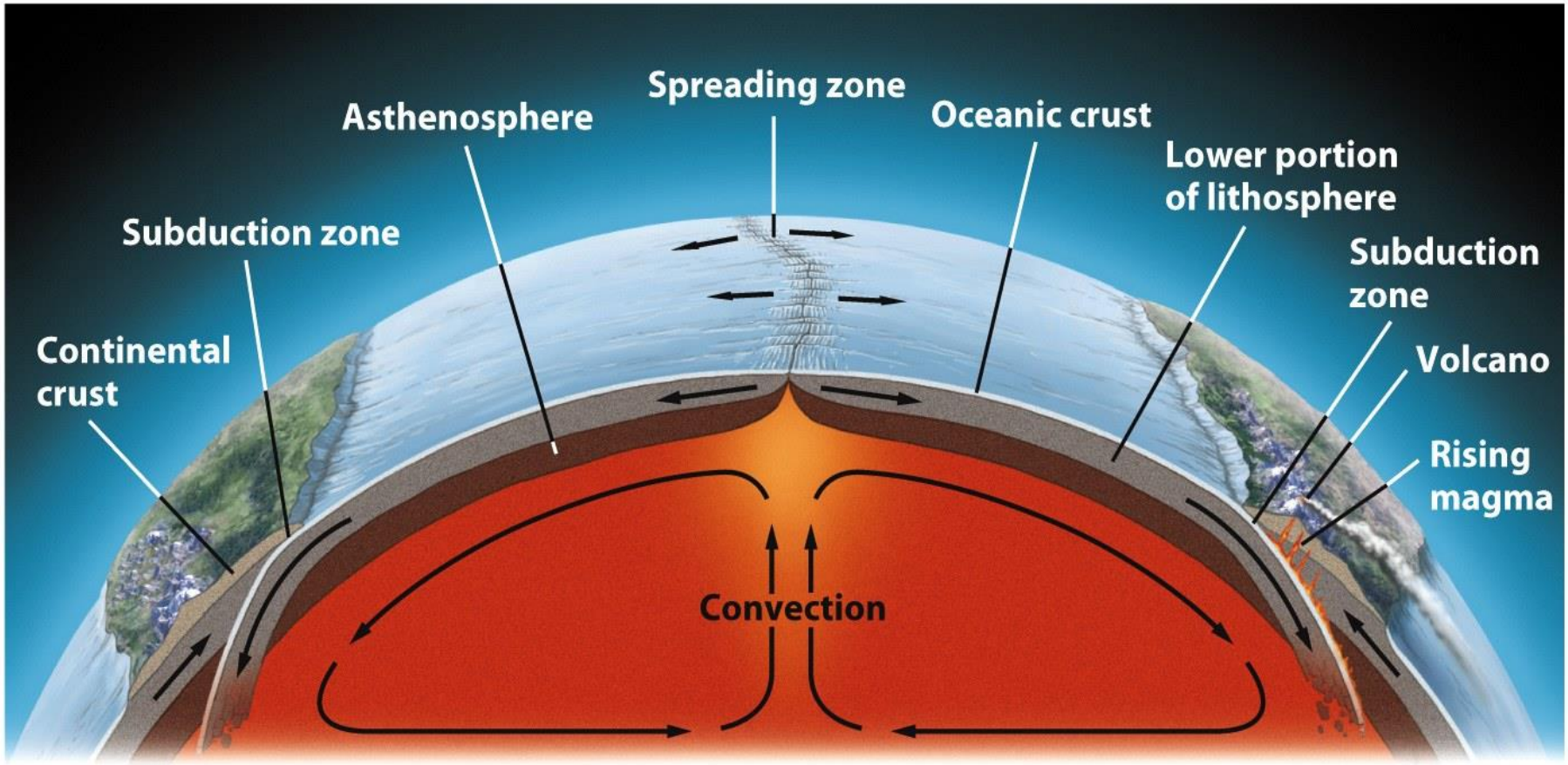


Figure 8.5
Environmental Science

Theory of Plate Tectonics

- ***Plate tectonics:*** the theory that states that Earth's *lithosphere* is divided into plates, most of which are in constant motion.

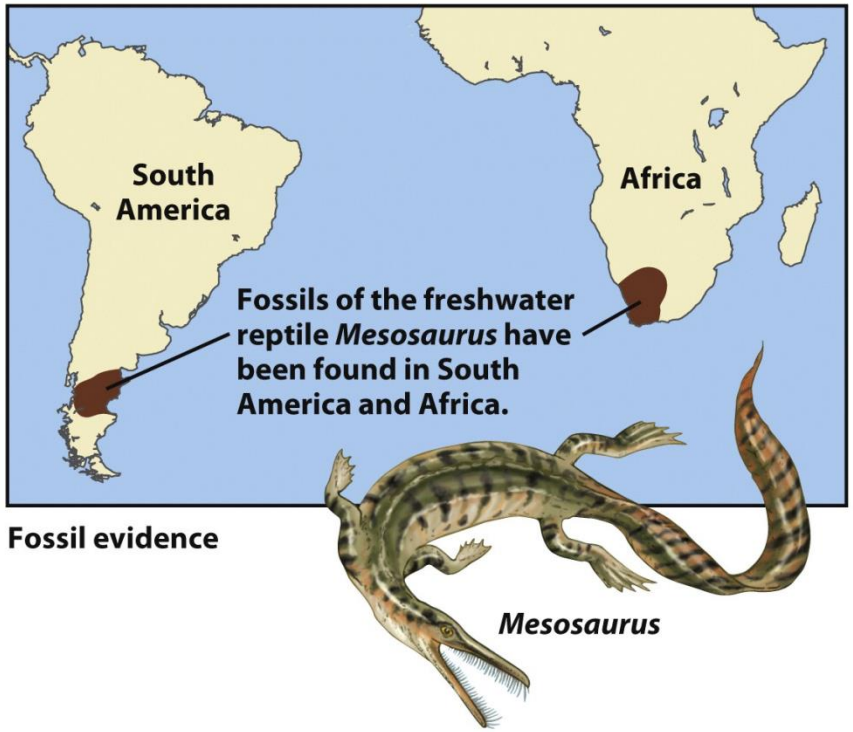


Figure 8.3b
Environmental Science

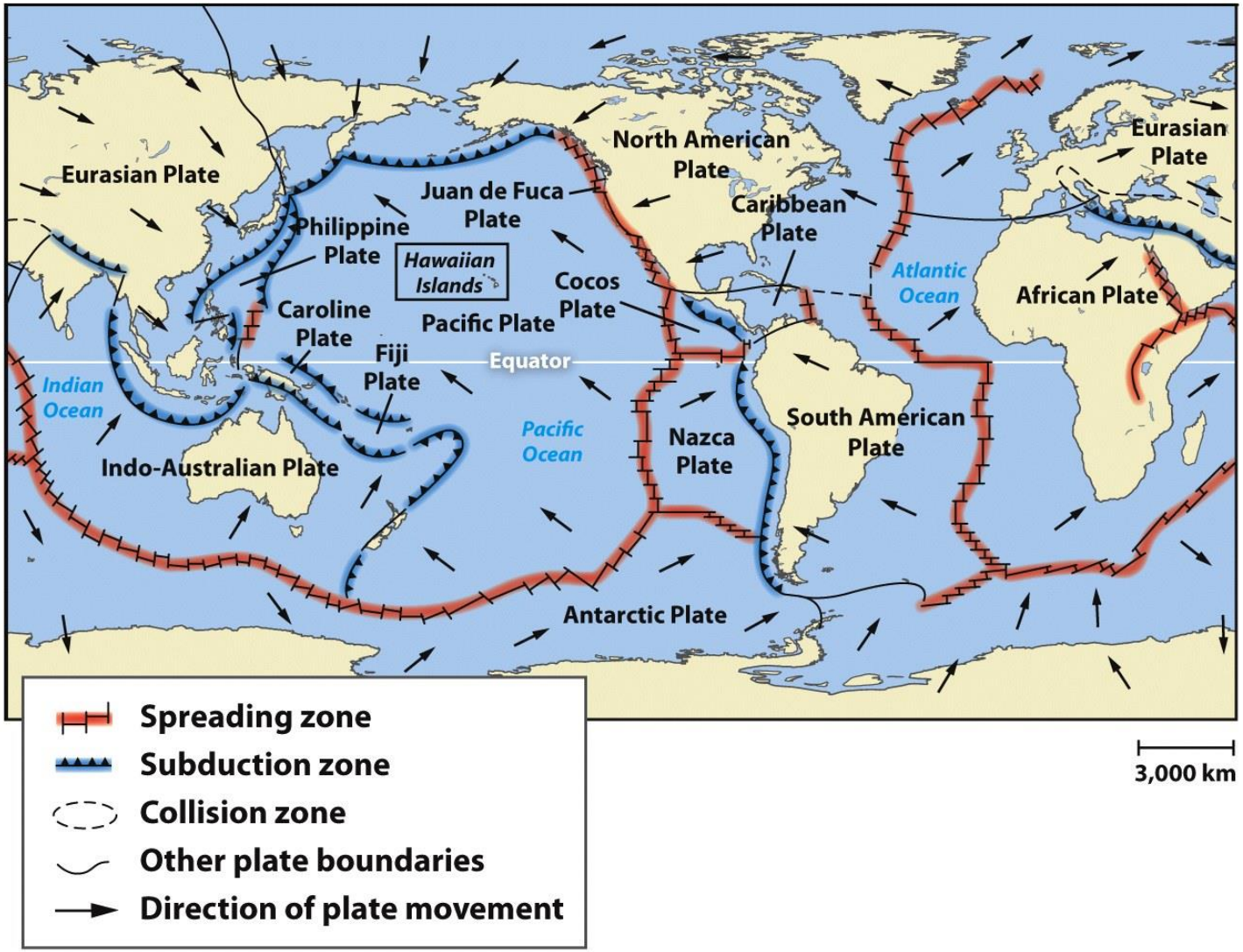


Figure 8.4
Environmental Science

Consequences of Plate Movement

- ***Volcanoes:*** as a plate moves over a hot spot, rising magma forms a volcano.
- Volcanoes vent ash, gases, and molten *lava*.

Consequences of Plate Movement

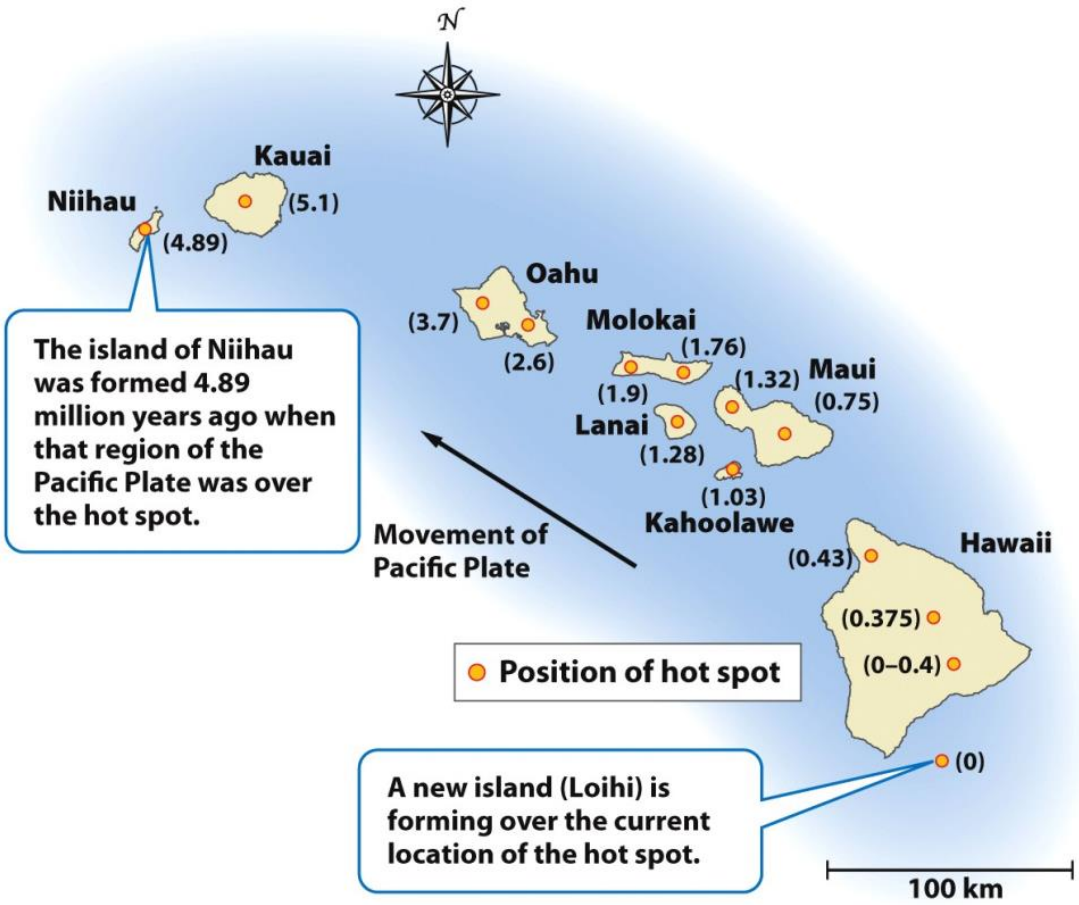
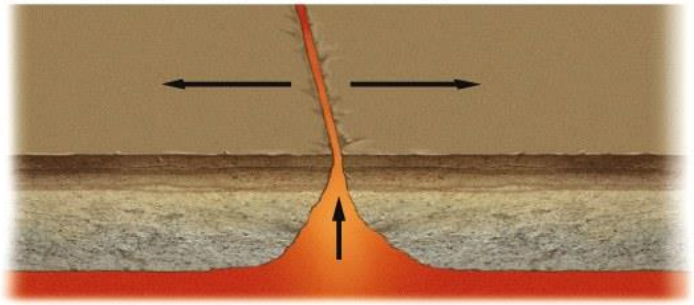


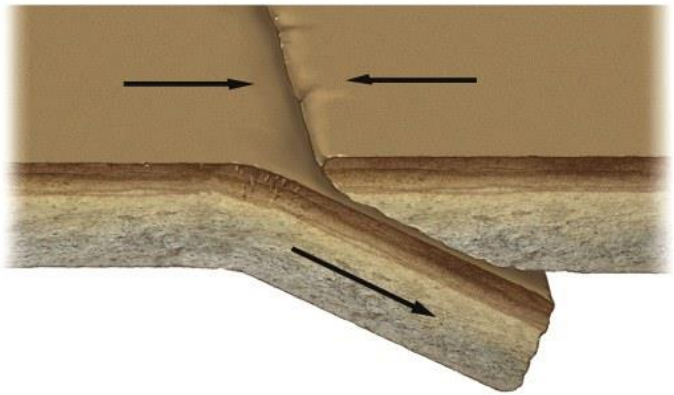
Figure 8.7
Environmental Science

Types of Plate Contact

- ***Divergent plate boundaries:*** plates move apart from one another.
- ***Convergent plate boundaries:*** plates move toward one another and collide, with great force.
- ***Transform fault boundaries:*** plates move sideways past each other.



(a) Divergent plate boundary



(b) Convergent plate boundary

(c) Transform fault boundary

Figure 8.8
Environmental Science

Tectonic Cycle

- The ***tectonic cycle*** is the sum of all processes that build up and break down the Earth's lithosphere.

Faults and Earthquakes

- ***Faults:*** a fracture in rock across which there is movement.
- ***Earthquakes:*** occur when the rocks of the lithosphere rupture unexpectedly along a fault.

Faults and Earthquakes

Figure 8.10
Environmental Science

Faults and Earthquakes

- ***Fault zone:*** large expanses of rock where movement has occurred.
- ***Epicenter:*** the exact point on the surface of Earth directly above the location where the rock ruptures.

Faults and Earthquakes

- ***Richter scale:*** a measure of the largest ground movement that occurs during an earthquake.
- The scale increases by a factor of 10, so an earthquake of 7 is 10 (10^1) times greater than an earthquake of magnitude 6.
- An earthquake of intensity 8 is 100 (10^2) times greater than an earthquake of magnitude 6.

The rock cycle recycles minerals and elements.

The Rock Cycle

- ***Rock cycle:*** the constant formation and destruction of rock.
- This is the slowest of all of Earth's cycles.

The Rock Cycle

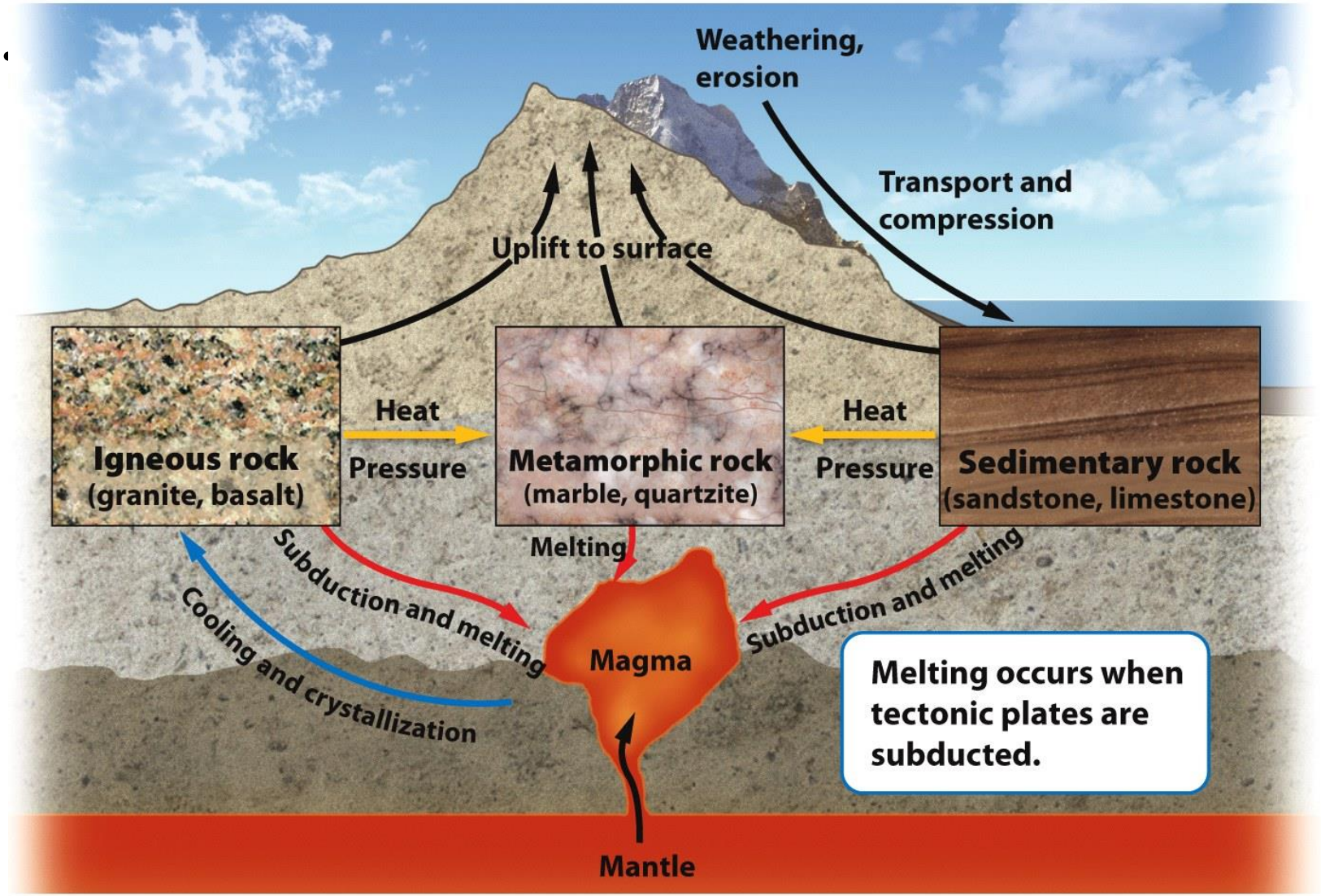


Figure 8.15
Environmental Science

The Rock Cycle

- ***Igneous rocks:*** rocks that form directly from magma.
  - ***Intrusive igneous:*** form from within Earth as magma cools.
  - ***Extrusive igneous:*** form when magma cools above Earth (e.g., formed when volcano ejects magma).

The Rock Cycle

- ***Sedimentary rocks:*** sediments such as mud, sands, or gravels are compressed by overlying sediments.
- ***Metamorphic rocks:*** sedimentary, igneous, or other metamorphic rocks are subjected to high temperatures and pressures.

- ***Weathering:*** rocks are exposed to air, water, certain chemicals, or biological agents that degrade the rock.
  - ***Physical weathering:*** mechanical breakdown of rocks and minerals.

Figure 8.16a
Environmental Science

Figure 8.16b
Environmental Science

- ***Chemical weathering:*** breakdown of rocks and minerals by chemical reactions.

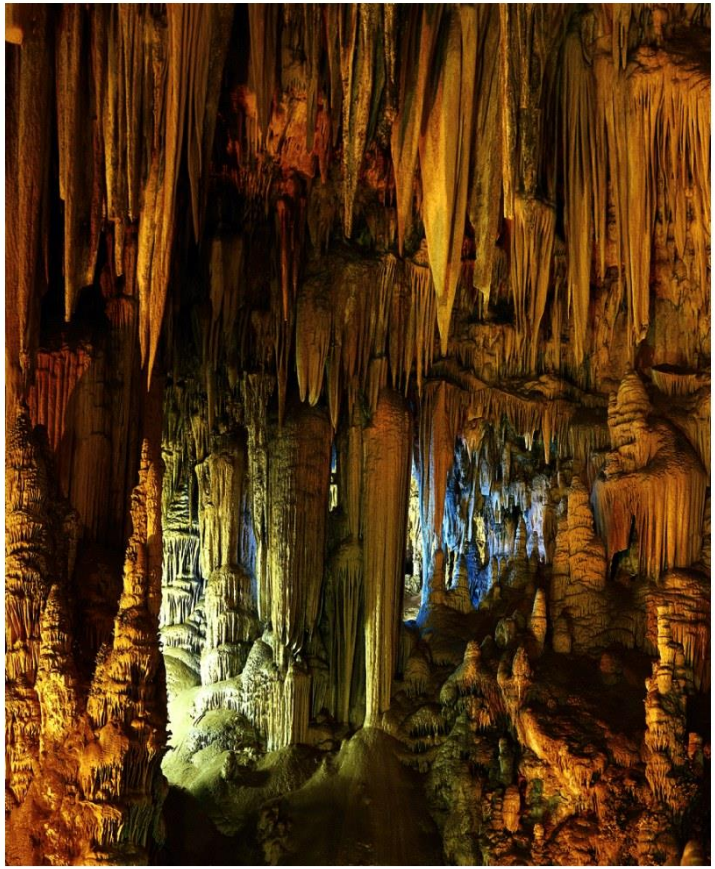


Figure 8.17
Environmental Science

- ***Erosion:*** physical removal of rock fragments from a landscape or ecosystem. Wind, water, ice transport, and living organisms can erode materials.

Figure 8.18
Environmental Science

- ***Deposition:*** accumulation or depositing of eroded material such as sediment, rock fragments, or soil.

- ***Soil*** is important because it
  - Is a *medium* for plant growth
  - Serves as a primary *filter* for water
  - Is a *habitat* for living organisms
  - Serves as a *filter* for pollutants

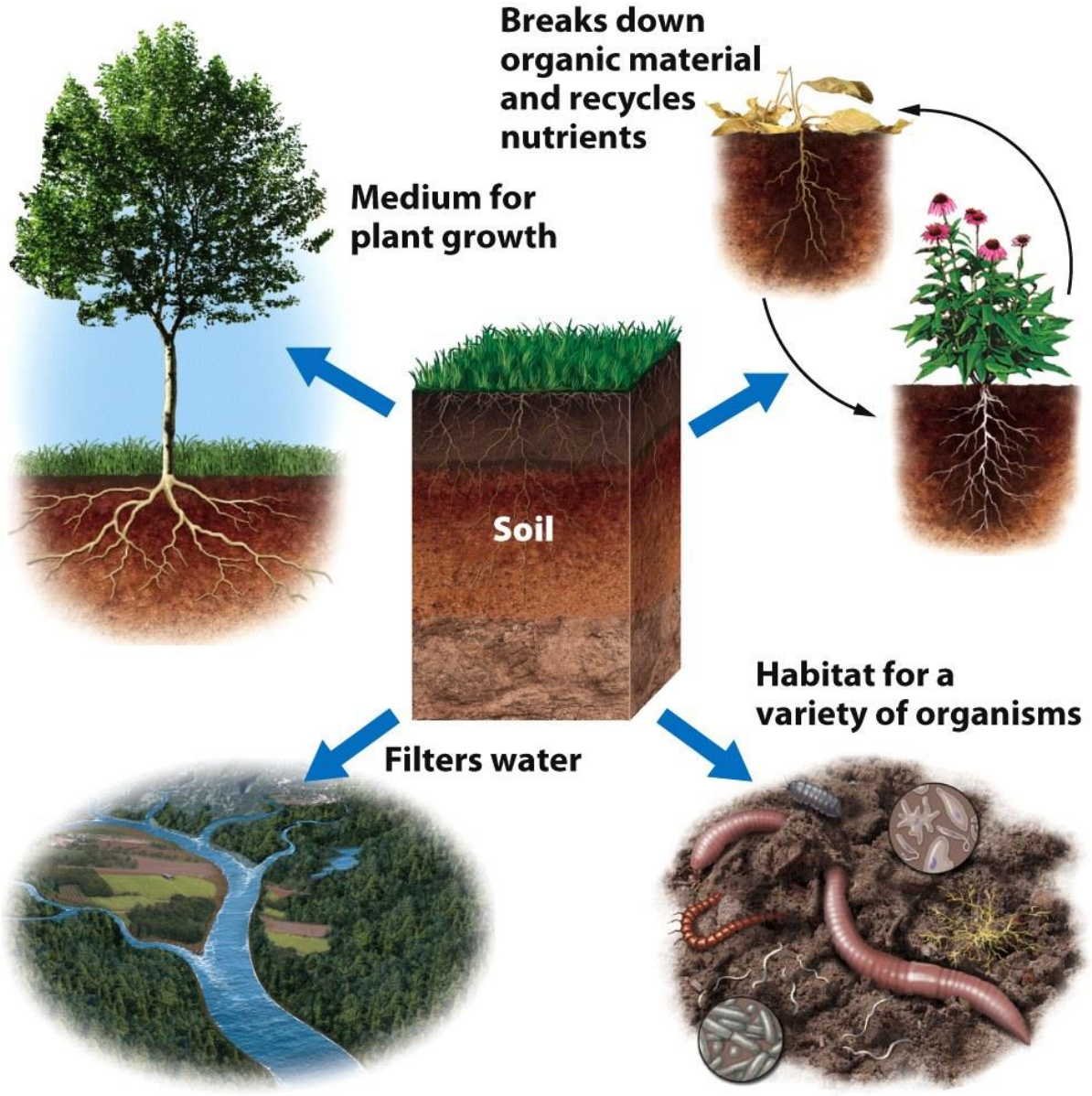


Figure 8.19
Environmental Science

- *Five factors* that determine the formation of soil:
    1. ***Parent material:*** what the soil is made from influences soil formation.
    2. ***Climate:*** type of climate influences soil formation.
    3. ***Topography:*** surface and slope can influence soil formation.

1. ***Organisms:*** plants and animals can have an effect on soil formation.
2. ***Time:*** the amount of time a soil has spent developing can determine soil properties.

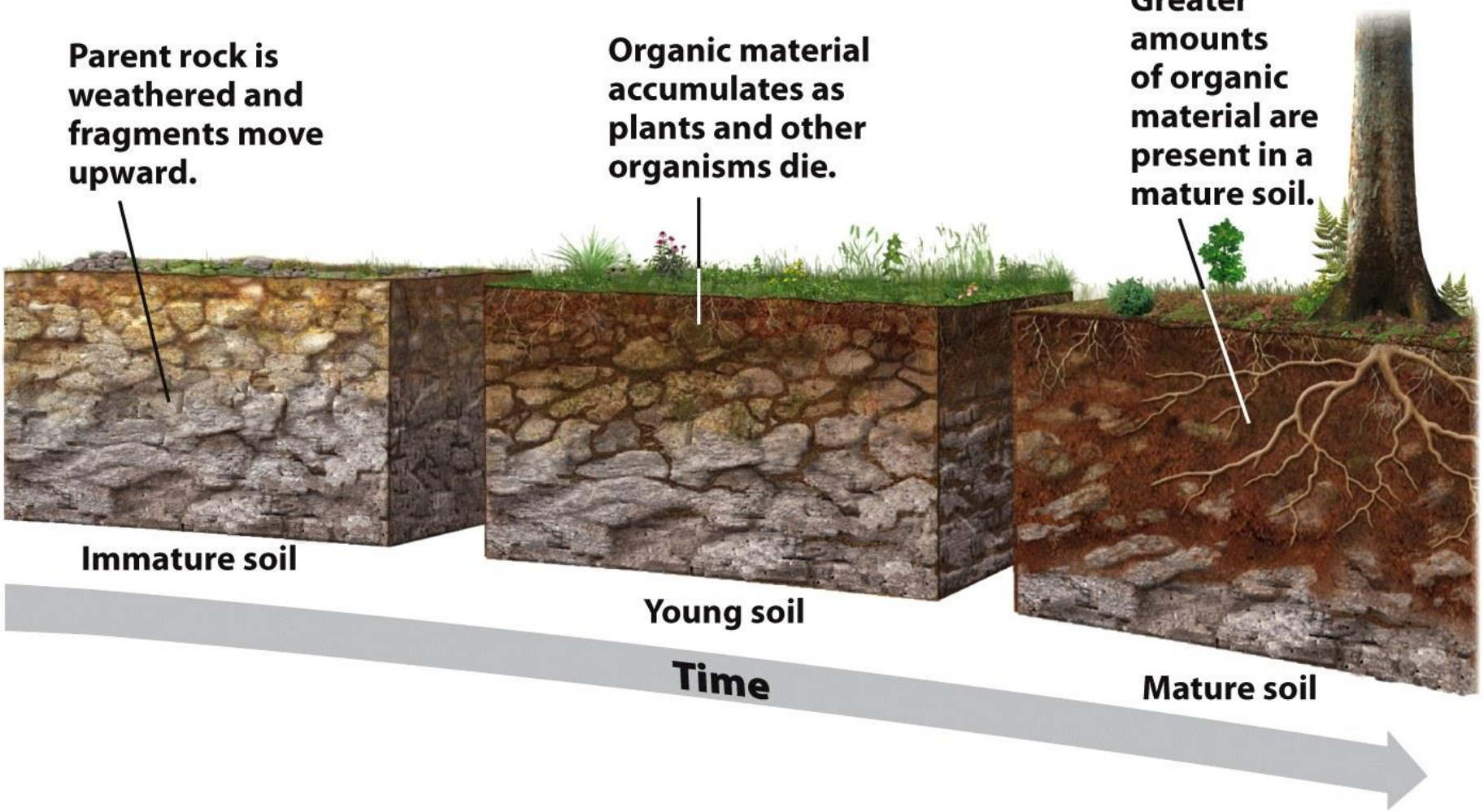


Figure 8.20
Environmental Science

- Soils form and develop characteristic layers.

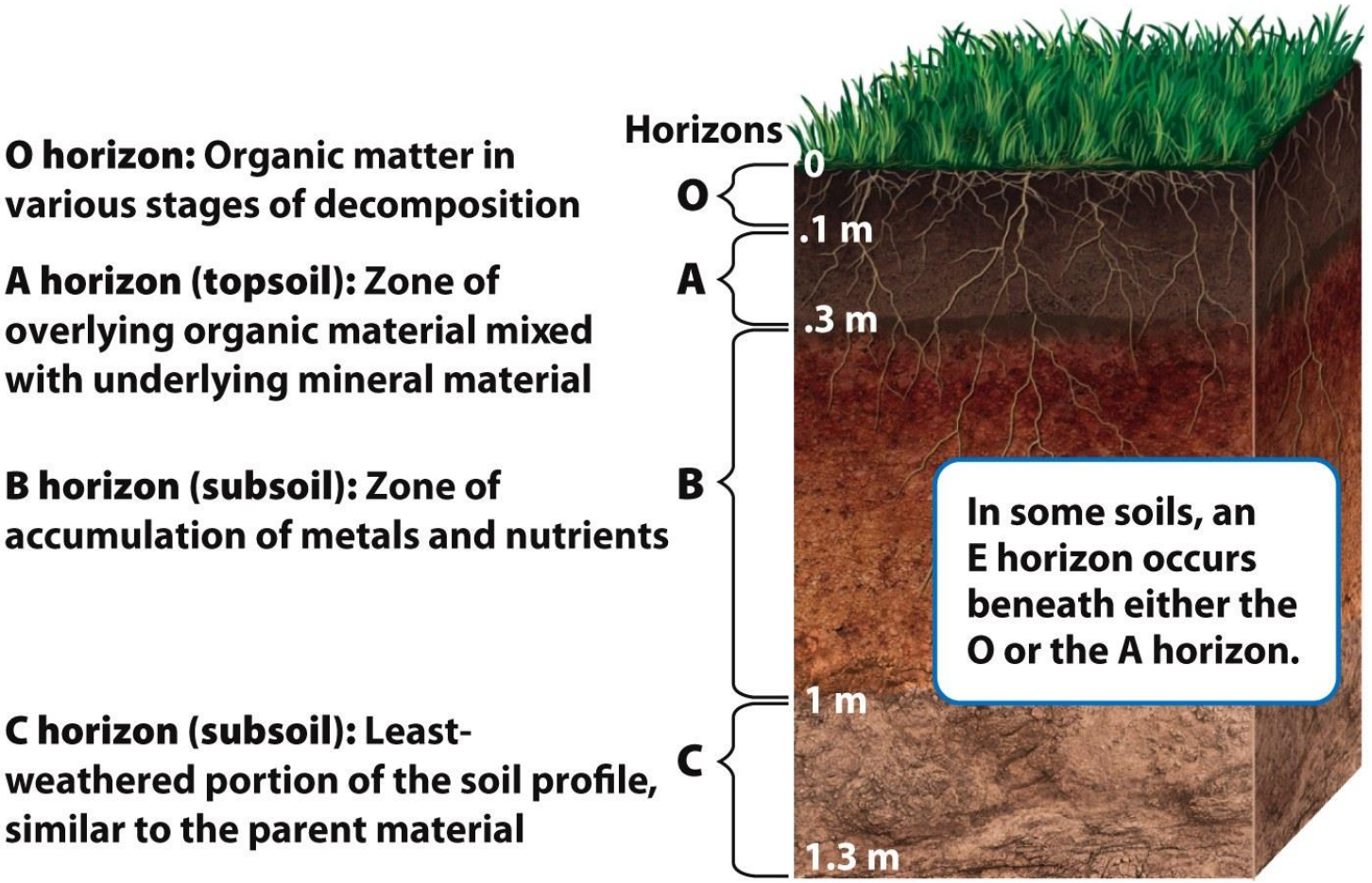


Figure 8.21
Environmental Science

- ***O horizon:*** (*organic* layer) composed of the leaves, needles, twigs, and animal bodies on the surface.
- **A horizon:** (*topsoil*) zone of organic material and minerals mixed together.

- ***B horizon:*** (*subsoil*) composed primarily of mineral material with very little organic matter.
- ***C horizon:*** (*parent material*) the least weathered horizon; similar to the parent material.

- ***Texture:*** the percentage of sand, silt, and clay the soil contains.

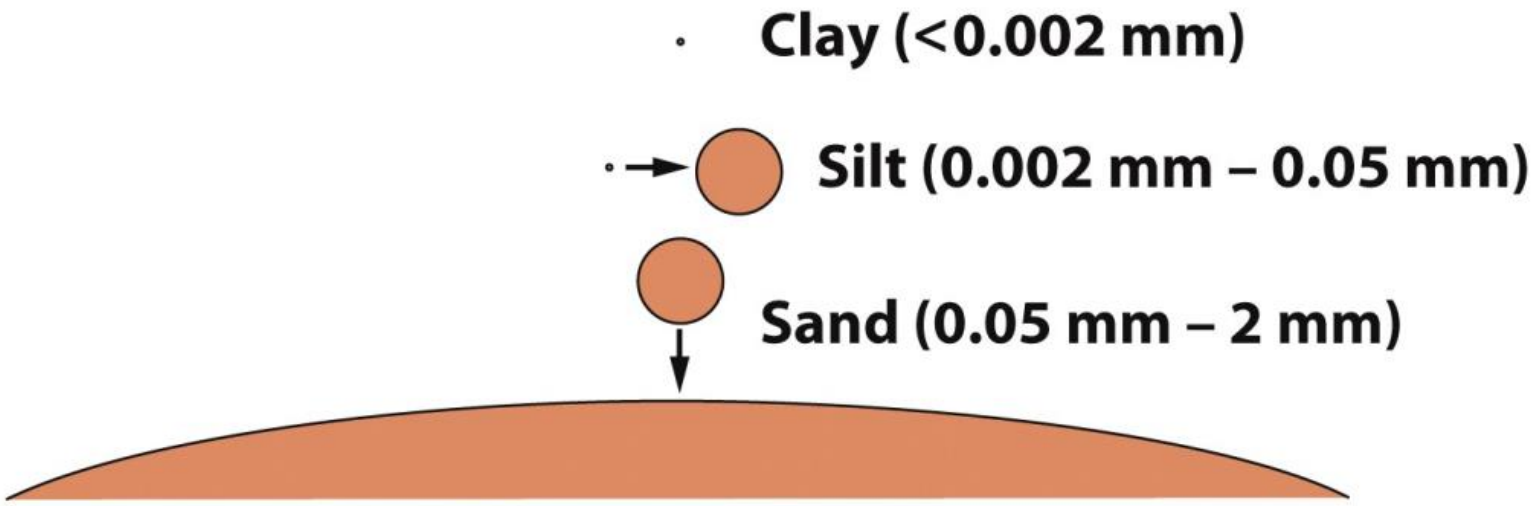
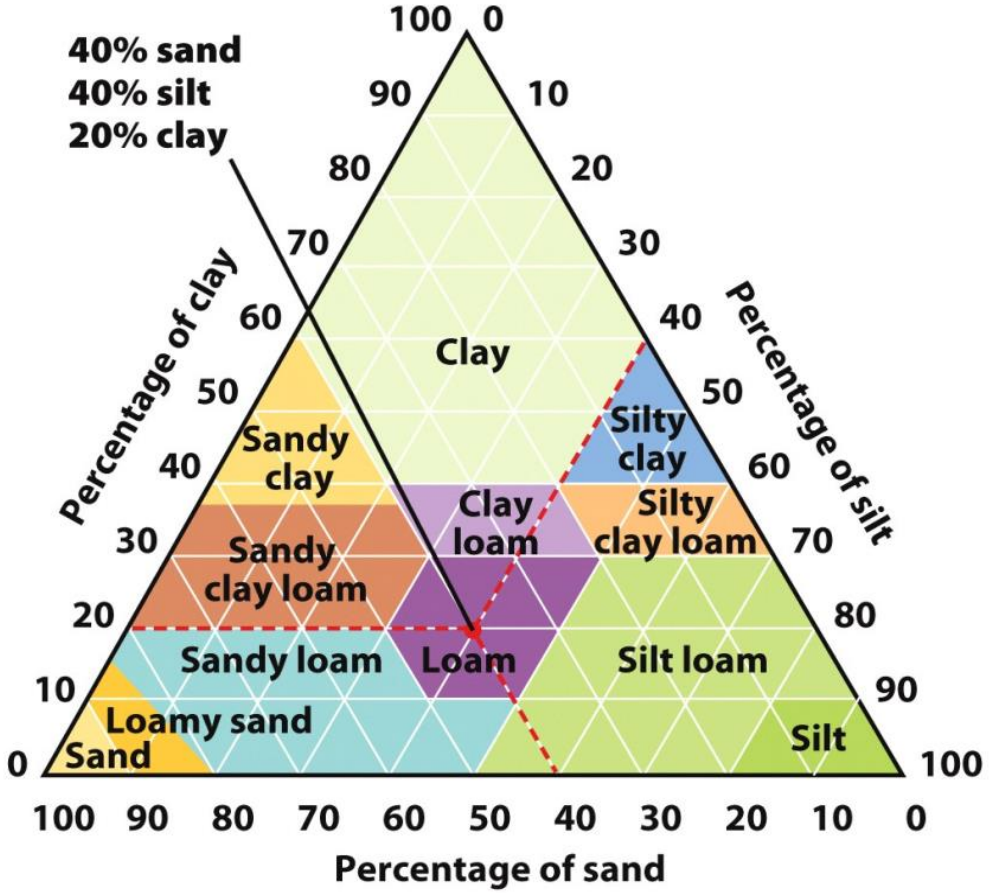


Figure 8.22b
Environmental Science



Soil texture chart

Figure 8.22a
Environmental Science

- ***Porosity:*** how quickly the soil *drains* (which depends on its texture).

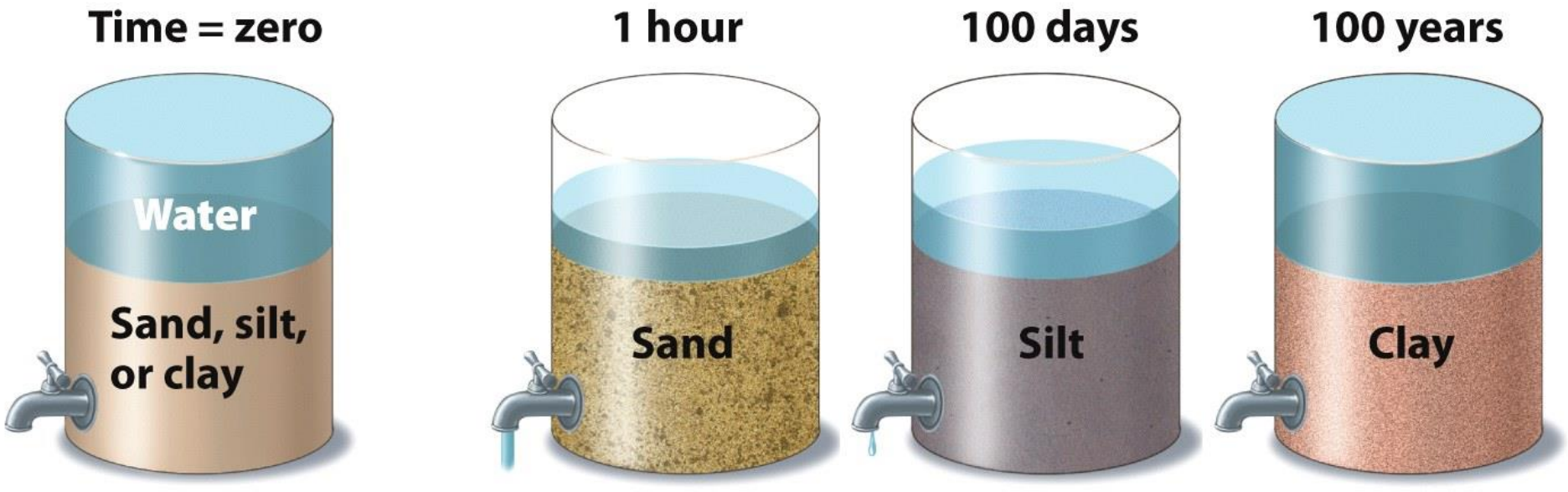


Figure 8.23
Environmental Science

Chemical Properties of Soil

- ***Cation exchange capacity:*** ability of a soil to absorb and release cations (+ charged mineral ions), also called *nutrient holding capacity.*

- ***Soil bases:*** calcium, magnesium, potassium, and sodium.

- **Soil acids:** aluminum and hydrogen.

- ***Base saturation:*** the proportion of soil bases to soil acids.

Biological Properties of Soil

- Many *organisms* are found in the soil including fungi, bacteria, protozoans, rodents, and earthworms.

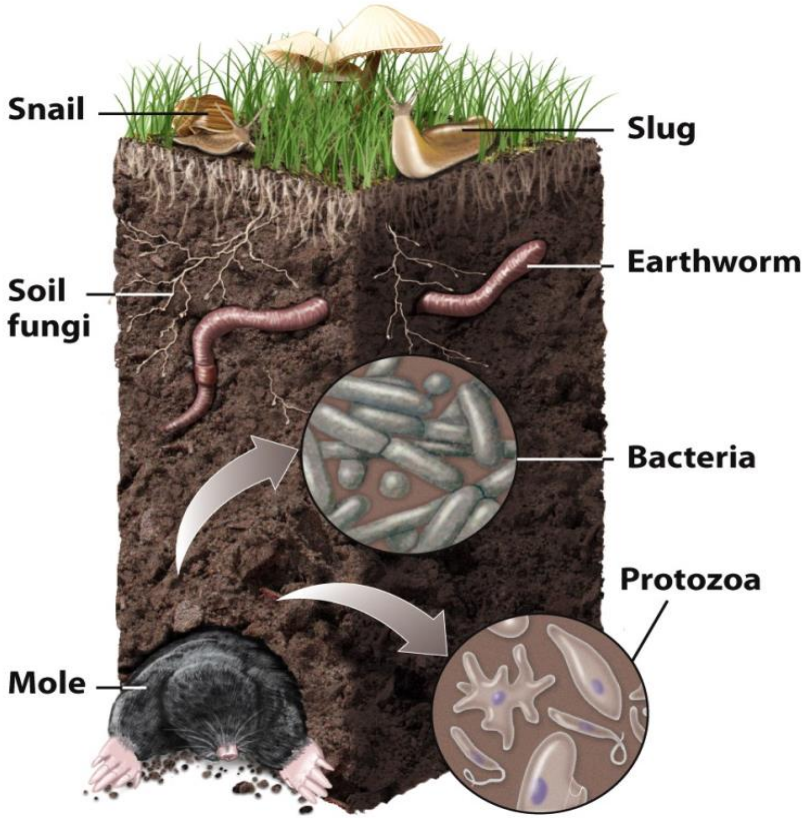


Figure 8.24
Environmental Science

Elemental Composition of the Earth's Crust

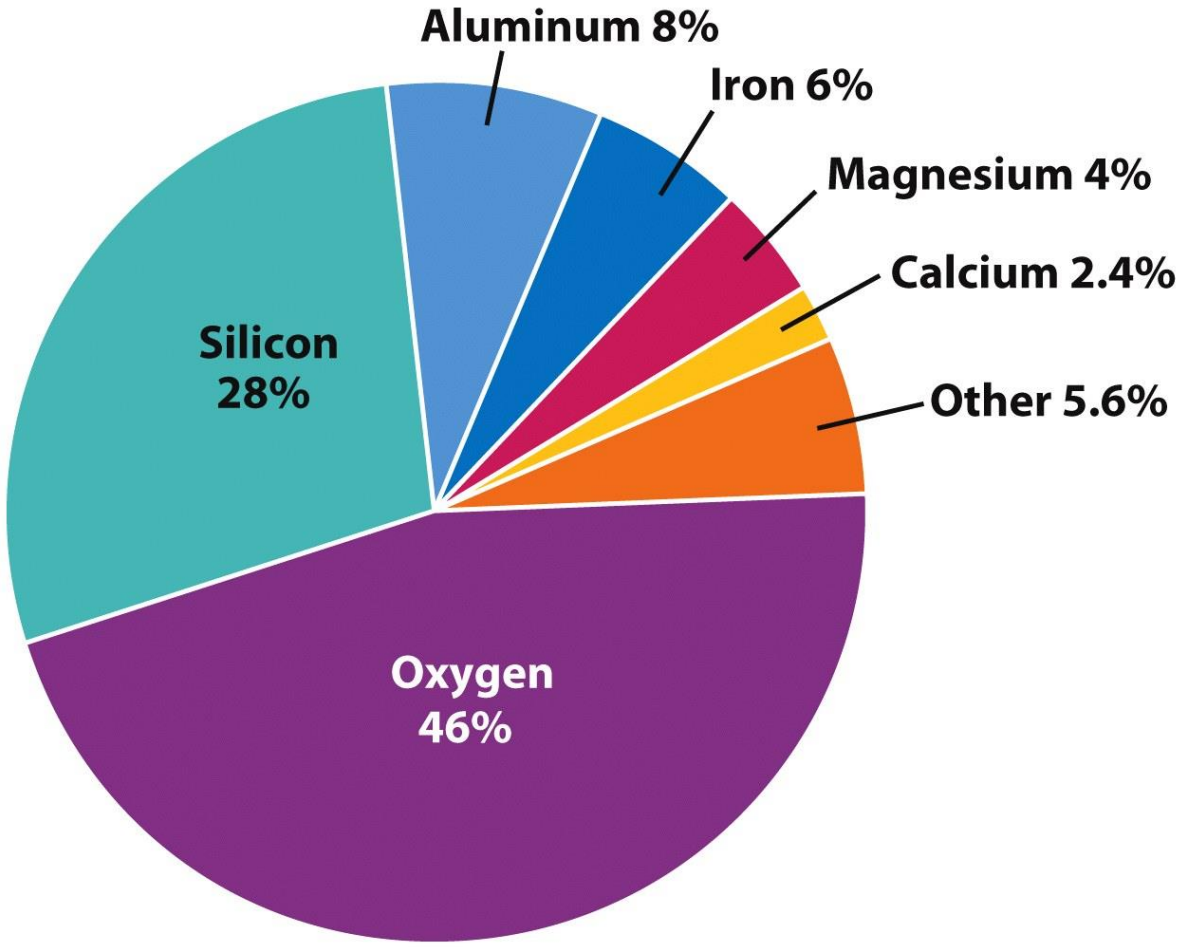


Figure 8.26
Environmental Science

Reserves

- *Reserves:* known quantity of a resource that can be economically recovered.

TABLE 8.1 Approximate supplies of metal reserves remaining

Metal	Global reserves remaining (years)	U.S. reserves remaining (years)
Iron (Fe)	120	40
Aluminum (Al)	330	2
Copper (Cu)	65	40
Lead (Pb)	20	40
Zinc (Zn)	30	25
Gold (Au)	30	20
Nickel (Ni)	75	0
Cobalt (Co)	50	0
Manganese (Mn)	70	0
Chromium (Cr)	75	0

Sources: **S. Marshak, *Earth: Portrait of a Planet,* 3rd ed. (W. W. Norton, 2007); U.S. Geological Survey Mineral Commodity Summaries, http://minerals.er.usgs.gov/minerals/pubs/mcs/.**

Table 8.1
Environmental Science

The unequal distribution of mineral resources has social and environmental consequences.

Types of Mining—Surface

- ***Surface mining:*** removing minerals that are close to Earth's surface.
  - ***Strip mining:*** removes strips of soil and rock to expose ore. Produces waste *tailings*.
  - ***Open pit mining:*** creates large pit or hole in the ground that is visible from the surface. Copper is typically mined this way.

Types of Mining—Surface

- ***Mountain top removal:*** removes the entire top of a mountain with explosives.
- ***Placer mining:*** searching for metals and stones in river sediments; gold is often recovered in this manner.

Types of Mining—Subsurface

Subsurface mining: mining for resources that are 100 m or more below Earth's surface.

TABLE 8.2 Types of mining operations and their effects

Type of mining operation	Effects on air	Effects on water	Effects on soil	Effects on biodiversity	Effects on humans
Surface mining	Significant dust from earth-moving equipment	Contamination of water that percolates through tailings	Most soil removed from site; may be replaced if reclamation occurs	Habitat alteration and destruction over the surface areas that are mined	Minimal in the mining process, but air quality and water quality can be adversely affected near the mining operation
Subsurface mining	Minimal dust at the site, but emissions from fossil fuels used to power mining equipment can be significant	Acid mine drainage as well as contamination of water that percolates through tailings		Road construction to mines fragments habitat	Occupational hazards in mine; possibility of death or chronic respiratory diseases such as black lung disease

Table 8.2
Environmental Science

Types of Mining

- *Surface mining* is generally more damaging to the environment.
- *Subsurface mining* is more significantly dangerous to miners.
- In general, mining legislation does not address environmental issues, with the exception of coal mining.

Review Questions

1. About how long ago did the Earth form?
2. What is the brittle, outermost portion of the Earth called?
3. About how thick is this layer?
4. What are *hot spots*?
5. Briefly define *plate tectonics*.

Review Questions

1. How does *a divergent plate boundary* differ from a *convergent* one?
2. Define "fault."
3. Where do earthquakes occur?
4. What is an *epicenter*?

Review Questions

1. In terms of intensity, how does an earthquake of magnitude 4 differ from one of magnitude 7?
2. What is a *mineral?* Give several examples.
3. Why do *volcanoes* occur?

Review Questions

1. How is igneous rock formed?
2. How is *metamorphic rock* formed?
3. How is *sedimentary rock* formed?
4. In which type of rock are *fossils* found?
5. What are the two types of *weathering?*

Review Questions

1. What is *erosion*?
2. *Soil* is composed of what three types of particles?
3. What is a *soil horizon*?
4. Explain the *CEC* of a soil.
5. Name three forms of *surface mining*.
6. What are some effects associated with mining?