Chapter 8
Earth Systems and Resources

The Earth's resources were determined when the planet formed.

Earth formed roughly 4.6 billion years ago from cosmic dust in the solar system

This determined the distribution and abundance of elements and minerals today.

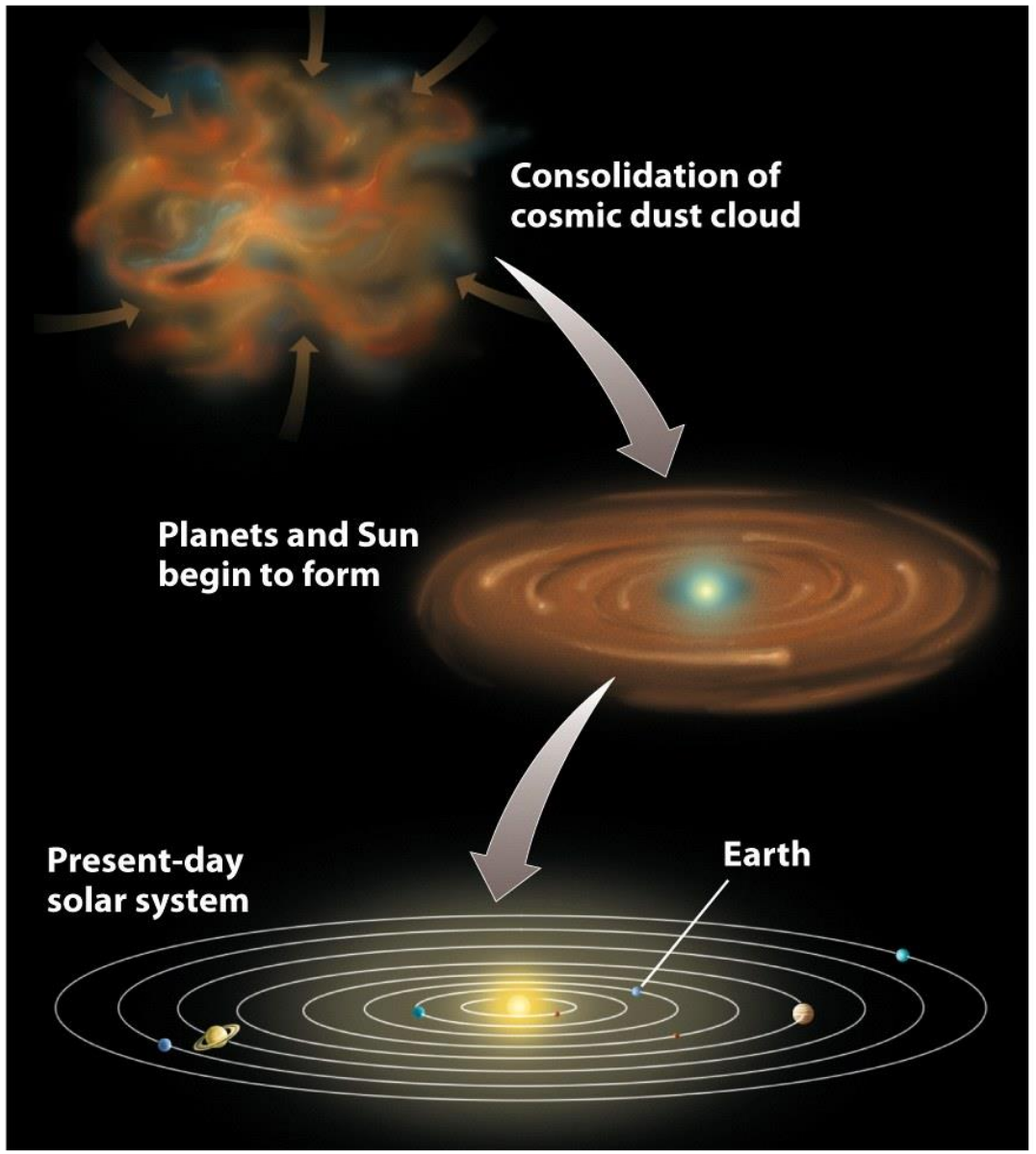
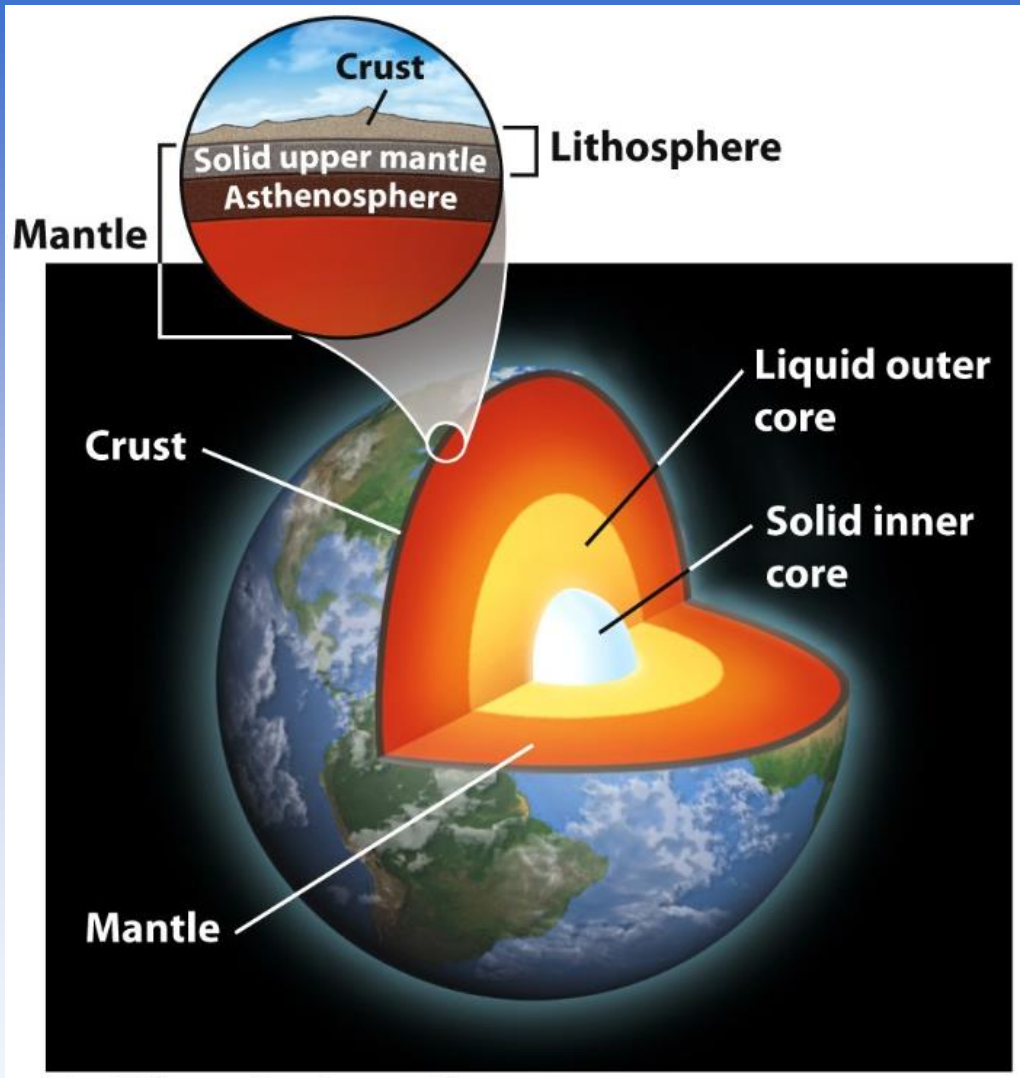


Figure 8.1
Environmental Science

The Earth's Layers

- **Core-** *(3rd layer)* the innermost zone of the planet made of nickel and iron.
- **Mantle-** *(2nd layer)* above the core containing magma
- **Crust-***(1st layer)* the outermost layer of the planet (we live)



Earth's vertical zonation

Figure 8.2a
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Elemental Composition of the Earth's Crust

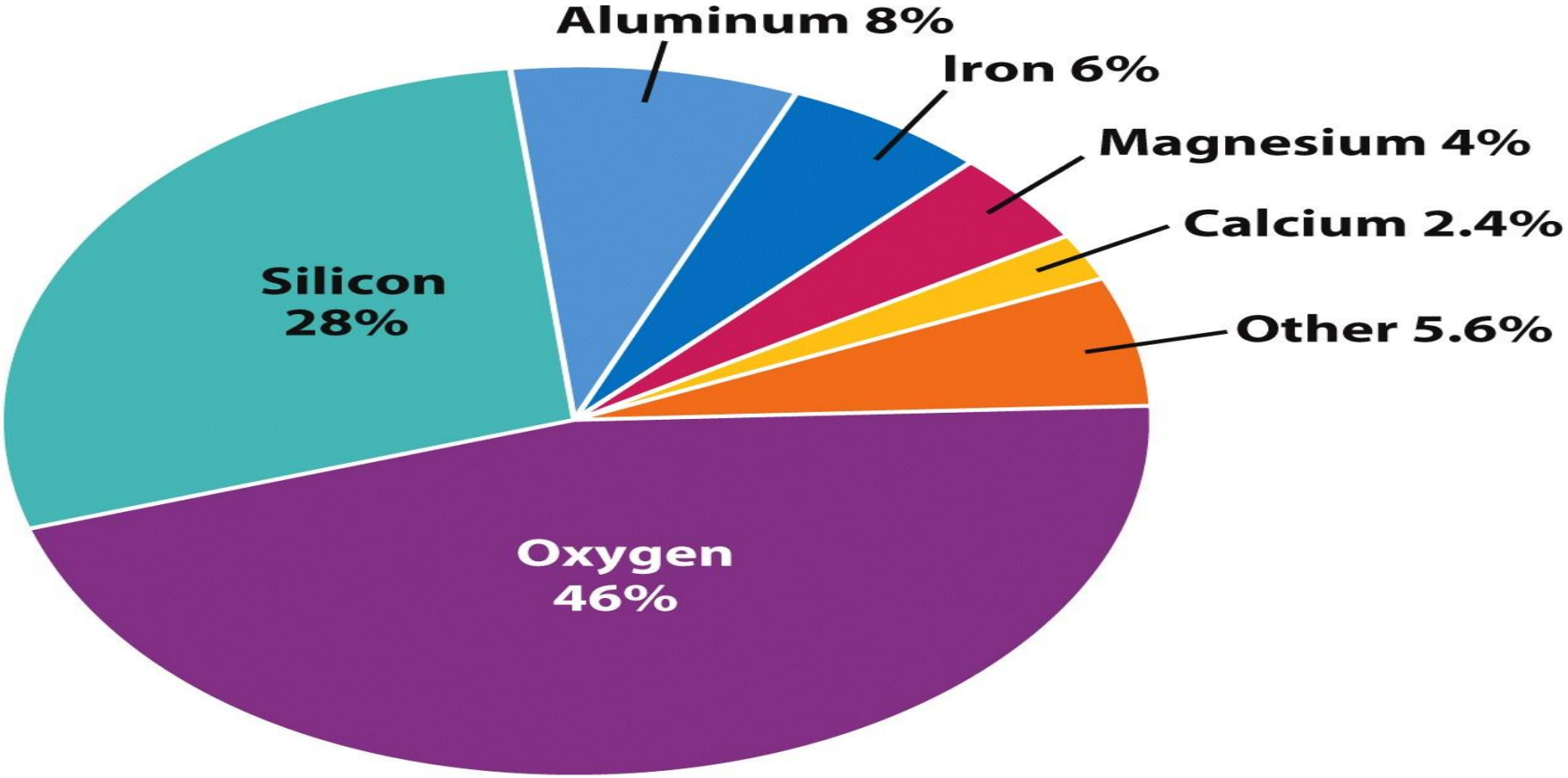

Figure 8.26
Environmental Science

The Earth's Layers

- **Lithosphere**-*(crust + solid upper mantle)* the brittle outermost layer of the planet that is approximately 100 km thick.
- **Asthenosphere**-*(below lithosphere)* the outer part of the mantle, composed of semi-molten, ductile (flexible) rock.

Convection and Hot Spots

- The Earth is very hot at the center due to the release of heat from the radioactivity decay from varies of isotopes (critical consequence)
- This heat causes trails of hot magma to well upward from the mantle produces **Hotspots**- places where molten material from the mantle reaches the lithosphere.

- Mantle convection drives the continuous change, creation and renewal of Earth's material in the lithosphere.

Theory of Plate Tectonics

(scientists found additional evidence toward plate tectonics theory)

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

1st Revolutionary Hypothesis proposed that the world's continents had once been joined in a single landmass… 'Pangaea'

Evidence – fossils of the same species found on different continents that are separated by oceans.

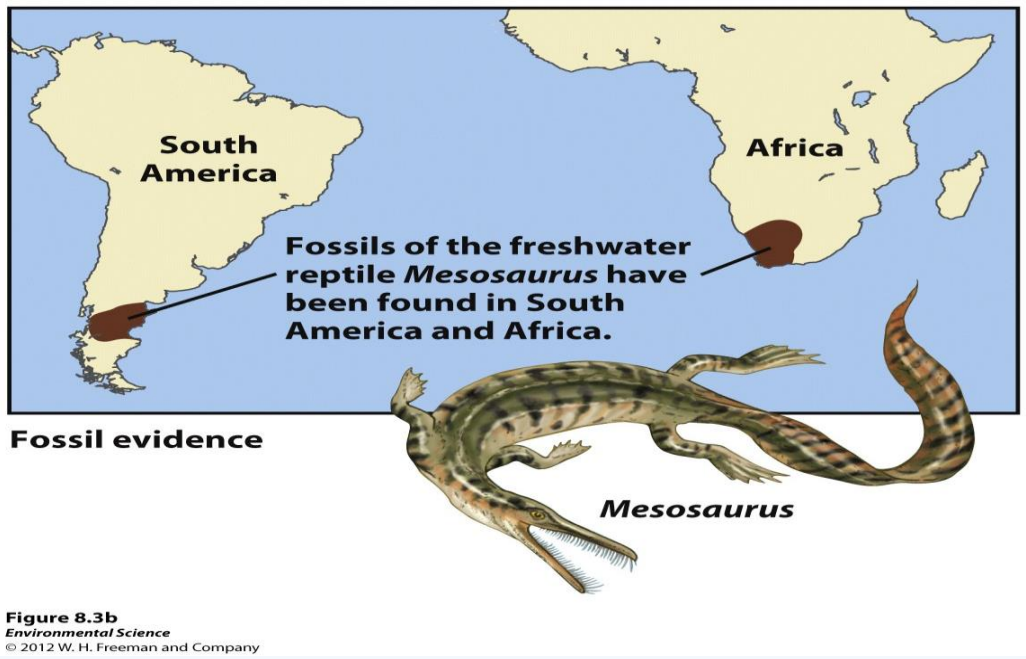

Figure 8.3b
Environmental Science

Lithosphere is broken into a number plates:

- **Oceanic Plates** – lie primarily beneath the oceans, dense and rich in Iron
- **Continental Plates** – lie beneath land masses, less dense due to containing more silicon dioxide, results in a lighter plate…typically rise above oceanic plates when in motion

Slow movements (constantly in motion) are driven by convection cells in Earth's mantle.

- As continental plates move, the continents slowly drift
- As oceanic plates move apart, rising magna forms new oceanic crust on the seafloor at the boundaries btwn those plates, process called **seafloor spreading** brings up Ag, Cu, Pb to the surface

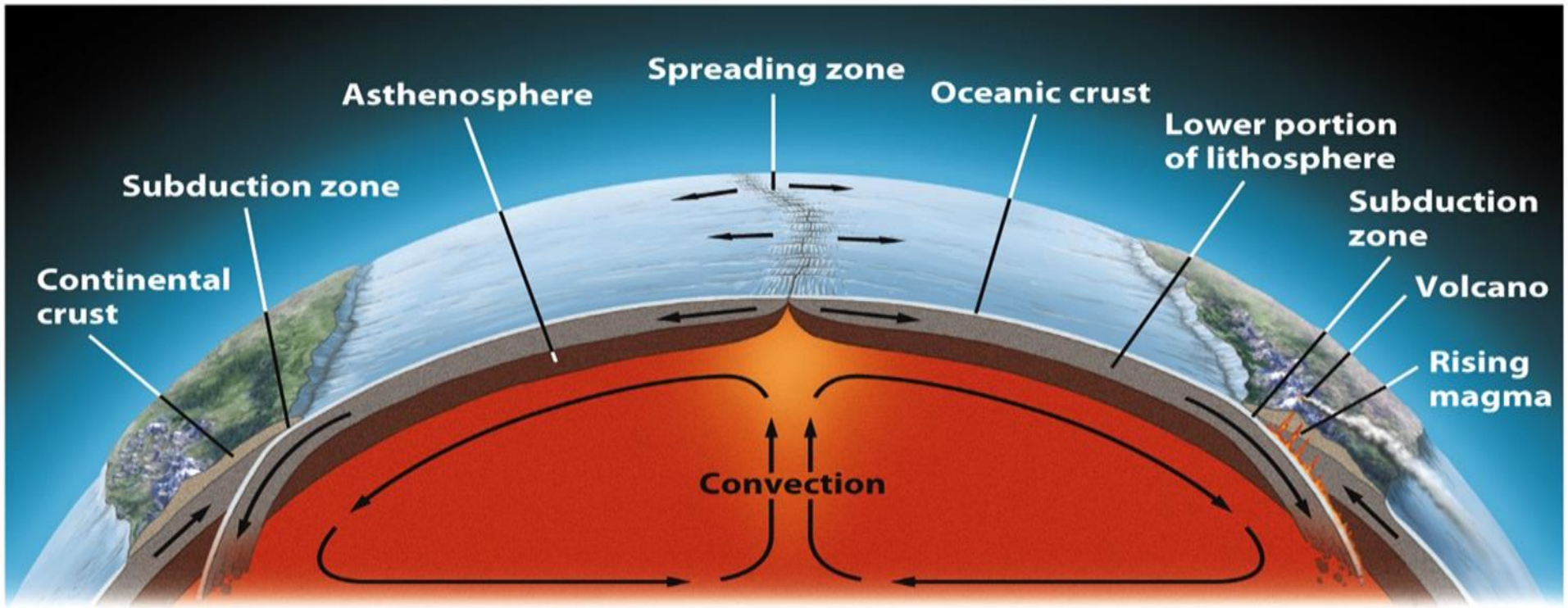

Figure 8.5
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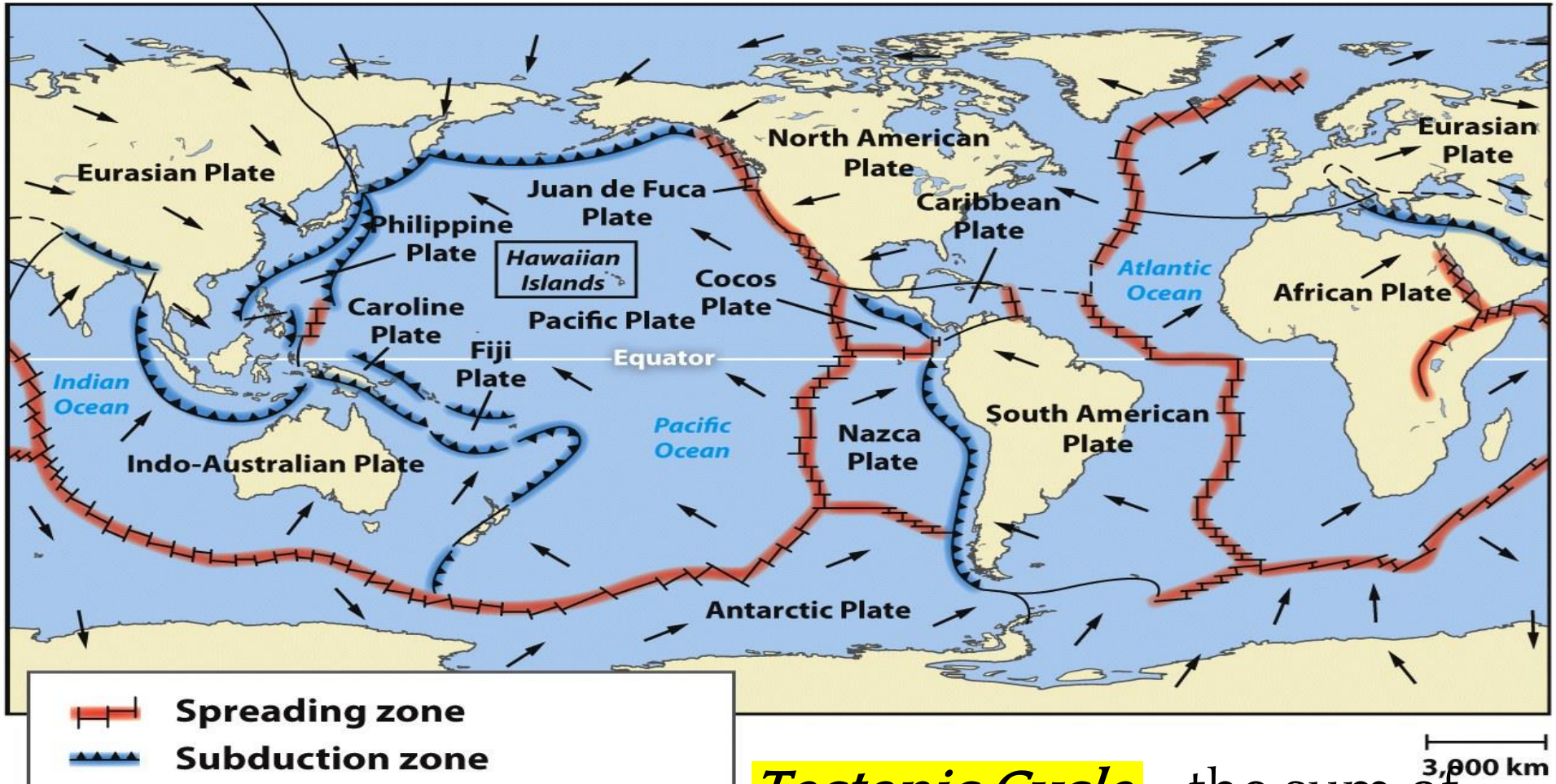
Tectonic Plates



Earthquake zones

"Ring of Fire" -volcanos

Figure 8.4

Tectonic Cycle – the sum of the processes that build up and break down the lithosphere

Consequences of Plate Movement

As a plate moves over a geologic hot spot, heat from rising magma trails melts the crust producing....Volcano

- Volcano: A vent in Earth's Surface that emits gas, and molten lava

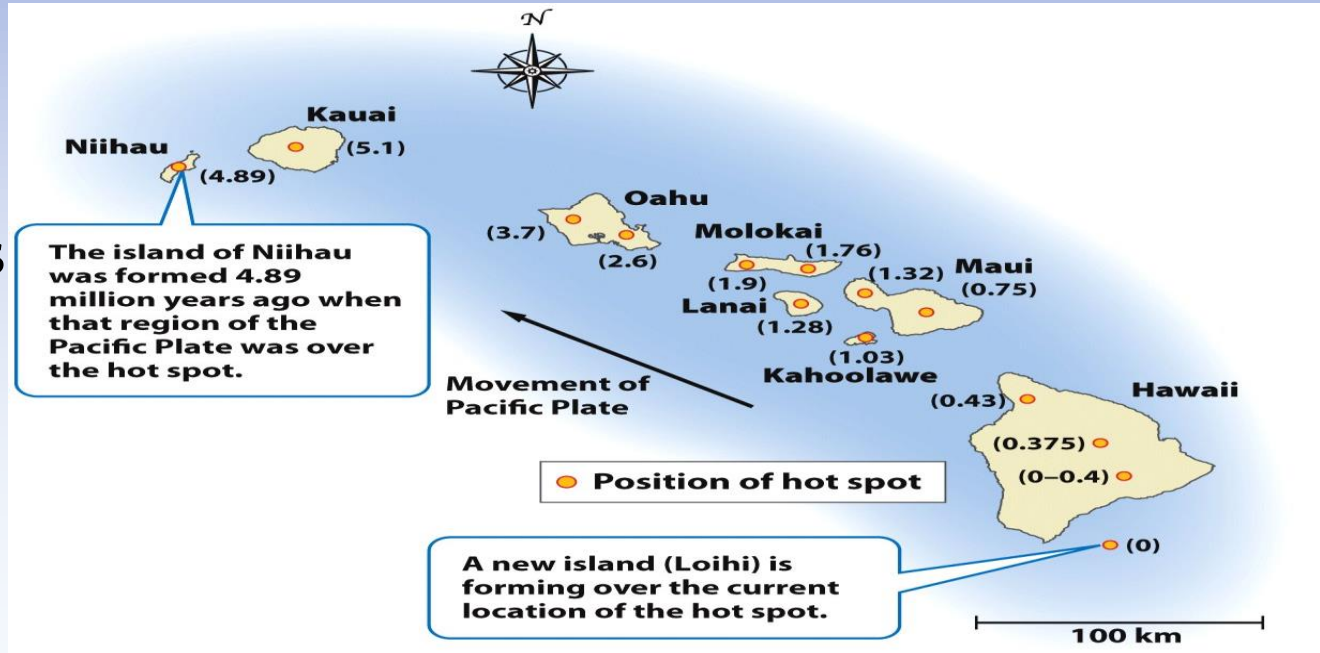
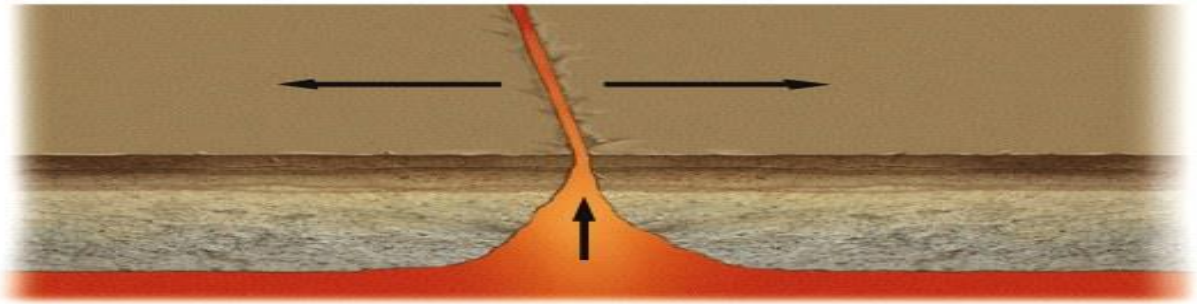


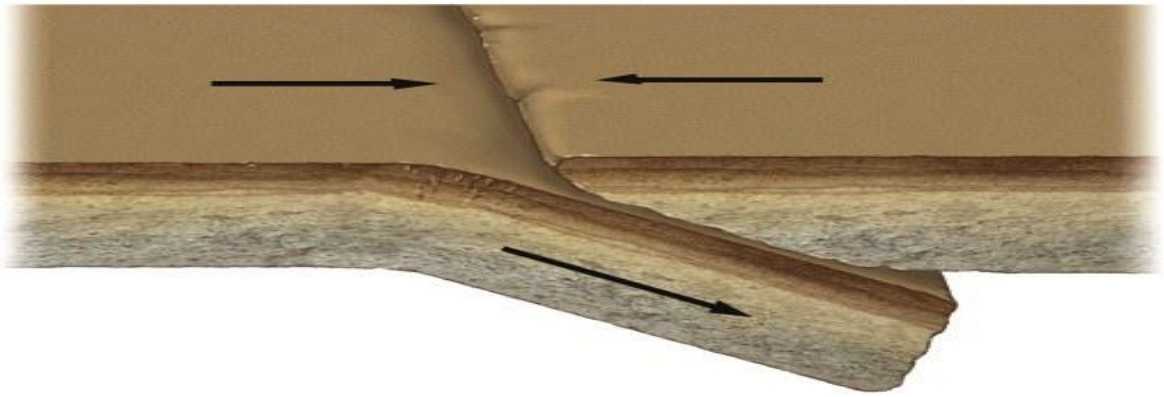
Figure 8.7
Environmental Science

Types of Plate Contact

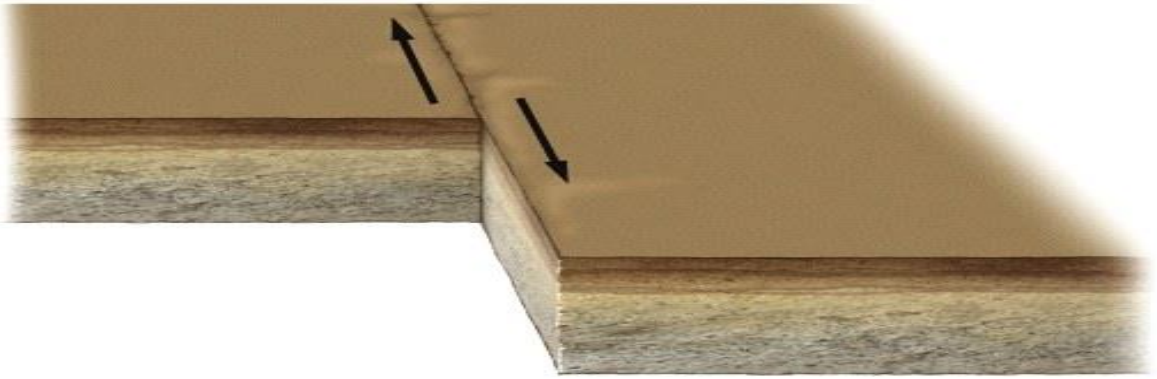
- **Divergent plate boundaries-** when plates move apart from one another.
- **Convergent plate boundaries-** when plates move toward one another and collide.
- **Transform fault boundaries-** then plates move sideways past each other.



(a) Divergent plate boundary



(b) Convergent plate boundary



(c) Transform fault boundary

Figure 8.8
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Plates Move Apart

Plates Collide

Plates slide past each other

Faults and Earthquakes

- **Faults**- a fracture in rock across which there is movement (not smooth movement).
- **Earthquakes**- occur when the rocks of the lithosphere rupture unexpectedly along a fault.

Figure 8.10
Environmental Science

Faults and Earthquakes

- **Fault zone-** large expanses of rock where movement has occurred (area of *Seismic activity*).
- **Epicenter**- the exact point on the surface of Earth directly above the location where the rock ruptures.
- **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 times greater than an earthquake of 6.

The Rock Cycle

- **Rock cycle-** the constant formation and destruction of *rock-substance of lithosphere, composed of 1 or more minerals*)
- **Mineral** – solid chemical substance w/uniform structures that form under specific temp and pressure.

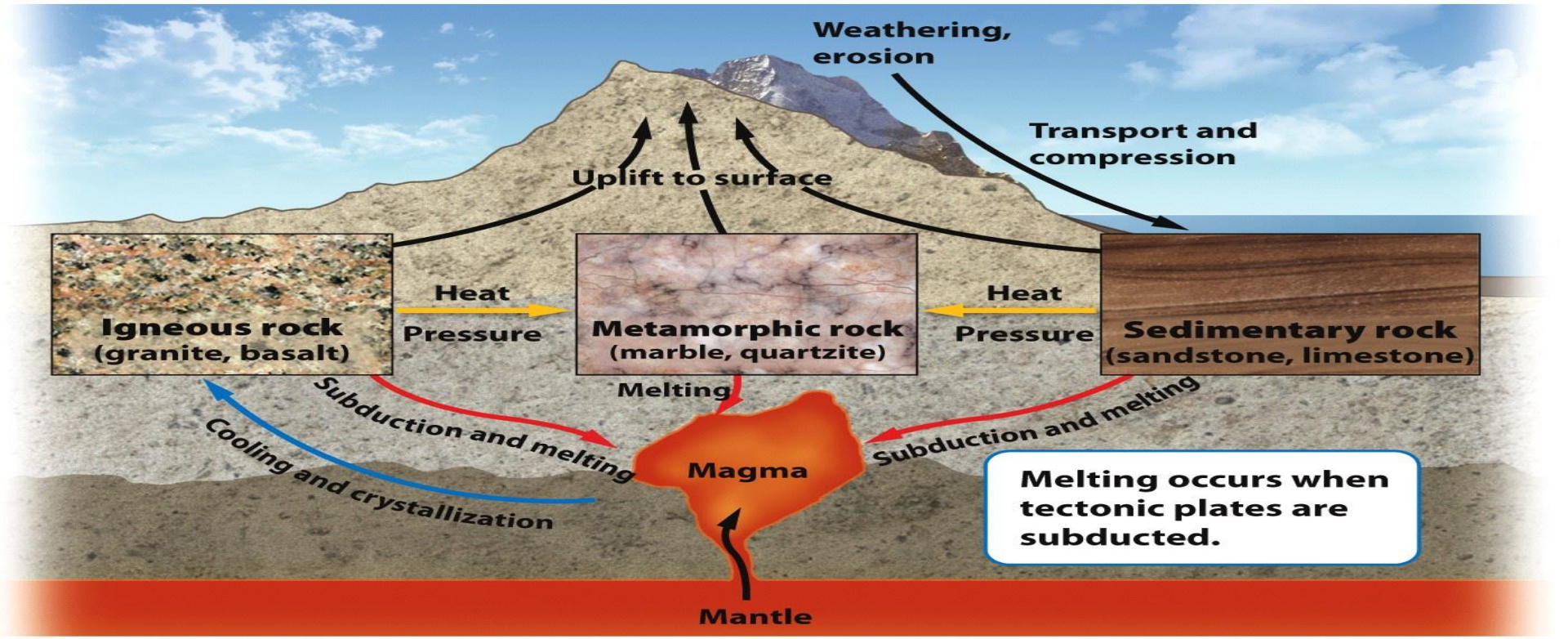


Figure 8.15
Environmental Science

The Rock Cycle

- **Igneous rocks-** rocks that form directly from magma. (granite)
  - *Intrusive igneous*- form from within Earth as magma cools.
  - *Extrusive igneous*- from when magma cools above Earth. (ex. A volcano that **ejects magma** out will form this)
- **Sedimentary rocks-** form when sediment such as mud, sands, or gravels are compressed by overlying sediments. (sandstone)
- **Metamorphic rocks-** form when sedimentary, igneous or other metamorphic rocks are subjected to high temperatures and pressures. (marble or slate)

Weathering and Erosion

- **Weathering-** when rocks are exposed to air, water, certain chemicals or biological agents that degrade the rock.

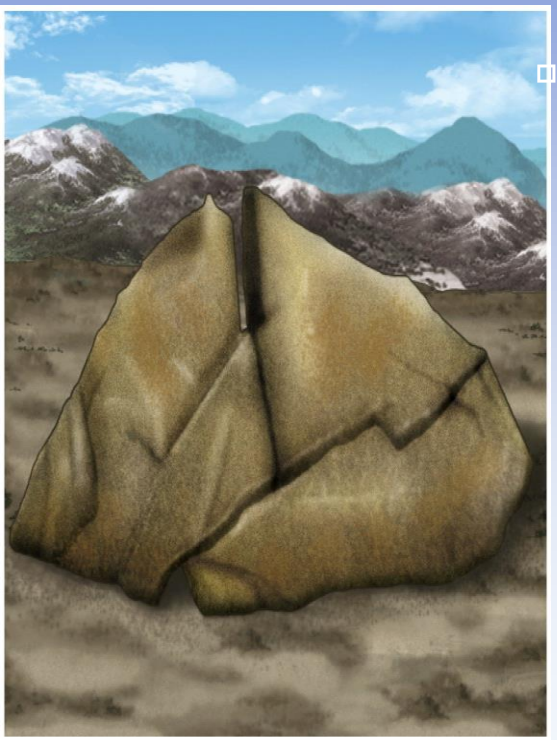


Figure 8.16a
Environmental Science

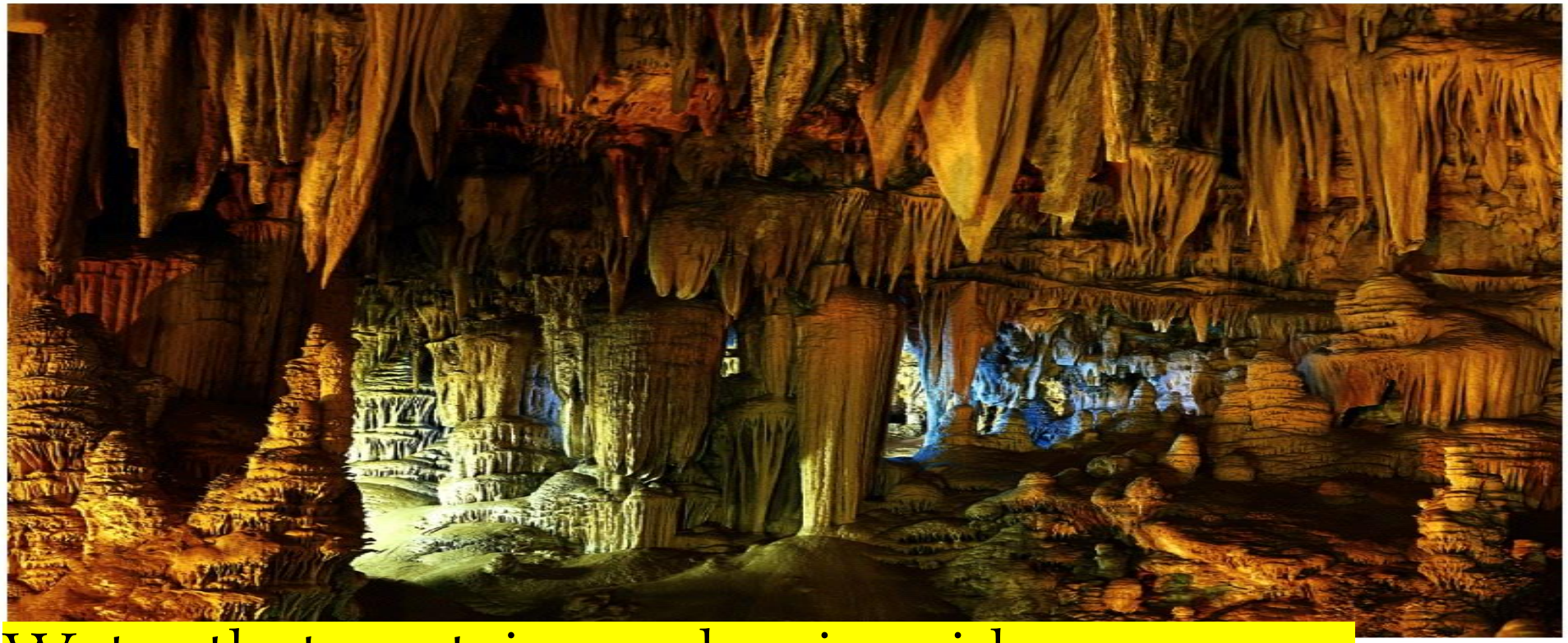
- water in cracks, expand when freeze

Figure 8.16b
Environmental Science

Physical weathering - the mechanical breakdown of rocks and minerals. (roots from trees)

Weathering and Erosion

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



Water that contains carbonic acid wear away limestone, forming caves like above.

Erosion

- **Erosion**- the physical removal of rock fragments from a landscape or ecosystem. *Wind, water, ice transport and living organisms can erode materials*.
  - **Natural process**...poor land use practices (deforestation, overgrazing, road building..etc) can accelerate erosion *(erosion leads to deposition of the eroded material somewhere else)*

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

Soil

- Soil is important because it...
  1. Is a **medium** for plant growth (Sand, Slit, Clay)
  2. Serves as a **filter** for **water**
  3. A **habitat** for living organisms
  4. Serves as a **filter** for **pollutants (Clay)**

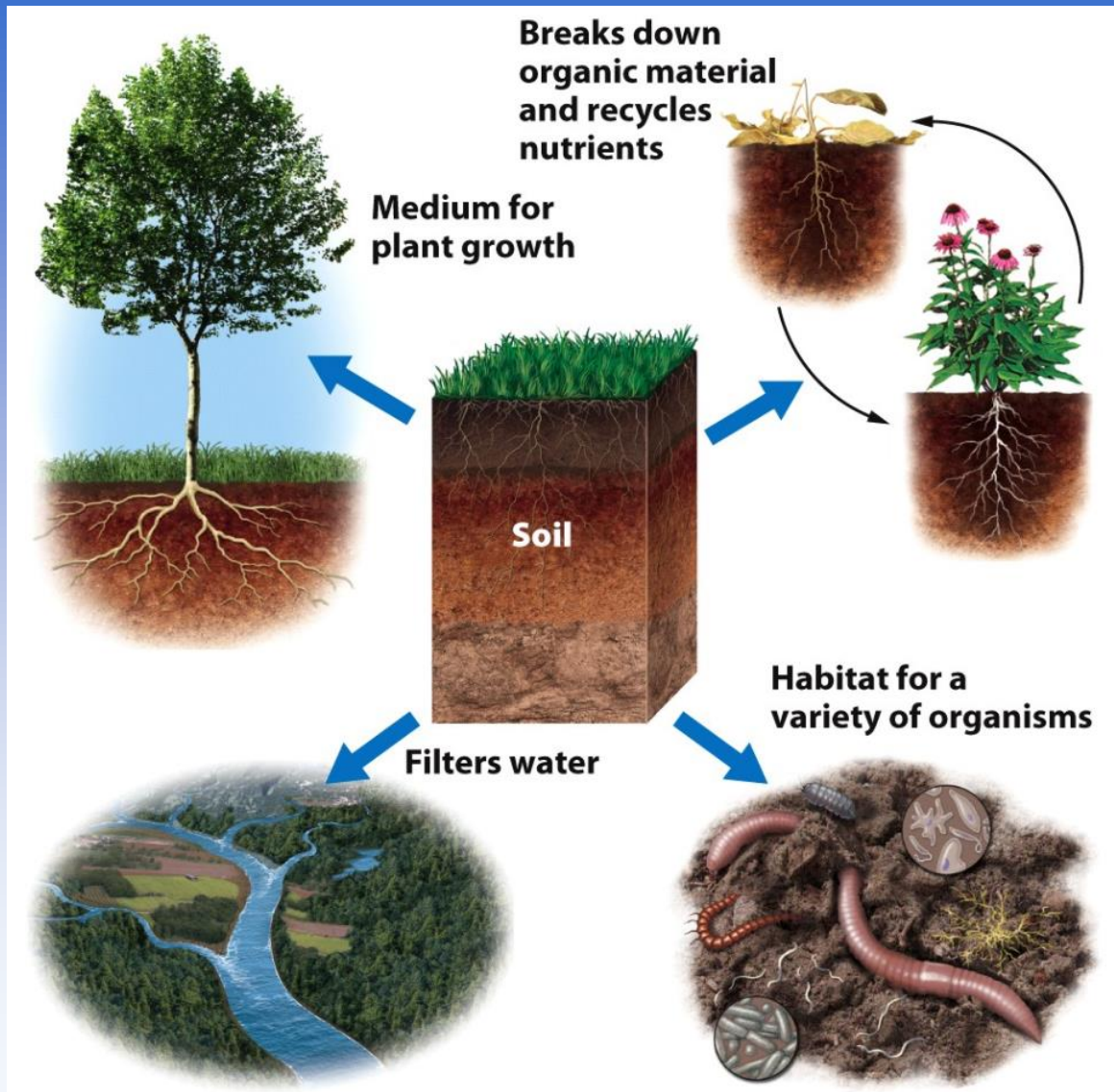


Figure 8.19
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The Formation of Soil

- Factors that determine the formation of soil (they work simultaneously):
  - **Parent material** (rock material underlying it, inorganic) - what the soil is made from influences soil formation

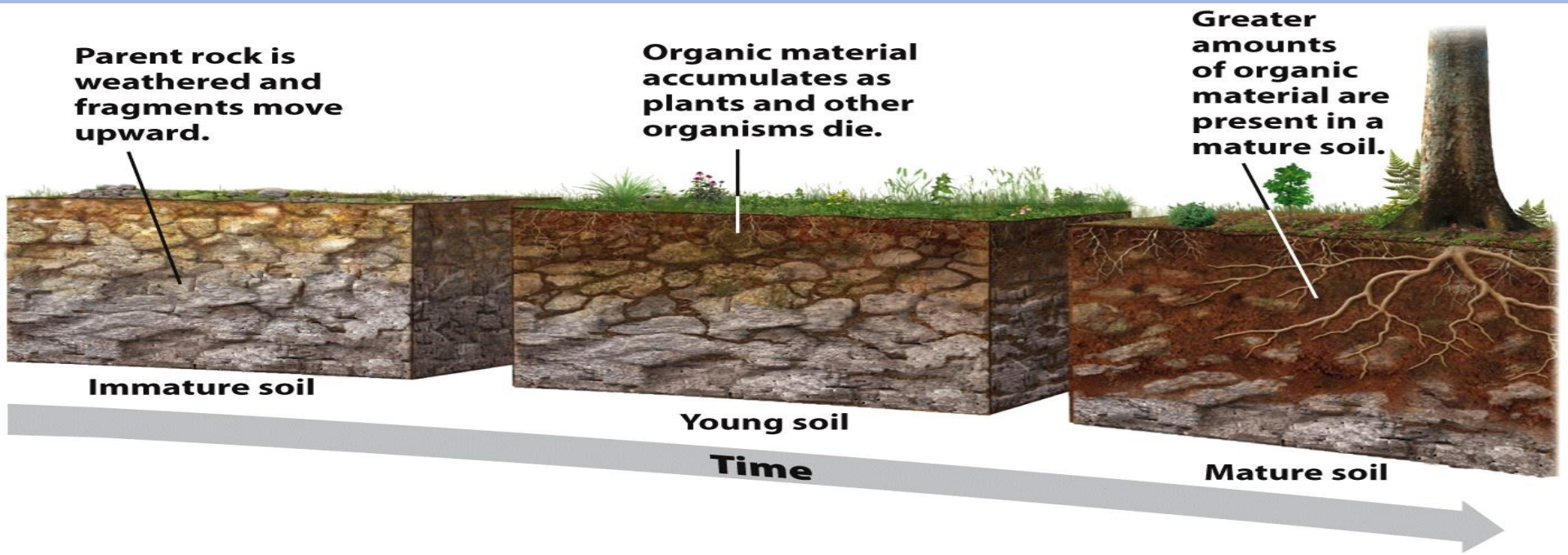

Figure 8.20
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- **Climate**- what type of climate influences soil formation (below temps, bad for soil, decomposition and water movement is slow)
- **Topography**- the surface and slope can influence soil formation (disruption)
- **Organisms**- plants and animals can have an effect on soil formation
- **Time**- the amount of time a soil has spent developing can determine soil properties.

Soil Horizons

- As soils form, they develop characteristics layers.
- If present...

E horizon- (zone of leaching or eluviation) forms under O or A horizon (less often), collects & transports (to B horizon) excess Fe, Al, & other organic acids

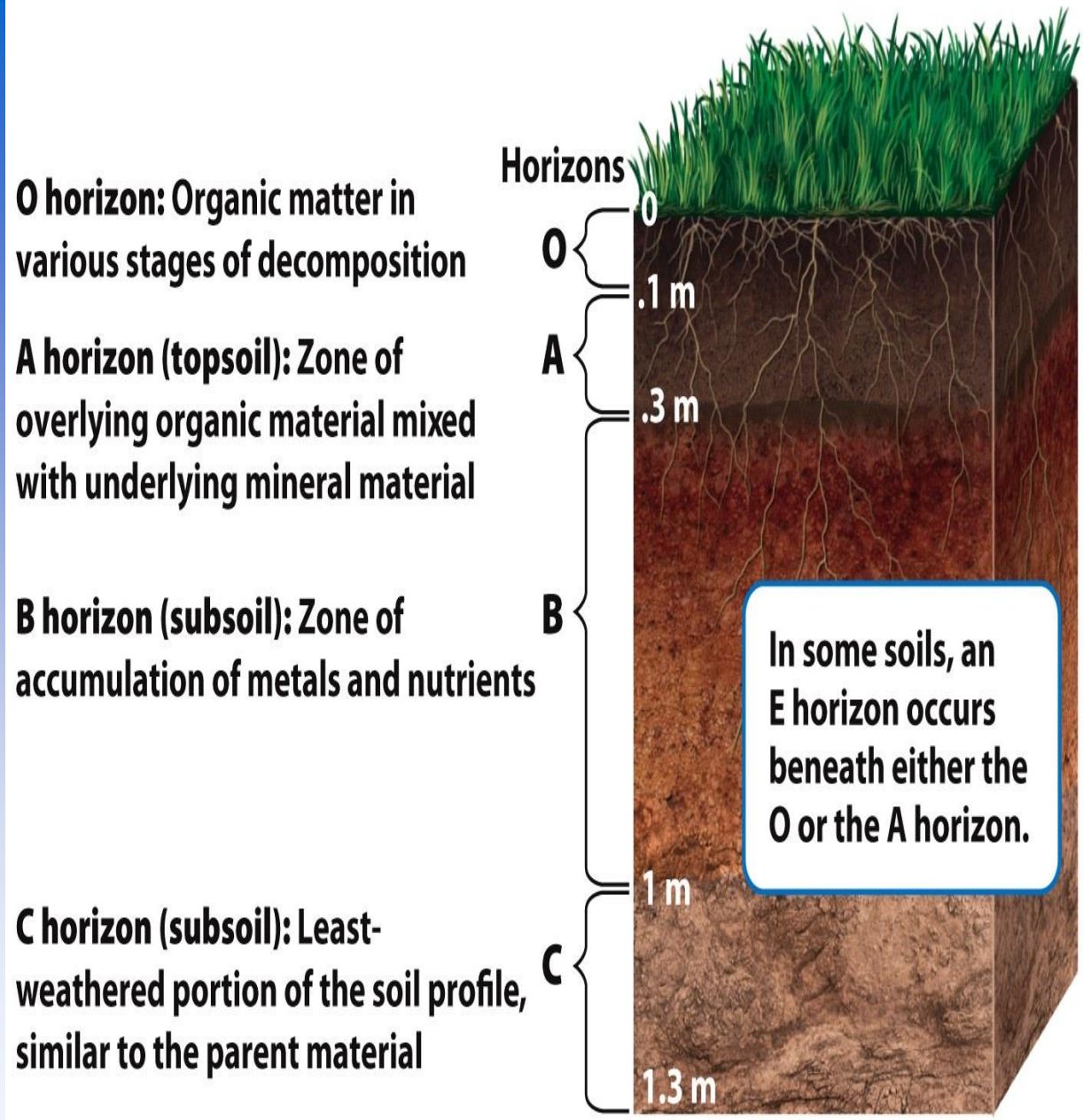

Figure 8.21
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Soil Horizons

- O horizon- (organic layer) composed of the leaves, needles, twigs and animal bodies on the surface.
- A horizon- (topsoil) the 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 and is similar to the parent material.

Physical Properties of Soil

- **Texture**- the percentage of sand(40%), silt (40%) and clay (20%) the soil contains (LOAM).
- *Porosity of soil* – how quickly soil drains.

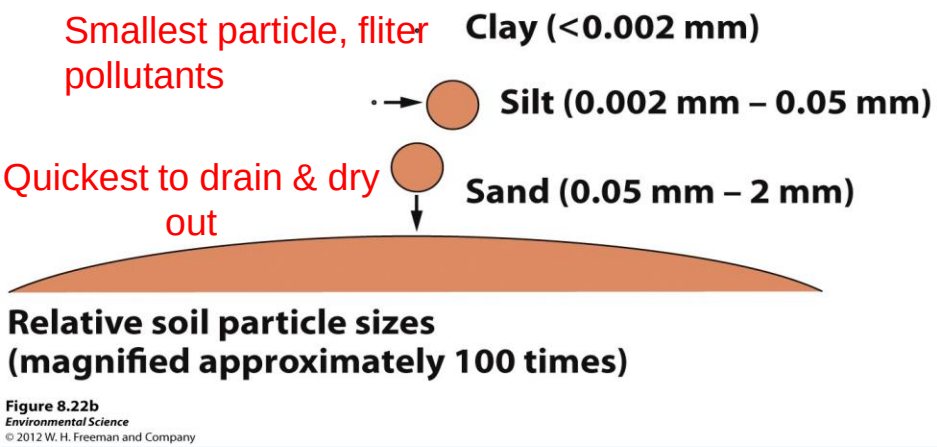

Figure 8.22b
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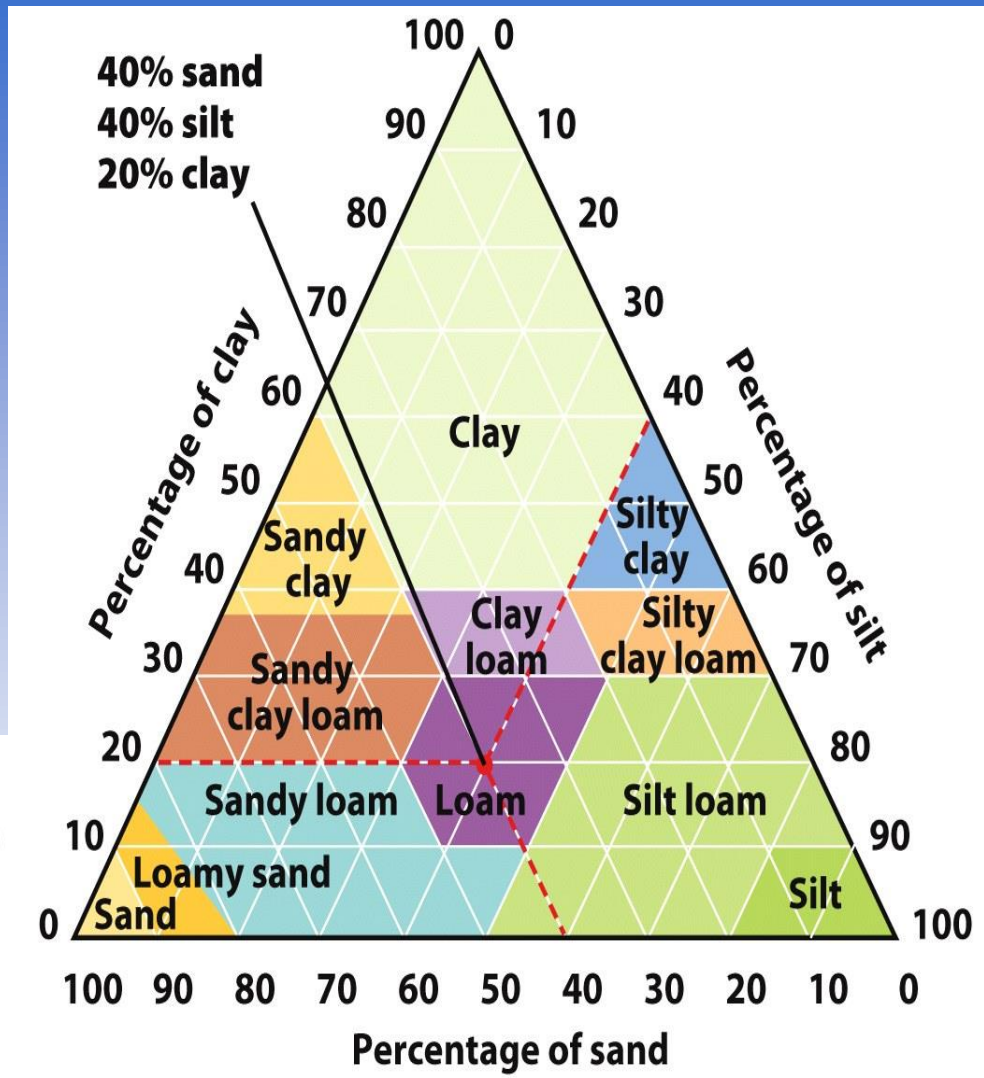
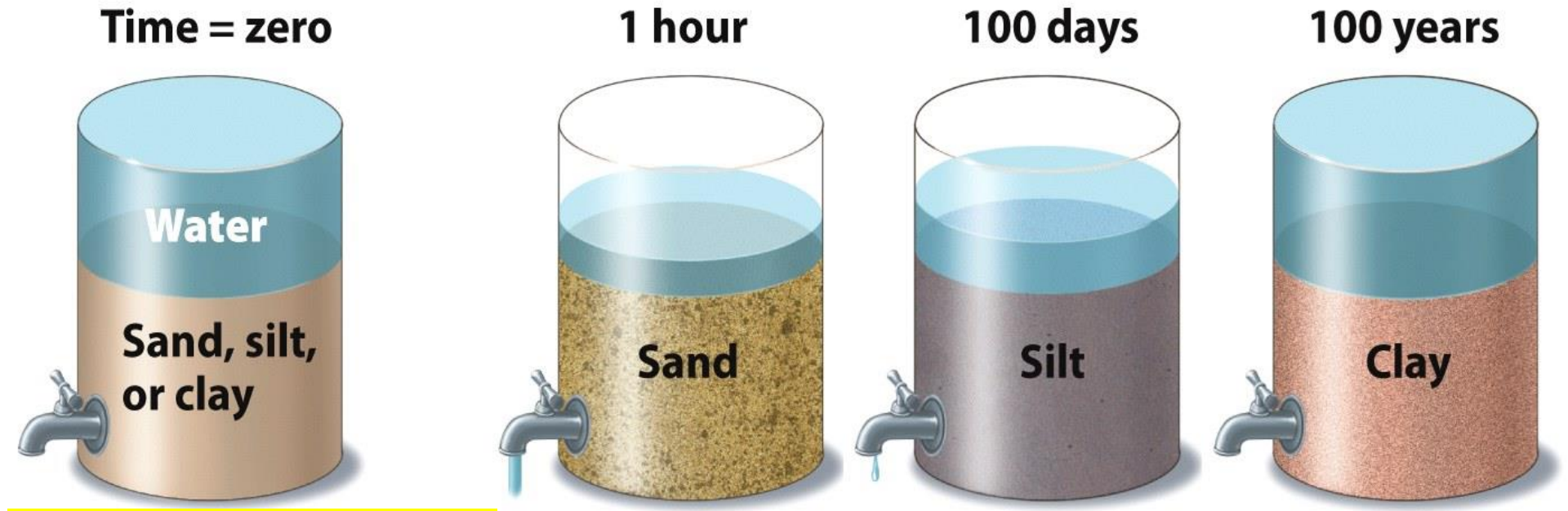


Soil texture chart

Figure 8.22a
Environmental Science

Physical Properties of Soil

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



Ideal…balance mixture of sand (40%), silt (40%) and Clay(20%)for draining and

Loosely packed, lots of drainage of water

Intermediate in size and drainage of water

Less pore space, little/no drainage of water

Chemical Properties of Soil

- **Cation exchange capacity(CEC)-** the ability of a soil to adsorb and release cations, positively charged mineral ions (*Clay*, negatively charged, absorbs positively charged cations).

  - High CEC's = desirable for agriculture
  - Clay higher than 20%, soil becomes waterlogged, high water retention

Relationship btwn soil bases and soil acids due to the neutralizations processes.

- **Soil bases-** calcium, magnesium, potassium and sodium
- **Soil Acids-** aluminum and hydrogen

Soil acids are generally detrimental to plant nutrition, while Soil Bases ten to promote plant growth

- **Base saturation-** the proportion of soil bases to soil acids, expressed in percentage.

CEC & base saturation are determinant of overall ecosystem productivity.

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Biological Properties of Soil

- Many **organisms are found in the soil** including fungi, bacteria, protozoans (all 3 together 90%), rodents and earthworms.

Majority of soil organisms are Detritivores

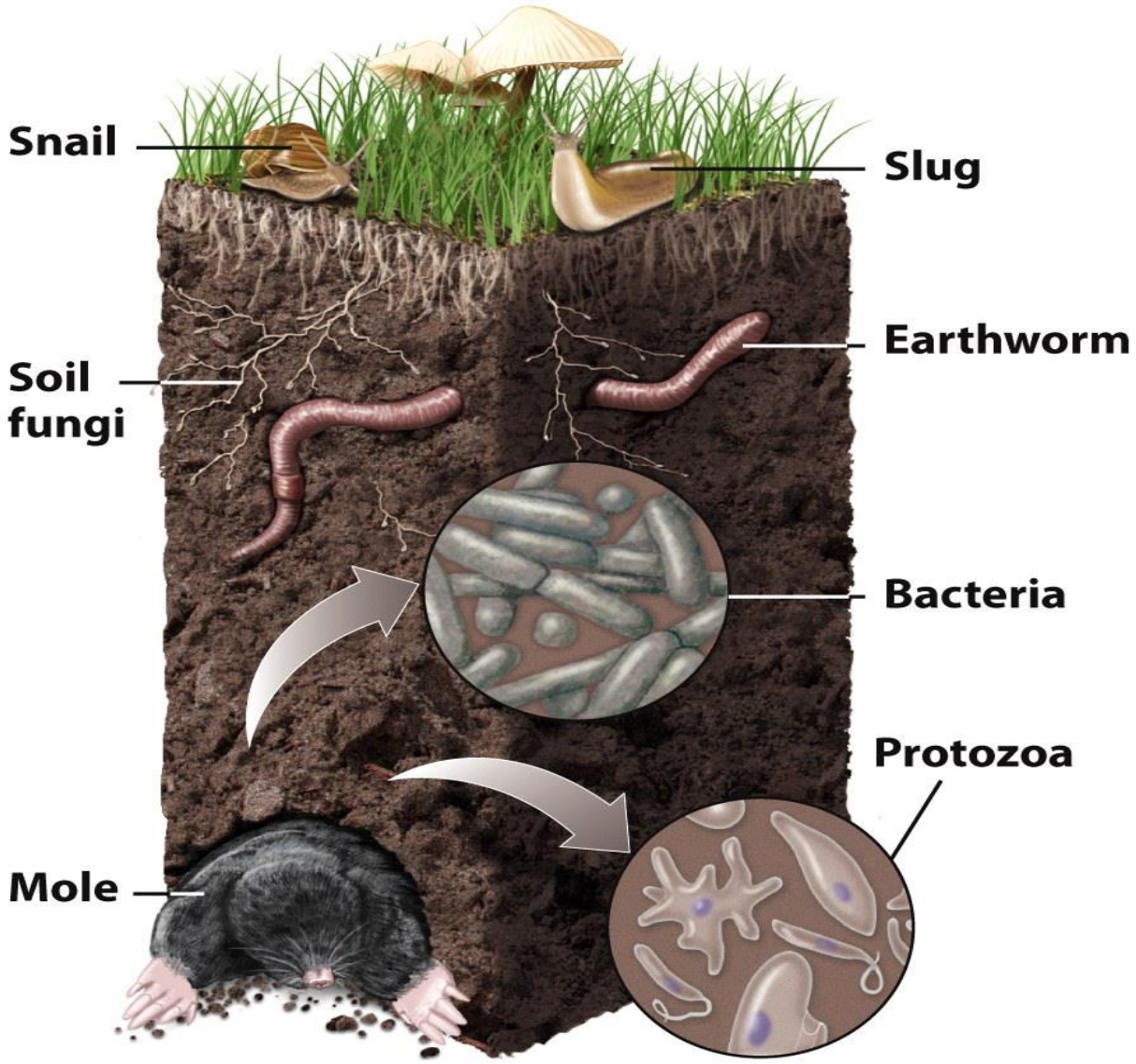

Figure 8.24
Environmental Science

- **Soil Degradation** – the loss of some or all of the ability of soils to support plant growth.

- One of the **major causes of soil degradation** is soil **erosion**, which occurs when topsoil is disturbed. (plowing, vegetation is removed, erosion by wind or water occurs).

- Once topsoil is lost, it may take up to centuries to replace it.

Reserves

- **Reserves**- the 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

Types of Mining

1. **Surface mining-** removing minerals or ore deposits that are close to Earth's surface.
   - **Strip mining-** removing strips of soil and rock to expose **ore** (concentrated accumulations of minerals, economically valuable material)
     - **Mining spoils/tailings** – returned unwanted waste material to the hole
   - **Open pit mining-** the creation of a large pit or hole in the ground that is visible from the surface (ex. copper mines).
     - Largest one Kennecott Bingham Canyon near Salt Lake City, Utah

- **Mountain top removal-** removing the entire top of a mountain with explosives (often near or in a stream & rivers).
- **Placer mining-** looking for metals and stones in river sediments (California Gold rush).

Types of Mining

2. **Subsurface mining-** mining for resources that are 100 m below Earth's surface (use of tunnels and vertical shafts).

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
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Mining Methods

Determined by the resource location and formation

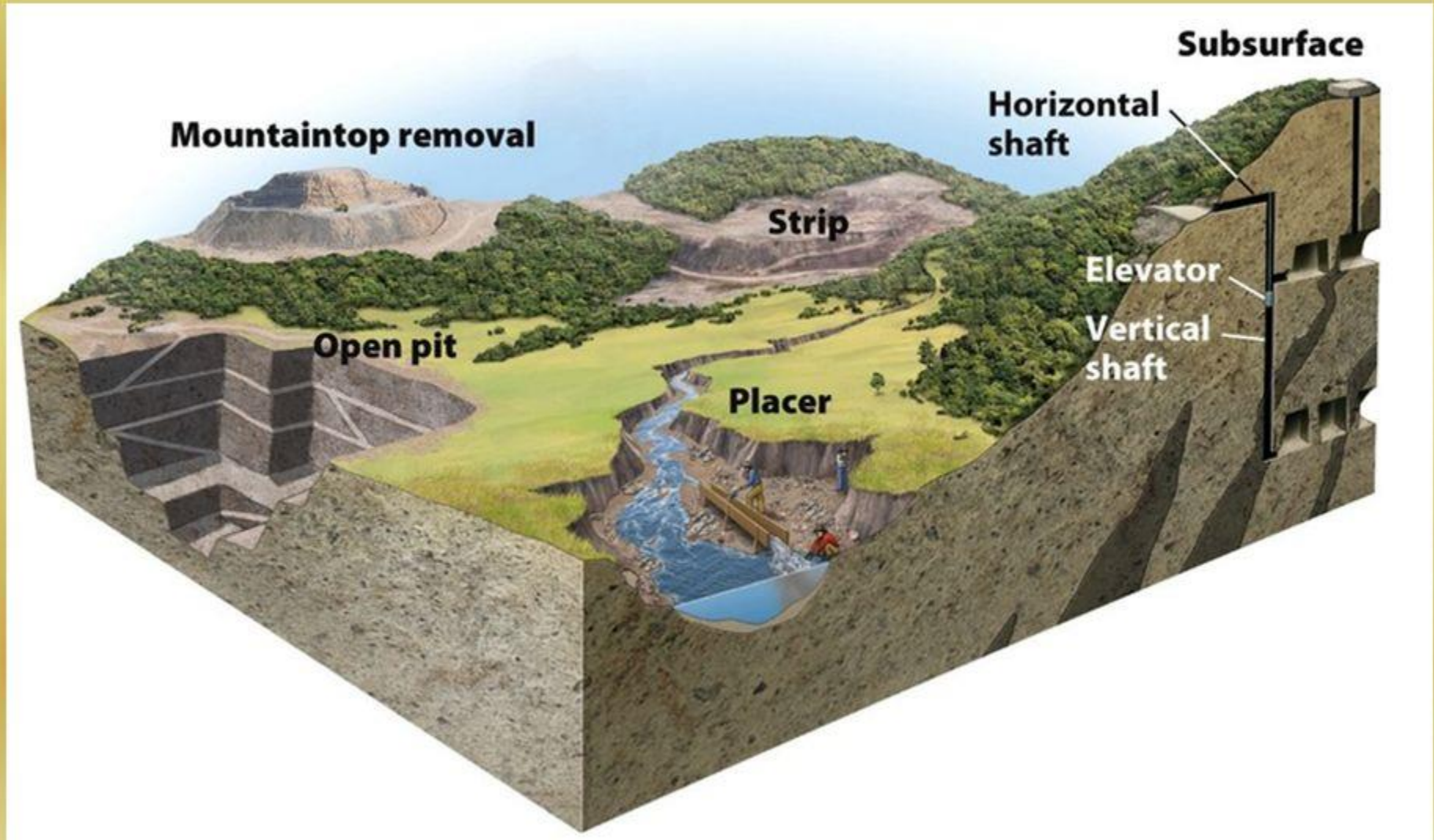

Figure 8.27 **Surface and subsurface mining.** Surface mining methods include strip, open pit, mountaintop removal, and placer mining.

Mining Legislations

- **Mining Law of 1872 (General Mining Act)** – passed by U.S Congress, regulating the mining of sliver, copper and gold ore as well as fuels, including natural gas and oil, on federal lands.
  - Allowing individuals and/or companies to recover ores or fuels from federal lands

- **Surface Mining Control & Reclamation Act of 1977** – regulates surface mining of coal and the surface effects of subsurface coal mining.
  - Act mandates that land be minimally disturbed during the mining process and reclaimed after mining is completed.

Mining Legislation DOES NOT regulate all the mining practices that can have harmful effects on air, water and land (other acts Clean Air Act, Clean Water Act, Superfund Act).

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