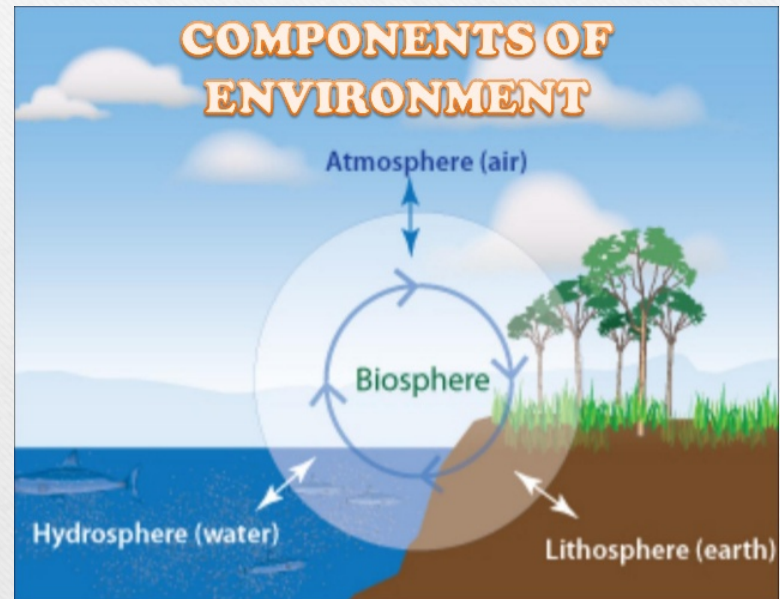


# Ecosystems and The physical environment

# The Physical Environment: The Cycling of Matter and Energy

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- The Atmosphere (Air)
  - Layers, circulation
  - Solar irradiation
- The Hydrosphere (Water)
  - Hydrologic cycle
  - Circulation in the ocean
- Air and Ocean Interactions
  - Weather and global climate change





# The Hydrosphere



# Global Oceans Circulation

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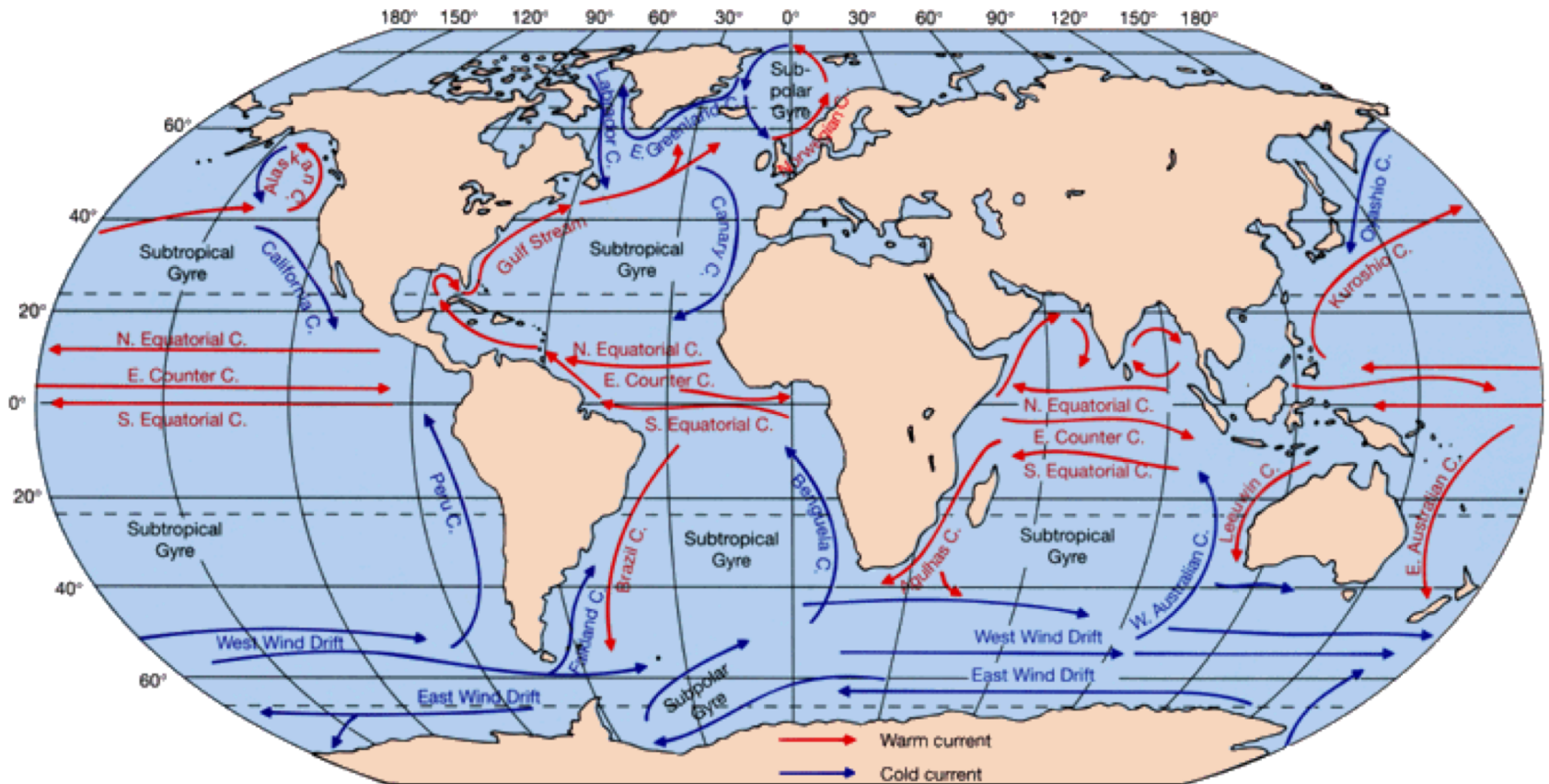
- Oceans: Huge bodies of salt water covering  $\frac{3}{4}$  of the Earth's surface.
- The atmosphere and the ocean interact to produce ocean circulation
- Major circulations:
  - Currents and Gyres (circular currents)
- Can be divided into two main components:
  - Wind-driven surface circulation: Prevailing winds blowing over the ocean. Fast and energetic.
  - Density-driven: Dominates the deep sea. Slow and large.





# The Hydrosphere

## Wind-Driven Surface Currents in February and March



© 1996 by Prentice-Hall, Inc.



# Global Oceans Circulation

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- Also affected by the position of landmasses (e.g. continents)
- The Coriolis effect (from earth's W to E rotation)
- Northern Hemisphere: counterclockwise current pattern
- Southern Hemisphere: clockwise current pattern

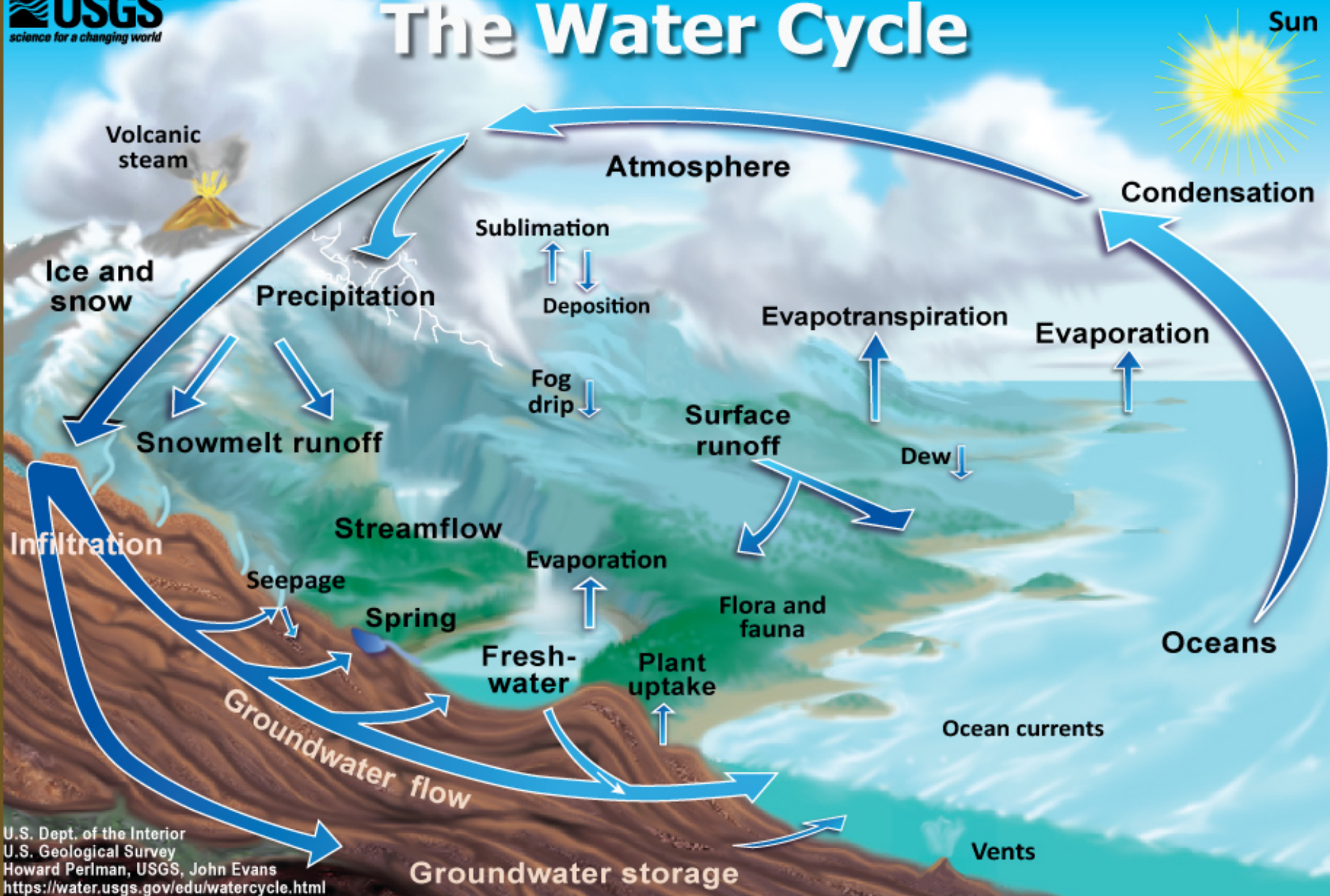


# Coriolis Effect

<https://www.youtube.com/watch?v=2Djg4XQVP>

[Hw](#)

# The Water Cycle



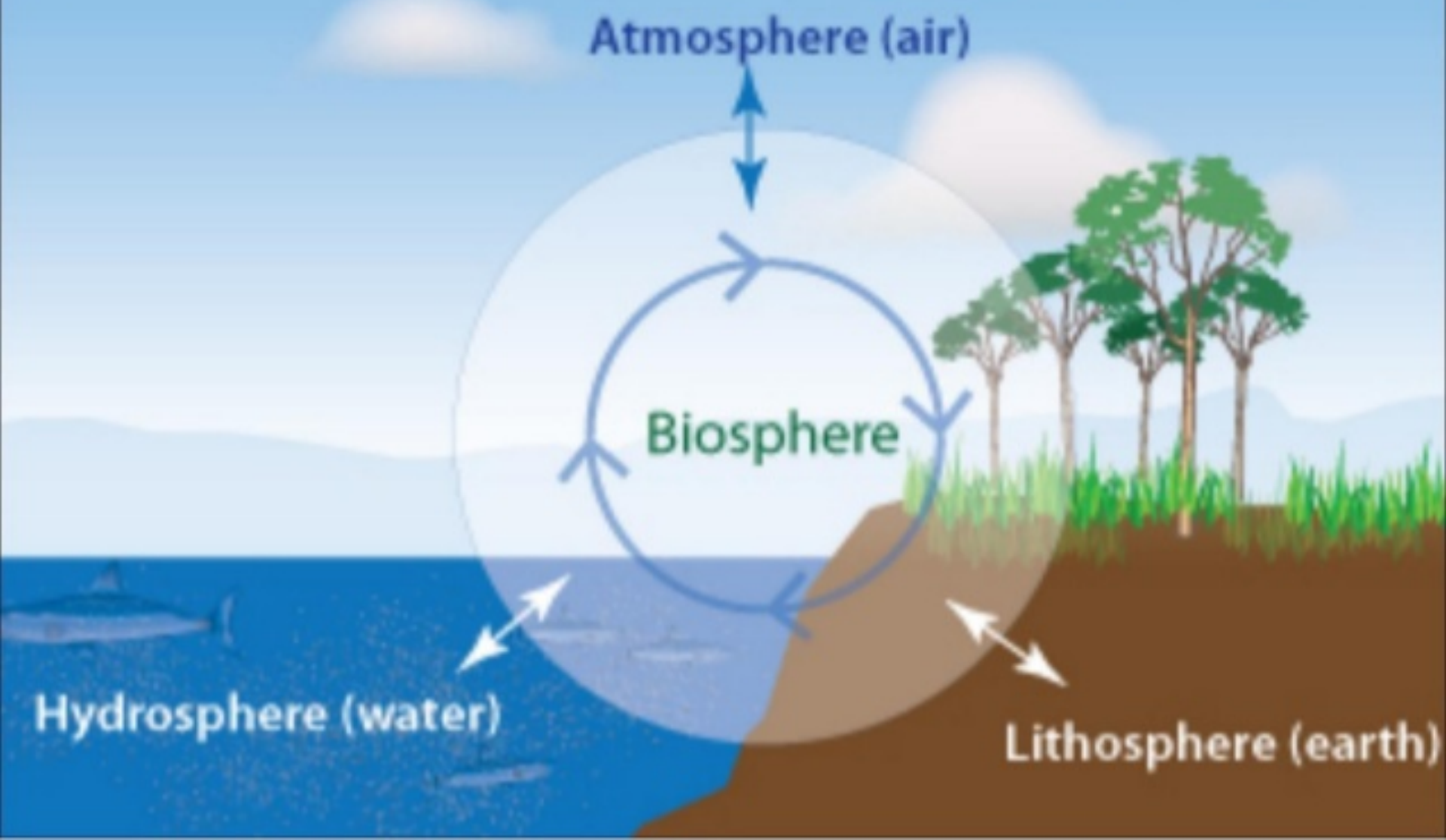


# Matter is moved through earth's systems in numerous cycles (the biogeochemical cycles)

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- The Hydrological Cycle
- The Carbon Cycle
- The Nitrogen Cycle
- The Phosphorous cycle
- The Sulfur cycle

# COMPONENTS OF ENVIRONMENT







# The Lithosphere

Mudslide in Oso, WA (2014)



# Overview of Lecture

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- ❖ Composition of the Lithosphere
- ❖ The Soil System
- ❖ Soil Properties and Major Soil Types

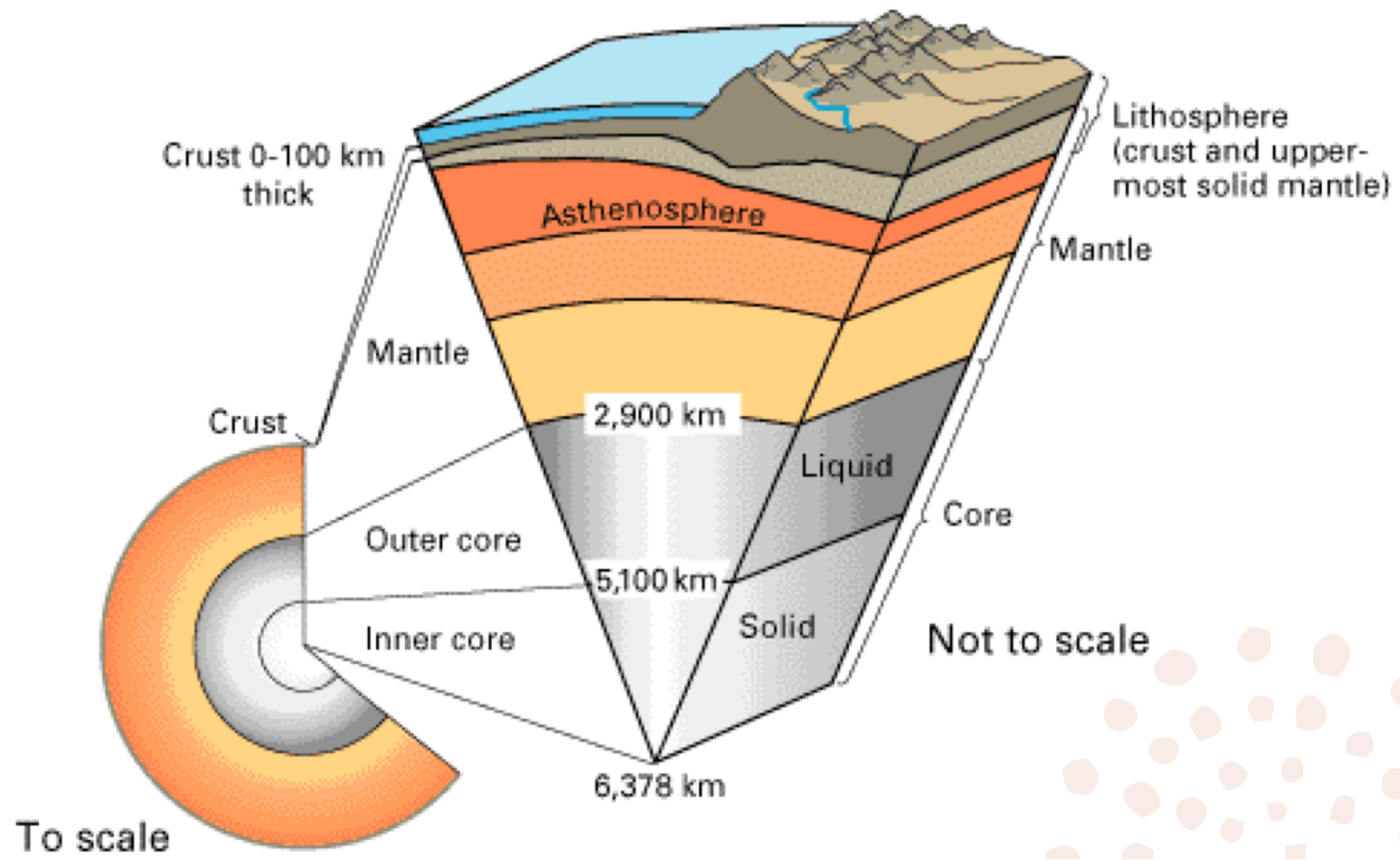


Anders Blomqvist / Getty Images

# The Lithosphere

[*lithos*] for "rocky", and [*sphaira*] for "sphere".

Is the rigid (rocky), outermost shell of a terrestrial-type planet, that is defined by its rigid mechanical properties.





# The Lithosphere

- Consists of ***tectonic plates***. There are two types: oceanic and continental.
- There are eight major and many minor plates.
- Earthquakes, volcanic activity, mountain-building, and oceanic trench formation occur along plate boundaries (faults).



# The Soil

Thin, uppermost layer of earth's crust



Leung Vai Chi, Rosanna / Getty Images

- ❖ Supports plants, animals, fungi, agriculture, food webs, and microorganisms
- ❖ Consists of minerals and organic matter

# State Factors: Soil Forming Factors

- **Weathering of parent material** (*bedrock that slowly breaks down into smaller particles*) due to biological, physical, chemical processes.
- **Time** (*thousands of years*): 20—1000y for 1in (2.5cm) of soil to form; continuous process
- **Climate** air and water (e.g. runoff),  $\text{CO}_2$
- **Organisms** produce organic matter and acids or  $\text{CO}_2$  (which diffuses and reacts with  $\text{H}_2\text{O}$  to produce  $\text{H}_2\text{CO}_3$  (Carbonic acid)), which etch tiny cracks in the rock
  - Humans?
- **Topography** surface features, e.g. mountains can not hold soil due to gravity



# Soil Composition is layered

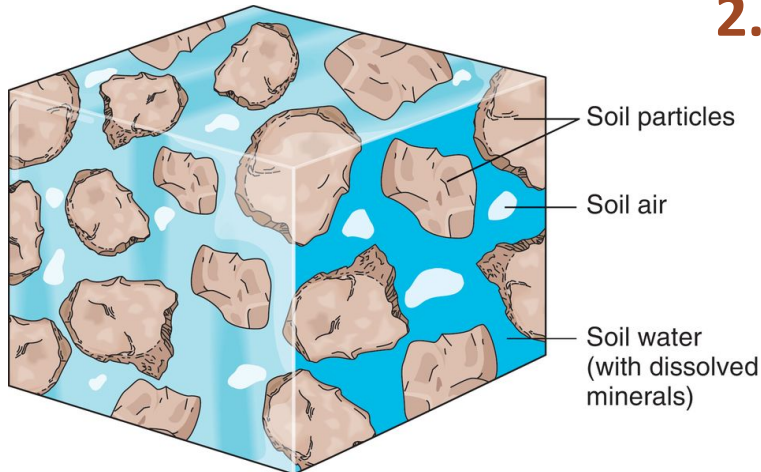
## “typical soil”

### 1. Mineral Particles (45%)

- Weathered rock, provides anchorage

### 2. Organic Material (5%)

- Litter, animal dung, dead remains of plants and animals
- Humus – black organic matter remaining after most decomposition (returns Nutrients to the soil)
- *Collective name for many different organic compounds*



### 3. Water (25%)

Help in producing aerated moist soil

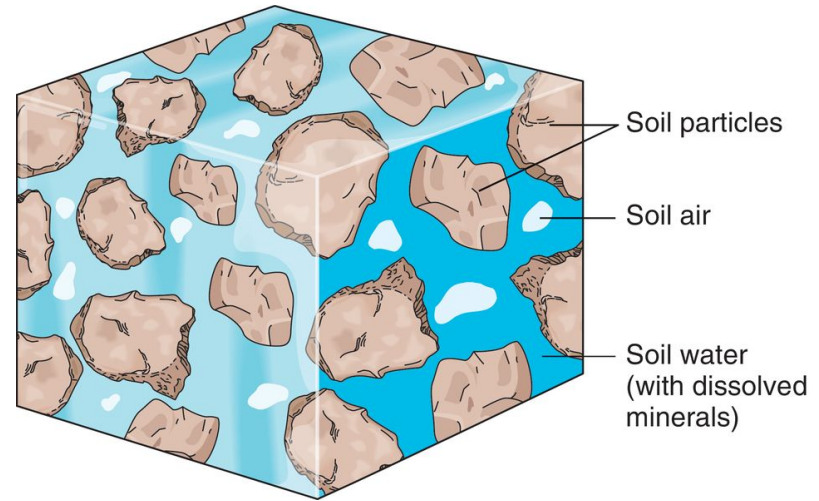
### 4. Air (25%)

# Soil Composition

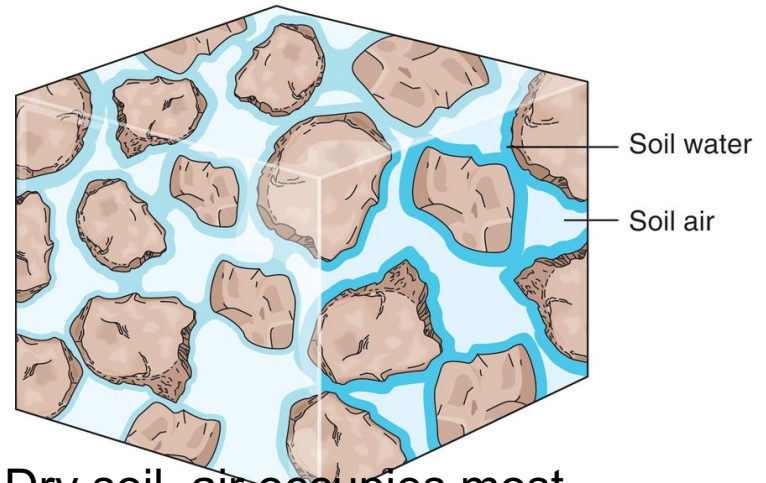
## “typical soil”

### Pore space (50%)

- Soil air - good for aeration
- Soil water - provides water to roots



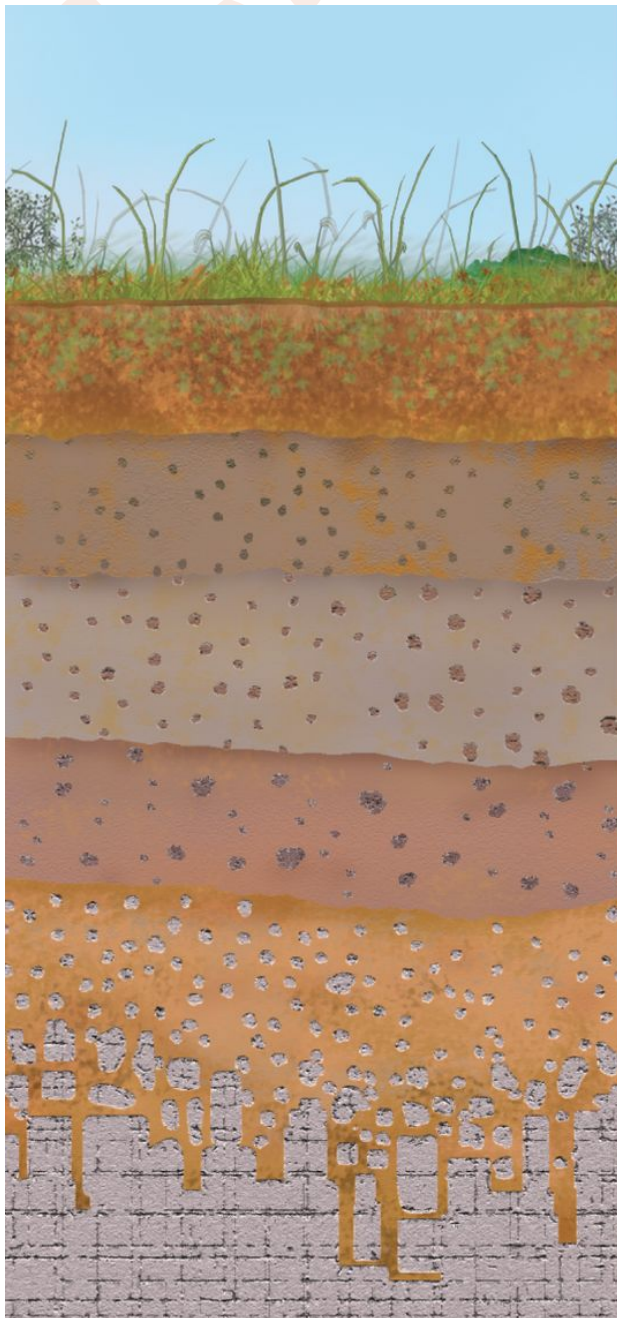
Wet soil, pore space is filled with water



Dry soil, air occupies most of the space

# Soil Horizons

soil profile



## **O-horizon**

(accumulation of plant litter)

## **A-horizon**

(accumulation of organic matter and humus)

## **E-horizon**

(heavily leached)

## **B-horizon**

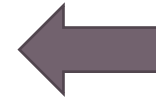
(accumulation of clay and nutrient minerals)

## **C-horizon**

(weathered pieces of rock)

## **Solid parent material**

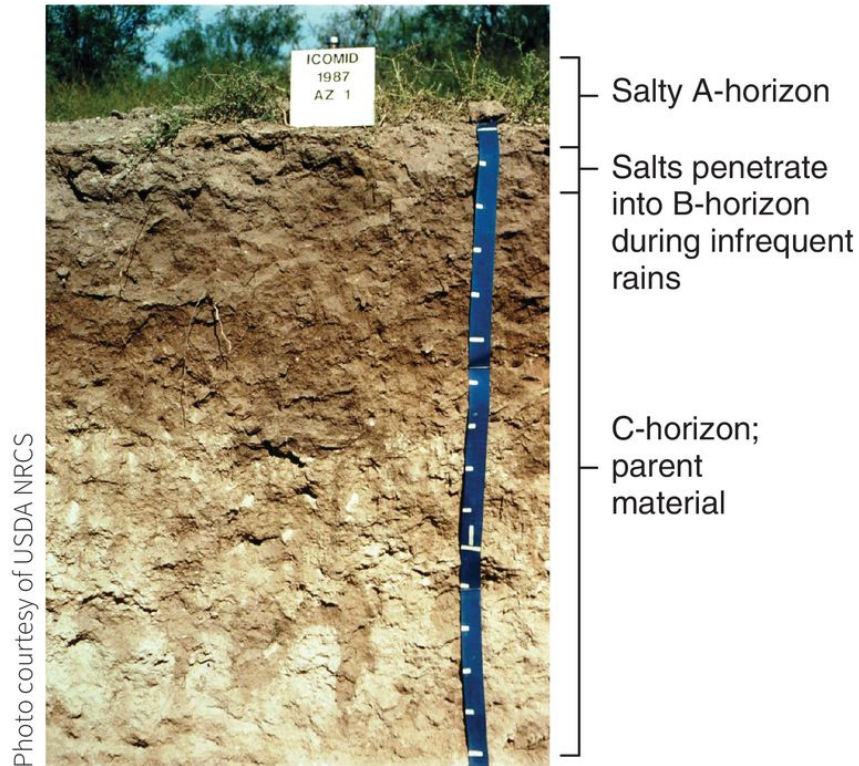
(bedrock)



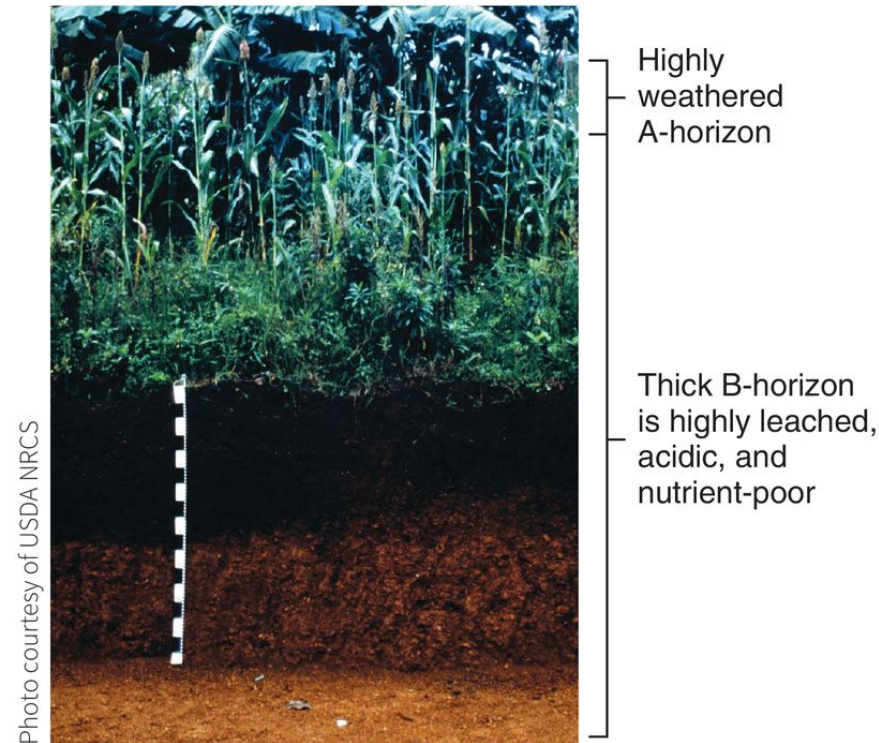
Topsoil



# Major Soil Groups



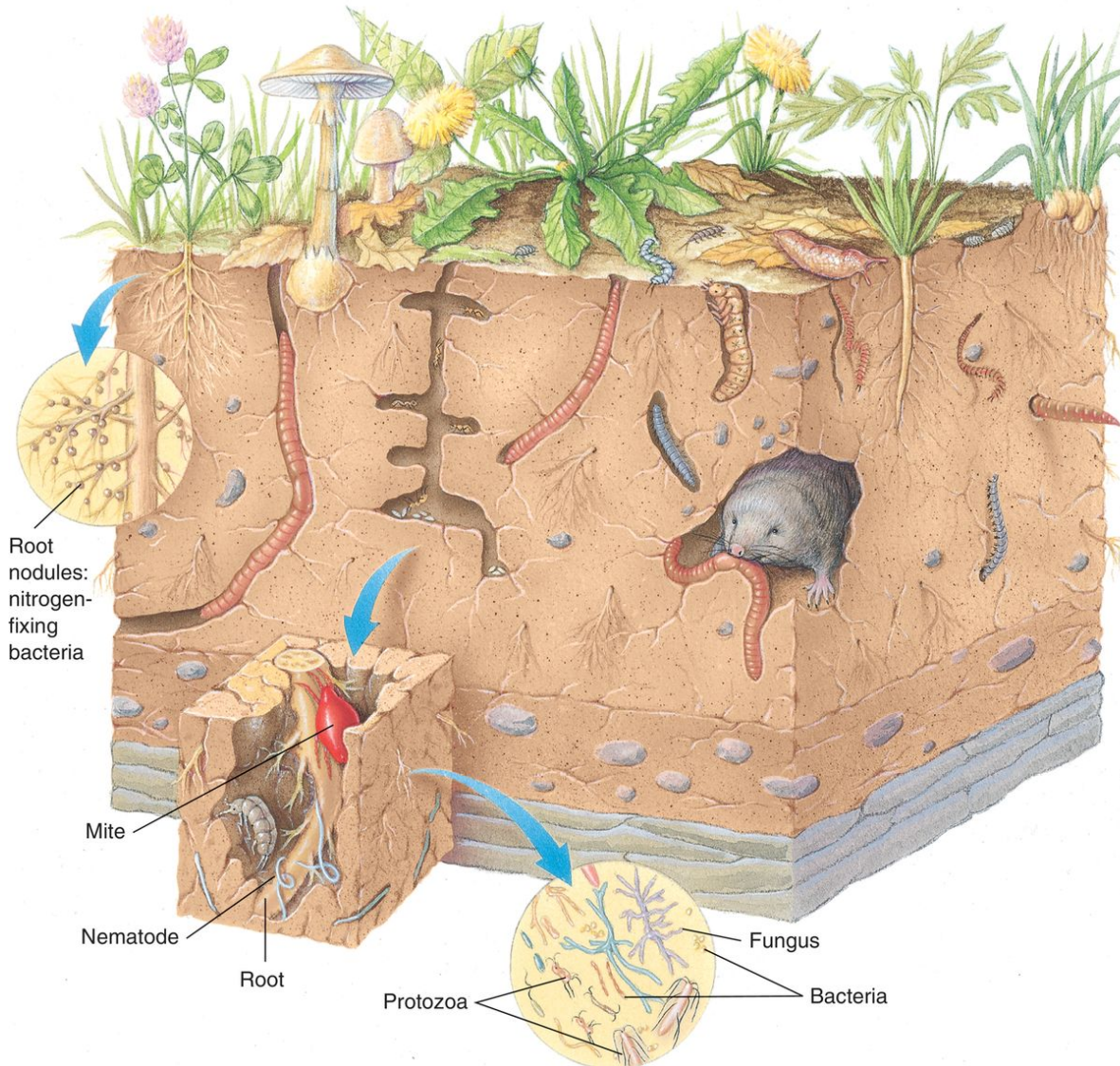
Aridisols



Oxisols



# Soil Organisms



- ❖ Soil bacteria often number in the hundreds of millions per gram of soil.
- ❖ Scientists have identified about 170,000 species of soil organisms



# Soil Organisms

There are millions of microorganisms in 1 tsp of fertile agricultural soil

Soil organisms provide ecosystem services (Important environmental benefits that ecosystems provide)

- ✓ Decaying and **cycling organic material**
- ✓ Castings – from gut of earthworms
- ✓ Breaking down toxic materials
- ✓ Cleansing water
- ✓ Soil aeration
- ✓ Mycorrhizae ( $N_2$  fixation)



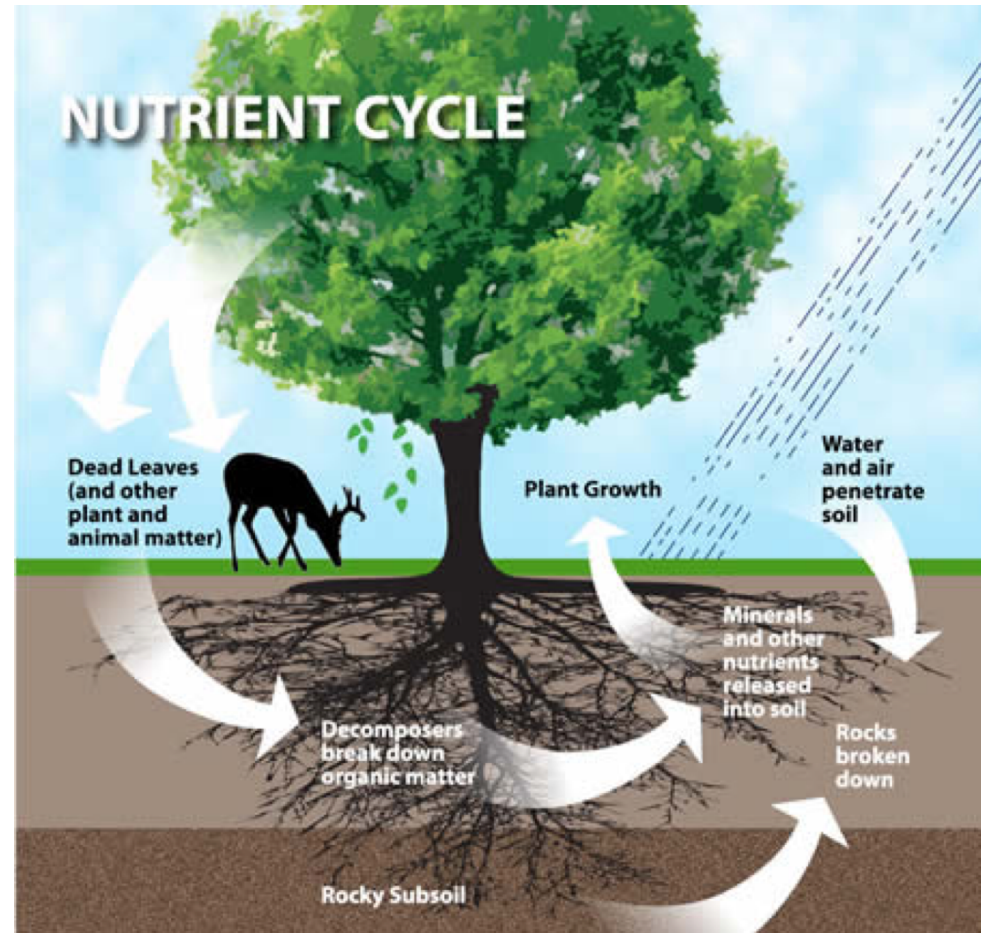
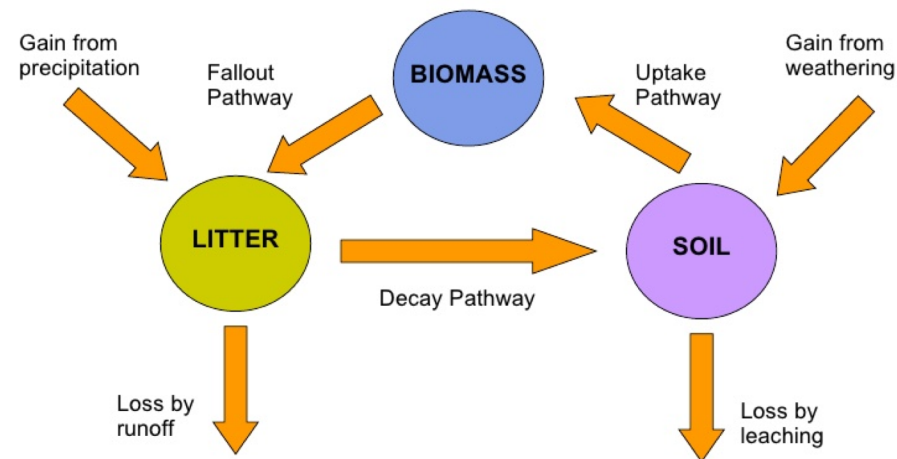


# Nutrient Cycling

The pathway of various nutrient minerals or elements from the environment through organisms and back to the environment

$N_2$ , C, P, S

## Nutrient Cycle



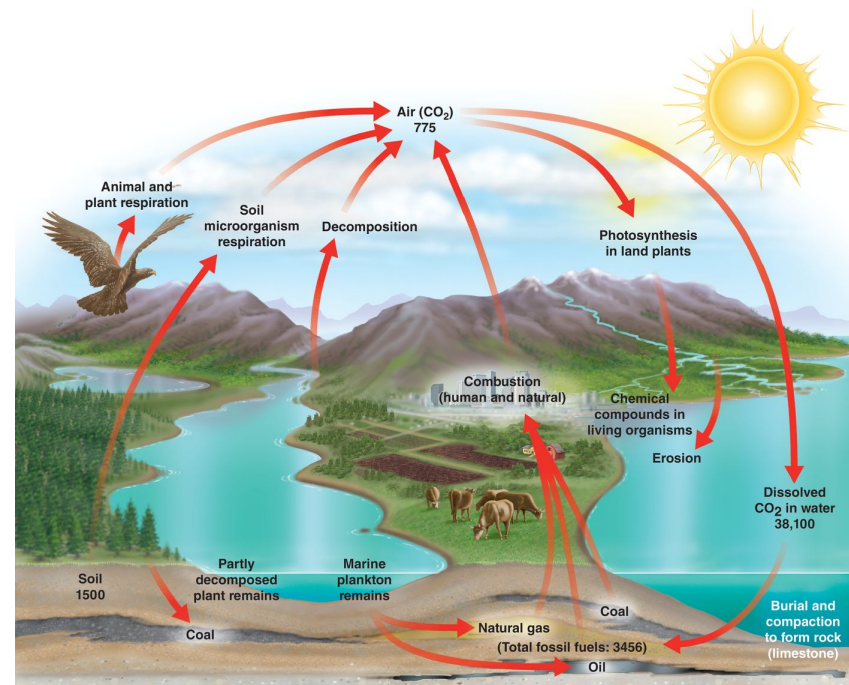
Soil fertility

# The Carbon (C) Cycle

Molecules essential for life: Proteins, Carbohydrates

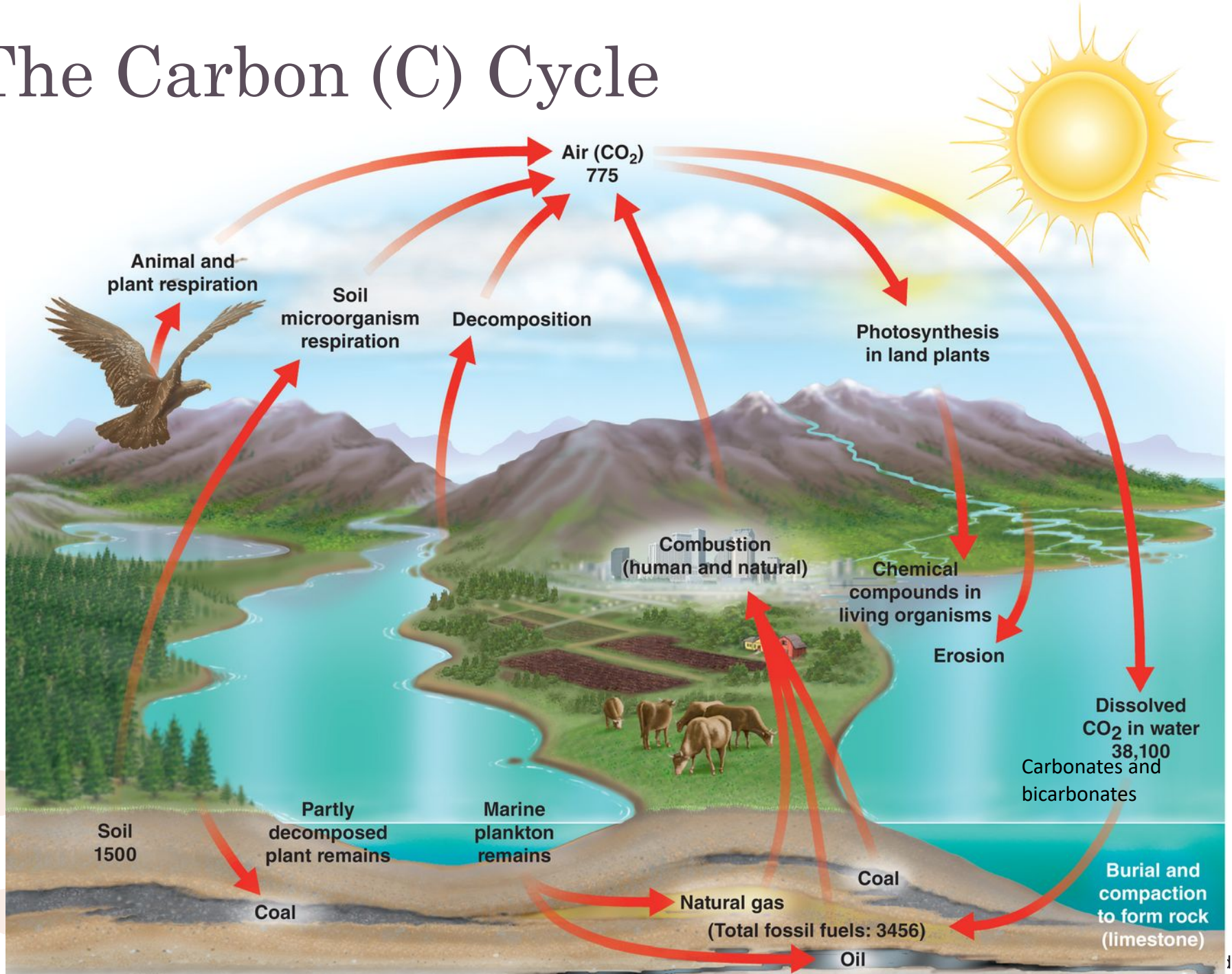
## Major Processes

- ▣ Photosynthesis
- ▣ Respiration
- ▣ Decomposition (Soil, in particular)
- ▣ Combustion of fossil fuels
- ▣ CO<sub>2</sub> dissolving into ocean





# The Carbon (C) Cycle





# Human-induced changes on C Cycle?

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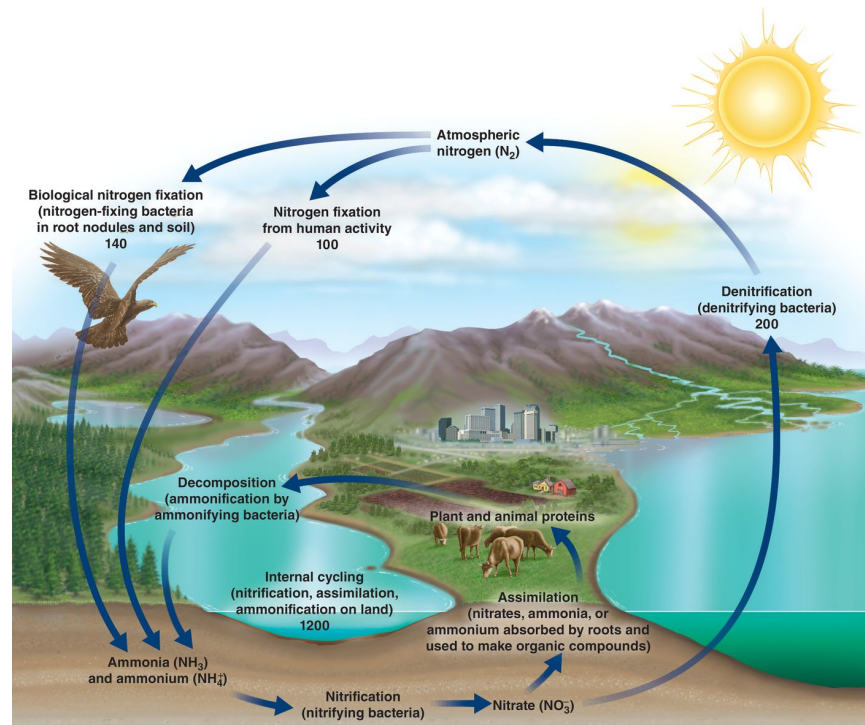
- CO<sub>2</sub> was 0.029% of atmosphere (1700s)
- CO<sub>2</sub> is 0.04% (2014)
- Expected 0.06% by 2100
- Higher CO<sub>2</sub> creates lots of feedbacks in environment
  - ▣ > CO<sub>2</sub> dissolved in ocean

# The Nitrogen (N) Cycle

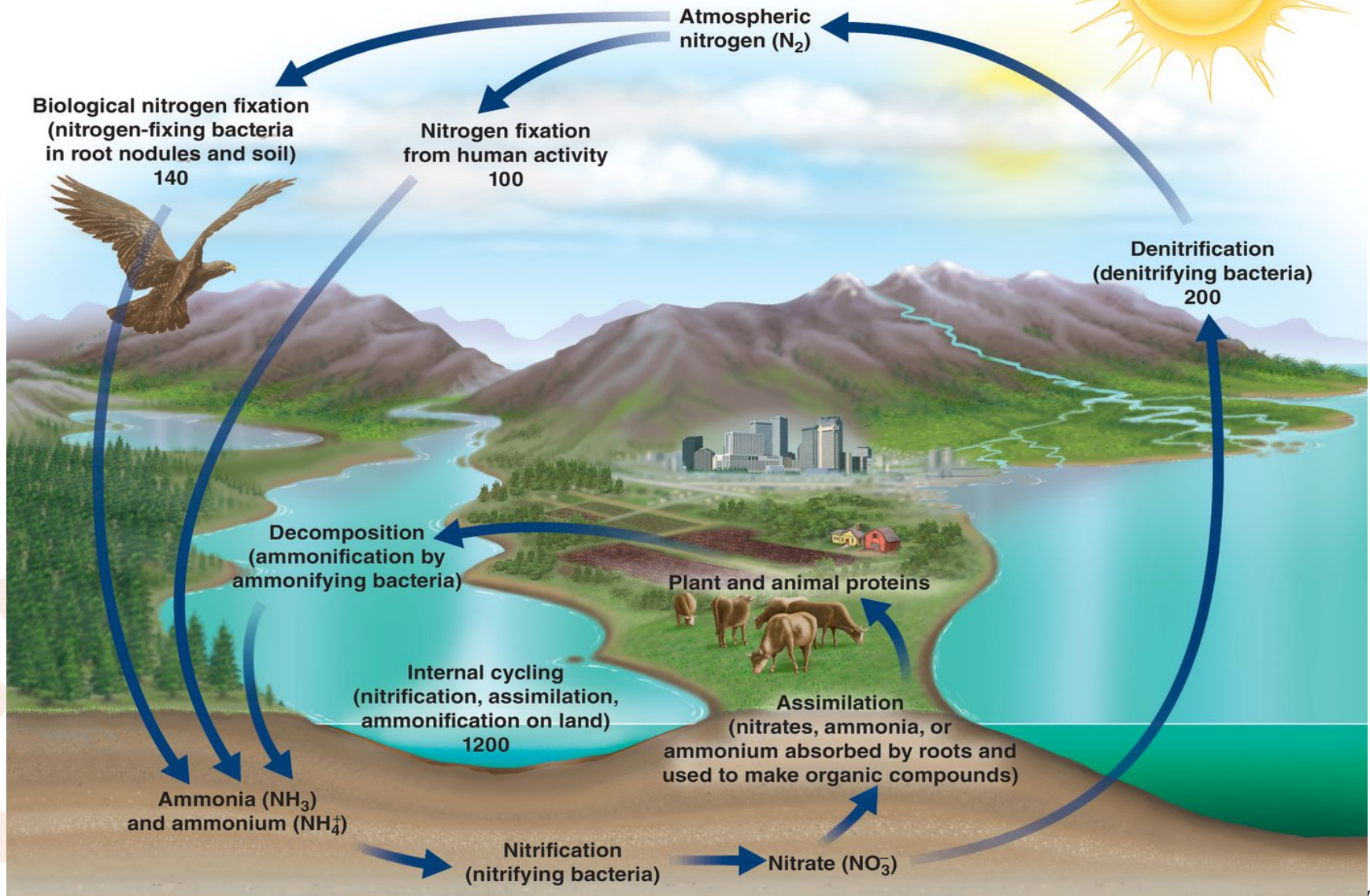
- N needed for proteins and nucleic acids (DNA)
- Atmosphere is 78%  $N_2$ , but most cannot use this form

## – Five steps

- Nitrogen fixation
- Nitrification
- Assimilation
- Ammonification
- Denitrification



# The Nitrogen Cycle





# Human Disruption of the N cycle?

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- Artificial Fertilizers
- Industrial Nitrogen fixation
- Humans doubled the amount of fixed N entering the cycle
- Has caused nutrient enrichment
  - An excess of nutrients has damaged ecosystems
  - Ex. Trough Algae blooms and Ocean Dead Zones

# Case in Point: American Dust Bowl

- Great Plains has low precipitation and is subject to drought
  - 1930–1937 severe drought
  - Crops die, soils eroded.
  - The 'black blizzards' begin. Dust begins to blow.
  - Winds blew soil as far east as NYC and DC.
  - Farmers went bankrupt
  - Families had to migrate to other states (2.5m people “the okies” left the plains)



# Case in Point: American Dust Bowl

## Causes:

- No natural vegetation (prairie grasses) roots to hold soil in place.
- Soils are good for small-scale crops and grazing.
- Grasses were replaced by annual crops (*e.g* cotton).
- Poor agricultural practices.
- Soil was depleted of nutrients.
- Extended Drought

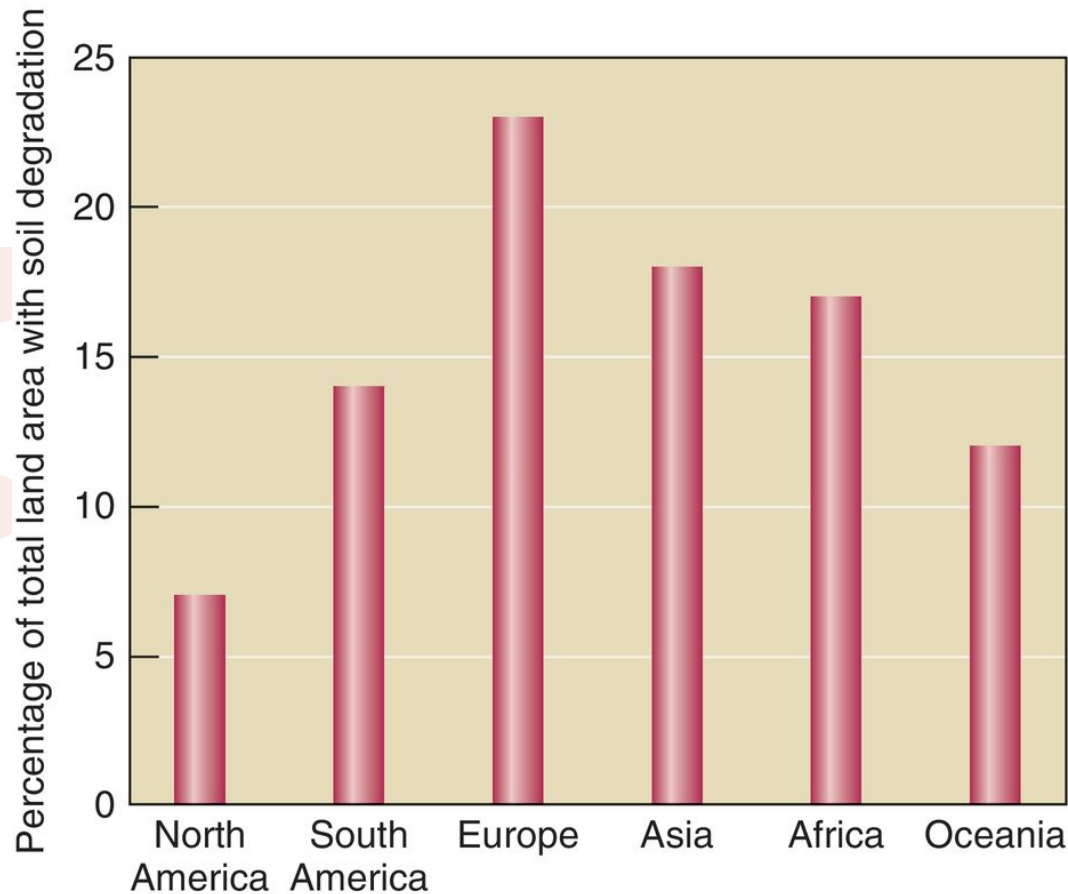




# Soil Problems:

## Soil Erosion, Desertification and Salinization

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# Soil Problems

- **Soil Erosion**

- Caused primarily by water and wind
  - Wearing away or removal of soil (usually topsoil)
- **Why a problem?**
    - Causes a loss in soil fertility as organic material and nutrients are eroded



Richard Hansen/Science Source

# Soil Problems

- **Soil Erosion**

- Why a problem?

- Causes a loss in soil fertility as organic material and nutrients are eroded
- More fertilizers must be used to replace nutrients lost to erosion
- Increases movement of sediment among ecosystems
  - *Into streams and waterways*
  - *Increases water pollution*
  - *Degradation of water infrastructure (ex: dams)*



© Joel Day/Alamy

Accelerated by poor soil management practices



# Soil Problems

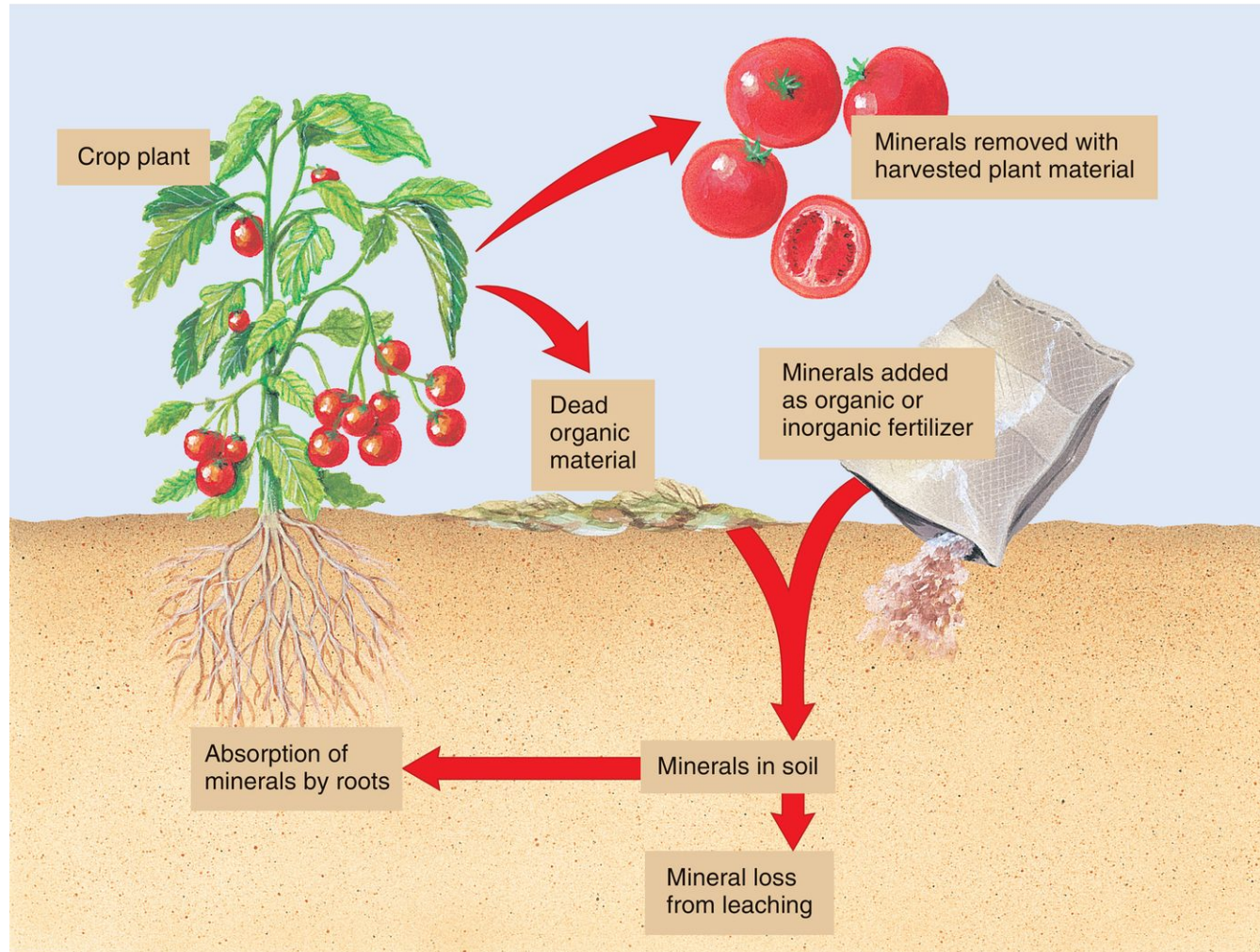
## Soil Erosion

- Water erosion in grain belt (large rainstorm can remove ~1mm, but can add up too)
- Annual loss of 75 billion metric tons of topsoil?
  - Problems from loss and problems from where it goes



© Joel Day/Alamy

# Soil Problems - Nutrient Mineral Depletion





# Soil Problems- Desertification

- Degradation of once-fertile rangeland, agricultural land, or tropical dry forest into non-productive desert



K. Tumanowicz / Science Source