

# ENVIRONMENT

*THE SCIENCE BEHIND THE STORIES*

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## Ch 7

### Environmental Systems and Ecosystem Ecology

Part 1: Foundations of  
Environmental Science

PowerPoint® Slides prepared by  
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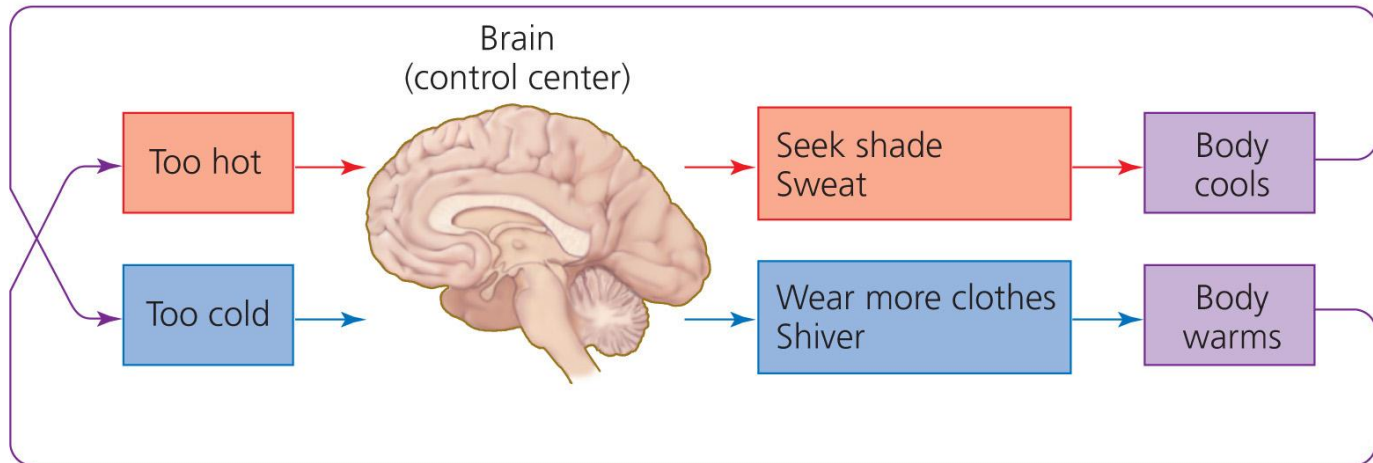
**Third Edition**

# The Earth's systems

- **System** = a network of relationships among parts elements or components that interact with and influence one another
  - Exchange of energy, matter, or information
  - Receives inputs of energy, matter, or information; processes these inputs; and produces outputs
- Systems often show behavior that is hard to understand and predict
- **Feedback loop** = a system's output serves as input to that same system
  - A circular process

# Negative feedback loop

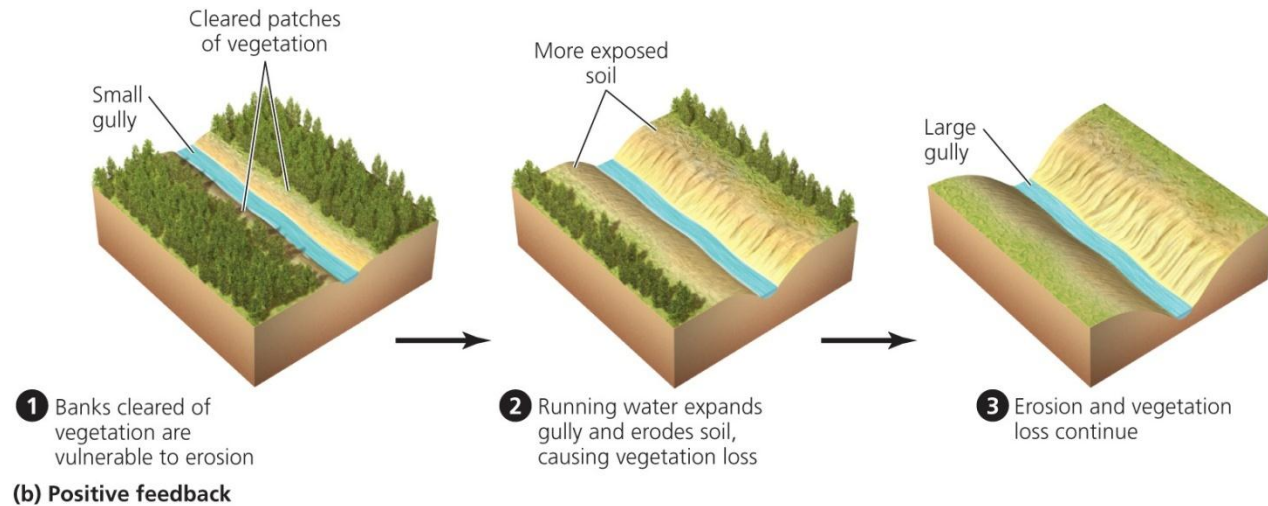
- **Negative feedback loop** = output that results from a system moving in one direction acts as input that moves the system in the other direction.
  - Input and output essentially neutralize one another
  - Stabilizes the system
  - Example: body temperature
  - Most systems in nature



(a) Negative feedback

# Positive feedback loop

- **Positive feedback loop** = instead of stabilizing a system, it drives it further toward one extreme or another
- Examples: exponential growth in human population, spread of cancer, erosion
- Rare in nature
  - *But are common in natural systems altered by human impact*



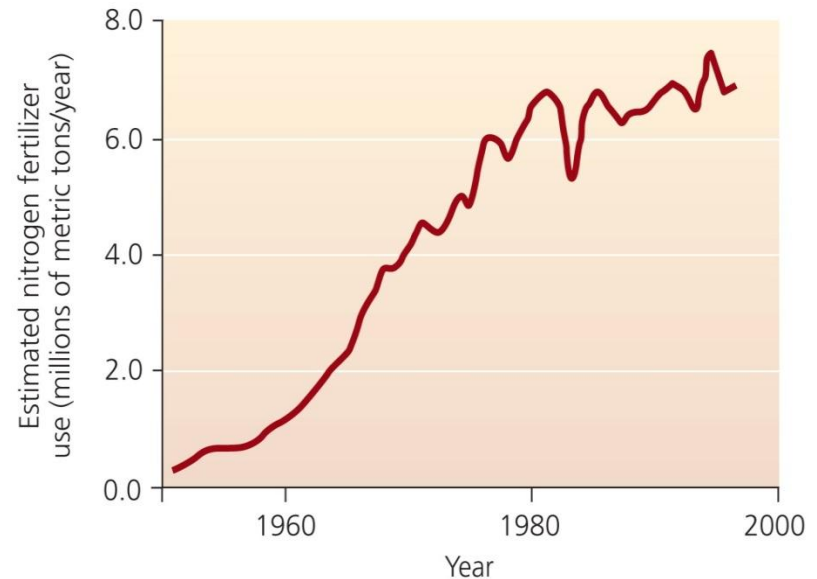
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# Systems are perceived in various ways

- Categorizing environmental systems helps make Earth's dazzling complexity comprehensible
- For example, the earth consists of structural spheres
  - **Lithosphere** = rock and sediment
  - **Atmosphere** = the air
  - **Hydrosphere** = liquid, solid or vapor water
  - **Biosphere** = all the planet's living organisms and the abiotic portions of the environment
- Boundaries overlap, so the systems interact

# The Gulf of Mexico from a systems perspective

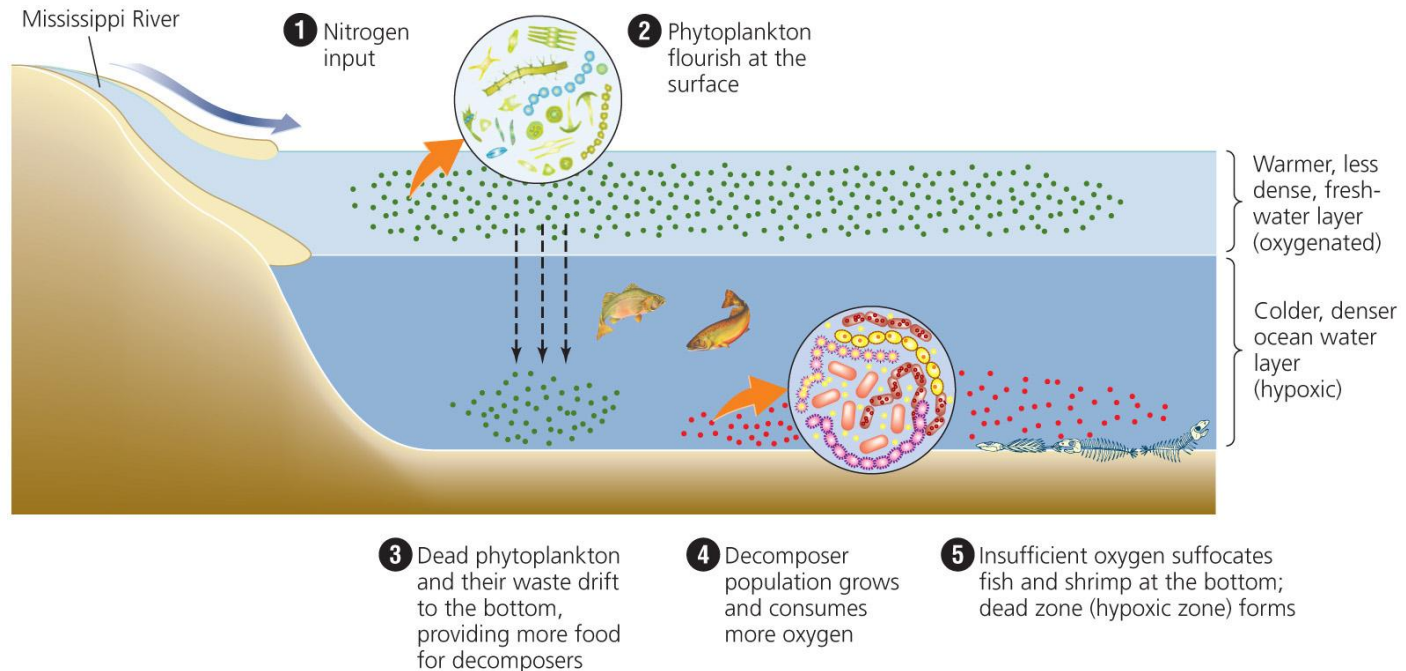
- Nutrients from fertilizer enter the Mississippi River from Midwestern farms
- Fertilizer use has increased, which causes....
  - Phytoplankton to grow, then...
  - Bacteria eat dead phytoplankton and wastes and deplete oxygen, causing...
  - Fish and other aquatic organisms to suffocate



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# Eutrophication

- The process by which a soil nutrient is reduced and released to the atmosphere as a gas.



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# Nutrient runoff is devastating aquatic systems

- Dead zones of water result from nutrient pollution from farms, cities, and industry
- Pollution and human impact have devastated fisheries and altered aquatic ecosystems
- Scientists are investigating innovative and economical ways to reduce nutrient runoff



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*Phytoplankton blooms off the Louisiana coast*



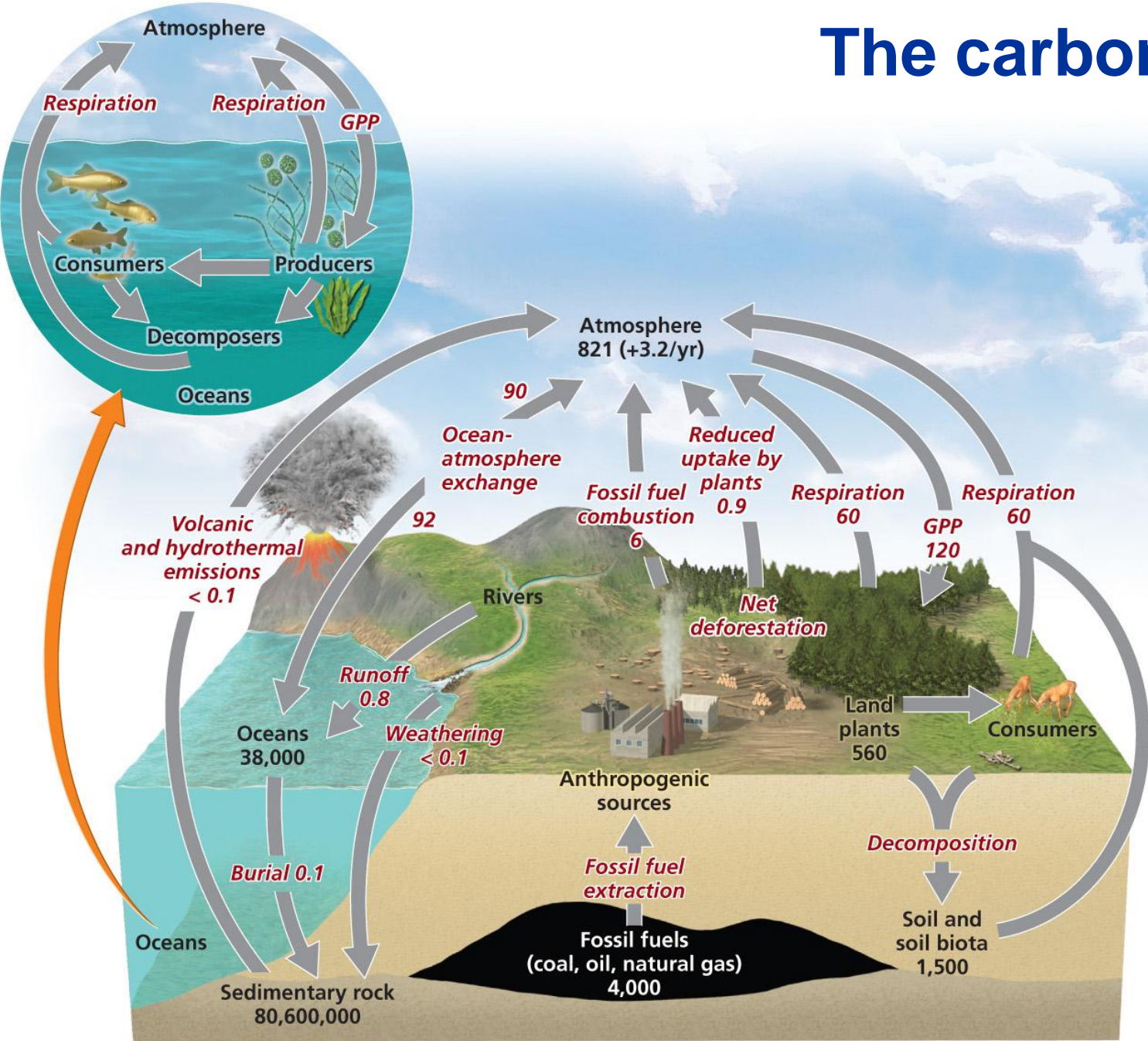
# Nutrients circulate through ecosystems

- Physical matter is circulated continually in an ecosystem
- **Nutrient (biogeochemical) cycle** = the movement of nutrients through ecosystems
  - Atmosphere, hydrosphere, lithosphere, and biosphere
- **Pools (reservoirs)** = where nutrients reside for varying amounts of time
- **Flux** = movement of nutrients among pools, which change over time and are influenced by human activities
- **Sources** = pools that release more nutrients than they accept
- **Sinks** = accept more nutrients than they release

# The carbon cycle

- Carbon is found in carbohydrates, fats, proteins, bones
- **Carbon cycle** = describes the routes that carbon atoms take through the environment
  - Photosynthesis moves carbon from the air to organisms
  - Respiration returns carbon to the air and oceans
- Decomposition returns carbon to the sediment, the largest reservoir of carbon
  - Ultimately, it may be converted into fossil fuels
- Sedimentary rock comprises the largest reservoir of carbon
- The world's oceans are the second largest reservoir of carbon

# The carbon cycle



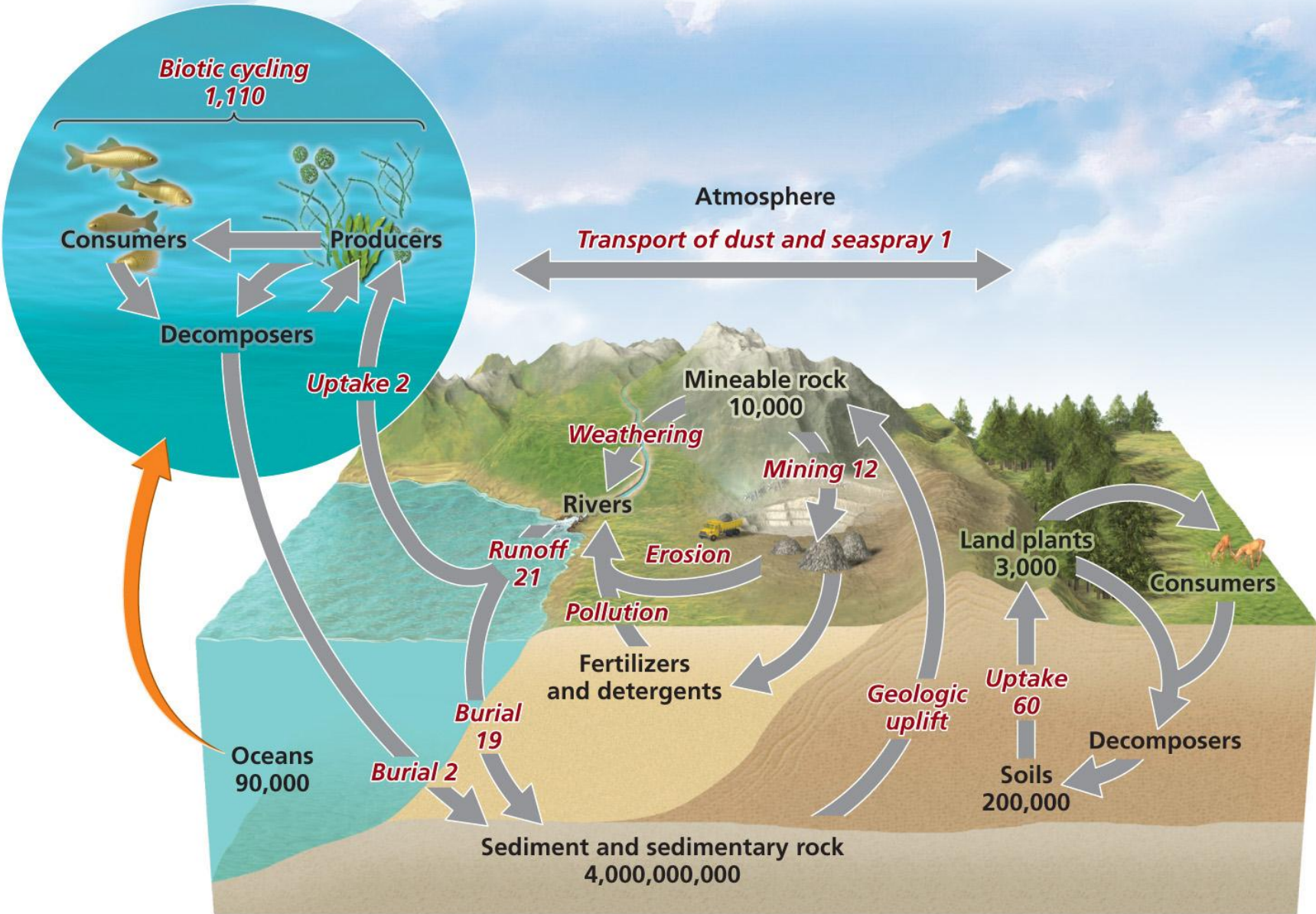
# Humans affect the carbon cycle

- Burning fossil fuels moves carbon from the ground to the air
- Cutting forests and burning fields moves carbon from organisms to the air
- Today's atmospheric carbon dioxide reservoir is the largest in the past 650,000 years
  - The driving force behind climate change
- The missing carbon sink: 1-2 billion metric tons of carbon are unaccounted for
  - It may be the plants or soils of northern temperate and boreal forests

# The phosphorus cycle

- Phosphorus is a key component of cell membranes, DNA, RNA, ATP and ADP
- **Phosphorus cycle** = describes the routes that phosphorus atoms take through the environment
  - *No significant atmospheric component*
  - Most phosphorus is within rocks and is released by weathering
- With naturally low environmental concentrations, phosphorus is a limiting factor for plant growth

# The phosphorus cycle



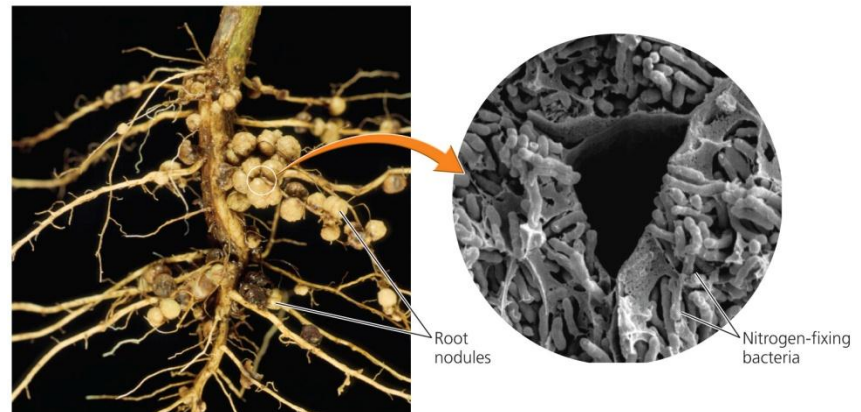
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# Humans affect the phosphorus cycle

- Mining rocks for fertilizer moves phosphorus from the soil to water systems
  - Wastewater discharge also releases phosphorus
- Runoff containing phosphorus causes eutrophication of aquatic systems

# The nitrogen cycle

- Nitrogen comprises 78% of our atmosphere, and is contained in proteins, DNA and RNA
- **Nitrogen cycle** = describes the routes that nitrogen atoms take through the environment
  - Nitrogen gas is inert and cannot be used by organisms
- **Nitrogen fixation** = Nitrogen gas is combined (fixed) with hydrogen by nitrogen-fixing bacteria to become ammonium
  - Which can be used by plants



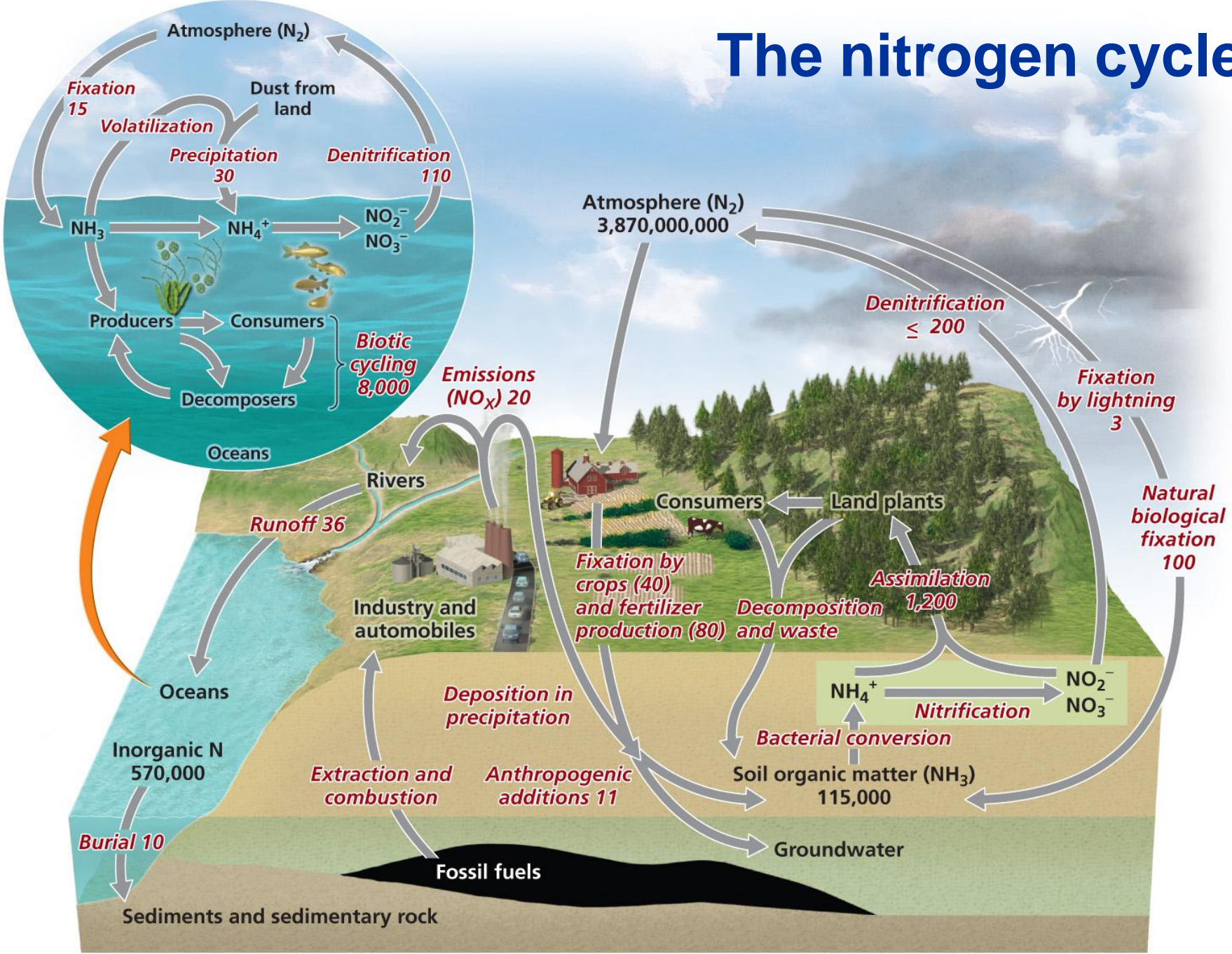
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# Nitrification and denitrification

- **Nitrification** = bacteria that convert ammonium ions first into nitrite ions then into nitrate ions
  - Plants can take up these ions
- Animals obtain nitrogen by eating plants or other animals
- **Denitrifying bacteria** = convert nitrates in soil or water to gaseous nitrogen, releasing it back into the atmosphere

# The nitrogen cycle



# Humans affect the nitrogen cycle

- **Haber-Bosch process** = synthetic production of fertilizers by combining nitrogen and hydrogen to synthesize ammonia
  - Dramatically changed the nitrogen cycle
  - Humans are fixing as much nitrogen as nature does
- Increased emissions of nitrogen-containing greenhouse gases
- Calcium and potassium in soil washed out by fertilizers
- Acidified water and soils
- Moved more nitrogen into plants and terrestrial systems
- Reduced biodiversity of plants adapted to low-nitrogen soils
- Changed estuaries and coastal ecosystems and fisheries

# A law addressing hypoxia in the Gulf

- The Harmful Algal Bloom and Hypoxia Research and Control Act (1998) called for an assessment of hypoxia in the Gulf
- Solutions outlined included:
  - Reduce nitrogen fertilizer use in Midwestern farms
  - Change timing of fertilizer applications to minimize runoff
  - Use alternative crops
  - Restore wetlands and create artificial ones
  - Improve sewage = treatment technologies
  - Evaluate these approaches

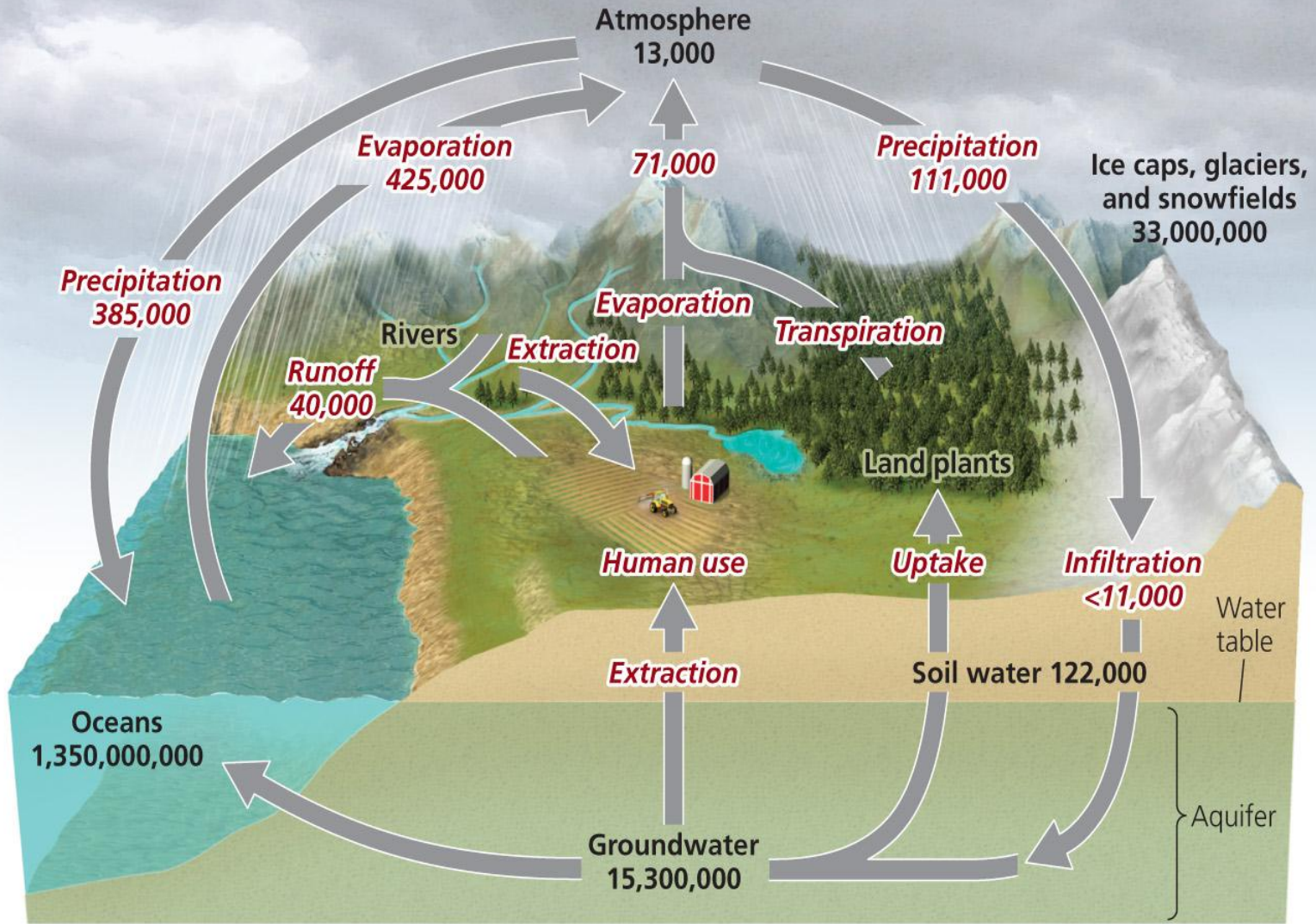
# The hydrologic cycle

- Water is essential for biochemical reactions and is involved in nearly every environmental system
- **Hydrologic cycle** = summarizes how liquid, gaseous and solid water flows through the environment
  - Oceans are the main reservoir
- **Evaporation** = water moves from aquatic and land systems to air
- **Transpiration** = release of water vapor by plants
- **Precipitation** = condensation of water vapor as rain or snow

# Groundwater

- **Aquifers** = underground reservoirs of sponge-like regions of rock and soil that hold ...
  - **Groundwater** = water found underground beneath layers of soil
  - **Water table** = the upper limit of groundwater held in an aquifer
  - Water may be ancient (thousands of years old)
- Groundwater becomes exposed to the air where the water table reaches the surface

# The hydrologic cycle



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# Human impacts on hydrologic cycle

- Damming rivers increases evaporation and infiltration
- Altering the surface and vegetation increases runoff and erosion
- Spreading water on agricultural fields depletes rivers, lakes and streams
- Removing forests and vegetation reduces transpiration and lowers water tables
- Emitting pollutants changes the nature of precipitation
- The most threatening impact is overdrawing groundwater for drinking, irrigation, and industrial use