Biogeochemical Cycles

Sustainability

- Long-term ecological balance
- Maintaining the ecosystem **indefinitely**

Standard

- **SEV1. Obtain, evaluate, and communicate information to investigate the flow of energy and cycling of matter within an ecosystem.**
- c. **Analyze** and **interpret** data to construct an argument of the necessity of biogeochemical cycles (hydrologic, nitrogen, phosphorus, oxygen, and carbon) to support a sustainable ecosystem.

Essential Questions – Day 1

- What purpose do biogeochemical cycles serve?
- How is water recycled?

Learning Target(s):

1) Explain the recycling of water and the tie to the First Law of Thermodynamics
2) Create a model of the water cycle

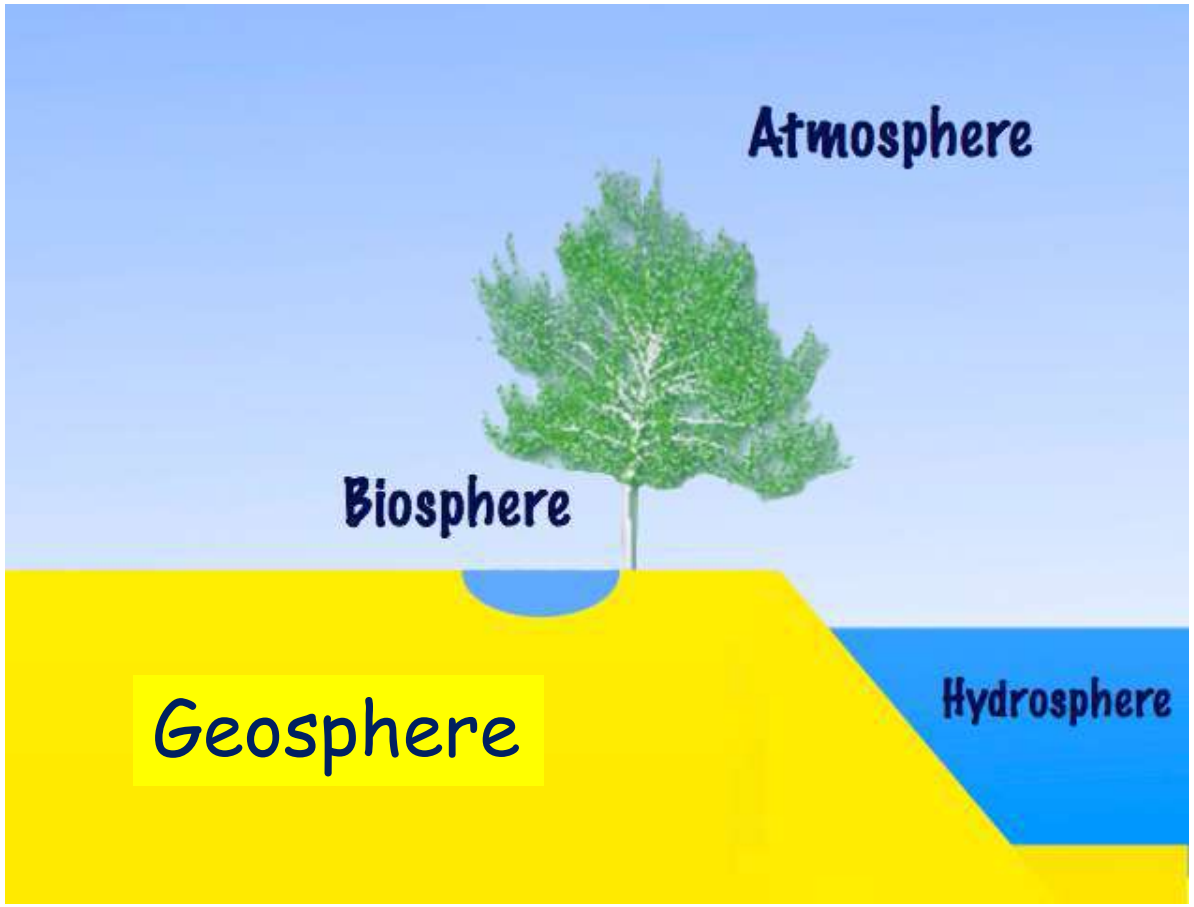
Our Environment's Homeostasis (balance)

- Atoms of carbon, hydrogen, nitrogen, oxygen and phosphorous (CHNOPS) make up living organisms
- This matter recycles through ecosystems.
  - Remember, energy does NOT recycle.
- Remember Conservation of Matter
  - Matter cannot be created or destroyed

How Chemicals Cycle

Key Concepts

Remember, we can subdivide the Earth system into the atmosphere, hydrosphere, geosphere, and biosphere.



How Chemicals Cycle - Review

Atmosphere – ***atmos*** refers to vapor so in this case we mean the gases in the environment

Hydrosphere – ***hydro*** refers to "water" so in this case we mean oceans, rivers, lakes, groundwater, and glaciers

Geosphere – ***geo*** means "earth" so in this case we mean rocks and soils

Biosphere – ***bio*** means "life" so in this case we mean living things such as plants and animals

How Chemicals Cycle

What is Biogeochemical?

- *Bio (life) geo (atmosphere, rock, and/or soil), chemical (stored in elements)*

- BIO-GEO-CHEMICAL – Nutrient Cycles where elements, chemical compounds, are passed from one organism to another and from one part of the biosphere to another system

- recycle **nutrients** through the earth's air, land, water, and living organisms.
  – connects the past, present and future forms of life.

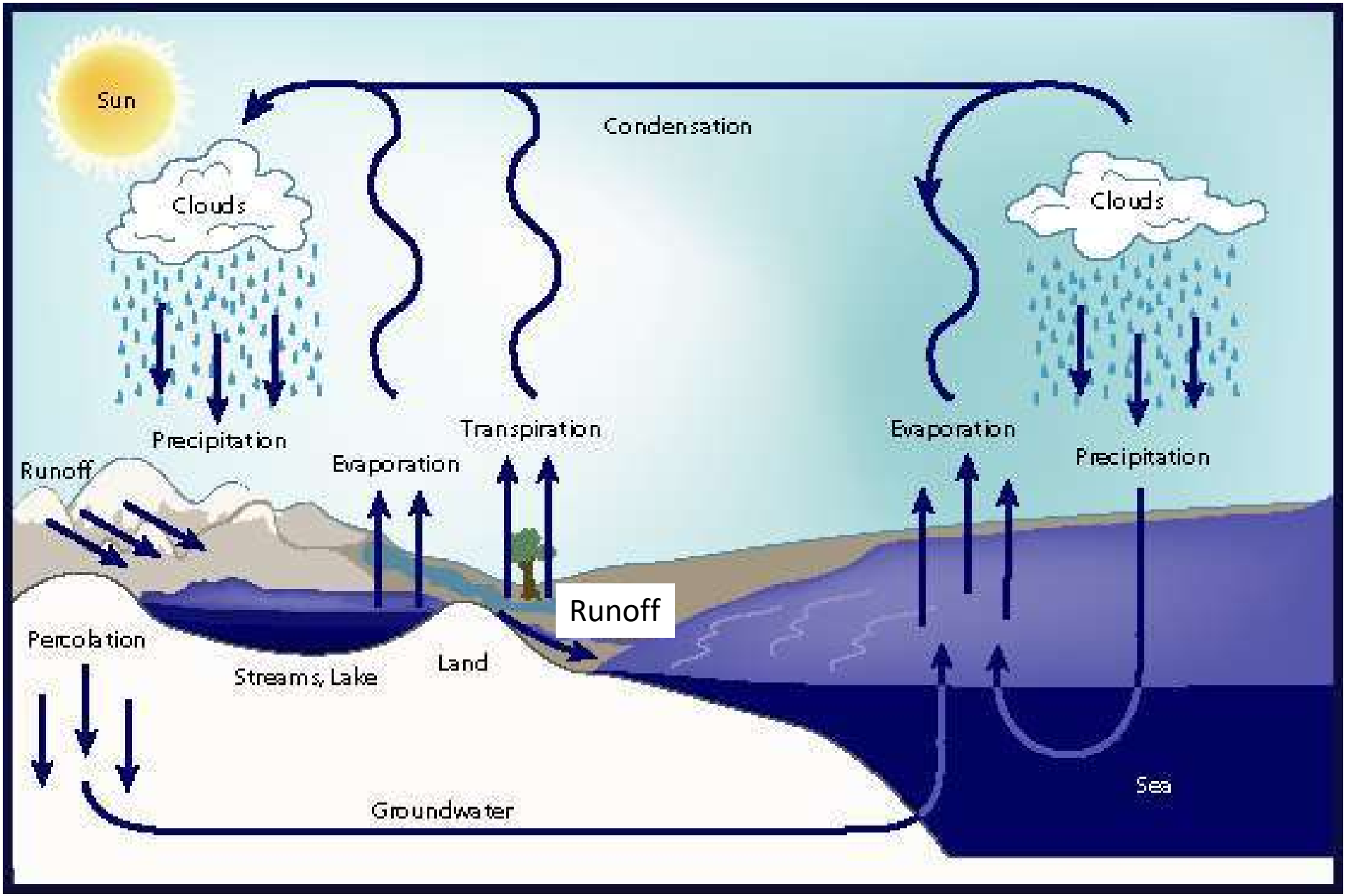
Types of Cycles

Cycle	Primary Storage Site
Carbon (C) & Nitrogen (N)	Atmosphere
Water (H_2O)	Oceans
Phosphorus (P)	Geosphere
Oxygen (O)	Atmosphere

Hydrological Cycle

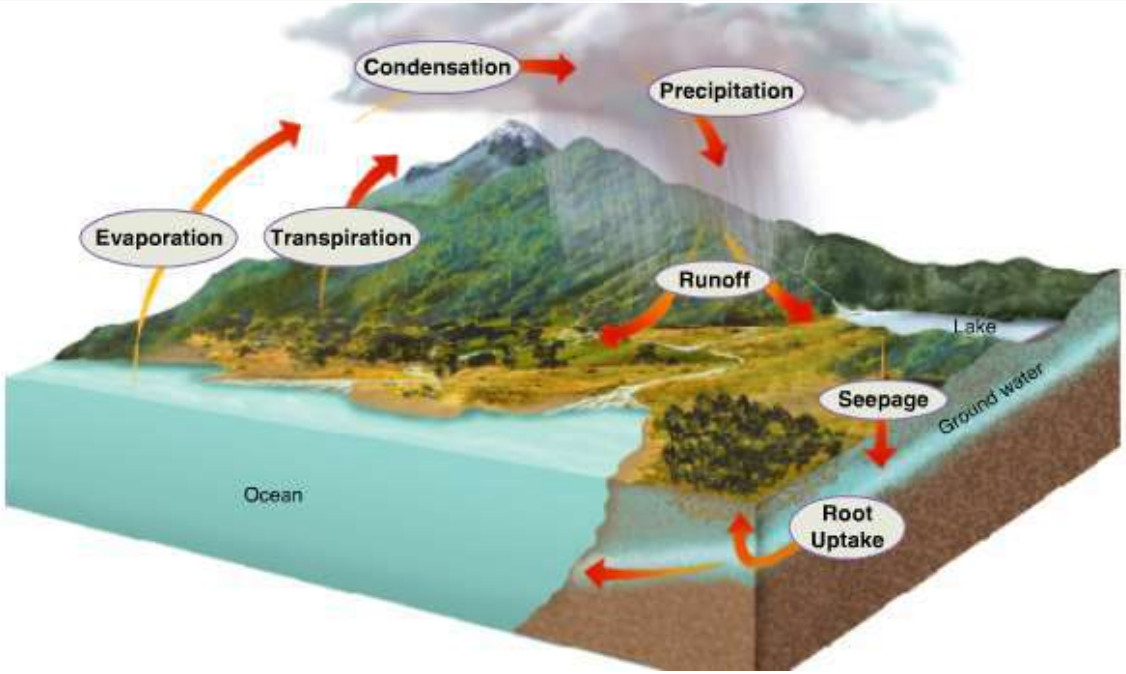
– Most of earth's water is **stored in the oceans**, but solar energy continually evaporates this water, and winds distribute water vapor around the Earth.

Water cycle-


Sun
Condensation
Clouds
Clouds
Precipitation
Transpiration
Evaporation
Evaporation
Precipitation
Runoff
Runoff
Percolation
Streams, Lake
Land
Sea
Groundwater

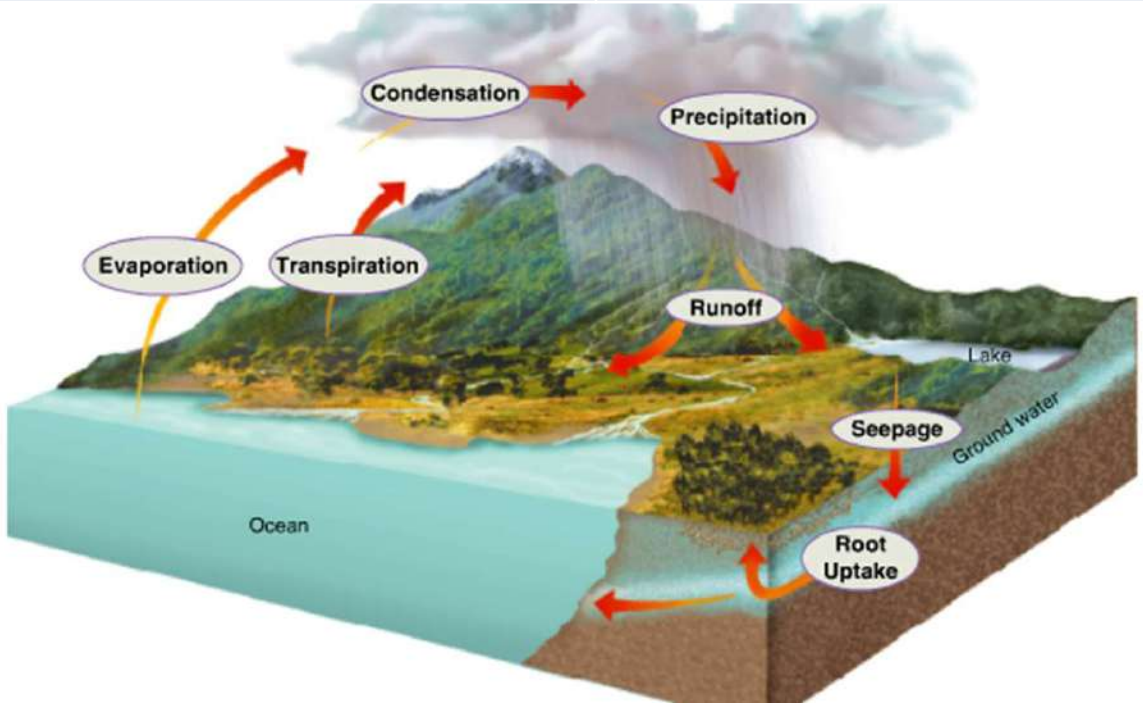
Hydrologic Cycle - Processes

Process	How it Works
Evaporation	Liquid water is **heated** by the sun and **rises** into the atmosphere as water vapor
Transpiration	Evaporation of water from leaves of plants



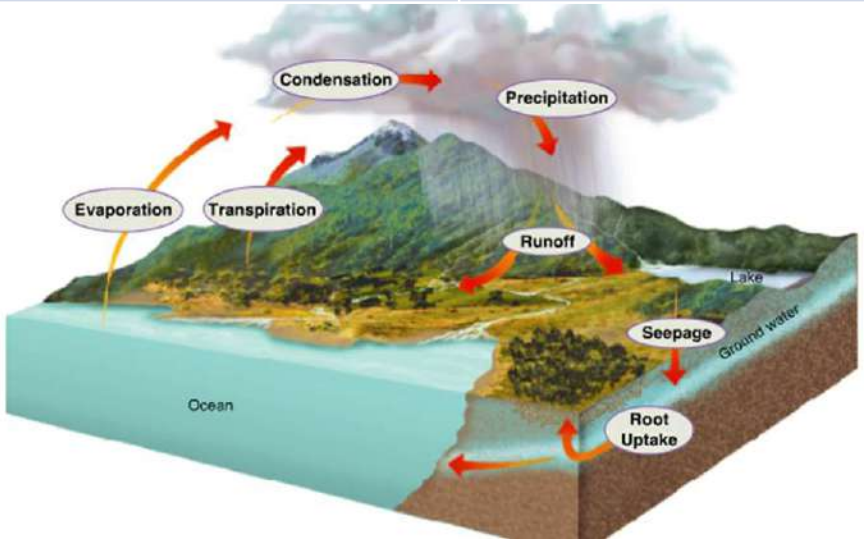
Hydrologic Cycle - Processes

Process	How it Works
Condensation	Water vapor forms water droplets
Precipitation	When droplets get large enough they fall to earth as either rain, snow, sleet, or hail.



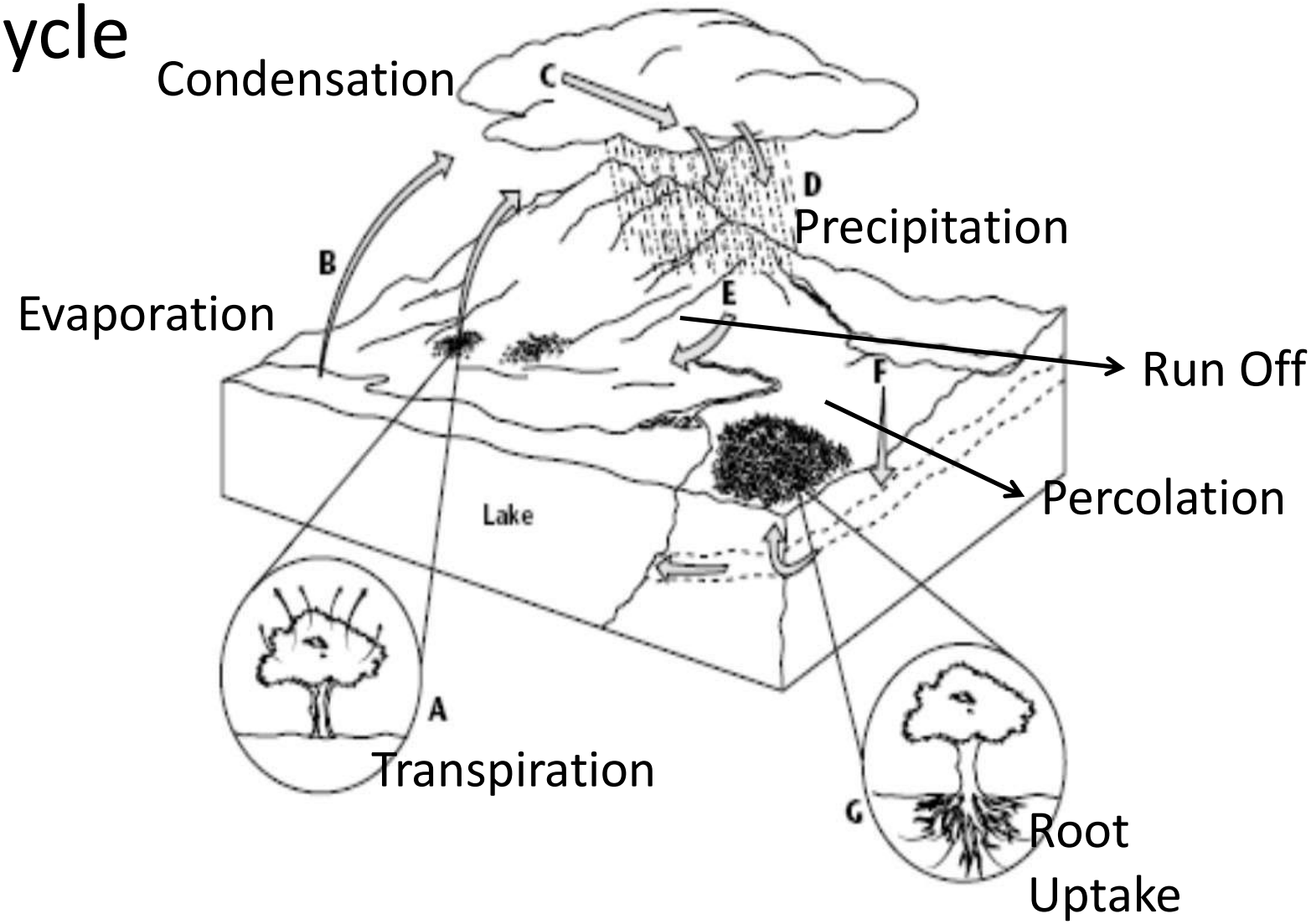
Hydrologic Cycle - Processes

Process	How it Works
Runoff	Precipitation runs along the surface of the ground until it enters a river or stream
Percolation (seepage)	When water soaks into the ground sometimes deep enough to become groundwater
Root Uptake	Water in the soil enters plants through roots



Quick Check

- ID the different steps of the hydrologic cycle



Work Session – Water Cycle Poster

- Working alone or in PAIRS (that means 2!)
- Choose an ecosystem
- Draw the water cycle, clearly depicting the 7 processes we discussed.
- Grading (25 pt):
  - Title (1 pt)
  - Choice of ecosystem is clear (2 pt)
  - Neat/planned/colorful (1 pt)
  - Processes are clearly labeled (7 pt)
  - Arrows showing movement of water are correct (7 pt)
  - Process matches the picture(7 pt)

Essential Questions – Day 2

- Why is carbon important to life?
- How is it recycled?

Learning Target(s):

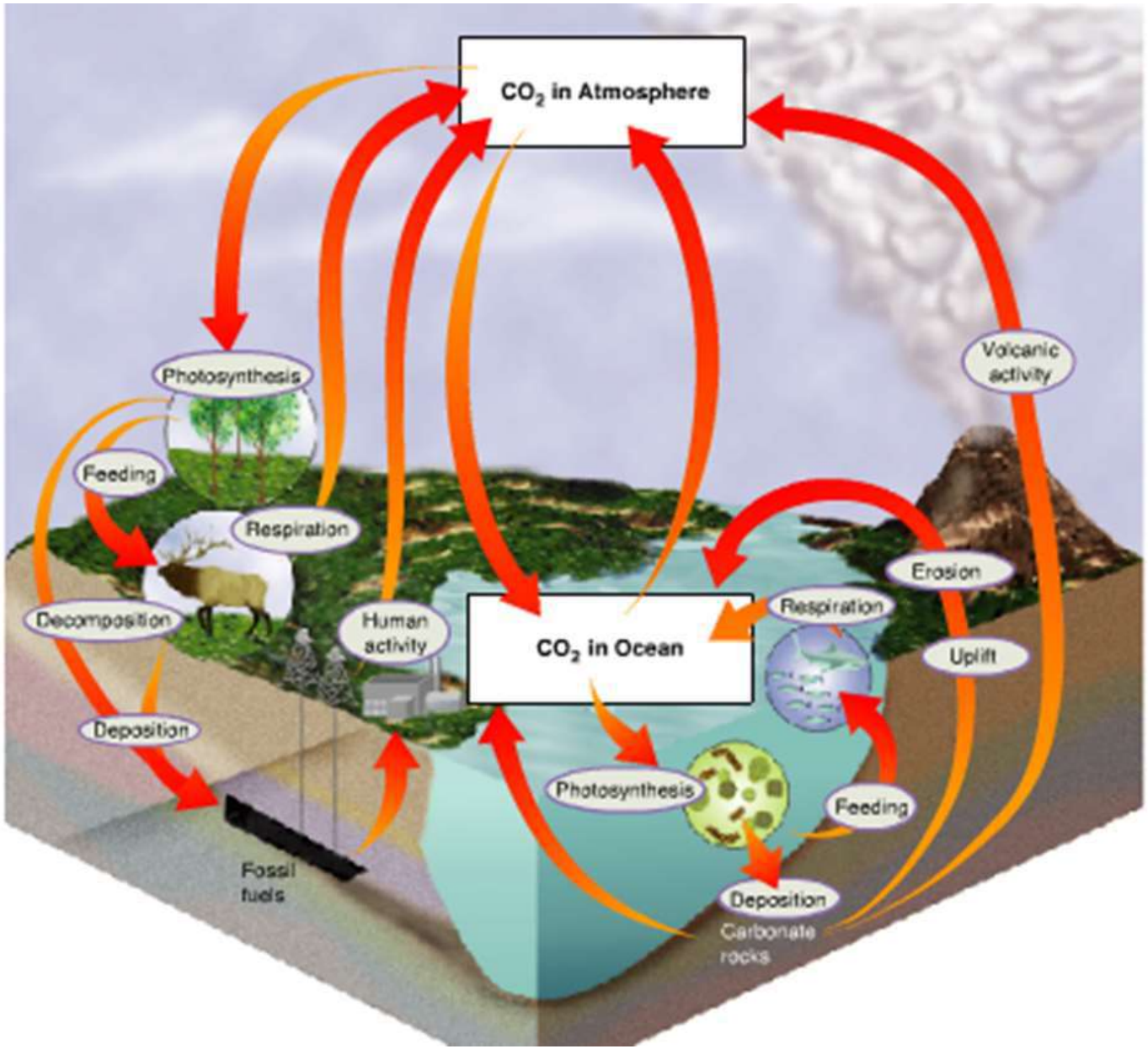
1) Explain the recycling of carbon and the tie to the First Law of Thermodynamics
2) Create a model of the carbon cycle

Master Challenge

- What is Carbon?

- You will work with you group to create a profile about carbon. Include: What carbon is, who discovered it, how it impacts humans, when is it used, where do we find it, and why is it important. You have **15** minutes.

Carbon Cycle



Carbon Cycle

- Carbon Cycle is a process where carbon cycles between the atmosphere, land, water, and organisms.

- Carbon is the element that anchors all organic substances.

The Carbon Cycle

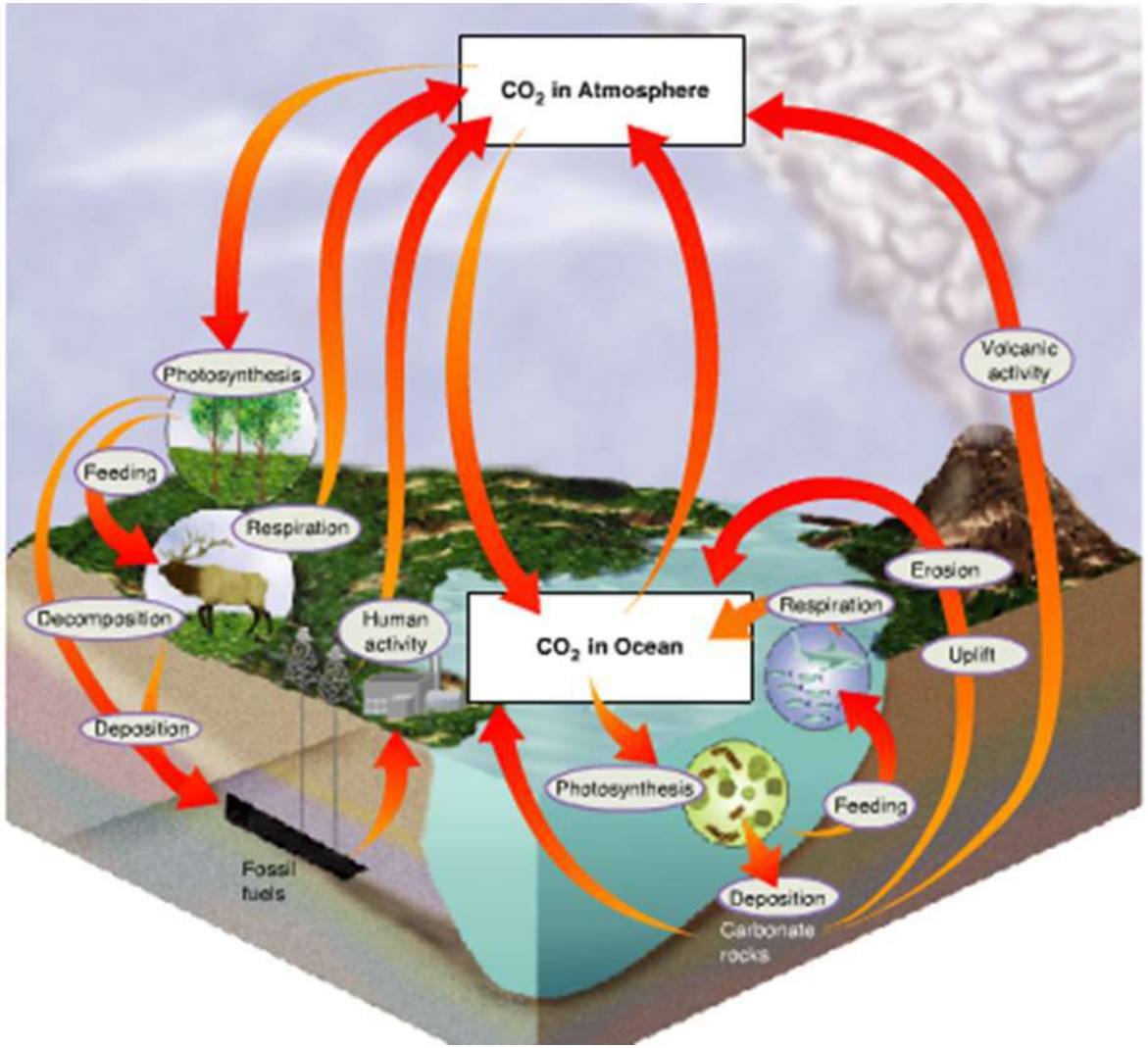
- Carbon has a gaseous phase
  - Enters atmosphere (CO_2 and CH_4) through respiration, fires and diffusion. (CH_4 = methane)

$C_6H_{12}O_6 + 6O_2 + 6H_2O \rightarrow 12H_2O + 6CO_2 + \text{Energy}$

  - Removed from the (0.03%) atmosphere by photosynthesis

$12H_2O + 6CO_2 + \text{sun} \rightarrow C_6H_{12}O_6 + 6H_2O + 6O_2$

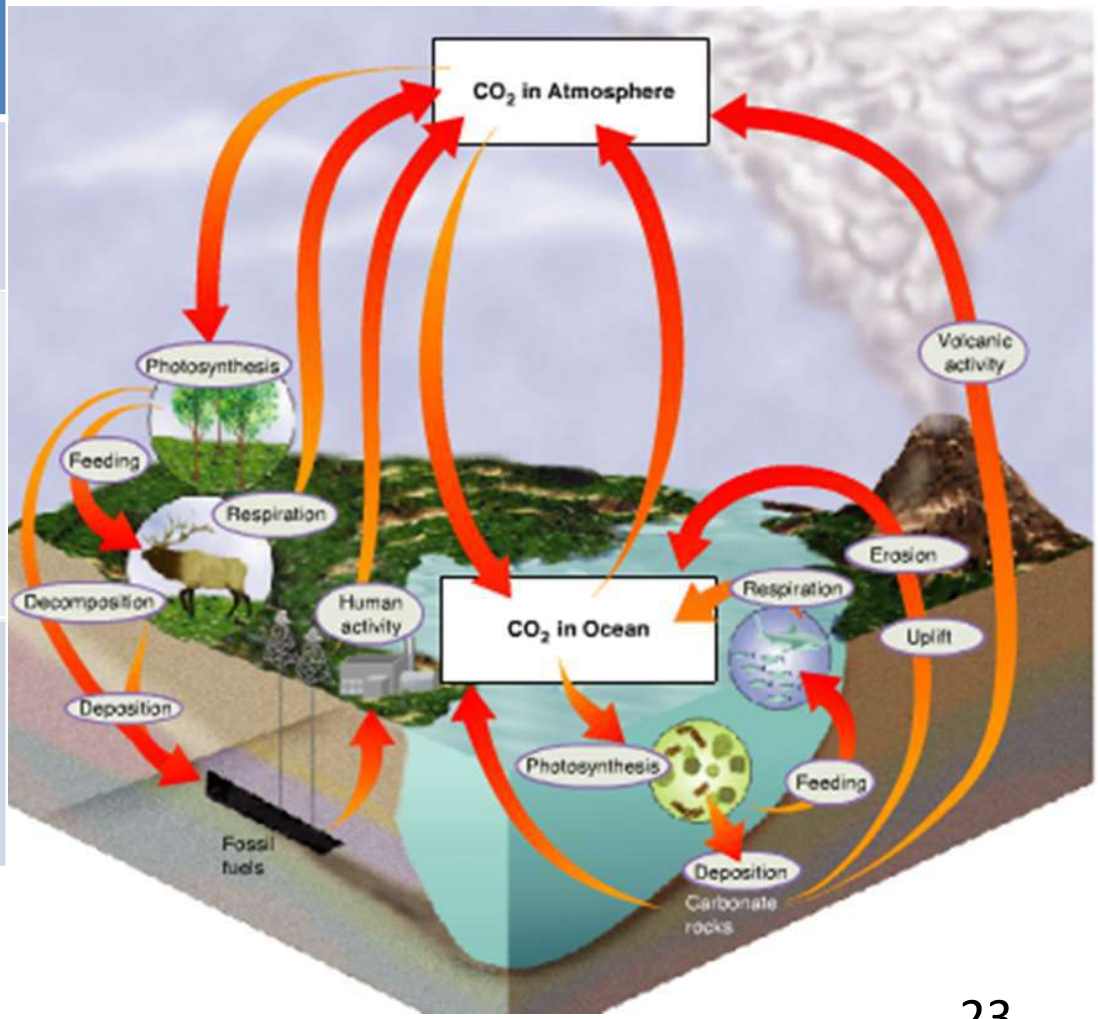
Carbon Movers



Released in Atmosphere
Volcanic Activity
Human Activity
Respiration
Decomposition

Carbon Movers

Carbon movement through the Earth and Organisms
Plants use carbon dioxide (CO_2) for photosynthesis
Carbon **ONLY** enters consumers through **plants** receiving it from the **atmosphere**.
Organisms use **carb**ohydrates to store energy



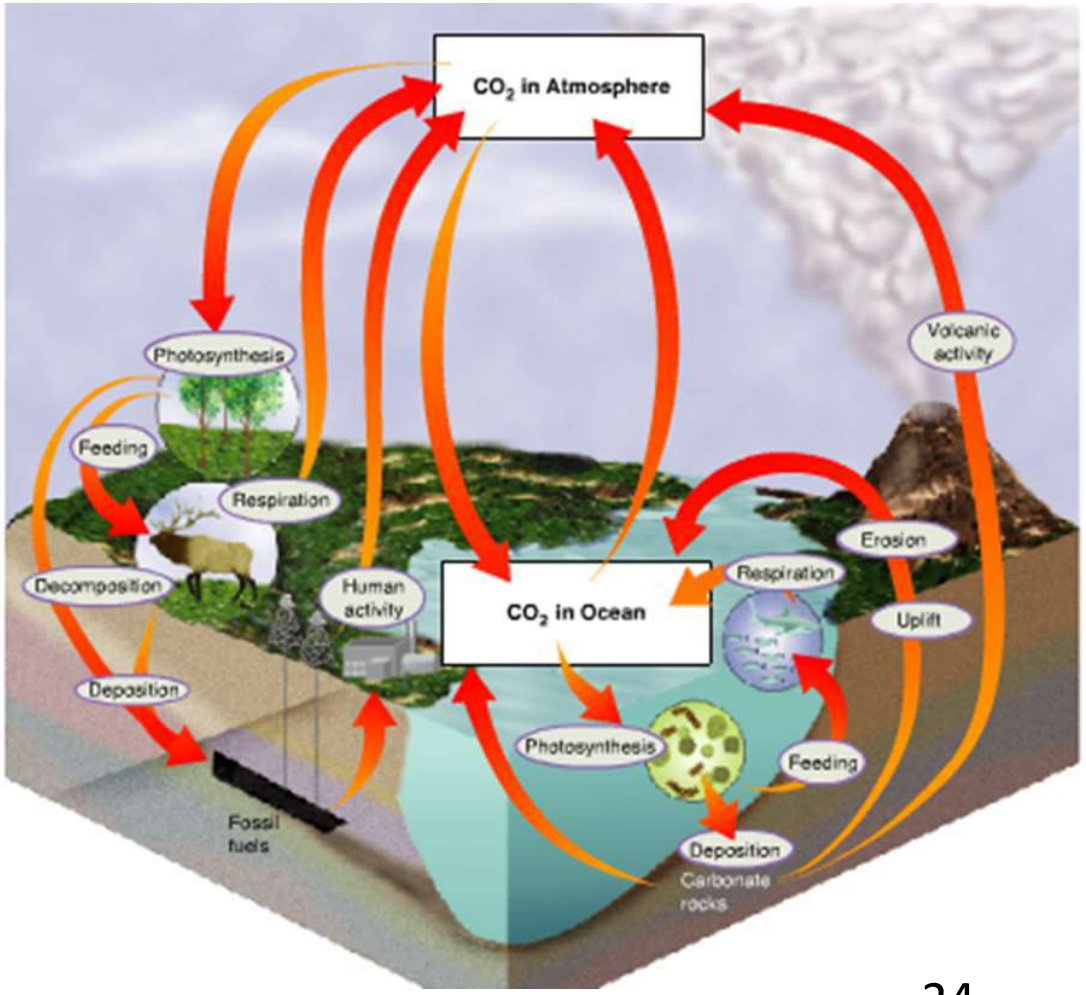
Carbon Movers

Carbon movement through the Earth and Organisms

Consumers obtain the carbon they need from producers.

Carbonates make up bones and shells

Dead organism? Their carbon can circulate through the hydrosphere or geosphere. **It must enter the atmosphere** before plants help it enter the biosphere again.



Quick Check

- What role does human activity play in the carbon cycle?

Releases carbon into the atmosphere

- How do organisms use carbon?

Carbohydrates, Carbonates & Photosynthesis

Essential Questions- Day 3

- Why is nitrogen important to life?
- How is nitrogen recycled?
- What is eutrophication?

Learning Target(s):

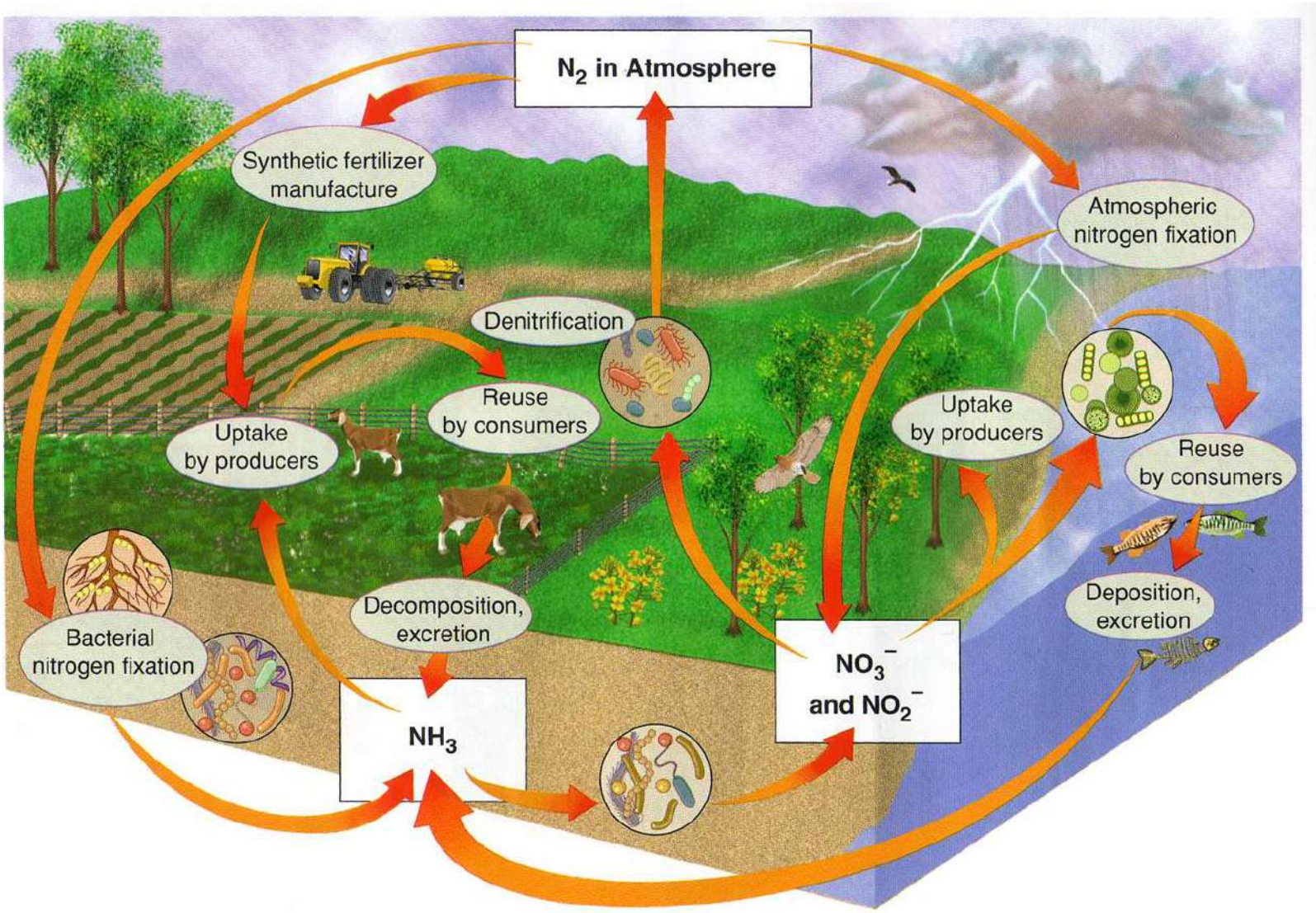
1) Explain the recycling of nitrogen, phosphorus, and oxygen and the tie to the First Law of Thermodynamics

Master Challenge

- What's up with Nitrogen?

- Read the article provide by your teacher. Pick out the paragraph that stood out to you. In your group, discuss what made the paragraph stand out to you. You have 20 minutes to complete this activity.

Nitrogen Cycle



Nitrogen cycle-

Atmospheric nitrogen (N_2) makes up nearly 78% of air.

Organisms cannot use it in that form.

Lightning and bacteria convert nitrogen into usable forms.

Stages – Nitrogen Fixation

- **Nitrogen fixation** – when **atmospheric** N_2 is converted or 'fixed' by bacteria and algae into ammonia (NH_4) so other organisms may consume it.

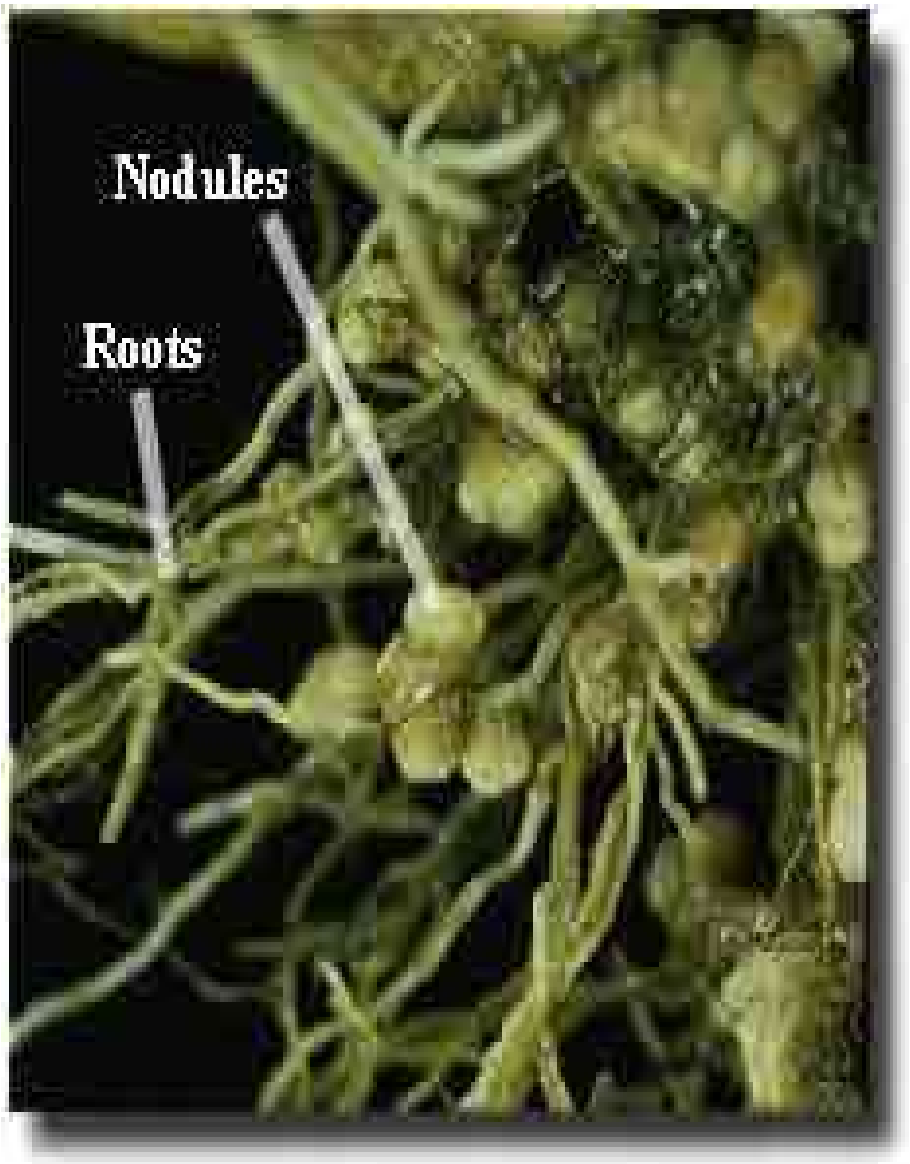
$$N_2 \longrightarrow NH_4^+$$

- Some nitrogen-fixing bacteria live free in the soil.
- Nitrogen-fixing cyanobacteria - maintain the fertility of semi-aquatic environments like rice paddies.

Nitrogen fixation-

Nitrogen-fixing bacteria:

Some live in a symbiotic relationship with plants of the legume family (e.g., soybeans, clover, peanuts).

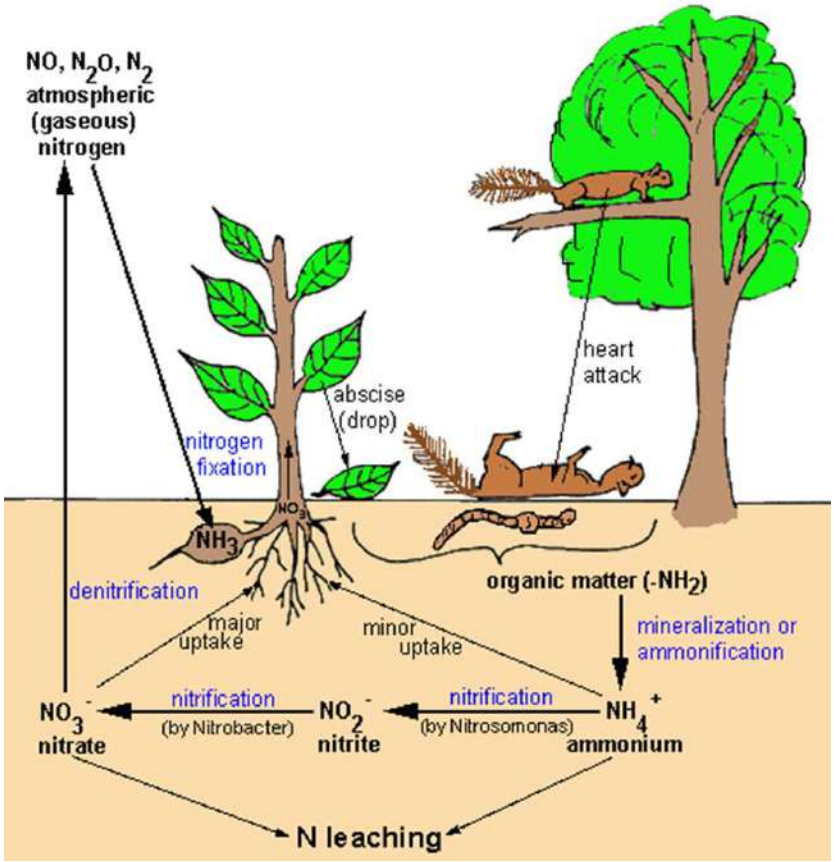


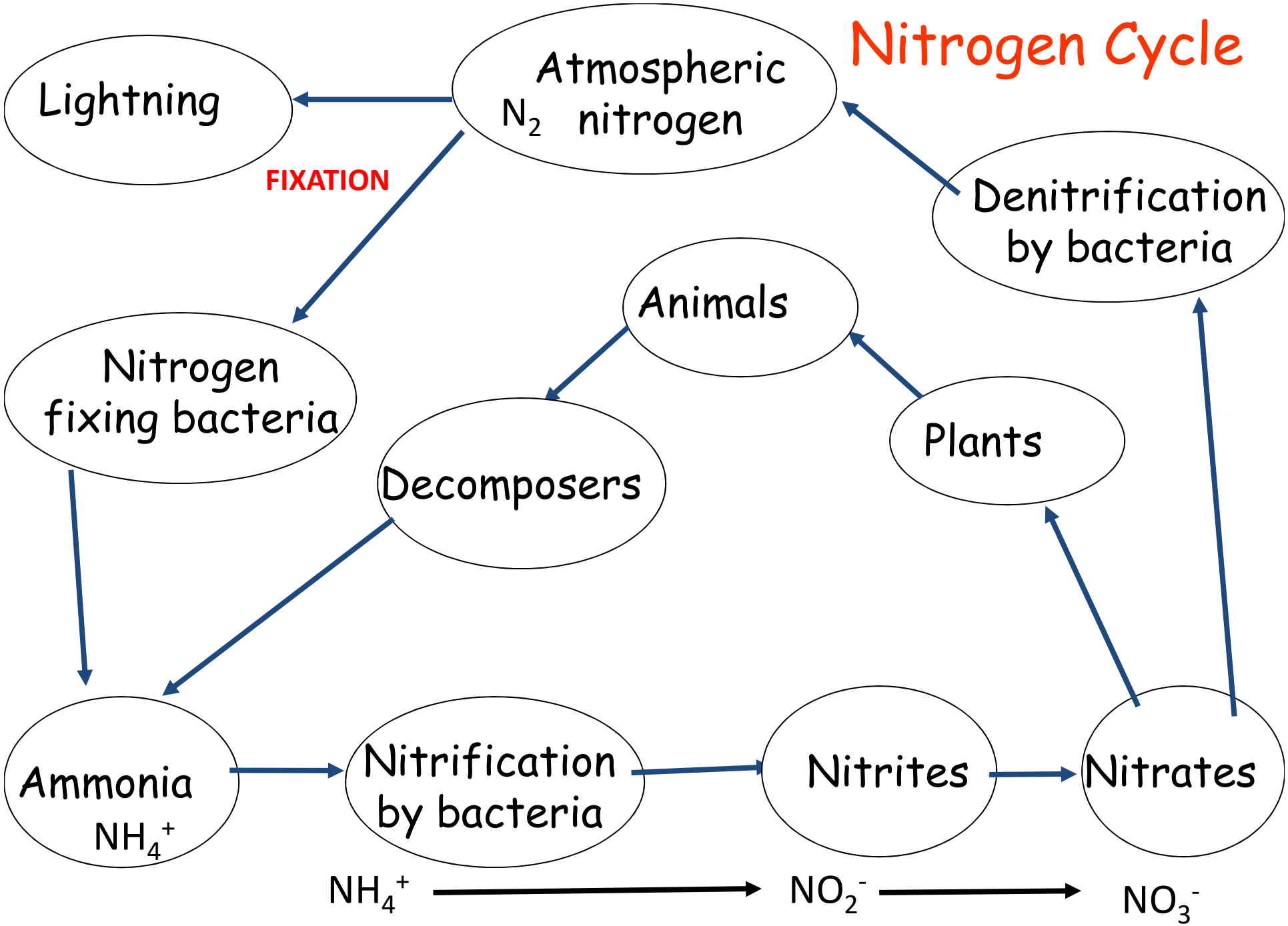
Stages - Nitrification

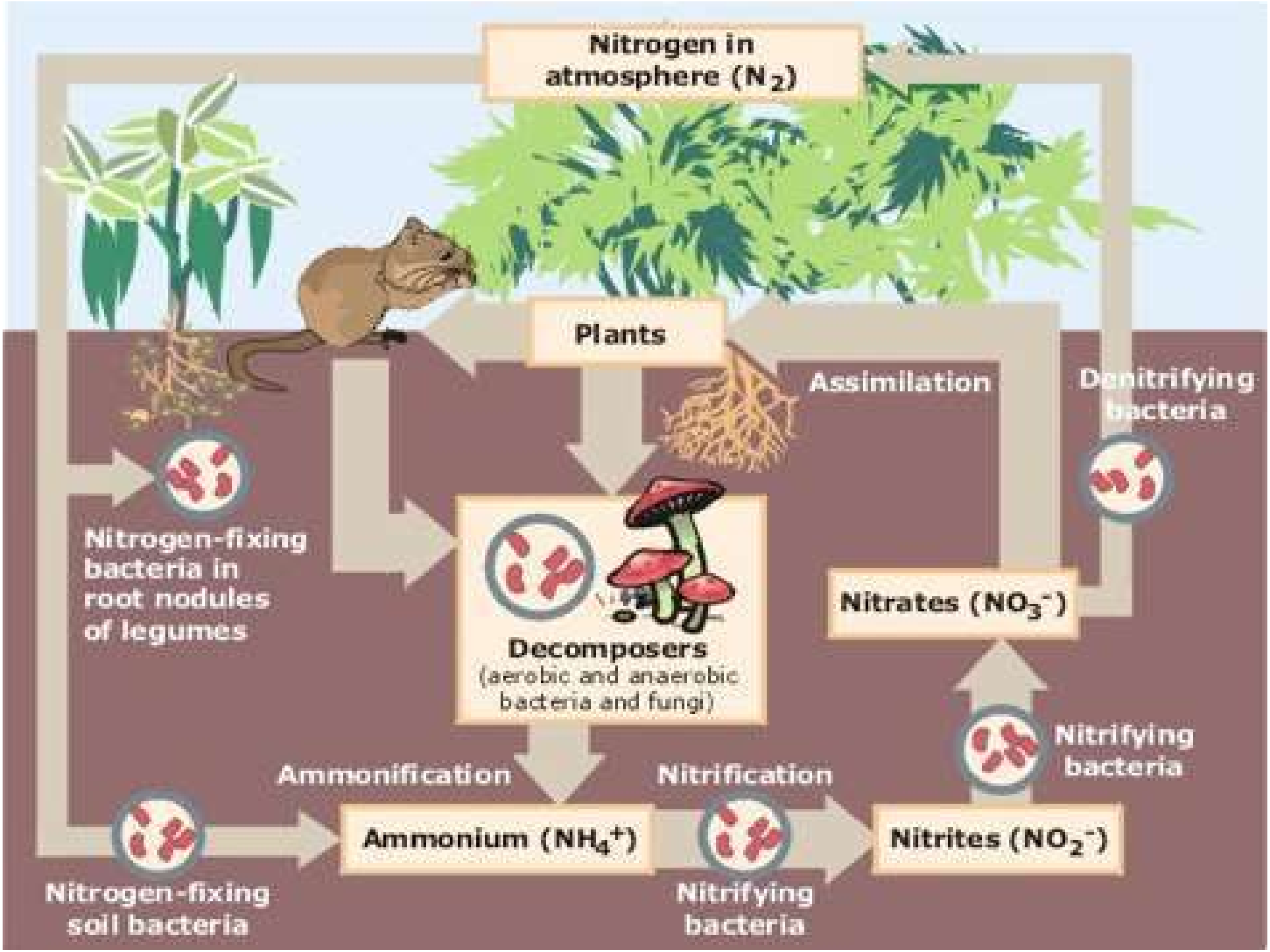
- Ammonia (NH_4) is toxic to many plants and organisms so it is converted to nitrite (NO_2) and then nitrate (NO_3).
- Nitrates are now usable by plants; they can absorb them through the soil.

Stages - Denitrification

- Bacteria will work to change NO_3 back to N_2 which is released back into the atmosphere to complete the cycle.




Nitrogen Cycle
Lightning
Atmospheric N_2 nitrogen
FIXATION
Denitrification by bacteria
Animals
Nitrogen fixing bacteria
Decomposers
Plants
Ammonia NH_4^+
Nitrification by bacteria
Nitrites
Nitrates
NH_4^+
NO_2^-
NO_3^-


Nitrogen in atmosphere (N_2)
Plants
Assimilation
Denitrifying bacteria
Nitrogen-fixing bacteria in root nodules of legumes
Decomposers
(aerobic and anaerobic bacteria and fungi)
Nitrates (NO_3^-)
Nitrifying bacteria
Ammonification
Nitrification
Ammonium (NH_4^+)
Nitrites (NO_2^-)
Nitrogen-fixing soil bacteria
Nitrifying bacteria

Quick Check

- True or False: Organisms can consume nitrogen.

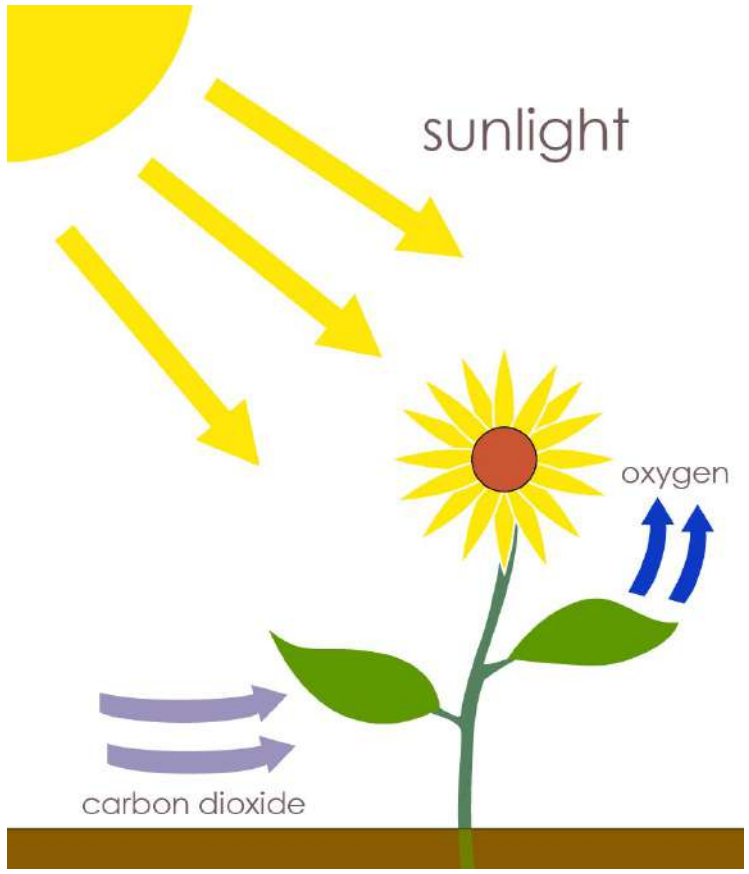
  FALSE

- True or False: Nitrification is when ammonia is converted to nitrites and nitrates.

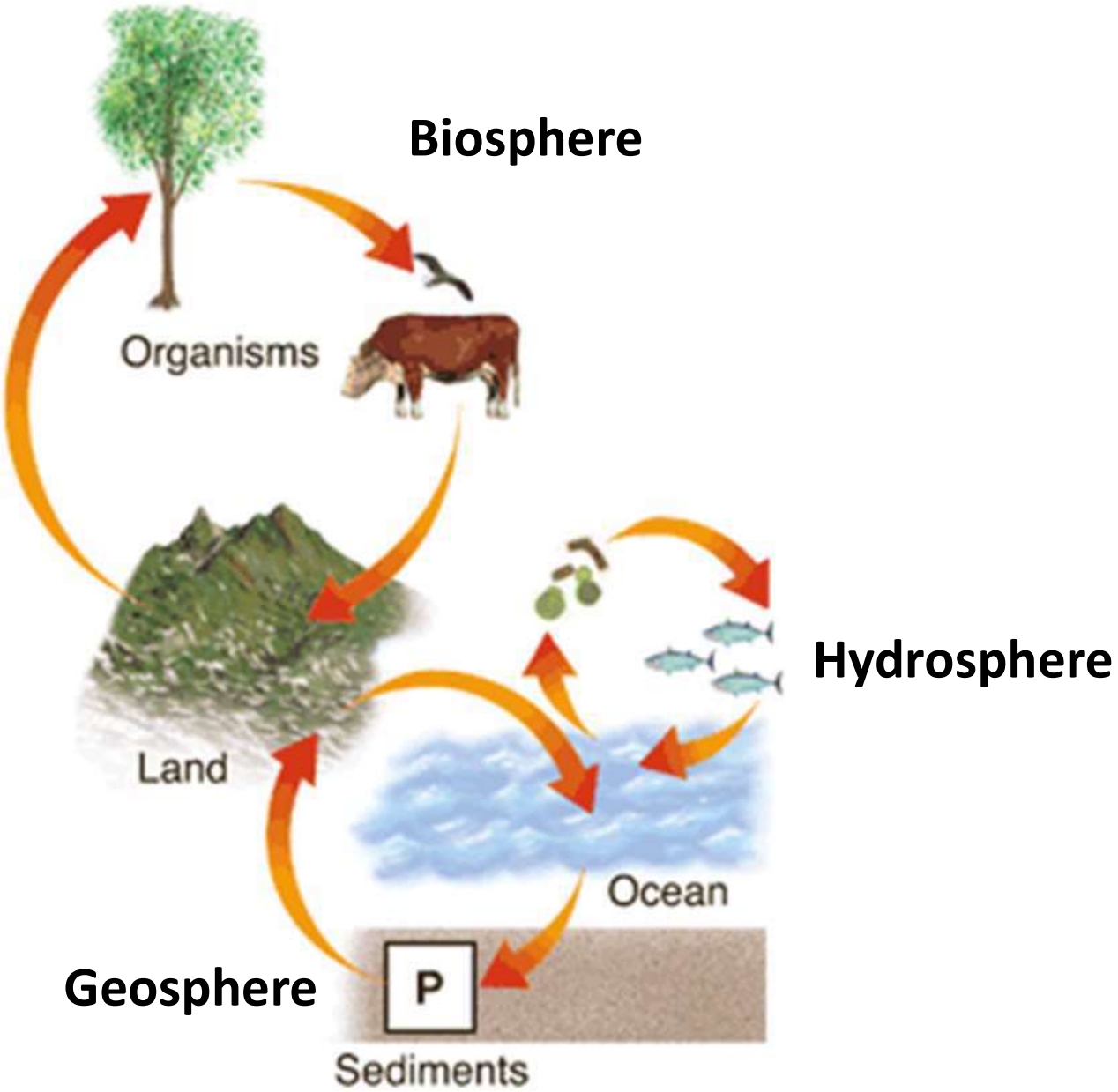
  TRUE

Oxygen Cycle

- Supports life (mostly found in atmosphere)
- 2 main sources:
  - photosynthesis
  - break up of water vapor (via sunlight)
- Other reservoirs
  - CO_2
  - Water
- Cycling of oxygen is complex due to reactivity



Phosphorus Cycle



Phosphorus Cycle

- This cycle is slow and does not normally include the **atmosphere**

- Phosphorus is used in many major life processes such as ATP, DNA and RNA.

Phosphorus Cycle

- Abundant phosphorus stimulates plant and algal productivity.
  - Major component of water pollution.
  - Due to erosion of fertilizers.
    - Reduced levels of dissolved oxygen. (eutrophication)

Eutrophication

- Nutrient enrichment of a body of water
  - Can occur naturally from plant runoff of nitrates
  - **Cultural Eutrophication** – human activities, such as agriculture increase nitrates and phosphates in the water
- Algal blooms – red, green, or brown tide. Excessive algae growth results in eutrophication

FLOW CHART OF EUTROPHICATION

1. Fertilizers leach into rivers/ponds.
2. Algae use these extra nutrients, reproducing rapidly.
3. These “algal blooms” block out sunlight for plants below them causing the death of these plants.
4. Microbes feed on dead plant material, resulting in them rapidly increasing in number.
5. Oxygen is used up quickly by the huge numbers of microbes as they respire.
   - There is an increase in the biological oxygen demand (BOD) and a decrease in dissolved oxygen.
6. Fish and other aquatic animals suffocate due to lack of oxygen in the water.

Quick Check

- The Phosphorus cycle does not
  A) Include the atmosphere
  B) Work in certain parts of the world
  C) Utilize water
  D) None of the above

  Answer: A

Master Challenge

- What are the biogeochemical cycles we have studied?

- In your group, work together to create a rap or poem comparing and contrasting the biogeochemical cycles we have studied. You will share with the class. You have 15 minutes.