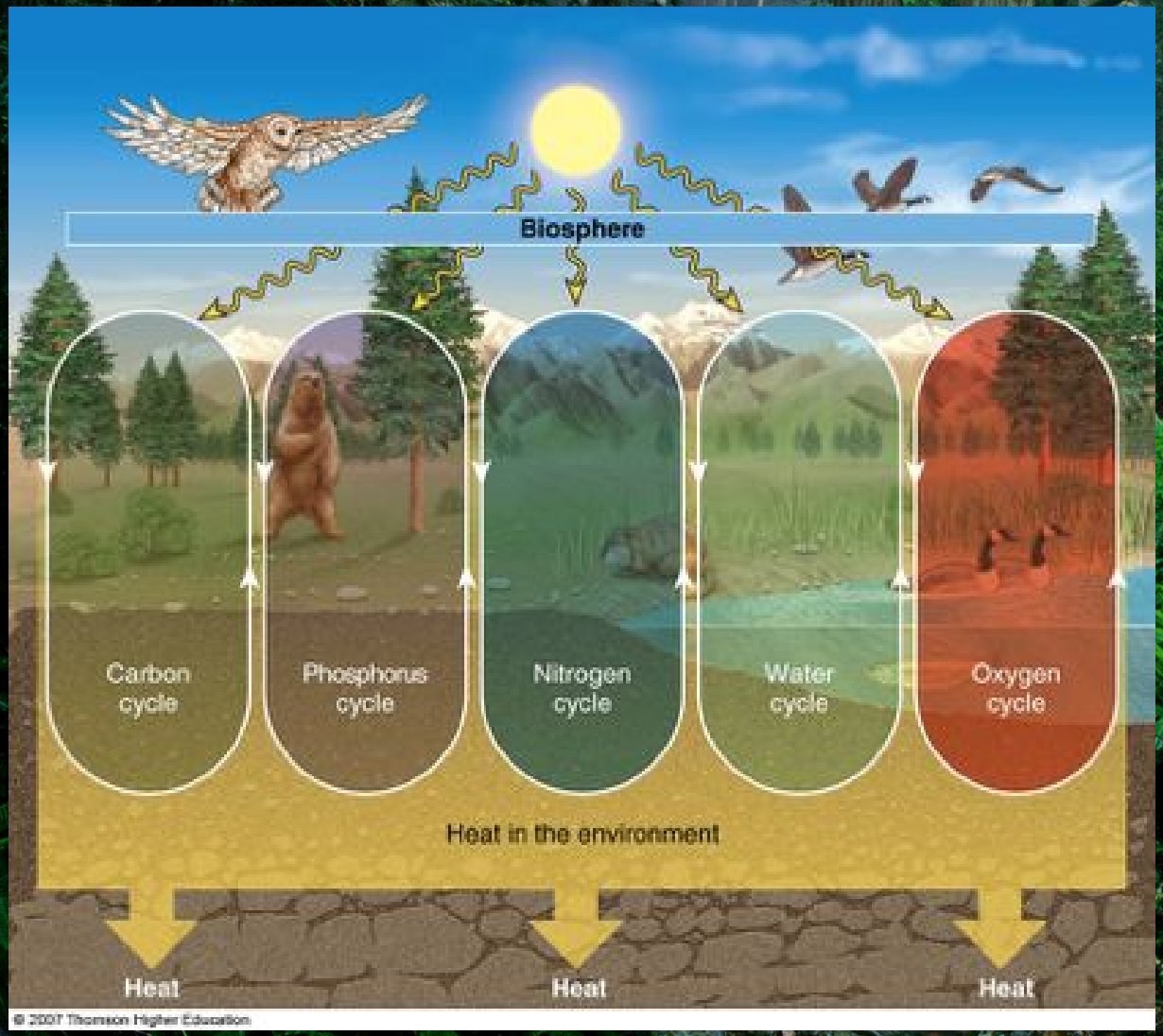
Biogeochemical Cycles

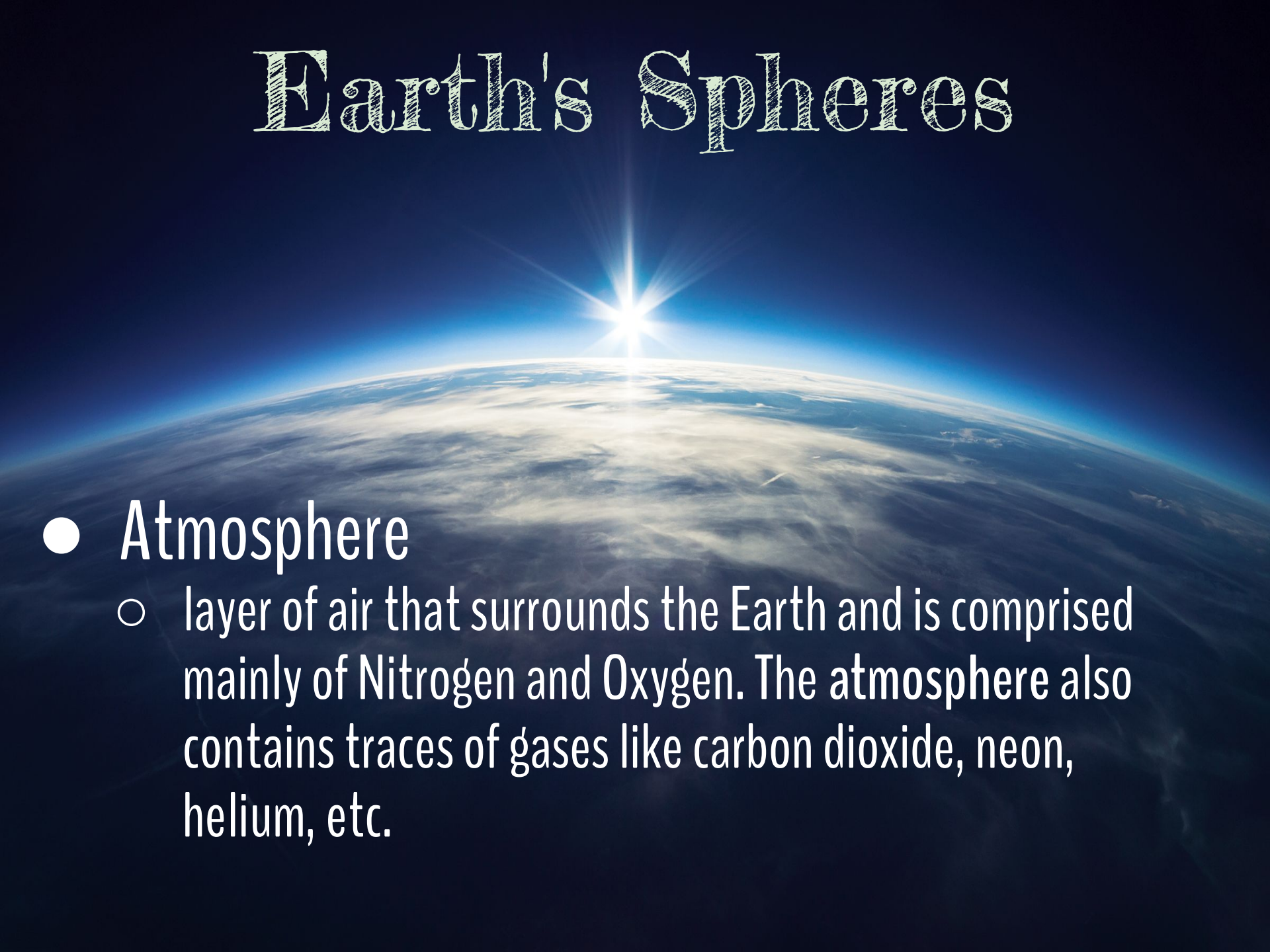
{Living World

What Sustains Life on Earth?



Solar energy, the cycling of matter, and gravity sustain the earth's life.

Earth's Spheres



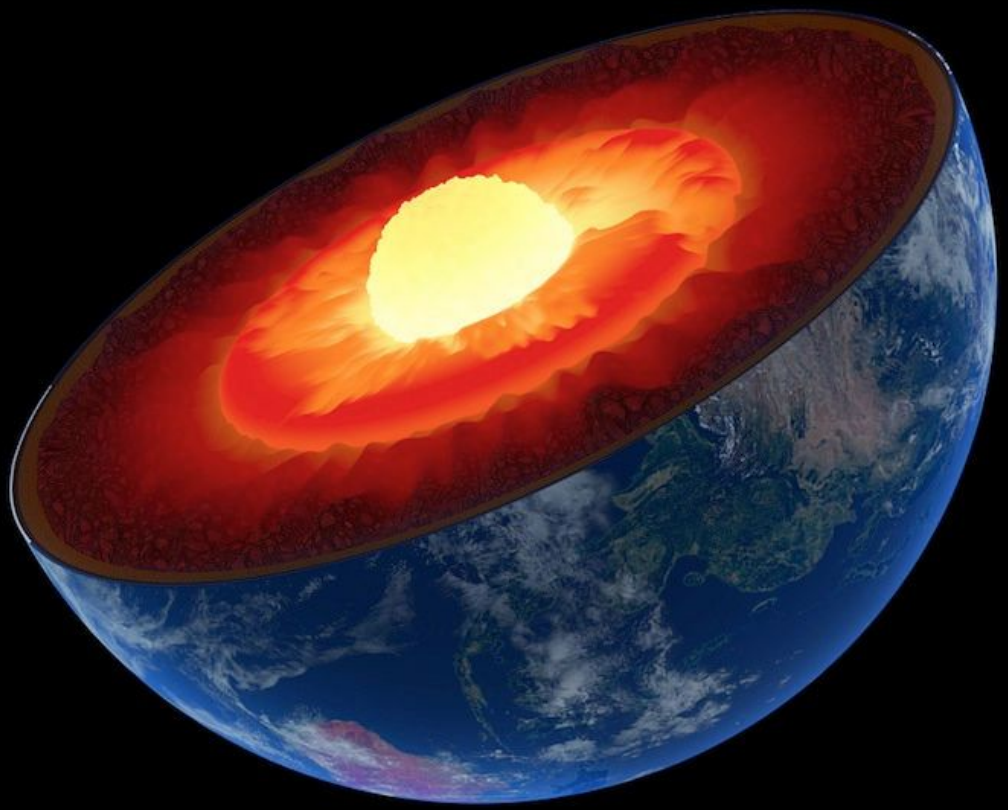
- Atmosphere
  - layer of air that surrounds the Earth and is comprised mainly of Nitrogen and Oxygen. The **atmosphere** also contains traces of gases like carbon dioxide, neon, helium, etc.

Earth's Spheres

- Hydrosphere
  - The watery layer of the earth's surface; includes water vapor. The area of earth that contains the major water bodies such as underground water, oceans, seas, lakes and rivers.

Earth's Spheres

- Geosphere
  - The solid parts of the Earth. consists of the core, mantle and crust of the Earth.



Earth's Spheres

- Biosphere
  - Zone of air, land and water where organisms exist. It is commonly known as the global sum of all ecosystems and consists of several layers including the atmosphere, the lithosphere and the hydrosphere.


THE HYDROSPHERE
Such a small amount!
Study.com

Cycles of Matter

- Within Earth's spheres, matter that is essential for life, is cycled.
- The 5, and most essential matter includes
  - Carbon
  - Hydrogen/Hydrologic
  - Nitrogen
  - Phosphorous
  - Sulfur


Carbon Cycle

Directions Game

1. On a piece of paper, write your starting location.
2. Create a chart: Name of station, What happened there, and Where are you going
3. At that station, roll the dice to see where you are going
4. Head to that location and roll the dice to see where you are going next.
5. Continue on your journey until the timer runs out. (you should have at least 15 stops
6. See the chart on the next slide (you will have 25 minutes)

Game Chart

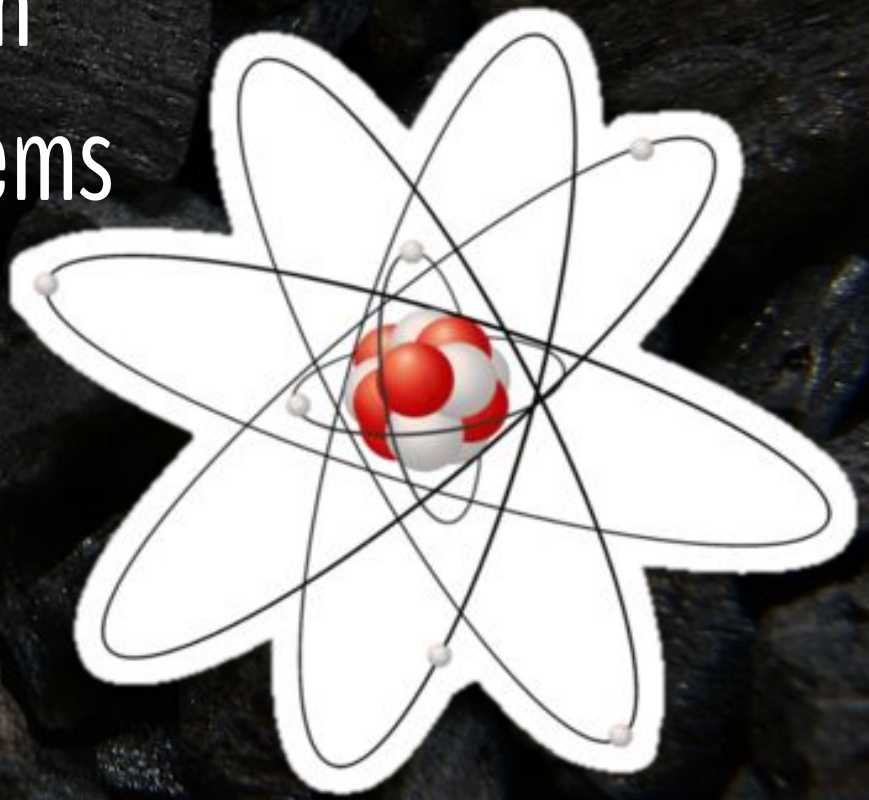
Name of Station	What Happened There	Where are you Going
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		

Questions

1. Where did you go the most?
    a. Why?
2. Where did you go the least?
    a. Why?

What Is Carbon?

- An element: 6 protons, 6 neutron
- The basis of life of earth
- Found in all earth systems

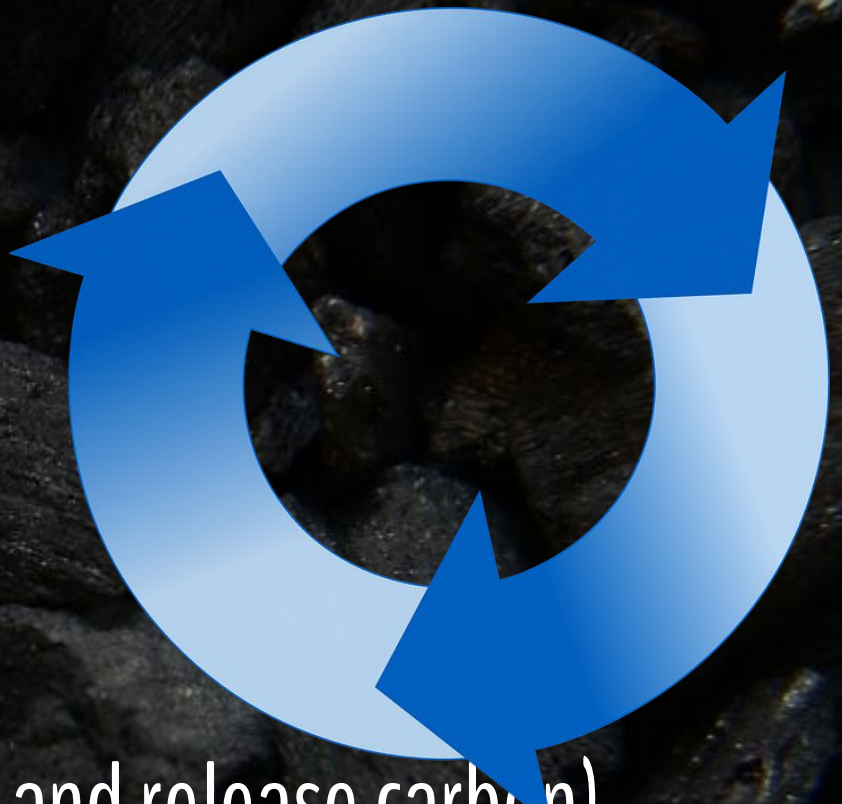


What is the Carbon Cycle?

The same carbon atoms are used repeatedly on earth. They cycle between the atmosphere, hydrosphere, geosphere and biosphere.

How is Carbon Transferred?

Between earth systems



- Photosynthesis
- Respiration
- Consumption
- Decomposition
- Combustion (Burning)
- Weathering (rocks break down and release carbon)
- Dissolve/Vaporize (Between ocean and atmosphere)

Plants and Carbon

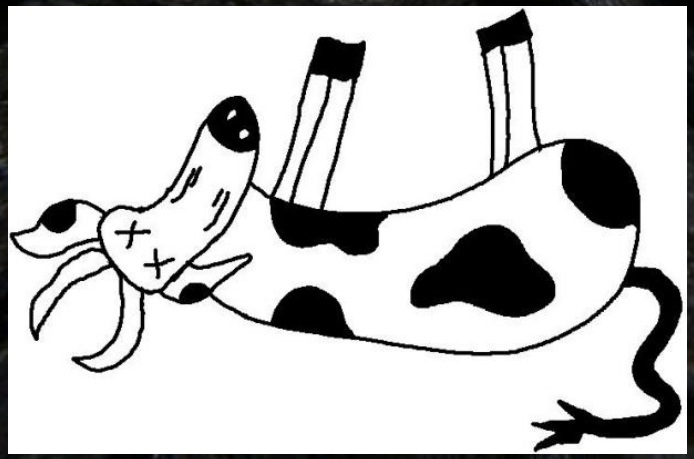
- Plants pull carbon from the atmosphere or hydrosphere and use it to make food (photosynthesis).
- Plants release carbon by glucose in photosynthesis ($C_6H_{12}O_6$), then in respiration when consumed or decomposed (CO_2).
- Photosynthesis: $CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$
- Respiration: $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$

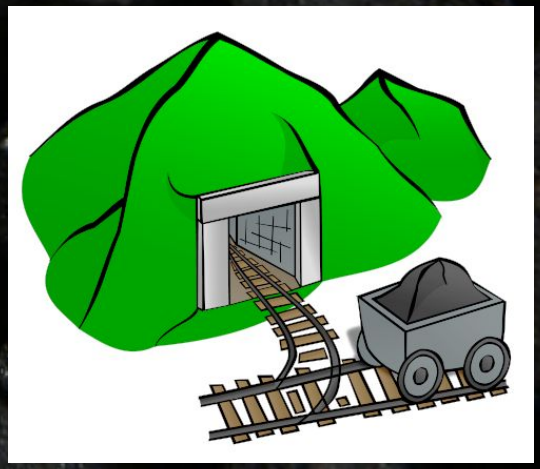
Animals and Carbon

- When organisms eat (consume) plants or other organisms, they take in the carbon and some of it becomes part of their own bodies.
- When they breathe (respiration) they release carbon.

Plants & Animal Die

- When plants and animals die, most of their bodies are decomposed and carbon atoms are returned to the atmosphere.
- Some are not decomposed fully and end up in geosphere deposits underground (soil, oil, coal, etc.) or at the bottom of ocean.





Natural Combustion

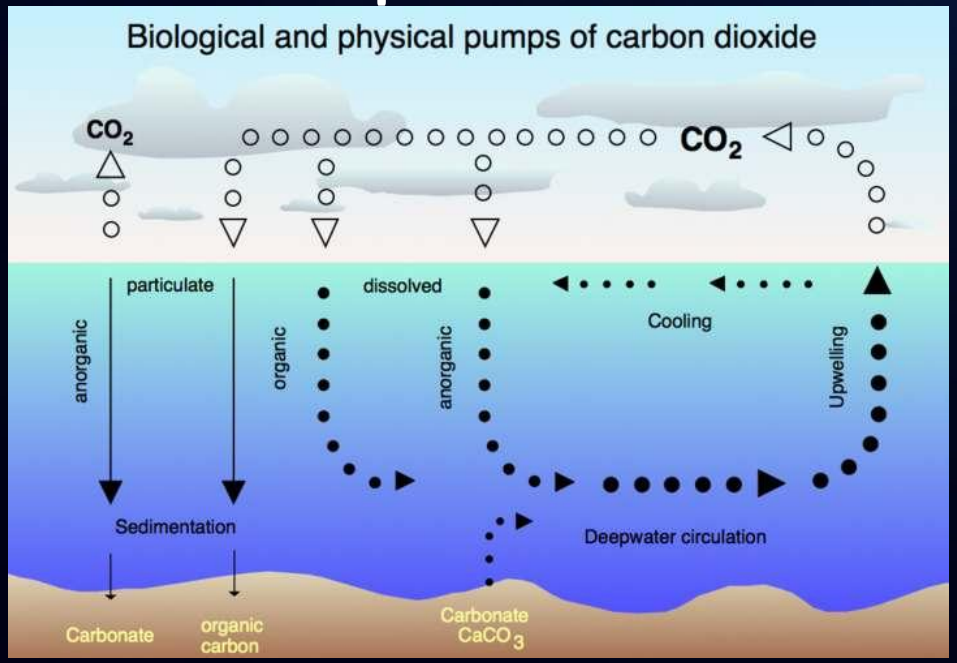
- Forest and grass fires are a natural, required part of the carbon cycle that release carbon into the atmosphere and geosphere.
- Fire returns carbon to the soil and “cleans out” unhealthy plants, allowing new plants to grow.

Carbon Slowly Returns to Atmosphere

- Carbon in rocks and underground deposits is released very slowly into the atmosphere.
- This process takes many years and is usually caused by weathering.

Carbon in Oceans

- Oceans store large amounts of carbon.
- Largest exchange of carbon in carbon cycle is the dissolving and vaporization of carbon dioxide between the atmosphere and ocean surface.



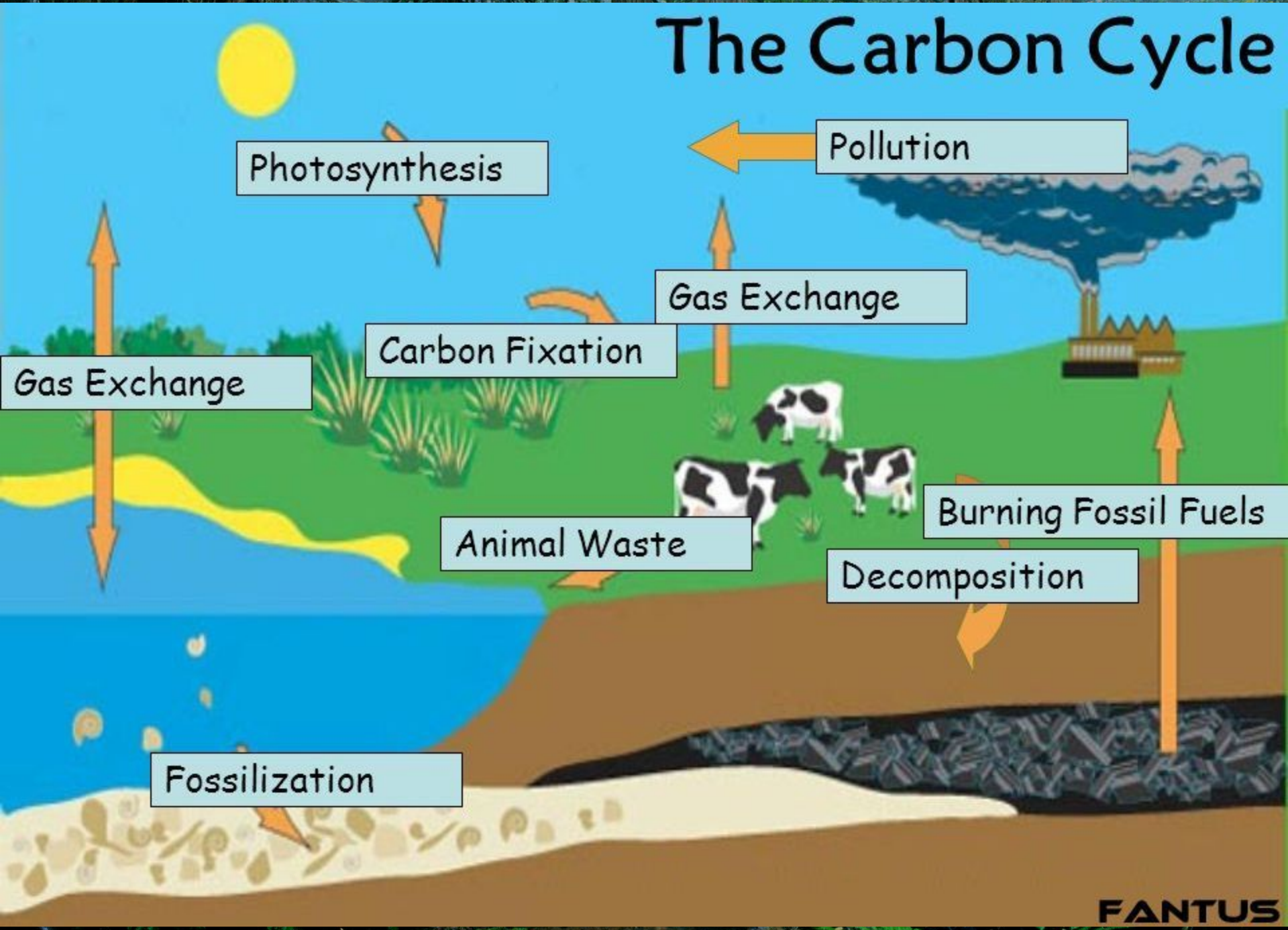
Oceans Store Carbon on Ocean Floor

- Many animals pull carbon from water to use in shells, etc. When these animals die, the carbon substances are deposited at the bottom of the ocean.

Human Impact

- Under balanced conditions, fossil fuels release carbon stores very slowly into atmosphere.
- When humans burn fossil fuels, it releases a tremendous amount of carbon into the atmosphere over a very short time span.
- Increased carbon dioxide in atmosphere increases global warming
- Fewer plants mean less CO_2 removed from atmosphere

Sec 46-0 THE GLOBAL CARBON CYCLE


The Carbon Cycle
Photosynthesis
Pollution
Gas Exchange
Carbon Fixation
Gas Exchange
Animal Waste
Burning Fossil Fuels
Decomposition
Fossilization
FANTUS


Hydrologic Cycle

Usable Water is Rare

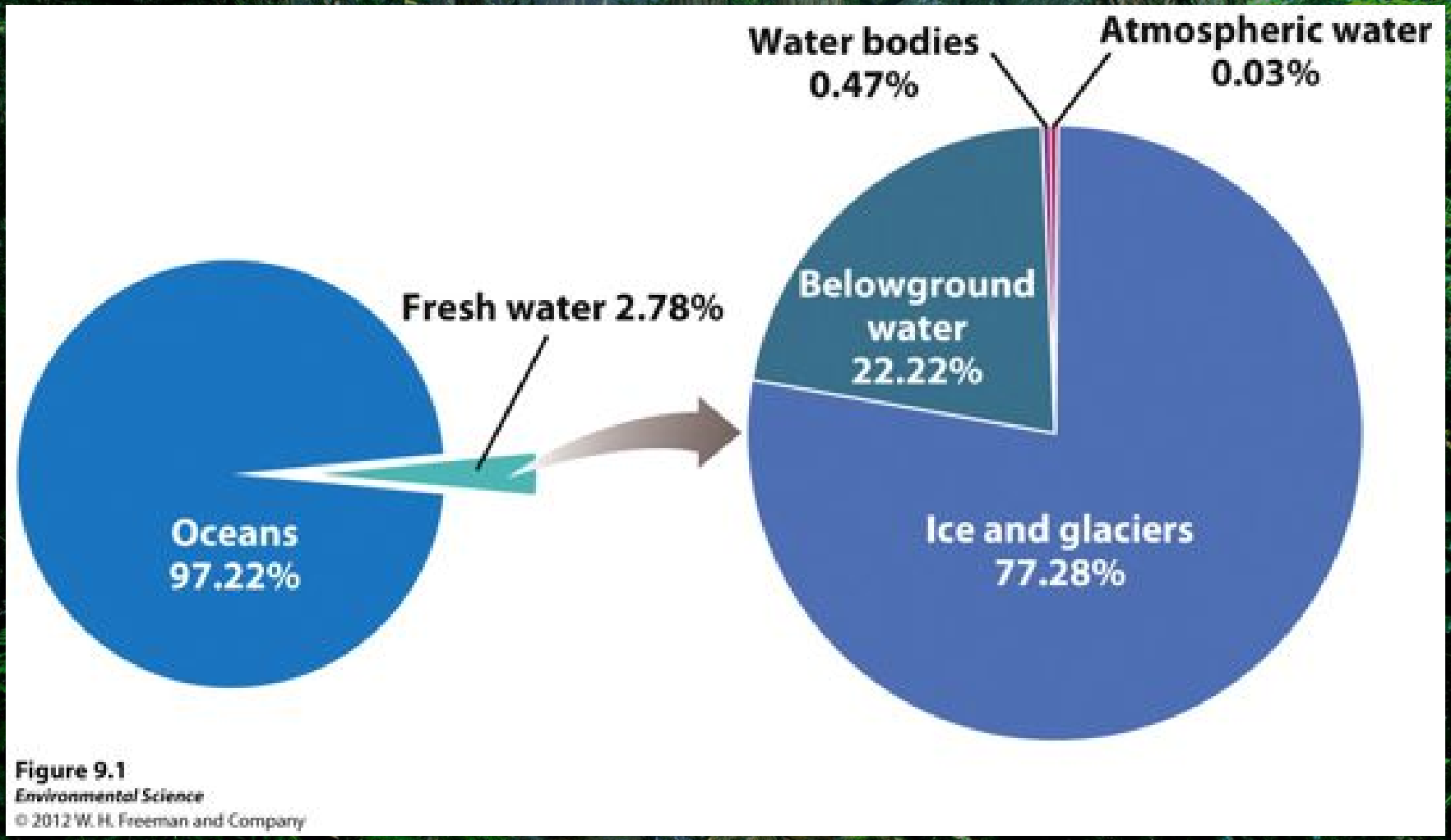


Figure 9.1
Environmental Science

Freshwater

- Only 2.5% of the planet's water is freshwater.
- And only 1% of that exists on Earth's surface.
- Only 1 part in 10,000 of water is easily accessible for drinking and irrigation.

Importance of Water

Water

- Keeps us alive
- Moderates climate
- Sculpts the land
- Removes and dilutes wastes and pollutants
- Moves continually through the hydrologic cycle

How we use Water

- Agriculture- 70%
- Industry- 20%
- Household/ Residential- 10%

Too Much Water

- Leads to pollution of water supply and sewage seeping into the ground.
- Too much precipitation
- Deforestation
- Destruction of wetlands
- Removal of permeable surfaces creating impervious surfaces-
  - covering the ground with asphalt, concrete, building

Too Little Water

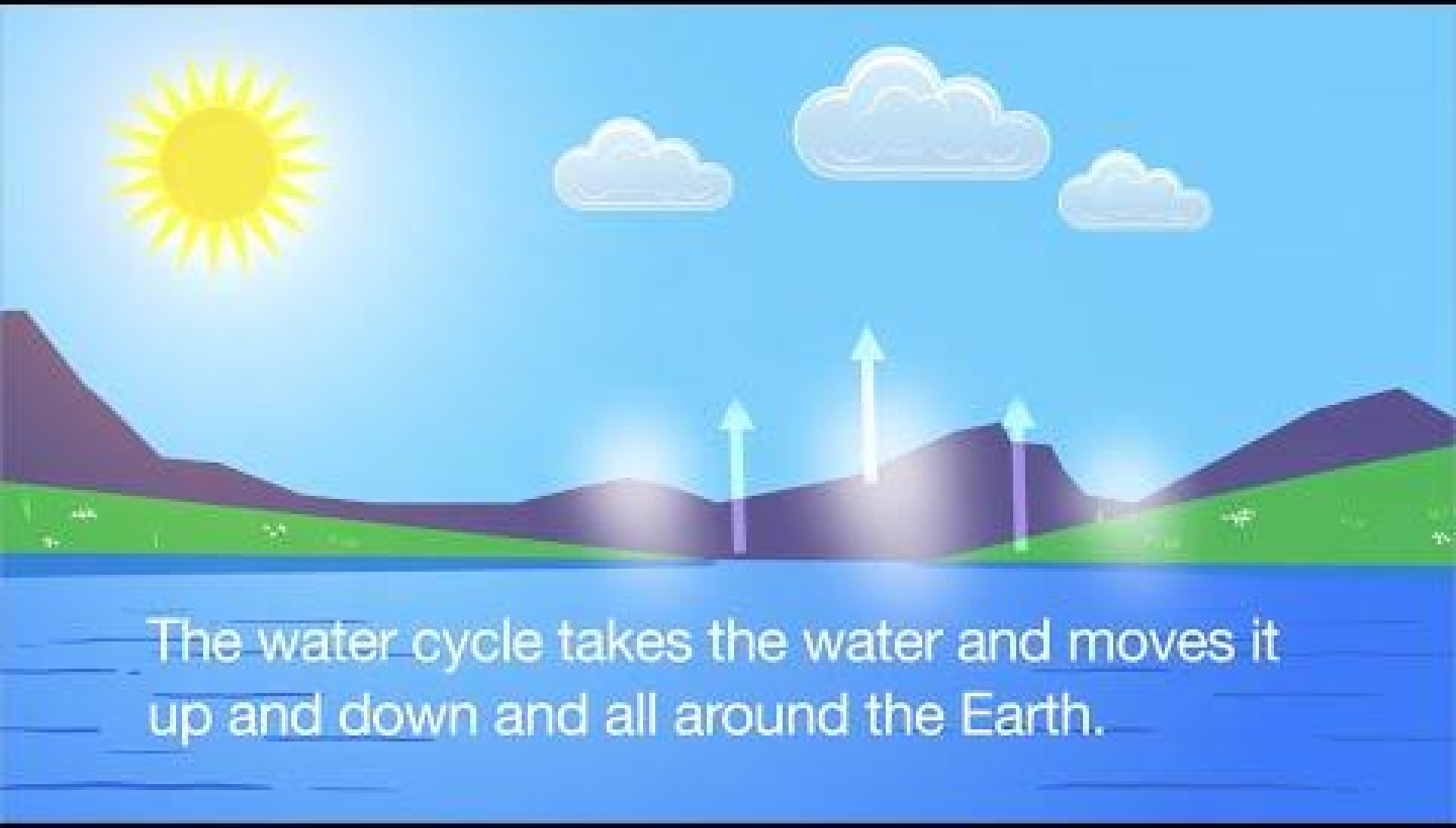
Leads to soil erosion, hydrophobic soil conditions and expanding deserts.

The Water Cycle

- Water is naturally recycled through the water cycle.
- The water cycle is the continuous process by which water moves through the living and nonliving parts of the environment.
- The sun is the source of energy that drives the water cycle.
- In the water cycle, water moves from bodies of water, land, and living things on Earth's surface to the atmosphere and back to Earth's surface.

Steps to the Water Cycle

- Water Evaporates
- Clouds Form from condensation
- Water Falls as Precipitation
- And then it starts again


The water cycle takes the water and moves it up and down and all around the Earth.

Water Evaporates

Evaporation is the process by which molecules at the surface of a liquid absorb enough energy to change to the gaseous state. Water can evaporate from where?

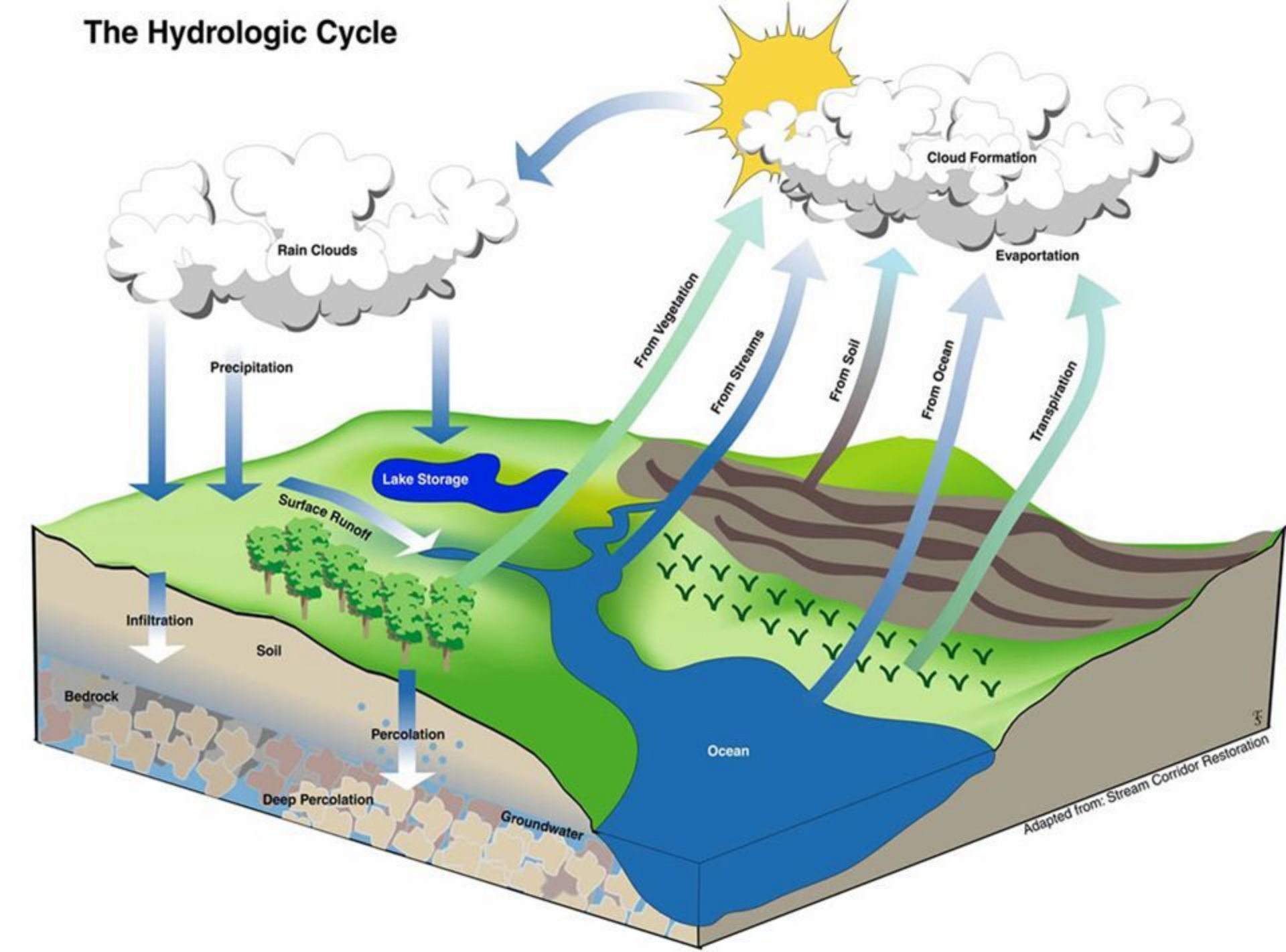
- Ocean
- Lakes
- Soil, puddles, and even from your skin
- Plants
- Eventually the water is given off through the leaves as water vapor in a process called **transpiration**

Clouds

- Water molecules find their way into the atmosphere, *warm* air carries it upward.
- Higher up, air tends to become much *colder*.
- Cold air holds *less* water vapor than warm air.
- Some of the water vapor cools and *condenses* into liquid water.
- Condensed droplets of water clump together around tiny dust particles in the air, forming *clouds*

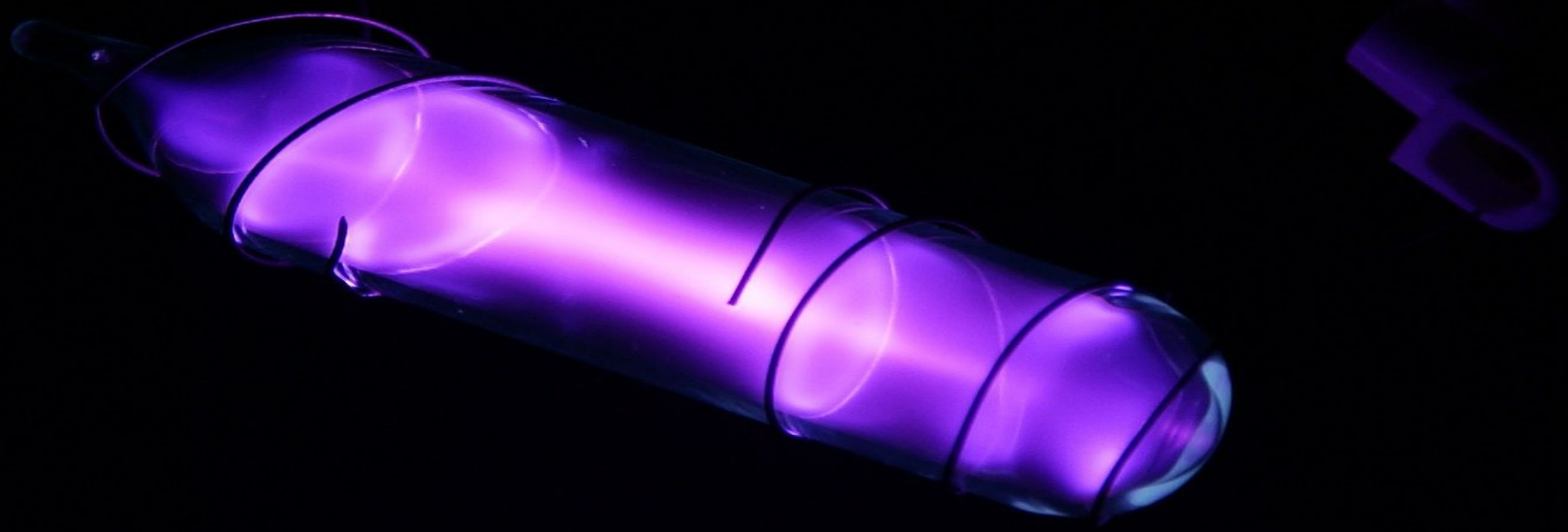
Water Falls as Precipitation

- As more water vapor condenses, water droplets in a cloud eventually become so heavy that they fall back to Earth.
- Water that falls to Earth as rain, snow, hail, or sleet is called *precipitation*.
- Most precipitation falls directly into the oceans.
- Precipitation is the *source* of all fresh water on and below Earth's surface.
- The water cycle *renews* the usable supply of fresh water on Earth.


The Hydrologic Cycle
Cloud Formation
Rain Clouds
Evaportation
From Vegetation
From Streams
From Soil
From Ocean
Transpiration
Precipitation
Lake Storage
Surface Runoff
Infiltration
Soil
Bedrock
Percolation
Deep Percolation
Groundwater
Ocean
Adapted from: Stream Corridor Restoration


EPISODE 24.2
A GLASS OF DINO PEE
KIDS

Nitrogen Cycle



What is Nitrogen?

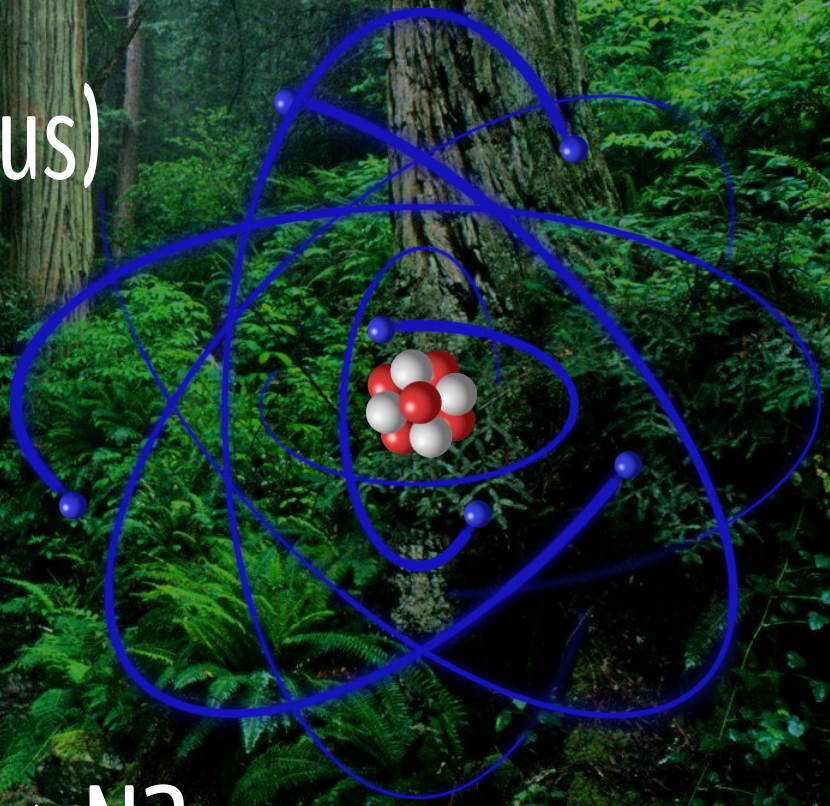
- Nitrogen is essential to life on Earth.
- It is a component of all proteins and it can be found in all living systems.
- Nitrogen compounds are present in organic materials, foods, fertilizers, explosives and poisons.
- Nitrogen is crucial to life, but in excess it can also be harmful to the environment.

Sources of Nitrogen

- Lightning
- Inorganic fertilizers
- Nitrogen Fixation
- Animal Residues
- Crop residues
- Organic fertilizers

Forms of Nitrogen

- Urea -> CO(NH2)2
- Ammonia -> NH3 (gaseous)
- Ammonium -> NH4
- Nitrate -> NO3
- Nitrite -> NO2
- Atmospheric Dinitrogen -> N2
- Organic N



Roles of Nitrogen

- Plants and bacteria use nitrogen in the form of NH_4^+ or NO_3^-
- It serves as an electron acceptor in anaerobic environment
- Nitrogen is often the most limiting nutrient in soil and water.
  - A nutrient required for the growth of an organism but available in a lower quantity than other nutrients.

Process

1. Nitrogen fixation (air to soil)
   a. A process by which some organisms can convert nitrogen gas molecules directly into ammonia.
   b. Biological- bacteria live on roots of legumes
   c. Geochemical- atmospheric fixation (lightening)
2. Nitrification (usable form of nitrogen)- nitrifying bacteria convert ammonia to nitrite and then to nitrate
   a. The conversion of ammonia (NH_4^+) into nitrite (NO_2^-) and then into nitrate (NO_3^-).

Process

3. Assimilation (picked up)

a. The process by which producers incorporate elements into their tissues.

b. producers take up nitrogen from soil through roots

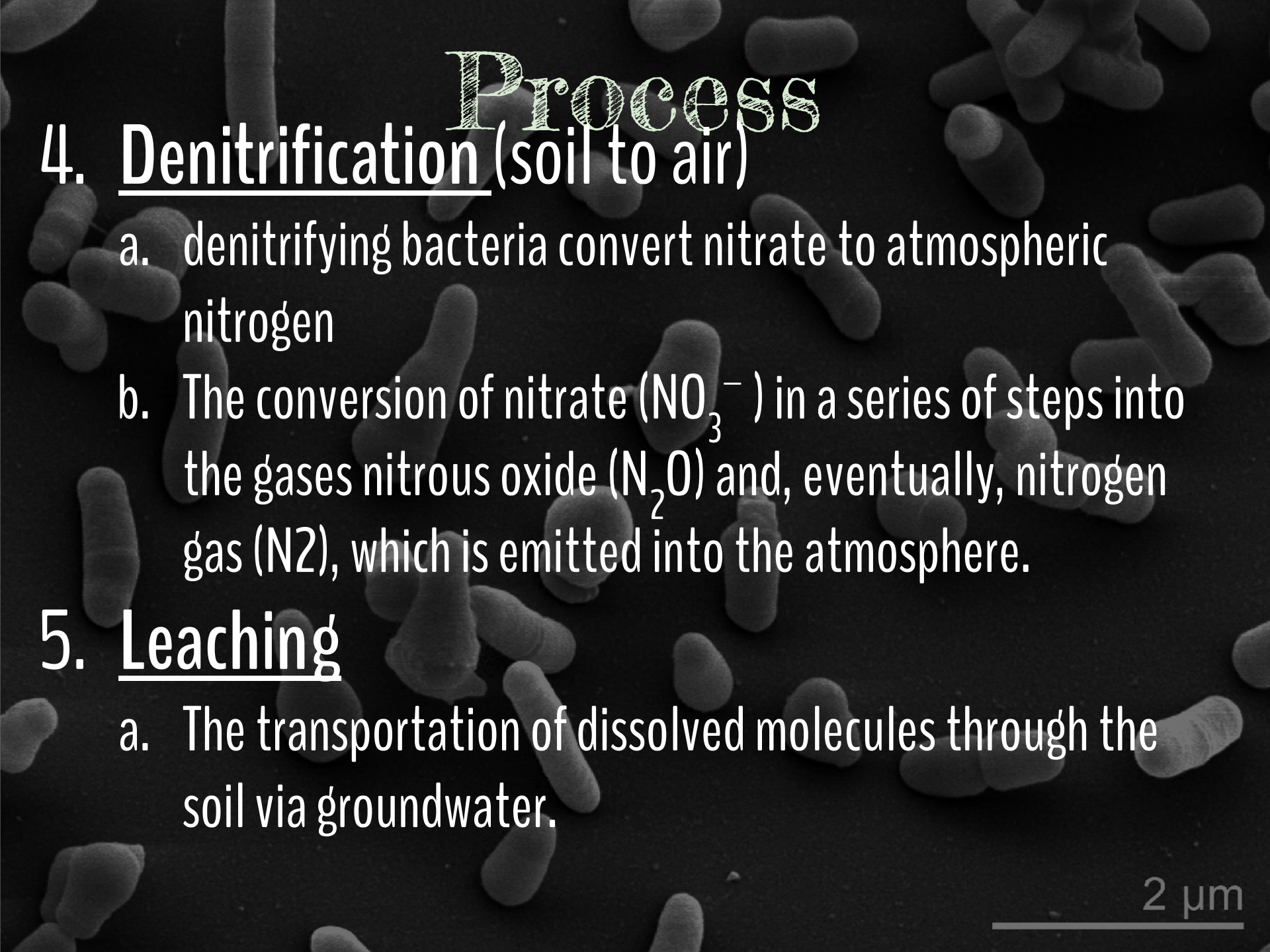
c. Consumers take in nitrogen by eating

Process

4. Mineralization
   a. The process by which fungal and bacterial decomposers break down the organic matter found in dead bodies and waste products and convert it into inorganic compounds.
5. **Ammonification** (thrown out)
   a. The process by which fungal and bacterial decomposers break down the organic nitrogen found in dead bodies and waste products and convert it into inorganic ammonium (NH_4^+).
   b. decomposers break down dead matter
   c. Animal waste

Process

4. Denitrification (soil to air)
   a. denitrifying bacteria convert nitrate to atmospheric nitrogen
   b. The conversion of nitrate (NO_3^-) in a series of steps into the gases nitrous oxide (N_2O) and, eventually, nitrogen gas (N2), which is emitted into the atmosphere.
5. Leaching
   a. The transportation of dissolved molecules through the soil via groundwater.



Human Impacts

- Use of inorganic fertilizers ---
  - Increase in atmospheric nitrogen= acid rain
  - Loss of biodiversity
  - Eutrophication (nutrification of waters)---algae bloom---death---decomposition---decomposers deplete the oxygen= zone of hypoxia

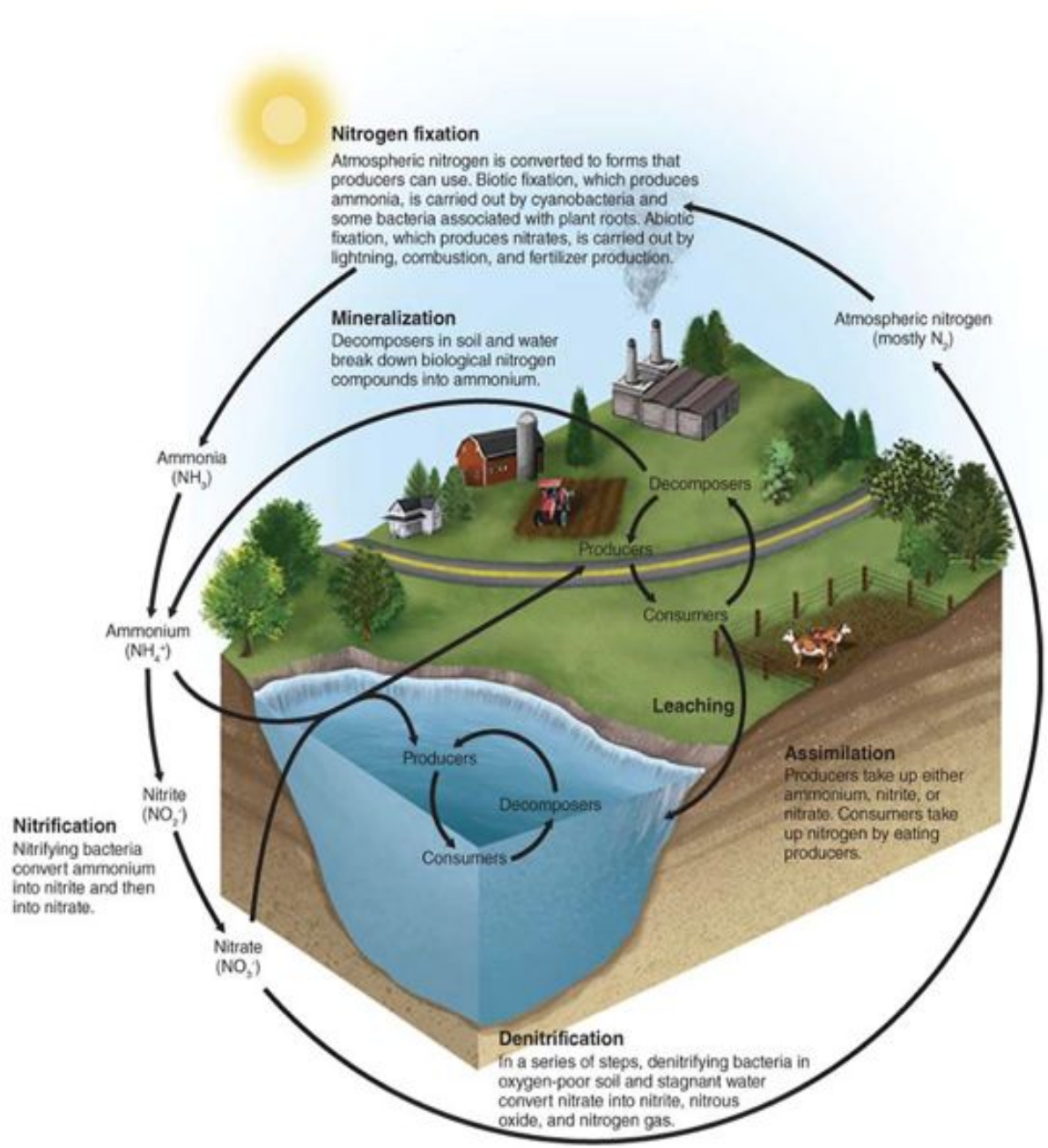
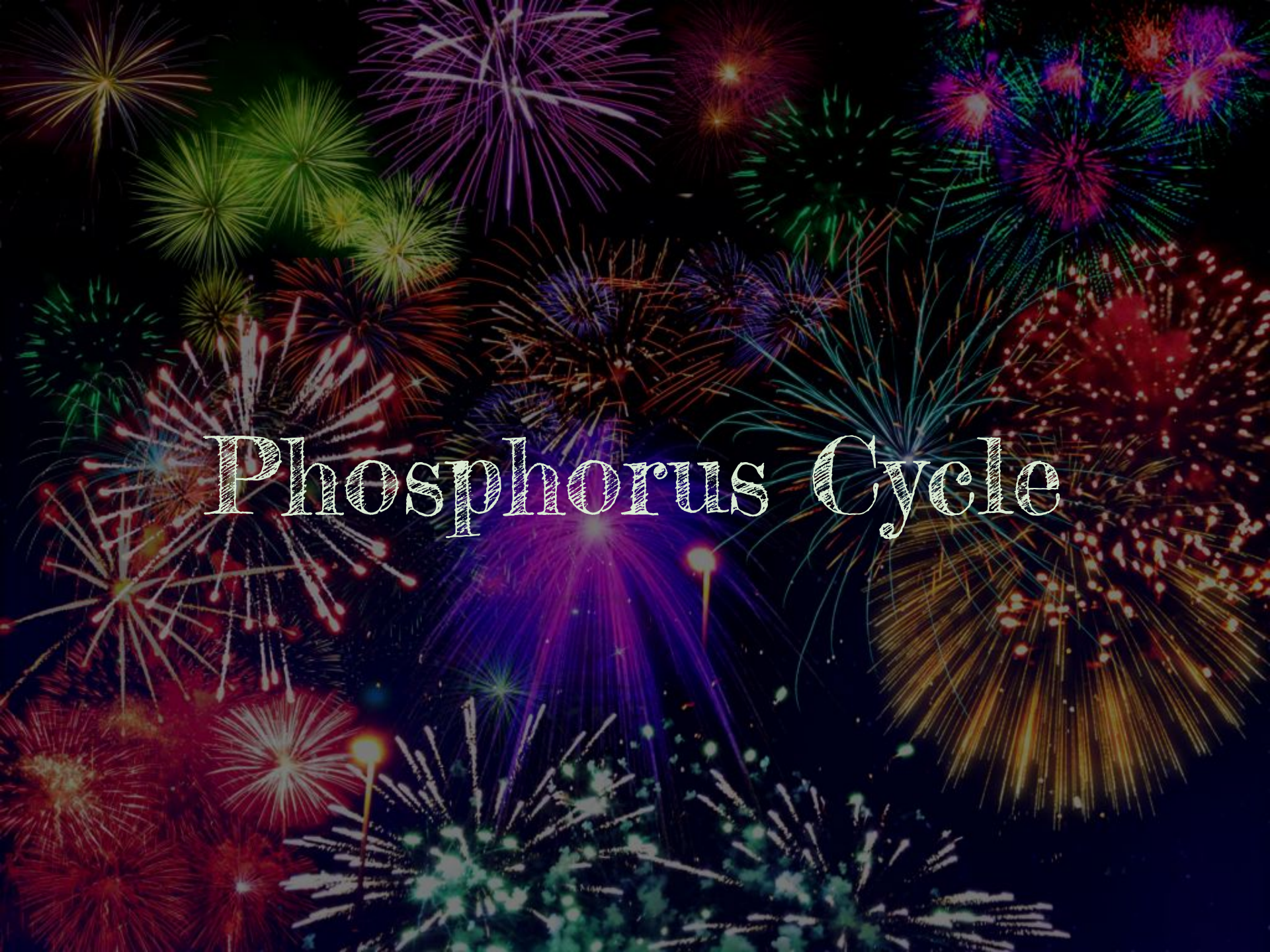


Figure 7.3
Environmental Science for AP®, Second Edition

The nitrogen cycle moves nitrogen from the atmosphere and into soils through several fixation pathways, including the production of fertilizers by humans. In the soil, nitrogen can exist in several forms. Denitrifying bacteria release nitrogen gas back into the atmosphere.

Nitrogen Cycle


Phosphorus Cycle

What is Phosphorus?

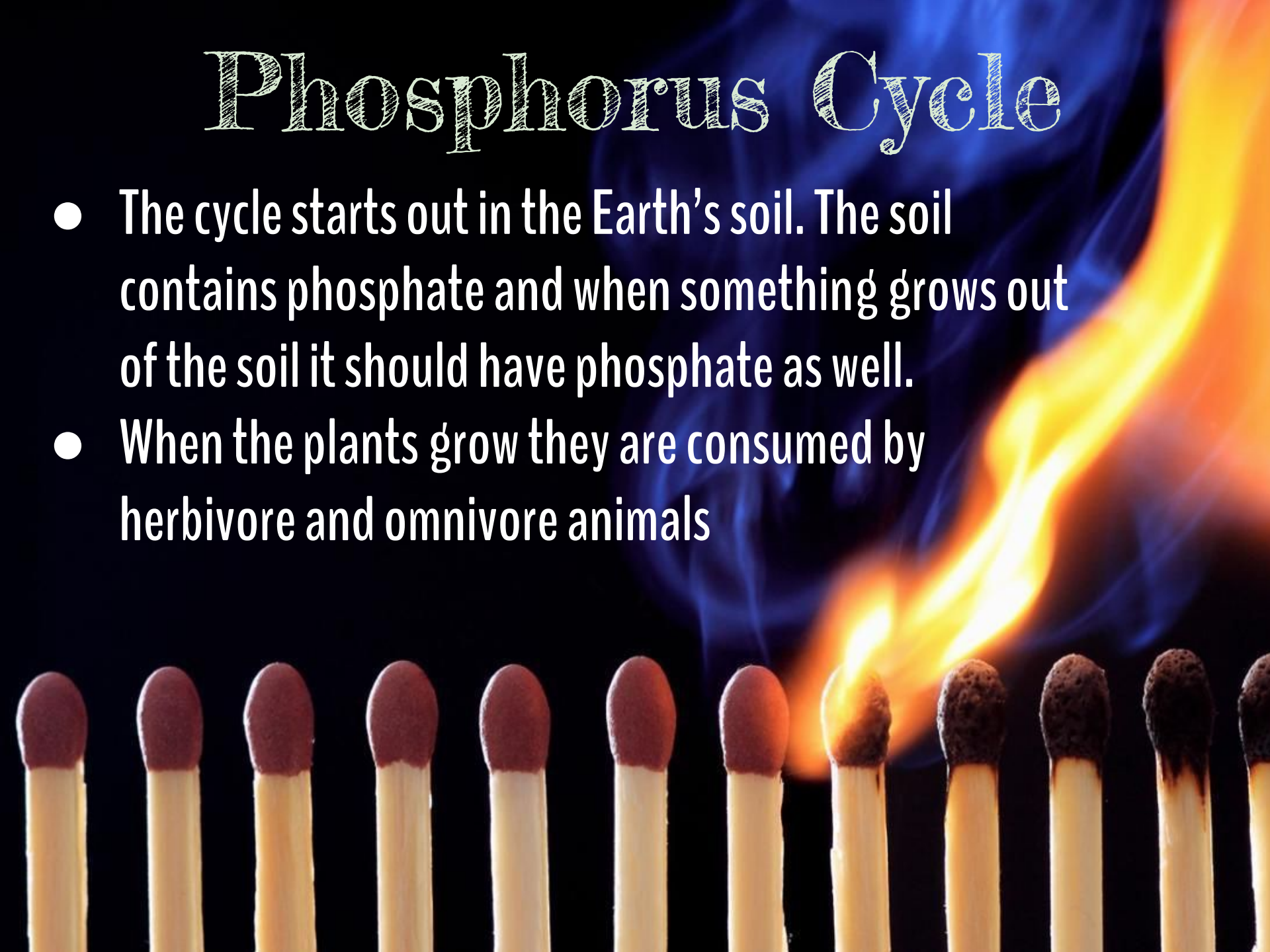
The phosphorus cycle, is the circulation of phosphorous among the rocks, soils, water, and plants and animals of the earth. Human beings and all other organisms must have phosphorus to live. In nature, most phosphorus occurs in phosphate rock, which contains phosphate ions combined with calcium, magnesium, chlorine, and fluorine.

Fun Facts

- It cannot be found in air in the gaseous state . This is because phosphorus is usually liquid at normal temperatures pressures.
- This cycle is the slowest of the matter cycles.
- Phosphorus is most commonly found in rock formations and ocean sediments as phosphate salts. Phosphates are also limiting factors for plant-growth in marine ecosystems, because they are not very water-soluble.

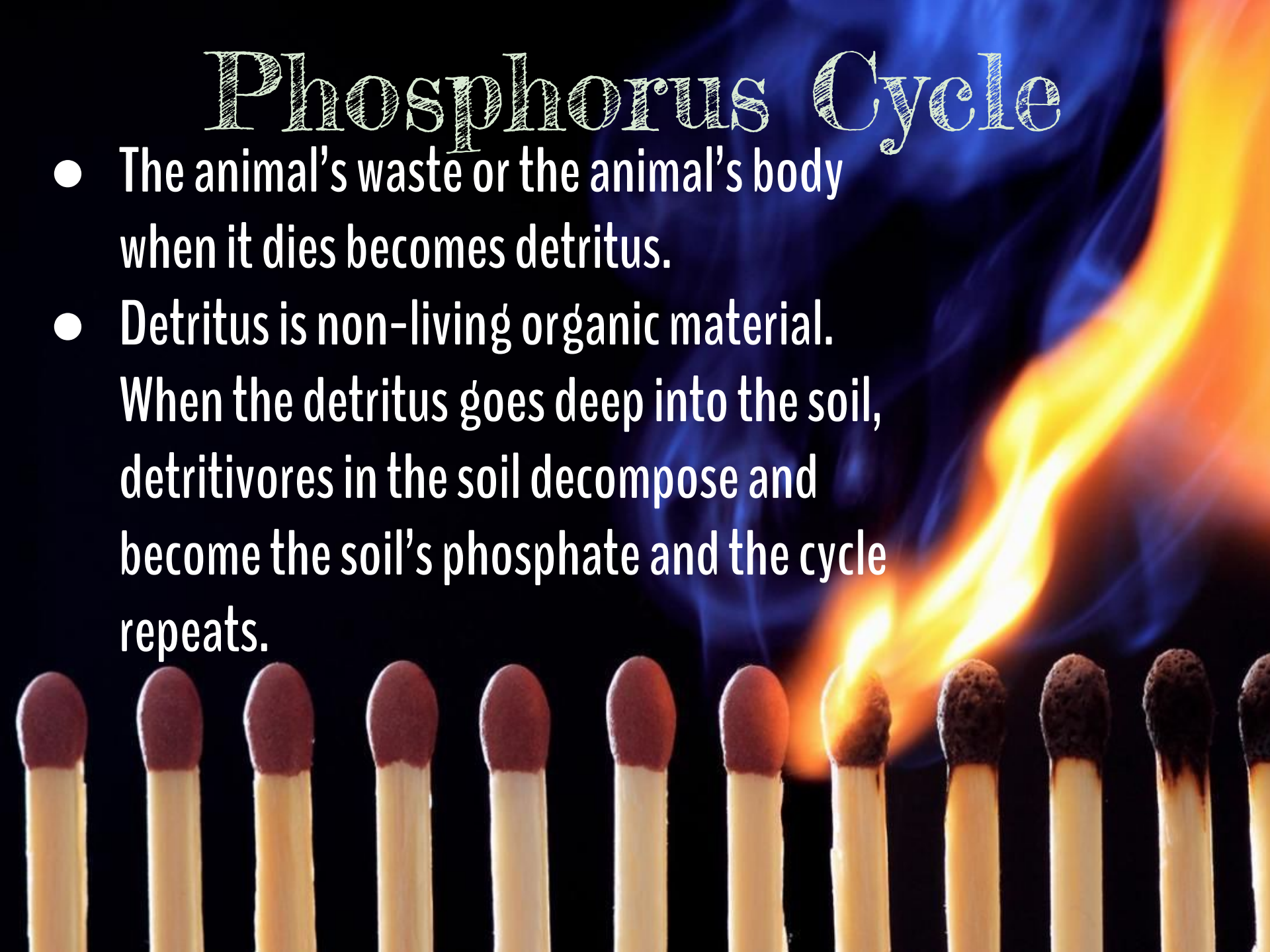
Phosphorus Cycle

- The cycle starts out in the Earth's soil. The soil contains phosphate and when something grows out of the soil it should have phosphate as well.
- When the plants grow they are consumed by herbivore and omnivore animals



Phosphorus Cycle

- The animal's waste or the animal's body when it dies becomes detritus.
- Detritus is non-living organic material. When the detritus goes deep into the soil, detritivores in the soil decompose and become the soil's phosphate and the cycle repeats.



Human Impact

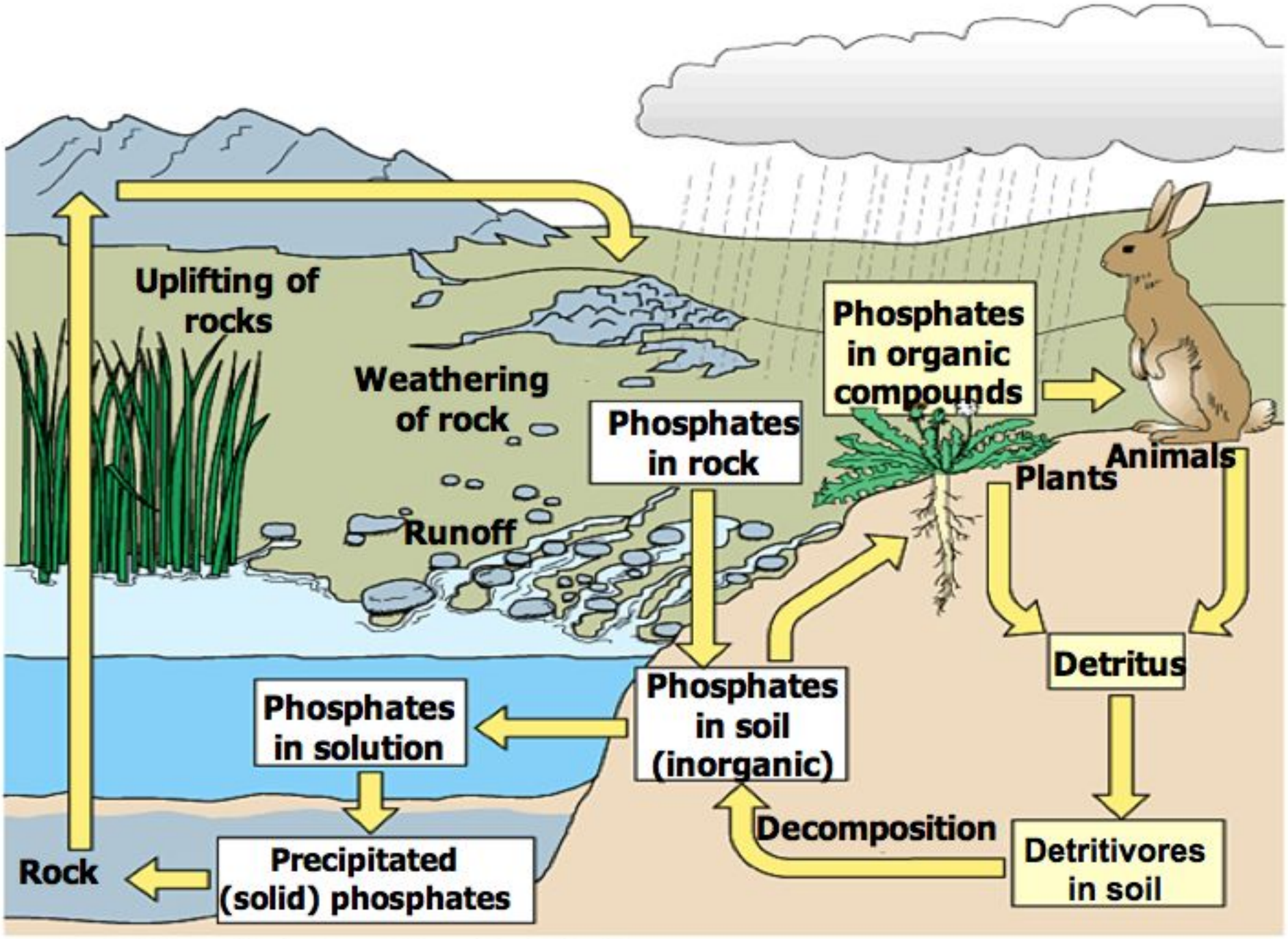
Cutting and burning of tropical rain forests affects the phosphorus cycle. As the forest is cut and/or burned, nutrients originally stored in plants and rocks are quickly washed away by heavy rains, causing the land to become unproductive.

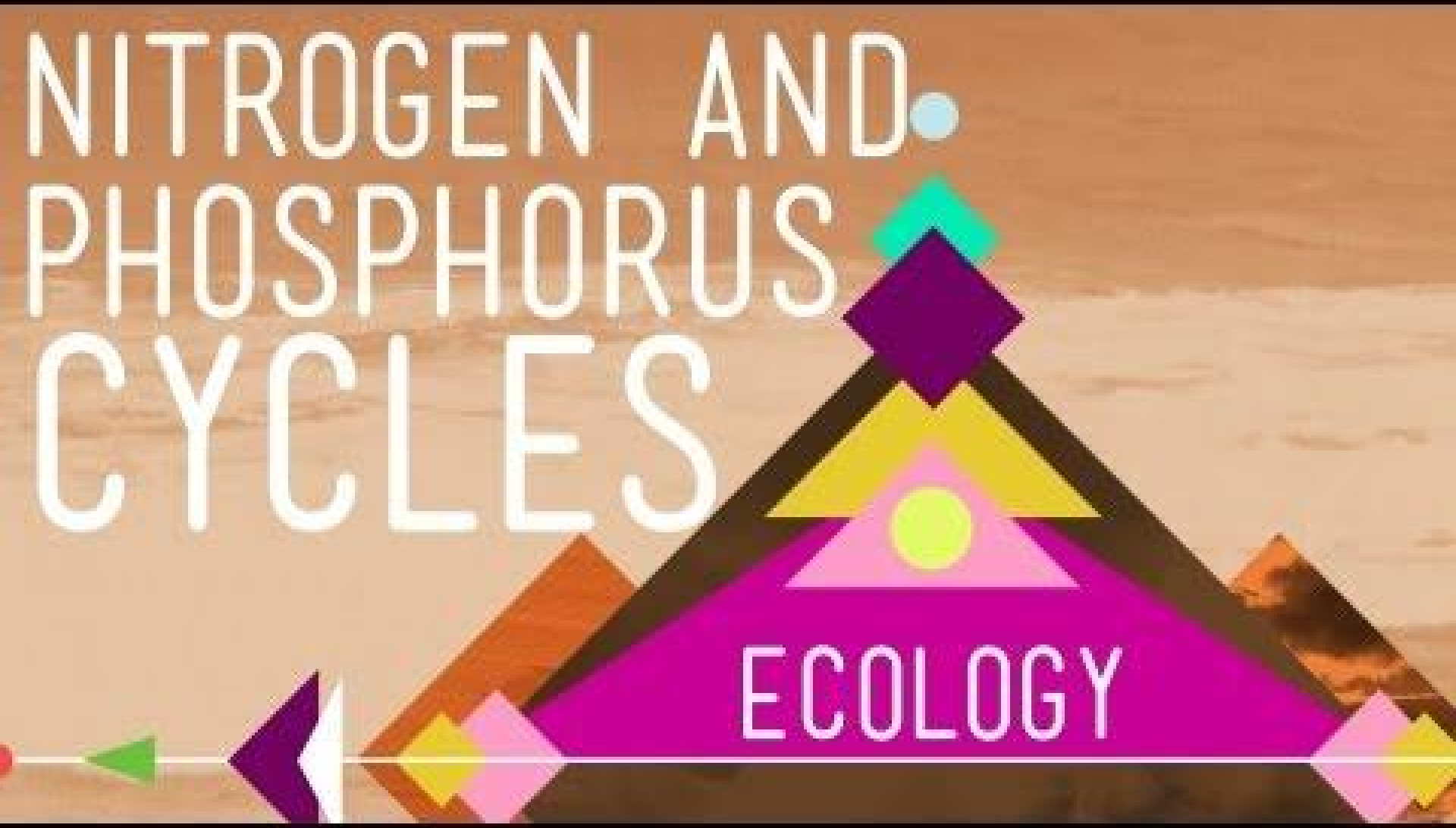
Human Impact

Another human cause of artificial eutrophication is run-off from mines. Mining in areas where rock is rich in phosphorus minerals can create dust that is blown by wind into nearby water systems.

Human Impact

A major problem with the use of phosphorus in fertilizers is the process of artificial eutrophication. Eutrophication is a large increase in the primary productivity of a lake. Eutrophication can be harmful to the natural balance of a lake and result in massive death of fish and other animals as dissolved oxygen levels are depleted from the water.




NITROGEN AND PHOSPHORUS CYCLES
ECOLOGY


Sulfur Cycle

What is Sulfur?

Atomic number: 16.

Symbol: S

Sulfur is a yellow crystall.

What is Sulfur?

- In nature it can be found as the pure element, and as sulfide and sulfate minerals.
- It is critical in the environment, climate and the health of ecosystems.

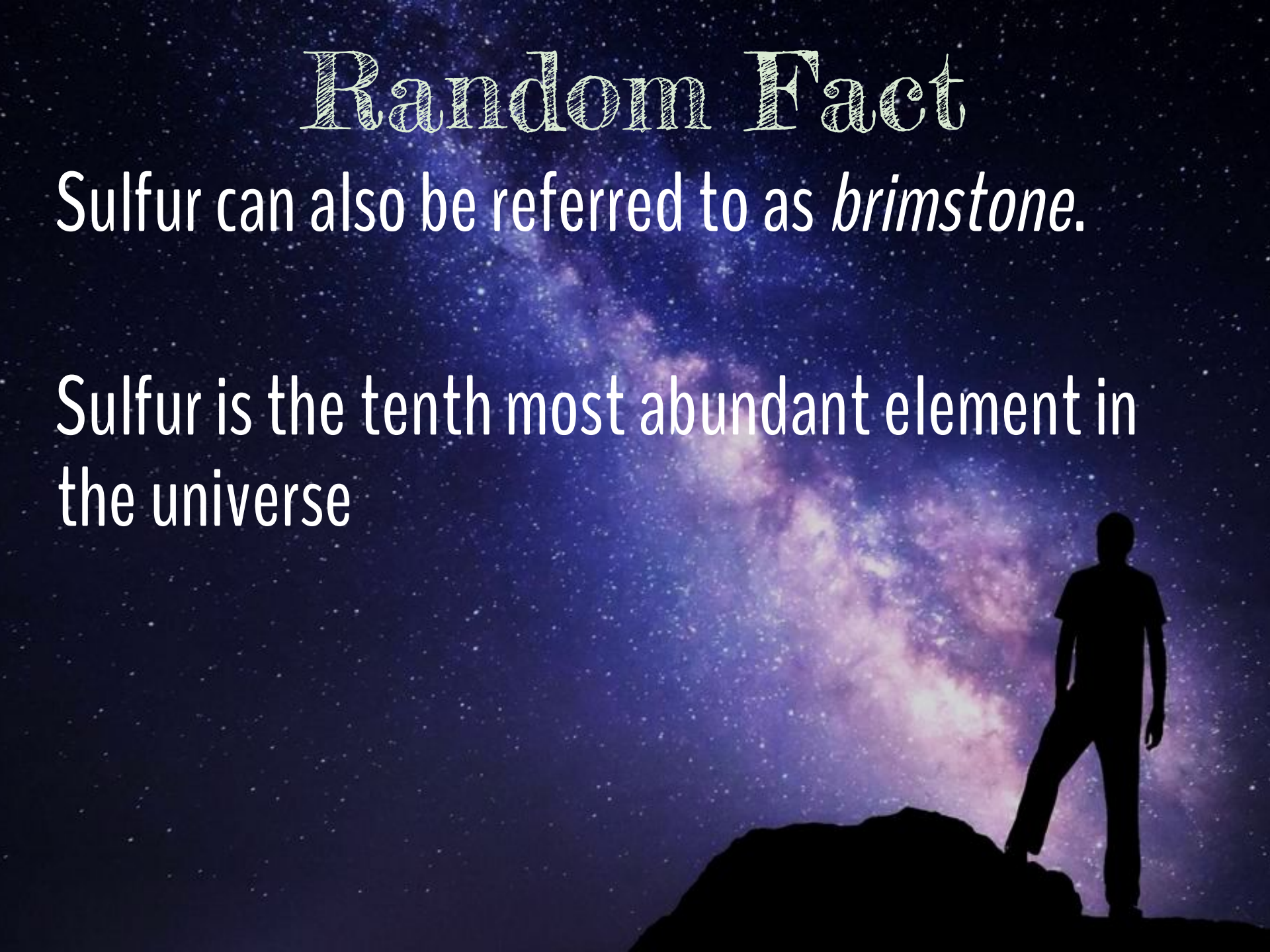
Commercial Uses

- Fertilizers
- Gunpowder
- Matches
- Insecticides
- Fungicides
- Vitamins
- proteins
- hormones.

Random Fact

Sulfur can also be referred to as *brimstone*.

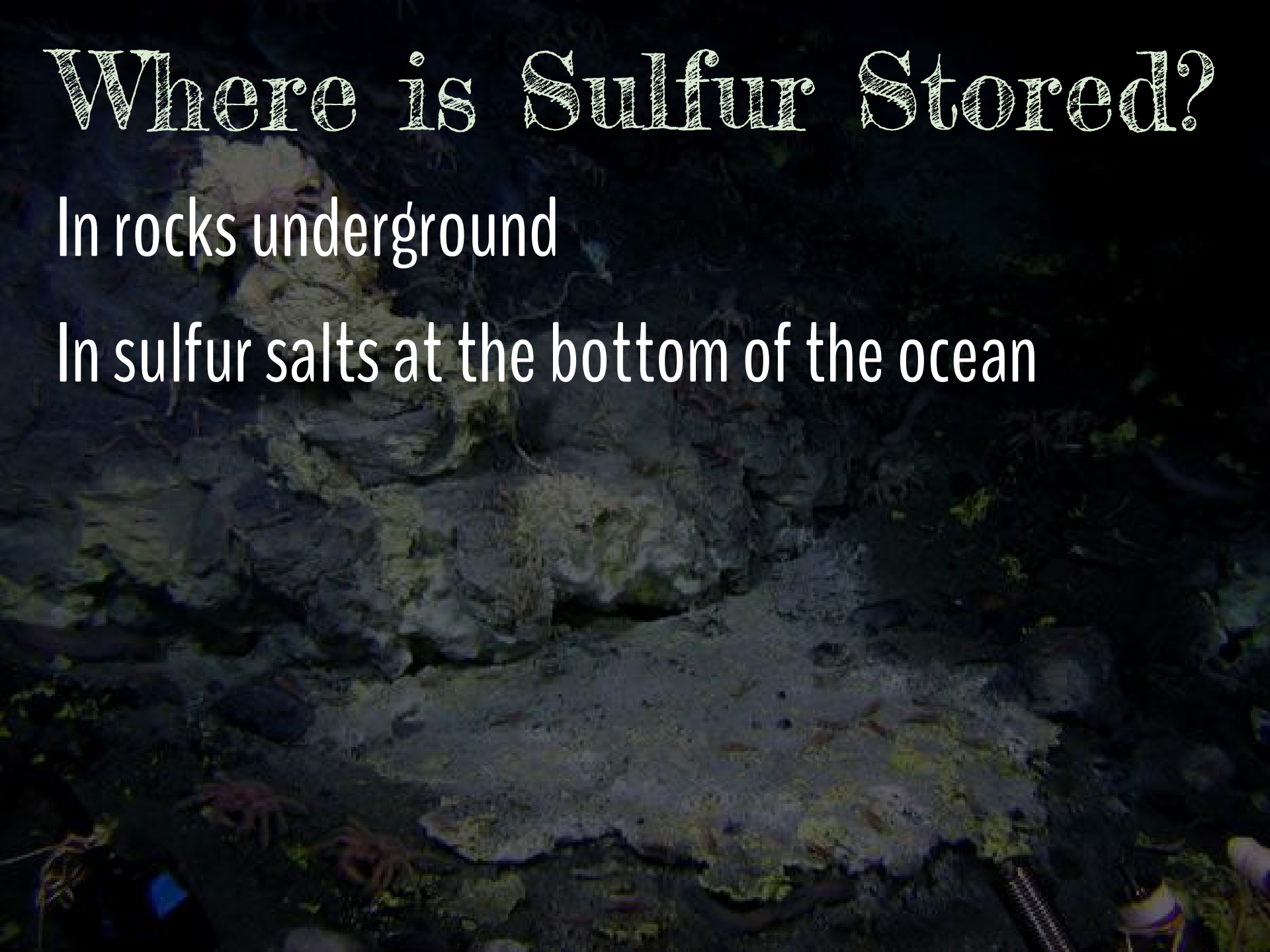
Sulfur is the tenth most abundant element in the universe



Where is Sulfur Stored?

In rocks underground

In sulfur salts at the bottom of the ocean



Sulfur Cycle

Erosion, weathering, deposition

Predominantly atmospheric cycle

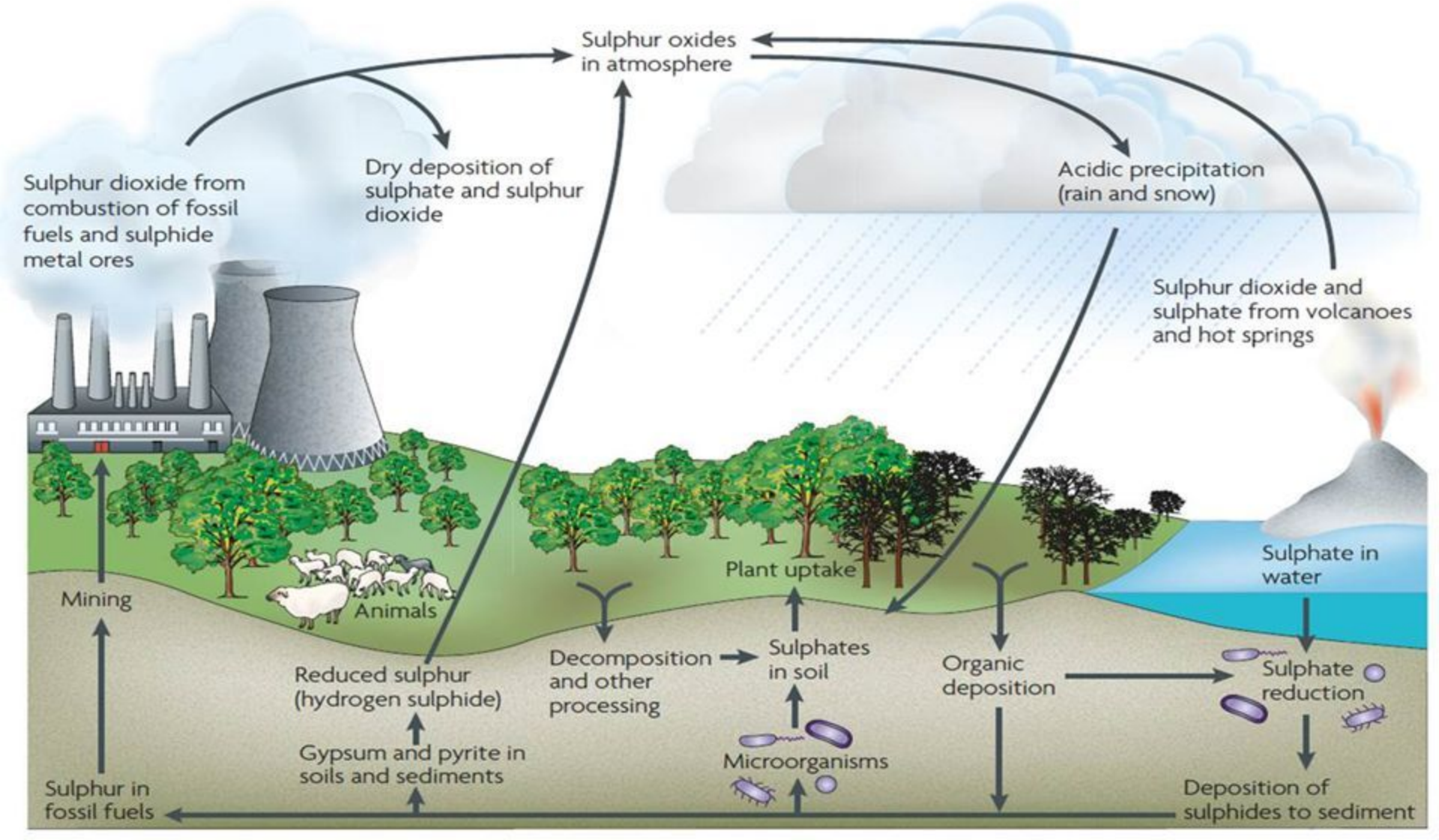
Marine cycle

Soil-plant cycle

Sulfur Cycle

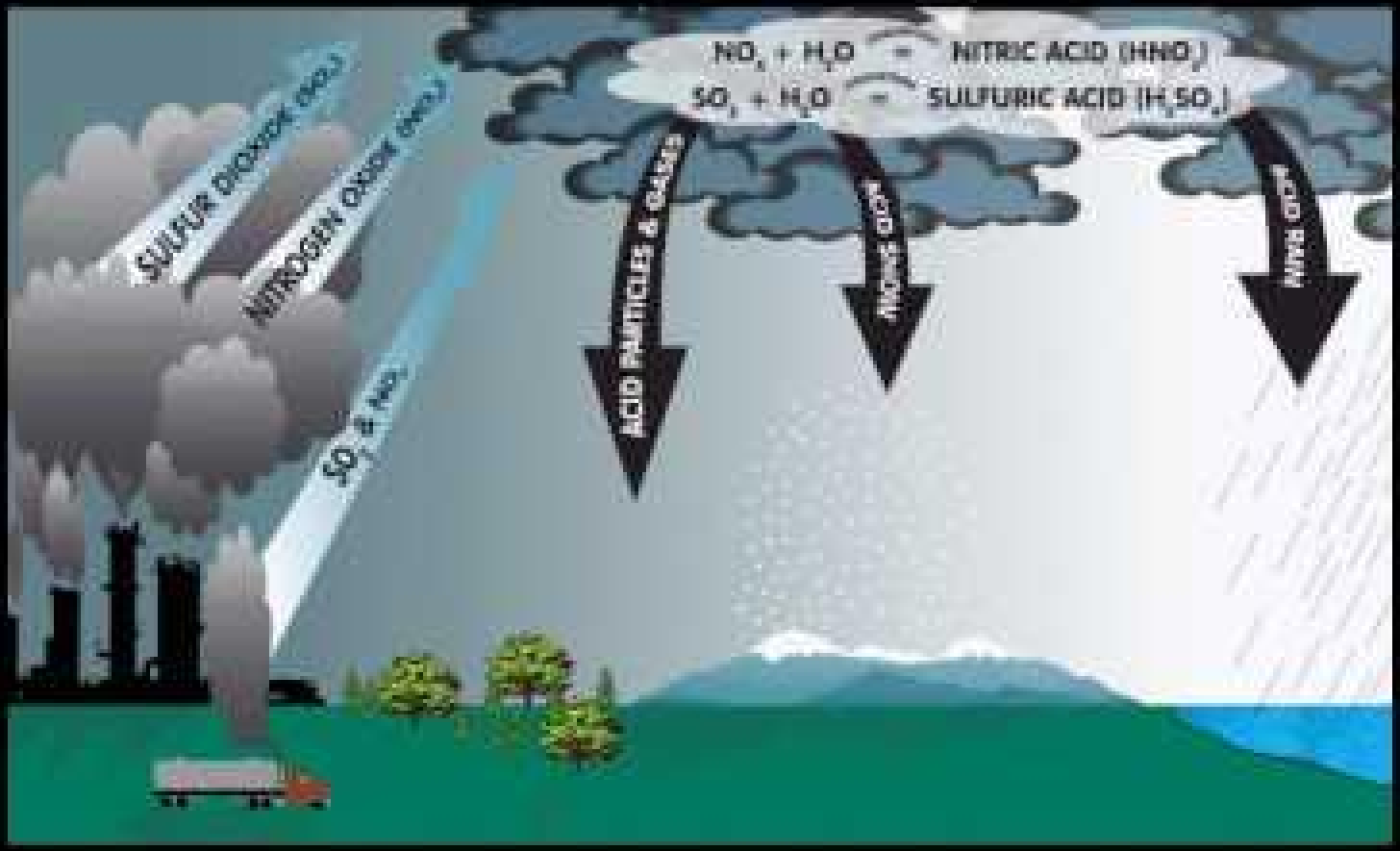
- Mineralization of organic sulfur to the inorganic form hydrogen sulfide (H_2S).
- Oxidation of sulfide and elemental sulfur (S) and related compounds to sulfate (SO_4).
- Reduction of sulfate to sulfide
- Microbial immobilization of the sulfur compounds and subsequent incorporation into the organic form of sulfur!

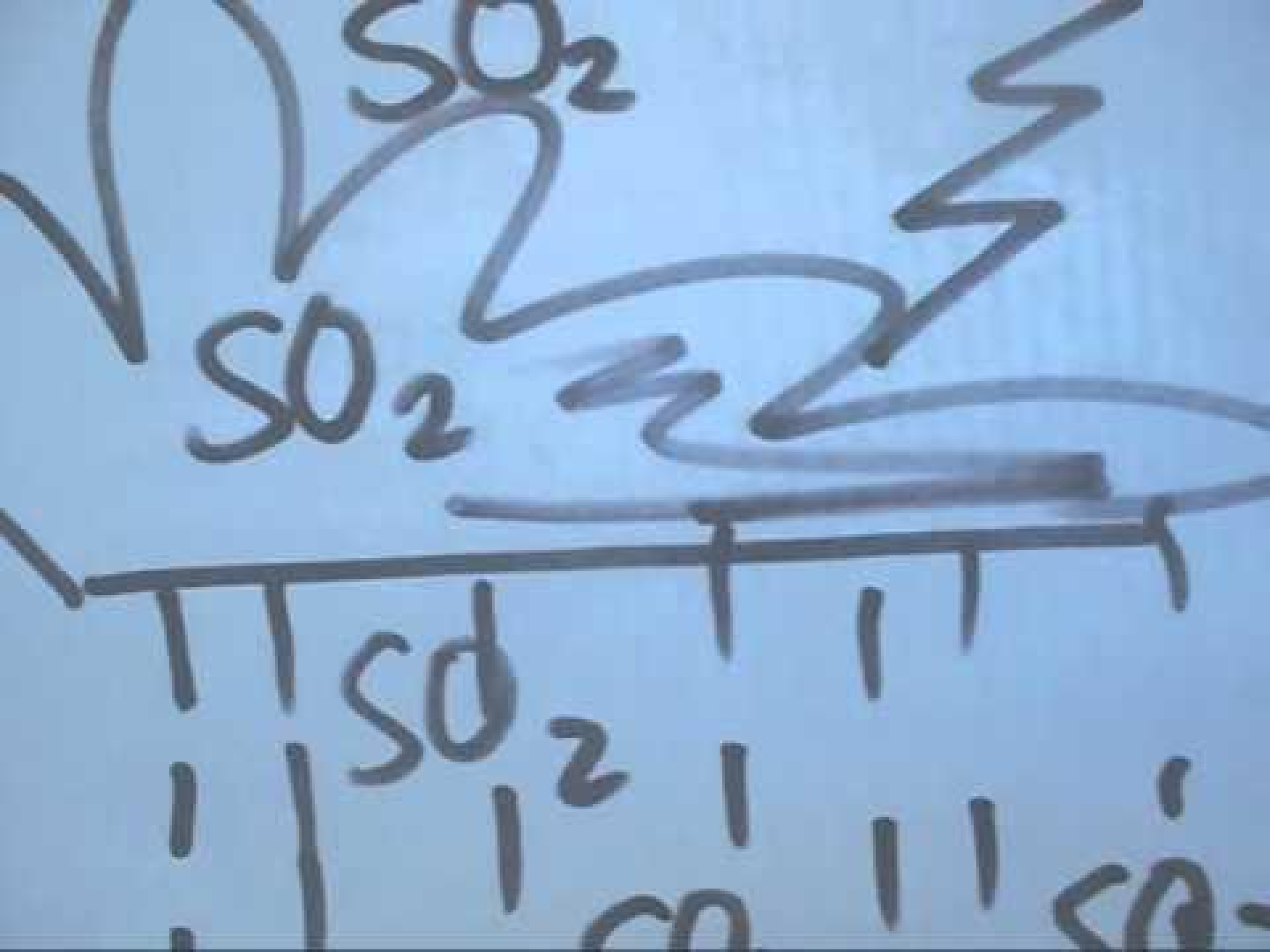
Sulfur Cycle



Human Impacts

- The burning of fossil fuels and processing of metals releases huge quantities of sulfur into the atmosphere
- Human activities are responsible for one-third of all sulfur emissions and 90% of all sulfur dioxide emissions
- Sulfur dioxide emissions lead to acid rain as sulfur dioxide reacts with water to form H_2SO_4 and sulfur trioxide reacts with water to form H_2SO_4


$NO_2 + H_2O$ = NITRIC ACID (HNO_3)
$SO_2 + H_2O$ = SULFURIC ACID (H_2SO_4)
SULFUR DIOXIDE (SO_2)
NITROGEN OXIDE (NO_2)
SO_2 & NO_2
ACID PARTICLES & GASES
ACID SNOW
ACID RAIN


SO2
SO2

Nutrients vs. Energy