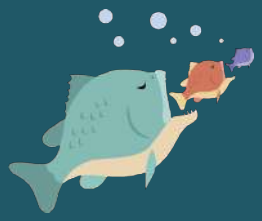
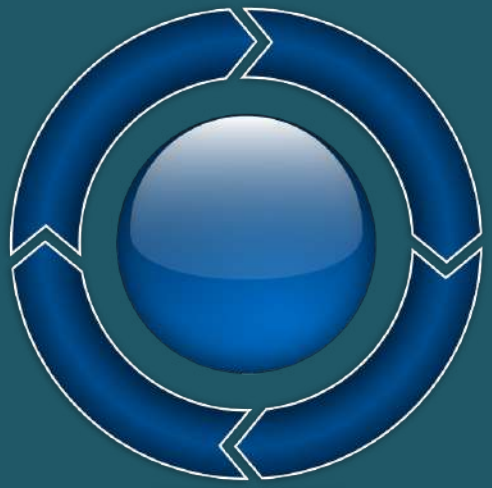
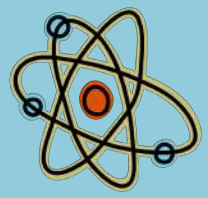


Matter and Biogeochemical Cycles

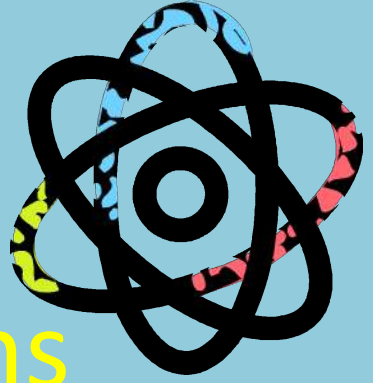


Matter

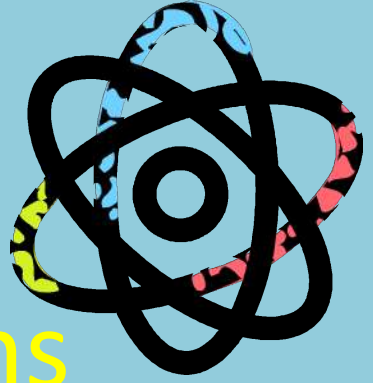


- All material in the universe that has mass and occupies space is called **matter.**
- ***Atoms***- smallest unit of **an element**

Example: **Oxygen, hydrogen, carbon, gold**, etc



- ***Molecules***- a cluster of atoms with **unique** characteristics. Organic compounds have **carbon**. Inorganic compounds do not have **carbon**. **Hydrocarbons** are organic compounds containing ONLY hydrogen and carbon.



- ***Molecules***- a cluster of atoms with **unique** characteristics. Organic compounds have **carbon**. Inorganic compounds do not have **carbon**. **Hydrocarbons** are organic compounds containing ONLY hydrogen and carbon.

Biogeochemical Cycles

- BIO – refer to the **LIVING** organisms

- GEO – refers to the Earth, rock and **LAND**.

- CHEMICAL – molecules, **REACTIONS** and atoms.

Biogeochemical Cycles

- Matter **cycles** through the environment. **Nutrients** are matter that organisms require for life process, circulate throughout the **environment** in biogeochemical cycles.

Biogeochemical Cycles

- The movement of a particular chemical through the biological and geological, or living and nonliving, parts of an ecosystem.

Biogeochemical Cycles

- **Law of Conservation of Matter:**
- Matter can be transformed, but cannot be **created** or destroyed.

Elements of Life

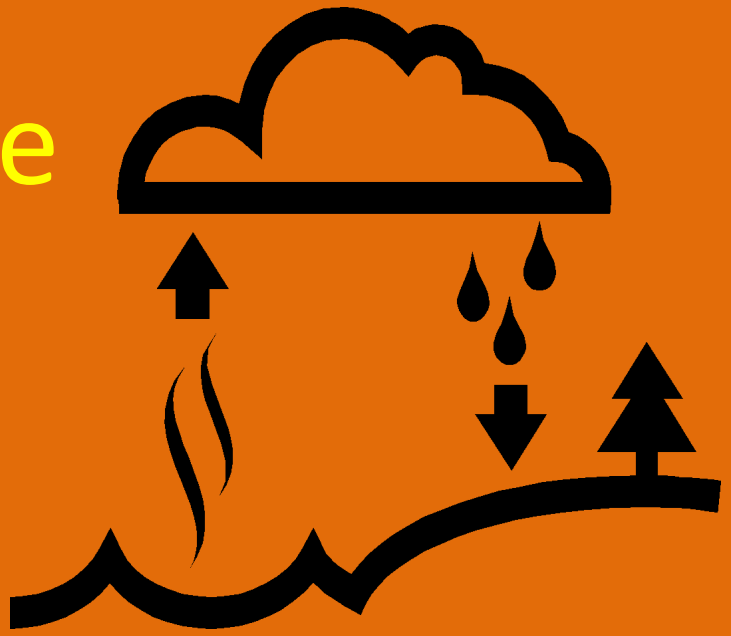
- C-
- H-
- O-
- N-
- P-

Elements of Life

- C Carbon 18.5%
- H Hydrogen 9.56%
- O Oxygen 65.0%
- N Nitrogen 3.3%
- P Phosphorus 1.0%
- S Sulfur Trace
- Other trace 3.0% (Copper, magnesium, etc)

Water Cycle

- The water cycle summarizes how **water** plays a role in our environment.
- It is also called the hydrologic cycle.



The Water Cycle

Everyone knows that water is crucial to life. Living cells are 70 to 80% water.

Water provides the environment in which most of the chemical reactions of the cell occur.

At any given time, the water of earth can be found in the following places:

1. Bodies of water such as the oceans, lakes, and rivers.
2. Stored in the bodies of living organisms.
3. In the atmosphere as clouds and water vapor.
4. Stored in underground formations as ground water.
5. Oceans contain 97% of the water on earth. 2% is found in the glaciers on earth.
   Only 1% of the water on earth is found in lakes, rivers, and in groundwater.

- Water Cycle Video

The movement of water between these various _reservoirs_ is known as the _water cycle_.

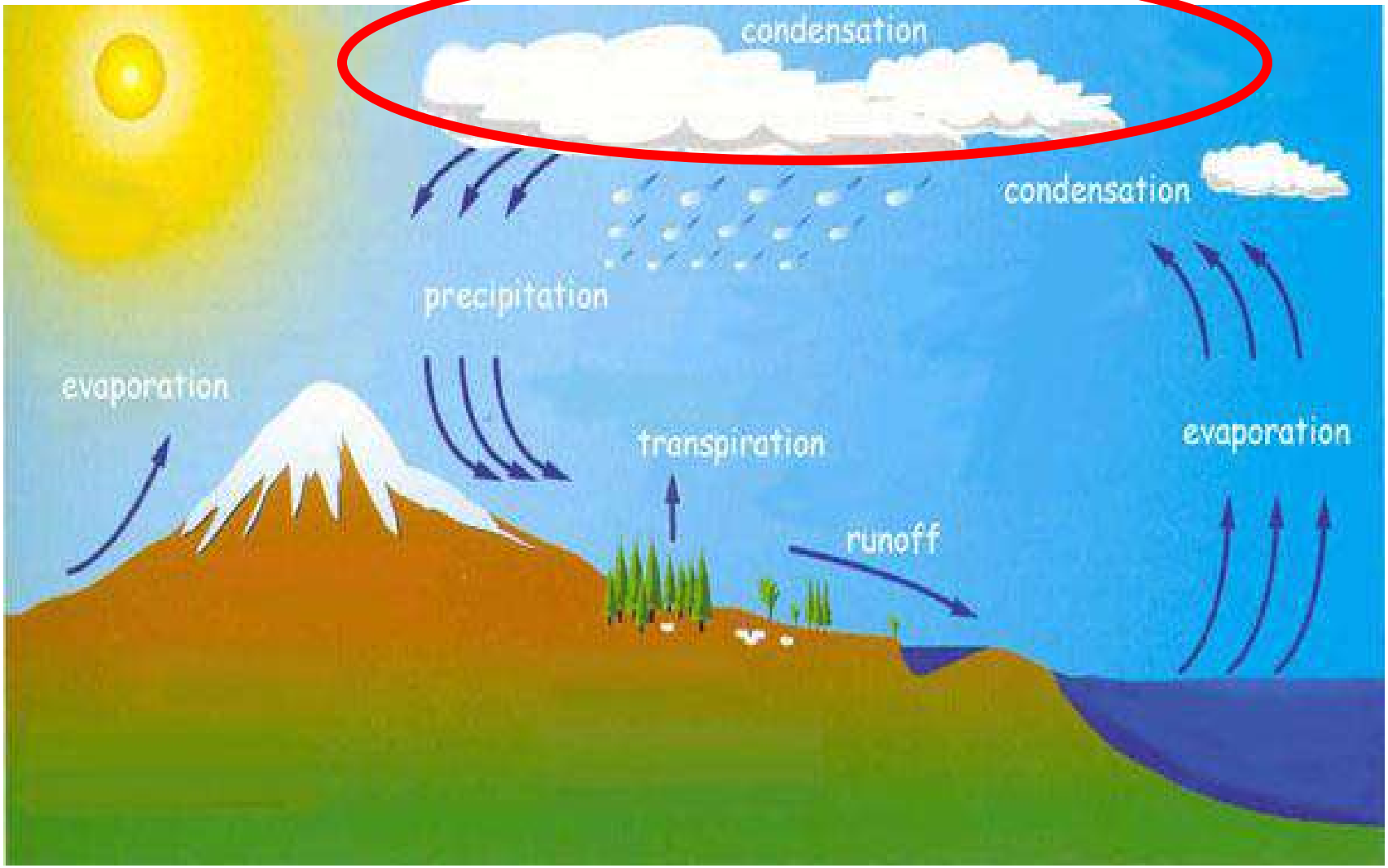
Four processes account for the movement of water molecules through the ecosystem:

1. Condensation
2. Transpiration
3. Evaporation
4. Precipitation
5. Percolation

As water (in the form of gas) rises higher in the atmosphere, it starts to cool and become a liquid again. This process is called condensation. When a large amount of water vapor condenses, it results in the formation of clouds.

STEPS TO THE WATER CYCLE

Condensation is the process that turns water vapor in to liquid, which causes the formation of a clouds.


condensation
condensation
precipitation
evaporation
transpiration
runoff
evaporation

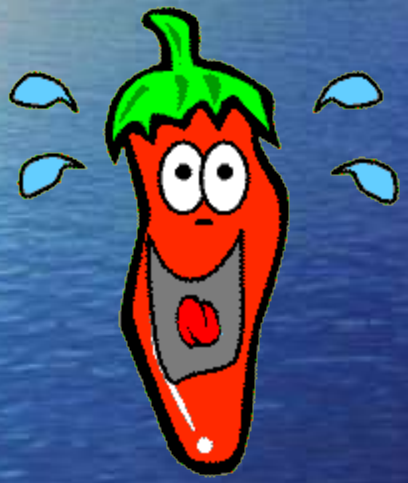
STEPS TO THE WATER CYCLE

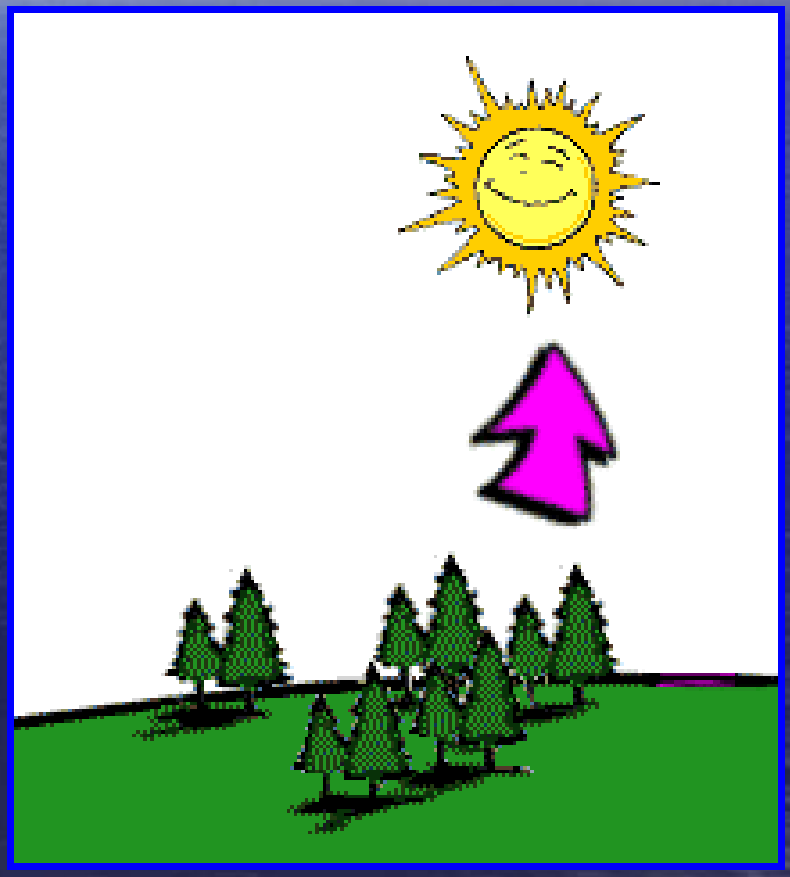
The water vapor in the atmosphere condenses to form the clouds. This is known as condensation.

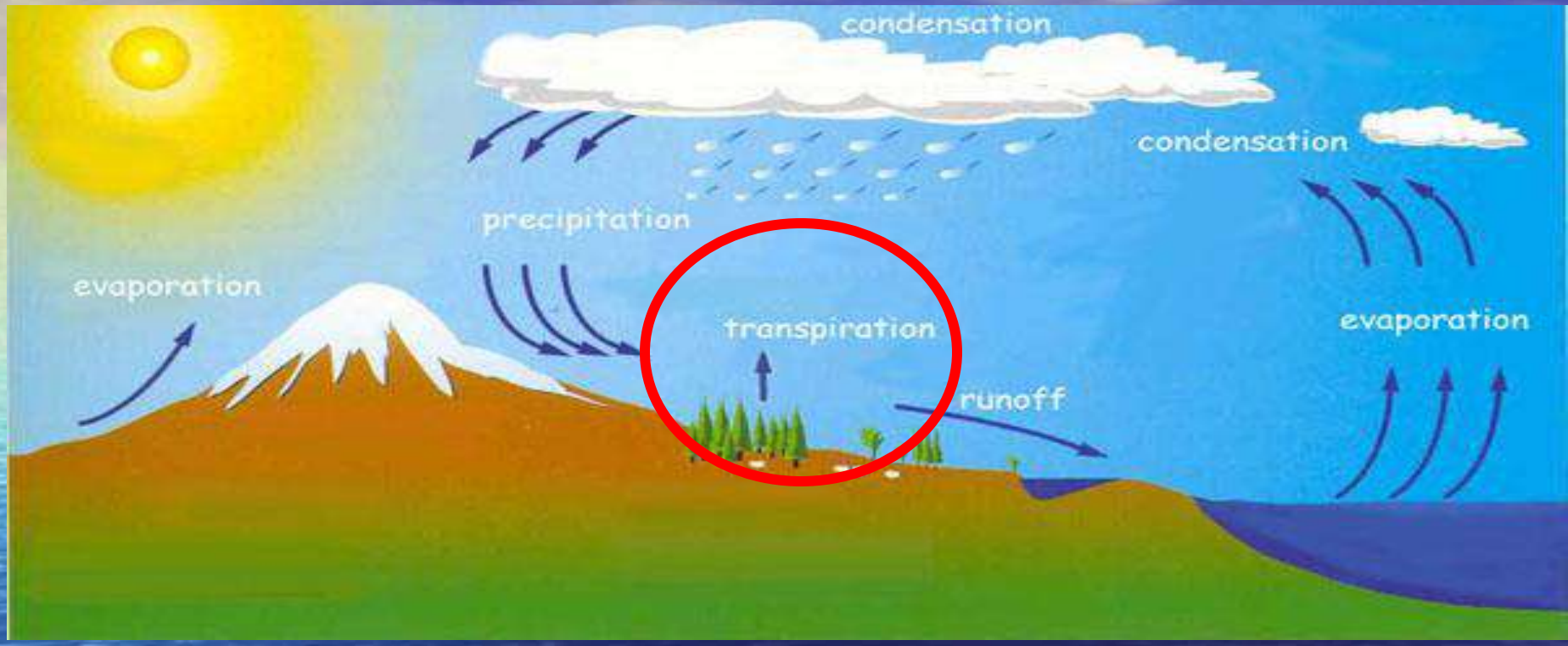
STEPS TO THE WATER CYCLE

After it rains, the water can either end up on land, or _____. (such as _____, _____, and _____.)

The process of evaporation from plants is called transpiration. (In other words, it's like plants sweating.)



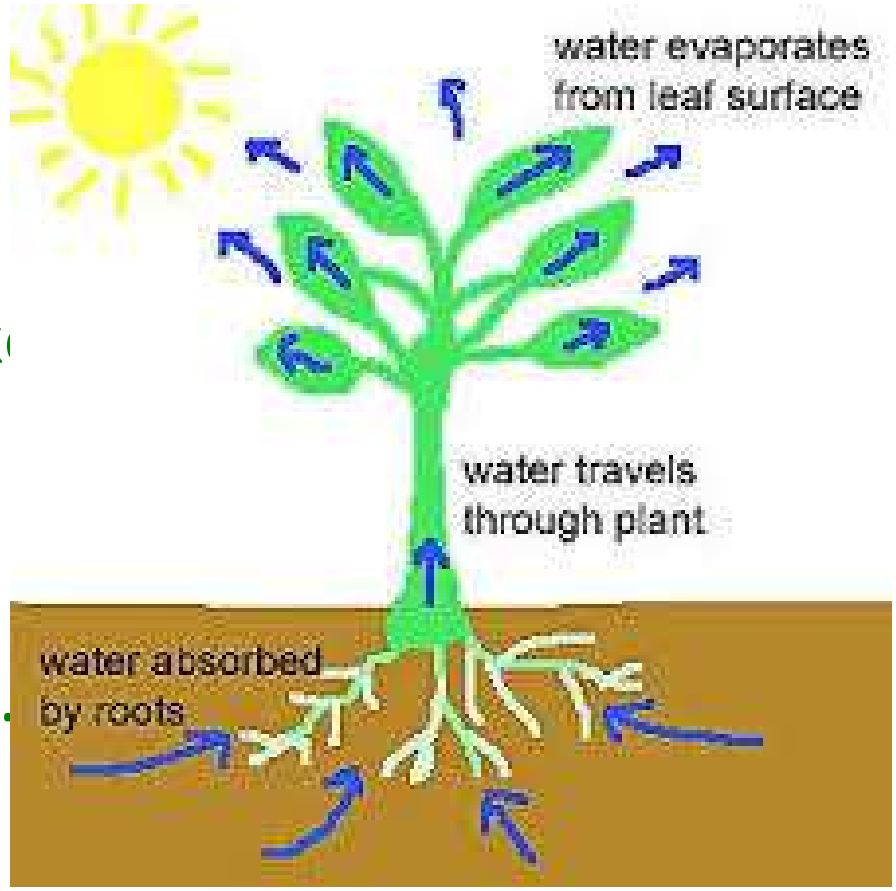



condensation
condensation
precipitation
evaporation
transpiration
runoff
evaporation

STEPS TO THE WATER CYCLE

When water evaporates from a leaf, this process is called _____.

The leaves contain pores called stomata that open to tak in the carbon dioxide that is needed for photosynthesis.



When the stomata are open, molecules of water evaporate from the leaf and enter the atmosphere.

Animals also contribute water molecules to the water cycle, but in a much less significant way than plants.

Animals lose water when they breathe, sweat, or excrete. This is called _____.

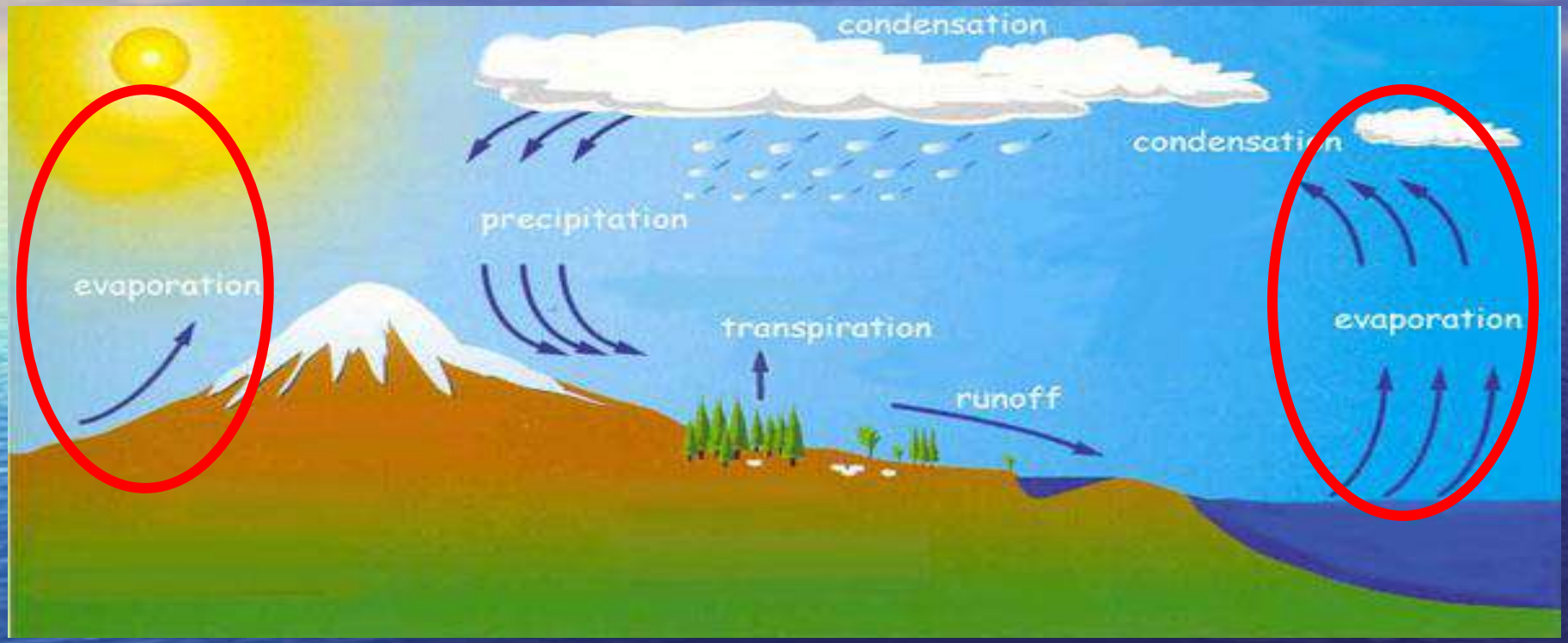
STEPS TO THE WATER CYCLE

When water is heated in an ocean, the liquid water changes form and turns into

_____.

During part of the water cycle, the sun heats up liquid water and changes it to a gas by the process of evaporation. Water that evaporates from Earth's oceans, lakes, rivers, and moist soil rises up into the atmosphere.

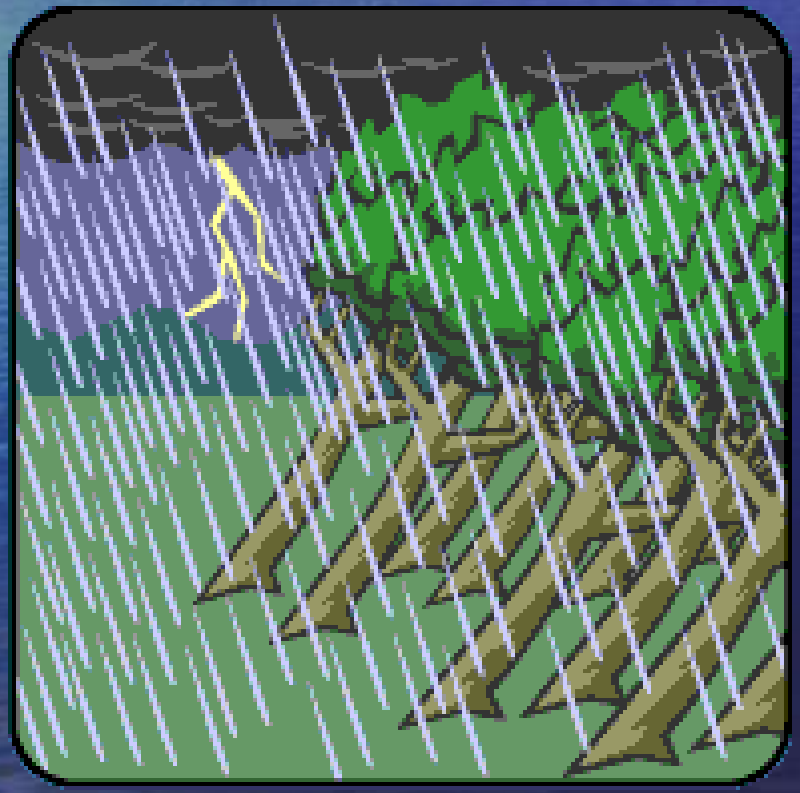
The Water Cycle

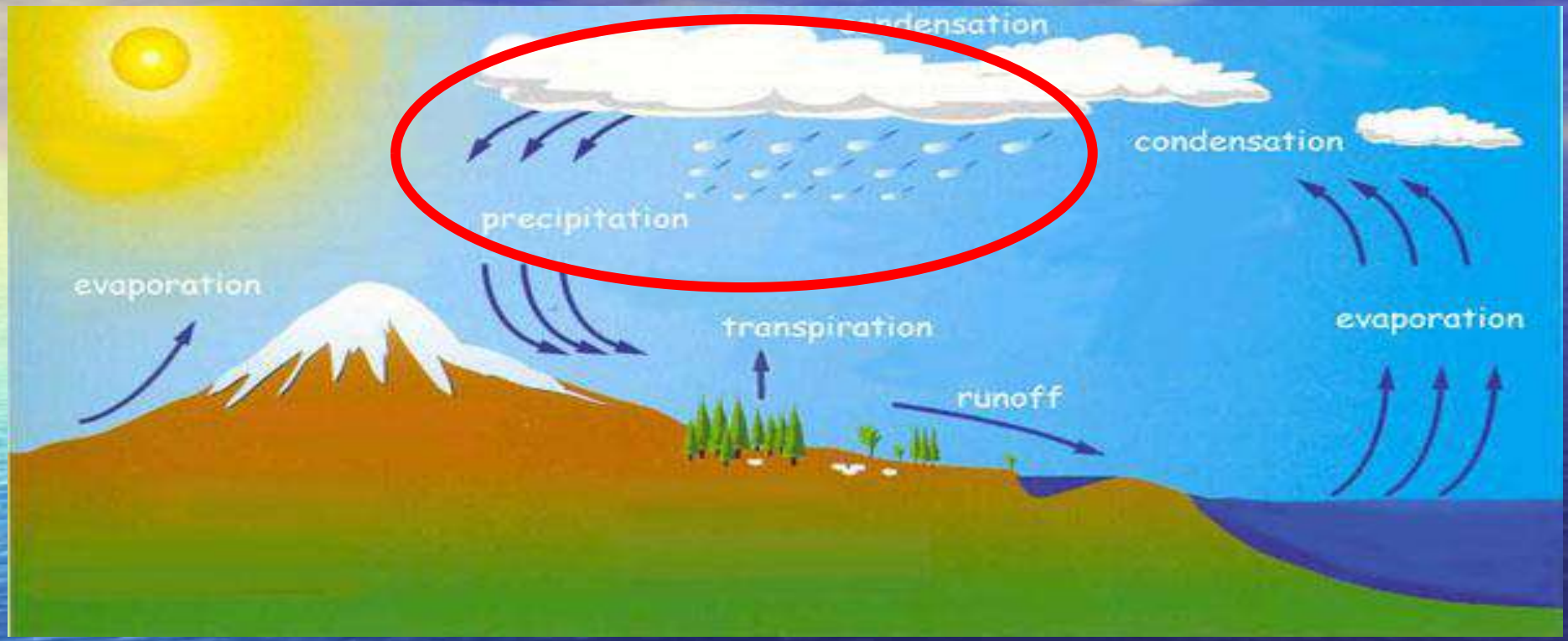


STEPS TO THE WATER CYCLE

When water leaves a body of water after it is heated, the process is called _____.

When the water in the clouds gets too heavy, the water falls back to the earth. This is called precipitation.

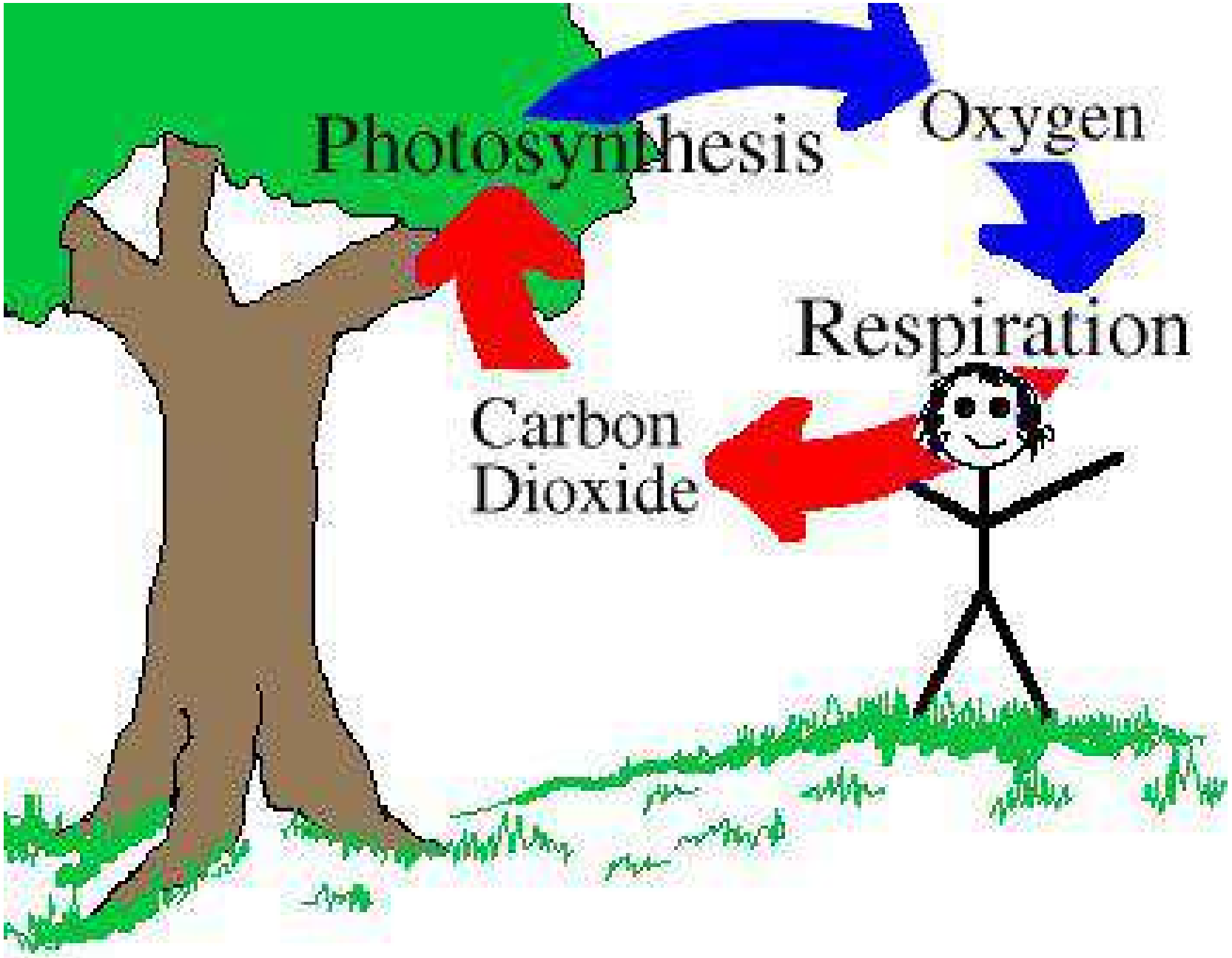


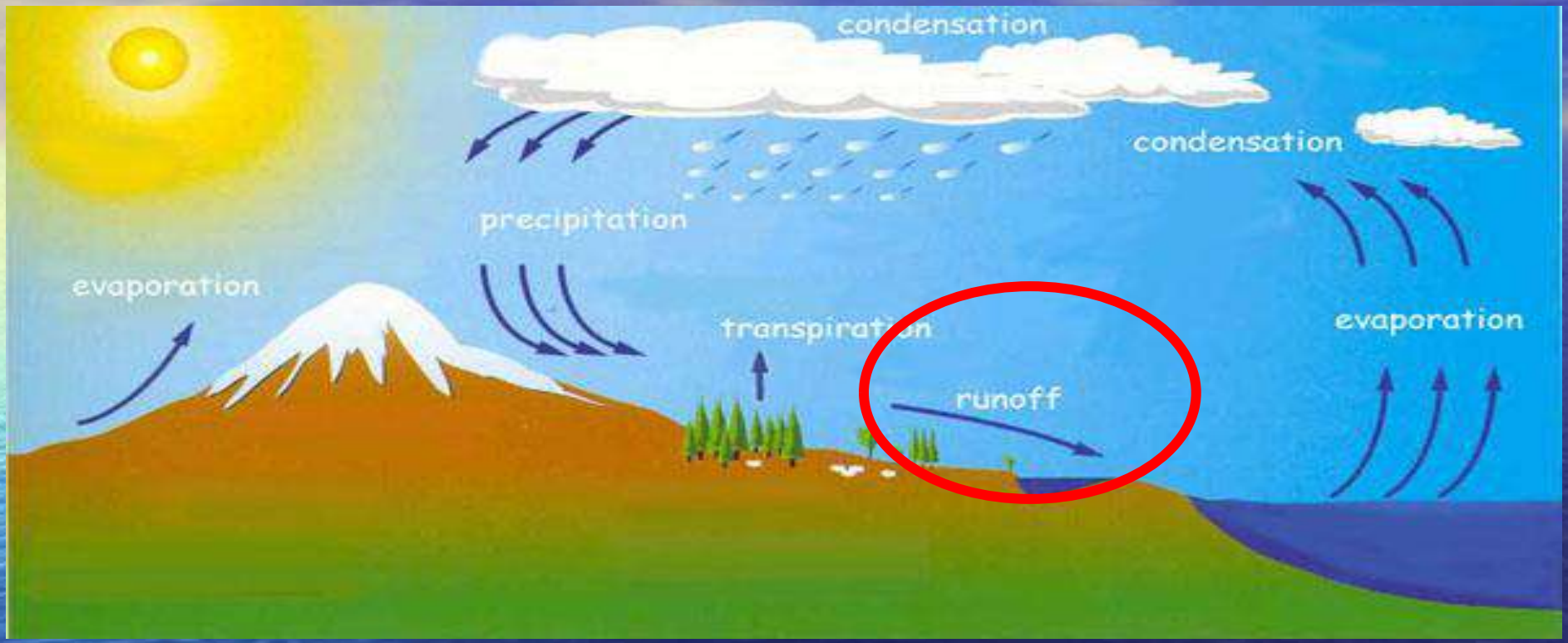

condensation
precipitation
condensation
evaporation
transpiration
runoff
evaporation

STEPS TO THE WATER CYCLE

When water falls from the sky, the process is known as _____.

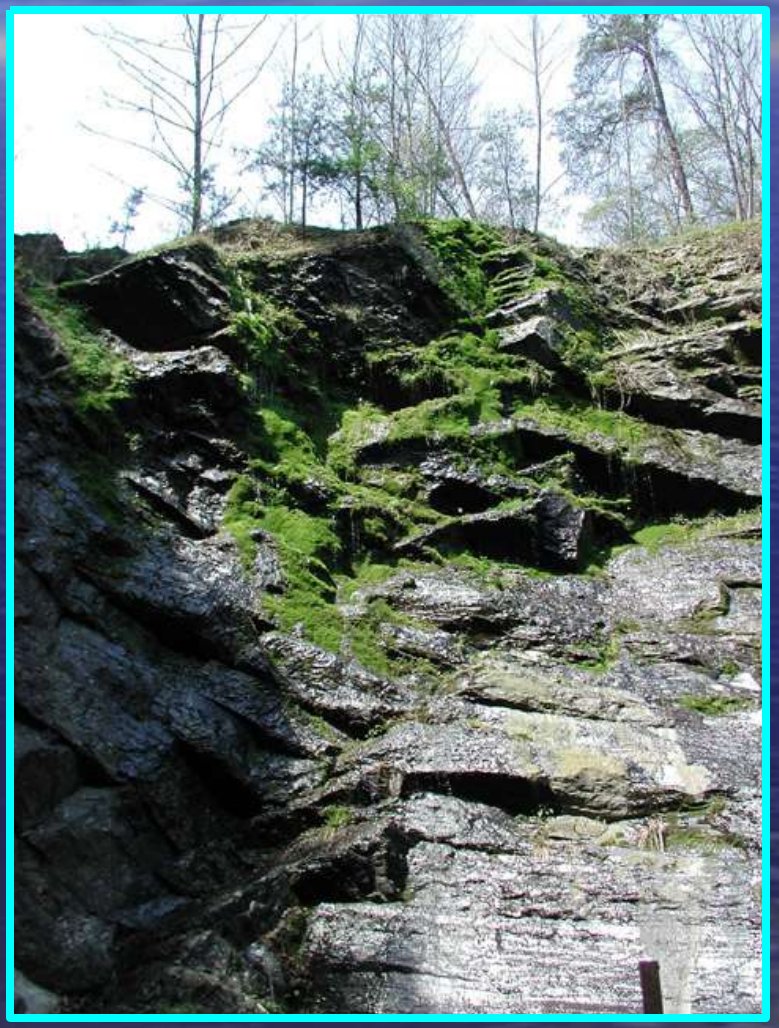
When rain falls on the land, some of the water is absorbed into the ground forming pockets of water called groundwater. Most groundwater eventually returns to the ocean. Other precipitation runs directly into streams or rivers. Water that collects in rivers, streams, and oceans is called runoff.


Photosynthesis
Oxygen
Respiration
Carbon Dioxide


condensation
condensation
precipitation
evaporation
transpiration
runoff
evaporation

Percolation (Infiltration)

Percolation is an important process where rain water soaks into (infiltrates) the ground, into the soil and underlying rock layers.



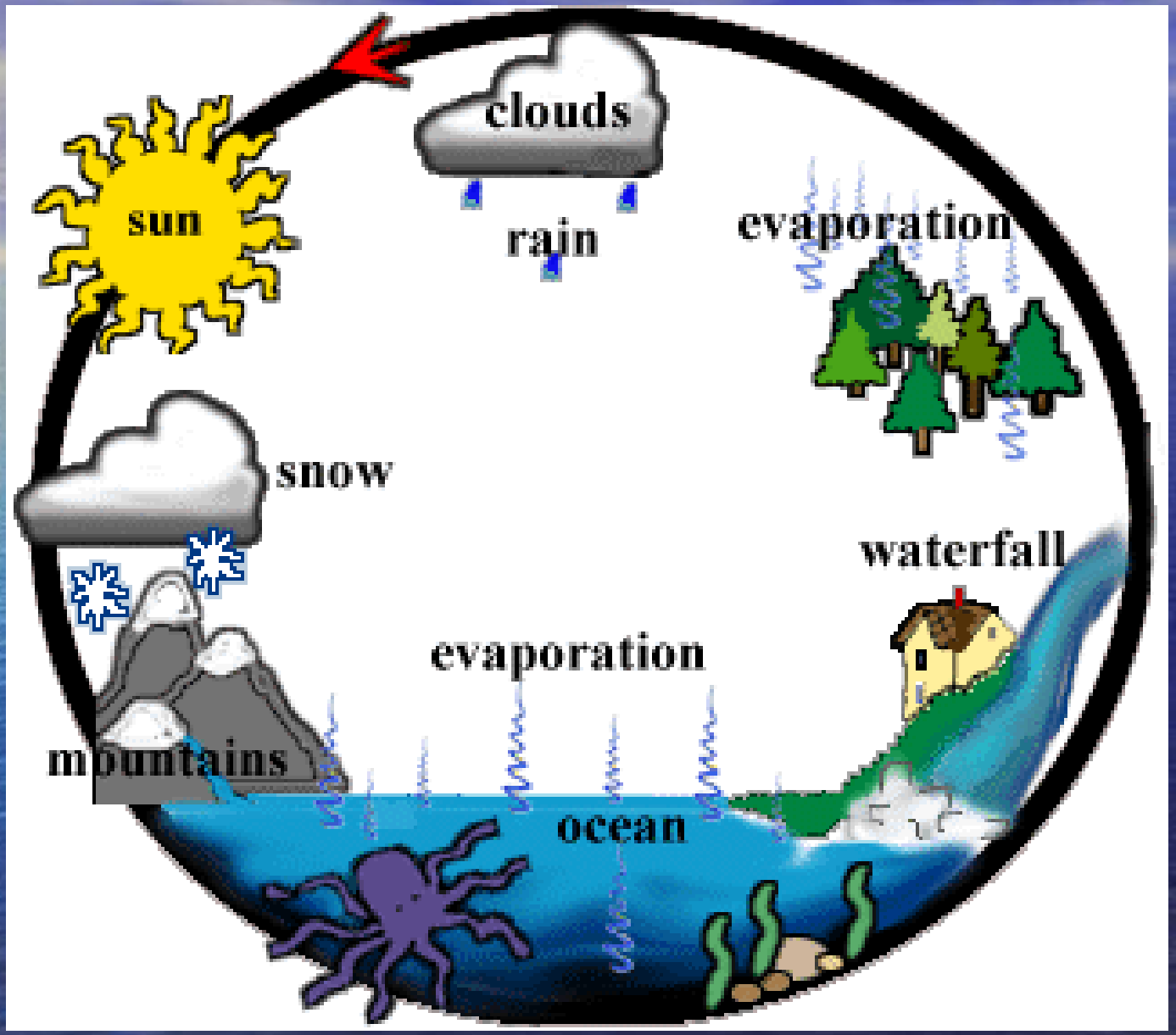
STEPS TO THE WATER CYCLE

When water hits land and is soaked into the ground, the water becomes _____.

Water Cycle Rap

TRUE OR FALSE

The water cycle is a continual process.


clouds
sun
rain
evaporation
snow
waterfall
evaporation
mountains
ocean

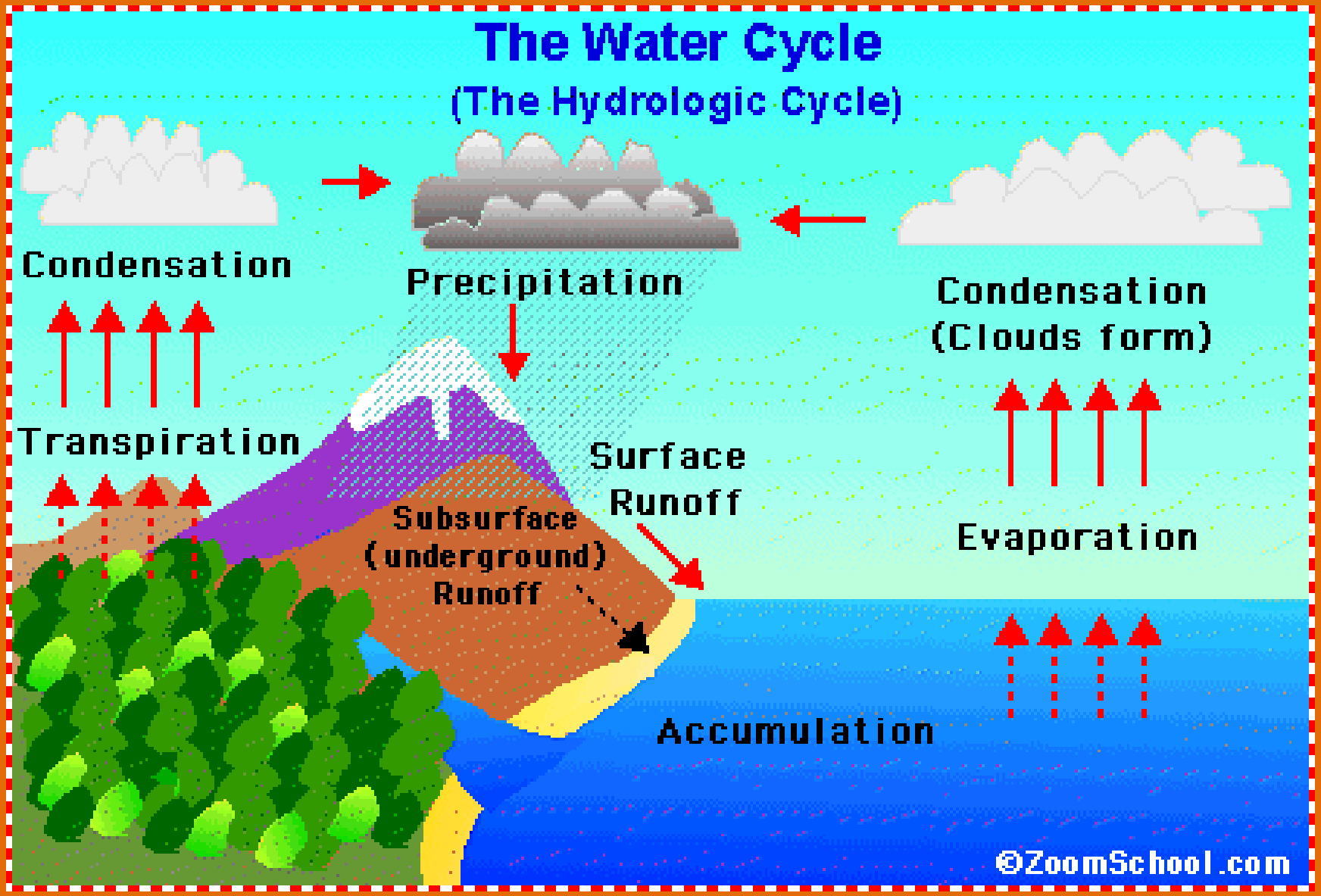
TRUE OR FALSE

Transpiration is a process that occurs on plants and animals.

Label the water cycle diagram

- ***Evaporation***
- ***Condensation***
- ***Precipitation***
- ***Transpiration***
- ***Percolation***

Label the water cycle diagram



- http://earthguide.ucsd.edu/earthguide/diagrams/watercycle/index.html

Oxygen Cycle

Carbon and Oxygen Video

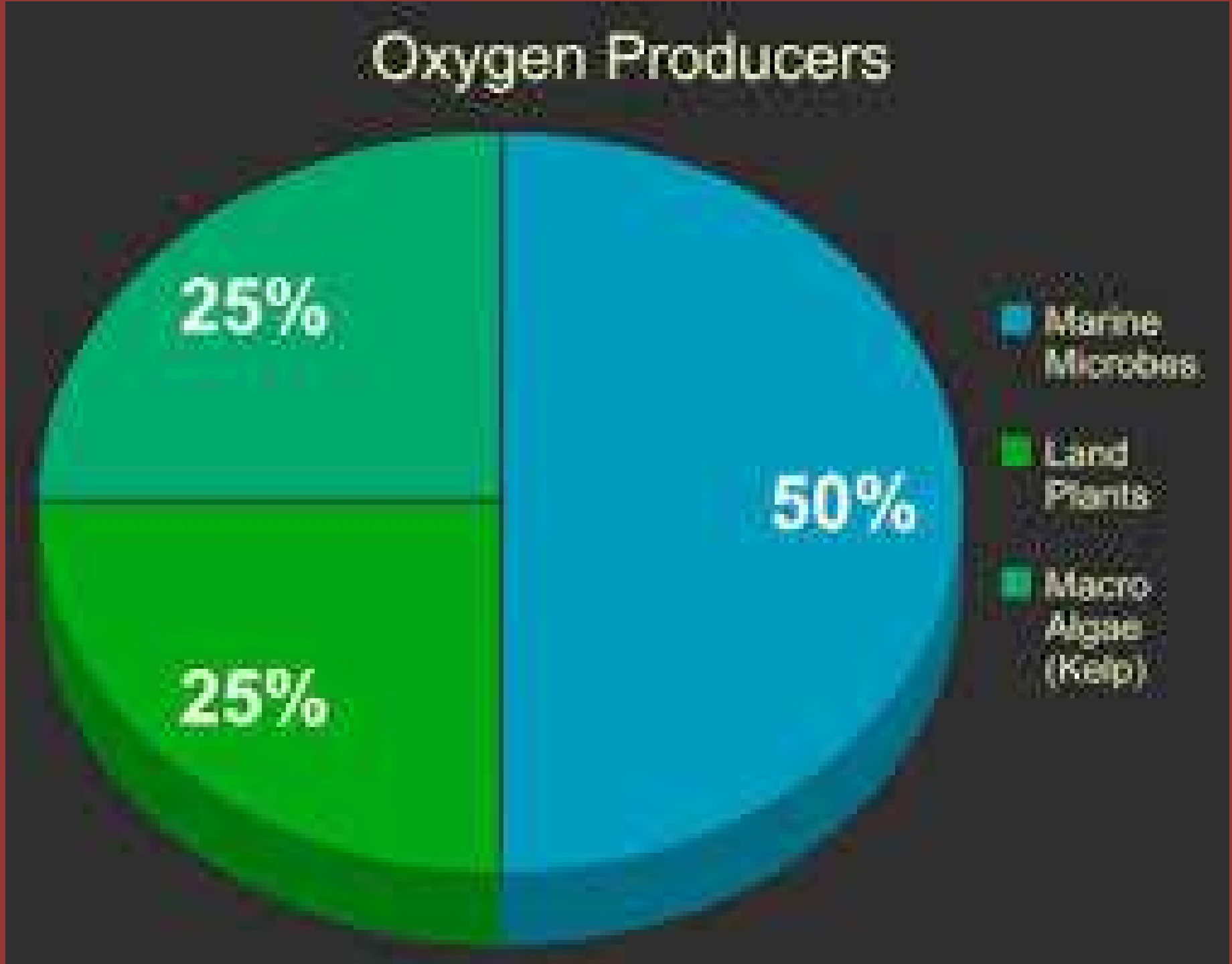
Oxygen Cycle

This cycle only consists of **photosynthesis** & respiration. Photosynthesis & respiration are **OPPOSITE** reactions & they rely on each other.

Oxygen Cycle

- We use oxygen to break down simple sugar and release energy.
- This can be done through respiration or fermentation.
- Animals mainly use respiration.

Plants produce **OXYGEN** through the process of photosynthesis. Animals take in the oxygen from the **air** & change it into energy & release **carbon dioxide** through the process of respiration.


Oxygen Producers
25%
25%
50%
Marine Microbes
Land Plants
Macro Algae (Kelp)

OXYGEN CYCLE

Plants release 430-470 billion tons of oxygen during the process of _____.

Oxygen Cycle

- We breathe oxygen in the form of O_2
- In the atmosphere oxygen in the ozone layer protects us from dangerous ultraviolet rays.


O Z O3 N E
LAYER

OXYGEN CYCLE

Atmospheric oxygen in the form of _____ provides protection form harmful ultraviolet rays.

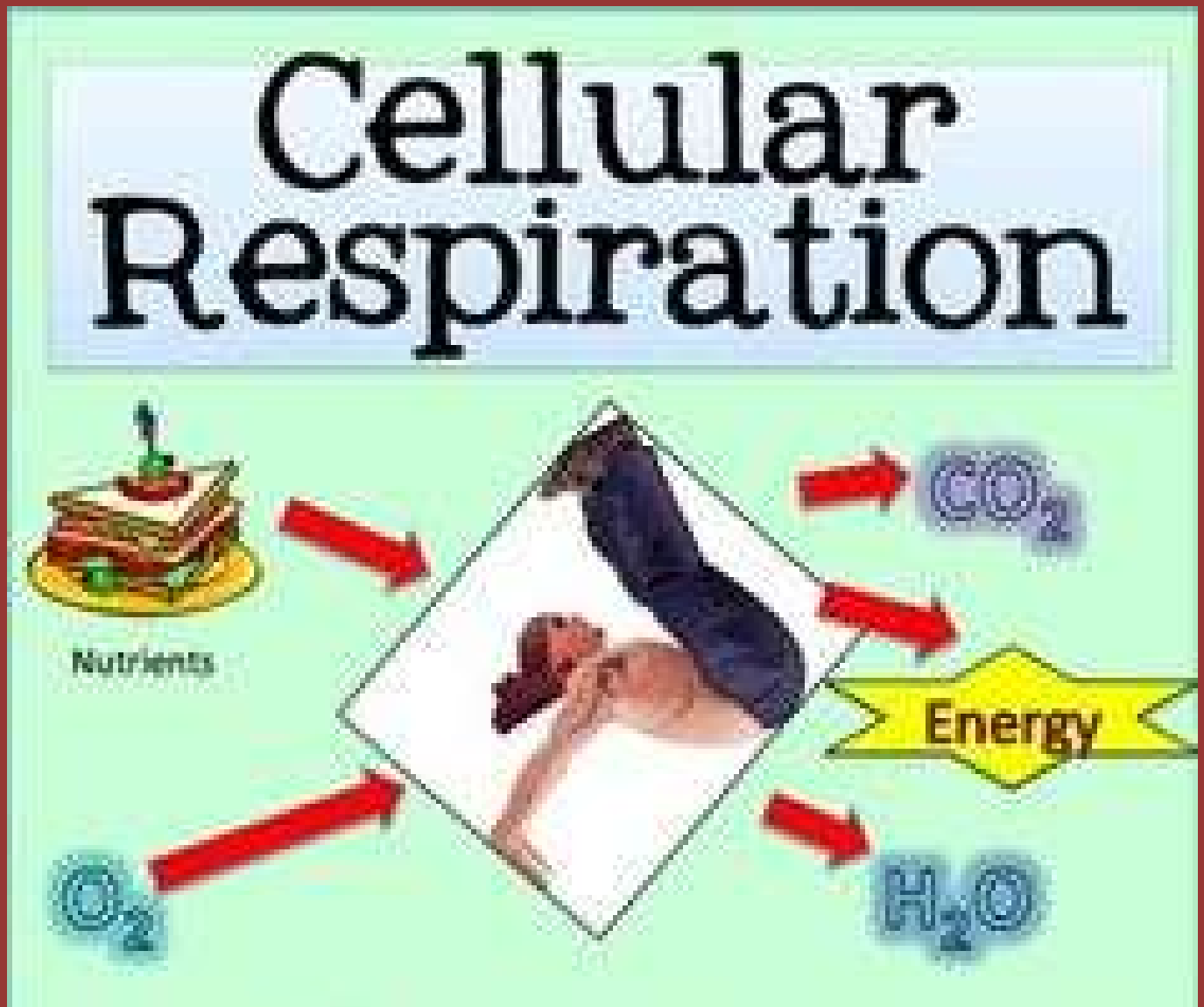
Where is Oxygen found?

Where is Oxygen found?

OXYGEN CYCLE

Oxygen is found everywhere on Earth, from Earth's _____ (rocks) to the _____ where it is dissolved.

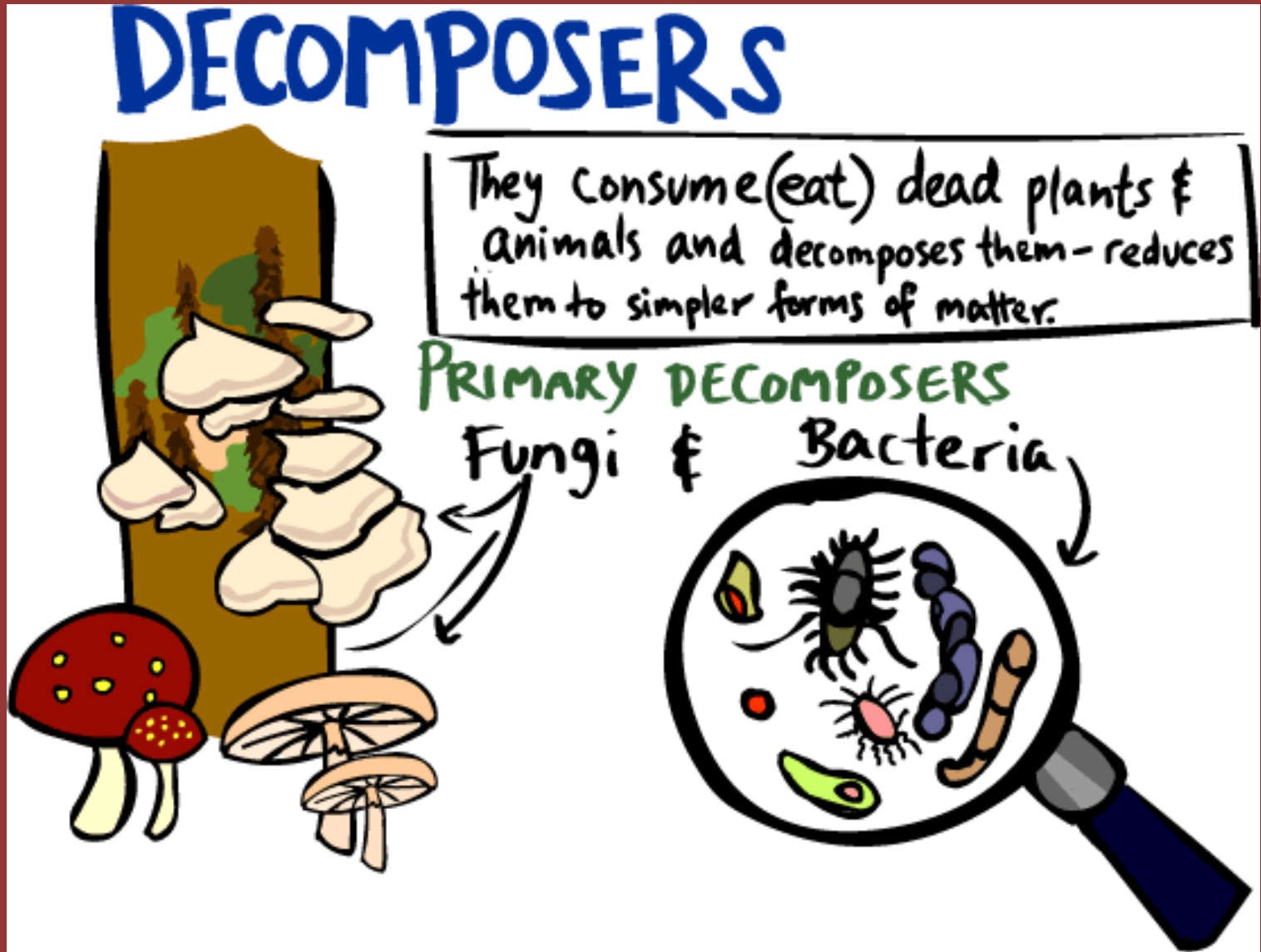
Oxygen Cycle



OXYGEN CYCLE

Oxygen is vital for _____ _____ by animals, a process which produces CO_2 and water.

Oxygen Cycle



OXYGEN CYCLE

Oxygen is also necessary for the decomposition of _____ into other elements necessary for life.

Respiration

$C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2 + 36\ ATP$

Oxygen Cycle

- Plants take the carbon off the CO_2, freeing the oxygen so it can be used for respiration.
- During respiration, organisms attach a carbon to the O_2 and release CO_2 so it can be used for photosynthesis.
- One big cycle — all living things depend on each other for it to work!

Carbon Cycle

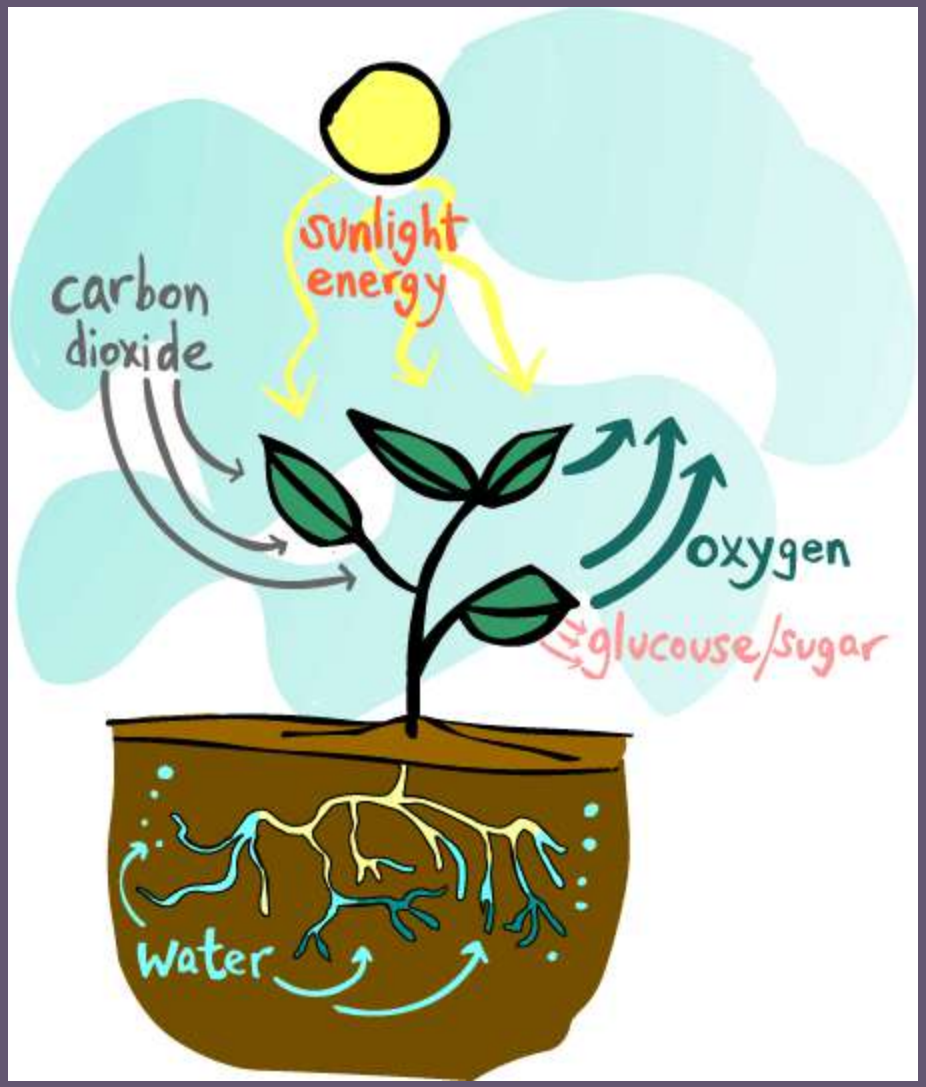
Circle of Life Video

Carbon Cycle

Carbon is a ***building block*** of life. All ***organic*** compounds have ***carbon***.

Carbon is essential for ***DNA***, fats, proteins, ***carbohydrates*** & other substances.

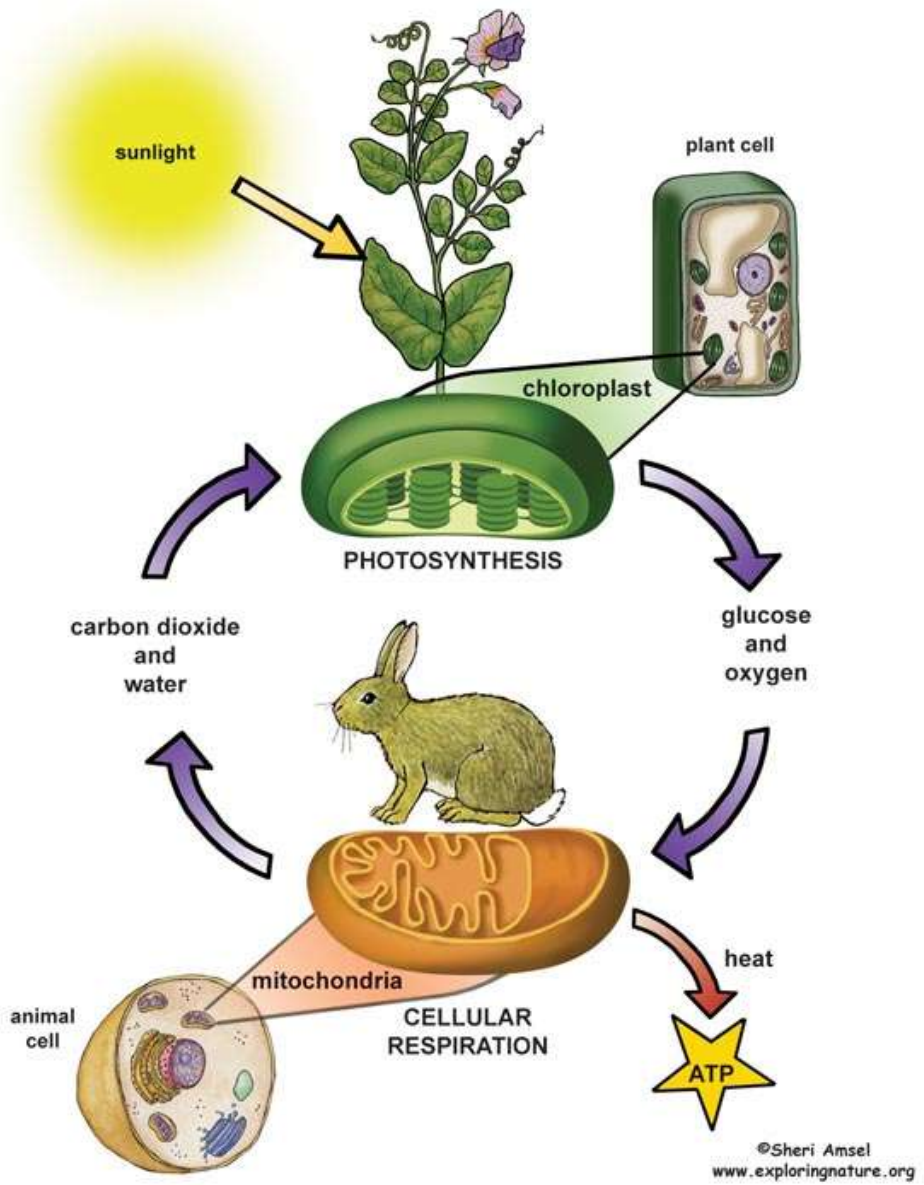
Carbon Cycle



CARBON CYCLE

Plants use CO_2 in the process of _____ to make _____ and oxygen.

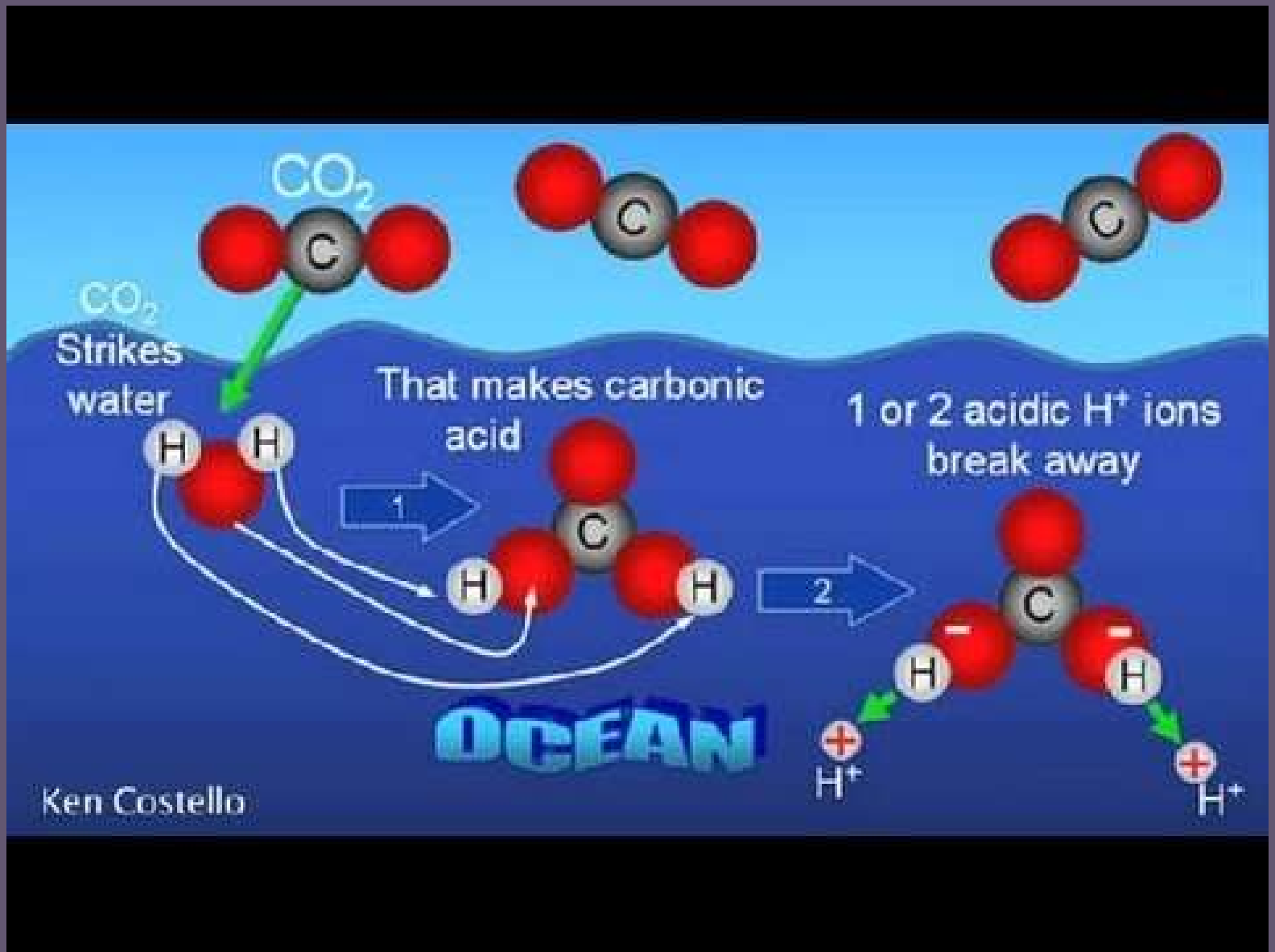
Photosynthesis and Cellular Respiration



CARBON CYCLE

Animals use oxygen in the process of _____ and make more CO_2.

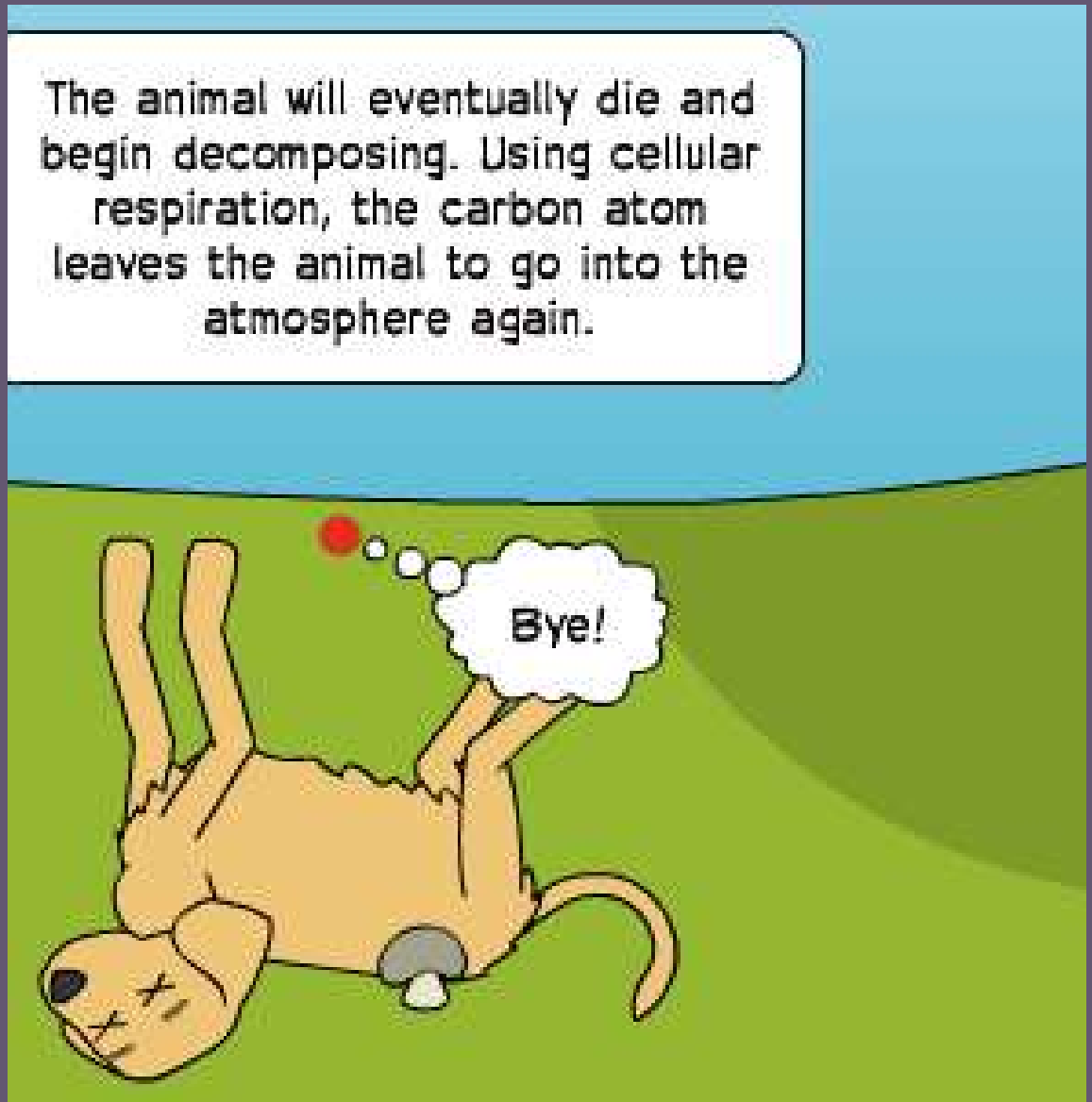
Carbon Cycle



CARBON CYCLE

The _____ is the main regulator of CO_2 in the atmosphere because CO_2 dissolves easily in it.

Carbon Cycle



CARBON CYCLE

In the past, huge deposits of carbon were stored as dead plants and animals

_____.

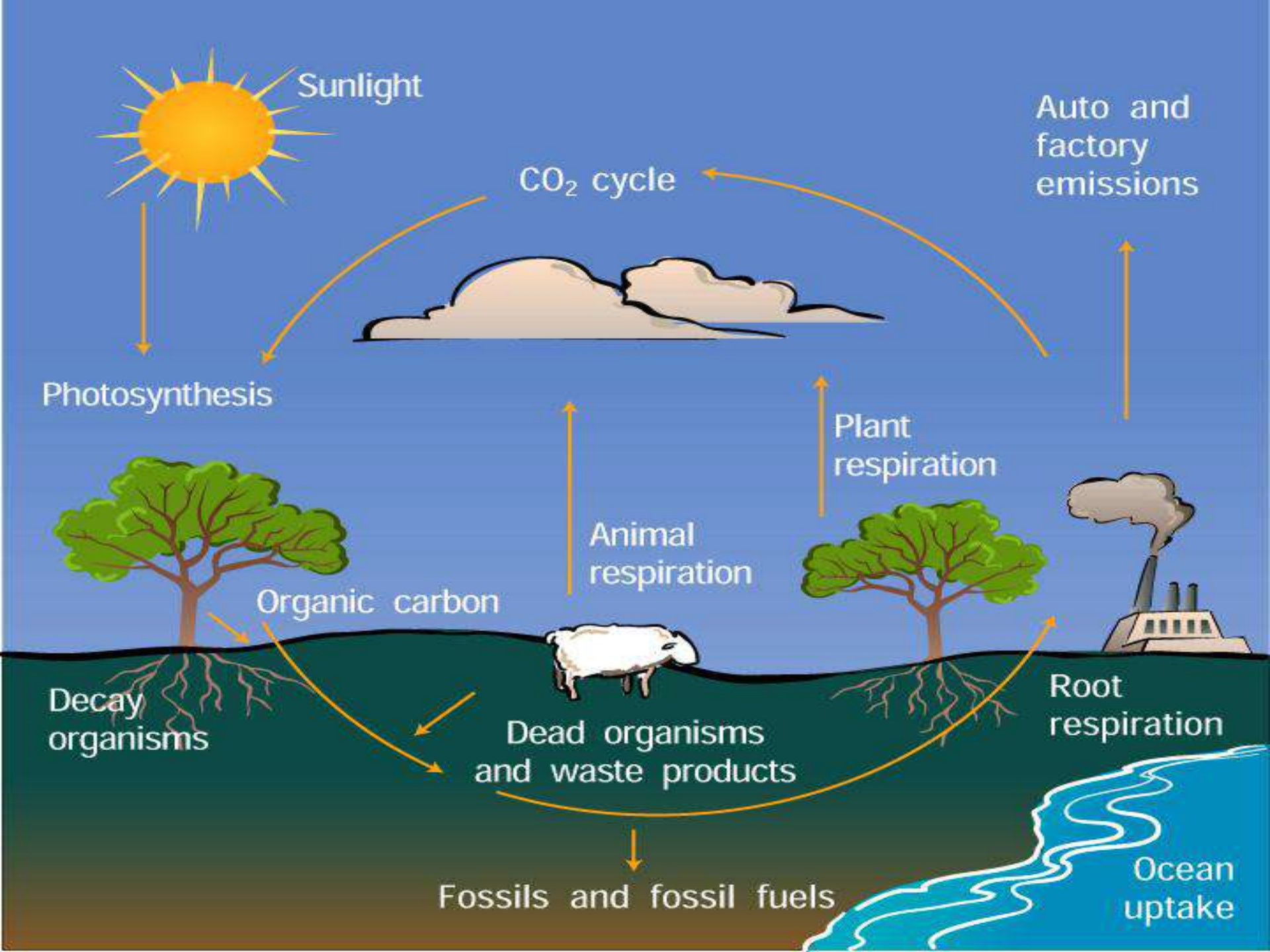
Carbon Cycle

Carbon is gas form is ***carbon dioxide*** & it's a ***greenhouse*** gas that helps to maintain earth's temperature.

Carbon is stored in the ocean, atmosphere & ***rocks***.

Carbon Cycle

A place where a lot of carbon is stored are called ***carbon sinks.***

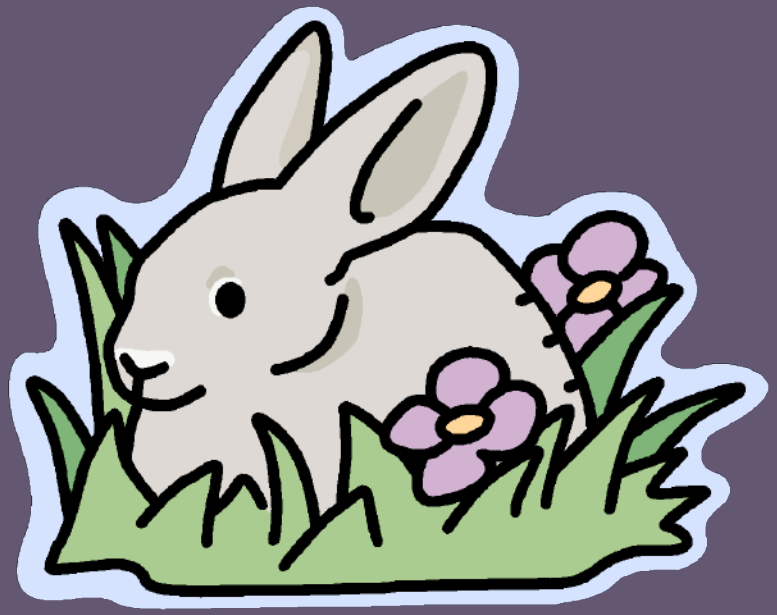

Sunlight
CO_2 cycle
Auto and factory emissions
Photosynthesis
Plant respiration
Animal respiration
Organic carbon
Decay organisms
Dead organisms and waste products
Root respiration
Fossils and fossil fuels
Ocean uptake

Pathway 1

1. Carbon moves between the **atmosphere**, oceans & living things.

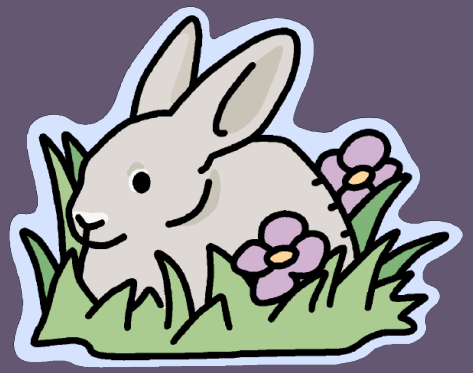
2. Through photosynthesis, plants use CO_2 from the air & ocean to make ***glucose*** (organic compound….$C_6H_{12}O_6$)

3. A ***consumer*** eats plants & animals that eat plants & the carbon moves through the ***food webs***.



4. Respiration is one way ***carbon*** is released directly into the air.

Example: exhaling of animals



5. ***Decomposition*** of living things also returns ***carbon*** to the soil, ***water*** & air in the form of carbon dioxide.

Pathway 2

1. Carbon travels from ***living*** things to ***rocks*** & back to air or water where living things will use it again.

Example: Shells of marine animals contain ***carbon***. These shells fall to bottom of ***ocean*** when they ***die*** & pile up. They are covered with sediment & compacted to form ***rock*** (limestone). Erosion on land eventually dissolve the carbon containing minerals to air & water.

2. This process takes millions of years.

Pathway 3

1. This pathway involves the ***formation*** & ***burning*** of fossil fuels.
2. Coal, Oil & natural gas form from the remains of ***dead*** organisms.

CARBON CYCLE

Today these deposits are burned as fossil fuels, which include _____, _____, and _____.

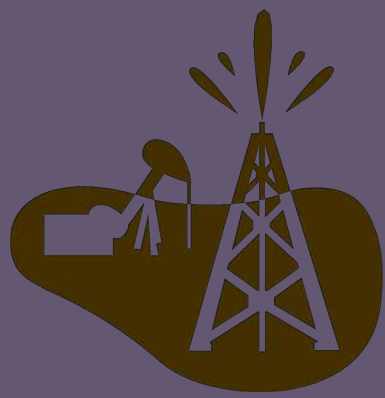
3. After buried for a long time, a ***chemical change*** takes place & it turns them into ***petroleum***.

4. This process takes ***millions*** of years.

CARBON CYCLE

More carbon dioxide is released in the atmosphere today than in the past because of the _____.

5. When the ***oil*** is ***removed*** & we burn it. The combustion releases carbon dioxide into the atmosphere. Then it's available plants to use for photosynthesis.



CARBON CYCLE

Another natural source for CO_2 is _____.

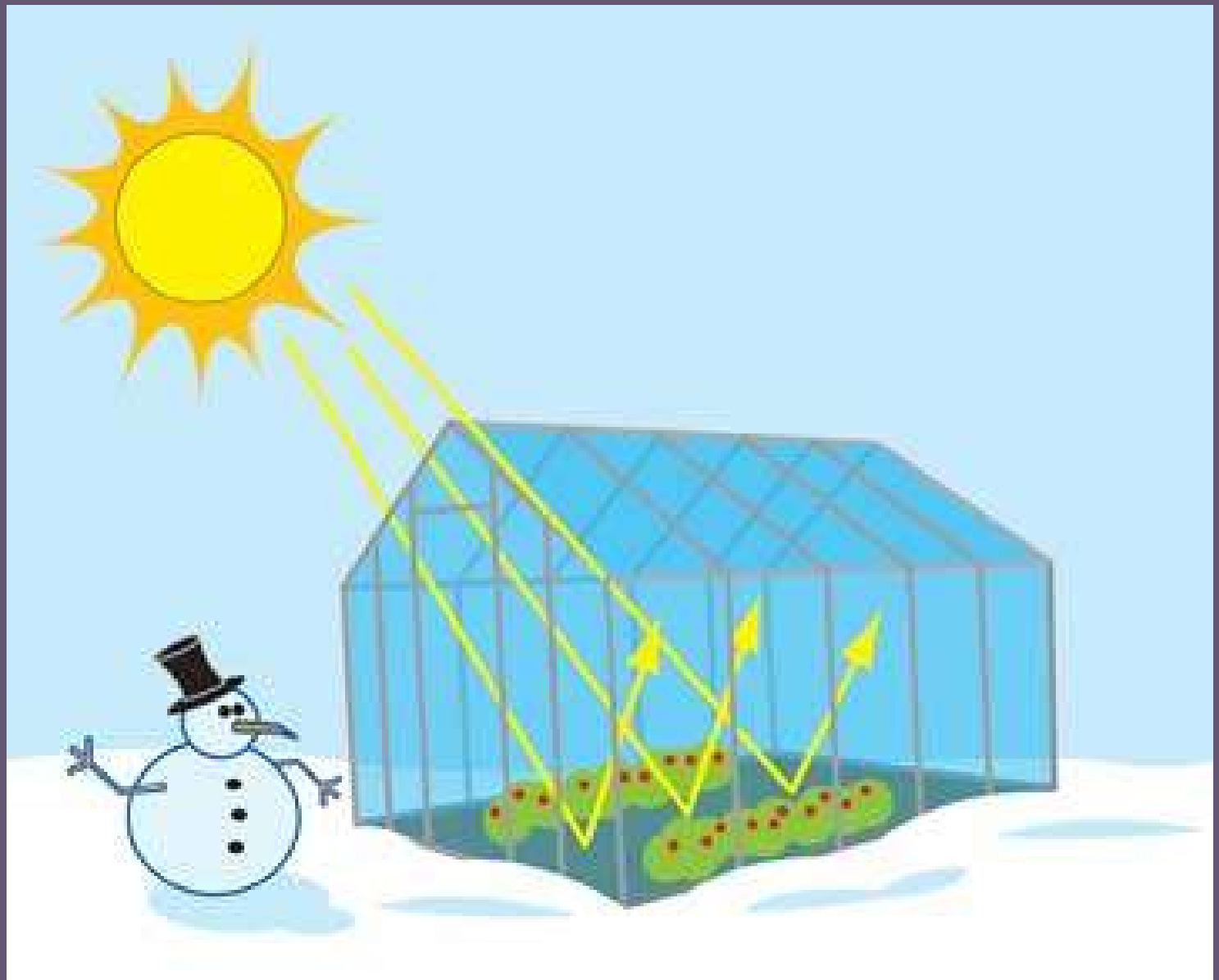
Ways ***HUMANS*** affect Carbon Cycle

Deforestation: removing trees that ***absorb*** carbon dioxide from the atmosphere. Fewer trees mean less carbon dioxide is being absorbed.

Artificial Trees

video

Greenhouse Effect



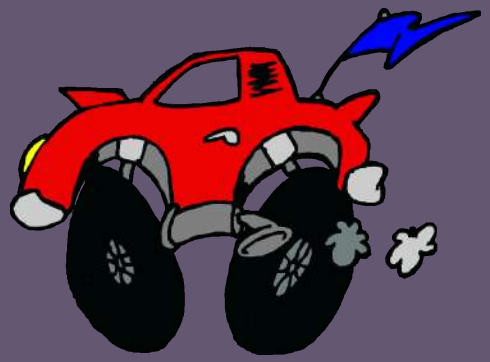
Life on Earth depends on the "greenhouse effect".

Carbon dioxide, water vapor and other gases: trap the heat from the sun in our atmosphere.

This warms the Earth and insulates it from the deep cold of space.

Greenhouse Effect

Burning of fossil fuels in industry & vehicles: Carbon is a by-product of combustion. The amount of carbon dioxide in the atmosphere has been rising. Some say it is contributing to ***global warming***.



Our industrial society depends on the energy that comes from….
----the burning of the fossils fuels such as oil, coal and natural gas.

But the burning of these fossil fuels _increases_ the amount of carbon dioxide entering the atmosphere.

CARBON CYCLE

Too much carbon dioxide in the atmosphere may be responsible for the _____ effect.

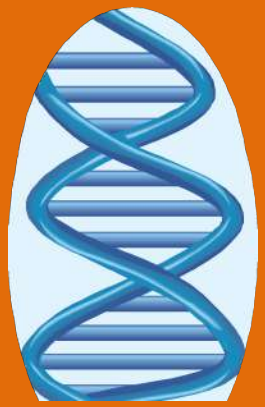
Photosynthesis

- $6CO_2 + 6H_20 + Sunlight \rightarrow C_6H_{12}O_6 + 6O_2$

Carbon Cycle

Carbon Cycle Video

Nitrogen Cycle

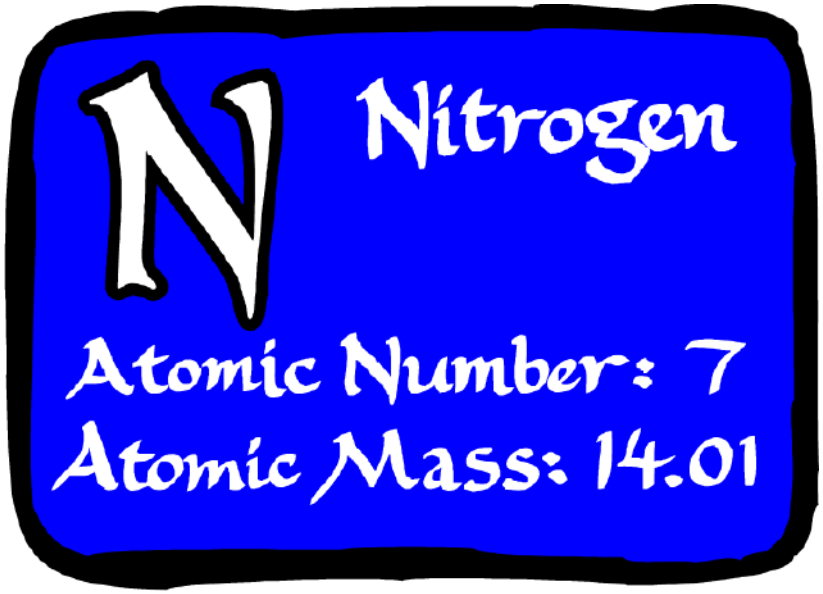


- Nitrogen is an important element in ***organic*** compound such as ***proteins***, DNA, ***amino acids*** & chlorophyll.

Nitrogen is the most ***abundant*** gas in the atmosphere. It cycles from the ***atmosphere*** to ***living things*** & back to ***atmosphere***.

The Nitrogen Cycle

All organisms must have nitrogen in order to build….
….proteins and nucleic acids.



Nitrogen gas makes up about 78% of Earth's atmosphere.
It would appear that nitrogen is readily available for use in manufacturing proteins and amino acids.
However, most organisms *do not have the ability* to make use of atmospheric nitrogen.

NITROGEN CYCLE

Our atmosphere is _____% nitrogen gas.

- But living things cannot use it in its gas form, therefore living things get ***nitrogen*** from the ***food***.

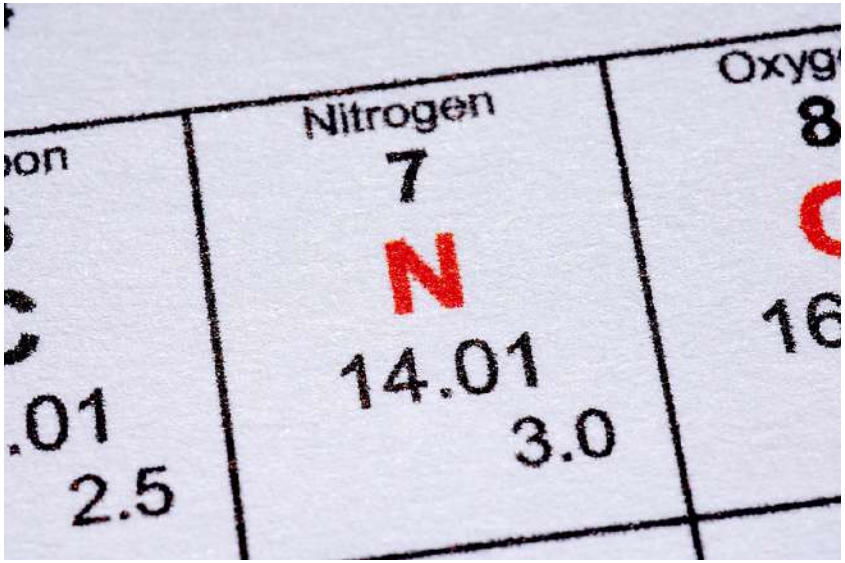
1. Living organisms cannot use simple nitrogen molecules (NH_2).

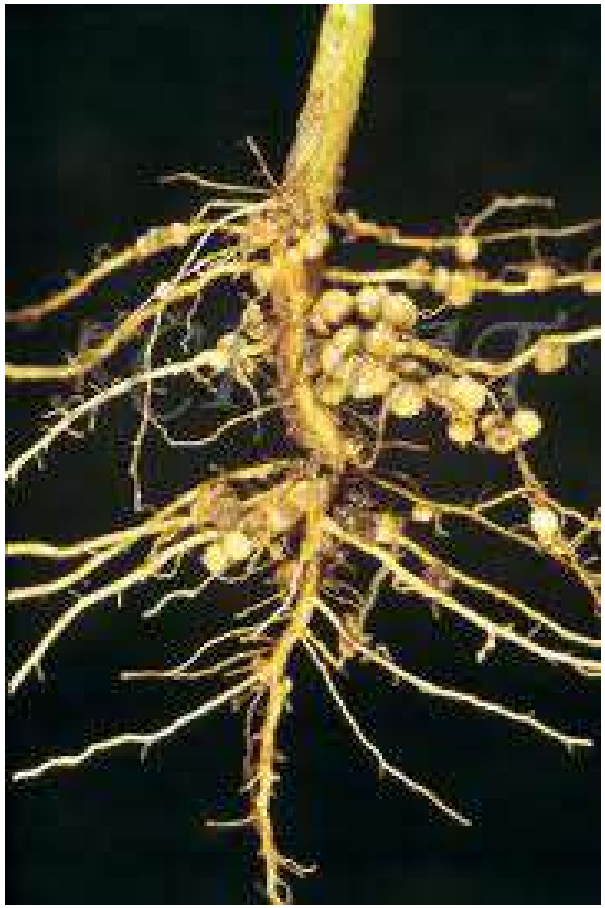
2. Living things take it in as a nitrate (NO_3^-).

NITROGEN CYCLE

Animals and plants cannot directly use all the nitrogen found in our _____.

Nitrogen is also found in….
….ammonia, the bodies of dead plants and animals, and in the wastes (both urine and feces) of living organisms.





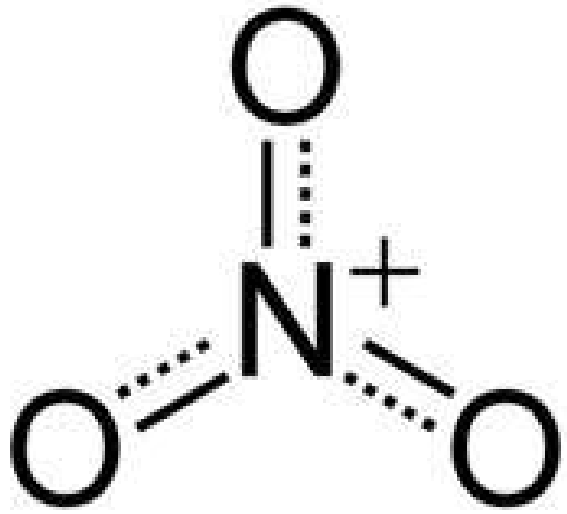
The nitrogen cycle is possible only because of several different types of soil-dwelling bacteria.
Each type of bacteria plays a particular role in the recycling of nitrogen.

The nitrogen cycle requires 4 different types of bacteria. What is the role of each of the following groups of bacteria?

3. Nitrate is formed when nitrogen is combined with oxygen. This process is called ***nitrogen fixation.***

Nitrogen-fixing bacteria live on root nodules of ***legumes*** & convert the gaseous ***nitrogen*** to ammonia (NH_4) then to ***nitrates or nitrites*** (NO_2 or NO_3).

NITRATE



NITRITE

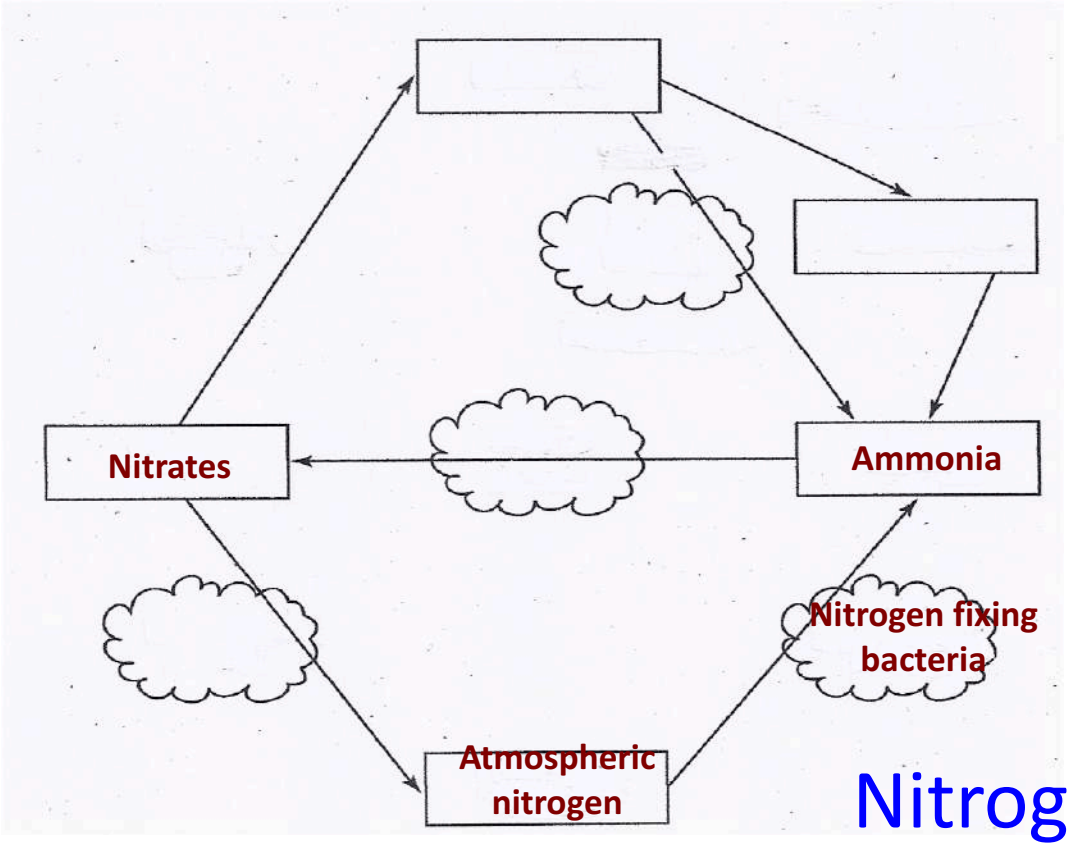
5. Examples of legumes: clover, peas, soybeans & alfalfa.

6. Plants use ***nitrates*** to make proteins. Animals only take in nitrogen by eating ***plants***.

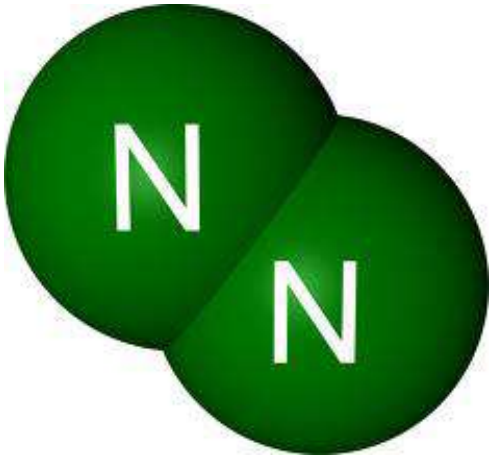
NITROGEN CYCLE

Only special bacteria can directly use nitrogen in out atmosphere and “fix” it so other organisms can benefit. These bacteria are called _____ bacteria.

The nitrogen cycle is a complex cycle with five important

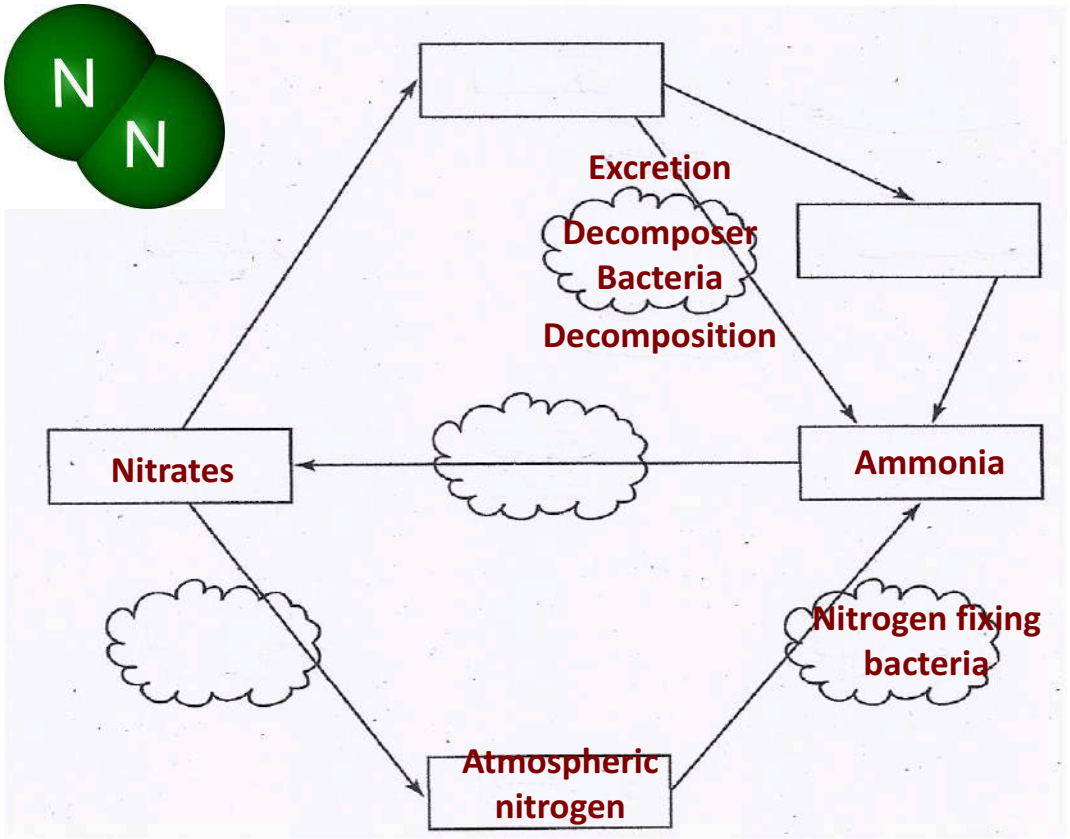


1 – Nitrogen Fixation



Nitrogen Fixation:
The process of converting atmospheric nitrogen into ammonia and nitrates.

The nitrogen cycle is a complex cycle with five important



2 - Ammonification

Many animals excrete and eliminate nitrogen in:
urine and in feces.
Soil bacteria convert these waste products into ammonia (NH_3).
In addition, these bacteria convert the nitrogen compounds in dead plants and animals to ammonia.

Some of this ammonia is absorbed by plants and used to make proteins and nucleic acids.

Ammonification is:
the production of ammonia by bacteria during the decay of nitrogen containing organic matter.

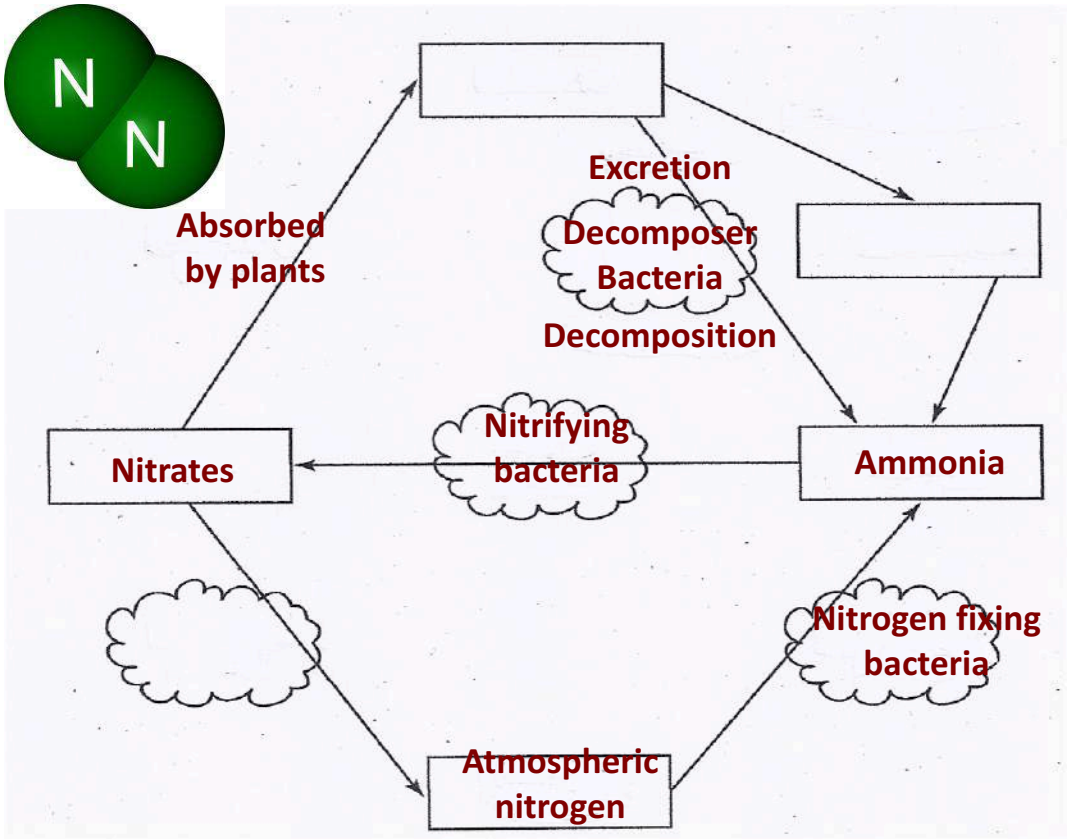
NITROGEN CYCLE

Higher organisms use nitrogen to make their _____.

NITROGEN CYCLE

Animal waste decays by the action of bacteria which create _____ and _____ products rich in nitrogen, and useful for plants to use again.

The nitrogen cycle is a complex cycle with five important

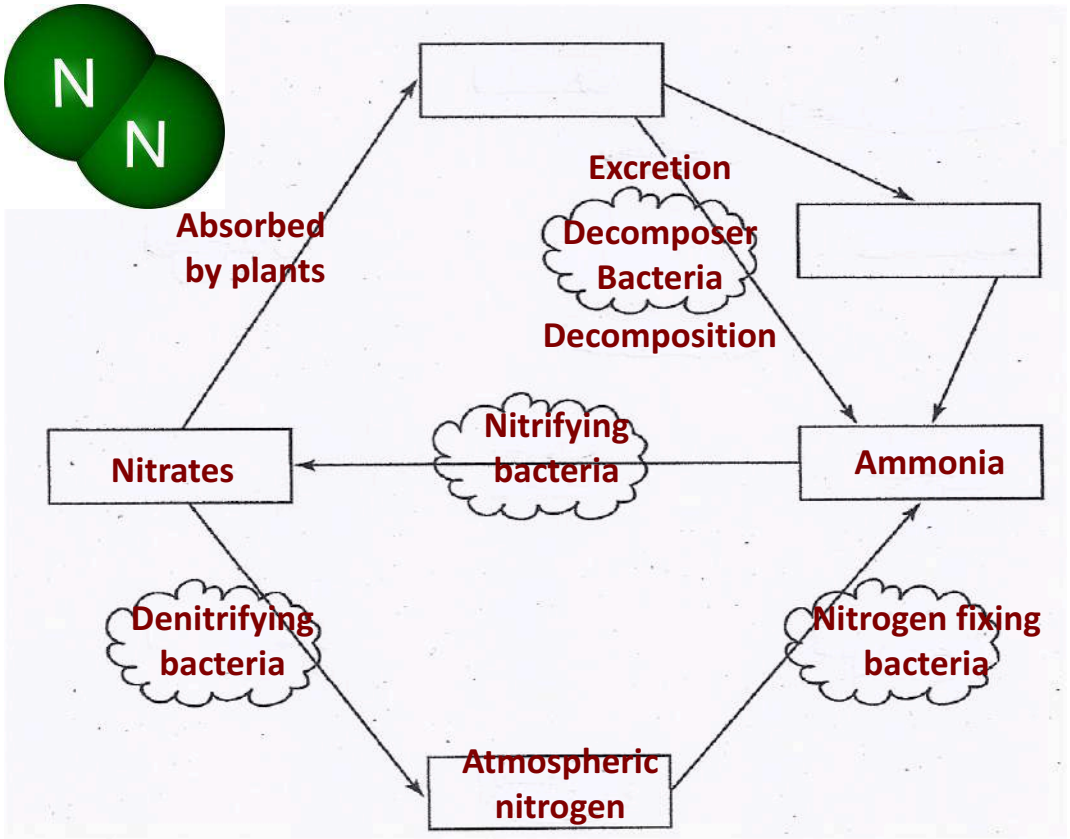


3 - Nitrification

Some of the ammonia in the soil is converted by several kinds of bacteria to: nitrates, NO_3^-.

These nitrates are absorbed from the soil by plants.
Nitrification is the production of nitrates from ammonia.

The nitrogen cycle is a complex cycle with five important



4 - Denitrification

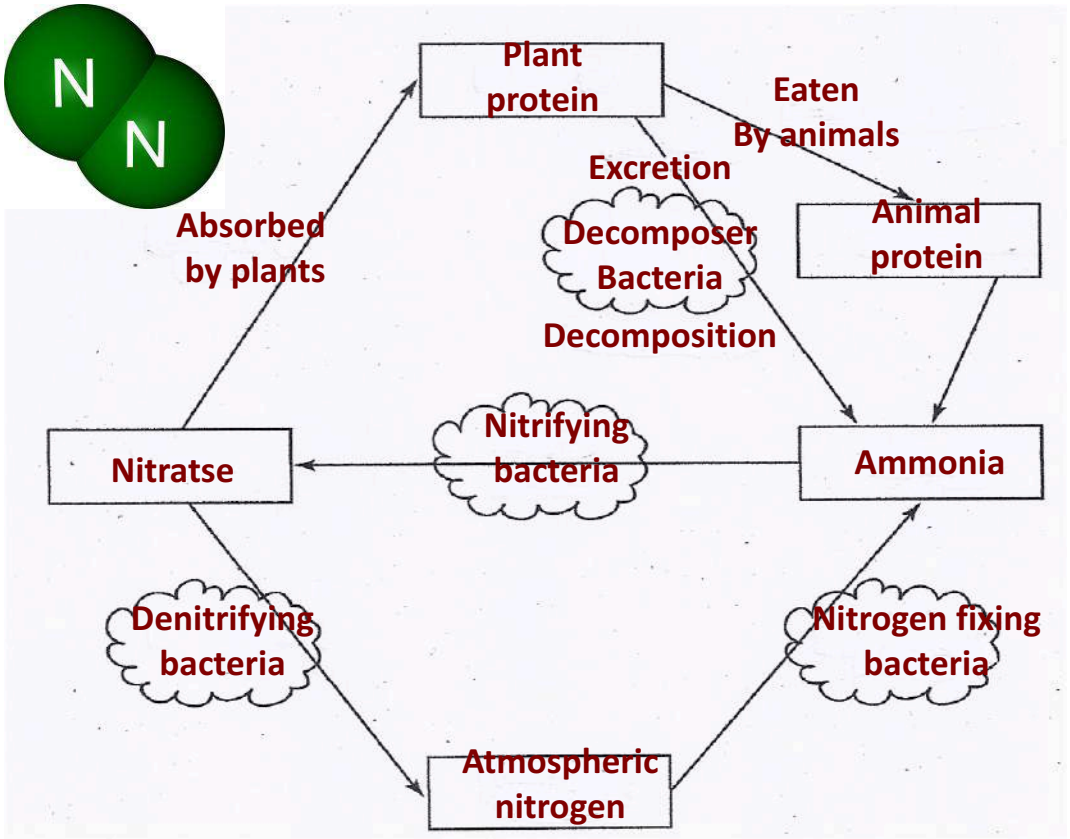
Another kind of bacteria acts on: the remaining nitrate, converting it back into nitrogen gas.

This nitrogen gas is released into the atmosphere.
Denitrification is the conversion of nitrate to nitrogen gas.

NITROGEN CYCLE

_____ bacteria in the soil can break down the ammonia into the gaseous form of nitrogen, which is not available for use by plants or animals.

The nitrogen cycle is a complex cycle with five important



5 - Assimilation

a) Ammonia and nitrates are picked up by plants.

b) Plants use ammonia and nitrates to build proteins and nucleic acids.

c) When animals eat the plants, they use the nitrogen to build: their own proteins and nucleic acids.

d) Nitrogen assimilation is the absorption and incorporation of nitrogen into plant and animal compounds.

7. Nitrogen flows through the ***food web*** as animals eat plants & animals eat other animals.

Nitrite, N-Nitroso Compounds and Nitrosamines

Nitrite, N-Nitroso Compounds and Nitrosamines

They are formed from nitrite (sodium nitrite) that is added to processed meat products.

Sodium nitrite is used as an additive for 3 reasons:

1. To preserve the red/pink color of meat.
2. To improve flavor by suppressing fat oxidation (rancidification).
3. To prevent the growth of bacteria, improving flavor and cutting the risk of food poisoning.

Processed meat that is fried or grilled may contain relatively high levels of nitrosamines. Studies suggest that these compounds may increase the risk of cancer in the stomach and bowel.

8. During ***decomposition,*** nitrogen compound are released. Bacteria will break down ammonia to nitrogen & oxygen & release ***nitrogen*** back to soil and atmosphere.

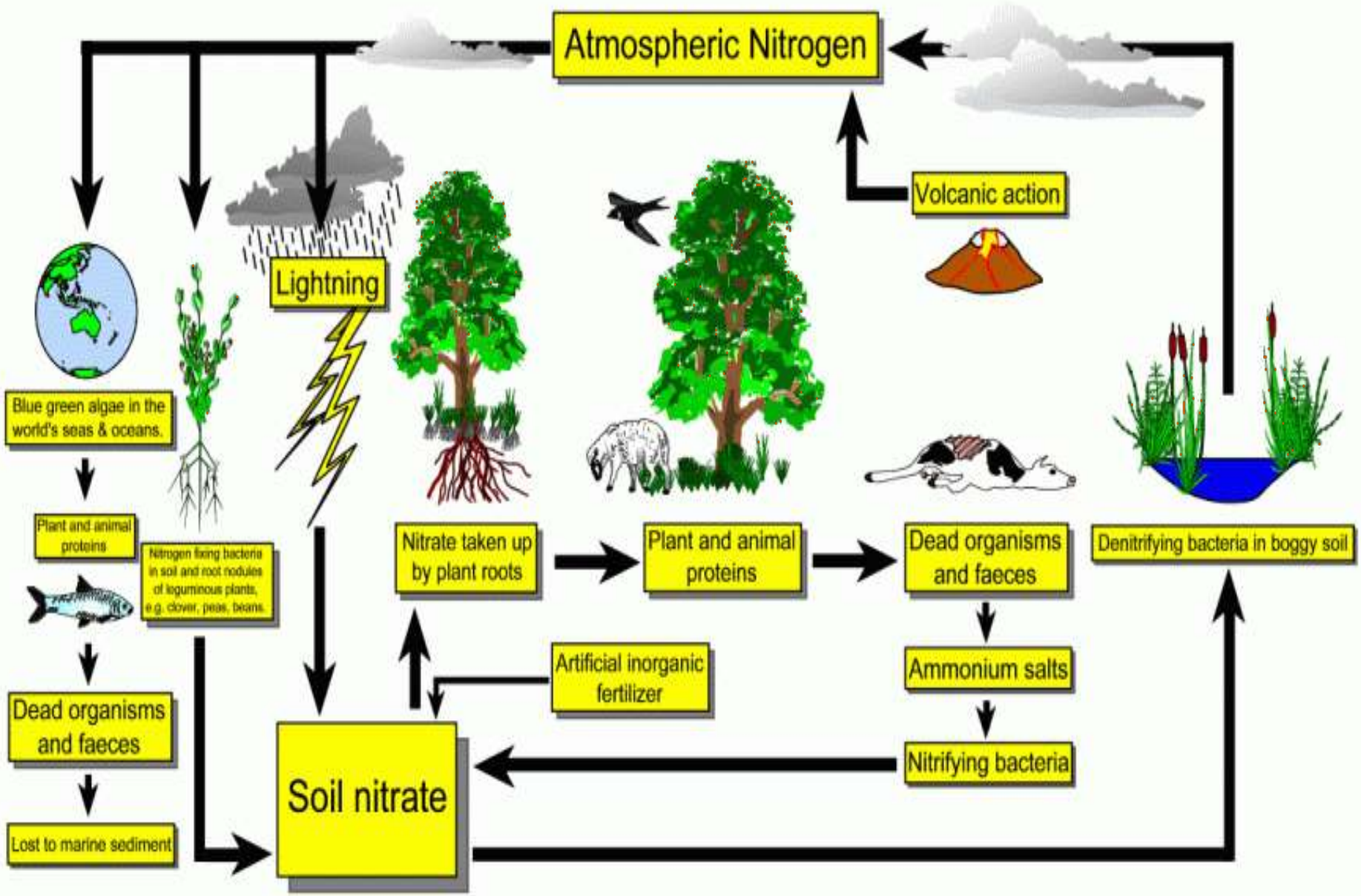
9. Some aquatic bacteria and ***lightning*** can also change nitrogen to nitrates.

NITROGEN CYCLE

In another part of the cycle, animals eat _____ containing nitrogen, which is again returned to the soil by animal _____ or decaying _____ and _____.

Nitrogen Cycle Video

The Nitrogen Cycle



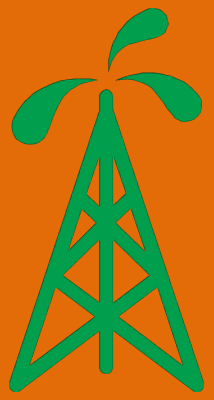
WAYS HUMANS ALTER THE NITROGEN CYCLE

- The rate of nitrogen fixation has ***doubled*** since the 1950s.

- ***Fertilizers***: contain nitrogen…place on lawn & farmlands

WAYS HUMANS ALTER THE NITROGEN CYCLE

- ***Burning of fossil fuels***: releases nitrogen during combustion



- ***Destruction of forests & <u>wetlands</u>***: release nitrogen thru decay

CONSEQUENCES

- ***Ecosystems***: Nitrogen additions to the soil can lead to changes that favor weeds over native plants, which in turn reduce species **diversity** and changes ecosystems.

- Research shows that nitrogen levels are linked with changes in grassland species, from mosses and lichens to grasses and flowers.

- ***Precipitation***: Nitrogen oxides react with water to form nitric acid, which along with sulfur dioxide is a major component of acid rain.

- **Acid rain** can damage and kill aquatic life and vegetation, as well as corrode buildings, bridges, and other structures.

***Air quality*:** High concentrations of nitrogen oxides in the lower atmosphere are a precursor to tropospheric ozone, which is known to damage living tissues, including human lungs, and decrease plant production.

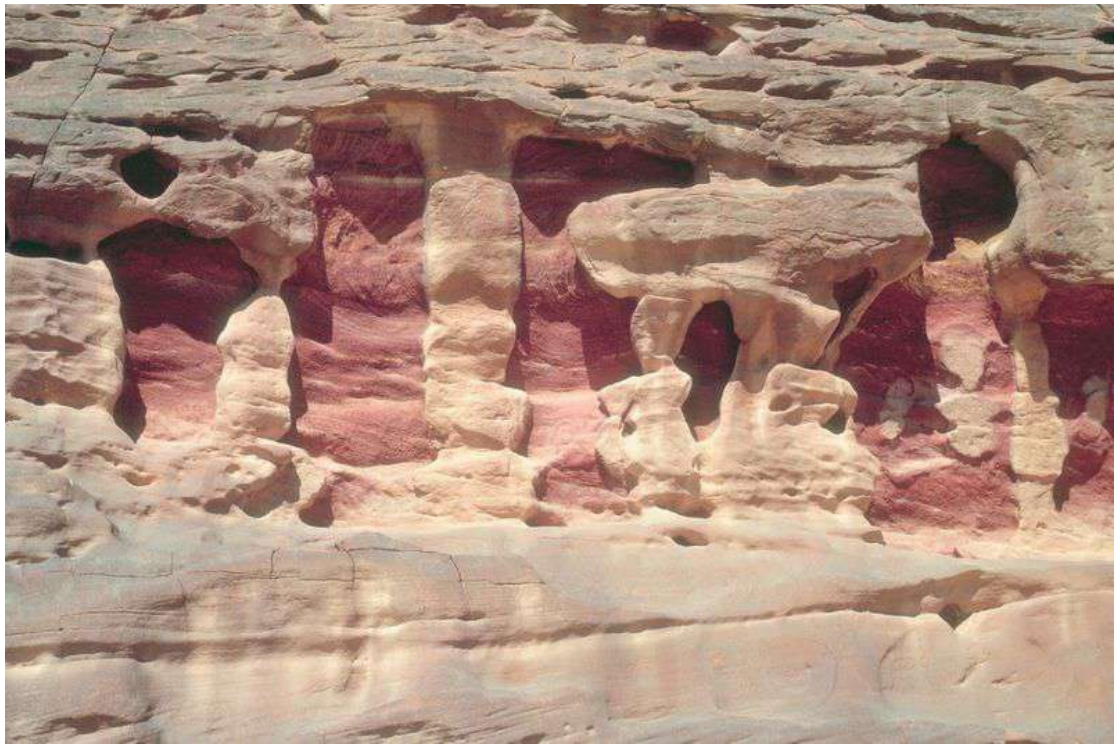
Water quality: Adding large amounts of nitrogen to rivers, lakes, and coastal systems results in **eutrophication,** a condition that occurs in aquatic ecosystems when **excessive** nutrient concentrations stimulate **blooms of algae** that deplete **oxygen**, killing fish and other organisms and ruining water quality.

Eutrophication

PHOSPHORUS CYCLE

- Phosphorus is not a **gas** and does not enter the atmosphere.

- Phosphorus cycles from **land** to ocean and then back to land.



Phosphates are usually present in rocks and soil as *calcium phosphate*. Calcium phosphate dissolves in water to form inorganic *phosphate ions*.

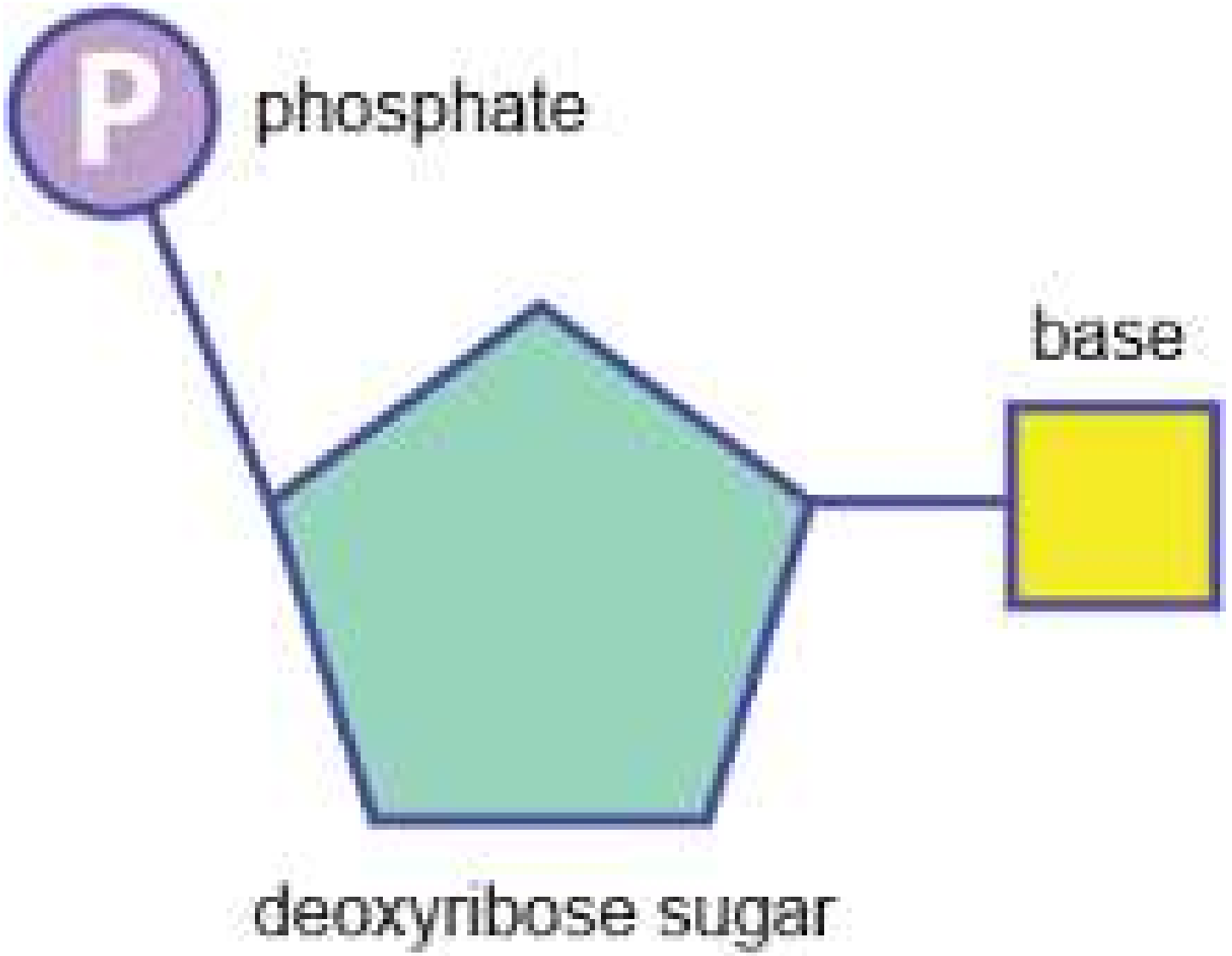
As phosphates are released from soil and rocks, it washes into streams and rivers, eventually making its way to the oceans where it is used by marine organisms .

- Water runs over ***rocks*** that contain phosphorus and places it in the water and soil. Plant roots absorb **phosphorus**.

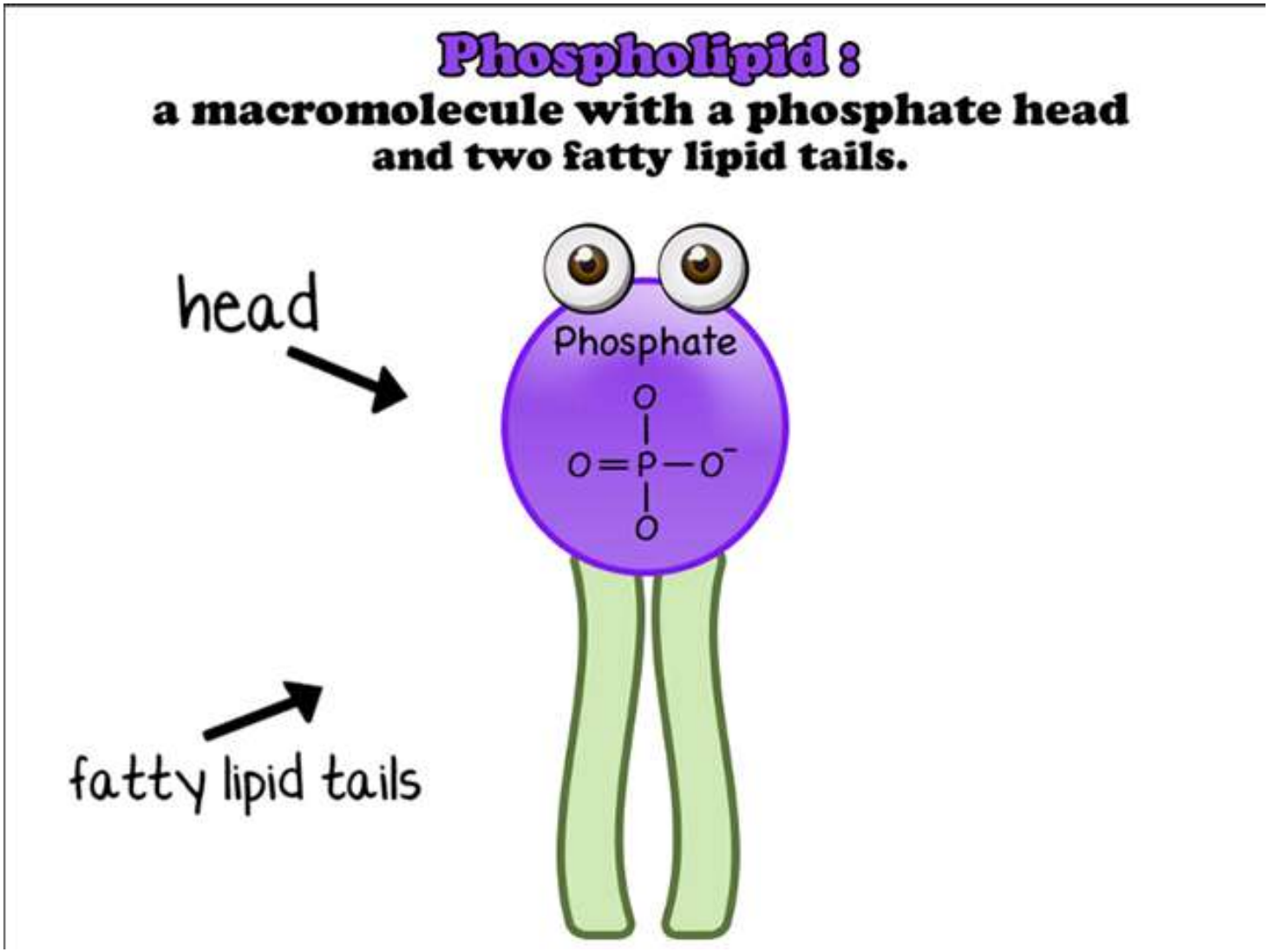
PHOSPHORUS CYCLE

Phosphorus is NOT found in the free state in nature, but is contained mostly in _____ and _____.

PHOSPHORUS CYCLE



PHOSPHORUS CYCLE

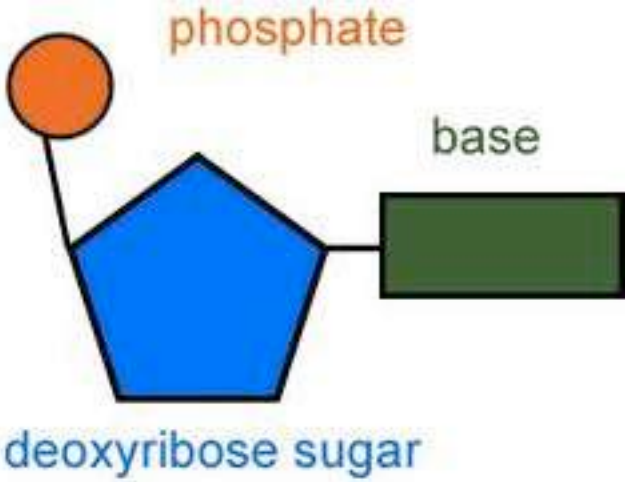


The Phosphorus Cy

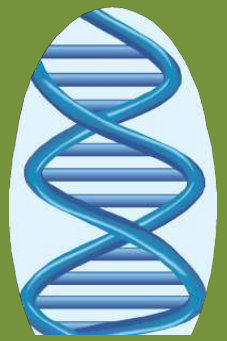
Phosphorus is essential in all living organisms because it is needed to: build molecules of ATP and the nucleotides that compose DNA and RNA.

Although phosphorus is of great biological importance, it is *not very common* in the biosphere.

Unlike the other essential elements that are recycled such as carbon, nitrogen, and oxygen, phosphorus does not enter the *atmosphere*.



- Phosphate makes up **DNA**. Animals get phosphates thru **food**. Phosphorus is release by **decomposition**.



PHOSPHORUS CYCLE

It is an essential nutrient for life, as it makes up important chemicals such as _____.

Some phosphates remain on land and cycle between organisms and the soil.

When **plants** absorb phosphate from the soil or from water, they bind the phosphate into **organic compounds**.

The phosphate moves through the **food web** from producers to consumers.

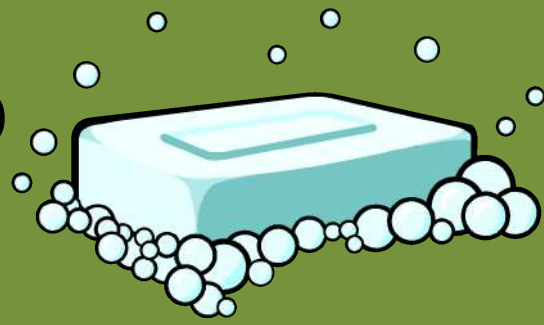
PHOSPHORUS CYCLE

In the phosphorus cycle, phosphorus moves between the soil and _____, which are eaten by animals.

PHOSPHORUS CYCLE

The animals use phosphorus, and then their _____ products help return the sulfur for the next generation of phosphorus in the soil.

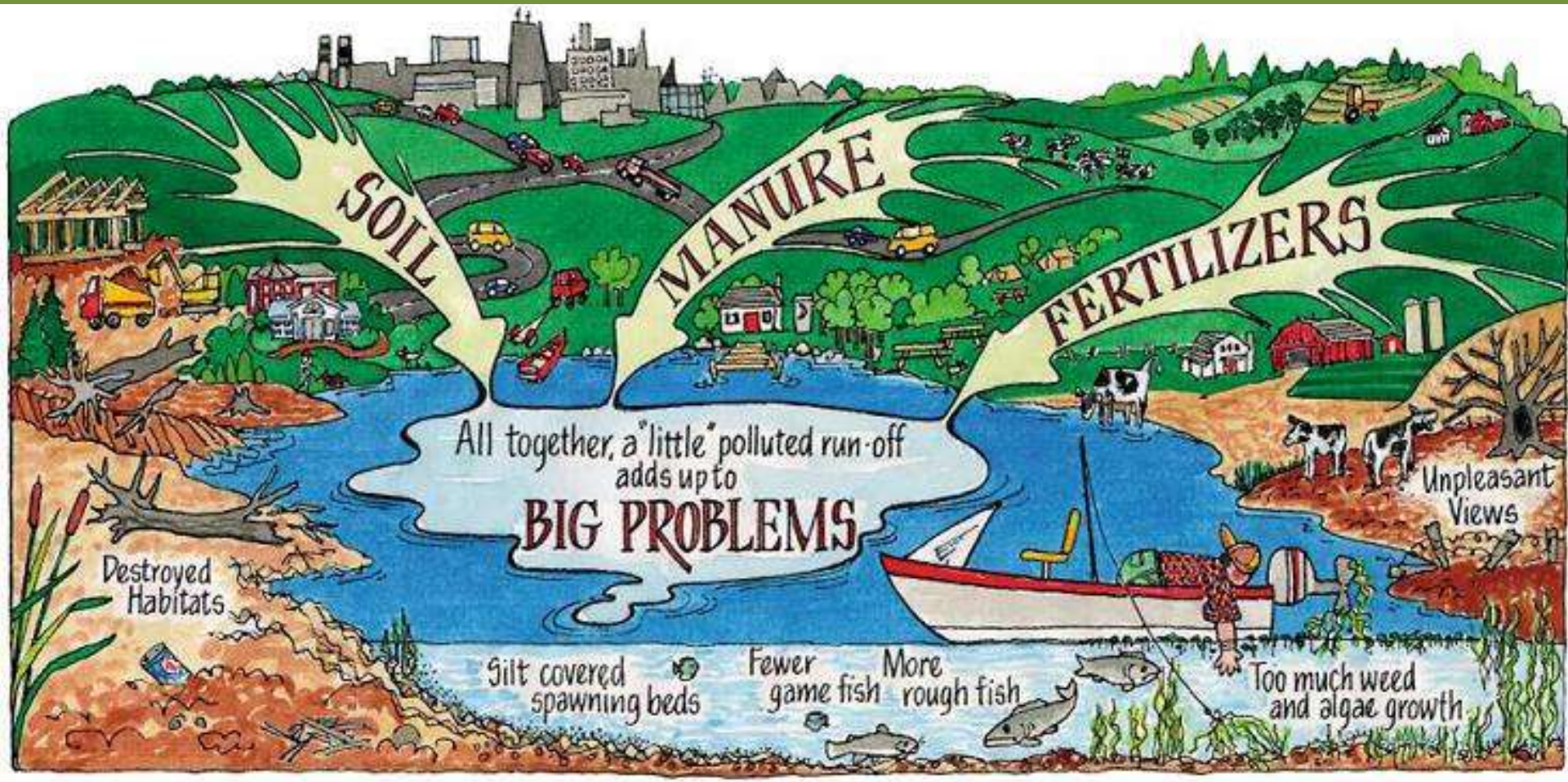
Phosphorus video



Phosphorus cycle video


Mediterranean Sea
EGYPT
Nile River
Euphrates River
Tigris River
Persian Gulf
THE FERTILE CRESCENT

Too much of a good thing??



PHOSPHORUS CYCLE

Some of the phosphorus in soils can be washed away into water _____.


gettyimages

PHOSPHORUS CYCLE

Another source of phosphorus in water comes from man-made _____.

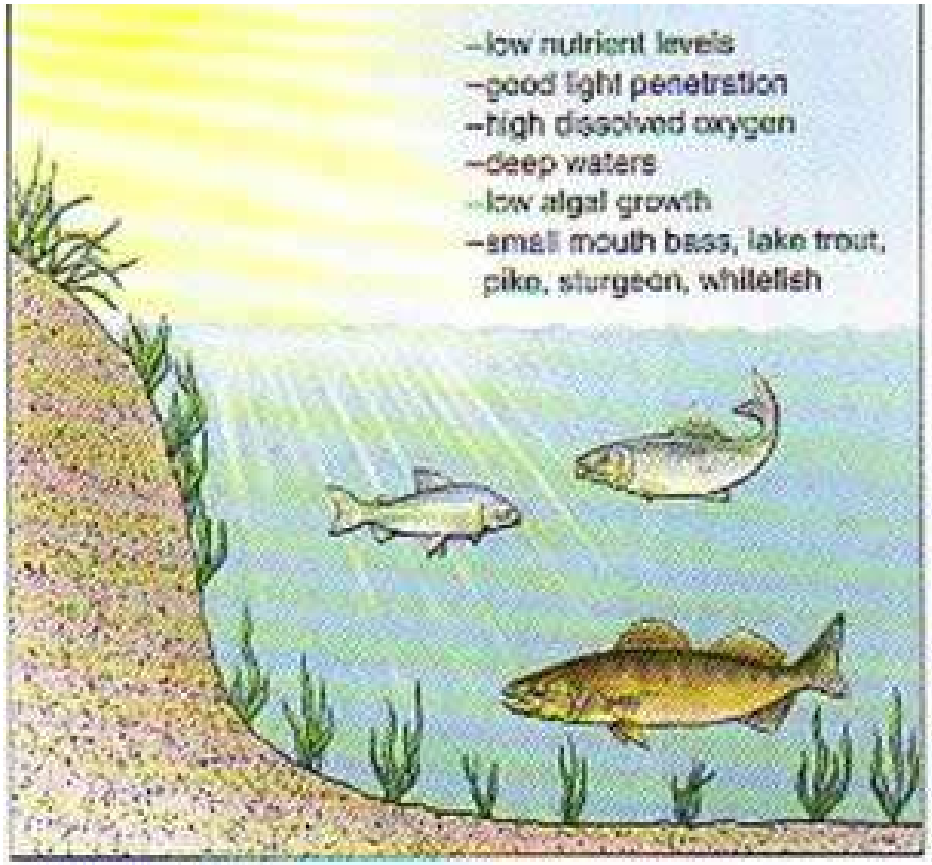
So what if there is a lot of phosphorus?

- OVERGROWTH.
- Lets say it again.
- OVERGROWTH.
- Not just above the ground, their roots will also grow large! This is why many fertilizers today use phosphorus.

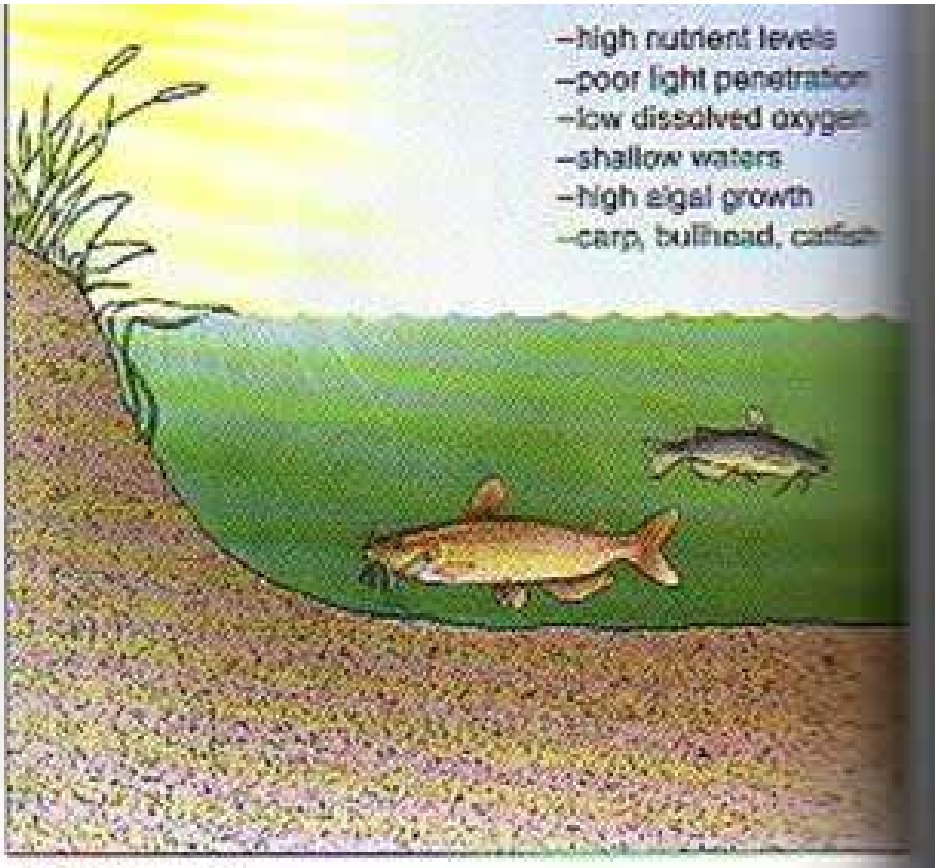
PHOSPHORUS CYCLE

Too much phosphorus in water leads to plant _____, strangling all other life forms in the water.

PHOSPHORUS CYCLE



(a) Oligotrophic lake



(b) Eutrophic lake

PHOSPHORUS CYCLE

Battling the Bloom

PHOSPHORUS CYCLE

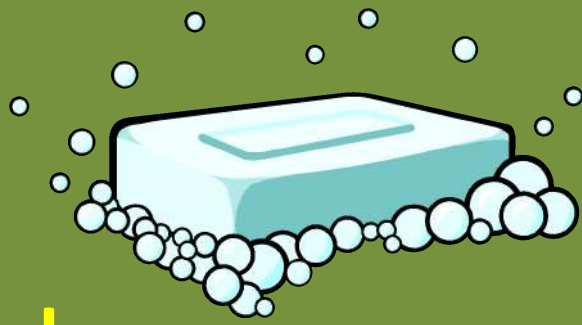
Why is the use of too many phosphorus-rich fertilizers bad for the environment?

_____-

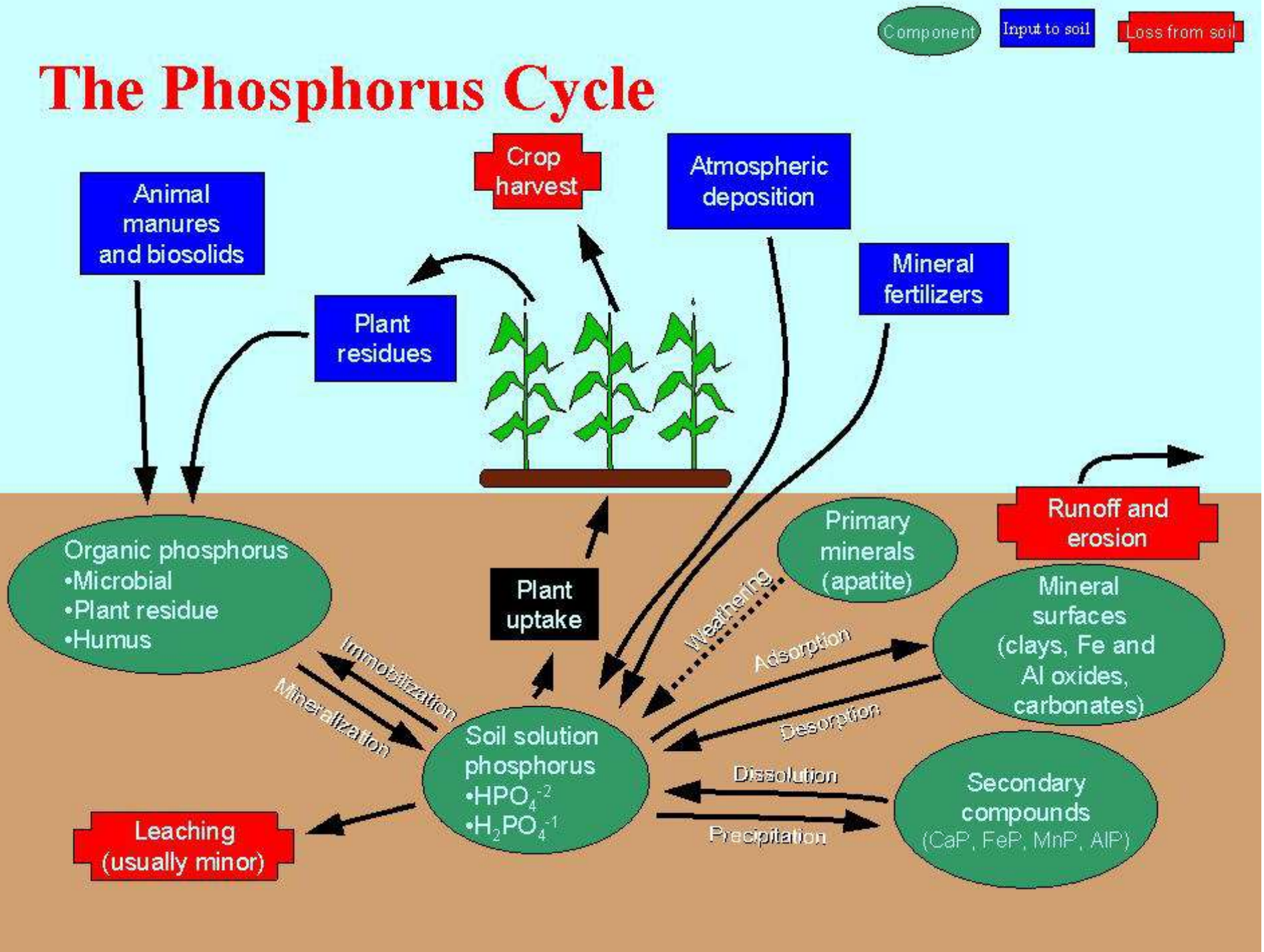
_____

_____

- Loss of **land** because of clear cutting and **erosion** of farmland.



- When we use **soaps** and detergents with phosphorus it integrates into our groundwater.
- Fertilizers


Component
Input to soil
Loss from soil
The Phosphorus Cycle
Crop harvest
Atmospheric deposition
Animal manures and biosolids
Mineral fertilizers
Plant residues
Runoff and erosion
Primary minerals (apatite)
Organic phosphorus
•Microbial
•Plant residue
•Humus
Plant uptake
Weathering
Mineral surfaces (clays, Fe and Al oxides, carbonates)
Adsorption
Immobilization
Mineralization
Desorption
Soil solution phosphorus
•HPO_4^{-2}
•$H_2PO_4^{-1}$
Dissolution
Secondary compounds
(CaP, FeP, MnP, AlP)
Precipitation
Leaching
(usually minor)

Nutrient Limitation

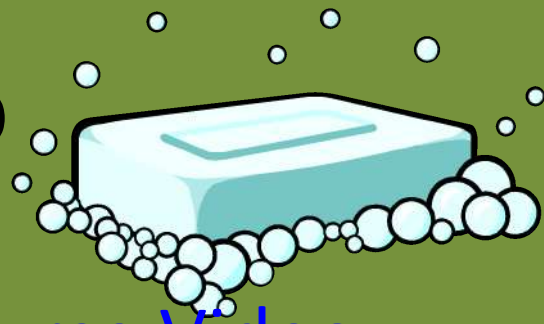
As we have already learned above, primary productivity is:
the rate at which organic compounds are created by producers during photosynthesis.

A factor that determines the primary productivity of an ecosystem is:
the amount of nutrients available.

Limiting nutrient:

A limiting nutrient is a single nutrient (such as nitrogen or phosphorus) that either is scarce or cycles very slowly, limiting the growth of the organisms in the ecosystem.

Phosphorus video



Phosphorus and Nitrogen Crash Course Video

- Get out a sheet of paper
- Write down 5 facts from the video
- Turn them in as you walk out of the door