Winogradsky Columns

The Young Scientist Program
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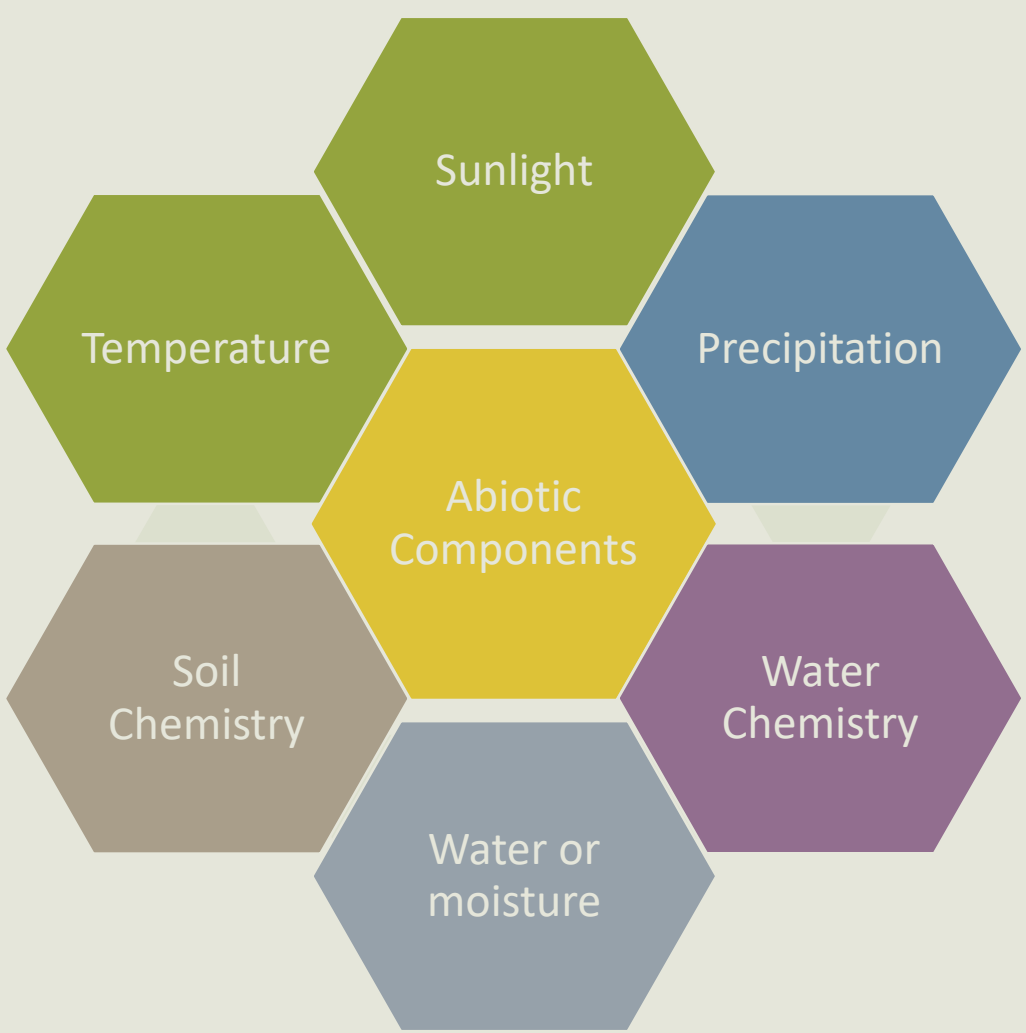
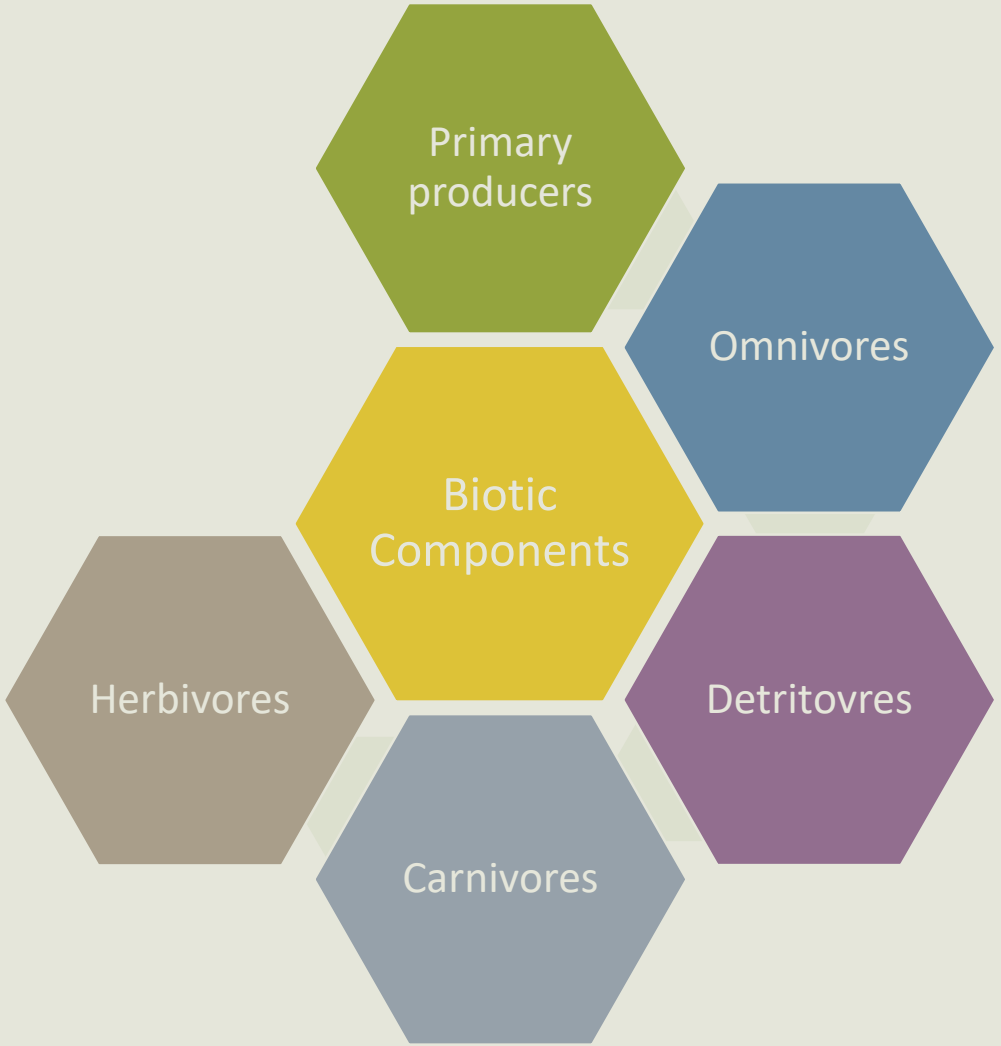
Ecology/Evolution Teaching Team

What is an ecosystem?

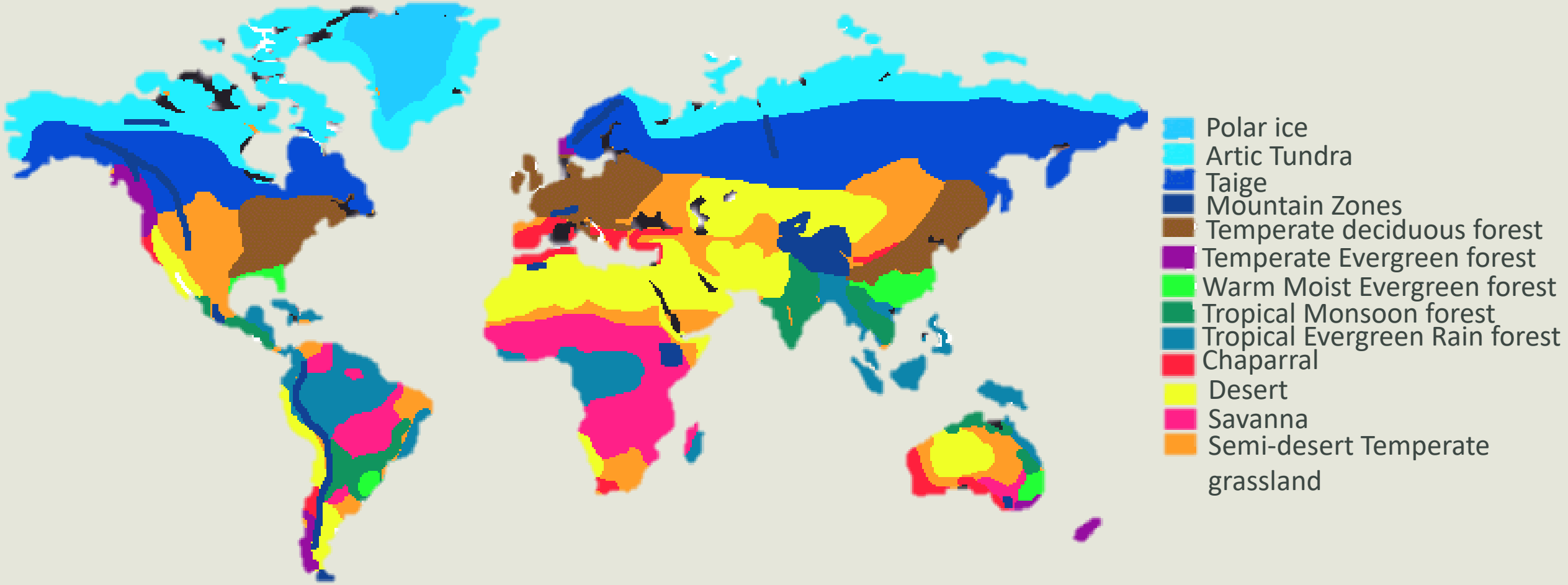
Ecosystems are sets of **living organisms** (plants, animals, and microorganisms) that interact among themselves and with the **environment in which they live** (soil, climate, water and light).

Ecosystems have both abiotic and biotic components

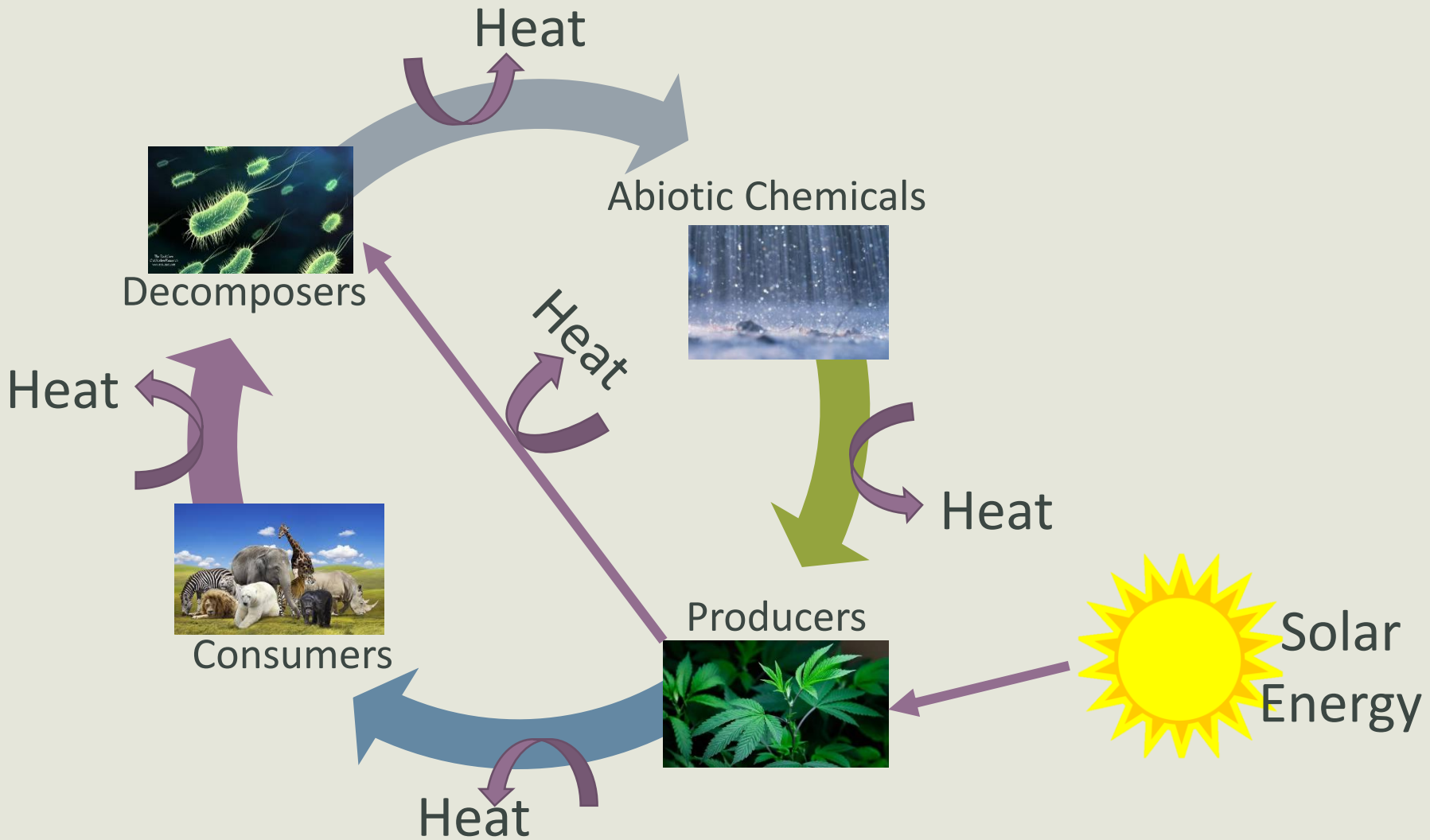




Different types of ecosystems are largely determined by climate



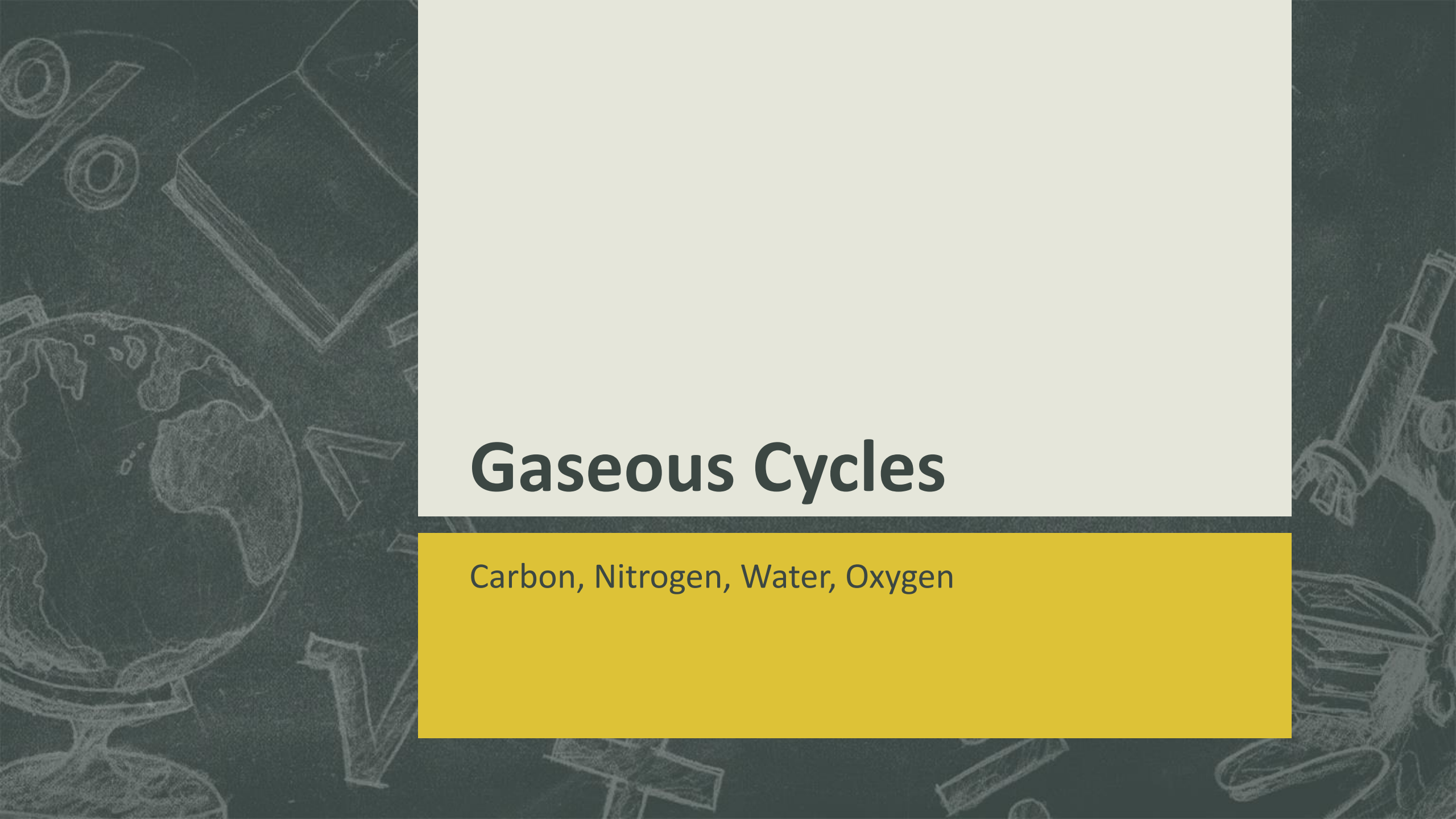
Ecosystems rely on cycling of nutrients to survive



Gaseous vs. Sedimentary Cycles

Gaseous cycles include those of **nitrogen, oxygen, carbon and water**.

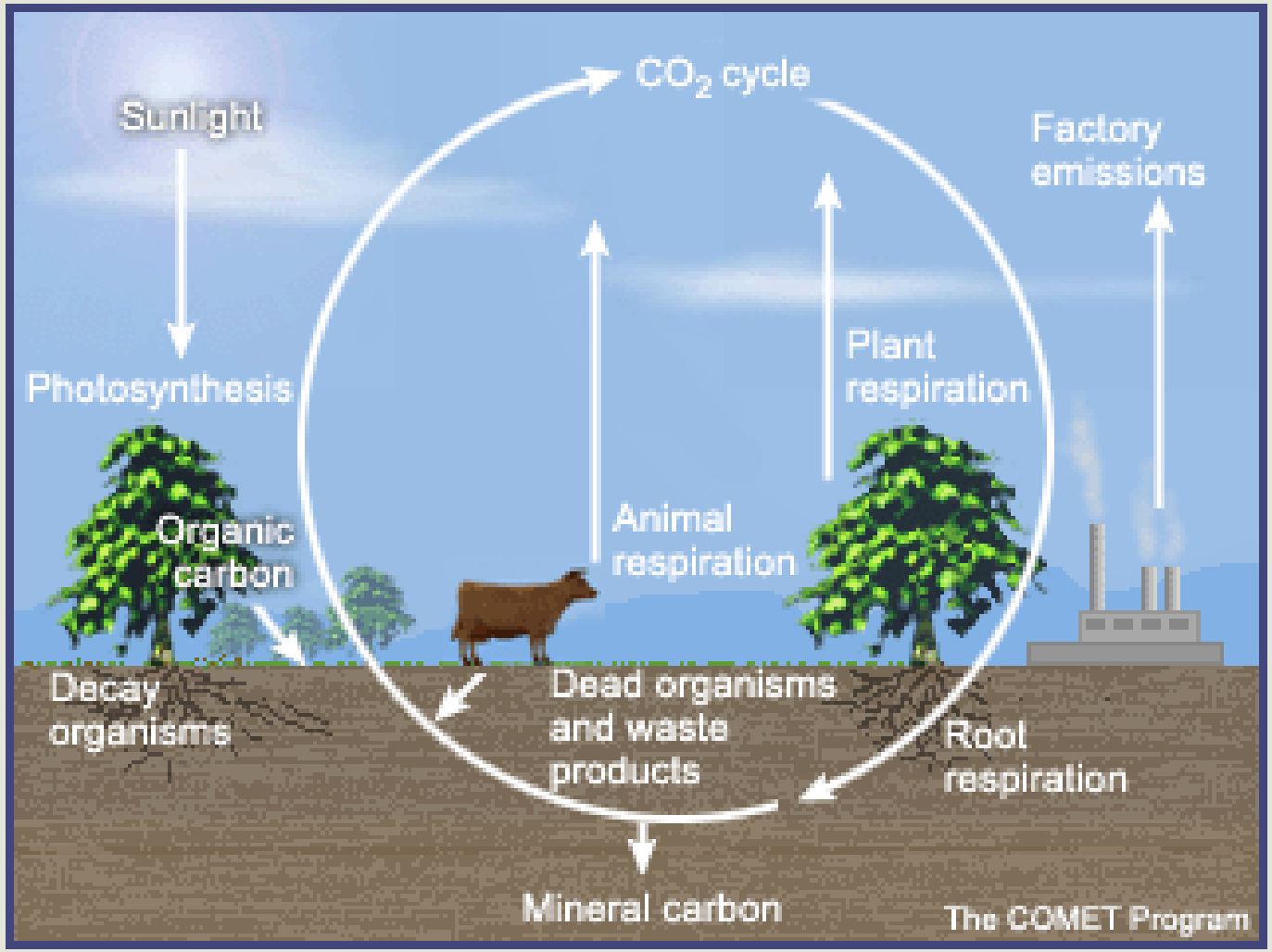
Sedimentary cycles include those of **iron, calcium, phosphorus, sulfur and other earthbound elements**. Each cycle consists fundamentally of a **solution phase and a rock phase**.



Gaseous Cycles

Carbon, Nitrogen, Water, Oxygen

Carbon Cycle



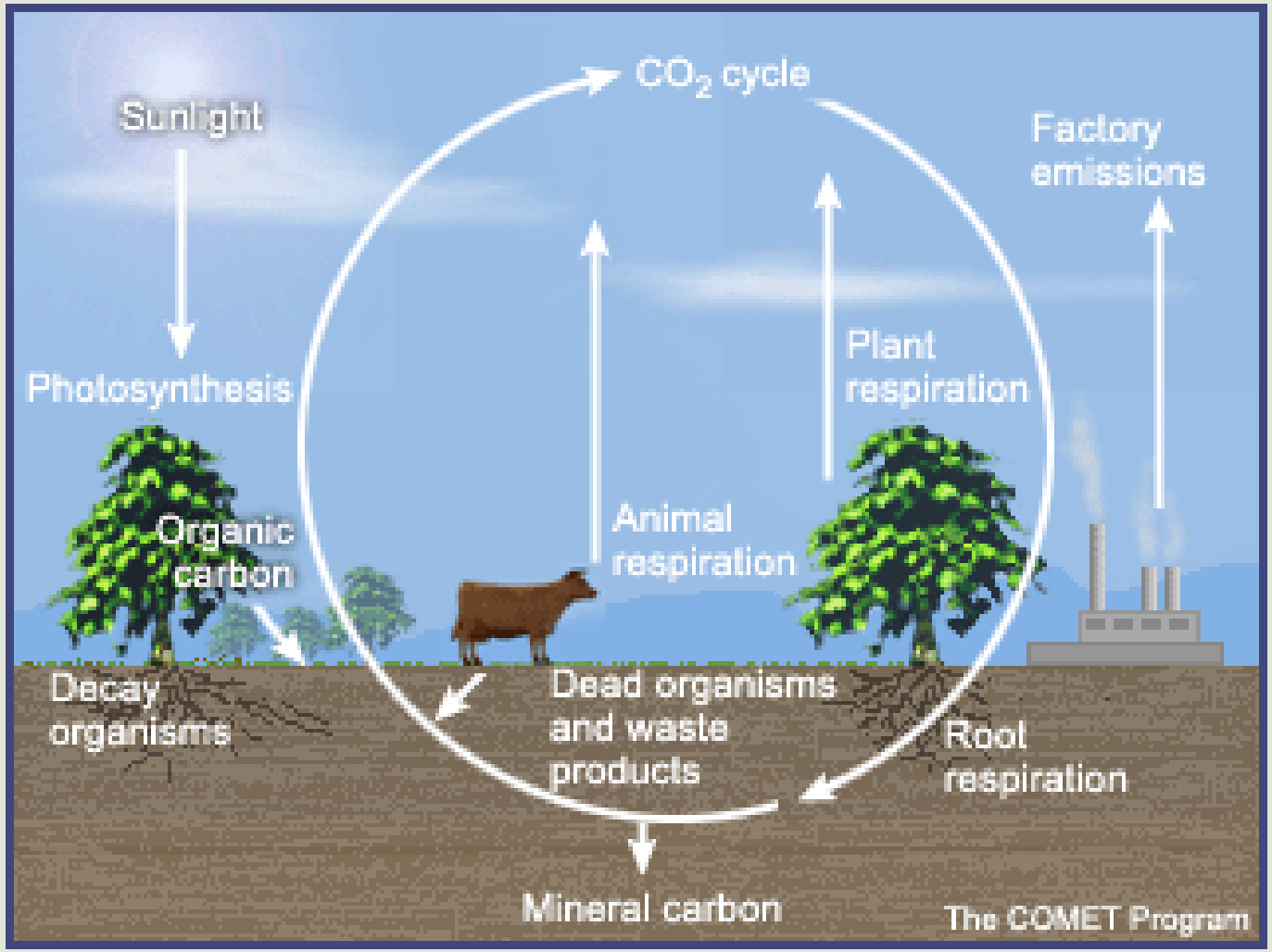
Carbon is attached to oxygen in a gas called carbon dioxide (CO_2) in the atmosphere

Through <u>photosynthesis</u>, CO_2 is pulled from the air to make food from the carbon component

Carbon moves from producers (plants) to consumers (animals) through food chains, when consumers eat producers and other consumers.

When plants and animals die their bodies **<u>decay</u>**, releasing carbon to the soil.

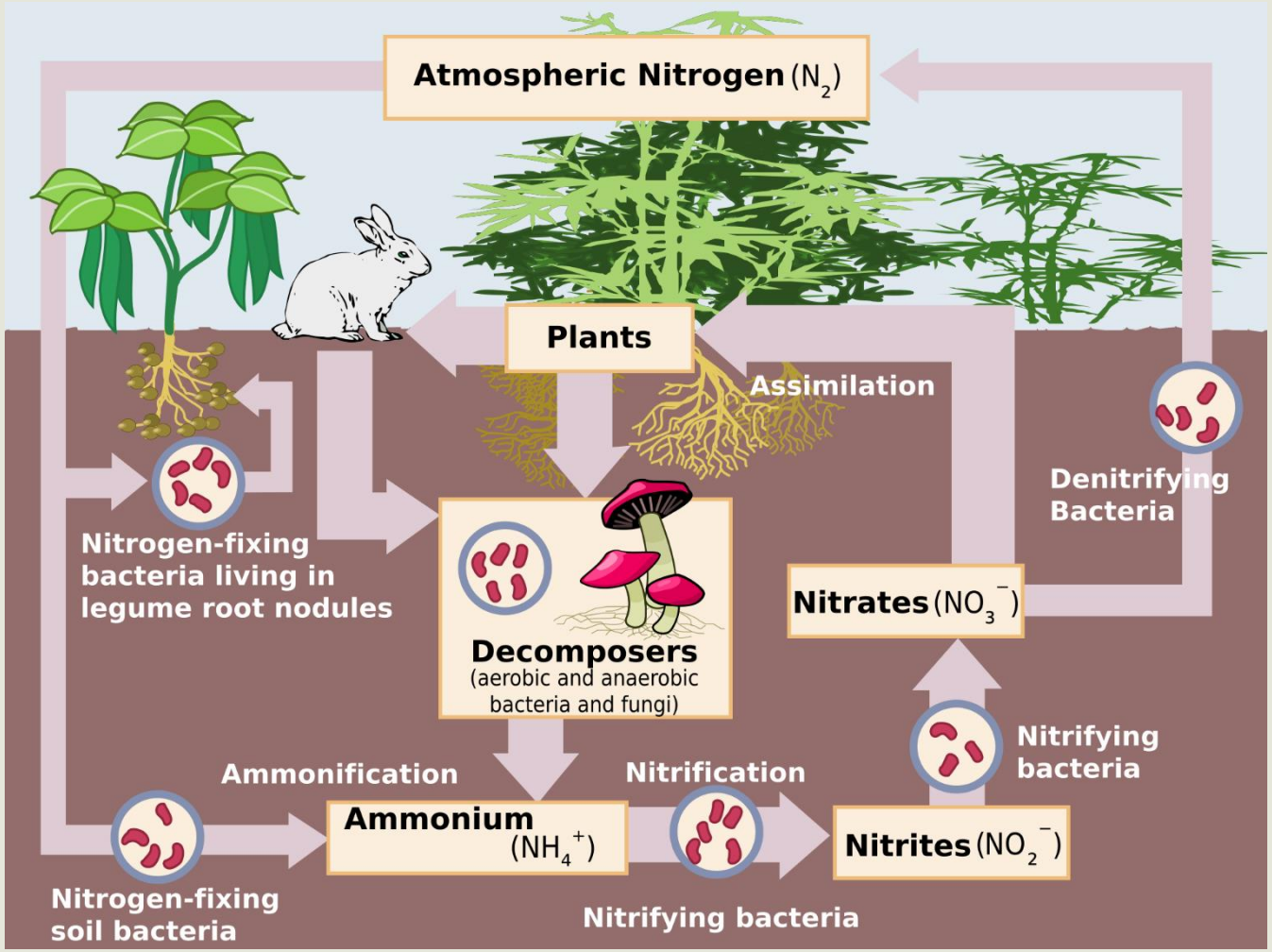
Carbon Cycle



Carbon can also move from living things to the atmosphere. For example, every time you breathe you release carbon dioxide into the atmosphere. This process is called **respiration**

Carbon dioxide is a greenhouse gas and traps heat in the atmosphere. Without it and other greenhouse gasses, Earth would be a **frozen world**.

Nitrogen Cycle



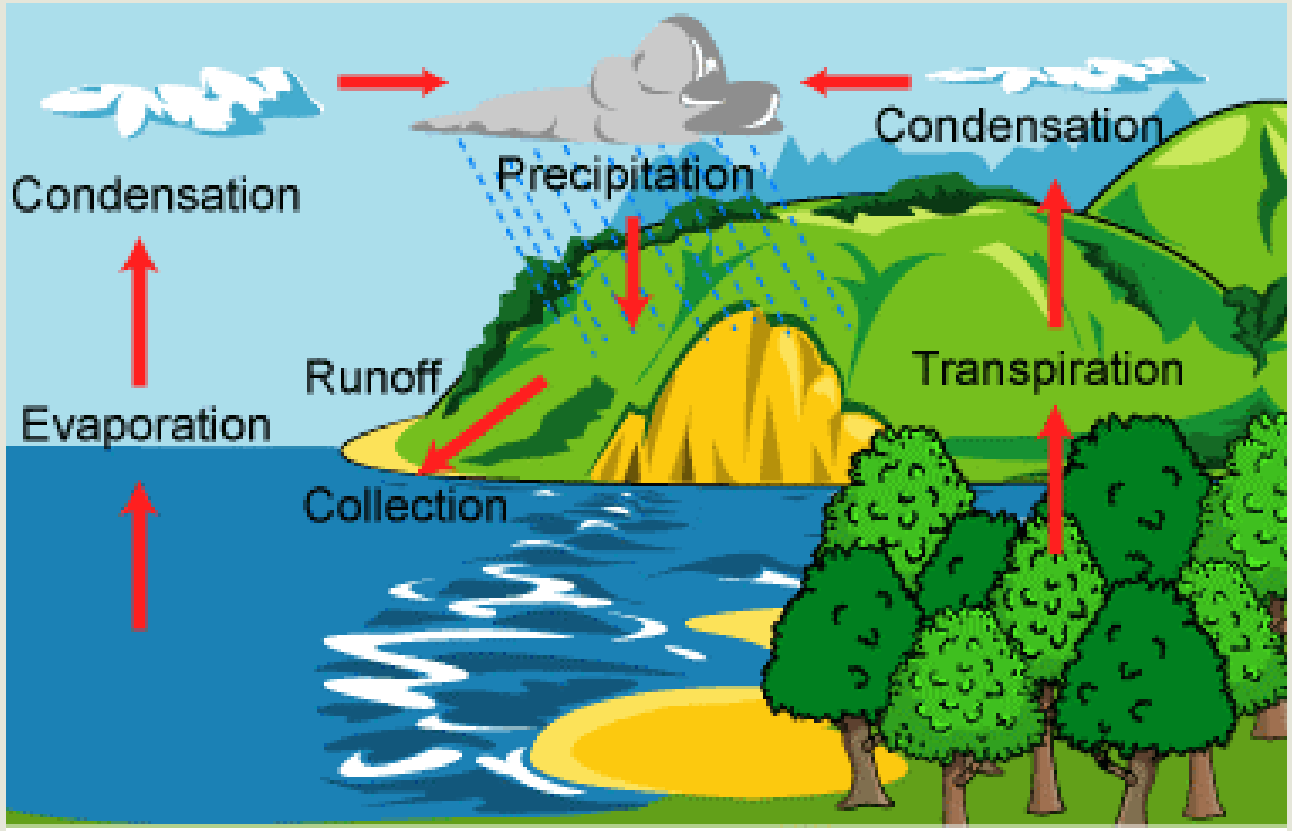
Nitrogen can be **fixed from the atmosphere** to ammonium (NH_4^+) by nitrogen-fixing organisms

The ammonium can then be taken up by plants or converted into nitrate (NO_3^-) through **nitrification**

Organic nitrogen can be converted back to inorganic nitrogen (ammonium) through **nitrogen mineralization** or **decomposition**.

Then denitrifying bacteria convert nitrate to dinitrogen (N_2) through **denitrification**.

Water Cycle



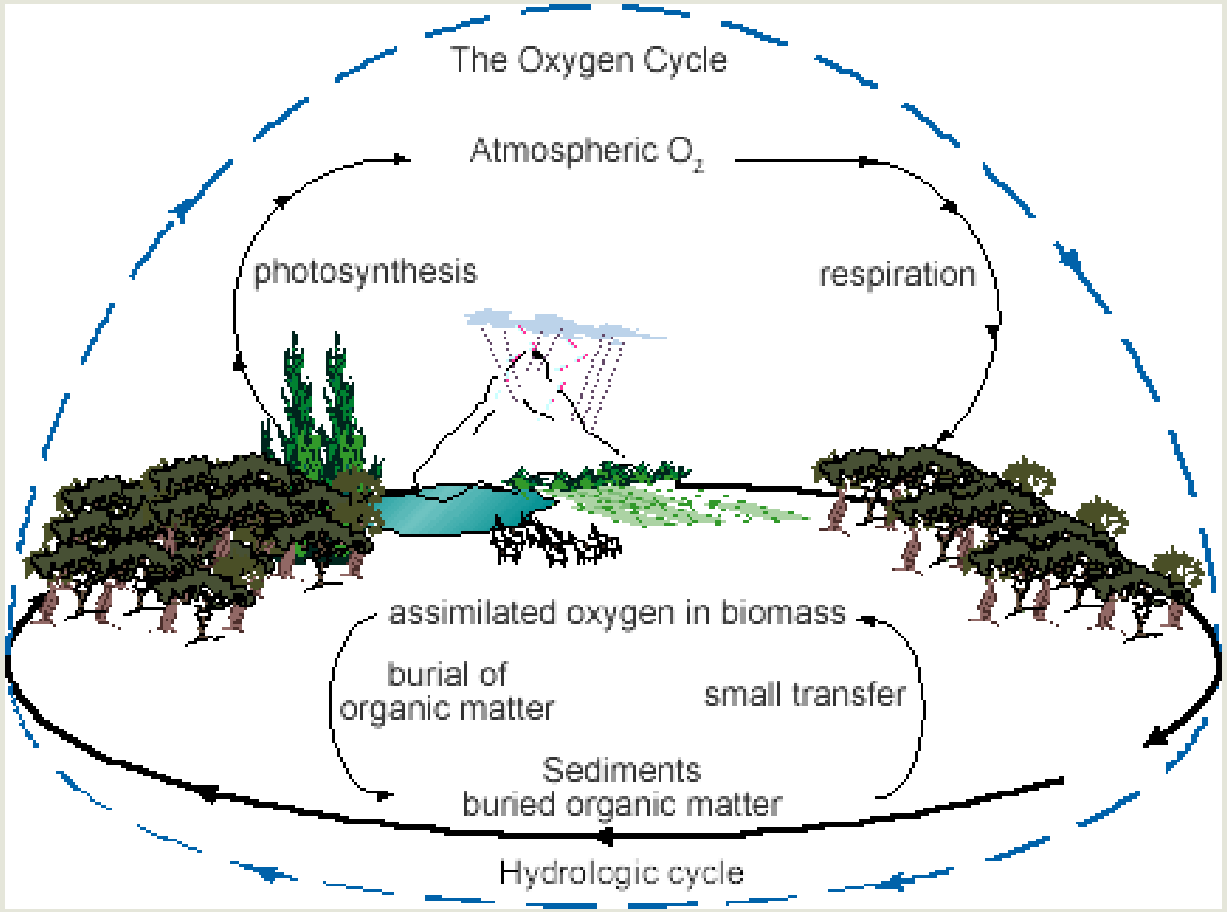
Water is **evaporated** from oceans and freshwater bodies into the atmosphere

During **condensation**, water is released from the atmosphere and is returned as tiny droplets which form clouds in the sky or fog at ground level

When water has returned to the ground, it flows down hills into streams, rivers, ponds, and lakes. This process is called **surface runoff**

Water in the soil can be absorbed by plant roots and transferred to their leaves. Water can then evaporate from the leaves, a process called **transpiration**.

Oxygen Cycle



Plants produce oxygen during **photosynthesis** when they use energy from sunlight to release carbon from carbon dioxide.

The sunlight frees up oxygen from the atmosphere by the process of **photolysis**

Animals breathe in oxygen through **respiration**

When water runs over rocks oxygen can enter water and persists as dissolved oxygen. Also oxygen can be fixed in minerals and freed by **chemical weathering**.

Winogradsky Columns

Winogradsky column

Biogeochemical cycles are **closed systems**, which means **nutrients are never lost or created**; they are continuously reused and recycled usually by soil microbes.

Sergei Winogradsky invented a system in order to study the biogeochemical recycling process: a long, sealed-column of muddy soil, water and shredded paper, called a **Winogradsky column**

Winogradsky column

You can think of the Winograsky column as a **small ecosystem**. As **oxygen diffuses downward** from the surface of the water, fermentation products from the breakdown of cellulose and **hydrogen sulfide move up to the top of the column**. Oxygen conditions remain very poor at the bottom of the column.

Bacteria that are present at the bottom of the column are mainly responsible for the decomposition of the cellulose found in the shredded paper. As the chemical products are released from bacteria, **they diffuse upward and are responsible for groups of organisms to accumulate based upon the stratification of nutrients** and their required conditions for survival.

Making a Winogradsky Column!

Making the mixture

- Add 2 cups of mud
- Slowly add water till thick
- Shed newspaper and add to mix
- Add 1 tbsp. chalk
- Add 1tsp of egg yolk

Adding mix to column

- Stir the mixture
- Use the funnel to the base of the column
- Tap the column to get rid of air bubbles
- Add until 90% full

Sit and Wait

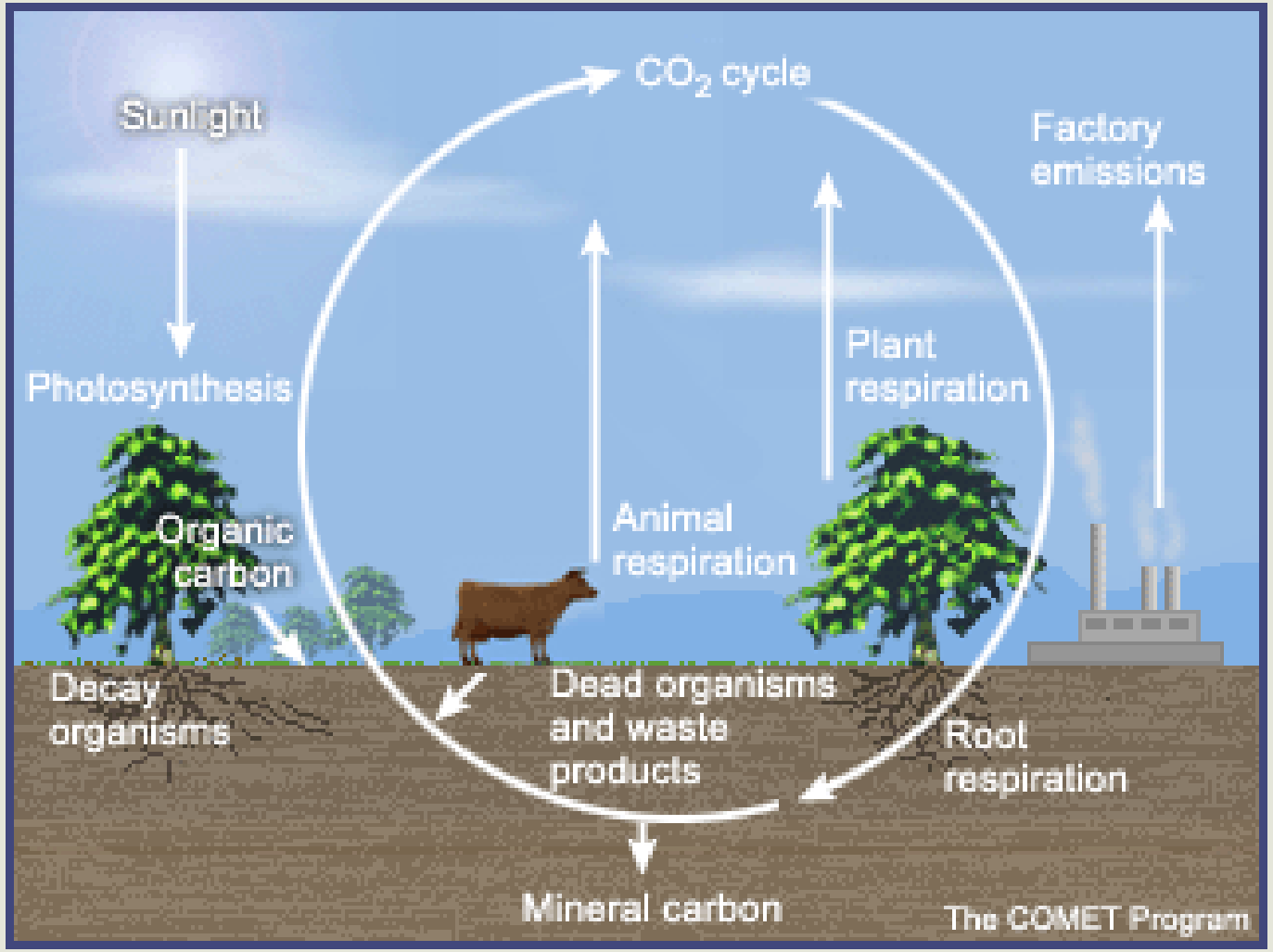
- Let the bottle sit for 30 min
- Measure water to make sure only 2 cm deep
- Cover bottle with plastic wrap and rubber bands

Discussion Questions

Different types of bacteria that we will find in the column over time

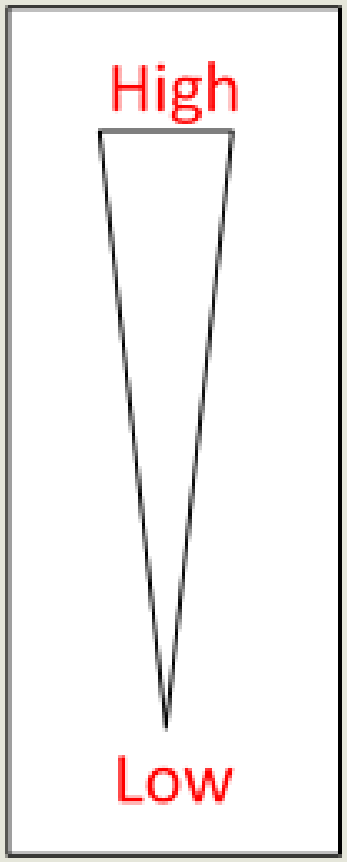
Column Position	Bacteria	Color
Top	Cyanobacteria	Green
	Purple non-sulfur bacteria	Red, purple, orange, or brown
	Purple sulfur bacteria	Red/purple
	Green sulfur bacteria	Green
Bottom	Sulfate reducing bacteria	Black

How are the elements carbon, hydrogen and oxygen cycled through the column?



Through **photosynthesis** and respiration.

Draw the oxygen gradient in the column and explain why there is a gradient.



The shredded newspaper and sulfate triggers microbial activity and the microbes **deplete the oxygen in the mud**. The loss of oxygen creates a gradient **with low oxygen at the bottom and high oxygen at the top**.

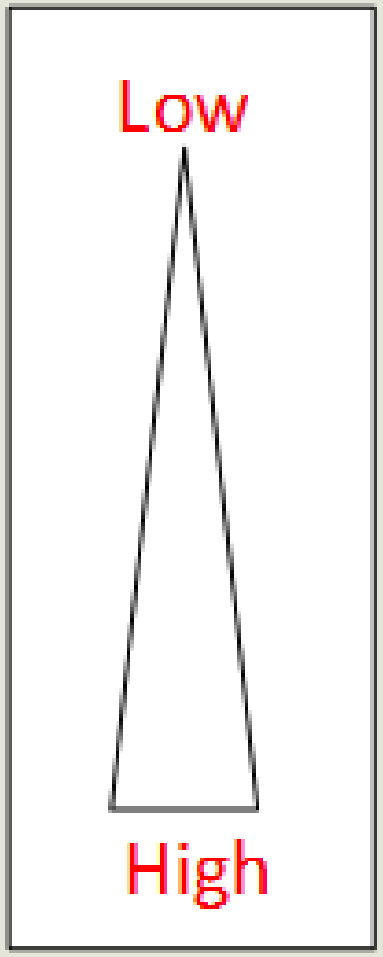
Is the Winogradsky column a closed system?

Yes, it is a mini ecosystem which contains microbes that are contributing to the biogeochemical cycles.

How do you think the oxygen gradient in a Winogradsky column will affect where different microbes are living in it?

Microbes that can tolerate oxygen or need oxygen in order to live will be found at the top of the column while the microbes that can grow in the absence of oxygen will be found at the bottom of the column.

Draw the sulfur gradient in the Winogradsky column. What is the difference between purple and green sulfur bacteria? What are the similarities?



Green sulfur bacteria are able to tolerate higher concentrations of sulfur than **purple sulfur bacteria**. They both us carbon dioxide as a carbon source and sulfur as an electron donor.

Click to watch an animation of the winogradsky column

http://www.sumanasinc.com/webcontent/animations/content/winogradsky.html

Thank you!!!