

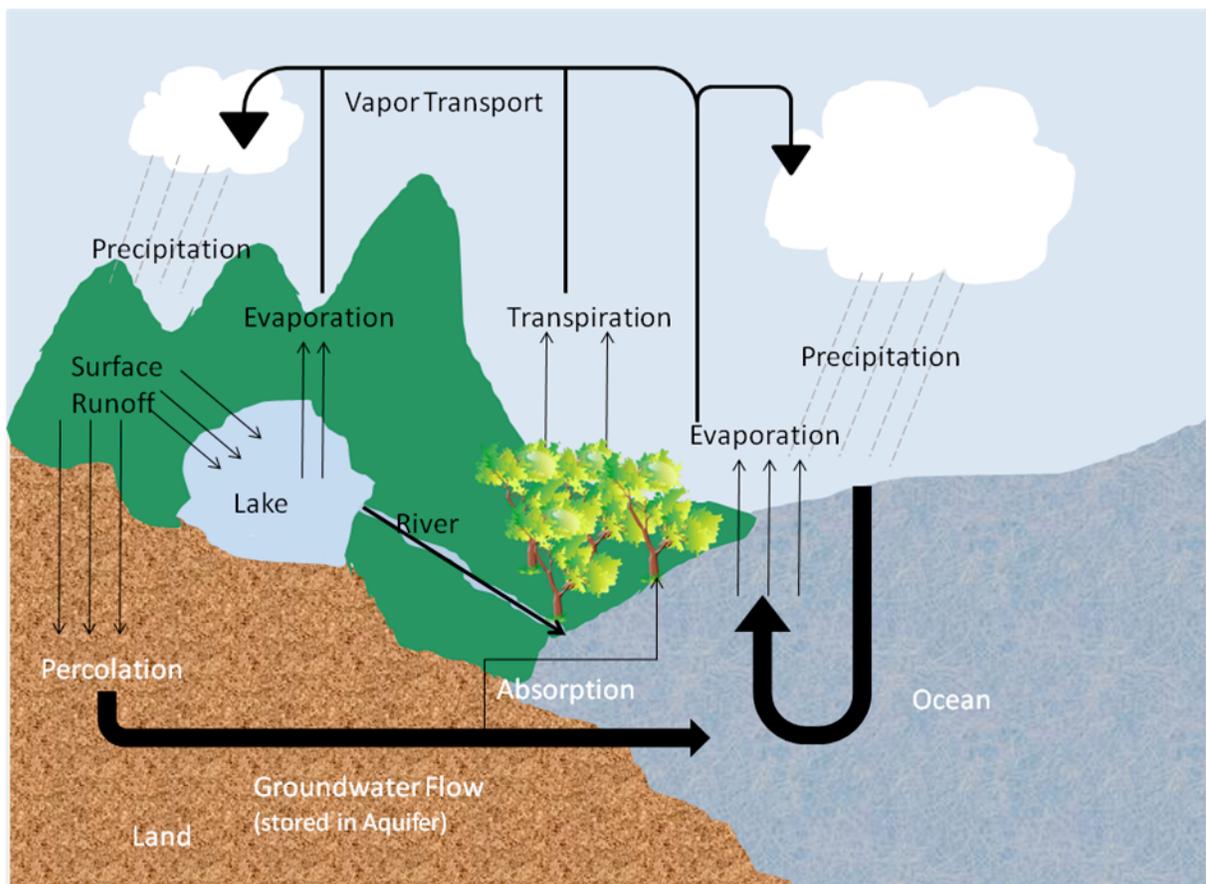
Nutrient Cycles

How are nutrients recycled through ecosystems?

Why?

We have learned the importance of recycling our trash. It allows us to use something again for another purpose and prevents the loss of natural resources. But what happens to the waste in nature? Why aren't we up to our necks in poop? Why is there always a supply of water? Why is there oxygen to breathe and carbon dioxide for photosynthesis? Organic compounds in nature are also recycled. This recycling process converts the complex organic compounds to simple, inorganic compounds, which then can be returned to the nutrient cycle and be used in nature again and again.

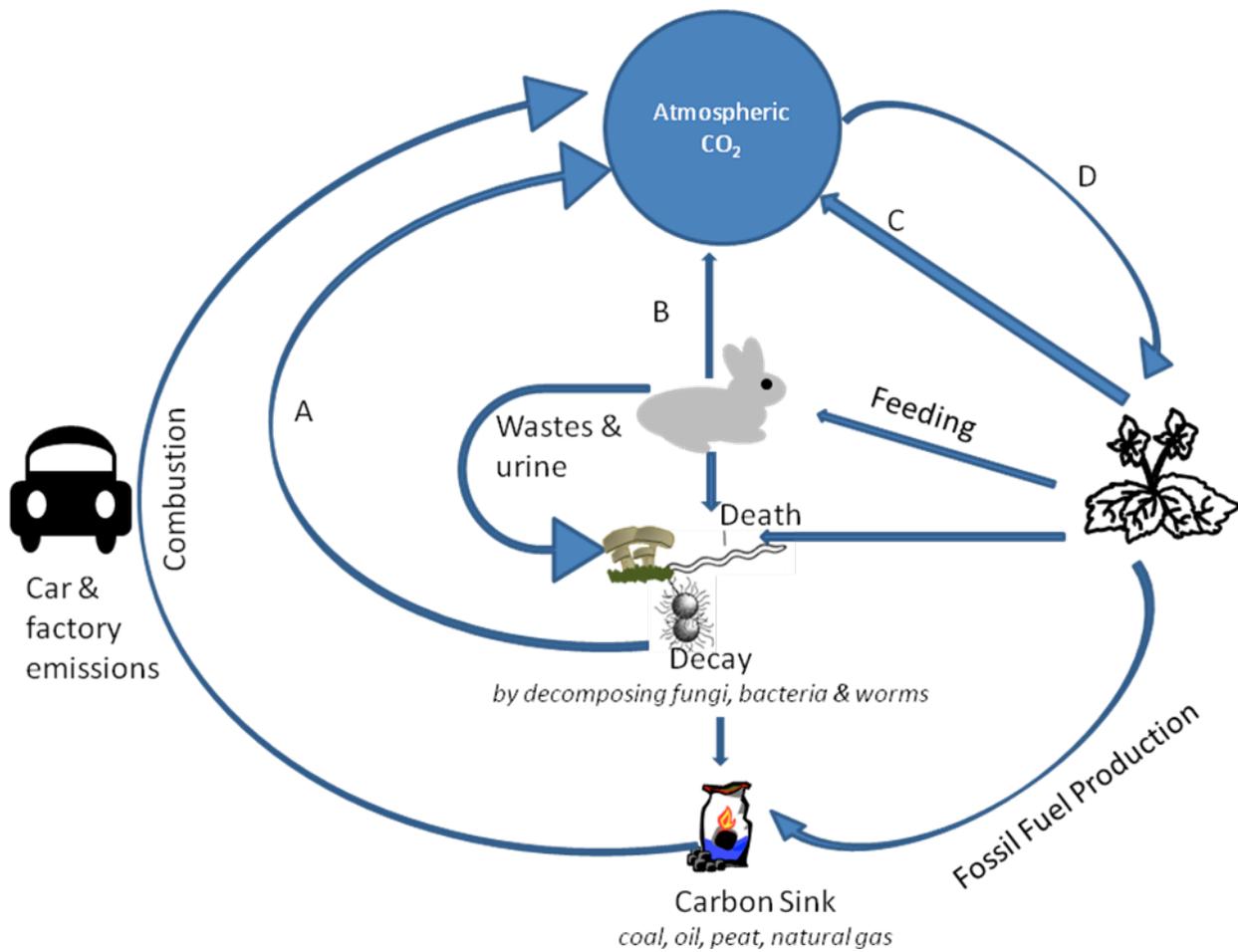
Model 1: The Water Cycle



1. What is the largest body of water on earth?
2. What process contributes to the formation of groundwater?

3. How is groundwater stored?
4. Name two ways in which water is converted to vapor.
5. How might water return from the land to lakes, rivers, and eventually to the oceans?
6. Rain, sleet and snow are examples of what?
7. Which of the processes associated with the water cycle might be responsible for helping to clean or filter the water?
8. If the air contains high levels of pollutants what effect might this have on water quality?
9. The water cycle, like the other cycles, is a “closed system.” What does that say about the importance of keeping the water on earth free from pollution?
10. Which process(es) of the water cycle – precipitation, evaporation, condensation, run-off, percolation or transpiration might contribute to the addition of pollutants to rivers, lakes and oceans? Why?

Model 2: The Carbon Cycle



11. Name two ways that carbon (usually in the form of CO_2) enters the atmosphere.
12. What process uses CO_2 from the atmosphere?
13. What organisms carry out that process?
14. Wastes and dead organisms must be broken down in order for their components to be used again. What organisms in the cycle carry out this process?



15. What would happen if decomposition did not occur?

16. Not all dead organisms are acted on by decomposers. Instead of being immediately recycled, the carbon from some organisms is kept in a type of long-term storage, or **carbon sink**.

Using the model, answer the questions below about this long-term storage.

- a. List four materials that contain this stored carbon.
- b. What is the collective term for these four materials?
- c. What process returns CO_2 to the atmosphere from the carbon stores?
- d. How do humans use these carbon stores?



- e. How does our use of these carbon stores affect the amount of CO_2 in the atmosphere?

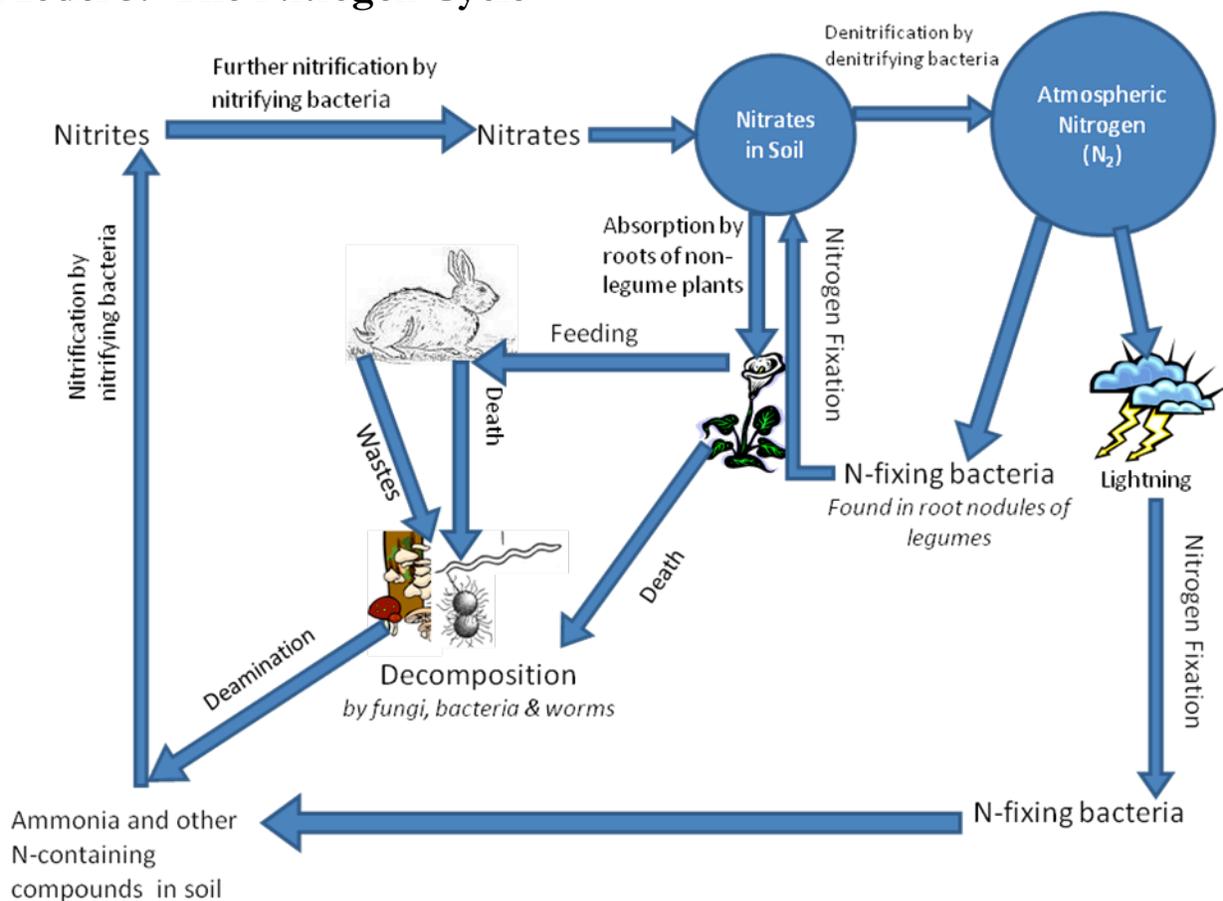
Read This!

Carbon dioxide (CO_2) is one of the so-called **greenhouse gases**. These gases hold heat energy in the atmosphere which raises the overall temperature of the Earth. This helps maintain the earth's biosphere, but also has led to environmental concerns.

17. What is another way in which human activity is increasing the amount of atmospheric CO_2 , and what are potential global effects of these changes in CO_2 levels?



Model 3: The Nitrogen Cycle



18. In what ways is N_2 gas removed from the atmosphere?
19. Name 3 types of bacteria involved in the nitrogen cycle.
20. By what process are animal wastes, urine and dead organisms converted to other nitrogen containing compounds?

Read This!

Nitrification is a process by which specific bacteria convert different forms of N-containing compounds in the soil to nitrites and nitrates. This process is important since the only forms of nitrogen that are usable by plants to build their proteins are the nitrates.

21. What is the only form of nitrogen that non-legume plants can take in and use?
22. What do the denitrifying bacteria do during the denitrifying process?
23. If the number of nitrifying bacteria decreased what effect would this have on the nitrogen cycle and what type of compounds would accumulate as a result?



Extension Questions

24. Plants and animals are part of all of the nutrient cycles through the foods they eat and what eats them (food chains and food webs). Name the four classes of organic compounds (containing carbon) and explain how the carbon cycle and nitrogen cycle, contribute to the usable supplies of these macromolecules.
25. In order to continually use the same area of land for agriculture, some farmers apply fertilizers to improve the level of nitrates in the soil. An alternative to this intensive use of fertilizer is to plow the roots of the leguminous plants back into the soil and leave the area unplanted for a season. Why would a farmer do this and what would be benefit of turning over the soil and leaving the old plant roots?

Teacher Resources

Learning Objectives:

1. Students will be able to trace the path of carbon, nitrogen, and water through the ecosystem.
2. Students will understand that nutrients must be recycled in order to sustain life on earth.
3. Students will understand the effects on living organisms when the cycles are disturbed.

Prerequisites:

1. Some basic ecology needs to be studied before doing this activity.
2. Students should also have completed a unit on photosynthesis and cellular respiration and have knowledge of the chemistry of organic macromolecules such as carbohydrates, lipids, proteins, and the nucleic acids.

Assessment Questions:

1. Explain the water cycle describing at least 4 of the processes involved in the cycle.

*The water cycle involves **precipitation** which includes rain, snow, or sleet falling to the ground, where it **percolates** down into the soil and reaches the groundwater, where it is stored. It is also taken into the atmosphere in a gaseous form through the process of **evaporation**. Water may also **run-off** across the land and return to waterways, such as rivers and streams and eventually go to the oceans. (The answer could also include transpiration and absorption.)*

2. One of the important tasks of the nitrogen cycle is to change atmospheric nitrogen (N_2) to the form of nitrogen that plants can use. What is the usable form of nitrogen for plants?
 - a. Ammonia
 - b. Nitrites
 - c. Nitrates**
 - d. All of these can be used by plants
3. Why must nutrients such as carbon, nitrogen and water be constantly recycled?
 - a. Life would not be properly sustained without them being recycled.
 - b. Nutrients would be locked in dead bodies and wastes and would not be available to organisms in a usable form.
 - c. Since these cycles are “closed systems” no more nutrients will be added to them.
 - d. All of these are why the nutrients are constantly recycled.**

Target Responses:

1. What is the largest body water on earth? *Oceans.*
2. What process contributes to the formation of groundwater? *Percolation.*
3. How is groundwater stored? *In the aquifer*

4. Name two ways in which water is converted to vapor. *Evaporation and transpiration.*
5. How might water return from the land to lakes, rivers and eventually to the oceans? *Surface run-off and groundwater flow.*
6. Rain, sleet and snow are examples of what? *Precipitation.*
7. Which of the processes associated with the water cycle might be responsible for helping to clean/filter water? *Percolation and the use of water by plants*
8. If the air contains high levels of pollutants what effect might this have on water quality? *Via condensation, the pollutants could be brought down to rivers, streams, lakes and oceans and pollute them.*
9. The water cycle, like the other cycles, is a “closed system.” What does that say about the importance of keeping the water on earth free from pollution? *If the water on earth is polluted anywhere in the cycle, it affects the water system in general. There is just so much that percolation and plant use can do to clean the water. If our atmosphere is polluted, it will then pollute the water. If there is pollution on the ground, run-off will take it to the lakes, rivers and ocean. The water that is on earth today is the same water that has been there forever and will continue to be the water that is available to us.*
10. Which process(es) of the water cycle – precipitation, evaporation, condensation, run-off, percolation or transpiration might contribute to the addition of pollutants to rivers, lakes and oceans? Why? *Precipitation and run-off would be the most responsible processes. Precipitation carries air pollutants into water, while run-off collects any pollutants that are in/on the ground into the water supply. The action of percolation and transpiration can filter and clean the water. Evaporation and transpiration produce water vapor, which is probably the cleanest water on earth at this point in history*
11. Name two ways that carbon (usually in the form of CO₂) enters the atmosphere. *Respiration from animals and plants, and combustion*
12. What process uses CO₂ from the atmosphere? *Photosynthesis.*
13. What organisms carry out that process? *Plants and other photosynthetic organisms*
14. Wastes and dead organisms must be broken down in order to be used again. What organisms in the cycle carry out this process? *Decomposing fungi, bacteria, and worms*
15. What would happen if decomposition did not occur? *The carbon would not be recycled into the atmosphere; it would be locked in the waste and dead matter leaving less and less carbon dioxide for photosynthesis. Meanwhile, the wastes and dead organisms would pile up.*
16. Not all dead organisms are acted on by decomposers. Instead of being immediately recycled, the carbon from some organisms is kept in a type of long-term storage. Answer the questions below about this long-term storage.
 - a. List four materials that contain this stored carbon. *Coal, oil, peat, natural gas*
 - b. What is the collective term for these three materials? *Fossil fuels*
 - c. What process returns CO₂ to the atmosphere from the carbon stores? *Combustion*

- d. How do modern humans use these carbon stores?
We burn them as energy sources
- e. How does our use of these carbon stores affect the amount of CO₂ in the atmosphere?
We are releasing the stored carbon into the atmosphere, thus increasing the amount of CO₂ in the atmosphere. We are releasing the carbon stores faster than they can be replenished by nature. The balance that had been in place by storing some of the carbon in the carbon sinks has been thrown off by human use of the fossil fuels.
17. What is another way in which human activity is increasing the amount of atmospheric CO₂, and what are potential global effects of these changes in CO₂ levels?
We are increasing the amount of CO₂ in the atmosphere by reducing the mass of photosynthetic organisms through deforestation and ocean pollution (aquatic algae are a huge photosynthetic community). Increases in greenhouse gases have been linked to global warming. This can melt the ice caps, cause flooding, and drastically affect weather patterns, as well as change the temperature of environments and affect the survival of organisms.
18. In what ways is N₂ gas removed from the atmosphere?
Nitrogen fixation by N-fixing bacteria in the soil and in the root nodules of legumes.
19. Name 3 types of bacteria involved in the nitrogen cycle.
Nitrogen-fixing bacteria, decomposing bacteria, nitrifying bacteria, and denitrifying bacteria
20. By what process are animal wastes, urine and dead organisms converted to other N-containing compounds?
By conversion to ammonia and ammonium compounds [by deamination].
21. What is the only form of nitrogen that non-legume plants can take in and use?
Nitrates
22. What do the denitrifying bacteria do during the denitrifying process?
They convert nitrates, which are what plants need, back to atmospheric nitrogen.
23. If the number of nitrifying bacteria decreased what effect would this have on the nitrogen cycle and what type of compounds would accumulate as a result?
The nitrogen cycle would be stopped. The nitrites would not be converted to nitrates and the ammonia compounds would accumulate.
24. Plants and animals (and all other living things) are part of all the natural cycles through food chains and food webs. Name the four classes of carbon-containing molecules used by living things, and explain how the nitrogen and carbon cycles contribute to the usable supplies of these macromolecules.
The carbon-containing (organic) macromolecules necessary for life are proteins, carbohydrates, lipids and nucleic acids. Proteins and nucleic acids also contain nitrogen. Plants get their carbon from the air and their nitrogen from the soil (except for legumes, who can get it directly from atmospheric nitrogen), supplied by the carbon and nitrogen cycles. Animals get their carbon and nitrogen compounds from their food (plants and/or other animals). In all organisms, the organic compounds are converted into tissue, fat and/or carbohydrate storage, energy for the organisms, and hereditary information. As the organisms die and decompose, the carbon and nitrogen are put back into the earth by decomposers.

25. In order to continually use the same area of land for agriculture, some farmers apply artificial fertilizers to improve the level of nitrates in the soil. An alternative to intensive use of artificial fertilizer is to plow the roots of the leguminous plants back into the soil and leave the area unplanted for a season. Why would a farmer plow this type of plant roots back into the soil and what would be the benefit of turning over the soil and leaving the old plant roots? *Leguminous plants contain root nodules and can convert atmospheric nitrogen into nitrates for use by plants. By leaving the old roots in the soil nitrates can be replaced.*