Key

WATER, CARBON AND NITROGEN CYCLE WORKSHEET/COLORSHEET

Directions: Color and make a key for each biogeochemical cycle.
As you read about each cycle answer the following questions:

THE WATER CYCLE

1. Name three important needs for water. photosynthesis, digestion, cellular respiration, habitats
2. How is water distributed through the biosphere? plants absorb through roots & release via transpiration
3. What draws water back to the earth? gravity
4. What is transpiration? water loss via plant leaves.
5. What determines which plants to grow where? precipitation
6. What is an aquifer? water-saturated zone of soil & rock
7. Name two ways water travels from land to enter the ocean. seepage from ground & runoff from surface
8. What does runoff include? river flow, melting of snowfield & glaciers
9. How much water enters the hydrologic cycle? over 80% of evaporated water
10. How much water falls back as rain? 52%.

THE CARBON CYCLE

1. What are macronutrients? C, H, O, N, P Micronutrients? I, Fe, Zn, etc... used by orgs in lg. qty vs. sm. qty
2. What is the role of each of the following in the carbon cycle? State an example of each.
   a. Primary producers - nutrients taken in & become organic compounds (grass)
   b. Secondary producers - consume primary producers (deer) primary cons.
   c. Decomposers - release material back into nonliving environment (earthworm)
3. Where is most of the Earth's carbon located and in what form? → lg carbon sinks: hydro, geo, atmo
4. How does carbon enter the biotic part of the ecosystem? photosynthesis
5. What function do plants have in the forest in the carbon cycle? take in CO_2 → glucose, starch, cellulose, ...
6. How is carbon dioxide returned to the atmosphere? respiration in plants
7. What is a primary producer? plants
8. What happens when primary and secondary consumers die? matter enters soil through decay
9. What do detritus feeders contribute to the carbon cycle? carbon to atmosphere
10. What is a fossil fuel? coal, oil, natural gas made from ↑P & ↑T of organic material
11. How does carbon get in the oceans? dissolves in oceans

THE NITROGEN CYCLE

1. What percent of the air is nitrogen? 78%
2. Why is nitrogen essential to life? Key component of amino acids & nucleic acid, ATP
3. How do plants and animals get nitrogen if not from the atmosphere? nitrogen fixing bacteria
4. What are nitrogen fixing bacteria? convert nitrogen in soil to ammonia
5. What is a major reservoir for ammonia? soil
6. Why do herbivores need nitrogen? amino acids, proteins, nucleic acids
7. What is denitrification? nitrates are broken down and nitrogen is released into the atmosphere

THE PHOSPORUS CYCLE

1. Why is phosphorus an important biological molecule? phospholipid bilayer, sugar phosphate backbone component of ATP & coenzyme of NADP used in
2. What happens to phosphorus that erodes from rock and soil? unites w/oxygen to form phosphates photosynth
3. How are phosphates incorporated into the organic molecules in plants and animals? absorbed by plants & animals eat them
4. What happens to the phosphates when plants and animals die? they go back into the lakes
5. What happens to the phosphorous that is carried by runoff to the oceans? it concentrates in marine sed. & scales & bones of fish fish eat
6. How are phosphates incorporated into the organic molecules in aquatic plants and animals? water to plants
7. What is different about the phosphorus cycle as compared to the water, carbon, and nitrogen cycles? atmosphere is not involved in this cycle - only bio, hydro, geo

Chapter 11-9: The Water Cycle

Water is the most abundant substance in living things. The human body, for example, is composed of about 70% water, and jellyfish are 95% water. Water participates in many important biochemical mechanisms, including photosynthesis, digestion, and cellular respiration. It is also the habitat for many species of plants, animals, and microorganisms, and it participates in the cycling of all of the materials used by living things. Water is distributed through the biosphere in a cycle known as the water, or hydrologic cycle. In this plate, we will examine some aspects of that cycle.

In this plate, we show the biosphere and several arrows that show the movement of water through it. Our primary emphasis will be on the arrows, and you should color them in darker colors than the other aspects of the biosphere.

We begin by looking at the atmosphere, which includes the clouds. When water vapor cools, it condenses and falls to Earth as rain. For instance, look at the arrow labeled (A), or precipitation over land; gravity draws the water back to Earth in the form of rain, sleet, and snow. Precipitation also occurs over oceans (B).

We have begun our discussion of the water cycle by showing how water reaches the Earth. We will now see how it is stored in living things before it is returned to the atmosphere. Continue your reading as you color the diagram, including its arrows.

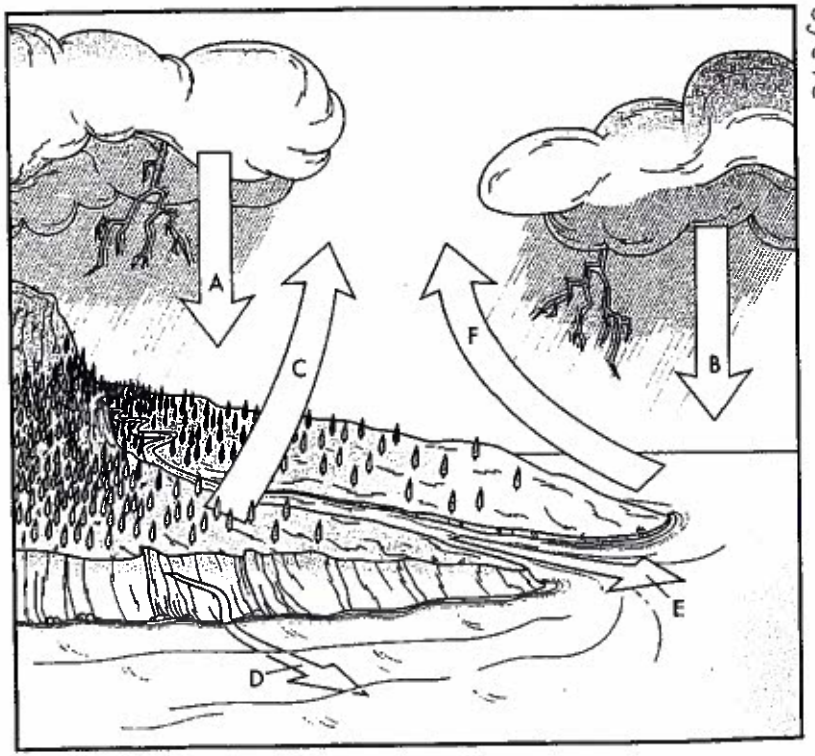
The living things on Earth are represented, in our diagram, by the trees. Water is absorbed by the roots of the trees and used in photosynthesis, but it is also lost from their leaves through the process of transpiration (C). Water also returns to the atmosphere through evaporation from the soil and from numerous other sources. In general, the amount of precipitation received by an area helps determine what types of plants will grow there. The nature of the vegetation, in turn, determines the types of animals that inhabit a region.

Water from the land enters the ocean through seepage from the ground (D); it percolates from the surface down to the water table. This water-saturated zone of soil and rock is called an aquifer, and water seeps from the aquifer to the ocean.

Water also reaches the ocean as runoff from the surface (E). Runoff from the surface includes flow from rivers as well as melting snowfields and glaciers.

Now that we have described how water reaches the oceans, we will explore how it returns to the atmosphere, completing the hydrologic cycle. Continue reading below as you complete your coloring.

The major reservoirs of water on Earth are the oceans. Oceans cover about three-quarters of Earth's surface and contain about 97% of its water. Solar radiation causes water's evaporation from the ocean (F). Over 80% of the evaporated water in the hydrologic cycle enters the atmosphere in this way, and about 52% of this falls back into the oceans in the form of rain. The remainder remains in the atmosphere as clouds, ice crystals, and water vapor and then precipitates over land. On a global scale, the quantity of ocean water that evaporates each year is equivalent to a layer that's 120 cm deep and covers the entire surface of the ocean.



The Water Cycle

- ○ Precipitation Over Land.....A
- ○ Precipitation Over Ocean.....B
- ○ Transpiration C
- ○ Seepage From Ground ....D
- ○ Runoff From Surface ....E
- ○ Evaporation from Ocean .....F

Why study this?
- Changes that put C gases into atm result in warmer temps on Earth

Chapter 11-10: The Carbon Cycle

Energy flows from the sun into the biosphere, but nutrients do not enter the biosphere from an outside source. Essentially, the same pool of nutrients has circulated for the billions of years that the Earth has been in existence. Some nutrients, called macronutrients, are used by organisms in large quantities, while others, micronutrients, are used only in trace quantities. Macronutrients include carbon, hydrogen, oxygen, nitrogen, and phosphorus; micronutrients include iodine, iron, zinc, and some others.

Both macronutrients and micronutrients are recycled; they are passed back and forth between living and nonliving components of the ecosystem in processes that we call biogeochemical cycles. This plate and the ones that follow trace the pathways of several elements through biogeochemical cycles.

> The prime focus of this plate is on the arrows that show how carbon travels among components of the biosphere. You should use darker colors for the arrows.

Material substances are incorporated into organic compounds by primary producers. Primary producers are then consumed by secondary consumers, and decomposers are ultimately responsible for releasing the material back into the nonliving environment.

We will begin our study of the carbon cycle with the atmosphere (A), which is Earth's major reservoir of carbon, in the form of carbon dioxide. Carbon enters the biotic (living) part of the ecosystem through photosynthesis (B). We suggest a green color for the arrow. Plants of the forest (C) take the carbon in carbon dioxide and fix it in organic compounds such as glucose, starch, cellulose, and other carbohydrates. Respiration in plants (D) returns carbon dioxide to the atmosphere; an arrow shows this process.

> We have seen how carbon enters the cycle of living things through photosynthesis, and we will now see how it passes through various life forms. Continue your reading below as you color.

Plants are primary producers. In the course of plant consumption (E), carbon passes into primary consumers, animals. When animal consumption (F) occurs, or when the primary consumer is eaten, carbon passes to a secondary consumer, represented by the lion in the plate. Respiration (G) takes place in cells of the primary and secondary consumers, and carbon is released back into the environment as carbon dioxide.

When the primary and secondary consumers die, their organic matter enters the soil through the process of decay (H). It is broken down by the decomposers, or detritus feeders (I), which are small animals and microorganisms that subsist on decaying matter such as fallen leaves, dead bodies, and animal waste. Earthworms, mites, centipedes, insects, and crustaceans are detritus feeders. Thus, respiration in detritus feeders (J) also returns carbon to the atmosphere.

> We have seen how carbon cycles through various living things on Earth. We will now turn to a storage process for carbon in the soil. Continue your reading below as you complete the plate.

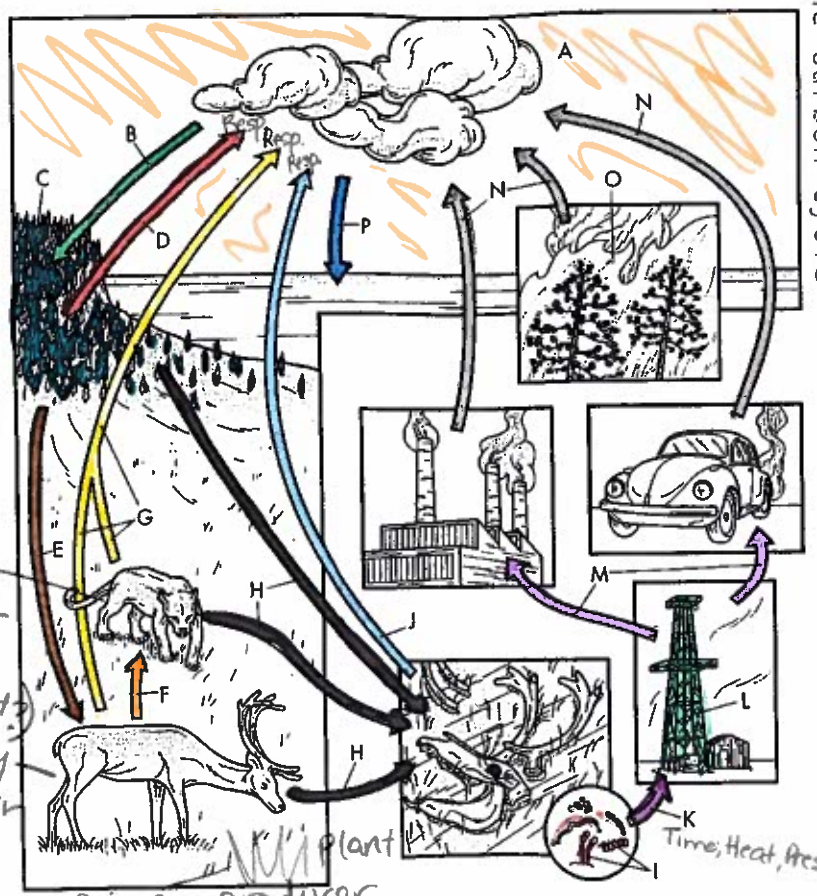
Throughout history, much carbon has been converted to fossil fuel (K). High pressure and temperature transform carbon-containing organic matter into coal, oil, and natural gas. Fossil fuel processing (L) follows. There are many uses for fossil fuels (M). Some power plants generate electricity using fossil fuels, and automobiles are powered by gasoline. The products of the combustion (N) of fossil fuels include carbon dioxide and other carbon compounds that enter the atmosphere. Carbon also enters the environment from the burning of wood and plants that occurs during forest fires (O).

A final aspect of the carbon cycle that we will examine is exchange with oceans (P). Some carbon dioxide from the air dissolves in oceans and combines with calcium to form calcium carbonate, which is incorporated into the shells of mollusks and other creatures. When these shells decay, they transform into limestone, which, over time, dissolves as it is exposed to water. Carbon is released from the limestone and may return to the atmosphere.

Atm C combines w/water to form weak carbonic acid.
↓
chem weathering (releases ions)
↓
ions to ocean - form Calcium Carbonate
(antacids, chalky on faucet, Shell building)
↓
limestone

Ocean - CO_2 & Ca → Calcium Carbonate (shells of marine orgs)
↓ decay
Limestone
↓ dissolves
return to ocean / atm

The Carbon Cycle



The Carbon Cycle

- Atmosphere ..... A
- Photosynthesis ..... B
- Forest C
- Respiration in Plants .. D
- Plant Consumption ..... E
- Animal Consumption .... F
- Respiration in Animals ..... G
- Decay ..... H
- Detritus Feeders I
- Respiration in Detritus Feeders ..... J
- Conversion to Fossil Fuel ..... K
- Fossil Fuel Processing L
- Uses for Fossil Fuel .. M
- Products of Combustion ..... N
- Forest Fire ..... O
- Exchange with Oceans .. P

Chapter 11-11: The Nitrogen Cycle

An important process in ecosystems is the recycling of nitrogen through its living (biotic) and nonliving (abiotic) components. The living components, or biota, of the ecosystem participate in the nitrogen cycle in a number of ways, as you will see in this plate.

If you look closely at the plate, you will notice that we show the various ways in which nitrogen cycles through nature. As you color the plate, the arrows should be emphasized.

Approximately 78% of the air is composed of diatomic nitrogen. Nitrogen is essential to life because it is a key component of amino acids and nucleic acids. Even ATP, the basic energy currency of living things, contains nitrogen.

Neither plants nor animals can obtain nitrogen directly from the atmosphere (A). Instead, they must depend on a process called nitrogen fixation (B). Key players in nitrogen fixation are legumes (C) and the symbiotic bacteria that are associated with their root nodules. Legumes include clover, peas, alfalfa, and soybeans. The bacteria associated with their root nodules are nitrogen-fixing bacteria (D). These bacteria convert nitrogen in the soil to ammonia (NH_3), which can be taken up by some plants. The bacteria and the plant are in a symbiotic relationship. Cyanobacteria are also nitrogen-fixing bacteria; they are prominent in aquatic ecosystems.

We have seen how nitrogen is brought into the biotic component of the ecosystem via nitrogen-fixing bacteria. We will now focus on how nitrogen is cycled through the living aspects of the ecosystem.

Nitrogen is fixed into the soil through the actions of free-living bacteria and, as we mentioned above, through bacteria that's associated with root nodules of legumes. Both of these methods of fixing nitrogen lead to its incorporation into ammonia (NH_3) in the process known as **ammonification** (E). The soil is a major reservoir for ammonia and other nitrogen-containing compounds. After nitrogen has been fixed, other bacteria convert it into nitrate, in a process called **nitrification** (F). In the first step of nitrification, *Nitrosomonas* (G) convert ammonia to nitrite (NO_2), and in the second step, nitrite is converted to nitrate (NO_3), by *Nitrobacter* (H). The nitrate (NO_3) is then consumed by plants (I), as the diagram shows.

But not all plants consume nitrate; as we mentioned before, some plants are able to use the ammonia from the soil. In both cases, nitrogen enters the primary producers in the biotic community. The plants may then be consumed by animals (J). Herbivores are the primary consumers, and the nitrogen of the plants is used for the synthesis of key organic compounds such as amino acids, proteins, and nucleic acids.

We have seen how nitrogen is fixed in the soil and eventually utilized by plants and then animals. We will now complete the cycle of nitrogen by showing how it returns to the atmosphere. Continue your reading as you color the final aspects of the plate.

The final aspect of the nitrogen cycle is the process of denitrification (K). This process is performed by a variety of microscopic bacteria, fungi, and other organisms. Nitrates in the soil are broken down by these organisms, and nitrogen is released into the atmosphere (A). This completes the nitrogen cycle.

building blocks of prot. DNA & RNA

denitrification → atmosphere → nitrogen fixation via legumes & bacteria

soil → absorbed

NH_3 ammonia absorbed by plants → consumed

animals → decaying matter & waste → to ammonium NH_4^+

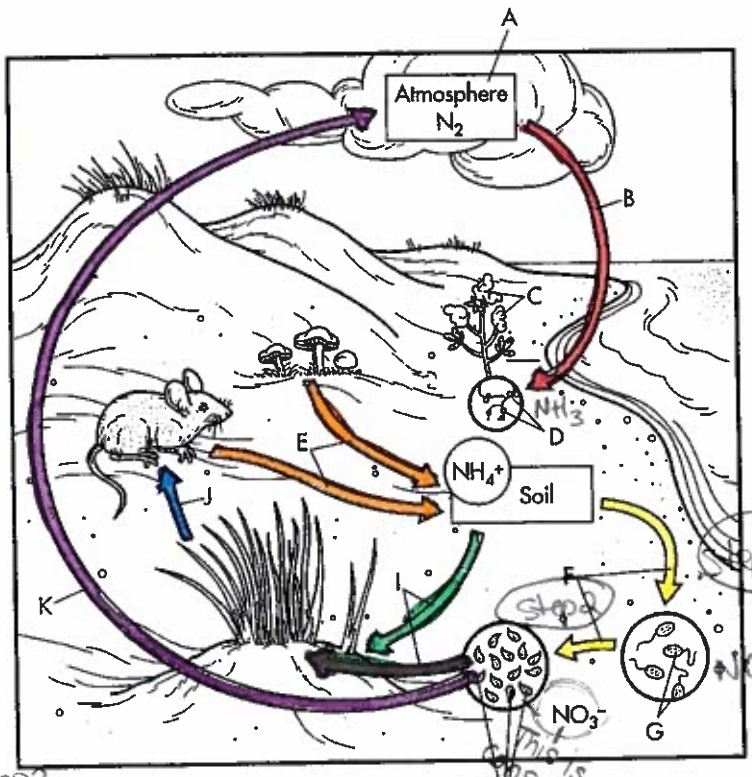
soil → denitrification → atmosphere

Nitrogen Fixation step1 step2

$N_2 \rightarrow NH_3 \rightarrow NO_2 \rightarrow NO_3$

nitrification

$N_2 \rightarrow NH_3$



decayed orgs → NH_3 NH_4^+

$NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$

The Nitrogen Cycle

- Atmosphere .....A
- Nitrogen Fixation.....B
- Legume Plant C
- Nitrogen-Fixing Bacteria .....D
- Ammonification .....E
- Nitrification.....F
- *Nitrosomonas* .....G
- *Nitrobacter*.....H
- Consumption by Plants I
- Consumption by Animals.....J
- Denitrification.....K $NO_3 \rightarrow N_2$

NO ATMOSPHERE

Chapter 11-12: The Phosphorus Cycle

Although nitrogen and carbon exist as gases, certain elements that cycle in the biosphere do not exist in gaseous form. These elements accumulate in rocks and soil, and participate in what are called biogeochemical cycles.

Among the elements that undergo sedimentary cycles are calcium, sulfur, magnesium, and phosphorus. As you will see in this plate, phosphorus is one of the key elements in organic matter.

In this plate, we will follow the cycling of phosphorus in nature. The arrows should be the most prominent feature in the final, colored drawing.

Phosphorus is one of the critical elements in biological molecules. For example, it is a component of adenosine triphosphate (ATP) and the coenzyme NADP, which are used in important cellular processes such as photosynthesis. Phosphorus is also present in the sugar-phosphate backbone of nucleic acids, and is an essential element of phospholipids, which make up the cell membrane.

The main reservoir of phosphorus is rock and soil, so we will begin the cycle with erosion from rocks (A). Erosion occurs as water rushes over rock, dissolving phosphorus and washing it into rivers and streams. Phosphorus unites with oxygen to form phosphate and enters a major body of water, depicted here as a lake.

In the plate, we see plants growing along the border of the lake. Here, the water gives up its phosphates, which are absorbed by the plants (B) and used in the synthesis of organic molecules. Some of the phosphates also enter the soil along the margins of the lake. Dissolved phosphate is readily absorbed by the roots of plants, concentrated by cyanobacteria and protists such as *Euglena*, and then incorporated into organic molecules.

The plant is the primary producer in the phosphorus cycle. The phosphate is concentrated in plant tissues (C), and then the plant is consumed (D) by an animal, which is seen grazing (E).

Phosphates are returned to the lake when the plants and animals die. Plant waste (F) and animal waste (G) return phosphate to the water. Once again it may be reabsorbed by plants that line the lake, and it enters the cycle again.

Having explored the passage of phosphorus through various aspects of the biosphere, we now turn to the marine environment to see how phosphorus cycles there. Continue your reading as you color the plate.

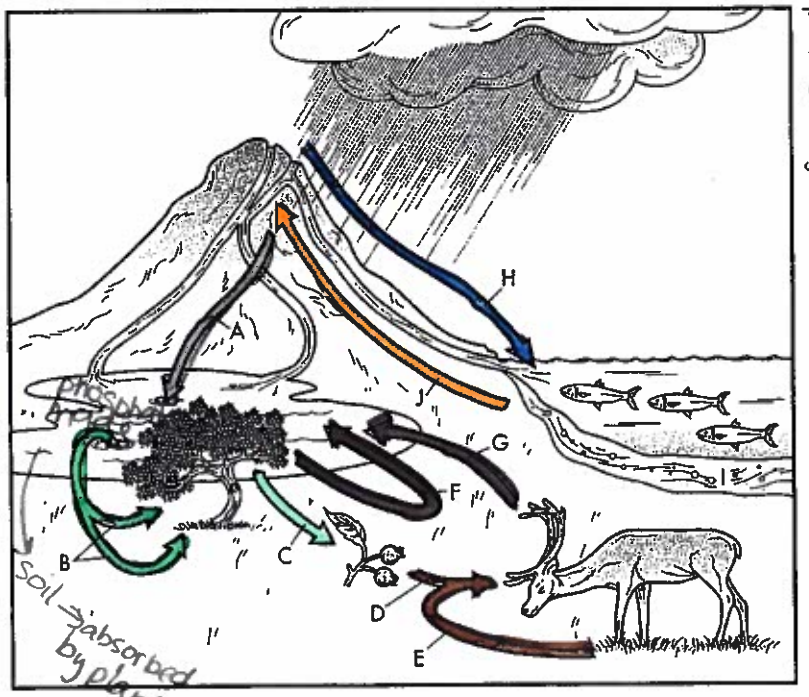
Large amounts of phosphorus are carried by rivers and streams as runoff to the ocean (H). Phosphorus exists in the form of phosphate here, as it does on land. Much of this phosphate then concentrates in marine sediment (I). Some of the phosphate is eventually incorporated into the bodies of marine animals such as fish. For example, the scales and bones of bony fish contain phosphorus. As is the case on land, primary producers in the ocean incorporate phosphates into organic compounds. These primary producers are eaten by fish and other invertebrates. For instance, sea birds consume the fish and return phosphorus to the ocean in the form of excrement.

As we have seen, the atmosphere is not involved in the phosphorus cycle. In order for the phosphorus to leave the oceanic environment, geologic upthrust must occur. Upthrust is the process through which once-submerged sedimentary rock rich in phosphorus is exposed because of the movement of the Earth's plates. This rock then enters the terrestrial ecosystem and begins to weather, participating in the phosphorous cycle.

Flux

Reservoirs: Rocks → erosion
water ⇄ absorption
plants ⇄ consumption
animals → poop
waste → runoff (phosphate)
marine sed. → incorp into marine animal bones
marine animals → ocean

no atm



The Phosphorus Cycle

- Erosion from Rock .....A
- Absorbtion by Plants ..B
- Concentration in Plant Tissues C
- Plant Consumption .....D
- Grazing .....E
- Plant Waste .....F (to lake)
- Animal Waste.....G (to lake)
- Runoff to Ocean .....H
- Marine Sediment I
- Geologic Upthrust .....J