## BACKGROUND

## **BIOGEOCHEMICAL CYCLES**

IN ECOLOGY A BIOGEOCHEMICAL CYCLE IS THE CIRCULATION OF MATTER THROUGH THE BIOTIC AND ABIOTIC COMPONENTS OF AN ECOSYSTEM. THE SUBSTANCES ARE RECYCLED OR ACCUMULATED IN SINKS. THE EARTH IS A SYSTEM OF INTERACTING SPHERES: ATMOSPHERE, HYDROSPHERE, LITHOSPHERE, AND BIOSPHERE WHERE ENERGY AND MASS ARE CYCLED BETWEEN THEM.

### THE WATER CYCLE

WATER IS THE MOST ABUNDANT SUBSTANCE IN LIVING ORGANISMS. EVAPORATION IS THE PROCESS BY WHICH WATER CHANGES INTO VAPOR AND ENTERS THE ATMOSPHERE FROM SOIL AND WATER ON THE SURFACE. THE ATMOSPHERE INCLUDES CLOUDS, WHICH CONTAIN WATER VAPOR. WHEN WATER VAPOR COOLS, IT CONDENSES AND GRAVITY PULLS THE WATER TO THE EARTH AS RAIN. SLEET, AND SNOW. PRECIPITATION OCCURS OVER LAND AS WELL AS THE OCEAN.

WATER IS ABSORBED BY PLANT ROOTS AND USED IN PHOTOSYNTHESIS. WATER IS LOST THROUGH PLANT LEAVES BY TRANSPIRATION.

PRECIPITATED WATER ENTERS THE OCEAN BY SURFACE AND SUBSURFACE RUN OFF. THE OCEANS ARE THE MAJOR STORE OF WATER, CONTAINING ~97% OF THE EARTH'S WATER. OVER 80% OF THE EVAPORATED WATER ENTERS THE ATMOSPHERE FROM THE OCEANS. OF THE WATER THAT IS PRECIPITATED, ~52% FALL INTO THE OCEANS; THE REMAINDER REMAINS IN THE ATMOSPHERE AS VAPOR, CLOUDS, AND ICE CRYSTALS THAT PRECIPITATE OVER LAND.

## PROCEDURE

## COLOR THE ARROWS

- 1. PRECIPITATION OVER LAND (A) LIGHT BLUE
- 2. PRECIPITATION OVER OCEAN (B) DARK BLUE
- 3. TRANSPIRATION (C) RED
- 4. EVAPORATION FROM OCEAN (F) ORANGE
- 5. SURFACE RUN OFF (E) GREEN
- 6. SUBSURFACE RUN OFF (D) BROWN

#### THE CARBON-OXYGEN CYCLE

PRODUCERS (AUTOTROPHS) PRODUCE ORGANIC COMPOUNDS FROM INORGANIC ELEMENTS. PRODUCERS ARE CONSUMED BY CONSUMERS (HETEROTROPHS). DECOMPOSERS (SAPROTROPHS) BREAKDOWN ORGANIC MATERIAL AND RELEASE IT BACK TO THE ENVIRONMENT.

DURING PHOTOSYNTHESIS, PLANTS USE SOLAR RADIATION, CARBON DIOXIDE, AND WATER TO PRODUCE SUGAR AND OXYGEN. IN RESPIRATION ANIMALS REACT SUGAR AND OXYGEN TO PRODUCE WATER, ENERGY, AND CARBON DIOXIDE. THE DECOMPOSERS FEED ON DEAD ORGANIC MATERIAL AND RETURN CARBON TO THE ATMOSPHERE AS CARBON DIOXIDE.

HIGH TEMPERATURE AND PRESSURES OVER TIME CAN CONVERT CARBON CONTAINING ORGANIC MATTER INTO COAL, OIL, AND NATURAL GAS. WHEN THESE FOSSIL FUELS ARE BURNED, 1 PRODUCT IS CARBON DIOXIDE WHICH IS RETURNED TO THE ATMOSPHERE. BURNING WOOD ALSO PRODUCES CARBON DIOXIDE.

DISSOLVED CARBON DIOXIDE IN THE OCEANS COMBINES WITH CALCIUM TO FORM CALCIUM CARBONATE, WHICH IS INCORPORATED INTO THE SHELLS OF MARINE ORGANISMS. THE HYDROSPHERE, LITHOSPHERE, AND BIOSPHERE ARE THE EARTH'S MAJOR STORES OF CARBON IN THE FORM OF DISSOLVED CARBON DIOXIDE AND ORGANIC MOLECULES.

THE LARGEST STORE OF OXYGEN IS WITHIN MINERALS OF THE EARTH'S CRUST AND MANTLE. OXYGEN IS HIGHLY REACTIVE AND READILY BONDS WITH OTHER ELEMENTS. THE REACTED OXYGEN CONTAINS 99.5% OF THE TOTAL OXYGEN. FREE OXYGEN IN THE BIOSPHERE IS ~0.01% AND IN THE ATMOSPHERE IS 0.36%.

#### PROCEDURE

COLOR THE ARROWS

- 1. CO<sub>2</sub> (A) YELLOW
- 2. O<sub>2</sub> (**D**) BLUE
- 3. PHOTOSYNTHESIS (B) GREEN
- 4. RESPIRATION BY PLANTS (C) RED
- 5. PLANT CONSUMPTION (E) DARK BLUE
- 6. RESPIRATION BY ANIMALS (G) LIGHT BLUE
- 7. ANIMAL WASTE AND DECAY (H) BROWN



1. WHERE IS THE STORE OF

2. IN WHAT ARE CARBON

3. DESCRIBE CARBON-OXYGEN CYCLE.



### THE NITROGEN CYCLE

THE AIR IS COMPOSED OF ~77% DIATOMIC NITROGEN. NITROGEN IS ESSENTIAL FOR LIFE BECAUSE IT IS A COMPONENT OF AMINO ACIDS. NUCLEIC ACIDS. AND ATP. THE INTERCELLULAR ENERGY TRANSFER MOLECULE.

BECAUSE NEITHER PLANTS NOR ANIMALS CAN OBTAIN NITROGEN DIRECTLY FROM THE ATMOSPHERE, THEY REQUIRE THE PROCESS OF NITROGEN FIXATION. LEGUMES SUCH AS CLOVER, PEAS, ALPHALFA, SOY BEANS, AND PEANUTS HAVE EVOLVED A SYMBIOTIC RELATIONSHIP WITH THE DIAZOTROPH BACTERIUM. THESE BACTERIUM RESIDE IN THE ROOT NODULES OF THE LEGUMES AND CONVERT NITROGEN IN THE SOIL TO AMMONIA (NH₃) WHICH CAN BE TAKEN UP BY THE PLANT. THE NITROGEN FIXATION INTO AMMONIA (NH<sub>3</sub>) IS CALLED AMMONIFICATION. AFTER AMMONIFICATION, CHEMOLITHOTROPHIC BACTERIA CONVERT THE AMMONIA INTO NITRATE IN THE PROCESS OF NITRIFICATION. THE NITROSOMONAS BACTERIUM CONVERT THE AMMONIA INTO NITRITE (NO2), THEN THE NITROBACTER BACTERIUM CONVERT THE NITRITE INTO NITRATE (NO3) WHICH PLANTS CAN USE.

THE PLANTS ARE THEN CONSUMED AND THE NITROGEN IS USED IN THE SYNTHESIS OF ORGANIC COMPOUNDS SUCH AS AMINO ACIDS, PROTEINS, AND NUCLEIC ACIDS.

DECOMPOSERS DO DENITRIFICATION WHERE NITRATES ARE BROKEN DOWN, AND NITROGEN IS RELEASED INTO THE ATMOSPHERE.

# PROCEDURE

COLOR THE ARROWS

- 1. ATMOSPHERE (A) BLUE
- 2. N2 ABSORBING INTO GROUND (B) PURPLE
- 3. NITROGEN FIXING BACTERIA (D) RED
- 4. AMMONIFICATION (E) YELLOW
- 5. CONSUMPTION BY PLANTS (I) GREEN
- 6. CONSUMPTION BY ANIMALS (J) ORANGE
- 7. DENITRIFICATION (K) BROWN



1. WHAT PROCESS MAKES NITROGEN AVAILABLE TO PLANTS AND ANIMALS?

2. FOR WHAT DO ORGANISMS USE NITROGEN?

3. DESCRIBE THE NITROGEN

#### THE PHOSPHOROUS CYCLE

PHOSPHOROUS IS AN ELEMENT IN ORGANIC COMPOUNDS. PHOSPHOROUS IS A COMPONENT OF ADENOSINE TRIPHOSPHATE USED IN PHOTOSYNTHESIS AND IS THE SUGAR PHOSPHATE OF NUCLEIC ACID. AND THE PHOSPHOLIPID IN CELL MEMBRANES.

THE ATMOSPHERE IS NOT INVOLVED IN THE PHOSPHOROUS CYCLE. PHOSPHOROUS BECOMES CONCENTRATED IN MARINE SEDIMENT AS A RESULT OF PRIMARY PRODUCERS INCORPORATING PHOSPHATES IN ORGANIC COMPOUNDS. WHEN CONSUMERS EAT THE PRODUCERS, THE PHOSPHATE IS USED IN THE PRODUCTION OF BONES AND SCALES. AS MARINE SEDIMENTARY ROCK IS UPTHRUSTED FROM BENEATH THE WATER. IT IS EXPOSED TO WEATHERING AND EROSION.

AS THE DISSOLVED PHOSPHOROUS COMBINES WITH OXYGEN, IT FORMS PHOSPHATE. THE PHOSPHATE THEN RUNS OFF INTO WATER WHERE THEY ARE ABSORBED BY PLANTS AND USED TO SYNTHESIZE ORGANIC MOLECULES. PLANTS CONCENTRATE PHOSPHATE, WHICH IS THEN EATEN BY CONSUMERS. PHOSPHATE IS RETURNED TO THE WATER AS PLANT AND ANIMAL WASTE.

