The Biosphere
Chapter 3

What Is Ecology?

Section 3-1

Interactions and Interdependence

- Ecology is the scientific study of interactions among organisms and between organisms and their environment, or surroundings.
- The word *ecology* is based on the Greek word *oikos* meaning house, which is also the root word for *economy.*
- The living world was perceived as a household with an economy in which each organism plays a role.
- "Houses" comes in many sizes-from single cells to the entire planet.
- The largest "house" is the biosphere.

- The biosphere contains the combined portions of the planet in which all of life exists, including land, water, and the atmosphere.
- It extends 8 kilometers above and below the Earth's surface.
- Interactions within the biosphere produce a web of interdependence between organisms and the environment in which they live.

Levels of Organization

- The study of ecology ranges from the study of individual organisms to populations, communities, ecosystems, biomes-and finally, to the entire biosphere.

Ecological Levels of Organization

Five Levels of Organization

1. Species is a group similar organisms that can breed and produce fertile offspring.
2. Populations are groups of individuals that belong to the same species and live in the same area.
3. Communities are a group of different populations that live together in a defined area.
4. Ecosystem is a collection of all organisms that live in a particular place together with their nonliving or physical environment.
5. Biome is a group of ecosystems that have the same climate and similar dominant communities.

Ecological Methods

- Ecologists use a wide range of tools and techniques to study the living world.
- Scientists conduct modern ecological research using three basic approaches:
  1. observing
  2. experimenting
  3. modeling

Observing

- Observing is the first step in asking ecological questions.
- The questions like:

  a) What species live here?

  b) How many individuals of each species are there?

Experimenting

- Experiments are used to test a hypothesis.
- An ecologist might set up an artificial environment in a lab to imitate and manipulate conditions that organisms would encounter in the natural world.

Modeling

- Because many ecological phenomena occur over long periods of time, ecologists make models to gain insight into complex issues such as the effects of global warming on ecosystems.
- The models consist of mathematical formulas based on data collected through observation and experimentation to make predictions about the future.

Energy Flow
Section 3-2

- **The flow of energy through an ecosystem is one of the most important factors that determines the system's capacity to sustain life.**

Producers

- Sunlight is the main energy source for life on Earth.
- Some organisms obtain energy from a source other than sunlight.
  - mineral water underground
  - boils out of hot springs
  - undersea vents

- **Autotrophs** use energy from the environment to fuel the assembly of simple organic compounds into complex molecules.
  - plants
  - algae
  - cyanobacteria

- Organisms that make their own food are also called **producers**.

Energy From the Sun

- **The best-known autotrophs obtain energy through the process of photosynthesis.**
- **Photosynthesis is the process by which light energy is used to convert** $CO_2 + H_2O \longrightarrow O_2 + C_6H_{12}O_6$ **(glucose).**
- **O_2 is added to and CO_2 is removed from the Earth's atmosphere.**

- On land, plants are the main autotrophs.
- In freshwater and the upper layer of the ocean, algae are the main autotrophs.
- In tidal flats and salt marshes, cyanobacteria is the most common source.

Life Without Light

- **Some autotrophs can produce food in the absence of light.**
  - **rely on energy within chemical bonds of inorganic molecules.**
- **Chemosynthesis is the use of chemical energy to produce carbohydrates.**
  - **bacteria represent a large portion of living autotrophs.**

Consumers

- **Heterotrophs** are organisms that rely on other organisms for their energy and food supply.
  - animals
  - fungi
  - some bacteria

- Heterotrophs are also called **consumers**.

- Types of heterotrophs are:
  - **Herbivores** - eat plants
    - cows, caterpillars, and deer

  - **Carnivores** - eat animals
    - snakes, dogs, and owls

  - **Omnivores** - eat both plants and animals
    - humans, bears, and crows

  - **Detritivores** - feed on plant and animals remains and other dead matter
    - mites, earthworms, snails, and crabs

  - **Decomposers** - break down organic matter
    - bacteria and fungi

Feeding Relationships

- **Energy flows through an ecosystem in one direction, from the sun or inorganic compounds to autotrophs (producers) and then to various heterotrophs (consumers).**

Food Chains

- **The energy stored by producers can be passed through an ecosystem along a food chain.**
- **A <u>food chain</u> is a series of steps in which organisms transfer energy by eating and being eaten.**

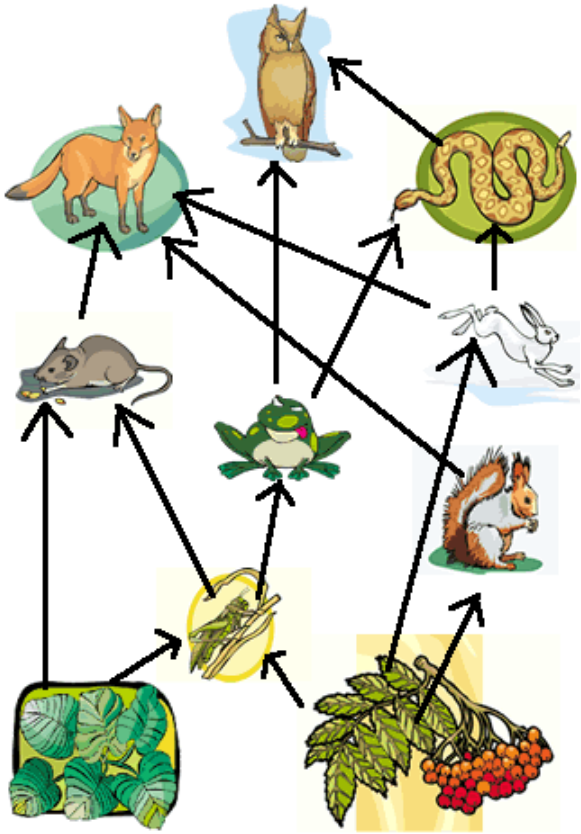
grass → grazing antelope → coyote

(producer) (herbivore) (carnivore)

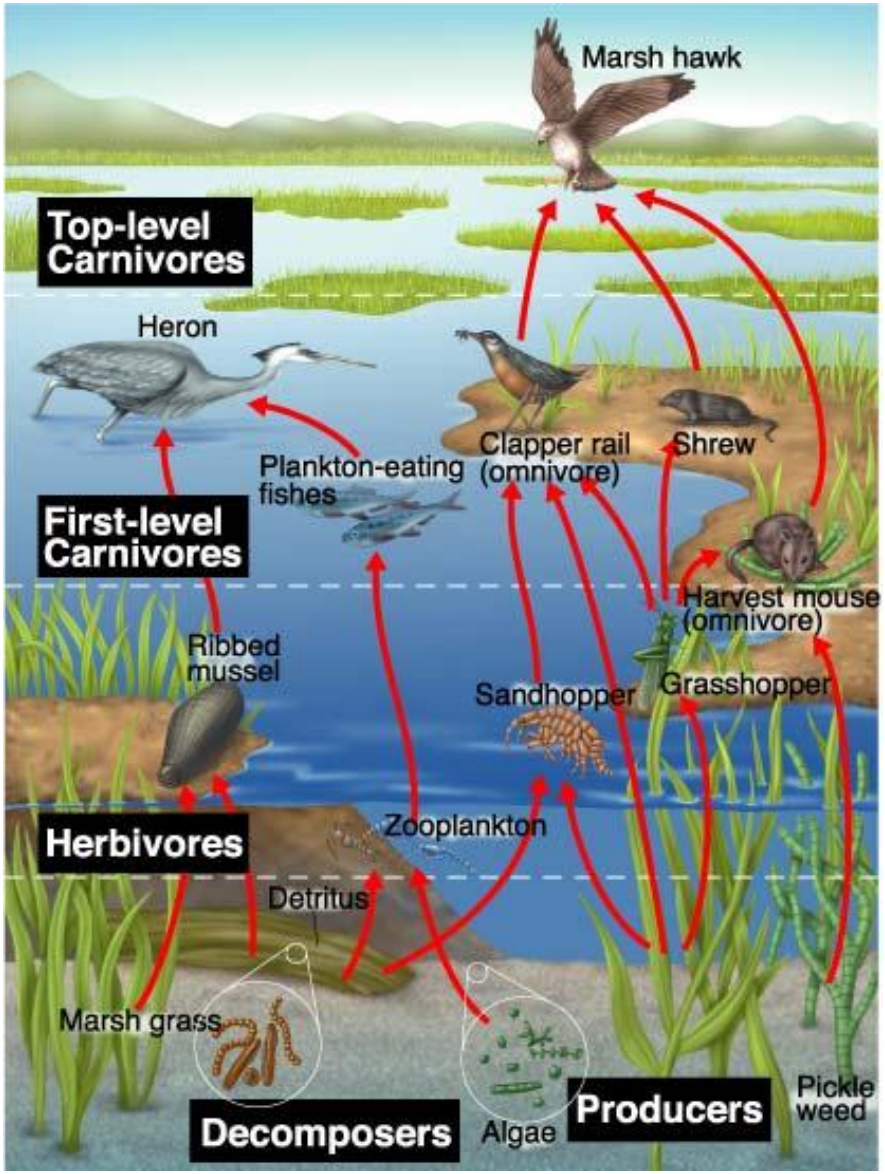
algae → zooplankton → small fish → squid → shark

Food Webs

- A **food web** is a feeding relationship among various organisms in an ecosystem that form a network of complex interactions.

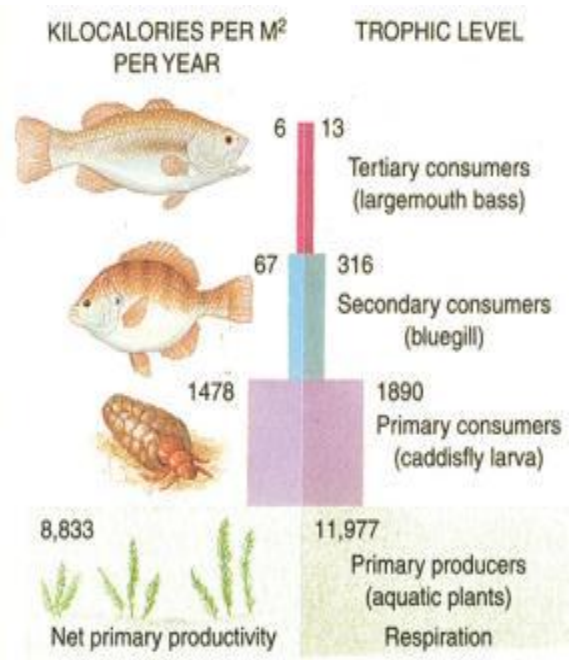


A Food Web


Marsh hawk
Top-level Carnivores
Heron
Clapper rail (omnivore)
Shrew
Plankton-eating fishes
First-level Carnivores
Harvest mouse (omnivore)
Ribbed mussel
Sandhopper
Grasshopper
Herbivores
Zooplankton
Detritus
Marsh grass
Decomposers
Algae
Producers
Pickle weed

Trophic Levels

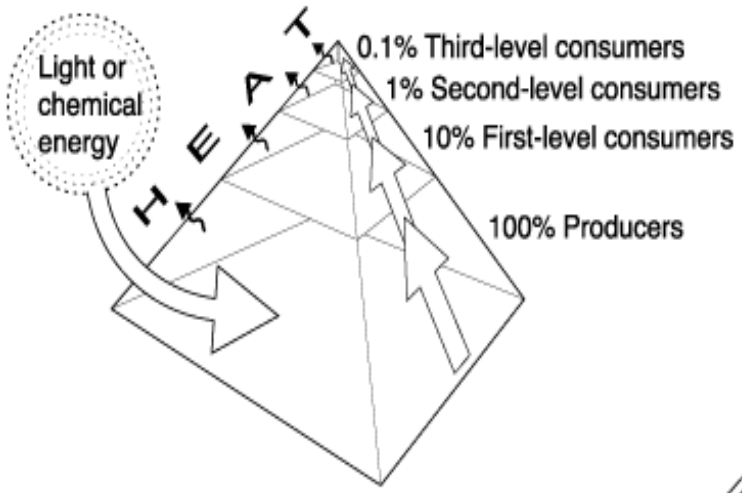
- A trophic level is each step in a food chain or food web.
- Producers make up the 1st trophic level.
- Consumers make up the 2nd, 3rd, or higher trophic levels.
- Each consumer depends on the trophic level below it for energy.

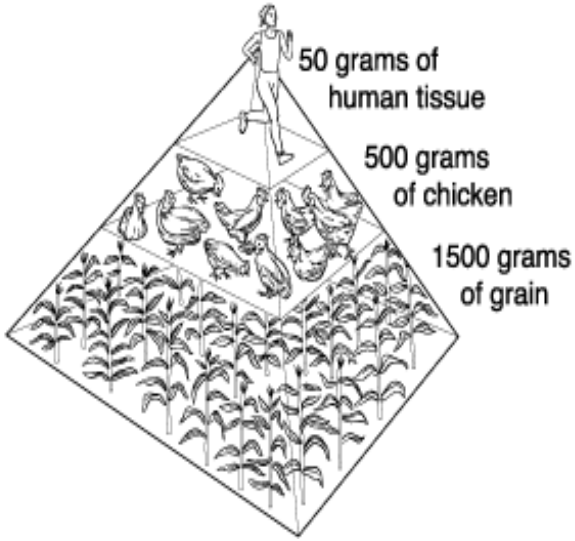


Ecological Pyramids

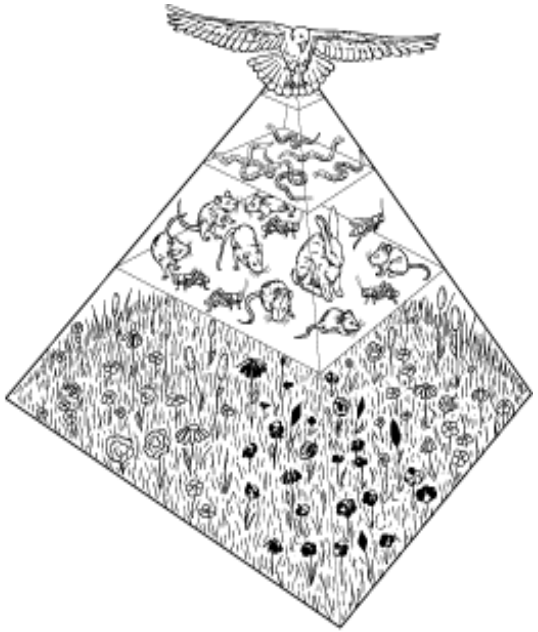
- **The amount of energy or matter in an ecosystem can be represented by an ecological pyramid.**
- **An ecological pyramid is a diagram that shows the relative amounts of energy or matter contained within each trophic level in a food chain or food web.**

Energy Pyramid
Shows the relative amount of energy available at each trophic level. Organisms use about 10 percent of this energy for life processes. The rest is lost as heat.



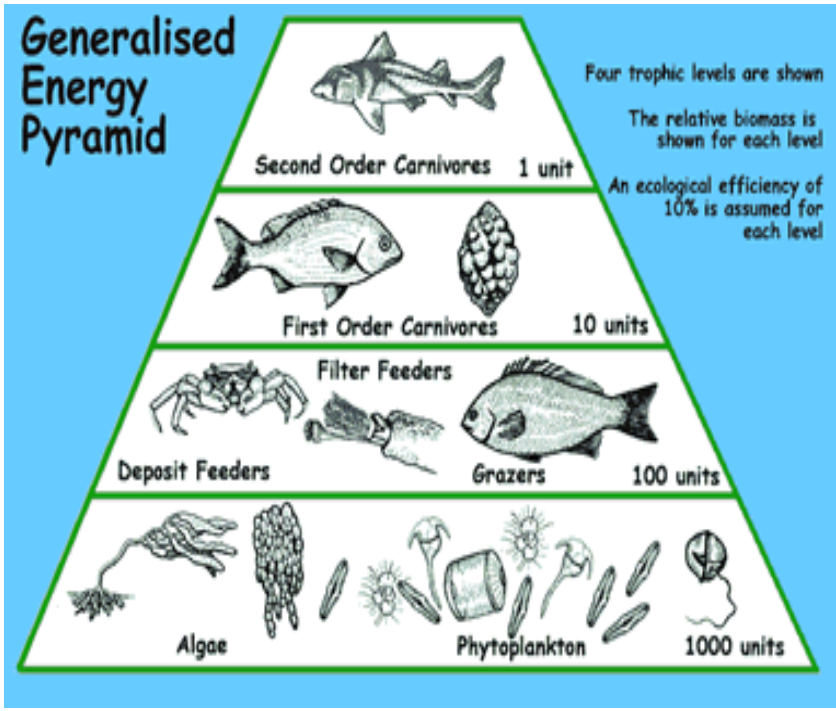


Biomass Pyramid
Represents the amount of living organic matter at each trophic level. Typically, the greatest biomass is at the base of the pyramid.



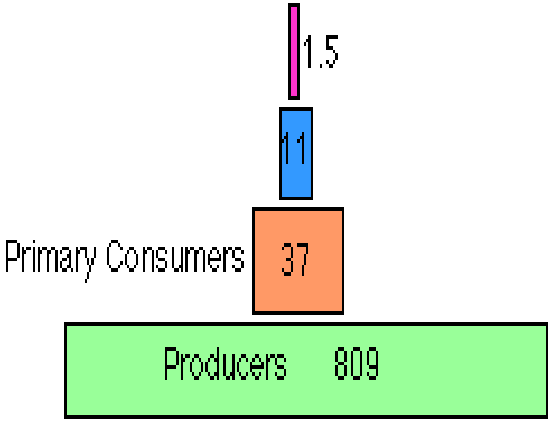
Pyramid of Numbers
Shows the relative number of individual organisms at each trophic level.

Energy Pyramid



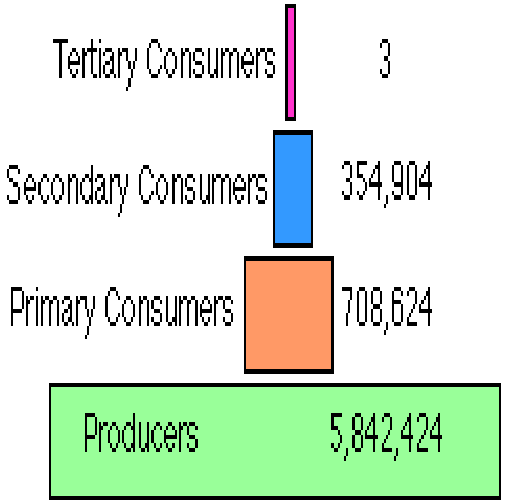
- **Only part of the energy that is stored in one trophic level is passed on to the next level.**
- **Only <u>10 percent</u> of the energy available within one trophic level is transferred to organisms at the next trophic level.**
- **The more levels that exist between a producer and a top-level consumer, the less energy that remains from the original amount.**

Biomass Pyramid



- **Biomass** is the total amount of living tissue within a given trophic level.
- Biomass is expressed in terms of grams of organic matter per unit of area.
- A biomass pyramid represents the <u>amount of potential food</u> available for each trophic level.

Pyramid of Numbers



- A pyramid of numbers is based on the numbers of individual organisms at each trophic level.
- For some ecosystems, such as a meadow, the pyramid of numbers is the same as that of the energy and biomass pyramids.
- For others, such as a forest, there are fewer producers that there are consumers.

Cycles of Matter
Section 3-3

- More than 95 percent of the body is made up of just four elements: O, C, H and N.

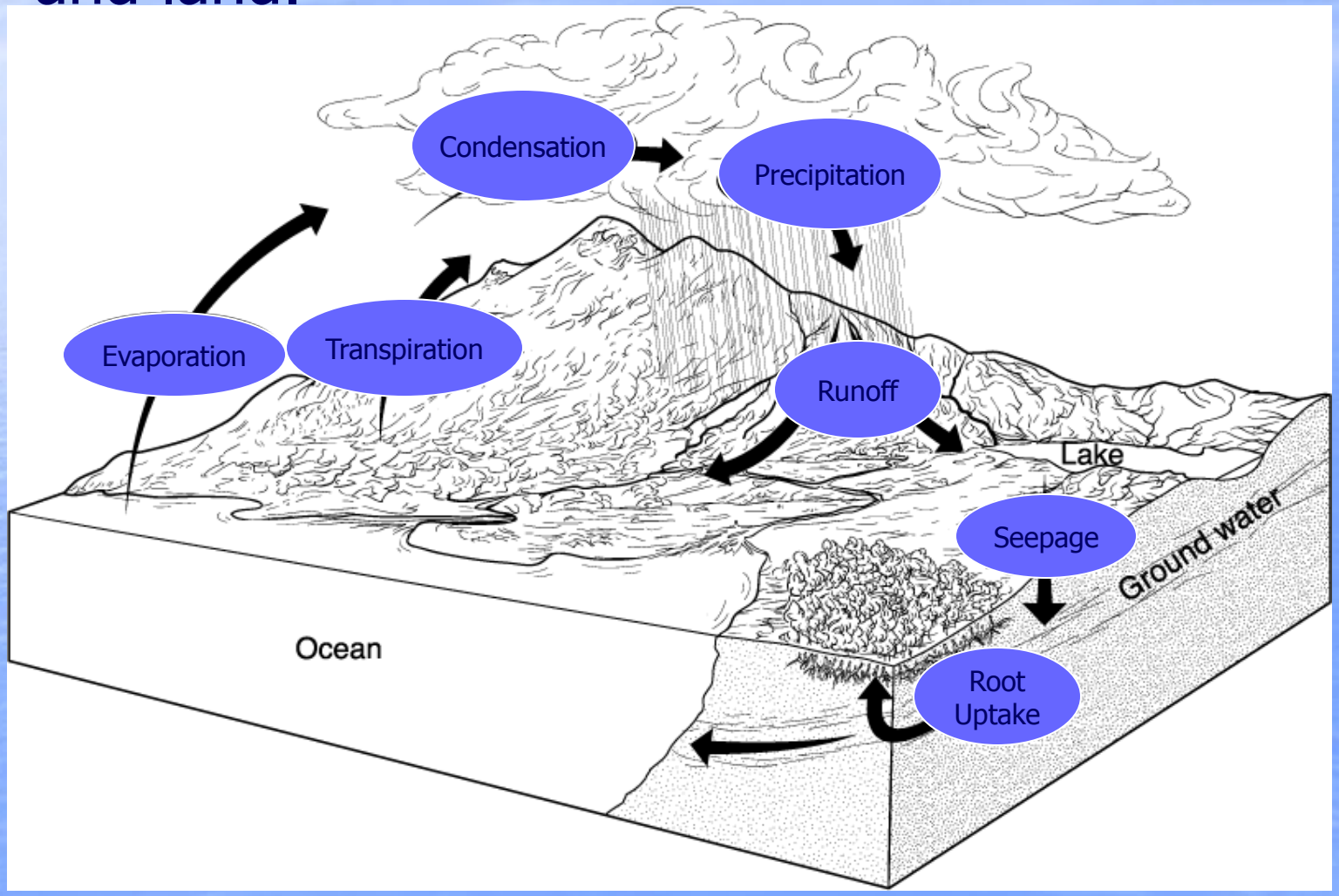
Recycling in the Biosphere

- Matter is recycled within and between ecosystems.
- Matter, elements and chemical compounds are passed from one organism to another through biogeochemical cycles.
- Biogeochemical cycles connect biological, geological and chemical aspects of the biosphere.

- Biological systems do not use up matter, they transform it.
- Biogeochemical cycles pass the same molecules around again and again within the biosphere.

The Water Cycle

- Water moves between the ocean, atmosphere, and land.



How does this cycle work?

1. Water molecules enter the atmosphere as water vapor when they evaporate from the ocean or other bodies of water.
   - Evaporation is the process by which water changes from liquid form to atmospheric gas.
   - Transpiration is water evaporating from the leaves of plants.
2. During the day, the sun heats the atmosphere and as warm, moist air rises, it cools.

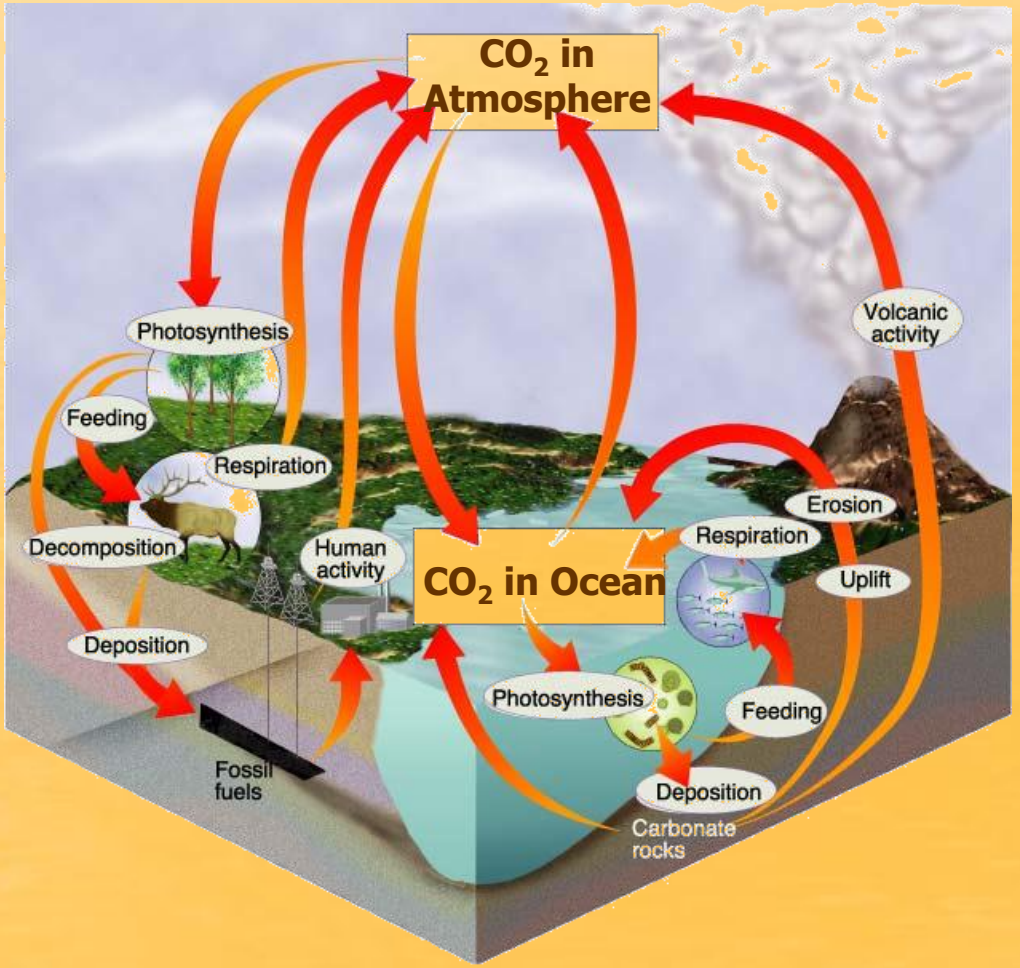
3. Water vapor condenses to form clouds and water returns to Earth in the form of precipitation
   - rain, snow, sleet or hail
4. On land, the precipitation runs along the surface of the ground and enters a river or stream that carries the runoff back to an ocean or lake.
5. Rain seeps into the soil and becomes groundwater.
6. Water in the soil enters plants through the roots, and the water cycle begins again.

Nutrient Cycles

- Nutrients are all the chemical substances that an organism needs to sustain life.
- Like water, nutrients are passed between organisms and the environment through biogeochemical cycles.
- The three cycles are:
    1. carbon
    2. nitrogen
    3. phosphorus
- Oxygen participates in all these cycles.

The Carbon Cycle

❖Carbon is a key ingredient of living tissue.



Four main types of processes move carbon through its cycle:

A. **Biological processes** - photosynthesis, respiration and decomposition, take up and release carbon and oxygen.

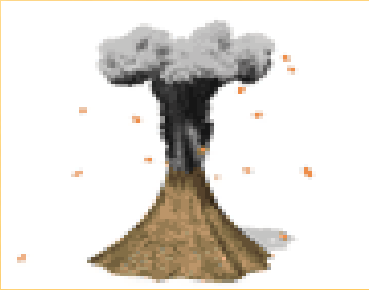
B. **Geochemical processes** - erosion and volcanic activity, release CO_2 into the atmosphere and oceans.

C. **Mixed biogeochemical processes** - burial and decomposition of dead organisms and their conversion under pressure into coal and petroleum, store underground carbon.

D. **Human activities** - mining, cutting and burning forests, and burning fossil fuels, release CO_2 into the atmosphere.

1. In the atmosphere, carbon is present as CO_2 gas. CO2 is released into the atmosphere by:

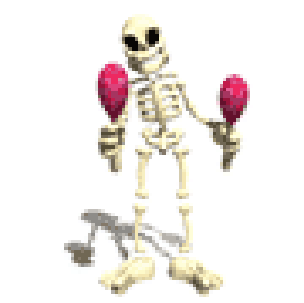
Volcanic Activity



Respiration

Burning Fossil Fuels

Decomposition of Organic Matter



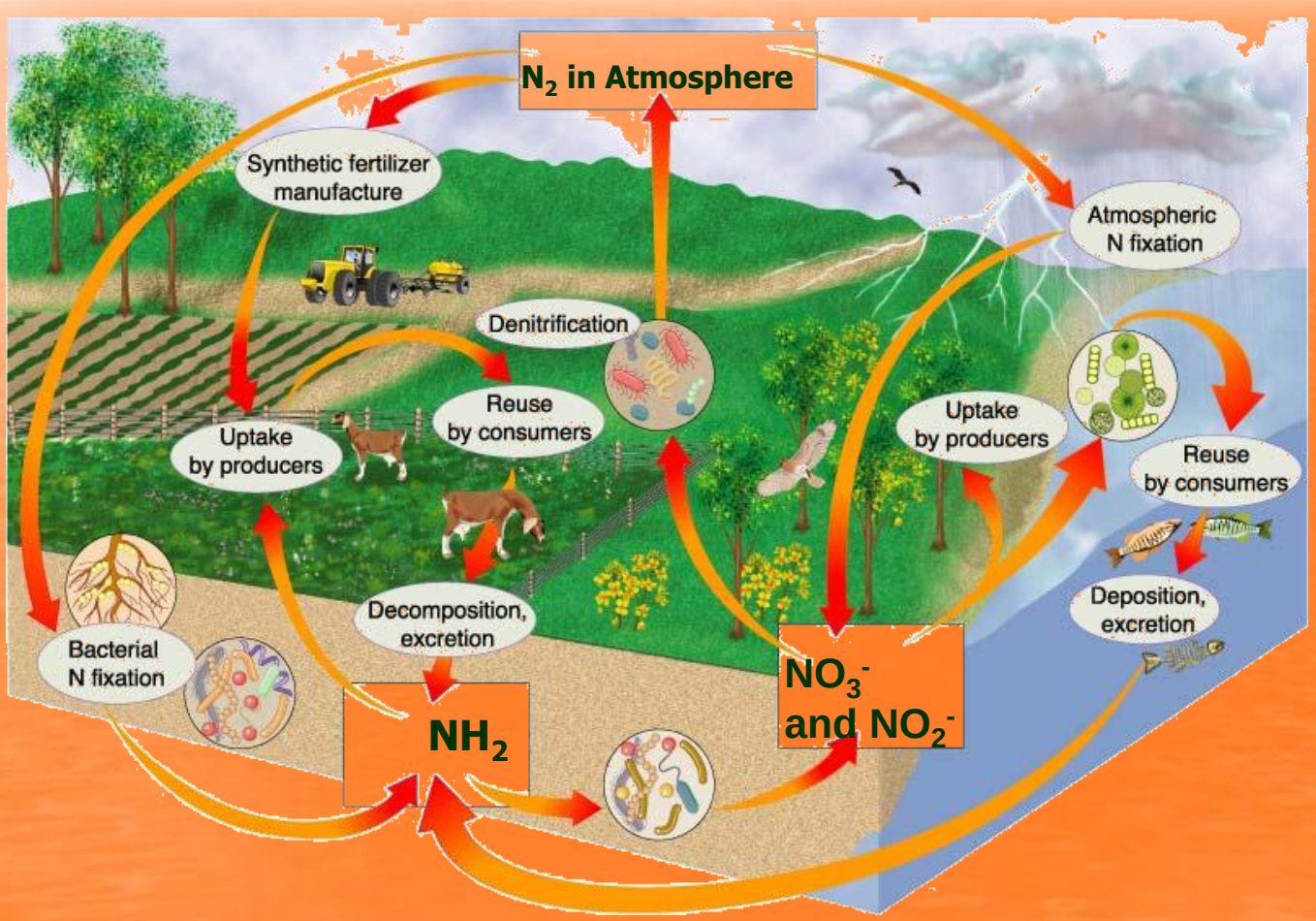
2. Plants take in CO_2 and use the carbon to build carbohydrates during photosynthesis.

3. The carbohydrates are passed along food webs to animals and other consumers.

4. In oceans, carbon is found along with calcium and oxygen, in calcium carbonate, which is formed by marine organisms. It accumulates in marine sediments and in the bones and shells of organisms.

5. Eventually these compounds break down and the carbon returns to the atmosphere.

The Nitrogen Cycle



- All organisms require nitrogen to make amino acids, which are used to build proteins.
- Nitrogen can be found in many different forms:

  a) nitrogen gas (N_2), which makes up 78% of Earth's atmosphere

  b) ammonia (NH_3), nitrate ions (NO_3^-), nitrite ions (NO_2^-) found in waste products and in dead and decaying matter

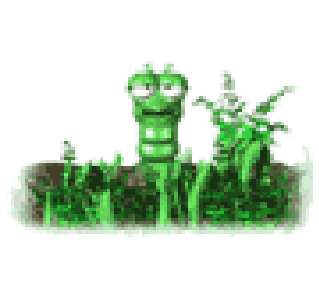
  c) plant fertilizers

How does this cycle work?

1. Bacteria, which live in the soil and on plant roots called legumes, convert nitrogen gas into ammonia in a process known as nitrogen fixation. Other bacteria in the soil convert ammonia into nitrites and nitrates.

2. Producers can use them to make proteins.

3. Consumers then eat the producers and reuse the nitrogen to make their own proteins.
4. When organisms die, decomposers return nitrogen to the soil as ammonia.



5. The ammonia may be taken up again by producers.

6. Other soil bacteria convert nitrates into nitrogen gas in a process called dentrification.

7. By this process, nitrogen is released into the atmosphere again.

The Phosphorus Cycle

- Phosphorus is important to living organisms because it forms part of DNA and RNA.
- It is NOT very common in the biosphere!
  - mostly on land in rock and soil minerals
  - in ocean sediments
- As the rocks wear down, phosphate washes into rivers and streams where it dissolves and eventually makes it to the ocean.

How does this cycle work?

1. The phosphate that stays on land cycles between organisms and the soil.
2. Plants absorb phosphate from the soil or from water and bind the phosphate into organic compounds.
3. Organic phosphate moves through the food web, from producers to consumers, and to the rest of the ecosystem.

Nutrient Limitation

- Primary productivity is the rate at which organic matter is created by producers.
- The amount of available nutrients controls the primary productivity of an ecosystem.
- If a nutrient is in short supply, it will limit an organism's growth.
- Farmers apply fertilizer to their crops to boost their productivity.

- Fertilizers contain 3 important nutrients:
  - nitrogen
  - phosphorus
  - potassium
- These nutrients help plants grow larger and more quickly.
- Areas where limiting nutrient occur:
  - open oceans - nitrogen
  - oceans - iron and silica
  - streams, lakes and freshwater - phosphorus

- When an aquatic system receives a LARGE AMOUNT of a limiting factor - runoff from a heavily fertilized field - an immediate increase in the amount of algae and other producers occurs resulting in a algal bloom.

- The producers grow and reproduce quickly and if there are not enough consumers to eat the excess algae, the surface of the water may be covered with algae.