

### Objectives for this Chapter

- A student reading this chapter will be able to:
  1. Discuss and define the concepts of biosphere and climate.
  2. List and explain the factors influencing climate.
  3. Define the term biome. List the major global biomes and discuss their primary features.

### Objectives for this Chapter

4. Describe the flow of energy through ecosystems. Describe and explain the various trophic levels.
5. List and explain the various nutrient cycles including the carbon, nitrogen, and phosphorous cycles.
6. Define the term succession, explain the mechanisms of succession, and discuss the types of human intervention that interfere with succession.

### LIVING WITH THE EARTH ECOSYSTEMS AND ENERGY FLOW

#### • INTRODUCTION

- We are immersed in life.
- Conditions for most life are found in a layer about the globe that extends from approximately 5 miles in the atmosphere (where some microbial spores and insects may be found) to 5 miles below the ocean surface.

### BIOSPHERE

- This theoretical "layer of life", is called a biosphere because life is thought not to exist outside this area.
- Most life occurs in a narrow layer extending from about a 600 foot depth in the ocean where sunlight is able to penetrate, to the summer snow line of high mountain peaks where a thin layer of soil supports plant life such as lichens and mosses.

### BIOMES

- Biomes are based on the dominant types of vegetation which are strongly correlated with regional climate patterns.

### CLIMATE - What is it?

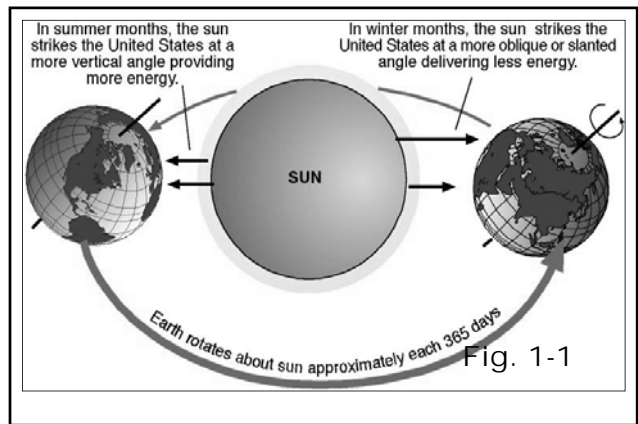
- Climate can be viewed as average weather within a geographical area viewed over years, or even centuries.
- Climate, like weather, includes temperature, precipitation, humidity, wind velocity and direction, cloud cover, and associated solar radiation.

### What Causes Climate?

1. Changes in ocean temperatures;
2. Changes in the earth's orbital geometry;
3. Volcanic activity with increased atmospheric dust and reduced sunlight penetration;
4. Variations in solar radiation; or
5. Increases in atmospheric gases that absorb heat energy.

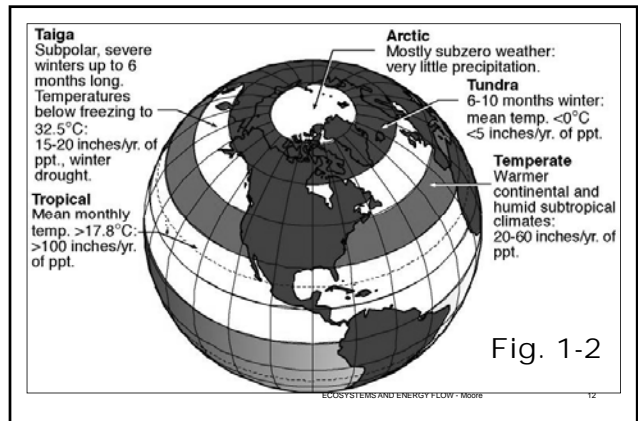
### How is Climate Affected?

- Climate is most affected by temperature
- The amount of sunlight striking the earth varies by region and time.
- The seasons are caused by the tilt of the earth on its axis as it revolves around the sun. (Figure 1-1).



### How is Climate Affected?

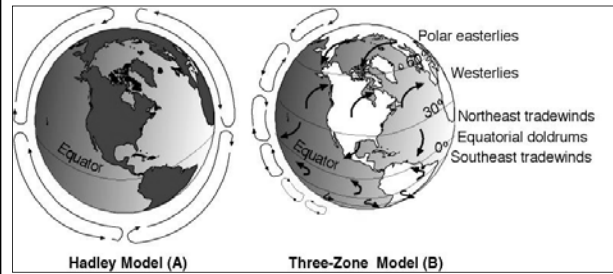
- The sun impacts the earth in bands of decreasing energy extending north and south from the equator (Fig. 1-2).



### How is Climate Affected?

- More recent models show that there are multiple Hadley cells known as the three-zone model (Fig. 1-3a and Fig. 1-3a).

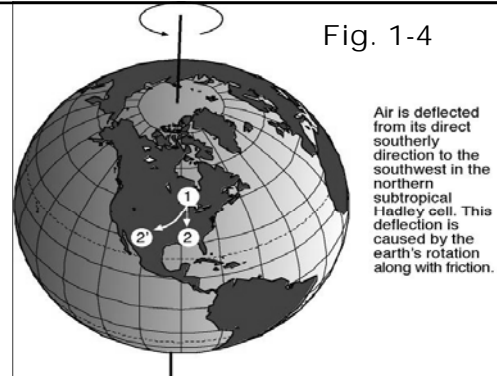
Fig. 1-3A, 1-3B



### How is Climate Affected?

- The deflection of air masses to the east or west is a result of the earth's rotation, causing the deflection of air from its northerly or southerly path and this is known as the Coriolis effect (Fig. 1-4).

Fig. 1-4

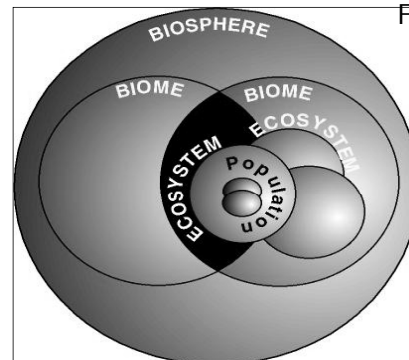


Air is deflected from its direct southerly direction to the southwest in the northern subtropical Hadley cell. This deflection is caused by the earth's rotation along with friction.

## ECOSYSTEMS AND BIOMES

- Ecosystems
  - Ecosystems are often a component of a biome. The relationship of biosphere, biomes, ecosystems and populations is shown in Figure 1-5.
  - Ecosystems refers to identifiable areas within nature where the organisms interact among themselves and their physical environment and exchange nutrient.

Fig. 1-5



## Ecosystems

- The biotic components include living organisms and the products of these organisms
- The abiotic components of the ecosystem include such things as water, air, sunlight, minerals, and their interaction.

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## Biomes

- Biomes may be seen as groupings of plants and animals on a regional scale whose distribution patterns depend heavily on patterns of climate.
- The biome is identified by the climax vegetation or community.
- A climax community forms in an undisturbed environment and continues to grow and perpetuate itself in the absence of further disturbance.

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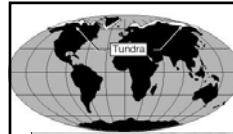
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## Biomes

- Tundra (Fig. 1-6)
  - Limited to the upper latitudes of the northern hemispheres and forms a belt around the arctic ocean.
  - Barren, treeless, low-lying shrubs, mosses and lichens.
  - Long winters, short growing season, little precipitation.
  - Little soil under permafrost.

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Tundra (Fig. 1-6)



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## Biomes

- Taiga (Fig. 1-7)
  - Coniferous (cone-bearing) trees extending in a giant arc from Alaska, North America and Canada, through Europe and Siberia.
  - Rainfall 15-20 inches annually, long severe winters.
  - Conical, needleleaf trees adapted to harsh winter.
  - Moose, elk, deer, snowshoe hare: Predators whose coats become white in winter.

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Taiga (Fig. 1-7)



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## Biomes

- Temperate Broadleaf Deciduous Forest (Fig. 1-8)
  - Broadleaf deciduous forests are located in western and central Europe, eastern Asia and eastern North America.
  - Receive 20 to 60 inches of precipitation distributed evenly throughout the year.
  - Carnivores have been mostly eliminated by habitat destruction and hunting.
  - Nut-eaters such as squirrels and chipmunks; omnivores such as raccoons, skunks, black bear and opossum.

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## Temperate Broadleaf Deciduous Forest (Fig. 1-8)



## Biomes

- Temperate Evergreen Forest
  - Where soil is poor and droughts and fires are frequent, the predominant species tend to be evergreens.
  - Cool coastal climates where there is considerable rainfall or frequent heavy fogs may produce temperate rainforests (redwoods).

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## Biomes

- Chaparrals
  - Moderately dry climate characterized by small (3-15 foot) shrubs with leathery leaves that contain aromatic and flammable substances.

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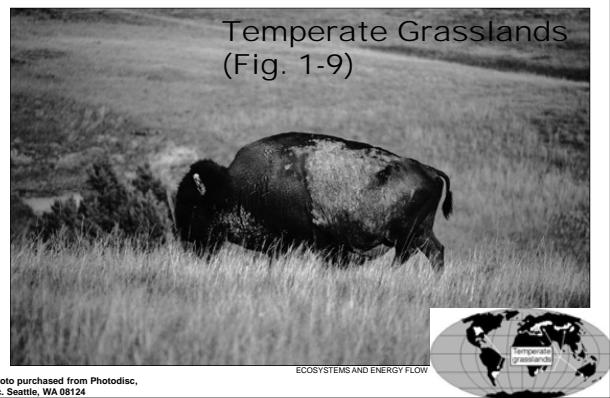
## Biomes

- Temperate Grasslands (Fig. 1-9)
  - Includes prairies, steppes, veldt, pampas.
  - 10 to 20 inches of precipitation a year, much of which falls as snow.
  - Predominant plant forms are perennial grasses, forbs, and members of the sunflower and pea families.
  - Ground squirrels, prairie dogs, and pocket gophers.

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## Temperate Grasslands (Fig. 1-9)



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## Biomes

- The Tropical Rainforest (Fig. 1-10)
  - Constant warmth, with average monthly temperatures above 17.8°C. There are no seasons in the rainforest.
  - Precipitation greater than 100 inches per year.
  - More than 40 percent of world's plant and animals grow in the tropical rainforest.
  - The life of the forest occurs in the canopy.

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## The Tropical Rainforest (Fig. 1-10)

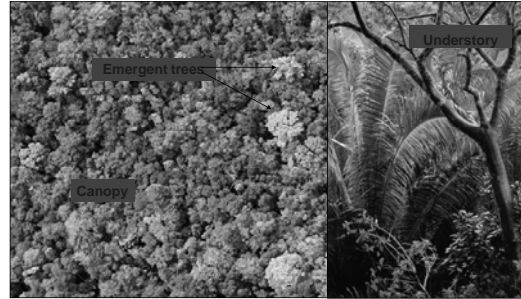


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## Biomes

- Deserts (Fig. 1-11).
  - Defined by arid climates averaging less than 10 inches of precipitation a year and where evaporation exceeds this precipitation.
  - Can reach temperatures higher than 37.8°C (100°F) on summer days while some plummet to -6.7°C (20°F) at night.

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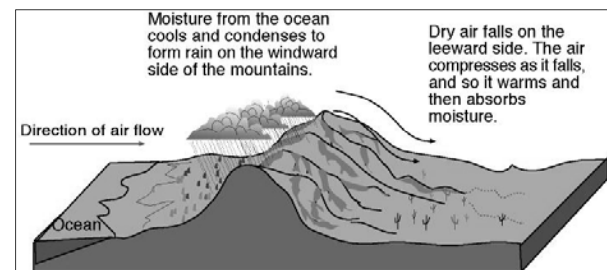
## Biomes

- Conditions Creating Deserts
  - Easterly winds keep moist air rising off the oceans from reaching the coast.
  - Near the 30° latitude, subtropical air descends in association with the Hadley cell, then compresses causing the formation of heat and dry, warm air.
  - Temperate deserts are generally located in areas known as rain shadows (Fig. 1-12).
  - Located in the interiors of continents.

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## Rain Shadows (Fig. 1-12)



Adapted from Turk & Turk, 3

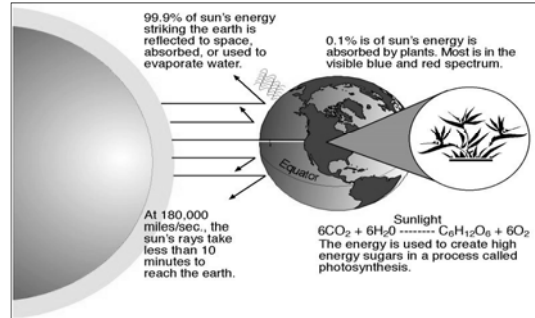
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### ENERGY FLOW

- Energy Source
  - The energy comes from the sun.
  - 99.9 % of the sun's energy reaching the earth is reflected into space, absorbed as heat, or evaporates water (Fig 1-13).
  - 0.1 % of sun's energy used by plants for photosynthesis to create simple sugars from carbon dioxide and water with the release of oxygen.

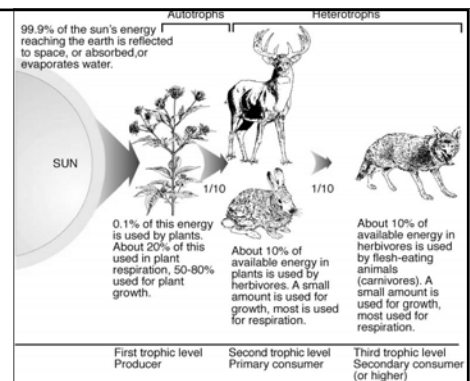
### Energy Flow (Fig 1-13)



### ENERGY FLOW

- Energy Source
  - Heterotrophs convert about 10 % of the consumed Kcalories into flesh or organic matter (Fig. 1-14).
  - 90 % of consumed energy used in respiration necessary for the energy of motion.
  - As energy is transferred through the food chain, about 90 percent of that available energy is lost with each transfer.

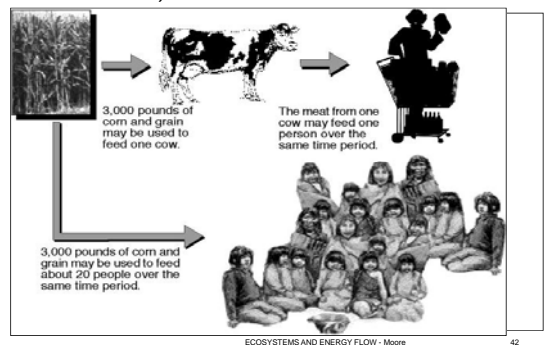
### Energy Flow and Heterotrophs (Fig. 1-14)



### ENERGY FLOW

- A wolf which consumes deer or rabbits that eat grass would be a secondary consumer and would receive  $(1/10 \times 1/10 = 1/100)$  of the available energy in the plant.
- 3,000 lbs. of corn would feed one steer which would feed one person, while the grain would feed 20 people. (Fig. 1-15).

### Efficiency of Primary Consumers (Fig. 1-15)



### Consumption Types

- Animals that eat only plants are **herbivores**.
- Animals that eat primarily animal flesh are called **carnivores**.
- Animals that eat plants and animals are termed **omnivores** and include rats, bears, humans, hogs, and foxes.

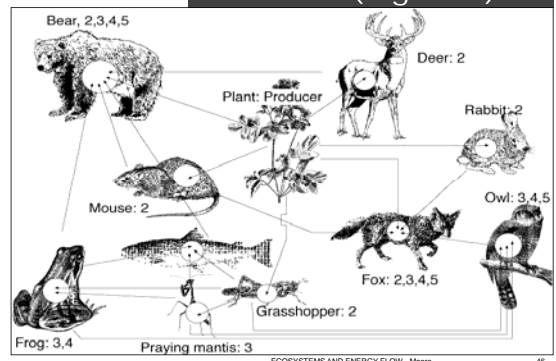
### Trophic Levels

- Plants are producers and belong to the first trophic level.
- Primary consumers or herbivores belong to the second trophic level.
- Secondary consumers (carnivores) belong to the third trophic level (or higher).

### Trophic Levels

- Patterns of consumption tend to be complicated and the term food web has been used to refer to these complex patterns (Fig 1-16).

### Food Web (Fig 1-16)



### Nutrients

- Recycling
  - Nutrients are recycled in a process called biogeochemical cycling.
  - Scavengers prefer to feed upon the dead remains of animals.
  - Decomposers are insects, bacteria, fungi, and protozoans that SEQUENTIALLY break down complex organic materials into low energy mineral nutrients that once again may be reabsorbed and used by plants.

### Recycling

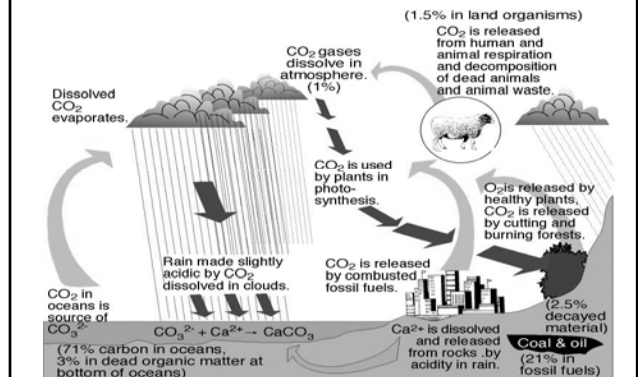
- Sulfur, phosphorous, carbon, oxygen, hydrogen, and nitrogen are known as macronutrients.
- Elements required in tiny amounts such as zinc, manganese, chlorine, iron, and copper that are termed trace elements.



### Nutrient Cycles

- Carbon Cycle
  - Includes physical states of gas, liquid, or solid, and chemical forms include organic and inorganic (Fig 1-17).
  - CO<sub>2</sub> comes from respiration, combustion of fossil fuels, and decomposition of organic matter.

### Carbon Cycle (Fig 1-17)



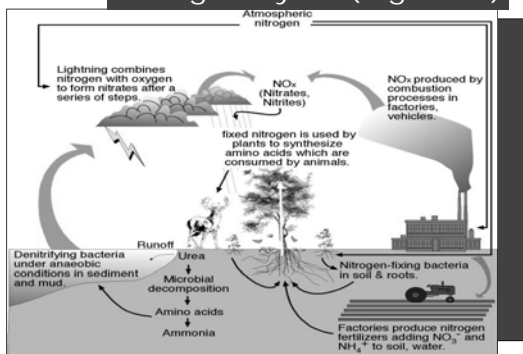
### Nutrient Cycles

- Carbon Cycle
  - Highest levels of carbon are found in oceans.
  - Plants convert inorganic carbon to carbohydrates by photosynthesis. The plants may be consumed, decompose, or eventually converted to fossil fuels.

### Nutrient Cycles

- Nitrogen Cycle (Fig. 1-18)
  - Atmospheric nitrogen must be converted to nitrates, nitrites, or ammonia before used by plants or animals.
  - Conversion to these forms is natural or synthetic.

### Nitrogen Cycle (Fig. 1-18)



### Nutrient Cycles

- Natural Nitrogen Conversion
  - By nitrogen-fixing bacteria (*Rhizobium* spp.) or some species of organobacteria.
  - By lightning.
  - Released from erosion of nitrate-rich rocks

### Nutrient Cycles

- Man-made Nitrogen Conversion
  - Manufacture of fertilizers
  - NO<sub>x</sub> created in boilers and internal combustion engines , then converted to nitrates and nitrites in the atmosphere.

### Nutrient Cycles

- Recycled
  - Converted from complex organics back into to atmospheric nitrogen by denitrifying bacteria.
  - The bacteria are anaerobic and live in mud and sediment of lakes, streams, and ponds.

### Nutrient Cycles

- Phosphorous
  - Gradually leached from sedimentary rock by the actions of rain or erosion, in a process referred to as the sedimentary cycle.
  - Phosphorous is the main element in compounds such as adenosine triphosphate (ATP).
  - Animal wastes and decomposing animals release phosphorous back to the soil for reuse by plants .

### Nutrient Cycles

- Phosphorous
  - Mining and agriculture can erode soil and carry phosphorous into streams, etc.
  - Phosphate rocks are a non-renewable resource that were created millions of years ago.
  - Phosphate being rapidly depleted.
  - Infertile soils likely to develop.

### SUCCESSION

- Succession refers to the predictable and gradual progressive changes of biotic communities toward the establishment of a climax community.
- A climax community is one which perpetuates itself with no further succession within an undisturbed ecosystem.

### SUCCESSION

- Primary succession must take place by first creating soil on the barren lava or exposed rock surfaces.
- Dust is captured in cracks and crevices along with microscopic organisms and seeds carried by the wind or deposited by small animals and birds. Mixtures of fungi and algae grow together and are known as lichens.

## SUCCESSION

- When soil conditions are disrupted but there remains topsoil and some limited vegetation, succession can take place much more quickly. This process has been termed secondary succession.
- Early plants are also known as pioneer plants, and may include wildflowers, followed by tall grasses and compact woody bushes.

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## SUCCESSION

- Stable ecosystems are ones in which materials are constantly recycled within the system through growth, consumption and decomposition.
- These processes tend to balance each other so that there is little net loss over long periods of time in a process called dynamic equilibrium.

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## SUCCESSION

- Poor land management techniques may result in fewer overall species in a process called retrogression.
- The species remaining may be less desirable from a human point of view.

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## THE CONCLUSION

- The human population is exerting enormous pressure upon ecosystems throughout the world as it continues to multiply in logarithmic proportions and develop energy intensive technologies resulting in the discharge of dramatic levels of toxic substance into the air, water, and land.

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## THE CONCLUSION

- Most biotic communities are proving unable to respond to the unrelenting pressures of disruption causing major losses in species, soil degradation, desertification, contaminated water, possible climate changes, and other changes in global ecosystems that are not in the best interests for human survival or quality of life.

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