Chapter 5
How Ecosystems Work
Section 1: Energy Flow in Ecosystems

DAY 1
Life Depends on the Sun

- Energy from the sun enters an ecosystem when plants use sunlight to make sugar molecules.
- This happens through a process called **photosynthesis**.
Life Depends on the Sun

- Photosynthesis is the process by which plants, algae, and some bacteria use sunlight, carbon dioxide, and water to produce carbohydrates and oxygen.
- End result of photosynthesis is a carbohydrate (sugar molecules).
- Gives you energy to do daily activities.

\[ 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{solar energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \]
From Producers to Consumers

- Because plants make their own food, they are called **producers**.
- A producer is an organism that can make **organic molecules from inorganic molecules**.
- Producers are also called **autotrophs, or self-feeders**.
From Producers to Consumers

• Organisms that get their energy by eating other organisms are called consumers.

• A consumer is an organism that eats other organisms or organic matter instead of producing its own nutrients or obtaining nutrients from inorganic sources.

• Consumers are also called heterotrophs, or other-feeders.
From Producers to Consumers

- Some producers get their energy directly from the sun by absorbing it through their leaves.
- Consumers get their energy indirectly by eating producers or other consumers.
An Exception to the Rule

- Deep-ocean communities of worms, clams, crabs, mussels, and barnacles, exist in total darkness on the ocean floor, where photosynthesis cannot occur.

- The producers in this environment are **bacteria that use hydrogen sulfide** present in the water.

- Other underwater organisms eat the bacteria or the organisms that eat the bacteria.
What Eats What?

- Organisms can be classified by what they eat.
- Types of Consumers:
  - Herbivores – *eat only plants*
  - Carnivores – *eat only animals*
  - Omnivores – *eat both plants and animals*
  - Decomposers – *eat dead organic matter*
What Eats What?

- Consumers that eat producers to get energy are what we call **primary consumers**.
- In other words they are **herbivores**.
- Most of the energy will be used up by the consumer (herbivore).
- A consumer that eats another consumer is called a **secondary consumer**.
### What Eats What?

#### What Eats What In an Ecosystem

<table>
<thead>
<tr>
<th>Energy source</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Producer</strong> makes its own food through photosynthesis or chemical sources</td>
<td>grasses, ferns, cactuses, flowering plants, trees, algae, and some bacteria</td>
</tr>
<tr>
<td><strong>Consumer</strong> gets energy by eating producers or other consumers</td>
<td>mice, starfish, elephants, turtles, humans, and ants</td>
</tr>
</tbody>
</table>

#### Types of Consumers In an Ecosystem

<table>
<thead>
<tr>
<th>Energy source</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herbivore</strong> producers</td>
<td>cows, sheep, deer, and grasshoppers</td>
</tr>
<tr>
<td><strong>Carnivore</strong> other consumers</td>
<td>lions, hawks, snakes, spiders, sharks, alligators, and whales</td>
</tr>
<tr>
<td><strong>Omnivore</strong> both producers and consumers</td>
<td>bears, pigs, gorillas, rats, raccoons, cockroaches, some insects, and humans</td>
</tr>
<tr>
<td><strong>Decomposer</strong> breaks down dead organisms in an ecosystem and returns nutrients to soil, water, and air</td>
<td>fungi and bacteria</td>
</tr>
</tbody>
</table>
Something to help you remember!

Energy Roles Song
Burning the Fuel

- An organism obtains energy from the food it eats.
- This food must be broken down within its body.
- The process of breaking down food to yield energy is called **cellular respiration**.
Burning the Fuel

- Cellular respiration is the process by which cells produce **energy from carbohydrates**; atmospheric oxygen combines with glucose to form water and carbon dioxide.

- Cellular respiration occurs inside the **cells** of most organisms.
**Burning the Fuel**

- During cellular respiration, cells **absorb oxygen and use it to release energy from food**.
- Through cellular respiration, cells use **glucose (sugar)** and oxygen to produce carbon dioxide, water, and energy.
Burning the Fuel

- Part of the energy obtained through cellular respiration is used to carry out daily activities.
- Excess energy is stored as fat or sugar.
Energy Transfer

- Each time an organism eats another organism, an energy transfer occurs.
- This transfer of energy can be traced by studying food chains, food webs, and trophic levels.
A food chain is a sequence in which energy is transferred from one organism to the next as each organism eats another organism.
Food Webs

- Ecosystems, however, usually contain more than one food chain.
- A **food web** shows many feeding relationships that are possible in an ecosystem.
Trophic Levels

- Each step in the transfer of energy through a food chain or food web is known as a **trophic level**.
- A **trophic level** is one of the **steps in a food chain or food pyramid**; examples include producers and primary, secondary, and tertiary consumers.
Trophic Levels

- Each time energy is transferred, some of the energy is lost as heat.
- Therefore, less energy is available to organisms at higher trophic levels.
- One way to visualize this is with an energy pyramid.
Trophic Levels

- Each layer of the pyramid represents one trophic level.
- Producers form the base of the energy pyramid, and therefore contain the most energy.
- The pyramid becomes smaller toward the top, where less energy is available.
Energy Loss Affects Ecosystems

- Decreasing amounts of energy at each trophic level affects the organization of an ecosystem.
- Energy loss affects the **number of organisms** at each level.
- Energy loss limits the **number of trophic levels** in an ecosystem.
Chapter 5
How Ecosystems Work
Section 2: Cycling of Materials

DAY 1
Georgia Standards

SEV1. Students will investigate the flow of energy and cycling of matter within an ecosystem and relate these phenomena to human society.

- a. Interpret biogeochemical cycles including hydrologic, nitrogen, phosphorus, oxygen, and carbon cycles. Recognize that energy is not recycled in ecosystems.
- b. Relate energy changes to food chains, food webs, and to trophic levels in a generalized ecosystem, recognizing that entropy is a primary factor in the loss of usable food energy during movement up the trophic levels.
- c. Relate food production and quality of nutrition to population growth and the trophic levels
- d. Relate the cycling of matter and the flow of energy to the Laws of Conservation of matter and energy. Identify the role and importance of decomposers in the recycling process.
- e. Distinguish between abiotic and biotic factors in an ecosystem and describe how matter and energy move between these.
The Carbon Cycle

- The **carbon cycle** is the movement of carbon from the nonliving environment into living things and back.
- Carbon is the essential component of **proteins, fats, and carbohydrates**, which make up all organisms.
How Ecosystems Work

Section 1

The Carbon Cycle
The Carbon Cycle

• Carbon exists in **air, water, and living organisms**.
• Producers convert **carbon dioxide** in the atmosphere into carbohydrates during photosynthesis.
• Consumers obtain carbon from the carbohydrates in the producers they eat.
The Carbon Cycle

- During cellular respiration, some of the carbon is released back into the atmosphere as carbon dioxide.
- Some carbon is stored in limestone, forming one of the largest “carbon sinks” on Earth.
How Ecosystems Work

Section 1

The Carbon Cycle

• Carbon stored in the bodies of organisms as fat, oils, or other molecules, may be released into the soil or air when the organisms dies.

• These molecules may form deposits of coal, oil, or natural gas, which are known as fossil fuels.

• Fossil fuels store carbon left over from bodies of organisms that died millions of years ago.
How Humans Affect the Carbon Cycle

• Humans burn fossil fuels, releasing carbon into the atmosphere.

• The carbon returns to the atmosphere as carbon dioxide.
How Humans Affect the Carbon Cycle

- Increased levels of carbon dioxide may contribute to **global warming**.
- Global warming is an **increase in the temperature** of the Earth.
Norton the Nucleus Explains the Carbon Cycle

Carbon Cycle Explained
The Nitrogen Cycle

• The **nitrogen cycle** is the process in which nitrogen circulates among the air, soil, water, plants, and animals in an ecosystem.

• All organisms need nitrogen to **build proteins**, which are used to build new cells.

• Nitrogen makes up **78** percent of the gases in the atmosphere.
The Nitrogen Cycle

• Nitrogen must be **altered, or fixed**, before organisms can use it.

• Only a few species of bacteria can fix atmospheric nitrogen into chemical compounds that can be used by other organisms.

• These bacteria are known as **“nitrogen-fixing”** bacteria.
**The Nitrogen Cycle**

- **Nitrogen-fixing bacteria** are bacteria that convert atmospheric nitrogen into ammonia.

- These bacteria live within the roots of plants called **legumes**, which include beans, peas, and clover.

- The bacteria use sugar provided by the legumes to produce nitrogen-containing compounds such as **nitrates**.

- Excess nitrogen fixed by the bacteria is released into the soil.
The Nitrogen Cycle

Atmospheric nitrogen, $\text{N}_2$

Lightning converts some atmospheric nitrogen into nitrates that organisms can use.

Runoff

Aquatic bacteria also process nitrogen.

Bacteria in soil and water add nitrogen to the atmosphere.

Nitrogen-fixing bacteria in soil and root nodules produce ammonia, $\text{NH}_3$.

Other bacteria convert ammonia into nitrates, which plants can use.
Decomposers and the Nitrogen Cycle

- Nitrogen stored within the bodies of living things is returned to the nitrogen cycle once those organisms die.
- **Decomposers** break down decaying plants and animals, as well as plant and animal wastes.
- After decomposers return nitrogen to the soil, bacteria transform a small amount of the nitrogen into nitrogen gas, which then returns to the atmosphere to complete the nitrogen cycle.
The Phosphorus Cycle

- **Phosphorus** is an element that is part of many molecules that make up the cells of living organisms.

- Plants get the phosphorus they need from **soil and water**, while animals get their phosphorus by **eating plants or other animals** that have eaten plants.

- The **phosphorus cycle** is the cyclic movement of phosphorus in different chemical forms from the environment to organisms and then back to the environment.
The Phosphorus Cycle
The Phosphorus Cycle

- Phosphorus may enter soil and water when rocks erode.
- Small amounts of phosphorus dissolve as phosphate, which moves into the soil.
- Plants absorb phosphates in the soil through their roots.
- Some phosphorus washes off the land and ends up in the ocean.
- Because many phosphate salts are not soluble in water, they sink to the bottom and accumulate as sediment.
Fertilizers and the Nitrogen and Phosphorus Cycles

- **Fertilizers**, which people use to stimulate and maximize plant growth, contain both nitrogen and phosphorus.
- Excessive amounts of fertilizer can enter terrestrial and aquatic ecosystems through **runoff**.
- Excess nitrogen and phosphorus can cause **rapid growth of algae, algal bloom**.
- Excess algae can deplete an aquatic ecosystem of important nutrients such as **oxygen**, on which fish and other aquatic organisms depend.
Acid Precipitation

- When fuel is burned, large amounts of nitric oxide is release into the atmosphere.
- In the air, nitric oxide can combine with oxygen and water vapor to form nitric acid.
- Dissolved in rain or snow, the nitric acid falls as acid precipitation.
• **Denitrification** is a microbially facilitated process of nitrate reduction (performed by a large group of heterotrophic facultative anaerobic bacteria) that may ultimately produce molecular nitrogen \((N_2)\)

• **Transpiration** is the process where plants absorb water through the roots and then give off water vapor through pores in their leaves.
Acid Rain Explained via YouTube!

Acid Rain Explained
Chapter 5
How Ecosystems Work
Section 3: How Ecosystems Change

DAY ONE
Ecological Succession

• Ecosystems are constantly changing.

• **Ecological succession** is a gradual process of change and replacement of the types of species in a community.

• Each new community that arises often makes it harder for the previous community to survive.
Ecological Succession

Ecological Succession Video
Ecological Succession

- **Primary succession** is a type of succession that occurs on a surface where *no ecosystem existed before*.
- It begins in an area that previously did not support life.
- Primary succession can occur on **rocks, cliffs, or sand dunes**.
Ecological Succession

- **Secondary succession** occurs on a surface where an ecosystem has previously existed.
- It is the process by which one community replaces another community that has been partially or totally destroyed.
- Secondary succession can occur in ecosystems that have been disturbed or disrupted by humans, animals, or by natural process such as storms, floods, earthquakes, or volcanic eruptions.
Ecological Succession

- A **pioneer species** is a species that colonizes an **uninhabited area** and that starts an ecological cycle in which many other species become established.

- Over time, a pioneer species will make the new area habitable for other species.

- A **climax community** is the final, stable community in equilibrium with the environment.

- Even though a climax community may change in small ways, this type of community may remain the same through time if it is not disturbed.
Climax Community

Climax Community
Ecological Succession

- **Natural fires** caused by lightning are a necessary part of secondary succession in some communities.

- Minor forest fires remove **accumulations of brush and deadwood** that would otherwise contribute to major fires that burn out of control.

- Some animal species also depend on occasional fires because they feed on the vegetation that sprouts after a fire has cleared the land.
Ecological Succession

- **Old-field succession** is a type of secondary succession that occurs when farmland is abandoned.

- When a farmer stops cultivating a field, grasses and weeds quickly grow and cover the abandoned land.

- Over time, taller plants, such as perennial grasses, shrubs, and trees take over the area.
Ecological Succession

- Year 1: annual plants
- Year 2: perennial plants and grasses
- Year 3–10: shrubs
- About year 20: young pine forest
- After about 150 years: mature oak forest
Ecological Succession

- **Primary succession** can occur on new islands created by volcanic eruptions.

- Primary succession is much slower than secondary succession. This is because it begins where there is no soil.
Ecological Succession

- The first pioneer species to colonize bare rock will probably be **bacteria and lichens**, which can live without soil.

- The growth of lichens **breaks down the rock**, which with the action of water, begins to form soil.
How Ecosystems Work

Section 1

Graphic Organizer

**Graphic Organizer**

**Chain-of-Events Chart**

Create the **Graphic Organizer** entitled “Chain-of-Events Chart” described in the Appendix. Then, fill in the chart with details about each step of ecological succession.