**Answers to Critical Thinking and Review End of Chapter Questions:**

1. Draw a food web containing organisms found in a Chesapeake Bay salt marsh.

Ans: Answers will vary

2. Describe the science of ecology?

Ans: Ecology is the study of systems that include interactions among organisms and between organisms and their abiotic environment.

3. Which scientist—a population ecologist or a landscape ecologist—would be most likely to study broad-scale environmental issues and land management problems? Explain your answer.

Ans:Landscape ecology is a subdiscipline of ecology that studies ecological processes that operate over large areas. Landscape ecologists examine the connections among ecosystems found in a particular region. Landscapes are based on larger land areas that include several ecosystems. Population ecologists work on a smaller scale. A population ecologist might study a population of polar bears or a population of marsh grass.

4. What is energy? How are the following forms of energy significant to organisms in ecosystems: (a) radiant energy, (b) mechanical energy, (c) chemical energy?

Ans:Energy is the capacity or ability to do work. Radiant energy is energy, such as radio waves, visible light, and X rays, which is transmitted as electromagnetic waves. Radiant energy is significant for providing energy for photosynthesis and visible light for sight. Mechanical energy is energy in the movement of matter, necessary for animals capturing food. Chemical energy is energy stored in the bonds of molecules; for example, food contains chemical energy. Thermal energy is heat energy that flows from an object with a higher temperature (the heat source) to an object with a lower temperature (the heat sink). Within ecosystems and organisms the different forms of energy are necessary for biological work such as growing, moving, reproducing, and maintaining and repairing damaged tissues.

5. Give two examples of potential energy, and in each case tell how it is converted to kinetic energy.

Ans: Energy can exist as stored energy—called potential energy—or as kinetic energy, the energy of motion. Think of potential energy as an arrow on a drawn bow, which equals the work the archer did when drawing the bow to its position. When the string is released, the bow's potential energy is converted to the arrow's kinetic energy of motion. Similarly, the cordgrass that a meadow vole eats has chemical potential energy in the bonds of its molecules; as molecular bonds are broken, this energy is converted to kinetic energy and heat as the meadow vole swims in the salt marsh. Thus, energy changes from one form to another.

6. Is this an example of an open system or a closed system? Explain your answer.

****

Ans: This is an example of an open system because an open system exhibits an exchange of energy with its surroundings.

7. How is the first law of thermodynamics related to the movement of an automobile?

Ans: The gasoline that you put in your automobile has potential energy stored as chemical energy in its molecular bonds. As gasoline is burned it releases energy, part of this energy is captured and transformed into mechanical energy to move the car forward. The remainder of the energy is lost as heat energy. The first law of thermodynamics explains how chemical energy converts to mechanical energy.

8. Give an example of a natural process in which order becomes increasingly disordered.

Ans: As a result of the second law of thermodynamics, no process requiring an energy conversion is ever 100% efficient because much of the energy is dispersed as heat, resulting in an increase in entropy. An automobile engine, which converts the chemical energy of gasoline to mechanical energy, is between 20 and 30% efficient. That is, only 20 to 30% of the original energy stored in the chemical bonds of the gasoline molecules is actually transformed into mechanical energy, or work. In our cells, energy use for metabolism is about 40% efficient, with the remaining energy given to the surroundings as heat.

9. How are photosynthesis and cellular respiration related? Write the overall equation for both processes.

Ans: Photosynthesis is the biological process in which light energy from the sun is captured and transformed into the chemical energy of carbohydrate molecules. The chemical energy that plants store in carbohydrates and other molecules is released within the cells of plants, animals, and other organisms through cellular respiration.

Photosynthesis

6CO2 +12H2O + radiant energy yields C6H12O6 + 6H2O + 6 O2

Cellular respiration

C6H12O6 + 6H2O + 6 O2  yields 6CO2 +12H2O

10. Why is the concept of a food web generally preferred over a food chain?

Ans: Simple food chains rarely occur in nature because few organisms eat just one kind of organism. More typically, the flow of energy and materials through an ecosystem takes place in accordance with a range of food choices for each organism involved. In an ecosystem of average complexity, numerous alternative pathways are possible. A hawk eating a rabbit is a different energy pathway than a hawk eating a snake. A food web is a more realistic model of the flow of energy and materials through an ecosystem.

11. Could you construct a balanced ecosystem that contained only producers and consumers? only consumers and decomposers? only producers and decomposers? Explain the reasons for your answers.

Ans: Ecosystems must contain a balanced representation of producers, consumers, and decomposers, all of which have indispensable roles in ecosystems. Producers provide both food and oxygen for the rest of the community. Consumers play an important role by maintaining a balance between producers and decomposers. Detritus feeders and decomposers are necessary for the long-term survival of any ecosystem because, without them, dead organisms and waste products would accumulate indefinitely.

12. Label these parts in the following simple ecosystem: producer, primary consumer, secondary consumer, decomposer. Which of these organisms photosynthesizes? Which carry out cellular respiration? Which give off heat into their surroundings?

Ans: The plant is a producer and carries out both photosynthesis and cellular respiration. The Bird can be either a primary consumer when it eats the berries on the plant or a secondary consumer when it eats insects. The bird only carries out cellular respiration. The earthworms are decomposers and only carryout cellular respiration. All release heat into their environments.

13. Suggest a food chain with an inverted pyramid of numbers—that is, greater numbers of organisms at higher than at lower trophic levels.

Ans: Inverted pyramids of numbers, in which higher trophic levels have *more* organisms than lower trophic levels, are often observed among decomposers, parasites, tree-dwelling herbivorous insects, and similar organisms.

14. Is it possible to have an inverted pyramid of energy? Why or why not?

Ans: It is not possible to have an inverted pyramid of energy. Energy pyramids show that most energy dissipates into the environment when going from one trophic level to the next. Less energy reaches each successive trophic level from the level beneath it because organisms at the lower level use some energy to perform work, and some is lost.

15. Relate the pyramid of energy to the second law of thermodynamics.

Ans: According to the second law of thermodynamics, when energy is converted from one form to another, some of it is degraded into heat. No biological process is ever 100% efficient so as energy is transferred from one trophic level to the next there is less energy available to the higher trophic level. Energy pyramids show that most energy dissipates into the environment when going from one trophic level to the next.

16. What is NPP? Do humans affect the global NPP? If so, how? If not, why?

Ans: NPP is net primary productivity. Energy in plant tissues after cellular respiration has occurred is net primary productivity. NPP is productivity after respiration losses are subtracted. Humans consume far more of earth’s resources than any other of the millions of animal species. It is estimated that humans use 32% of the annual NPP of land-based ecosystems. That is a huge amount considering that humans represent about 0.5% of the total biomass of all consumers on earth.

17. Alcohol fuels produced from corn are often considered a climate friendly answer to our energy needs. Explain why a large-scale increase in the production of corn to provide fuel could have a negative or even catastrophic impact on ecosystems.

Ans: If we grow corn and other biomass crops on a large scale for fuel, then we will be taking an even larger share of global NPP, which would leave even less for the planet’s

organisms. At some point, our use of global NPP will compromise Earth’s systems that sustain us. Indeed, we may have already exceeded the sustainable consumption of NPP.

**Answers to Review Questions**

**What is Ecology?**

1. What is ecology?

Ernst Haeckel, a 19th century scientist, developed the concept of ecology. Ecology is the study of systems that include interactions among organisms and between organisms and their abiotic environment.

1. What is the difference between a community and an ecosystem? Between an ecosystem and a landscape?

A community is defined as a natural association that consists of all the populations of different species that live and interact within an area at the same time. An ecosystem is a more inclusive term than community; it includes all the biotic interactions of a community as well as the interactions between organisms and their abiotic environment. A landscape encompasses a region that includes several interacting ecosystems.

**The Energy of Life**

1. Distinguish among energy, work, and heat.

Energy is the capacity or ability to do work, and is required for biological work such as growing, moving, reproducing, and maintaining and repairing damaged tissues. Energy exists in several forms: chemical, radiant, thermal, mechanical, nuclear, and electrical. Biologists generally express energy in units of work (kilojoules, kJ) or units of heat (kilocalories, kcal).

1. Is water stored behind a dam an example of potential or kinetic energy? What would cause the water to convert to the other form of energy?

Water stored behind a dam is an example of potential energy. The water could convert to kinetic energy (i.e., the energy of motion) if the dam were to break or be opened and water was released.

1. Is a rabbit an example of a closed system or an open system? Why?

A rabbit is an example of an open system because it exchanges energy with its surroundings. It receives energy from the food it eats, and releases energy in the form of cellular respiration and other waste products. Closed systems are very rare in nature.

1. When coal is burned in a power plant, only 3% of the energy in the coal is converted into light in a lightbulb. What happens to the other 97% of the energy? Explain your answer using the laws of thermodynamics.

There are two laws regarding energy that apply to all things in the universe, the first and second laws of thermodynamics. The first law of thermodynamics states that energy cannot be created or destroyed, although it can change from one form to another. Therefore, according to the first law of thermodynamics, the energy that is released when coal is burned in a power plant is converted into electricity, and again converted into the light that shines in a the lightbulb. However, when this energy is converted from the burning coal, to electricity, to light, some of it is degraded into heat. In the case of the lightbulb, 97% of this energy actually disperses into the environment as heat. This supports the second law of thermodynamics which states that when energy is converted from one form to another, some of it is degraded into heat, a less usable form that disperses into the environment.

1. Distinguish between photosynthesis and cellular respiration. Which organisms perform each process?

Photosynthesis is the biological process in which light energy from the sun is captured and transformed into the chemical energy of carbohydrate molecules. It is performed by plants, some bacteria, and algae. Cellular respiration makes the chemical energy stored in carbohydrate molecules available to the cell for biological work. All organisms, including plants, use cellular respiration to obtain energy.

**The Flow of Energy Through Ecosystems**

1. What is a food web?

A food web is a representation of the flow of energy and materials through an ecosystem. It represents the interlocking food chains and feeding relationships that indicate how a community is organized.

1. How does energy flow through a food web consisting of producers, consumers, and decomposers?

Energy that enters an ecosystem from the sun always flows linearly. During every energy transaction, some energy is lost to biological systems as it disperses into the environment as heat. Yet, organisms within this energy transaction each have a range of food choices available to them, so simple food chains (i.e., producer -> consumer -> decomposer) rarely occur in nature. More typically, in an ecosystem of average complexity, numerous pathways are possible and the flow of energy takes place in accordance. For example, a consumer may consume a producer or another consumer. That consumer may be consumed by decomposers or another consumer. And so on.

1. What is a pyramid of energy?

A pyramid of energy illustrates the energy content of the biomass of each trophic level in an ecosystem. It demonstrates that most energy dissipates into the environment when going from one trophic level to the next. Energy pyramids help explain why there are so few trophic levels, and that food webs are short because of the dramatic reduction in energy content at each trophic level.

1. What is gross primary productivity? Net primary productivity?

Gross primary productivity (GPP) is the total amount of photosynthetic energy that plants capture and assimilate in a given period. Net primary productivity (NPP) is the productivity after respiration losses are subtracted. NPP represents the rate at which organic matter is actually incorporated into plant tissues for growth. NPP = GPP – plant cellular respiration