Learning Objectives:

LO 4.14 The student is able to apply mathematical routines to quantities that describe interactions among living systems and their environment, which result in the movement of matter and energy. [See **SP 2.2**]

LO 4.15 The student is able to use visual representations to analyze situations or solve problems qualitatively to illustrate how interactions among living systems and with their environment result in the movement of matter and energy. [See **SP 1.4**]

LO 4.16 The student is able to predict the effects of a change of matter or energy availability on communities.[See **SP 6.4**]

Enduring understanding 4.B: Competition and cooperation are important aspects of biological systems.

Competition and cooperation play important roles in the activities of biological systems at all levels of organization. Living systems require a myriad of chemical reactions on a constant basis, and each of these chemical reactions relies on the cooperation between a particular enzyme and specific substrates, coenzymes and cofactors. Chemical inhibitors may compete for the active sites of enzymes that, in turn, affect the ability of the enzyme to catalyze its chemical reactions. Thus, interactions between molecules affect their structure and function. Other examples of this phenomenon include receptor-ligand interactions and changes in protein structure due to amino acid sequence.

Similar cells may compete with each other when resources are limited; for example, organisms produce many more spores or seeds than will germinate. Competition for resources also determines which organisms are successful and produce offspring. In the vertebrate immune system, competition via antigen-binding sites determines which B-cell lineages are stimulated to reproduce.

The cooperation of parts extends to the organism that depends on the coordination of organs and organ systems, such as between the digestive and excretory systems of an animal or the roots and shoots of a plant. Cooperation within organisms increases efficiency in the use of matter and energy. For example, without the coordination and cooperation of its shoot and roots, a plant would be unable to survive if its root system was too small to absorb water to replace the water lost through transpiration by the shoot. Similarly, exchange of oxygen and carbon dioxide in an animal depends on the functioning of the respiratory and circulatory systems. Furthermore, population interactions influence patterns of species distribution and abundance, and global distribution of ecosystems changes substantially over time.

Essential knowledge 4.B.1: Interactions between molecules affect their structure and function.

a. Change in the structure of a molecular system may result in a change of the function of the system. [See also **3.D.3**]

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b. The shape of enzymes, active sites and interaction with specific molecules are essential for basic functioning of the enzyme.

Evidence of student learning is a demonstrated understanding of each of the following:

1. For an enzyme-mediated chemical reaction to occur, the substrate must be complementary to the surface properties (shape and charge) of the active site. In other words, the substrate must fit into the enzyme's active site.
2. Cofactors and coenzymes affect enzyme function; this interaction relates to a structural change that alters the activity rate of the enzyme. The enzyme may only become active when all the appropriate cofactors or coenzymes are present and bind to the appropriate sites on the enzyme.

✘ *No specific cofactors or coenzymes are within the scope of the course and the AP Exam.*

c. Other molecules and the environment in which the enzyme acts can enhance or inhibit enzyme activity. Molecules can bind reversibly or irreversibly to the active or allosteric sites, changing the activity of the enzyme.

d. The change in function of an enzyme can be interpreted from data regarding the concentrations of product or substrate as a function of time. These representations demonstrate the relationship between an enzyme's activity, the disappearance of substrate, and/or presence of a competitive inhibitor.

Learning Objective:
LO 4.17 The student is able to analyze data to identify how molecular interactions affect structure and function. [See **SP 5.1**]

Essential knowledge 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.

a. Organisms have areas or compartments that perform a subset of functions related to energy and matter, and these parts contribute to the whole.
[See also **2.A.2**, **4.A.2**]

Evidence of student learning is a demonstrated understanding of each of the following:

1. At the cellular level, the plasma membrane, cytoplasm and, for eukaryotes, the organelles contribute to the overall specialization and functioning of the cell.
2. Within multicellular organisms, specialization of organs contributes to the overall functioning of the organism.

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