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Section 4.1 Currently the most serious drug problem on college campuses is binge drinking, which is associated with alcoholism. Drinking more alcohol than the body’s enzymes can detoxify can be lethal in both the short term and the long term.

Section 4.2 Energy is the capacity to do work. Energy cannot be created or destroyed (first law of thermodynamics), but it can be converted from one form to another and transferred between objects or systems. Energy tends to disperse spontaneously (second law of thermodynamics). A bit disperses at each energy transfer, usually in the form of heat.

Living things can maintain their organization only as long as they harvest energy from someplace else. Energy flows in one direction through the biosphere, starting mainly from the sun, then into and out of ecosystems. Producers and then consumers use the energy to assemble, rearrange, and break down organic molecules that cycle among organisms throughout ecosystems.

Section 4.3 Cells store and retrieve energy by making and breaking chemical bonds in chemical reactions, in which reactants are converted to products. Some reactions require a net energy input; others end with a net energy release. Activation energy is the minimum energy input required to start a reaction.

Section 4.4 Enzymes greatly enhance the rate of a chemical reaction. Each has an active site and works on a particular substrate within a characteristic range of temperature, salt concentration, and pH. Many enzymes require assistance from coenzymes or other cofactors.

ATP functions as an energy carrier between reaction sites in cells. It has three phosphate groups; when one of them is transferred to another molecule, energy is transferred along with it. Phosphate-group transfers (phosphorylations) to and from ATP couple reactions that release energy with reactions that require energy.

Cells build, convert, and break down substances in enzyme-mediated reaction sequences called metabolic pathways. Controls over enzymes and metabolic pathways allow cells to conserve energy and resources by producing only what they require. Feedback inhibition is an example of metabolic control. Electron transfer chains in some pathways harvest electron energy in small, manageable increments.

Section 4.5 Molecules or ions tend to spread spontaneously (diffuse), with the eventual result being a gradual and complete mixing. A concentration gradient is a difference in the concentration of a solute between adjoining regions of solution. The steepness of the gradient, temperature, solute size, charge, and pressure influence the diffusion rate.

Osmosis is the diffusion of water across a selectively permeable membrane, from the region with a lower solute concentration (hypotonic) toward the region with a higher solute concentration (hypertonic). There is no net movement of water between isotonic solutions. Osmotic pressure is the amount of turgor (fluid pressure against a cell membrane or wall) that stops osmosis.

Section 4.6 Gases, water, and small nonpolar molecules can diffuse across a lipid bilayer. Most other molecules, and ions in particular, cross only with the help of transport proteins.

Transport proteins allow a cell or membrane-enclosed organelle to control which substances enter and exit. The types of transport proteins in a membrane determine which substances can cross it. Calcium pumps and other active transport proteins use energy, such as a phosphate transfer from ATP, to pump a solute against its concentration gradient. Passive transport proteins work without an energy input; a solute’s movement is driven by its concentration gradient.

Substances in bulk and large particles are moved across plasma membranes by processes of exocytosis and endocytosis. In exocytosis, a cytoplasmic vesicle fuses with the plasma membrane, and its contents are released to the outside of the cell. The vesicle’s membrane lipids and proteins become part of the plasma membrane. In endocytosis, a patch of plasma membrane balloons into the cell, and forms a vesicle that sinks into the cytoplasm. Some cells engulf large particles such as prey or cell debris by the endocytic pathway of phagocytosis.
8. Which of the following statements is incorrect?
   a. Some metabolic pathways are cyclic.
   b. Glucose can diffuse through a lipid bilayer.
   c. Feedback inhibition controls some metabolic pathways.
   d. All coenzymes are cofactors.
   e. Osmosis is a case of diffusion.

9. Ions or molecules tend to diffuse from a region where they are _______ (more/less) concentrated to another where they are _______ (more/less) concentrated.

10. _______ cannot easily diffuse across a lipid bilayer.
   a. Water
   b. Gases
   c. Ions
   d. All of the above

11. Transporters that require an energy boost help sodium ions across a cell membrane. This is a case of _______.
   a. passive transport
   b. active transport
   c. facilitated diffusion
   d. a and c

12. If you immerse a red blood cell in a hypotonic solution, water will _______.
   a. diffuse into the cell
   b. diffuse out of the cell
   c. show no net movement
   d. move in by endocytosis

13. Fluid pressure against a wall or cell membrane is called _______.
   a. osmosis
   b. turgor
   c. diffusion
   d. osmotic pressure

14. Vesicles form in _______.
   a. endocytosis
   b. exocytosis
   c. phagocytosis
   d. a and c

15. Match each term with its most suitable description.

   i. reactant
   a. assists some enzymes
   b. forms at reaction’s end
   c. enters a reaction
   d. requires energy boost
   e. one cell engulfs another
   f. energy cannot be created
   g. faster with a gradient
   h. no energy boost required
   i. currency in an energy economy

   ii. phagocytosis
   a. a and c
   b. b
   c. d

   iii. first law
   a. energy-harvesting pathway that combines oxygen with iron–sulfur compounds in minerals such as pyrite. The reaction dissolves the minerals, so groundwater that seeps into the mine ends up accumulating high concentrations of metal ions such as copper, zinc, cadmium, and arsenic. Another reaction product, sulfuric acid, lowers the pH of the resulting solution to zero.

   Unwalled F. acidarmanus cells maintain their internal pH at a cozy 5.0 despite living in an environment with a composition essentially the same as hot battery acid. Thus, researchers investigating Ferroplasma metabolic enzymes were surprised to discover that most of the cells’ enzymes function best at very low pH (Figure 4.21 B).

   1. What does the dashed line in the graph signify?
   2. Of the four enzymes profiled in the graph, how many function optimally at a pH lower than 5? How many retain significant function at pH 5?
   3. What is the optimal pH for Ferroplasma carboxylesterase?

   ![A Deep inside one of the most toxic sites in the United States: Iron Mountain Mine, in California. The water in this stream, which is about one meter (3 feet) wide, is hot (around 40°C, or 104°F), heavily laden with arsenic and other toxic metals, and has a pH of zero. The slime streamers growing in it are a biofilm dominated by a species of archaea, Ferroplasma acidarmanus.](image)

   ![B pH profiles of four enzymes isolated from Ferroplasma. Researchers had expected these enzymes to function best at the cells’ cytoplasmic pH (5.0).](image)