Biology 317

Chapter 5: The Working Cell

Energy & the Cell

Energy for Life Processes

- Energy is the ability to move or change matter.
- Chemical reactions require ***reactants*** and produce ***products***
- Some reactions release energy, while others absorb it.
- This movement of energy occurs when the bonds b/n atoms are broken.
- All the chemical reactions that occur within an organism is called ***metabolism.***
- Energy needed to start a reaction is called ***activation energy.***

1. Describe the two laws that govern energy transformations

How Enzymes Function

Enzymes

- Activation energy is required for many chemical reactions in cells.
- ***Enzymes*** increase the speed of chemical reactions.
    - *For example carbonic anhydrase helps create carbonic acid quickly which enables the body to release CO2 quickly*
- Most enzymes are proteins and they work to decrease the activation energy of chem. reactions.
- The substance which the enzyme acts on is called a ***substrate.***
    - *For example, the enzyme amylase which helps convert starch to glucose, is the substrate for starch.*
- An enzyme's shape determines its activity. The place where it binds with the substrate is called the ***active site.***
- Some factors affect enzyme activity:
    - the range of temperatures
    - the range of pH levels.

2. How do enzyme inhibitors block enzyme action?

<u>Membrane Structure & Function</u>

Module 5.10 Membranes organize the chemical activities of cells.

A. Membranes separate cells from the outside environments, including, in multicellular organisms, the environment in other cells that perform different functions.

B. Membranes control the passage of molecules from one side of the membrane to the other.

C. In eukaryotes, membranes partition function into organelles.

D. Membranes are selectively permeable, which means some substances can pass through a membrane more easily than other substances. Compare ethanol (as a fixative) to glucose.

Module 5.11 Membrane phospholipids form a bilayer.

A. Phospholipids are like fats, with two nonpolar fatty acid "tails" that are hydrophobic and one polar phosphate "head" attached to the glycerol that is hydrophilic.

B. In water, thousands of individual molecules form a stable bilayer, aiming their polar heads out, toward the water, and their nonpolar tails in, away from the water.

C. The hydrophobic interior of this bilayer offers an effective barrier to the flow of most hydrophilic molecules but allows the passage of hydrophobic molecules.

Module 5.12 The membrane is a fluid mosaic of phospholipids and proteins.

A. It is a mosaic because the proteins form a "tiled pattern" in the "grout ground" of the <u>phospholipid bilayer.</u>

B. It is fluid (like salad oil) because the individual molecules are more or less free to move about laterally.

C. The two sides of the membrane usually incorporate different sets of proteins and lipids: glycoproteins and glycolipids.

D. Some proteins extend through both sides of the bilayer and bind to the cytoskeleton and/or the <u>extracellular</u> matrix.

Module 5.13 Proteins make the membrane a mosaic of function.

A. Enzymes: catalyzing intracellular and extracellular reactions.

B. Receptors: triggering cell activity when a messenger molecule attaches (e.g., signal transduction.

Module 5.14 Passive transport is diffusion across a membrane.

A. <u>Diffusion</u> is the tendency for particles of any kind to spread out spontaneously from an area of high concentration to an area of low concentration.

B. <u>Passive transport</u> across membranes occurs (as diffusion does everywhere) when a molecule diffuses down a concentration gradient. At equilibrium, molecules continue to diffuse back and forth, but there is no net change in concentration anywhere.

C. Different molecules diffuse independently of one another.

D. Passive transport is an extremely important way for small molecules to get into and out of cells. For example, O_2 moves into red blood cells and CO_2 moves out of these cells by this process in the lungs. The reverse process takes place in the tissue because the concentration gradients have reversed.

Module 5.15 Transport proteins facilitate diffusion across membranes

A. Facilitated diffusion occurs when a pored protein, spanning the membrane bilayer, allows a solute to diffuse down a concentration gradient.

B. The cell does not expend energy.

C. The rate of facilitated diffusion depends on the number of such transport proteins, in addition to the strength of the concentration gradient.

D. Water is a polar molecule and, therefore, needs the assistance of transport proteins when crossing membranes. A good example of this is the aquaporins (water transport proteins) in the collecting ducts of the kidneys.

Module 5.16 Osmosis is the diffusion of water across a membrane.

A. If a membrane that is permeable to water but not to a solute separates an area of high solute concentration (hypertonic) from an area of low solute concentration (hypotonic), the water diffuses by osmosis to the hypertonic area until the concentration of each solute is the same on both sides of the membrane.
NOTE: Osmosis can cause a physical force to be applied to the hypertonic solution. In the case shown in Figure 5.16, this osmotic force raises the level of the solution on the right against the force of gravity, until the weight difference in levels equals the osmotic force.

B. The direction of osmosis is determined only by the difference in total solute concentrations.

C. Two solutions equal in solute concentrations are isotonic to each other; therefore, osmosis does not occur.

D. However, even in isotonic solutions separated by a selectively permeable membrane, water molecules are moving in both directions at equal rates.

Module 5.17 Water balance between cells and their surroundings is crucial to organisms.

A. Cell membranes act as selectively permeable membranes between the cell contents and its surroundings. The propensity of a cell to gain or lose water with its surroundings is referred to as tonicity.

B. If a plant or animal cell is isotonic with its surroundings, no osmosis occurs, and the cells do not change. However, plant cells in such environments are flaccid or wilted, lacking the turgor that helps support some plant tissues.

C. An animal cell in a hypotonic solution will gain water and pop (lyse). A plant cell in a hypotonic solution will become turgid, as the cell wall counters the osmotic force of water moving in.

D. An animal cell in a hypertonic solution will lose water and shrivel (crenate). A plant cell in a hypertonic solution will lose water past the cell membrane but not the cell wall, resulting in the plasma membrane pulling away from the inside of the cell wall and the cell as a whole losing turgor. This process is called plasmolysis.

Module 5.18 Cells expend energy for active transport.

A. Active transport involves the assistance of a transport protein when moving a solute against a concentration gradient.

B. Energy expenditure in the form of ATP-mediated phosphorylation is required to help the protein change its structure and, thus, move the solute molecule. Preview: A very important example of a coupled active transport system is the Na^1-K^1 pump, which functions in nerve impulse transmission.

Module 5.19 Exocytosis and endocytosis transport large molecules.

A. In exocytosis, membrane-bounded vesicles containing large molecules fuse with the plasma membrane and release their contents outside the cell.

B. In endocytosis, the plasma membrane surrounds materials outside the cell, closes around the materials, and forms membrane-bounded vesicles containing the materials.

C. Three important types of endocytosis are phagocytosis (“cell eating”), pinocytosis (“cell drinking”), and receptor-mediated endocytosis.

Module 5.20 Connection: Faulty membranes can overload the blood with cholesterol

A. Cholesterol is carried in the blood by low-density lipoprotein (LDL) particles.

B. In people with normal cholesterol metabolism, excess LDL-bound cholesterol in the blood is eliminated by receptor-mediated endocytosis by liver cells.

C. In people with a genetic condition that results in increased levels of cholesterol (hypercholesterolemia), fewer or no such receptor sites exist, and the people accumulate LDL-bound cholesterol. These people are at high risk for developing heart disease.

Module 5.21 Chloroplasts and mitochondria make energy available for cellular work.

A. The subjects of this chapter (energy, enzymes, and membranes) are important parts of the functioning of these two organelles and the processes they carry out (photosynthesis and cellular respiration).

B. Photosynthesis and cellular respiration are linked.

C. Solar energy is used by chloroplasts to build energy-rich molecules in endergonic reactions.

Preview: Photosynthesis is discussed in Chapter 7.

D. The energy-rich molecules release their energy to form ATP in mitochondria. Preview: Cellular respiration is discussed in Chapter 6.

E. The chemicals involved as the reactants in chloroplasts are the products in mitochondria, and vice versa.