CHEMICAL REACTIONS AND ENZYME NOTES

Life is made up of chemical reactions—growth, interaction with environment, reproduction, nutrition, movement is all done by chemical reactions. A chemical reaction is a process that changes one set of chemical into another. Mass and energy have to be conserved during chemical reactions. They are never lost, just change form. Some reactions are slow like oxygen and iron reacting to make rust. Others are quicker. Elements and compounds that go into a reaction are called reactants and what is produced from the reaction is called products. Chemical bonds are broken and then new ones are formed.

Reactant(s) → Product(s)

Energy needs:

Some chemical reactions release energy and others absorb energy. Chemical reactions that release energy are called exergonic and can be spontaneous. Those that absorb energy are called endergonic. They require a source of energy to occur.

Organisms have to carry out reactions that require energy. Organisms have to have a source of energy. Plants get their energy from sunlight and store it in energy-rich compounds ie starch. Animals get their energy when they consume plants or other animals.

Activation energy:

Not all chemical reactions that release energy are spontaneous. Cellulose in paper burns in the presence of oxygen. But the cellulose only burns when first touched by a lit match which supplies the needed energy for the reaction to get started. This needed energy to start the reaction is called the activation energy. The activation energy needed for reactions that absorb energy (endergonic) is higher than those that give off energy (exergonic).

Endergonic

Exergonic

ENZYMES:

Some chemical reactions needed for life are too slow or have an activation energy that is too high to be practical for life. These reactions are made possible by the presence of a catalyst. These substances that speed up the rate of the chemical reactions. They do this by lowering the activation energy. Enzymes are proteins that act like living biological catalysts in cells. Lowering the activation energy has a big effect on how quickly the reaction happens. Enzymes speed up reactions 100's to 10^{14} times the normal rate of the reaction. Currently there are over 3000 known enzymes.

Structure of enzymes:

Enzymes are complex structures of long chains of amino acids. The largest enzymes are 1000's of amino acids long. They fold into their shapes which determine the characteristics of the enzyme. There are many different kinds of enzymes to control different kinds of reactions in the organism. But enzymes are very specific to the reaction(s) that they help with (catalyze). They help with only 1 or a few that are similar.

Many enzymes need a cofactor, or coenzyme, to work. Many of the coenzymes are vitamins. Vitamin deficiencies in an organism can cause enzymes not to work properly.

Enzymes are sensitive to their surrounding cell environment. The correct temperature and pH are important for them to function properly. i.e. the stomach must be very acidic for the enzyme pepsinase to work properly to help start digesting food(pepsin). Temperature for the best (optimal) enzyme function is 37 C or 98.6 F. A temperature below that slows the reaction rate slightly, but anything above that makes the reaction rate drop off dramatically. The temperature could rise during a fever and cause the enzyme to not work as well. Anything above 104 F will cause enzymes to denature, or become nonfunctional, because chemical bonds break in the enzyme. This is not reversible and the enzyme can be permanently damaged.

Naming enzymes:

Enzymes are so specific to the reaction(s) they help with (catalyze) that they are usually name for the substance, or substrate, they work on. They usually end in –ase.

ie Lipase enzyme breaks down lipids into fatty acids and glycerol
Protease break down proteins into amino acids
Amylase breaks down starch into simple sugars
Lactase breaks down the milk sugar lactose. People who are lactose intolerant are without the lactose enzyme and cannot break down the milk sugar lactose.

How enzymes work:

Chemical reactions need collisions between reactant molecules. Chemical reactions occur at a faster rate if there are more collisions. Normally heat and a higher concentration of the reactant chemicals could speed up the rate of collisions. But in living things, that is not usually a good option. This is why enzymes are important. Enzymes speed up reactions without heat or a higher concentration. Enzymes instead lower the activation energy needed to start the reaction.
ie Paper will not burn without the initial energy from the lit match.
ie A person pulling a sled up a snowy hill is slow but if another person were to help pull, it will lower the amount of energy needed and speed up the process.

The surface of the enzyme is important to its function and determines what chemicals it can and cannot react with. The shape of the enzyme and its substrate (substance it reacts with) is like a puzzle. The substrate molecule(s) and the enzyme react at a certain site in the enzyme called the active site. When the substrate molecule(s) connect with the enzyme this is then called the enzyme-subsrate complex. Now the activation energy needed to start the reaction is lowered. Enzymes may break apart a larger molecule into smaller parts or join smaller parts into a larger molecule. Enzymes are reusable. They do not get used up in the reactions.

Enzyme + substrate → enzyme-substrate complex → enzyme + product

Catalase enzyme

ie $2\ H_2O_2$ ----------→ $2\ H_2O + O_2$

1 molecule of catalase can break down about 40 million H_2O_2 / second

Inhibitors:

Enzymes can be turned on and off as the cell needs them. Inhibitors are produced by the cell which will block the enzyme's active site when the enzyme is not needed. The cell can signal the inhibitor to release when the enzyme is needed.