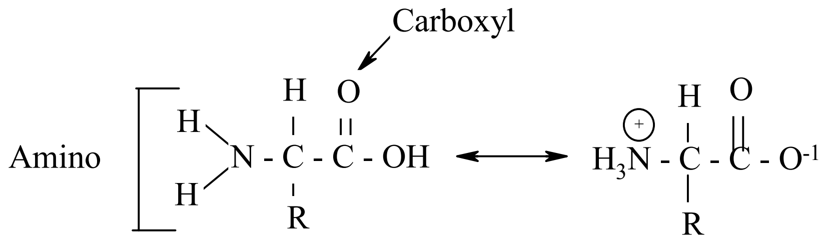
GENERAL INFO about BIOCHEMISTRY

Four Important Classes of Biomolecules:
Proteins, Carbohydrates, Lipids and Nucleic Acid

Example: Starch is a complex carbohydrate (polysaccharide), while glucose is a monosaccharide. Antibiotics work by disrupting the protein synthesis machinery of a disease 3

CLASSES	**POLYMERS**	**SUBUNITS**
Protein	Polypeptide	Amino-acid
Carbohydrate	Polysaccharide	Monosaccharide
Lipid	Triglyceride	Fatty acid, glycerol
Nucleic acid	DNA, RNA	Nucleotide

Functional Group		**Biomolecules**
Amino	H–N–	Amino-acid
Carboxyl	-C(=O)-OH	Amino-acid, Fatty acid
Amide	-C(=O)-NH_2	Bonds amino-acids in proteins
Carbonyl	-C(=O)-	Some Monosacharides
Hydroxyl	- OH	Monosacharides, glycerol
Carboxyl acid ester	-C(=O)-O-R	Tri-glycerides among lipids
Phospate ester	-C-O-P(=O)(O^{-1})-O^{-1}	ATP



Amino acids in water:

Glycerine R-H (Covalently Bonded)

Leucine R group includes a long carbon chain

Tryptophan R group is made up of two rings, made up of carbons

R group of amino acid can be Hydrophilic (water attracting) group, which are on the surface of a protein structure and orient towards water.

R group of amino acids can be Hydrophobic (water repelling) group, which can attract towards each other, and away from water.

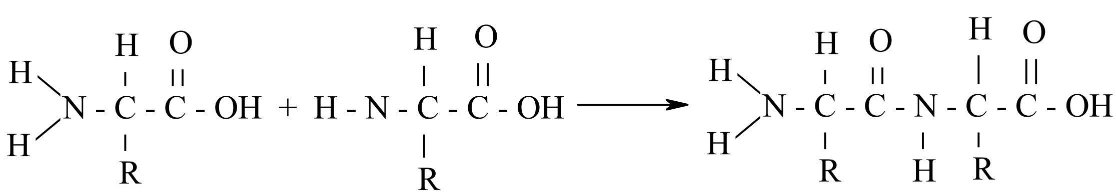
A Zwittwrion has many properties in common with salts; compounds consisting of positive and negative ions. (E.g. NaCl) Therefore unbound amino acids are crystalline and soluble in water. They also have high melting points, and they also have acid-base properties.

AMINO-ACID and pH: In an acidic solution (pH<7), amino acids accept protons on their negative ends. In basic solution (fewer proteins, with pH>7), they lose protons from their positive end.

The ISO-electric point is the pH at which the number of positive and negative charges is equal in an amino acid in solution. For alanine it is 6.0. Amino acids can dissolve in plasma (liquid part of blood). The pH pf human blood is about 7.4.

STRUCTURE:

Peptide bond: Two amino acids can bond, with the accompanying loss of a water molecule. (See the following reaction)



Dipeptide

Tri-peptide: Three bonded amino acid cells have the ability to make long chain like polymers of bonded amino acids. A POLYPEPTIDE consists of 10 to 100 bonded amino acids. A PROTEIN is even larger.

LEVELS OF STRUCTURES:

The Primary Structure is the sequence of amino acids covalently bonded together. With 20 amino acids in cells, the possibilities for different sequences are endless. The primary structure determines the other levels of structure and the over all shape of the protein molecule. In SICKLE CELL anemia, a change in only 1 of the 146 amino acids in a polypeptide of Hemoglobin changes the properties of this molecule. (Hemoglobin transports oxygen)

The Secondary Structure is a result of the amino acid sequence. HYDROGEN BONDING between amino acids of the polypeptide is responsible for the stability of the secondary structure. These amino acids are often far apart in the polypeptide. The bonding causes specific shapes. (Examples: Alpha Helix; Beta Pleated Sheet)

Tertiary Structure: is the three-dimensional folding of the alpha helix or the pleated sheet. Other bonds (E.g. disulfide bridges) between non-adjacent amino acids of a polypeptide produce this level of structure.

Quaternary Structure: is the splendid relationship between different polypeptides in the protein. The protein part of hemoglobin, for example, consists of four polypeptides.

Insulin: is a hormone that decreases the concentration of glucose in blood, consists of two polypeptides.

Denaturation: is the disruption of protein structure by heating or other means.

BIOLOGICAL FUNCTIONS of PROTEINS

Structures: They compose the make up of hair, bones, and muscles. Keratin, for example, is a protein found in hair. By shape it is a fibrous protein and insoluble in water. Collagen is a protein found in ligaments and tendons.

Regulation: Some hormones are proteins. Hormones as chemical messengers are transported in the blood. They control body processes. Insulin for example, controls the concentration of glucose in the blood.

Transport: Hemoglobin is a globular protein and is soluble in water. It transports oxygen.

Contractions: Actin and Myosin are contractile proteins in muscles. There proteins slide together, thus shortening the muscle and producing muscle contraction.

ENZYMES

Catalysts: All enzymes, which are organic catalysts, are mainly proteins. The digestion of starch requires an enzyme. Every step of human metabolism requires an enzyme in order to function rapidly enough to support life. Metabolism is the sum of all chemical reactions that occur in the organism. A catalyst increases the rate of a chemical reaction, while remaining unchanged in the process.

The apoenzyme alone is the protein component. How enzymes function in different temperatures and pH environments is related to how proteins react in these settings. The cofactor is the non-protein part of the enzyme. Often this is an organic molecule, called the coenzyme, which can be a vitamin. In some cases the cofactor is a mineral (metal ion). Without its cofactor, an enzyme is not structurally complete and cannot function as a catalyst. The complete enzyme-cofactor complex is called a hole-enzyme. Vitamins and minerals are key ingredients.

The Substrate is the reactant that an enzyme changes into a product in a chemical reaction. An enzyme is specific for the substrate it changes. In the following reaction, catalase is the enzyme, hydrogen peroxide is the substrate, and water and oxygen are the products. REACTION (it will not work with starch)

$$2H_2O_2 \xrightarrow[\text{Catalase}]{} 2H_2O + O_2$$

It is H_2O_2 specific.

Class of Enzymes: are classified by the kinds of reaction they can catalyze. There are six major classes. Most of the names of the enzymes end in the suffix –ASE.

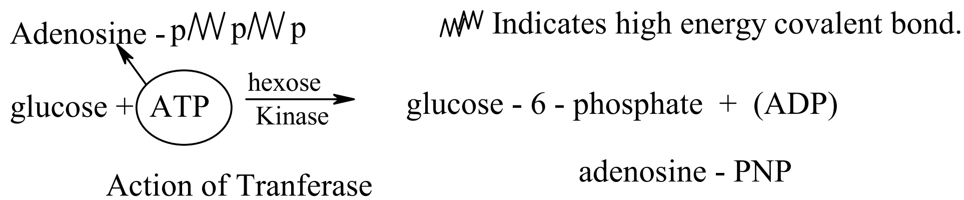
Hydrolases: Hydrolysis is the breaking of a chemical bond by the insertion of a water molecule. The chemical digestion of carbohydrates, lipids, and proteins into smaller molecules is an example of hydrolysis. Example: Salivary amylase is the hydrolase for digesting starch (polysaccharide) into maltose (disaccharide). Starch is the substrate and maltose is the product. The chemical changes occur when starch is digested in the oral cavity of the human body.

Isomerases: Isomers are compounds with the same molecular formula but different structural formula.

An isomerase is an enzyme that can convert one isomer into another.

Oxydoreduotases: Oxidation is the loss of hydrogen (or electron) from a substrate. Reduction is the gain of hydrogen (or electron). These two kinds of reactions occur together. Often another molecule connects these two kinds of reactions. NAD (Nichotinamide Adenine Dinucleotide), for example accepts hydrogen from a substrate during oxidation and delivers hydrogen to another substrate during reduction.

Ligases: Ligate means to tie together. A ligase bonds two substrate molecules together, building a larger molecule. The molecule ATP (adenosine triphosphate) provides energy to build the larger molecule.



Action of Tranferase

Lyases: Lysis is a breakage. A lyase catalyzes the breakage of a small molecule away from a larger one. Often this reaction is reversible and the same lyase catalyzes the attachment of the smaller molecule to the larger molecule.

Transferases: These enzymes transfer a specific group from one molecule to another. For example, hexose kinase is a transferase that removes the terminal phosphate of ATP. The terminal bond stores high energy. ATP is changed into ADP (adenosine diphosphate). The enzyme transfers this phosphate group to glucose to form glucose-6-phosphate. This is the first step in cells to metabolize glucose for energy.

MECHANISM of ENZYME ACTION

The action of an enzyme is specific. The substrate binds to an enzyme at an active site. The site occupies only a small fraction of the total area of the enzyme and is determined by amino-acid sequence of the enzyme. The shape of the active site of the enzymes and substrate are complementary.

Models of Action: The combination of substrate and enzyme is similar to how a key (substrate) fits into a lock (enzyme). This interaction was originally called the lock and key model. Enzyme specificity is related to the complimentary shapes of the enzyme and substrate molecules. Each substrate, or key, fits into a specific enzyme or lock.

The Induced-Fit Model is a modern interpretation of the interaction of enzymes and substrate. It recognizes that these molecules are not rigid; they are flexible. As they combine, each molecule induced the proper fit of the other one. AN enzyme, for example, can conform to the shape of the substrate. As it does this it places a strain on the chemical bond, in the substrate. This can chemically change the substrate.

Substrate Interactions: When the enzyme and substrate combine, they form an intermediate combination, the enzyme substrate complex. They are attracted by several kinds of bonds, including ionic attractions and hydrogen bonding. This combo forces the substrate into a less stable shape. This breaks some chemical bonds in substrate and forms new ones (products).

Each enzyme has a turnover number: the number of substrate molecules it changes into product per unit of time. For example, its turnover number is 10, if it converts 10 substrate molecules into product per second.

Chemical reactions have an energy barrier or energy of activation, that must be overcome in order for reaction to occur. By introducing a strain on the chemical bonds in the substrate, an enzyme lowers the activation energy barrier. This increases the rate of the reaction. The enzyme acts as a catalyst.

Enzymes require certain conditions to function optimally.

Temperature: Enzymatic reactions have an optimum temperature. As the temp. increases, the reaction rate increases to about 37 degrees centigrade. As temp. goes above 37 degrees centigrade, the reaction rate gradually decreases.

As the temp. increases to 37 degrees centigrade, the motion of reacting molecules also increases. This increases the reaction rate. However, at higher temp., the protein part of the enzyme denatures. Therefore the enzyme is disrupted and looses its activity. Most enzymes loose the catalytic ability at 50 to 60 degrees centigrade. 37 degrees centigrade is the normal temp. of human body. So you can see that enzymes can work as catalysts at optimum level.

pH: Each enzyme has a unique pH that is optimum.

Salivary Amylase	pH=7 in oral cavity
Pepsin	pH=2 (acid) in the stomach
Trypsin	pH=8 (base) in the small intestine

Its enzymatic activity continues the chemical breakdown of dietary proteins.

Enzyme/Substrate Concentration

In the substrate concentration is higher compared to the enzyme concentration, the reaction rate will double each time the enzyme concentration is doubles. This pattern will occur until all of the enzyme molecules are changing the substrate.

If the enzyme concentration is higher compared to the substrate, the reaction rate will increase as the substrate concentration is increased. More and more enzyme molecules will convert the substrate. Eventually, the enzyme will become saturated, a condition in which all the enzyme molecules are occupied with substrate. Increasing the substrate beyond the saturation point will not increase the reaction rate.

Competitive Inhibition: This occurs if a molecule that is structurally similar to a substrate also combines with its specific enzyme at its active site. This similar molecule competes with the substrate for binding to the enzyme. As fewer enzymes are available for the substrate, there is a decrease in rate of reaction. Increasing the substrate concentration will improve the rate.

Non-competitive Inhibition: This occurs when a molecule that is not similar to a substrate with its specific enzyme. This binding changes the shape of the enzyme at its active site and makes it less effective. Its activity is inhibited. Here more substrate has no effect on the reaction rate.

Irreversible Inhibition: The enzyme forms a strong unbroken bond with the inhibitor. The inhibitor can be a toxic metal such as lead. The shape of the active site of the enzyme is altered irreversibly. This inhibits future activity of the enzyme.

Feedback Control: This occurs with a series of steps in a metabolic pathway. An enzyme catalyzes each step. In the following pathway the last product, Z, can accumulate and feedback to the first enzyme, E_1. It inhibits the activity of this enzyme. This control slows down the additional production of Z. REACTION

$$W \xrightarrow{E_1} X \xrightarrow{E_2} Y \xrightarrow{E_3} Z$$

In some cases of feedback control, the last product stimulates the activity of the enzymes at the beginning of the metabolic pathway. This increases product formation.

Allosteric Control: A substance called a regulator combines with an enzyme and changes its shape.

Positive—increases activity

Negative—regulator decreases the activity

VITAMINS: are small organic molecules that are needed in the diet in trace amounts.

The water-soluble vitamins (B&C) are a part of the coenzyme structure of enzymes. The fat-soluble vitamins (A, D, E & K) also have important metabolic function.

Biotin (B vitamin) conenzyme involved in removal of carboxylic groups.

Folic acid (B vitamin) is a coenzyme in amino acid and nucleic acid metabolism.

Niacin (B vitamin) is a part of the coenzyme NAD, which transports hydrogen for oxidation and reduction.

Vitamin B1 (thiamin) is a coenzyme involved in the removal of carboxylic groups.

Vitamin B2 (Riboflavin) is a part of the coenzyme FAD (Flavin Adenine Dinucleotide), which transports hydrogen for oxidation and reduction.

Vitamin B6 (pyridoxine) is a coenzyme involved in the metabolism of lipids and amino acids.

Vitamin B12 (cobalamine) is a coenzyme involved in the metabolism of nucleic acid.

Vitamin C transports H ions and is antioxidant.

Vitamin A is a component in making a visual pigment in the rods of the retina of the eye.

Vitamin D is needed for the retention of Calcium and Phosphorous in the body. These minerals are needed for bone development.

Vitamin E preserves fatty acids. It is antioxidant.

Vitamin K needed to make protein for blood clotting.