Biomacromolecules

We all know that molecules make up every substance on the planet. Even in our bodies, our cells produce molecules. These molecules are called biomolecules. And the more complex and larger biomolecules are called biomacromolecules. Let us learn more about them.

Biomacromolecules

Biomolecules or biological molecules are substances which are produced by the cells of the body and are found in living organisms. Biomolecules are broadly classified into two categories based on their size:

- Biomicromolecules
- Biomacromolecules

Biomacromolecules are biomolecules which have a large size of 800 to 1000 daltons, high molecular weights and complex structures. They are biological polymers of different simple or monomeric units.

Examples of Biomacromolecules are Proteins, Nucleic Acids(DNA and RNA), Carbohydrates and lipids.

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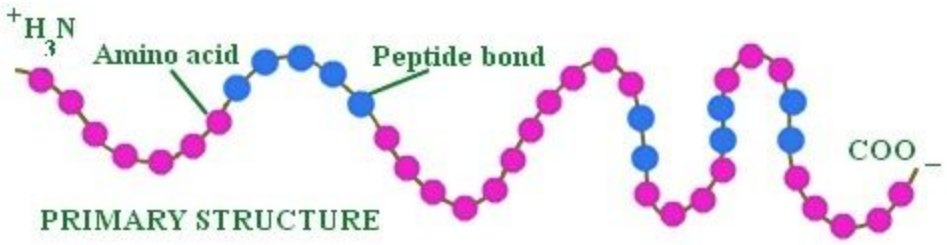
- Bond linking Monomers
- Enzymes
- Metabolic Basis For Living
- Nucleic Acids
- Polysaccharides
- Proteins

Let's look at each of these biomacromolecules in detail:

1. Proteins:

They are said to constitute the majority of biomolecules in a cell. Simpler units known as *amino* acids make up these biological polymers. They are linked together by covalent bonds known as peptide bonds. There are 21 different types of amino acids. Proteins are responsible for many functions in the body. Hence they are classified into different types based on their function e.g. structural proteins, enzyme proteins, transport proteins etc. Proteins have a

complex structure which divides into the Primary structure, Secondary structure and tertiary structure.



(Source: Wikipedia)

2. Nucleic Acids:

Smaller monomeric units that are known as *nucleotides* form nucleic acids. Nucleic acids regulate various functions in the body such as growth, reproduction and metabolism. These are parts which form the genes of an individual that is responsible for heredity. There are primarily two types of nucleic acids: DNA and RNA. DNA or deoxyribonucleic acid consists of nucleotides made up of four nitrogen bases namely adenine, guanine, thiamine and cytosine. Whereas adenine, guanine, cytosine and uracil(in place of thiamine) make up RNA or ribonucleic acid.

3. Carbohydrates:

These are biomolecules which primarily contain carbon, hydrogen and oxygen. Another name for them is *sugars*. Carbohydrates are classified into different classes depending on the number of monomer units present in them such as monosaccharides(single monomer unit), disaccharides(two monomer units), polysaccharides(multiple monomer units). Monosaccharides have other names e.g glucose, fructose. Glucose is the energy currency of the cells in animals and fructose is in plants. These sugars contain an aldehyde group or a keto group and the bond between these groups and an alcoholic group of another monomer unit is known as a glycoside bond or linkage. Polysaccharides are primarily of two types: structural and food storage.

4. Lipids:

Lipids are similar to carbohydrates in that they are made up of carbon, hydrogen and oxygen. But, they constitute a very heterogeneous group of substances. Unlike carbohydrates, on hydrolysis, lipids yield glycerol and fatty acids. The fatty acids are of two types: unsaturated and saturated fatty acids and all of them end with a carboxylic acid group. Lipids are also found in fats, oils, hormones and other structures such as the cell membrane. A complex form of lipids which is stored in the body as adipose tissue is known as triglycerides Lipids

are said to be ‘hydrophobic’ and are not miscible in water in contrast to the other biomacromolecules which are ‘hydrophilic’. Therefore, we can summarise to say that lipids function as energy-storage molecules, chemical messengers, and structural components of cells.

Solved Examples for You

Q: Which is the organic compound found in most cells?

a. Water
b. Glucose
c. Oxygen
d. Sodium Chloride

Solution: The correct answer is option “b”. Glucose is a monomer which is formed of six carbon atoms.

Bond Linking Monomers

Biomolecules are molecules that occur in living organisms. Based on their size and weight, they are classified into micromolecules and macromolecules. Macromolecules include proteins, nucleic acids, lipids, and carbohydrates. They are formed by polymerisation of

smaller units called as monomers. These monomeric units are held together by different kinds of bonds that depend upon the chemical nature of the monomeric unit. Let's find out more…

What kind of bonds link monomers?

As mentioned above, based on the macromolecule, the bonds linking monomers differ.

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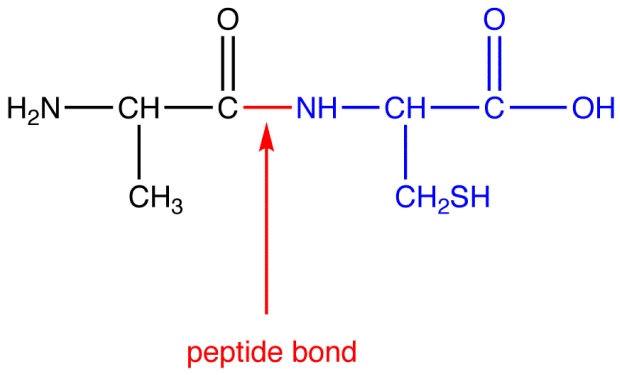
- Polysaccharides
- Proteins

Peptide Bonds

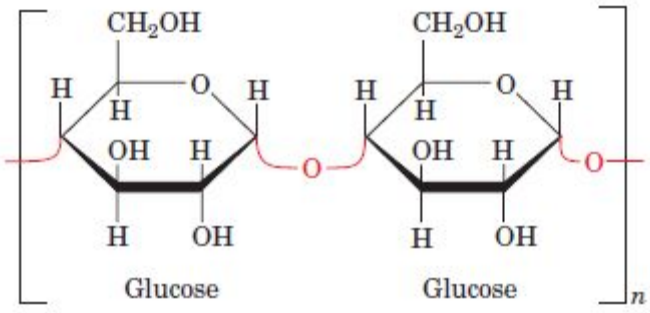
These bonds are found in proteins. Proteins are made up of amino acids that form polypeptide chains. Each amino acid has two functional groups- amine (-NH_2) group, and the carboxylic acid (-COOH) group. A peptide bond is formed (-CONH) between the

–NH_2 group and the –COOH group of any two adjacent amino acids and it leads to the elimination of a water molecule. The resultant product formed is an amide.



Glycosidic Bonds

These bonds are found in carbohydrates. When two adjacent monosaccharide units link to form disaccharides or polysaccharides, a glycosidic bond is formed. Whenever a glycosidic bond is formed, there is the elimination of a water molecule similar to the formation of a peptide bond. These reactions are called dehydration or condensation reactions. Glycosidic bonds are covalent chemical bonds that link ring-shaped sugar molecules to other molecules. Example: 1,4 glycosidic bonds are formed due to condensation reaction between a hydroxyl residue on carbon-1 and the anomeric carbon-4 on two monosaccharide units to form disaccharides.

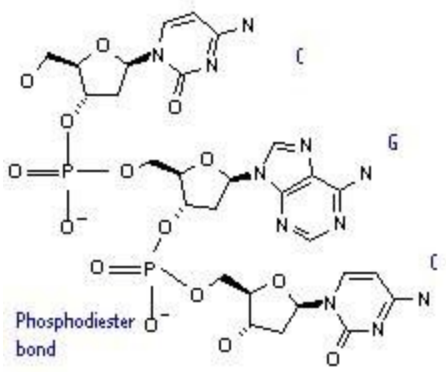


Glycosidic Bond

Phosphodiester Bonds

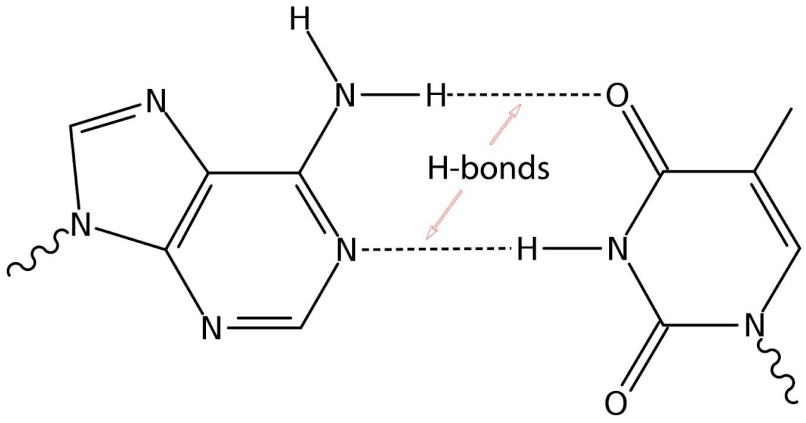
A phosphodiester bond is a covalent bond that is mainly found in nucleic acids(DNA and RNA) in which a phosphate group joins adjacent carbons through ester linkages. This bond also is formed by a condensation reaction between a hydroxyl group of two sugars and a phosphate group. During polymerization reaction of nucleotides, the hydroxyl group on the phosphate group attaches to the 3’ carbon of a sugar of one nucleotide to form an ester bond to the phosphate of another nucleotide. This leads to the formation of a phosphodiester bond with the elimination of a water molecule. DNA polymerases catalyze the formation of polynucleotide chains through the addition of new nucleotides. In the process of nucleotide addition that forms nucleotide chains, the 3’-end has a free hydroxyl group at the 3’-carbon of a sugar, and the 5’end has a free hydroxyl group or

phosphate group at the 5’-carbon of a sugar and the synthesis proceeds from the 5’ to the 3’-end.



Hydrogen Bonds

Once the nucleotides form nucleic acids, DNA and RNA formation occurs. DNA is double-stranded whereas RNA is single stranded. The two strands of the DNA are held together by weak hydrogen bonds that form between the nitrogen bases. The hydrogen bonds between the nitrogen bases are very specific. Adenine bonds only with thymine in the opposite strand by forming 2 hydrogen bonds, guanine forms 3 hydrogen bonds when it pairs with cytosine of the opposite strand. Two bonded nitrogenous bases from opposite strands constitute a base pair.



Solved Example for You

Q: What bonds are found in nucleic acids?

a. Peptide Bonds

b. Phosphodiester Bonds

c. Hydrogen Bonds

d. Both b and c

Sol: d. Both b and c

Nucleic acids DNA and RNA have both phosphodiester and hydrogen bonds linking them. The phosphate group of the DNA and RNA get linked with the adjacent carbon atoms to form an ester linkage leading to the formation of a phosphodiester bond. There exist weak hydrogen bonds between the nitrogen bases in DNA and RNA. Therefore, the correct option is d.

Enzymes

What are enzymes and what do they do in our bodies? Enzymes are basically proteins that are produced by living organisms to bring about certain metabolic and biochemical reactions in the body. They are biological catalysts that speed up reactions inside the body. Let's find out more about them.

What is the Structure of Enzymes?

Enzymes, as mentioned above, are biological catalysts. While they hasten or speed up a process, they are actually providing an alternative pathway for the process. But, in the process, the structure or composition of the enzymes remain unaltered.

Enzymes are actually made up of 1000s of amino acids that are linked in a specific way to form different enzymes. The enzyme chains fold over to form unique shapes and it is these shapes that provide the enzyme with its characteristic chemical potential. Most enzymes also contain a non-protein component known as the *co-factor*.

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- Nucleic Acids
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Types of Enzymes:

The biochemical reactions occurring in the body are basically of 6 types and the enzymes that bring about these reactions are named accordingly:

- Oxidoreductases: These enzymes bring about oxidation and reduction reactions and hence are called oxidoreductases. In these reactions, electrons in the form of hydride ions or hydrogen atoms are transferred. When a substrate is being oxidized, these enzymes act as the hydrogen donor. These enzymes are called dehydrogenases or reductases. When the oxygen atom is the acceptor, these enzymes are called oxidases.
- Transferases: These enzymes are responsible for transferring functional groups from one molecule to another. Example: alanine aminotransferase which shuffles the alpha-amino group between alanine and aspartate etc. Some transferases also transfer phosphate groups between ATP and other compounds, sugar residues to form disaccharides such as hexokinase in glycolysis.
- Hydrolases: These enzymes catalyze reactions that involve the process of hydrolysis.They break single bonds by adding water. Some hydrolases function as digestive enzymes because they break the peptide bonds in proteins. Hydrolases can also be a type of transferases as they transfer the water molecule from one compound to another. Example: Glucose-6-phosphatase

that removes the phosphate group from glucose-6-phosphate, leaving glucose and H_3PO_4.

- Lyases: These enzymes catalyze reactions where functional groups are added to break double bonds in molecules or where double bonds are formed by the removal of functional groups. Example: Pyruvate decarboxylase is a lyase that removes CO_2 from pyruvate. Other examples include deaminases and dehydratases.
- Isomerases: These enzymes catalyze the reactions where a functional group is moved to another position within the same molecule such that the resulting molecule is actually an isomer of the earlier molecule. Example: triosephosphate isomerase and phosphoglucose isomerase for converting glucose 6-phosphate to fructose 6-phosphate.
- Ligases: These enzymes perform a function that is opposite to that of the hydrolases. Where hydrolases break bonds by adding water, ligases form bonds by removal of the water component. There are different subclasses of ligases which involve the synthesis of ATP.

How do enzymes work?

For any reaction to occur in the universe, there is an energy requirement. In cases where there is no activation energy provided, a catalyst plays an important role to reduce the activation energy and carried forward the reaction. This works in animals and plants as well. Enzymes help reduce the activation energy of the complex molecules in the reaction. The following steps simplify how an enzyme works to speed up a reaction:

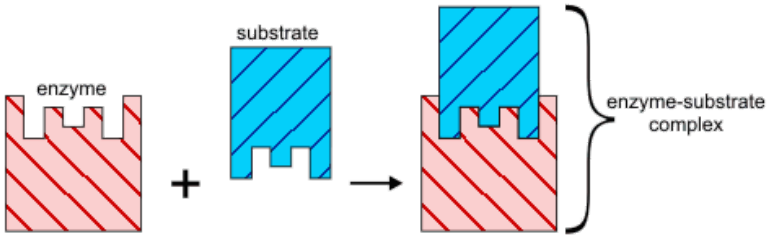
Step 1: Each enzyme has an ‘active site’ which is where one of the substrate molecules can bind to. Thus, an enzyme- substrate complex is formed.

Step 2: This enzyme-substrate molecule now reacts with the second substrate to form the product and the enzyme is liberated as the second product.

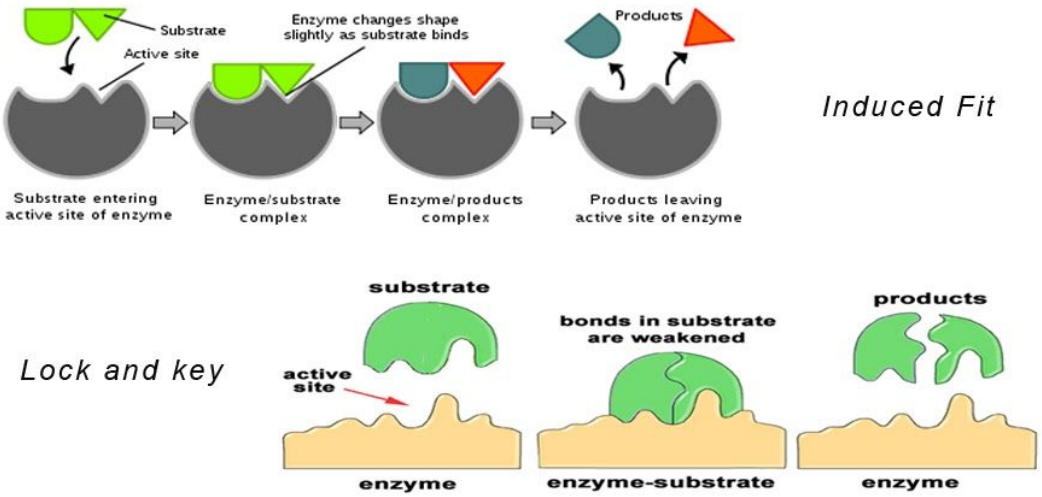
There are many theories that explain how enzymes work. But, there are two important theories that we will discuss here.

Theory 1: Lock and Key Hypothesis

This is the most accepted of the theories of enzyme action.



This theory states that the substrate fits exactly into the active site of the enzyme to form an enzyme-substrate complex. This model also describes why enzymes are so specific in their action because they are specific to the substrate molecules.



Theory 2: Induced Fit Hypothesis

This is similar to the lock and key hypothesis. It says that the shape of the enzyme molecule changes as it gets closer to the substrate molecule in such a way that the substrate molecule fits exactly into the active site of the enzyme.

What factors affect enzyme activity in the cell?

- Concentration of Enzymes and Substrates: The rate of reaction increases with increasing substrate concentration up to a point, beyond which any further increase in substrate concentration produces no significant change in reaction rate. This occurs because after a certain concentration of the substrate, all the active sites on the enzyme are full and no further reaction can occur.
- Temperature: With the increase in temperature, the enzyme activity increases because of the increase in kinetic energy of the molecules. There is an optimum level when the enzymes work at the best and maximum. This temperature is often the normal body temperature of the body. When the temperature increases beyond a certain limit, enzymes, which are actually made up of proteins, begin to disintegrate and the rate of reaction slows down.

- pH: Enzymes are very sensitive to changes in the pH and work in a very small window of permissible pH levels. Below or above the optimum pH level, there is a risk of the enzymes disintegrating and thereby the reaction slows down.
- Inhibitors: Presence of certain substances that inhibit the action of a particular enzyme. This occurs when the inhibiting substance attaches itself to the active site of the enzyme thereby preventing the substrate attachment and slows down the process.

Solved Example for You

Q: An enzyme acts by?

a. Increasing the energy of activation

b. Decreasing the energy of activation

c. Decreasing the pH

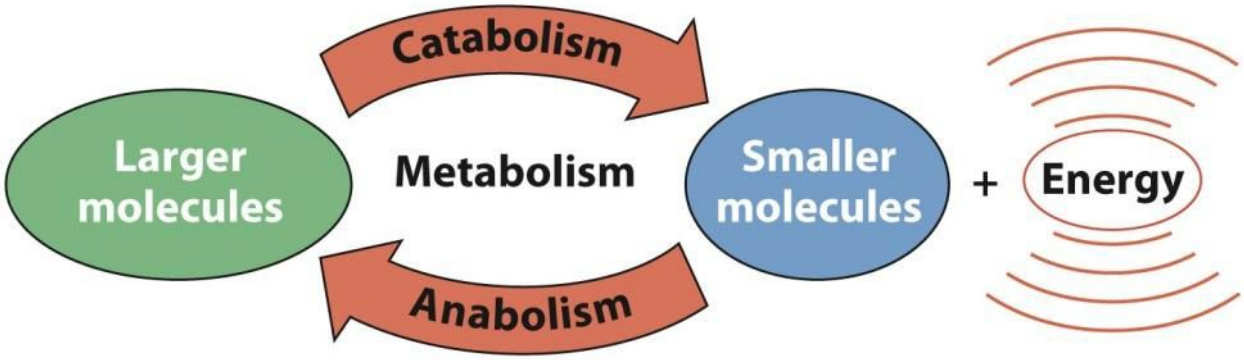
d. Increasing the pH

Sol: a. Increasing the energy of activation

The reactants do not undergo chemical change automatically. They do so in the transition state. Transition state has more free energy than reactants or products. The inability of reactants to undergo change due to the requirement of extra energy for converting them to transition state is called as ‘Energy Barrier’. The energy required to overcome energy barrier is called as ‘Activation Energy’.

Metabolic Basis For Living

A collection of chemical reactions that takes place in the body’s cells that convert the food we eat into the energy needed to power everything we do, from moving to thinking to growing is called as metabolism. It is the basis of living as without metabolism, our body will not be able to function. Let’s find out more.



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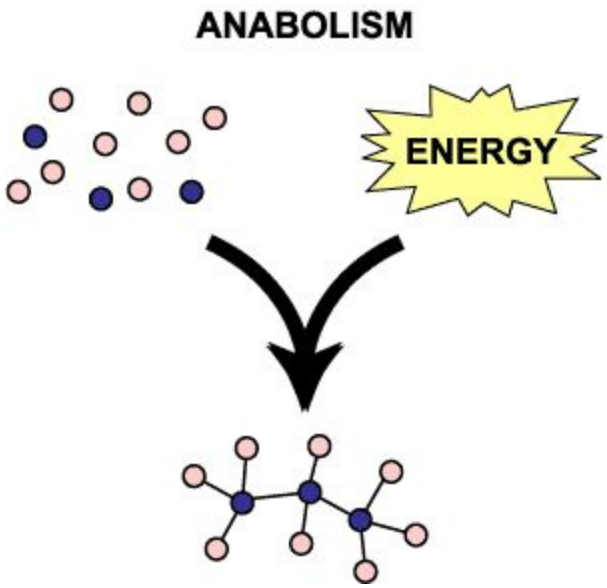
What phases does metabolism involve?

The process of metabolism occurs in two phases namely anabolism and catabolism.

Anabolism



Involves reactions that build up complex molecules from simpler ones.

Monosaccharides form polysaccharides by glycosidic bonds, amino acids form proteins by peptide linkages, nucleotides form nucleic acids by phosphodiester bonds.Anabolic reactions commonly are condensation reactions where water is the by-product of the

reaction.The purpose of an anabolic reaction is to form complex compounds. It absorbs energy in this process and so is an endergonic process. It is the process of anabolism that creates new cells, muscles, and other tissues.

Example of an anabolic process: Gluconeogenesis

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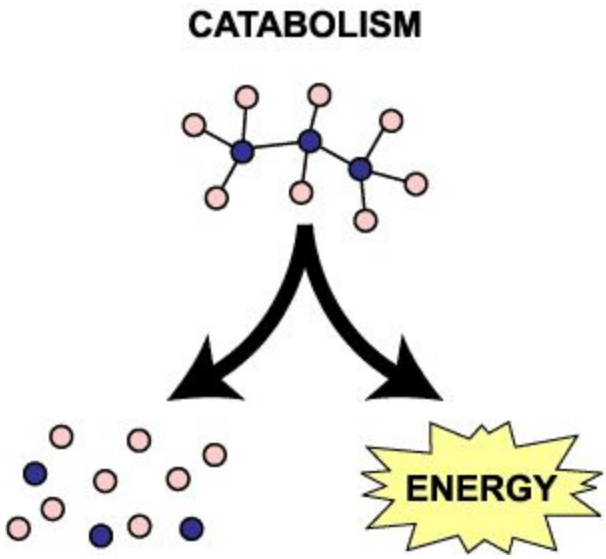
Catabolism



Catabolism is the breakdown of complex molecules into simpler molecules. This occurs by the process of hydrolysis where macromolecules are broken down into their respective monomeric units. Hydrolysis reactions require the consumption of water molecules to break the bonds within the polymer. Unlike an anabolic reaction, catabolism is exothermic where heat is released.

Example of a catabolic process: Glycolysis.

It is important to note that both anabolic and catabolic processes do not occur in isolation and are always linked with one another.

Important metabolic processes:

- Digestion: This metabolic process begins with the ingestion of food from the mouth. It travels through the oesophagus to the stomach, the small intestine and the large intestine. From the time it is ingested, the food is subjected to various physical and chemical substances. The chemical substances that are released by different cells of the body are called enzymes. Enzymes are responsible for facilitating a metabolic reaction. Different enzymes from different glands in the digestive tract act on the food and eventually break it down into amino acids, fats, fatty acids and simple sugars all of which are needed to provide the body with energy and nutrients.
- Circulation: Once the food is broken down into simple absorbable monomeric units, these are transported into the blood to be circulated to other parts of the body for storage in the muscles, liver or as fat in adipose tissues.
- Excretion: this is the process where the waste products of metabolic reactions are eliminated from the body through urination, defecation, sweating, and breathing. The waste substances are produced as a result of the catabolic reactions. The organs that help in excretion are kidneys, intestines, skin, and lungs.

- Regulation of body heat: Apart from these three processes, the body performs one more important function- regulating the body temperature. The energy that is released after a catabolic reaction is accompanied by heat. This heat generated is responsible for keeping a steady body temperature at all times. The body has the potential to vary temperatures at different times based on the body's physiological and the environmental conditions.

Solved Example for You

Q: Which of the metabolic process breaks down complex substances into simpler ones?

a. Anabolism

b. Catabolism

c. Both a and b

d. neither of the above

Sol: b. Catabolism

Catabolism is a metabolic pathway that breaks down complex substances to simpler ones accompanied by the release of heat with water as a by-product.

Nucleic Acids

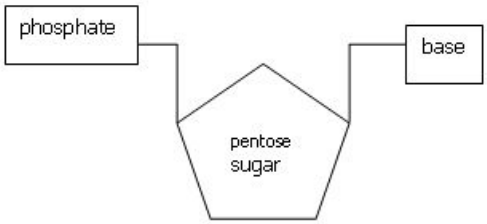
Have you ever come across ‘DNA match’ while watching a Crime Series? Well, DNA is a type of Nucleic acid. Nucleic acids are biomolecules that are the building blocks of an organism. They are the information carriers within each cell, which basically transfer genetic material from one generation to the next. Interesting? Let’s find out more.

What are the types of nucleic acids?

Nucleic acids are mainly of two types: DNA or Deoxyribonucleic acid and RNA or Ribonucleic acid. The other types of nucleic acids are tRNA, mRNA and rRNA.

What is the structure of these Nucleic Acids?

Nucleic acids are polymers which are made up monomer units called as nucleotides. Each nucleotide consists of three parts:



a. A nitrogen base(a base that contains N nitrogen atoms)
b. A five-carbon sugar
c. A Phosphate group

There are five nitrogen bases that are found in nucleic acids. Adenine, guanine, thiamin and cytosine are found in DNA, whereas, Adenine, guanine, uracil and cytosine are found in RNA. These nitrogen bases pair up very specifically and are held together by weak hydrogen bonds. Adenine always pairs up with thymine by two hydrogen bonds while guanine pairs up with cytosine with three hydrogen bonds.

Structure of DNA

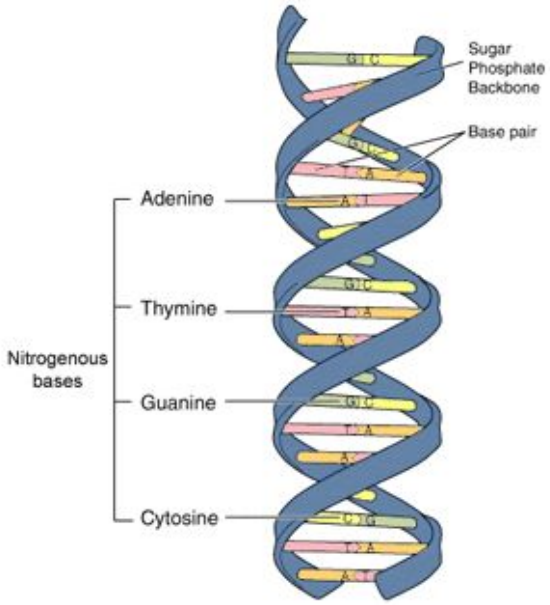
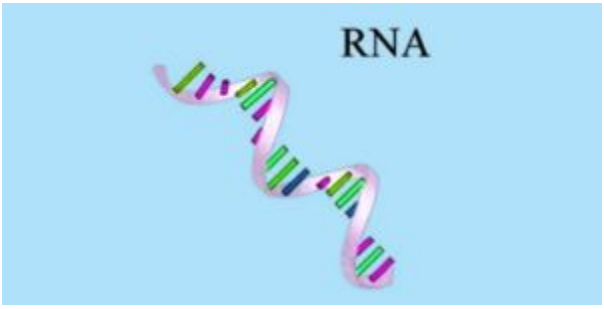


Image adapted from: National Human Genome Research Institute.

DNA has a double-stranded structure helical structure formed from two polynucleotide chains. Each of these chains is also helical in nature. The two helical chains which intertwine with each other are held together by the hydrogen bonds between the paired nitrogen bases. When the two helical chains intertwine, the hydrophobic nitrogen bases are on the inside while the phosphate groups on the outside.This hydrogen bonding between complementary bases on each strand provides a mechanism for the DNA replication and transmission of genetic information. DNA is present only in eukaryotic animals.

Structure of RNA



(Source: Wikipedia)

Unlike DNA, RNA is a single-stranded nucleic acid polymer. It has four nucleotides namely adenine, guanine, cytosine and uracil. During the process of DNA replication, RNA is the first intermediary that is formed. Where DNA is quite stable and the ideal genetic material, RNA is reactive in nature and is sensitive to oxidising agents. In DNA, the complementary base pairing occurs between both the strands but in RNA, the base pairing occurs with bases within the same strand. RNA is found as the genetic material in prokaryotes.

RNA are of different types depending upon their function:

1. Messenger RNA(mRNA): It helps to transfer the genetic information from the genes on the DNA to the ribosomes.
2. Ribosomal RNA(rRNA): This RNA forms the structural components of the ribosome. They play an active role in

recognizing conserved portions of mRNAs and tRNAs. They also assist with the catalysis of protein synthesis. In eukaryotes, rRNA genes are looped out of the main chromosomal fibres and coalesce in the presence of proteins to form a cell organelle called the nucleolus. The nucleolus is where the rRNA genes are transcribed and the early assembly of ribosomes takes place.

3. Transfer RNA(tRNA): t-RNA help to transfer amino acid residues from amino acid pool to the site of proteins synthesis i.e ribosomes. Specific tRNAs exist for each of the 20 amino acids that needed for protein synthesis. In a few cases, more than one tRNA for each amino acid is present.

Solved Example for You

Q: Which nitrogen base pairs up with Adenine?

a. Guanine

b. Thiamin

c. Uracil

d. Both b and c

Sol: d. Both b and c

Adenine pairs with both thiamin and uracil. Adenine forms two hydrogen bonds with thiamin in DNA and with uracil in RNA. So, the correct answer is option d.

Polysaccharides

Polysaccharides are complex biomacromolecules that are made up chains of monosaccharides. The bonds that form these chains are glycosidic bonds. Commonly found monomer units in polysaccharides are glucose, fructose, mannose and galactose which are simple sugars.

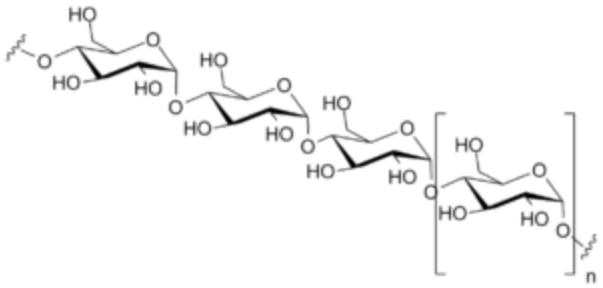
Types of Polysaccharides

Polysaccharides can be broadly classified into two classes:

- Homo-polysaccharides – are made up of one type of monosaccharide units. ex: cellulose, starch, glycogen.

- Hetero-polysaccharides – are made up of two or more types of monosaccharide units. ex. hyaluronic acid and they provide extracellular support for organisms.

Structure of Polysaccharides



All polysaccharides are formed by the same basic process where monosaccharides are connected via *glycosidic bonds*. These glycosidic bonds consist of an oxygen molecule bridging two carbon rings. The bond is formed when a hydroxyl group is lost from the carbon of one molecule, while the hydrogen is lost by the hydroxyl group of another monosaccharide. Because two molecules of hydrogen and one of oxygen are expelled, the reaction is a dehydration reaction. The structure of the molecules being combined determines the structures and properties of the resulting polysaccharide. A polysaccharide used for energy storage will give easy access to the constituent

monosaccharides whereas a polysaccharide used for support is usually a long chain of monosaccharides that form fibrous structures.

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Functions of Polysaccharides

Polysaccharides form a crucial part of cell function and structure.

- Storage polysaccharides: Polysaccharides such as starch and glycogen are called storage polysaccharides because they are stored in the liver and muscles to be converted to energy later for body functions. Starch is found in plants whereas glycogen is found in animals.

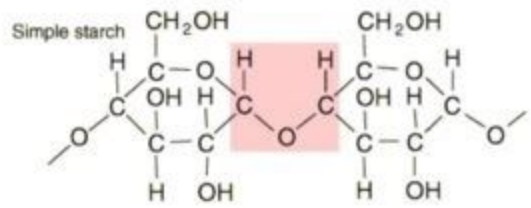
- Structural polysaccharides: Polysaccharides such as cellulose are structural polysaccharides which are found in the cell walls of plants. Another structural polysaccharide is chitin.

Read about Bond Linking Monomers here.

Important polysaccharides

Homopolysaccharides

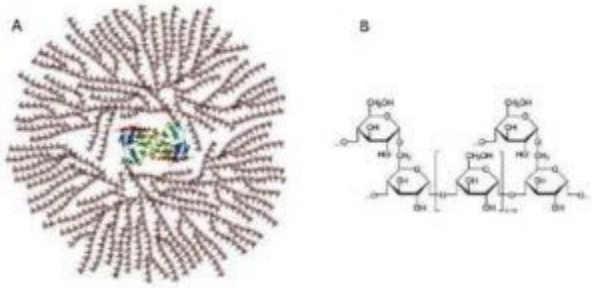
Structure of Starch



(Source: Wikipedia)

- Starch: It is the storage polysaccharide found in plant cells and exists in two forms: amylose is the helical form of starch comprised only of alpha-1,4 linkages and amylopectin that has

a structure like glycogen except that the branched alpha-1,6 linkages are present on only about one in 30 monomers.



(Source: Wikipedia)

- Glycogen: This polysaccharide is the polysaccharide found in animals to store energy and is composed of alpha-1,4-glycosidic bonds with branched alpha-1,6 bonds present at about every tenth monomer. It is mainly produced by the liver and muscles, but it can also be made during a process called *glycogenesis*.
- Cellulose: Is a structural polysaccharide that is found in the cell wall of plants and when consumed, it acts as a dietary fibre. Cellulose is said to be the most abundant organic molecule on earth. Wood, paper, and cotton are common forms of cellulose.

Heteropolysaccharides

These are found in different structural and functional roles in the human body.

- Hyaluronic Acid: Acts as a lubricant in the synovial fluid of joints
- Chondroitin Sulfate: It contributes to tensile strength and elasticity of cartilages, tendons, ligaments, and walls of the aorta.
- Dermatan sulfate: It is found mainly in the skin, and also is in vessels, heart, lungs. It may be related to coagulation and vascular diseases and other conditions.
- Keratan sulfate: Present in the cornea, cartilage bone and a variety of other structures as nails and hair.
- Heparin: Is present as an anticoagulant in the blood.

Another type of polysaccharides that are found in the human body is glycosaminoglycans or mucopolysaccharides that are formed by the endoplasmic reticulum. These mature in the Golgi apparatus. They

form important components of connective tissues and are found in collagen and elastin.

Solved Example for You

Q: Which is the storage polysaccharide that is found in plants?

a. Starch

b. Glycogen

c. Cellulose

d. Chitin

Sol: The correct option is “a”. The storage polysaccharide that is found in plants is starch. It is made up of two parts: amylose and amylopectin. They are made up of glucose monomers.

Proteins

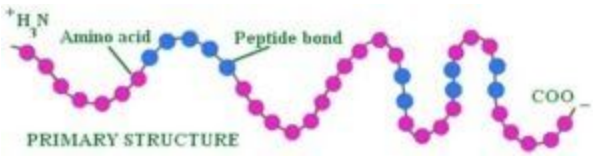
Here’s a fact that will boggle your mind. There is a retinal protein named after the cartoon character Pikachu! It is called Pikachurin. In

fact, proteins are known to have unique names. Proteins are complex biomolecules that are made up of smaller units known as amino acids. Let us learn about them in detail.

Structure of Proteins

Due to different rearrangement of amino acids, the structure of proteins divides into four types:

- Primary- the covalent linkages of the proteins



(Source: Wikipedia)

- Secondary- the linear peptide chains fold either into an alpha-helical structure(coiled) or a beta-pleated structure(sheets) which contain hydrogen bonds.

(Source: Wikipedia)

- Tertiary- The arrangement and interconnection of proteins into specific loops and bends forms the tertiary structures. This structure contains hydrogen, ionic and disulfide bonds.
- Quarternary- this structure is proteins containing more than one peptide chain.

Proteins are made up of smaller units known as amino acids and the bond linking them is known as a *peptide bond.* This bond is formed when the carboxyl group (-COOH) of one amino acid bonds with the amino group (– NH_2) of another amino acid releasing a molecule of water (H_2O). A peptide may be dipeptide, tripeptide, and polypeptide.

Classification of Proteins

Classification of proteins is done on the basis of the following:

- Shape
- Constitution
- Nature of molecules

On the basis of shape

- Fibrous protein(Scleroprotein): We can find these proteins in animals and are insoluble in water. Fibrous proteins are resistant to proteolytic enzymes and are coiled and exist in threadlike structures to form fibres. e.g. collagen, actin, and myosin, keratin in hair, claws, feathers, etc.
- Globular proteins: These proteins, unlike fibrous proteins are soluble in water. They are made up of polypeptides that are coiled about themselves to form oval or spherical molecules e.g. albumin, insulin, and hormones like oxytocin, etc.

On the basis of Constitution

- Simple proteins: These proteins are made up of amino acids only. e.g. albumins, globulins, prolamins, etc.

- Conjugated proteins: These are complex proteins that are combined with the characteristic of non–amino acid substance called as a prosthetic group. These are of following types:–
    - Nucleoproteins: Combination of protein and nucleic acid
    - Mucoproteins: Combination of proteins and carbohydrates (>4%)
    - Glycoproteins: Combination of proteins and carbohydrates(<4%)
    - Chromoproteins: Combination of proteins and coloured pigments.
    - Lipoproteins: Combination of proteins and lipids.
    - Metalloprotein: Combination of proteins and metal ions.
    - Phosphoprotein: Combination of proteins and phosphate group.
- Derived proteins: When proteins are hydrolyzed by acids, alkalies or enzymes, the degradation products obtained from them are called derived proteins.

On the basis of nature of Molecules

- Acidic proteins: They exist as anion and contain acidic amino acids. e.g. blood groups.
- Basic proteins: They exist as cations and are rich in basic amino acids e.g. lysine, arginine etc.

Functions of Proteins

- Structural functions: Proteins are called as the building blocks of the body. They are an essential component of various structures in the cell and tissues. We also find these proteins in the outer membrane of all cells in the human body. We can also find structural proteins in hair, skin, and muscles. Proteins often act to strengthen these structures. Proteins working together can allow movement within the body, such as contraction of muscles and movement of food through the digestive system etc. They are needed for the growth, development, healing, and repair of tissues.
- Protective: Proteins are the main constituent of antibodies that protect our body against antigens and pathogens thus preventing infections.

- Hormonal regulation: Hormones are majorly composed of proteins. Hormones play a vital role in regulating muscle mass, sex hormones, and growth and development.
- Enzymes: Proteins are called as biological buffers because they, as enzymes, regulate many different biochemical reactions that are occurring in the body.

Solved Example for You

Q: Peptide bond form between two amino acids through

(a) Addition of water (b) Loss of water

(c) Decarboxylation (d) Deamination

Sol. (b) loss of water.

The formation of a peptide bond is a dehydration reaction where a molecule of water is released. Therefore, the correct answer is the option (b).