# Module 2- Macromolecules of the cell

## For each of the six biological polymers listed, indicate which of the properties apply. Each polymer has multiple properties, and a given property may be used more than once.

Polymers:

(a)  Cellulose

(b)  Messenger RNA

(c)  Globular protein

(d)  Amylopectin

(e)  DNA

(f)  Fibrous protein

Properties  
1. Branched-chain polymer  
2. Extracellular location  
3. Glycosidic bonds  
4. Informational macromolecule

5. Peptide bond  
6. beta linkage  
7. Phosphodiester bridge  
8. Nucleoside triphosphates  
9. Helical structure possible

10. Synthesis requires a template.

A: 2-3-6

B: 4-7-9-10

C: 4-5-9-10

D: 1-3-9

E: 4-7-9-10

F: 4-5-9-10

## Protein Bonds

|  |  |  |
| --- | --- | --- |
| **Bond** | **Amino Acids** | **Levels of Structure** |
| Peptide | All | Primary |
| Hydrogen | All | Secondary |
| Disulfide (covalent) | Cysteine | Tertiary |
| Hydrogen | All | Secondary |
| Hydrophobic | Leucine | Tertiary, Quaternary |
| Ionic | Glutamate | Tertiary, Quaternary |

## Features of Nucleic Acids

For each of the following features of nucleic acids, indicate whether it is true of DNA only (D), of RNA only (R), of both DNA and RNA (DR), or of neither (N).

(a)  Contains the base uracil. R

(b)  Contains the nucleotide deoxythymidine monophosphate. N

(c)  Is usually double-stranded. D

(d)  Is a polymer. DR

(e)  Contains a phosphate group. DR

(f)  Is an inherently directional molecule, with an N-terminus on one end and a C-terminus on the other end. N

## Wrong Again. For each of the following false statements, change the statement to make it true, and explain why it is false as written:

(a) Nucleic acids are polymers consisting of chemically ~~identical~~ repeating nucleotide monomers.

(b)  A protein may have an alpha helical secondary structure. An alpha helix is spiral in shape and stabilized by covalent bonds between the NH group and the CO group in the adjacent polypeptide backbone.

(c)  Whereas a protein can be denatured by high-temperature treatment, extremes of pH both of which disrupt ~~generally have no effect on~~ tertiary structure.

(d)  Nucleic acids are synthesized from monomers that contain a high. Energy phosphodiester bond. They are already activated and do not require carrier molecule.

~~are activated by linking them to a carrier molecule in an energy-requiring reaction.~~

(e)  The disaccharide sucrose comprises two monosaccharide ~~glucose~~ monomers covalently linked together.

(f)  A beta-pleated sheet is an extended sheet-like conformation with the R groups of successive amino acids jutting out on the alternating ~~same~~ side of the sheet.

(g)  It is not easy to predict the final folded structure of a protein from its amino acid sequence using today’s powerful supercomputers.

## Telling Them Apart. For each of the following pairs of molecules, specify a property that would distinguish between them, and indicate two different tests that could be used to make that distinction:

(a)  The protein insulin and the DNA in the gene that encodes insulin

Phosphodiester bonds in DNA but not in protein.

(b)  The DNA that encodes insulin and the messenger RNA for insulin

Presence of purine thymine or pentose deoxyribose in DNA but not in RNA.

(c)  Starch and cellulose

Starch repeating unit: alpha-D glucose Cellulose repeating unit: beta-D glucose.

Use the enzyme amylase that can digest alpha (1-4) but not beta (1-4).

(d)  Amylose and amylopectin

Starch occurs in branched amylose alpha (1-6) glycosidic bonds or unbranched amylopectin alpha(1-4) glycosidic bonds.

(e)  The monomeric protein myoglobin and the tetrameric protein hemoglobin

Presence of 4 subunits in hemoglobin but not in myoglobin.

(f)  A triacylglycerol and a phospholipid with a very similar fatty acid content

Presence of glycerol but absence of phosphorus in triacylglycerol.

(g)  A glycolipid and a sphingolipid

Carbohydrate group (glycolipid) instead of phosphate group. (sphingolipid).

(h)  A bacterial cell wall polysaccharide and chitin

# Module 3 – Introduction to Cells and Organelles

**Describe and similarities and differences between archaea, bacteria and eukaryotes**

* They came from the same ancestor cell.
* Eukaryote cell has a plasma membrane, a nucleus, membrane bounded organelles and cytosol supported by the cytoskeleton.
* Main distinction between prokaryote (bacteria and archaea) and eukaryote cell (plant, animal, fungi, algae and protozoa) types is the membrane-bound nucleus of eukaryotic cells.
* Eukaryotic DNA is organized into linear molecules complexed with large amounts of histones.
* Bacterial DNA is present as a circular molecule associated with few proteins.
* Archaeal DNA is circular and complexes with proteins similar to eukaryotic histone proteins.



**Discuss the 3 main limitations on cell size**

1. Need to maintain adequate surface area to volume ratio

Larger cells have proportionally smaller surface areas.

Beyond a certain threshold of this ratio, large cells do not have enough surface area to accommodate the need for nutrients and release of enough wastes.

Cells like cells lining the small intestine have characteristics like fingerlike projections that increase the surface area.

1. Rate of diffusion of proteins decreases as the size of molecules increases

Eukaryotic cells avoid the problem by using carrier proteins or vesicles.

1. Need for adequate local concentrations and essential substances

To maintain the necessary concentration of a specific molecule, number of molecules must increase with cell volume. An effective solution to the concentration problem is the compartmentalization of activities within organelles.

**Discuss the role of plasma membrane**

**The main role: ensures that cell contents are retained.**

* Serves as a permeability barrier between the cell and outside environment.
* Localizes and organizes different functions within the cell.
* Facilitates transport of different molecules within the cell between organelles and also its outside environment: nutrients, ions or water, and wastes.
* Helps the cell to perceive its external environment and respond appropriately thru receptor mediated signal transduction, transmission of signals from outer surface to cell interior.
* Mediate interactions with other cells.

**List several eukaryotic organelles and their basic functions**

* Mitochondrion

Site of aerobic respiration

Provide energy to cell by oxidation of sugars and other fuel molecules.

* Rough ER

Has ribosomes either on the side of the membrane facing the cytosol or free in the cytosol which synthesize proteins; some of them to be transported out of the cell.

* Smooth ER

Involved in the synthesis of lipids and steroids such as cholesterol and steroid hormones derived from it.

* Golgi Complex

The post office: involved in processing and packaging secretory vesicles which are then passed to other components of the cell.

* Lysosome

Storage for hydrolase enzymes capable of digesting any biological molecules.

**Describe the Endosymbiont Theory**

Suggests that mitochondria and chloroplast evolved from the same ancestor bacteria. This is based on similarities in size, membrane lipid composition, rRNA sequences, presence of circular DNA molecules, and bacterial type ribosomes, and ability to reproduce autonomously.

**Describe the eukaryotic cytoskeleton and its structural components**

Eukaryotic cytoskeleton is an array of fibers giving structure to the cytoplasm giving the cell its shape. In addition, it plays a role in cell movement and cell division.

A 3-D array of interconnected microfilaments, microtubules, and intermediate filaments.

A microtubule is a cylinder of protofilaments with a hollow center (lumen). Each protofilament is a linear polymer of tubulin with polarity. Tubulin consists of two proteins: alpha-tubulin and beta-tubulin.

Microfilaments are polymers of F-actin strands twisted in a helical structure. F-actin polymers are made of G-actin. Microfilaments have a polarity.

Explain key characteristics of prions, viruses, and bacteriophages

* **Viruses** are small and consists of a coat of protein surrounding a core, containing DNA or RNA. They have no cytoplasm, organelles or ribosome and infect cells, using their machinery to produce more viruses. When they infect bacteria, they are called bacteriophages or phages. They are responsible for many diseases, also important tools as research tools.
* **Prions** are infective particles which induce existing, properly folded proteins to convert into disease-associated prion form, and they induce amyloid plaques.
* A **bacteriophage** exists in theory for every type of bacterium, can be highly specific for their hosts.

## Module 4 – Enzymes

**Describe the basic properties of the enzymes**

<https://infinitabiotech.com/blog/properties-of-enzymes/>

* Act as biological catalyst by increasing the rate of reactions without increasing the temperature.
* Are proteins.
* Have a globular shape.
* A complex 3-D structure.
* They are depleted and remain unchanged at the end of a reaction.
* Specificity.

**Explain why enzymes are good biological catalysts**

* They increase the rate of a reaction by lowering the activation energy requirements, without increasing the temperature.
* They change the rate at which equilibrium is achieved without changing its position.
* Most of the enzyme catalyzed reactions are reversibility.

**Explain why enzymes only work on a single substrate**

Because of the precise chemical fit between the active site of the enzyme and its reactants, enzymes are very specific.

Two models to explain this specificity: lock-and-key and induce-fit (conformational change of the enzyme).

**Explain that enzymes function by lowering the activation energy for biochemical reactions**

Before a chemical reaction happens, there is an activation energy, which is the minimal amount of energy the reactants must contain before collisions between them will be successful in giving rise to products. Enzymes lower the activation energy ensuring that a higher proportion of molecules possess enough energy to undergo reaction without increasing the temperature.

**The Need for Enzymes. You should now be in a position to appreciate the difference between the thermodynamic feasibility of a reaction and the likelihood that it will actually proceed.**

1. Define the terms activation energy and transition state.

**Activation energ**y: minimum amount of energy reactants must contain before a chemical reaction happens.

**Transition state**: chemical state which separate the state in which molecules exists as reactants and the state in which they exist as product.

1. Describe the effect of heat on enzyme activity and explain why using heat to alter enzyme activity is problematic in cells.

Reaction rate is the highest at the optimal temperature (370c for human enzymes). Above this optimal temperature, enzyme activity decreases sharply until the enzyme is denatured (inactive).

1. An alternative solution is to lower the activation energy barrier. What does it mean in molecular terms to say that a catalyst lowers the activation energy barrier of a reaction?

A catalyst by lowering the activation energy requirements, allows a higher proportion of the molecules to possess sufficient energy to undergo reaction without elevation of temperature.

1. Organic chemists often use inorganic catalysts such as nickel, platinum, or cations in their reactions, whereas cells use proteins called enzymes. What advantages can you see to the use of enzymes? Can you think of any disadvantages?

**Advantages**: specificity and more exact control.

**Disadvantages**: more susceptible to inactivation by heat, pH, substrate concentration and; also, more energy needed to be expanded to synthesize the enzyme molecules.