Different Functions of Proteins in the Biological System

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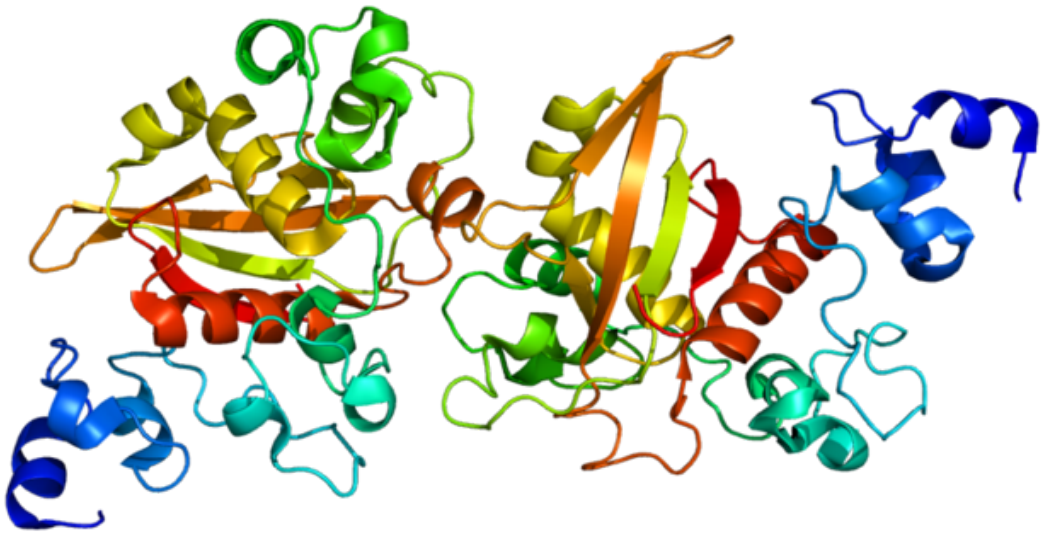
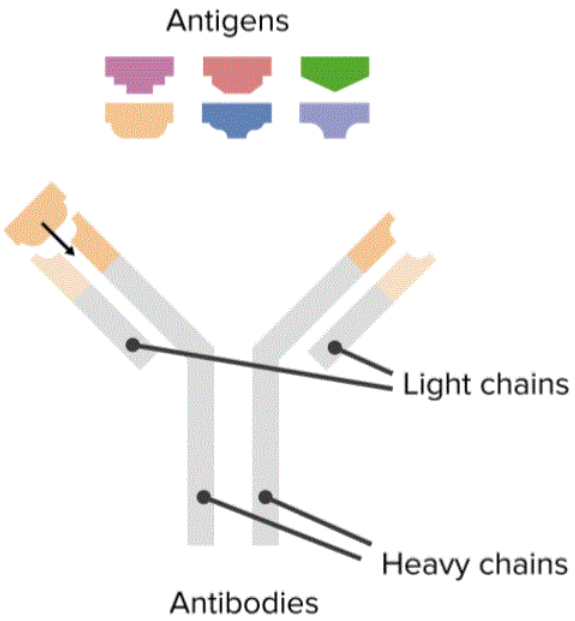
Proteins are complex biomolecules that serve a number of essential functions related to the formation, function, and regulation of the body's cells, tissues, and organs. Proteins play many important biological roles as enzymes, hormones, antibodies, and structural components of cells. Carrier proteins assist in the transport of substances within the body. In this article, the different functions of proteins in the body are highlighted. Specifically, antibodies and their role in the immune response, proteins acting as catalysts for biological reactions, proteins involved in gene regulation, and proteins that transport materials are discussed in this article.



Antibodies

Antibodies are glycoproteins that uniquely bind to a protein or other molecules. They belong to a family of globular proteins called immunoglobulins. They are antigen-reactive proteins that are present in the immune serum, called antiserum. They are produced after a vertebrate host is exposed to a given antigen, called an immunogen.



“Antibodies. Proteins of the Immune System” Image created by Lecturio

The main function of an antibody is to bind to foreign molecules. Most antibodies are structurally similar because of their Y-shaped molecules; however, each antibody is unique because they have different amino acid sequences. The structural properties of antibodies enable it to exhibit binding versatility, binding specificity, and biological activity. An individual can produce hundreds of thousands of antibodies.

This enables him to detect the presence of foreign or non-self molecules inside it. The Y-shaped arm of the antibody defines to which molecules they will interact. It also defines what response will be made by the cell. Possible responses include complement-mediated lysis, enhanced phagocytosis, and or occurrence of allergic reactions. These responses occur once antibodies bind to the antigens. Humans are able to express five types of antibody or immunoglobulin classes.

The five classes are:

- IgM
- IgA
- IgG
- IgE
- IgD

These five classes may differ in their physicochemical properties which include charge, solubility, and size. This variability is caused by the differences in the amino acid sequences they have. They may also differ in their serologic properties or the way they react with antigens. The greatest factor that divides the antibodies into five classes is their differences in their behavior as antigens.

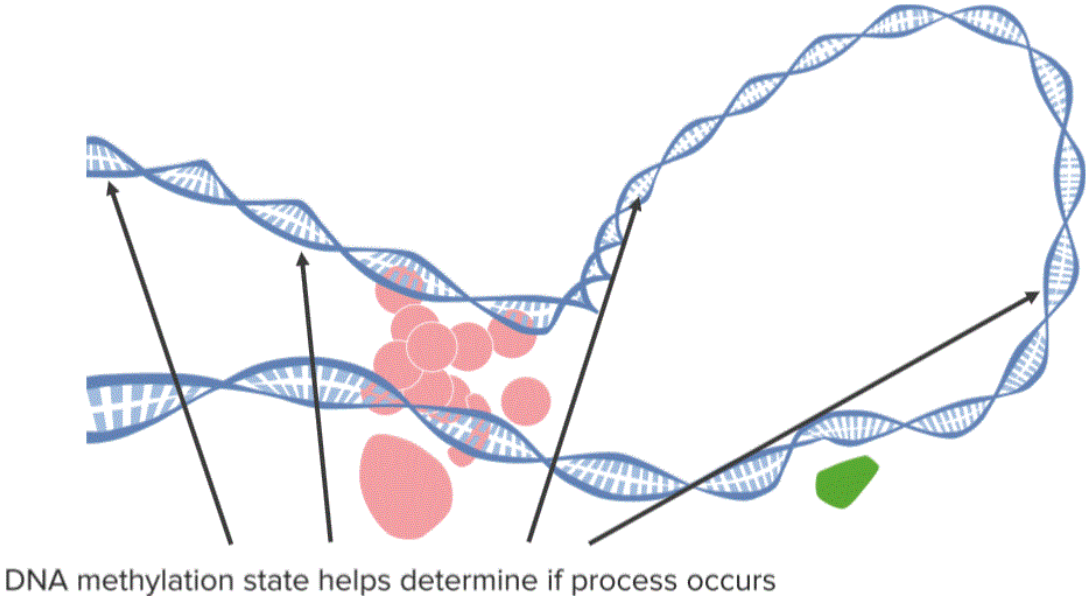
IgG is the antibody induced by protein antigens and constitutes 80% of the antibody in the serum. Human IgA, on the other hand, is the predominant class of antibodies in extravascular secretions. It consists of 13% of the antibodies in human serum. Human IgM is the antibody induced by polysaccharide antigens. It is the first antibody that appears during an immune response. It is also the first one to develop in the fetus. IgD is the antibody that remains membrane-bound. It is one of the main receptors on mature B cells.

It regulates the cell’s activation. Human IgE is the antibody that binds through its Fc part of mast cells or basophils. When the mast cell and the basophil are exposed to the same antigens, it triggers allergic reactions.

Gene Expression

Gene expression is the process by which genetic instructions are processed to produce specific gene products. Common products include proteins that are essential for different biological activities. This includes enzymes, hormones, and receptors. To prevent the overproduction of certain gene products, different control mechanisms are installed in the cells. Transcriptional regulators are proteins that recognize certain areas in the DNA.

When these transcriptional regulators bind to the DNA, it acts as a switch that regulates the transcription of a distinct set of genes. Transcription switches also allow cells to respond to changes in the environment. Transcription switches may act either as repressors or activators. Repressors are proteins that switch genes off. On the other hand, activators are proteins that promote or activate genes.



“Gene Expression. Controlling the Expression of Cellular Proteins” Image created by Lecturio

Catalysis

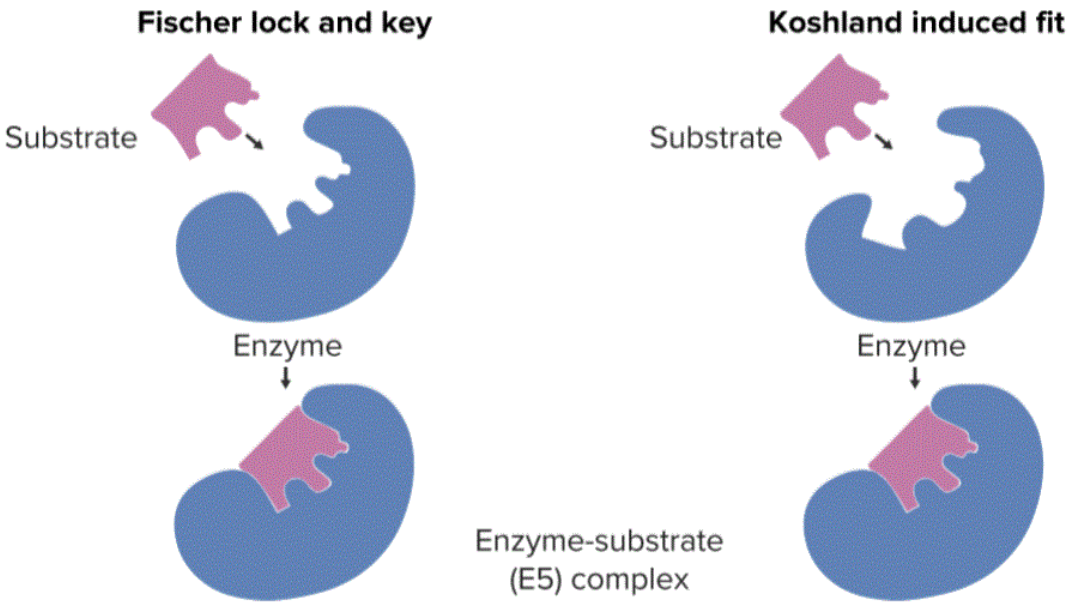
Another important function of proteins is catalyzing a number of reactions. Most of the metabolic reactions in biological systems involve the use of enzymes. In fact, these reactions will not occur if an individual does not have the enzyme to catalyze the reaction. Enzymes are highly specific that they usually catalyze a single reaction or very few related ones.

Enzyme	Turnover number (per second)
Carbonic anhydrase	699.000
3-Ketoesteroid isomerase	280.000
Acetylcholinesterase	25.500
Penicillinase	2.000

Lactate dehydrogenase	1.000
Chymotrypsin	100
DNA polymerase I	15
Tryptophan synthetase	2
Lysozyme	0.5

Differences in the structure of the active sites of an enzyme determine its specificity to specific substrates or reactants. Enzymes enable the lowering of the activation energies of biological reactions. During the reaction, enzymes undergo structural changes to not accommodate other substrate molecules. After the reaction, they will return to their original state and are ready to interact with a new substrate molecule.

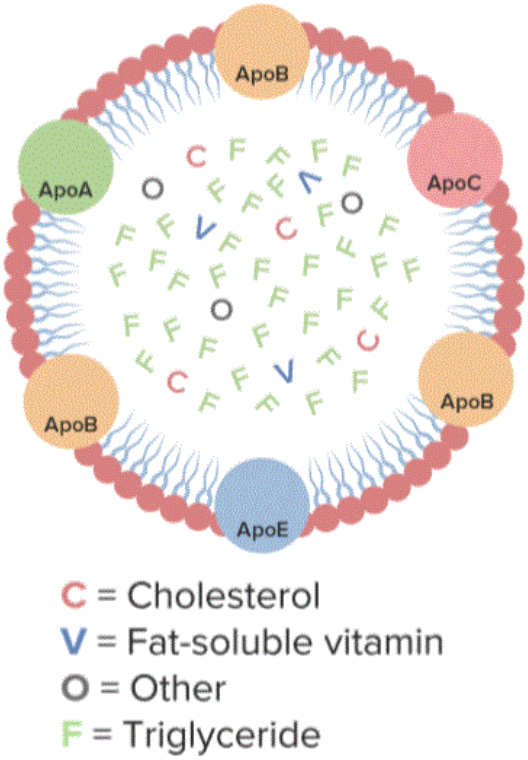
Different models were used to describe the action of enzymes during catalysis. The most common models are the lock and key model and the induced-fit model. In the lock and key model, Emil Fischer postulated that enzymes and substrates are like locks and keys. They fit perfectly with each other. This explains the high specificity of enzymes to its substrate because this means an enzyme will only interact with a specific substrate that fits in its active site. If the substrate and the enzyme do not fit, then no reaction will occur.



“Catalysis. Enzyme Substrate Interaction” Image created by Lecturio

In the induced-fit model, the enzyme and the substrate interact forming a weak covalent bond. The enzyme then undergoes some conformational changes that further strengthen the binding. The reaction then occurs until the product is formed. Changes in the confirmation of the enzymes will again happen to facilitate the release of the products. The enzymes then return to their original state. This model of enzyme catalysis can provide an explanation of the action of inhibitors. Aside from the active site of the enzyme, there are other allosteric sites where other molecules may attach. Inhibitors may act on these allosteric sites, and, when conformational change happens, entry of the substrate to the active site will be inhibited.

Transport Proteins



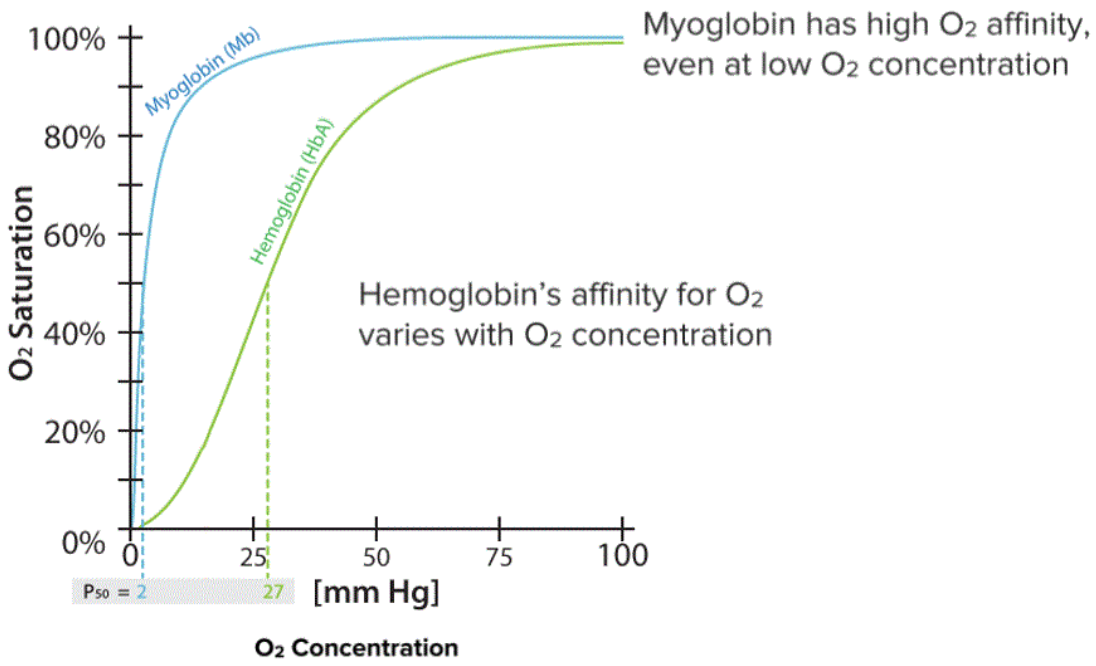
"Transport Proteins. Cellular and Organismal" Image created by Lecturio

Another important function of proteins is as a transporting medium for some biomolecules. Transport proteins are protein molecules that serve to move materials within an organism. Examples of transport proteins are low and high-density lipoproteins, hemoglobin and serum albumin. Lipoproteins are transport proteins responsible for the transfer of hydrophobic lipids.

Hemoglobin is the transport protein responsible for transporting oxygen from the lungs to the rest of the body. Albumins are carrier proteins for steroids, fatty acids, and the thyroid hormone. Another type of transport proteins are membrane transport proteins. They are responsible for the movement of ions, small molecules or other macromolecules across a biological membrane. They assist in the transport through active transport or facilitated diffusion.

Oxygen Transport

Two major proteins are responsible for the transport of oxygen molecules; these are myoglobin and hemoglobin. Oxygen molecules have different affinities to these two types of proteins. Myoglobin has a higher O_2 affinity even at low O_2 concentration. On the other hand, hemoglobin has a variable degree of O_2 affinity depending on the concentration of O_2.



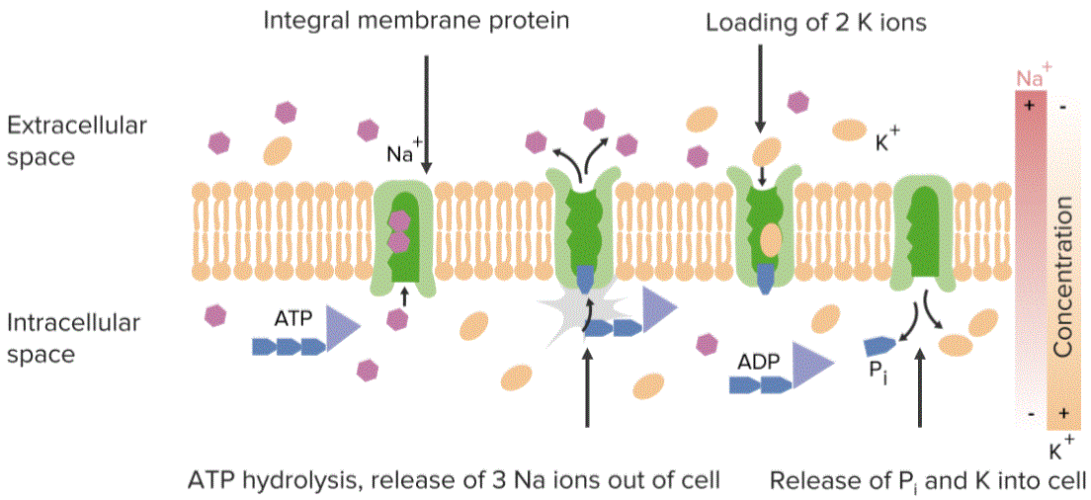
"Oxygen Transport. Hemoglobin and Myoglobin" Image created by Lecturio

There are a number of structural similarities between myoglobin and hemoglobin; both proteins contain a Fe atom where the O_2 molecule may act as a ligand. Their major difference is that myoglobin can only accommodate one oxygen molecule, while the hemoglobin can transport up to 4 oxygen molecules. An explanation to this is that hemoglobin transports oxygen from the lungs to the muscles where the myoglobin molecules are. When they interact, oxygen will be transferred to the myoglobin molecules which will be the one transferring that oxygen molecule to the muscle cells.

Na^+/K^+ ATPase

Na^+/K^+ ATPase is an enzyme formed of two membrane-bound polypeptides that serve as a solute pump to transport sodium ions out of cells while pumping potassium ions into the cells. Transport of the ions is due to a concentration gradient. The basic mechanism of action of this transport protein involves the binding of ATP to the pump before 3 intracellular Na^+ ions also bind to it.

ATP is then hydrolyzed, leading to phosphorylation and the eventual release of ADP. Conformational changes lead to the opening of the pump to the outside of the cells allowing the release of the ions. Two extracellular K^+ions then bind to the pump causing dephosphorylation of the pump. The pump reverts to its original conformation and transports K^+ to the inside of the cell. The process is repeated to regulate the ionic conditions inside and outside the cell.



"Na/K ATPase. Transmembrane Ion Transport" Image created by Lecturio

References

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Antibody Structure and Function via wiley.com

Control of Gene Expression via garlandscience.com

Correct answers: 1C; 2D

Notes