**Protein**

Proteins are the key working molecules and building blocks in all cells. They are produced in a similar two-step process in all organisms – DNA is first transcribed into RNA, then RNA is translated into protein.

Proteins are the major ‘working molecules’ within every organism. Among their many jobs, proteins catalyse reactions, transport oxygen and defend organisms from infection. They’re also crucial building blocks of organisms. They are the major components of wool, cartilage and milk, they package up the DNA in chromosomes and they insulate the cells of the nervous system. In short, proteins are hugely important!

Proteins are made of large numbers of amino acids joined end to end. The chains fold up to form three-dimensional molecules with complex shapes – you could think of it as origami with a very long and thin piece of paper. The precise shape of each protein, along with the amino acids it contains, determines what it does. Proteins are expressed from genes. All organisms make proteins in essentially the same way. The process starts with a gene – the ‘instruction manual’ for constructing the protein. For this reason, the process of making a protein is also called gene expression.

Within any cell, only a proportion of proteins are produced at any one time. Proteins that perform essential roles are produced constantly, while others are expressed only when they are needed. Cells also need large amounts of some proteins (such as the enzymes involved in continuous processes like transcription and translation) and smaller amounts of others (such as hormones).

**Transcription factor binding to DNA**

Transcription factors are proteins that control the production of other proteins. Enzymes involved in the same pathway in the cell are often controlled by the same transcription factor.

Promoters are the sequences of DNA that determine when a gene is expressed. These sections of DNA sit in front of genes and provide a ‘landing site’ for transcription factors (proteins that switch gene expression on and off) and RNA polymerase (the protein that reads DNA and makes an mRNA copy).

Different promoter sequences have different strengths, and genes with ‘strong’ promoters are expressed at a higher level than those with ‘weak’ promoters.

**Function of Proteins**

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| Type | Examples | Functions |
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| Digestive Enzymes | Amylase, lipase, pepsin, trypsin | Help in digestion of food by catabolizing nutrients into monomeric units |
|  |  |  |
| Transport | Hemoglobin, albumin | Carry substances in the blood or lymph throughout the body |
|  |  |  |
| Structural | Actin, tubulin, keratin | Construct different structures, like the cytoskeleton |
| Hormones | Insulin, thyroxine | Coordinate the activity of different body systems |
| Defense | Immunoglobulins | Protect the body from foreign pathogens |
| Contractile | Actin, myosin | Effect muscle contraction |
| Storage | Legume storage proteins, egg white (albumin) | Provide nourishment in early development of the embryo and the seedling |

Two special and common types of proteins are enzymes and hormones. Enzymes, which are produced by living cells, are catalysts in biochemical reactions (like digestion) and are usually complex or conjugated proteins. Each enzyme is specific for the substrate (a reactant that binds to an enzyme) it acts on. The enzyme may help in breakdown, rearrangement, or synthesis reactions. Enzymes that break down their substrates are called catabolic enzymes, enzymes that build more complex molecules from their substrates are called anabolic enzymes, and enzymes that affect the rate of reaction are called catalytic enzymes. It should be noted that all enzymes increase the rate of reaction and, therefore, are considered to be organic catalysts. An example of an enzyme is salivary amylase, which hydrolyzes its substrate amylose, a component of starch.

Hormones are chemical-signaling molecules, usually small proteins or steroids, secreted by endocrine cells that act to control or regulate specific physiological processes, including growth, development, metabolism, and reproduction. For example, insulin is a protein hormone that helps to regulate the blood glucose level.

Proteins have different shapes and molecular weights; some proteins are globular in shape whereas others are fibrous in nature. For example, hemoglobin is a globular protein, but collagen, found in our skin, is a fibrous protein. Protein shape is critical to its function, and this shape is maintained by many different types of chemical bonds. Changes in temperature, pH, and exposure to chemicals may lead to permanent changes in the shape of the protein, leading to loss of function, known as denaturation. All proteins are made up of different arrangements of the same 20 types of amino acids.

# **FUNCTION OF PROTEINS**

Proteins are a class of macromolecules that perform a diverse range of functions for the cell. They help in metabolism by providing structural support and by acting as enzymes, carriers, or hormones. The building blocks of proteins (monomers) are amino acids. Each amino acid has a central carbon that is linked to an amino group, a carboxyl group, a hydrogen atom, and an R group or side chain. There are 20 commonly occurring amino acids, each of which differs in the R group. Each amino acid is linked to its neighbors by a peptide bond. A long chain of amino acids is known as a polypeptide.

Proteins are organized at four levels: primary, secondary, tertiary, and (optional) quaternary. The primary structure is the unique sequence of amino acids. The local folding of the polypeptide to form structures such as the α helix and β-pleated sheet constitutes the secondary structure. The overall three-dimensional structure is the tertiary structure. When two or more polypeptides combine to form the complete protein structure, the configuration is known as the quaternary structure of a protein. Protein shape and function are intricately linked; any change in shape caused by changes in temperature or pH may lead to protein denaturation and a loss in function.

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| **Nucleic Acid**  Important nucleic acids in nature include deoxyribonucleic acid, or DNA, and ribonucleic acid, or RNA. They are called acids because they are proton (i.e., hydrogen atom) donors, and therefore they carry a negative charge.  Chemically, DNA and RNA are polymers, meaning that they consist of repeating units, often a very large number of them. These units are called nucleotides. All nucleotides in turn include three distinct chemical portions: a pentose sugar, a phosphate group and a nitrogenous base.  DNA differs from RNA in three primary ways. One is that it the sugar that makes up the structural "backbone" of the nucleic acid molecule is deoxyribose, whereas in RNA it is ribose.The second difference is that while one of the four nitrogenous bases found in DNA is thymine, the corresponding base in RNA is uracil. The nitrogenous bases of nucleic acids are what dictate the ultimate characteristics of these molecules, because the phosphate and sugar portions do not vary within or between molecules of the same type.  Finally, DNA is double-stranded, meaning that it consists of two long chains of nucleotides chemically bound by two nitrogenous bases. The DNA is wound into a "double helix" shape, like a flexible ladder twisted in opposite directions at both ends.  **Nucleic Acids and the Emergence of Life**  DNA, RNA and proteins are considered biopolymers because they are repeated sequences of information and amino acids that are associated with living things ("bio"means "life").  Molecular biologists today recognize that DNA and RNA in some form predate the emergence of life on Earth, but as of 2018, no one had figured out the pathway from early biopolymers to simple living things. Some have theorized that RNA in some form was the original source of all of these things, including DNA. This is the "RNA world hypothesis." However, this presents a sort of chicken-and-egg scenario for biologists, because sufficiently large RNA molecules seemingly could not have emerged by any means other than transcription. In any event, scientists are, with increasing eagerness, presently investigating RNA as a target for the first self-replicating molecule.  **Medical Therapies**  Chemicals that mimic the constituents of nucleic acids are being used as drugs today, with further developments in this area underway. For example, a slightly modified form of uracil, 5fluorouracil (5-FU), has been used for decades to treat carcinoma of the colon. It does this by imitating a true nitrogenous base closely enough so that it becomes inserted into newly manufactured DNA. This ultimately leads to a breakdown in protein synthesis.  Imitators of nucleosides (which, you may recall, are a ribose sugar plus a nitrogenous base) have been used in antibacterial and antiviral therapies. Sometimes, it is the base portion of the nucleoside that undergoes modification, and at other times the drug targets the sugar portion. |

There are many different roles that nucleic acids, which include DNA and RNA, play in the human body and in other living organisms. Scientists continue to identify new and different functions of nucleic acids on a regular basis. The most common functions, however, relate to the encoding of genetic information and production of proteins.

## **Encoding Information**

Perhaps the most familiar function of a nucleic acid in the body is that of DNA, or deoxyribonucleic acid. DNA contains the genetic code, which consists of the sum of all information a cell or organism requires to perform its functions. Your cells, for instance, have a central nucleus that contains your DNA. Based upon the information contained in the DNA, the cell can produce structural and functional proteins that allow it to function, explain Drs. Reginald Garrett and Charles Grisham in their book "Biochemistry."

## **Transferring Information**

To make a structural or functional protein, a cell needs to get genetic information from DNA out of the nucleus and into the rest of the cell, where the protein-producing machinery is located. Nucleic acids called mRNA, for messenger ribonucleic acid, form in the nucleus. They copy information from the DNA, and then leave the nucleus. Out in the cytoplasm, or liquid medium of the cell, the mRNA serves as a working template of genetic information for the protein-producing machinery.

## **Reading Templates**

Another kind of RNA, rRNA, forms a portion of a cellular organelle called the ribosome. A ribosome is a bit of cellular machinery that actually reads mRNA and generates protein, explains Dr. Lauralee Sherwood in her book "Human Physiology." The lowercase "r" in rRNA stands for "ribosomal." Once mRNA leaves the nucleus, ribosomes--made up of rRNA and protein--bind to the mRNA and begin to read the template.

## **Fetching Amino Acids**

Protein production requires one more type of nucleic acid: tRNA. Short for "transfer RNA," these nucleic acids work with rRNA to generate proteins from mRNA templates. Proteins consist of long chains of building blocks called amino acids. As rRNA reads mRNA, the rRNA builds proteins by putting together amino acids in the correct order. The tRNA helps out by fetching the appropriate amino acids and bringing them to the ribosome for assembly into a protein.

## **Get Needed Nucleic Acid from Your Diet**

Examples of nucleic acids can be acquired from food once it is broken down. It helps in building up your DNA. Nucleic acids are typically in all cells thus present in all foods. Here are some foods that are rich in nucleic acids:

1. **Fish**

Fish contains a number of cells that have large quantities of nucleic acids. Fish also provides the body with healthy proteins that can be used in building human cells and tissues. Fish will also give you healthy fats in form of omega-3. Examples of such fishes are salmon, tuna and sardines.

1. **Fruit**

Fruit is a great source of nucleic acids. Each cell in a fruit has plenty of nucleic acids from the skin, flesh to the seed. Fruits also offer fiber and natural sugars. Examples of such fruits are mangoes, pears and apples.

1. **Beans and Legumes**

Legumes and beans are rich in nucleic acid. In addition, they contain a high level of proteins and dietary fiber. Beans and legumes promote healthy structure of your cells and muscles. Examples include clovers, peas and lentils.