

Biologically Active Metal Elements and Cavernous Analytics

Shradha Bhardwaj

Research Scholar

Sri Venkateshwara University

Gajraula, U.P., India

Dr. Pradeep Yadav

Associate Professor

Sri Venkateshwara University

Gajraula, U.P., India

Abstract

Biometals are metals normally present, in small but important and measurable amounts, in biology, biochemistry, and medicine. The metals copper, zinc, iron, and manganese are examples of metals that are essential for the normal functioning of most plants and the bodies of most animals, such as the human body. A few (calcium, potassium, sodium) are present in relatively larger amounts, whereas most others are trace metals, present in smaller but important amounts (the image shows the percentages for humans). Approximately 2/3 of the existing periodic table is composed of metals with varying properties, accounting for the diverse ways in which metals (usually in ionic form) have been utilized in nature and medicine.

Keywords: Biologically Active Metals, Biologically Active Substances, Biological Substances

Metal ions are essential to the function of many proteins present in living organisms, such as metalloproteins and enzymes that require metal ions as cofactors. Processes including oxygen transport and DNA replication are carried out using enzymes such as DNA polymerase, which in humans requires magnesium and zinc to function properly. Other biomolecules also contain metal ions in their structure, such as iodine in human thyroid hormones.

Metal ions and metallic compounds are often used in medical treatments and diagnoses. Compounds containing metal ions can be used as medicine, such as lithium compounds and auranofin. Metal compounds and ions can also produce harmful effects on the body due to the toxicity of several types of metals. For example, arsenic works as a potent poison due to its effects as an enzyme inhibitor, disrupting ATP production.

Much of biochemistry deals with the structures, functions, and interactions of biological macromolecules, such as proteins, nucleic acids, carbohydrates, and lipids. They provide the structure of cells and perform many of the functions associated with life. The chemistry of the cell also depends upon the reactions of small molecules and ions. These can be inorganic (for example, water and metal ions) or organic (for example, the amino acids, which are used to synthesize proteins). The mechanisms used by cells to harness energy from their environment via chemical reactions are known as metabolism. The findings of biochemistry are applied primarily in medicine, nutrition and agriculture. In medicine, biochemists investigate the causes and cures of diseases. Nutrition studies how to maintain health and wellness and also the effects of nutritional deficiencies. In agriculture, biochemists investigate soil and fertilizers. Improving crop cultivation, crop storage, and pest control are also goals.

At its most comprehensive definition, biochemistry can be seen as a study of the components and composition of living things and how they come together to become life. In this sense, the

history of biochemistry may therefore go back as far as the ancient Greeks. However, biochemistry as a specific scientific discipline began sometime in the 19th century, or a little earlier, depending on which aspect of biochemistry is being focused on. Some argued that the beginning of biochemistry may have been the discovery of the first enzyme, diastase (now called amylase), in 1833 by Anselme Payen, while others considered Eduard Buchner's first demonstration of a complex biochemical process alcoholic fermentation in cell-free extracts in 1897 to be the birth of biochemistry. Some might also point as its beginning to the influential 1842 work by Justus von Liebig, *Animal chemistry, or, Organic chemistry in its applications to physiology and pathology*, which presented a chemical theory of metabolism, or even earlier to the 18th century studies on fermentation and respiration by Antoine Lavoisier. Many other pioneers in the field who helped to uncover the layers of complexity of biochemistry have been proclaimed founders of modern biochemistry. Emil Fischer, who studied the chemistry of proteins, and F. Gowland Hopkins, who studied enzymes and the dynamic nature of biochemistry, represent two examples of early biochemists.

The term "biochemistry" itself is derived from a combination of biology and chemistry. In 1877, Felix Hoppe-Seyler used the term (biochemie in German) as a synonym for physiological chemistry in the foreword to the first issue of *Zeitschrift für Physiologische Chemie* (Journal of Physiological Chemistry) where he argued for the setting up of institutes dedicated to this field of study. The German chemist Carl Neuberg however is often cited to have coined the word in 1903, while some credited it to Franz Hofmeister.

It was once generally believed that life and its materials had some essential property or substance (often referred to as the "vital principle") distinct from any found in non-living matter, and it was thought that only living beings could produce the molecules of life. Then, in 1828, Friedrich Wöhler published a paper on the synthesis of urea, proving that organic compounds can be

created artificially. Since then, biochemistry has advanced, especially since the mid-20th century, with the development of new techniques such as chromatography, X-ray diffraction, dual polarisation interferometry, NMR spectroscopy, radioisotopic labeling, electron microscopy and molecular dynamics simulations. These techniques allowed for the discovery and detailed analysis of many molecules and metabolic pathways of the cell, such as glycolysis and the Krebs cycle (citric acid cycle), and led to an understanding of biochemistry on a molecular level.

Another significant historic event in biochemistry is the discovery of the gene, and its role in the transfer of information in the cell. In the 1950s, James D. Watson, Francis Crick, Rosalind Franklin and Maurice Wilkins were instrumental in solving DNA structure and suggesting its relationship with the genetic transfer of information. In 1958, George Beadle and Edward Tatum received the Nobel Prize for work in fungi showing that one gene produces one enzyme. In 1988, Colin Pitchfork was the first person convicted of murder with DNA evidence, which led to the growth of forensic science. More recently, Andrew Z. Fire and Craig C. Mello received the 2006 Nobel Prize for discovering the role of RNA interference (RNAi), in the silencing of gene expression.

Around two dozen chemical elements are essential to various kinds of biological life. Most rare elements on Earth are not needed by life (exceptions being selenium and iodine), while a few common ones (aluminum and titanium) are not used. Most organisms share element needs, but there are a few differences between plants and animals. For example, ocean algae use bromine, but land plants and animals seem to need none. All animals require sodium, but some plants do not. Plants need boron and silicon, but animals may not (or may need ultra-small amounts).

Just six elements—carbon, hydrogen, nitrogen, oxygen, calcium and phosphorus—make up almost 99% of the mass of living cells, including those in the human body (see composition of

the human body for a complete list). In addition to the six major elements that compose most of the human body, humans require smaller amounts of possibly 18 more.

The four main classes of molecules in biochemistry (often called biomolecules) are carbohydrates, lipids, proteins, and nucleic acids. Many biological molecules are polymers: in this terminology, monomers are relatively small macromolecules that are linked together to create large macromolecules known as polymers. When monomers are linked together to synthesize a biological polymer, they undergo a process called dehydration synthesis. Different macromolecules can assemble in larger complexes, often needed for biological activity.

The simplest type of carbohydrate is a monosaccharide, which among other properties contains carbon, hydrogen, and oxygen, mostly in a ratio of 1:2:1 (generalized formula $C_nH_{2n}O_n$, where n is at least 3). Glucose ($C_6H_{12}O_6$) is one of the most important carbohydrates; others include fructose ($C_6H_{12}O_6$), the sugar commonly associated with the sweet taste of fruits,[a] and deoxyribose ($C_5H_{10}O_4$), a component of DNA. A monosaccharide can switch between acyclic (open-chain) form and a cyclic form. The open-chain form can be turned into a ring of carbon atoms bridged by an oxygen atom created from the carbonyl group of one end and the hydroxyl group of another. The cyclic molecule has a hemiacetal or hemiketal group, depending on whether the linear form was an aldose or a ketose.

In these cyclic forms, the ring usually has 5 or 6 atoms. These forms are called furanoses and pyranoses, respectively—by analogy with furan and pyran, the simplest compounds with the same carbon-oxygen ring (although they lack the carbon-carbon double bonds of these two molecules). For example, the aldohexose glucose may form a hemiacetal linkage between the hydroxyl on carbon 1 and the oxygen on carbon 4, yielding a molecule with a 5-membered ring, called glucofuranose. The same reaction can take place between carbons 1 and 5 to form a

molecule with a 6-membered ring, called glucopyranose. Cyclic forms with a 7-atom ring called heptoses are rare.

Two monosaccharides can be joined together by a glycosidic or ether bond into a disaccharide through a dehydration reaction during which a molecule of water is released. The reverse reaction in which the glycosidic bond of a disaccharide is broken into two monosaccharides is termed hydrolysis. The best-known disaccharide is sucrose or ordinary sugar, which consists of a glucose molecule and a fructose molecule joined together. Another important disaccharide is lactose found in milk, consisting of a glucose molecule and a galactose molecule. Lactose may be hydrolysed by lactase, and deficiency in this enzyme results in lactose intolerance.

When a few (around three to six) monosaccharides are joined, it is called an oligosaccharide (oligo- meaning "few"). These molecules tend to be used as markers and signals, as well as having some other uses. Many monosaccharides joined together form a polysaccharide. They can be joined together in one long linear chain, or they may be branched. Two of the most common polysaccharides are cellulose and glycogen, both consisting of repeating glucose monomers. Cellulose is an important structural component of plant's cell walls and glycogen is used as a form of energy storage in animals.

Sugar can be characterized by having reducing or non-reducing ends. A reducing end of a carbohydrate is a carbon atom that can be in equilibrium with the open-chain aldehyde (aldose) or keto form (ketose). If the joining of monomers takes place at such a carbon atom, the free hydroxy group of the pyranose or furanose form is exchanged with an OH-side-chain of another sugar, yielding a full acetal. This prevents opening of the chain to the aldehyde or keto form and renders the modified residue non-reducing. Lactose contains a reducing end at its glucose moiety, whereas the galactose moiety forms a full acetal with the C4-OH group of glucose.

Saccharose does not have a reducing end because of full acetal formation between the aldehyde carbon of glucose (C1) and the keto carbon of fructose (C2).

Structures of some common lipids. At the top are cholesterol and oleic acid. The middle structure is a triglyceride composed of oleoyl, stearoyl, and palmitoyl chains attached to a glycerol backbone. At the bottom is the common phospholipid, phosphatidylcholine. Lipids comprise a diverse range of molecules and to some extent is a catchall for relatively water-insoluble or nonpolar compounds of biological origin, including waxes, fatty acids, fatty-acid derived phospholipids, sphingolipids, glycolipids, and terpenoids (e.g., retinoids and steroids). Some lipids are linear, open-chain aliphatic molecules, while others have ring structures. Some are aromatic (with a cyclic [ring] and planar [flat] structure) while others are not. Some are flexible, while others are rigid.

Lipids are usually made from one molecule of glycerol combined with other molecules. In triglycerides, the main group of bulk lipids, there is one molecule of glycerol and three fatty acids. Fatty acids are considered the monomer in that case, and may be saturated (no double bonds in the carbon chain) or unsaturated (one or more double bonds in the carbon chain).

Most lipids have some polar character in addition to being largely nonpolar. In general, the bulk of their structure is nonpolar or hydrophobic ("water-fearing"), meaning that it does not interact well with polar solvents like water. Another part of their structure is polar or hydrophilic ("water-loving") and will tend to associate with polar solvents like water. This makes them amphiphilic molecules (having both hydrophobic and hydrophilic portions). In the case of cholesterol, the polar group is a mere -OH (hydroxyl or alcohol). In the case of phospholipids, the polar groups are considerably larger and more polar, as described below.

Lipids are an integral part of our daily diet. Most oils and milk products that we use for cooking and eating like butter, cheese, ghee etc., are composed of fats. Vegetable oils are rich in various polyunsaturated fatty acids (PUFA). Lipid-containing foods undergo digestion within the body and are broken into fatty acids and glycerol, which are the final degradation products of fats and lipids. Lipids, especially phospholipids, are also used in various pharmaceutical products, either as co-solubilisers (e.g., in parenteral infusions) or else as drug carrier components (e.g., in a liposome or transfersome).

Structural elements of common nucleic acid constituents. Because they contain at least one phosphate group, the compounds marked nucleoside monophosphate, nucleoside diphosphate and nucleoside triphosphate are all nucleotides (not simply phosphate-lacking nucleosides). The most common nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). The phosphate group and the sugar of each nucleotide bond with each other to form the backbone of the nucleic acid, while the sequence of nitrogenous bases stores the information. The most common nitrogenous bases are adenine, cytosine, guanine, thymine, and uracil. The nitrogenous bases of each strand of a nucleic acid will form hydrogen bonds with certain other nitrogenous bases in a complementary strand of nucleic acid (similar to a zipper). Adenine binds with thymine and uracil, thymine binds only with adenine, and cytosine and guanine can bind only with one another. Adenine and Thymine & Adenine and Uracil contains two hydrogen Bonds ,while Hydrogen Bonds formed between cytosine and guanine are three in number.

Aside from the genetic material of the cell, nucleic acids often play a role as second messengers, as well as forming the base molecule for adenosine triphosphate (ATP), the primary energy-carrier molecule found in all living organisms. Also, the nitrogenous bases possible in the two nucleic acids are different: adenine, cytosine, and guanine occur in both RNA and DNA, while thymine occurs only in DNA and uracil occurs in RNA.

References

- [1] Banci, Lucia, ed. (2013). *Metallomics and the Cell*. Series editors Sigel, Astrid; Sigel, Helmut; Sigel, Roland K.O. Springer. ISBN 978-94-007-5560-4. electronic-book ISBN 978-94-007-5561-1 ISSN 1559-0836 electronic-ISSN 1868-0402
- [2] Aggett, PJ (1985). "Physiology and metabolism of essential trace elements: an outline". *Clin Endocrinol Metab.* 14 (3): 513–43. doi:10.1016/S0300-595X(85)80005-0. PMID 3905079.
- [3] Cavalieri, RR (1997). "Iodine metabolism and thyroid physiology: current concepts". *Thyroid.* 7 (2): 177–81. doi:10.1089/thy.1997.7.177. PMID 9133680.
- [4] http://authors.library.caltech.edu/25052/10/BioinCh_chapter9.pdf Stephen J. Lippard, Department of Chemistry, Massachusetts Institute of Technology. Accessed 26 July 2014.
- [5] <https://www.nlm.nih.gov/medlineplus/druginfo/meds/a681039.html> U.S. National Library of Medicine, Lithium. Drug information provided by AHFS Consumer Medication Information, 2014.
- [6] Kean, W. F.; Hart, L.; Buchanan, W. W. (1997). "Auranofin". *British Journal of Rheumatology.* 36 (5): 560–572. doi:10.1093/rheumatology/36.5.560. PMID 9189058.
- [7] http://authors.library.caltech.edu/25052/10/BioinCh_chapter9.pdf Stephen J. Lippard, Department of Chemistry, Massachusetts Institute of Technology. Accessed 26 July 2014.
- [8] Singh, AP; Goel, RK; Kaur, T (2011). "Mechanisms pertaining to arsenic toxicity". *Toxicology International.* 18 (2): 87–93. doi:10.4103/0971-6580.84258. PMC 3183630. PMID 21976811.