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General Concepts of Plant Biochemistry

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Abstract

Biochemistry is the study of the chemical processes in living organisms. It deals with the structure and the function of cellular components such as: proteins, carbohydrates, lipids, nucleic acids and other biomolecules. Although there is a vast number of different biomolecules, many of them are complex and large molecules (called polymers), composed of similar repeating subunits (called monomers). Each class of polymeric biomolecules has a different set of subunit types. For example, a protein is a polymer whose subunits are selected from a set of 22 or more amino acids. Biochemistry studies the chemical properties of important biological molecules, like proteins, in particular the chemistry of enzyme–catalyzed reactions. Other areas of biochemistry include the genetic code (DNA, RNA), protein synthesis, transport cells membranes and signal transduction. Since all known life forms that are still alive today are descended from the same common ancestor, generally they have similar biochemistries. It is unknown whether alternative biochemistries are possible or practical.

Keywords: Plant biochemistry; Proteins; Carbohydrates; Lipids; Nucleic acids; Biomolecules

Introduction and statement of problem

Originally, it was generally believed that life was not subject to the laws of science the way non-life was. It was thought that only living beings could produce the molecules of life (from other, previously existing biomolecules). Biomonomers and biopolymers are the structural basis of the four main macromolecules classes in biochemistry: carbohydrates, lipids, proteins and nucleic acids or biopolymers. Monomers are smaller micro molecules that are put together to make macromolecules. Biopolymers are those macromolecules that are created when monomers are synthesized together. When they are synthesized, the two molecules undergo a process called catabolization or decomposition. A biomolecule is a chemical compound that naturally occurs in living organisms. Biomolecules consist primarily of carbon and hydrogen, along with nitrogen, oxygen, phosphorus and sulfur. Other elements sometimes are incorporated but these are much less common. Biomolecules are necessary for the existence of all known forms of life. For example, humans possess skin and hair. The main component of hair is keratin, an agglomeration of proteins which are themselves polymers built from amino acids. Amino acids are some of the most important building blocks used in nature, to construct larger molecules. Another type of building block are the nucleotides, each of which consists of three components: a purine or pyrimidine base, a pentose and a phosphate group. These nucleotides, mainly, form the nucleic acids. Besides the polymeric biomolecules, numerous small organic molecules are absorbed or synthesised by living systems [1].

Then, in 1828, Friedrich Wöhler published a paper on the synthesis of urea, proving that organic compounds can be created artificially. The dawn of biochemistry may have been in 1833 the discovery of the first enzyme, diastase (also known as amylase), by Anselme Payen. Eduard Buchner contributed to the first demonstration of a complex biochemical process at the outside of a cell in 1896: the alcoholic fermentation based on cells coming from yeast. Although the term biochemistry seems to have been first used in 1882, it is generally accepted that the formal coinage of biochemistry was mentioned in 1903 by Carl Neuberg, a German chemist. Previously, this area would have been referred to as physiological chemistry. 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, radio isotopic labelling, electron microscopy and molecular dynamics simulations [2].

These techniques allowed the discovery and detailed analysis of many molecules and metabolic pathways of the cell, such as glycolysis and the Krebs cycle (citric acid cycle). Another significant historic event in biochemistry is the discovery of the gene and its role in the informational transfer in the cell. This part of biochemistry is often called molecular biology. In the 1950s, James D. Watson, Francis Crick, Rosalind Franklin, and Maurice Wilkins were instrumental in solving DNA structure and suggesting its relationship with 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 with murder with DNA evidence, which led to 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 [3].

Plant biochemistry involves the study of the biochemistry of autotrophic organisms such as photosynthesis and other biochemical processes specific to plants. Plant Biochemistry presents each topic from the cellular level to the ecological and environmental levels, placing it in the context of the whole plant. Biochemical pathways are represented as route maps, showing how one reaction follows another. These maps emphasize the dynamism and flexibility of the plant facing the environmental challenges. The unique and wide–ranging approach of this book emphasizes the importance of teaching and learning pathways within the framework of what the pathway does and why it is

needed. Plant Biochemistry illustrates the impact of plants on human activity and success, in terms of their importance as a food supply and as raw materials for industrial and pharmaceutical products, and considers that humans can benefit from exploiting plant biochemical pathways. So, Plant Biochemistry is the science which studies chemical and physico–chemical processes that take place in the living organisms having the role to establish the material substrate of the life's phenomena. Usually the development of the organisms is possible due to the biochemical processes that take place in them in different environmental conditions. The influence exerted by the environment is reflected in the morphological and chemical structure of the organisms [4].

The fundamental problems of the animal biochemistry cannot be broken from the vegetal biochemistry and from the unicellular organisms. The universal principle of nature's integrity is the base of the chemical composition of the organisms and of the processes that are continuously developing and whose meaning is life. The organic matter is forming, transforming and degrading in any living body (plant, animal or microorganism); it doesn't differ from an organism to other by the component substances that are always the same or related also differs through secondary and unessential features determined by the proportion and the conditions of the formation and transformation of the organic matter. This is the reason why in the organisms' life there are some formation and degradation developing processes of the live matter and they vary between certain limits determining the variability and heredity of the organisms. Animal, plant and environment are forming an indissoluble unit and the biochemistry shows the diversity of the live matter.

Plant biochemistry is related to the animal and human activity where there are similar, however in all plants each cell has achieved a much more complicated metabolic process comparing to the animal organisms which are specialized on different functions. Animal, plant and environment form an inseparable unit, and only this way, in a comparing and general way, biochemistry shows a material world and the different shapes that it can take. So, when studying biochemistry there have to be treated at the same time both the fundamental chemistry of animals and that one of chemical plants and their need. Biochemistry has a particular role in the acquisition of agricultural raw materials for finished products with good yields, quality, and economic conditions in high yield. Biochemistry is involved in obtaining such materials in the conduct of technological processes, to conserve packaging and finished products, waste recovery in manufacturing, etc. During their industrial transformation raw materials and agricultural products suffer biochemical processes necessary or harmful, caused by enzymes, processes that must be traced, suppressed or directed [5].

Any living organism is an energetic system. The amount of energy received from the environment is equal to the consumed energy, plus the accumulations. If the accumulations are positive the organism will gain weight, and if the accumulations are negative it will lose weight. In a healthy organism it is desired that the accumulation should be maintained constant in time. The totality of the energetic exchanges that take place permanently between the living body and the environment, meaning that the organism is spending (losing) energy replaced by the energy contained in food is called energetic expenses.

The energy from the nutrients is the potential chemical energy and it is contained in the C–H, C–O, and the C–N links from proteins, lipids and carbohydrates, these links being able to split in the conditions of the high temperatures, the pH and the chemical environment created by cellular activities. After the usual oxidative splitting of the nutrients, the organism stocks the potential chemical energy and transforms the energy in other energy forms necessary to it. If the energetic needs of the organism are reduced and the energetic effort is increased, the glucose, the fatty acids and the amino acids are being entirely catabolised and transformed in stocking forms such as glycogen, triglucides and proteins [6, 7].

The basis of all the biological processes is the exchange of matter, information and energy, this exchange process being active between the living body and the environment. The nutrients, the environmental factor indispensable for life, are crude or processed substances designated for the nutrition and satisfaction of the energy necessary for the maintaining the vital functions, for providing the growing and development of the living body and for maintaining the aptitudes for a good physical and mental activity.

The nutrients are complex products which are capable to suffer the necessary transformations in the living organism in order to maintain life and forming the tissues. Along with the oxygen, the living body also incorporates water and minerals, proteins, lipids, carbohydrates and vitamins from environment. Except oxygen, which is essential for the respiration process and the water, which is the vital environment, the other compounds are imported. The consumption of substances coming from external sources is a fundamental biological necessity of any organism. Other substances are named nutritive principles or alimentary principles and for their definition are used the terms nutrients or trophynes. All metabolic processes take place in cells where the mitochondria is the main centre of the energogenesis, and the ribosomes are the place for the proteins' synthesis [8].

The functions of the nutritive principles found in food are:

- catalytic–favouring the normal development of the biological processes;
- Energetic–providing the necessary energy for the development of the vital processes;
- Plastic–providing the synthesis of the substances owned by the organism; etc.

Biochemistry studies the process of the incorporation of the substances which participate in the metabolic processes, the transformation of the nutrients in soluble substances capable to be absorbed by the blood and produced in the digestive apparatus [9].

Food's nutritive factors have some complex combinations that cannot be used and necessitate their transformation in simple elements which can be easily assimilated by the organism.

The nutritive principles, Fundamental substances

Modern biochemistry agrees with the existence of nine categories of nutritive principles: water, alimentary fibres, lipids, carbohydrates, macrominerals, oligominerals, proteins, bioactive substances and vitamins.

The chemical substances which are part of these categories have precise functions useful to the organism that ingrates them. Thus, some of them provide energy and heat, others provide construction material for the organism helping with the growth or the repair of the degraded tissues, and others participate directly or indirectly in the regulation of the biochemical and physiological processes from the organism. Yet none of these nutritive principles activate independently. For a good metabolic activity and health of the organism the alimentation should contain all those nine nutritive principles in

adequate amounts. Due to their structure and properties the organic substances are the basic material of the living bodies and activate in all living cells. The organic compounds mainly consist of: carbon, hydrogen, oxygen, nitrogen, phosphorus and sulphur. Proteins, lipids and carbohydrates are part of this category and serve as plastic and energetic material with a distinct structural and functional role in the living bodies. The living matter is formed of two main groups of substances: inorganic and organic. The inorganic substances (water, minerals) are up taken from environment and are not synthesized by plants. The organic substances are the main compounds of the living bodies. According to their role in organism they can be classified as:

- plastic substances: (carbohydrates, proteins, and lipids) with a structural and energetic role;
- substances with informational role: nucleic acids;
- substances with catalytic role: enzymes;
- substances with a role in balance: enzymes, vitamins, phytohormons, pigments, antibodies etc.;
- substances with an energetic role: macroergic compounds;

Intermediary and final substances of the metabolism: glycosides, lignin, eteric oils, alkaloids, antibiotic substances, alcohols, amides, amines, esters etc. [10].

The living matter is formed especially of the compounds of 12 chemical elements called plastic macroelements or constitutive elements. These are: C, H, O, N, P, S, Cl, K, Na, Ca, Mg, and Si. These plastic elements, together with other elements a.i. oligoelements or microelements: Mo, Cu, Zn, Fe, B, Mn, Co, As, F, Br, Al etc. make less than 1% of the dry matter. The main source of supply with inorganic compounds for plants is the soil. Mineral substances, component part of the food, are important in forming tissues and participate in the biological and physiological processes of the body. They are classified into macroelements (K, Ca, P, Na, Mg, Fe, Cl, S), which exist in the body in large amounts and microelements (Zn, Cu, Cr, Mn, Co, Mo, I, F, Ni etc.) found in small quantities. The microelements have a very important functional role in the reduction reactions, in the balance of the osmotic pressure and of the acid–base balance, and in maintaining cellular integrity even if they are found in small amount. Having also an essential role in the activation of some enzymes they become catalytic elements. Studies show the presence in the vegetal organisms of more than 60 chemical elements. From these only seven are fundamental or macroelements and together with the C, H, O and N they form about 99% of the body weight. These macroelements are: Na, K, Ca, P, Mg, Cl, and S. The other mineral elements found in very small amount are called microelements. The most important microelements are: Fe, Cu, Co, Zn, I, Mn, Cd, Se, Nil, Cr, Pb, Hg, and As. Macro and microelements are indispensable for the physiological equilibrium of the vegetal, animal and human organisms and the lack of one or more minerals results in pathological manifestations more or less severe[11].

Carbon is part of those organic compounds existing in the organisms and represents 48–50% of the dry substance. Hydrogen represents 6–7% of the dry matter and just as carbon, is found in all organic substances and in the water from body. It also participates in the oxidation–reduction reactions. Oxygen is found in most of the organic compounds from the living bodies in a proportion of 41–43% and along with the hydrogen, takes part in the oxidatio–reduction processes. Nitrogen is one of the basic elements of protides, and represents 16% of plant protides. In living tissues the proportion of nitrogen reaches 1.4–1.6%. Phosphorus is part of some important biologic compounds such as: enzymes, complex lipids, ATP etc. and interferes in many biochemical processes (photosynthesis etc.). In living bodies is found in a proportion near to 0.1–1.1%. Sulphur is part of some proteins, vitamins and carbohydrates etc. and can be found as 0.02–1.8% of the dry matter. It has important role in the growth and development of the living bodies.

The basic components in the alimentation of living organisms are the essential amino acids, polyunsaturated fatty acids, all the vitamins and minerals. Some components with high physiological activity, such as phospholipids, glycoproteidele, phosphoproteinele and many other compounds, are considered essential substances. The basic principles of a balanced nutrition are the proper correlations based on substances and biologically active nutrients, like proteins, lipids, carbohydrates, vitamins, mineral substances, depending on age, gender, activity at work and lifestyles. Nutritional factors are subjected to a series of changes before their addition to the body tissues a.i. the burning and the disposal of unused remainders, formed as a result of metabolic processes taking place in the body.

The metabolism represents the chemical and energetic changes of the products resulted from digestion and which are necessary in the anabolic and catabolic processes in the organism. The anabolism is the synthesis and repair process of simple substances' tissues. The catabolism (decomposition, degradation) is a decomposition process of the composed substances used as an energy source [12].

Conclusions and recommendations

Plants or animals Biochemistry is the research of the basic chemistry of living things. This includes organic molecules (proteins, carbohydrates, lipids, nucleic acids and other biomolecules) and their biochemical reactions (anabolic and catabolic processes). Most scientific research, consider biochemistry to be synonymous with molecular biology. Biochemistry has a particular role in the industrialization of the raw materials in order to obtain finished products with good quality yields, under economic conditions of high profitability. Biochemistry involves in obtaining such materials, in the conduct of some technological processes, to conserve packaging and finished products, in waste recovery in manufacturing, etc. There is an industrial transformation taking place in the raw materials and their agricultural products, along with some biochemical processes which some are necessary and other are harmful, caused by enzymes; these processes identify themselves as suppressed or directed.

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