International Journal of Engineering Research & Management Technology

ISSN: 2348-4039

Volume 9, Issue-4 July-August- 2022

Email:editor@ijermt.org www.ijermt.org

ROLE OF BIOCHEMISTRY IN TRANSFORMING BOTANY AND GENETICS IN 20TH CENTURY

Siddhant Khare

UNDERGRADUATE STUDENT

MATS SCHOOL OF BIOLOGICAL AND CHEMICAL SCIENCES

MATS UNIVERSITY RAIPUR

ABSTRACT

Biochemistry or biological chemistry is science study all the chemical processes that take place in the living organism of humans, animals, protozoa and plants. Biochemistry is the science that explores the chemical processes within and in relation to living organisms. It is a laboratory science that combines biology and chemistry. By using chemical knowledge and techniques, biochemists can understand and solve biological problems. Biochemistry covers a wide range of sciences, including genetics, microbiology, forensics, plant science, and medicine. Because of its breadth, biochemistry is important, and the advances made in this area of science over the past 100 years have been astounding. It is a very exciting time to be a part of this fascinating field of study. In this Artical we reveal to you, how biochemistry helps transform the field of Botany and Genetics in the early 20th century.

INTRODUCTION

Biochemistry, study of the chemical substances and processes that occur in plants, animals, and microorganisms and of the changes they undergo during development and life. It deals with the chemistry of life, and as such it draws on the techniques of analytical, organic, and physical chemistry, as well as those of physiologists concerned with the molecular basis of vital processes. All chemical changes within the organism—either the degradation of substances, generally to gain necessary energy, or the build up of complex molecules necessary for life processes—are collectively called metabolism. These chemical changes depend on the action of organic catalysts known as enzymes, and enzymes, in turn, depend for their existence on the genetic apparatus of the cell. It is not surprising, therefore, that biochemistry enters into the investigation of chemical changes in disease, drug action, and other aspects of medicine, as well as in nutrition, genetics, and agriculture. The term *biochemistry* is synonymous with two somewhat older terms: *physiological chemistry* and *biological chemistry*. Those aspects of biochemistry that deal with the chemistry and function of very large molecules (e.g., proteins and nucleic acids) are often grouped under the term *molecular biology*. Biochemistry is a young science, having been known under that term only since about 1900. Its origins, however, can be traced much further back; its early history is part of the early history of both physiology and chemistry.

THE ENCOUNTER BETWEEN BIOCHEMISTRY AND GENETICS

The development of molecular biology is also the encounter of two disciplines that made considerable progress in the course of the first thirty years of the twentieth century: biochemistry and genetics. The first

studies the structure and function of the molecules which make up living things. Between 1900 and 1940, the central processes of metabolism were described: the process of digestion and the absorption of the nutritive elements derived from alimentation, such as sugars. Every one of these processes is catalyzed by a particular enzyme. Enzymes are proteins, like the antibodies present in blood or the proteins responsible for muscular contraction. As a consequence, the study of proteins, their structure, and synthesis, became one of the principal objectives of biochemists.

The second discipline of biology which developed at the beginning of the 20th century is genetics. After the rediscovery of the laws of Mendel through the studies of Hugo de Vries, Carl Correns, and Erich von Tschermak in 1900, this science began to take shape thanks to the adoption by Thomas Hunt Morgan, in 1910, of a model organism for genetic studies, the famous fruit fly (Drosophila melanogaster). Shortly after, Morgan showed that the genes are localized on chromosomes. Following this discovery, he continued working with Drosophila and, along with numerous other research groups, confirmed the importance of the gene in the life and development of organisms. Nevertheless, the chemical nature of genes and their mechanisms of action remained a mystery. Molecular biologists committed themselves to the determination of the structure, and the description of the complex relations between, genes and proteins.

The development of molecular biology was not just the fruit of some sort of intrinsic "necessity" in the history of ideas, but was a characteristically historical phenomenon, with all of its unknowns, imponderables, and contingencies: the remarkable developments in physics at the beginning of the 20th century highlighted the relative lateness in development in biology, which became the "new frontier" in the search for knowledge about the empirical world. Moreover, the consequences of the theory of information and cybernetics in the 1940s, in response to military exigencies, brought to the new biology a significant number of fertile ideas and, especially, metaphors. The choice of bacteria and its virus, the bacteriophage, as models for the study of the fundamental mechanisms of life was almost natural - they are the smallest living organisms known to exist - and at the same time the fruit of individual choices. This model owes its success, above all, to the fame and the sense of organization of Max Delbrück, a German physicist, who was able to create a dynamic research group, based in the United States, whose exclusive scope was the study of the bacteriophage: the phage group.[1]

The phage group was an informal network of biologists that carried out basic research mainly on bacteriophage T4 and made numerous seminal contributions to microbial genetics and the origins of molecular biology in the mid-20th century. In 1961, Sydney Brenner, an early member of the phage group, collaborated with Francis Crick, Leslie Barnett, and Richard Watts-Tobin at the Cavendish Laboratory in Cambridge to perform genetic experiments that demonstrated the basic nature of the genetic code for proteins.[2] These experiments, carried out with mutants of the IRB gene of bacteriophage T4, showed, that for a gene that encodes a protein, three sequential bases of the gene's DNA specify each successive amino acid of the protein. Thus the genetic code is a triplet code, where each triplet (called a codon) specifies a particular amino acid. They also found that the codons do not overlap with each other in the DNA sequence encoding a protein and that such a sequence is read from a fixed starting point. During 1962-1964 phage T4 researchers provided an opportunity to study the function of virtually all of the genes that are essential for the growth of the bacteriophage under laboratory conditions.[3][4] These studies were facilitated by discovering two classes of conditional lethal mutants. One class of such mutants is known as amber mutants.[5] Another class of conditional lethal mutants is referred to as temperature-sensitive mutants.[6] Studies of these two classes of mutants led to considerable insight into numerous fundamental biologic problems. Thus understanding was gained of the functions and interactions of the proteins

employed in the machinery of DNA replication, DNA repair, and DNA recombination. Furthermore, an understanding was gained of the processes by which viruses are assembled from protein and nucleic acid components (molecular morphogenesis). Also, the role of chain-terminating codons was elucidated. One noteworthy study used amber mutants defective in the gene encoding the major head protein of bacteriophage T4.[7] This experiment provided strong evidence for the widely held, but before 1964 still unproven, "sequence hypothesis" that the amino acid sequence of a protein is specified by the nucleotide sequence of the gene determining the protein. Thus, this study demonstrated the co-linearity of the gene with its encoded protein.

The geographic panorama of the developments of the new biology was conditioned above all by preceding work. The US, where genetics had developed the most rapidly, and the UK, where there was a coexistence of both genetics and biochemical research of highly advanced levels, were in the avant-garde. Germany, the cradle of the revolutions in physics, with the best minds and the most advanced laboratories of genetics in the world, should have had a primary role in the development of molecular biology. But history decided differently: the arrival of the Nazis in 1933 - and, to a less extreme degree, the rigidification of totalitarian measures in fascist Italy - caused the emigration of a large number of Jewish and non-Jewish scientists. The majority of them fled to the US or the UK, providing an extra impulse to the scientific dynamism of those nations. These movements ultimately made molecular biology a genuinely international science from the very beginning.

DEVELOPMENT IN BOTANY WITH RESPECT TO BIOCHEMISTRY

20th-century developments in plant biochemistry have been driven by modern techniques of organic chemical analysis, such as spectroscopy, chromatography, and electrophoresis. With the rise of the related molecular-scale biological approaches of molecular biology, genomics, proteomics, and metabolomics, the relationship between the plant genome and most aspects of the biochemistry, physiology, morphology, and behavior of plants can be subjected to detailed experimental analysis.[8] One of the great biological themes of the century concerned the source of energy for life processes. Early in the century, biologists were aware of the energy needed for muscular activity and of the ability of plants to absorb radiant energy and convert it into potential energy in the form of combustible food. However, the connection between these two processes was poorly understood. The discovery of ATP by Lohman in 1929 marked the beginning of an era of great progress in understanding bioenergetics. By the mid-1950s the Krebs cycle had been widely accepted (9), and shortly thereafter the path of carbon in photosynthesis was described. An excellent account of the early history of photosynthesis can be found in the three volume review by 61. A model of the structure of the chlroplast from this book is shown in fig 1 is also very helpful in understanding the conceptual issues of the early years of photosynthesis research.

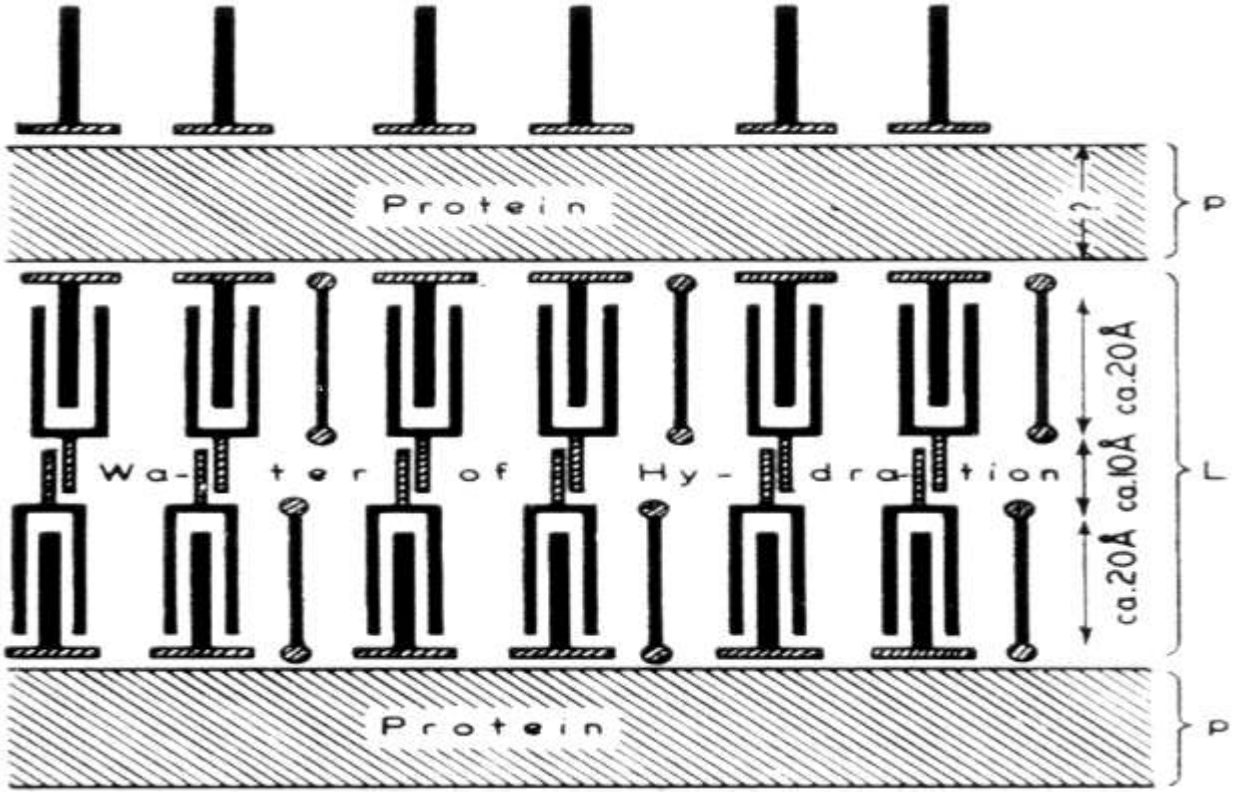

Figure 1 Hypothetical Structure of Chloroplast Membranes Circa 1945

By the beginning of the twentieth century, it was generally understood that photosynthesis took place in chloroplasts and that light provided the energy for the release of oxygen and the conversion of CO_2 into carbohydrates and other forms of reduced carbon. In 1905 Blackman separated the sequence of processes into two parts: the first required light and proceeded rapidly, the second took place in darkness and proceeded more slowly. A controversial idea of the first decade was the proposal by Bredig, Hofman, and Schumpelt that the primary effect of light in photosynthesis was the decomposition of water into oxygen and hydrogen, and that the latter was used to reduce CO_2 by an unknown process. Willstätter and Soll proposed instead that oxygen originated from the decomposition of CO_2.

A contemporaneous problem concerned the nature of respiration. In 1913 Wieland explained respiration as the transfer of hydrogen atoms from a substrate such as glucose to oxygen. In 1926 Kluyver and Donker extended this concept to include anaerobic fermentations as similar transfers of hydrogen to acceptors other than oxygen. The first clear formulation of the idea that photosynthesis was also an oxidation reduction between water and CO_2 was made by van Niel (1931), who recognized that the superficially dissimilar mechanisms of photosynthesis by sulfur, bacteria, and plants was fundamentally the same process. van Niel proposed photosynthesis to be a hydrogen transfer from water to CO_2 in higher plants and from other hydrogen donors to carbon dioxide in bacteria. In the words of his contemporary Hans Gaffron, "Purple bacteria furnished van Niel with the key to the first generally convincing picture of the photosynthetic process in terms of modern metabolic ideas" (11).van Niel's work was soon followed by the groundbreaking work of Robin Hill (12, 13), who showed that illumination of isolated chloroplast membranes in the presence of electron acceptors such as ferricyanide resulted in high rates of O_2 evolution without a concomitant requirement for CO_2 reduction. This provided a clear separation of the light and dark reactions of photosynthesis as originally proposed by Blackman. It also led rather rapidly to the demonstration that NADP was also an excellent electron acceptor and the recognition that NADPH could be a source of the reductant for the dark reactions. More generally, this result opened the way for the in vitro biochemical and biophysical methods that remain in use today. The discovery that certain dyes could also serve as electron donors, the development of photoelectric spectrophotometry in 1937 (14), and the

subsequent application to spectrofluorometry also paved the way for the modern era. It was also at about this time that Sam Ruben and colleagues at Berkeley first showed, using mass spectrometry, that the $^{18}O_2/^{16}O_2$ ratio of evolved O_2 was the same as water, thereby conclusively demonstrating the source of photosynthetically produced oxygen.After approximately twenty years of study of the Hill reaction by many groups, a number of observations had accumulated that were not readily understood by the concept of a single reaction center that accepted electrons from chlorophyll and accessory pigments .The final major piece of the puzzle, the mechanism of photophosphorylation, was discovered after the conceptual breakthrough of the Mitchel hypothesis (15) showed that electron flow is accompanied by the formation of proton gradients that give rise to phosphorylation by coupling factor.

Thus, by the late 1960s, a methodology had been established for investigating the light reactions, and robust models had been developed that have continually been refined until the present time. The development of methods, such as gel electrophoresis, for identifying the protein components led to the characterization of most or all of the proteins that participate in the various aspects of electron transport. In addition, the use of genetics, particularly mutants of algae and cyanobacteria, have permitted a refined dissection of the components of the apparatus and a reasonably good understanding of the physical properties and arrangements of most or all of the components. The determination of the tertiary structure of the bacterial reaction center by Deisenhofer, Michel, and Huber provided the first direct view of the molecular mechanism that actually carries out the photochemistry. However, the central enigma of photosynthesis, the mechanism underlying the photolysis of water, remains unsolved and a challenge for the next century.

CONCLUSION

Over the years, instrumentation advanced rapidly and novel physical techniques made possible the detailed analysis of structure. Biochemistry provided to science a new path of research, contributing to every field of medicine, helping also to establish better therapies for several diseases. Helped revolutionarise botany and played a vital role in the advancement in genetics and molecular biology. Currently biochemistry is considered the science of future and its applications to diagnoses, pharmacy, biotechnology and even agriculture promise a better world.

REFERENCES

1. ^ *Keen, E. C. (2015). "A century of phage research: Bacteriophages and the shaping of modern biology". BioEssays.* ***37*** *(1): 6–9. doi:10.1002/bies.201400152. PMC 4418462. PMID 25521633.*
2. ^ Crick FH, Barnett L, Brenner S, Watts-Tobin RJ (December 1961). "General nature of the genetic code for proteins". Nature. 192 (4809): 1227–32. Bibcode:1961Natur.192.1227C. doi:10.1038/1921227a0. PMID 13882203. S2CID 4276146
3. ^ Edgar RS Conditional lethals: in Phage and the Origins of Molecular Biology (2007) Edited by John Cairns, Gunther S. Stent, and James D. Watson, Cold Spring Harbor Laboratory of Quantitative Biology, Cold Spring Harbor, Long Island, New York ISBN 978-0-87969-800-3
4. ^ Edgar B (October 2004). "The genome of bacteriophage T4: an archeological dig". Genetics. 168 (2): 575–82. doi:10.1093/genetics/168.2.575. PMC 1448817. PMID 15514035
5. ^ Epstein RH, Bolle A, Steinberg CM, Kellenberger E, Boy de la Tour E, Chevalley R, Edgar RS, Susman M, Denhardt GH, Lielausis A (1963). "Physiological studies of conditional lethal mutants of bacteriophage T4D". Cold Spring Harbor Symposia on Quantitative Biology. 28: 375–394. doi:10.1101/SQB.1963.028.01.053. ISSN 0091-7451

6. ^ Edgar RS, Lielausis I (April 1964). "Temperature-sensitive mutants of bacteriophage T4D: Their isolation and Characterization". Genetics. 49: 649–62. doi:10.1093/genetics/49.4.649. PMC 1210603. PMID 14156925
7. ^ Sarabhai AS, Stretton AO, Brenner S, Bolle A (January 1964). "Co-linearity of the gene with the polypeptide chain". Nature. 201 (4914): 13–7. Bibcode:1964Natur.201...13S. doi:10.1038/201013a0. PMID 14085558. S2CID 10179456
8. ^ Ehrhardt & Frommer 2012, pp. 1–21.
9. Beevers H **Conceptual developments in metabolic control, 1924–1974.***Plant Physiol.* 1974; **54**: 437-442
10. Deisenhofer JMichel H**Structures of bacterial photosynthetic reaction centers.** *Annu. Rev. Cell Biol.* 1991; **7**: 1-23
11. Gaffron H **van Niel's theory.**in: Gest H San Pietro A Vernon L.P Bacterial Photosynthesis. Antioch Press, Yellow Springs, OH1963 (3–14.pp)
12. Hill R**Oxygen evolved by isolated chloroplasts.***Nature.* 1937; **139**: 881-882
13. Hill R Scarisbrick R **Production of oxygen by illuminated chloroplasts.***Nature.* 1940; **146**: 61-62
14. Hogness T.R Zscheile F.P Sidwell A.E **Photoelectric spectrophotometry.***J. Phys. Chem.* 1937; **41**: 379-415
15. Jagendorf A.T Uribe E **Photophosphorylation and the chemiosmotic hypothesis. In Energy Conversion by the Photosynthetic Apparatus.** *Brookhaven Symp. Biol.* 1966; **19**: 215-245