J. Expt. & Clin Anat 1(2): 28-32 (2002)

Anatomy: Where Molecular Biology Stands

EKPO B. O
Department Of Biochemistry, College Of Medicine
And Health Sciences, Abia State, University, Uturu, Nigeria.

ABSTRACT
The paper examines the subject matter and scope of molecular biology and the value of its concepts and techniques in advancing the frontiers of the life sciences in our time.

KEY WORDS: Molecular biology, Central Dogma of Biology, Tertiary structure, Quaternary structure.

From Organism To Molecule And Atom

At any given epoch, contemporary knowledge concerning the structure and properties of the living organism (the subject matter of anatomy) and indeed of matter as a whole, corresponds to the capability, reliability and resolution capacity of the research instrumentation. In the early periods of its development, the main research instrument of anatomy was the human eye which has a resolution of 0.1 mm. That is, any organism or structure thereof of magnitude below 0.1 mm was beyond the scope of anatomy. Thus with the help of the biological instrument, the eye, scientists could only carry out inventory and systematization of some of large number of plant and animal species inhabitant on earth. The culmination of this was the formulation of Darwin's theory of evolution according to which advanced forms of life developed from simple ones as a result of gradual and continuos escalation in structural complexity.

The invention and introduction of light microscope into anatomy increased the resolution capacity to 0.2 micrometre during research. The biological cell and the microbial world became accessible to investigation. In 1839 Mathias Schleidem and Theodore Schwann formulated the theory that all animal and plant species are composed of common universal functional units called cells. It hen became clear that to understand the phenomenon of life, all aspects of cell that structure and functions must, as necessity, be studied. Anatomy thus came down to the cellular level. This was historically inevitable because there was no alternative way of advancing the frontiers of the science, and with the discovery of bacteria and viruses, the phylogenetic tree became fully sketched. From the study of anatomy of viruses came the inference that transition from non-living to living forms came to be achieved through gradual and continuos increase in structural complexity and organisation of first chemical, and then biological forms. Alongside with this also came the realization that fundamental processes which underlie life and its manifestations proceed at a level beyond the scope of light microscopy.

One of the most complex and fundamental manifestations of life is the ability of organisms to reproduce themselves and to transmit their characteristics to offsprings. Although the phenomenon of hereditary was known even in every ancient times, elucidation of the material basis of the process only became possible towards the end of the 19th century, when cellular processes such as mitosis, meiosis and fertilization were studied in details. It became established that of all cellular components, only the chromosomes are divided equally between daughter cells during cell divisions. In 1865 Gregor Mendel established that hereditary traits in organisms are controlled certain discrete factors which later became known as genes. In the beginning of the 20th century, it became known that genes are located in he chromosomes. From that time, the study of genes with the aim of establishing by what way they perform their main functions, namely, continuous and stable transmission of hereditary information through generations, control of all characteristics of organisms including their similarities and variation, either as systematic groups or as individuals within a population, became the central problem of biology. Atomic-molecular approach to anatomy thus became eminent.

Anatomy has come down to atom-molecular level in our time courtesy of advances in instrumentation and research methodology. Development in chemistry and physics contributes in no small measures to the growth of the science in the molecular direction. The interatomic distance in organic molecules ranges from 0.1 0.2 mm, and with the discoveries of election microscopy with its presen resolution of 0.2 mm, and x-ray crystallography with resolution of 0.11 mm, exact spatial location of atoms in molecules can be defined, making it possible to "visualize" biological molecules, supramolecular complexes and ultra-anatomical structures of the cell. With advent and perfection in techniques of fractionation of cell components including analytical and preparative ultracentrifugation, high profile methods of chromatography and electrophoresis, the use of radioactive isotopes and a host of others, the complex and coordinated network of biochemical reactions which constitute the molecular basis of functional organisation of anatomical structures is being determined and analysed. Molecular biology is making deliberate and systematic incursion into classical anatomy.

Immediately upon inception in 1953, molecular biology made its first and sensational impact with the discovery by john Watson and Francis Crick of the DNA molecular structure. The DNA molecule is organized by the specific pairing of adenine to thymine and guanine to cytosine (A = T; G = C). This specific pairing is the cornerstone and material principle of molecular biology. It is translated into the language of cell metabolism and proliferation in all species and consequently, into the language of organisation of cells into tissues, tissues into organs, organs into system and its anatomy are no longer a superstition of the universe but based on the molecular logics of complementary interaction of nucleobases, in the nucleic acid structure. Comprehensive study and investigation of the properties of the living system or its components can no longer be carried out without ideas and concepts of molecular biology. Morphological studies should proceed hand in hand with studies at the molecular level to further advance the frontiers of the science of anatomy. This is a necessity of our time, and a scientific inevitability.

Scope And Relevance To Anatomy And Medicine

Molecular biology is an aspect of biochemistry which studies life and its processes from the standpoint of complementary interaction of nucleobases in nucleic acid molecules. At the heart of the discipline lies the Central Dogma of Biology which establishes the universal pathway of information flow in living systems:

DNA ⇆ RNA → Protein

The conception and birth of molecular biology at the cross-road of biology, chemistry, physics, mathematics and kibernetics in the second half of the 20th century, signalized an important historical landmark in the evolution of our comprehension of the phenomenon of life. Molecular biology sets as its aim the evaluation of life and its processes on the basis of the role of atoms and molecules in the formation and functioning of biological structures. The today biology is no longer the study of living things at the gross level but the study of same at the molecular level.

We are all living witnesses to the tremendous pace of development and deepening of our understanding of biological processes at the molecular level. Some underlying mechanism determining the functional organisation of anatomical structures, which were previously given general and stetchy morphological explanations are currently being characterized and elucidated in terms of atomic and molecular interaction. For instance, the fundamental pathway of biological information flux has been established; the basic mechanisms of transformation of matter and energy in living systems are known. Consequently, the cell as unit of biological activity; now acquires the features of a dynamic system in which the relationship between structure of components and functions constitutes the fundamental principle of operation.

Molecular biology attaches great importance to the relationship between structure and functions of biological macromolecules as well as between composition, structure and roles of macromolecular complexes. This is because biological macromolecules and macromolecular complexes acquire new properties and specific functions when compared to their monomeric components. A case in point is the respiratory protein, haemoglobin found in erythrocytes of most animals. Neither the composite amino acids, the apoprotein globin, not the prosthetic group haem, is capable of independently combining with and transporting oxygen: the gas transport. Function of the protein is the protein is the activity of the entire haemoglobin molecule. Similar cases of the phenomenon abound in living systems. The explanation to this is that biological macromolecules, formed on the basis of the information in their original components, acquire tertiary and quaternary structures with intrinsically novel functional information.

The object of study of molecular biology is the living system. While this is so, molecular biology does not however primarily deal with, but only seeks to supplement, morphological studies of such the structural formulae of bioorganic compounds and the three-dimensional architecture of biological macromolecules which form the physico-chemical basis of organisation and functioning of morphological structures. Thus, the structure of the ribosome is discussed in connection with its role in protein biosynthesis, that of biomembrane in connection with transport of metabolites, that of muscle fibres in line with their interaction during locomotion, and so on.

Armed with modern instrumentation and techniques, molecular biology is very precise in the study of its subject matter. The subject matter of molecular biology is not only the physicio-chemical principles of biological processes, but also the search for ways and means by which these processes could be controlled. This underscores the importance and relevance of molecular biology to agriculture and medicine as close assessment of Nobel prize awards in these fields would show. A contemporary biologist, medial scientist or practitioner cannot be proficient in his field without knowledge of biological ultrastructures of the cell and molecular-biological evaluation of their functions at various levels of cellular organisation.

Molecular biology is very precise in approach to the study of the structure-functional organisation of the living system. Rather than take on the diverse properties of different species, it focuses on those characteristics which are universal to all living things. This approach forms the bais of the success story of molecular biology and gives rise to the inference that variations among different forms of life are but mere external manifestations which properties of the cell in turn depend on common, universal chemical systems. The first of them is the system which determines the synthesis of compounds responsible for sell reproduction of the cell. The processes involved here have common underlying chemical principles in all living systems. A second system is the membrane system which not only isolates the cellular content from the environment and divides the cellular space into compartments, but also brings about appropriate orientation of biological macromolecules in the cell. It is this orientation, which imparts "life" to biological macromolecules in vivo. There is yet a third system, which is that which supplies energy to the cell. These three systems form the foundation of organisation and functioning of the cell. The chemical similarity between species is he basis of molecular biological generalization and a proof that all forms of life evolded from a common ancestral molecule.

Molecular biology is a very dynamic discipline. The pace of development of the young science is so terrific that the mechanisms of biosynthesis of specific biomolecules are no longer obscure; genetic engineering continues to widen the horizon of our knowledge about biological processes; studies of influence of physical and chemical factors on nuclei acids continue to provide explanation to the phenomena of hereditary and variation; comparative studies of protein and nucleic acid structures continue to serve as basis for the development of biochemical systematic, molecular evolution and biochemical genetics. The morphological and descriptive character of biology is undergoing changes in approach and profundity, giving rise to new areas like chemical phylogeny, chemical zoology, phyto-chemical ecology, etc. Even fields like population analysis, autoregulation of sex groups in the population etc are not removed from the discipline because problems associated with them are now tackled at the molecular level.

In medicine, molecular biology is the source of new methods in disease diagnosis and management. Of relevance here is the fact that many hereditary diseases are manifestations of derangement in metabolism of nucleic acid, protein, lipid, hormones, carbohydrate etc. These forms the theoretical basis of a field like enzymopathy, which deals with conditions, associated with impairment of enzyme functions. Insight into the molecular biology of viruses, the interaction between viral and host cell genomes, conditions of viral propagation in the host, etc, all are vital in the prophylaxis and management of viral infections. The use of certain biologically active peptides like endorphins and enkephalins in psychotherapy and control of behavioural reactions is yet another impact of molecular biology, even on the society.

CONCLUSION

Molecular biology is the branch of biochemistry, which evaluates life and its processes on the basis of complementary interaction of nucleobases in nucleic acid molecules. It hinges on the Central Dogma of Biology which describes the universal pathway of information flow in living systems. It is the borderline of biology and presents the objective direction of development of the life sciences in our time. Its birth as a discipline in 1953 marked the commencement of the era of chemical biology.

REFERENCES

Allen JM (1967). Molecular Organisation and Biological Function. Harper and Row Pub., New York.

Anphinsen KB (1962). Molekuliarnie Osnovi evoluchi (The molecular basis of evolution.) Innostr. Pub. Moscow.

Asmarin IP (1974). Molekyliarnaya biologia (Molecular Diology) Medicina Pub., Leningrad.

Baev AA (1979) Obshie predstavlvenia O geneticheskoi indgeneric (General Concepts of genetic engineering). In: Itogi nauki I technicki; ser: Molekul. Biol., v. 78, No 1., p. 23-41.

Bentvelzen P. (1984) Molecular mechanisms of leukaemogenesis. Leuk. Res. V. 8, p. 169-71

Bernal J (1964) Biochemicheskaya evolucia. Gorizonti biochimii (Biochemical Evolution. Horizons of biochemistry). Mir. Pub., Moscow.

Bluemanfeld LA (1957). Gemoglobin

I abratimoe prissoedinenie kisloroda (Haemoglobin and reversible combination with oxygen). Sov. Nauka Pub., Moscow.

Bresler S, Jerusalemsky B (1965). Physika I chimia makromolekul (physics and chemistry of macromolecules). Nauka Pub., Leningrad.

Bresker S (1973) Molekuliarnaya biologia (Molecular biology) Nauka Pub., Moscow.

Calvin M (1971). Chimicheskaya evolution (Chemical evolution) Mir. Pub., Moscow

Cavalier Smith T (1981). The origin and early evolution of eukaryotic cell. - In: molecular and cellular aspects of microbial evolution. P.

Ekpo BO, Okechi OO (2002). HIV: The roundable virus. J. Exp. Clin Anat. 1 (I): 30-33

Green D, Goldbergeder P (1968). Molekularnie aspeckti shizni (Molecular aspects of life). Mir. Pub., Moscow.

Guyton A, Hall J (1996). Textbook of Medical Physiology. Sanders Comp. Pub. Philadephia.

Handwerker H, Kobal G (1993). Psycophysiology of experimentally induced pain. Phys. Rev., 73. P. 639-644.

Horst A (1982). Molekuliarine Osnovi patogeneza boleznei (Molecular basis of disease pathogenesis). Medicini Pub. Moscow.

Ingrem VM (1975). Biosyntez Makromolekul (Biosynthesis of macromolecules). Mir. Pub. Moscow

Kalinin FL (1978). Osnovi Molekuliarnoi biollogii (Basic Molecular Biology). Vishaya Shkola pub. Kiev.

Kendrew J (1968). Nit. Zshizni (The Thread of life). Mir. Pub., Moscow.

Kiselev L, Engelgardt V (1977). Problemi geneticheskoi enzimologii (The problems of genetic enzymology). Mol. Boil., T.II, P. 1293 1303.

Korataev A, Lishenko N (1987). Molekuliarnaya biologia I meditzana (Molecular biology ans medicine). Medizina Pub., Moscow.

Krasnopolskaya K (1982). Metodi I principi massovoi diagnostiki nasledstvinnich boleznei (Methods of mass diagnosis of hereditary diseases). In Perspectivi Meditzinkoi geneiki. Medizina Pub., Moscow.

Kuleshov NP, Shram P (1982). Genetichesky Monitoring populace Cheloveka V Cvizi C Zagriasninem Okrushaoshei sredi (Genetic Monitoring of human population during environmental polution). In: Perspektivi Medizinskoi genetiki. Medizina Pub., Moscow.

Lewim B (1987). Geni (Genes). Mir. Pub. Moscow.

Limborskaya SA (1982). Molekuliarnaya biology nasledstvennih bolesnei (The molecular biology of hereditary diseases) In: Perspectivi medizenskoi genetiki, ed. Buchkova. Med. Pub. Moscow.

Metzler D (1980). Biochemia. Chimicheskie reaktii V dshivoi kletke. (Biochemistry. Chemical reactions in the living cell). Mir. Pub., Moscow.

Poglazov BF (1970). Sborka biologicheskih strktur (The assembly of biological structures). Nauka Pub., Moscow.

Raff R, Kaufman T (1986). Embrioni, geni I evolucia (Embryos, genes and evolution). Mir. Pub., Moscow.

Sachin NP, Samar ND (1986). Peptides of the diffuse neutroendocrine system. In: Pharmacology in Medicine, Ed. Sachin N.P. Sp Press Intern. Inc., Maryland, USA.

Volkenshtein MV (1965). Molekuli I dzshizn (Molecules and life). Nauka Pub., Moscow.

Watson J (1978). Molekuliarnaya biologia gena (Molecular biology of the gene). Mir. Pub., Moscow.

Watson J, Alberts B, Bray D, Lewis J, Raff M, Roberts K (1987). Molekuliarnaya biologia kletki (Molecular Biology of the cell in 5 volumes). Mir. Pub., Moscow.

Wolstenholme G, O' Conor M (1966). Principles of biomolecular organisation. Little Brown and Comp., Boston.