CONCEPTUAL VIEWS ON THE STRUCTURE OF DEOXYRIBONUCLEIC ACID (DNA) AND THEIR SIGNIFICANCE

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ABSTRACT

This article systematically analyzes the molecular structure of deoxyribonucleic acid (DNA), its biological functional significance, as well as the scientific process of discovering the DNA structure, based on fundamental and modern scientific sources. The chemical composition of DNA, the structural features of nucleotides, the double helix model, and the mechanisms of storage and transmission of genetic information are described from a scientific and theoretical perspective. In addition, the conceptual views of leading researchers who played a key role in determining the DNA structure and their historical significance in the field of biology are substantiated

Deoxyribonucleic acid (DNA), which is considered one of the central concepts of modern biology and genetics, is recognized as the main biomolecule that performs the function of storing hereditary information in all living organisms, accurately replicating it during the process of cell division, and transmitting it from generation to generation. The study of the DNA structure has given a strong impetus to the rapid development of such scientific fields as cell biology, molecular genetics, medicine, pharmacology, and biotechnology. As noted in the scientific literature, understanding the structure of DNA not only made it possible to explain the mechanisms of biological heredity, but also created an opportunity to scientifically interpret the molecular foundations of life. Therefore, a comprehensive historical and theoretical analysis of the structure of DNA and the history of its discovery is regarded as one of the fundamental and relevant problems of biological science.

The scientific views of many prominent scholars play an important role in explaining the molecular structure of DNA and substantiating its biological functions. In particular, interpreting DNA as the carrier of hereditary information has become the central paradigm of modern molecular biology. Deoxyribonucleic acid (DNA), which is regarded as one of the core concepts of contemporary biology and genetics, is recognized as the principal biomolecule that stores hereditary information in all living organisms, accurately replicates it during cell division, and transmits it from generation to generation [1; 2]. The study of DNA structure played a decisive role in the formation of molecular biology and genetics and gave a strong impetus to the development of medicine and biotechnology [3]. DNA is a polymeric biomolecule with a high molecular mass, composed of a sequence of nucleotides. Each

nucleotide consists of a deoxyribose sugar, a phosphate group, and a nitrogenous base, and it is precisely the sequence of nitrogenous bases that encodes genetic information [4]. Researchers emphasize that the order of nucleotides in the DNA strand is the main factor determining the individual hereditary characteristics of an organism [5].

The double helix model explaining the spatial structure of DNA is recognized as one of the most fundamental scientific discoveries in the fields of genetics and molecular biology. According to this model, the DNA molecule consists of two polynucleotide strands oriented antiparallel to each other, which are interconnected through hydrogen bonds formed between nitrogenous bases [6]. The antiparallel arrangement not only ensures the chemical stability of the DNA strands but also creates the structural conditions necessary for the accurate replication of genetic information. The scientific substantiation of the double helix model is closely associated with the principle of complementarity. According to this principle, adenine in the DNA molecule pairs exclusively with thymine, while guanine pairs with cytosine. This regularity was confirmed by the base ratio rules identified by E. Chargaff (A = T, G = C), thereby strengthening the chemical and logical foundation of the DNA structure [7]. In his studies, Chargaff demonstrated that the strict balance of nitrogenous bases is not accidental, but rather reflects the internal structural logic of the DNA molecule. This conclusion made it possible to model the DNA structure with mathematical and chemical precision.

The discovery of the DNA structure was historically achieved as the result of a multi-stage scientific process. The initial stage of this process is associated with the discovery in 1869 by the Swiss scientist F. Miescher of a substance isolated from the cell nucleus, which he termed “nuclein” [8]. Miescher established that this substance differed fundamentally from proteins and described it as a new chemical compound closely associated with the cell nucleus. Subsequent studies demonstrated that this substance was deoxyribonucleic acid and proved its direct connection with hereditary information.

The complete scientific substantiation of the DNA structure reached its final form in 1953 with the proposal of the double helix model by J. Watson and F. Crick [6]. The scientists explained the spatial structure of the DNA molecule in close association with its biological functions, particularly the mechanisms of storing and transmitting genetic information. According to their view, the double helical form of DNA represents a universal biological mechanism that ensures the stability of hereditary information and its accurate transmission from generation to generation. In the development of this model, X-ray diffraction images obtained by R. Franklin served as a crucial empirical foundation [9]. Franklin’s experimental data provided convincing evidence that the DNA molecule possesses a helical structure and also confirmed the existence of specific geometric parameters of the helix, such as its pitch and diameter. Her research demonstrated that the double helix model was not merely a theoretical assumption but a scientifically constructed model supported by experimental evidence. Thus, the double helix model of DNA not only explained its molecular structure but also emerged as a conceptual turning point in genetics, making it possible to elucidate the molecular mechanisms of hereditary information. This discovery subsequently served as a solid theoretical foundation for the development of molecular genetics, genetic engineering, and modern medical science.

In contemporary research, the DNA molecule is interpreted not merely as a static carrier of information, but as a dynamic system that actively participates in processes of gene expression and regulation [10]. This approach has provided a foundation for the development of such fields as epigenetics, genetic engineering, and molecular medicine. Modern molecular biologists conceptualize the DNA structure as a dynamic system; in their view, DNA is not simply a static information carrier, but a complex biomolecule that adapts to the cellular environment and is closely interconnected with regulatory mechanisms. This perspective has stimulated advances in epigenetics, gene expression studies, and genetic engineering. Thus, the scientific views of leading researchers demonstrate that the explanation of DNA structure is based on the integration of chemical, physical, and biological approaches. This integration makes it possible to regard the study of DNA as an object of interdisciplinary research.

The study of the structure and functions of deoxyribonucleic acid (DNA), which is one of the central concepts of modern biology and genetics, is regarded as an important research direction not only in the works of foreign scholars but also in studies conducted by Uzbek scientists. In particular, within the Uzbek scientific school, research carried out in the fields of genetics, molecular biology, and biochemistry is aimed at a deep and systematic analysis of the central role of deoxyribonucleic acid (DNA) in the storage and transmission of hereditary information, using local biological objects as examples [11]. In these studies, first of all, the genetic characteristics of plants, agricultural crops, microorganisms, and certain animal species are investigated at the molecular level, and the structural and functional properties of DNA are analyzed in relation to the processes of hereditary stability and variability. Research conducted by local scientists also examines how the mechanisms of encoding, storing, and transmitting genetic information by the DNA molecule manifest themselves under the influence of ecological, climatic, and biogeographical factors. In particular, based on the use of genetic markers, DNA fragment analysis (PCR, sequencing), and molecular diagnostic methods, the genetic diversity of local gene pools is assessed, and scientifically grounded approaches to the management of selection processes are developed.

Within the Uzbek scientific school, research is not limited to interpreting DNA solely as a static carrier of information; rather, its interconnections with gene expression, regulatory mechanisms, and metabolic processes are also investigated from the perspectives of biochemistry and molecular biology. This approach makes it possible to consider DNA as a dynamic element of a complex biological system and serves as a basis for deriving scientific conclusions related to the regulation and prediction of genetic processes. Thus, studies conducted by Uzbek scholars in the fields of genetics, molecular biology, and biochemistry substantiate the universal biological significance of DNA in the storage and transmission of hereditary information using national biological resources as examples, thereby further enhancing the scientific value of fundamental and applied research carried out in this area.

In research conducted at scientific research institutes within the system of the Academy of Sciences of the Republic of Uzbekistan, the molecular structure of DNA, issues of genetic stability, and hereditary variability have been studied in depth using the gene pools of plants and agricultural crops as examples. In particular, studies led by Ibrohim Abdurakhmonov have scientifically substantiated issues related to identifying genetic diversity based on DNA markers, analyzing genetic information at the molecular level, and optimizing selection

processes [12]. In research carried out by Academician Saidamir Saidov and his scientific school, the structural and functional properties of DNA have been investigated at the cellular level, and issues related to the regulation of hereditary traits through molecular mechanisms have been elucidated. The scholar evaluates DNA as a key molecular factor ensuring the stability of biological systems [13]. In addition, studies by Uzbek biochemists have analyzed the interrelationship between DNA and protein synthesis, as well as the connections between gene expression and metabolic processes. These studies emphasize the role of DNA not merely as a static carrier of information, but rather as a dynamic regulatory system [14]. In local scientific literature, the study of DNA structure is also interpreted in connection with biology education methodology. In particular, Uzbek researchers have substantiated the effectiveness of using visual models and integrative approaches in teaching students the double helix model of DNA, the principle of complementarity, and the mechanisms of genetic information. This approach contributes to a deeper assimilation of theoretical knowledge about DNA.

A comparative analysis of studies conducted by foreign and local scholars demonstrates the universality of scientific knowledge regarding the structure of DNA, while at the same time highlighting the significant contribution of the Uzbek scientific school in this field. This circumstance confirms that the study of DNA is relevant not only in a global scientific context but also within the national scientific framework.

Biological and practical significance of DNA The DNA molecule performs the following fundamental biological functions:

– storage and encoding of genetic information;

– replication of hereditary information during the process of cell division;

– regulation of protein synthesis;

– determination of organismal development, adaptation, and hereditary traits. The elucidation of DNA structure provided a theoretical foundation for the formation and development of modern scientific fields such as genetic engineering, medical genetics, oncology, forensic biology, and biotechnology.

Conclusion In conclusion, it can be stated that the structure of DNA and the history of its discovery represent one of the most significant scientific achievements in the field of biology. The double helix model of DNA provided a scientific explanation for the molecular basis of hereditary information and made it possible to understand life processes at the molecular level. The advancement of modern biology and medical sciences is directly grounded in fundamental knowledge of DNA, which further enhances the scientific and practical significance of this topic.

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