International Journal of Advanced Research and Review

www.ijarr.in

A SHORT REVIEW ON CENTRAL DOGMA OF MOLECULAR BIOLOGY

Shopnil Akash, Mst.Fateha Arefine,

Department of Pharmacy, Daffodil International University, 4,2, Sukrabad, Dhaka, Bangladesh
Email: shopnil29-059@diu.edu.bd & fatehah1548@gmail.com
Corresponding Author: shopnil29-059@diu.edu.bd

ABSTRACT

Francis Crick announced the Central Dogma of molecular biology upwards of half a century (1958) to clarify the interconnections between the fundamental informational macromolecules, including DNA, RNA, and proteins. This dogma asserted that genetic information could be transferred from DNA to DNA/RNA or nucleic acid to protein. Nevertheless, transmitting information from one protein to another or from one protein to nucleic acid is difficult. The purpose of this essay is to assess Central Dogma's Basic concept.

Keyword: Central Dogma, DNA, RNA, Protein, Ribosome

1. INTRODUCTION

Francis Crick wrote to his 12-year-old son Michael on March 19, 1953, informing him about the finding of the Central Dogma Model that he and James Watson had been discovered[1]. Francis Crick did a presentation over seven decades ago. He introduced the "central dogma" schematic. This dogma asserted that genetic information could be transferred from DNA to DNA/RNA or nucleic acid to protein. However, there is no way to transmit data from one protein to another or from one nucleic acid to another[2].After that, This concept of Central dogma was proposed in 1958 [3].

Figure 1: **The central dogma, according to Watson**

The central dogma meanly a molecular biology technique that has been transmitted genetic information from DNA to RNA, resulting in the formation of a protein molecule[4].The central dogma system has been described as the transformation of DNA replication, RNA coding by transcription, and protein-coding by translation[5].The central dogma holds that DNA consists of instructions on how to build all biological proteins. RNA acts as a carrier (messengers) to deliver those instructions to the ribosomes [6, 7]. Ribosomes work as industries in the organism, converting instructions from a code into a usable product through a process known as translation

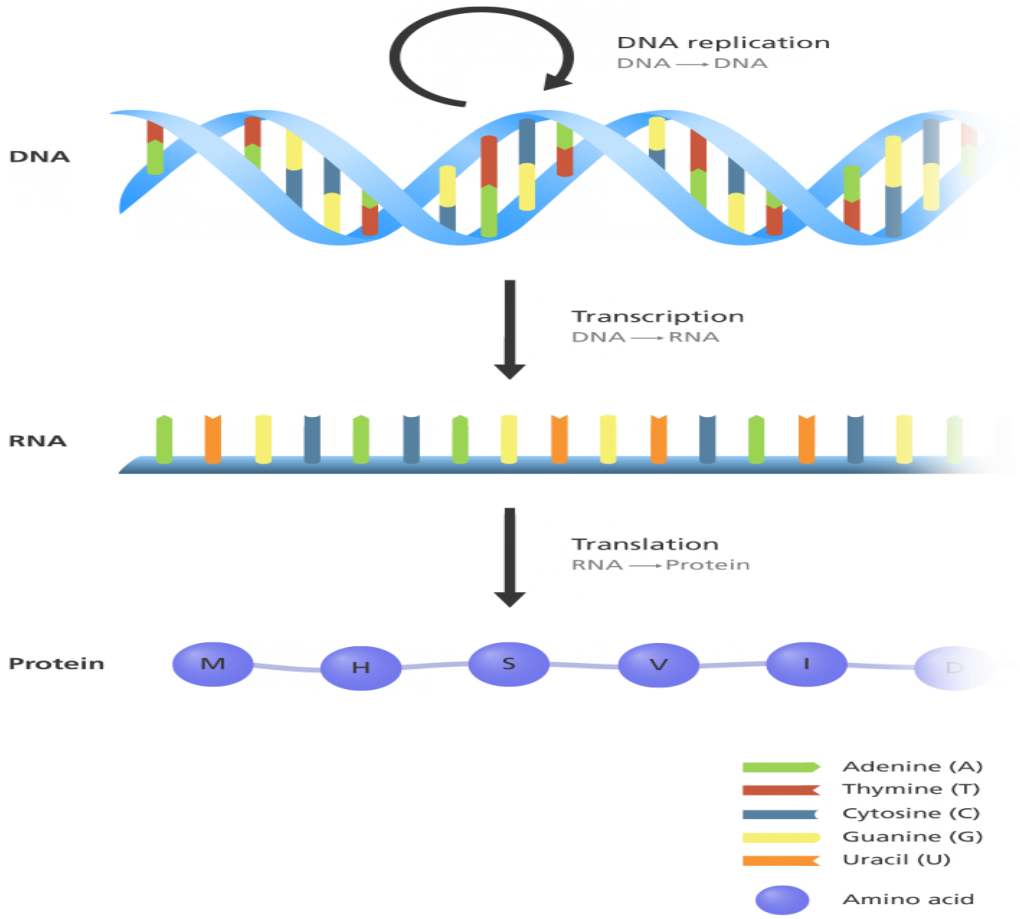

Figure 2: **The central dogma, according to Watson (An illustration showing the flow of information between DNA, RNA, and protein. Image credit: Genome Research Limited**

1.2. Terminology Used Throughout the Method

DNA.DNA means Deoxyribonucleic Acid, which has stored all biological organisms' genetic information [8, 9].

RNA. RNA stands for ribonucleic acid, whereas mRNA stands for messenger RNA. mRNA assists in the molecular encoding of any functional protein[10, 11].

Ribosome. The ribosome is a macromolecule that has been responsible for the synthesis of protein in cells[12].

Replication. Replication is the process of making an exact copy of a double-stranded nucleic acid[13, 14]. This mechanism ensures that genetic information is passed down from generation to generation[15].

Transcription. The act of copying information from a strand of DNA into a new messenger RNA molecule has been known as transcription (mRNA)[16, 17].

Translation. Creating a protein molecule from the information contained in a messenger RNA molecule is known as translation (mRNA)[18, 19].

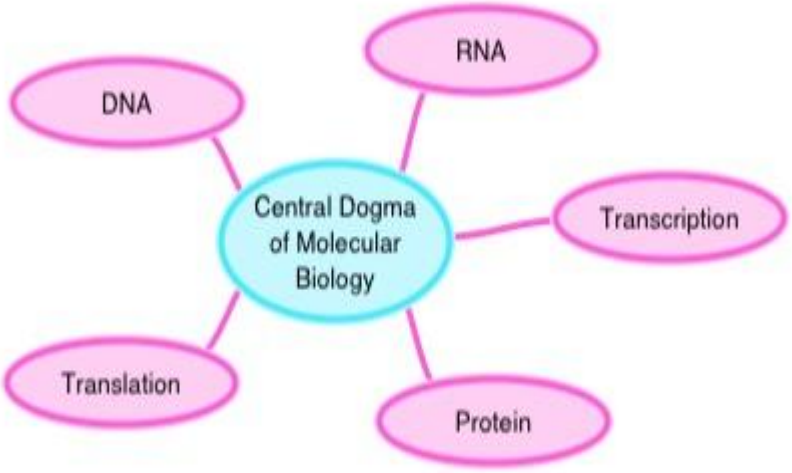

Figure 3. Making Connections (Ref.[20])

General	Special	Unknown
DNA → DNA	RNA → DNA	protein → DNA
DNA → RNA	RNA → RNA	protein → RNA
RNA → protein	DNA → protein	protein → protein

Table 2. The three classes of information transfer suggested by the dogma (Ref.[3]

1.3. DNA description

DNA is the genetic component of organisms made up of lengthy nucleotide base pair patterns. These nucleotide sequences generate many proteins required by the organism[21-24]. The essential elements of DNA have been known as nucleotides.

There are four different nucleotides:

- dATP: deoxyadenosinetriphosphate
- dGTP: deoxyguanosinetriphosphate
- dTTP: deoxythymidinetriphosphate

- dCTP : deoxycytidinetriphosphate

DNA is created by joining two nucleotides together via the phosphate group[25].The sugar molecule has been positioned on the 5th C-atom[26].

1.4. DNA Presents in which organelles and Size of DNA in organelles

Eukaryotic cells are made up of a variety of organelles[27].Most of a cell's DNA is found in the nucleus called chromosomal DNA[28-30].The DNA found in the endomembrane chloroplast has been termed chloroplast DNA (cpDNA)[31, 32].

Type of DNA	Organism	size in base pairs
chromosomal DNA[33]	mammals	6×10^9
	plants	2×10^8 - 2×10^{11}
	fungi	2×10^7 - 2×10^8
mitochondrial DNA[34]	animals	16×10^3 - 19×10^3
	higher plants	150×10^3 - 250×10^4
	fungi	17×10^3 - 78×10^3
	green alga	16×10^3
	protozoa	22×10^3 - 40×10^3
chloroplast DNA[35]	higher plants	120×10^3 - 200×10^3
	green alga	180×10^3

1.6. How do the nucleotides form a DNA chain?

DNA is just a structure consisting of four unique bases (nucleotides) that repeatedly repeat [36, 37].Nucleotides are composed of sugar[38] (deoxyribose) sandwiched by phosphate groups and nitrogenous bases in the center of the molecule[25, 39].The nucleotide pairs in a DNA molecule are formed by hydrogen bonding between the two neighboring bases[22, 40, 41].A particular manner in which the nitrogenous bases of DNA couple up is always maintained, purine with pyrimidine (A with T, G with C), which is kept together by intermolecular hydrogen bonding[42-45].

DNA's four basic components are as regards:

- adenine (A) - a purine
- cytosine(C) - a pyrimidine
- guanine (G) - a purine
- thymine (T) - a pyrimidine

2. CONCLUSION

The central dogma has represented the transfer of genetic material in cells, DNA replication, and RNA coding via transcription, and then RNA coding for protein synthesis throughout the translation process. This paradigm helps to clarify the idea of a series of interactions. Biopolymers are among the most prevalent. Proteins, RNA, and DNA are the three primary categories of biopolymers, further classified into general transfers, unknown transfers, and special transfers. In the laboratory, special transfers are made when necessary due to a unique situation. General transfers almost all cells are capable of transferring information in this way. It refers to the continuous flow of data due to the result of transcription and translation. Unknown transfers have been believed to be extremely rare and not happen.

REFERENCE

[1] C. L. Tan and E. Anderson, "The New Central Dogma of Molecular Biology," Retrieved 2020-06-14 from https://www. researchgate. net/publication 2020.

[2] M. Cobb, "60 years ago, Francis Crick changed the logic of biology," *PLoS biology,* vol. 15, no. 9, p. e2003243, 2017.

[3] F. Crick, "Central dogma of molecular biology," *Nature,* vol. 227, no. 5258, pp. 561-563, 1970.

[4] P. Šustar, "Crick's notion of genetic information and the 'central dogma'of molecular biology," *The British journal for the philosophy of science,* vol. 58, no. 1, pp. 13-24, 2007.

[5] P. R. Wills, "Genetic information and the determination of functional organization in biological systems," *Systems Research,* vol. 6, no. 3, pp. 219-226, 1989.

[6] A. Costello and A. H. Badran, "Synthetic biological circuits within an orthogonal central dogma," *Trends in biotechnology,* vol. 39, no. 1, pp. 59-71, 2021.

[7] J. A. Shapiro, "Revisiting the central dogma in the 21st century," *Annals of the New York Academy of Sciences,* vol. 1178, no. 1, pp. 6-28, 2009.

[8] M. W. Nirenberg, "The genetic code," *Scientific American,* vol. 208, no. 3, pp. 80-95, 1963.

[9] F. H. Crick, "The genetic code," *Scientific American,* vol. 207, no. 4, pp. 66-77, 1962.

[10] M. Grunberg-Manago, "Messenger RNA stability and its role in control of gene expression in bacteria and phages," *Annual review of genetics,* vol. 33, no. 1, pp. 193-227, 1999.

[11] E. M. Harcourt, A. M. Kietrys, and E. T. Kool, "Chemical and structural effects of base modifications in messenger RNA," *Nature,* vol. 541, no. 7637, pp. 339-346, 2017.

[12] J. W. Whittaker, "Cell-free protein synthesis: the state of the art," *Biotechnology letters,* vol. 35, no. 2, pp. 143-152, 2013.

[13] A. Dounce, "A new hypothesis for nucleic acid replication," *Journal of Theoretical Biology,* vol. 2, no. 2, pp. 152-158, 1962.

[14] W. Gilbert and D. Dressler, "DNA replication: the rolling circle model," in *Cold Spring Harbor Symposia on Quantitative Biology,* 1968, vol. 33, pp. 473-484: Cold Spring Harbor Laboratory Press.

[15] D. Wilkinson and S. Weller, "The role of DNA recombination in herpes simplex virus DNA replication," *IUBMB life,* vol. 55, no. 8, pp. 451-458, 2003.

[16] J. Scott, "Messenger RNA editing and modification," *Current opinion in cell biology,* vol. 1, no. 6, pp. 1141-1147, 1989.
[17] M. F. Singer and P. Leder, "Messenger RNA: an evaluation," *Annual review of biochemistry,* vol. 35, no. 1, pp. 195-230, 1966.
[18] J. Gurdon, C. Lane, H. Woodland, and G. Marbaix, "Use of frog eggs and oocytes for the study of messenger RNA and its translation in living cells," *Nature,* vol. 233, no. 5316, pp. 177-182, 1971.
[19] E. A. Barnard, R. Miledi, and K. Sumikawa, "Translation of exogenous messenger RNA coding for nicotinic acetylcholine receptors produces functional receptors in Xenopus oocytes," *Proceedings of the Royal Society of London. Series B. Biological Sciences,* vol. 215, no. 1199, pp. 241-246, 1982.
[20] "Central Dogma of Molecular Biology (https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/Book%3A_Introductory_Biology_(CK-12)/04%3A_Molecular_Biology/4.01%3A_Central_Dogma_of_Molecular_Biology)," Mar 6, 2021.
[21] B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, and P. Walter, "The structure and function of DNA," in *Molecular Biology of the Cell. 4th edition*: Garland Science, 2002.
[22] J. D. Watson and F. H. Crick, "The structure of DNA," in *Cold Spring Harbor symposia on quantitative biology*, 1953, vol. 18, pp. 123-131: Cold Spring Harbor Laboratory Press.
[23] P. D. Cristea, "Conversion of nucleotides sequences into genomic signals," *Journal of cellular and molecular medicine,* vol. 6, no. 2, pp. 279-303, 2002.
[24] N. C. Seeman, "DNA nanotechnology," *Materials Today,* vol. 6, no. 1, pp. 24-29, 2003.
[25] Y. Li, Y. Liu, and R. R. Breaker, "Capping DNA with DNA," *Biochemistry,* vol. 39, no. 11, pp. 3106-3114, 2000.
[26] S. Neidle and Z. Abraham, "Structural and sequence-dependent aspects of drug intercalation into nucleic acid," *Critical Reviews in Biochemistry,* vol. 17, no. 1, pp. 73-121, 1984.
[27] T. Cavalier-Smith, "The origin of nuclei and of eukaryotic cells," *Nature,* vol. 256, no. 5517, pp. 463-468, 1975.
[28] B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, and P. Walter, "Chromosomal DNA and its packaging in the chromatin fiber," in *Molecular Biology of the Cell. 4th edition*: Garland Science, 2002.
[29] C. L. Peterson and J. Côté, "Cellular machineries for chromosomal DNA repair," *Genes & development,* vol. 18, no. 6, pp. 602-616, 2004.
[30] Y. Higuchi, "Chromosomal DNA fragmentation in apoptosis and necrosis induced by oxidative stress," *Biochemical pharmacology,* vol. 66, no. 8, pp. 1527-1535, 2003.
[31] R. G. Herrmann, H.-J. Bohnert, K. V. Kowallik, and J. M. Schmitt, "Size, conformation and purity of chloroplast DNA of some higher plants," *Biochimica et Biophysica Acta (BBA)-Nucleic Acids and Protein Synthesis,* vol. 378, no. 2, pp. 305-317, 1975.
[32] C. Y. Huang, M. A. Ayliffe, and J. N. Timmis, "Direct measurement of the transfer rate of chloroplast DNA into the nucleus," *Nature,* vol. 422, no. 6927, pp. 72-76, 2003.
[33] A. T. Annunziato, "DNA Packaging: Nucleosomes and Chromatin (https://www.nature.com/scitable/topicpage/dna-packaging-nucleosomes-and-chromatin-310/)," 2008

[34] P. D. Heidi Chial, "mtDNA and Mitochondrial Diseases (https://www.nature.com/scitable/topicpage/mtdna-and-mitochondrial-diseases-903/," vol.), 2008.
[35] J. De Las Rivas, J. J. Lozano, and A. R. Ortiz, "Comparative analysis of chloroplast genomes: functional annotation, genome-based phylogeny, and deduced evolutionary patterns," *Genome research,* vol. 12, no. 4, pp. 567-583, 2002.
[36] E. Albuquerque, M. Vasconcelos, M. Lyra, and F. de Moura, "Nucleotide correlations and electronic transport of DNA sequences," *Physical Review E,* vol. 71, no. 2, p. 021910, 2005.
[37] J. C. Fiddes, "The nucleotide sequence of a viral DNA," *Scientific American,* vol. 237, no. 6, pp. 54-67, 1977.
[38] G. K. Wagner, T. Pesnot, and R. A. Field, "A survey of chemical methods for sugar-nucleotide synthesis," *Natural product reports,* vol. 26, no. 9, pp. 1172-1194, 2009.
[39] B. Schneider, K. Patel, and H. M. Berman, "Hydration of the phosphate group in double-helical DNA," *Biophysical journal,* vol. 75, no. 5, pp. 2422-2434, 1998.
[40] M. M. Georgiadis, I. Singh, W. F. Kellett, S. Hoshika, S. A. Benner, and N. G. Richards, "Structural basis for a six nucleotide genetic alphabet," *Journal of the American Chemical Society,* vol. 137, no. 21, pp. 6947-6955, 2015.
[41] C. Schaper, "Structural Symmetry of DNA Nucleotides and Steroid Hormones," 2020.
[42] J. D. Watson and F. H. Crick, "Genetical implications of the structure of deoxyribonucleic acid," *JAMA,* vol. 269, no. 15, pp. 1967-1969, 1993.
[43] C. Robertson, "MODELING DNA," *The Science Teacher,* vol. 83, no. 5, p. 26, 2016.
[44] A. J. Griffiths, J. H. Miller, D. T. Suzuki, R. C. Lewontin, and W. M. Gelbart, "Structure of DNA," in *An Introduction to Genetic Analysis. 7th edition*: WH Freeman, 2000.
[45] R. R. Sinden, *DNA structure and function*. Gulf Professional Publishing, 1994.