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# Pathway for the Transfer of Genetic Information The Central Dogma of Molecular Biology

A cell is the basic unit of life. The living cells are seemingly very complex entities with a number of intracellular compartments and cell organelles. However, critical analysis of entire cell content reveals that it is composed of a number of chemical substances which are similar to other chemicals in their nature and follow the basic principles of physics, chemistry and thermodynamics. How does the living cell, then differ from a test tube with all these chemicals? In the cell these compounds are present in a well defined and organized manner. Some of these cell constituents are simple chemicals such as NaCl, glucose, ATP etc. while others are very complex compounds of large molecular weight. Many of the complex substances, referred as bio-macromolecules, are found only in living cells. The numerous compounds of different size, shape and chemical composition as well as having different properties interact with each other and many chemical reactions are continuously and simultaneously taking place in the cell at any given moment. Again these reactions take place in a highly ordered manner and are very precisely regulated. The proper organization of the complex chemicals and the precise regulation of the biochemical reactions is the basis of life. Any distortion or impairment of these events results in pathological conditions and may even lead to cell death.

The principal bio-macromolecules can be divided into four major classes namely, proteins, lipids, carbohydrates and nucleic acids. Each of these has diverified but well defined roles. The carbohydrates and lipids are the main source of energy in the body. Besides being the source of energy, the lipids have certain other roles also, such as these are the essential part of the membrane structure. Majority of the cellular functions are mediated through enzymes, which are mostly protein in nature. Proteins also serve as important structural constituent of the cell. Besides, a number of protein factors serve as the regulator of various metabolic pathways. Nucleic acids on the other hand, are involved in storage and transfer of genetic information and provide the biological diversity and specific characters to different organism and also to cells.

Nucleic acids are complex molecules, synthesized by polymerization of small building blocks, the nucleotides. Two types of structurally related but functionally distinct nucleic acids, the ribonucleic acid (RNA) and deoxy-ribonucleic acid (DNA), are found in the cell. DNA is the basic genetic material in almost all the organisms. Further, it is the only molecule which has the capability to produce its own copies by a process known as replication. The only known exceptions to these fundamental rules

are certain viruses (retroviruses and the reoviruses), which have RNA as their genetic material. In retroviruses, the replication of genomic RNA requires an obligatory synthesis of DNA as an intermediate in the process However, the RNA genome of reoviruses replicates without any asistance or involvement of DNA. The DNA is arranged in a highly ordered manner to form long thread like structures, the chromosomes. A number of proteins participate in the organization of chromosomal structure. The chromosomes are highly condensed structure and accomodate large amounts of DNA in relatively small space. There are usually more than one chromosomes in a cell, the number of chromosomes depends upon the evolutionary complexity of the organism. The amount of DNA, its organization and the number of chromosomes are the characteristic properties of any species. These properties do not vary from cell to cell or individual to individual within the same species. However, these vary from species to species. The chromosomes are present in the nucleus of eukaryotes. Prokaryotes donot have defined nucleus. However, the DNA in prokaryotes is also arranged in form of a chromosome. The bacterial chromosomes are present in a relatively dense region of the cytoplasm, referred as nucleoid. While DNA stores and transfers the genetic information from one generation to another, most of the cellular functions are mediated through proteins. This information is finally expressed in the form of a protein by a series of intermediary processes. The first step in the expression of genetic information involves the transfer of the information present in DNA to RNA. The DNA and RNA, both have similar basic structure and are made with four different types of nucleotides (the A,T,C and G in DNA and A,U,C and G in RNA) which are their building blocks. Different informations are stored in coded form by different sequence of these four nucleotides. This process of transfer of information from DNA to RNA is known as the transcription. Transcription is primarily carried out by the enzyme RNA poly-merase, though a number of other enzymes and trans acting factors assist in this process. In the retroviruses (which have RNA as their genetic material but replicate through DNA) first a true copy of the genome in the form of DNA which is complementary to RNA, is synthesized by a process which is the reversal of transcription. This process is mediated by reverse transcriptase, an enzyme present only in retro-viruses and not in any other organism. The DNA is then replicated and transcribed by normal pro-cesses to produce multiple copies of genomic RNA. The genomic RNA of reoviruses, on the other hand, is self replicated through a specialized enzyme, the RNA dependent RNA polymerase or the RNA replicase. The RNA is then transported to cytoplasm where the information carried by it is decoded and transferred to a structurally unrelated form, the proteins. This process is probably the most complex cellular process and is referred as the translation. The ribosomes serve as the site of protein synthesis and a number of enzymes and other trans acting factors participate in this process. As will be discussed later, the proteins are madeup of totally unrelated building blocks, the aminoacids. There are twenty different aminoacids which participate in the synthesis of proteins. Thus an information written in a language of only four letters is finally translated to a entirely different language with a complex alphabet of twenty aminoacids. This general pathway for the transfer of genetic information from DNA to proteins constitutes the central dogma of molecular biology. It has been diagrammatically illustrated in Fig. 1.1.

It is thus clear that the transfer of information between two types of nucleic acids is reversible and it is possible to interchange it from one form to another. However, once the information has been transfered to the proteins, the transfer is irreversible and it can not revert back to nucleic acid.

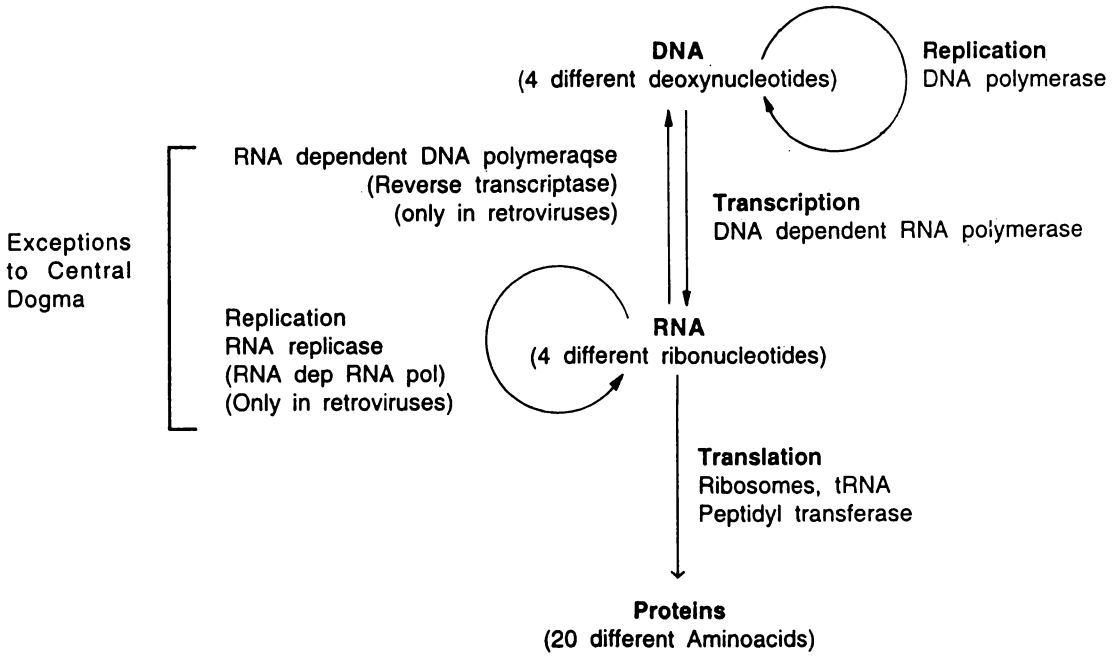


**Fig. 1.1.** Central dogma of molecular biology.