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REPLICATION AND SEGREGATION OF THE DNA MOLECULE

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Abstract:
The article is focused on the issues of providing theoretical information in the teaching of genetics and strengthening students' cognitive activity .

Keywords: dezoxyribonucleic acids (DNK), ribonucleic acids, gene, replication, segregation, nucleoside triphosphate (dNP), d-nucleoside (dN) , adenine - A, guanine - G, thymine - T and cytosine S

Introduction

The transfer of genetic information to future generations of cells and organisms is carried out through the replication (autoreproduction) of the DNA molecule and the segregation of chromosomes. The second function of this biopolymer is the transmission of newly formed DNA as a result of DNA replication to the next generation of cellular organisms. The first function of DNA is to ensure the encoding of genetic information - genes - in its structure, as described above. Replication results in two DNAs that are identical to each other and to the original DNA. Replication of DNA takes place in all organelles (chromosomes, plastids, and mitochondria) that contain DNA in the cell itself. In eukaryotes, replication occurs before each mitosis and meiosis, and in bacteria, the body replicates before each cell division. After that, the newly synthesized DNA molecules are distributed in the chromosomes in an equal amount to the nucleus of the newly formed cells as a result of division through the process of segregation.

Segregation in eukaryotic organisms is carried out by cell division in two ways (mitosis and meiosis). In bacteria, segregation is distributed equally to new cells formed during cell division. When organisms reproduce sexually, genetic information is transmitted through macro- and microgametes with a haploid (n) number of karyotypes formed by meiosis. The zygote formed from their union (fertilization) contains parental genetic information. When organisms reproduce asexually, genetic information is transmitted to future generations through somatic cells with a diploid (2n) number of chromosomes formed by mitosis. Genetic information in the zygote is usually completely transferred to all new cells formed during the ontogenesis of multicellular organisms, starting from the zygote, through the process of mitosis. Now let's get acquainted with the molecular basis of replication and segregation processes.

DNA replication takes place through the following molecular genetic processes:

1) Building block - synthesis of nucleotides. Deoxyribonucleoside triphosphates, which are synthesized and collected in the cell, serve as the necessary building block for the synthesis of new DNA molecules. They are more concisely called d-nucleoside triphosphate and denoted by the symbol dNP. The Latin letter d stands for deoxyribose, N for nucleoside, and finally P for phosphate. The synthesis of this substance called nucleotide is carried out through the following processes:

a) synthesis of d-nucleoside (dN) takes place as a result of joining one of the nitrogenous bases (A, T, G and S) with deoxyribose. This synthesis takes place by splitting one molecule of water.

b) d-nucleoside, in turn, combines with adenosine triphosphoric acid, which is an energy source, to form d-nucleoside triphosphate. This process also takes place through condensation. In this case, dNPs, i.e. nucleotides, are ready to function as building blocks of DNA replication.

2) A DNA molecule twisted in a double helix state by bringing the twist into the written position and denaturing it two division into a polynucleotide chain is the second stage of replication. In this case, the hydrogen bonds connecting the nucleotides in two polynucleotide chains of DNA are removed with the help of the helicase enzyme. As a result, the DNA begins to separate from one end into two separate polynucleotide chains. Next to each of the two polynucleotide chains, two new polynucleotide chains are synthesized parallel to it in a complementary position. DNA replication in this state is called a semi-conservative method.

Thus, both polynucleotide chains of mother DNA perform the function of template (matrix) for replication.

3) New polynucleotide chains are synthesized with the participation of DNA polymerase I, DNA polymerase II and DNA polymerase III enzymes. As mentioned above, dN triphosphate - nucleotides perform the function of a building block for the synthesis of new polynucleotide chains during DNA replication. Their placement in the synthesized polynucleotide chain is carried out through the following three processes:

1) Diphosphate nuclease is cut from them before connecting to a new polynucleotide chain. As a result, dN triphosphate becomes dN monophosphate. They are usually referred to as mononucleotides or polynucleotides, as a more compact and convenient term.

The replication process is manifested due to the energy released as a result of the breakdown of triphosphate into monophosphate.

2) Thus, ready nucleotides are composed of three different chemical substances - nitrogenous base, deoxyribose and monophosphate. Depending on which nitrogenous base they contain, they are in the form of 4 types of nucleotides: adenine - A, guanine - G, thymine - T and cytosine S. They are connected to the synthesizing polynucleotide chain of DNA in a specific order, in a complementary position to the nucleotides in the old chain using DNA polymerase enzymes. A complex ether bond is formed between two connecting nucleotides through the process of condensation with each other. As a result, a phosphodiester bridge connecting the phosphate of one nucleotide with the deoxyribose of the second nucleotide is formed. This bridge connects the 3 carbon atoms of one nucleotide deoxyribose with the 5 carbon atoms of the second nucleotide through oxygen. The next nucleotide is connected to the polynucleotide chain being synthesized through the described process.

3) The last process that takes place in the synthesis of a DNA molecule consists in connecting the nucleotides in its old and newly synthesized nucleotide chains with each other through hydrogen bonds. This process is called renaturation. By renaturation, an adenine nucleotide is connected to a thymine nucleotide by two hydrogen bonds, and a guanine nucleotide to a cytosine nucleotide by three hydrogen bonds. As a result, two new double-stranded DNA molecules are formed from the starting DNA with one polynucleotide double helix. One of the polynucleotide chains in both of them is passed from the original DNA, and the other is newly synthesized.

The basic principles of DNA replication described above are the same in prokaryotic and eukaryotic organisms . But recent evidence in molecular biology has shown that they have some differences in DNA replication. Therefore, we describe their replication separately, emphasizing their differences.

Unlike eukaryotes, prokaryotic organisms - bacteria and viruses with DNA - do not have chromosomes that are formed, but instead have a free-standing DNA molecule that looks like a ring. In addition, prokaryotes have only one point of replication in their DNA. Therefore, replication begins at only one place on the circular DNA and ends with the synthesis of two new circular DNAs from one initial circular DNA through the three processes mentioned above. They divide into two newly formed cells one at a time. It should be noted that the molecular mechanism of DNA replication was first discovered in microorganisms. In 1956, the American scientist A. Kornberg discovered E.coli bacteria . 3 1 5 1 conducted an experiment as follows. DNA polymerase enzyme, deoxyribonucleoside triphosphate (dN-triphosphate) and its circular DNA as a template were isolated from E.coli and mixed in an artificially created container. As a result, he demonstrated that DNA replication occurs under laboratory conditions. The results of A. Kornberg's discovery in 1967 were of great importance in the development of research in the field of replication of eukaryotic organisms. The two polynucleotide chains present in a DNA molecule are antiparallel. Nucleotides are 5 1 in one of them 3 1 in the direction and 3 1 in the other 5 will be located in the 1 direction. In other words, they have 5 1 3 1 will be opposite each other. Therefore, the starting point and direction of the synthesis of new polynucleotide chains are opposite in them. Direction of DNA 5 1 Next to the 3 1 polynucleotide chain, the synthesis of a new chain takes place continuously and integrally. Because DNA polymerase is only one 5 1 of DNA 3 continuously synthesizes only the polynucleotide chain in direction 1 .

This is how the first double-helix DNA synthesized by replication is synthesized. 3 1 of DNA Synthesis of the second new polynucleotide chain with 5 1 direction: a) is in the opposite direction; b) there are many replication origins;

c) for the synthesis of a polynucleotide chain in this direction, some of its parts are first synthesized. These fragments are called Okazaka fragments. This process is carried out by the enzyme DNA polymerase III . At the next stage of the synthesis of this polynucleotide chain, Okazaka fragments are connected to each other in a certain sequence with the help of DNA ligase enzyme. As a result, a second new polynucleotide chain is synthesized. It hydrogen bonds with the second starting polynucleotide chain to form a second new double helix DNA. DNA replication takes place during the DNA synthesis phase of the mitotic cycle of cell division.

Segregation of DNA. Segregation refers to the process of distribution of new DNA molecules synthesized and multiplied as a result of DNA replication to newly formed cells within the structure of chromosomes.

In prokaryotic organisms, the DNA molecule is in a free state, so the process of segregation takes place in a normal state. In them, the new DNA molecules formed as a result of the replication of the DNA molecule are distributed to newly formed cells in a "naked" state without proteins.

In eukaryotic organisms, the process of segregation is manifested in a complex state. In them, new DNA molecules formed as a result of DNA replication are distributed to future cell generations in newly formed chromosomes. Therefore, before explaining how this process occurs in eukaryotes, we will provide an understanding of the chemical composition and molecular structure and function of chromosomes in them. Chromosomes perform the following functions that ensure the life of organisms and all their cells. 1) The function of placing and storing the DNA molecule, which contains genetic information; 2) Distribution of new DNA molecules synthesized as a result of replication in the primary cell in equal amounts to cells of the next generation, i.e. segregation function; 3) The function of

ensuring the realization of genetic information transferred to cells of the new generation (DNA replication, iRNA transcription).

The molecular structure of chromosomes is adapted to fulfill its stated functions. During the division and reproduction of cells (cell cycle), there are two successively alternating structural and functional stages: 1) preparation for segregation and its implementation, DNA storage and transfer to new cells, i.e., the stage of carrying out the task of transport. This stage corresponds to the division and reproduction period of the cell cycle; 2) the stage when chromosomes and the DNA molecule contained in them are in a functionally active state. This stage corresponds to the interphase period of the cell cycle.

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