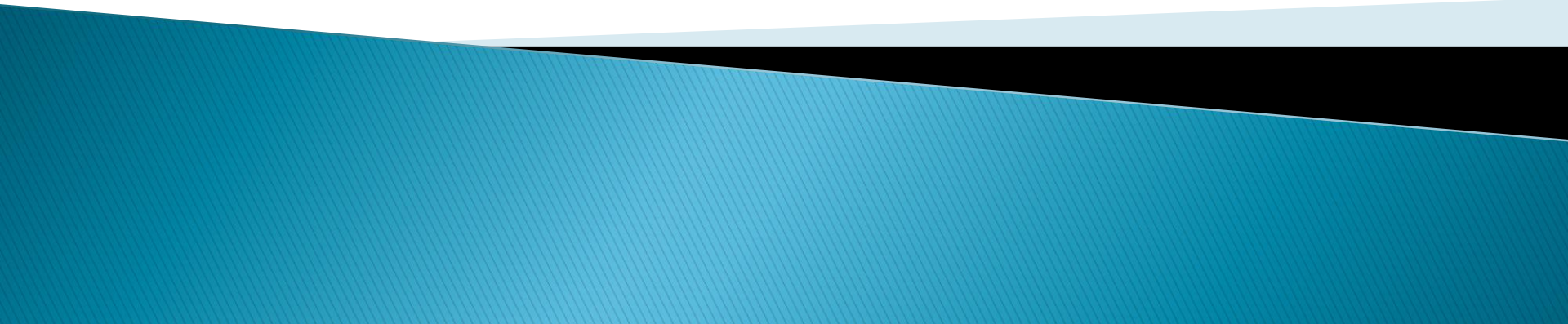


DNA Structure and DNA replication in eukaryotes

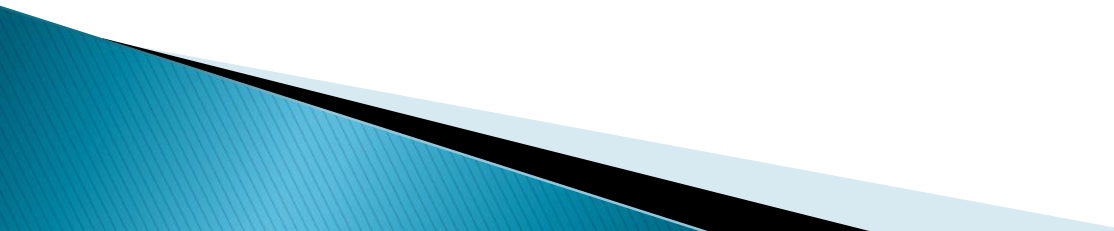


DNA: The Genetic Material

The genetic material must have certain characteristics. These characteristics can explain the properties of life.

1. First, the genetic material must be able to code for the sequence of amino acids in proteins. It must control protein synthesis.
2. Second, it must be able to replicate itself before cell division.
3. Third, the genetic material must be in the nucleus of eukaryotic cells.
4. Fourth, it must be able to change over time for the evolutionary changes.

DNA (deoxyribonucleic acid) is the only molecule which fulfills all of the following requirements.



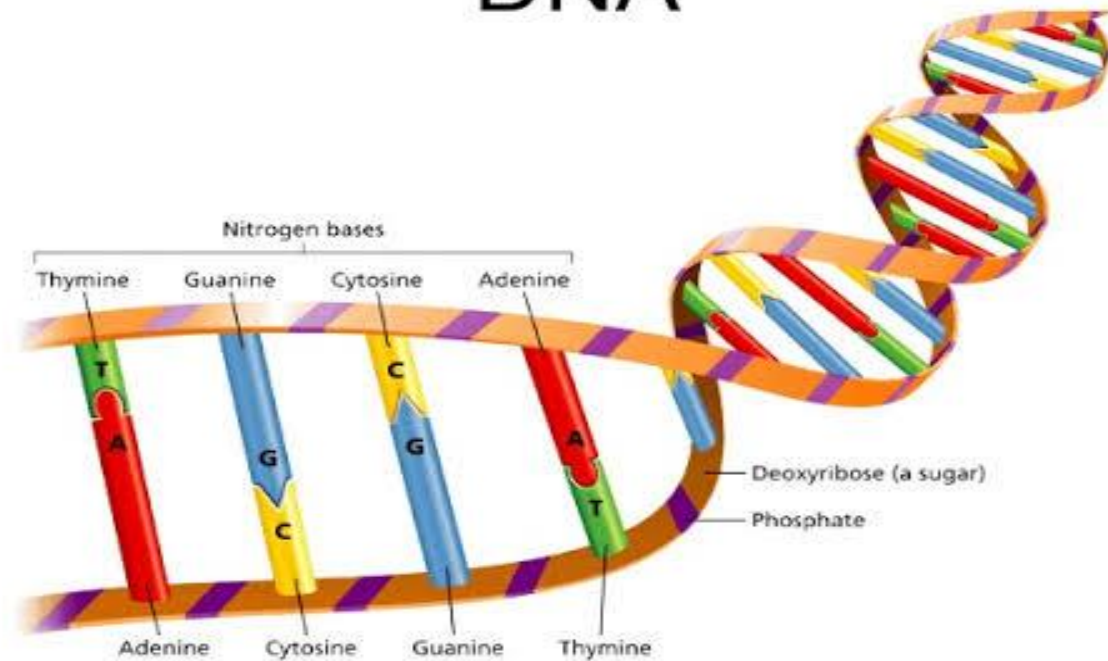
The double helix model of DNA

DNA is a large molecule made up of subunits called nucleotides. A nucleotide consists of a nitrogen containing organic base, pentose sugar and phosphate group. It was discovered in 1950s that covalent bonds are present in nucleic acids. Watson and Crick proposed the model of DNA;

1. The DNA is helical in shape. It is made up of two strands.
2. The helix has uniform width of 2 nm.
3. Its nitrogenous bases are 0.34 nm apart. Ten layers of base pairs are present on each turn of helix.
4. The phosphate groups are present outside the helix. But the nitrogenous bases are present in the interior of the double helix.
5. The double helix is a ladder like. It has rigid rings. Its ladder twists in a spiral fashion. The side ropes are the equivalent sugar-phosphate backbone. The rungs are pairs of nitrogenous bases.
6. Franklin's X-ray data indicate that helix makes one full turn after every 3.4nm of its length.
7. The pairing of nitrogenous bases are complementary. Adenine(A) pairs with thymine(T) and Guanine(G) with cytosine(C). Adenine and Guanine are larger bases. They have two ringed structures. They are called as **purines**. On the other hand, the Cytosine and thymine are **pyrimidine** bases. They have single ring.

8. Both the strands of the DNA are antiparallel. One strand is in 5-3 direction and other strand is in 3-5 direction.

The Structure & Replication of DNA



DNA Replication in eukaryotes


Following steps take place in replication of DNA.

1. Origin of replication:

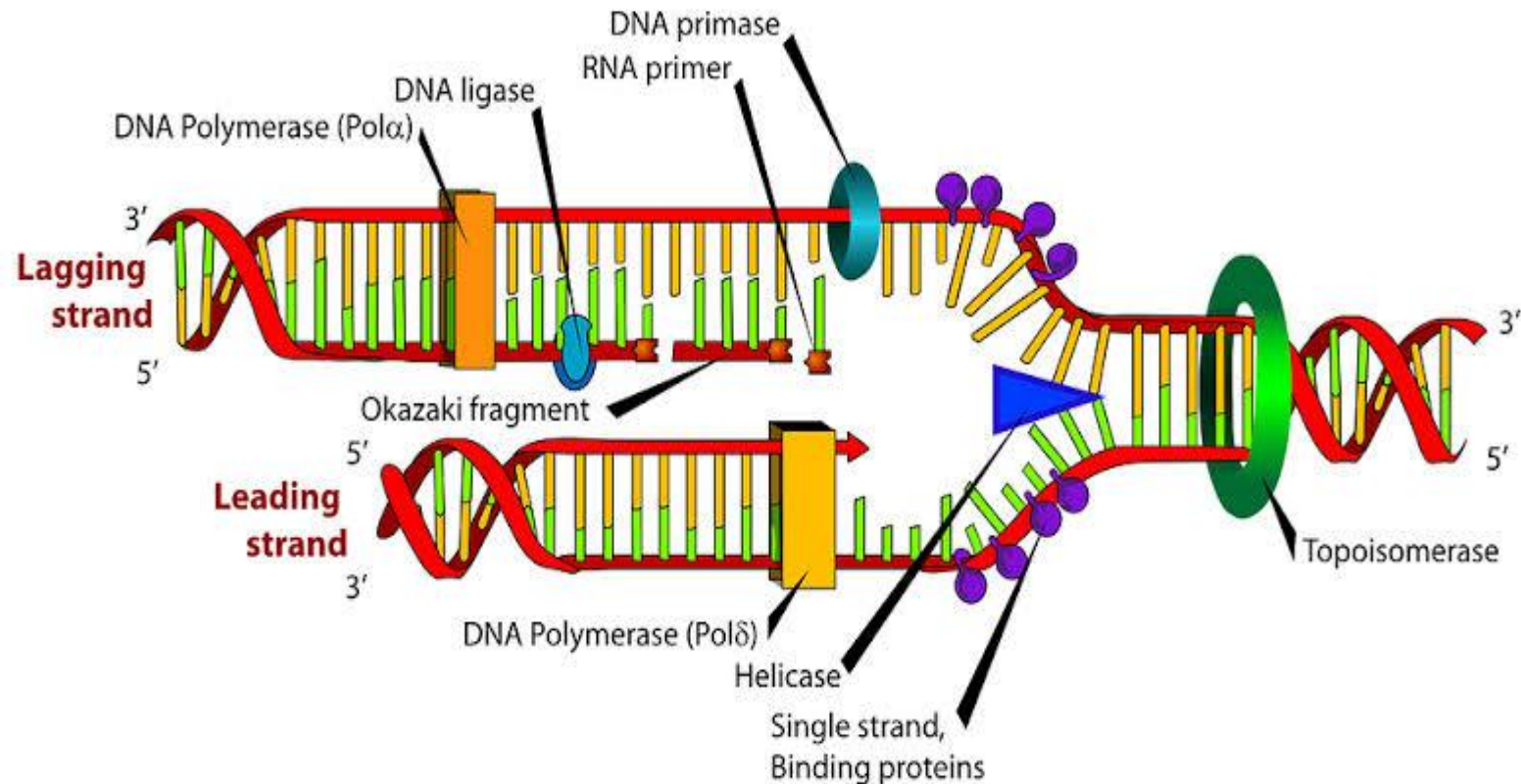
The replication of DNA molecule begins at specific sites called origins of replication. The eukaryotic DNA contains thousands of such replication origins. A protein initiates DNA replication it recognizes these sequences of origins and attach to the DNA. It separates the two strands and these open up to form a replication **bubble**. Multiple replication bubbles are formed in eukaryotes. These bubbles fuse with each other. The replication of DNA then proceeds in the both directions and entire molecule is copied. There is replication fork at each end of the replication bubble. It is Y-shaped region. New strands of DNA elongates on these replication fork.

3. Elongation a new DNA strands:

An enzymes DNA polymerases catalyzes elongation of new DNA at a replication fork. The nucleotides align with complementary basis on “old” template strand of DNA . They are added by DNA polymerase one by one. The rate of elongation is about 500 nucleotides per second in Human cell.



The substrate for DNA are nucleoside triphosphate. The nucleoside triphosphates have three phosphate groups like ATP. Each monomer losses two phosphates and joins to the growing end of a DNA strand. Hydrolysis of the phosphate is the exergonic reaction. Therefore it drives polymerization of nucleotides to form DNA.



3. The problem of antiparallel strands:

There is a problem of DNA synthesis at the replication fork. The two DNA strands are antiparallel. Their sugar- phosphate backbones run in opposite directions. Phosphate group of each nucleotides is attached to the 5' carbon of deoxyribose. The phosphate group of one nucleotide is joined to the 3' carbon of the adjacent nucleotide. Therefore, there is different mechanism of replication in both strands:

(a) Leading strand:

The enzyme DNA polymerase can only add nucleotides to the free 3' end of the DNA strand. It can never add it to the 5' end. Thus, a new DNA strand is formed in 5-3 directions. The DNA polymerases can synthesize a continuous complementary strand along 5-3 direction. This DNA strand is called leading strand.

(b) Lagging strand:

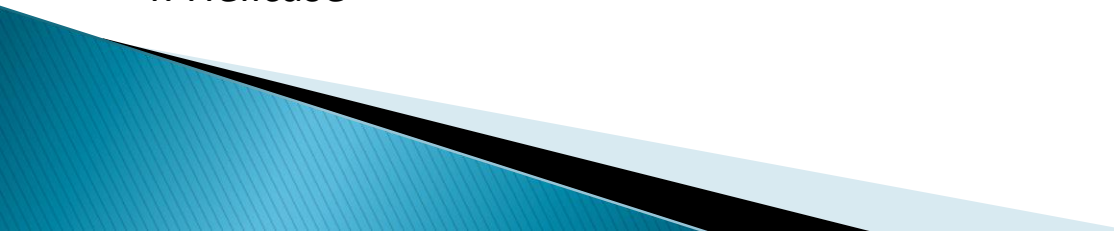
The DNA polymerase move away from the replication fork to elongation in 3-5 strand of DNA. The DNA synthesized in this direction is called lagging. The lagging strand is first synthesized as a series of segments. These pieces are called as **okazaki fragments**. These segments were discovered by Japanese scientist Okazaki. These fragments are about 100 to 200 nucleotides long in eukaryotes.

4. RNA primer:

There is another problem for DNA polymerase. It can only add nucleotide to a polynucleotide that is already correctly paired with the complementary strand. This means that DNA polymerase cannot actually initiate synthesis of a DNA strand. Nucleotides must be added to the end of an already existing chain. This chain of nucleotides is called a **primer**. The primer is a short stretch of RNA. It is synthesized by another enzyme **primase**. It is about 10 nucleotides long in eukaryotes. Only one primer is required for the leading strand of new DNA. Each fragment must have separate primer in the lagging strand. An enzyme then replaces the RNA nucleotides of the primer with DNA. Another enzyme **ligase** joins all the DNA fragments into a strand.

5. Protein assisting the DNA replication:

Following proteins assist in the synthesis of DNA:

1. DNA polymerase
 2. Ligase
 3. Primase
 4. Helicase
- 

5. Single strand binding protein: It is attached to the separated strands of DNA and does not allow them to recoil.

6. Proof reading:

The errors in the completed DNA molecule are only one in one billion nucleotides. These errors must be corrected. Some enzyme removes these errors.

