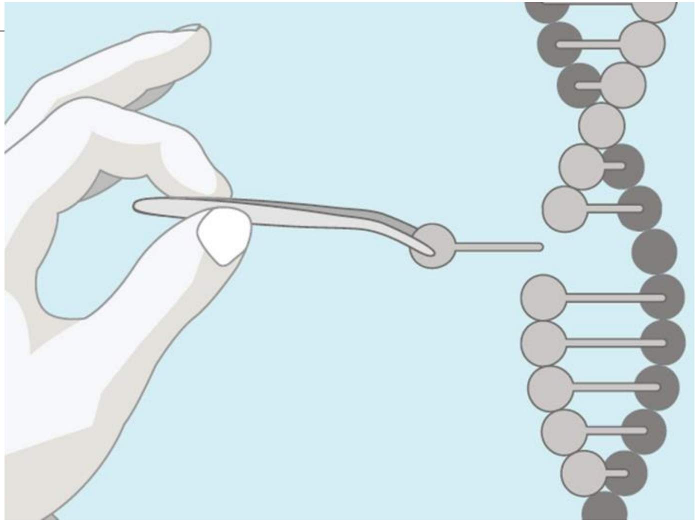
Module 6

Information Transfer

Dr. Pravin Patil

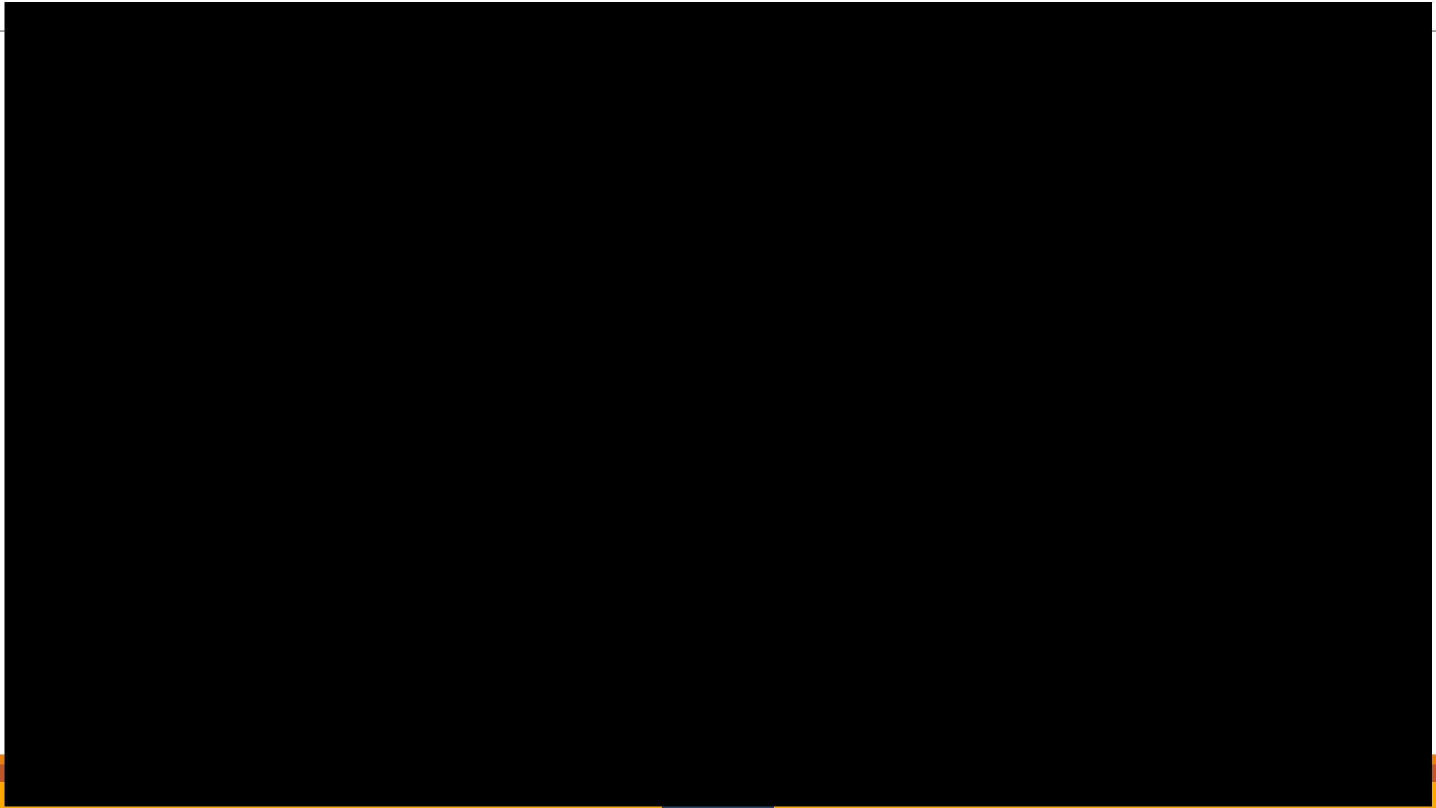
Objectives:

- Genetic Composition
- Nucleic Acid
- Concept of genetic code
- DNA Replication
- Central dogma of life



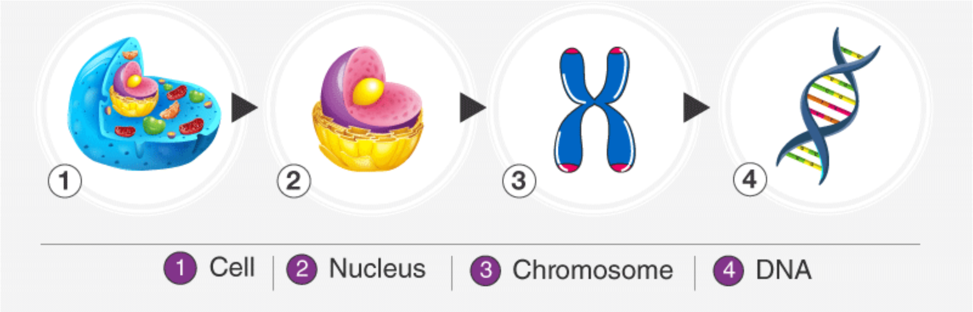
Introduction: Genetic Composition

Introduction: Replication



Genetic Composition:

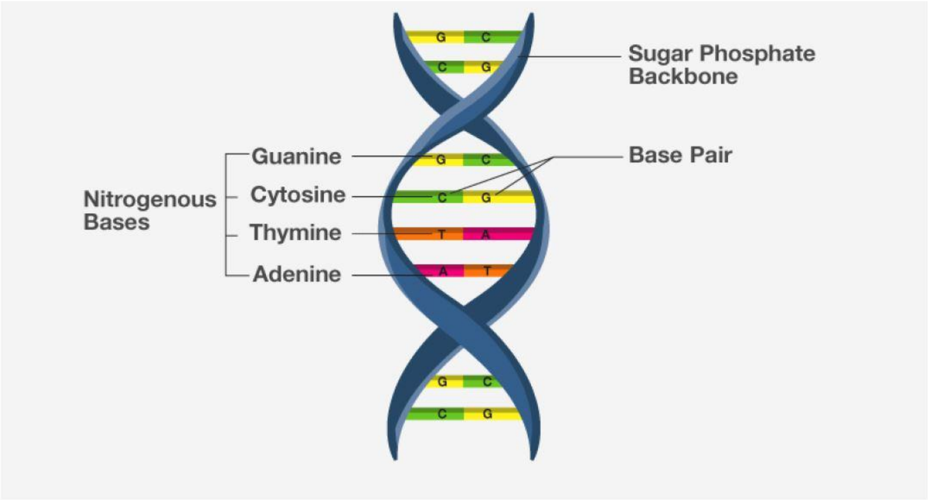
- **Nucleic acid structure (DNA Diagram):** The following diagram explains the DNA structure representing the different parts of the DNA. DNA comprises a sugar-phosphate backbone, and the nucleotide bases (guanine, cytosine, adenine and thymine).



Genetic Composition: DNA Structure

The DNA structure can be thought of like a twisted ladder. This structure is described as a double-helix, as illustrated in the figure above. It is a nucleic acid, and all nucleic acids are made up of nucleotides. The DNA molecule is composed of units called nucleotides, and each nucleotide is composed of three different components, such as sugar, phosphate groups, and nitrogen bases.

Structure of DNA

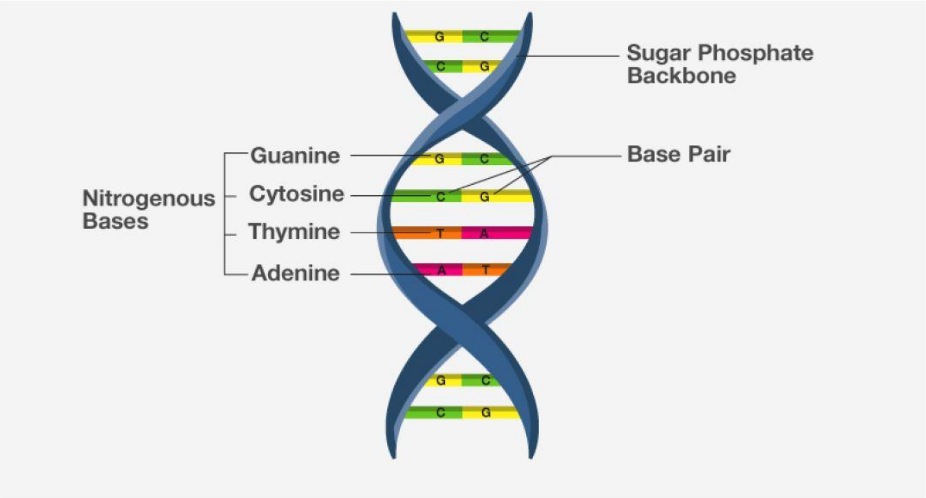


DNA Diagram representing the DNA Structure

Genetic Composition: DNA Structure

The basic building blocks of DNA are nucleotides, which are composed of a sugar group, a phosphate group, and a nitrogen base. The sugar and phosphate groups link the nucleotides together to form each strand of DNA. Adenine (A), Thymine (T), Guanine (G) and Cytosine (C) are four types of nitrogen bases.

Structure of DNA

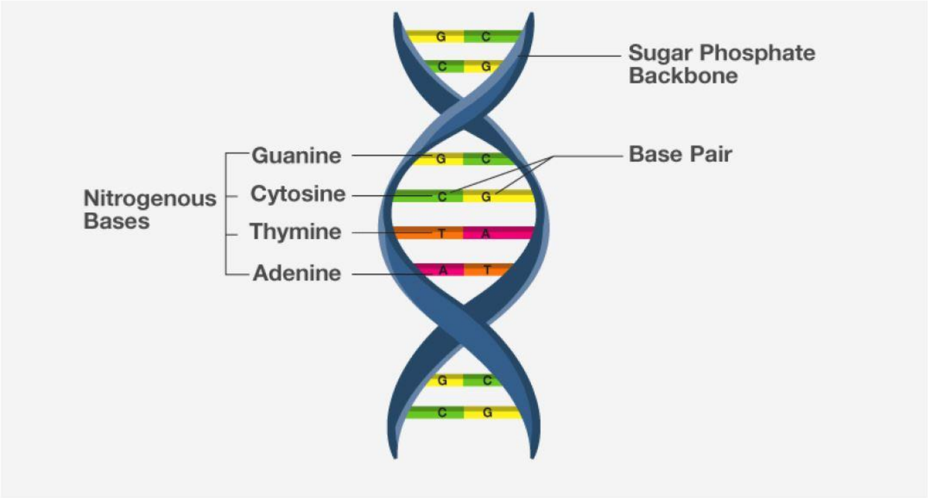


DNA Diagram representing the DNA Structure

Genetic Composition: DNA Structure

These 4 Nitrogenous bases pair together in the following way: A with T, and C with G. These base pairs are essential for the DNA's double helix structure, which resembles a twisted ladder.

Structure of DNA

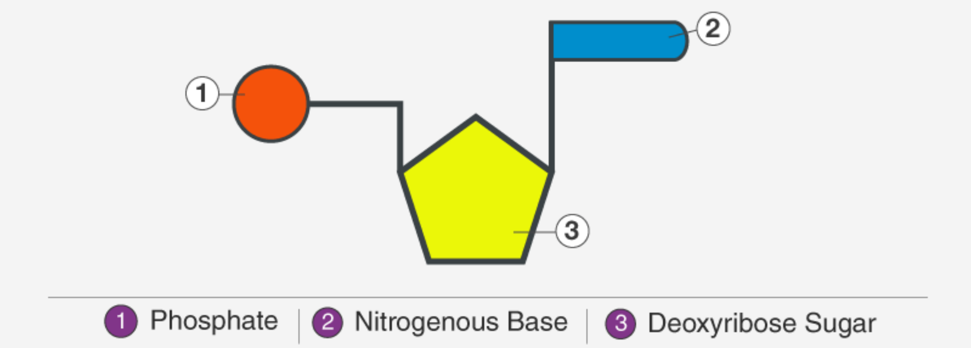


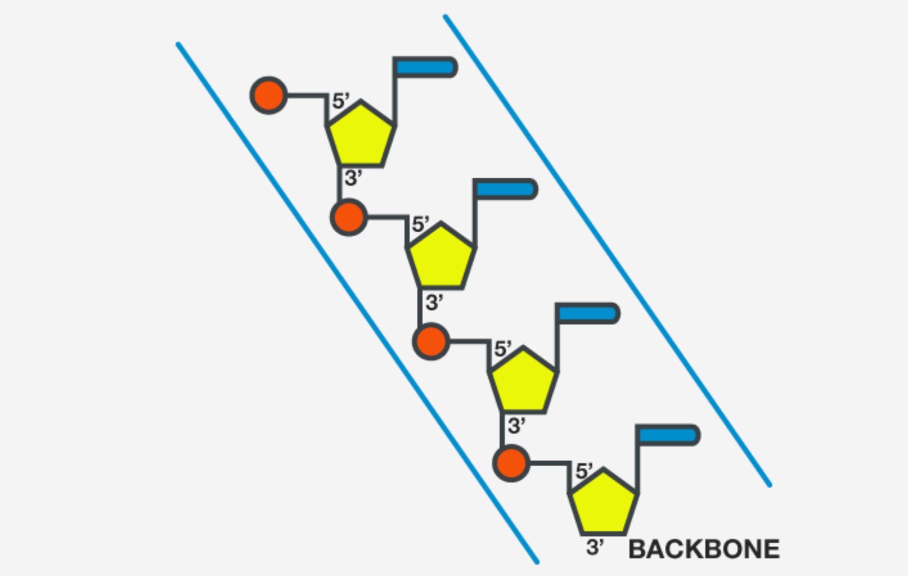
DNA Diagram representing the DNA Structure

Genetic Composition: DNA Structure

- The order of the nitrogenous bases determines the genetic code or the DNA's instructions.

- Among the three components of DNA structure, sugar is the one which forms the backbone of the DNA molecule. It is also called deoxyribose. The nitrogenous bases of the opposite strands form hydrogen bonds, forming a ladder-like structure. **(DNA Structure Backbone)**





Function of Nucleic Acid:

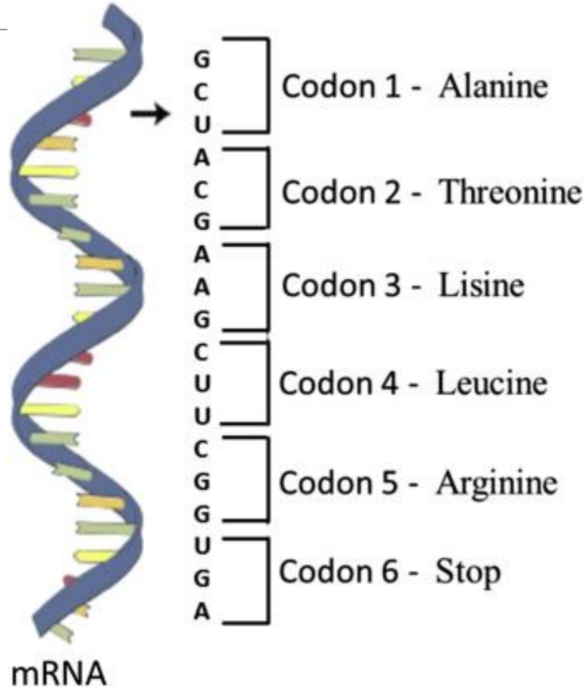
Main functions of Nucleic Acid:

- 1. Replication process: Transferring the genetic information from one cell to its daughters and from one generation to the next and equal distribution of DNA during the cell division
- 2. Mutations: The changes which occur in the DNA sequences
- 3. Transcription
- 4. Cellular Metabolism
- 5. DNA Fingerprinting
- 6. Gene Therapy

Concept of genetic code:

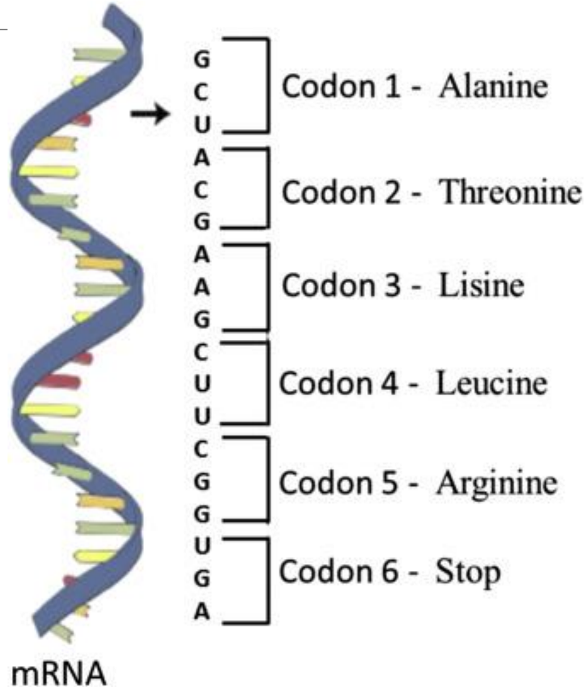
- To summarize what we know to this point, the cellular process of transcription generates messenger RNA (mRNA), a mobile molecular copy of one or more genes with an alphabet of A, C, G, and uracil (U).

- Translation of the mRNA template converts nucleotide-based genetic information into a protein product. This flow of genetic information in cells from DNA to mRNA to protein is described by the Central Dogma, which states that genes specify the sequence of mRNAs, which in turn specify the sequence of proteins.

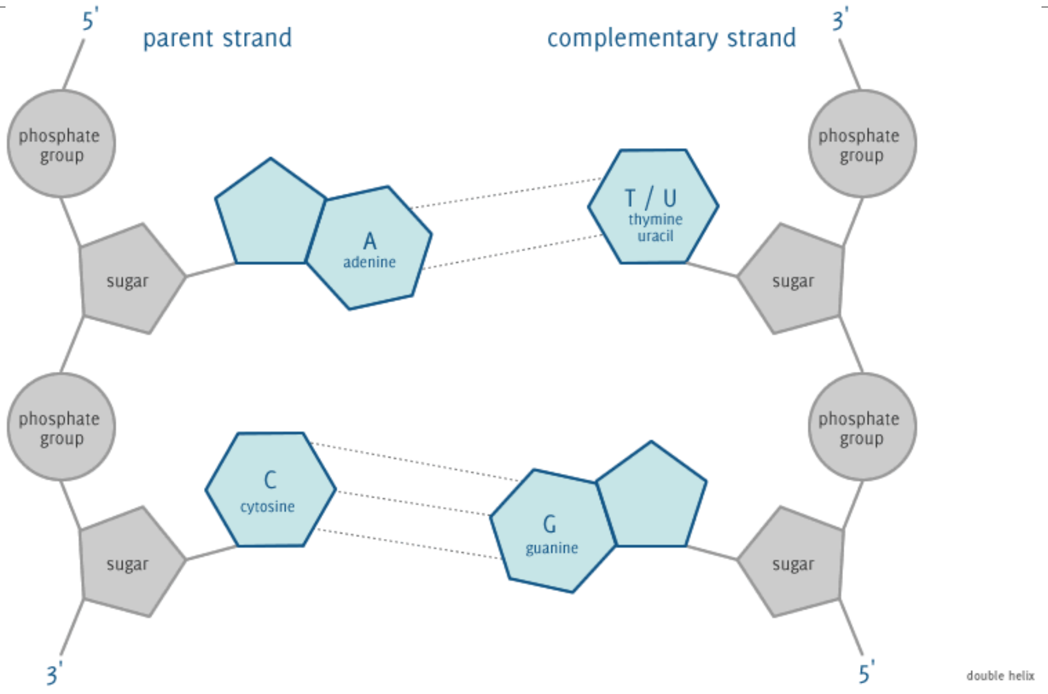


Concept of genetic code:

- The decoding of one molecule to another is performed by specific proteins and RNAs. Because the information stored in DNA is so central to cellular function, it makes intuitive sense that the cell would make mRNA copies of this information for protein synthesis, while keeping the DNA itself intact and protected.



Concept of genetic code:



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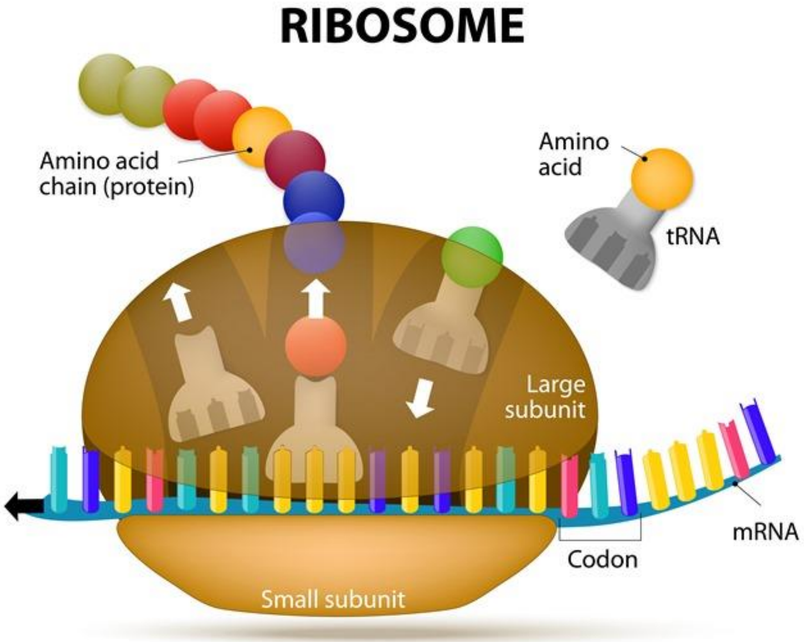
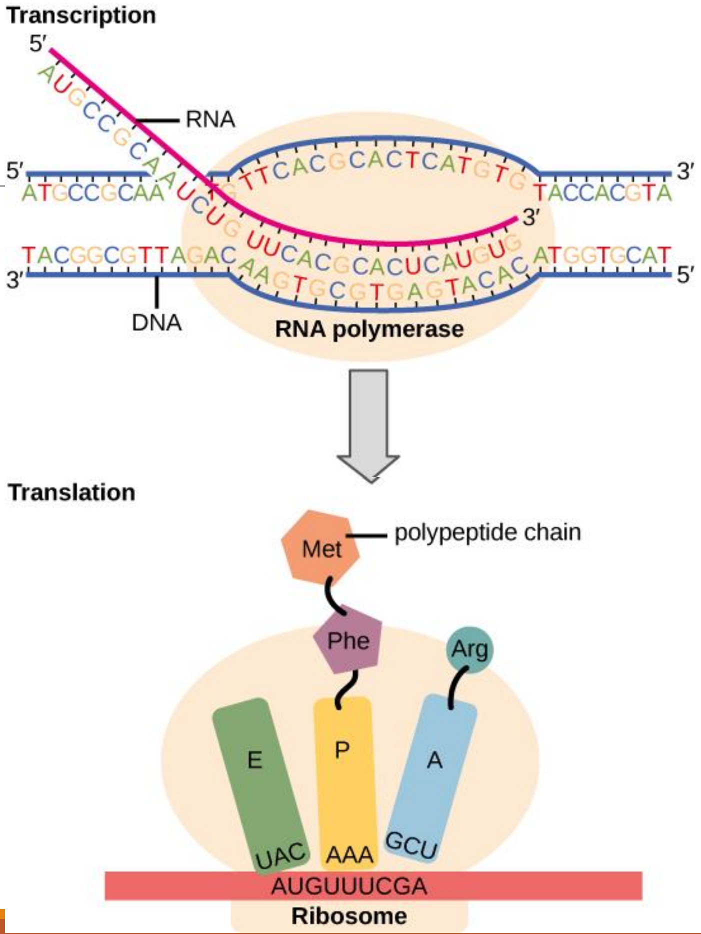
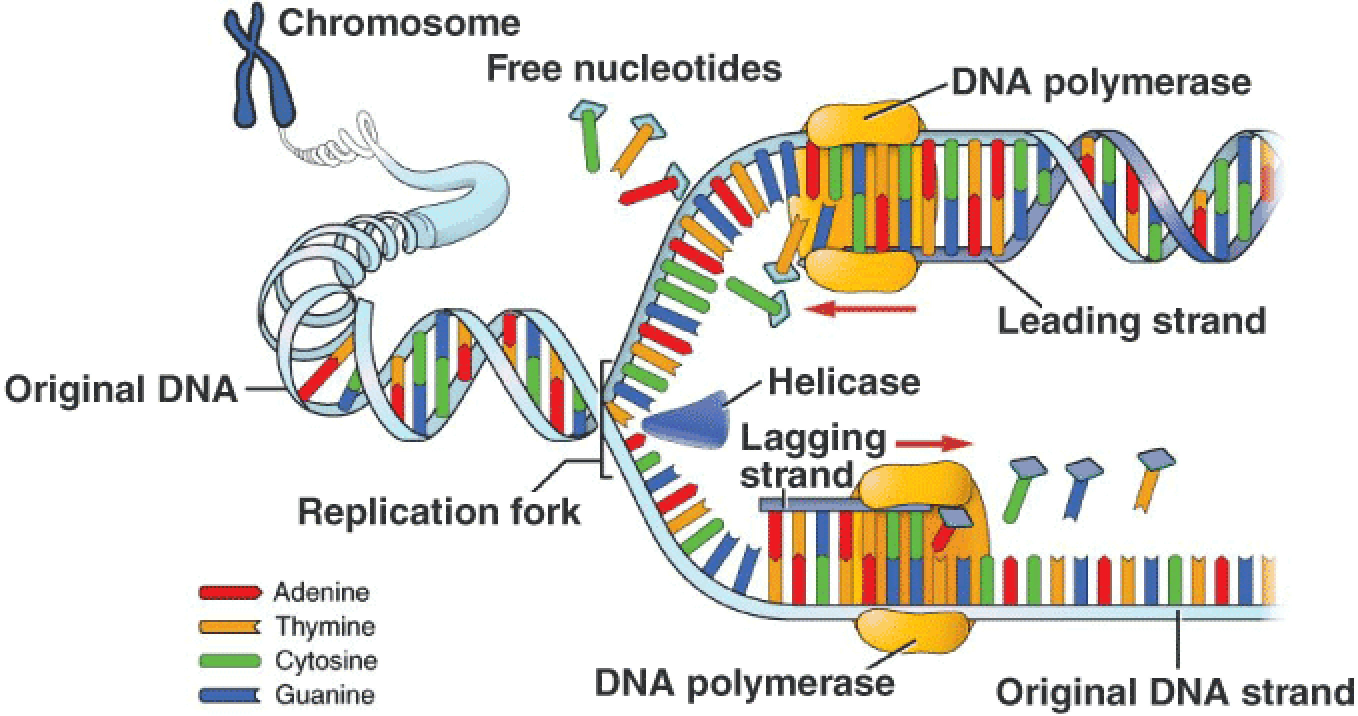




DNA Replication:

- DNA replication, also known as semi-conservative replication, is the process by which DNA is essentially doubled. It is an important process that takes place within the dividing cell.
- In this article, we shall look briefly at the structure of DNA, at the precise steps involved in replicating DNA (initiation, elongation and termination), and the clinical consequences that can occur when this goes wrong.

DNA REPLICATION

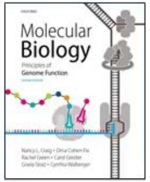


DNA Replication: Steps

1. Initiation
2. Elongation
3. Termination

DNA Replication: Steps

DNA Replication: Steps



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Second Edition

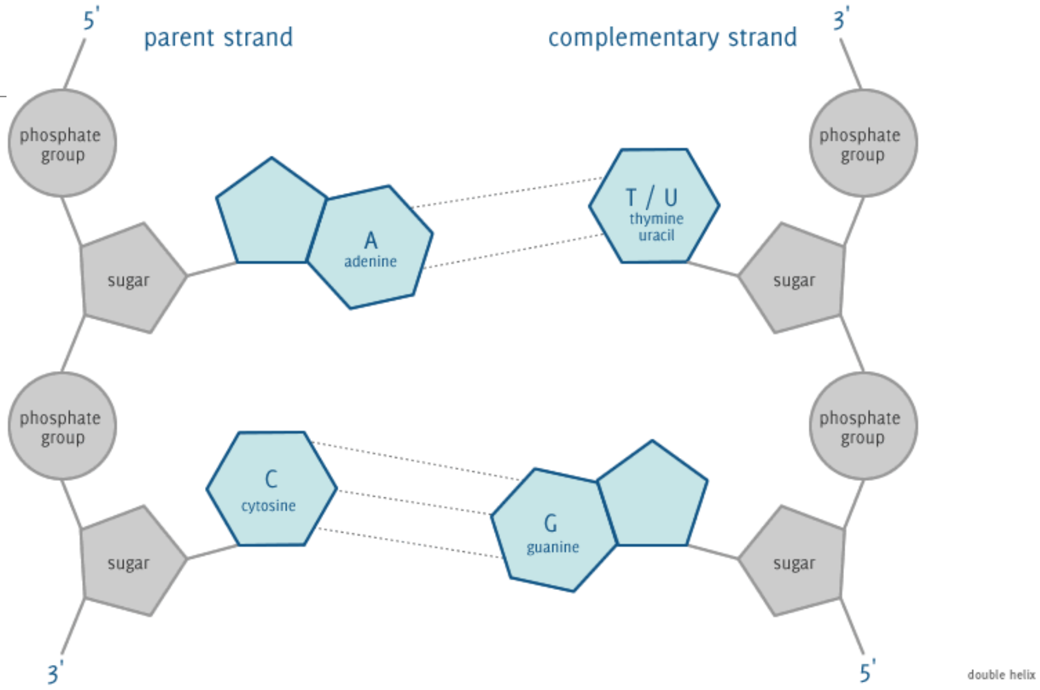
OXFORD
UNIVERSITY PRESS

Animation 1:
DNA replication

Animation produced by Connor Hendrich

DNA Replication: Steps

- DNA strands are made of a sugar-phosphate backbone. The DNA strand is ordered in a 5' → 3' (five prime to three prime) direction, with the number derived from which carbon on the sugar is connected to the chain. The sugar is then connected to a base.



DNA Replication: Steps

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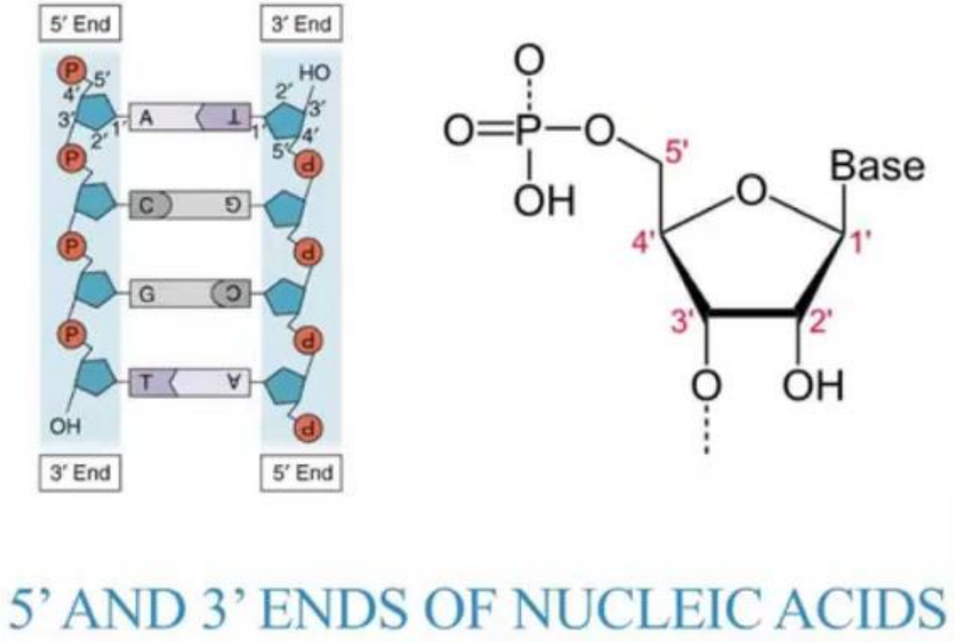
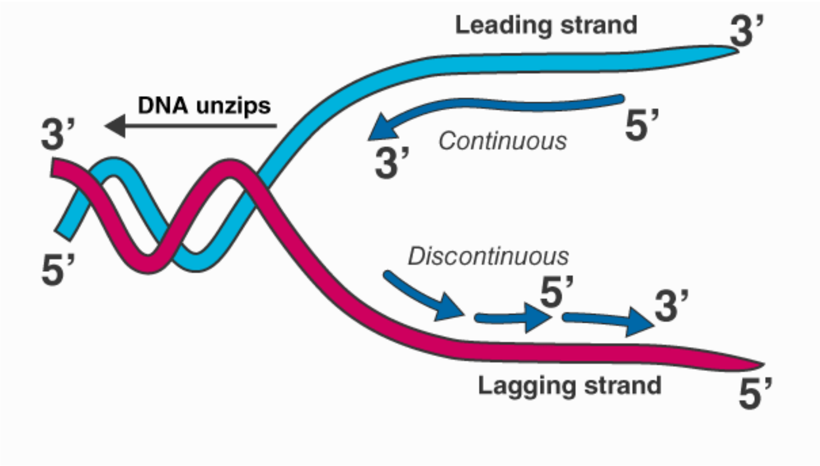


DNA Replication: Steps

1. Initiation:

Within the replication complex is the enzyme **DNA Helicase**, which unwinds the double helix and exposes each of the two strands, so that they can be used as a template for replication.

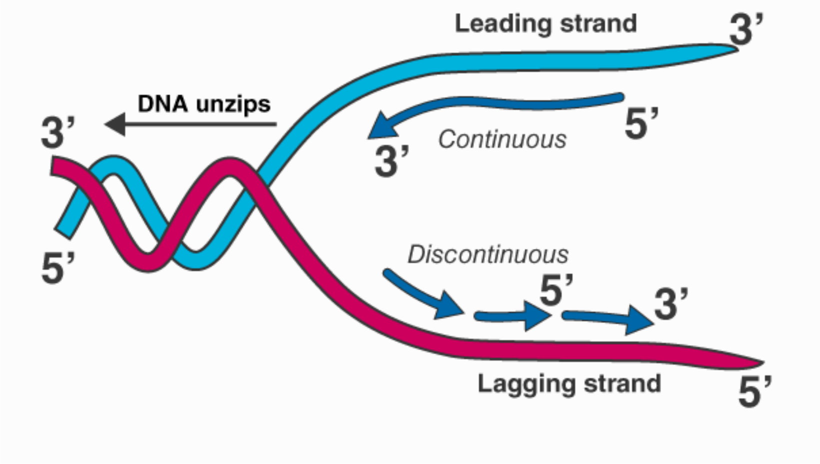
It does this by hydrolyzing the ATP used to form the bonds between the nucleobases, therefore breaking the bond holding the two strands together.



DNA Replication: Steps

1. Initiation:

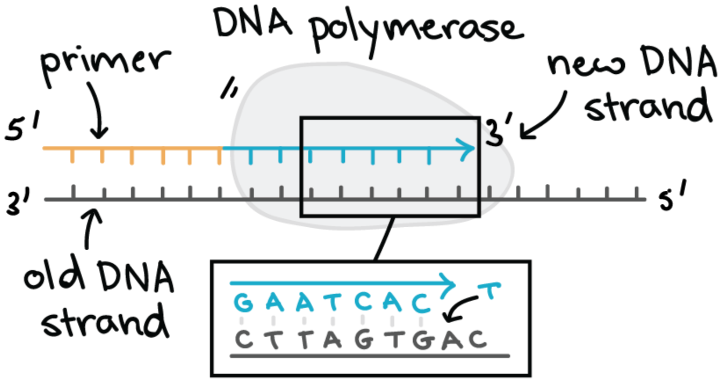
DNA Primase is another enzyme that is important in DNA replication. It synthesizes a small RNA primer, which acts as a 'kick-starter' for DNA Polymerase. DNA Polymerase is the enzyme that is ultimately responsible for the creation and expansion of the new strands of DNA.



DNA Replication: Steps

2. Elongation:

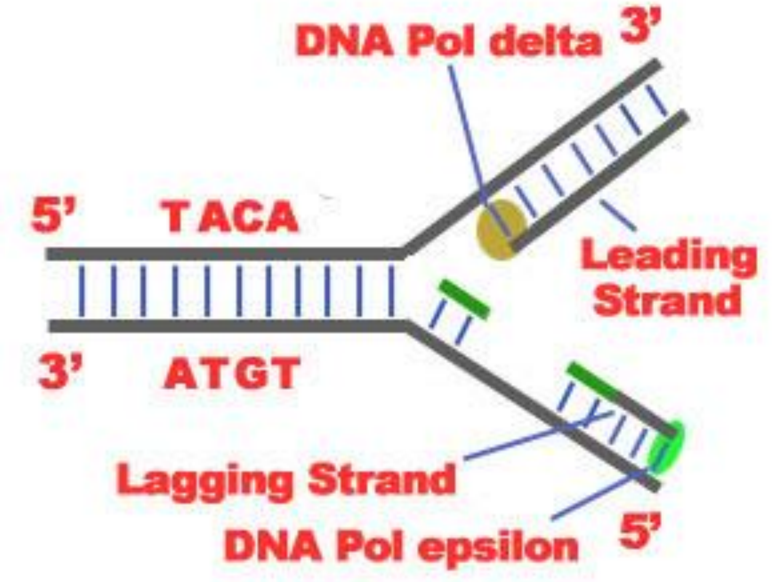
Once the **DNA Polymerase** has attached to the original, unzipped two strands of DNA (i.e. the template strands), it is able to start synthesizing the new DNA to match the templates. It is essential to note that DNA polymerase is only able to extend the primer by adding free nucleotides to the 3’ end.



DNA Replication: Steps

2. Elongation:

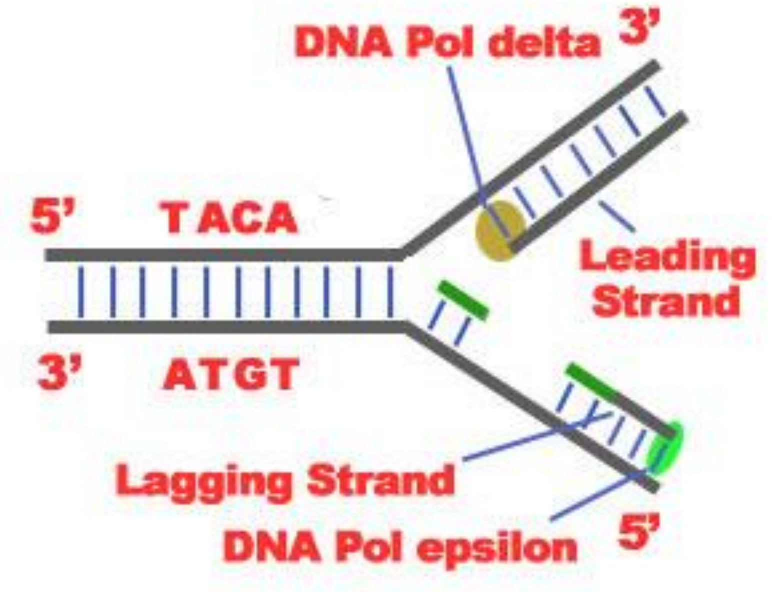
One of the templates is read in a 3’ to 5’ direction, which means that the new strand will be formed in a 5’ to 3’ direction. This newly formed strand is referred to as the Leading Strand. Along this strand, DNA Primase only needs to synthesize an RNA primer once, at the beginning, to initiate DNA Polymerase. This is because DNA Polymerase is able to extend the new DNA strand by reading the template 3′ to 5′, synthesizing in a 5′ to 3′ direction as noted above.



DNA Replication: Steps

2. Elongation:

However, the other template strand (the lagging strand) is antiparallel, and is therefore read in a 5' to 3' direction. Continuous DNA synthesis, as in the leading strand, would need to be in the 3′ to 5′ direction, which is impossible as we cannot add bases to the 5′ end. Instead, as the helix unwinds, RNA primers are added to the newly exposed bases on the lagging strand and DNA synthesis occurs in fragments, but still in the 5′ to 3′ direction as before. These fragments are known as Okazaki fragments.

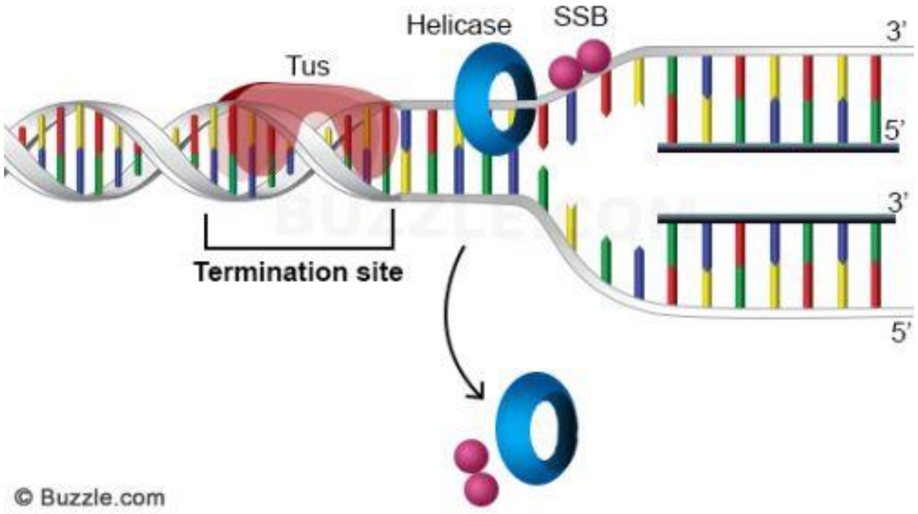


DNA Replication: Steps

- **3. Termination:**

- The process of expanding the new DNA strands continues until there is either no more DNA template left to replicate (i.e. at the end of the chromosome), or two replication forks meet and subsequently terminate.

- The meeting of two replication forks is not regulated and happens randomly along the course of the chromosome.

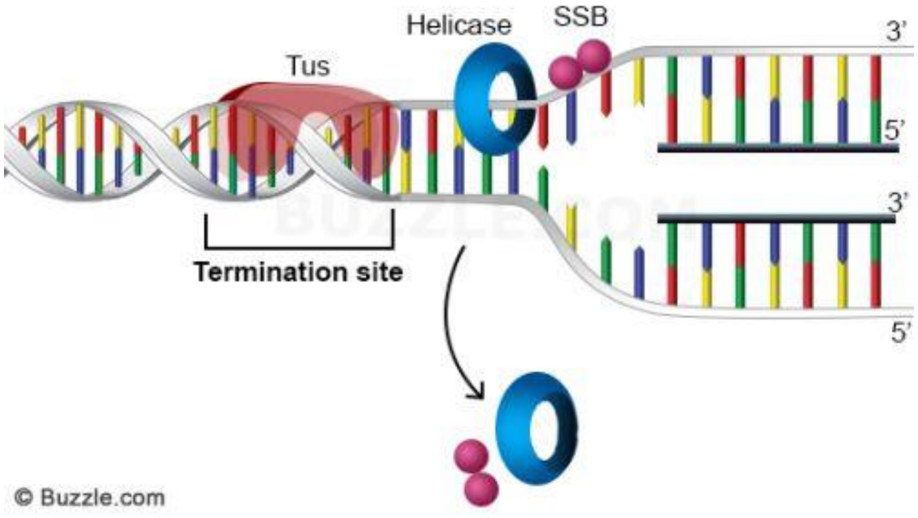


DNA Replication: Steps

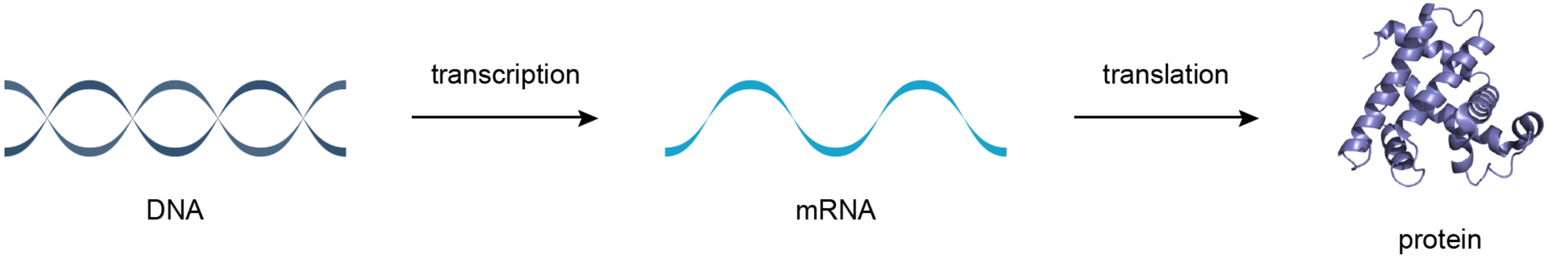
3. Termination:

Once DNA synthesis has finished, it is important that the newly synthesized strands are bound and stabilized.

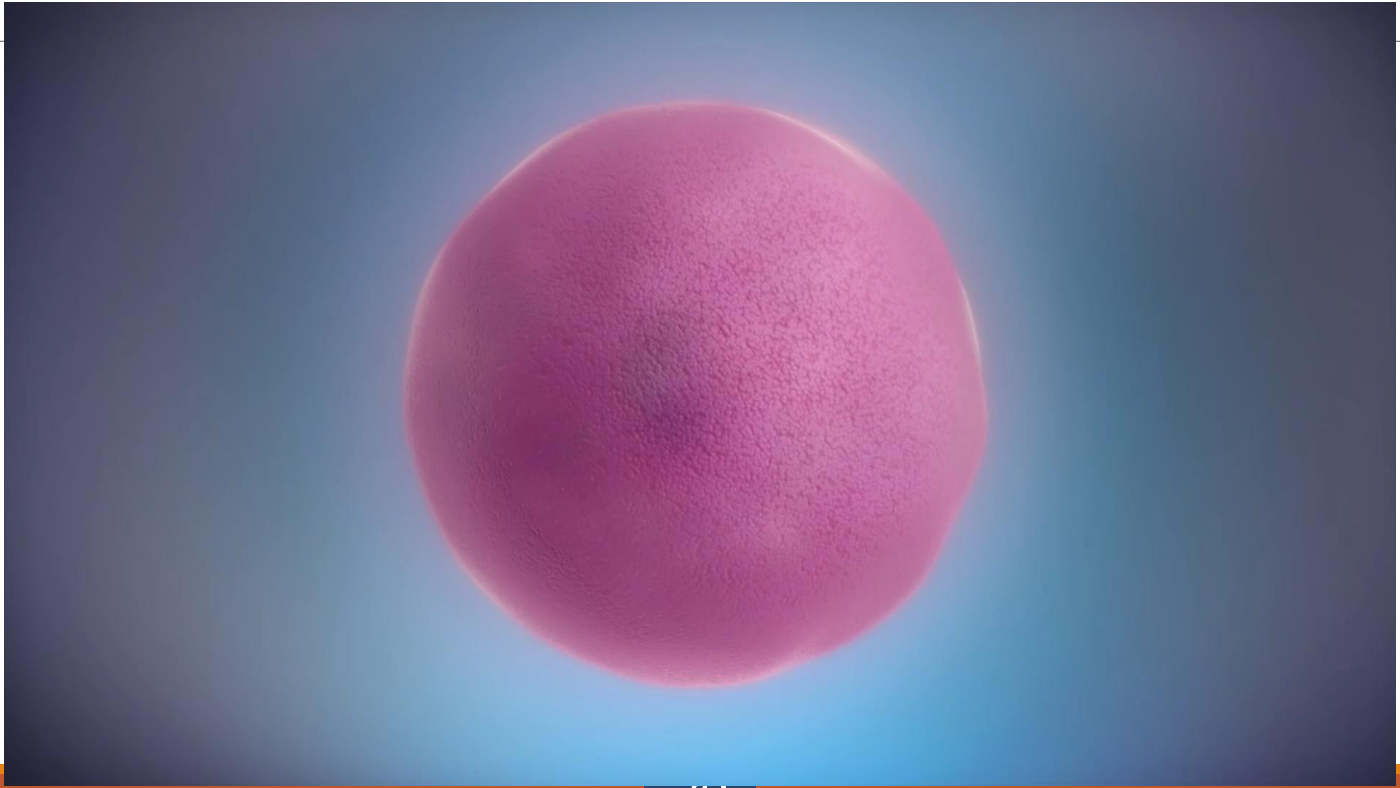
With regards to the lagging strand, two enzymes are needed to achieve this; **RNAase H** removes the RNA primer that is at the beginning of each Okazaki fragment, and **DNA Ligase** joins fragments together to create one complete strand.



Protein synthesis: Central Dogma of Life.



Protein Translation: Central Dogma of Life.



Thank you…