

Replication Study Guide

This study guide is a written version of the material you have seen presented in the replication unit.

Self-reproduction is a function of life that human-engineered systems have been unable to recreate. It is the foundation for all of biology. In this section of the presentation, you will find out how cells carry out the key step in biological self-reproduction: the replication of the cell's DNA.

A cell's DNA contains instructions for how to create new cells. Before a cell divides, it needs to copy that DNA completely and accurately so that its progeny will also be able to reproduce and function. This copying process is called replication.

Components

In this section, you will be introduced to the components involved in the dynamic process of DNA replication, in which a cell makes a complete and accurate copy of its DNA, thereby passing on the instructions for how to build new cells.

DNA



What is DNA?

- DNA stores and encodes all of the information in an organism, such as
 - which proteins to make, and
 - how to make them.
- DNA encodes all of the functions of the cell, including its ability to reproduce

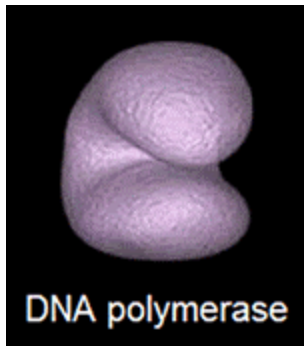
What is the composition of DNA?

- DNA is a double helix made up of two strands twisted together.
- The strands each have a sugar phosphate polymer as a backbone with nucleotide bases attached in series along each strand.
- DNA is made up of four different nucleotide bases. They are
 - adenosine (A)
 - thymidine (T)
 - cytidine (C), and
 - guanosine (G)

How is the DNA held together?

- DNA's two strands are held together by hydrogen bonds between G and C and between A and T.
- G always binds to C and A always binds to T because they fit with each other both physically and chemically.
- The two strands are complementary, so that the composition of one can be determined by examining the other.
- They are also oriented in opposite directions.
- In the animation of replication, you will see how each chain of DNA is copied.

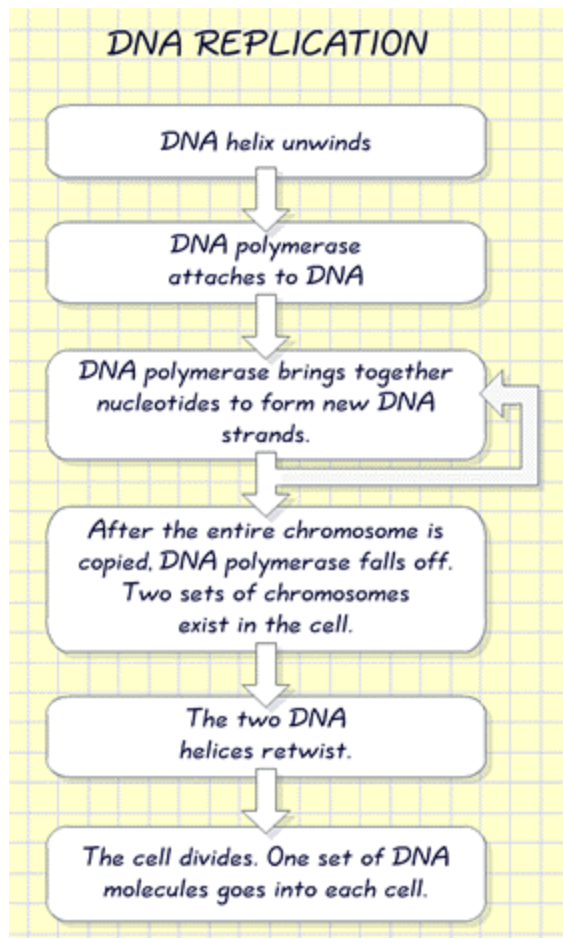
DNA Polymerase



What is DNA polymerase?

- This molecular machine is an enzyme that helps DNA molecules to reproduce.
- In the upcoming animation, you will see DNA polymerase attracting nucleotides that complement each existing strand of DNA in order to assemble new strands

Process Flow Chart

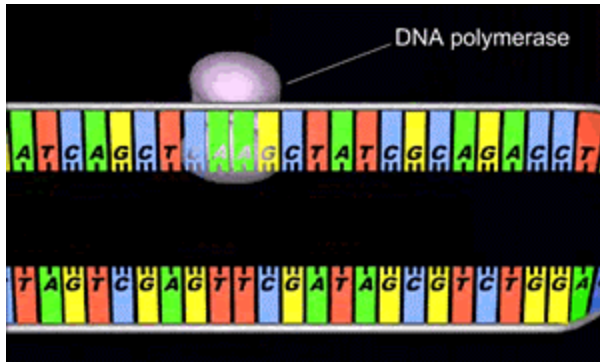


Animation script

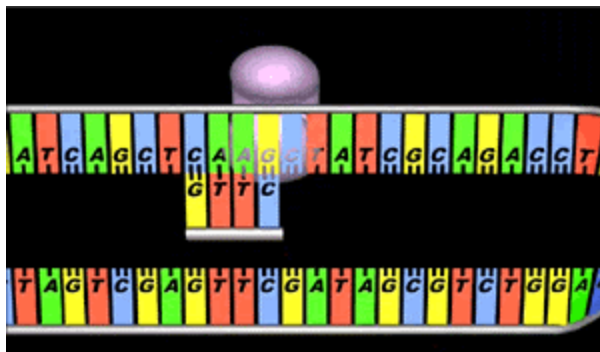
By replicating its DNA, a cell passes on a copy of its genetic information to its offspring. This cell is about to reproduce itself. Watch the dark mass at its center -- its chromosome, made up of DNA.

The cell first copies its DNA and then divides in two. Each cell receives one copy of the genetic information.

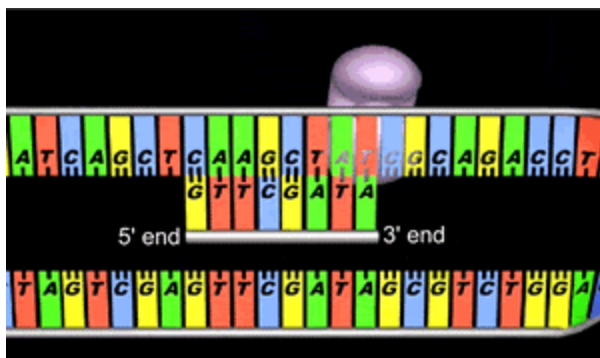
Now let's watch this process at the molecular level.



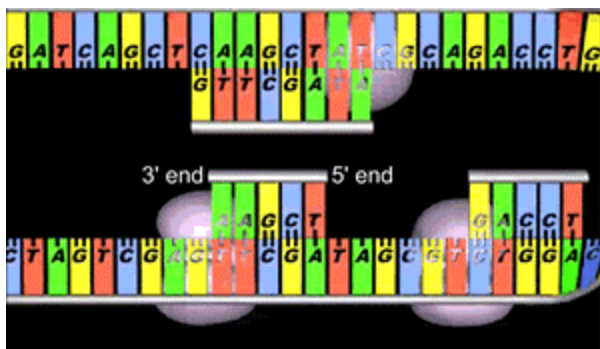
Enzymes called DNA polymerase float inside the cell. They are molecular machines, and their function is to make new DNA strands. When DNA is ready to be copied, a small section of the helix unwinds and molecules of DNA polymerase attach to each strand of the DNA.



The DNA polymerase attracts nucleotides floating in the cell that complement, and hydrogen-bond to, the nucleotides on the DNA strand to which it is attached. As the DNA strand moves through the polymerase, more nucleotides are added.

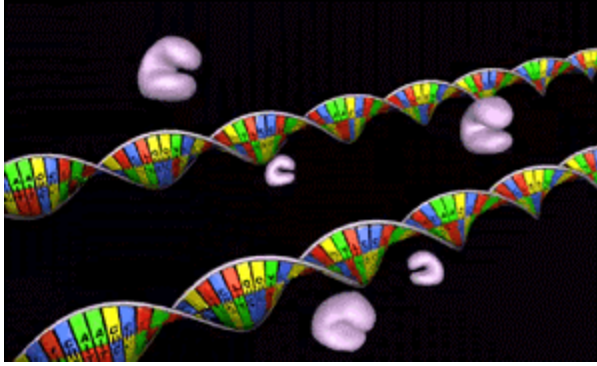


On each new strand, DNA polymerase adds nucleotides beginning from what is called the 5' end of the strand and building towards what is called the 3' end. These labels refer to the way that the DNA is constructed chemically. One of the original strands of DNA is oriented so that DNA polymerase can built the new strand continuously, creating a long unbroken sequence of nucleotides as the DNA helix unwinds



The other original DNA strand is oriented in the opposite direction. DNA polymerase must always add nucleotides to the growing strand in the 5' to 3' direction, which in this case is in the direction moving away from the unwinding helix. DNA polymerase builds this new strand in short segments that are later joined together by another enzyme.

DNA polymerase keeps adding nucleotides to the new strands until the entire chromosome has been copied.



The molecules of DNA polymerase fall off of the DNA, and the two DNA molecules twist into their familiar helix shapes. The cell now contains two identical sets of DNA, each made up of one new and one old strand.

Glossary of terms

adenosine - one of the nucleotide bases in which cells store their genetic code. Adenosine bonds with thymidine in DNA and uridine in RNA.

complementary - matching, such as between pairs of nucleotides in a DNA molecule

chromosome - the entire collection of a cell's DNA, which contains all of the cell's genetic information

cytidine - one of the nucleotide bases in which cells store their genetic code. Cytidine bonds with guanosine in both DNA and RNA.

DNA - the molecule that stores and encodes an organism's genetic information. DNA is a double helix molecule made up of two twisted strands that are held together by hydrogen bonds between paired nucleotides. The two strands are chemically oriented in opposite directions.

DNA polymerase - a molecular machine that helps DNA molecules to reproduce

enzyme - a type of protein that performs cellular activities

guanosine - one of the nucleotide bases in which cells store their genetic code. Guanosine bonds with cytidine in both DNA and RNA.

helix - a spiraling coiled shape

hydrogen bond - a weak bond that holds together complementary base pairs in a DNA molecule

nucleotides - the building blocks of DNA and RNA molecules that contain the cell's genetic code. Adenosine, cytidine, guanosine, thymidine, and uridine are all nucleotides.

phosphate - the chemical anion PO_4^{3-} , often used in biological systems

polymer - a chemical with repeated structural units

protein - a molecular machine that carries out vital tasks in the cell, such as providing structural support, processing nutrients, copying a cell's DNA, and regulating other cellular functions. Proteins are made of long chains of amino acids that fold into complex three-dimensional shapes. Each type protein has a unique amino acid sequence and a specific function in the cell.

replication - the process in which a cell's DNA is copied prior to cellular reproduction

thymidine - one of the nucleotide bases in which cells store their genetic code. Thymidine is found only in DNA, where it bonds with adenosine.