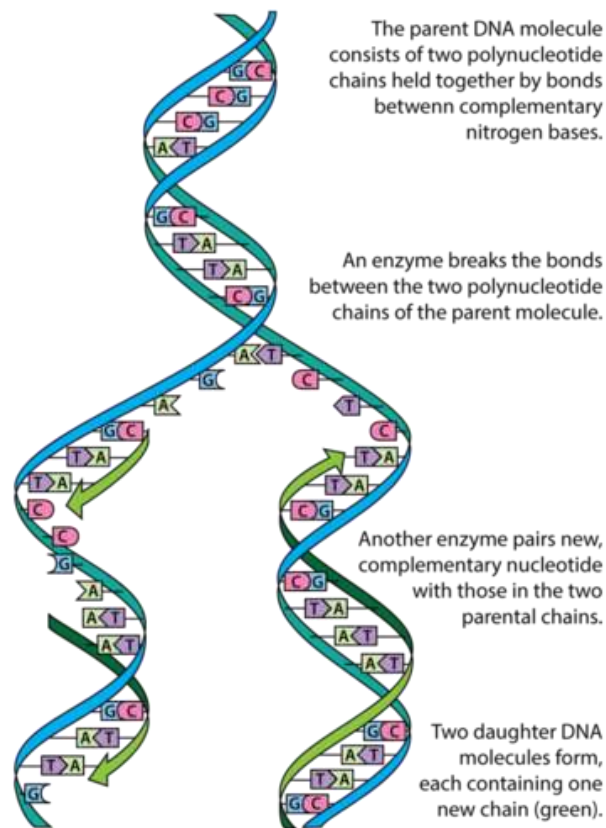


DNA replication

DNA replication is the process in which a cell’s entire DNA is copied, or replicated. The identification of the structure of DNA suggested that each strand of the double helix would serve as a template for synthesis of a new strand. DNA replication process occurs during the **Synthesis (S) phase** of the eukaryotic cell cycle. As each DNA strand has the same genetic information, both strands of the double helix can serve as templates for the reproduction of a complementary new strand. The two resulting double helices, which each contain one "old" strand and one "new" strand of DNA, are identical to the initial double helix. DNA replication is said to be **semi-conservative** because of this process of replication, where the resulting double helix is composed of both an old strand and a new strand.



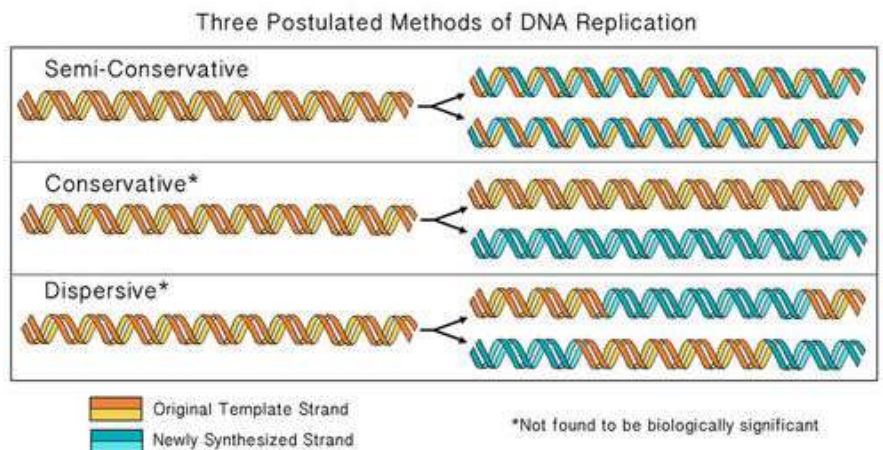
The semi-conservative mechanism of replication was one of three models originally proposed for DNA replication:

Semiconservative replication

would produce two copies that each contained one of the original strands and one new strand.

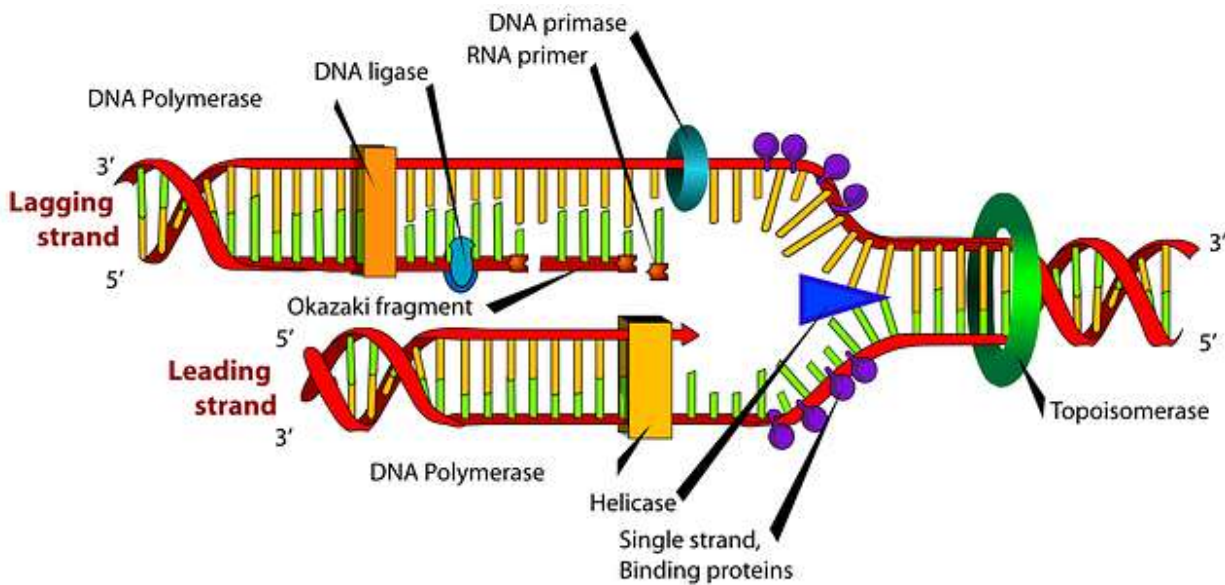
Conservative replication would leave the two original template DNA strands together in a double helix, with the new DNA composed entirely of two new strands.

Dispersive replication would produce two copies of the DNA, both containing a mixture of old and new material.



Genetics

DNA replication begins as an enzyme **DNA helicase** which breaks the hydrogen bonds holding the two strands together and forms a **replication fork**. The strands are held open by a single strand of **binding proteins**, preventing premature reannealing. **Topoisomerase** solves the problem caused by tension generated by winding/unwinding of DNA. This enzyme wraps around DNA and makes a cut permitting the helix to spin and relax. Once DNA is relaxed, topoisomerase reconnects broken strands. The resulting structure has two branching strands of DNA backbone with exposed bases. These exposed bases allow the DNA to be "read" by another enzyme, **DNA polymerase**, which then builds the complementary DNA strand. As DNA helicase continues to open the double helix, the replication fork grows.



5' → 3

The two new strands of DNA are "built" in opposite directions, through either a leading strand or a lagging strand. **The leading strand** is the DNA strand that DNA polymerase constructs in the **5' → 3' direction**. This strand of DNA is made in a continuous manner, moving as the replication fork grows. **The lagging strand** is the DNA strand at the opposite side of the replication fork from the leading strand. It goes in the opposite direction, from **3' to 5'**. DNA polymerase cannot build a strand in the 3' → 5' direction. Thus, this "lagging" strand is synthesized in short segments known as **Okazaki fragments**. On the lagging strand, an enzyme known as **primase** builds a short **RNA primer**. DNA polymerase is then able to use the free 3'-OH group on the RNA primer to make DNA in the 5' → 3' direction. The RNA fragments are then degraded and new DNA nucleotides are added to fill the gaps where the RNA was present. Another enzyme, **DNA ligase**, is then able to attach (ligate) the DNA nucleotides together, completing the synthesis of the lagging strand.

Many replication forks develop along a chromosome. This process continues until the replication forks meet, and the all of the DNA in a chromosome has been copied. Each new strand that has formed is complementary to the strand used as the template. Each resulting DNA molecule is identical to the original DNA molecule. During prophase of mitosis or prophase I of meiosis, these molecules of DNA condense into a chromosome made of two identical "**sister**" **chromatids**. This process ensures that cells that result from cell division have **identical sets of genetic material**, and that the DNA is an exact copy of the parent cell's DNA.

Genetics

Vocabulary

DNA replication: The process of copying DNA prior to cell division (eukaryotes) or reproduction (prokaryotes).

semi-conservative replication : DNA replication process where half of the parent DNA molecule is conserved in each of the two daughter DNA molecules.

DNA helicase: The enzyme that breaks the hydrogen bonds holding the two DNA strands together during DNA replication.

replication fork: Site where DNA helices unwind the DNA, allowing DNA replication to proceed.

DNA polymerase: The enzyme that builds a new DNA strand during DNA replication.

leading strand: The DNA strand that DNA polymerase constructs in the 5' → 3' direction.

lagging strand: The DNA strand at the opposite side of the replication fork from the leading strand.

primase: An enzyme that builds a short RNA primer on the lagging strand during DNA replication.

Okazaki fragments: Short fragments of DNA that comprise the lagging strand.

DNA ligase: Enzyme that can attach together (ligates) strands of DNA with double strand breaks.

Review

What is DNA replication and why must DNA be replicated?

When does replication occur?

Describe the first step of replication.

Why is each strand of DNA able to serve as a template for replication?

How is DNA replicated (describe the steps as they follow)?

What is a replication fork?

What is difference between leading and lagging strand?

Why the Okazaki fragments have to be synthesized?

What are the roles of the following enzymes?

DNA polymerase

DNA helicase

DNA ligase

primase

Explain the meaning of semi-conservative replication.