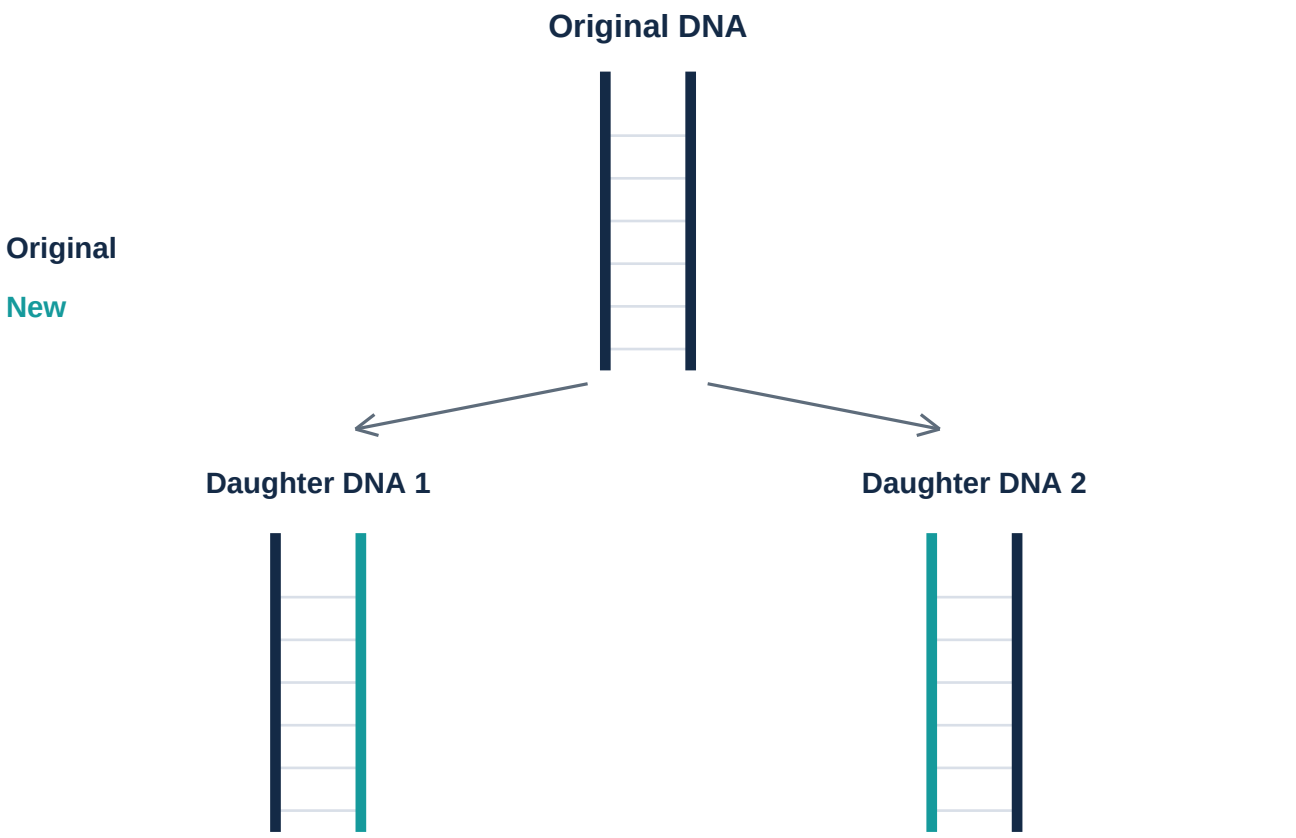
Each copy keeps one original strand

DNA replication occurs in S phase of interphase, before mitosis. Each original strand serves as a template for a new complementary strand.



Untwisted strand schematic, not to scale. Each coloured line is one entire strand; grey rungs stand for base pairs. Both daughter molecules contain one navy strand and one teal strand.

WHAT "SEMI-CONSERVATIVE" MEANS

One strand of each daughter DNA molecule is conserved from the original molecule. The other strand is newly synthesised. It does not mean that only half the DNA sequence is copied.

The amount of DNA doubles during S phase. Provided replication is accurate, the two daughter DNA molecules have the same base-pair sequence as the original. Copying DNA and separating chromosomes during mitosis are different processes.

Semi-conservative model: OpenStax Biology 2e, section 14.3.
Purpose of genome copying: NHGRI, DNA Replication.

Scope: Cambridge Biology 9700 syllabus, section 6.1, outcome 4, p. 24.

Separate, match, build, join

The old strands provide the sequence information. DNA polymerase builds the new DNA; DNA ligase completes joins in the backbone.

1. EXPOSE THE TEMPLATES

The double helix unwinds and the two strands separate as hydrogen bonds between paired bases are disrupted. The original covalent backbones remain intact.

2. MATCH COMPLEMENTARY NUCLEOTIDES

Free DNA nucleotides pair with exposed template bases: A with T, and C with G. Each original strand directs construction of a complementary new strand.

3. EXTEND WITH DNA POLYMERASE

DNA polymerase adds nucleotides to the free 3-prime end of a growing strand, forming phosphodiester links. The new strand therefore grows only from 5-prime to 3-prime.

4. SEAL WITH DNA LIGASE

After fragments have been processed into DNA, ligase seals remaining nicks in the sugar-phosphate backbone. It forms the final phosphodiester links that join neighbouring fragments.

POLYMERASE NEEDS AN EXISTING END

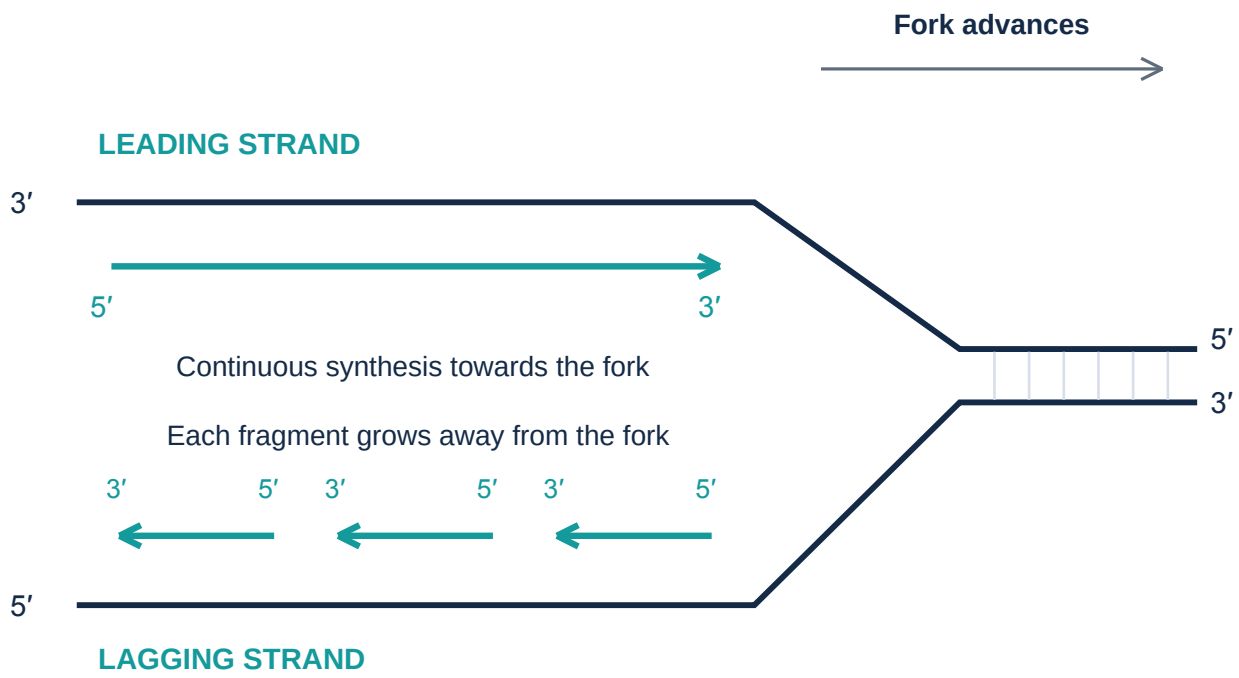
A primer provides a starting 3-prime end; polymerase does not begin a strand from nothing. Primers are later removed and replaced with DNA. Primer details are supporting context; the required enzyme names here are DNA polymerase and DNA ligase.

Template copying and DNA synthesis: Alberts et al., DNA Replication Mechanisms.
Primer processing and ligase: OpenStax Biology 2e, section 14.4.

Scope: Cambridge Biology 9700 syllabus, section 6.1, outcome 4, p. 24.

One direction rule, two patterns

The templates are antiparallel, but DNA polymerase always builds new DNA from 5-prime to 3-prime. At a moving fork, this produces continuous and discontinuous synthesis.



Navy = original templates. Teal arrows = new DNA and its growth direction. One fork is shown; primers and enzymes are omitted. Schematic, not to scale.

WHY THE LAGGING STRAND NEEDS FRAGMENTS

As the fork opens, new template becomes exposed. New fragments start near the fork and grow away from it, each from 5-prime to 3-prime. These short sections are called Okazaki fragments. Ligase ultimately joins them into a continuous strand.

THE RULE THAT NEVER CHANGES

Leading synthesis is continuous towards fork movement; lagging synthesis is discontinuous away from it. Both new strands are made from 5-prime to 3-prime. The template is read in the opposite direction. "Lagging" does not mean DNA is built from 3-prime to 5-prime.

Fork asymmetry and fragment synthesis: Alberts et al., DNA Replication Mechanisms.
Leading and lagging strand comparison: OpenStax Biology 2e, section 14.4.

Scope: Cambridge Biology 9700 syllabus, section 6.1, outcome 4, p. 24.