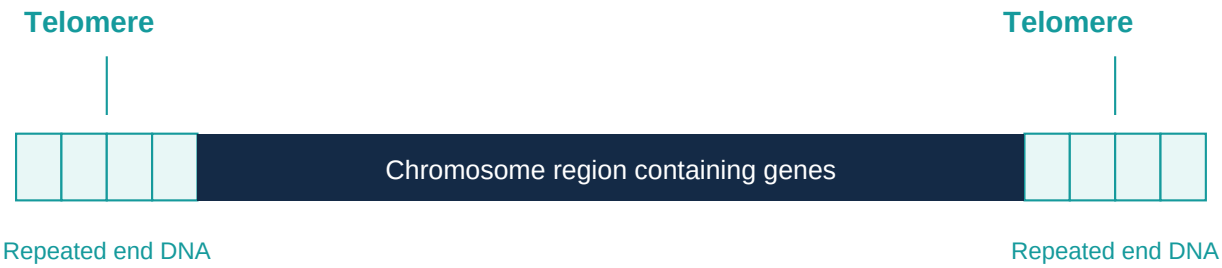
Protect the chromosome ends

Telomeres are regions of repeated DNA at the ends of linear chromosomes. Their position allows them to protect genetic information farther inward.

1. LOCATION MAKES THE DIFFERENCE



One unreplicated chromosome shown as a simplified linear map. Both ends have telomeres. Blocks represent repeat DNA, not individual genes or a scale drawing.

2. REPEATED DOES NOT MEAN USELESS

Telomeric repeats do not encode proteins. They are functional DNA: they form a protective end region rather than instructions for making a protein.

3. A BUFFER BETWEEN THE END AND THE GENES

When terminal DNA is lost during repeated replication, telomeric repeats can be lost first. This helps prevent the immediate loss of genes farther from the end.

A replicated chromosome has two sister chromatids. Each chromatid has its own DNA molecule and a telomere at each end.

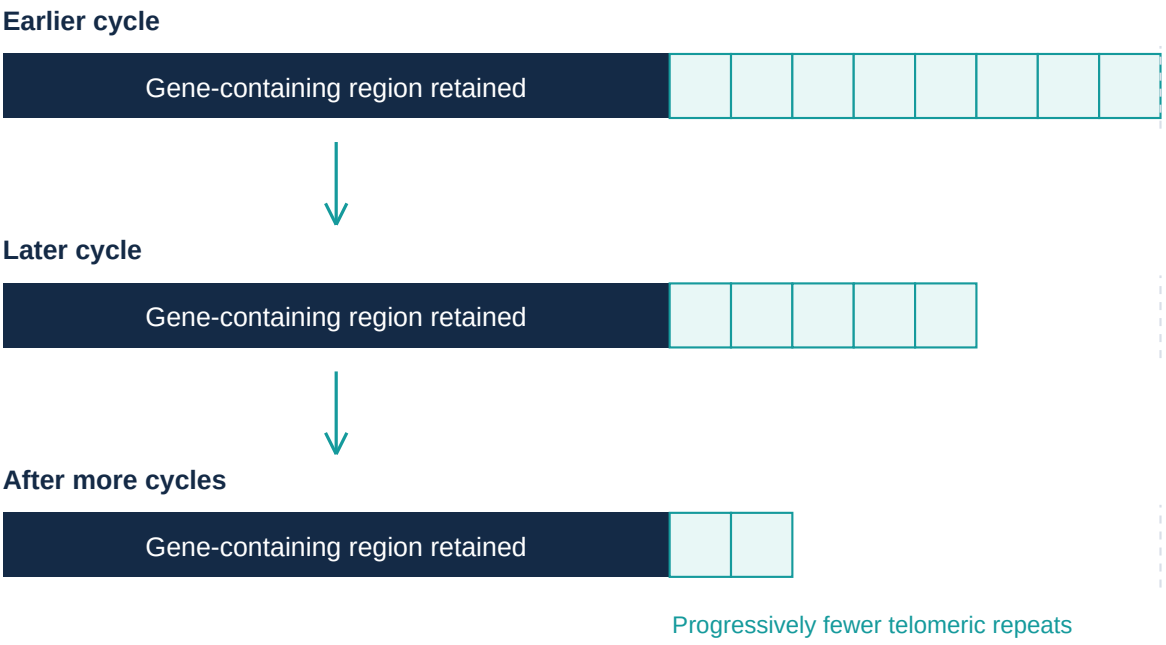
Telomere location and repeated DNA: NHGRI, Telomere.
Chromosome-end protection: Gilson & Geli, 2007.

Scope: Cambridge Biology 9700 syllabus, section 5.1, outcome 4, p. 23.

Lose repeats before losing genes

Conventional DNA replication cannot fully copy the ends of a linear DNA molecule. Without enough maintenance, telomeres can shorten over successive cell cycles.

1. FOLLOW ONE CHROMOSOME END



Schematic: only one end is shown. The number of blocks is illustrative; it does not specify how much DNA is lost per cycle.

2. LINK CAUSE TO PROTECTION

Incomplete copying at a chromosome end can reduce terminal DNA. A repeated, non-protein-coding telomere provides a buffer, so this shortening need not remove genes immediately.

3. DO NOT CONFUSE REPLICATION WITH DIVISION

The copying problem is linked to DNA replication in S phase. Mitosis distributes chromosomes; cytokinesis separates the cytoplasm. Neither is a process that deliberately cuts off genes.

End-replication problem: Alberts et al., Molecular Biology of the Cell.

Scope: Cambridge Biology 9700 syllabus, section 5.1, outcome 4, p. 23.

Protection has limits

The central lesson is a structure-function link: repetitive DNA at a chromosome end helps preserve genes during DNA replication.

1. TELOMERE IS NOT CENTROMERE

A telomere is at a chromosome end. A centromere is the chromosome region where the kinetochore forms for spindle attachment. End protection and chromosome movement are different roles.

2. SHORTER TELOMERES DO NOT MEAN FEWER CHROMOSOMES

Shortening changes the amount of DNA at chromosome ends, not automatically the number of chromosomes. A cell can retain its chromosome count while its telomeres become shorter.

3. THE BUFFER IS NOT UNLIMITED

Critically short or dysfunctional telomeres can lose their protective function and trigger a DNA-damage response. Cells may stop dividing or die; shortening is not an unlimited, harmless process.

4. EXTENSION: TELOMERASE

Telomerase is an enzyme complex that adds telomeric DNA repeats using an RNA template. It can counteract shortening in cells where it is active. Telomere means the end region; telomerase means the enzyme. Its detailed mechanism is beyond this lesson's syllabus outcome.

Core connection: repeated end DNA + a buffer against replication-associated shortening = reduced risk of losing genes from chromosome ends.

Protective function and failure: Gilson & Geli, 2007.
Telomerase: Alberts et al., Molecular Biology of the Cell.

Scope: Cambridge Biology 9700 syllabus, section 5.1, outcome 4, p. 23.