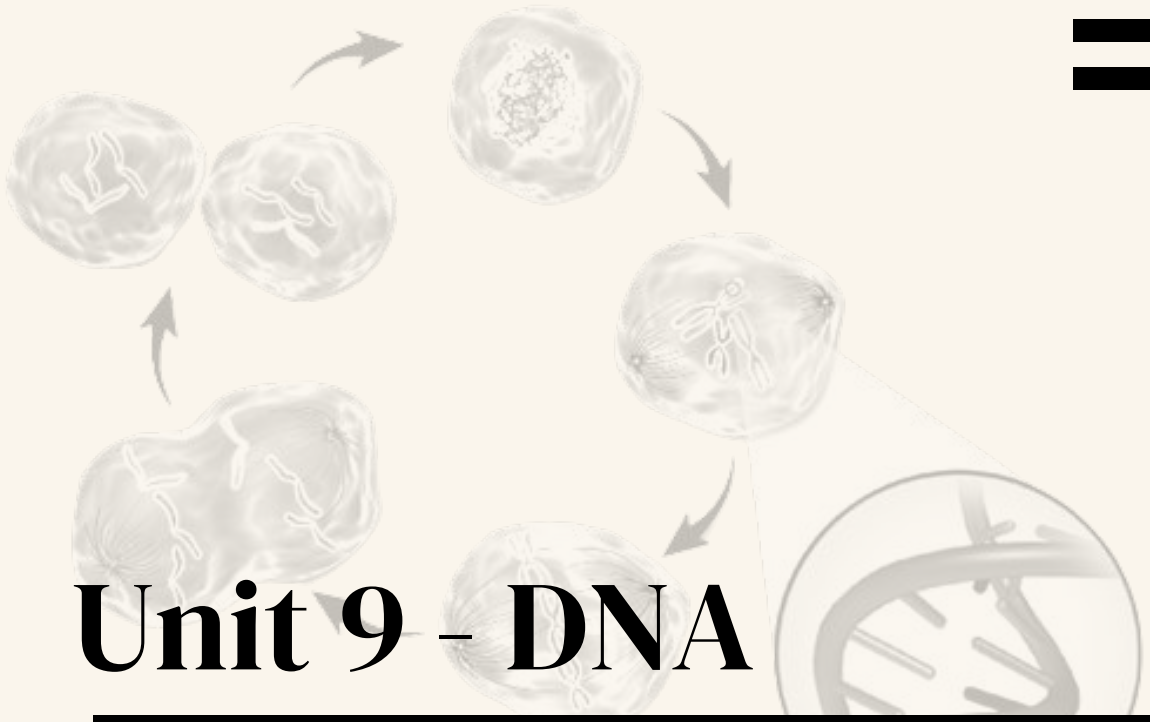
MAMMOTH

SCIENCE

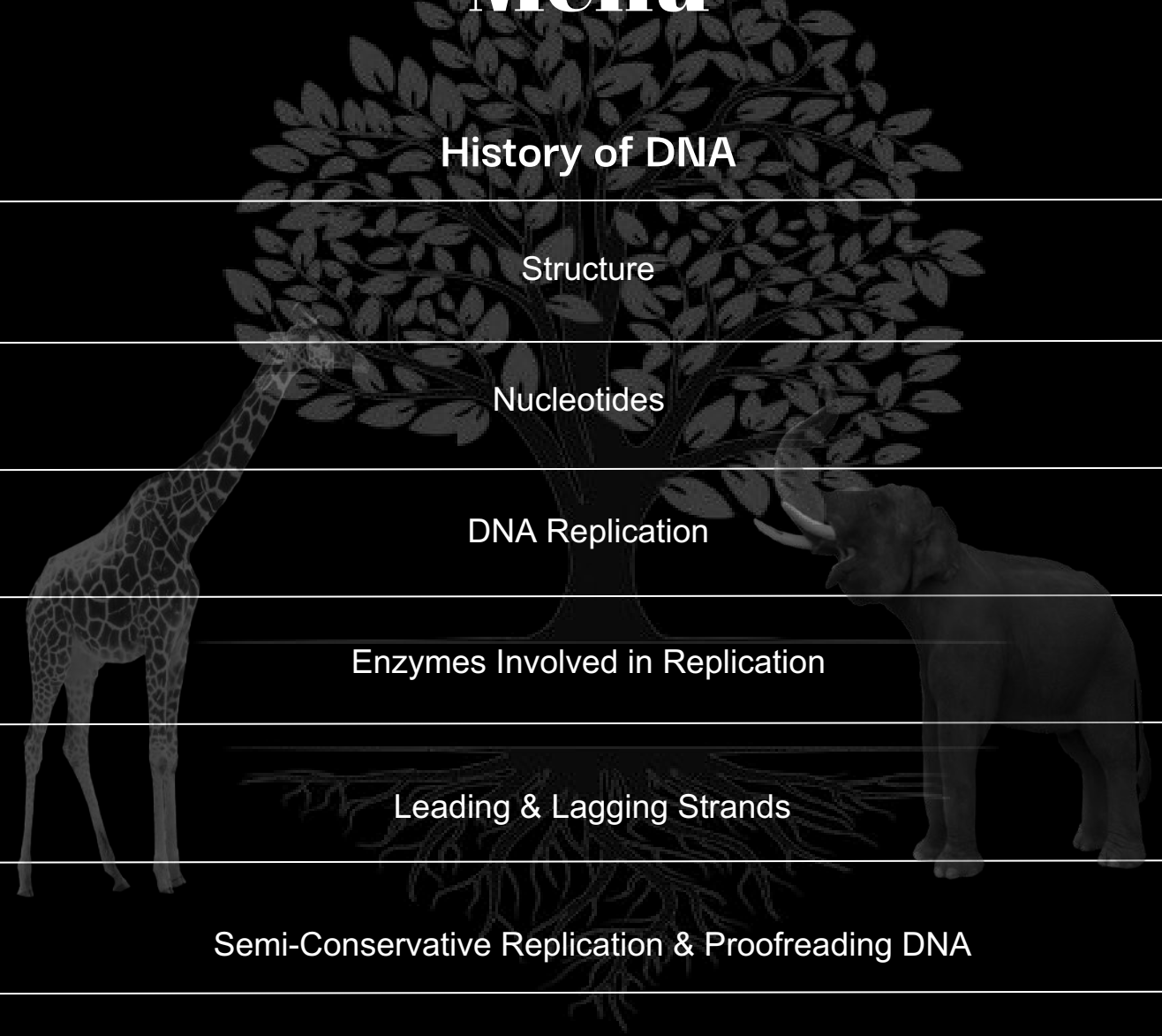


Unit 9 - DNA

- *Identify the components of DNA*
- *Know that traits are determined by proteins that are built according to instructions - coded in DNA*
- *Summarize the process of DNA replication*
- *Understand that enzymes proofread the newly synthesized DNA correcting mistakes*

MAMMOTH
SCIENCE

Menu



History of DNA

Structure

Nucleotides

DNA Replication

Enzymes Involved in Replication

Leading & Lagging Strands

Semi-Conservative Replication & Proofreading DNA

History of DNA

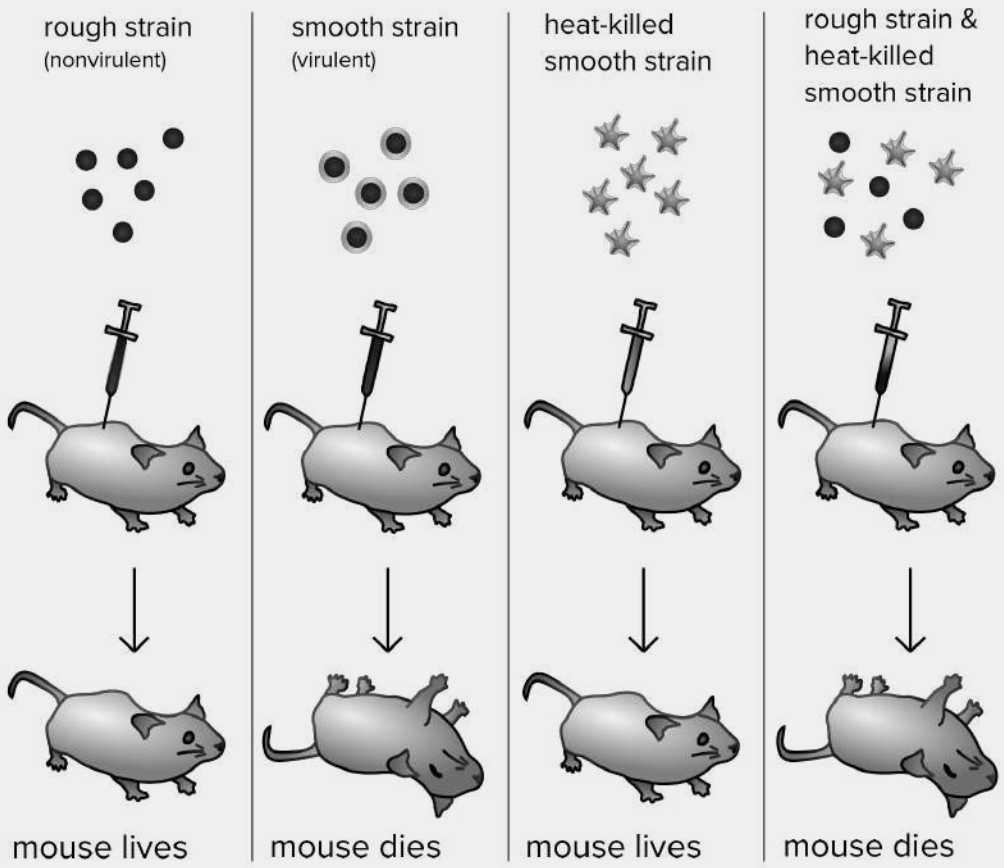
History of DNA

- Early scientists thought protein was the cell's hereditary material because it was more complex than DNA
- **Proteins** were composed of **20 different amino acids in** long **polypeptide** chains
- **Griffith Transformation:**
  - ➔ Fred Griffith worked with virulent S and non-virulent R strain Pneumococcus bacteria
  - ➔ He found that R strain could become virulent when it took in DNA from heat-killed S strain
  - ➔ **Study suggested that DNA was probably the genetic material**
- **Hershey & Chase**
  - ➔ **Chromosomes** are made of both **DNA** and **protein**
  - ➔ Experiments on bacteriophage viruses by Hershey & Chase proved that **DNA was** the cell's **genetic material**

Frederick Griffith

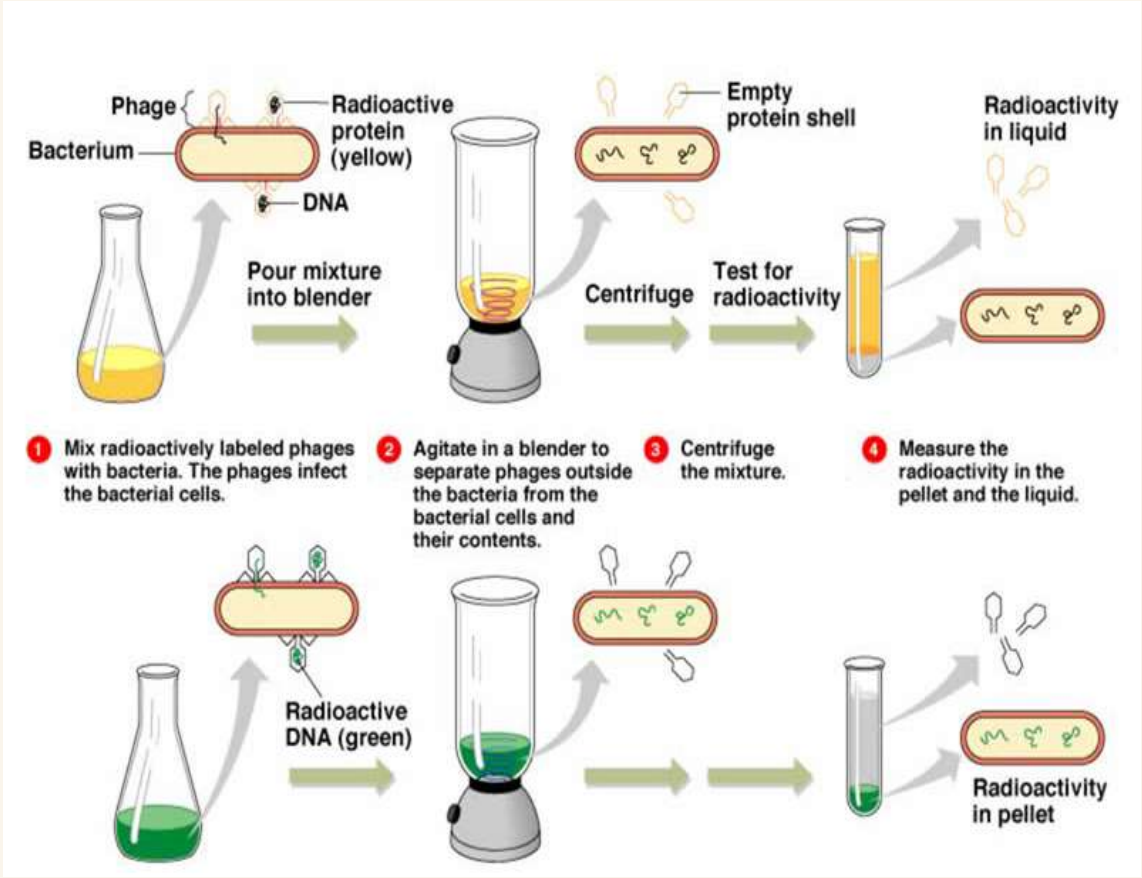
Martha Chase / Alfred Hershey

Experimentation

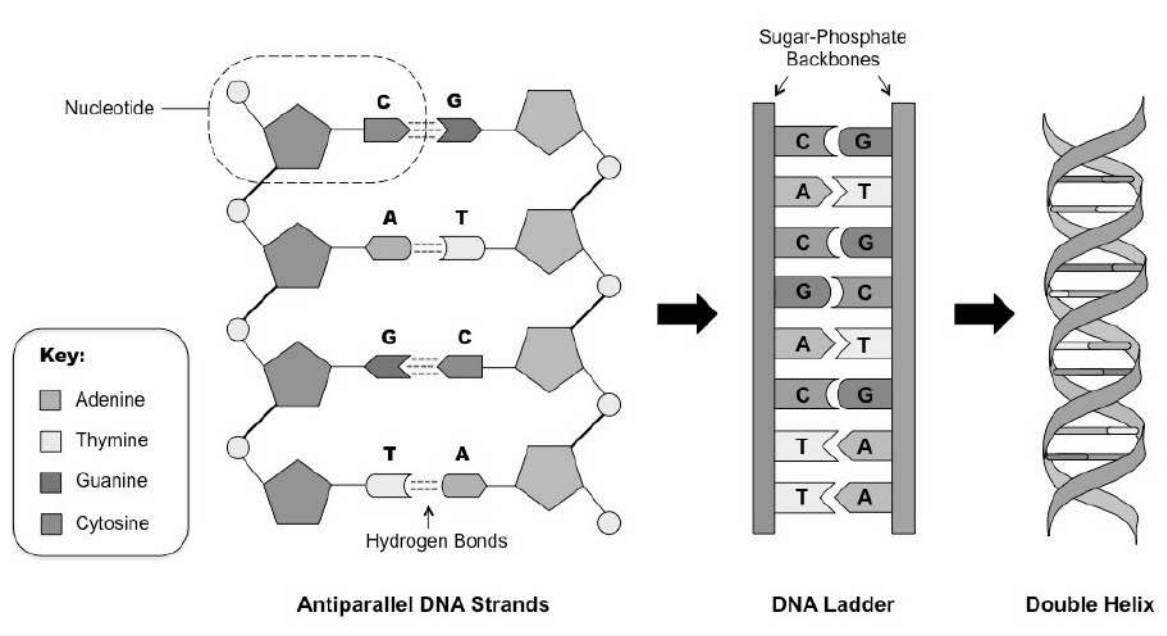


Griffith's Transformation

Hershey - Chase



DNA Structure



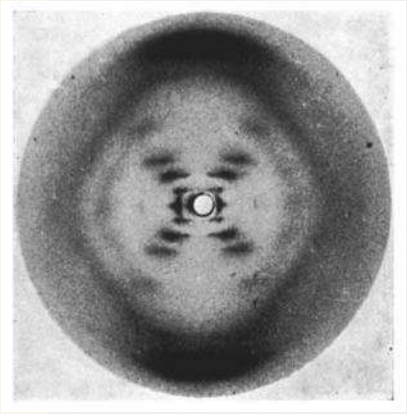
DNA Structure:

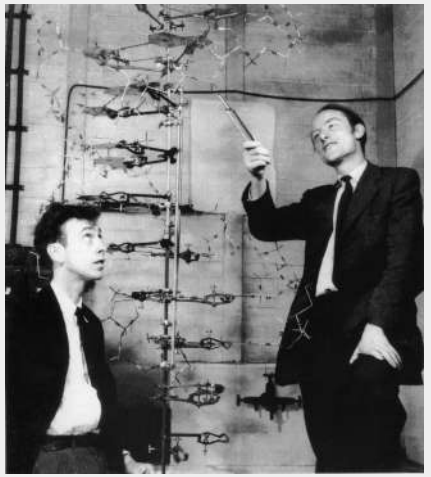
- **Erwin Chargaff** showed the amounts of the four bases on **DNA (A,T,C,G)**
- **In a body or somatic cell:**
  - **→A = 30.3%**
  - **→T = 30.3%**
  - **→G = 19.5%**
  - **→C = 19.9%**
- **Chargaff's Rule:**
  - **→Adenine** must pair with **Thymine**
  - **→Guanine** must pair with **Cytosine**

DNA Structure Continued

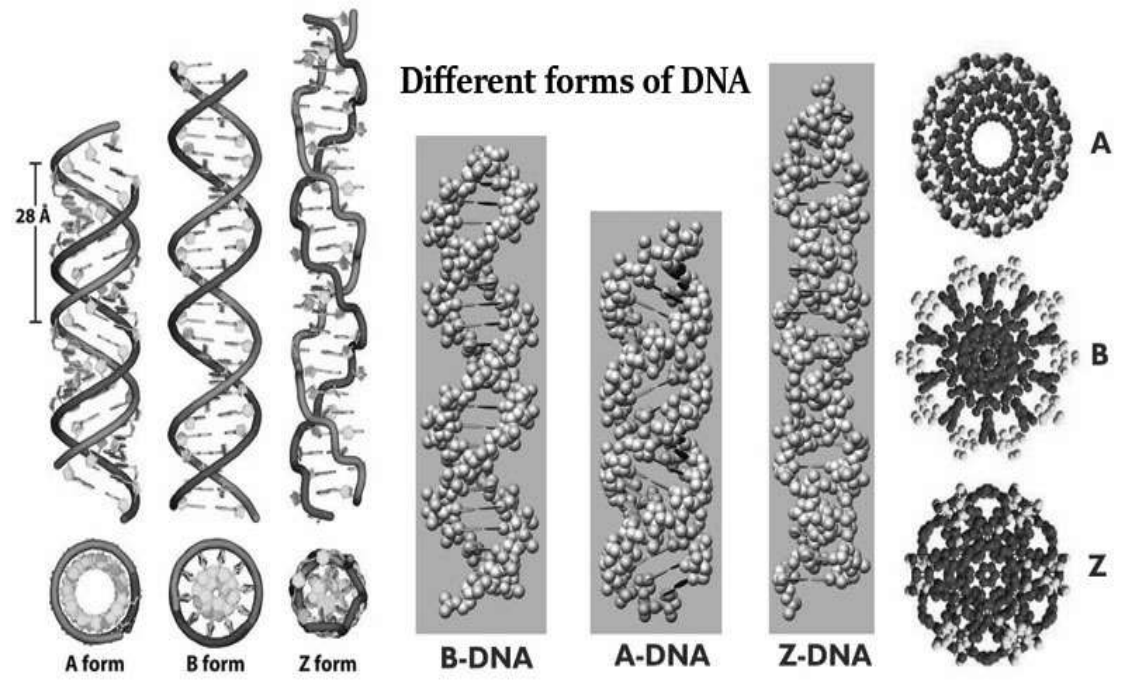
- **The bases are held together by weak hydrogen bonds**
- **DNA's First Photograph**
  - ➔**Rosalind Franklin** took diffraction x-ray photographs of DNA crystals
  - ➔In the 1950's, **Watson & Crick** built the first model of DNA using Franklin's X-rays

Francis Crick | James Watson | Rosalind Franklin





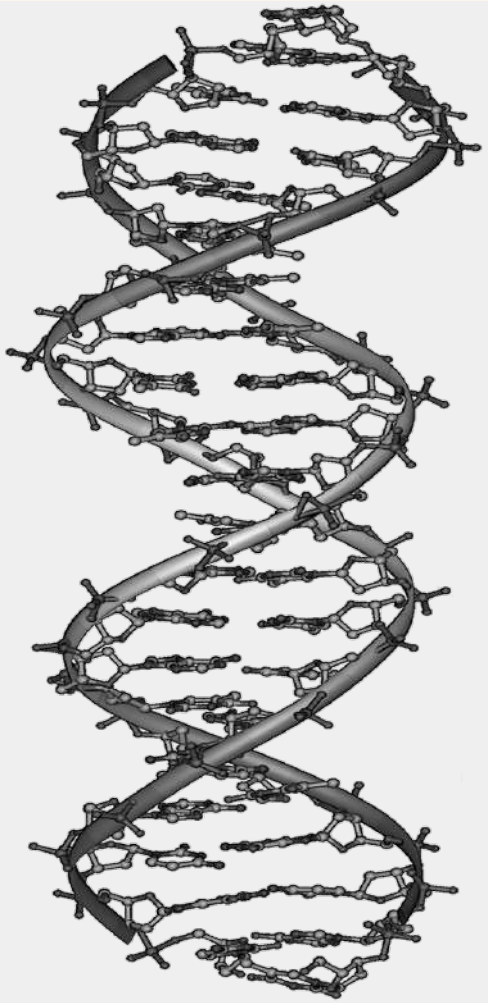
DNA Structure Continued

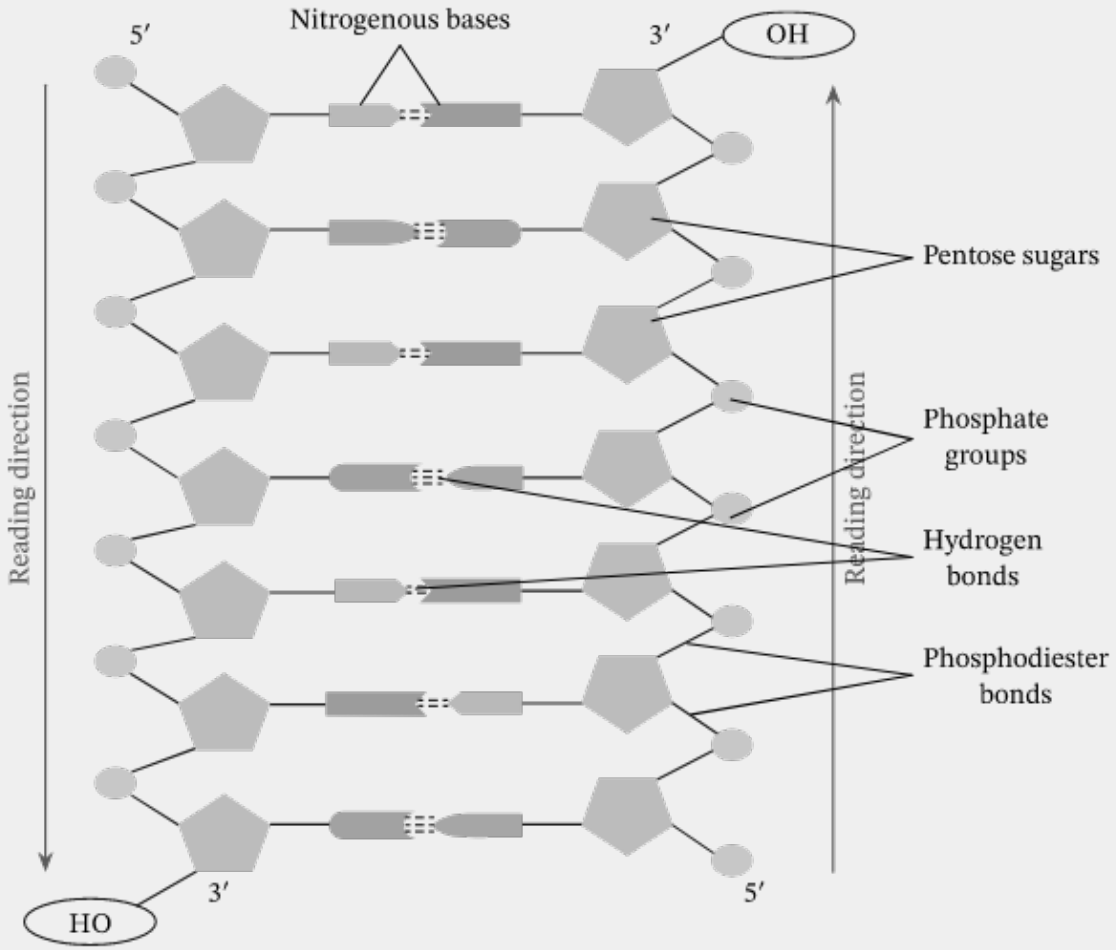


Structure

- Two strands coiled called a **double helix**
- **Sides** made of a **pentose sugar Deoxyribose** bonded to **phosphate (PO4)** groups by **phosphodiester bonds**
- **Center** made of **nitrogen bases** bonded together by weak **hydrogen bonds**
- **Helix**
  - ➔**Most DNA** (B-DNA) has a right-hand twist with 10 base pairs in a complete turn
  - ➔**L**eft twisted DNA is called Z-DNA or southpaw DNA
  - ➔Hot spots occur where right and left twisted DNA meet producing mutations

DNA Structure Continued

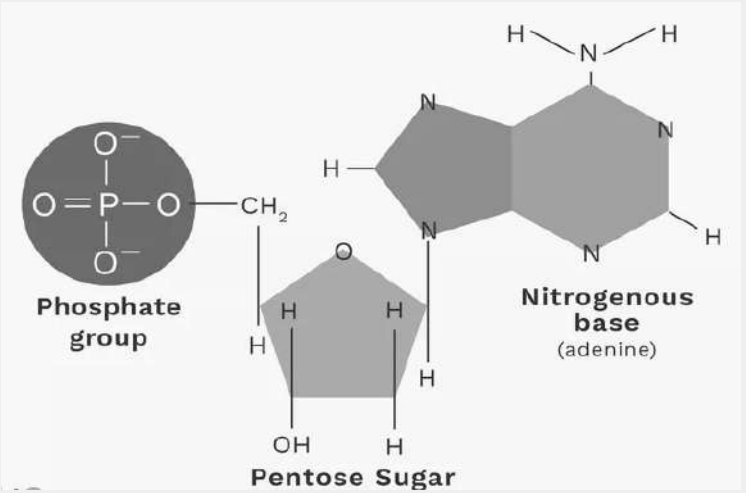


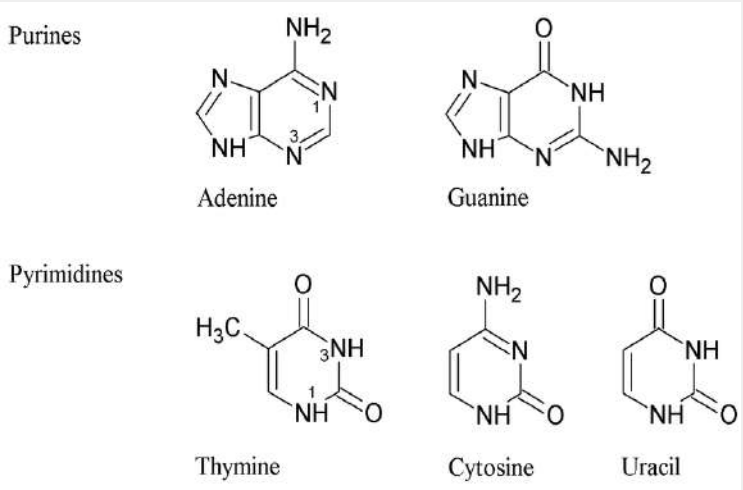


Nucleotides

Nucleotides

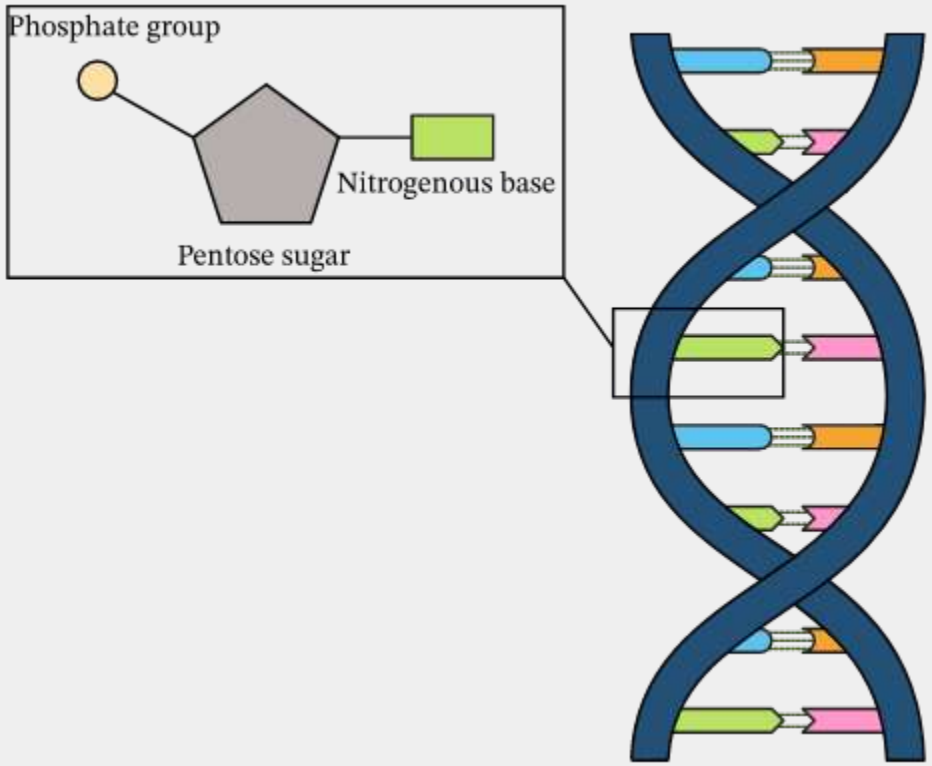
- **DNA** Stands for **Deoxyribonucleic acid**
- Made up of subunits called **nucleotides**
- **Nucleotide** made of:
  - ➔ **Phosphate group**
  - ➔ **5-carbon sugar**
  - ➔ **Nitrogenous base (**genetic code**)**
- **Double** ring **PURINES**
  - ➔ **Adenine (A)**
  - ➔ **Guanine (G)**
- **Single** ring **PYRIMIDINES**
  - ➔ **Thymine (T)**
  - ➔ **Cytosine (C)**
- **Base Pairings**
  - ➔ **Purines** only pair with **Pyrimidines**
  - ➔ **Three hydrogen bonds** required to bond **Guanine** *to* **Cytosine**
  - ➔ **Two hydrogen bonds** are required to bond **Adenine** to **Thymine**
  - ➔ These are what allows for DNA to be copied exactly



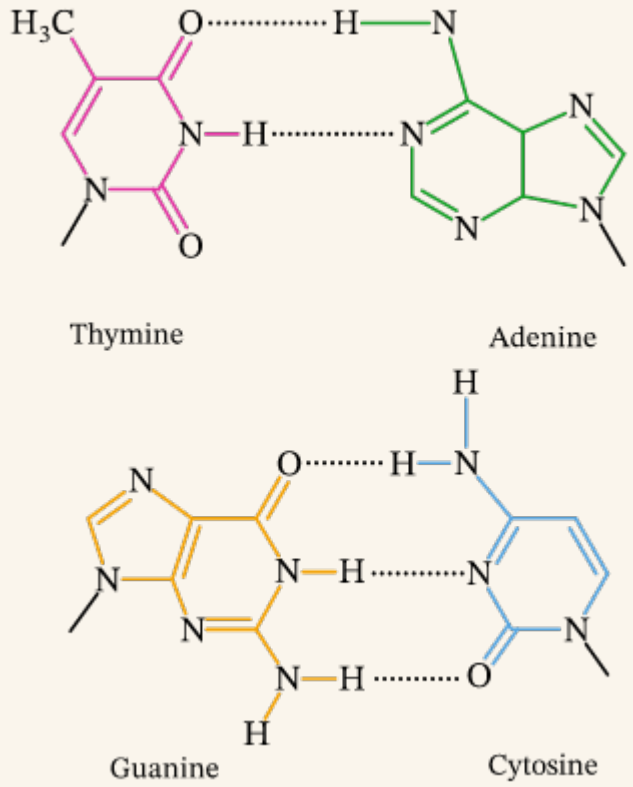


Nucleotides Continued

Nucleotide Structure



Base Pairing



DNA Replication

DNA Replication:

- **DNA** has to be **copied** before a cell **divides**
- DNA is copied during the **S or synthesis phase** of **interphase**
- New cells will need **identical DNA** strands

➔ Occurs in the Nucleus of eukaryotes

➔ **Replication Fork -**

❑ Begins at **Origins of Replication** **-** Two strands open forming **Replication Forks:** (Y-shaped region)

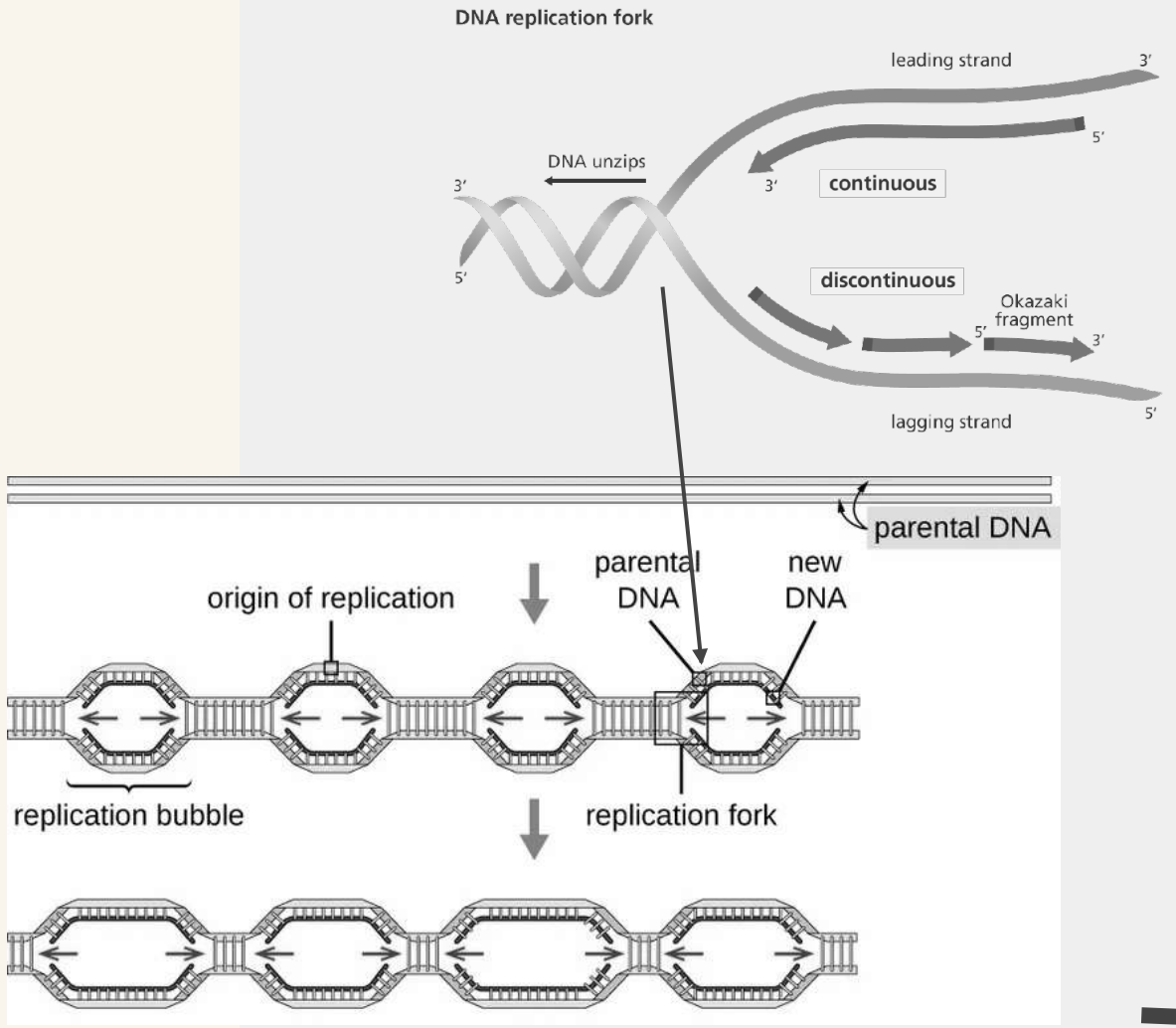
❑ New strands grow at the forks

➔ **Replication Bubbles**

❑ As the 2 DNA strands open at the origin, Replication Bubbles form

❑ **Eukaryotic** chromosomes have **MANY** bubbles

❑ **Prokaryotes** (bacteria) have a **single** bubble



Enzymes for Replication

01

Helicase

- Enzyme: **Helicase unwinds** and **separates** the 2 DNA strands by **breaking** the weak **hydrogen bonds**.
- **Single-Strand Binding Proteins** attach and **keep** the 2 DNA strands **separated** and **untwisted**

02

Topoisomerase

- **Topoisomerase**
  - ➔ Enzyme: **Topoisomerase attaches** to the 2 forks of the bubble to **relieve stress on the DNA molecule as it separates**

03

RNA Primase

- **RNA Primers and Primase**
  - ➔ Before new DNA strands can form, there must be **RNA primers present to start** the addition of new **nucleotides**
  - ➔ Primase is the enzyme that **synthesizes** the **RNA Primer**
  - ➔ **DNA polymerase** can then **add** the new **nucleotides**

04

DNA Polymerase

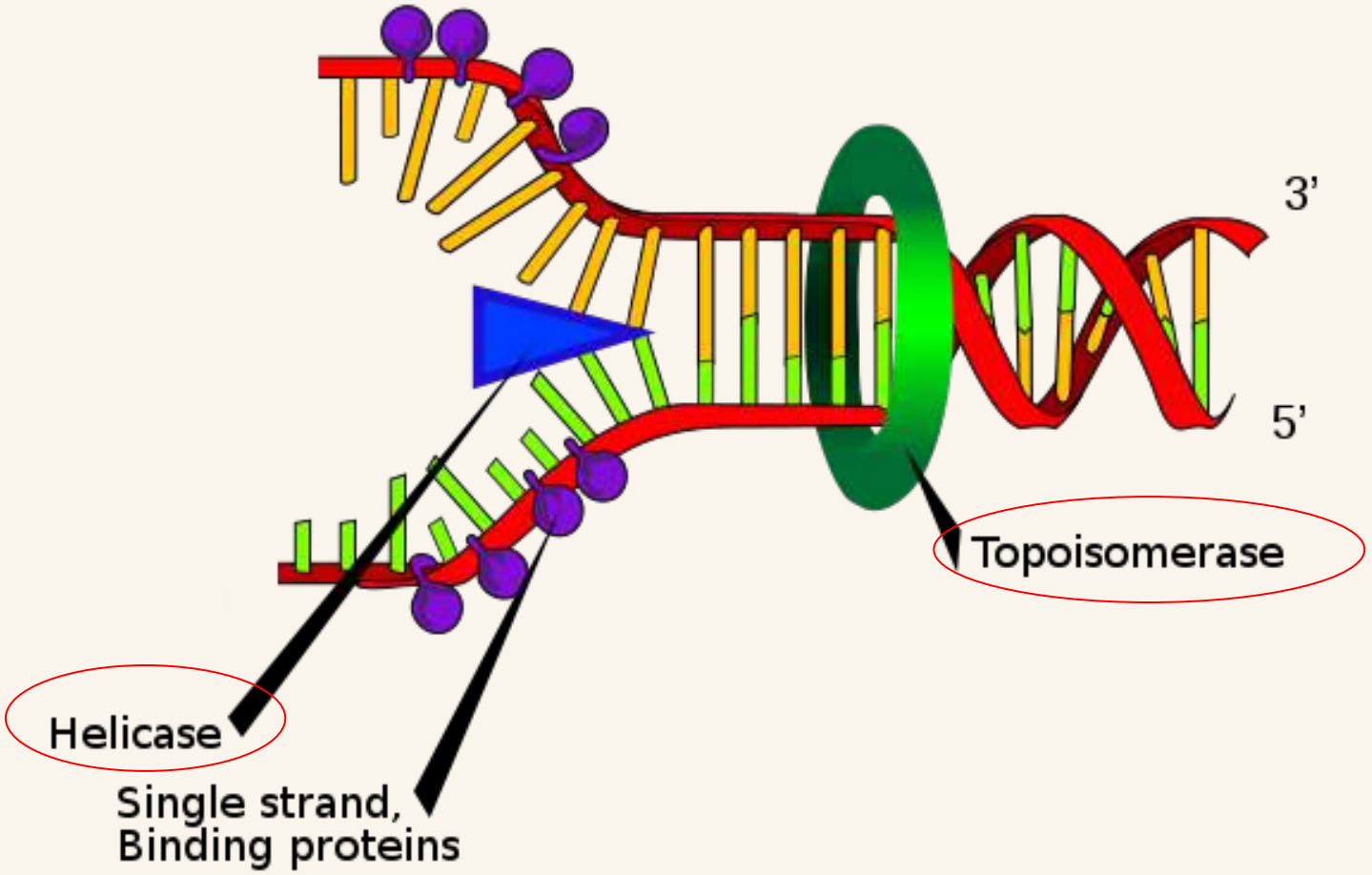
- **DNA Polymerase**
  - ➔ DNA polymerase can only add nucleotides to the 3’ end of the DNA
  - ➔ This causes the NEW strand to be built in a 5’ to 3’ direction

05

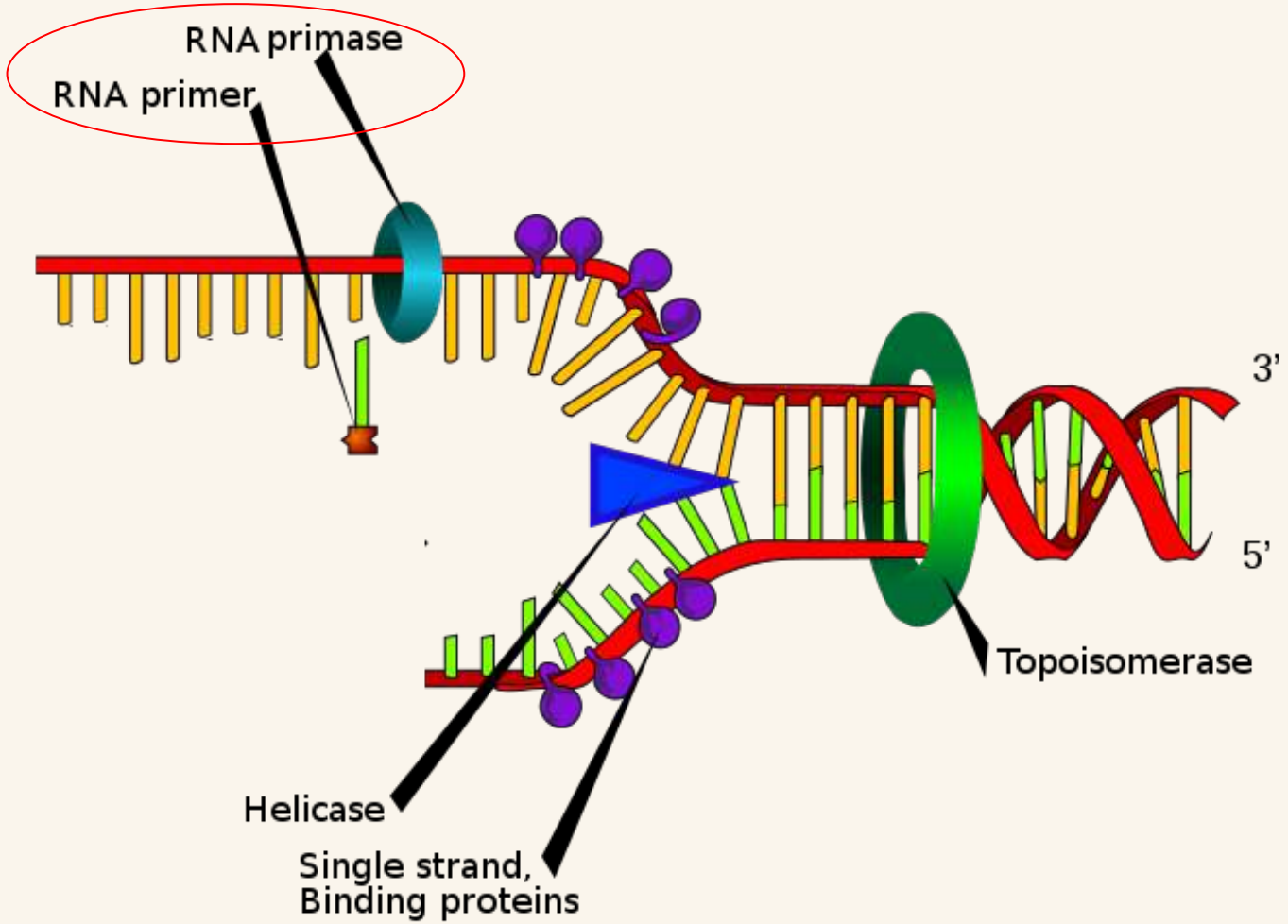
Ligase

- **DNA Ligase**
  - ➔ **Okazaki Fragments** - *series of short segments on the lagging strand*
  - ➔ Okazaki Fragments must be *joined together* by an *enzyme* – **DNA Ligase**

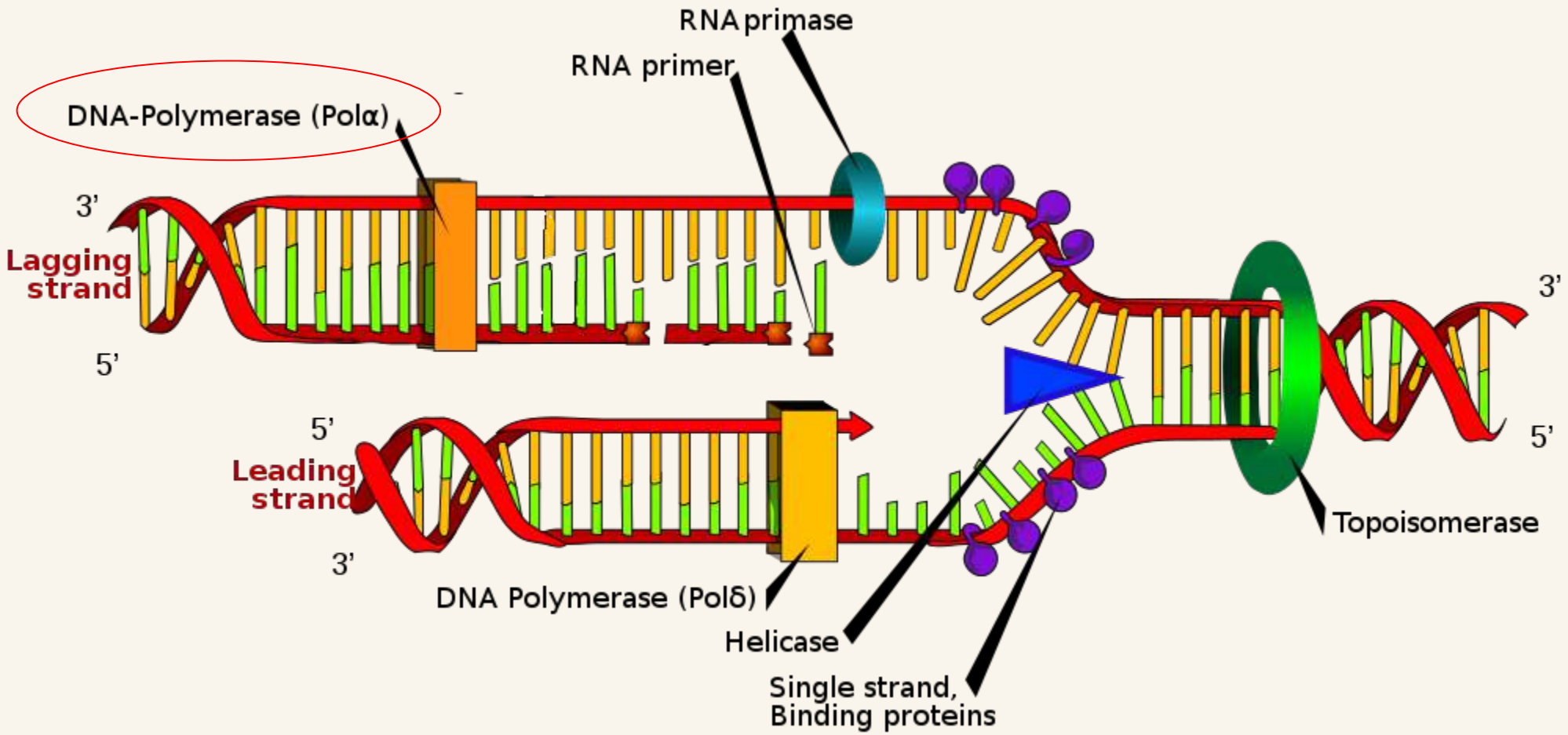
Helicase & Topoisomerase



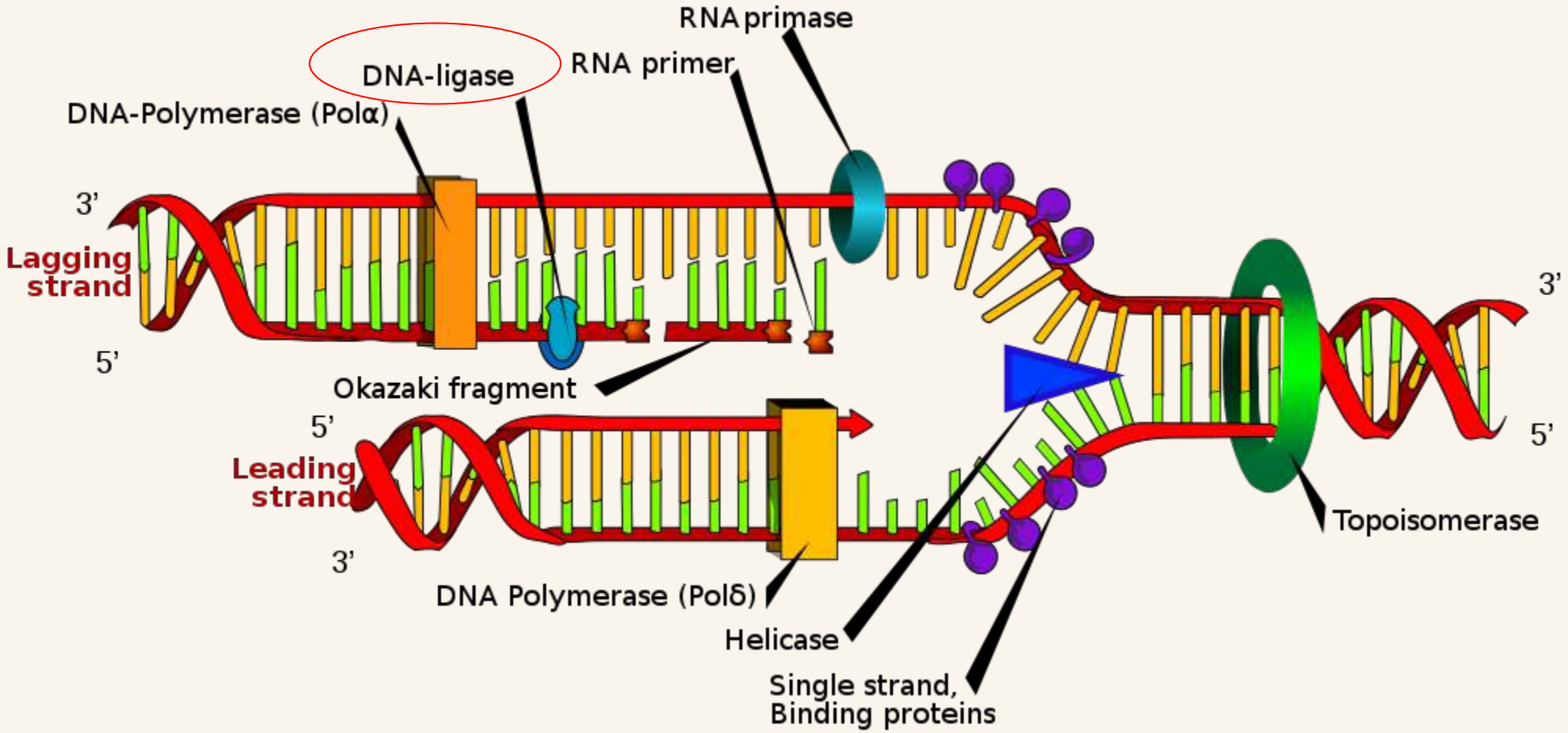
RNA Primase



DNA Polymerase



DNA Ligase



Leading & Lagging Strands

The Leading Strand - (continuous)

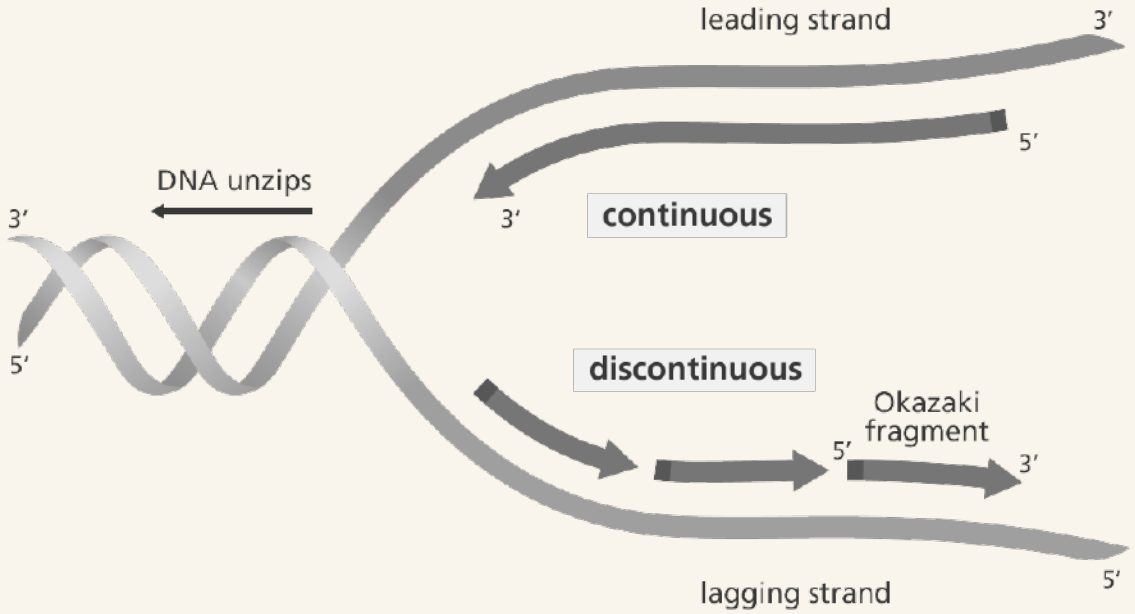
➔ is synthesized as a single strand from the point of **origin toward the opening replication fork**

Lagging Strand: (discontinuous)

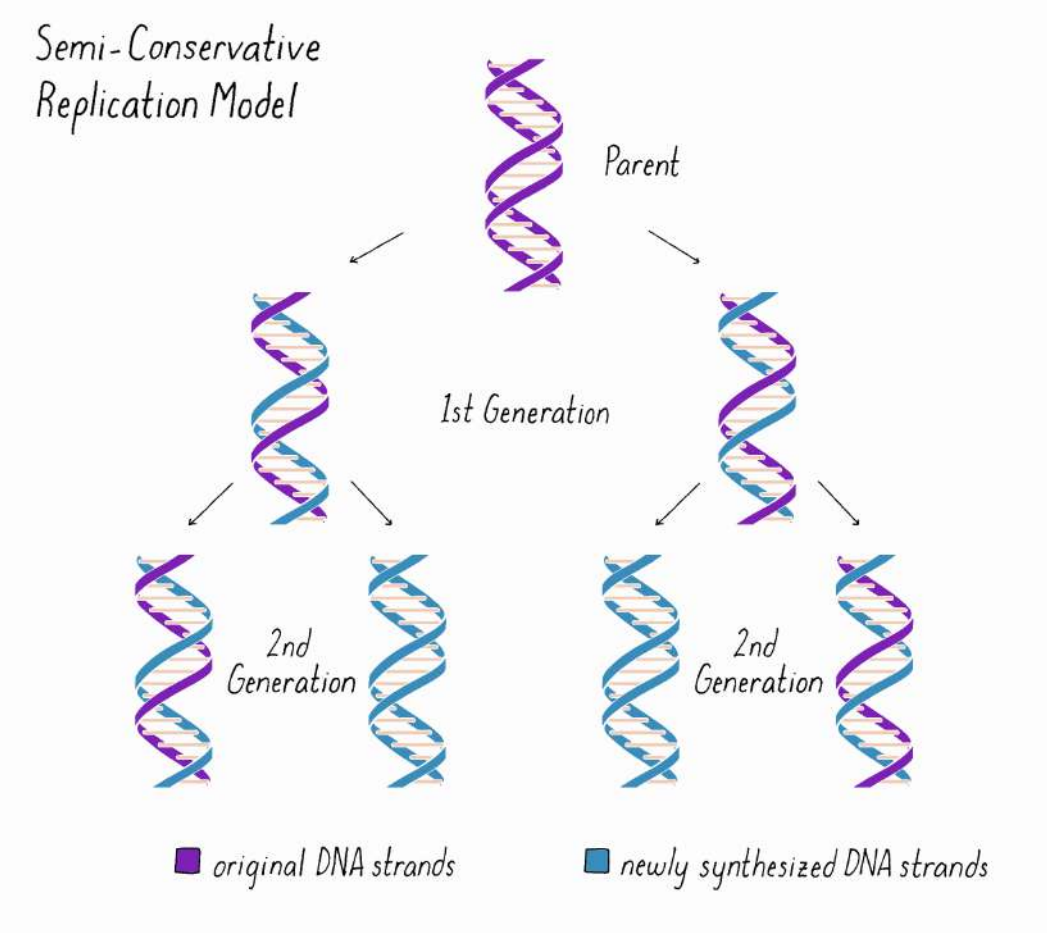
➔ The Lagging Strand is synthesized discontinuously against overall direction of replication

➔ This strand is made in MANY short segments It is replicated from the **replication fork toward the origin**

➔ **Okazaki Fragments** - series of short segments on the lagging strand



Semi-Conservative Replication & Proofreading



Semiconservative Model for Replication

- ➔Idea presented by Watson & Crick
- ➔The two strands of the parental molecule separate, and each acts as a template for a new complementary strand
- ➔New DNA consists of 1 PARENTAL (original) and 1 NEW strand of DNA

Proofreading DNA

- ➔DNA polymerase initially makes about 1:10,000 base pairing errors
- ➔Enzymes proofread and correct these mistakes
- ➔The new error rate for DNA that has been proofread is 1 in 1 billion base pairing errors

DNA Damage & Repair

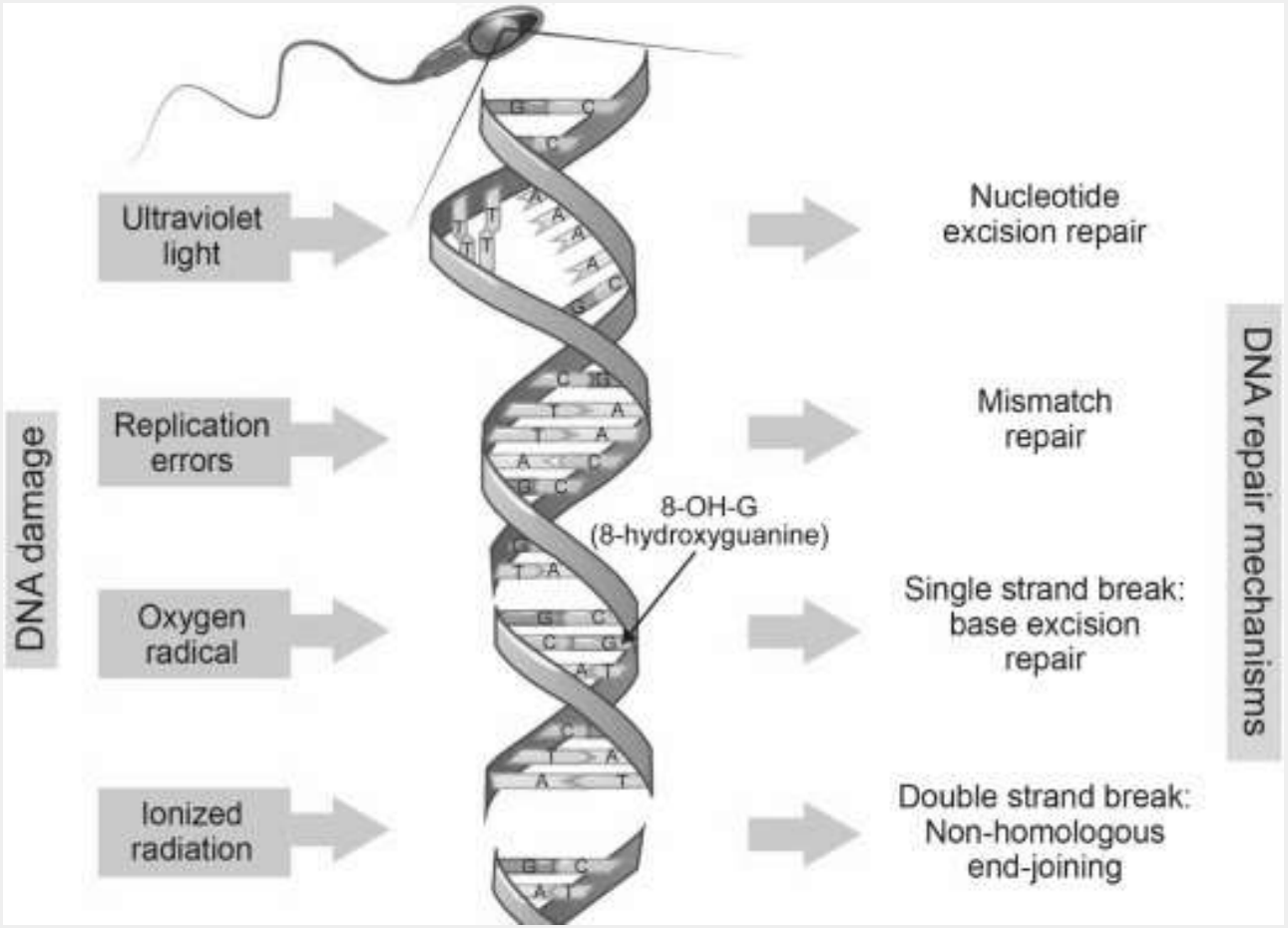
DNA Damage & Repair:

➔Chemicals & ultraviolet radiation damage the DNA in our body cells

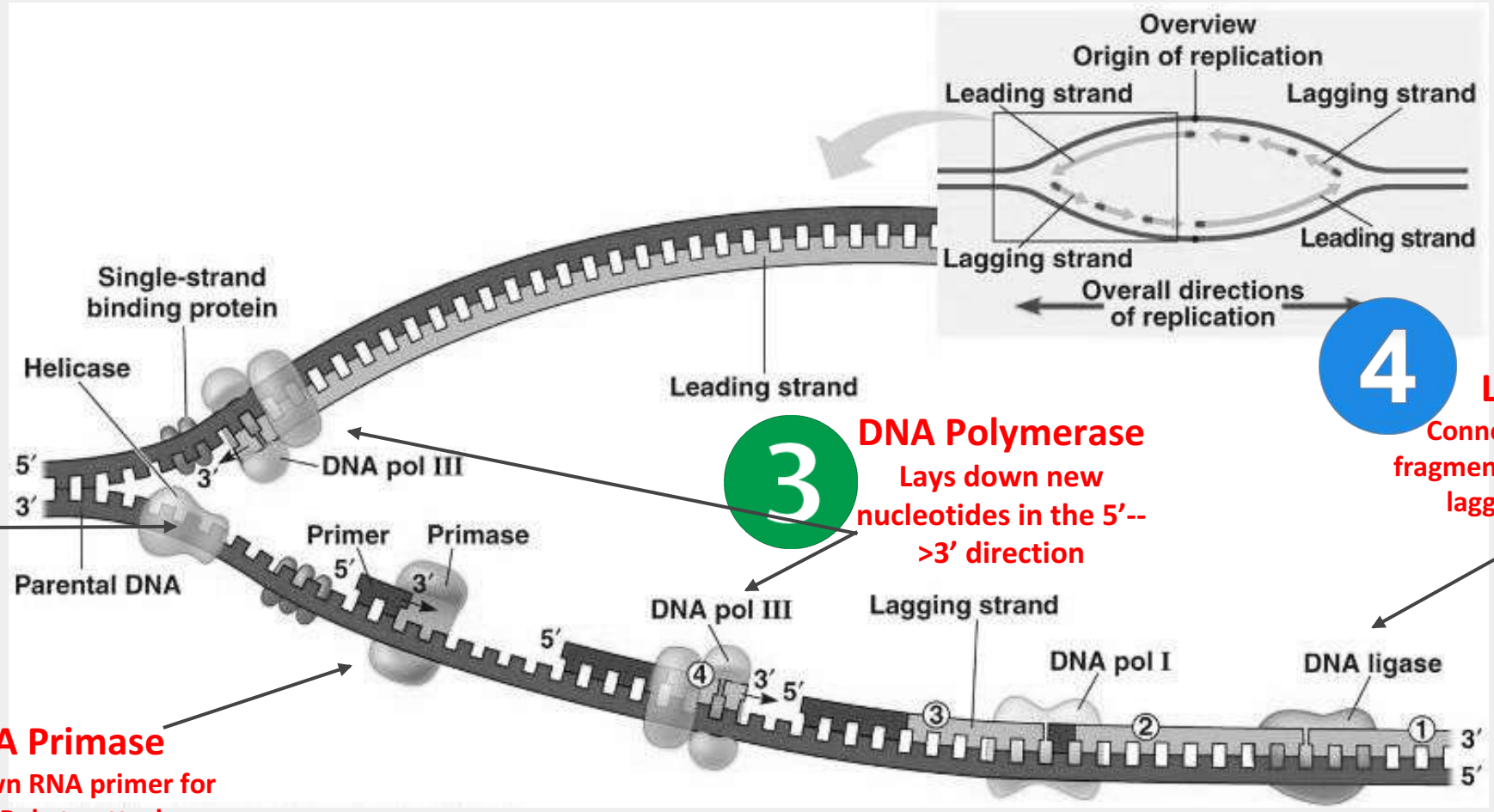
➔Cells must continuously repair DAMAGED DNA

➔Excision repair occurs when any of over 50 repair enzymes remove damaged parts of DNA

➔DNA polymerase and DNA ligase replace and bond the new nucleotides together



DNA Replication Summary



1

Helicase & Topoisomerase

Unzips and unwinds DNA

2

RNA Primase

Lays down RNA primer for DNA Poly to attach

3

DNA Polymerase

Lays down new nucleotides in the 5'-->3' direction

4

Ligase

Connects okazaki fragments together on lagging strand

Thank you!

Do you have any questions?

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