

# DNA and its Replication

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# History of DNA

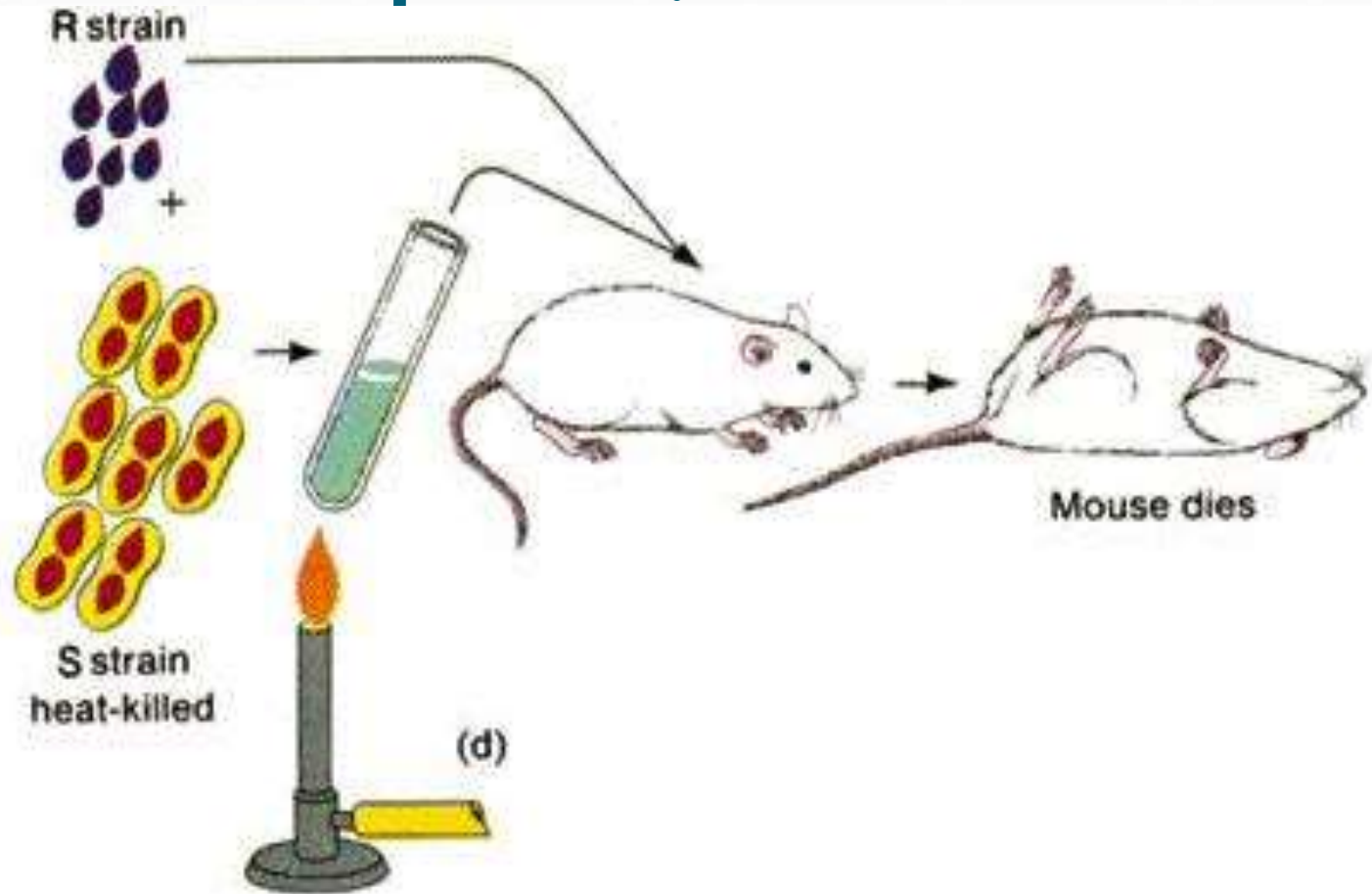
# History of DNA

- 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

# Transformation

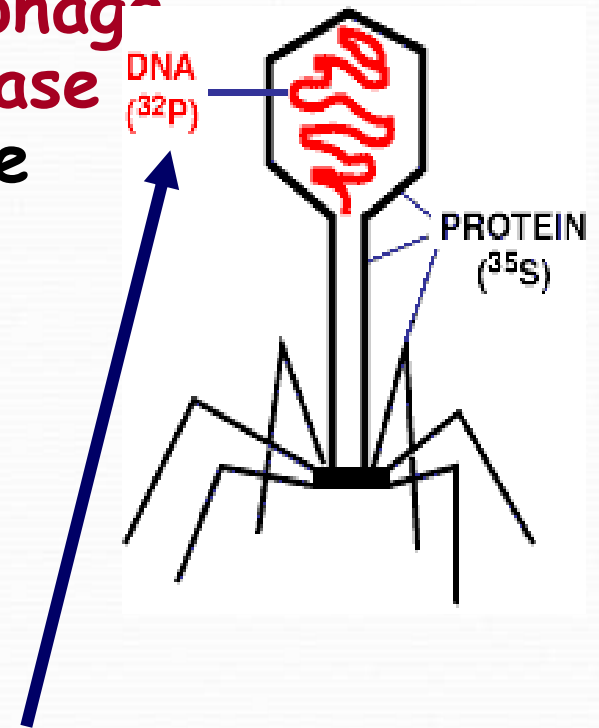
- Fred Griffith worked with virulent S and nonvirulent R strain *Pneumococcus* bacteria
- He found that R strain could become virulent when it took in DNA from heat-killed S strain
- Study suggested that DNA was probably the genetic material

# Griffith Experiment



# History of DNA

- **Chromosomes** are made of both DNA and protein
- Experiments on **bacteriophag-**viruses by **Hershey & Chase** proved that DNA was the cell's genetic material



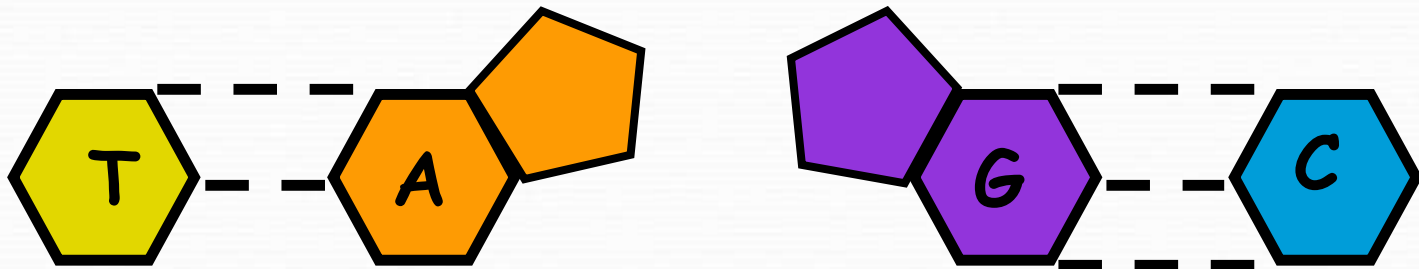
Radioactive  $^{32}\text{P}$  was injected into bacteria!

# Discovery of 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**
- The bases form weak hydrogen bonds





# DNA Structure

- **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**

# Rosalind Franklin

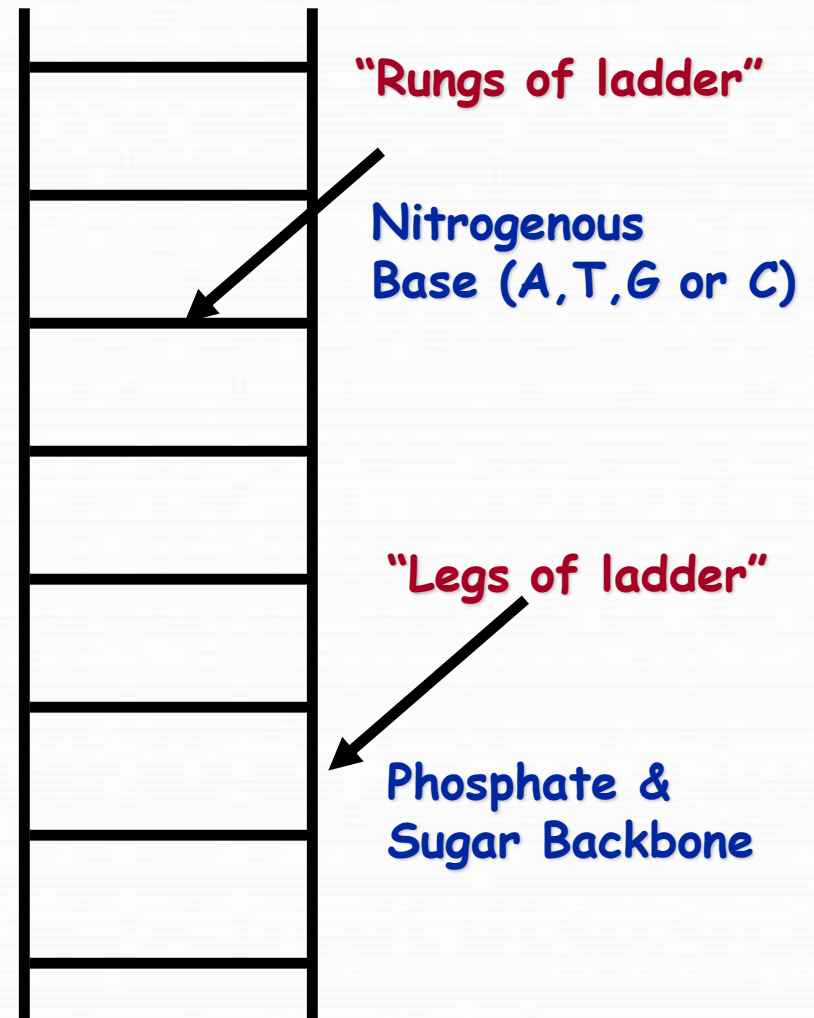
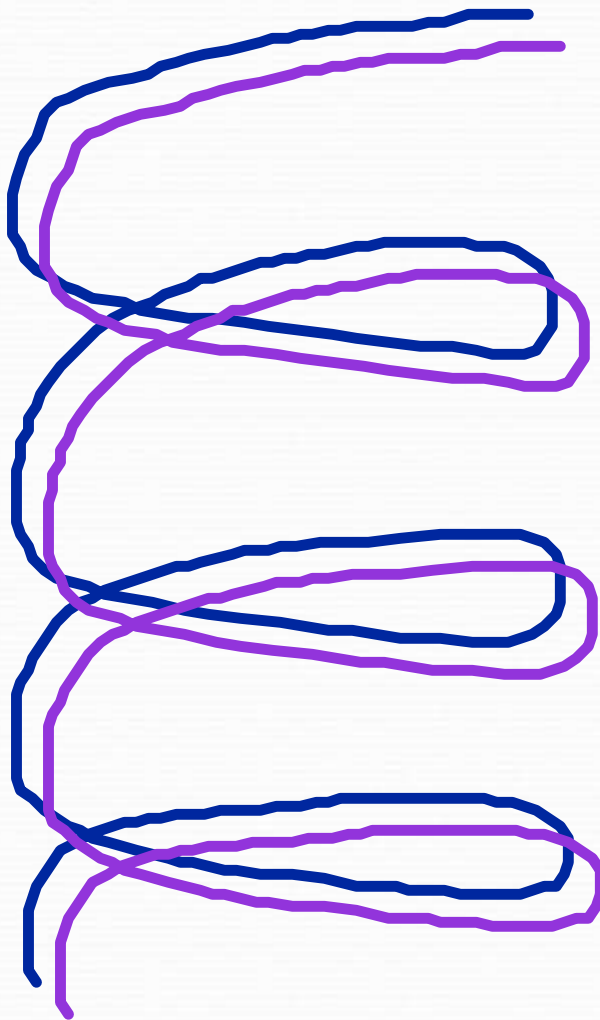


# DNA Structure

# DNA

- Two strands coiled called a **double helix**
- **Sides** made of a pentose sugar **Deoxyribose** bonded to **phosphate** ( $\text{PO}_4$ ) groups by **phosphodiester bonds**
- **Center** made of **nitrogen bases** bonded together by **weak hydrogen bonds**

# DNA Double Helix



# Helix

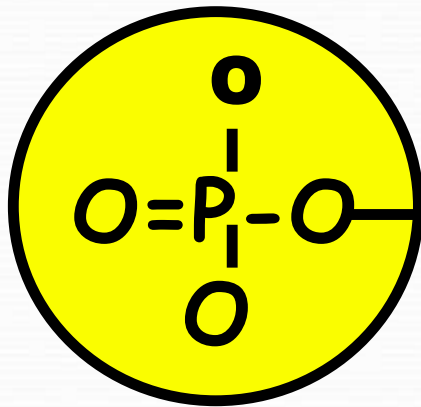
- Most DNA has a **right-hand** twist with **10 base pairs** in a complete turn
- Left twisted DNA is called **Z-DNA** or **southpaw** DNA
- **Hot spots** occur where right and left twisted DNA meet producing **mutations**

# DNA

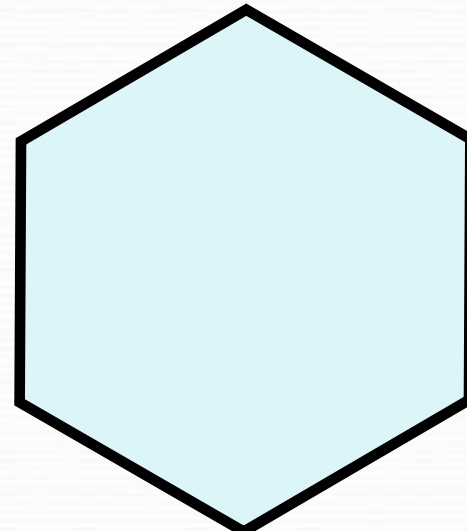
- Stands for **Deoxyribonucleic acid**
- Made up of subunits called **nucleotides**
- **Nucleotide** made of:
  1. **Phosphate group**
  2. **5-carbon sugar**
  3. **Nitrogenous base**

# DNA Nucleotide

Phosphate  
Group



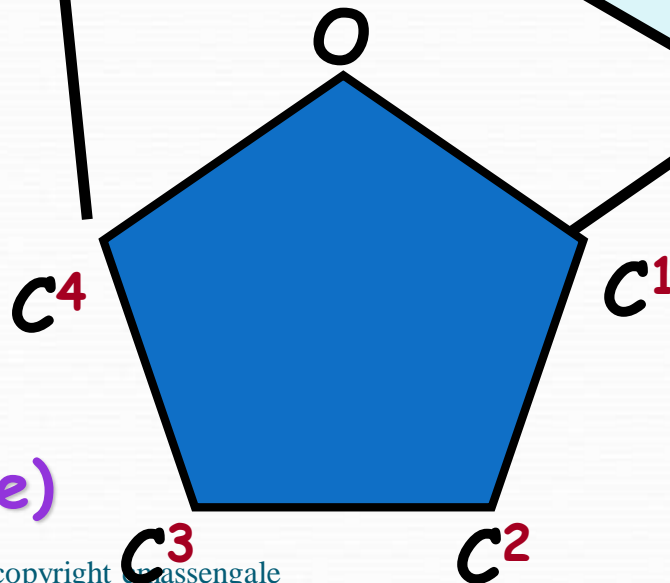
<sup>5</sup>  
CH<sub>2</sub>



N

Nitrogenous base  
(A, G, C, or T)

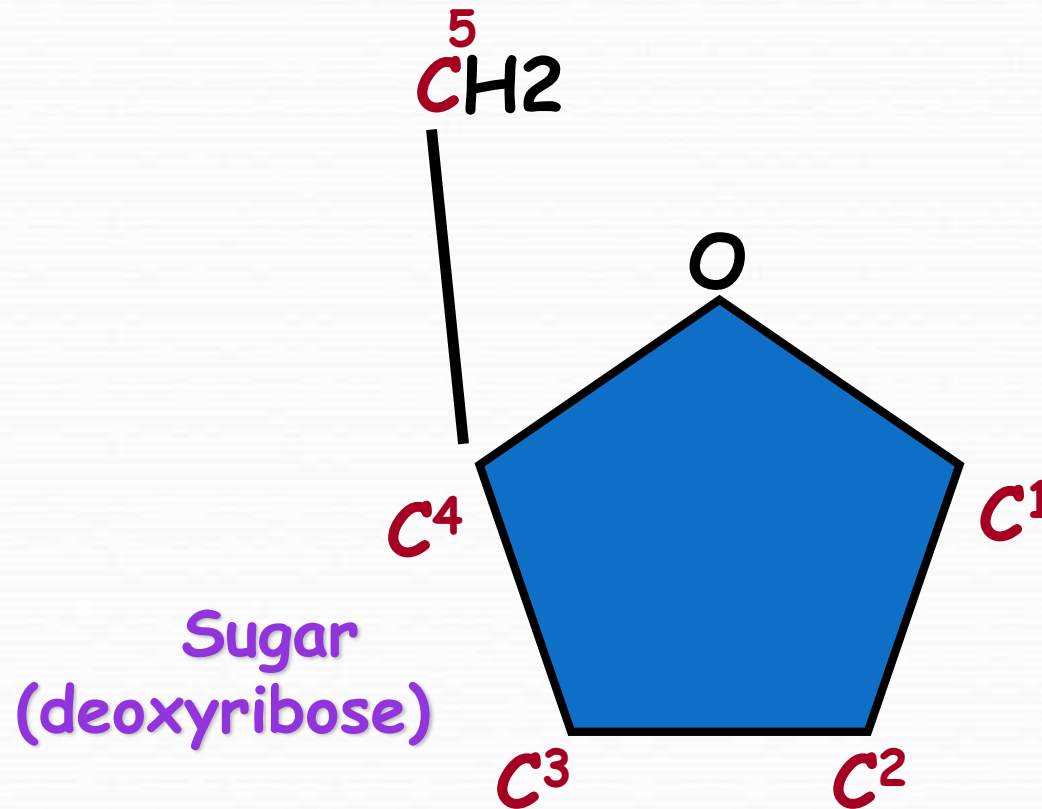
Sugar  
(deoxyribose)



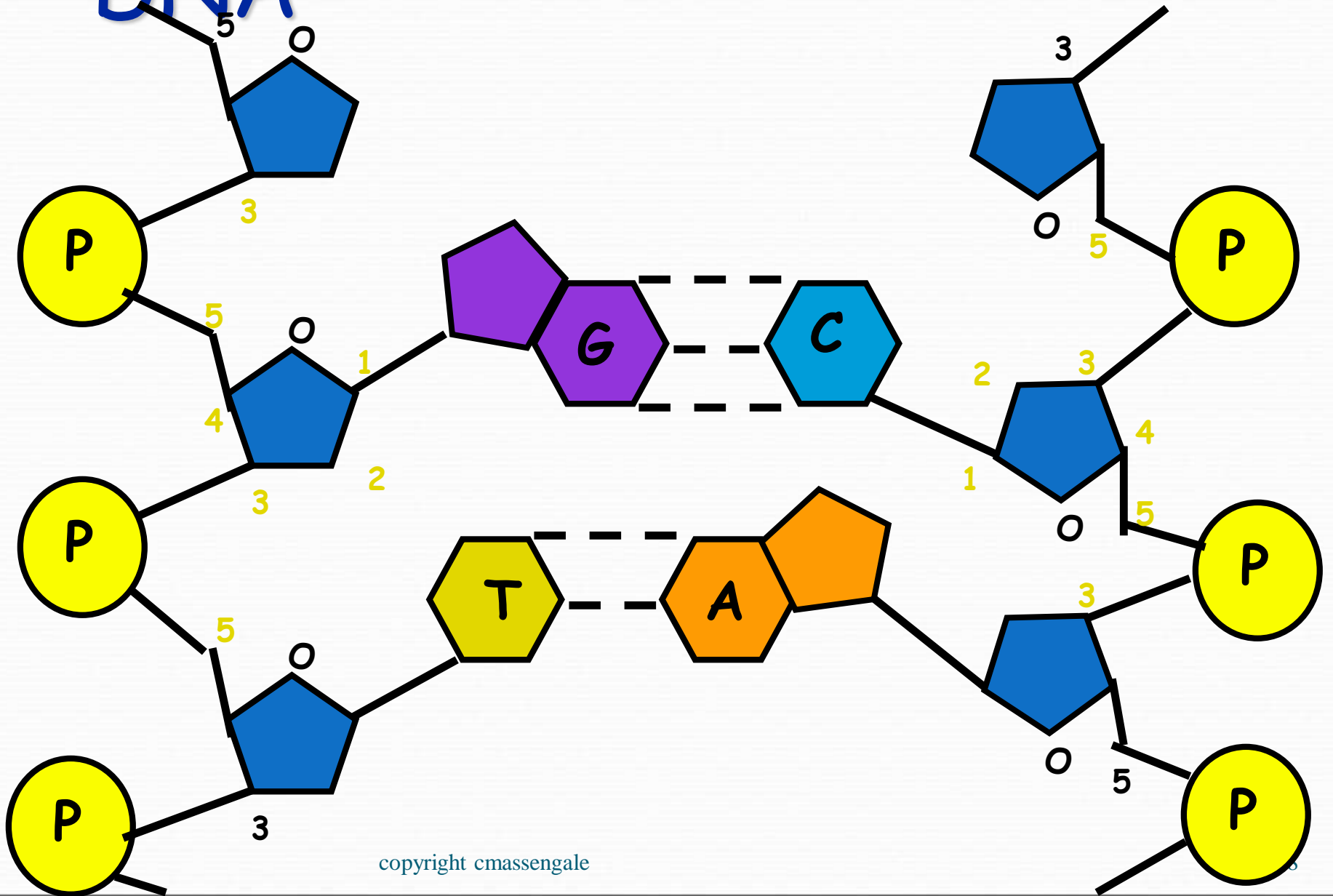


# Pentose Sugar

- Carbons are numbered clockwise 1' to 5'

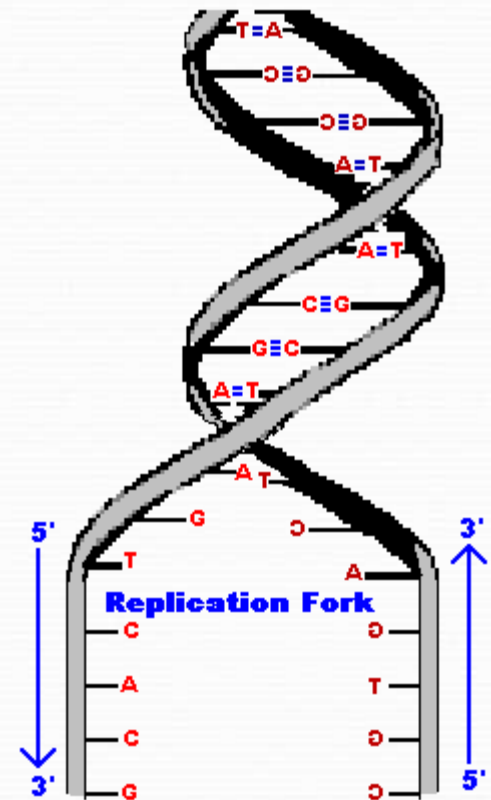


# DNA



# Antiparallel Strands

- One strand of DNA goes from 5' to 3' (sugars)
- The other strand is **opposite in direction** going 3' to 5' (sugars)

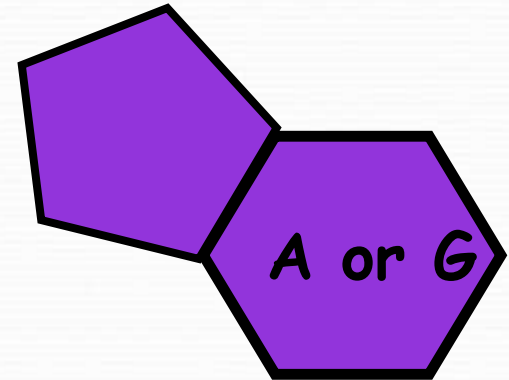


# Nitrogenous Bases

- Double ring **PURINES**

Adenine (A)

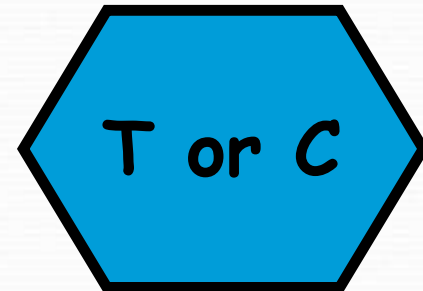
Guanine (G)



- Single ring **PYRIMIDINES**

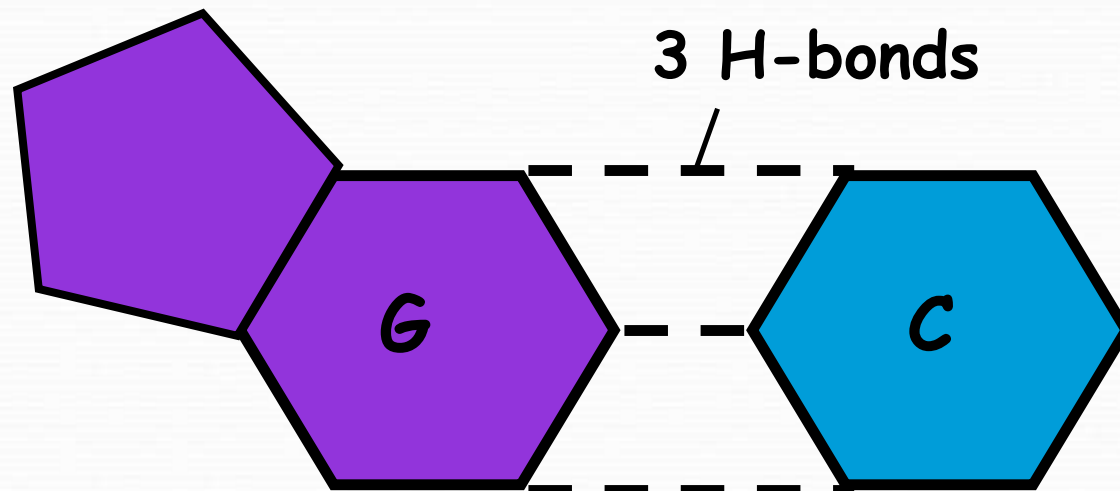
Thymine (T)

Cytosine (C)

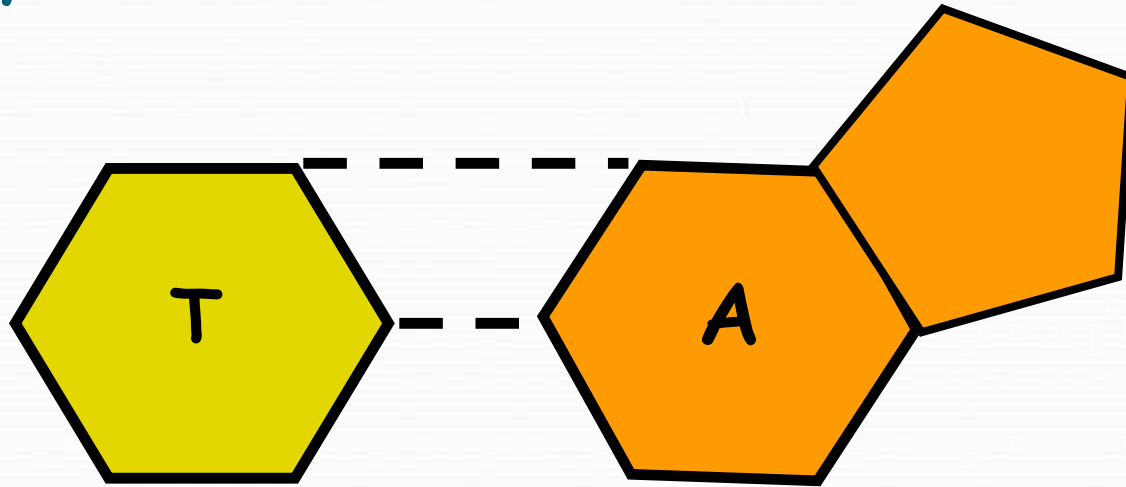


# Base-Pairings

- **Purines** only pair with **Pyrimidines**
- **Three** hydrogen bonds required to bond **Guanine** & **Cytosine**



- **Two** hydrogen bonds are required to bond Adenine & Thymine



# Question:

- If there is 30% Adenine, how much Cytosine is present?

# Answer:

- There would be 20% Cytosine
- Adenine (30%) = Thymine (30%)
- Guanine (20%) = Cytosine (20%)
- Therefore, 60% A-T and 40% C-G



# DNA Replication

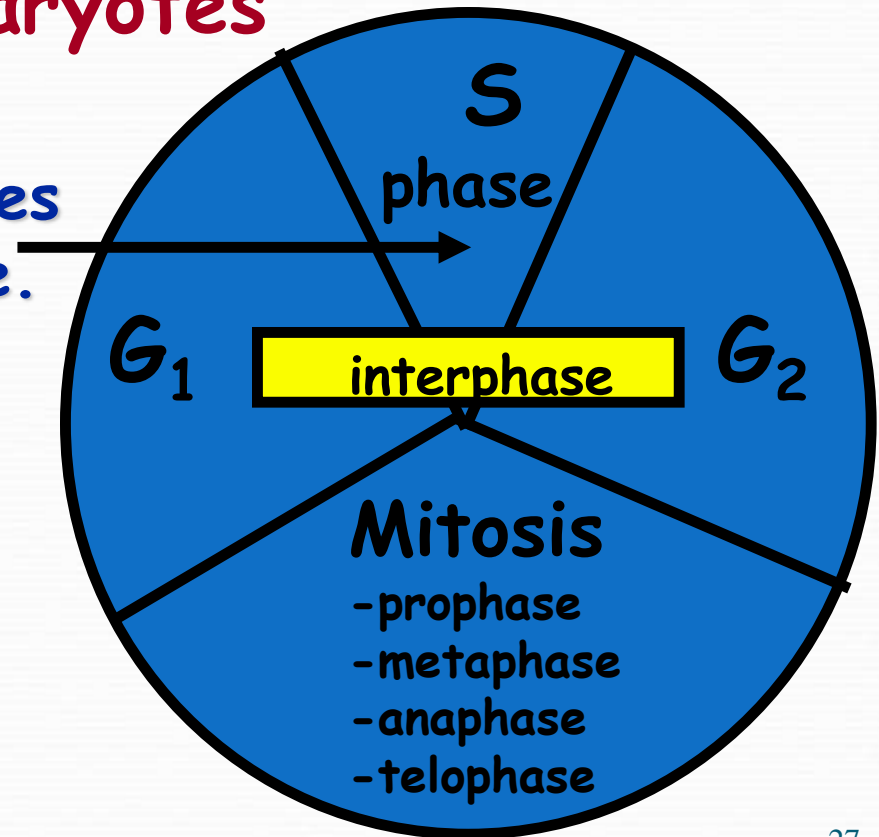
# Replication Facts

- 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

# Synthesis Phase (S phase)

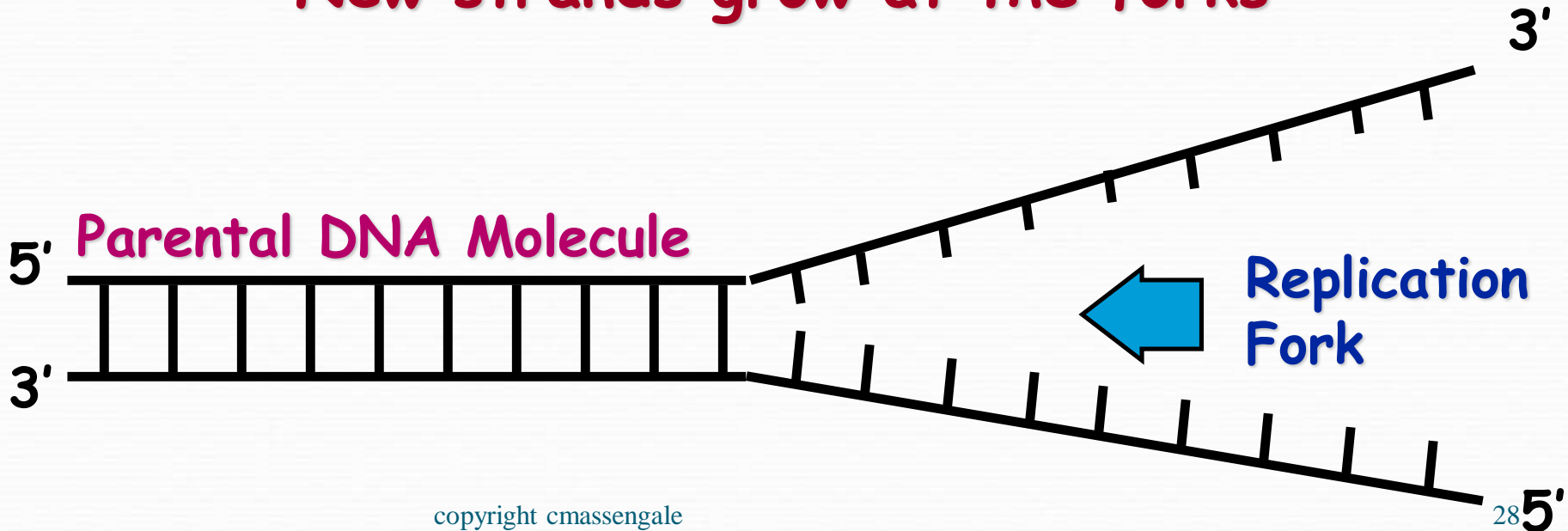
- S phase during **interphase** of the cell cycle
- **Nucleus of eukaryotes**

DNA replication takes place in the S phase.



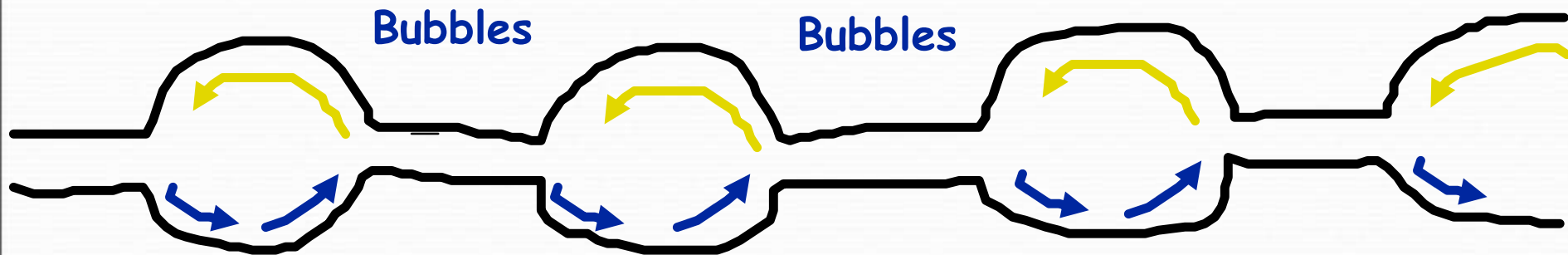
# DNA Replication

- Begins at **Origins of Replication**
- Two strands open forming **Replication Forks (Y-shaped region)**
- **New strands grow at the forks**



# DNA Replication

- As the 2 DNA strands open at the origin, **Replication Bubbles** form
- **Prokaryotes** (bacteria) have a **single** bubble
- **Eukaryotic** chromosomes have **MANY** bubbles

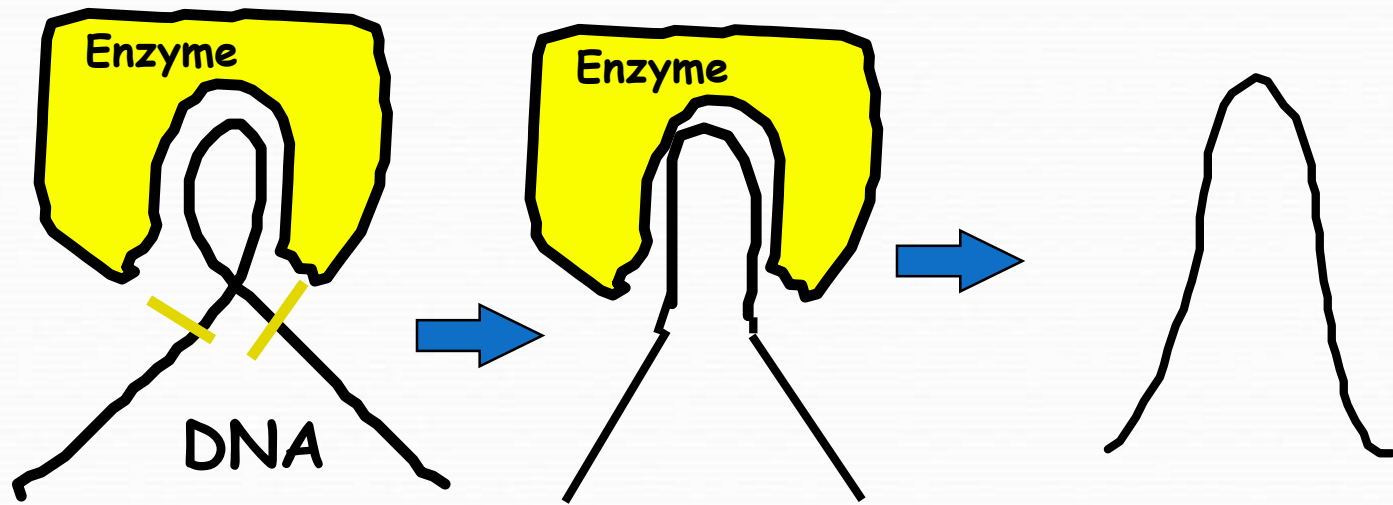


# DNA Replication

- 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**

# DNA Replication

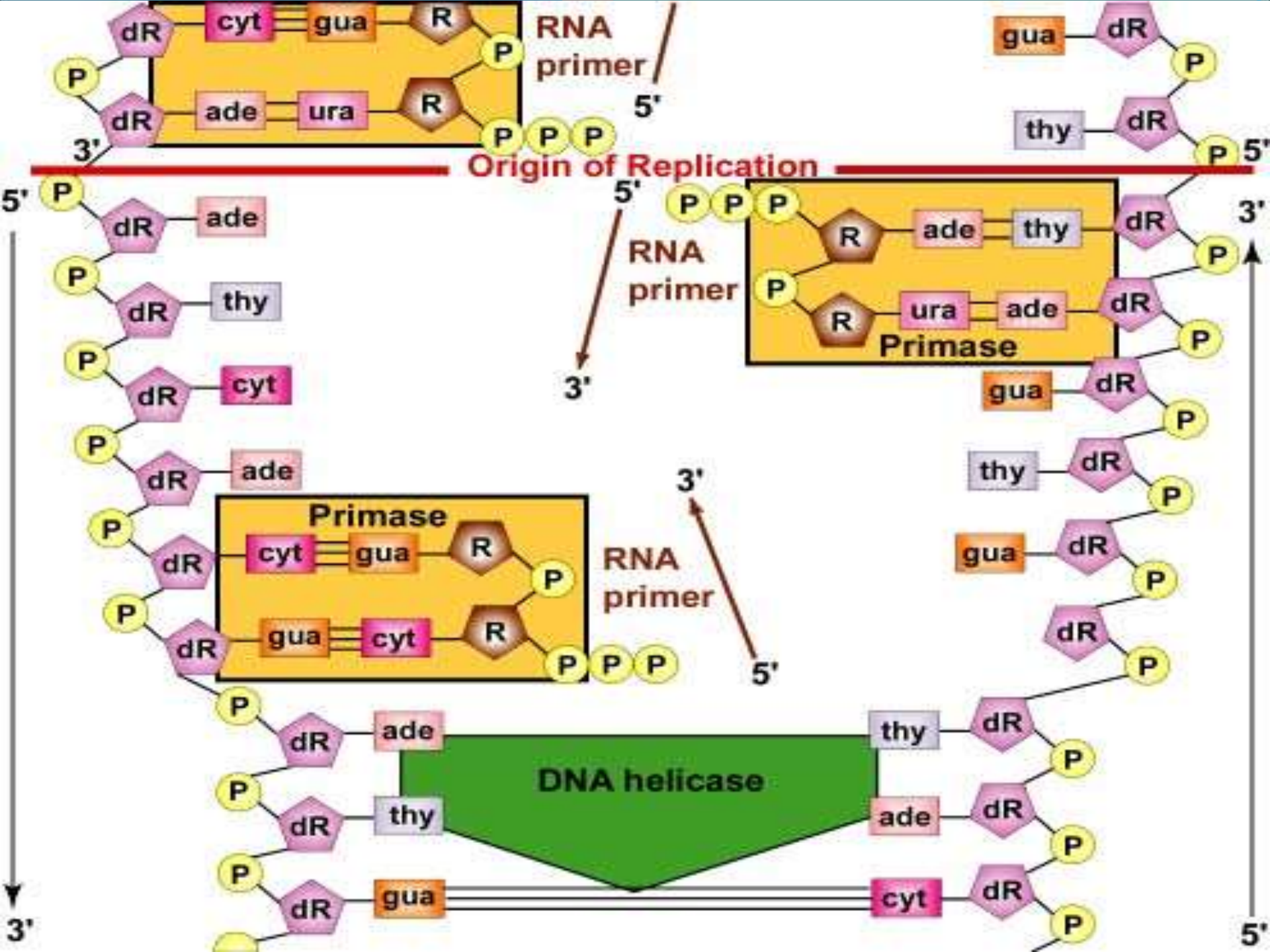
- Enzyme **Topoisomerase** attaches to the 2 forks of the bubble to **relieve stress** on the DNA molecule as it separates



# DNA Replication

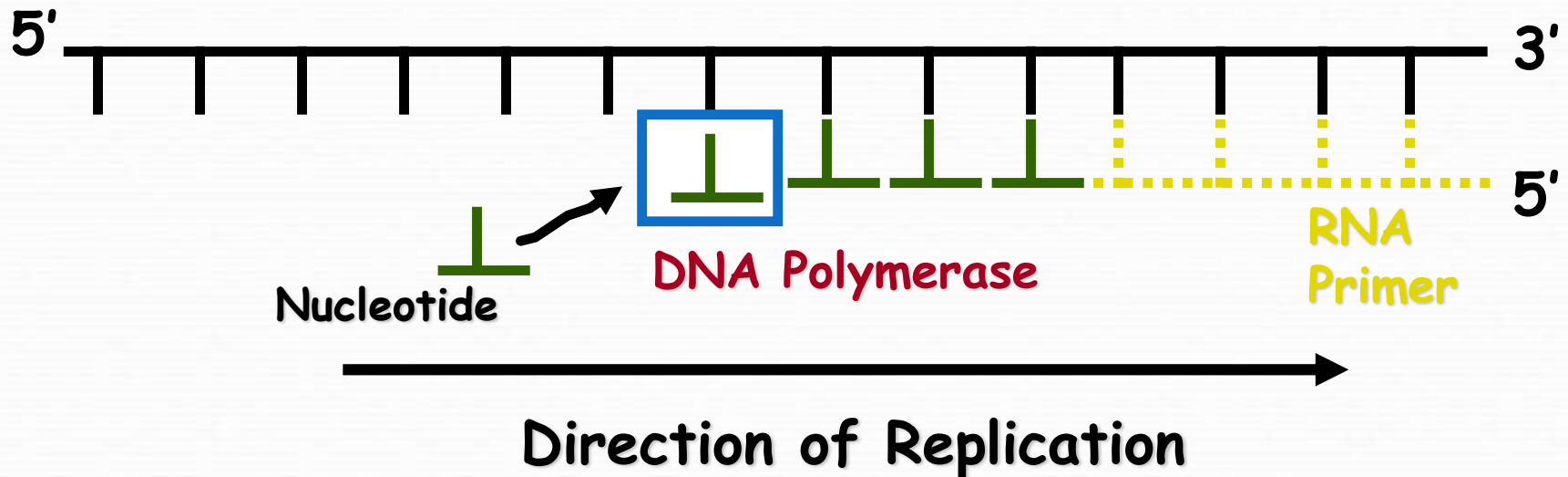
- Before new DNA strands can form, there must be **RNA primers** present to start the addition of new nucleotides
- **Primase** is the enzyme that synthesizes the RNA Primer
- **DNA polymerase** can then add the new nucleotides





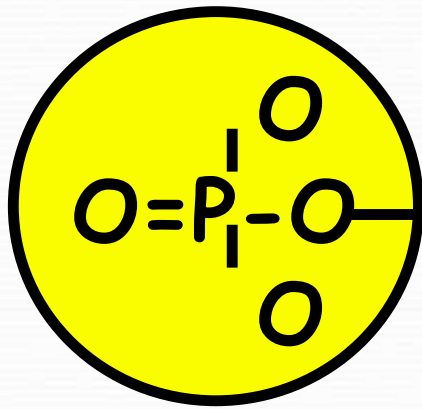
# DNA Replication

- 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



# Remember HOW the Carbons Are Numbered!

Phosphate Group



<sup>5</sup>CH<sub>2</sub>

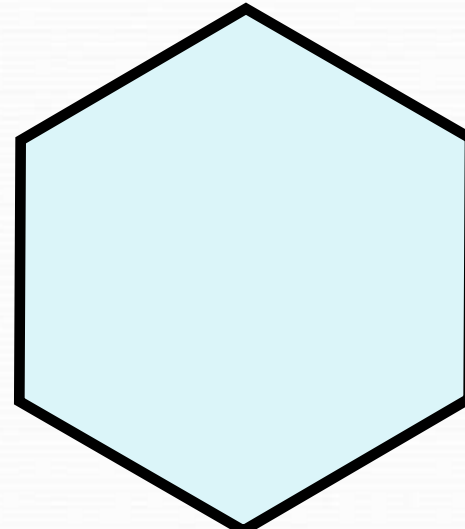
C<sup>4</sup>

Sugar  
(deoxyribose)

C<sup>3</sup>

C<sup>2</sup>

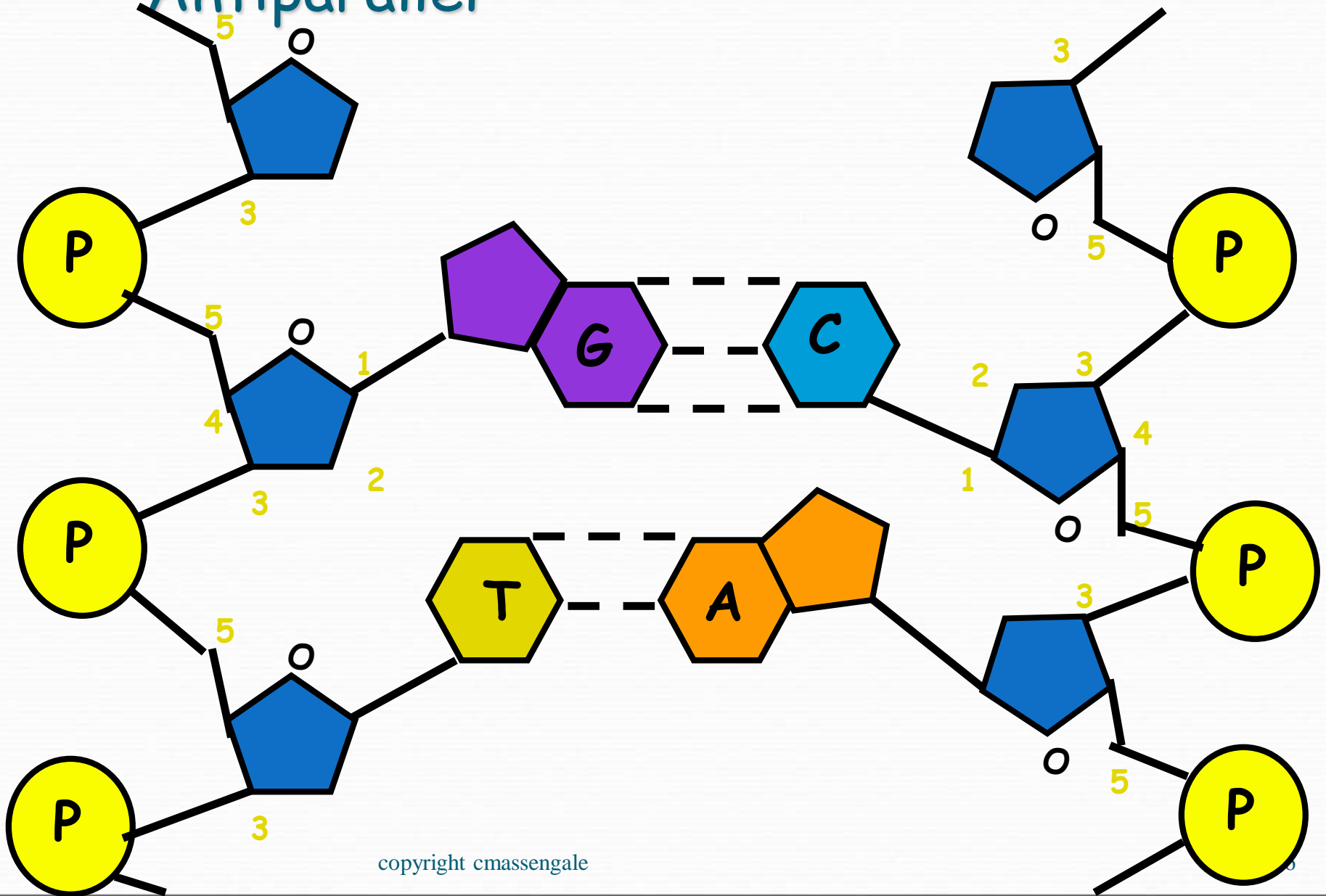
C<sup>1</sup>



N

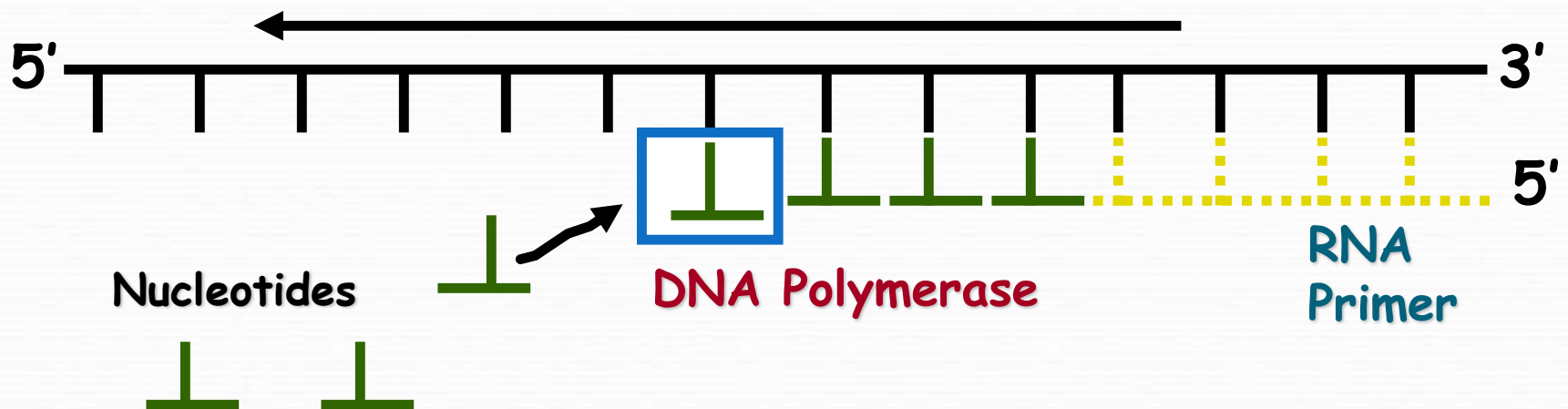
Nitrogenous base  
(A, G, C, or T)

# Remember the Strands are Antiparallel



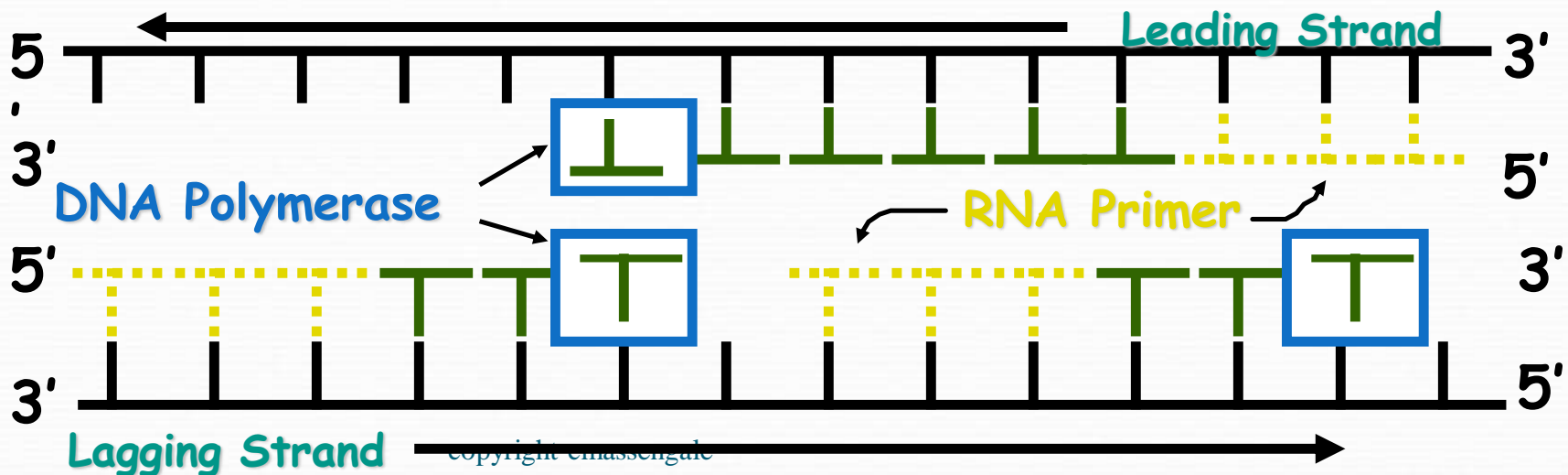
# Synthesis of the New DNA Strands

- The **Leading Strand** is synthesized as a single strand from the **point of origin** toward the opening replication fork



# Synthesis of the New DNA Strands

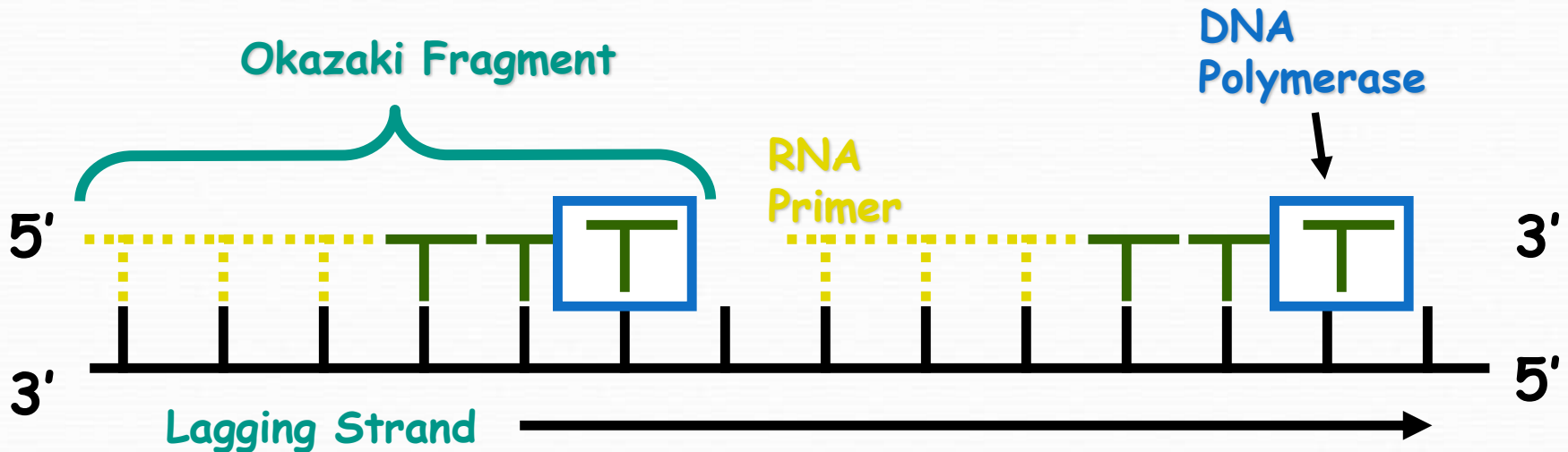
- The **Lagging Strand** is synthesized discontinuously **against** overall direction of replication
- This strand is made in **MANY short segments** It is replicated from the replication fork toward the origin





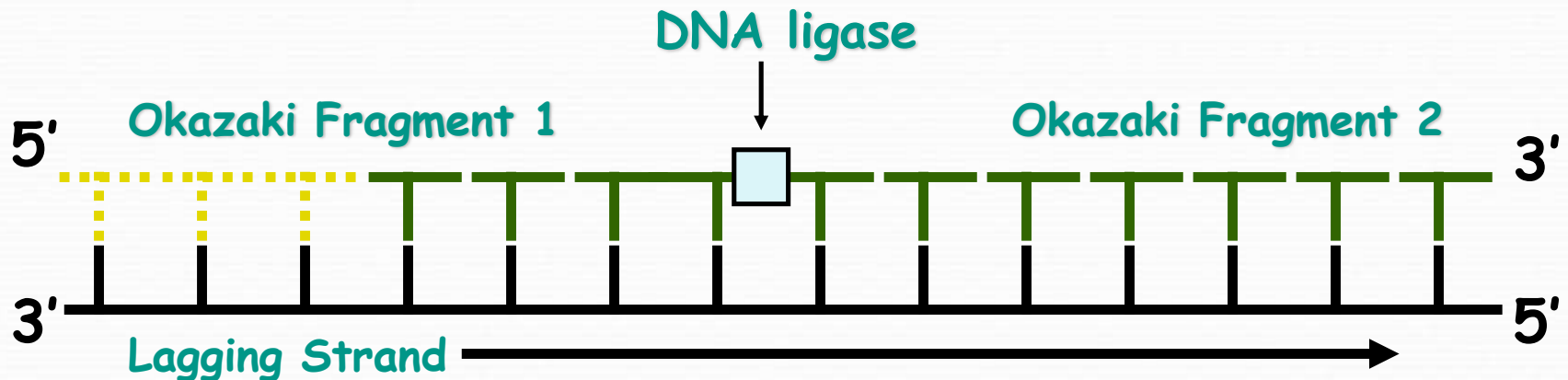
# Lagging Strand Segments

- **Okazaki Fragments** - series of short segments on the lagging strand
- Must be joined together by an **enzyme**



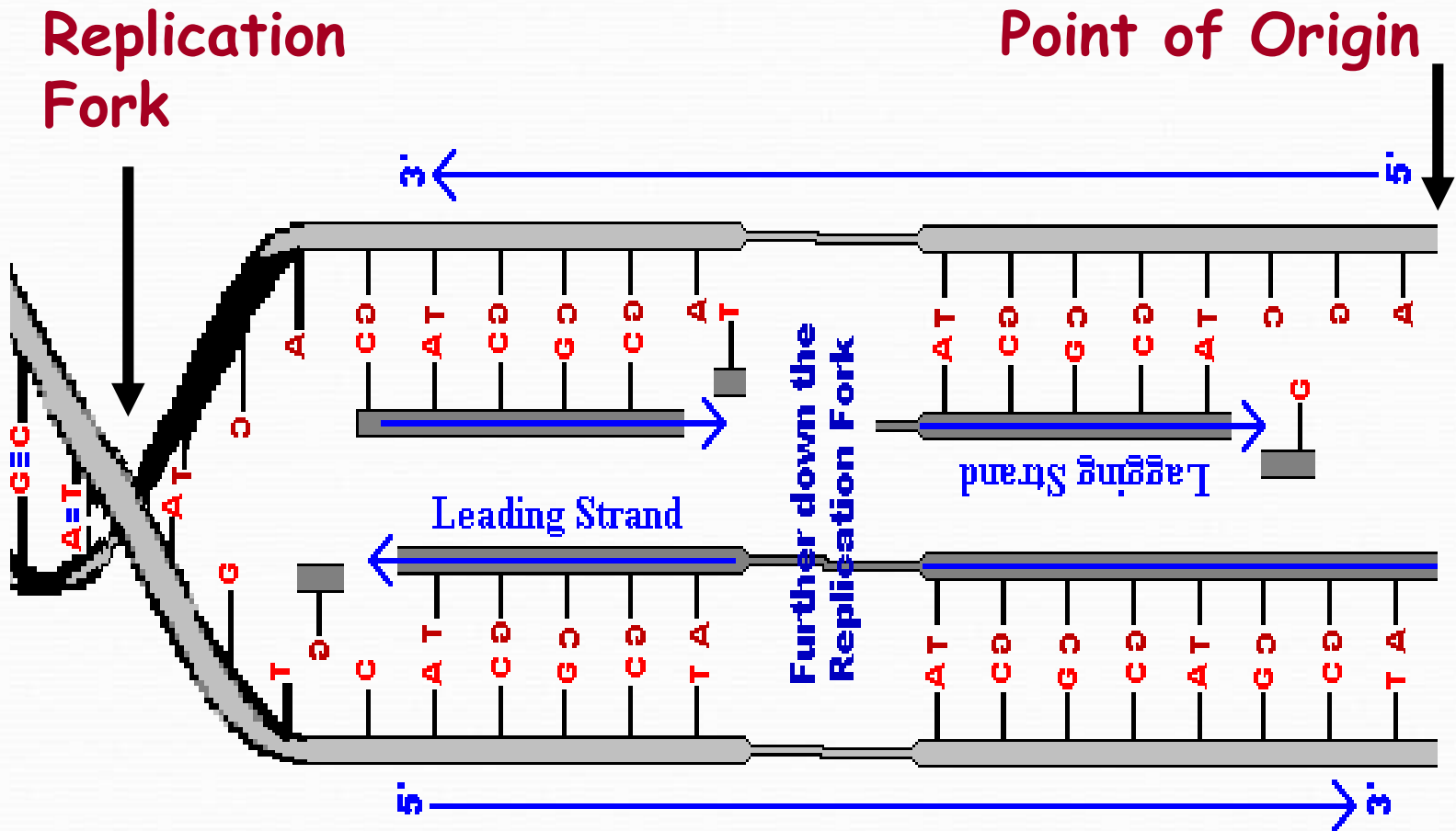
# Joining of Okazaki Fragments

- The enzyme **Ligase** joins the Okazaki fragments together to make one strand





# Replication of Strands

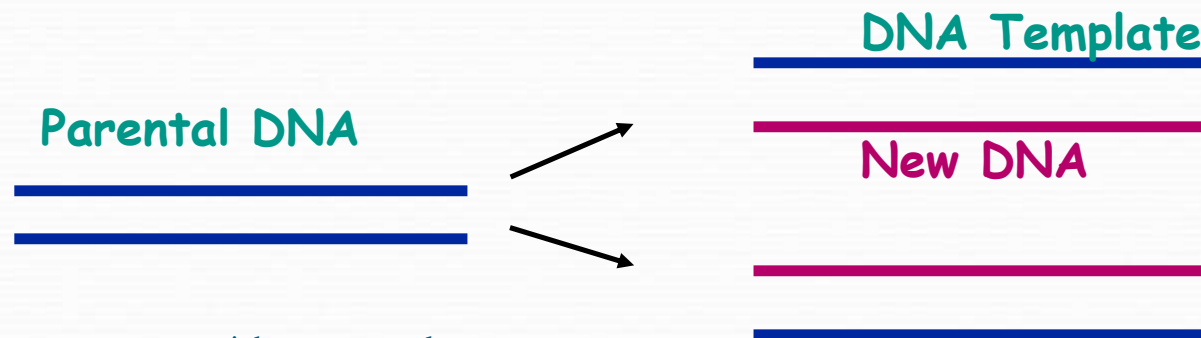


# Proofreading New DNA

- DNA polymerase initially makes about **1 in 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

# Semiconservative Model of 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



# 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

# Question:

- What would be the complementary DNA strand for the following DNA sequence?

**DNA 5'-CGTATG-3'**

**Answer:**

**DNA 5'-CGTATG-3'**

**DNA 3'-GCATAC-5'**

Thank  
You