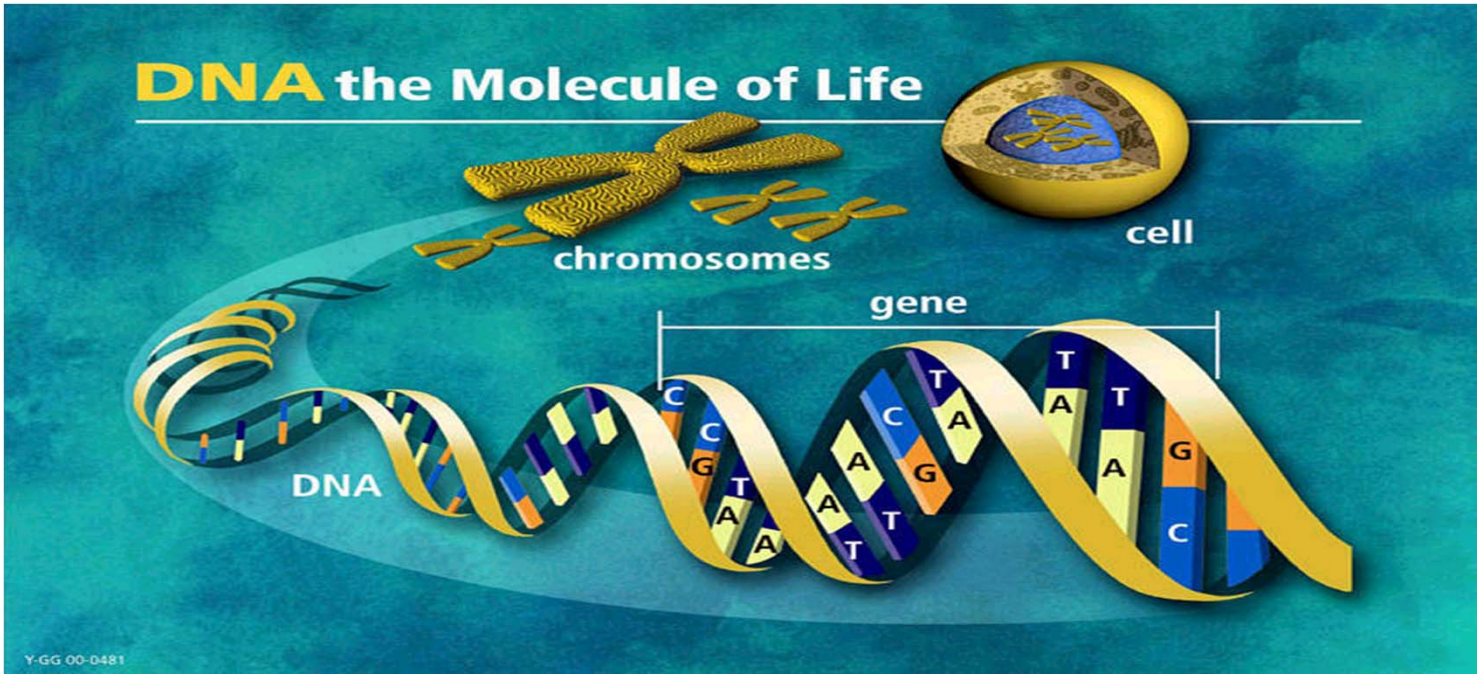
## "Biology in Computational terms"-An Attempt.




A Cell-an Autonomous work station

⬇

Nucleus -CPU of the cell

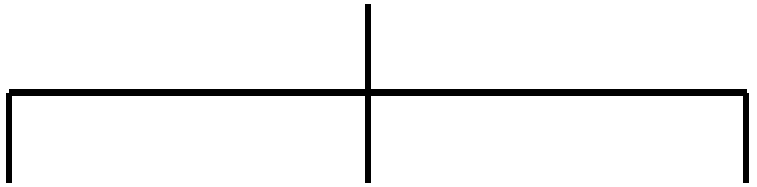
⬇

DNA-Silicon Chip of the cell

# DNA structure

**Monomer:polymer = Nucleotides:DNA**

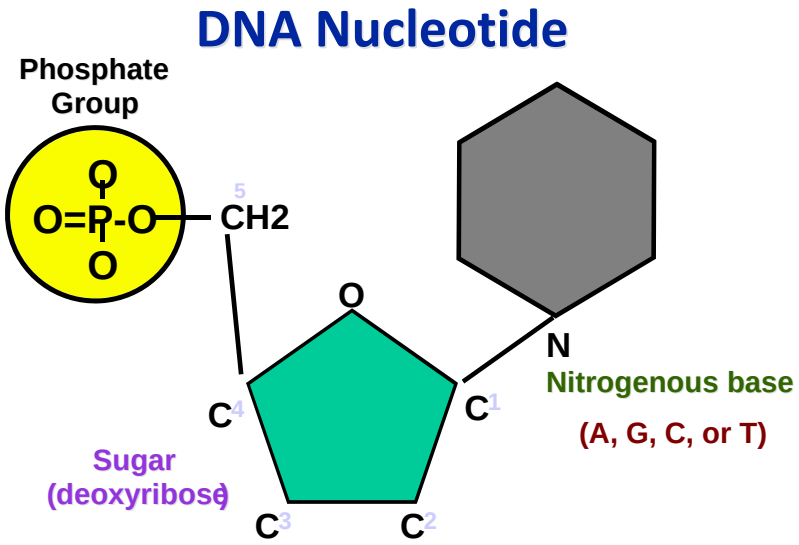
**NUCLEOTIDES**




**Information part**

**Scaffold to hold the base**

**Connector to link 2 nucleotides**




**Base + sugar = Nucleosides**

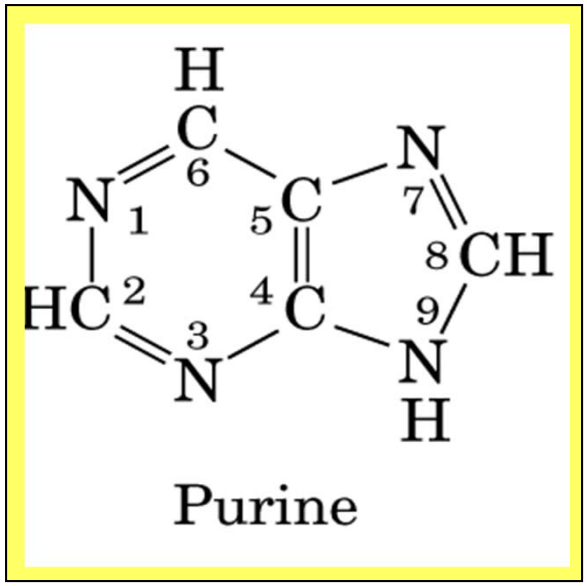
**Nucleoside + Phosphate(s) = Nucleotides**

# Bases present in nucleic acids

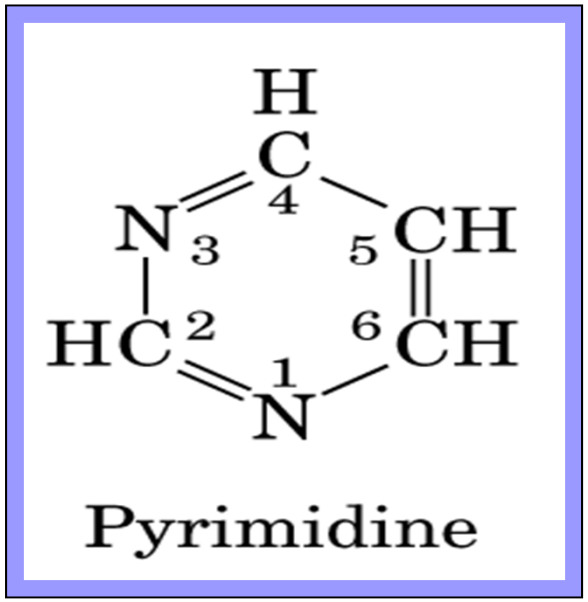
- Bases- Nitrogenous molecules- heterocyclic amine bases
- 2 classes of bases

PURINES VS PYRIMIDINE

Fused double ring structure Vs single ring structure

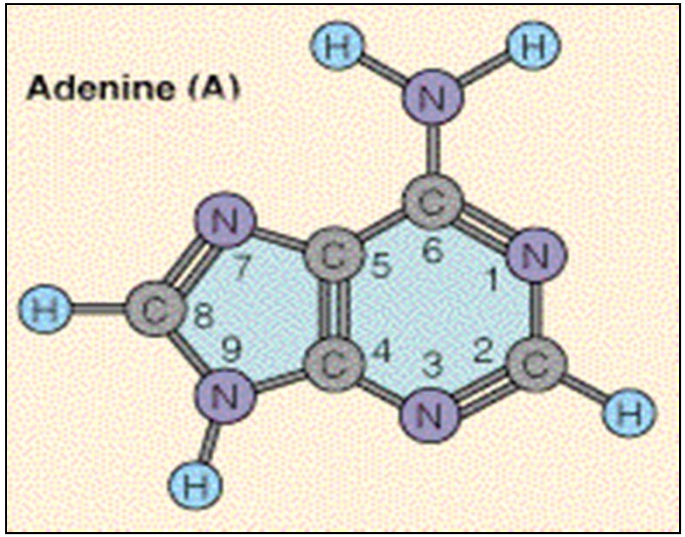


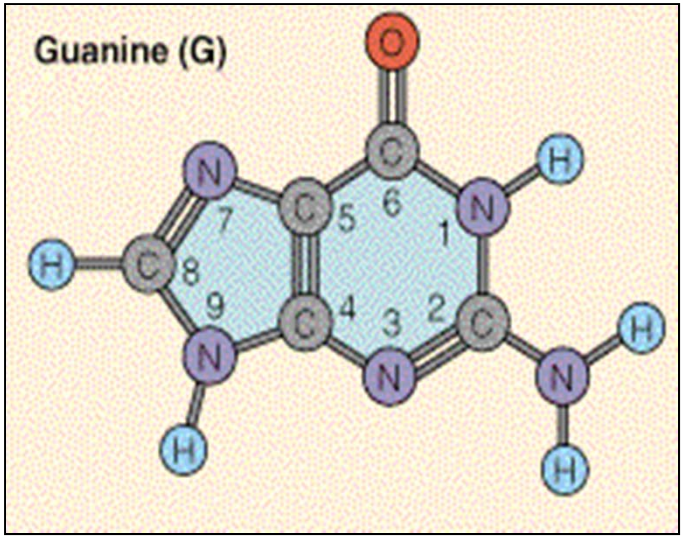
Purine



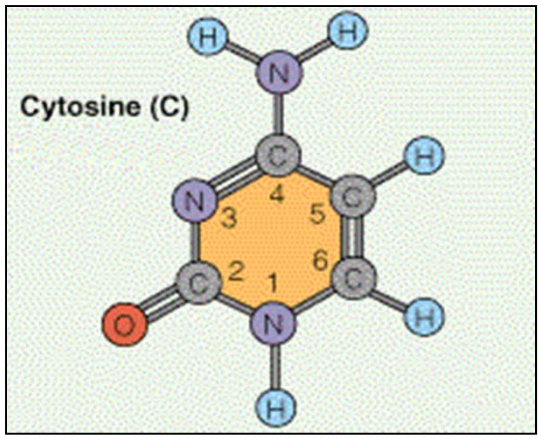
Pyrimidine

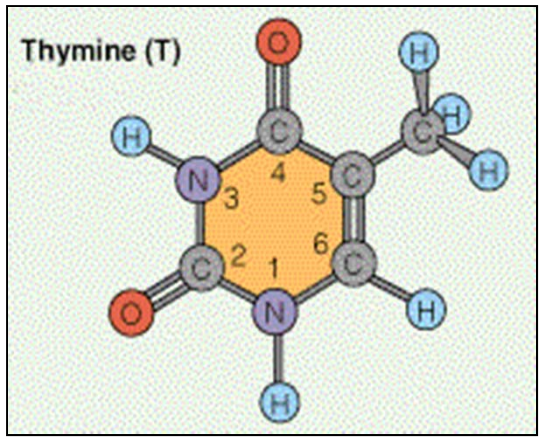
# Purines

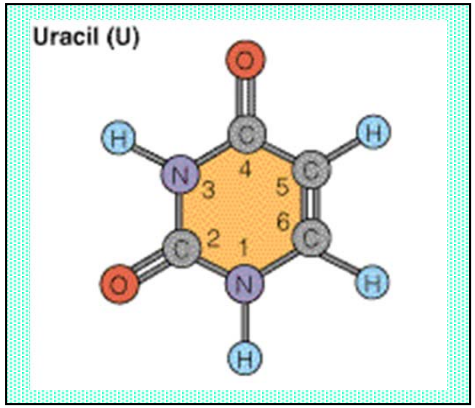

Adenine (A)
H
H
N
C
N
C
N
H
C
8
7
5
6
1
9
C
4
3
2
C
N
N
H
H


Guanine (G)
O
C
N
H
N
C
C
H
C
8
7
5
6
1
9
C
4
3
2
C
N
N
H
N
H
H
H

# Pyrimidines




Only in RNA

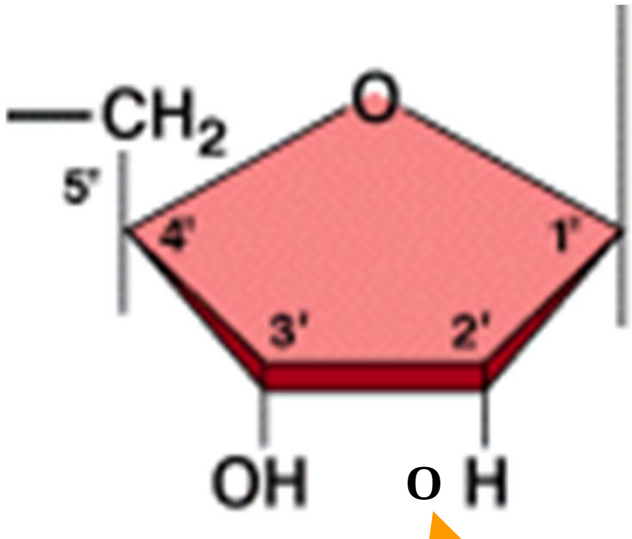
## Sugars present in nucleic acids.

## Pentose Sugars


five-carbon sugar

**deoxyribose**

Present in DNA



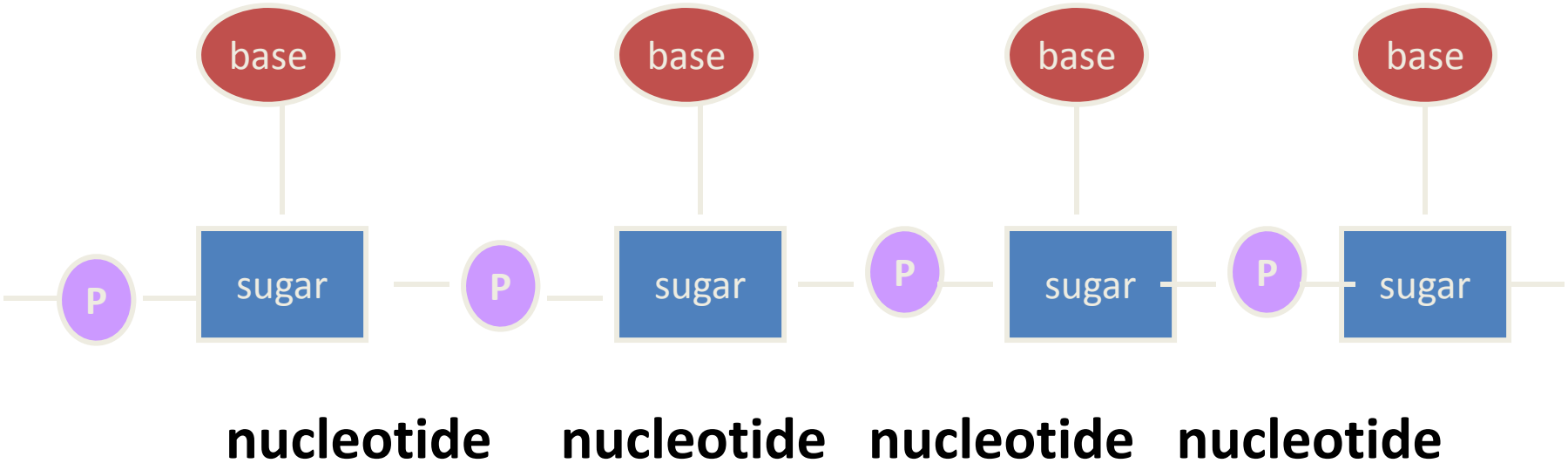

five-carbon sugar

**ribose**

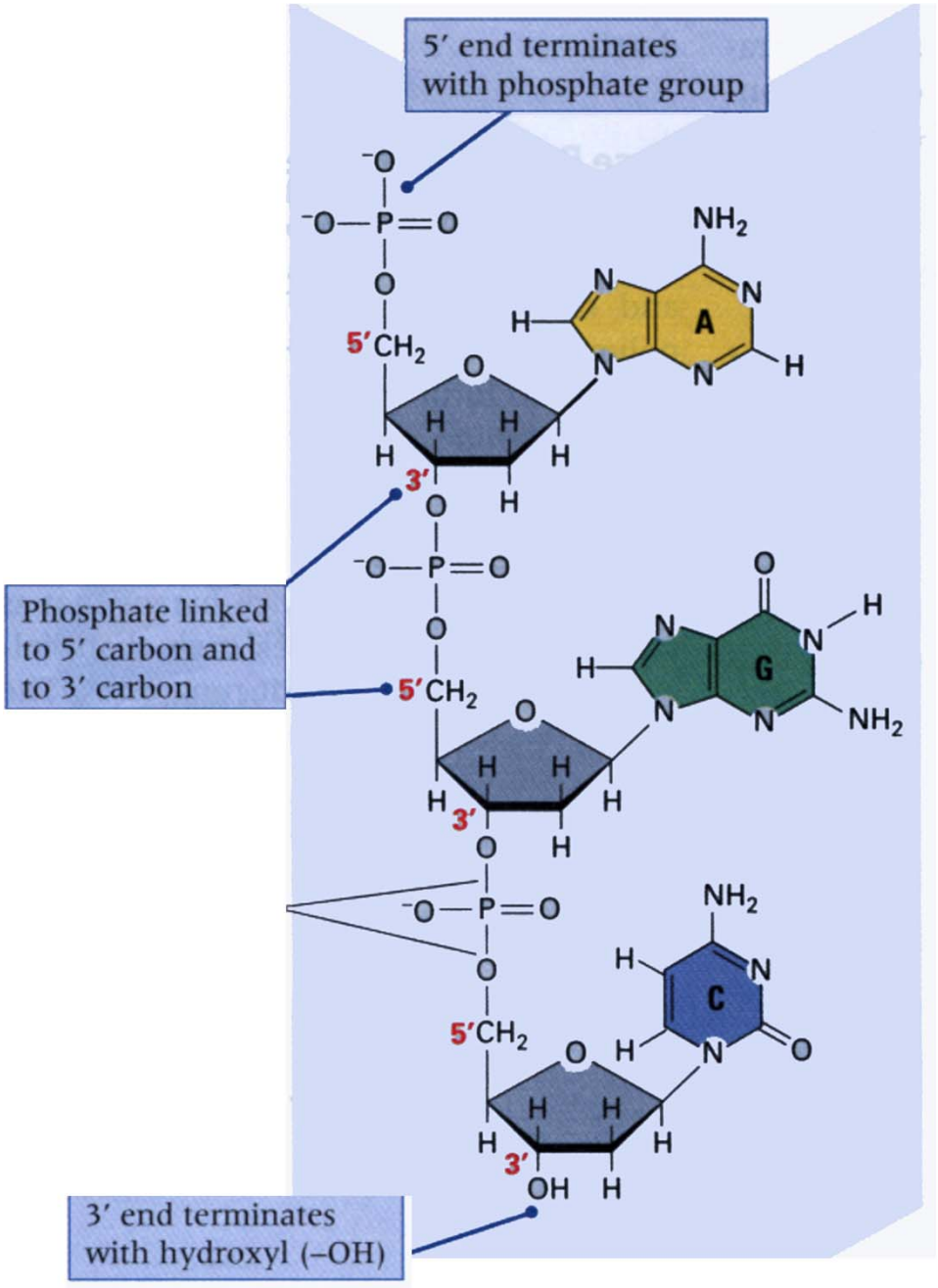
only difference

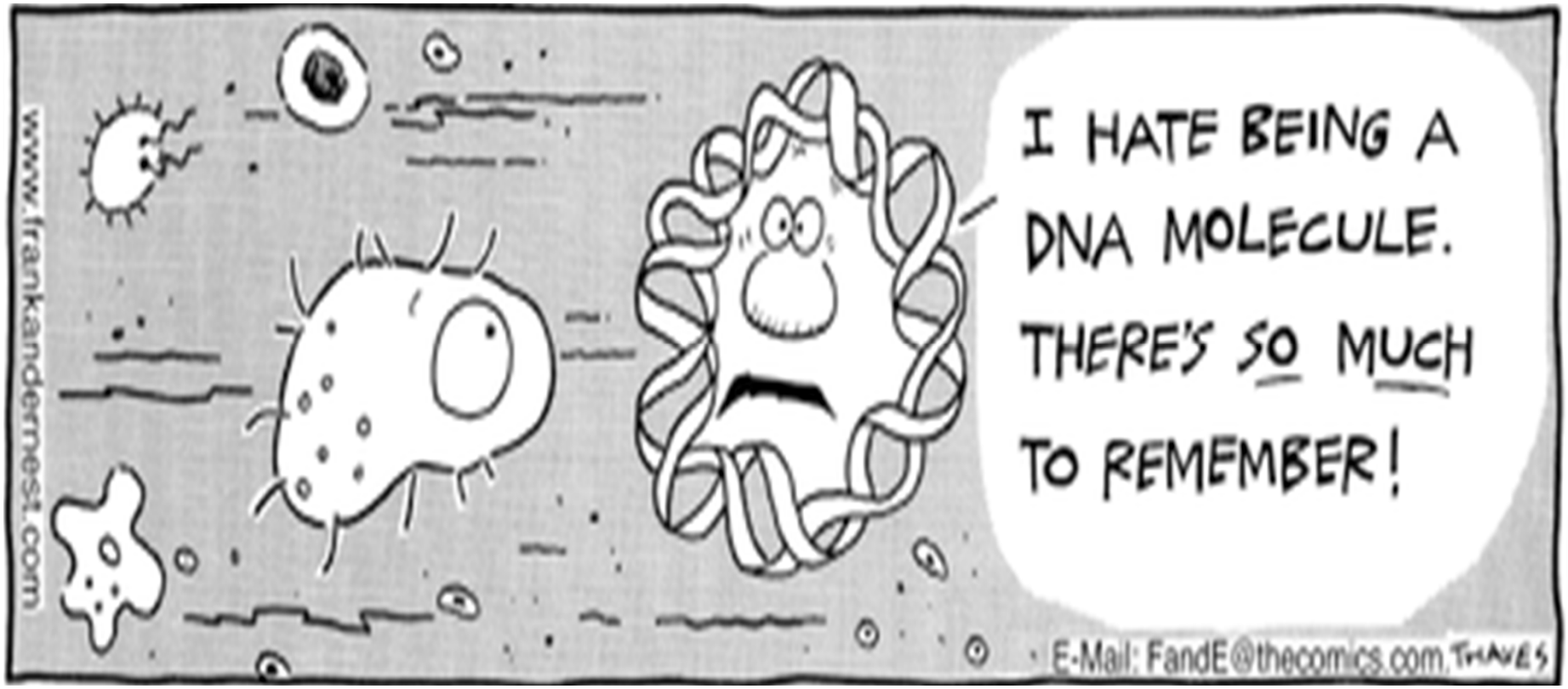
Present in RNA

# Linear array of nucleotides



## Concept of 5’end &3’end






Sequence of bases is the form in which genetic information is stored

- **Primary Structure of DNA**

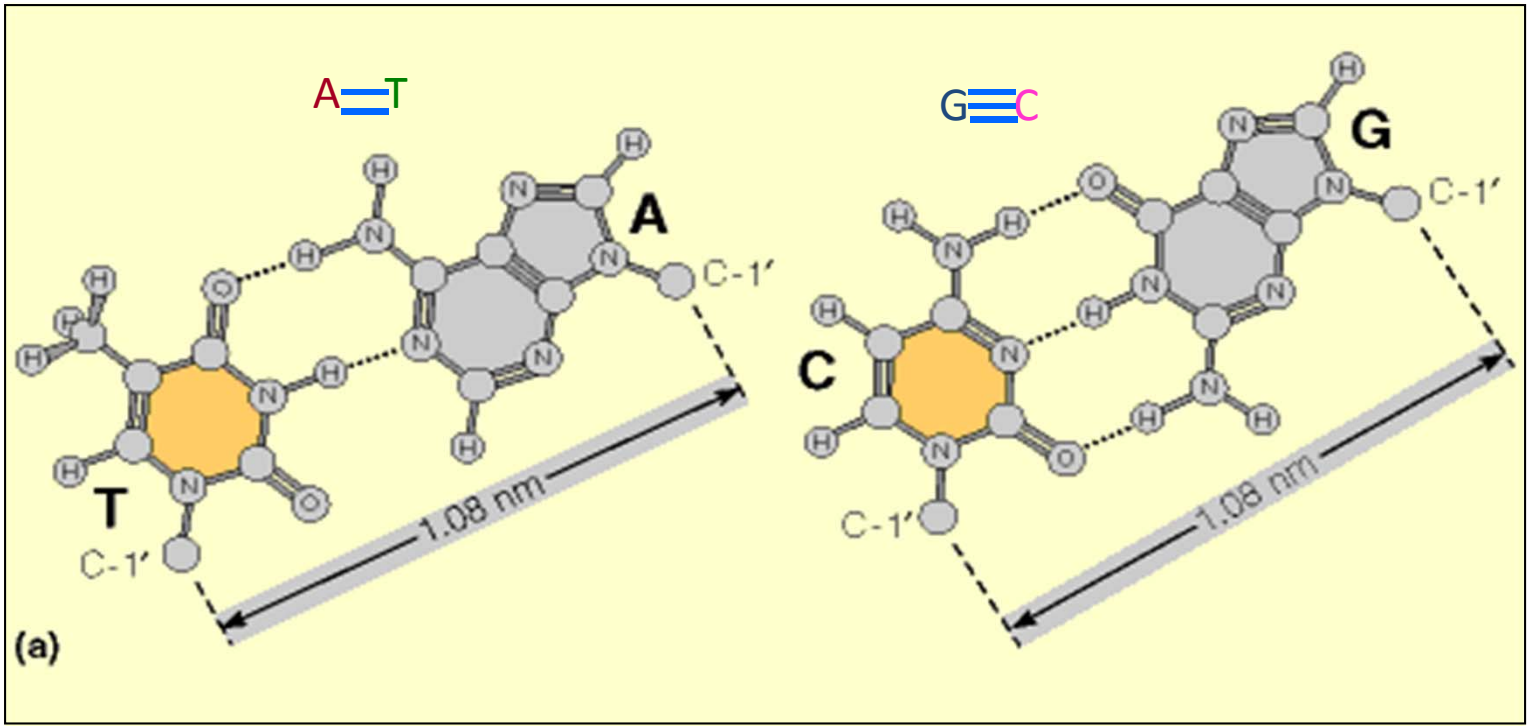


Frank & Ernest

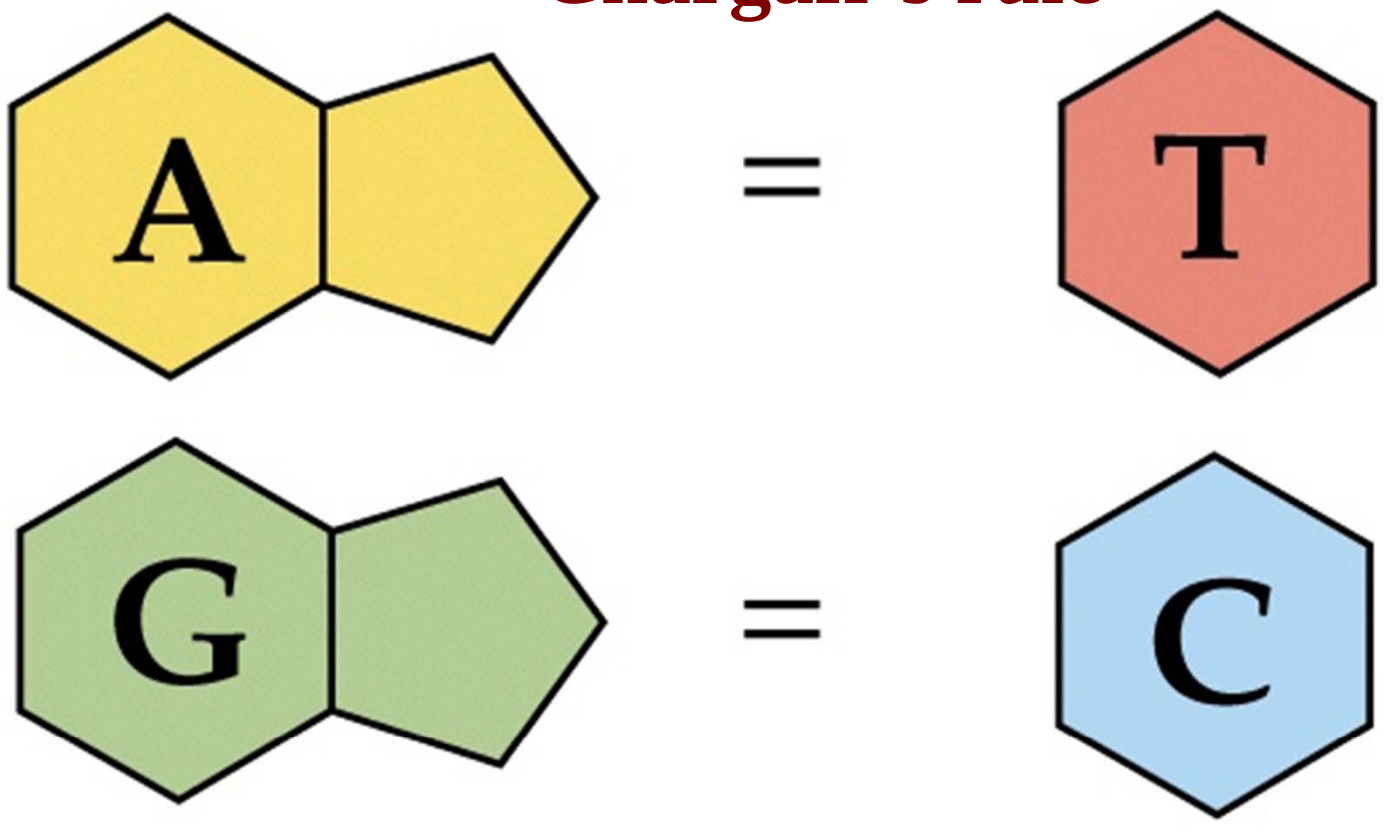
# Base pairing rules

- **Base Pairing by hydrogen bonds**
- **Base pairing is complementary: purine-pyrimidine**

Watson Crick Base Pairing



# Chargaff's rule

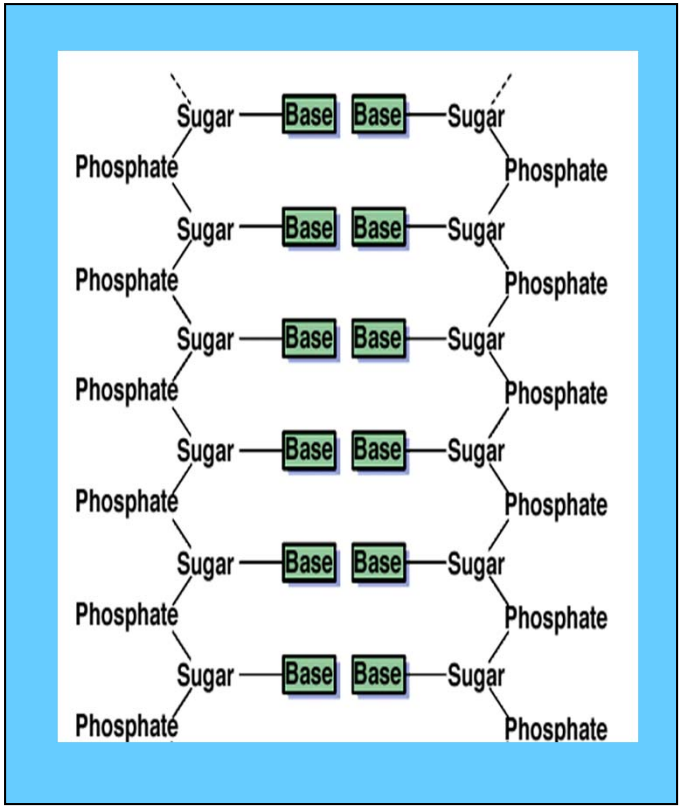



Purines = Pyrimidines

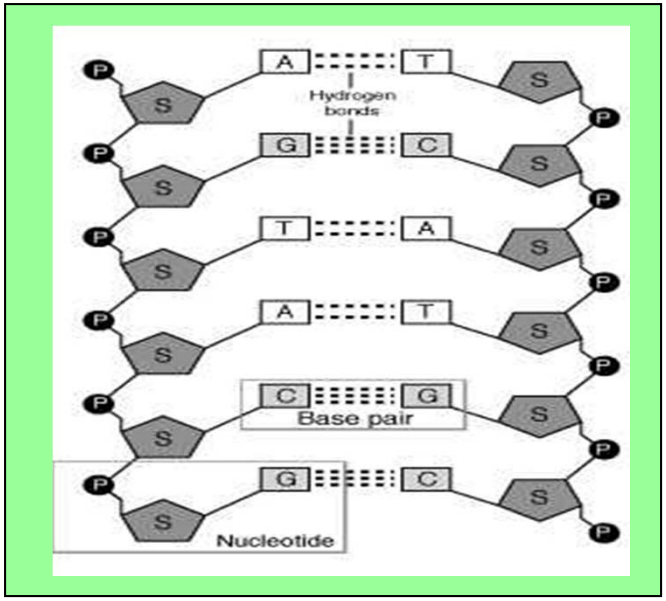
**Amount of purines (A + G) = amount of pyrimidines (C + T)**

# Secondary structure

- Double stranded structure
- Analogy of a ladder
- steps = bases
- rungs of the ladder = sugar phosphate backbone



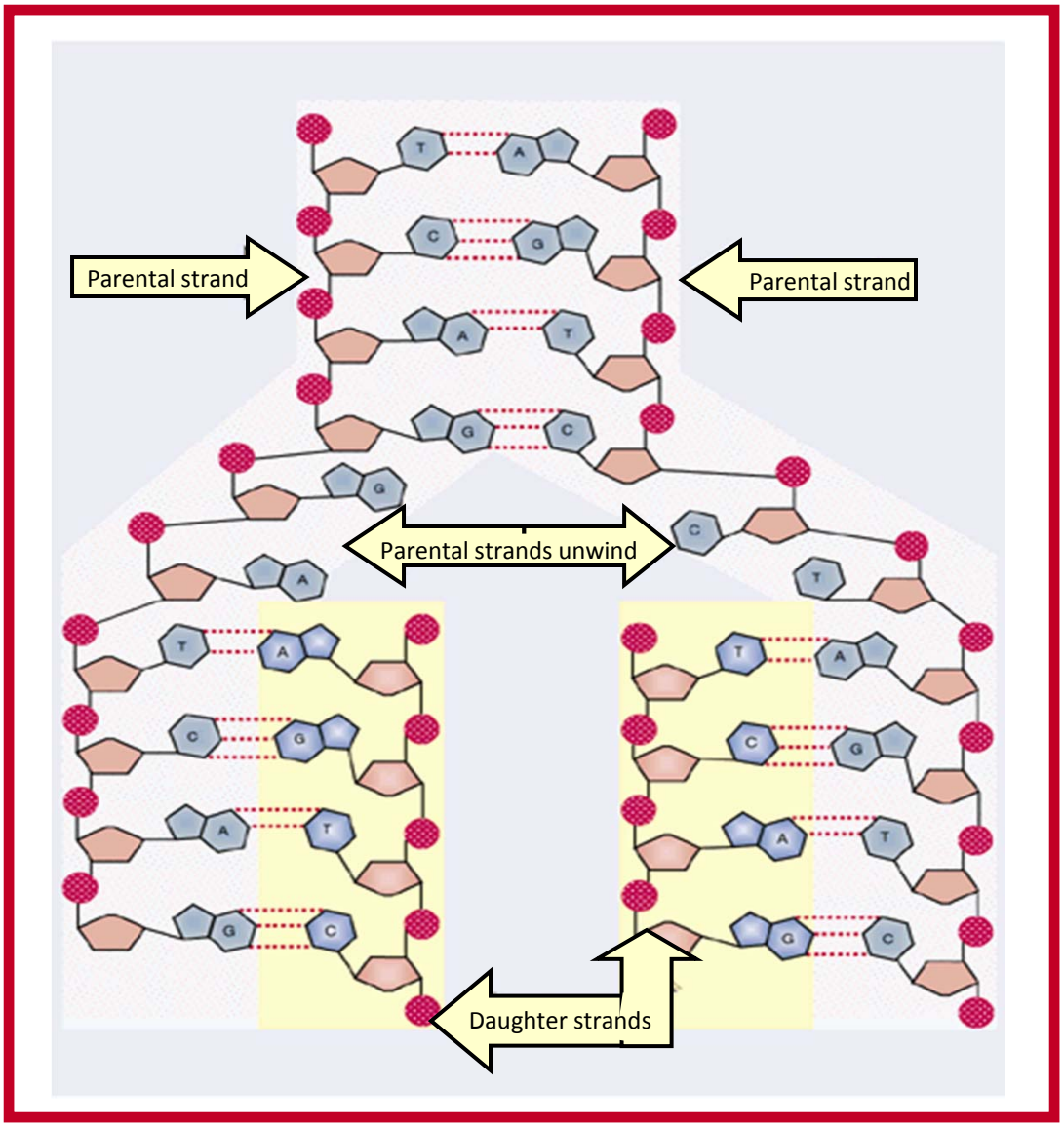

Anti-parallel Strands




Hydrophobic interaction
Hydrogen binding b/w bases

# DNA Replication

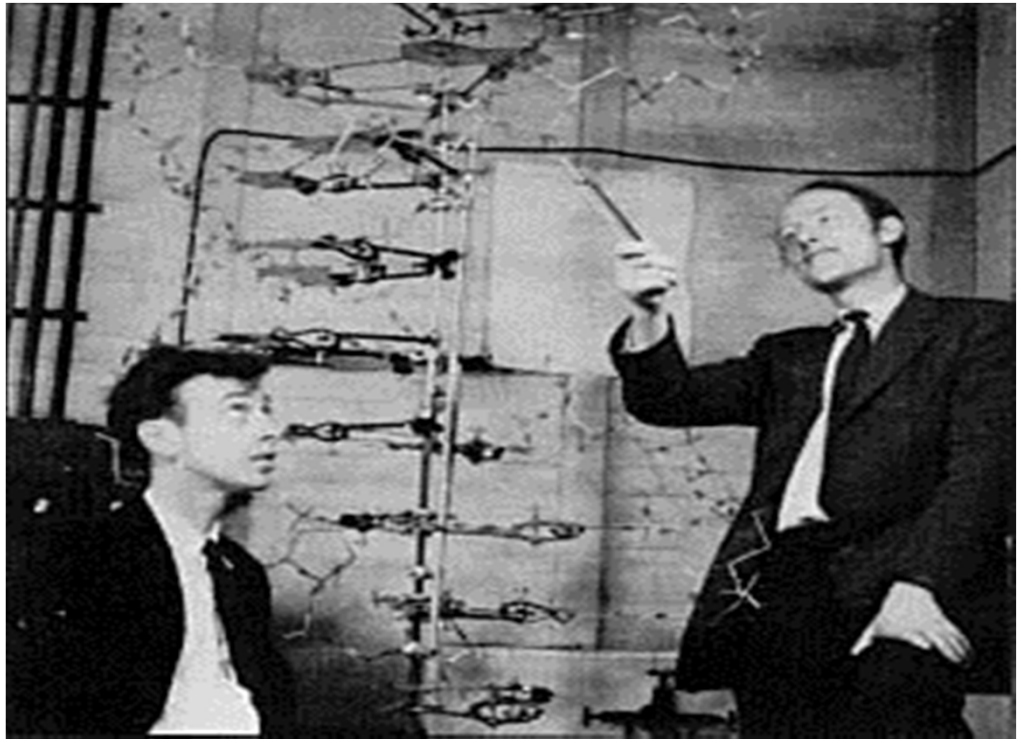
# Base pairing provides the mechanism for DNA replication



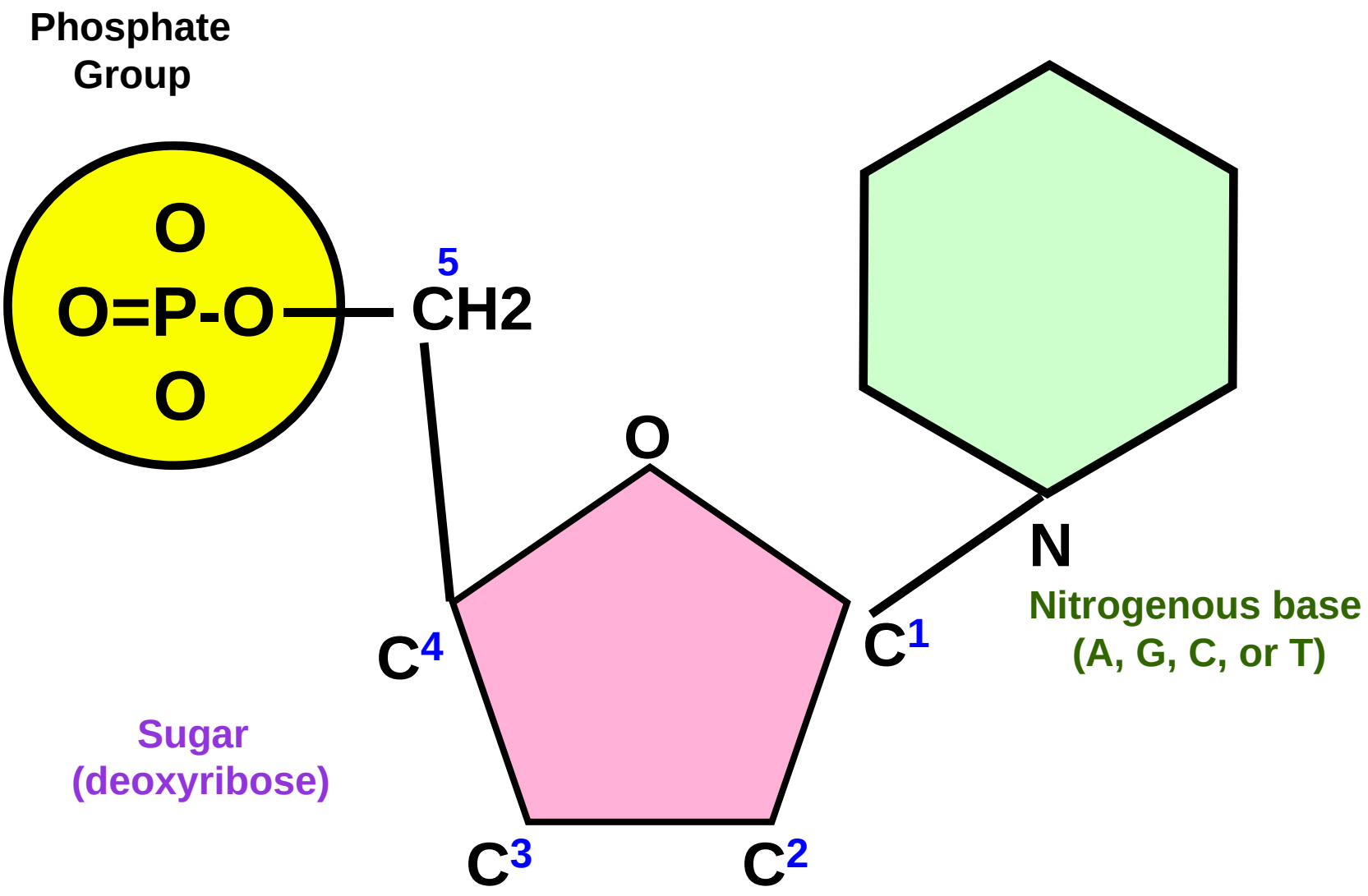
# DNA Replication

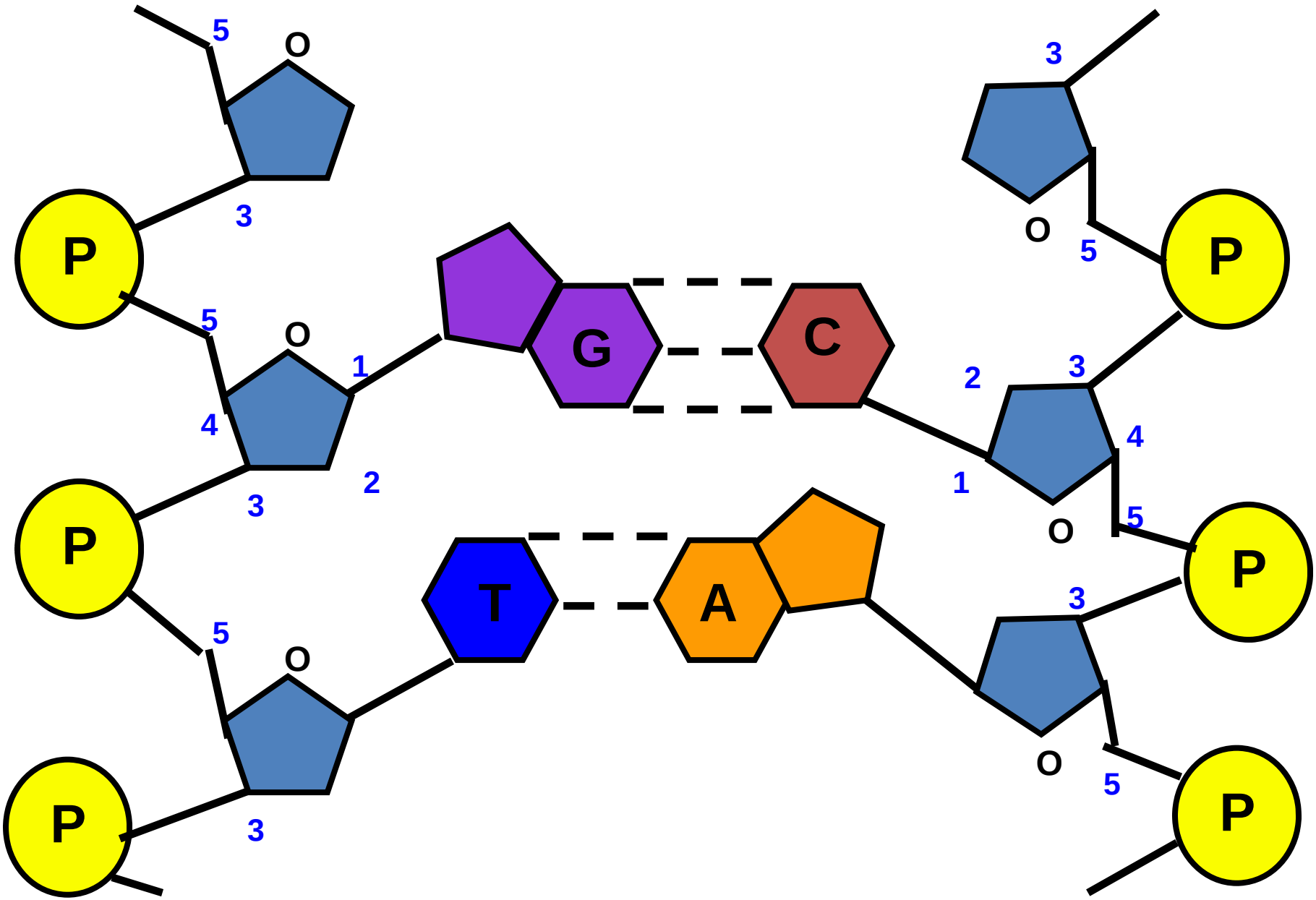
Nature (1953), 171:737

"It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material."

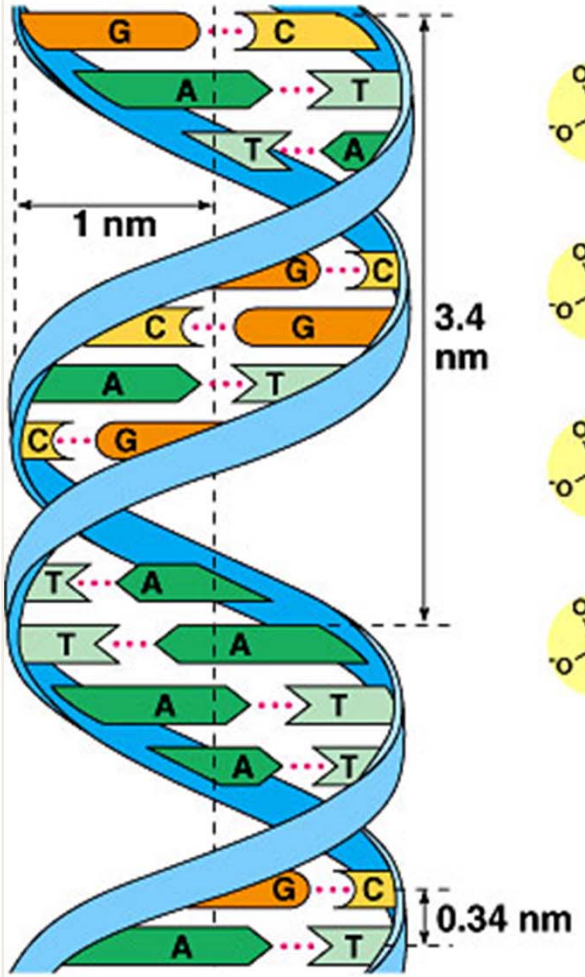


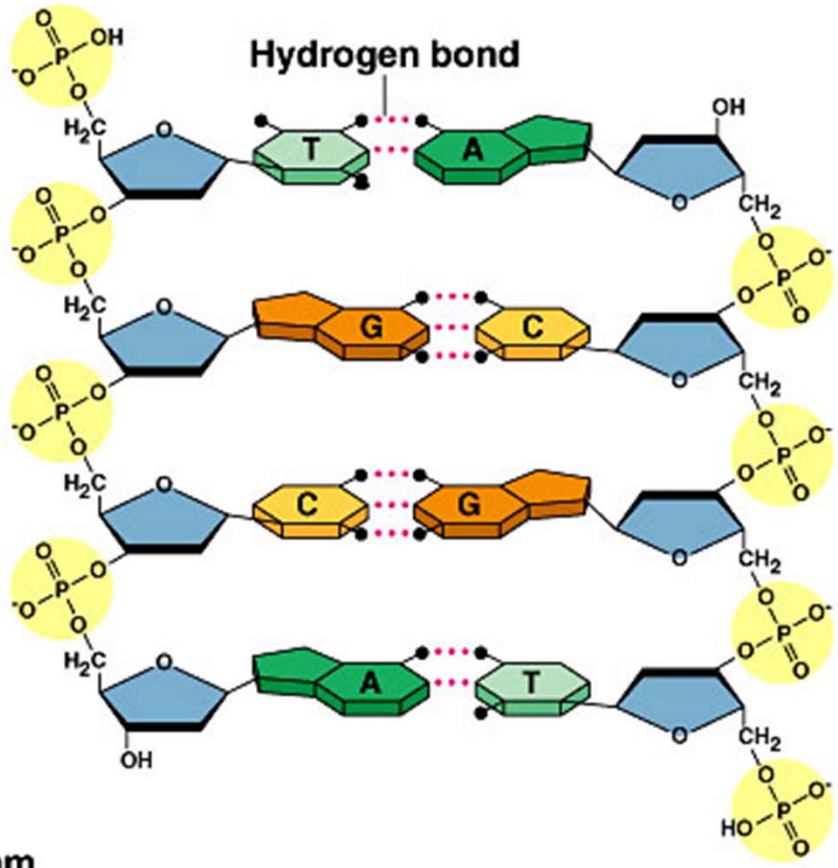
# Remember!!!!

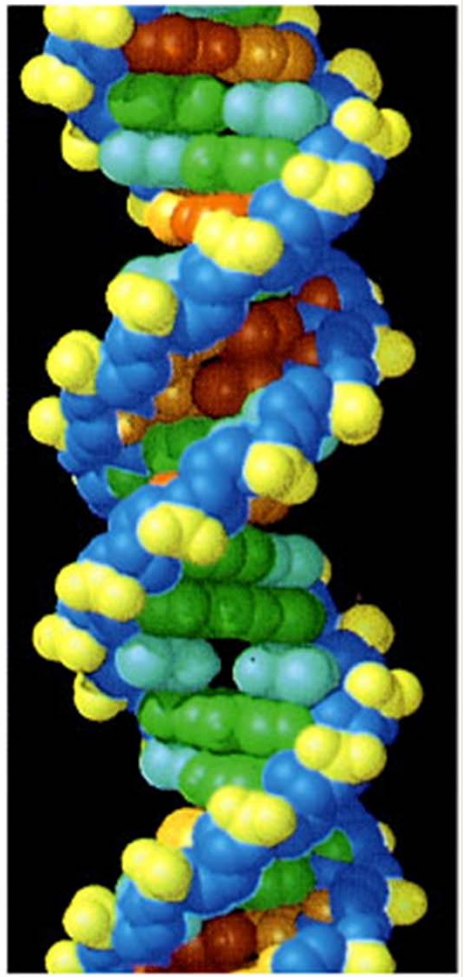

Phosphate Group
O
O=P-O
O
5
CH2
O
C4
C3
C2
C1
N
Nitrogenous base (A, G, C, or T)
Sugar (deoxyribose)


5
O
3
P
5
O
1
G
C
3
O
5
P
4
2
2
3
4
3
2
1
5
P
P
T
A
5
O
3
P
3
O
5
P

# Double helix structure



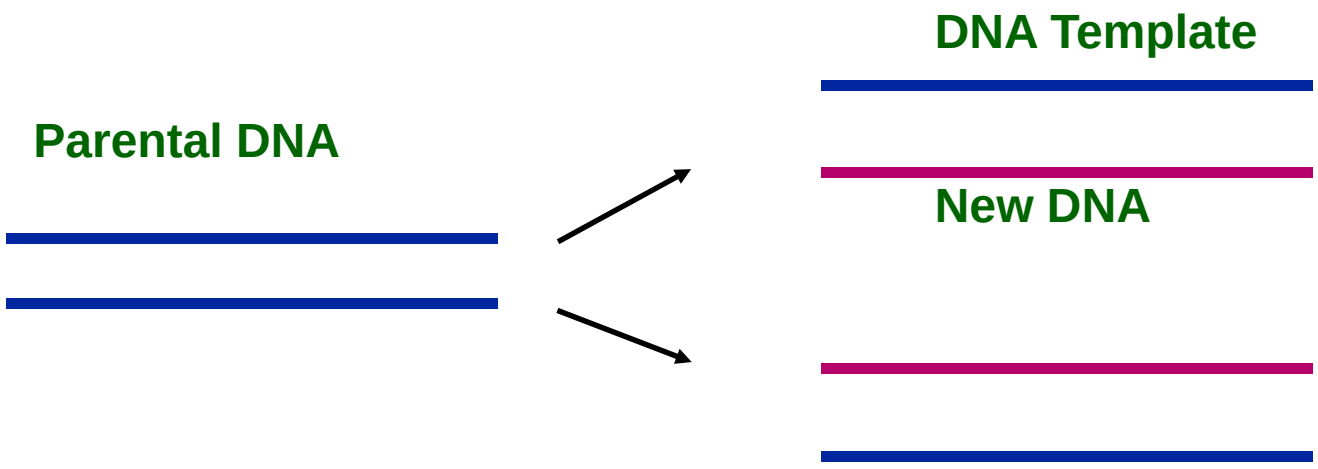



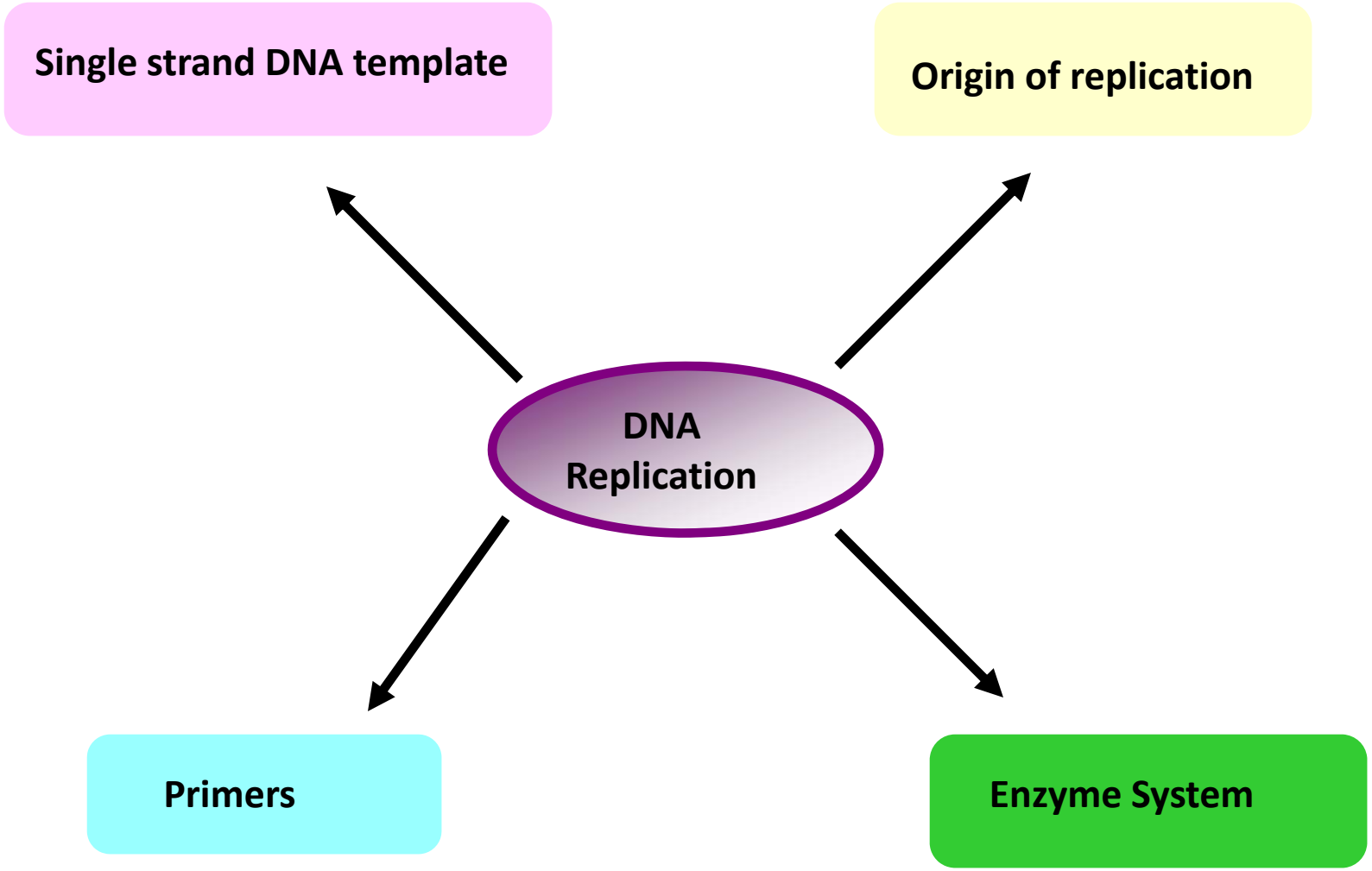
**Super coiled DNA**

# Messelson and Stahl

- Used DNA labelled with heavy ($^{15}N$) nitrogen to show that...
  - DNA, after each replication, contains
    - one strand from the previous molecule and
    - one new strand
- **Replication is...** **Semiconservative**



# Basic Requirements for DNA Replication



# Origin of Replication

Replication starts at a specific site called the origin

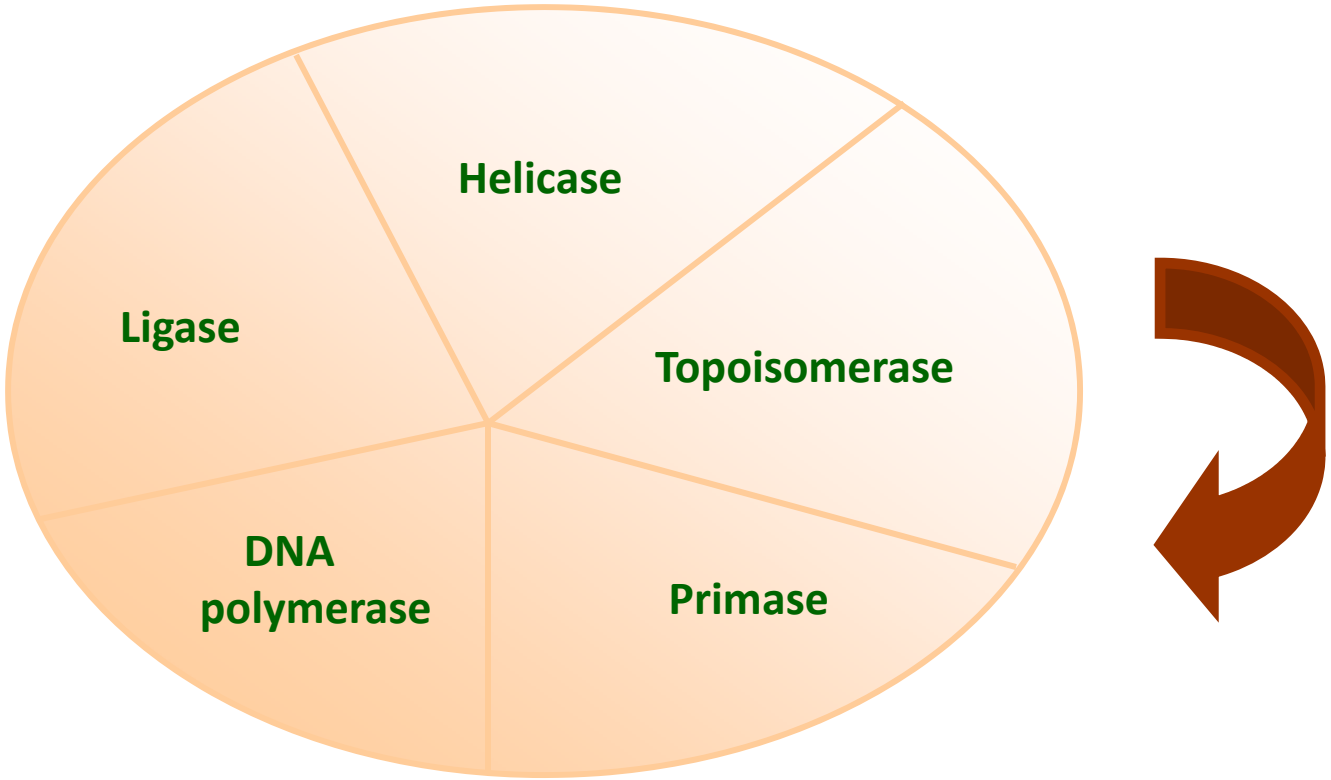
**Bacterial & viral chromosomes** → **Single origin controls the replication of the entire chromosome**

**Origins of replication**

**Eukaryotic chromosomes** → **Multiple origins collectively control replication of DNA present in each chromosome**

# Enzyme System

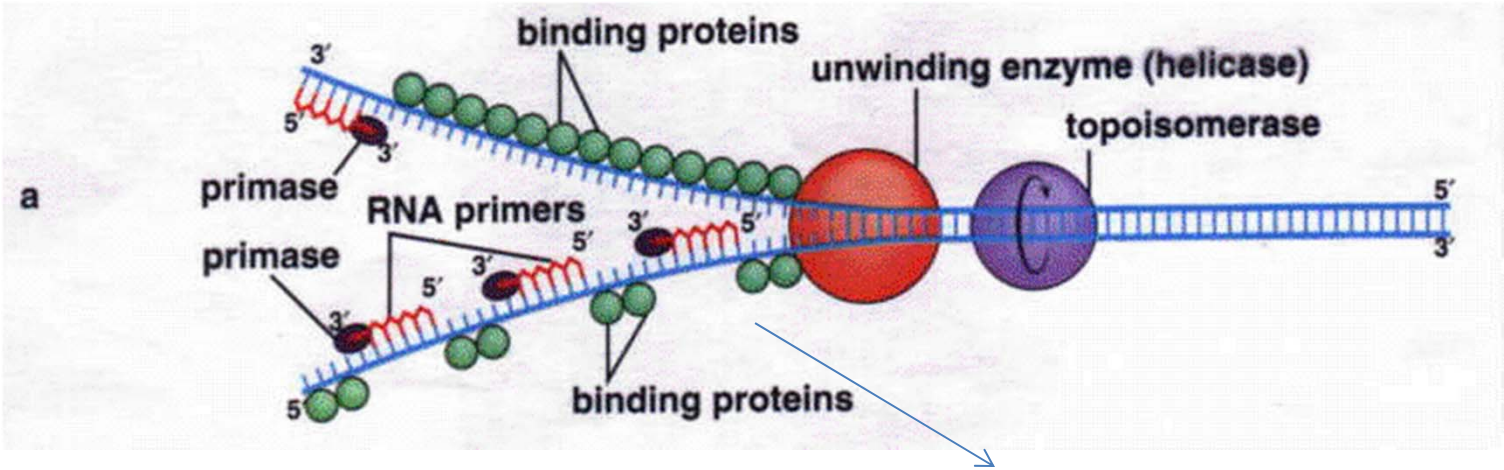
**Cluster of enzymes involved in the process of DNA replication**



# Topoisomerase

An enzyme that removes super coils from DNA

**enzyme which relieves stress** on the **DNA molecule** by allowing free rotation around a single strand.



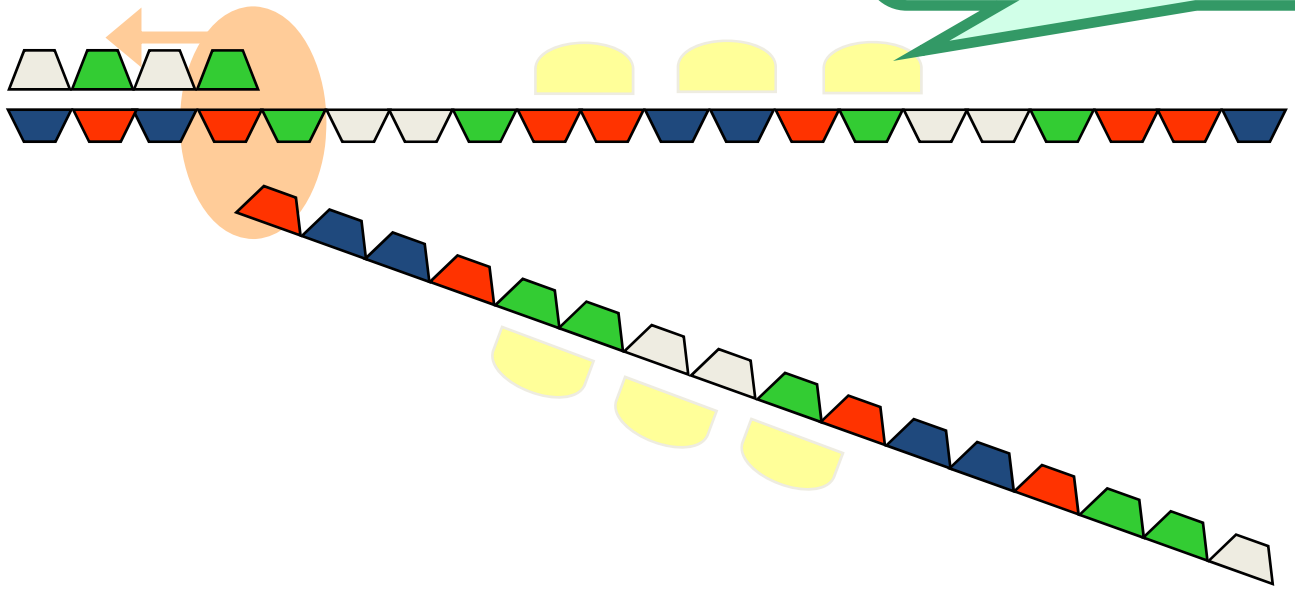

**Replication Fork**

# DNA Replication : The Process

**Double stranded DNA**

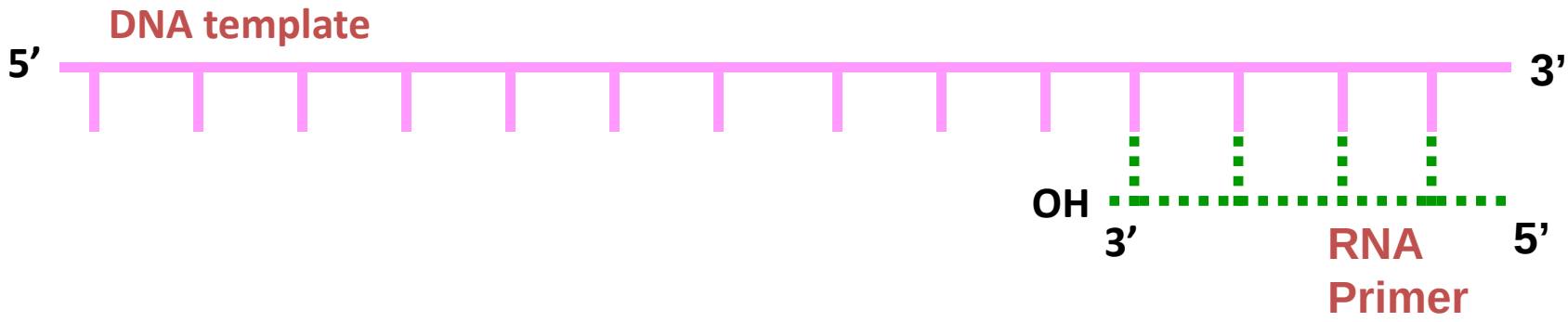
**Helicase:** enzyme which catalyze the **unwinding** and **separation** (breaking H-Bonds) of the parental double helix

**Single-Strand Binding Proteins:** proteins which attach and help keep the separated strands apart.

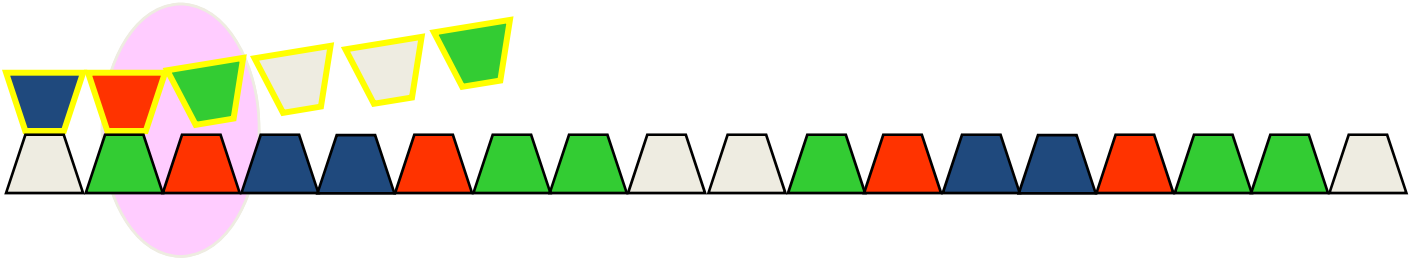


# RNA Primers

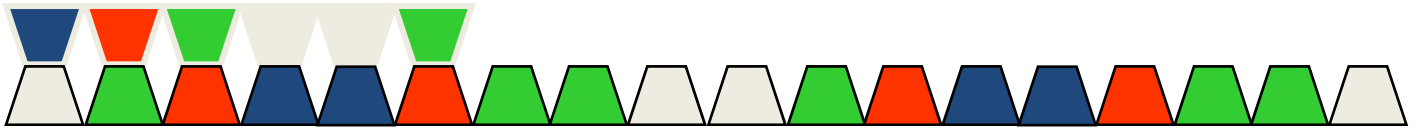
Short nucleotide sequence with a reactive 3’-OH that initiates DNA synthesis along a template



# Primase



DNA **primase**

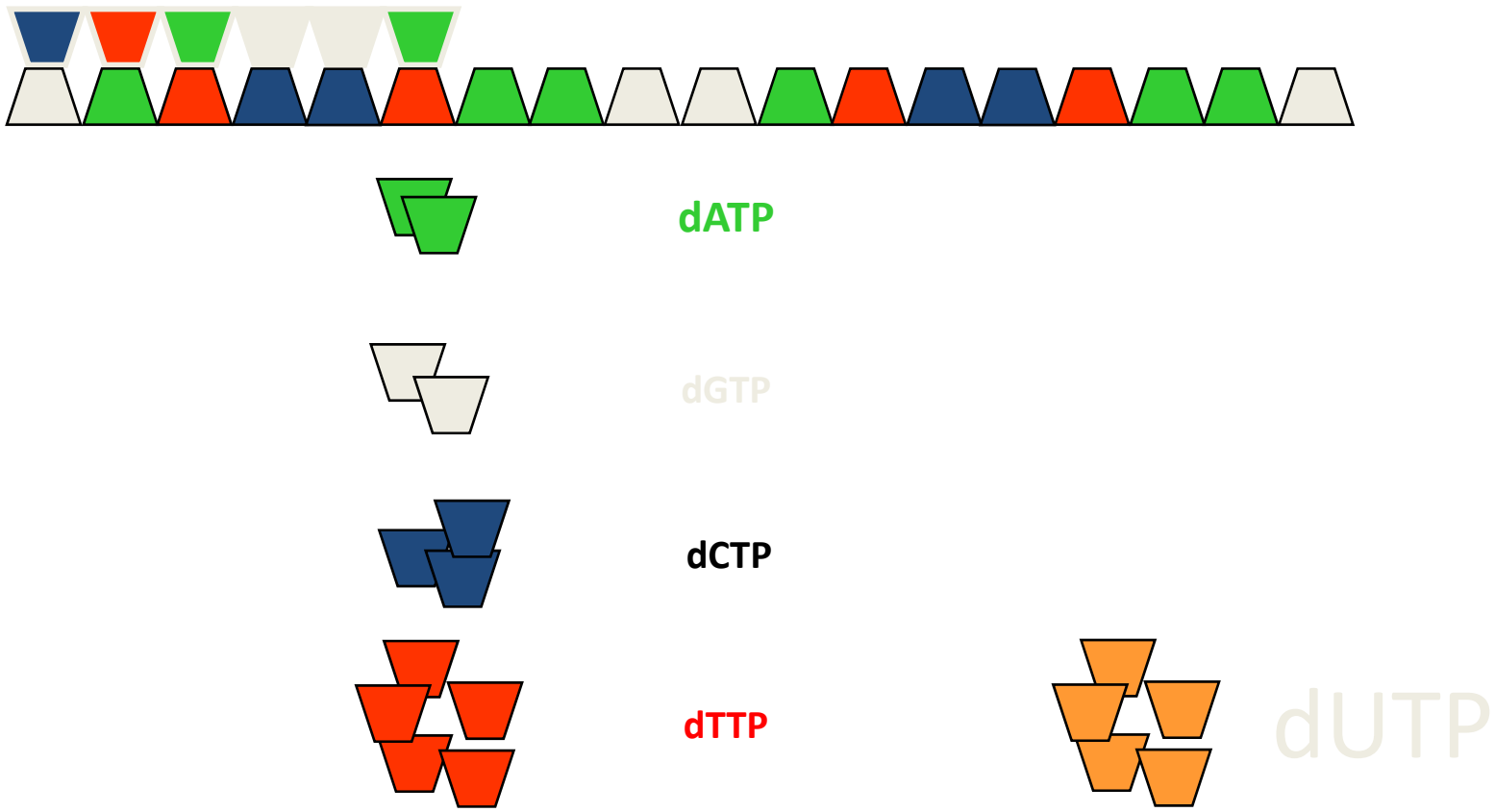


**RNA primers**: before new DNA strands can form, there must be small pre-existing primer (RNA) present to start the addition of new nucleotides (DNA Polymerase).

**Primase**: enzyme that polymerizes (synthesizes) the RNAPrimer

DNA chain is initiated by a short RNA primer synthesized by DNA primase

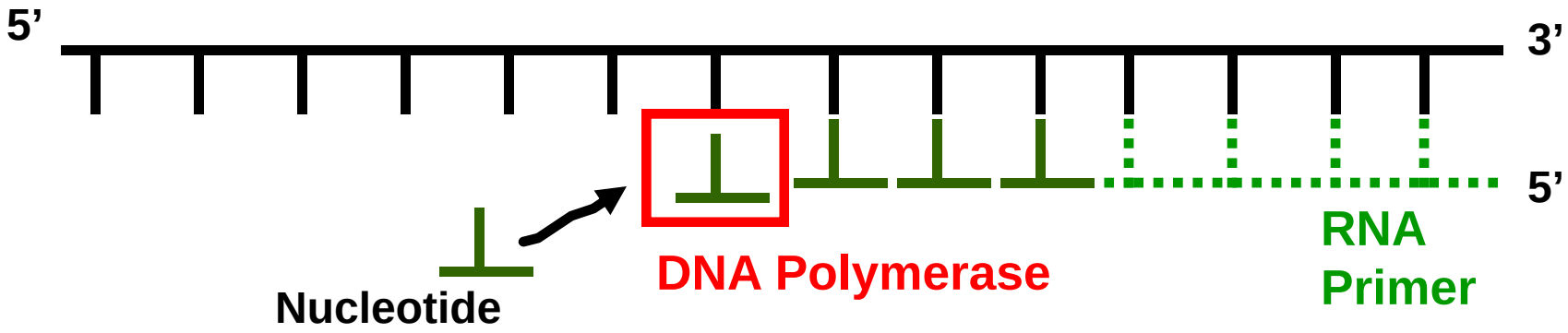
# Nucleotides



# Polymerase

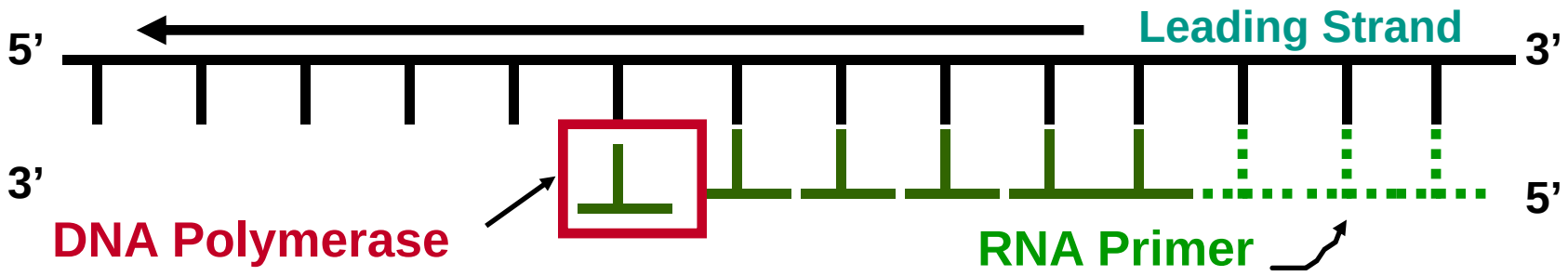
**•Synthesis of the new DNA Strands:**

**DNA Polymerase**: with a **RNA primer** in place, DNA Polymerase (enzyme) catalyze the **synthesis of a new DNA strand in the 5'to 3' direction**.

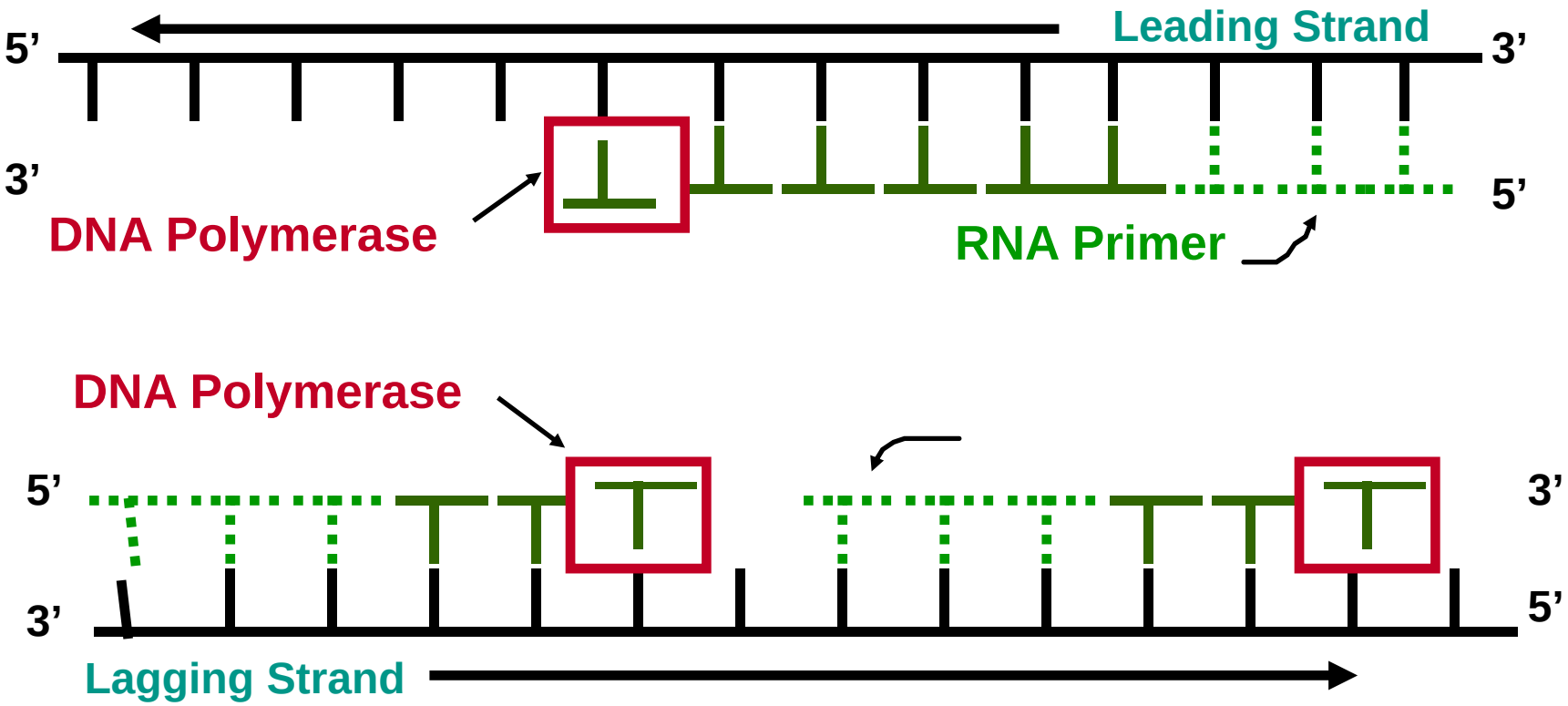


# Synthesis of new DNA strands

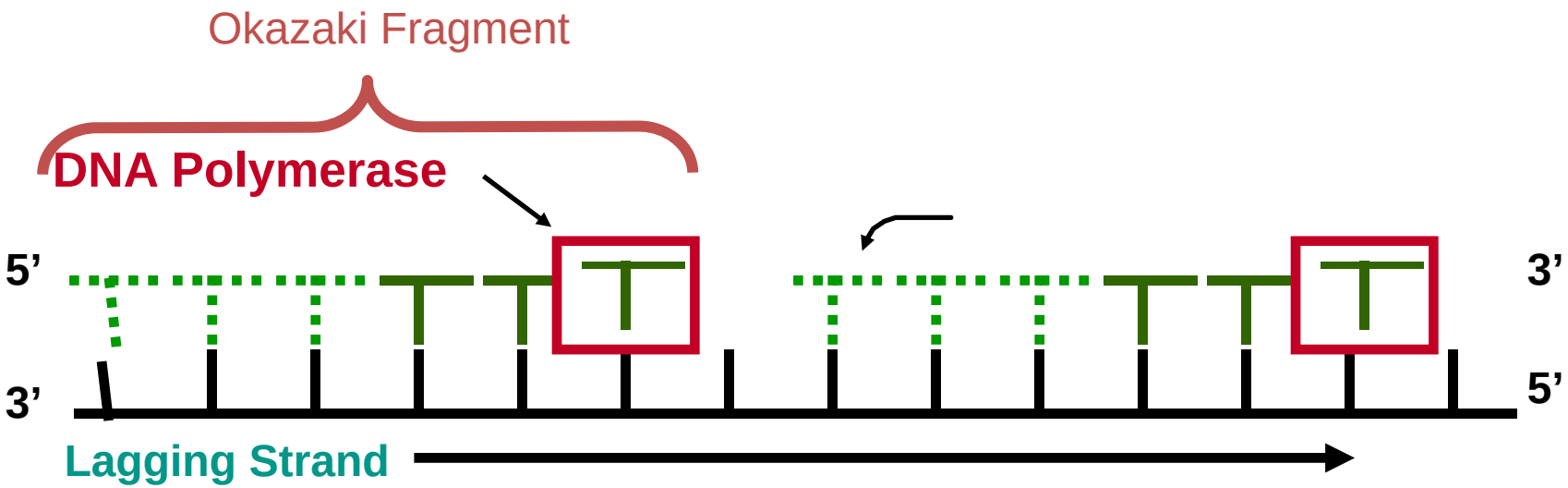
**Leading Strand**: synthesized as a single polymer in the 5’ to 3’ direction.



**Lagging Strand**: also synthesized in the **5' to 3' direction**, but **discontinuously** against overall direction of replication.

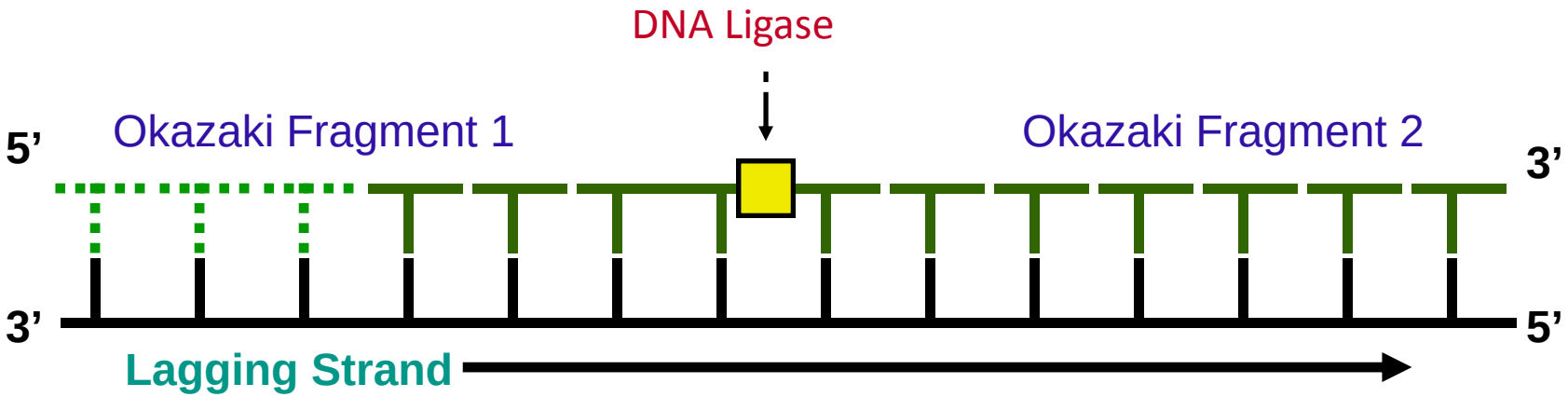


**Okazaki Fragments**: series of short segments on the **lagging strand.**



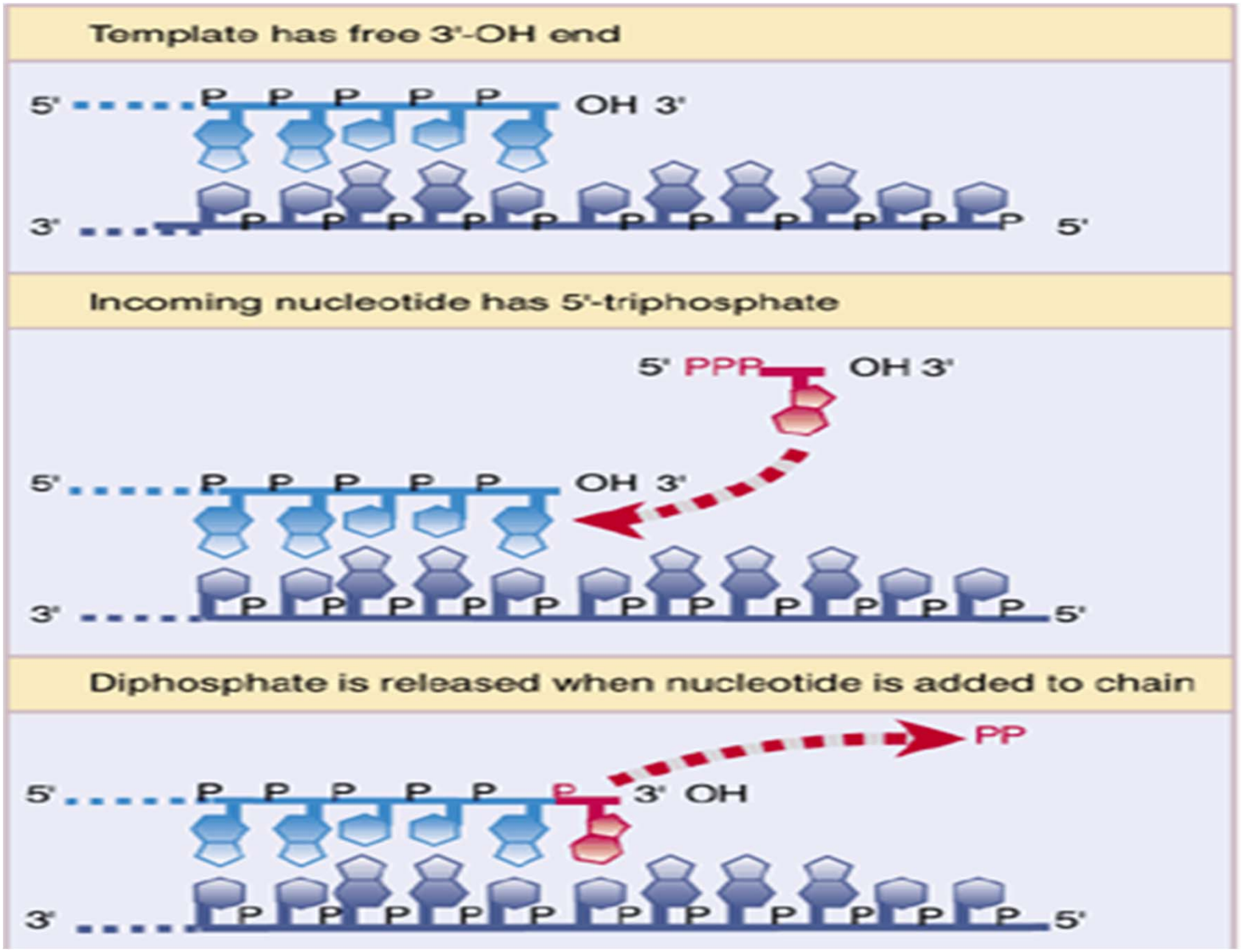
**DNA ligase:** **a linking enzyme that catalyzes the formation of a covalent bond from the 3’ to 5’ end of joining stands.**

Example: joining two Okazaki fragments together.



# Enzymes involved in DNA replication

| Enzyme | Function in DNA replication |
|---|---|
| DNA Helicase | Also known as helix destabilizing enzyme. Unwinds the DNA double helix at the Replication Fork. |
| DNA Polymerase | Builds a new duplex DNA strand by adding nucleotides in the 5' to 3' direction. Also performs proof-reading and error correction. |
| DNA clamp | A protein which prevents DNA polymerase III from dissociating from the DNA parent strand. |
| Single-Strand Binding (SSB) Proteins | Bind to ssDNA and prevent the DNA double helix from re-annealing after DNA helicase unwinds it thus maintaining the strand separation. |
| Topoisomerase | Relaxes the DNA from its super-coiled nature. |
| DNA Gyrase | Relieves strain of unwinding by DNA helicase. |
| DNA Ligase | Re-anneals the semi-conservative strands and joins Okazaki Fragments of the lagging strand. |
| Primase | Provides a starting point of RNA (or DNA) for DNA polymerase to begin synthesis of the new DNA strand. |
| Telomerase | Lengthens telomeric DNA by adding repetitive nucleotide sequences to the ends of eukaryotic chromosomes. |




- DNA synthesis occurs by adding 3’-OH end of the growing strand
- New chain synthesized in the 5’-3’ direction

**Proofreading**: initial base-pairing errors are usually corrected by **DNA polymerase**.

- **Excision repair:**

Damaged segment is **excised** by a **repair enzyme** (there are over 50 repair enzymes).

**DNA polymerase** and **DNA ligase** replace and bond the new nucleotides together.