






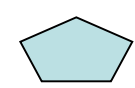
# OKAZAKI FRAGMENTS

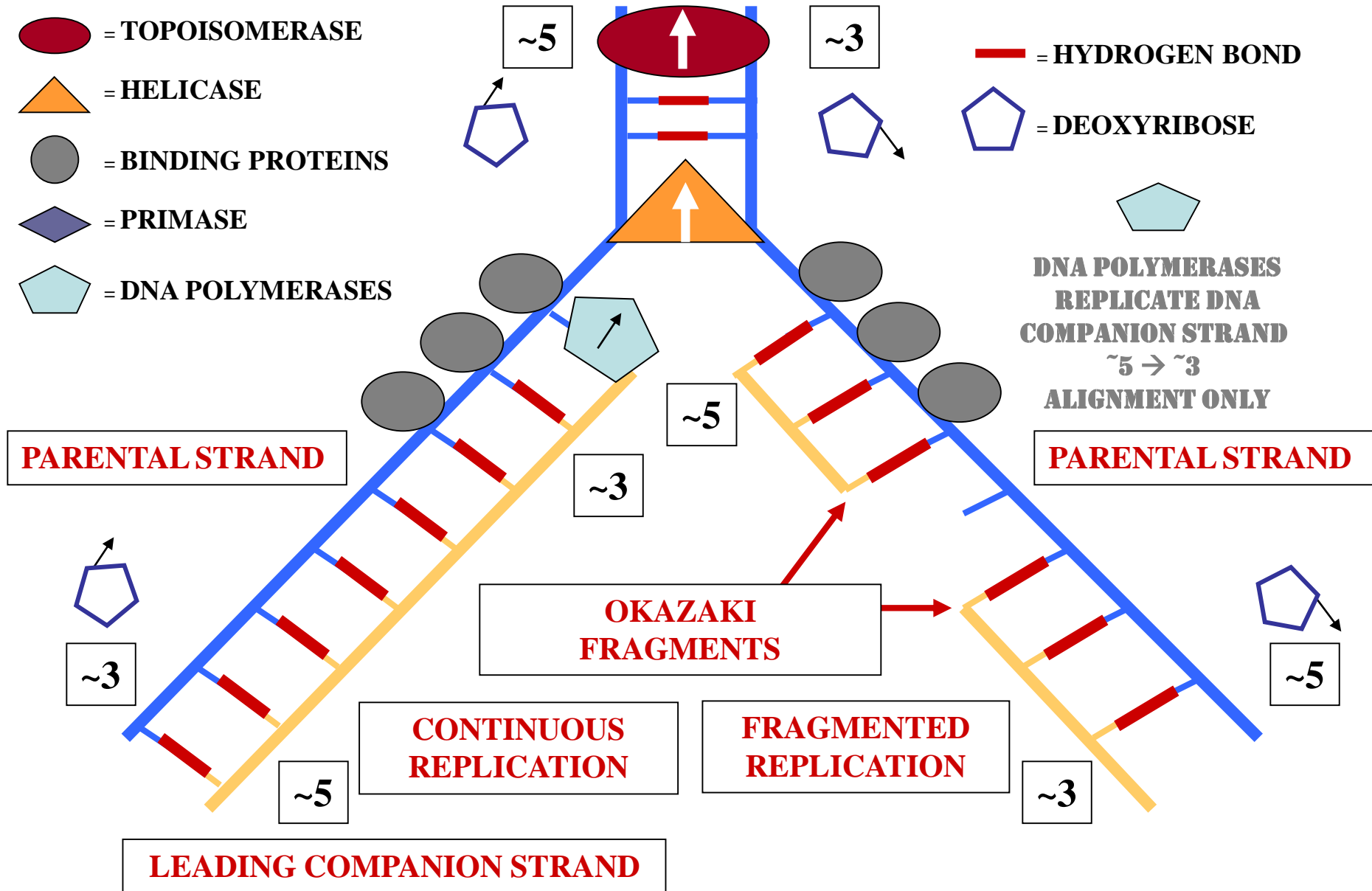
# REPLICATION - SPECIFICS

-  = TOPOISOMERASE
-  = HELICASE
-  = BINDING PROTEINS
-  = PRIMASE
-  = DNA POLYMERASES

 = HYDROGEN BOND

 = DEOXYRIBOSE

  
DNA POLYMERASES  
REPLICATE DNA  
COMPANION STRAND  
~5 → ~3  
ALIGNMENT ONLY



**LIGASE**



**LIGASE**

**JOINS**

**OKAZAKI FRAGMENTS**

**LIGASE**



# REPLICATION - SPECIFICS



 = TOPOISOMERASE

 = HELICASE

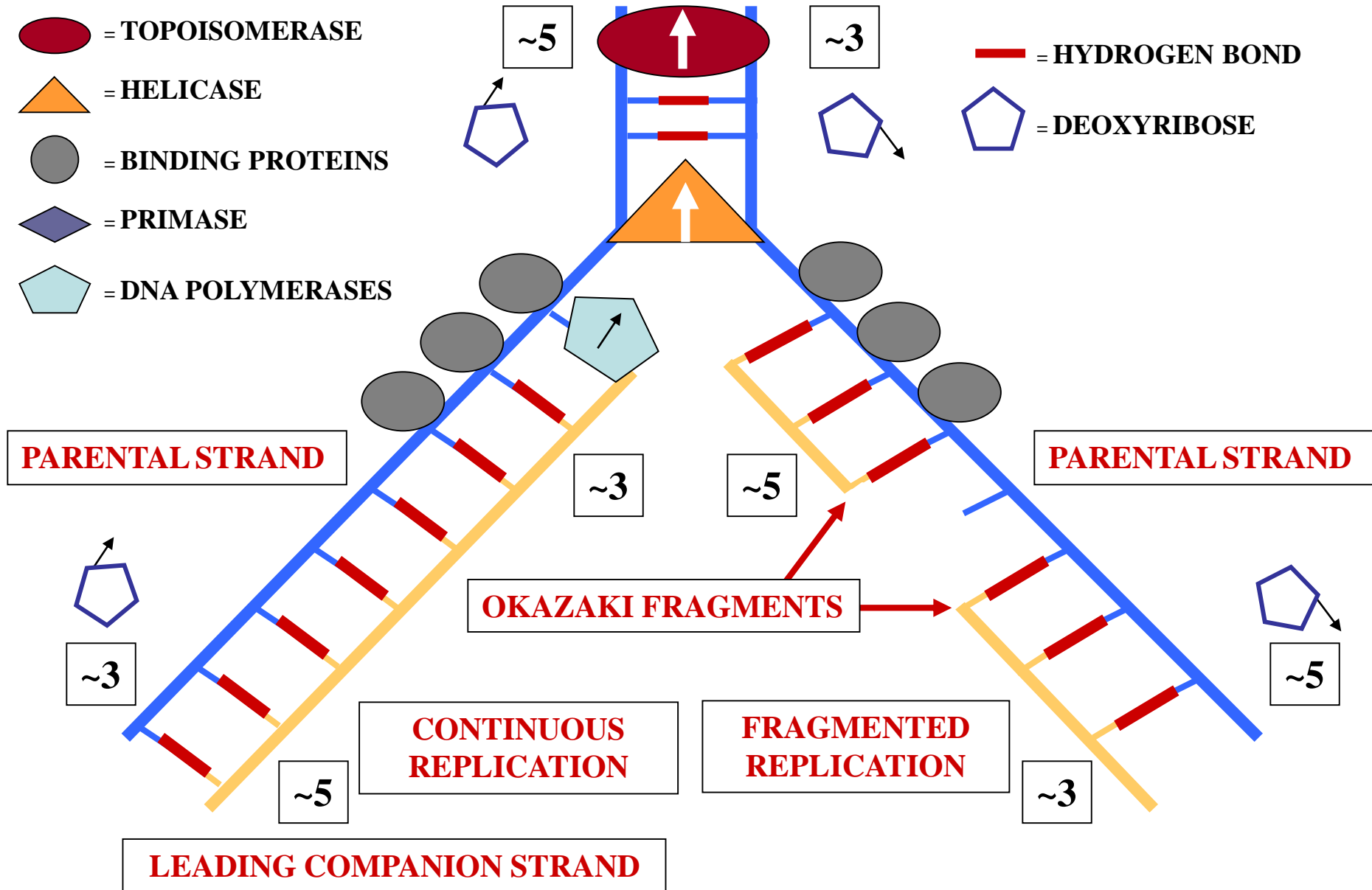
 = BINDING PROTEINS

 = PRIMASE

 = DNA POLYMERASES

 = HYDROGEN BOND

 = DEOXYRIBOSE



# REPLICATION - SPECIFICS


 = TOPOISOMERASE

 = HELICASE

 = BINDING PROTEINS

 = PRIMASE

 = DNA POLYMERASES

 = LIGASE

 = HYDROGEN BOND

 = DEOXYRIBOSE

  
LIGASE  
JOINS  
OKAZAKI FRAGMENTS

**PARENTAL STRAND**

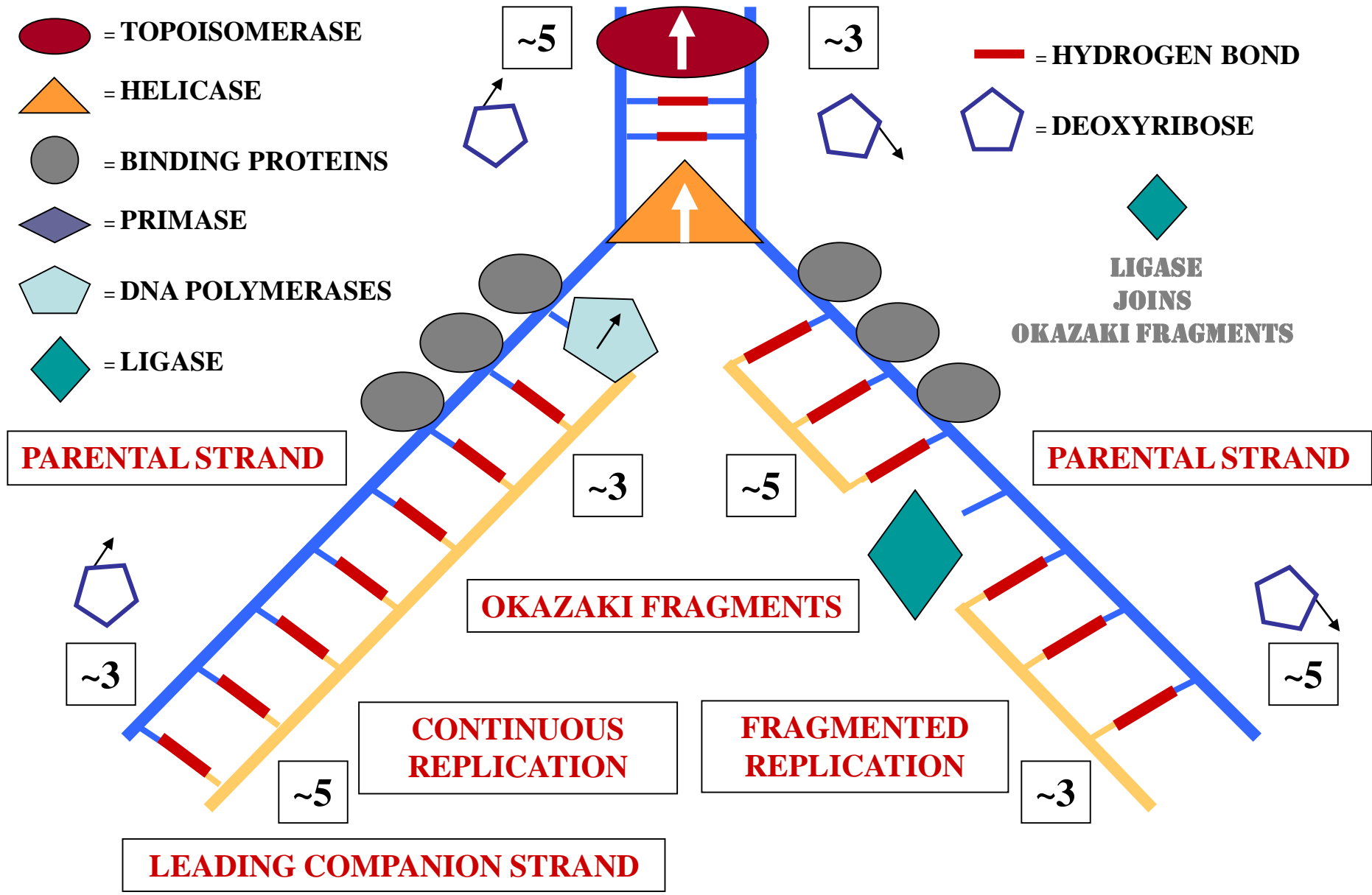
**PARENTAL STRAND**

**OKAZAKI FRAGMENTS**

**CONTINUOUS REPLICATION**

**FRAGMENTED REPLICATION**

**LEADING COMPANION STRAND**



# REPLICATION - SPECIFICS


 = TOPOISOMERASE

 = HELICASE

 = BINDING PROTEINS

 = PRIMASE

 = DNA POLYMERASES

 = LIGASE

 = HYDROGEN BOND

 = DEOXYRIBOSE

  
LIGASE  
JOINS  
OKAZAKI FRAGMENTS

**PARENTAL STRAND**

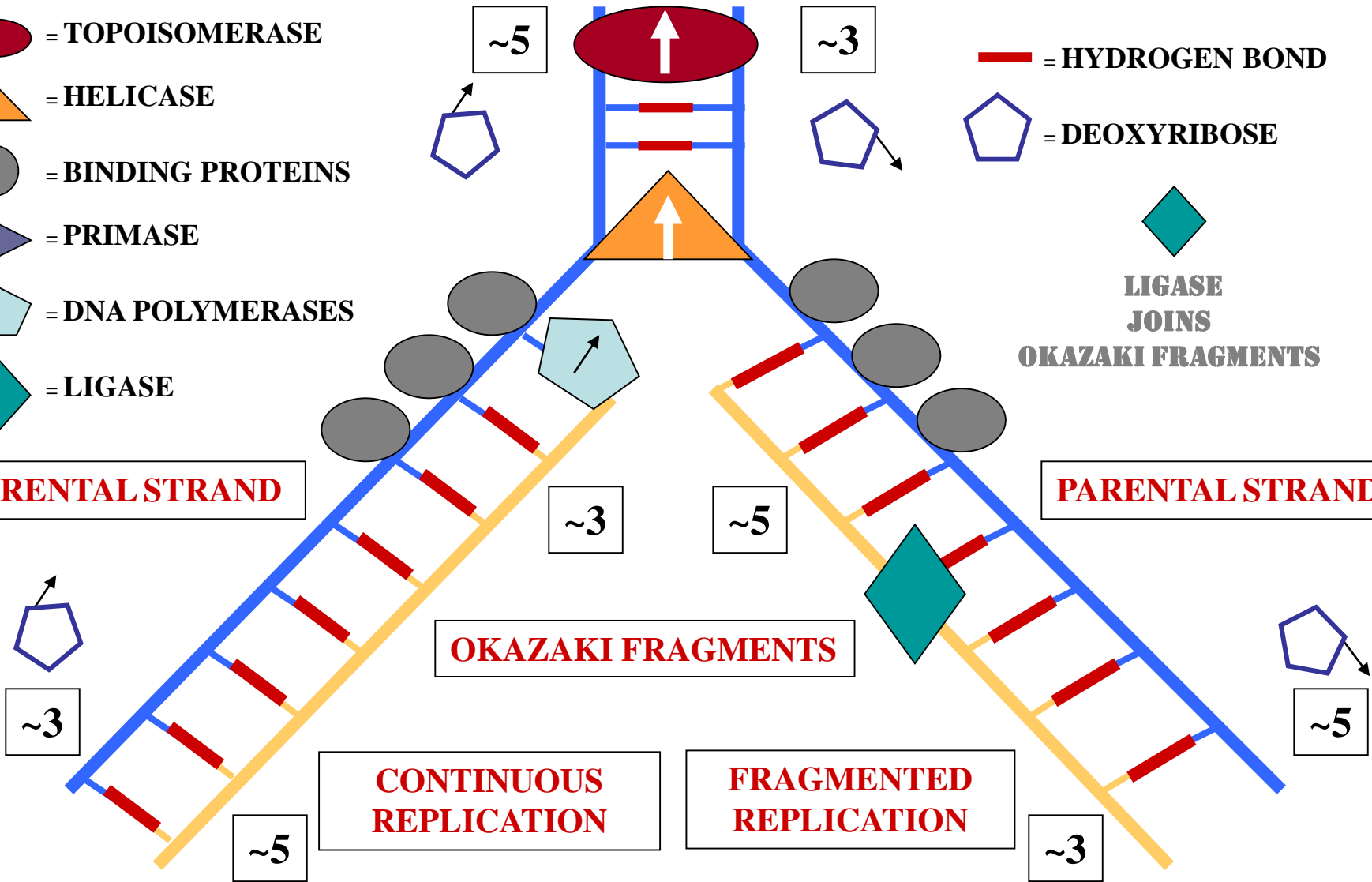
**PARENTAL STRAND**

**OKAZAKI FRAGMENTS**

**CONTINUOUS REPLICATION**

**FRAGMENTED REPLICATION**

**LEADING COMPANION STRAND**



# REPLICATION - SPECIFICS

 = TOPOISOMERASE

 = HELICASE

 = BINDING PROTEINS

 = PRIMASE

 = DNA POLYMERASES

 = LIGASE

 = HYDROGEN BOND

 = DEOXYRIBOSE

  
LIGASE  
JOINS

OKAZAKI FRAGMENTS  
OUTCOME INTACT  
COMPANION STRAND

**PARENTAL STRAND**

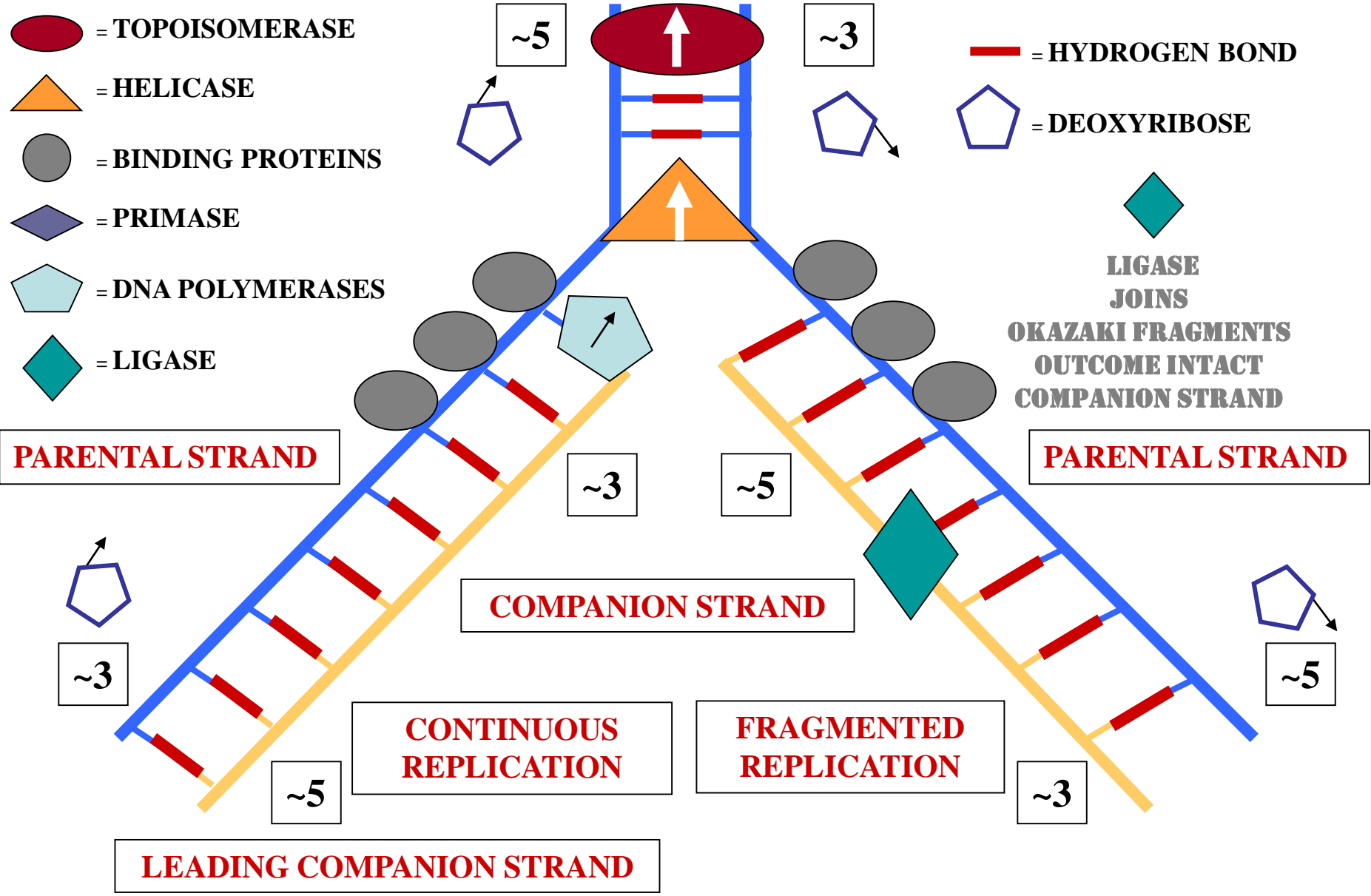
**PARENTAL STRAND**

**COMPANION STRAND**







**CONTINUOUS  
REPLICATION**

**FRAGMENTED  
REPLICATION**

**LEADING COMPANION STRAND**




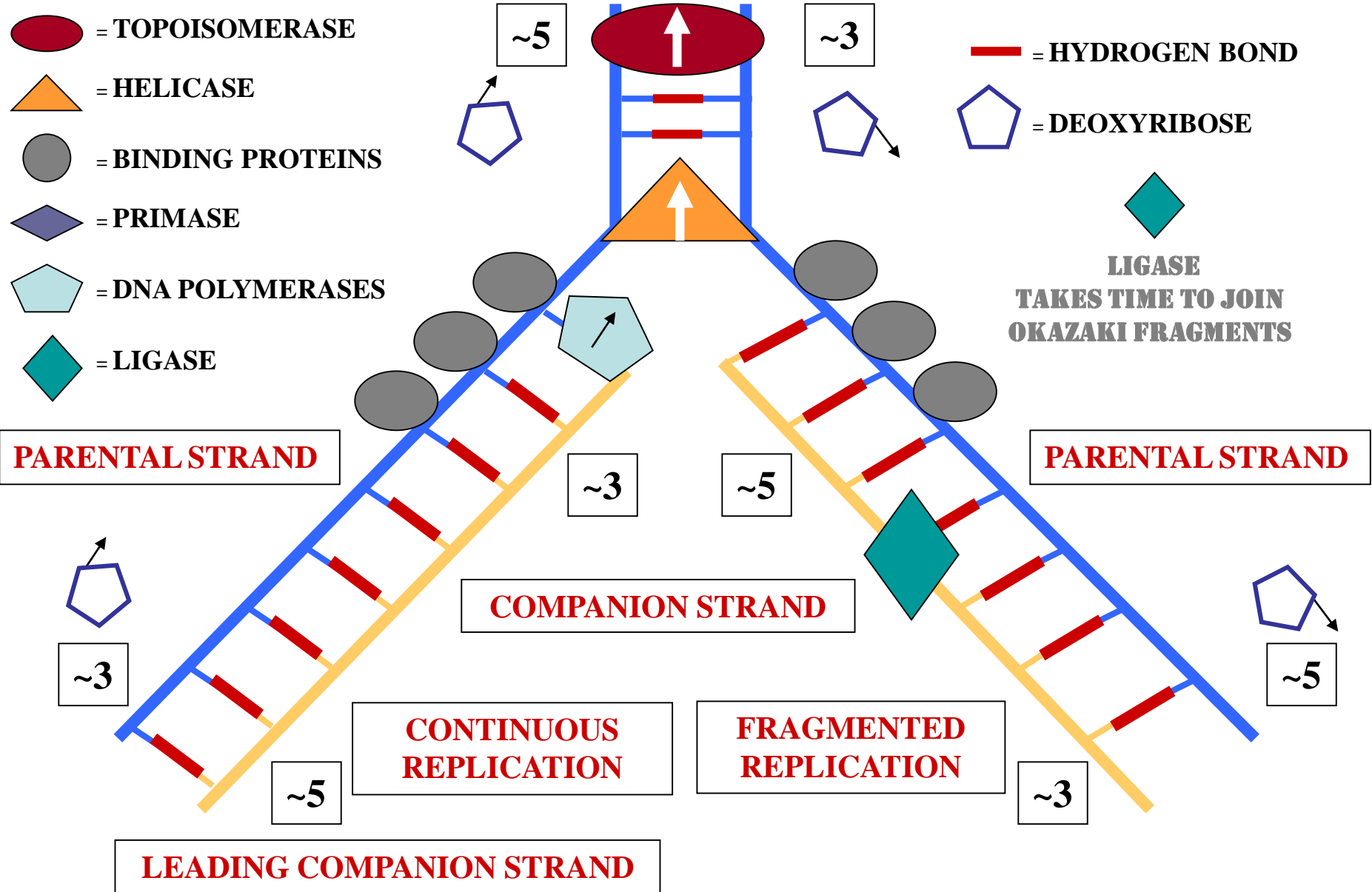
# REPLICATION - SPECIFICS

-  = TOPOISOMERASE
-  = HELICASE
-  = BINDING PROTEINS
-  = PRIMASE
-  = DNA POLYMERASES
-  = LIGASE

 = HYDROGEN BOND

 = DEOXYRIBOSE

  
**LIGASE**  
TAKES TIME TO JOIN  
OKAZAKI FRAGMENTS



# REPLICATION - SPECIFICS


 = TOPOISOMERASE

 = HELICASE

 = BINDING PROTEINS

 = PRIMASE

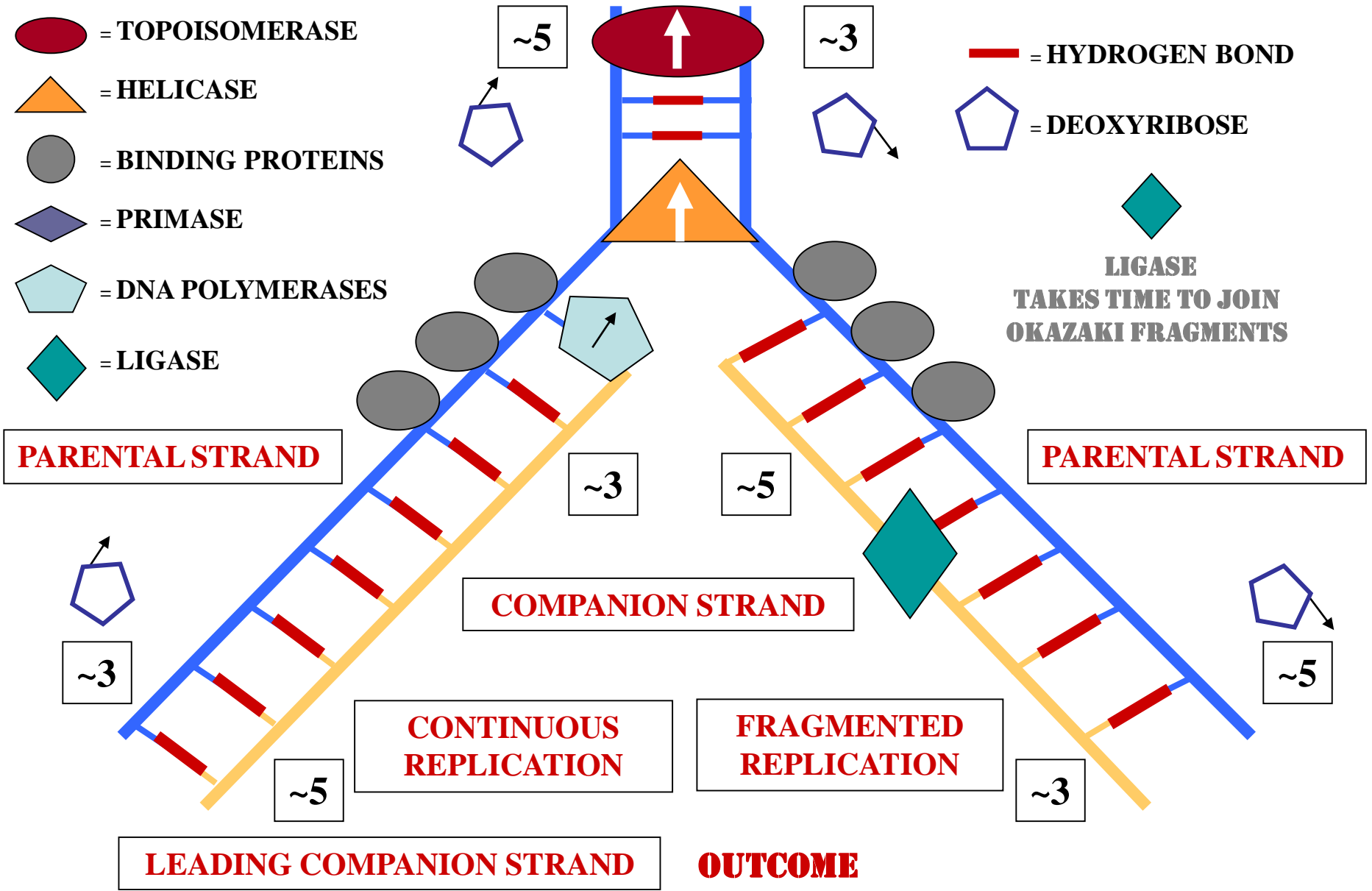
 = DNA POLYMERASES

 = LIGASE

 = HYDROGEN BOND

 = DEOXYRIBOSE

  
LIGASE  
TAKES TIME TO JOIN  
OKAZAKI FRAGMENTS



**PARENTAL STRAND**

**PARENTAL STRAND**

**COMPANION STRAND**

**CONTINUOUS REPLICATION**

**FRAGMENTED REPLICATION**

**LEADING COMPANION STRAND**

**OUTCOME**



# REPLICATION - SPECIFICS

= TOPOISOMERASE

= HELICASE

= BINDING PROTEINS

= PRIMASE

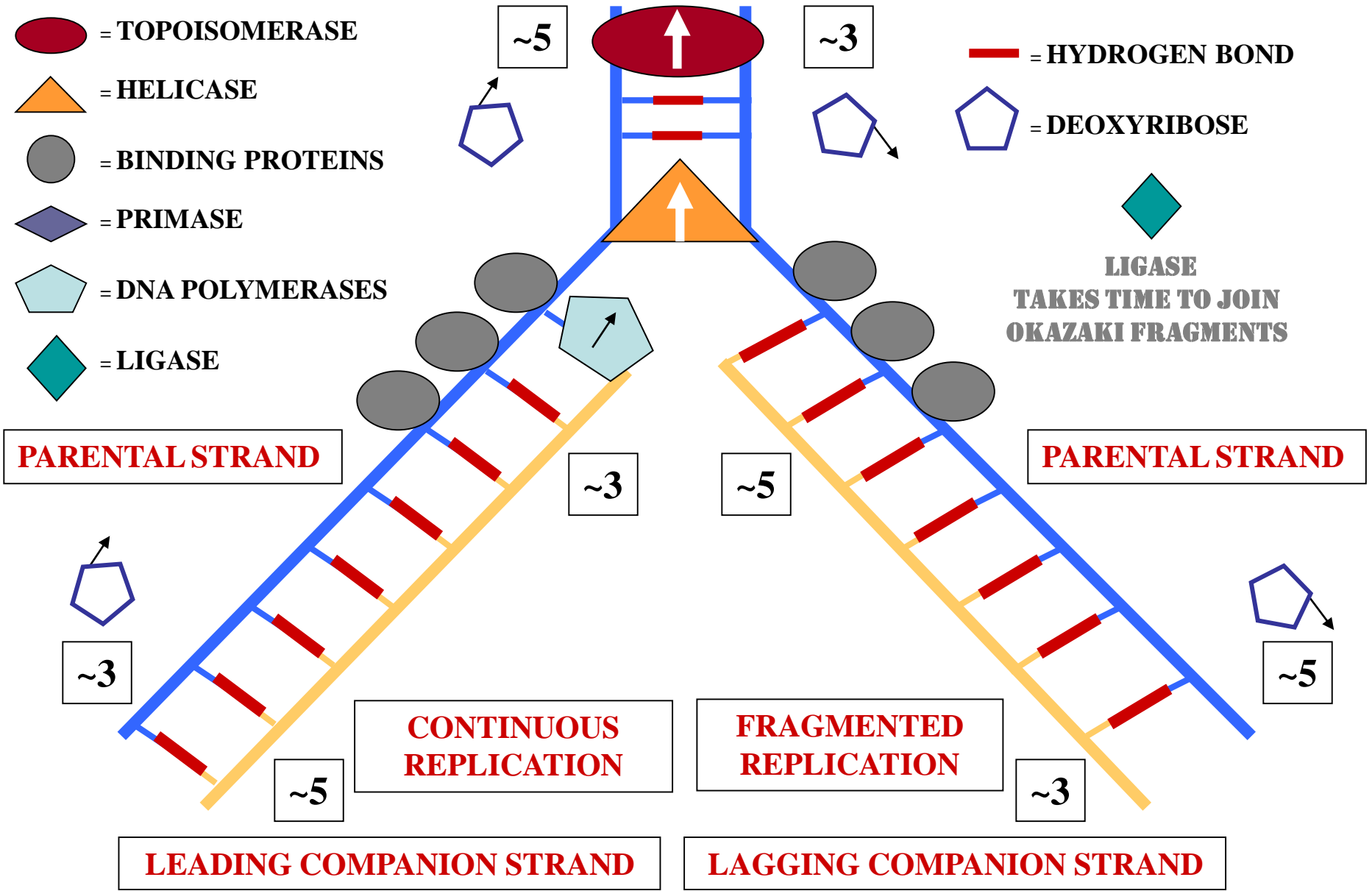
= DNA POLYMERASES

= LIGASE

= HYDROGEN BOND

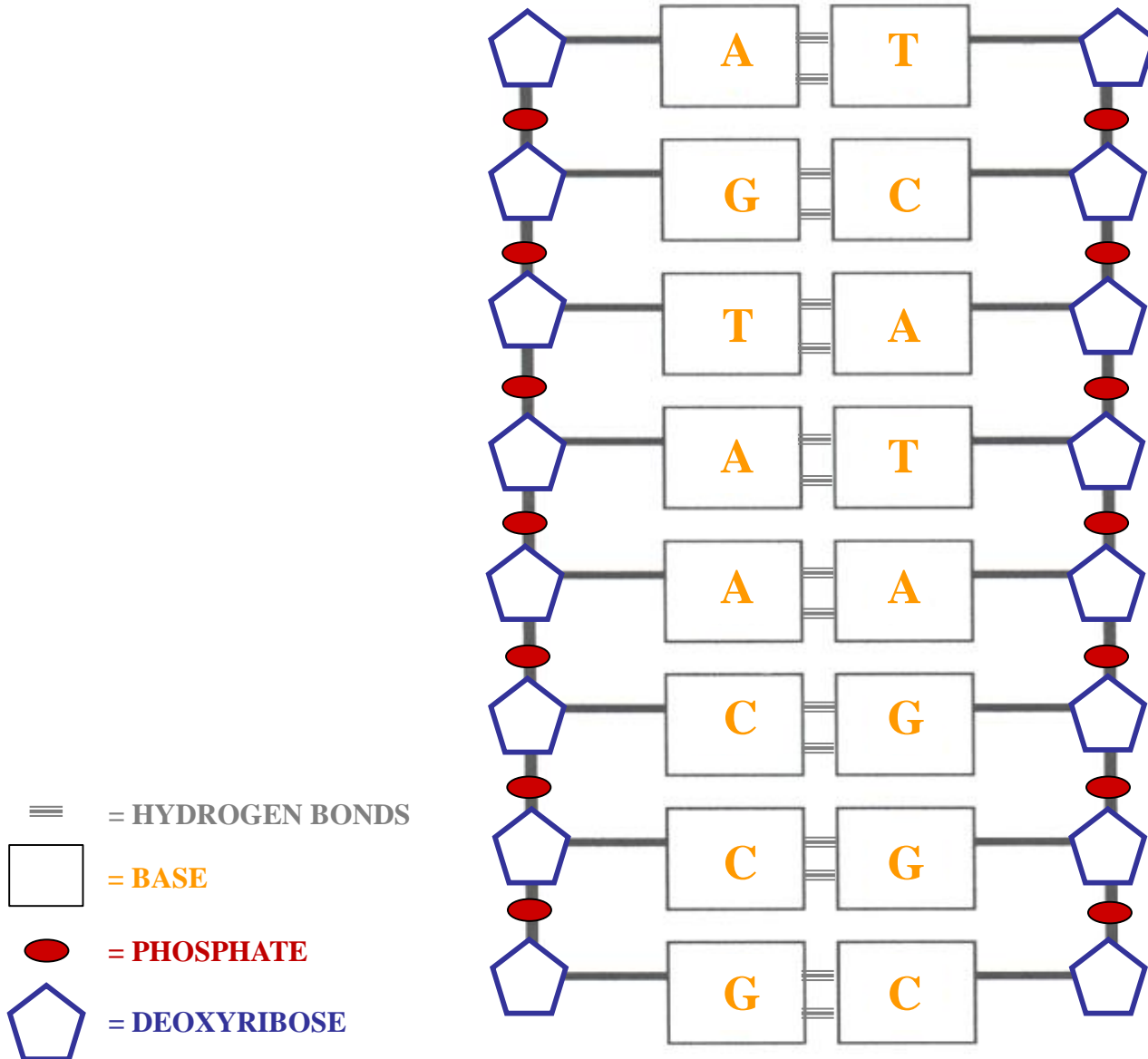
= DEOXYRIBOSE

**LIGASE**  
**TAKES TIME TO JOIN**  
**OKAZAKI FRAGMENTS**





# REPLICATED DNA



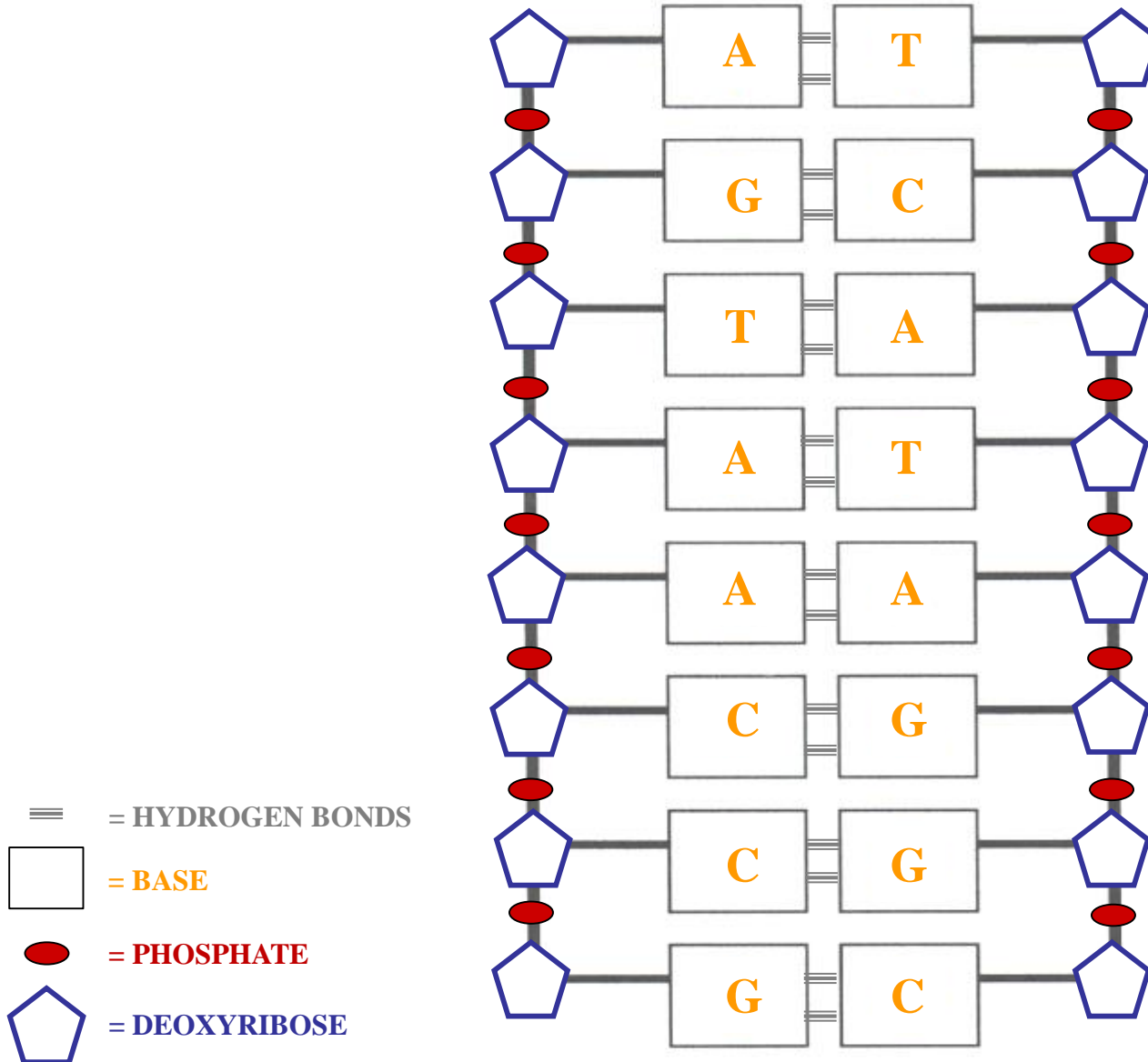




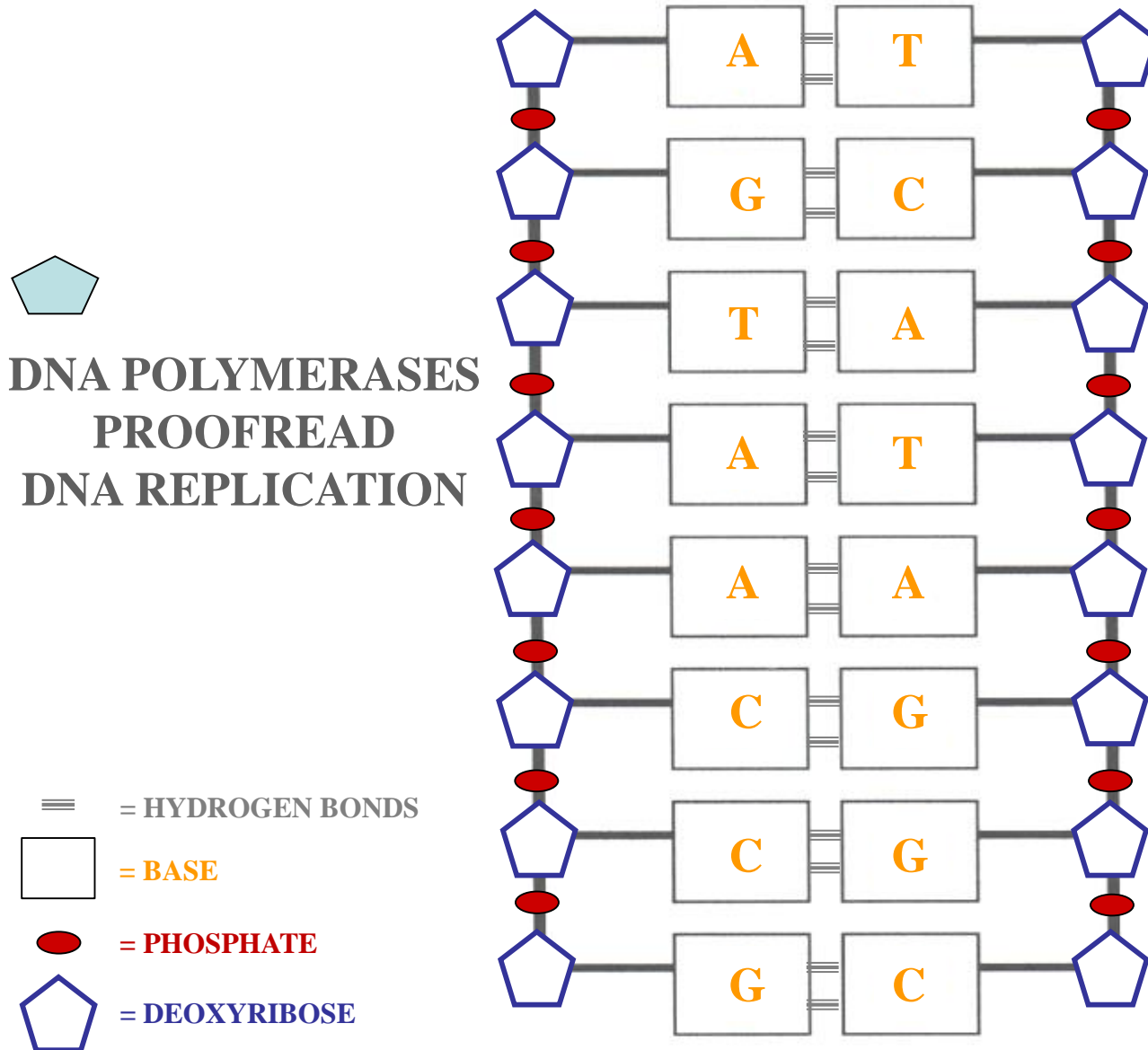
# PROOFREADING DNA REPLICATION

# REPLICATED DNA

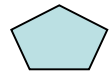
D



# REPLICATED DNA



# REPLICATED DNA



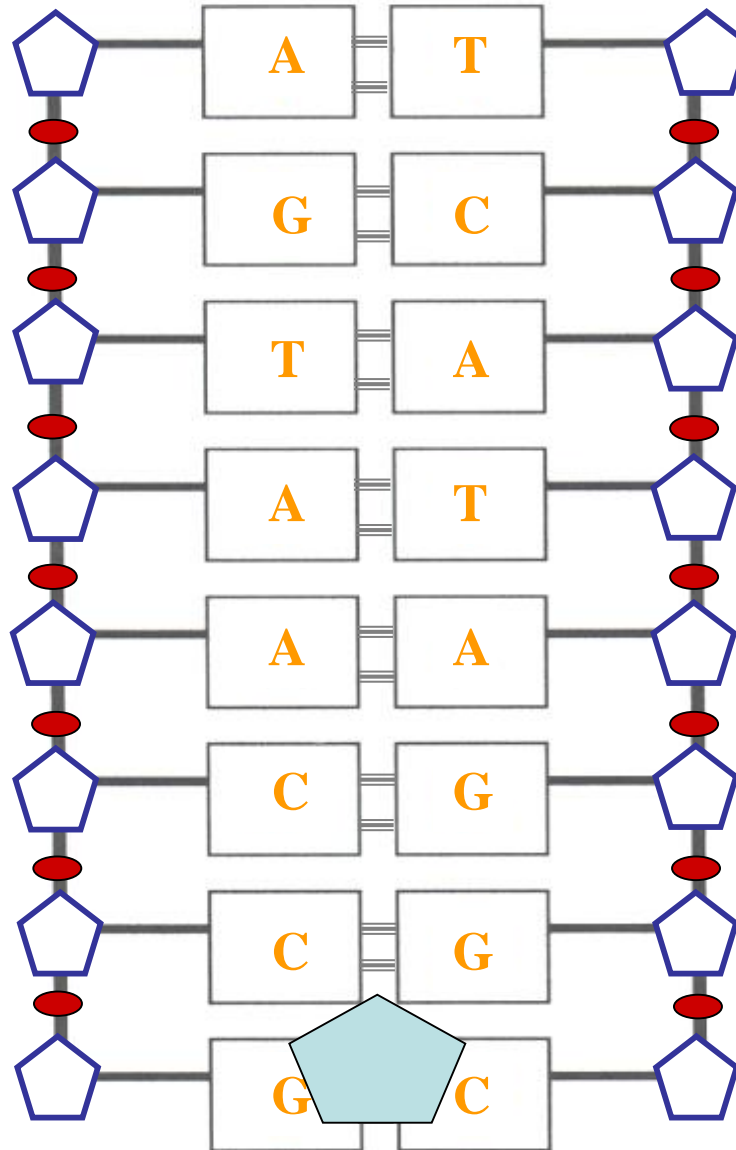
DNA POLYMERASES  
PROOFREAD  
DNA REPLICATION  
LOOK FOR  
NUCLEOTIDE BASE  
PAIRING ERRORS

≡ = HYDROGEN BONDS

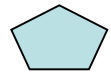
□ = BASE

● = PHOSPHATE

⬡ = DEOXYRIBOSE



# REPLICATED DNA



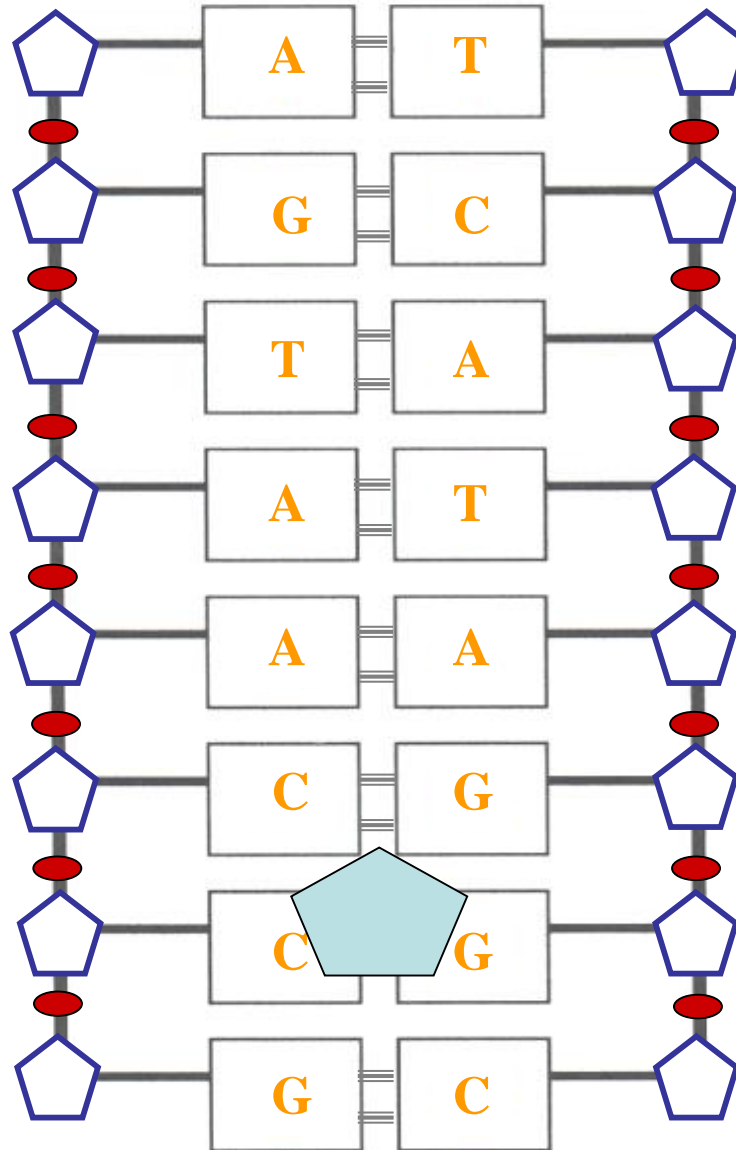
DNA POLYMERASES  
PROOFREAD  
DNA REPLICATION  
LOOK FOR  
NUCLEOTIDE BASE  
PAIRING ERRORS

≡ = HYDROGEN BONDS

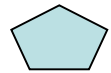
□ = BASE

● = PHOSPHATE

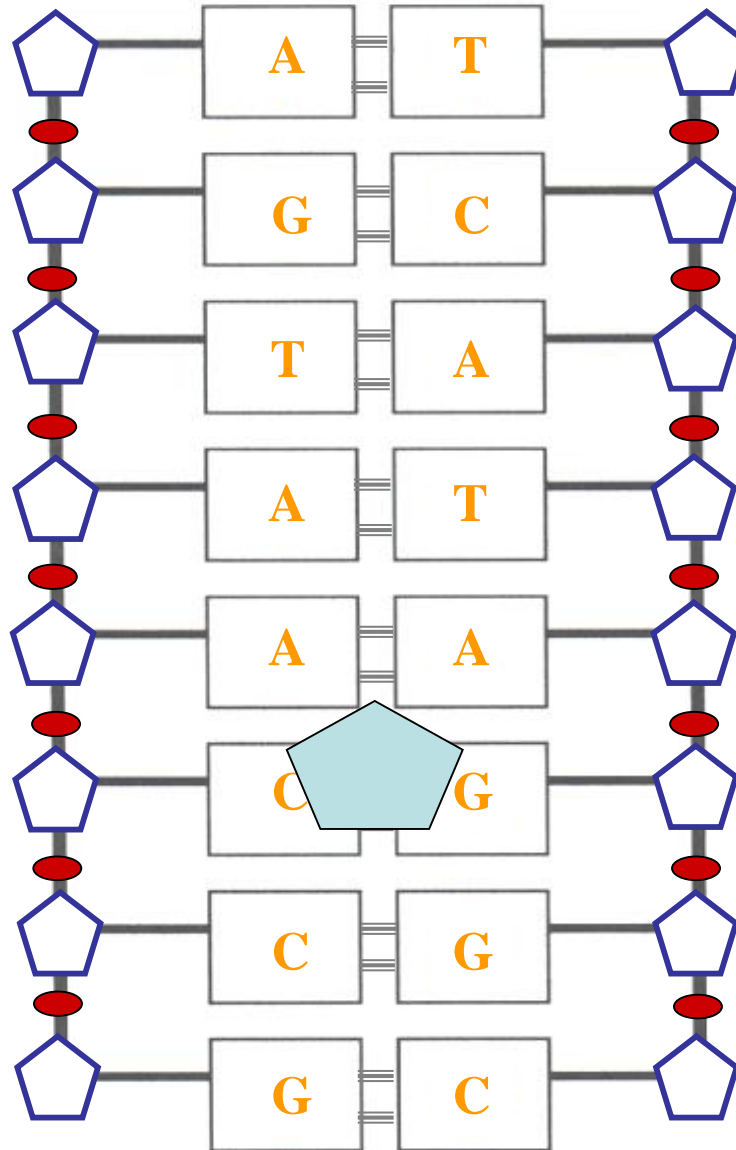
⬡ = DEOXYRIBOSE



# REPLICATED DNA



DNA POLYMERASES  
PROOFREAD  
DNA REPLICATION  
LOOK FOR  
NUCLEOTIDE BASE  
PAIRING ERRORS



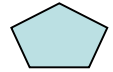
≡ = HYDROGEN BONDS

□ = BASE

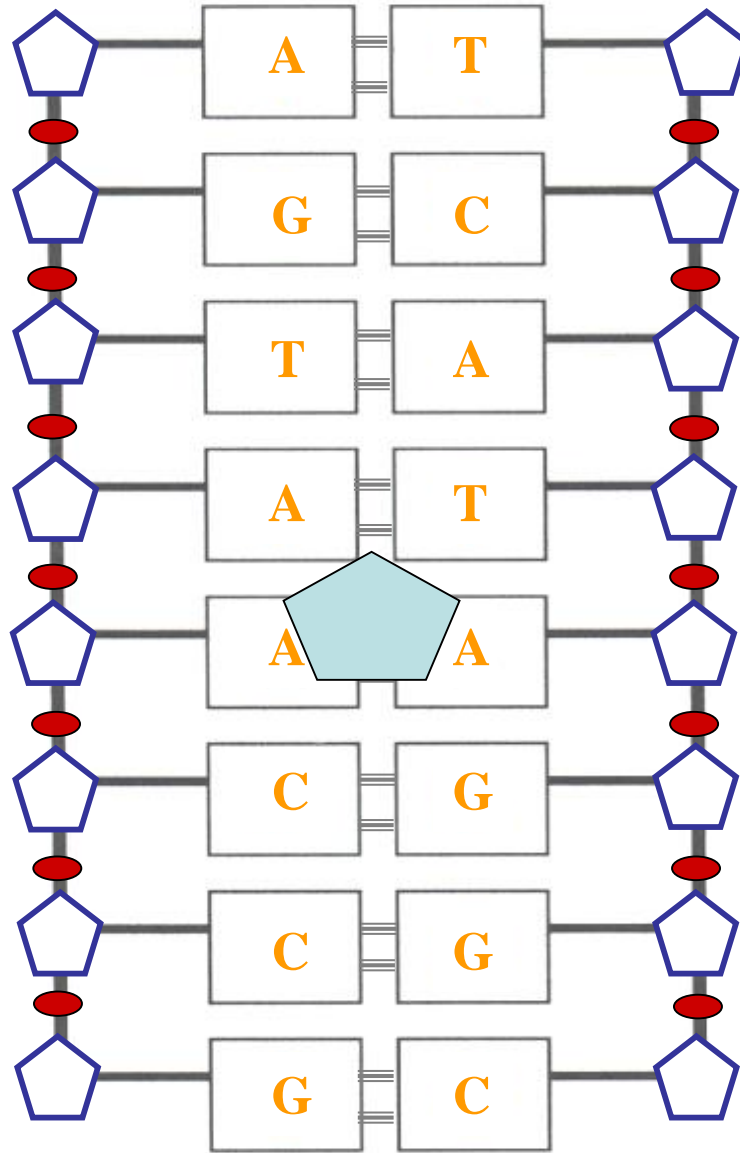
● = PHOSPHATE

⬡ = DEOXYRIBOSE

# REPLICATED DNA



DNA POLYMERASES  
PROOFREAD  
DNA REPLICATION  
LOOK FOR  
NUCLEOTIDE BASE  
PAIRING ERRORS



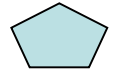
≡ = HYDROGEN BONDS

□ = BASE

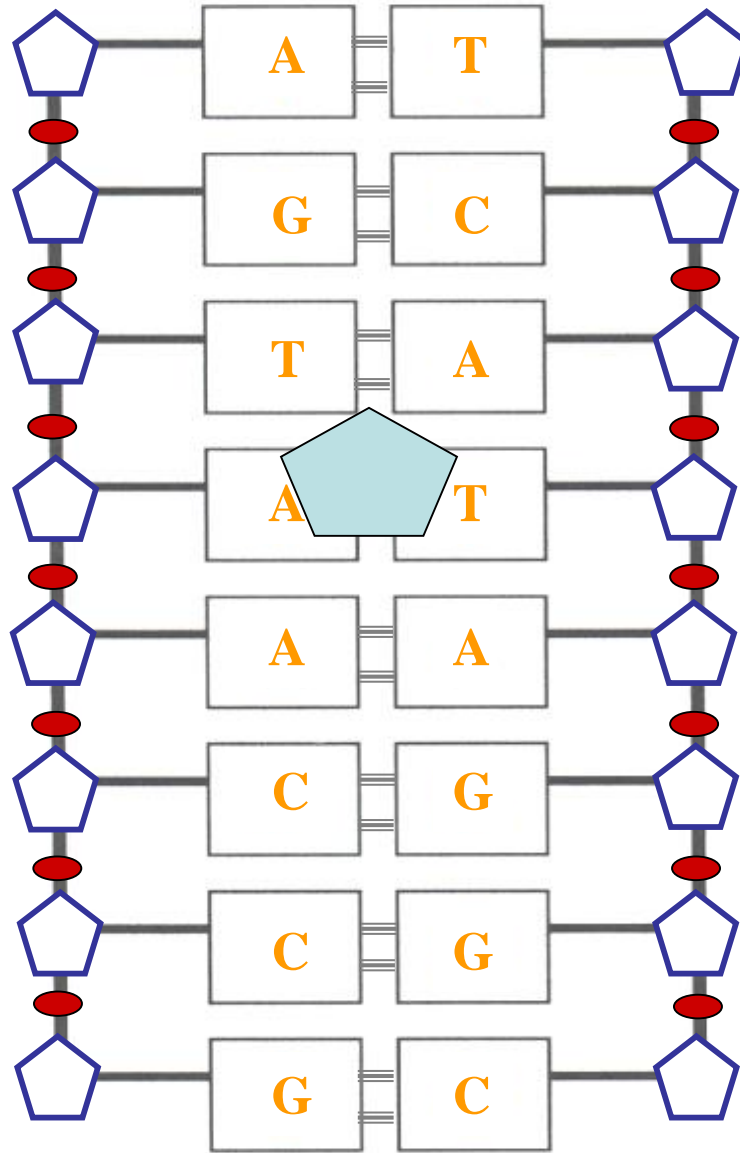
● = PHOSPHATE

⬡ = DEOXYRIBOSE

# REPLICATED DNA



DNA POLYMERASES  
PROOFREAD  
DNA REPLICATION  
LOOK FOR  
NUCLEOTIDE BASE  
PAIRING ERRORS



≡ = HYDROGEN BONDS

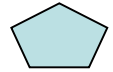
□ = BASE

● = PHOSPHATE

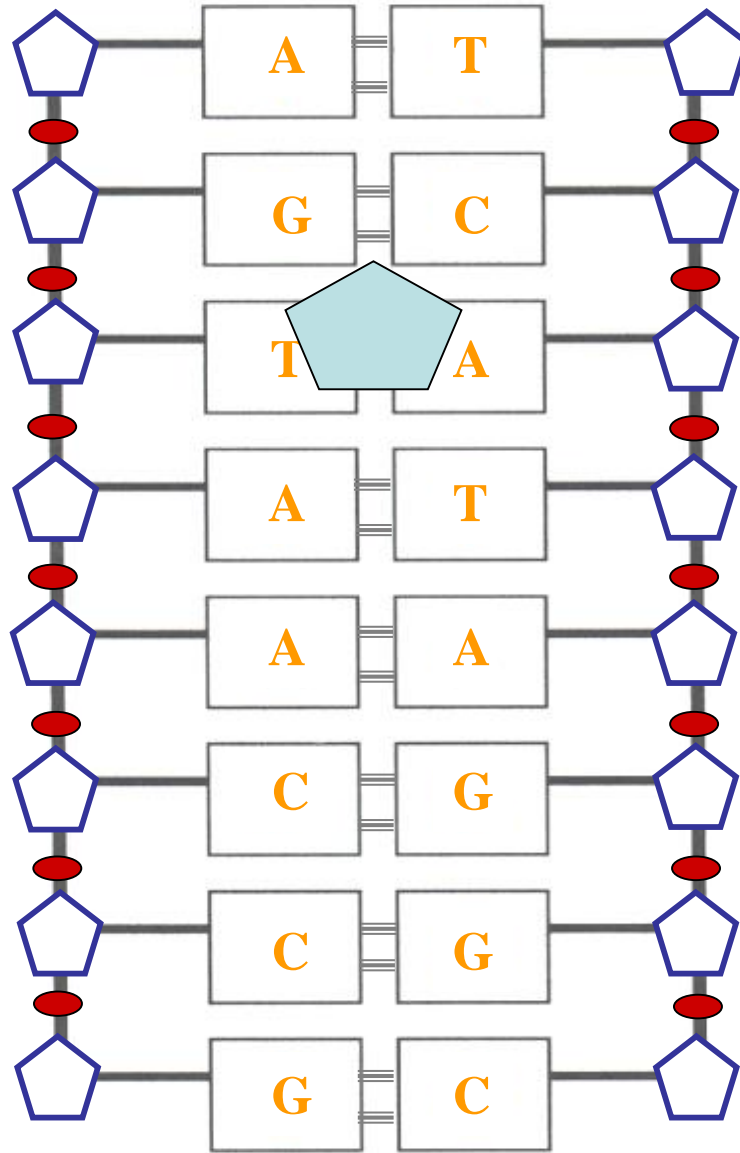
⬡ = DEOXYRIBOSE



# REPLICATED DNA



DNA POLYMERASES  
PROOFREAD  
DNA REPLICATION  
LOOK FOR  
NUCLEOTIDE BASE  
PAIRING ERRORS



≡ = HYDROGEN BONDS

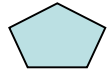
□ = BASE

● = PHOSPHATE

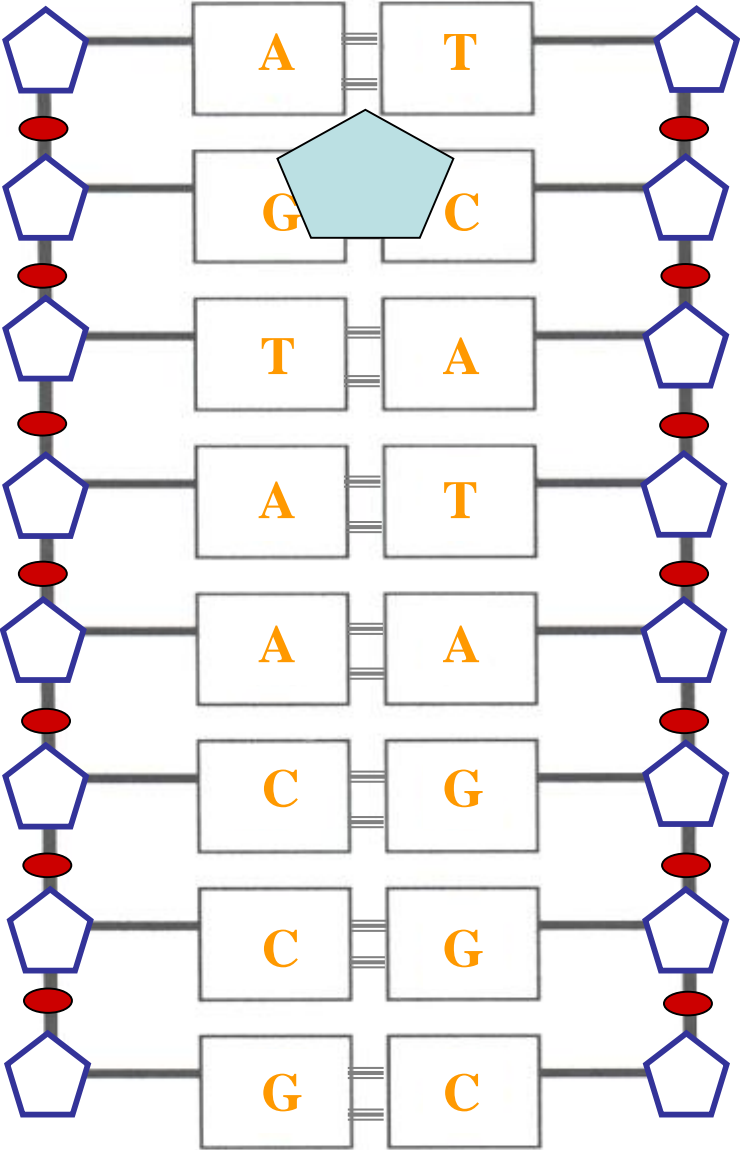
⬡ = DEOXYRIBOSE



# REPLICATED DNA



DNA POLYMERASES  
PROOFREAD  
DNA REPLICATION  
LOOK FOR  
NUCLEOTIDE BASE  
PAIRING ERRORS



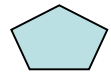
≡ = HYDROGEN BONDS

□ = BASE

● = PHOSPHATE

⬡ = DEOXYRIBOSE

# REPLICATED DNA



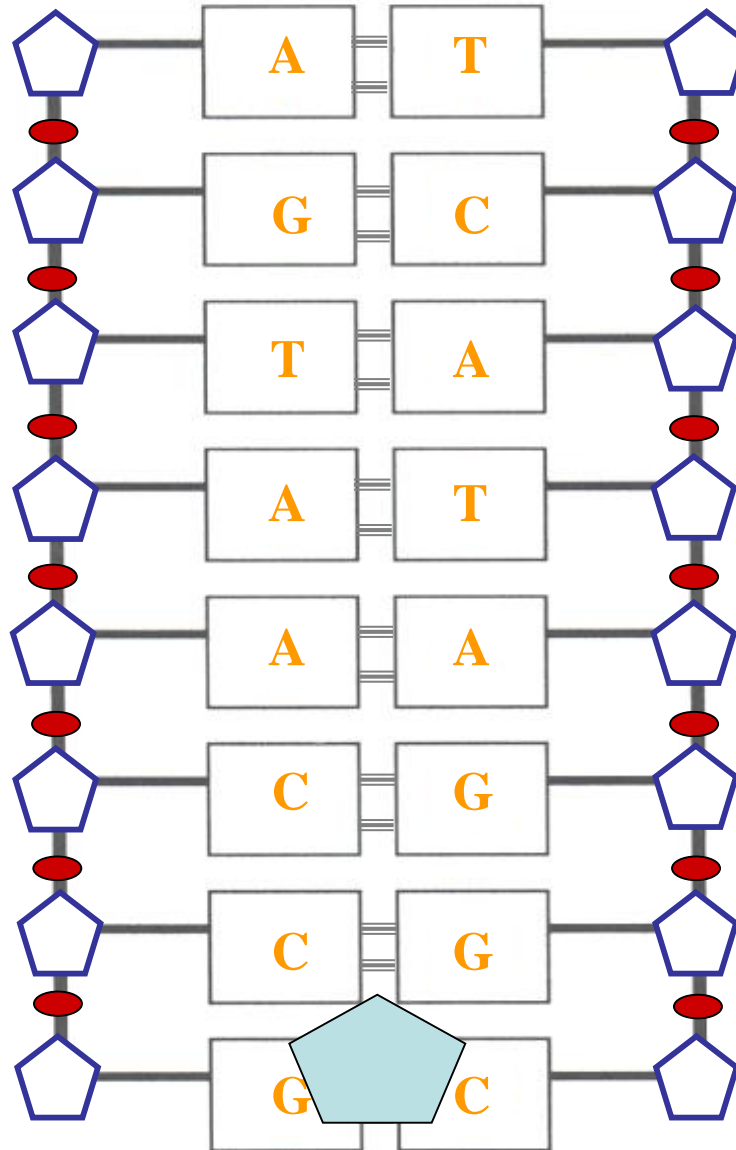
DNA POLYMERASES  
PROOFREAD  
DNA REPLICATION  
LOOK FOR  
NUCLEOTIDE BASE  
PAIRING ERRORS

≡ = HYDROGEN BONDS

□ = BASE

● = PHOSPHATE

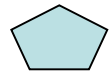
⬡ = DEOXYRIBOSE



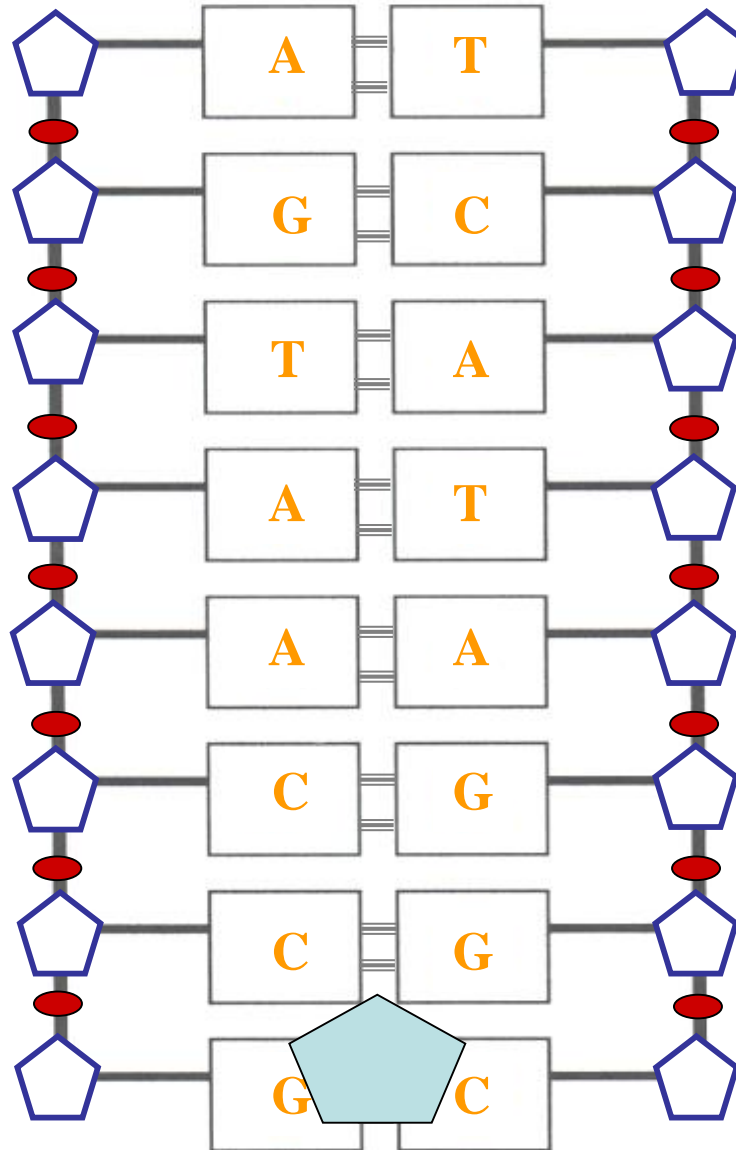
# REPLICATED DNA

A

+



DNA POLYMERASES  
PROOFREAD  
DNA REPLICATION  
LOOK FOR  
NUCLEOTIDE BASE  
PAIRING ERRORS



QUESTION

ANY NUCLEOTIDE  
PAIRING ERRORS?

QUESTION

≡ = HYDROGEN BONDS

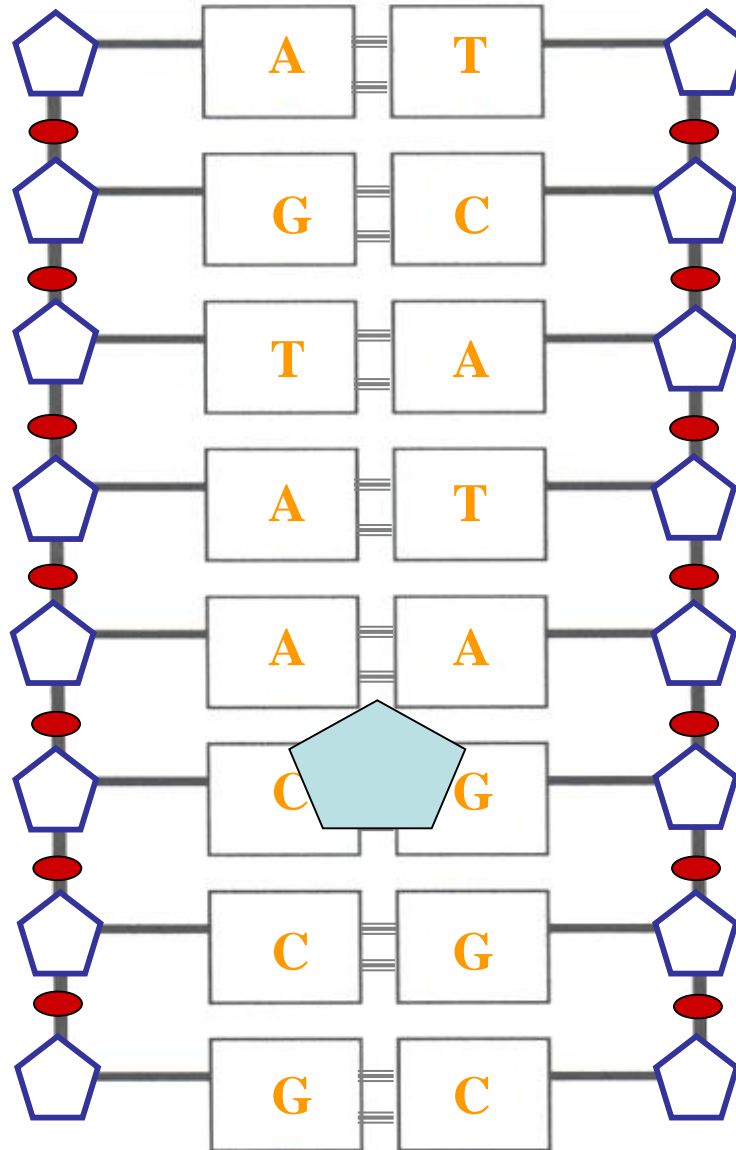
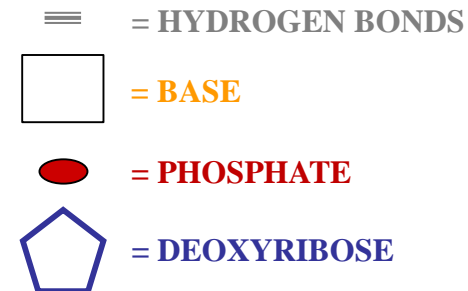
□ = BASE

● = PHOSPHATE

⬡ = DEOXYRIBOSE

# REPLICATED DNA

DNA POLYMERASES  
 PROOFREAD  
 DNA REPLICATION  
 LOOK FOR  
 NUCLEOTIDE BASE  
 PAIRING ERRORS

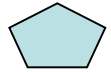


**QUESTION**

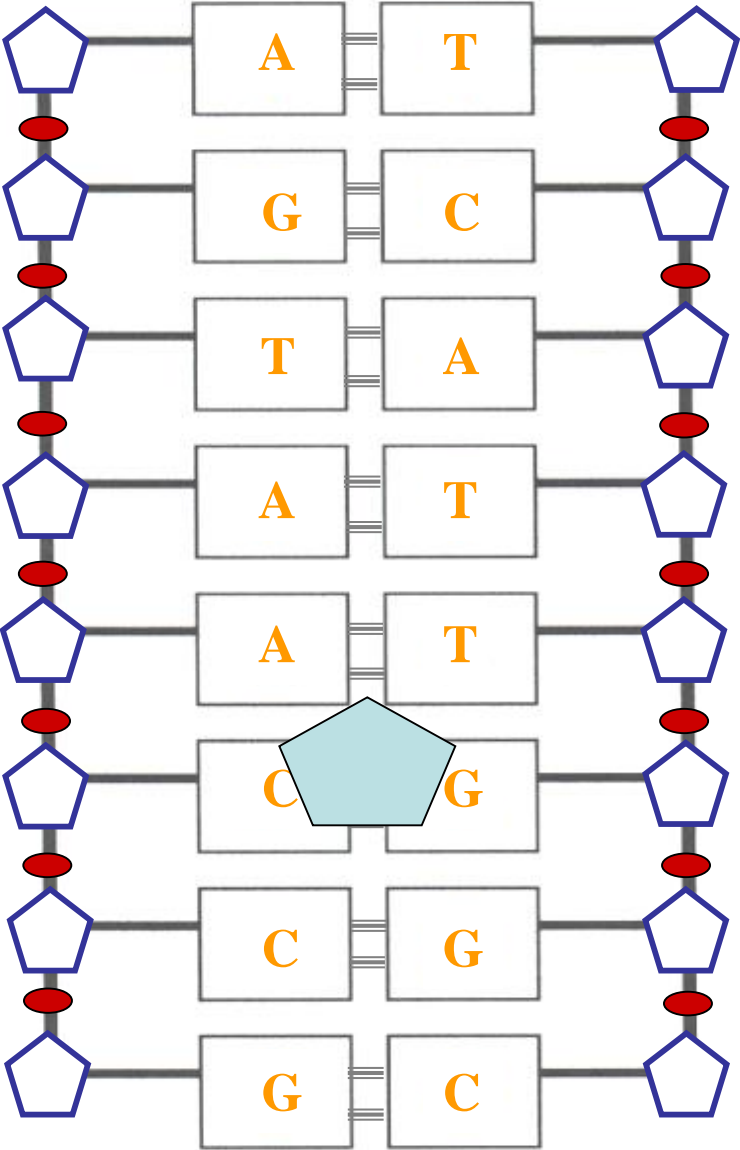
ANY NUCLEOTIDE  
 PAIRING ERRORS?

**QUESTION**

# REPLICATED DNA



DNA POLYMERASES  
CORRECT  
NUCLEOTIDE BASE  
PAIRING ERRORS



≡ = HYDROGEN BONDS

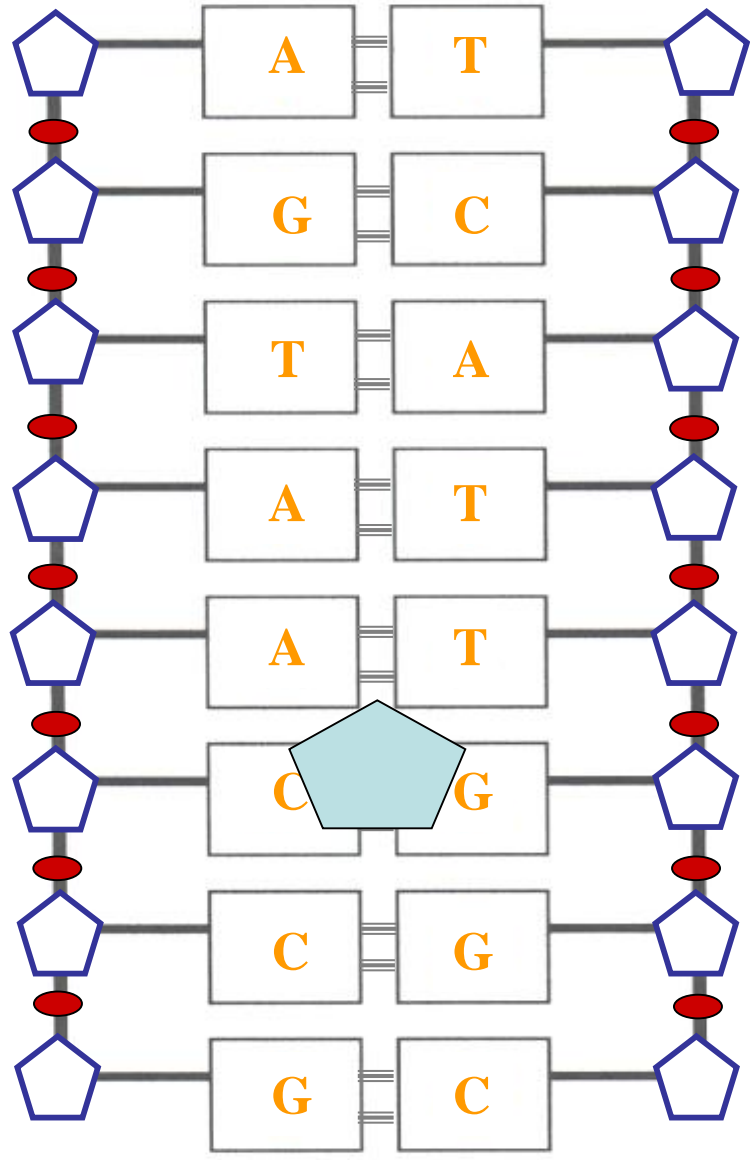
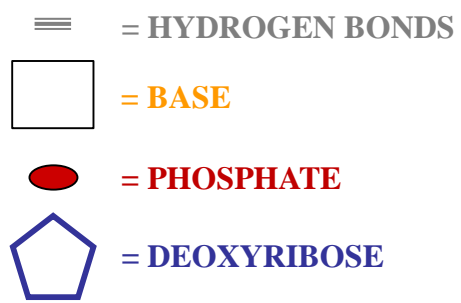
□ = BASE

● = PHOSPHATE

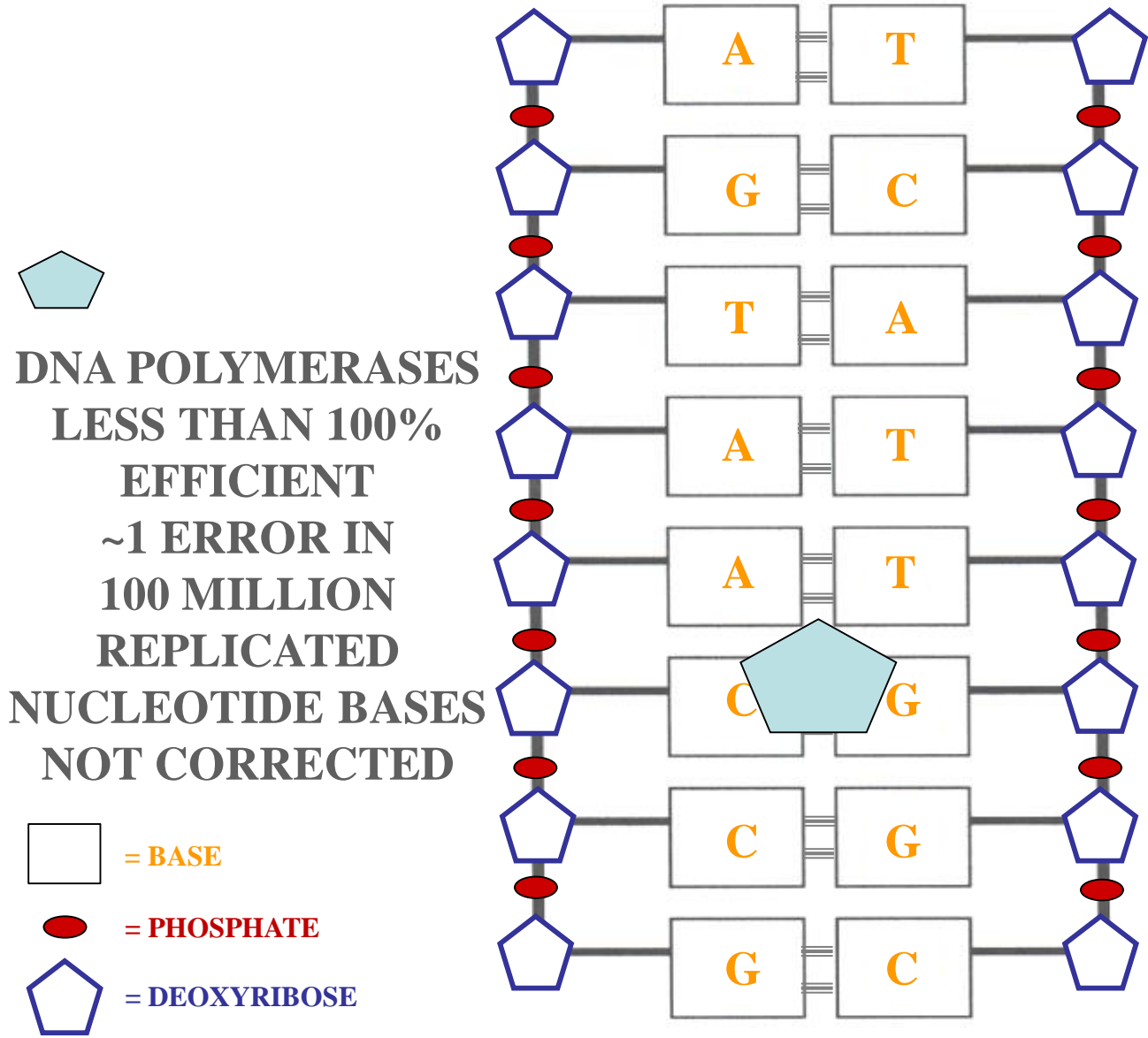
⬡ = DEOXYRIBOSE

# REPLICATED DNA

**DNA POLYMERASES  
LESS THAN 100%  
EFFICIENT  
FINDING  
BASE PAIRING  
ERRORS**

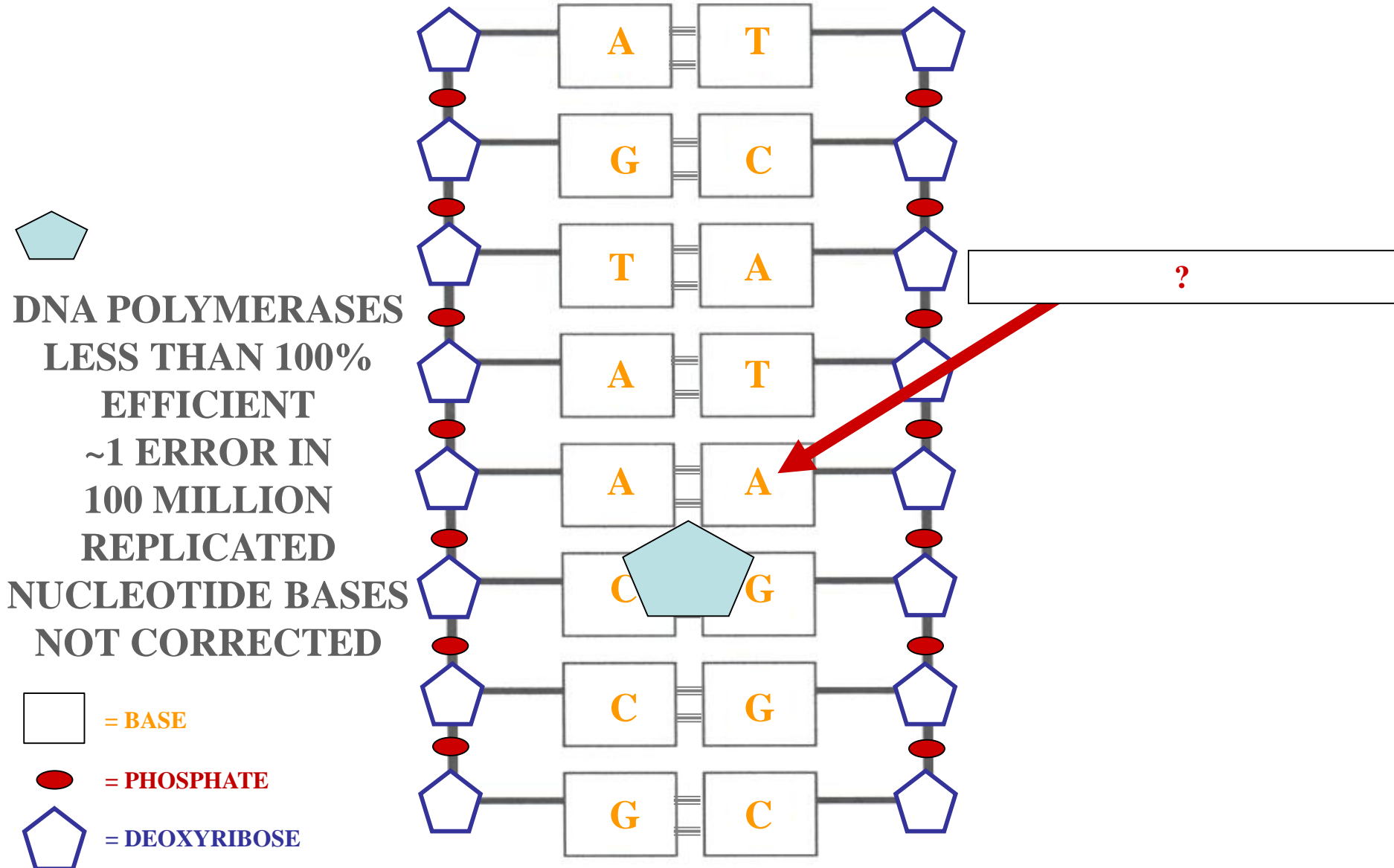


# REPLICATED DNA



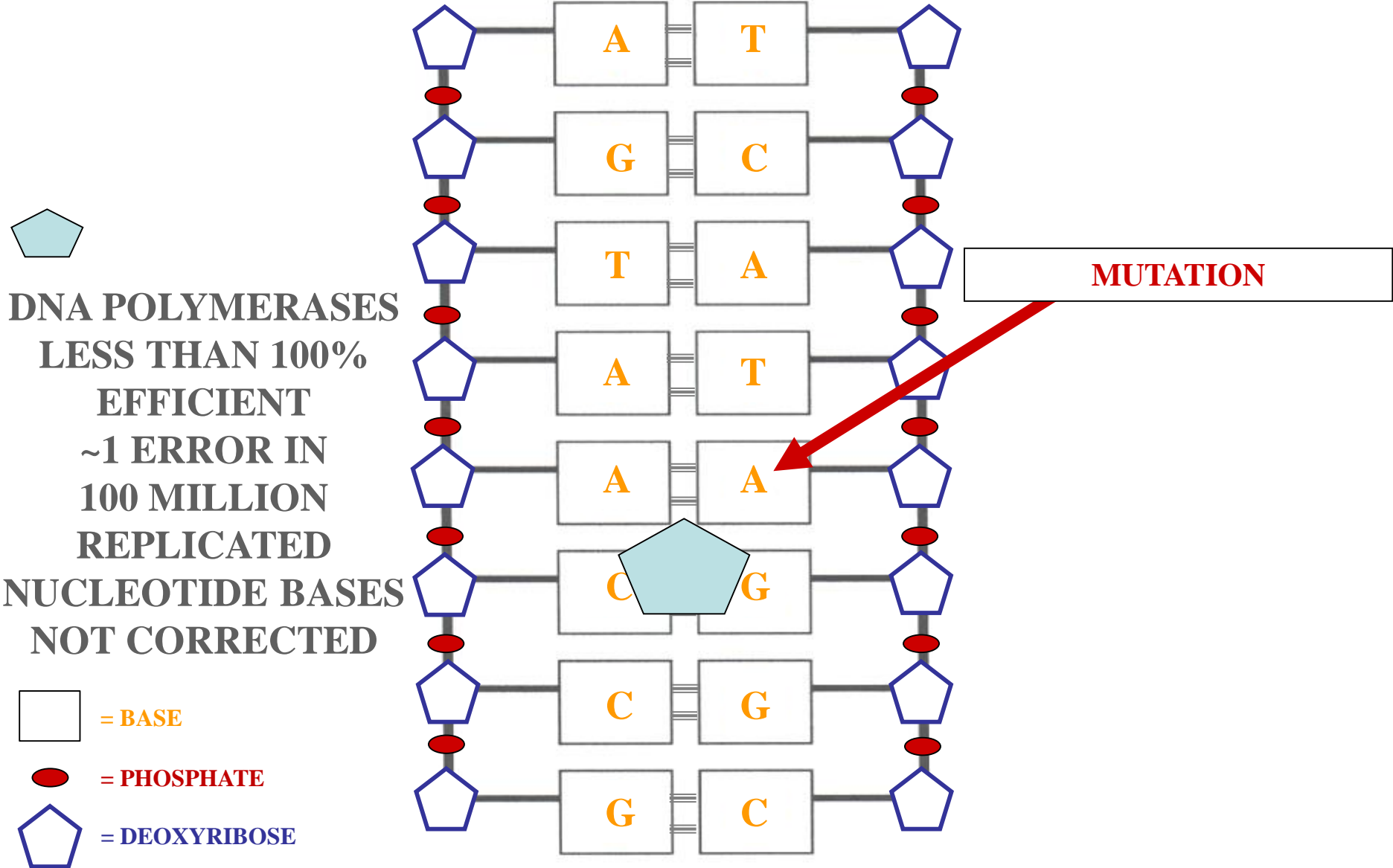


# REPLICATED DNA



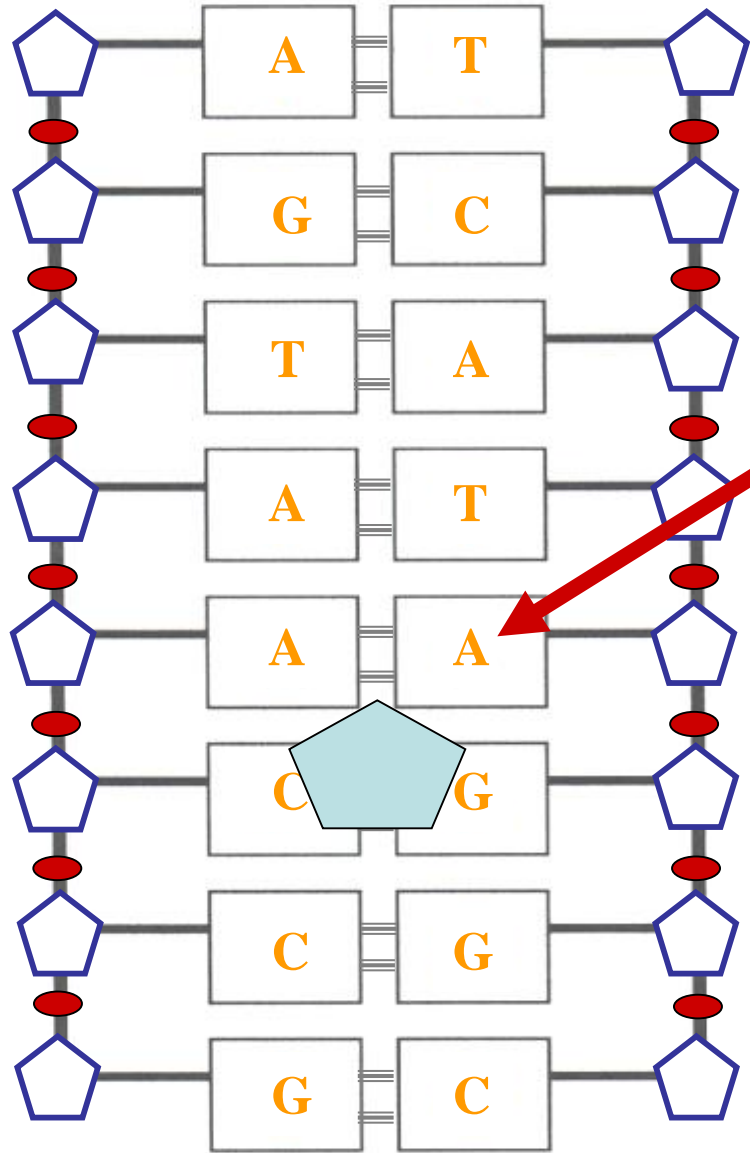
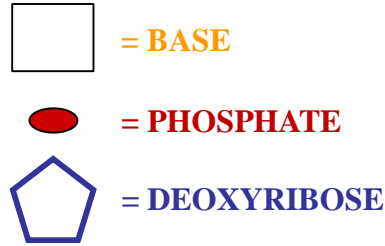
**DNA POLYMERASES  
LESS THAN 100%  
EFFICIENT  
~1 ERROR IN  
100 MILLION  
REPLICATED  
NUCLEOTIDE BASES  
NOT CORRECTED**

# REPLICATED DNA

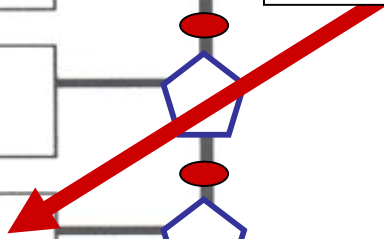


# REPLICATED DNA

DNA POLYMERASES  
LESS THAN 100%  
EFFICIENT  
~1 ERROR IN  
100 MILLION  
REPLICATED  
NUCLEOTIDE BASES  
NOT CORRECTED



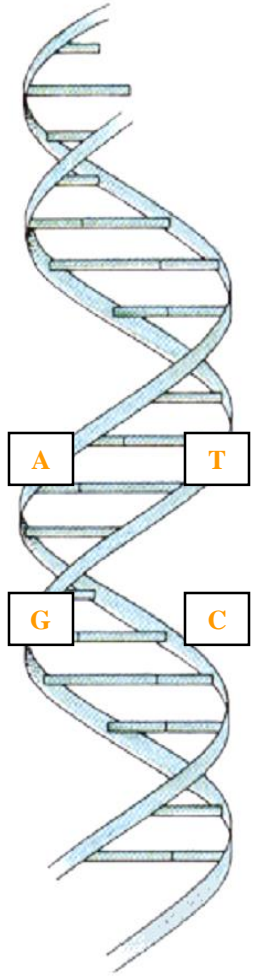
**GENE POINT MUTATION**





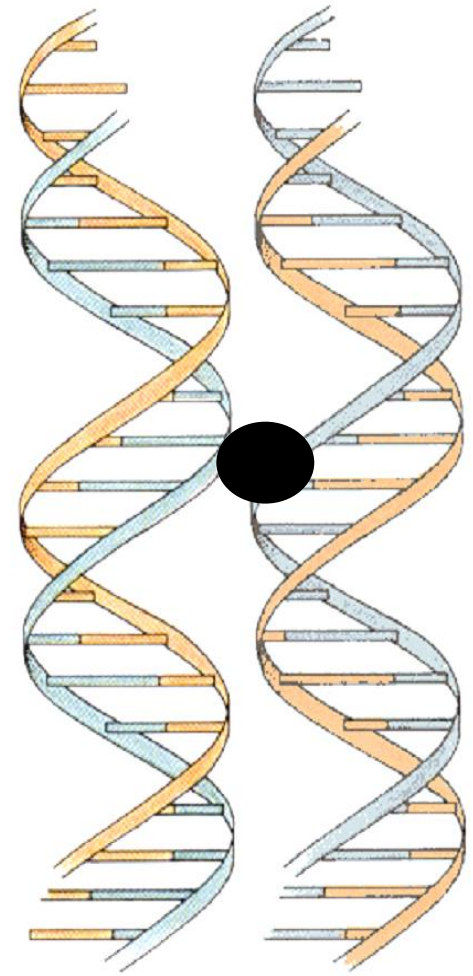
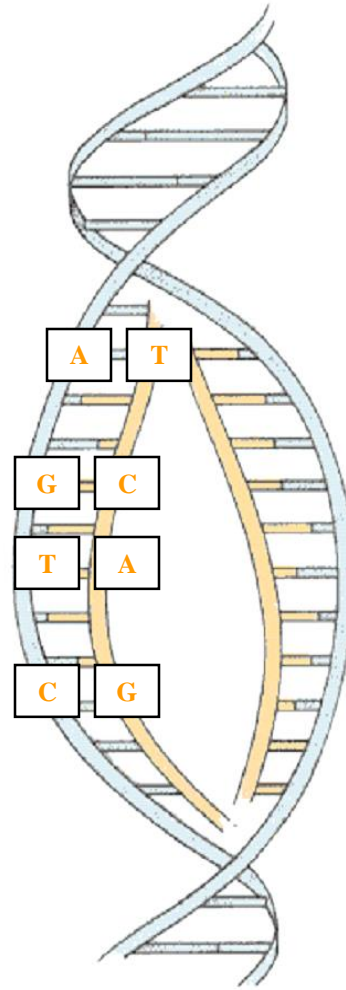
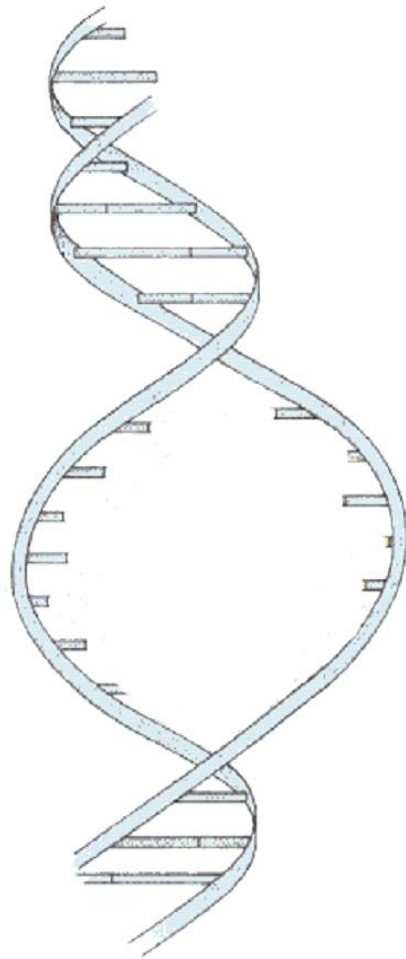
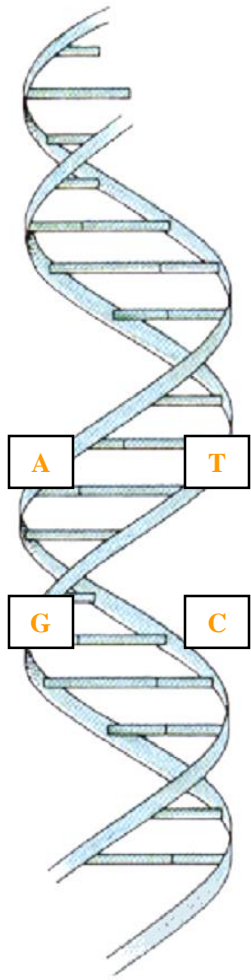
**DNA**  
**REPLICATION**  
**SPECIFICS**  
**OUTCOME**

# REPLICATION - OUTCOME



**CHROMOSOME**

# REPLICATION - OUTCOME

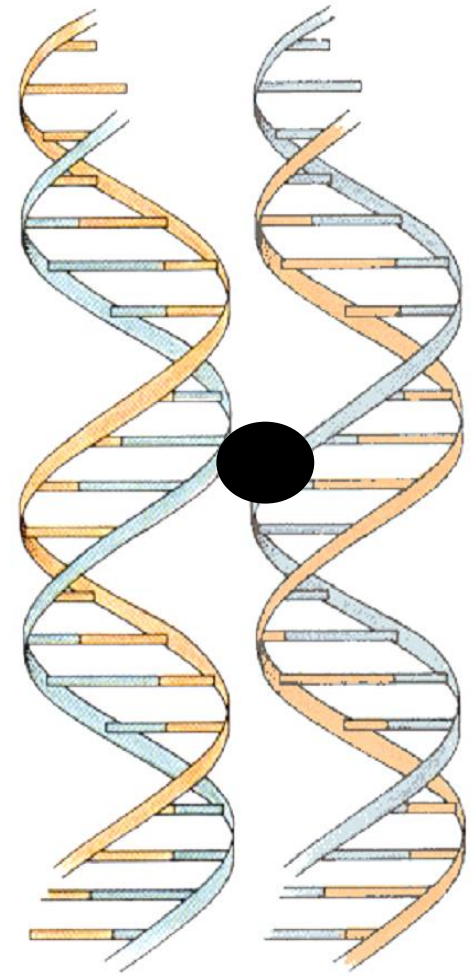
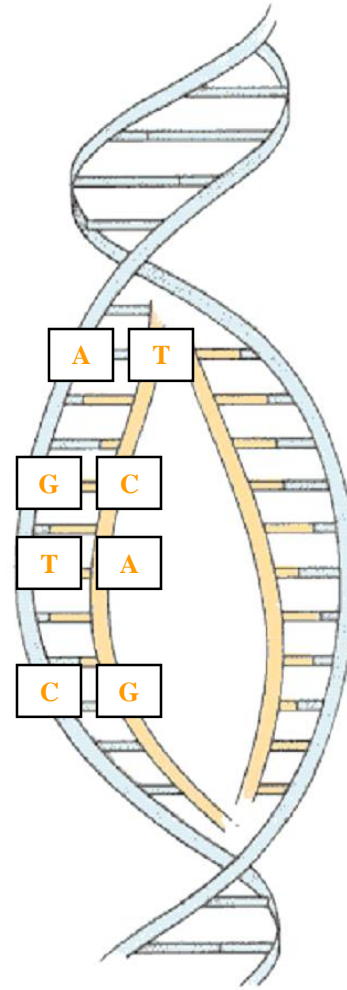
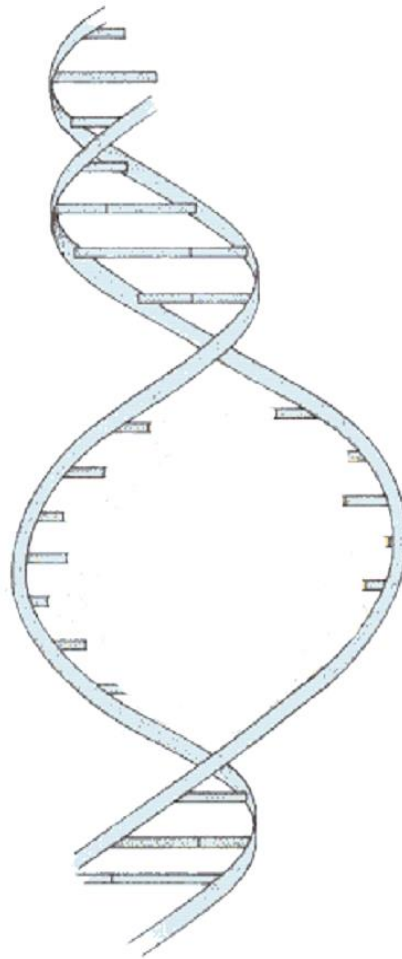
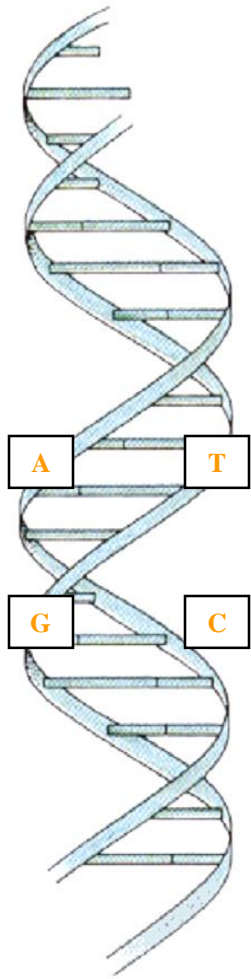


CHROMOSOME

REPLICATION

? CHROMOSOME

# REPLICATION - OUTCOME



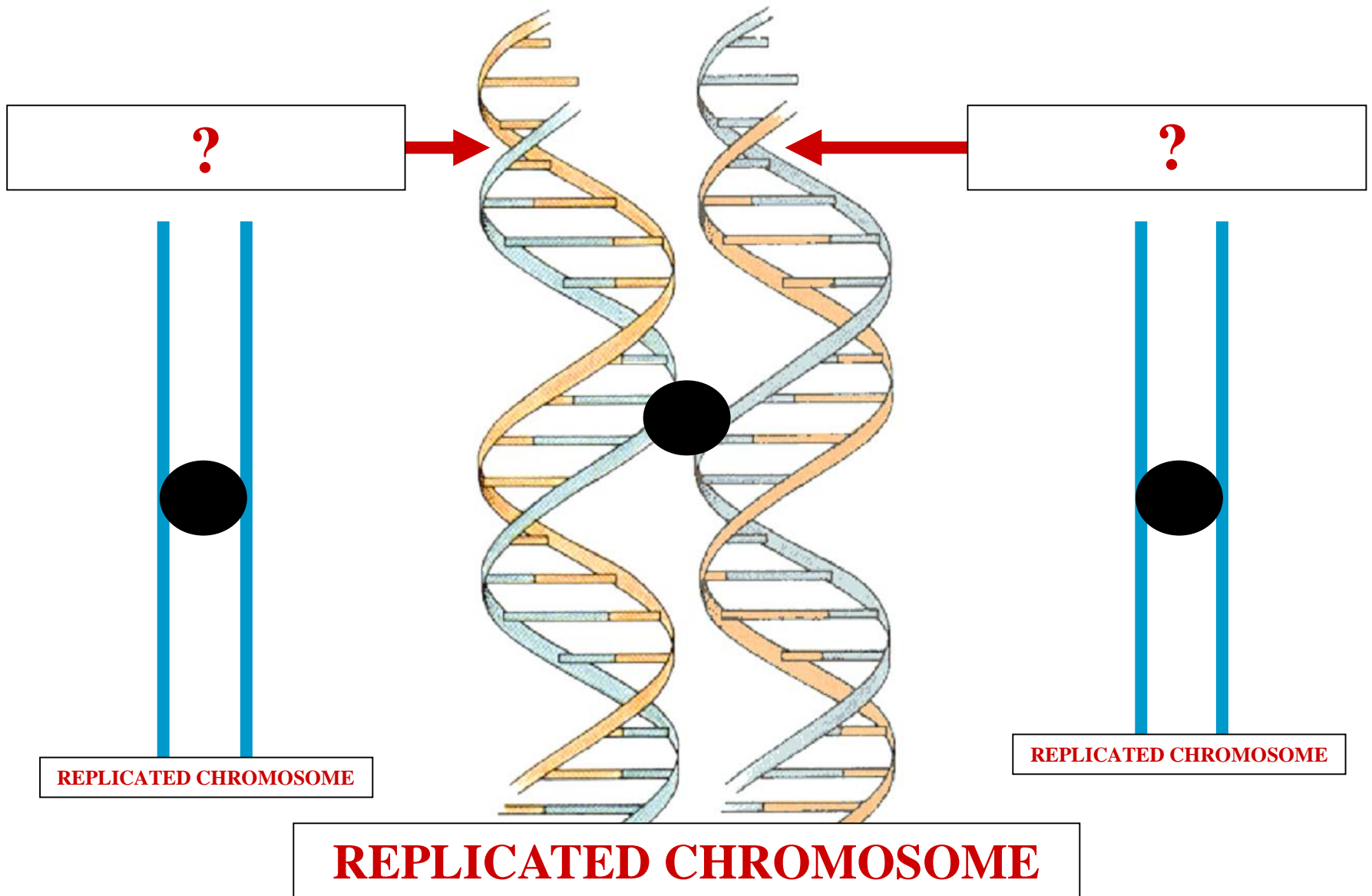
CHROMOSOME

REPLICATION

REPLICATED CHROMOSOME

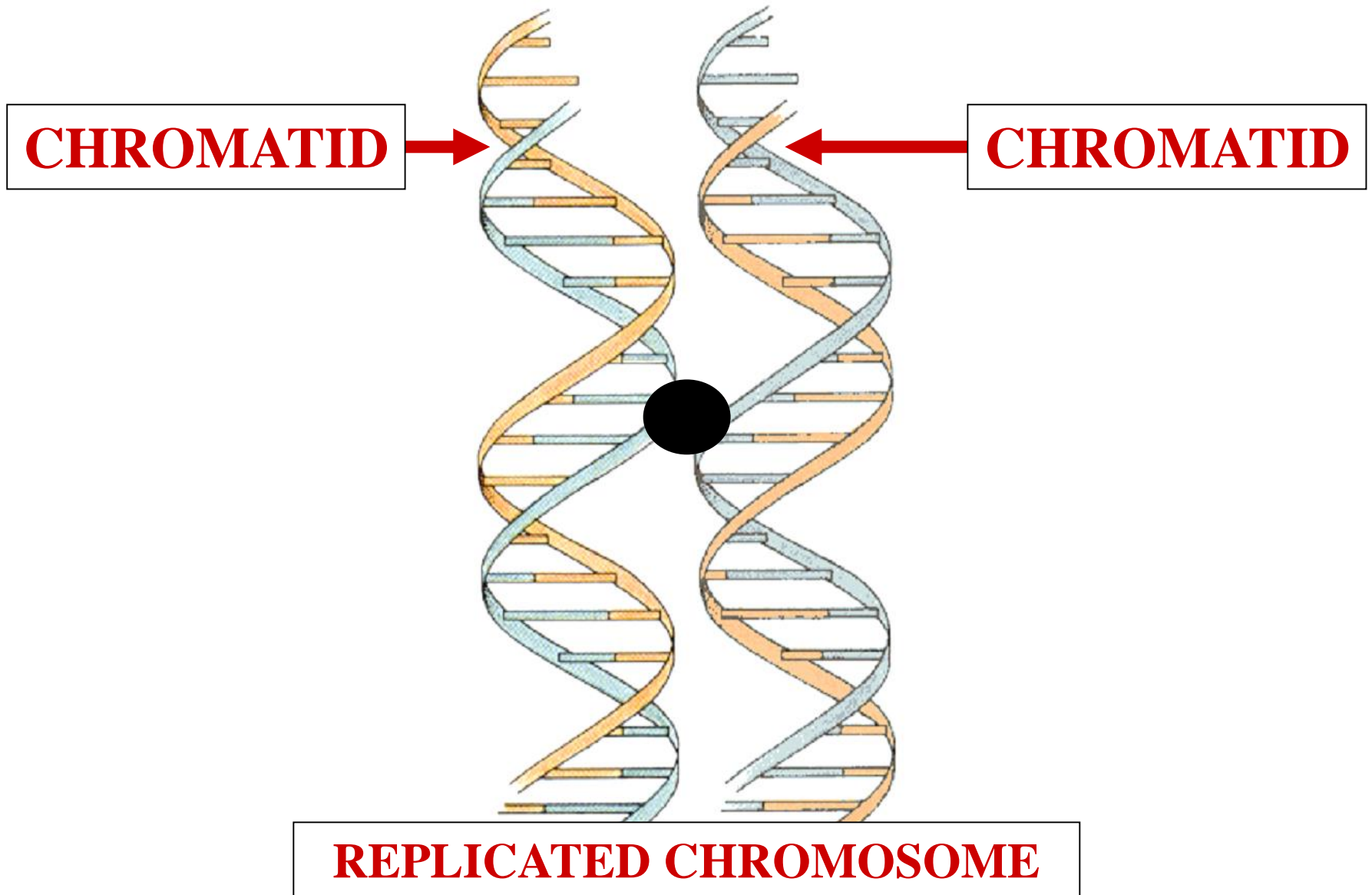


# REPLICATION - OUTCOME

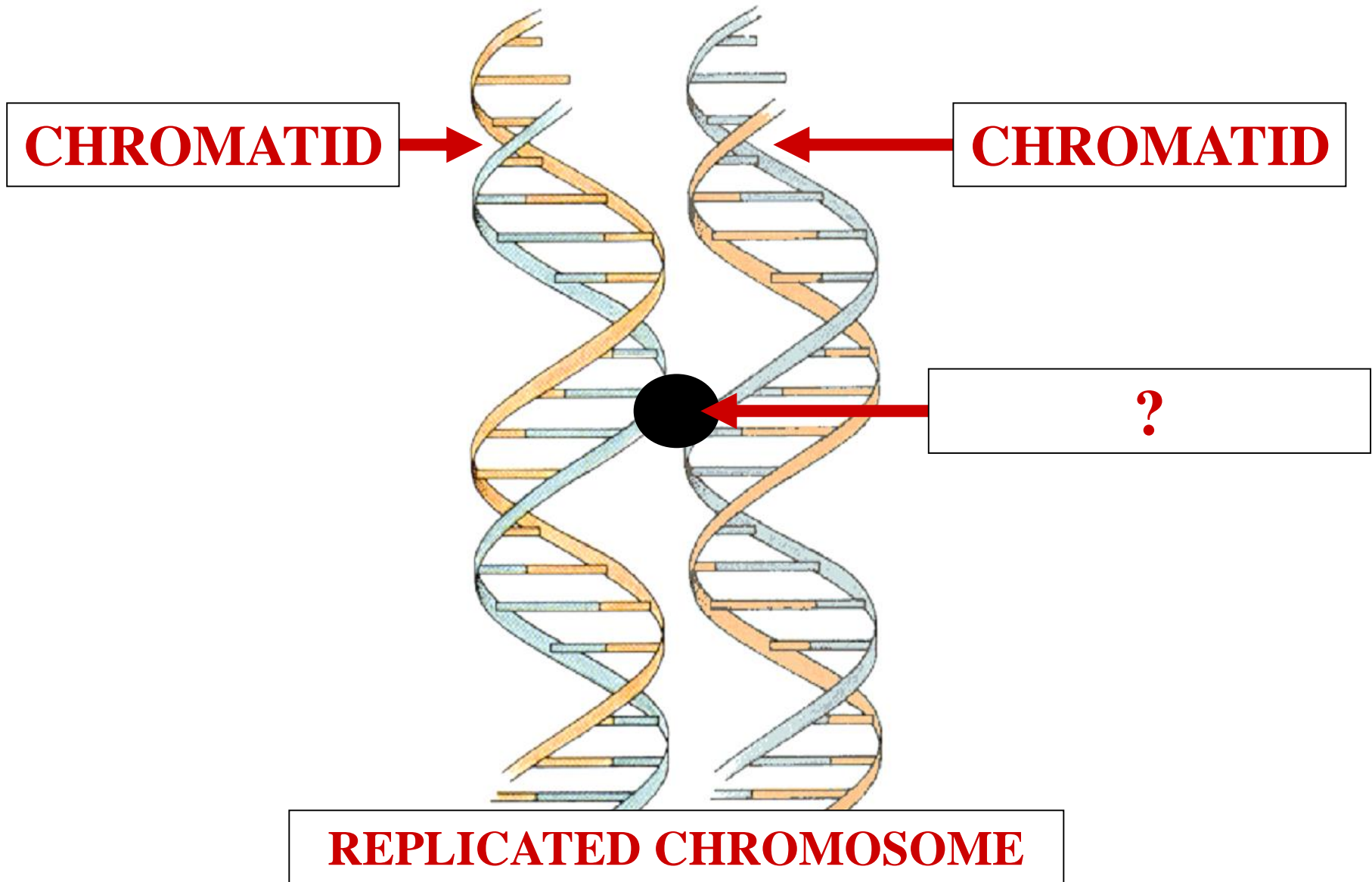




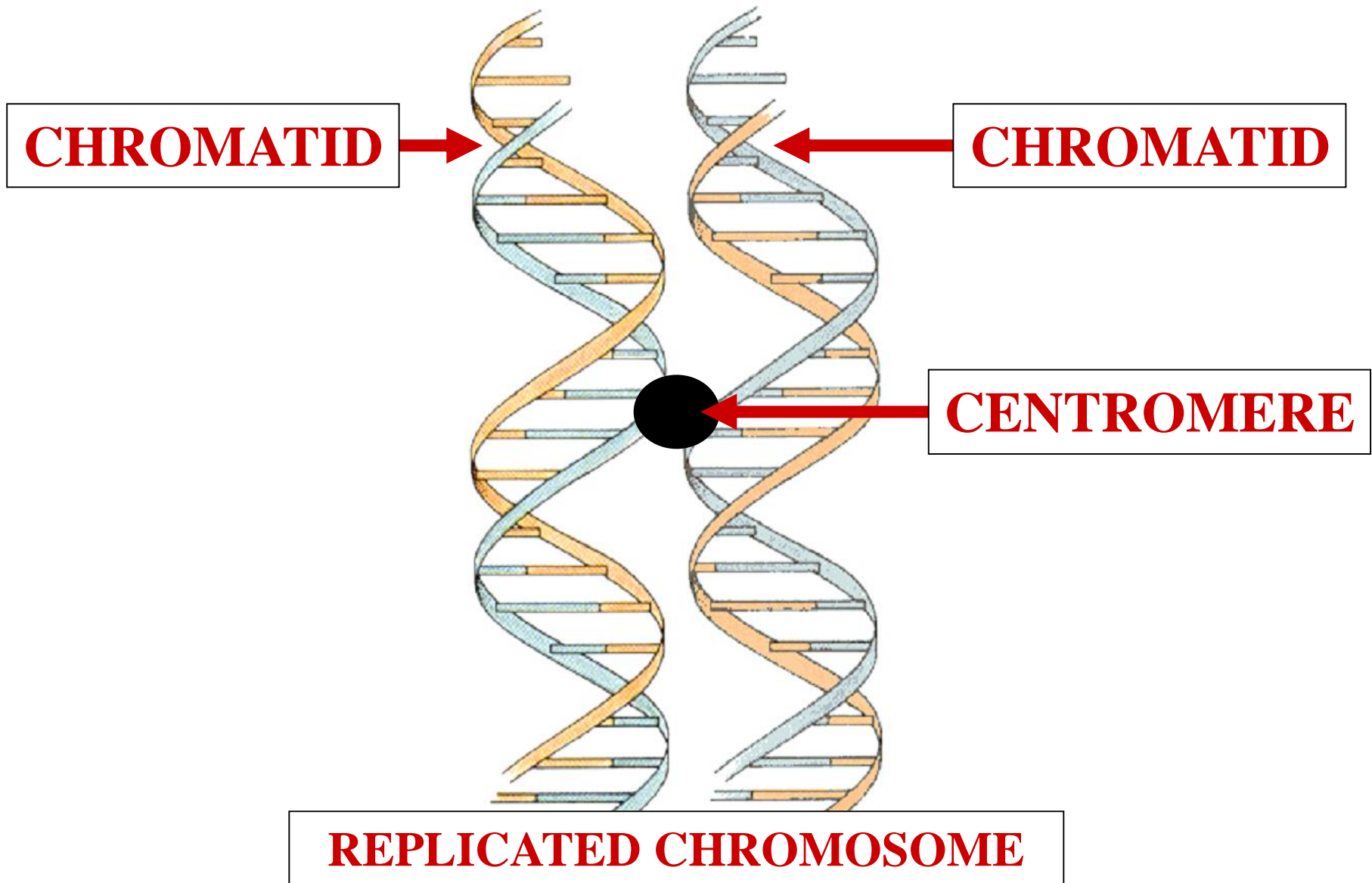
# REPLICATION - OUTCOME



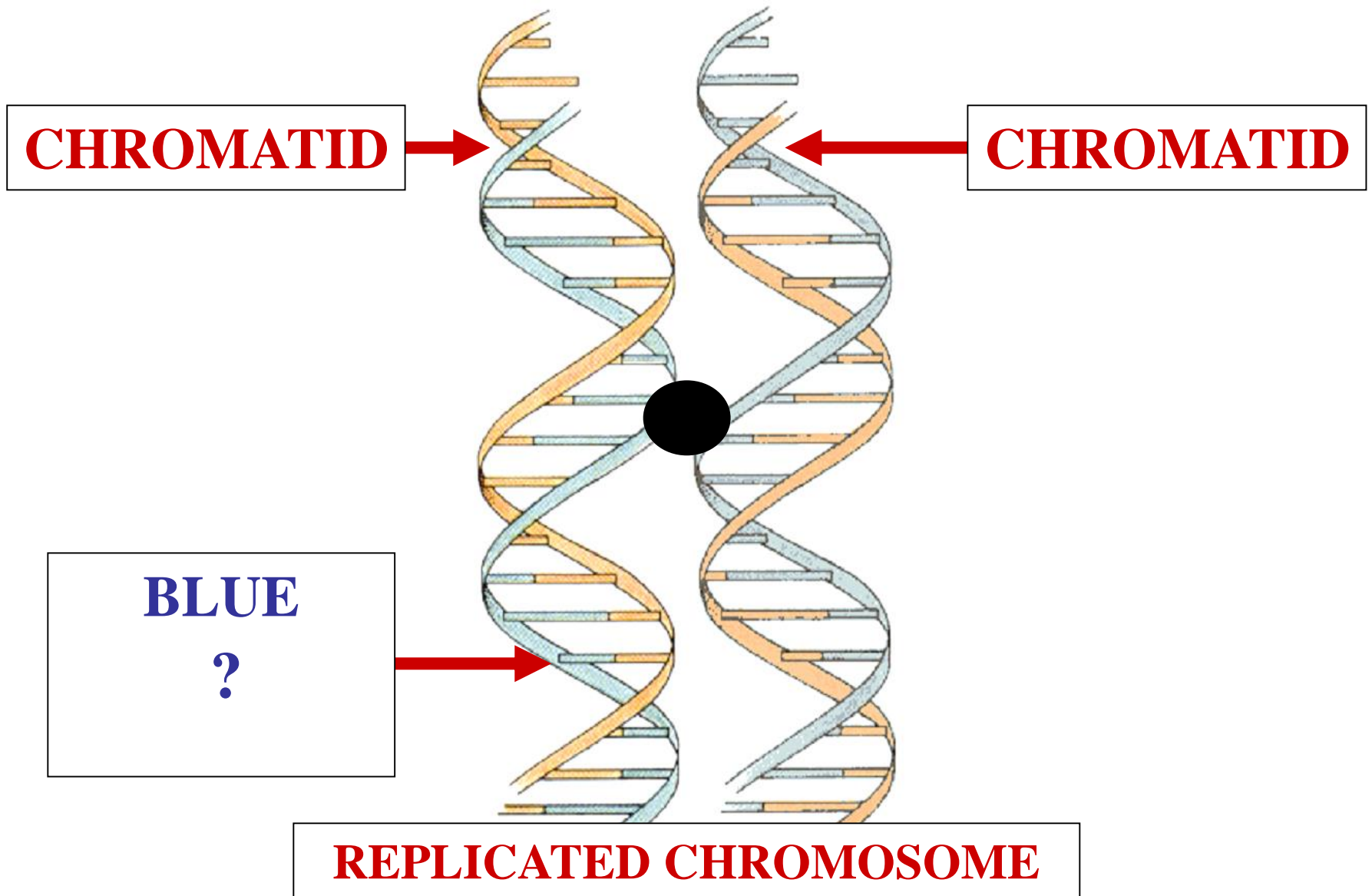
# REPLICATION - OUTCOME



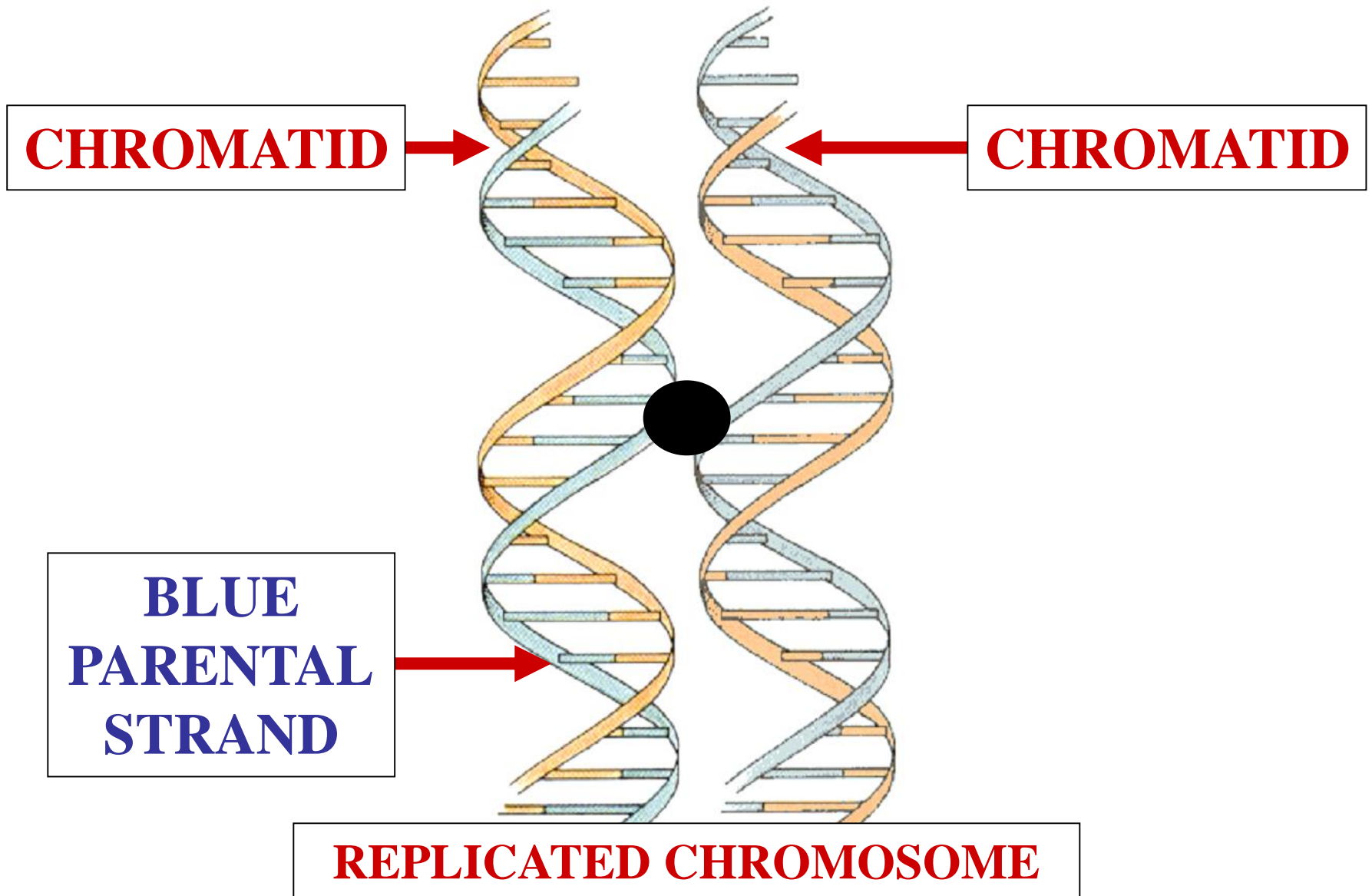
# REPLICATION - OUTCOME



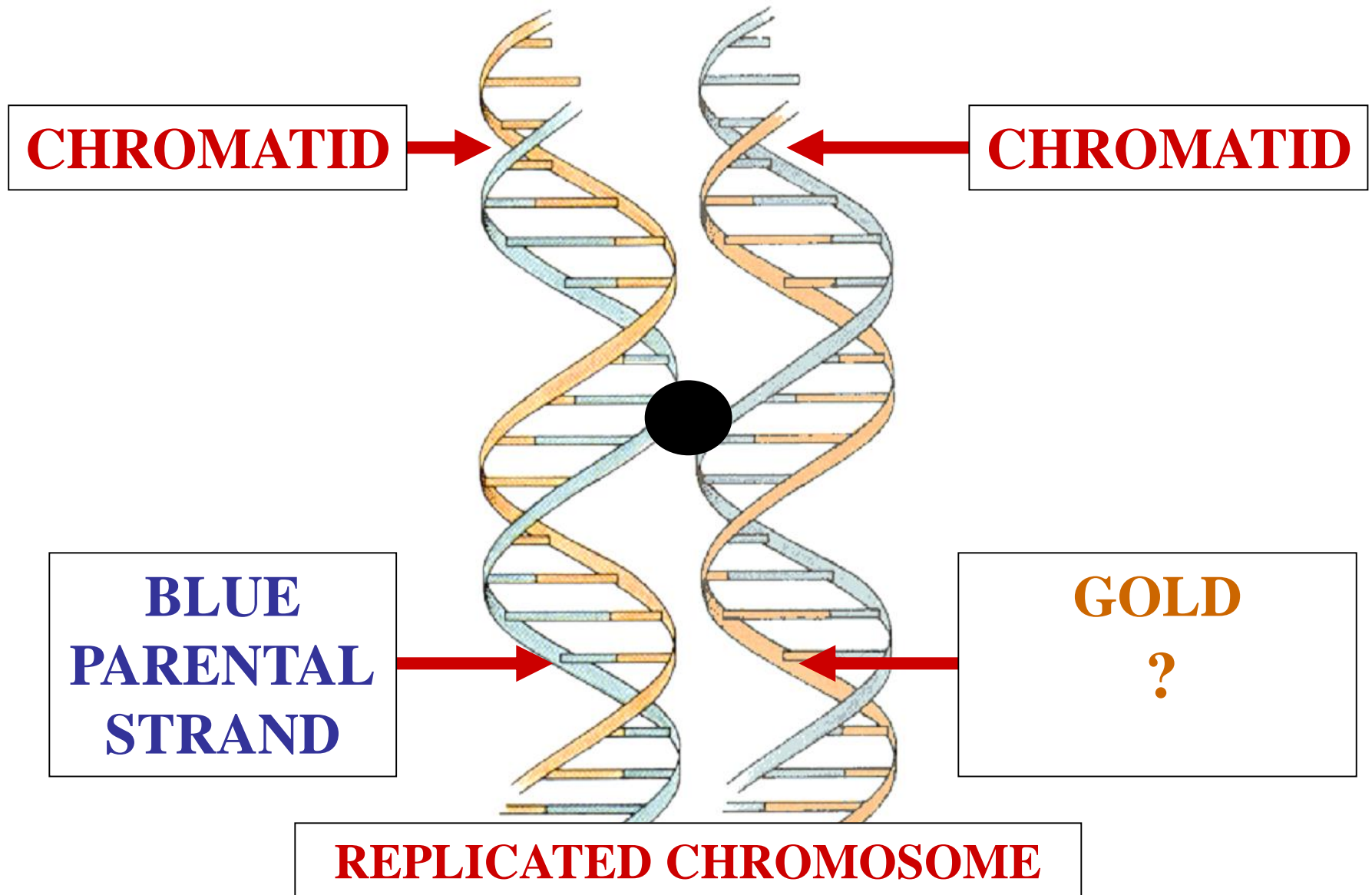
# REPLICATION - OUTCOME



# REPLICATION - OUTCOME

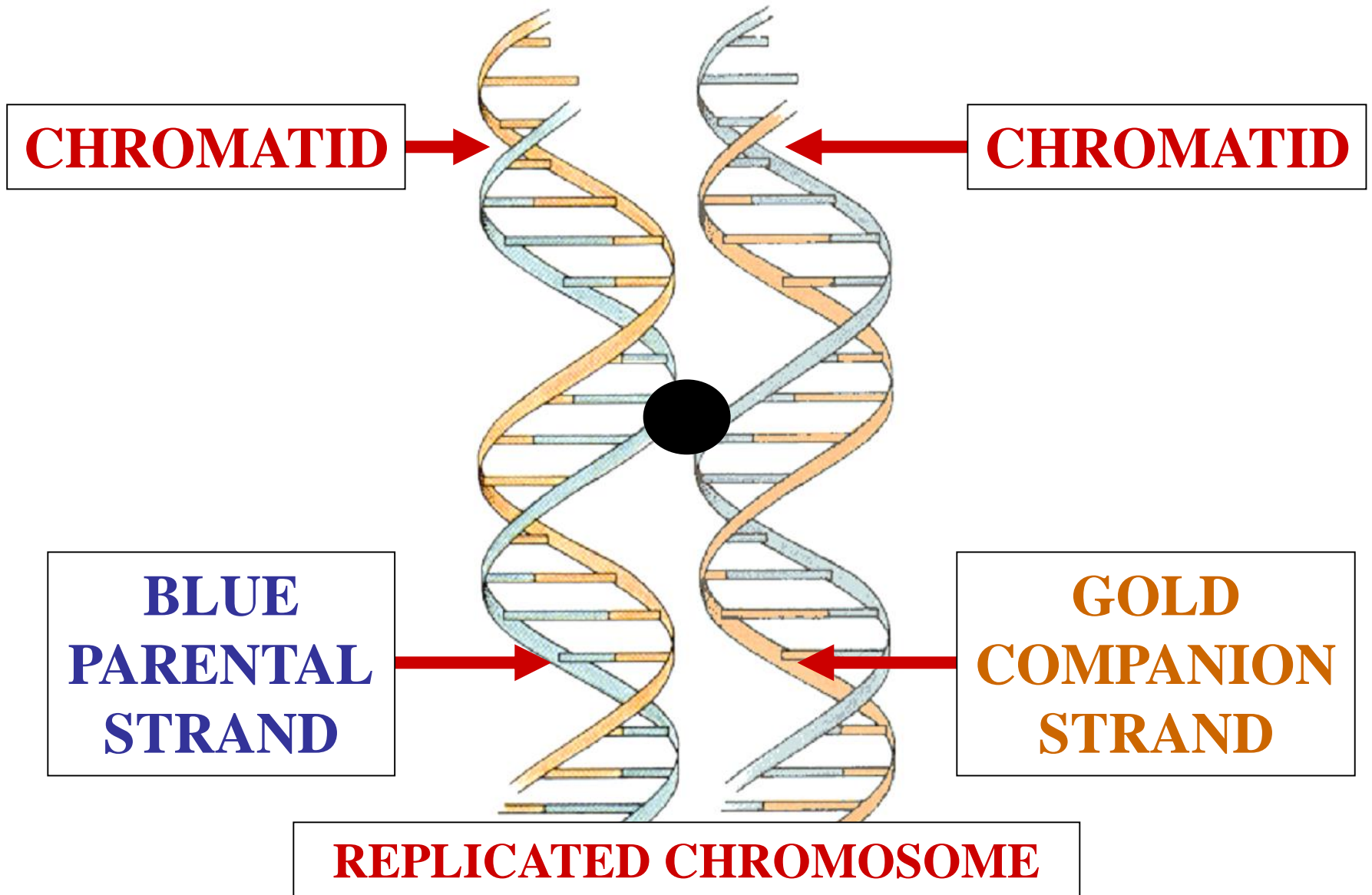


# REPLICATION - OUTCOME

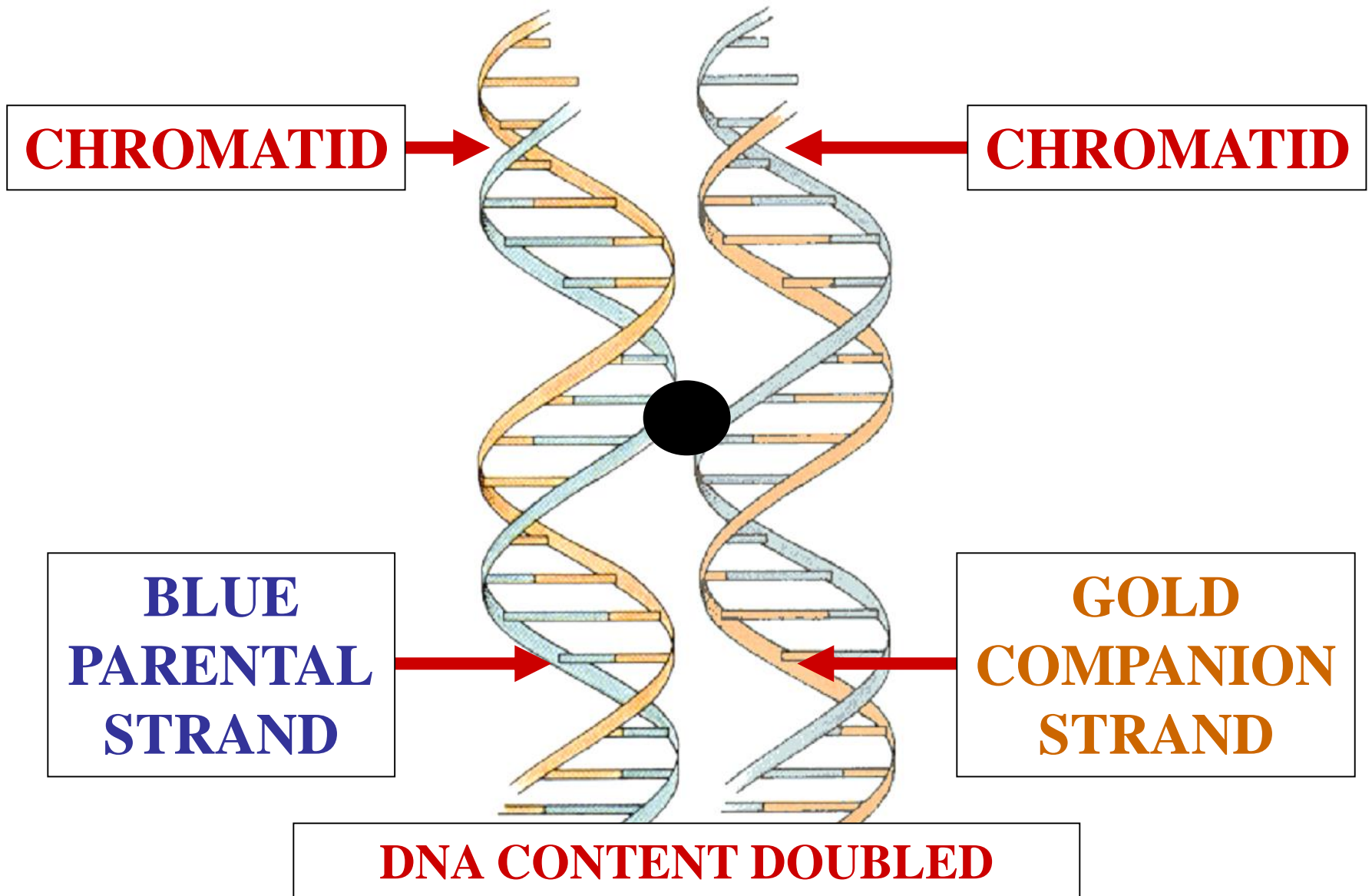




# REPLICATION - OUTCOME

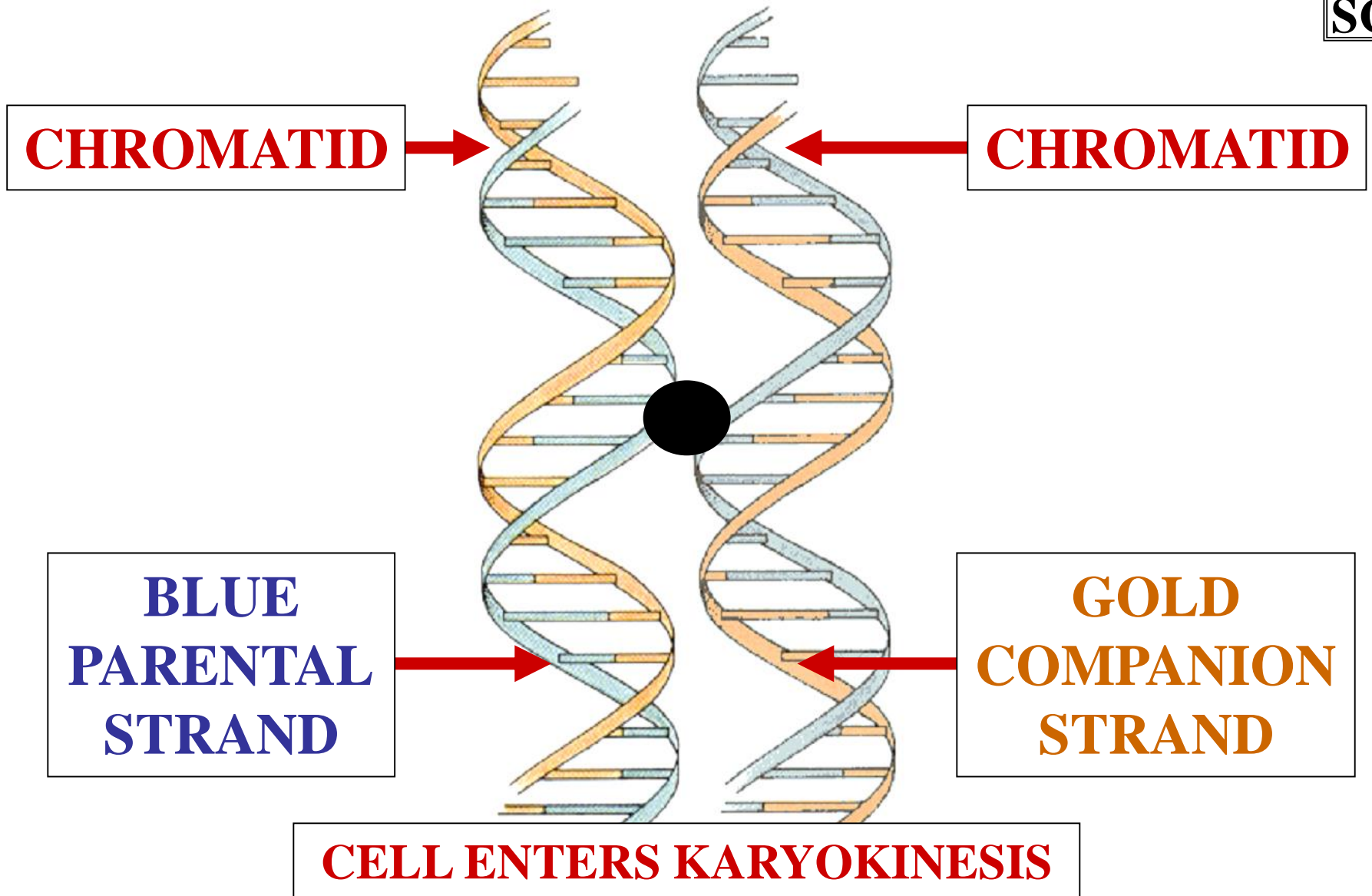


# REPLICATION - OUTCOME





# REPLICATION - OUTCOME



**CHROMATID**

**CHROMATID**

**BLUE  
PARENTAL  
STRAND**

**GOLD  
COMPANION  
STRAND**

**CELL ENTERS KARYOKINESIS**



**NUCLEUS**  
46  
**CHROMOSOMES**

**SOMATIC  
CELL**

**KARYOKINESIS**



**NUCLEUS**  
46  
CHROMOSOMES

**SOMATIC  
CELL**

**MITOSIS**

**NUCLEUS**  
46  
CHROMOSOMES

**SOMATIC  
CELL**

**NUCLEUS**  
46  
CHROMOSOMES

**SOMATIC  
CELL**



**NUCLEUS**  
**46**  
**CHROMOSOMES**

**GERM**  
**CELL**

**KARYOKINESIS**



**NUCLEUS**  
46  
CHROMOSOMES

**GERM CELL**

**MEIOSIS**

**NUCLEUS**  
23  
CHROMOSOMES

**GAMETE**

**NUCLEUS**  
23  
CHROMOSOMES

**GAMETE**

**NUCLEUS**  
23  
CHROMOSOMES

**GAMETE**

**NUCLEUS**  
23  
CHROMOSOMES

**GAMETE**





# CHAPTER 17

## PROTEIN SYNTHESIS





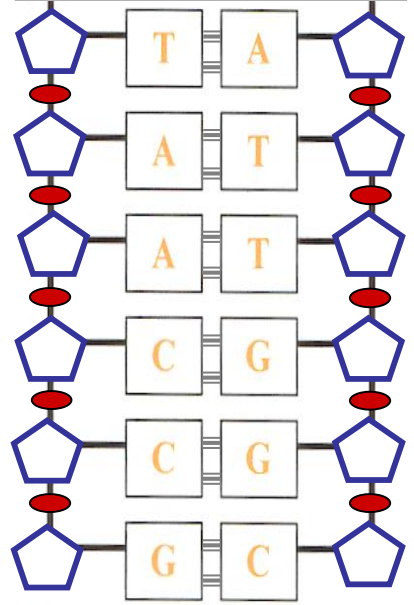
**~10 MILLION SPECIES**



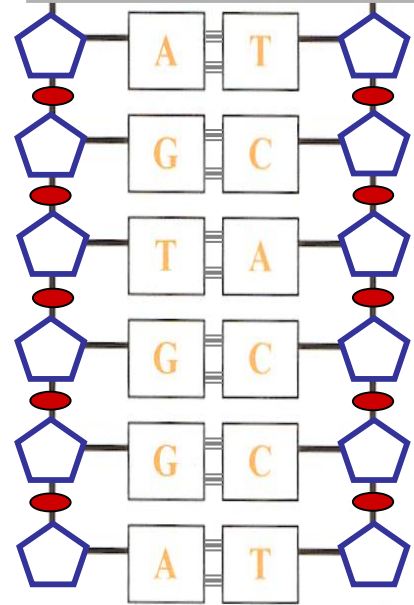
**EARTH**

# DIFFERENT SPECIES

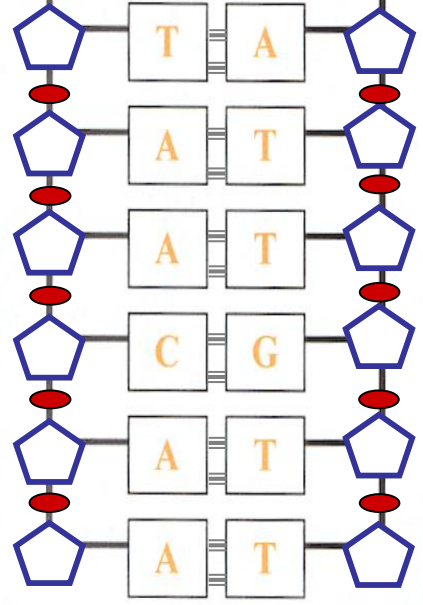
SPECIES #1



SPECIES #2



SPECIES #3



= BASE



= PHOSPHATE



= DEOXYRIBOSE

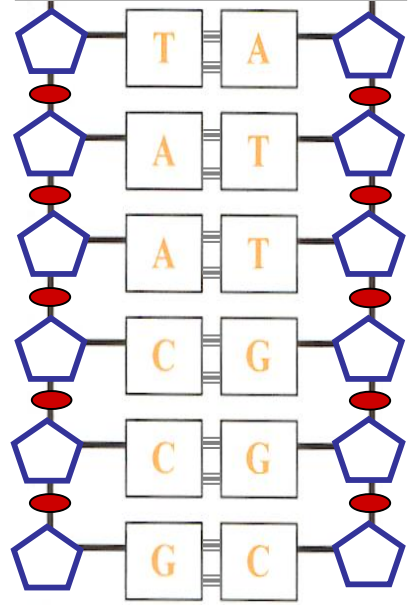


= HYDROGEN BONDS

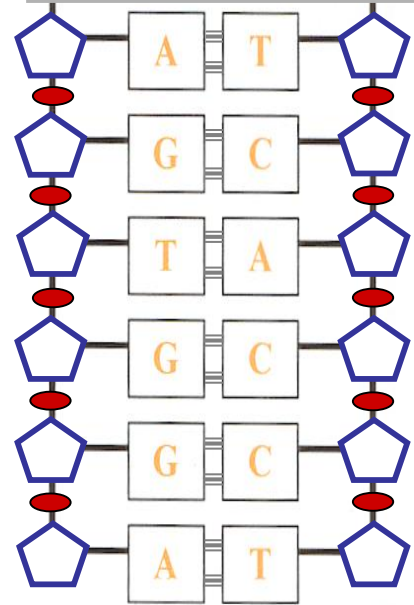


# DIFFERENT SPECIES / DIFFERENT DNA

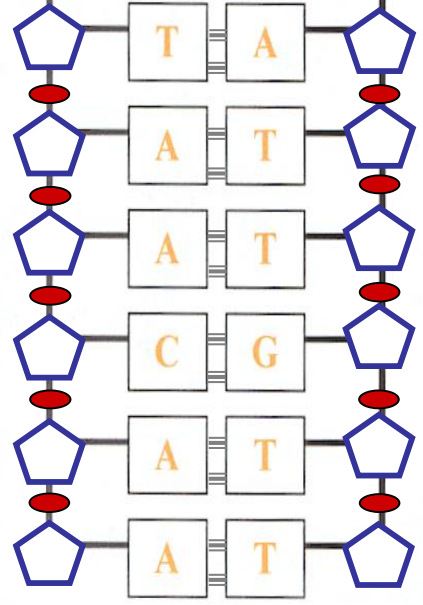
SPECIES #1



SPECIES #2



SPECIES #3



 = BASE     = PHOSPHATE     = DEOXYRIBOSE     = HYDROGEN BONDS

**QUESTION**

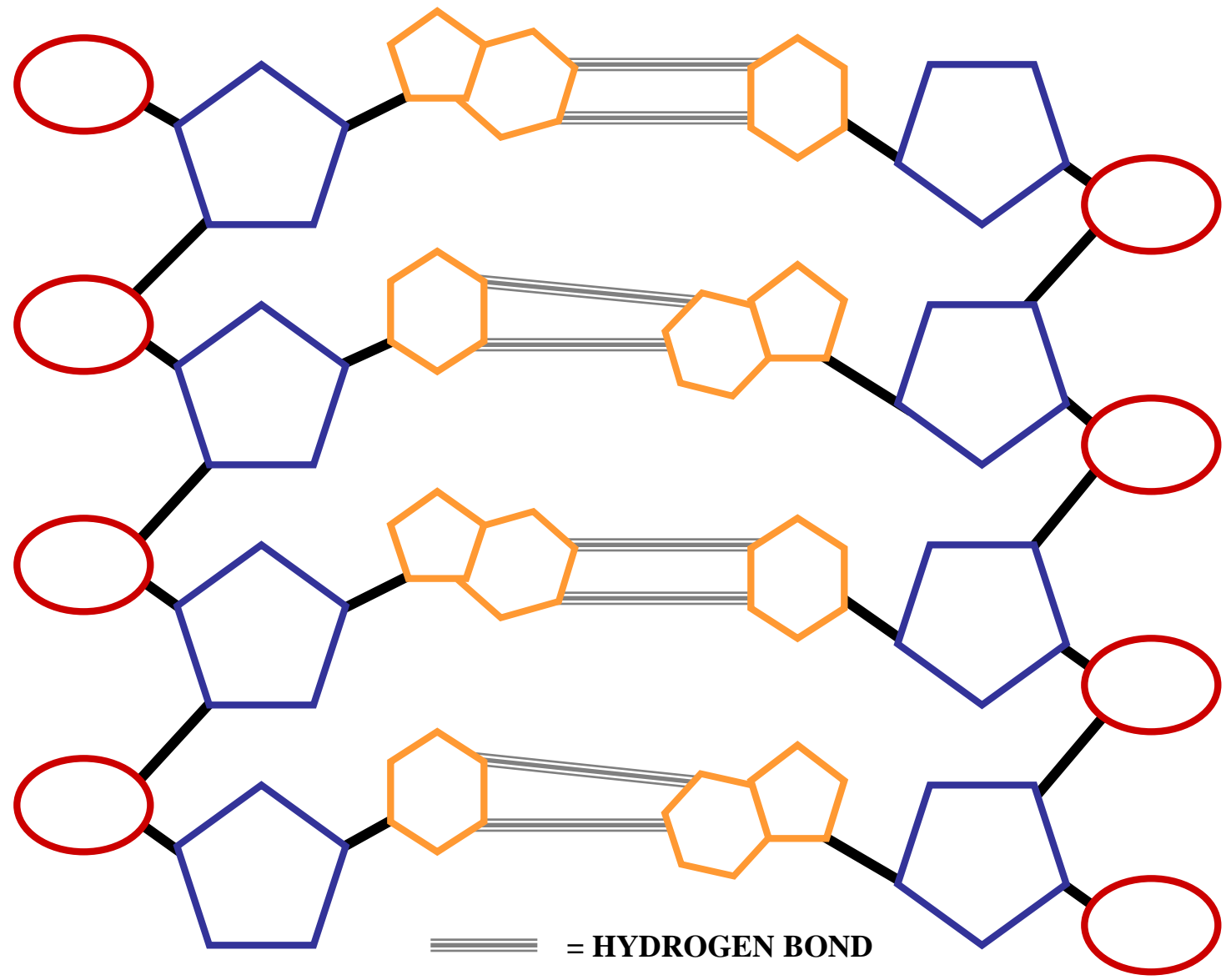


**WHAT DIFFERS  
BETWEEN  
SPECIES DNA?**

**QUESTION**

# DNA DOUBLE HELIX MODEL

ANTIPARALLEL  
POLYNUCLEOTIDE CHAIN



ANTIPARALLEL  
POLYNUCLEOTIDE CHAIN

== = HYDROGEN BOND

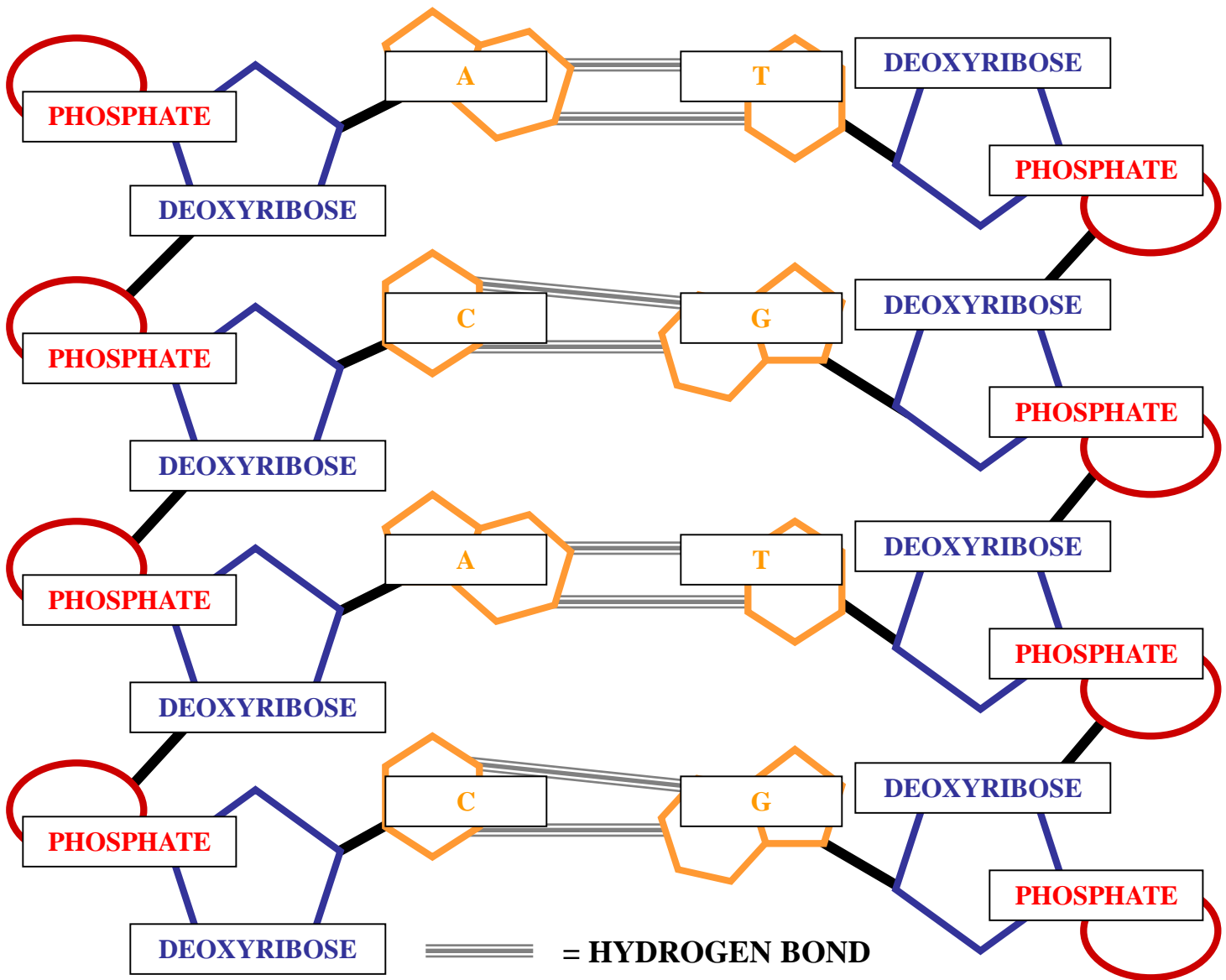




# DNA DOUBLE HELIX MODEL

ANTIPARALLEL  
POLYNUCLEOTIDE CHAIN

ANTIPARALLEL  
POLYNUCLEOTIDE CHAIN



== = HYDROGEN BOND



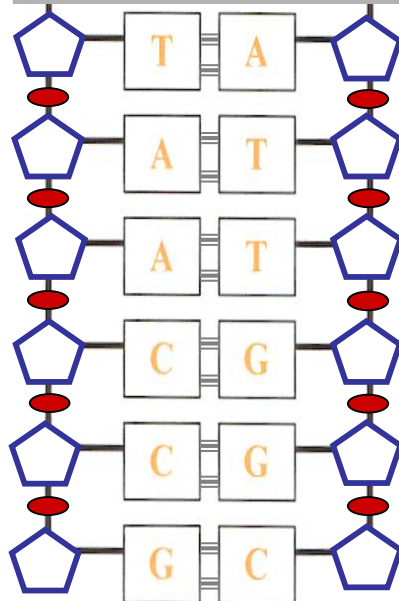
**ANSWER**

**SEQUENCE  
NUCLEOTIDE  
BASES**

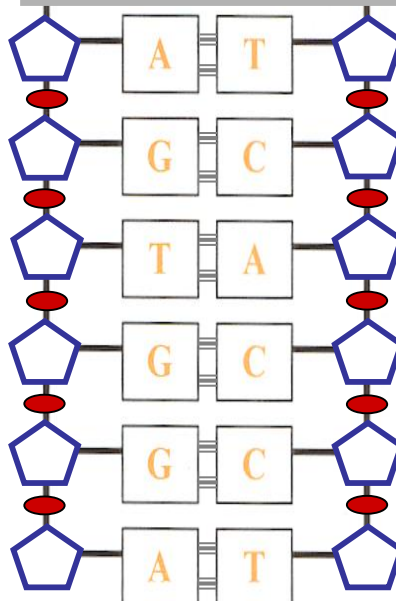
**ANSWER**

# DIFFERENT SPECIES

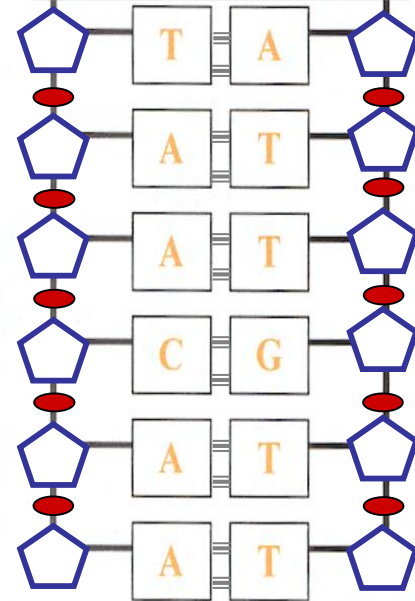
SPECIES #1



SPECIES #2



SPECIES #3



 = BASE

 = PHOSPHATE



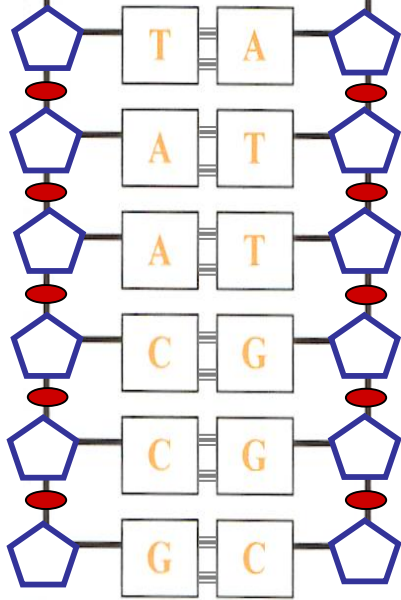
= DEOXYRIBOSE

 = HYDROGEN BONDS

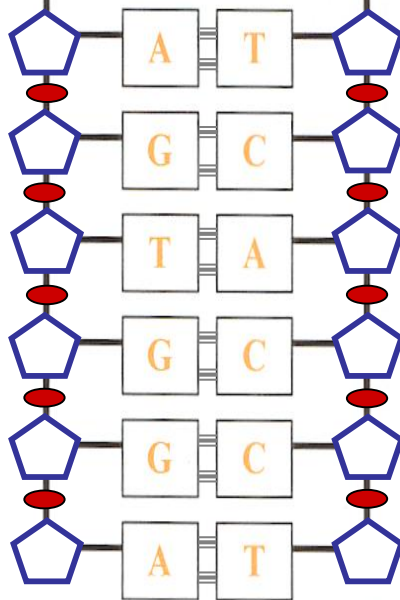


# DIFFERENT SPECIES / DIFFERENT DNA

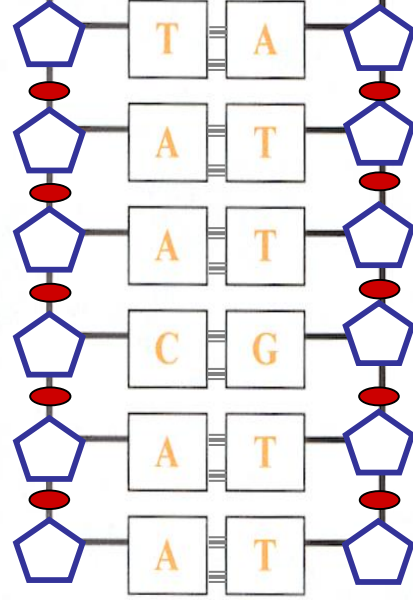
SPECIES #1



SPECIES #2



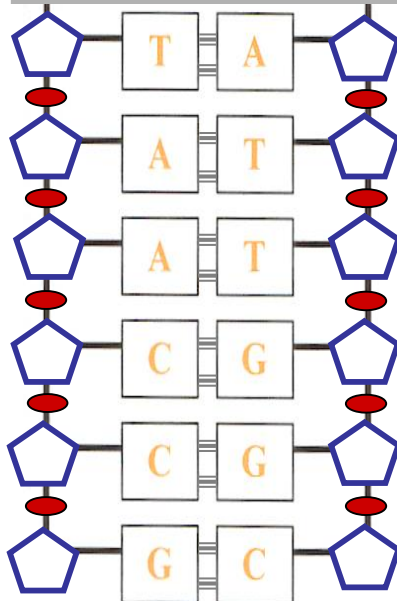
SPECIES #3



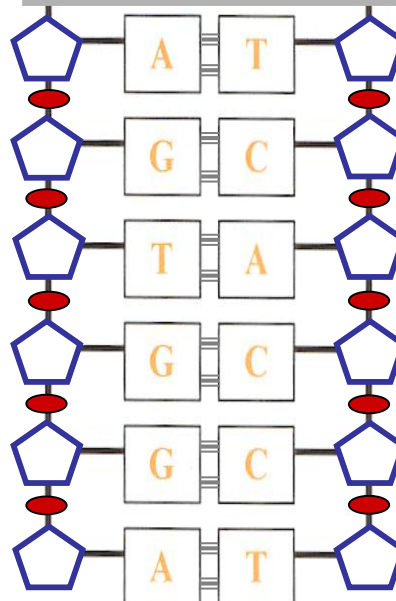
 = BASE     = PHOSPHATE     = DEOXYRIBOSE     = HYDROGEN BONDS

# DIFFERENT SPECIES / DIFFERENT DNA

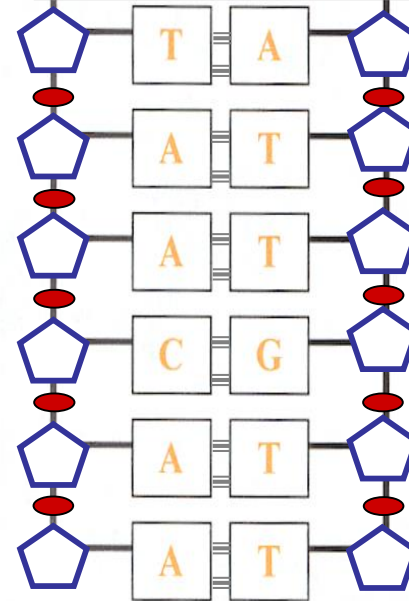
SPECIES #1



SPECIES #2



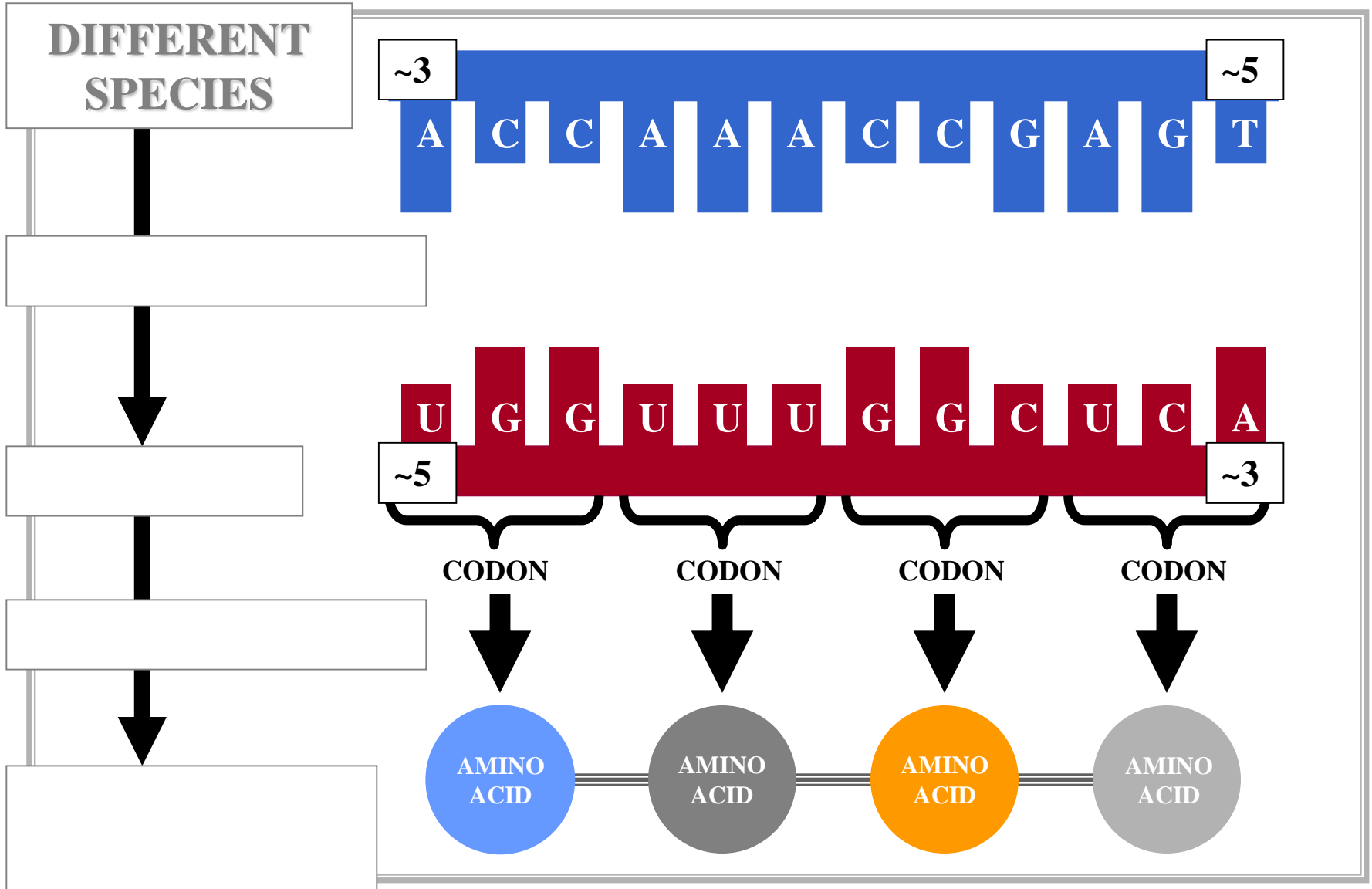
SPECIES #3



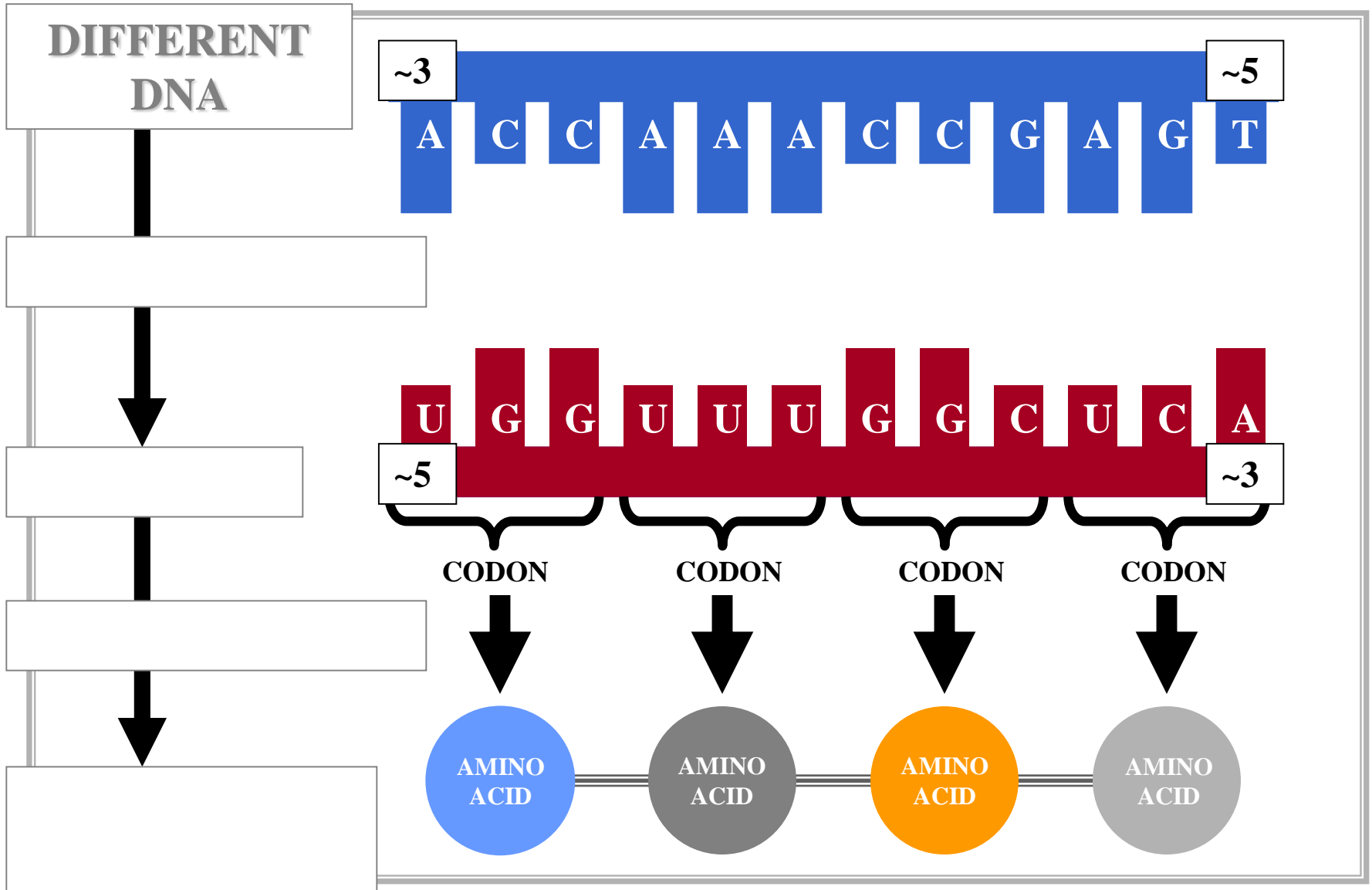
DIFFERENT DNA NUCLEOTIDE SEQUENCES



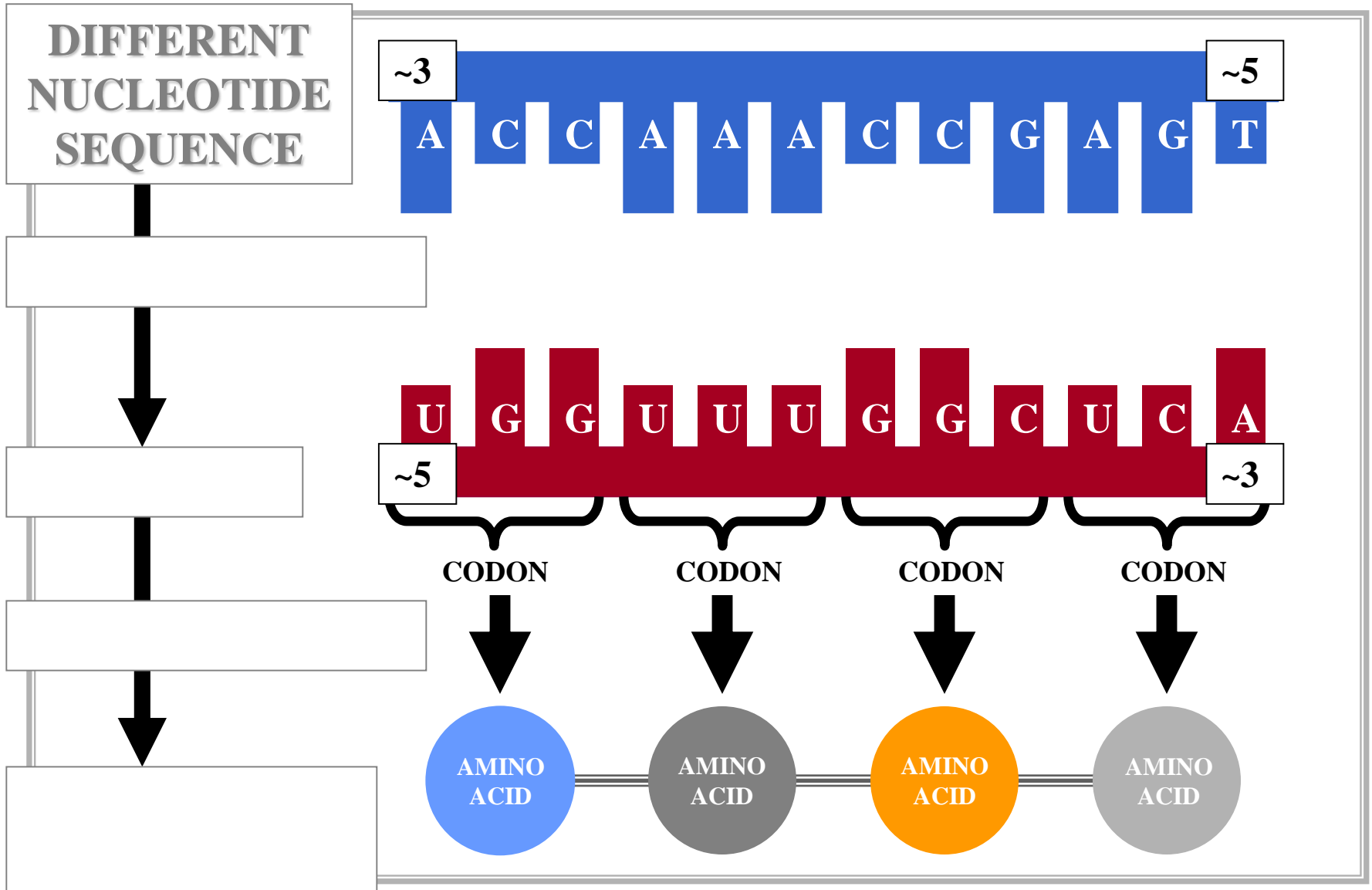
# PROTEIN SYNTHESIS



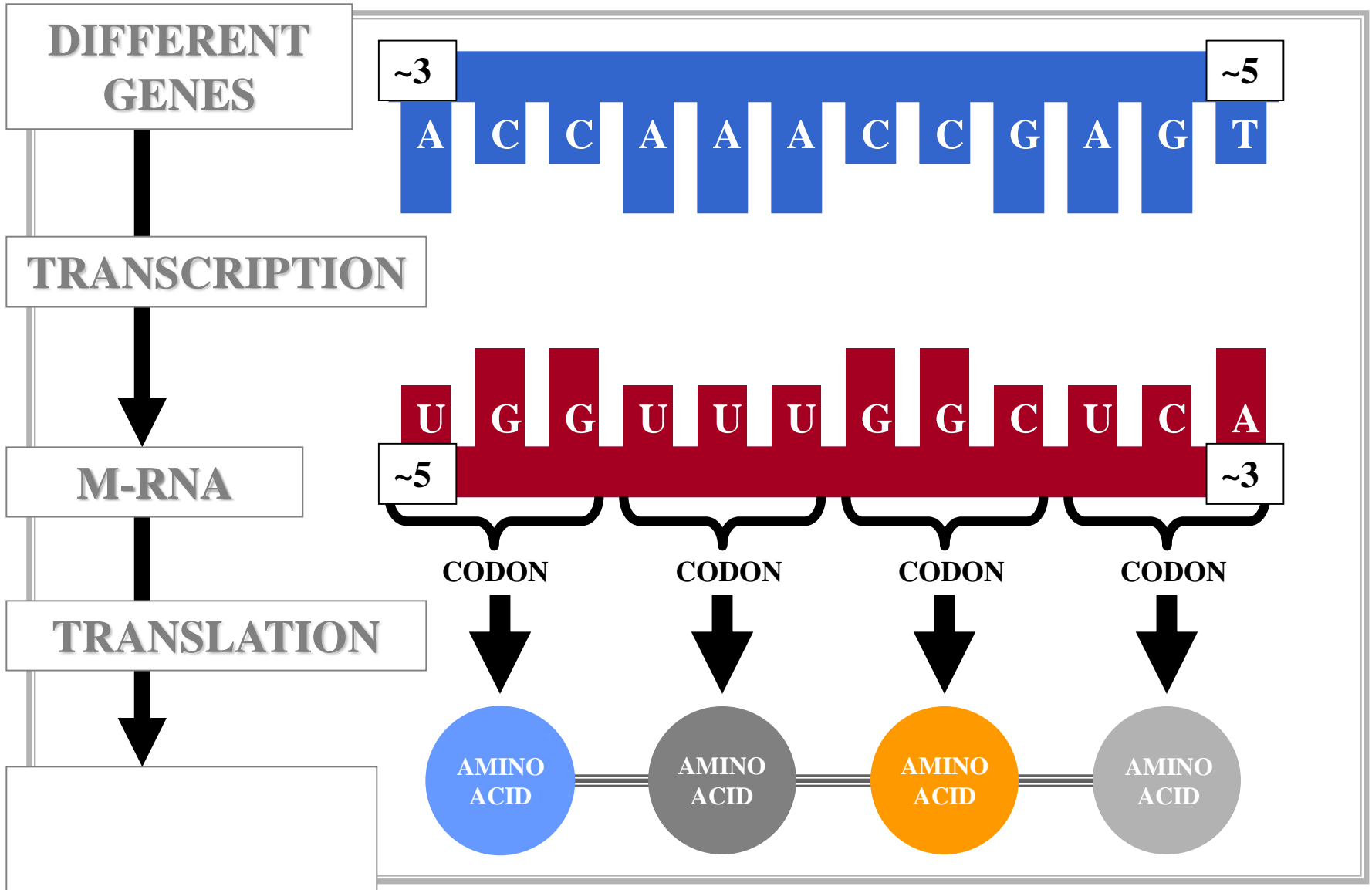
# PROTEIN SYNTHESIS



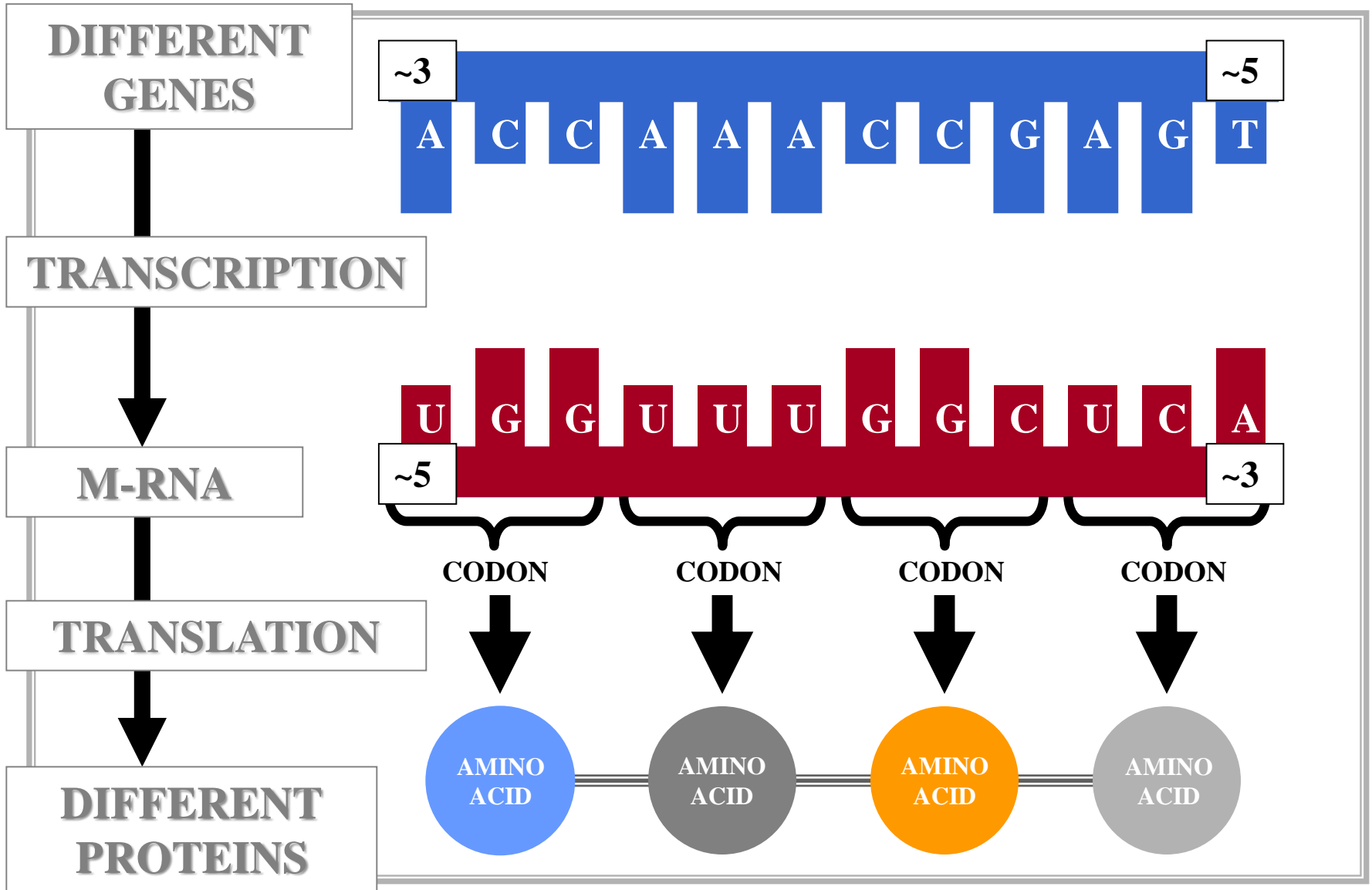
# PROTEIN SYNTHESIS



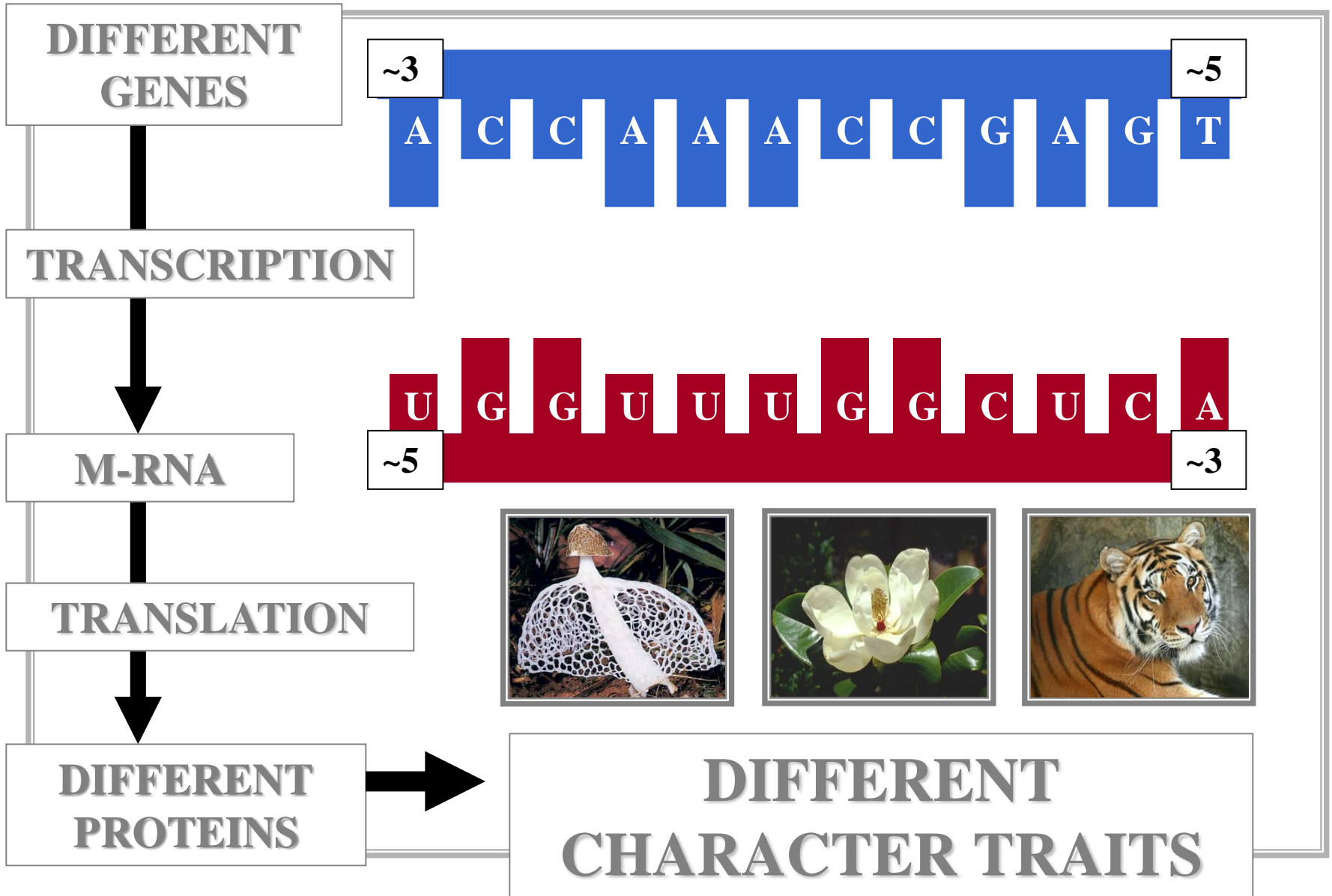
# PROTEIN SYNTHESIS



# PROTEIN SYNTHESIS

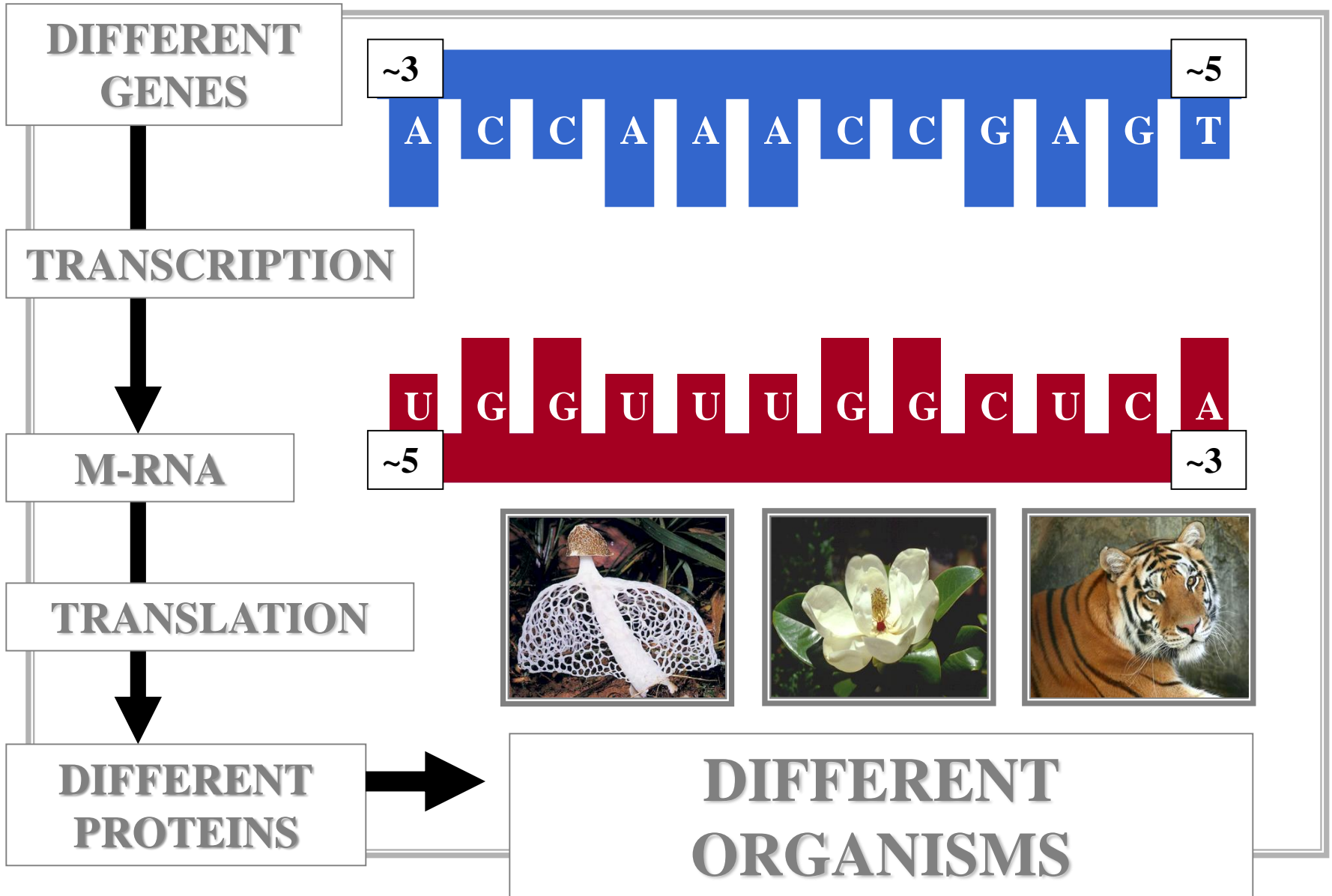


# PROTEIN SYNTHESIS





# PROTEIN SYNTHESIS







# FUNGUS DIVERSITY







# PLANT DIVERSITY







# ANIMAL DIVERSITY





# HUMAN DIVERSITY

D



## HUMAN DIVERSITY



## CHARACTER DIFFERENCES

# HUMAN DIVERSITY



**DIFFERENT DNA**



**CHARACTER DIFFERENCES**



# HUMAN DIVERSITY

D



**DIFFERENT DNA NUCLEOTIDE SEQUENCES**



**CHARACTER DIFFERENCES**

# HUMAN DIVERSITY

D



**DIFFERENT GENES**



**CHARACTER DIFFERENCES**



# HUMAN DIVERSITY

D



**DIFFERENT PROTEINS**



**CHARACTER DIFFERENCES**

# HUMAN DIVERSITY



**DIFFERENT CHARACTER TRAITS**



**CHARACTER DIFFERENCES**



# HUMAN DIVERSITY



**DIFFERENT ORGANISM**



**CHARACTER DIFFERENCES**

# HUMAN DIVERSITY

A

>



**GENOTYPE  
GENES**

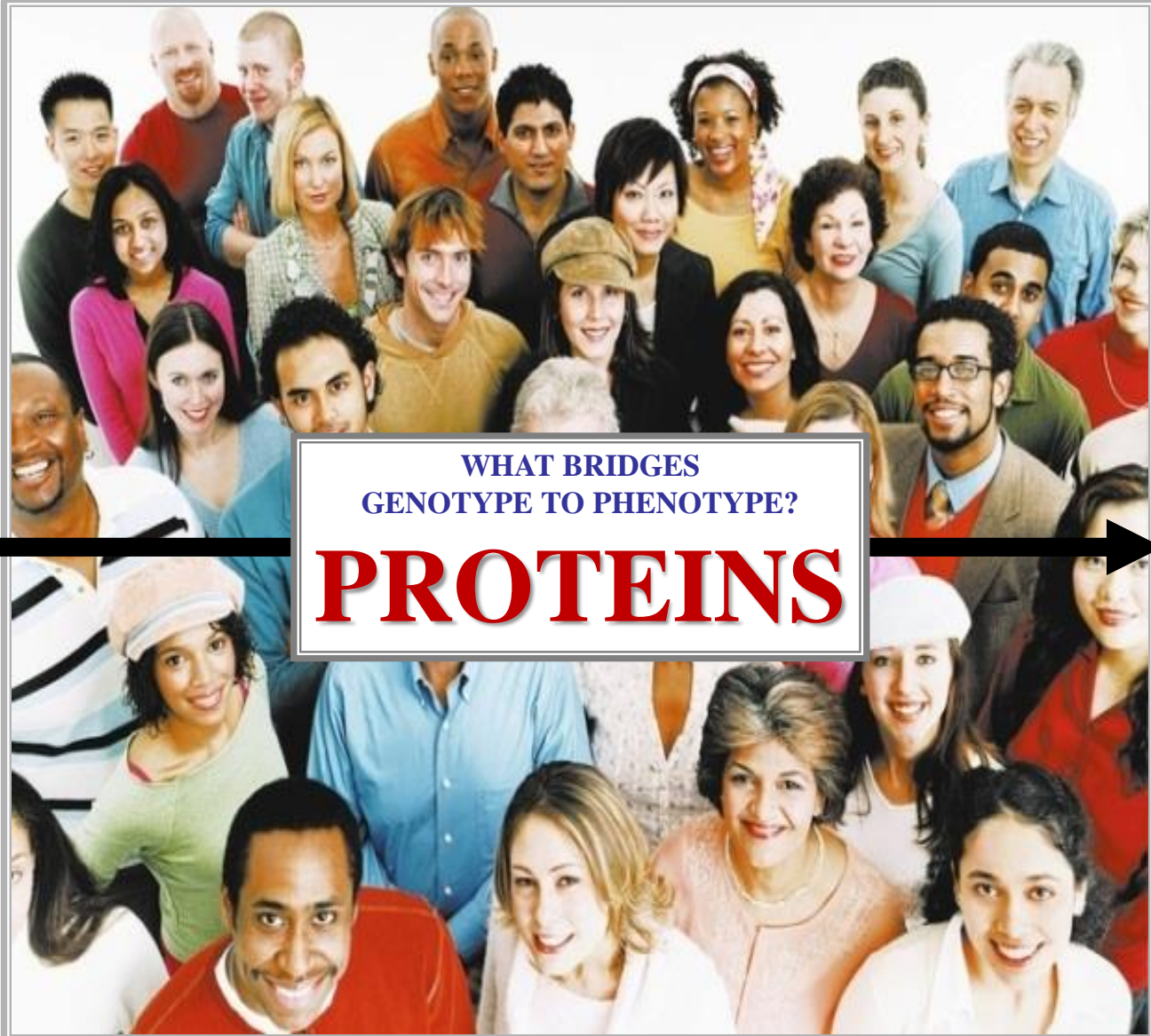
**WHAT BRIDGES  
GENOTYPE TO PHENOTYPE?**

**PHENOTYPE  
EXPRESSION**

**CHARACTER DIFFERENCES**



# HUMAN DIVERSITY



**GENOTYPE  
GENES**

WHAT BRIDGES  
GENOTYPE TO PHENOTYPE?

**PROTEINS**

**PHENOTYPE  
EXPRESSION**

**CHARACTER DIFFERENCES**



# PROTEIN SYNTHESIS OVERVIEW

# PROTEIN SYNTHESIS COMPONENTS

# **PROTEIN SYNTHESIS COMPONENTS**

**TRANSCRIPTION**

# **PROTEIN SYNTHESIS COMPONENTS**



# **PROTEIN SYNTHESIS COMPONENTS**

**TRANSCRIPTION  
MODIFICATION**

**PROTEIN SYNTHESIS  
COMPONENTS**

# **PROTEIN SYNTHESIS COMPONENTS**



**TRANSCRIPTION**  
**MODIFICATION**  
**TRANSLATION**

**PROTEIN SYNTHESIS  
COMPONENTS**

**CELL**

PROTEIN / SYNTHESIS

**T**

NUCLEUS

**PROTEIN SYNTHESIS  
COMPONENTS SEQUENCE**

CYTOSOL

# CELL

## PROTEIN / SYNTHESIS

### NUCLEUS

CHROMOSOME



DNA/GENE

**TRANSCRIPTION**



NON-MODIFIED M-RNA

CYTOSOL

# CELL

T

## PROTEIN / SYNTHESIS

### NUCLEUS

CHROMOSOME



DNA/GENE

**TRANSCRIPTION**



NON-MODIFIED M-RNA

**MODIFICATION**

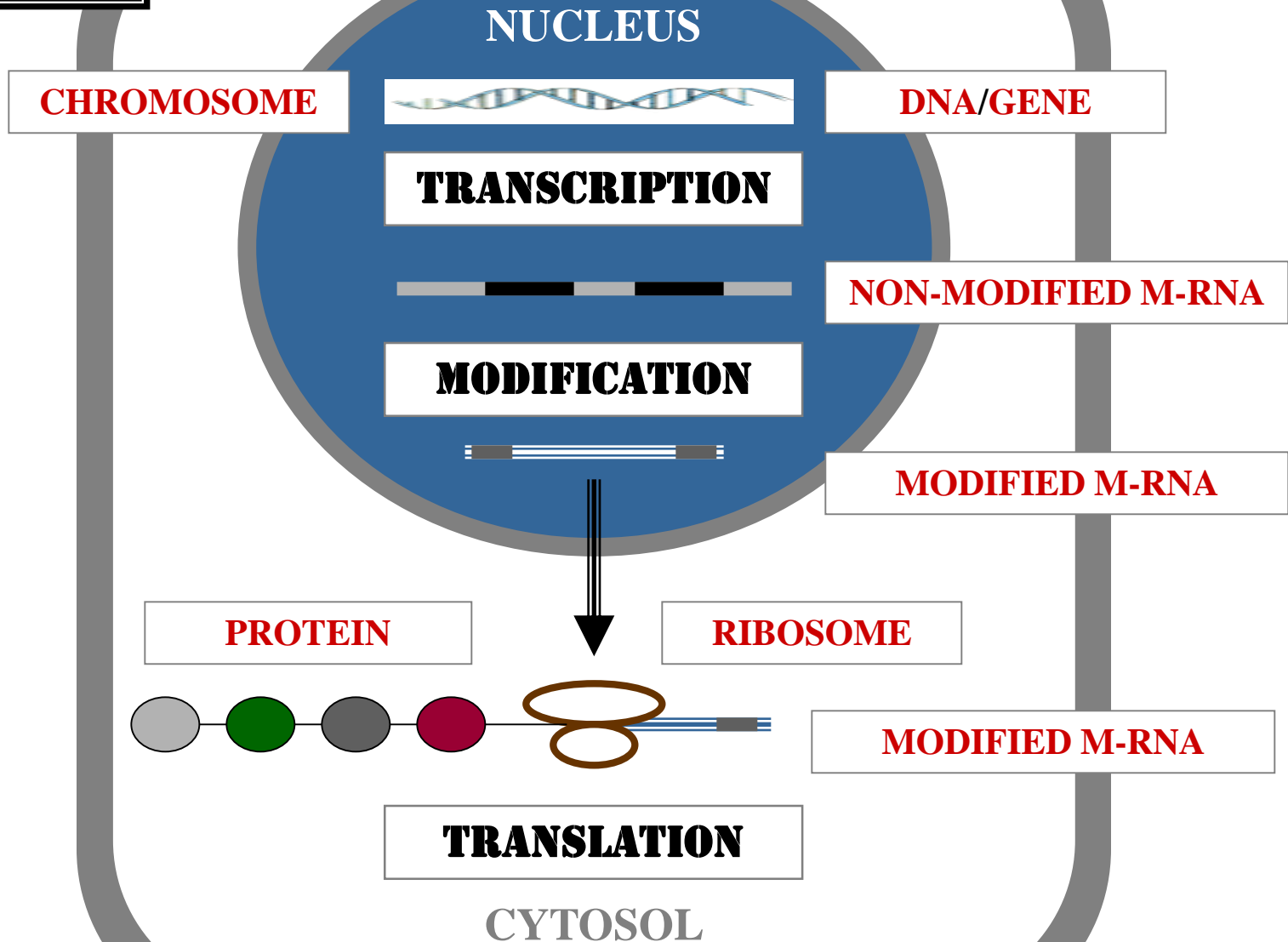


MODIFIED M-RNA

CYTOSOL

# CELL

## PROTEIN / SYNTHESIS



**PROTEIN  
SYNTHESIS  
OVERVIEW**

**TRANSCRIPTION**

# TRANSCRIPTION





# TRANSCRIPTION

GENETIC INFO  
TRANSCRIBED TO  
NON-MODIFIED  
MESSENGER-RNA

# TRANSCRIPTION

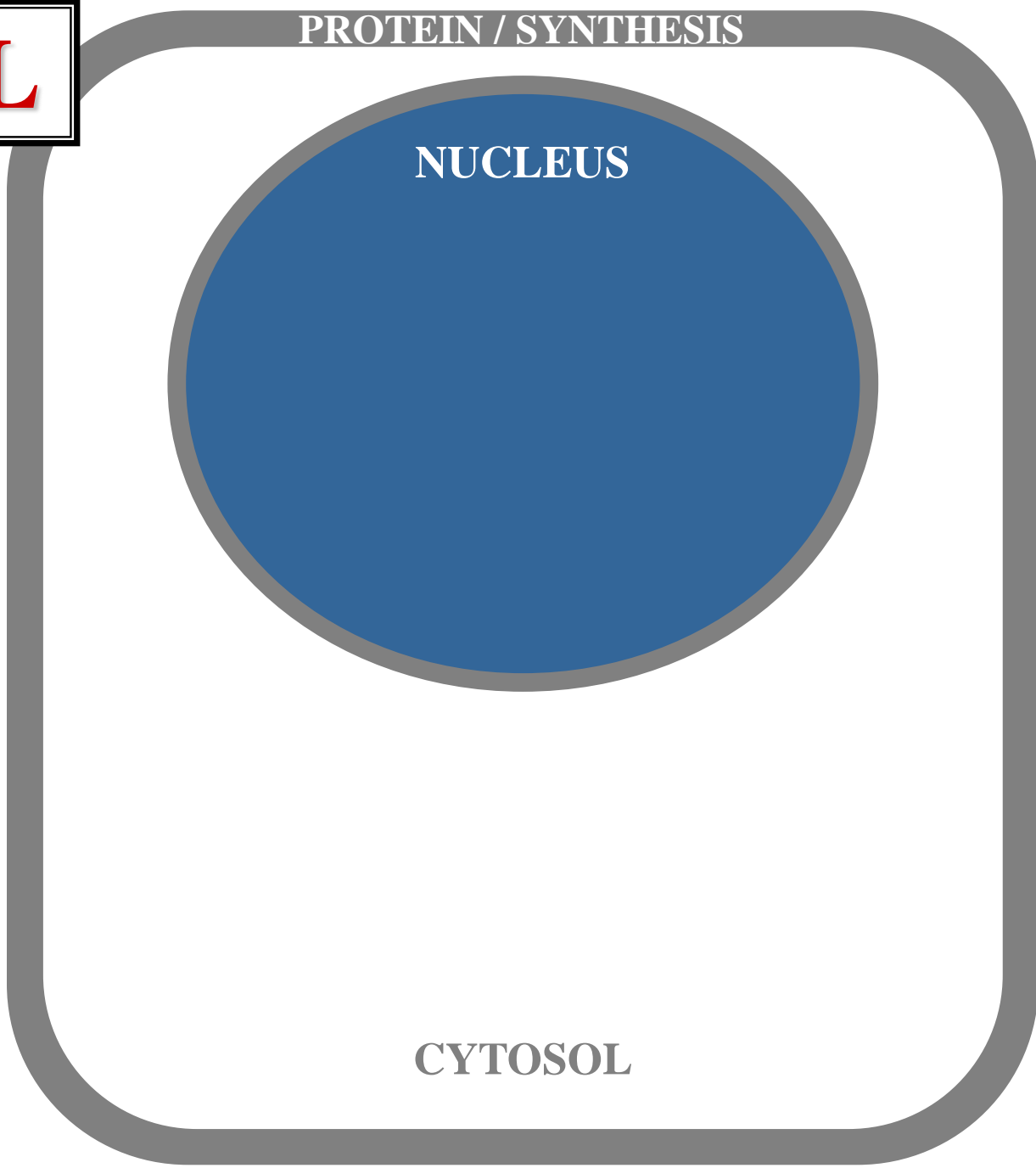
# CELL

PROTEIN / SYNTHESIS

L

NUCLEUS

CYTOSOL



# CELL

PROTEIN / SYNTHESIS

T

NUCLEUS

LOCATION

CYTOSOL

# CELL

PROTEIN / SYNTHESIS

C

NUCLEUS

**TRANSCRIPTION**

CYTOSOL

# CELL

PROTEIN / SYNTHESIS

D

NUCLEUS

CHROMOSOME



**TRANSCRIPTION**

CYTOSOL

# CELL

PROTEIN / SYNTHESIS

0

NUCLEUS

CHROMOSOME



DNA/GENE

**TRANSCRIPTION**

CYTOSOL

# CELL

## PROTEIN / SYNTHESIS

N

NUCLEUS

CHROMOSOME



DNA/GENE

**TRANSCRIPTION**

OUTCOME

CYTOSOL

# CELL

## PROTEIN / SYNTHESIS



### NUCLEUS

**CHROMOSOME**



**DNA/GENE**

**TRANSCRIPTION**



**NON-MODIFIED M-RNA**

CYTOSOL