

AP Biology Insta-Review Unit 5/6: Heredity & Molecular Genetics



Tiffany Jones

@apbiopenguins



AP Biology students are
penguins because they are
Dressed for Success!
You are now an AP Bio
Penguin!



Today's Plan:

Inheritance Patterns
Molecular Genetics
Operons & BioTech
Practice Questions
Unit 5/6 Q&A

Special Thank You to
Mrs. Kingett from
[@theapsoluterecap](#)
(Chat Q&A)



Inheritance Patterns

Complete Dominance

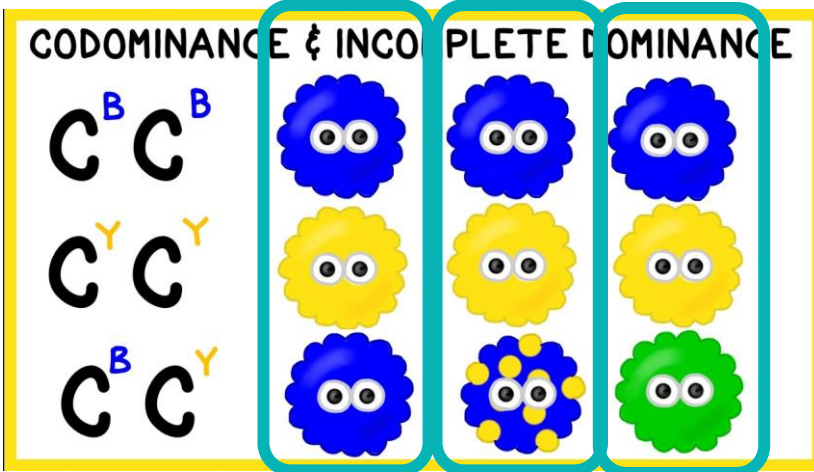
Homozygous dominant and heterozygous look the same

Codominance

Heterozygous is both dominant traits in organism

Incomplete Dominance

Heterozygous is a blend between the two dominant traits



	Y	y
Y	YY	Yy
y	Yy	yy

Yellow: $\frac{3}{4}$
Green: $\frac{1}{4}$

	R	r
R	RR	Rr
r	Rr	rr

Round: $\frac{3}{4}$
Wrinkled: $\frac{1}{4}$

Yellow & Round: $\frac{3}{4} \times \frac{3}{4} = \frac{9}{16}$
Yellow & Wrinkled: $\frac{3}{4} \times \frac{1}{4} = \frac{3}{16}$
Green & Round: $\frac{1}{4} \times \frac{3}{4} = \frac{3}{16}$
Green & Wrinkled: $\frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$

Monohybrid

Heterozygous for ONE trait

Complete Dominance:
3:1 ratio

Incomplete or Codominance:
1:2:1

Dihybrid

Heterozygous for TWO traits

Complete Dominance:
9:3:3:1 ratio

Incomplete or Codominance:
6:3:3:2:1:1



Inheritance Patterns

Autosomal Inheritance

Allele is located on an autosome
(non-sex chromosome)

Sex-Linked

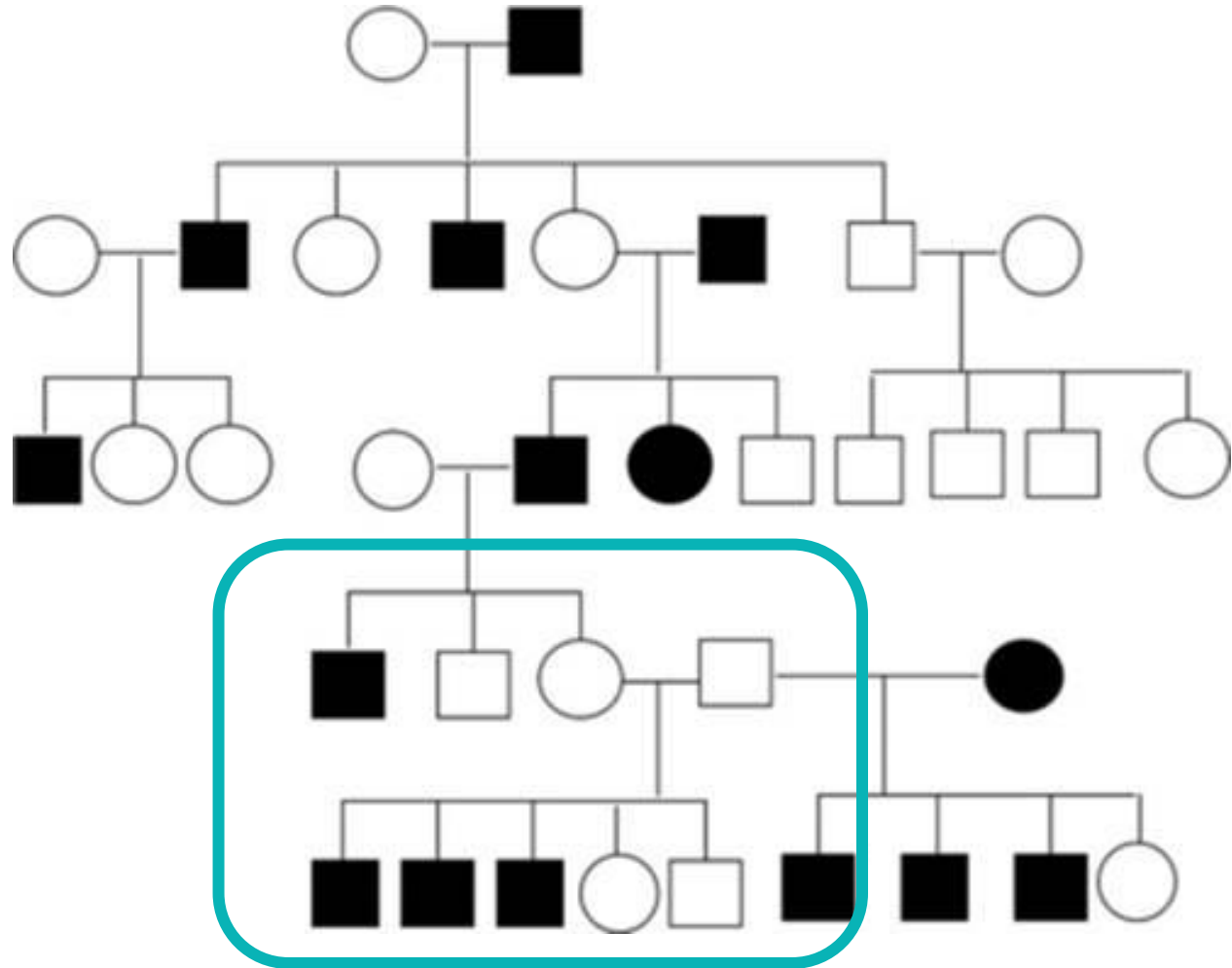
Allele is located on a
sex chromosome

Maternal Inheritance

Allele is located on the DNA
found in a mitochondrial or
chloroplast

Linked Genes

Genes located on the same
chromosome closely together



Autosomal Recessive



Inheritance Patterns

Autosomal Inheritance

Allele is located on an autosome
(non-sex chromosome)

Sex-Linked

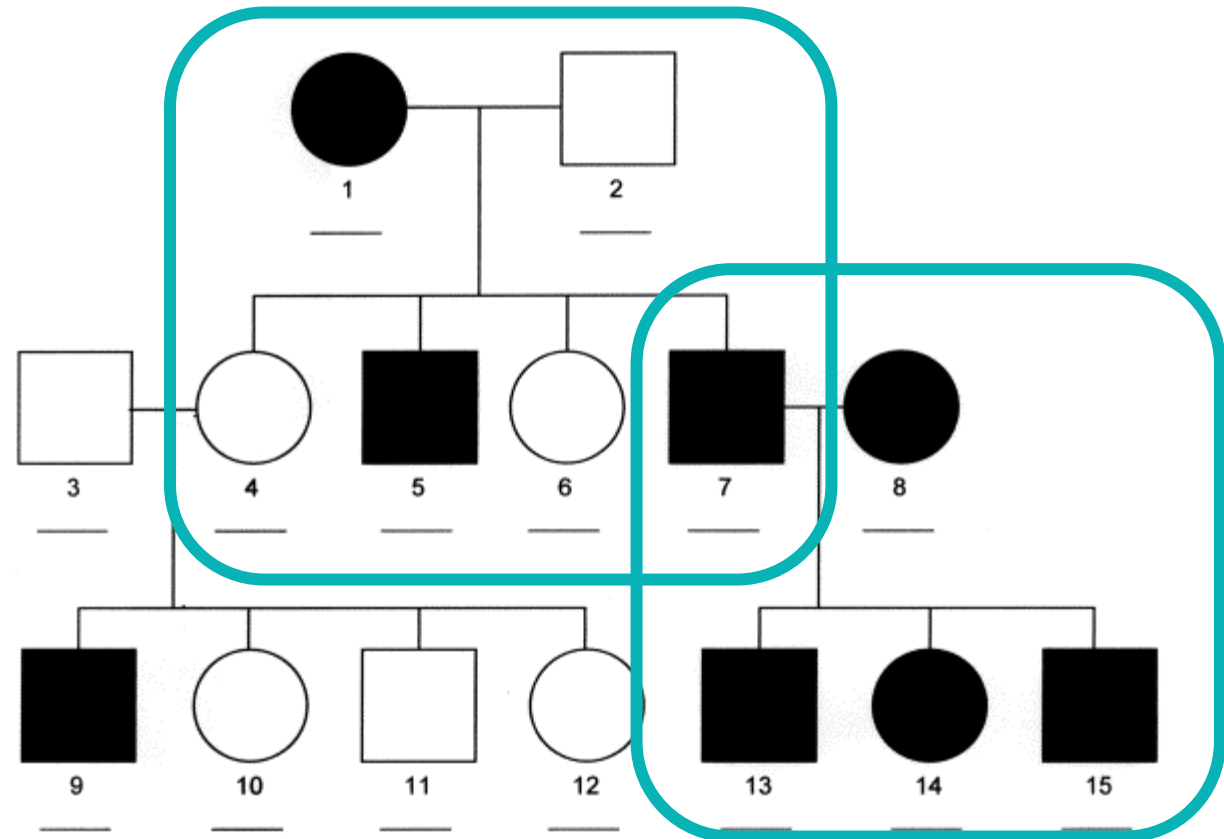
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Sex-Linked Recessive



Inheritance Patterns

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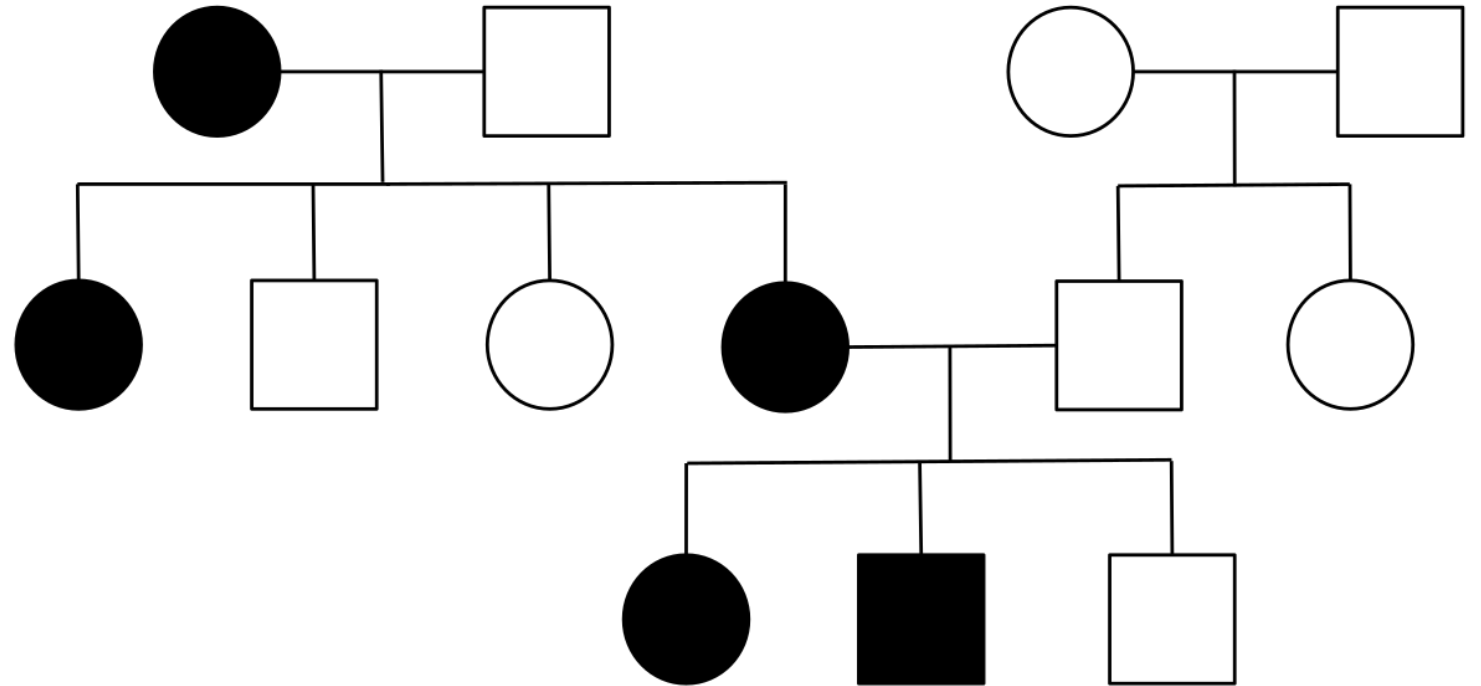
Allele is located on a
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Maternal Inheritance

Allele is located on the DNA
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Linked Genes

Genes located on the same
chromosome closely together



Autosomal Dominant



Inheritance Patterns

Autosomal Inheritance

Allele is located on an autosome
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Sex-Linked

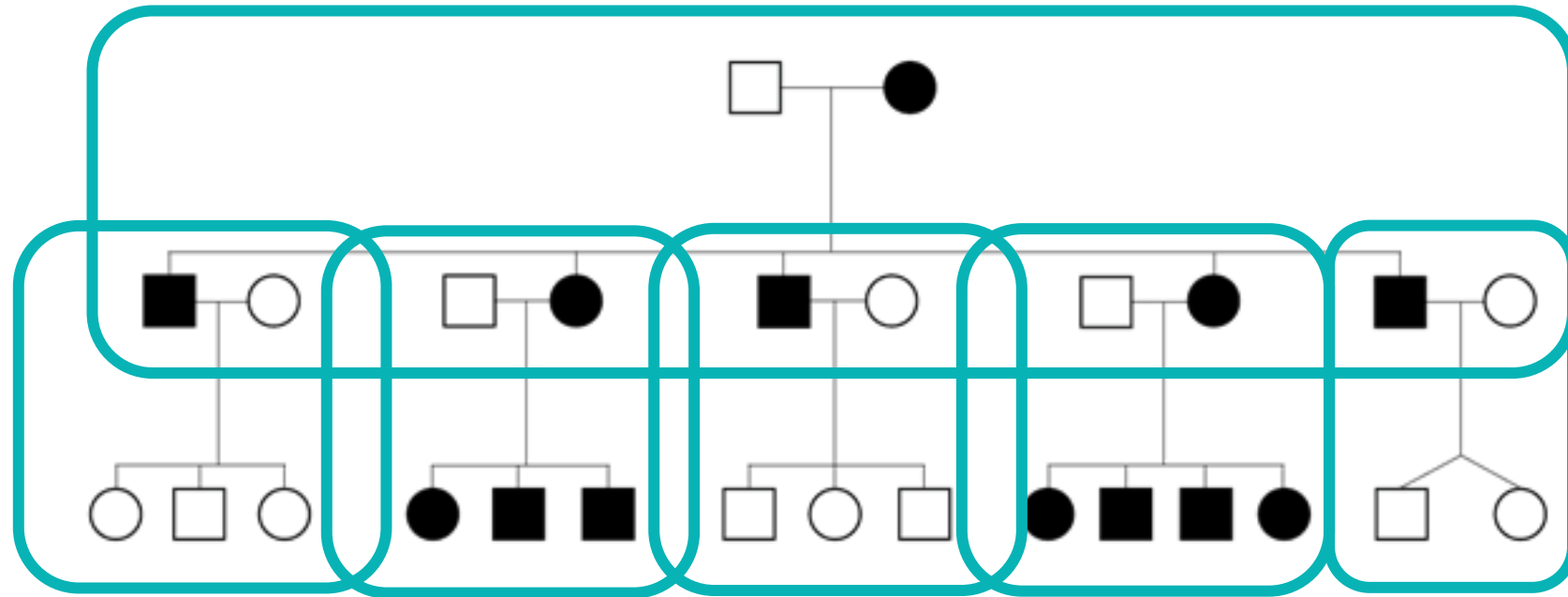
Allele is located on a
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Maternal Inheritance

Allele is located on the DNA
found in a mitochondrial or
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Linked Genes

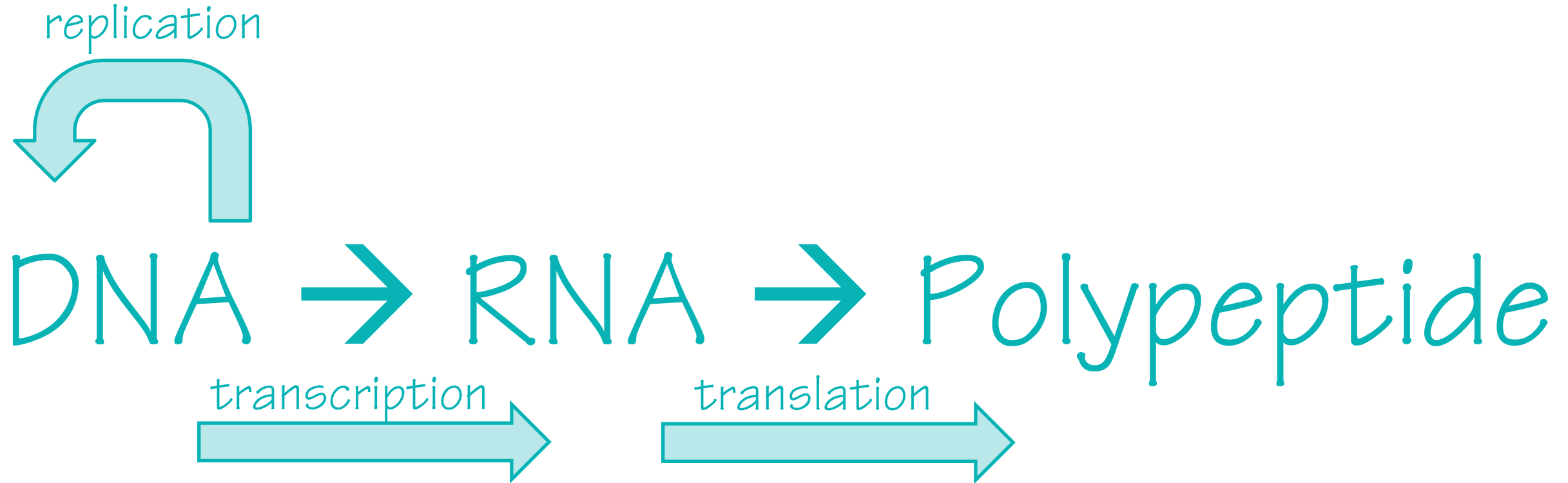
Genes located on the same
chromosome closely together



Mitochondrial Inheritance



Central Dogma



Retroviruses will use reverse transcriptase to synthesize DNA from their RNA genome



Replication

Location

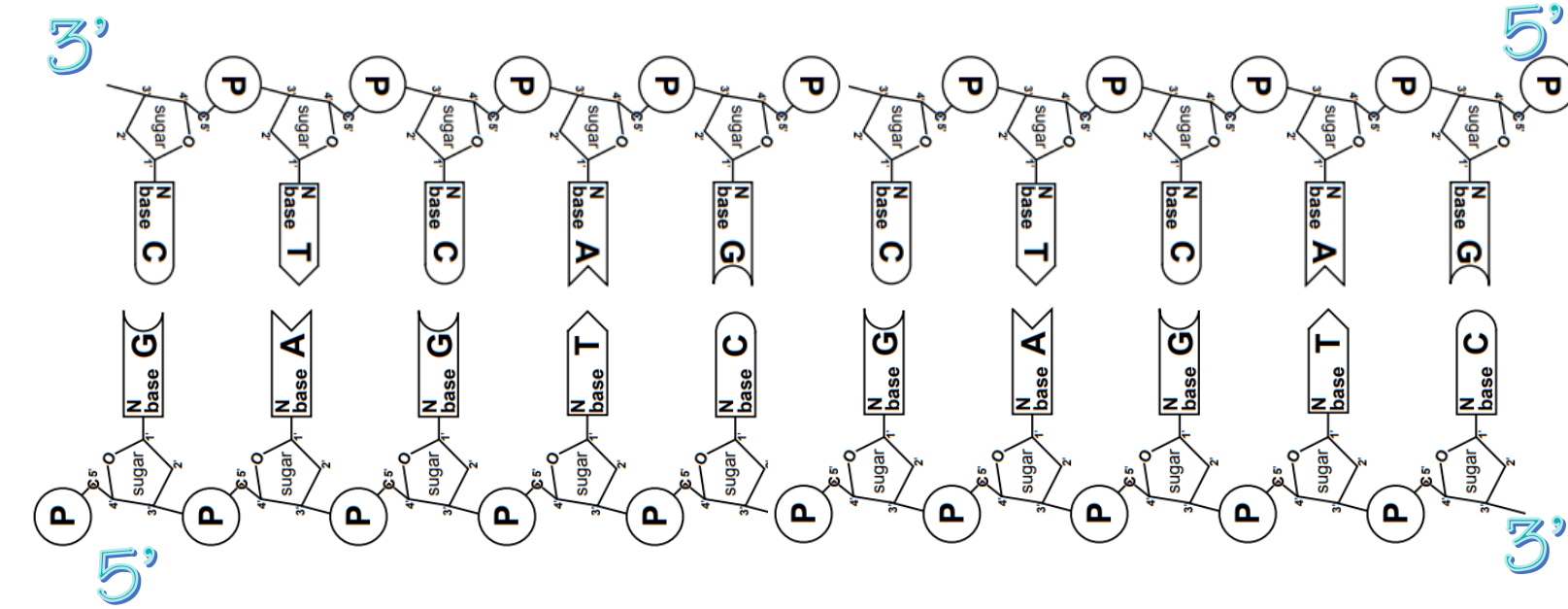
- Eukaryotes: nucleus
- Prokaryotes: nucleoid

Structure

- Eukaryotes: multiple linear
- Prokaryotes: single circular

Reminders about DNA:

- DNA made up of:
 - nitrogenous base (A, T, C, G)
 - pentose sugar (deoxyribose)
 - phosphate group
- Purine (A/G) have a double ring structure
- Pyrimidine (C/T) have a single ring structure
- Base Pair Rules
 - A & T with 2 H bonds
 - C & G with 3 H bonds



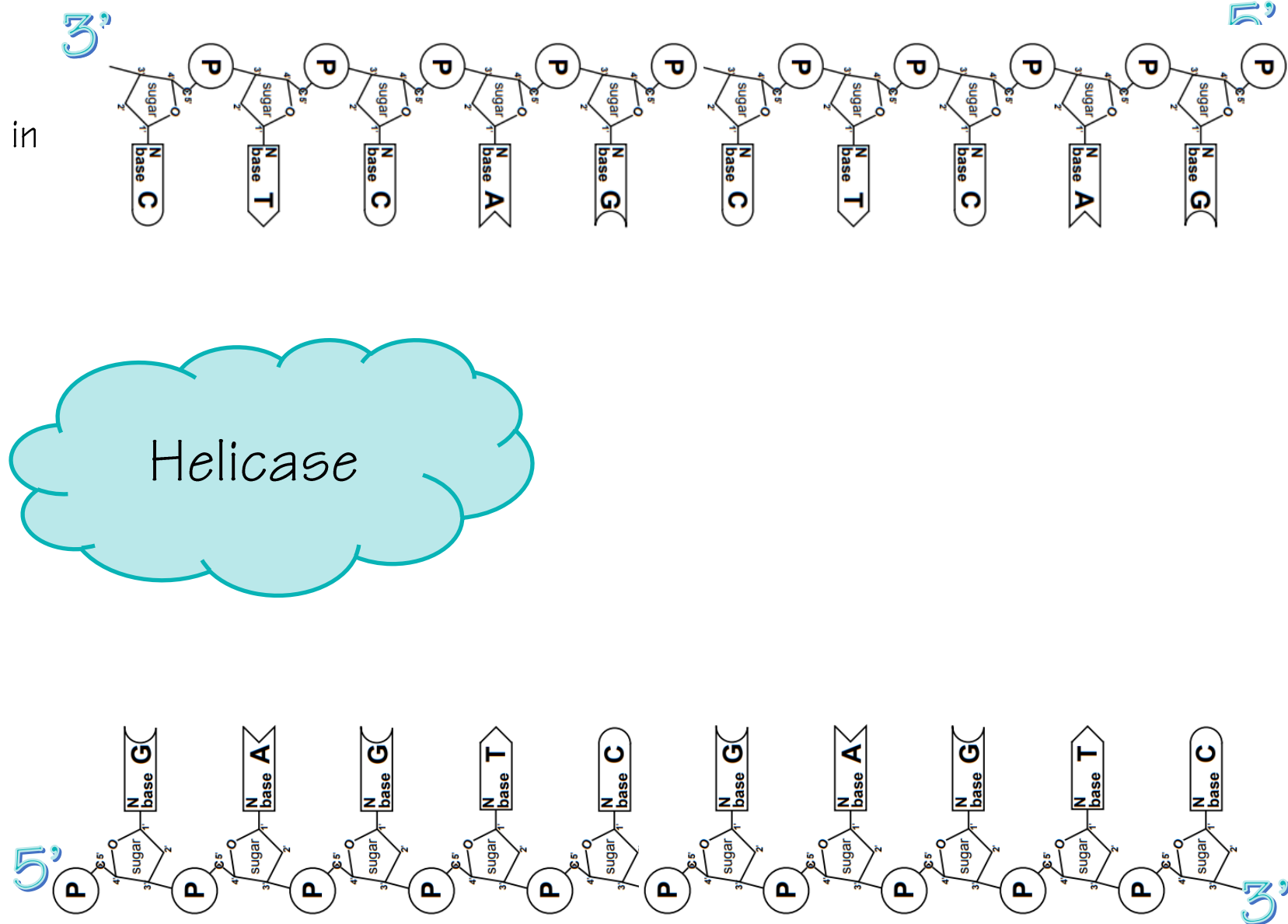
- Sideedness
 - 5' end: phosphate
 - 3' end: hydroxyl group
 - Directionality
 - Read 3' to 5'
 - Synthesize 5' to 3'
- (Remember ANTIPARALLEL)



Replication

Important Enzymes

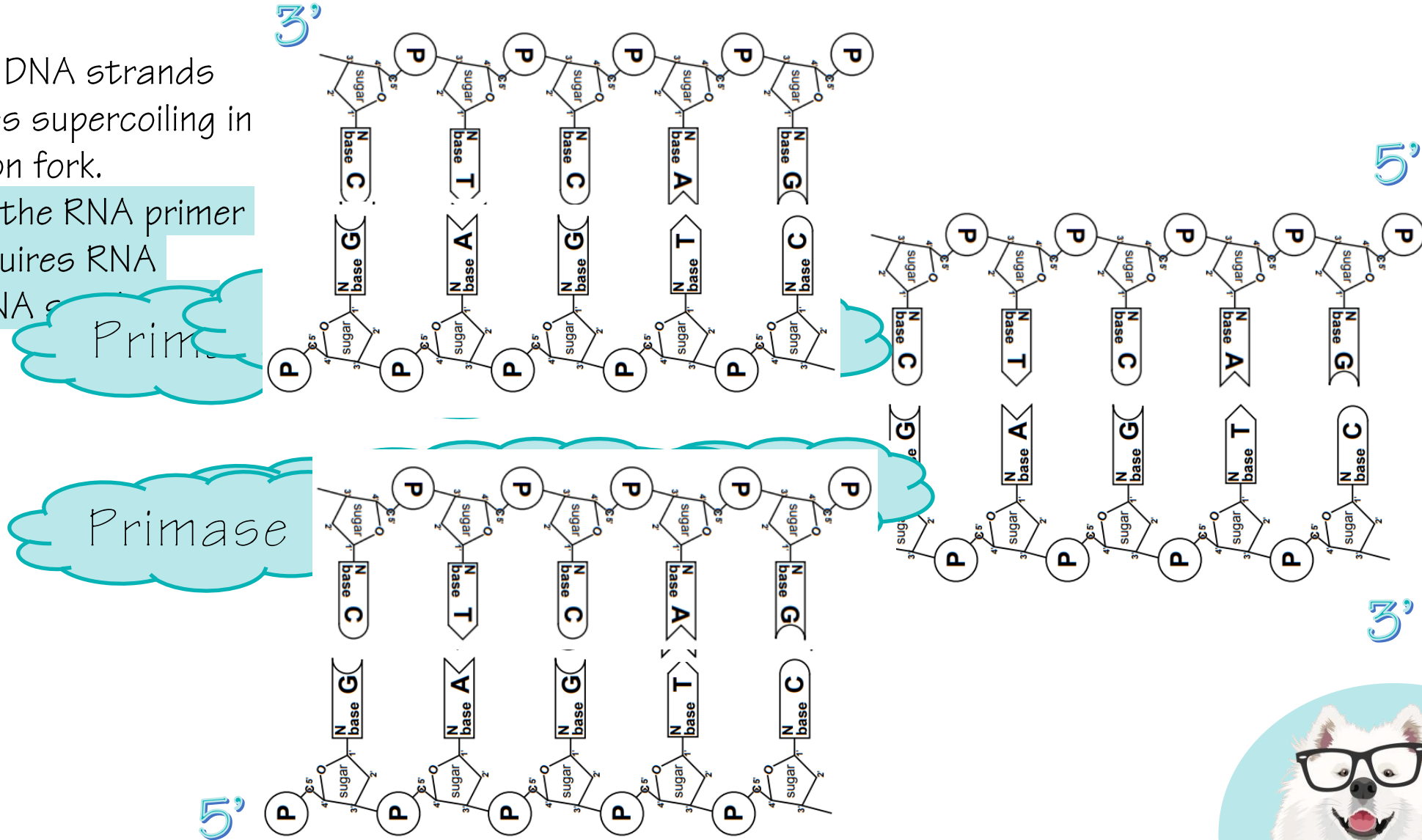
- Helicase unwinds the DNA strands
- Topoisomerase relaxes supercoiling in front of the replication fork.



Replication

Important Enzymes

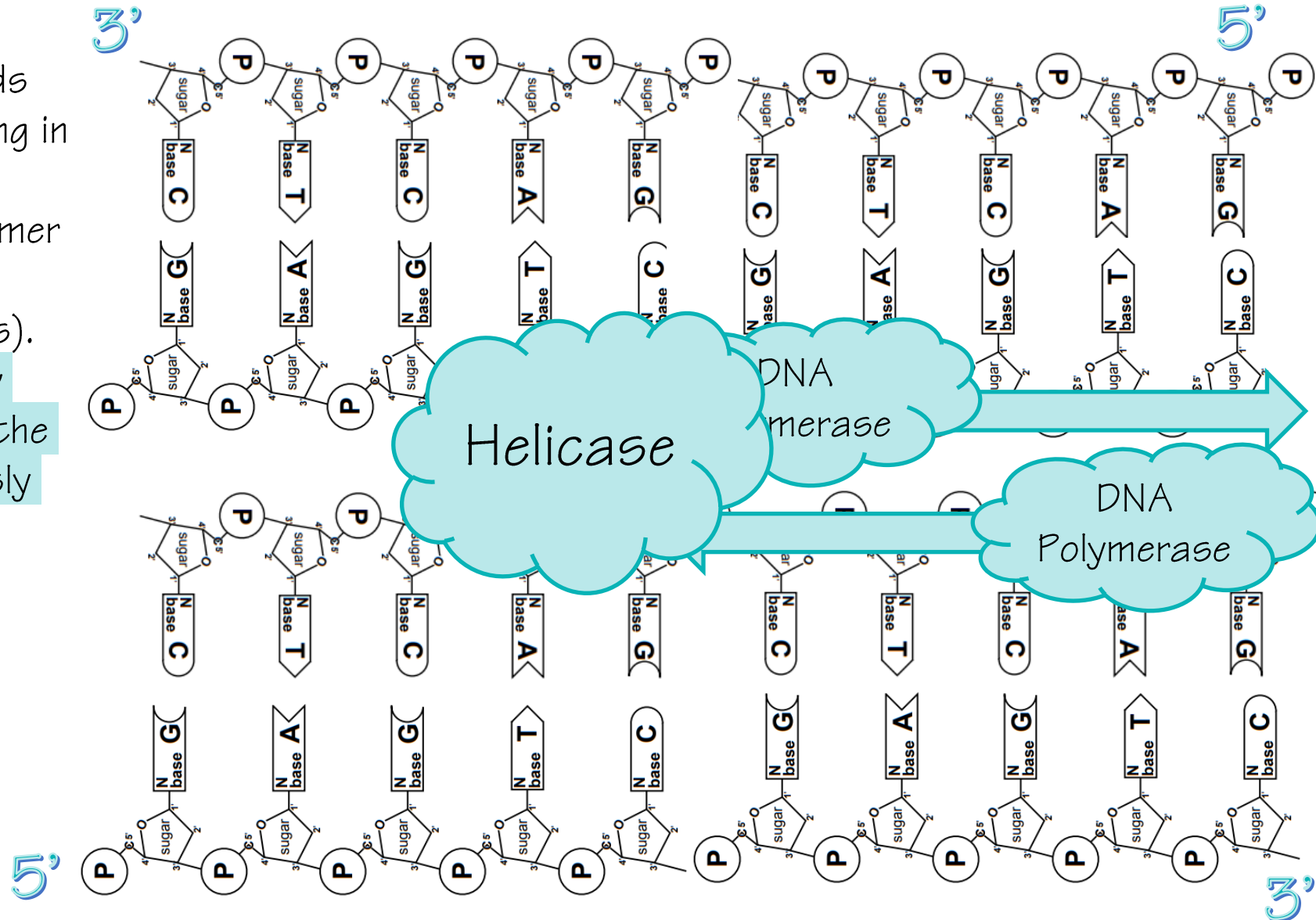
- Helicase unwinds the DNA strands
- Topoisomerase relaxes supercoiling in front of the replication fork.
- Primase synthesizes the RNA primer (DNA polymerase requires RNA primers to initiate DNA synthesis)



Replication

Important Enzymes

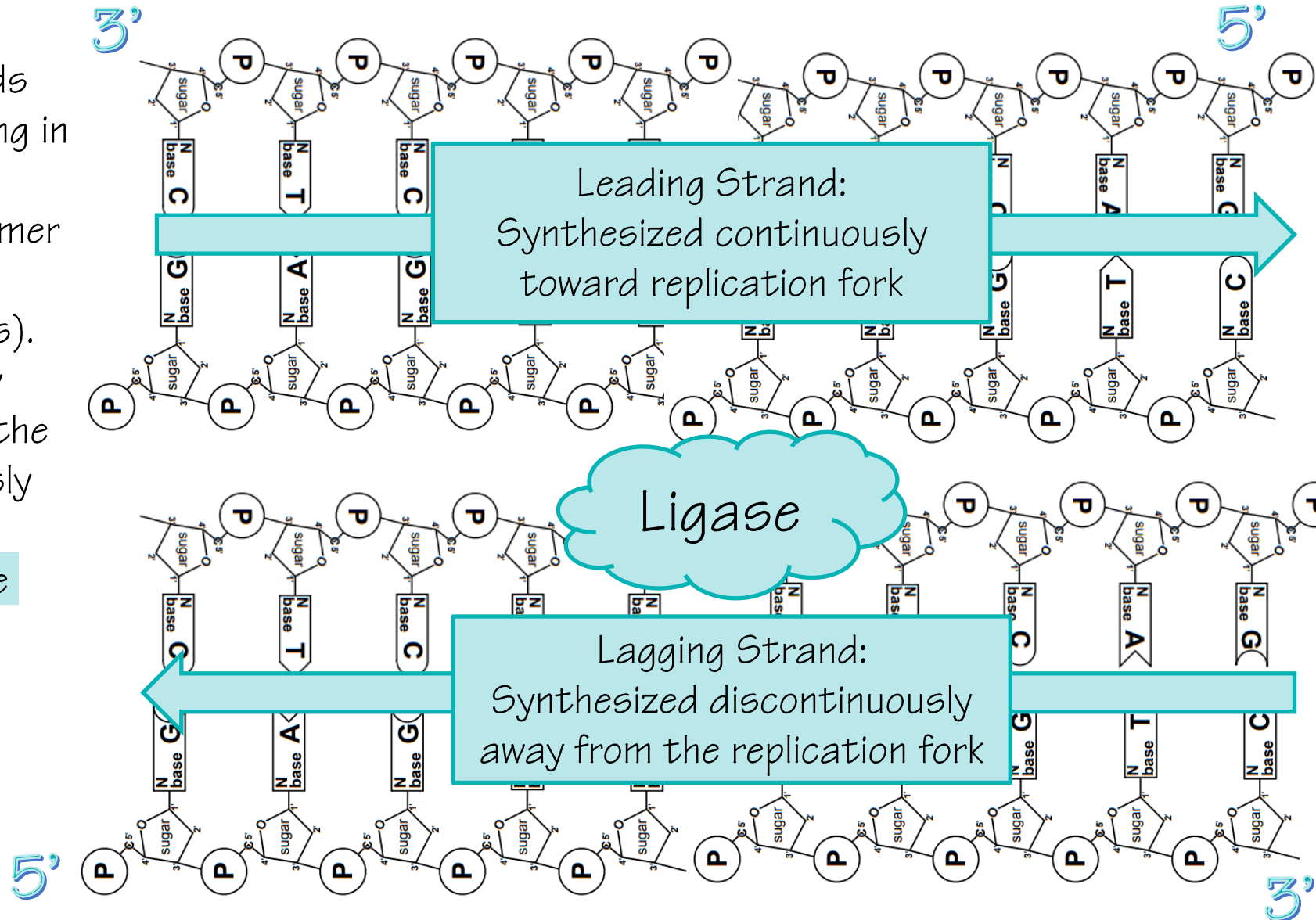
- Helicase unwinds the DNA strands
- Topoisomerase relaxes supercoiling in front of the replication fork.
- Primase synthesizes the RNA primer (DNA polymerase requires RNA primers to initiate DNA synthesis).
- DNA polymerase synthesizes new strands of DNA continuously on the leading strand and discontinuously on the lagging strand.



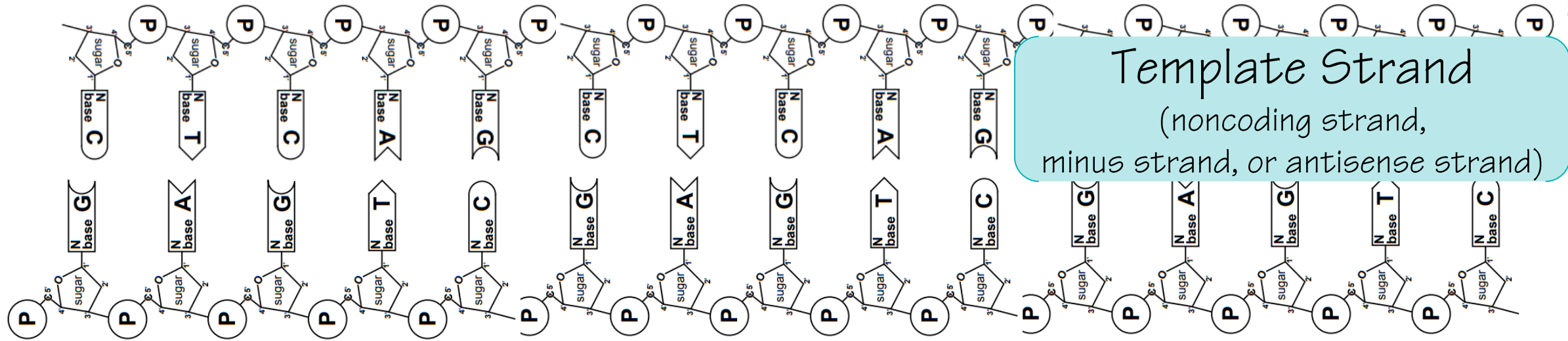
Replication

Important Enzymes

- Helicase unwinds the DNA strands
- Topoisomerase relaxes supercoiling in front of the replication fork.
- Primase synthesizes the RNA primer (DNA polymerase requires RNA primers to initiate DNA synthesis).
- DNA polymerase synthesizes new strands of DNA continuously on the leading strand and discontinuously on the lagging strand.
- Ligase joins the fragments on the lagging strand.



Transcription



Location

- Eukaryotes: nucleus
- Prokaryotes: nucleoid (cytosol)

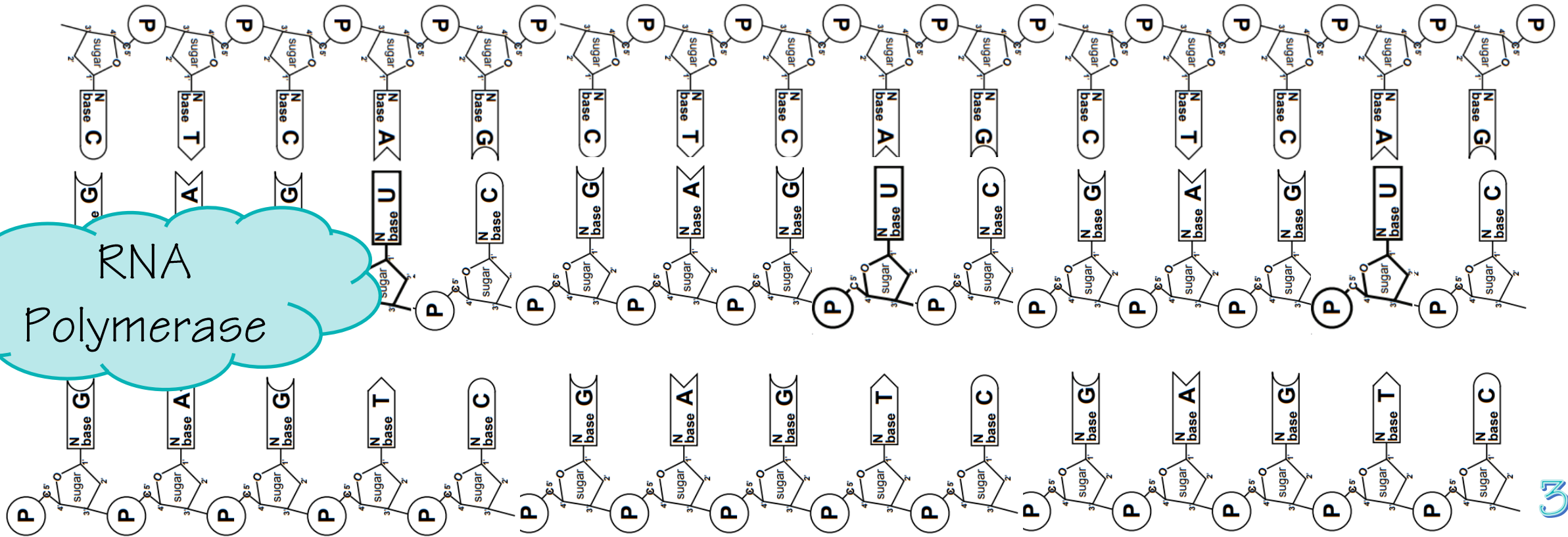
Reminders about RNA:

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 - nitrogenous base (A, U, C, G)
 - pentose sugar (ribose)
 - phosphate group
- Purine (A/G) have a double ring structure
- Pyrimidine (C/U) have a single ring structure

- Base Pair Rules
 - A & T(DNA)/U(RNA) with 2 H bonds
 - C & G with 3 H bonds
- Sidenesses
 - 5' end: phosphate
 - 3' end: hydroxyl group
- Directionality
 - Read 3' to 5'
 - Synthesize 5' to 3'



Transcription



Important Enzyme & Components

- RNA polymerase synthesizes mRNA molecules in the 5' to 3' direction by reading the template DNA strand in the 3' to 5' direction.
- Promoter: site where RNA polymerase binds to start transcription
- Transcription Factors: activators/inhibitors to turn on/off gene expression



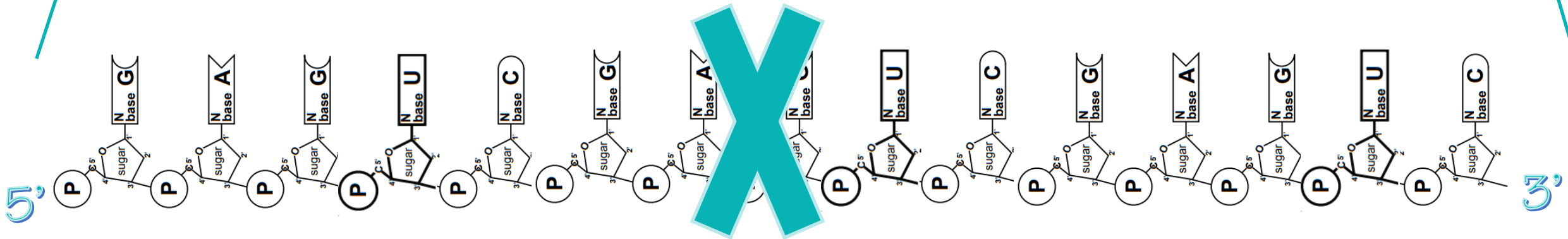
Post-Transcriptional Modifications

5' Guanine Cap

- Signals the “start” of the mRNA transcript for ribosome to bind
- Facilitates export from nucleus

Poly-A Tail

- Inhibits degradation from hydrolytic enzymes in cytosol

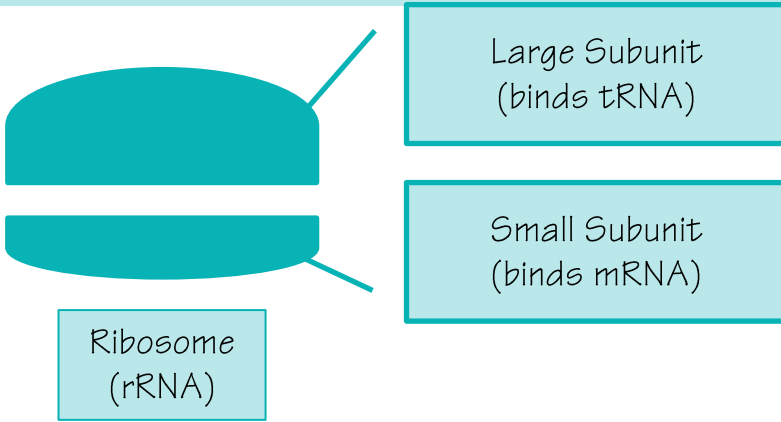


Splicing

- Removal of introns from pre-mRNA transcript



Translation



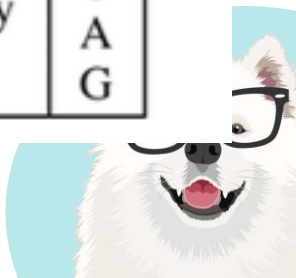
Location

- Eukaryotes: cytosol/rough ER
- Prokaryotes: cytosol

Steps of Translation

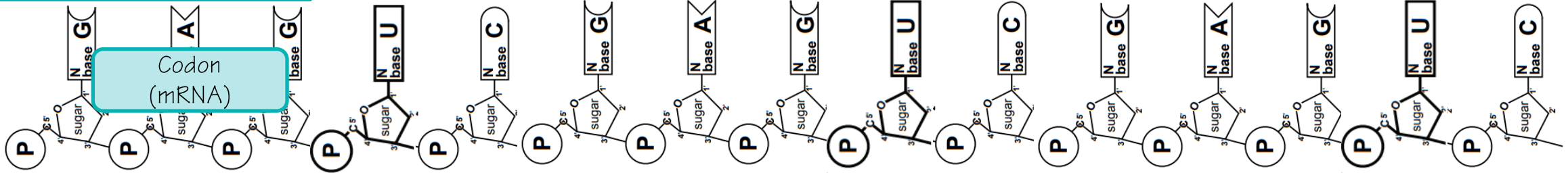
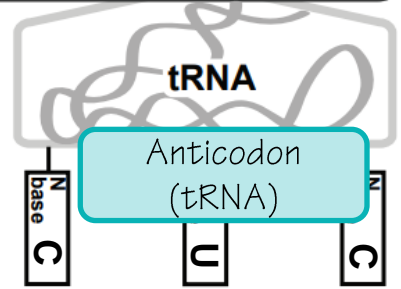
- Initiation: start codon (AUG)
- Elongation: base pair between tRNA/mRNA with amino acid added
- Termination: stop codon (UAG, UAA, UGA)

		Second Base in Codon				
		U	C	A	G	
U	UUU } Phe	UCU } Ser	UAU } Tyr	UGU } Cys	U	
	UUC } Phe	UCC } Ser	UAC } Tyr	UGC } Cys	C	
	UUA } Leu	UCA } Ser	UAA Stop	UGA Stop	A	
	UUG } Leu	UCG } Ser	UAG Stop	UGG Trp	G	
C	CUU } Leu	CCU } Pro	CAU } His	CGU } Arg	U	
	CUC } Leu	CCC } Pro	CAC } His	CGC } Arg	C	
	CUA } Leu	CCA } Pro	CAA } Gln	CGA } Arg	A	
	CUG } Leu	CCG } Pro	CAG } Gln	CGG } Arg	G	
A	AUU } Ile	ACU } Thr	AAU } Asn	AGU } Ser	U	
	AUC } Ile	ACC } Thr	AAC } Asn	AGC } Ser	C	
	AUA } Ile	ACA } Thr	AAA } Lys	AGA } Arg	A	
	AUG } Met or Start	ACG } Thr	AAG } Lys	AGG } Arg	G	
G	GUU } Val	GCU } Ala	GAU } Asp	GGU } Gly	U	
	GUC } Val	GCC } Ala	GAC } Asp	GGC } Gly	C	
	GUA } Val	GCA } Ala	GAA } Glu	GGA } Gly	A	
	GUG } Val	GCG } Ala	GAG } Glu	GGG } Gly	G	



Translation

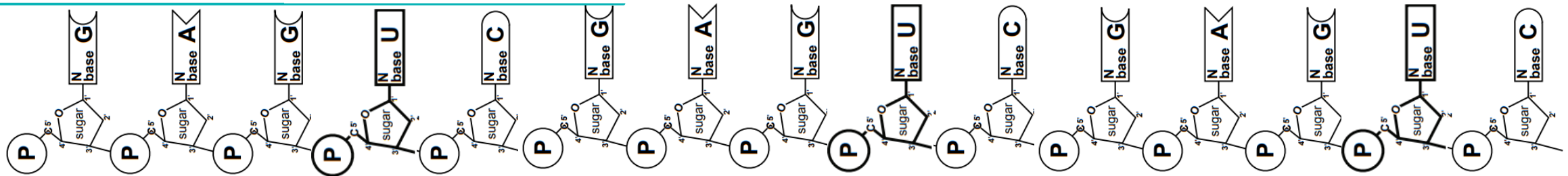
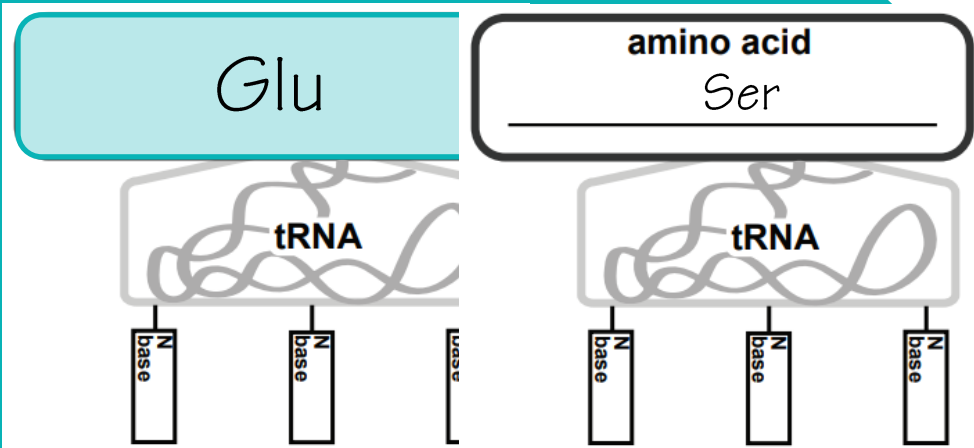
amino acid
Glu



		Second Base in Codon				
		U	C	A	G	
U	UUU	UCU } Ser	UAU	UGU } Cys	U C A G	
	UUC		UAC			UGC
	UUA		UAA	UGA		Stop
	UUG	UAG	UGG	Trp		
C	CUU	CCU } Pro	CAU	CGU } Arg	U C A G	
	CUC		CAC			CGC
	CUA		CAA			CGA
	CUG	CAG	CGG			
A	AUU	ACU } Thr	AAU	AGU } Ser	U C A G	
	AUC		AAC			AGC
	AUA		AAA	AGA		
	AUG	Met or Start	AAG	AGG		
G	GUU	GCU } Ala	GAU	GGU } Gly	U C A G	
	GUC		GCC			GAC
	GUA		GCA			GAA
	GUG	GCG	GAG			



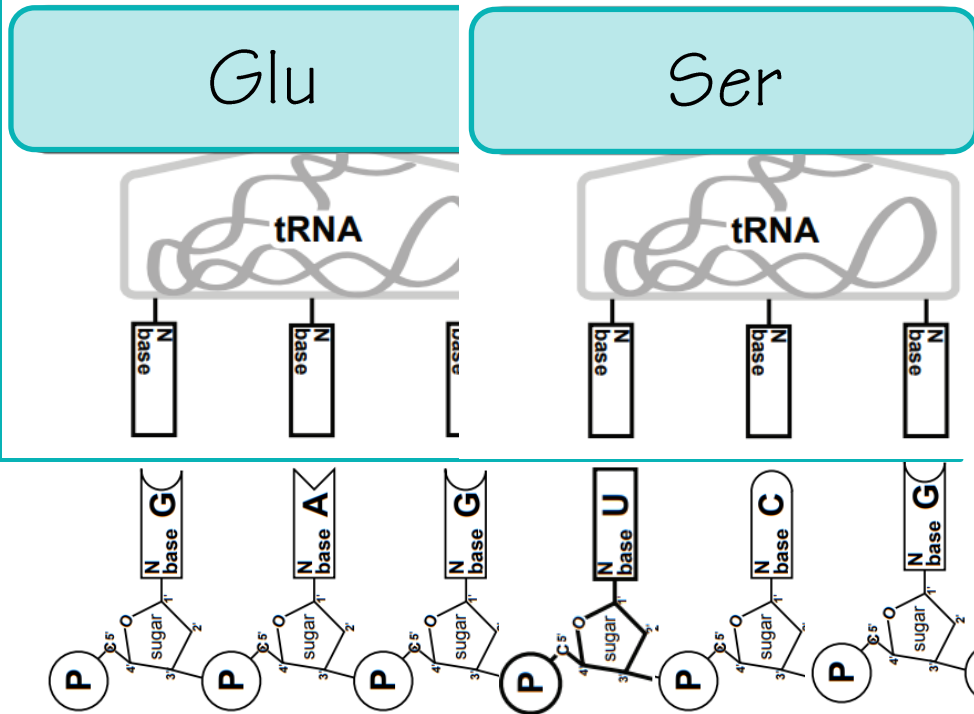
Translation



		Second Base in Codon									
		U	C	A	G						
U	UUU	Phe	UCU	UAU	UGU	U	Third Base in Codon				
	UUC							Ser	UAC	UGC	C
	UUA										
	UUG	UAG	UGG	G							
C	CUU	Leu	CCU	CAU	CGU	U					
	CUC						Pro	CAC	CGC	C	
	CUA										Gln
	CUG	CAG	CGG	G							
A	AUU	Ile	ACU	AAU	AGU	U					
	AUC						Thr	AAC	AGC	C	
	AUA										Met or Start
	AUG	AAG	AGG	G							
G	GUU	Val	GCU	GAU	GGU	U					
	GUC						Ala	GAC	GGC	C	
	GUA										Glu
	GUG	GAG	GGG	G							



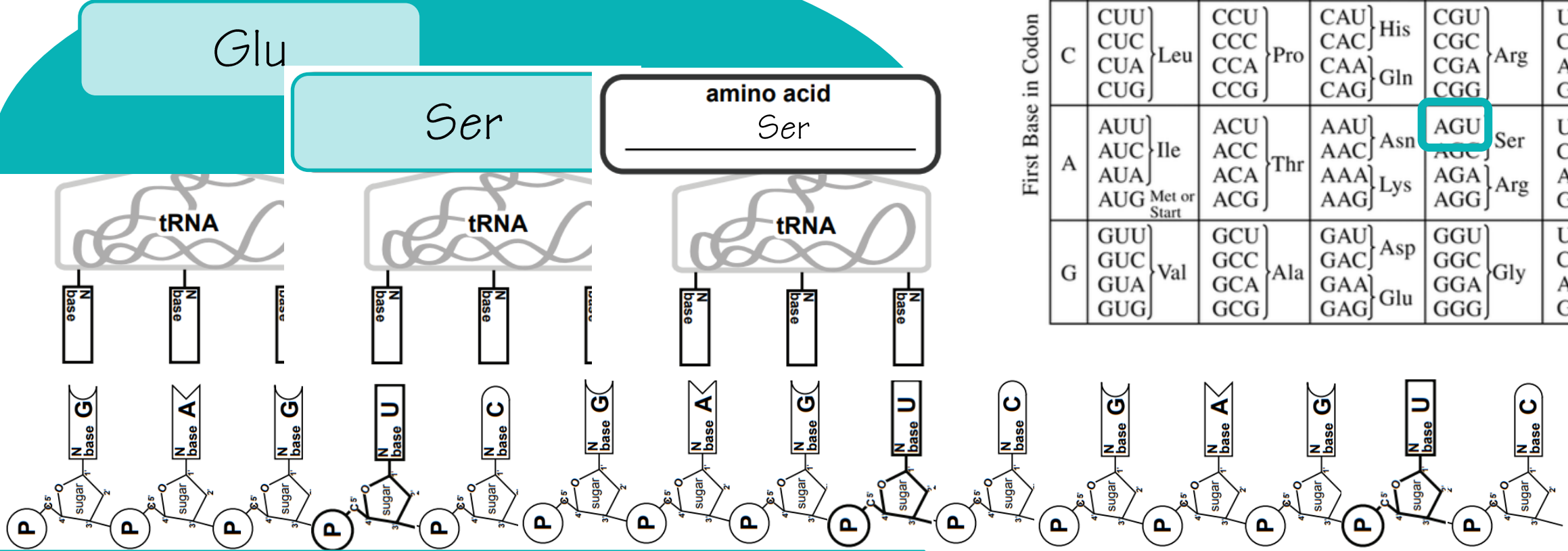
Translation



		Second Base in Codon						
		U	C	A	G			
U	UUU	} Phe	} Ser	UAU	} Tyr	UGU	} Cys	U
	UUC			UAC		UGC		C
	UUA			UAA Stop		UGA Stop		A
	UUG	UAG Stop		UGG Trp	G			
C	CUU	} Leu	} Pro	CAU	} His	CGU	} Arg	U
	CUC			CAC		CGC		C
	CUA			CAA		CGA		A
	CUG	CCG		CGG	G			
A	AUU	} Ile	} Thr	AAU	} Asn	AGU	} Ser	U
	AUC			AAC		AGC		C
	AUA			AAA		AGA		A
	AUG Met or Start	AAG		AGG	G			
G	GUU	} Val	} Ala	GAU	} Asp	GGU	} Gly	U
	GUC			GAC		GGC		C
	GUA			GAA		GGA		A
	GUG	GAG		GGG	G			



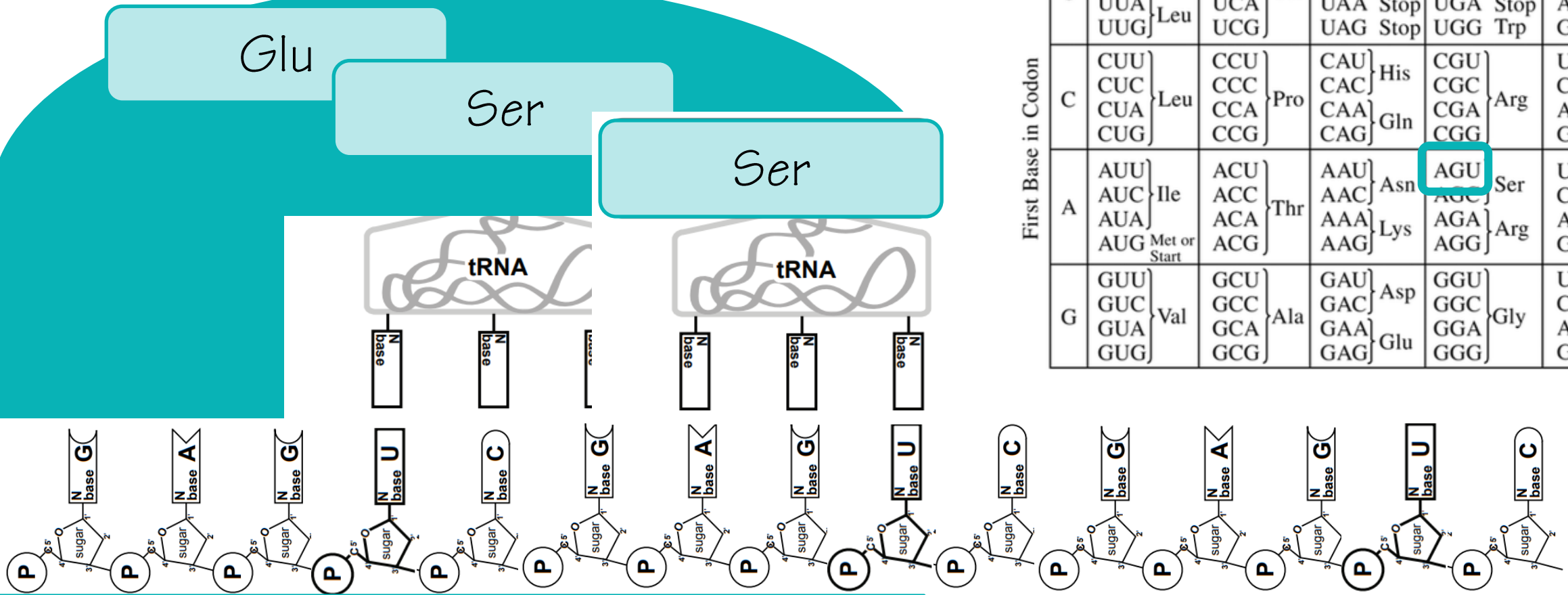
Translation



		Second Base in Codon								
		U	C	A	G					
U	UUU	Phe	UCU } Ser	UAU } Tyr	UGU } Cys	U				
	UUC						UCC	UAC	UGC	C
	UUA						UCA	UAA Stop	UGA Stop	A
	UUG	UCG		UAG Stop	UGG Trp		G			
C	CUU	Leu	CCU } Pro	CAU } His	CGU } Arg	U				
	CUC						CCC	CAC	CGC	C
	CUA						CCA	CAA	CGA	A
	CUG	CCG		CAG	CGG		G			
A	AUU	Ile	ACU } Thr	AAU } Asn	AGU } Ser	U				
	AUC						ACC	AAC	AGC	C
	AUA						ACA	AAA	AGA	A
	AUG Met or Start	ACG		AAG	AGG		G			
G	GUU	Val	GCU } Ala	GAU } Asp	GGU } Gly	U				
	GUC						GCC	GAC	GGC	C
	GUA						GCA	GAA	GGA	A
	GUG	GCG		GAG	GGG		G			



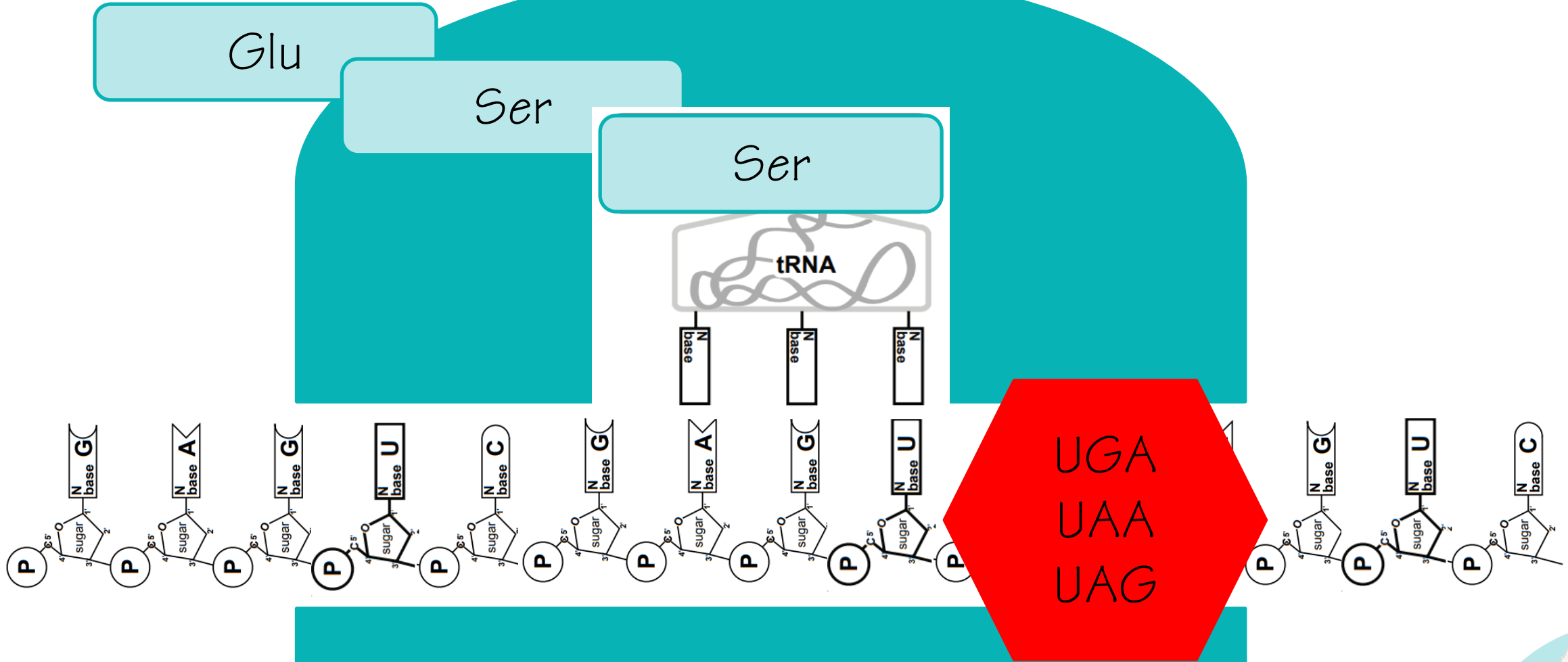
Translation



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		U	C	A	G	
U	UUU	UCU } Ser	UAU	UGU } Cys	U	
	UUC		UAC			UGC
	UUA		UAA	UGA		A
	UUG	UAG	UGG	G		
C	CUU	CCU } Pro	CAU	CGU } Arg	U	
	CUC		CAC			CGC
	CUA		CAA	CGA		A
	CUG	CCG	CAG	G		
A	AUU	ACU } Thr	AAU	AGU } Ser	U	
	AUC		AAC			AGC
	AUA		ACA	AGA		A
	AUG	ACG	AAG	G		
G	GUU	GCU } Ala	GAU	GGU } Gly	U	
	GUC		GCC			GGC
	GUA		GCA	GGA		A
	GUG	GCG	GAG	G		



Translation



Mutations

Point Mutations

Mutation at one nucleotide base pair

Silent

no change in amino acid (AA)

Missense

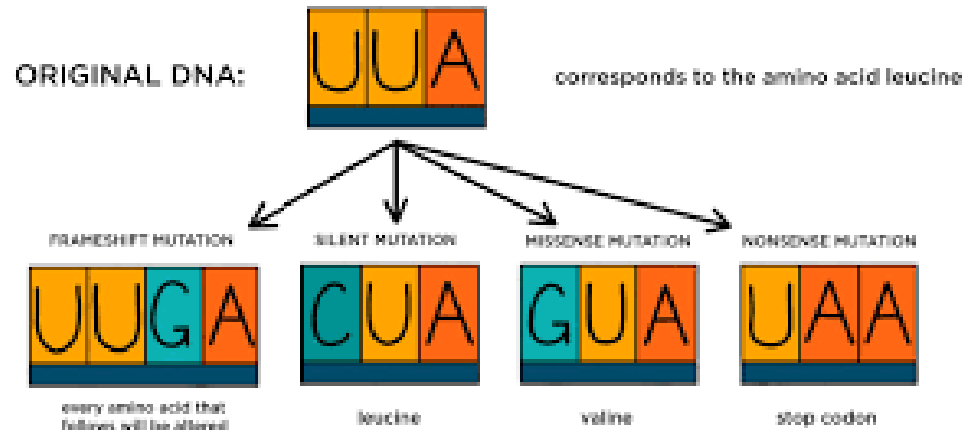
change from one AA to another AA

Nonsense

change from AA to STOP codon

Frameshift

insertion/deletion of 1 or 2 nucleotide base pairs shifts the reading frame for codons



Chromosomal Mutations

Rearrangement of chromosome parts or changes in chromosome numbers

Rearrangement

- Insertion
- Deletion
- Duplication
- Inversion
- Translocation

Changes in Chromosome Number

- Nondisjunction
- Polyploidy



Operons

Gene Regulation found in prokaryotes

Promoter

Site when RNA polymerase binds

Operator

Site when repressor binds

Genes

DNA

Repressible Operon

Example: Trp Operon
synthesizes tryptophan

Starts: ON

Repressor: INACTIVE

If trp is present...

Trp binds to repressor to ACTIVATE
Repressor binds to operator to turn
the operon OFF

Inducible Operon

Example: Lac Operon
synthesizes enzymes to break down lactose

Starts: OFF

Repressor: ACTIVE

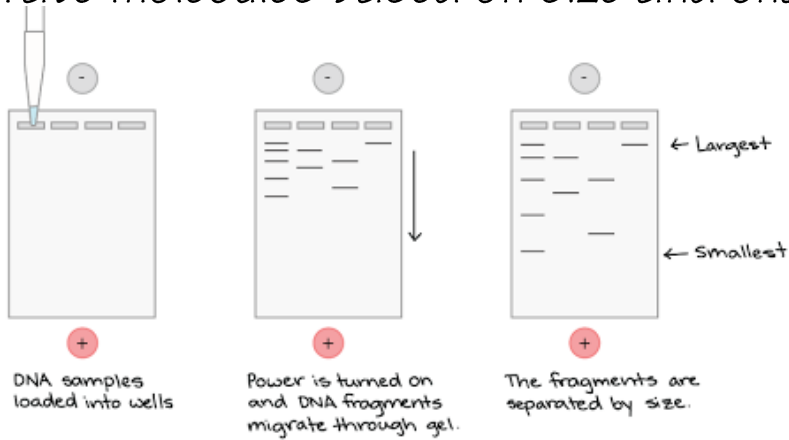
If lactose is present...

lactose binds to repressor to INACTIVATE
Repressor no longer binds to operator to
turn the operon ON



Gel Electrophoresis

Separate molecules based on size and charge



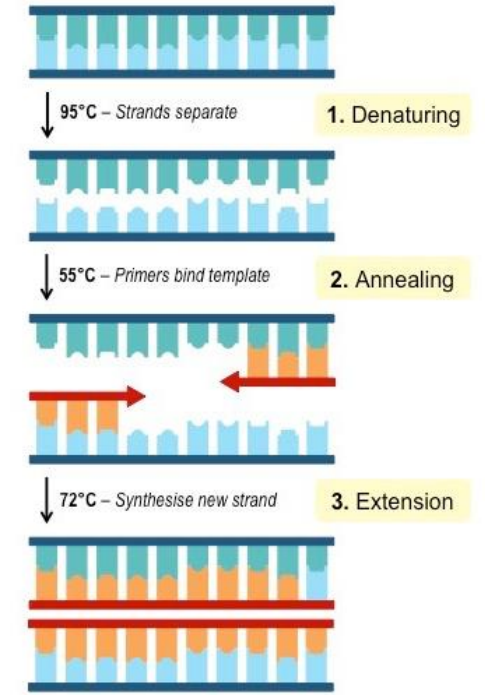
Polymerase Chain Reaction (PCR)

Makes multiple copies of DNA fragments

Steps

1. Heating
2. Cooling
3. Annealing

PCR Process (ONE Cycle)



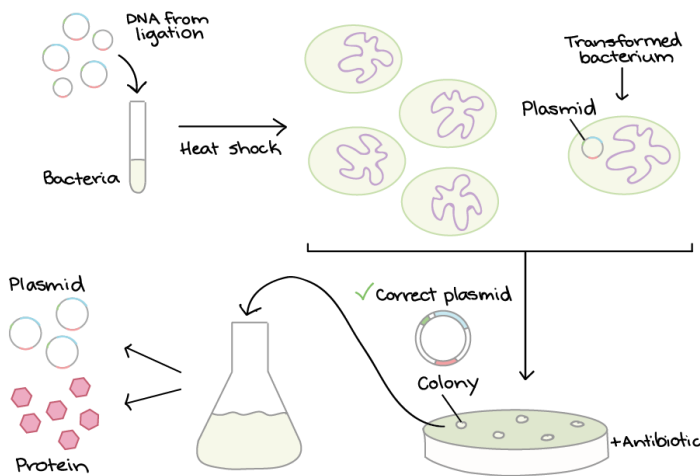
BioTechnology

Bacterial Transformation

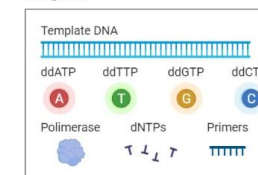
Introduce genetic material (plasmid) to bacteria

DNA Sequencing

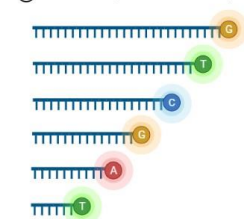
Use radioactive nucleotides to determine the sequence of a DNA strand



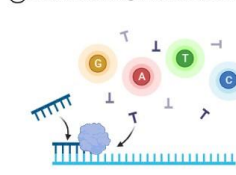
Reagents



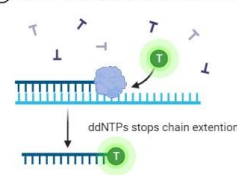
③ Fluorescently labelled DNA sample



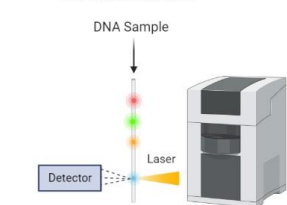
① Primer annealing and chain extension



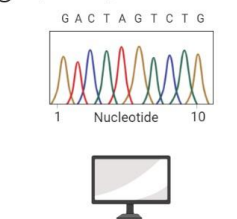
② ddNTP binding and chain termination



④ Capillary gel electrophoresis and fluorescence detection



⑤ Sequence analysis and reconstruction



Phenotype	Number of Offspring
Gray body, long wings	42
Black body, apterous wings	41
Gray body, apterous wings	9
Black body, long wings	8

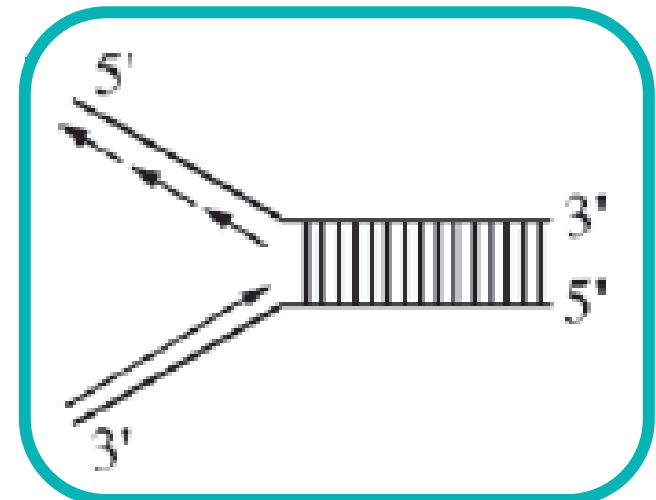
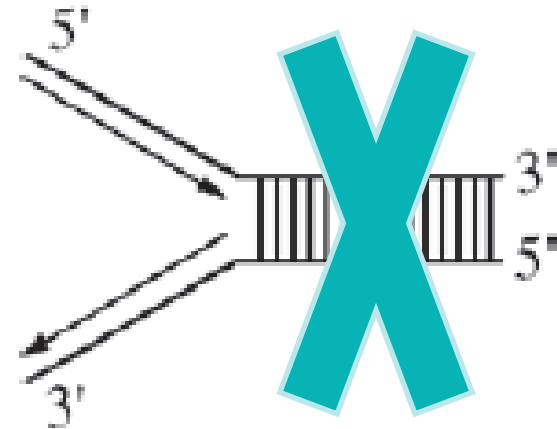
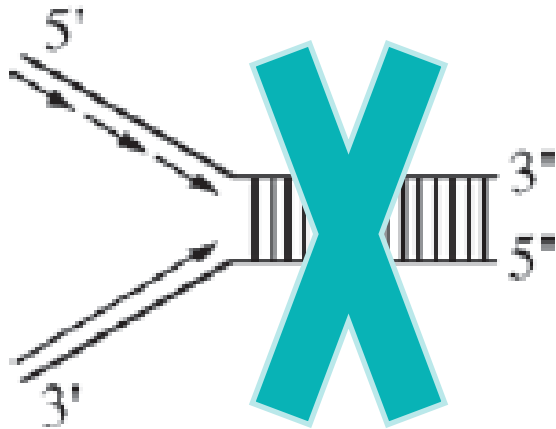
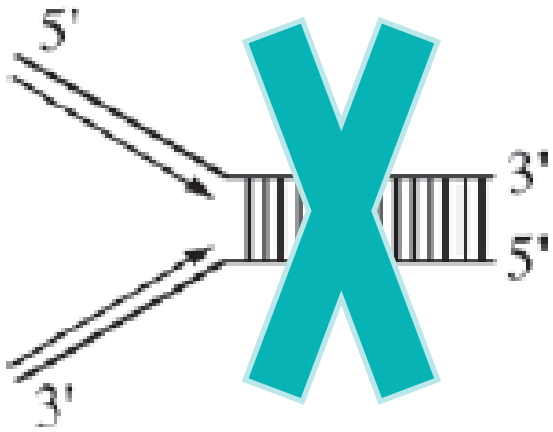
A student in a biology class crossed a male *Drosophila melanogaster* having a gray body and long wings with a female *D. melanogaster* having a black body and apterous wings. The following distribution of traits was observed in the offspring.

Which of the following is supported by the data?

- The alleles for gray body and long wings are dominant.
- The alleles for gray body and long wings are recessive.
- Genes for the two traits are located on two different chromosomes, and independent assortment occurred.
- Genes for the two traits are located close together on the same chromosome and crossing over occurred between the two gene loci.

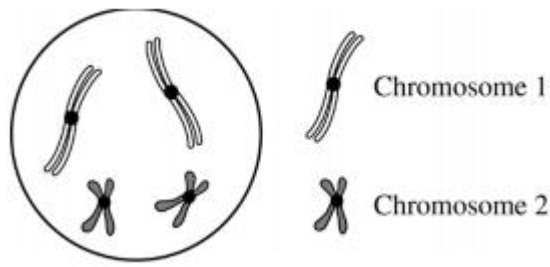


When DNA replicates, each strand of the original DNA molecule is used as a template for the synthesis of a second, complementary strand. Which of the following figures most accurately illustrates enzyme-mediated synthesis of new DNA at a replication fork?



Sickle-cell anemia results from a point mutation in the HBB gene. The mutation results in the replacement of an amino acid that has a hydrophilic R-group with an amino acid that has a hydrophobic R-group on the exterior of the hemoglobin protein. Such a mutation would most likely result in altered

- a. properties of the molecule as a result of abnormal interactions between adjacent hemoglobin molecules
- b. DNA structure as a result of abnormal hydrogen bonding between nitrogenous bases
- c. fatty acid structure as a result of changes in ionic interactions between adjacent fatty acid chains
- d. protein secondary structure as a result of abnormal hydrophobic interactions between R-groups in the backbone of the protein

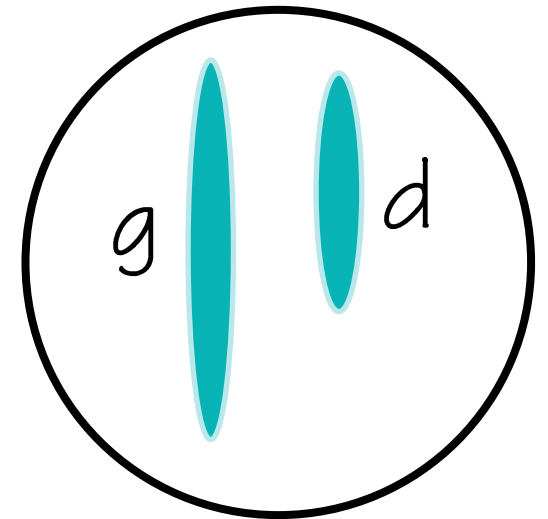
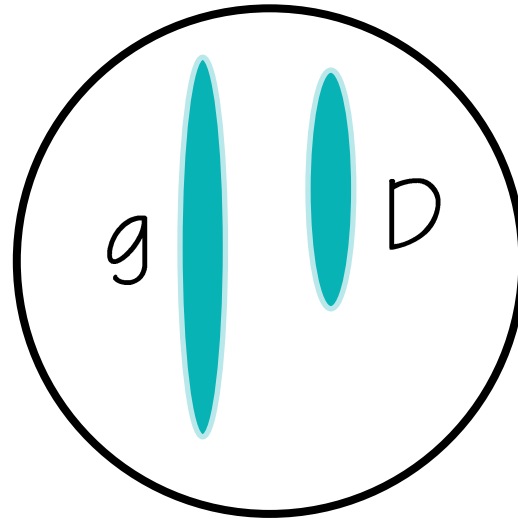
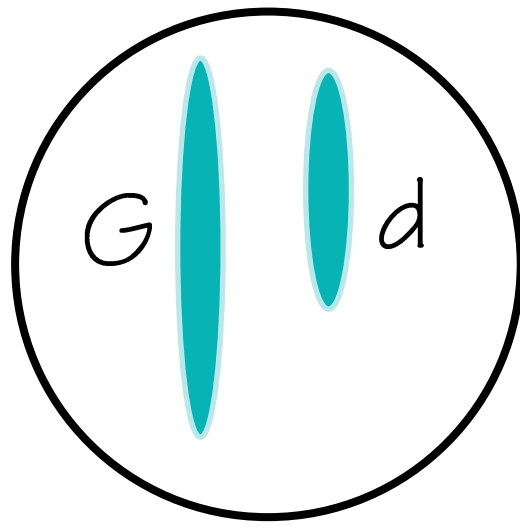
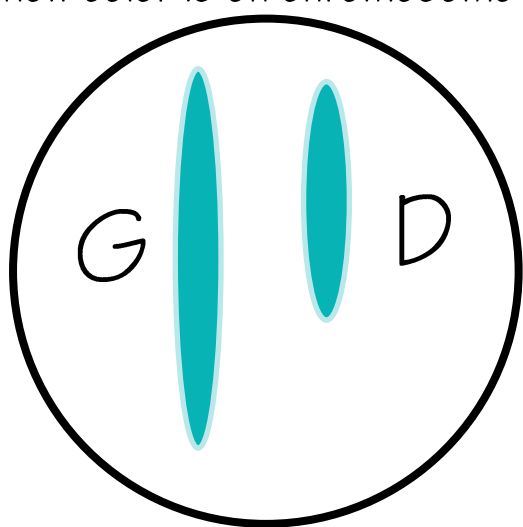


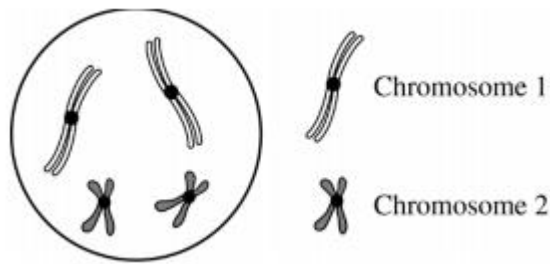
Free Response Practice:

In a certain species of plant, the diploid number of chromosomes is 4 ($2n = 4$). Flower color is controlled by a single gene in which the green allele (G) is dominant to the purple allele (g). Plant height is controlled by a different gene in which the dwarf allele (D) is dominant to the tall allele (d). Individuals of the parental (P) generation with the genotypes $GGDD$ and $ggdd$ were crossed to produce F_1 progeny.

$$F_1 = GgDd$$

(a) Construct a diagram below to depict the four possible normal products of meiosis that would be produced by the F_1 progeny. Show the chromosomes and the allele(s) they carry. Assume the genes are located on different chromosomes and the gene for flower color is on chromosome 1.





Free Response Practice:

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Test Cross = $GgDd \times ggdd$

(b) **Predict** the possible phenotypes and their ratios in the offspring of a testcross between an F_1 individual and a $ggdd$ individual.

Gg	gg
Gg	gg

$\frac{1}{2}$ Green
 $\frac{1}{2}$ Purple

Dd	dd
Dd	dd

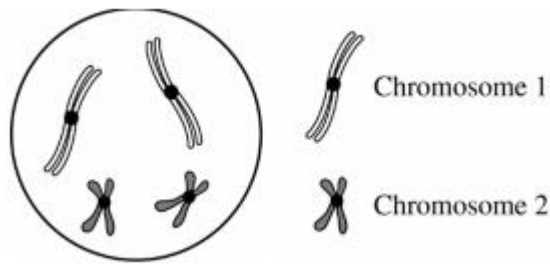
$\frac{1}{2}$ Dwarf
 $\frac{1}{2}$ Tall

Green
Green

Prediction (1 point)

- 1 green dwarf: 1 green tall: 1 purple dwarf: 1 purple tall

$\frac{1}{4}$
 $\frac{1}{4}$



Free Response Practice:

In a certain species of plant, the diploid number of chromosomes is 4 ($2n = 4$). Flower color is controlled by a single gene in which the green allele (G) is dominant to the purple allele (g). Plant height is controlled by a different gene in which the dwarf allele (D) is dominant to the tall allele (d). Individuals of the parental (P) generation with the genotypes $GGDD$ and $ggdd$ were crossed to produce F_1 progeny.

$$F_1 = GgDd$$

(b) **Predict** the possible phenotypes and their ratios in the offspring of a testcross between an F_1 individual and a $ggdd$ individual.

Prediction (1 point)

- 1 green dwarf: 1 green tall: 1 purple dwarf: 1 purple tall

(c) If the two genes were genetically linked, **describe** how the proportions of phenotypes of the resulting offspring would most likely differ from those of the testcross between an F_1 individual and a $ggdd$ individual.

Identify difference (1 point)

- The majority/greater than 50 percent would have the parental plant phenotypes
- Greater than 25 percent would be green dwarf plants and greater than 25 percent would be purple tall plants
- Less than 25 percent would be green tall plants and less than 25 percent would be purple dwarf plants

Free Response Practice:

In humans, the gene that determines a particular condition has only two alleles, one of which (*B*) is completely dominant to the other (*b*). The phenotypes of three generations of a family with respect to the condition are shown in the pedigree in Figure 1. Individuals are numbered.

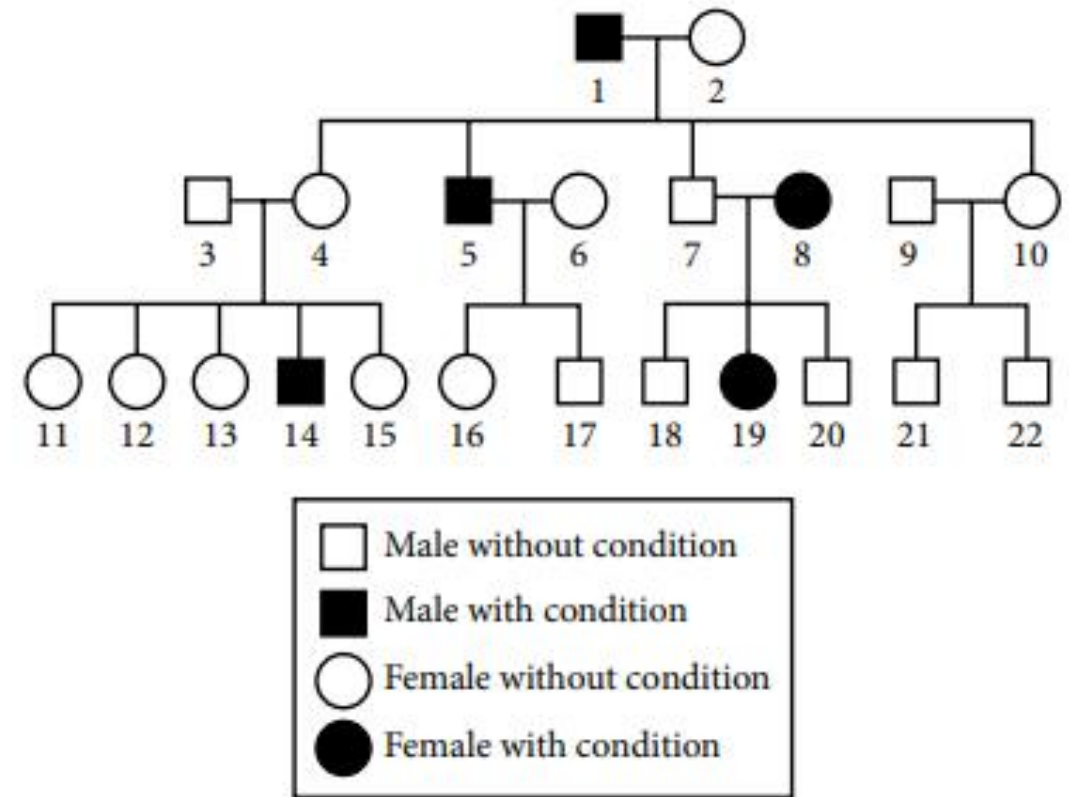


Figure 1. Inheritance of a particular condition over three generations of a family



Free Response Practice:

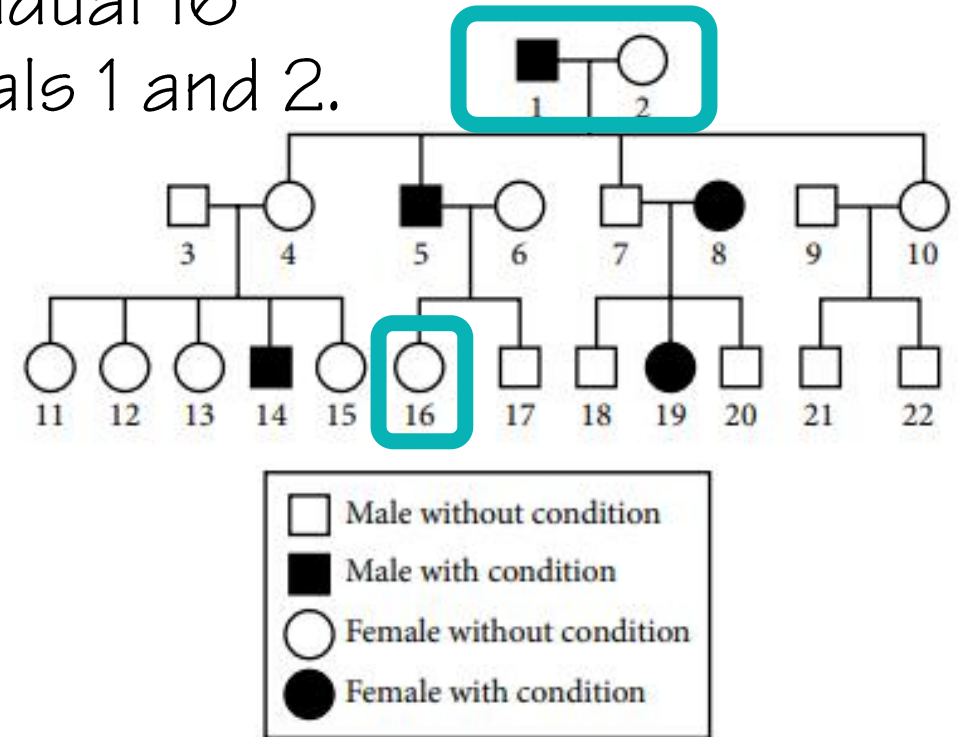
(a) *Describe* the process in eukaryotes that ensures that the number of chromosomes will not double from parent to offspring when gametes fuse during fertilization.

Describe the process in eukaryotes that ensures that the number of chromosomes will not double from parent to offspring when gametes fuse during fertilization.

- Homologous pairs of chromosomes separate in meiosis I, so the gametes are haploid (n), and each gamete receives only one member of each chromosome pair.

Free Response Practice:

(b) Explain how any one chromosome in individual 16 contains DNA that came from both individuals 1 and 2.

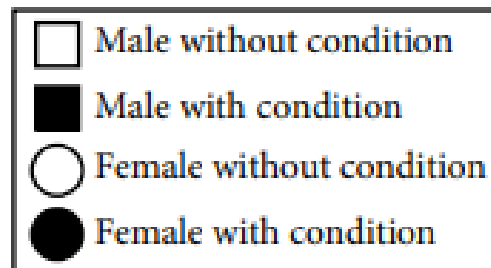
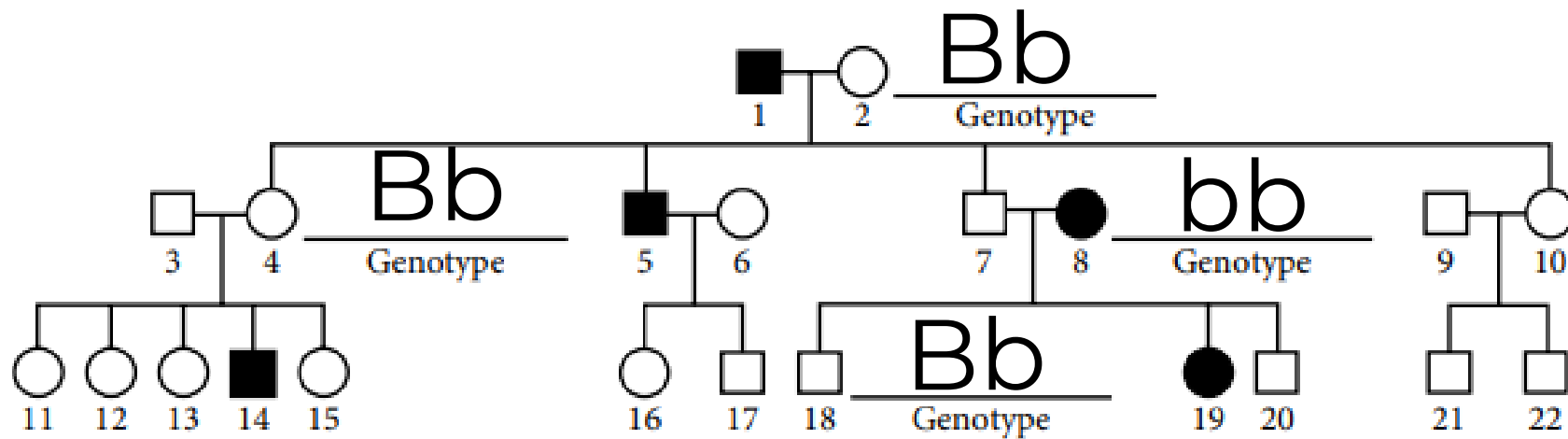


Individual 5 inherited one member of each homologous pair. During gamete formation in individual 5, crossing over occurred between members of a homologous pair. Thus each chromosome formed and passed on to both 1 and 2.

Figure 1. Inheritance of a particular condition over three generations of a family

Free Response Practice:

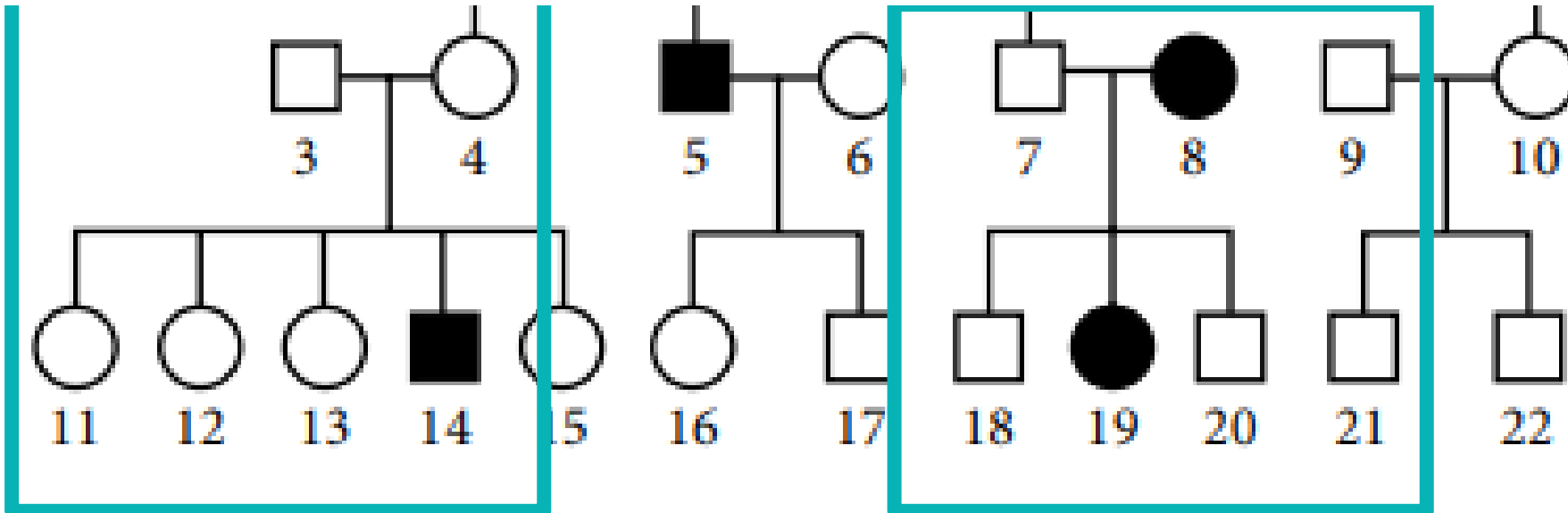
(c) Use the *template* figure of the pedigree and the allele designations B and b to *indicate* the genotypes of individuals 2, 4, 8, and 18.



Free Response Practice

(d) Based on the pedigree, explain whether the inheritance pattern of the condition is sex-linked or autosomal and dominant or recessive.

The disease phenotype is recessive and is autosomal/not sex-linked. It cannot be dominant because individuals 3 and 4 do not have it, but their offspring 14 does. It is not sex-linked because if it was Y-linked, all male offspring of males with the disease phenotype would have the trait, and they do not.





Q & A



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