SNS COLLEGE OF TECHNOLOGY

(AN AUTONOMOUS INSTITUTION)

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Department of Biomedical Engineering

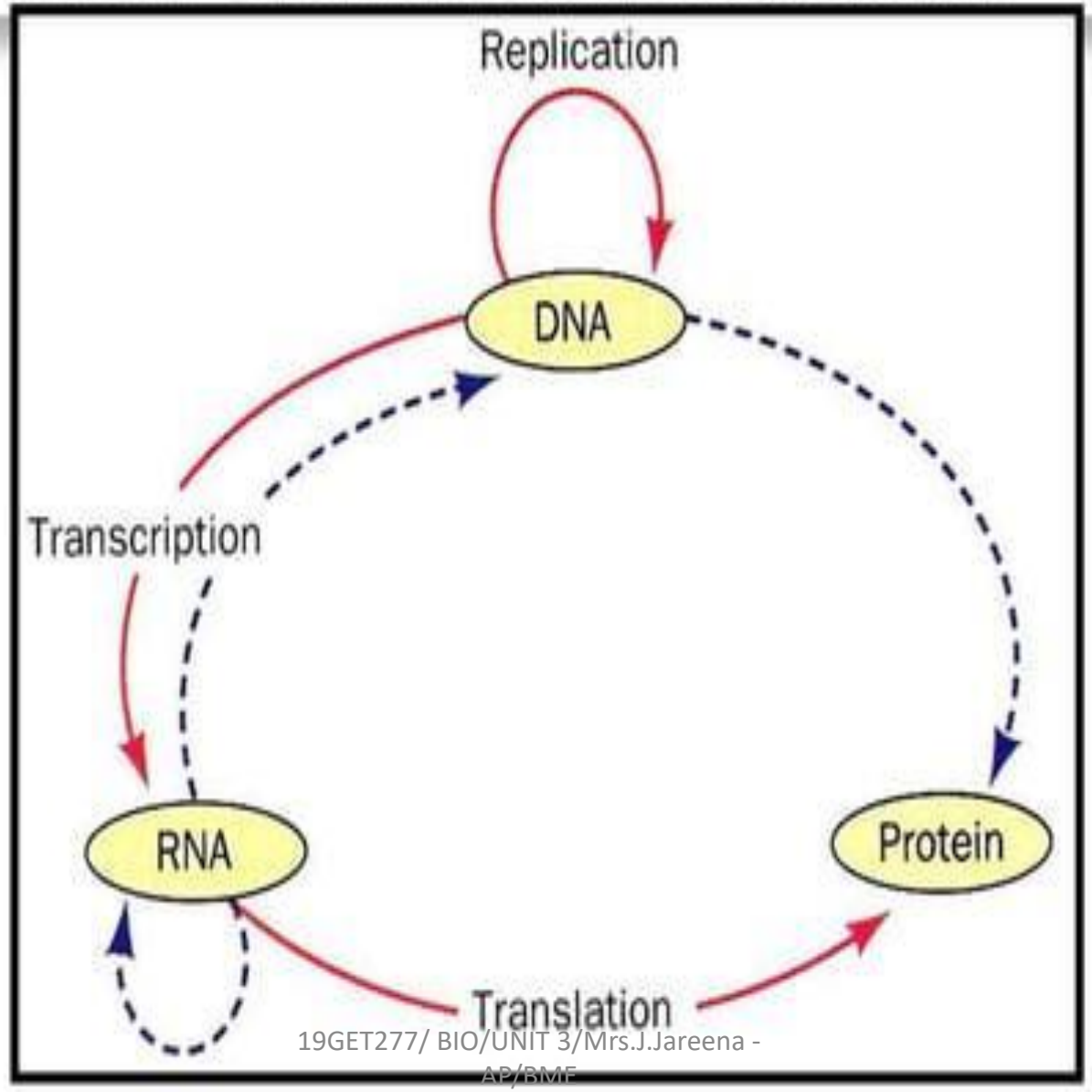
Course Name: 19GET277 – Biology for Engineers

IV Year : VII Semester

UNIT III – GENETICS AND IMMUNE SYSTEM

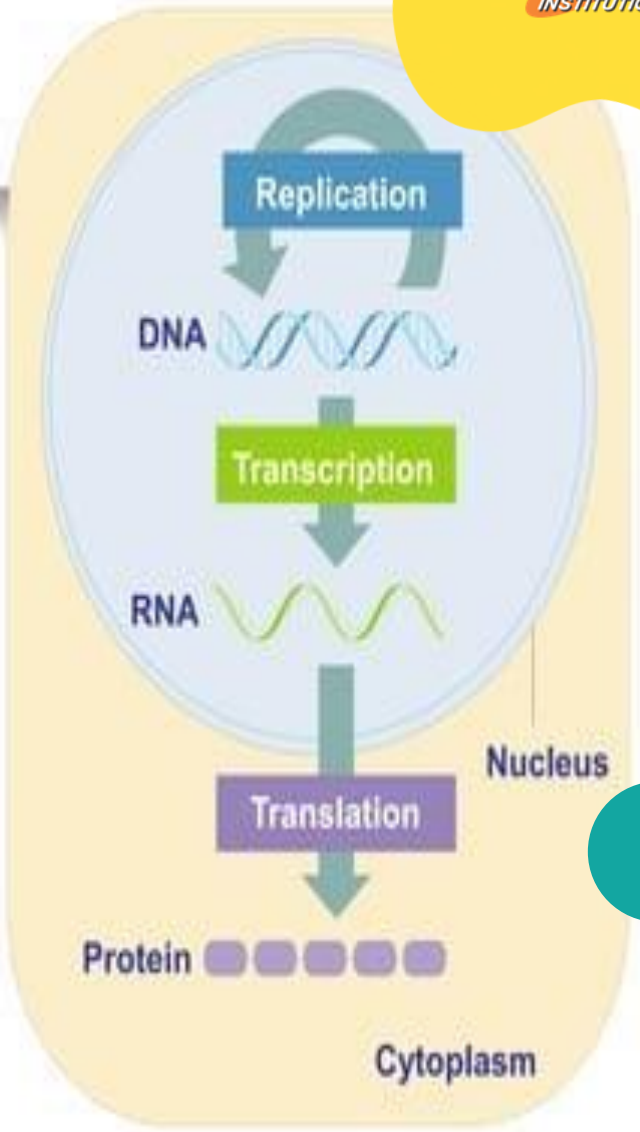
Topic :Central DOGMA

THE CENTRAL DOGMA

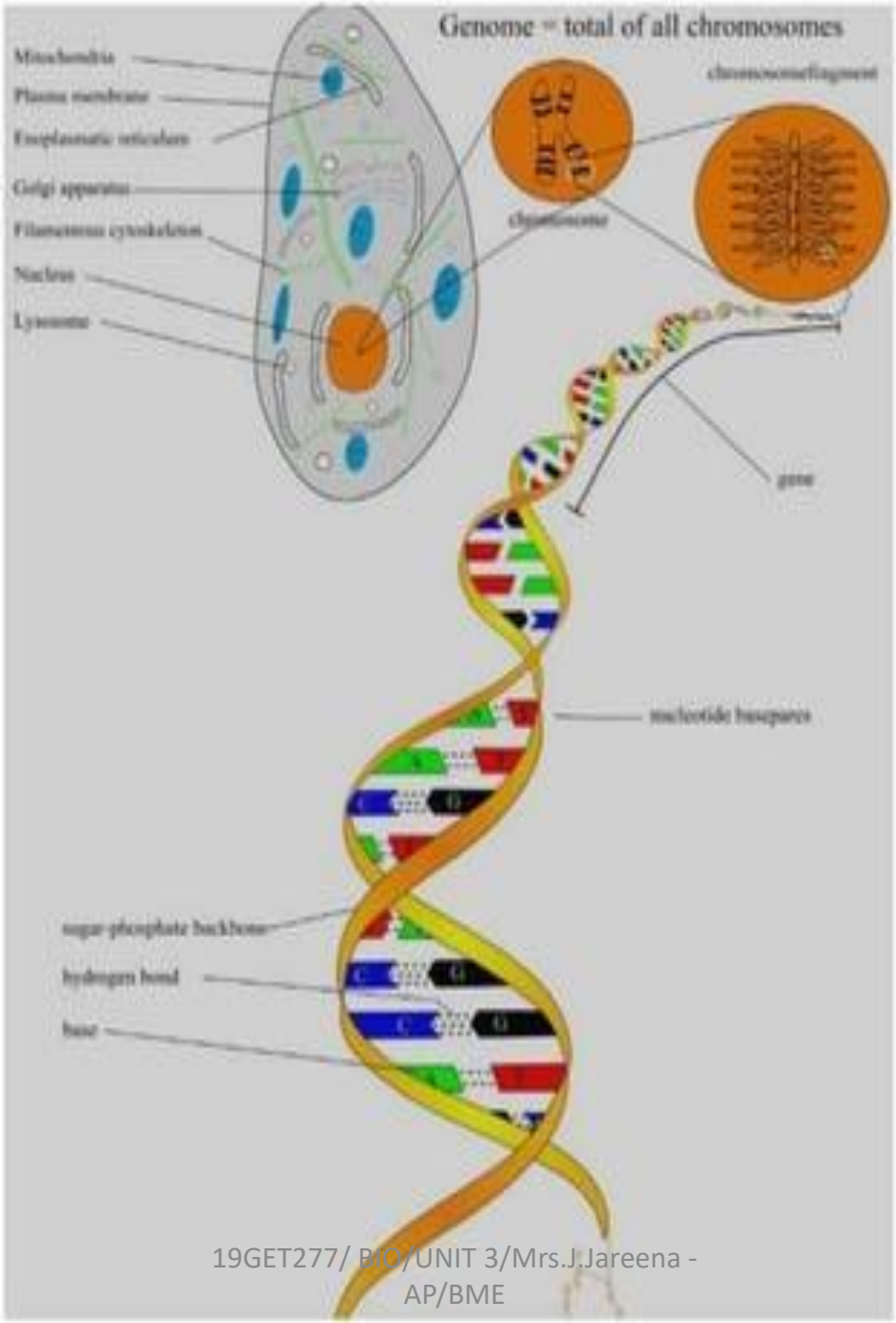


THE CENTRAL DOGMA

- **DNA** is the genetic material within the nucleus.
- **Replication** creates new copies of DNA.
- **Transcription** creates an RNA using DNA information.
- **Translation** creates a protein using RNA information.

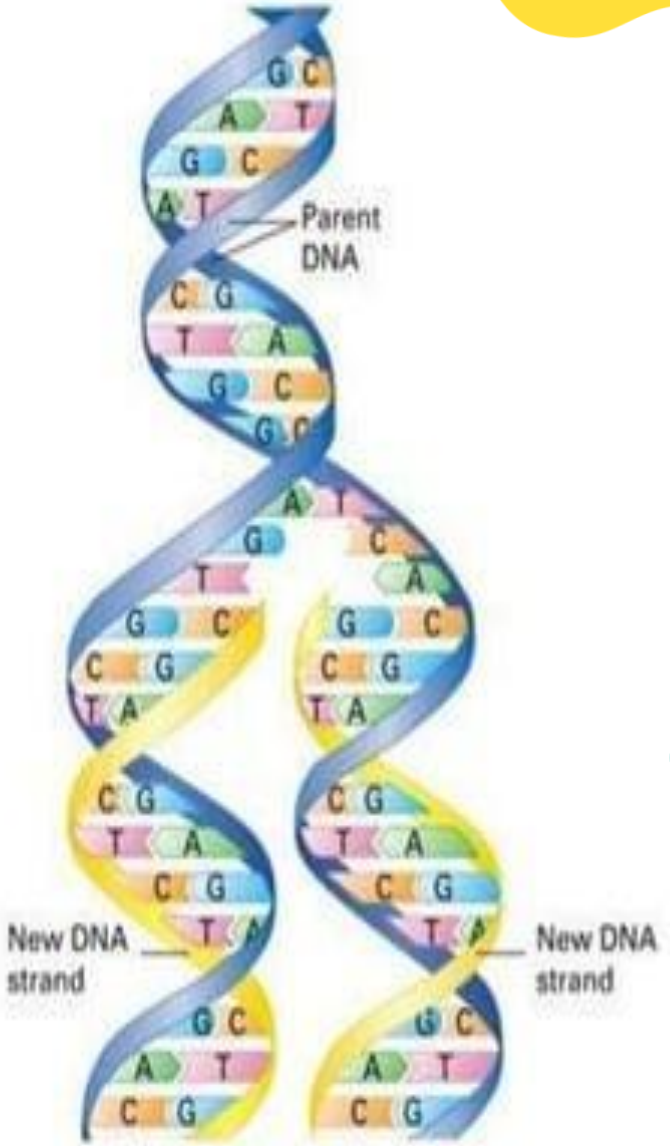


The DNA


Genome = total of all chromosomes
Mitochondria
Plasma membrane
Endoplasmic reticulum
Golgi apparatus
Filamentous cytoskeleton
Nucleus
Lysosome
chromosome fragment
chromosome
gene
nucleotide basepairs
sugar-phosphate backbone
hydrogen bond
base

REPLICATION

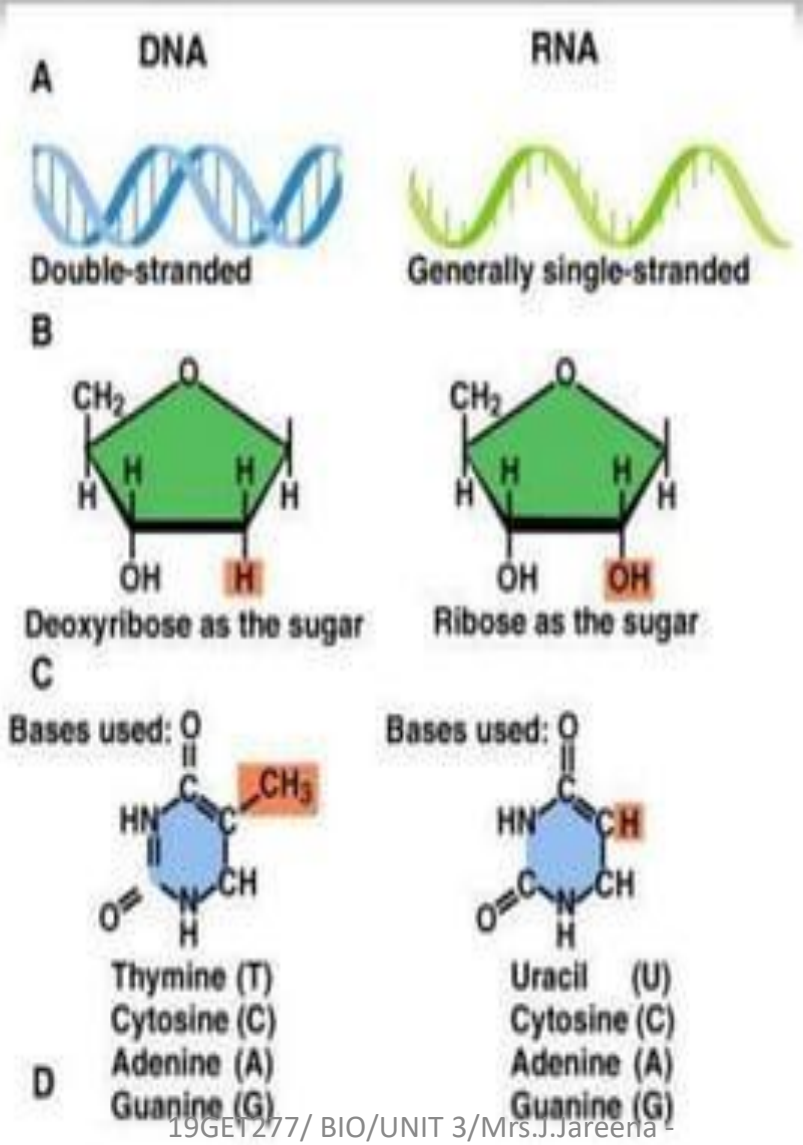
- DNA Replication is semi-conservative.
- Each newly synthesized molecule contains 1 "parent template" strand and 1 new "daughter" strand.



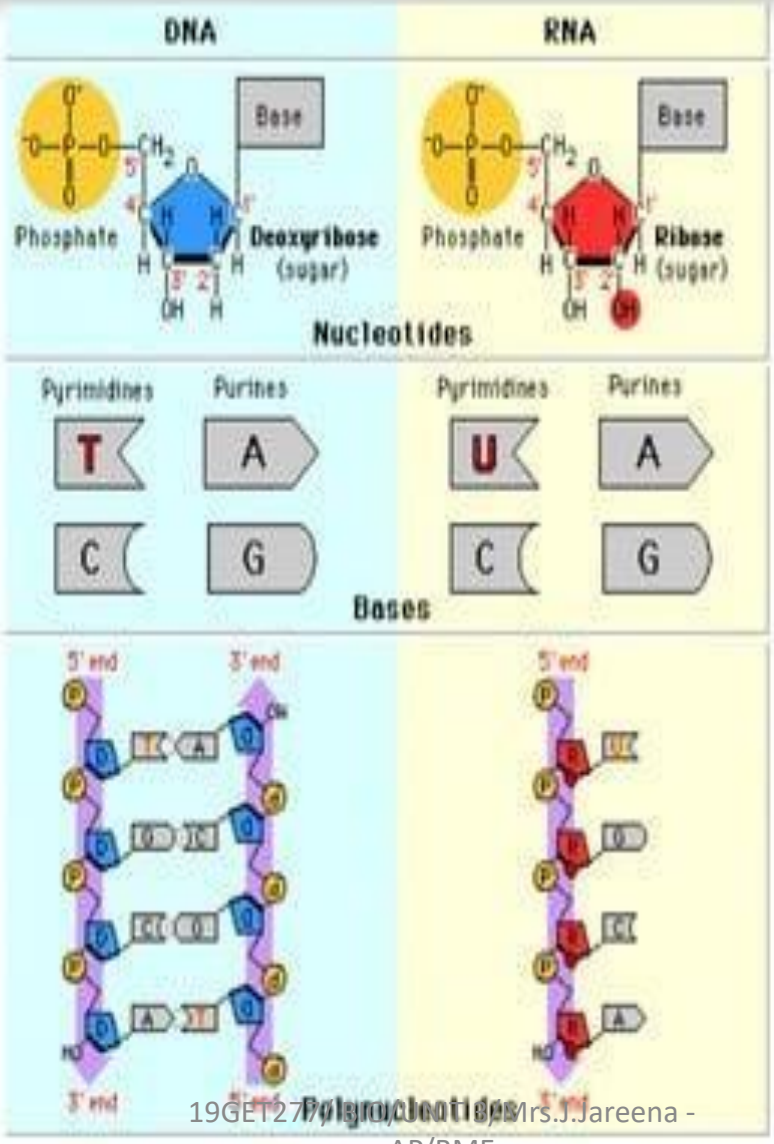
TRANSCRIPTION: RNA Synthesis

- RNA is an important type of nucleic acid that plays several roles in the production of protein
- RNA is necessary to carry the instructions of the DNA out of the nucleus and to the ribosomes.

Two Types of Nucleic Acids

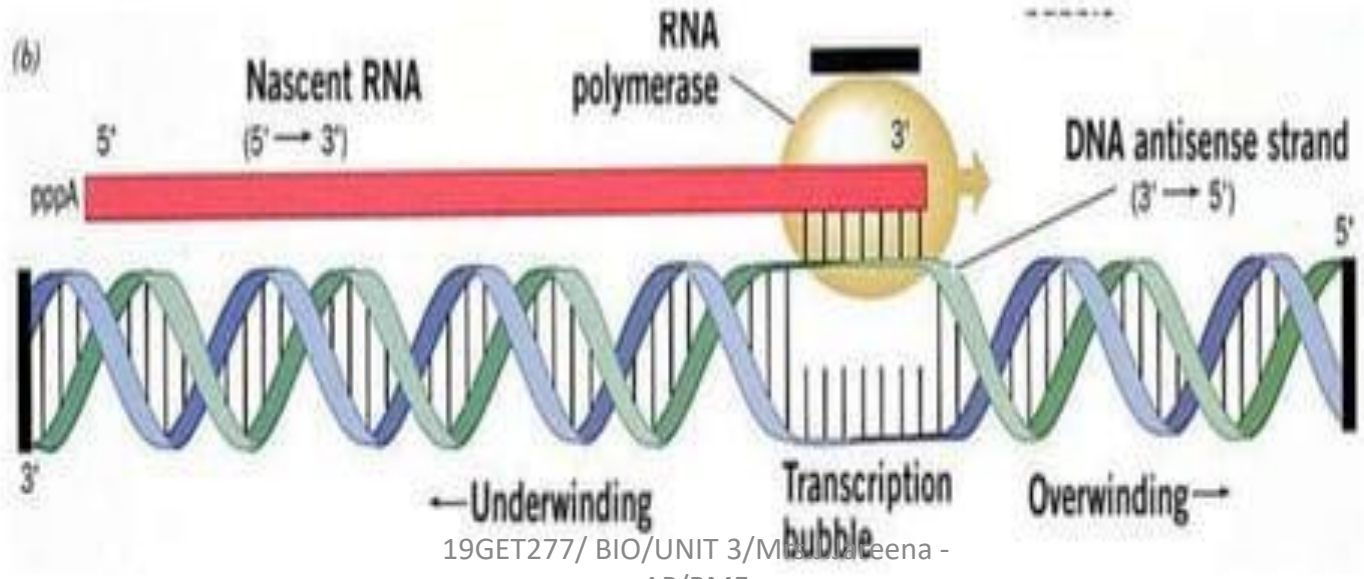


The RNA Molecule



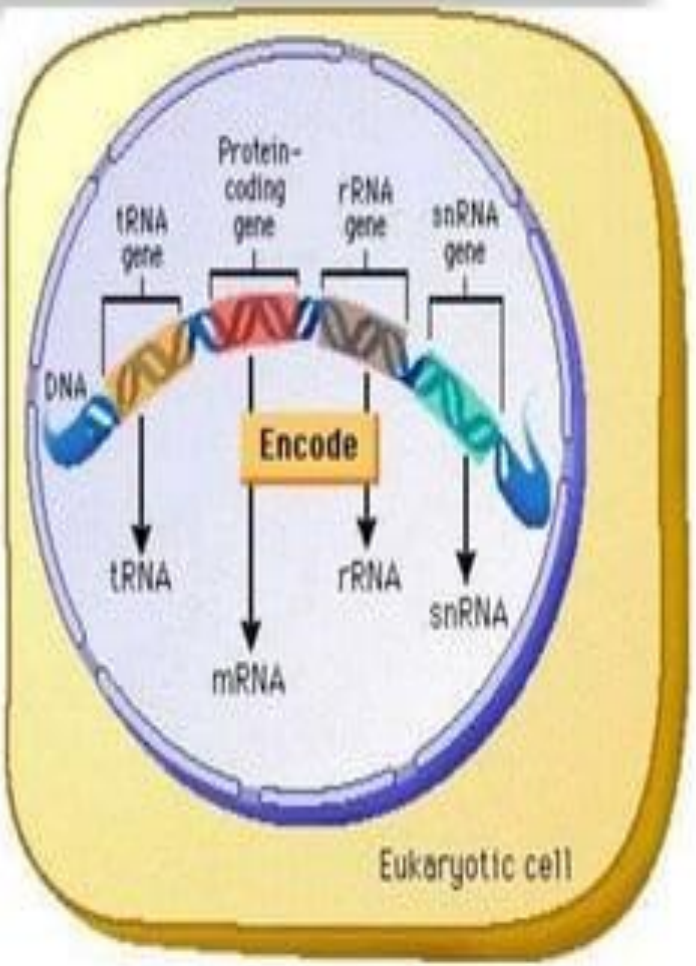
TRANSCRIPTION

- It is the mechanism by which a template strand of DNA is utilized by specific **RNA polymerases** to generate one of the 4 different types of RNA.



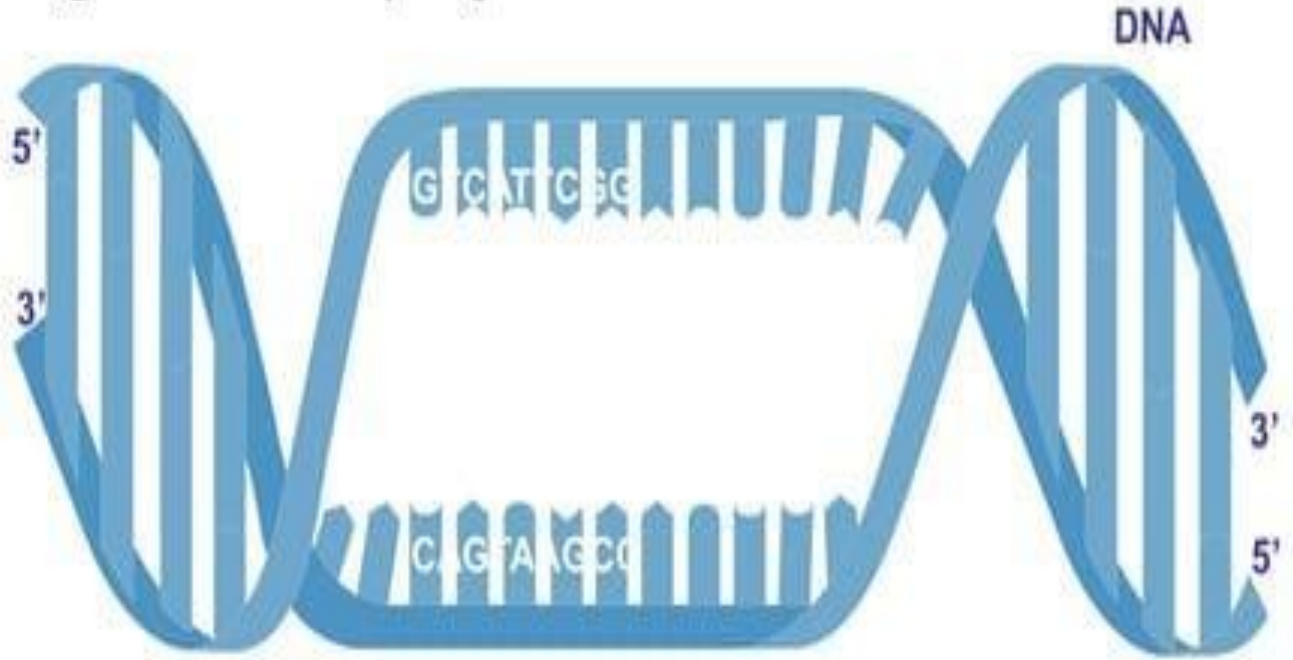
Types of RNA

1. mRNA (messenger RNA)
2. tRNA (transfer RNA)
3. rRNA (ribosomal RNA)
4. snRNA (small nuclear RNA)



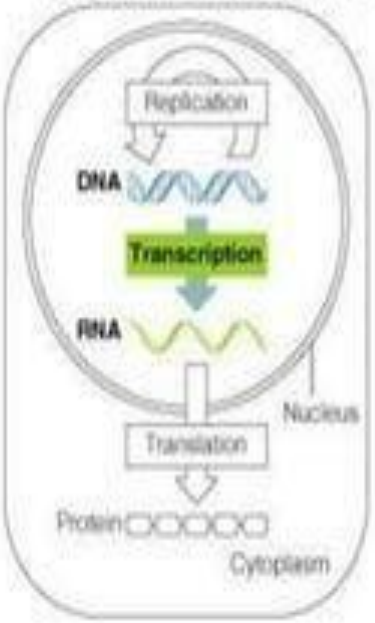
TRANSCRIPTION

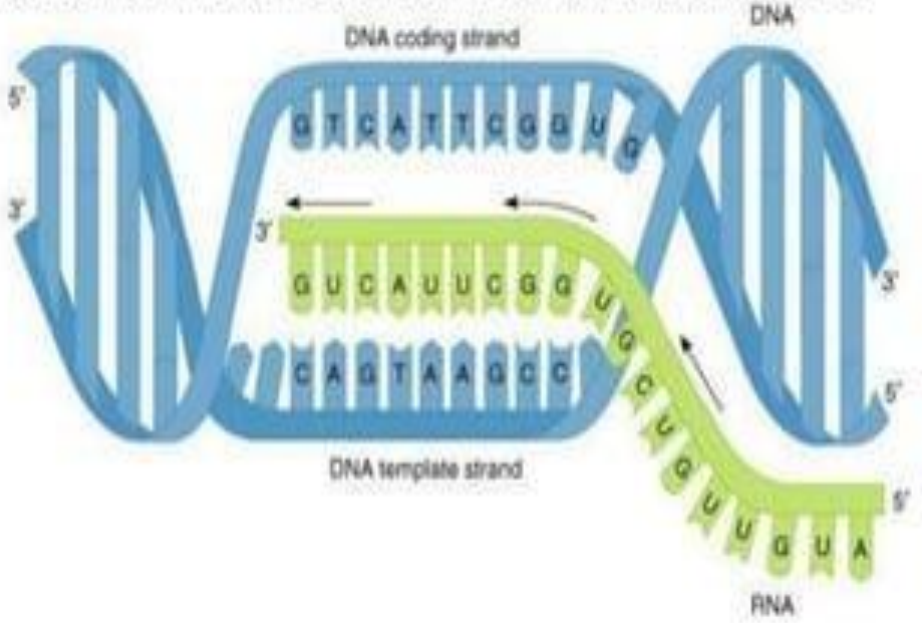
- DNA is used as a template for creation of RNA using the RNA polymerase.



TRANSCRIPTION

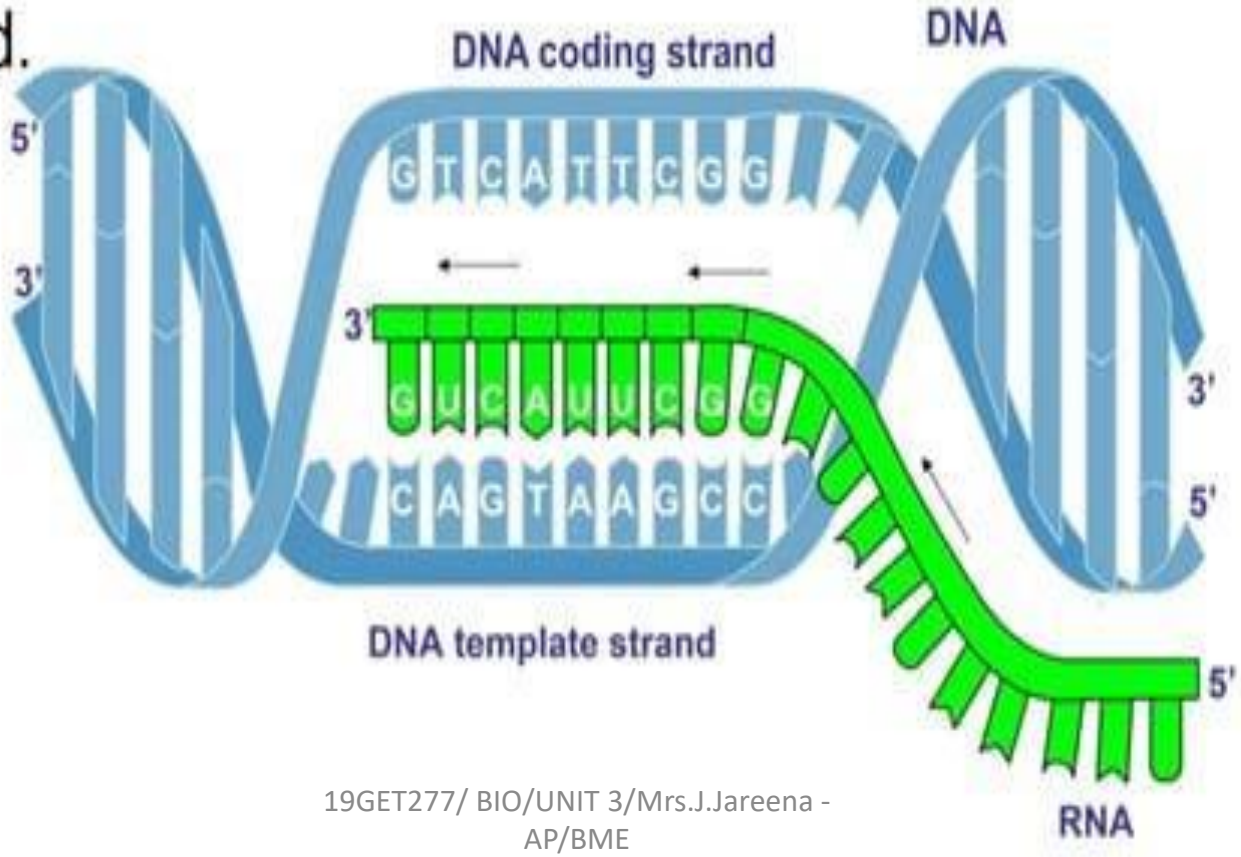
- RNA polymerase reads the nucleotides on the template strand from 3' to 5' and creates an RNA molecule in a 5' to 3' direction that looks like the coding strand.





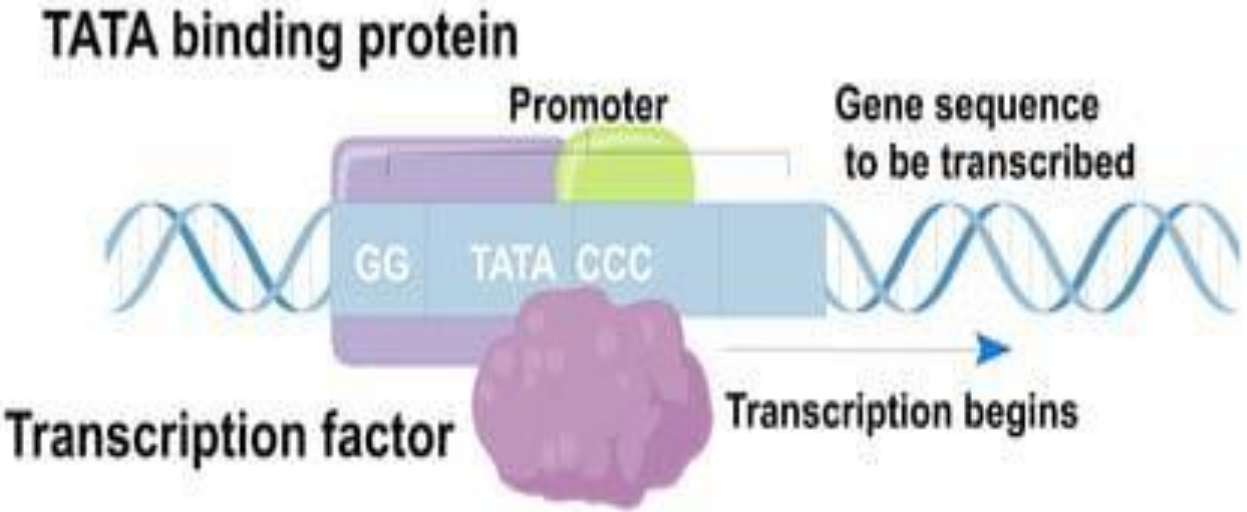
TRANSCRIPTION

- The new RNA molecule is formed by incorporating nucleotides that are complementary to the template strand.



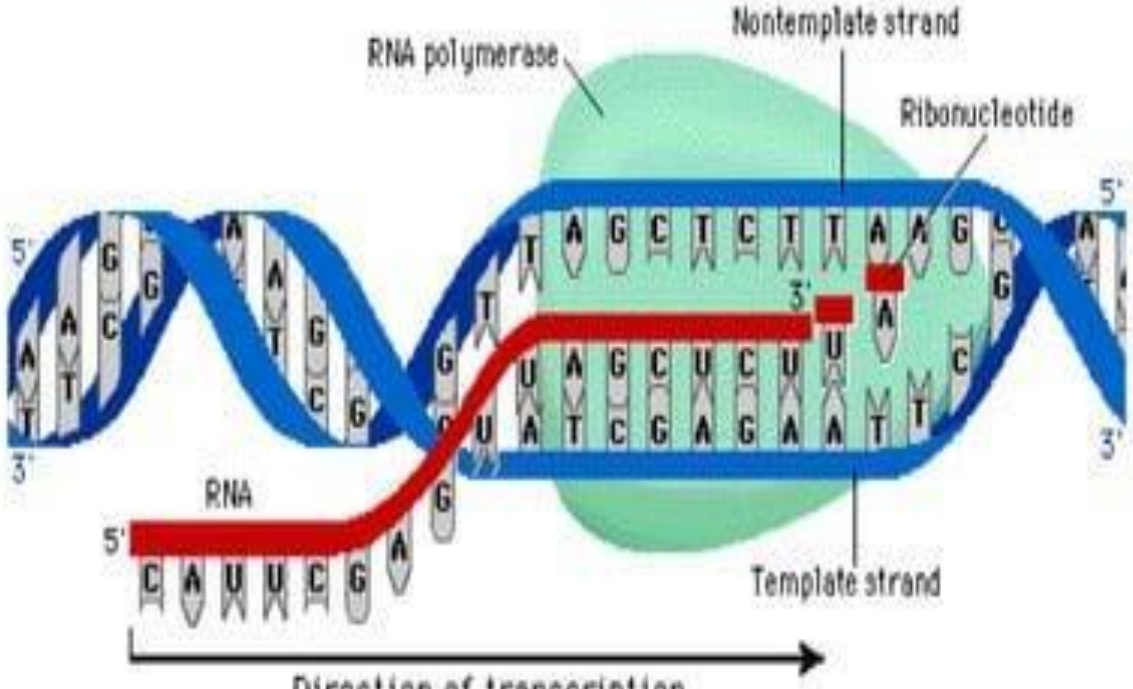
Initiation of Transcription

- Transcription begins at the 3' end of the gene in a region called the promoter.
- The promoter recruits TATA protein, a DNA binding protein, which in turn recruits other proteins.



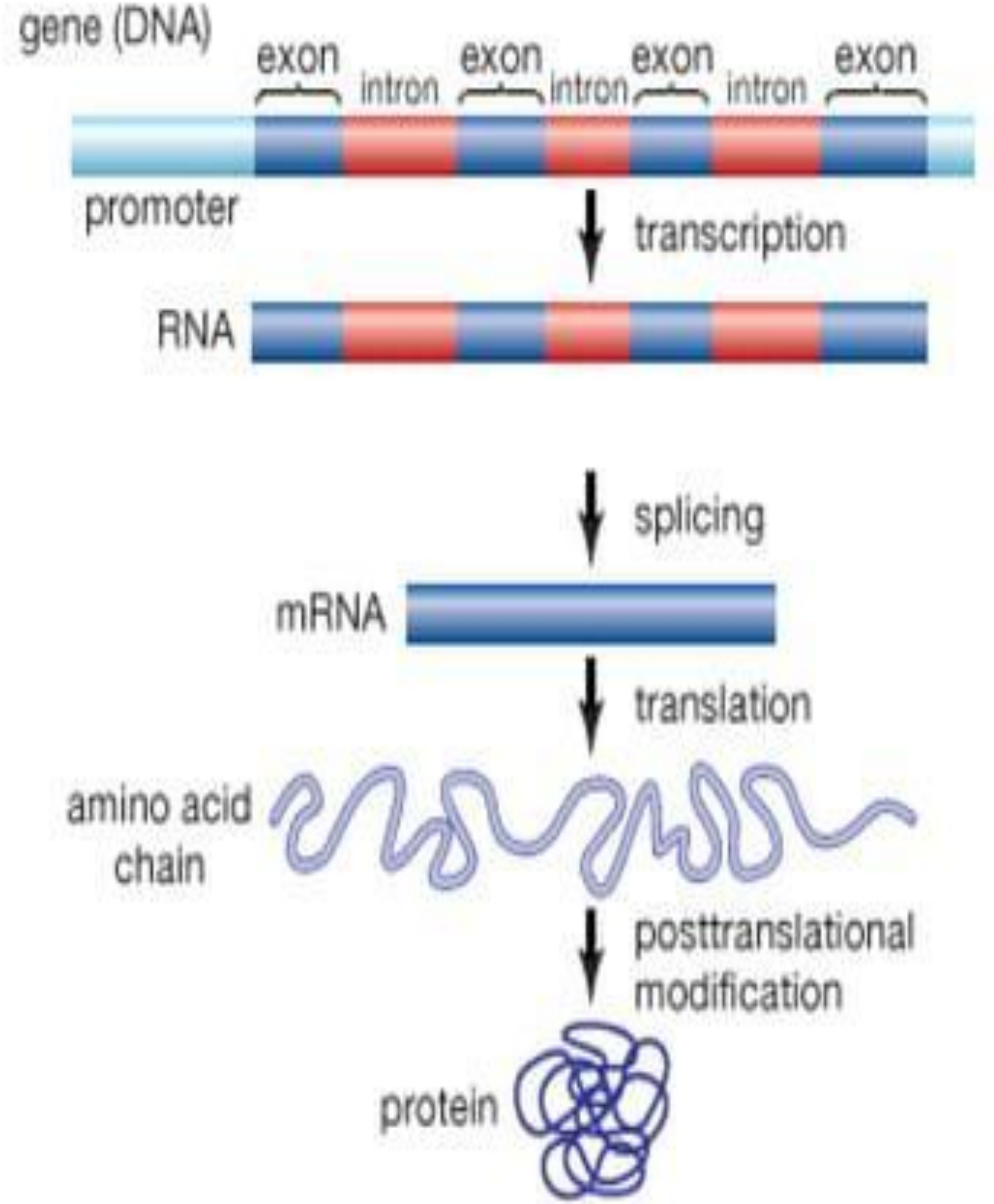
The Transcription Process

- RNA synthesis involves separation of the DNA strands and synthesis of an RNA molecule in the 5' to 3' direction by RNA polymerase, using one of the DNA strands as a template.



Complete Transcription of an RNA Molecule

- Transcription begins at the promoter, proceeds through the coding region, and ends at the terminator.

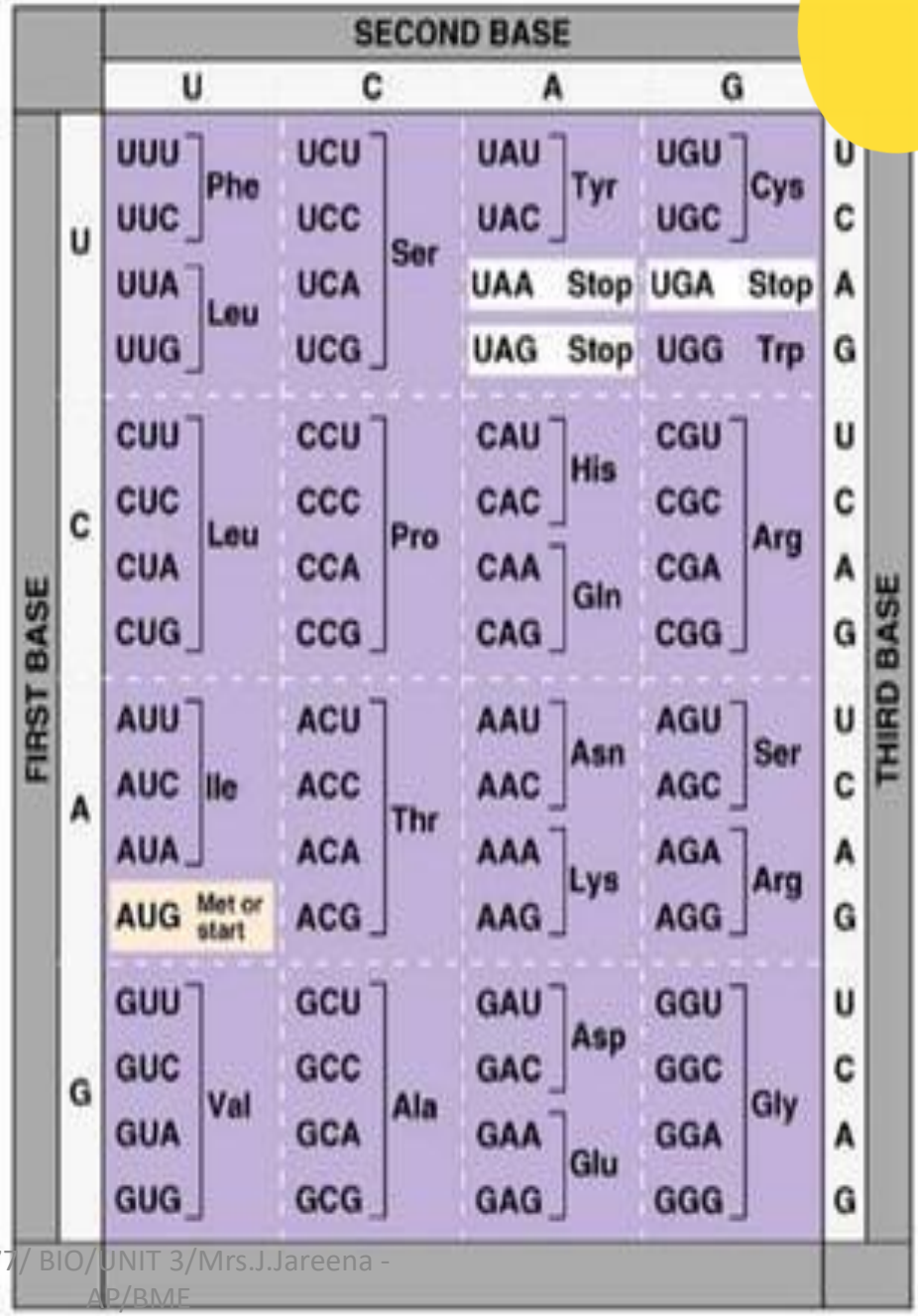


Codon

- A triplet of adjacent nucleotides in the messenger RNA chain that codes for a specific amino acid in the synthesis of a protein molecule.
- Each codon corresponds to a single amino acid (or stop signal), and the full set of codons is called the genetic code.

The Genetic Code

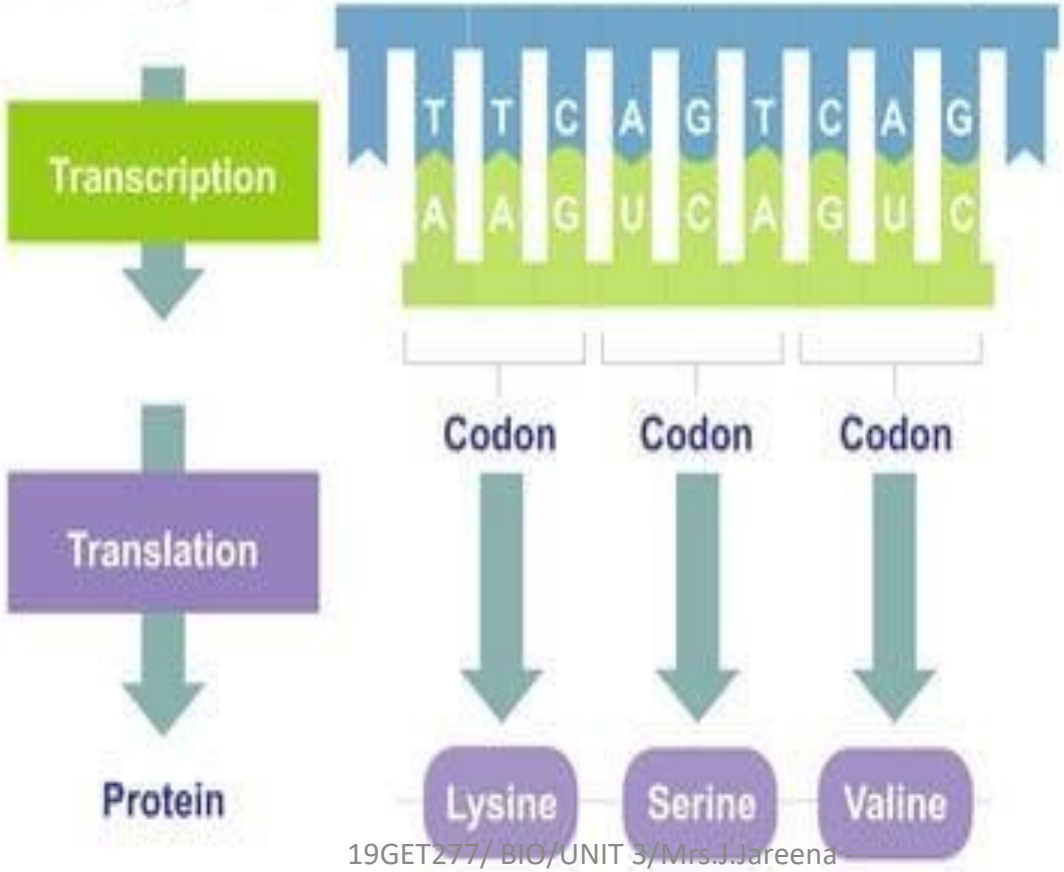
- All organisms use the same 20 aa
- Each codon specifies a particular aa



FIRST BASE	SECOND BASE U	SECOND BASE C	SECOND BASE A	SECOND BASE G	THIRD BASE
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

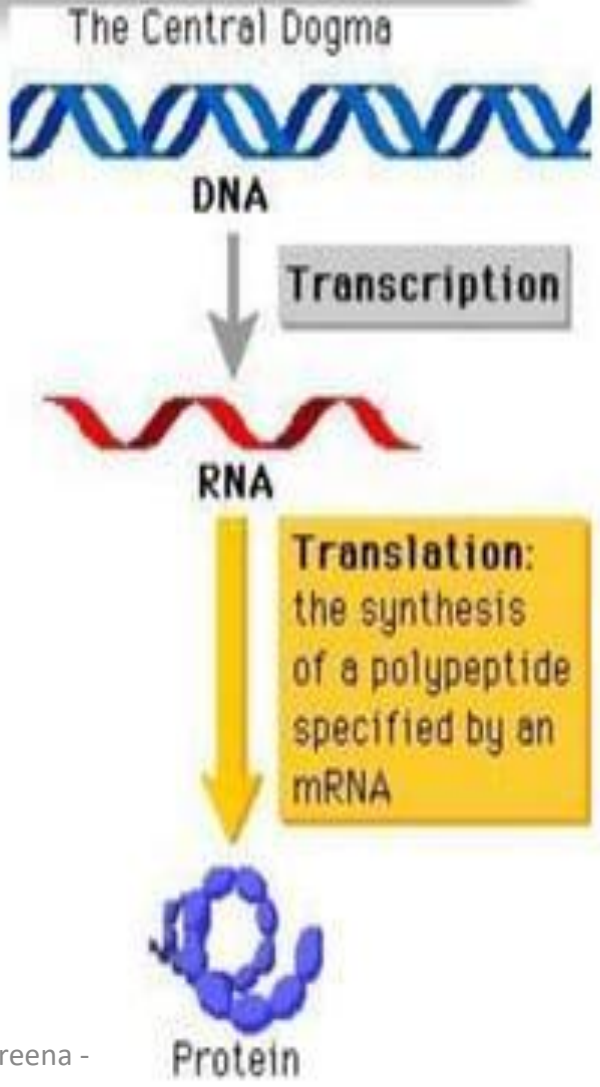
TRANSLATION: Protein Synthesis

- The process of reading the RNA sequence of an mRNA and creating the amino acid sequence of a protein.



TRANSLATION

- The language of nucleic acids in translated into the language of proteins
- Nucleic acids have a 4 letter language
- Proteins have a 20 letter language

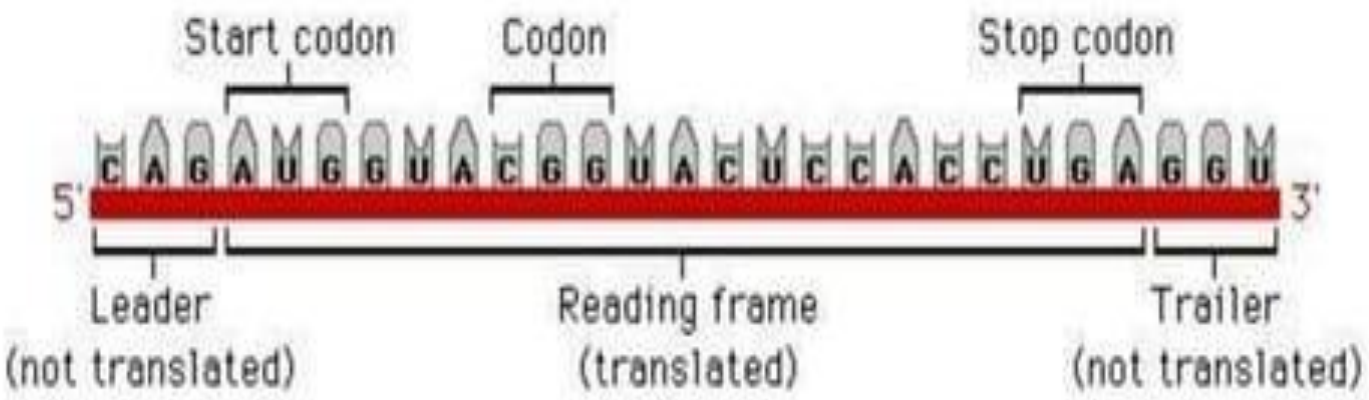


TRANSLATION

The "Players"

- Messenger RNA (mRNA)
- Ribosomes
- Transfer RNA (tRNA)
- Amino Acids

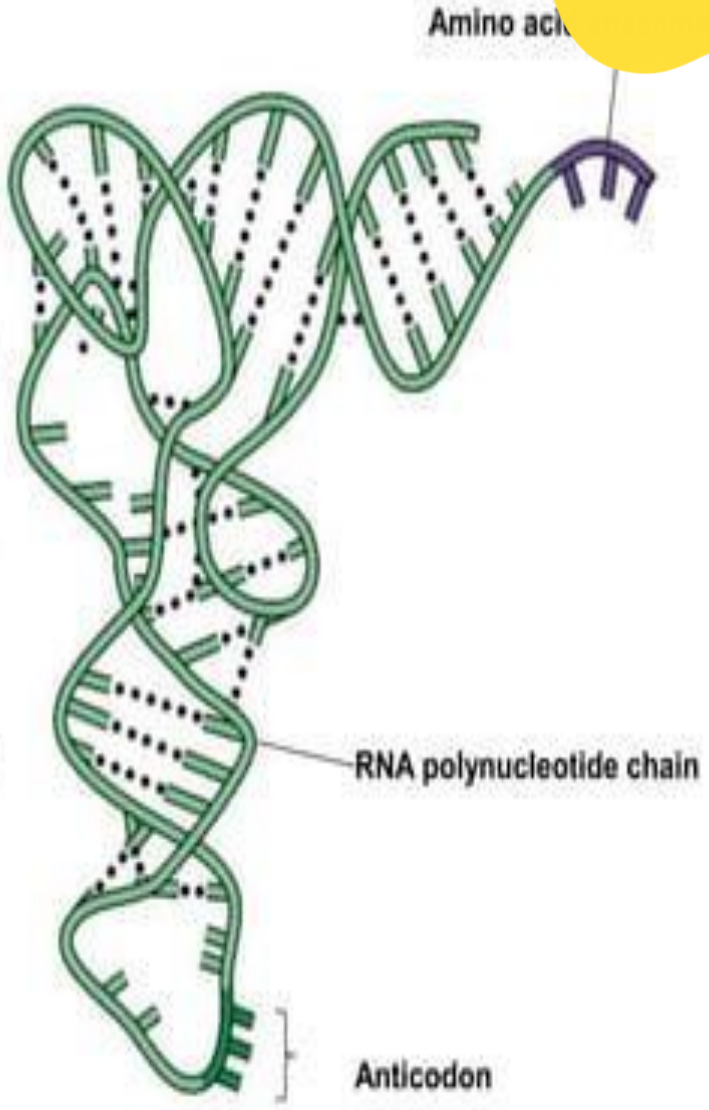
mRNA



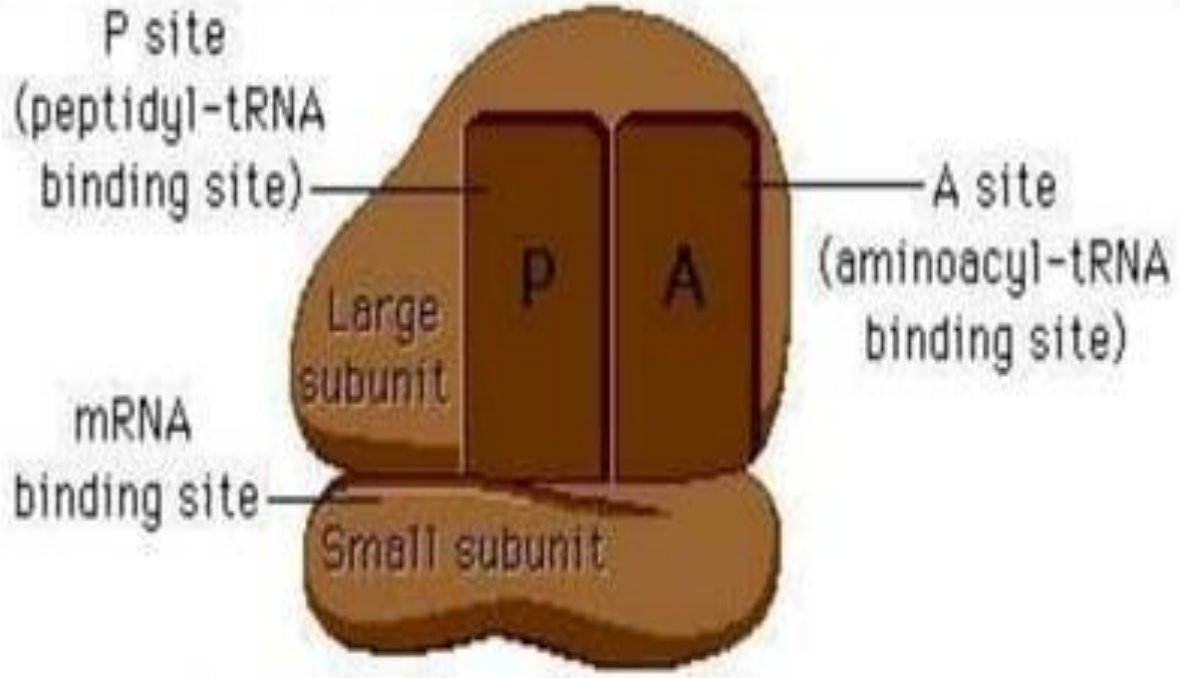
- Synthesized in transcription
- Composed of Codons
- Codons are 3-base sequences of mRNA

Transfer RNA

- In the cytoplasm, a ribosome attaches to the mRNA and translates its message into a polypeptide.
- The process is aided by transfer RNAs.

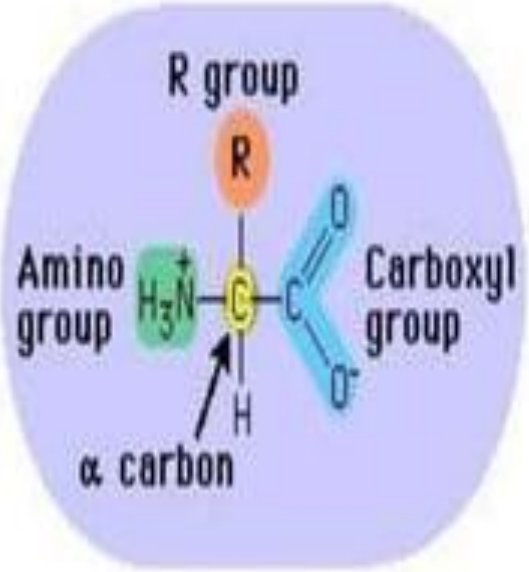


Ribosomes

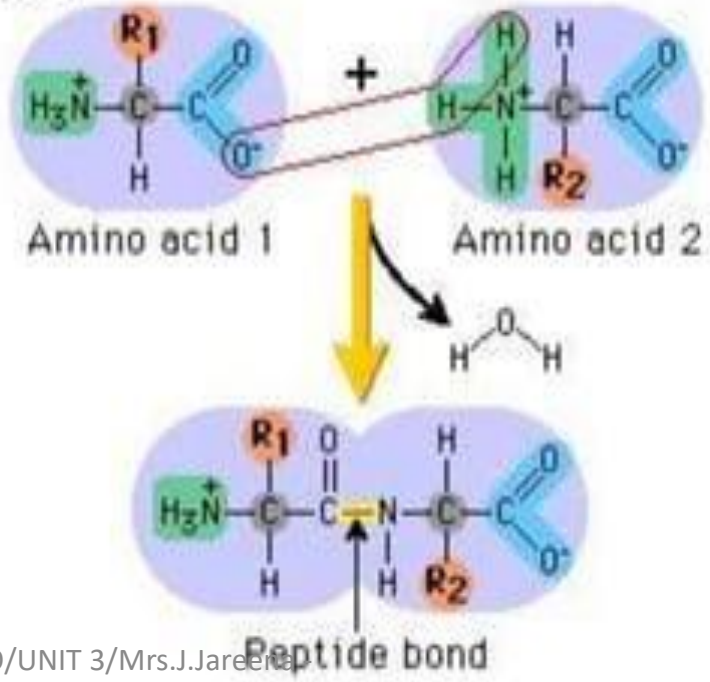


- Made of rRNA and protein
- 2 subunits (large and small) form a 3D groove

Amino acids

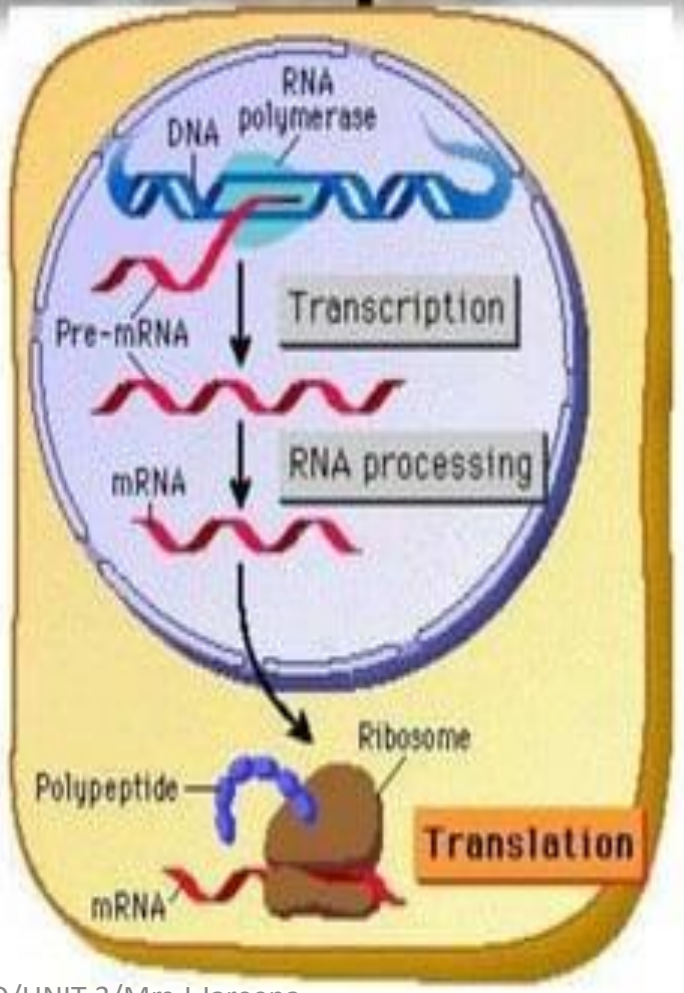


- There are 20 amino acids, each with a basic structure
- Amino acids are held together by peptide bonds

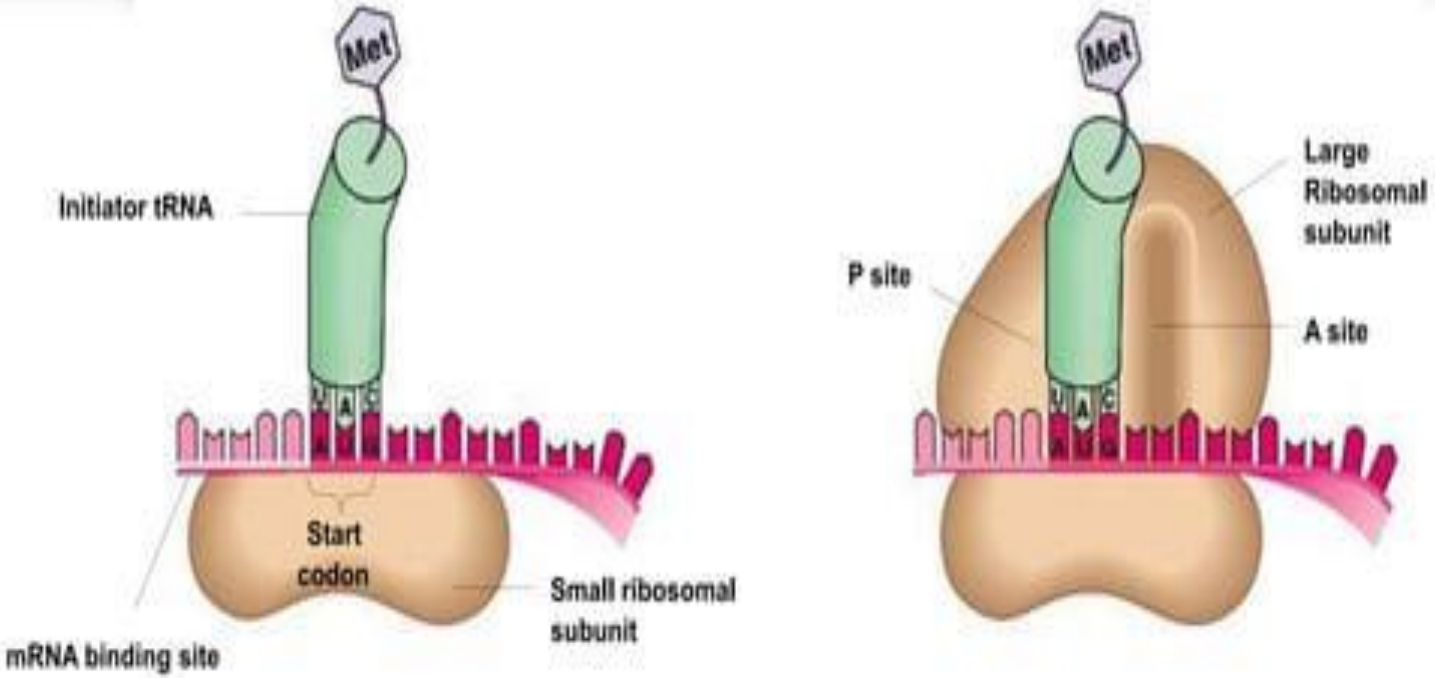


Translation has 3 steps

1. Initiation
2. Elongation
3. Termination

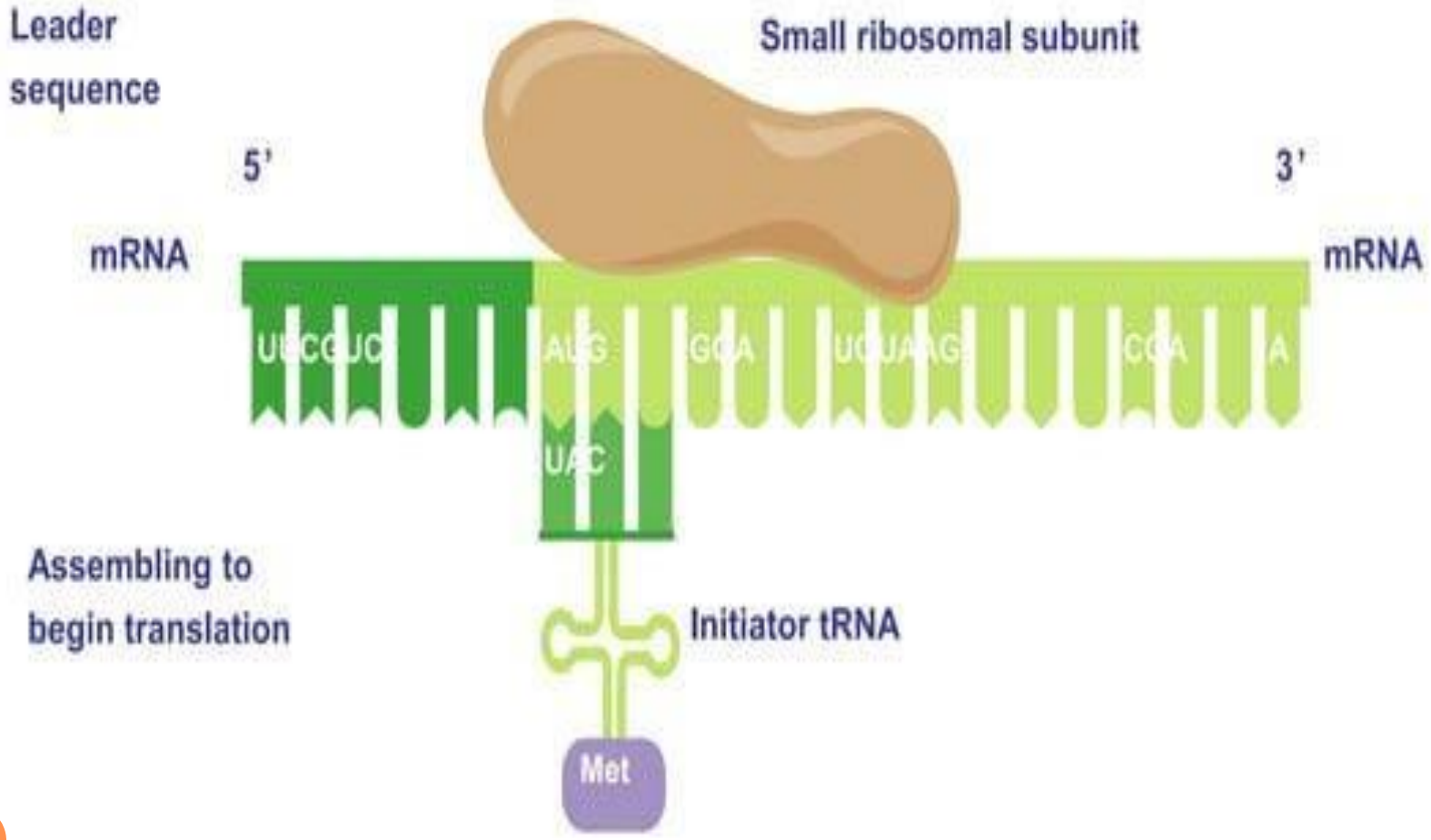


Step 1. Initiation

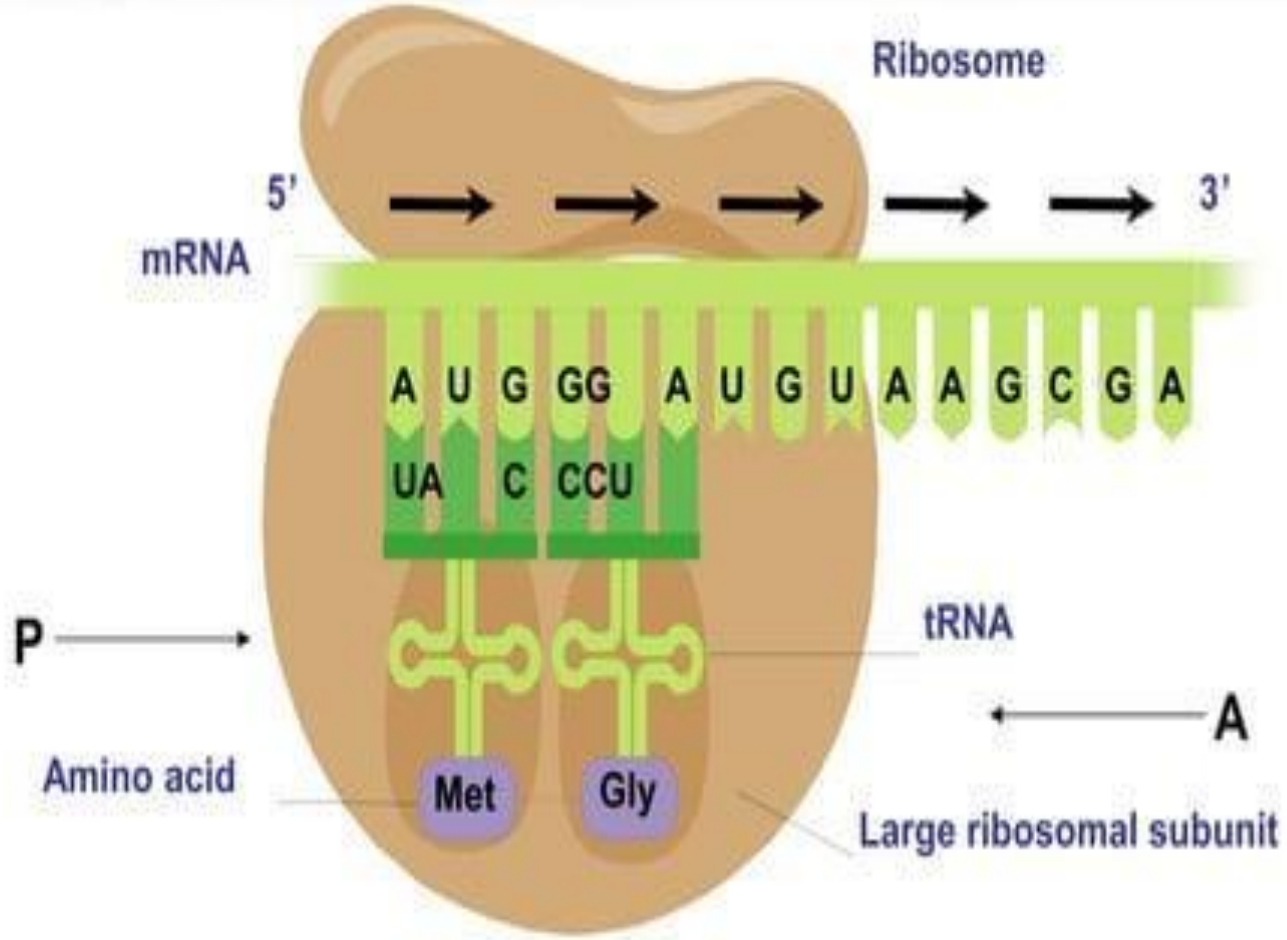


**mRNA, a specific tRNA, and the ribosome subunits assemble during initiation

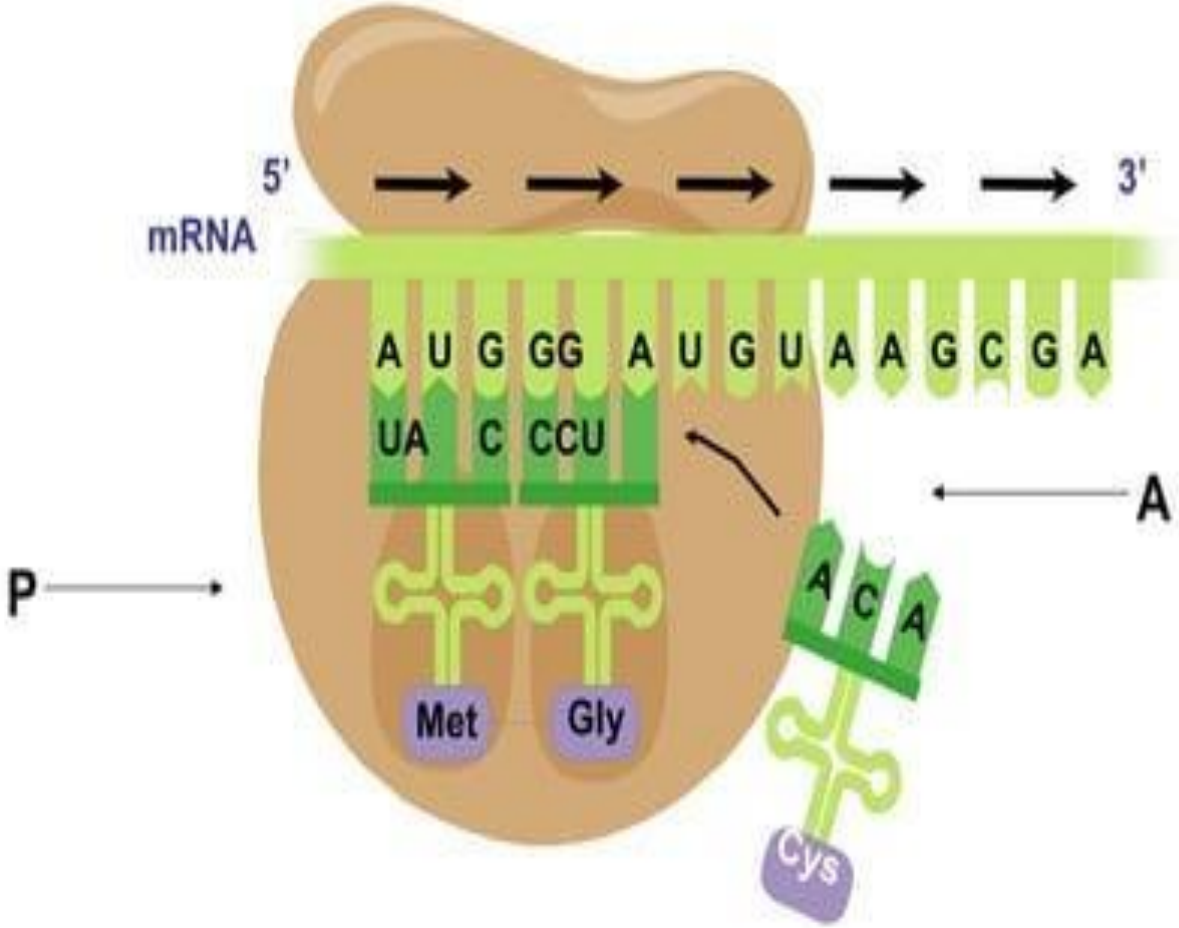
Initiation


Leader
sequence
Small ribosomal subunit
5'
3'
mRNA
mRNA
Assembling to
begin translation
Initiator tRNA
Met

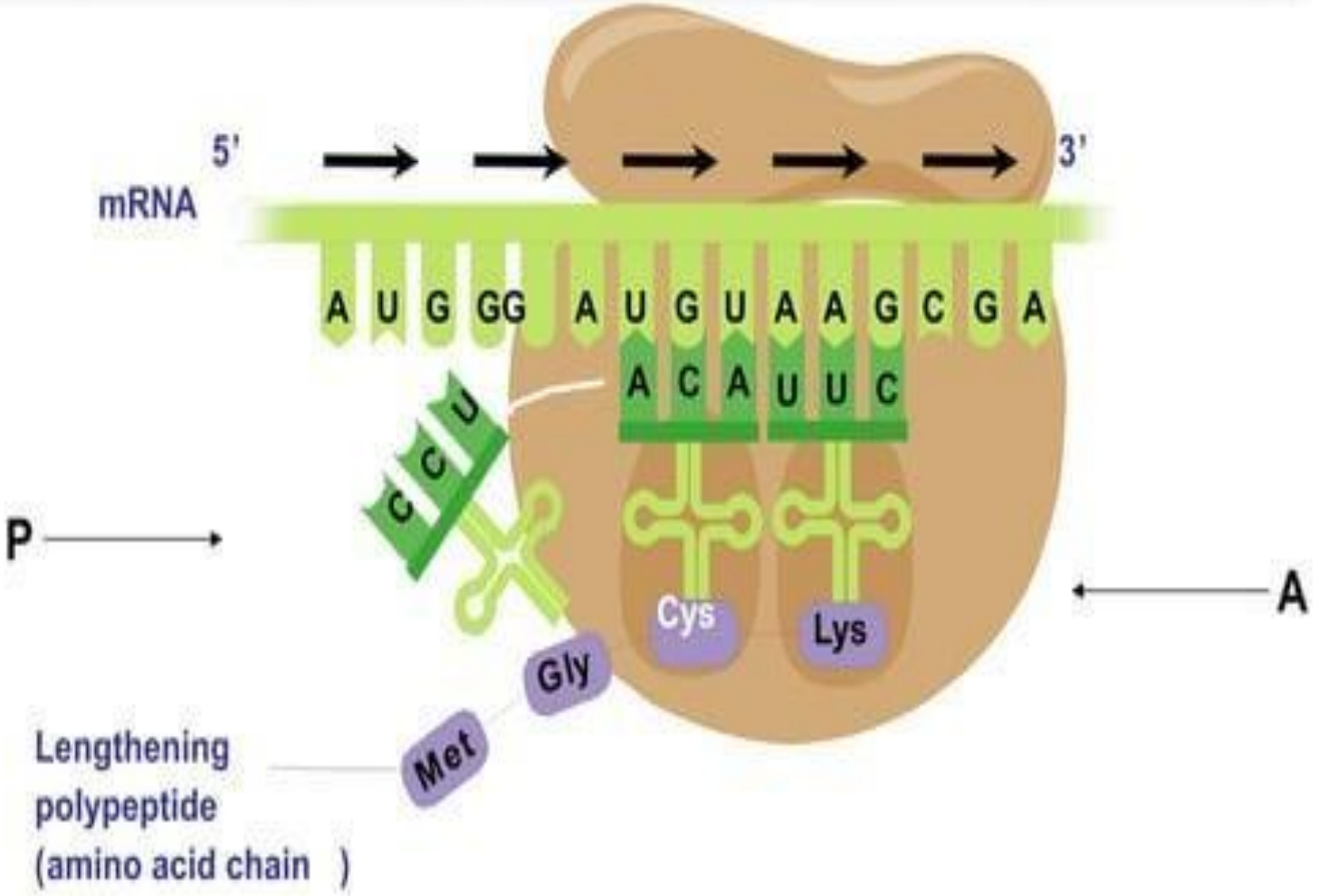
Step 2. Elongation



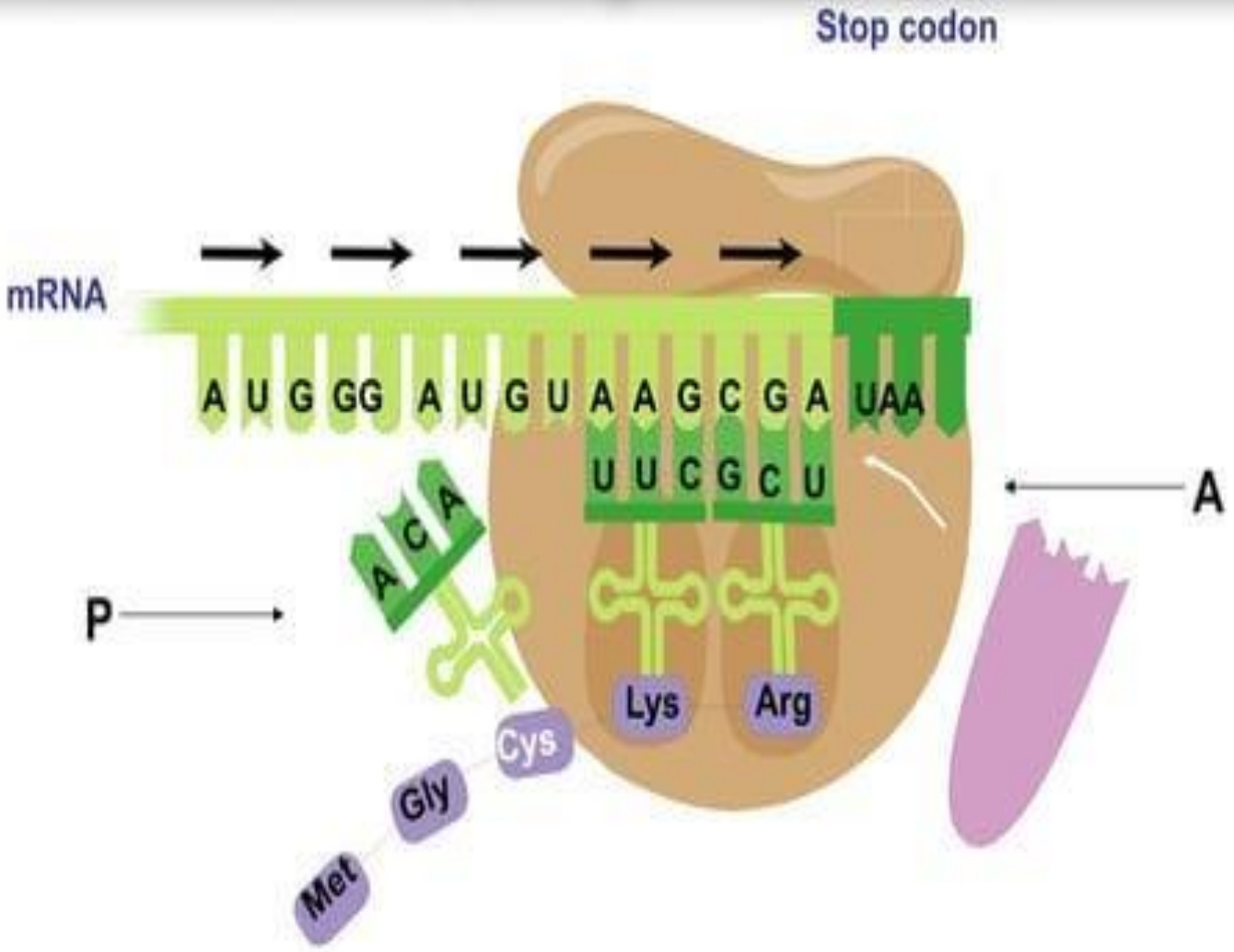
Elongation



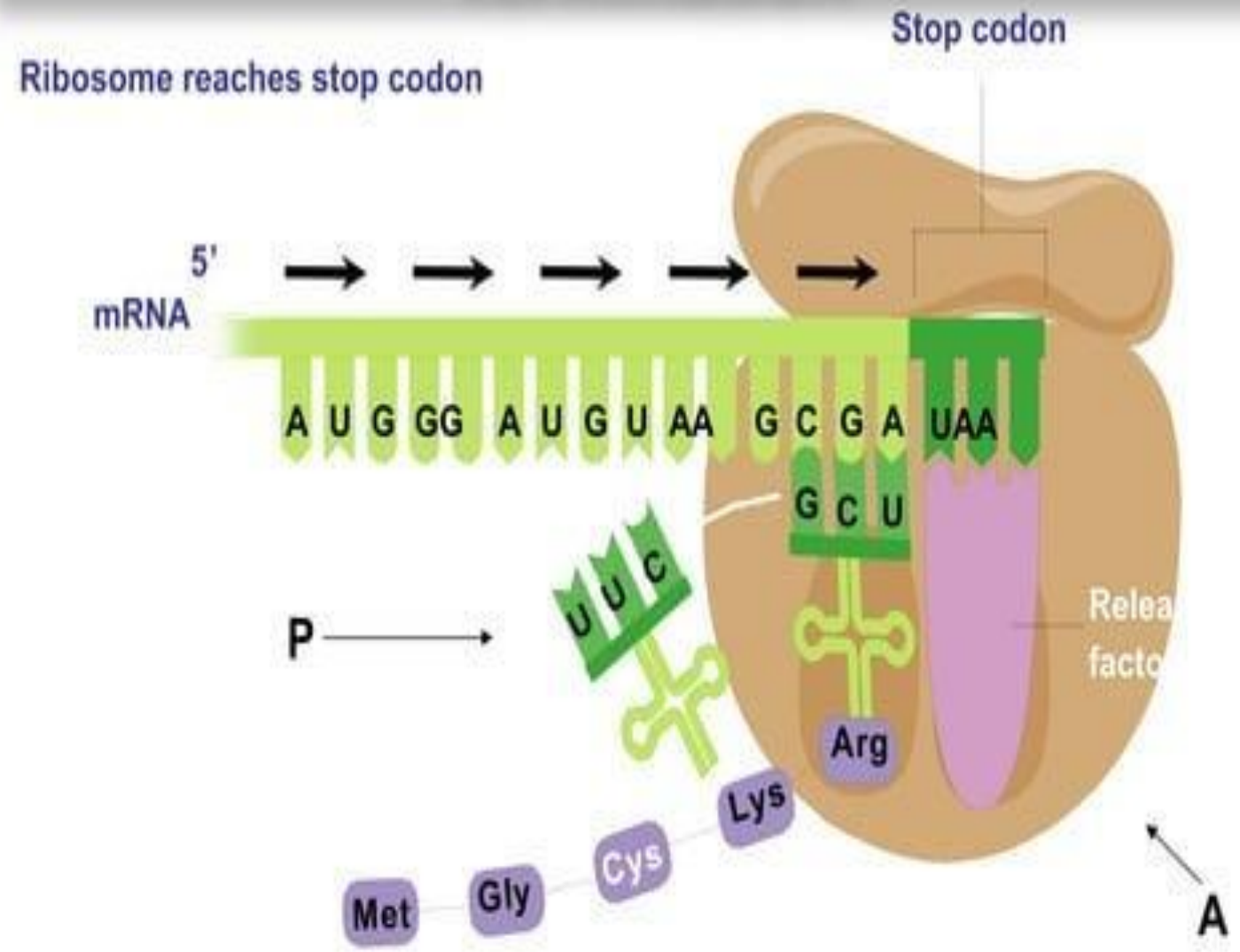
Elongation


5'
3'
mRNA
A U G GG A U G U A A G C G A
A C A U U C
C C U
P
A
Cys
Lys
Gly
Met
Lengthening
polypeptide
(amino acid chain)

Elongation

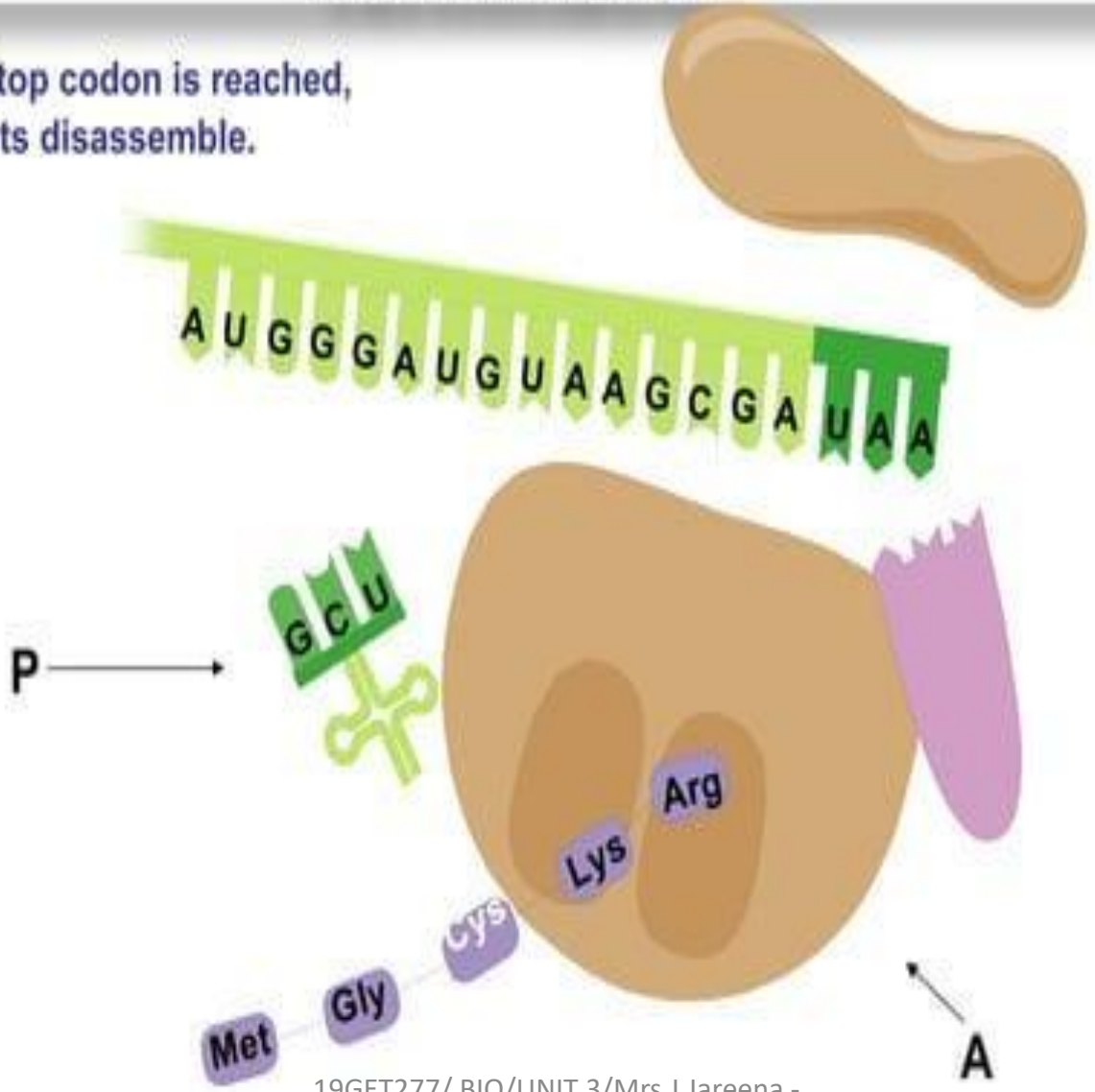

Stop codon
mRNA
A U G GG A U G U A A G C G A UAA
U U C G C U
A
P
A C A
Lys
Arg
Cys
Gly
Met

Termination



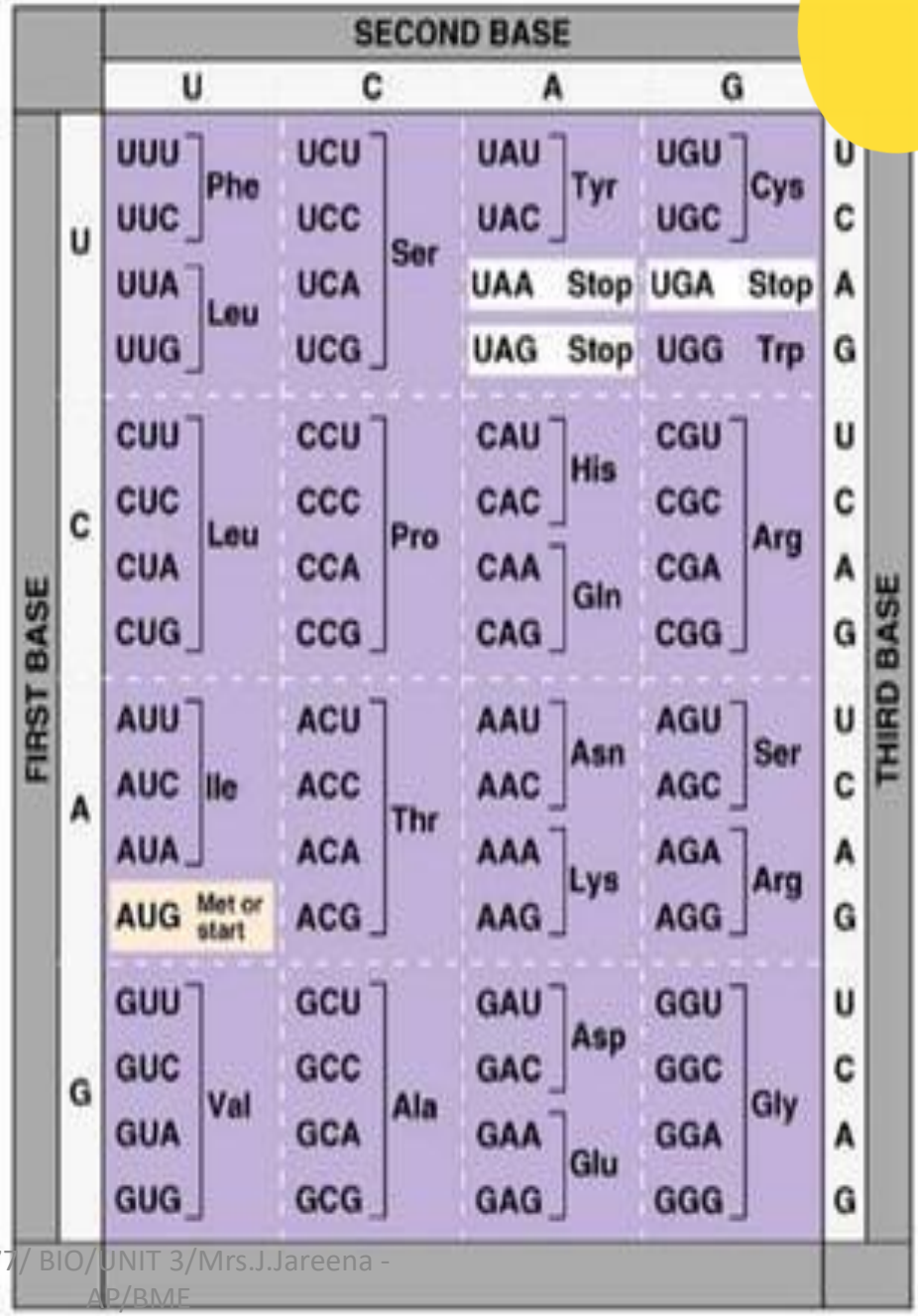
Termination

Once stop codon is reached, elements disassemble.



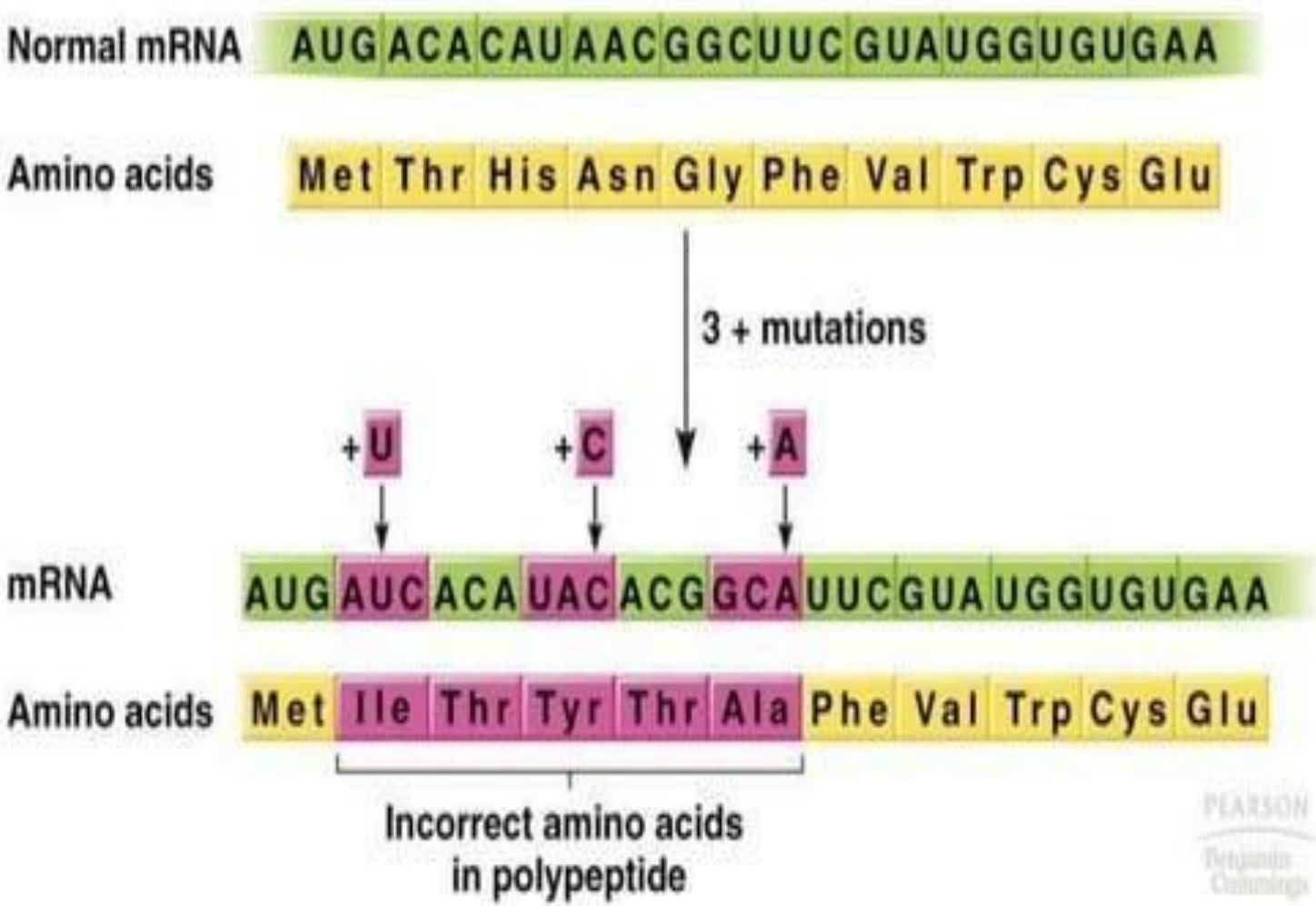
The Genetic Code

- All organisms use the same 20 aa
- Each codon specifies a particular aa



FIRST BASE	SECOND BASE U	SECOND BASE C	SECOND BASE A	SECOND BASE G	THIRD BASE
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

The Genetic Code is a triplet code



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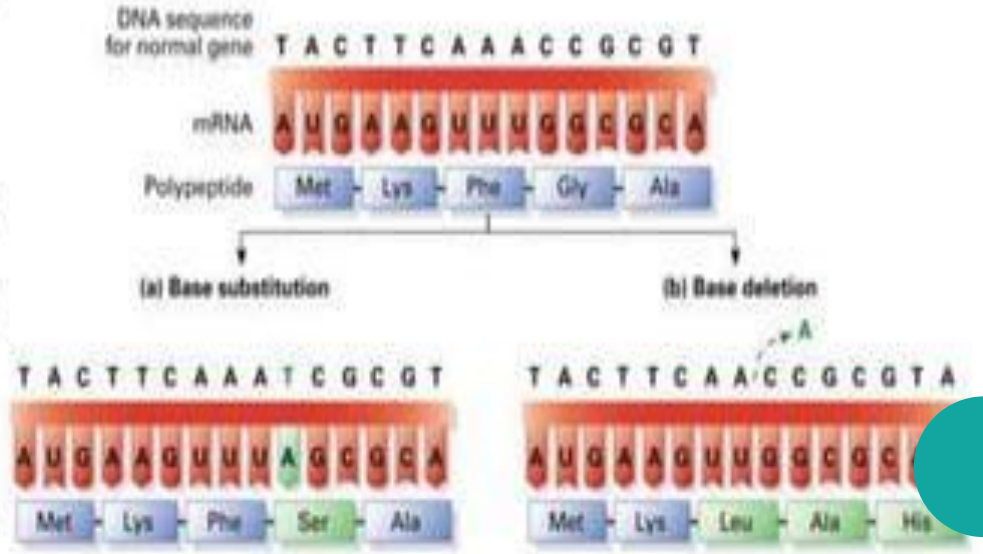
Mutations

- Normally, the genetic code is translated and the correct protein is formed from a long chain of amino acids.
- Translation of codons is dependent on the **reading frame**, or a grouping of codons in a gene transcript.

AAU GCG GAC UAC GGC AAC GCC

Mutation

- Any change in the nucleotide sequence of DNA
- It may involve large sections of chromosomes or single base pairs
- Mutations can change the reading frame of a gene transcript.



Mutation

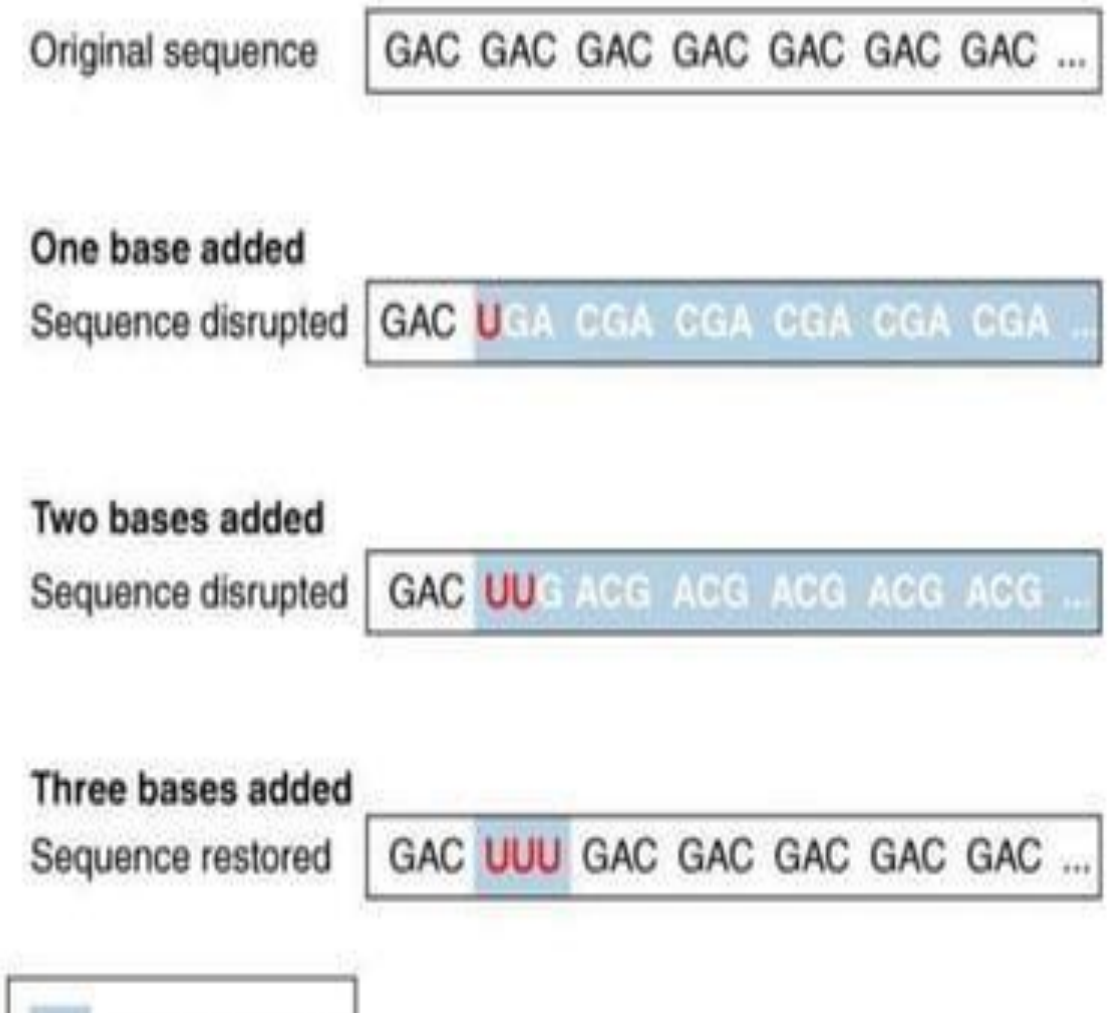
	Normal Hemoglobin	Sickle Cell Hemoglobin
DNA	GGA CTT GCA	GGA CAT GCA
mRNA	CCU GAA CGU	CCU GUA CGU
A.A.	PRO GLU ARG	PRO VAL ARG

Changes in one or a few bases is called a Point Mutation
2 Types: Substitution or Insertion/Deletions

Mutation

- **Deletion or insertion mutations** are most disruptive because they change the reading frame, causing a frame shift.
- **Substitution mutations** have varied impact on amino acid sequences.

Size of a genetic code word (codon)



What causes Mutations?

- Errors in DNA Replication
- Errors in chromosome crossover in meiosis
- Mutagens

Mutagens are physical or chemical factors that cause mutations

- UV Radiation and X-Rays
- Chemicals like DDT

Recent research paper (2015)

- "Single-cell transcriptogenomics reveals transcriptional exclusion of ENU-mutated alleles" by Wengi Li, R., et al.
- It showed a novel relationship between genotype and phenotype
- SCTG

References

- What is the 'Central Dogma'? Retrieved from https://www.frontiersin.org/articles/10.3389/fgene.2015.00305/full
- The Central Dogma BioCoach Activity. Retrieved from http://www.phschool.com/science/biology_place/biocoach/transcription/overview.html