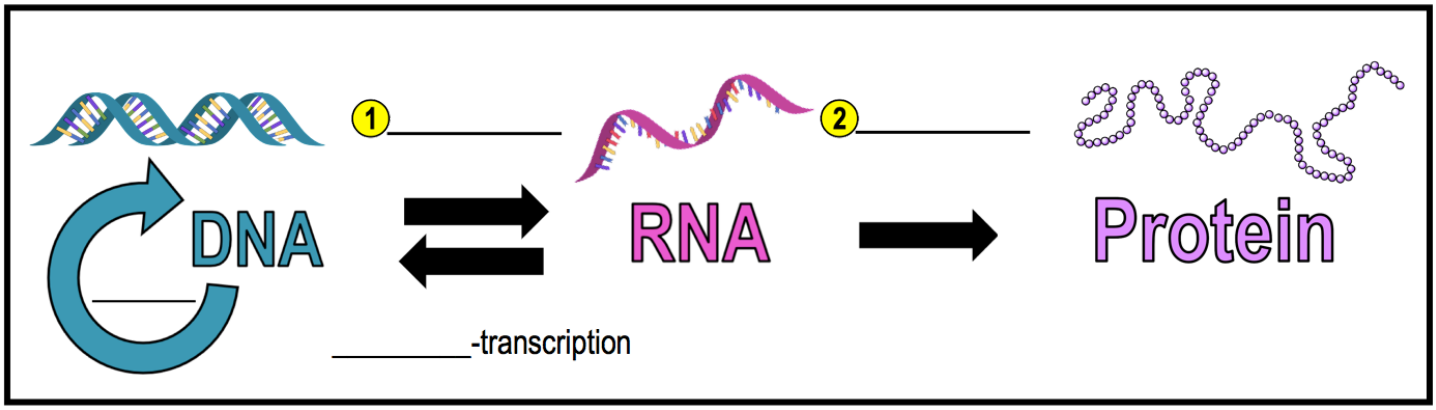
CONCEPT: CENTRAL DOGMA

●**Central Dogma** of biology refers to the _____ flow of biochemical info from *DNA* to *protein*.

1. **Transcription**: process that builds _____ using DNA as the coding template.
2. **Translation**: process that builds _____ using the encoded *messages* of RNA (mRNA).

□ Sometimes transcription & translation are collectively referred to as _____ *expression*.

EXAMPLE: Central Dogma of Molecular Biology.



●DNA is *replicated*; RNA can be _____-transcribed into DNA, but transfer of *nucleic acid* to *protein* is *irreversible*.

PRACTICE: According to the central dogma, what is the intermediate molecule involved in the flow of information in a cell that should go in the blank? DNA → _____ → Proteins

a) Ribosome.
b) rRNA.
c) mRNA.
d) tRNA.

PRACTICE: The full process by which genotype becomes expressed as phenotype is called:

a) Transcription.
b) Translation.
c) DNA Replication.
d) Gene expression.

CONCEPT: INTRODUCTION TO TRANSCRIPTION

●*Recall:* **Transcription**: process that builds _____ using DNA within a *gene* as the coding template.

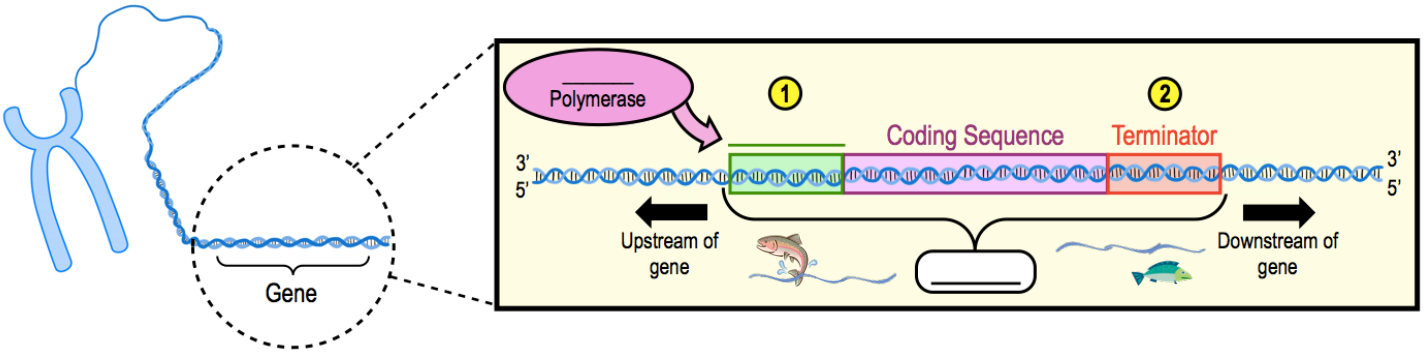
□ **Genes**: small units of _____ that encode a product (ex. protein).

●Specific sequences of DNA mark where transcription of a gene *begins* & *ends*:

1 **Promoter**: DNA sequence where transcription _____ (site of RNA polymerase attachment).

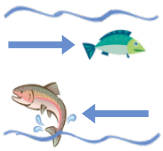
□ _____ **Polymerase**: an *enzyme* that polymerizes/builds _____ from scratch (no primer needed).

2 **Terminator**: DNA sequence where transcription _____.



□ "_____*stream*" refers to DNA sequences in the _____ direction of transcription.

□ "_____*stream*" refers to DNA sequences in the _____ direction of transcription.



PRACTICE: Which of the following is the best definition of a gene?

a) An RNA molecule transcribed from a sequence of DNA.
b) A stretch of DNA that can be transcribed.
c) A sequence of DNA where the process of transcription ends.
d) A sequence of DNA that encodes a product like an RNA or a protein.
e) A sequence of DNA where the process of transcription begins.

PRACTICE: Which of the following statements is false?

a) Transcription is the process that creates an RNA product from a sequence of DNA.
b) RNA polymerase builds RNA molecules from a DNA template.
c) A promoter is a sequence of DNA within a gene where RNA polymerase can begin transcription.
d) RNA polymerase, like DNA polymerase, requires a primer to begin RNA synthesis.

CONCEPT: INTRODUCTION TO TRANSCRIPTION

Overview of Transcription

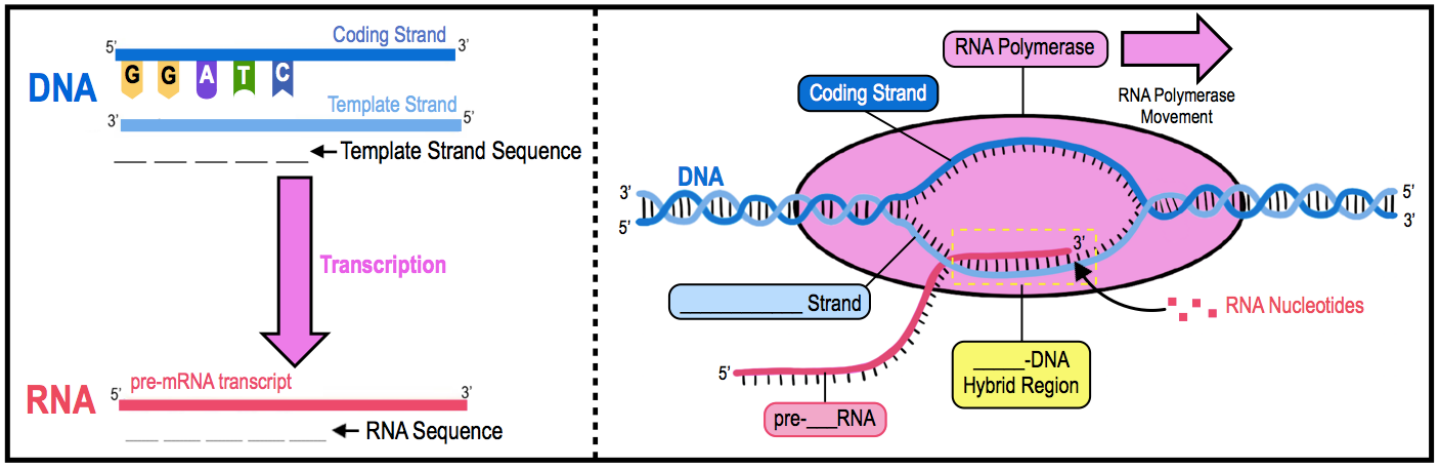
●The 2 strands of DNA in a gene are referred to as: 1) _____ Strand & 2) _____ Strand

□ RNA molecules have *same sequence* as the _____ DNA strand (except *replacing* T with U).

●During transcription, RNA is built from _____ to _____ end by pairing *free RNA nucleotides* on a *DNA template*.

□ Nucleotide pairing occurs via *Watson & Crick Base-Pairing*: A T (or A ___) & ___ C .

EXAMPLE: Determine the sequence for the template DNA strand and mRNA transcript given the following coding strand.



PRACTICE: The strand of DNA that has the same sequence as the RNA molecule being created during transcription is the:

a) Lagging strand.
b) Leading strand.
c) Coding strand.
d) Template strand.
e) Parent strand.

PRACTICE: Transcription is sometimes described as a process in which RNA is "copied" from the template strand of DNA. This statement is potentially misleading _____.

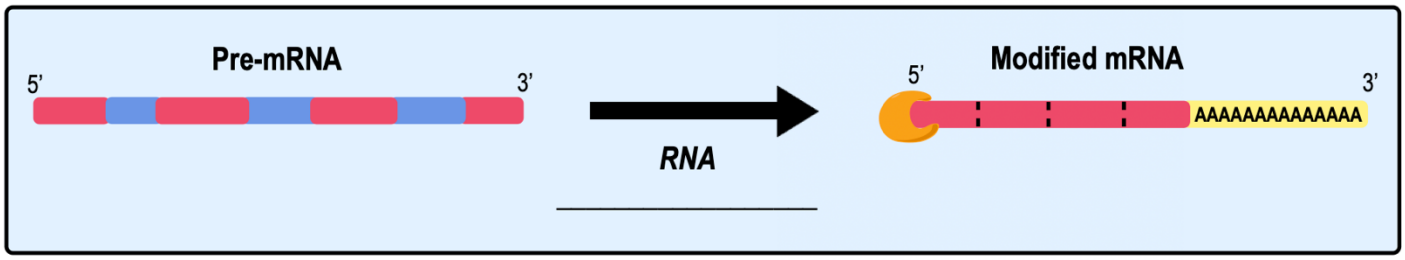
a) The nucleotides in RNA contain ribose and cannot be an exact copy of DNA.
b) RNA molecules contain uracil instead of thymine and cannot be an exact copy of DNA.
c) The RNA transcript has a sequence complementary to the template.
d) The RNA transcript and the DNA template strand are antiparallel.
e) All of the above.

CONCEPT: EUKARYOTIC RNA PROCESSING & SPLICING

●*Recall:* unlike prokaryotic mRNA, _____ mRNA requires further *modification* upon transcription termination.

□ _____**-mRNA**: eukaryotic mRNA *before* modification via *RNA processing* & *splicing*.

□ **RNA Processing & Splicing**: eukaryotic processes converting pre-mRNA into mRNA that's ready for *translation*.



1) RNA Processing

●Eukaryotic RNA processing involves _____ events that alter both ends of the pre-mRNA:

1) Addition of a **5' cap** (modified *guanine* nucleotide) to the _____ end of the pre-mRNA.

2) Addition of a **Poly-_____ Tail** (sequence of *adenine* nucleotides) to the _____ end of the pre-mRNA.

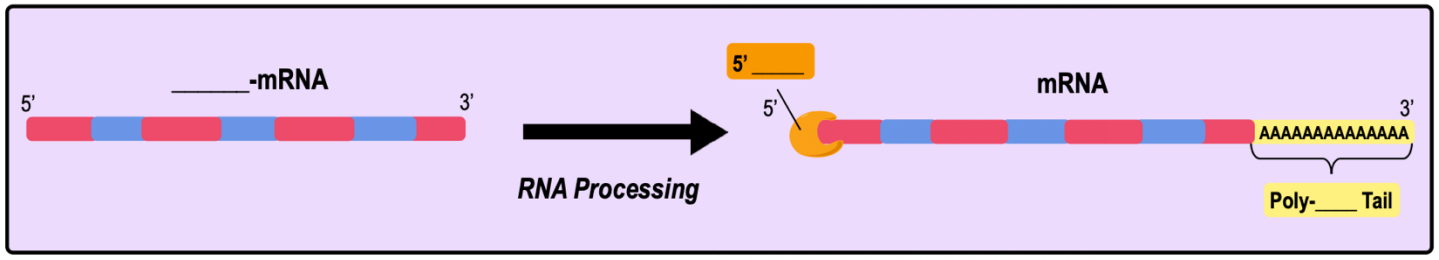
●**5' cap** & **poly-A tail** share several important *functions* including the following:

□ Facilitate _____ of mRNA from the nucleus to the cytoplasm.

□ _____ the mRNA from degradation by enzymes.

□ Help ribosomes _____ to the mRNA for translation.

EXAMPLE: pre-mRNA is processed into a mature mRNA transcript.



PRACTICE: Which of the following processes occurs in eukaryotic gene expression?

a) mRNA, tRNA, and rRNA are translated.

b) A cap is added to the 5' end of the mRNA.

c) Adenine nucleotides are added to the 5' end of the mRNA.

d) RNA polymerase requires tRNA to elongate the molecule.

PRACTICE: An mRNA poly-A tail:

a) Prevents translation.

b) Prevents transcription.

c) Marks the RNA for degradation.

d) Protects the mRNA from degradation.

CONCEPT: EUKARYOTIC RNA PROCESSING & SPLICING

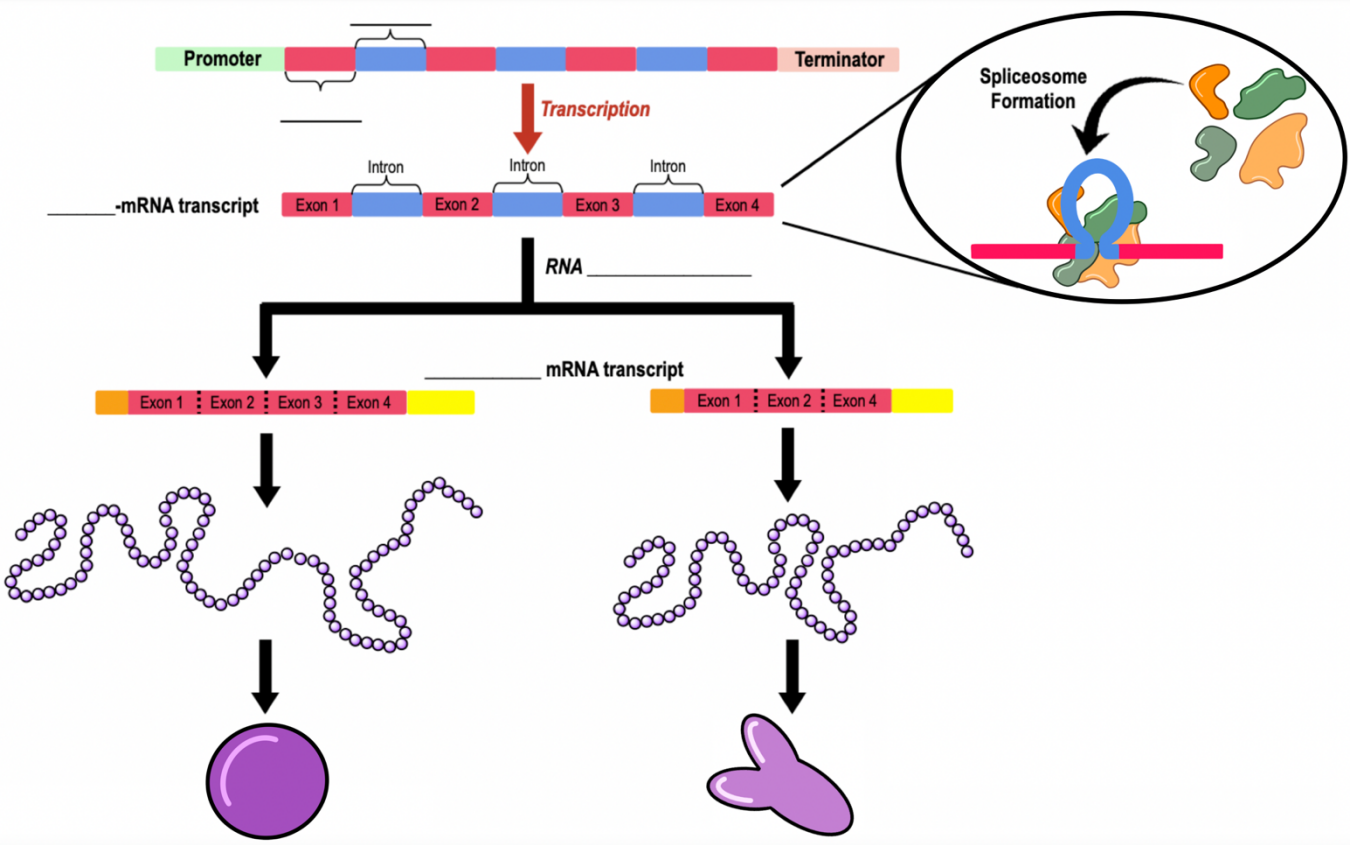
2) RNA Splicing Creates Mature mRNA

●Within eukaryotic genes are regions called _____ & _____ that are transcribed into pre-mRNA.

●**RNA Splicing:** process _____ some regions of pre-mRNA (*introns*) & *reconnecting* remaining regions (*exons*).

- □ _____**trons**: *non*coding regions of DNA/RNA that **in**tervene/**in**terrupt coding regions, but do NOT get translated.
- □ _____**ons**: *coding* regions of DNA/RNA that are **ex**pressed & do get _____.
- □ **Spliceosome**: large complex of RNA & protein responsible for removing introns.

EXAMPLE: The spliceosome removes introns from the pre-mRNA transcript after transcription.



●**Alternative RNA Splicing**: genes can be spliced in _____ ways to give _____ products.

PRACTICE: The regions in DNA & RNA that encode actual gene products are known as:

a) Terminators.
b) mRNA.
c) Exons.
d) tRNA.
e) Promoters.

<u>**CONCEPT:** GENETIC CODE</u>

●**Genetic Code**: a table that reveals how DNA/RNA encode the sequence of amino acids in a protein.

- □ Relatively universal across all organisms but can have some differences.
- □ Analyzes one ____________ at a time, each which reveals one amino acid.

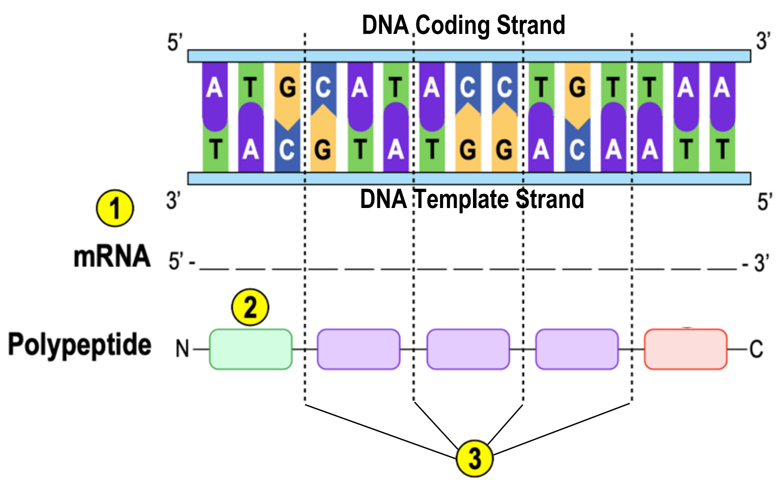
<u>**How to Use the Genetic Code**</u>

●Using the genetic code is a _____-step process:

1. Use the *coding* DNA sequence to reveal the mRNA sequence (replacing T with U).
2. Identify the ____-nucleotide codon *frames* within the mRNA transcript (including start & stop codons).
3. Identify the *amino acid* that corresponds with each codon until a __________ codon is reached.

●The genetic code shows the ____ letter (left side) ____ letter (top) and ____ letter (right side) of all possible codons.

EXAMPLE: Determine the polypeptide sequence from the following DNA sequence:



_______________ Letter of Codon

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

PRACTICE: The redundancy of the genetic code is a consequence of ______.

a) Having more codons than amino acids.

b) Having four different letters (As, Cs, Gs, and Us) in the codon alphabet.

c) Having fewer codons than there are amino acids.

d) Each codon having a single amino acid.

CONCEPT: GENETIC CODE

PRACTICE: A particular triplet of bases in the template strand of DNA is 5'-AGT-3'. What would be the corresponding codon for the mRNA that is transcribed?

a) 3'-UCA-5'.
c) 5'-TCA-3'.
b) 3'-UGA-5'.
d) 3'-ACU-5'.

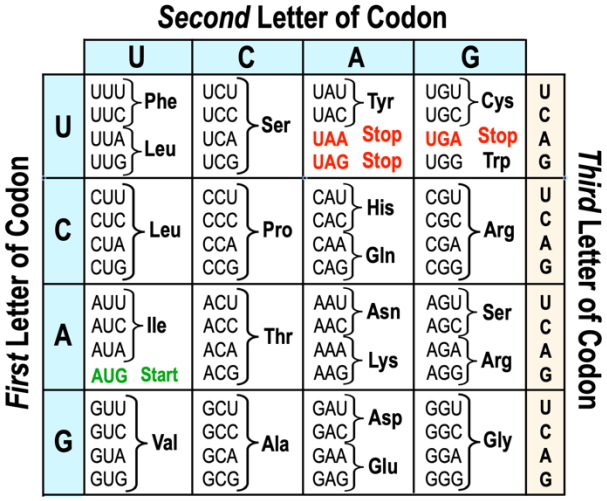
PRACTICE: A particular triplet of bases in the coding sequence of DNA is AAA. The anticodon on the tRNA that binds the mRNA codon is _____.

a) TTT.
c) UUU.
b) UUA.
d) AAA.

Use the codon table on the right to answer the following questions:

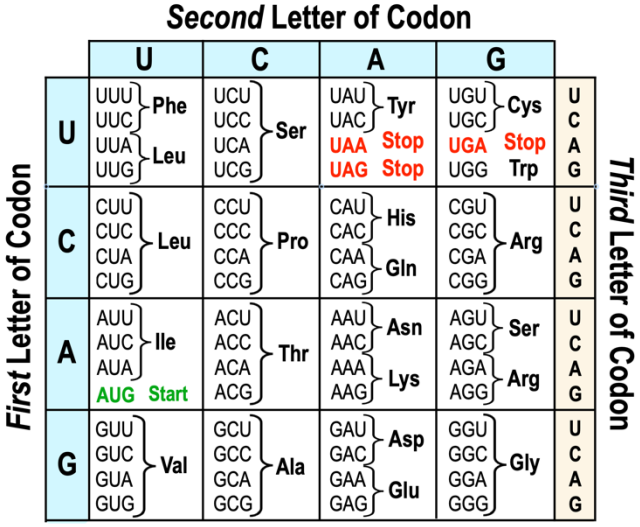
PRACTICE: Which of the following sequences of nucleotides are possible in the template strand of DNA that would code for the polypeptide sequence Phe–Leu–Ile–Val?

a) 5'–TTG–CTA–CAG–TAG–3'.
b) 5'–AUG–CTG–CAG–TAT–3'.
c) 3'–AAA–AAT–ATA–ACA–5'.
d) 3'–AAA–GAA–TAA–CAA–5'.



PRACTICE: What amino acid sequence will be generated, based on the following mRNA codon sequence?
5'–AUG–UCU–UCG–UUA–UCC–UUG–3'

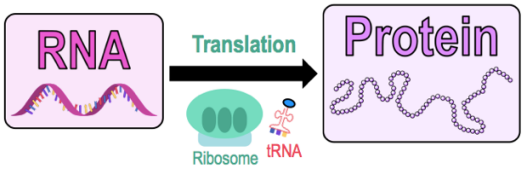
a) Met-Arg-Glu-Arg-Glu-Arg.
b) Met-Glu-Arg-Arg-Glu-Leu.
c) Met-Ser-Leu-Ser-Leu-Ser.
d) Met-Ser-Ser-Leu-Ser-Leu.

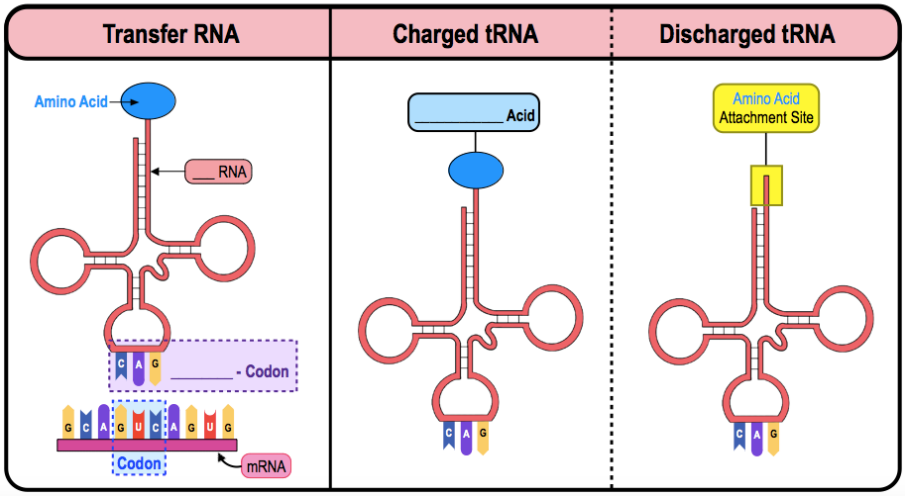


CONCEPT: INTRODUCTION TO TRANSLATION

- *Recall:* **Translation**: process that builds _____ using the encoded messages of mRNA.
  - □ **Ribosomes**: complex structure that builds _____ & performs _____.
  - □ **Transfer RNA** (**tRNA**): RNA structure that carries/transfers _____ *acids* to ribosomes.
    - □ tRNA contains _____-codons that pair with mRNA codons during translation.
    - □ *Charged* tRNA is attached to an amino acid; *Discharged* tRNA is _____ attached to an amino acid.

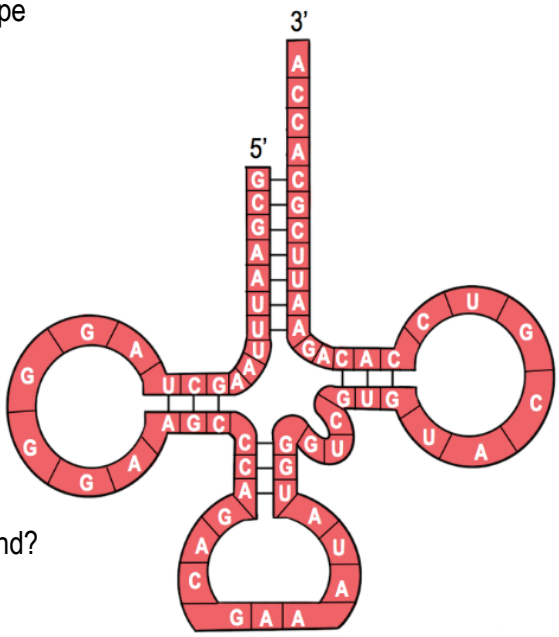
EXAMPLE: The different variations of transfer RNA (tRNA) during translation.





PRACTICE: What type of bonding is responsible for maintaining the shape of the tRNA molecule shown in the figure?

a) Ionic bonding between phosphates.
b) Hydrogen bonding between base pairs of nucleotides.
c) Van der Waals interactions between hydrogen atoms.
d) Peptide bonding between amino acids.



PRACTICE: The tRNA shown in the figure has its 3' end projecting beyond its 5' end. Which of the following processes will occur at this 3' end?

a) The amino acid binds covalently.
b) The excess nucleotides (ACCA) will be cleaved off at the ribosome.
c) The small and large subunits of the ribosome will attach to it.
d) These nucleotides represent the anti-codon.

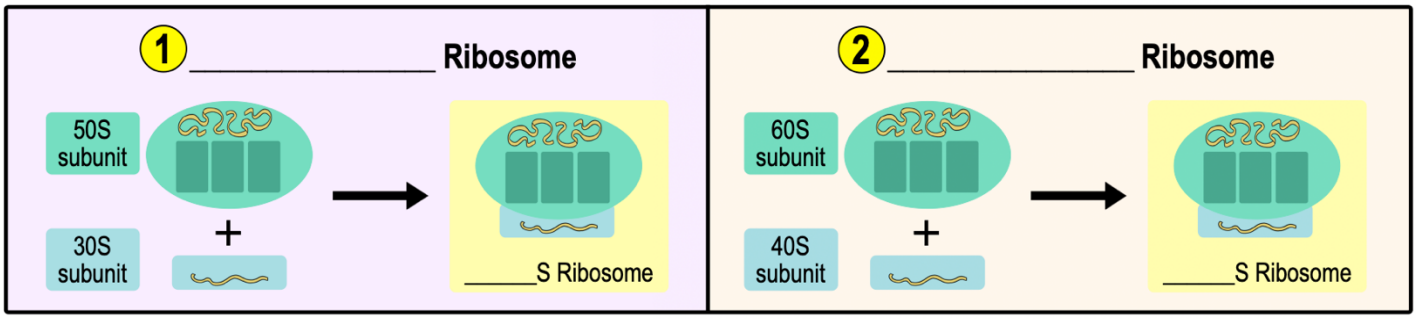
CONCEPT: INTRODUCTION TO TRANSLATION

Ribosome Subunits

●Ribosomes consist of a small & large ribosomal _____, each made of proteins & rRNA.

1. Prokaryotes have _____S ribosomes consisting of a large _____S & small _____S ribosomal subunits.
2. Eukaryotes have _____S ribosomes consisting of a large _____S & small _____S ribosomal subunits.

EXAMPLE: Prokaryotic vs. Eukaryotic Ribosomal Subunits.

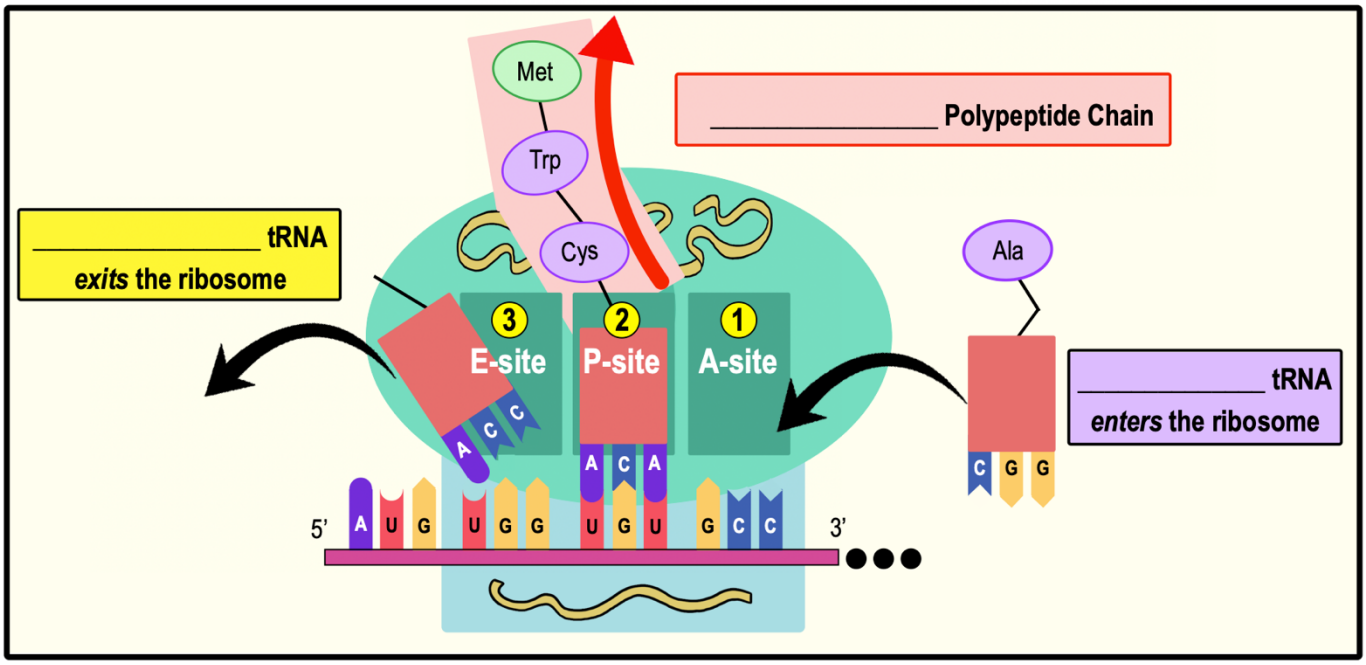


Ribosomal tRNA Binding Sites

●Each ribosome has _____ tRNA binding sites:

1. _____**minoacyl-tRNA Binding Site** (_____**-Site**): holds the tRNA carrying the next amino acid to be added.
2. _____**eptidyl-tRNA Binding Site** (_____**-Site**): holds the tRNA carrying the *growing* polypeptide chain.
3. _____**xit Site** (_____**-Site**): discharged tRNAs leave the ribosome from this site.

EXAMPLE: Overview of tRNA binding sites.



CONCEPT: INTRODUCTION TO TRANSLATION

PRACTICE: A ribosome has three tRNA binding sites. Which answer matches the tRNA binding site with the correct function:

a) The A-site acts as the loading site, holding the tRNA with the next amino acid in the polypeptide sequence.
b) The E-site releases charged tRNA from the ribosome.
c) The P-site is holding the growing strand of amino acids making up the polypeptide.
d) A and B are correct.
e) B and C are correct.
f) A and C are correct.
g) All of the above are correct.

PRACTICE: Which of the following statements concerning ribosomes are true?

a) Several ribosomes are often attached to and translating the same mRNA.
b) Ribosomes join amino acids to form a polypeptide.
c) Ribosomes have a binding site for mRNA and three binding site for tRNA molecules.
d) No protein synthesis within a cell would occur without ribosomes.
e) All of the above statements are true.

PRACTICE: The direction of ribosome movement during translation is in the _____.

a) 3' → 5' direction of DNA.
b) 5' → 3' direction of tRNA.
c) 3' → 5' direction of mRNA.
d) 5' → 3' direction of mRNA.

PRACTICE: Many antibiotics work by blocking the function of ribosomes. Therefore, these antibiotics will:

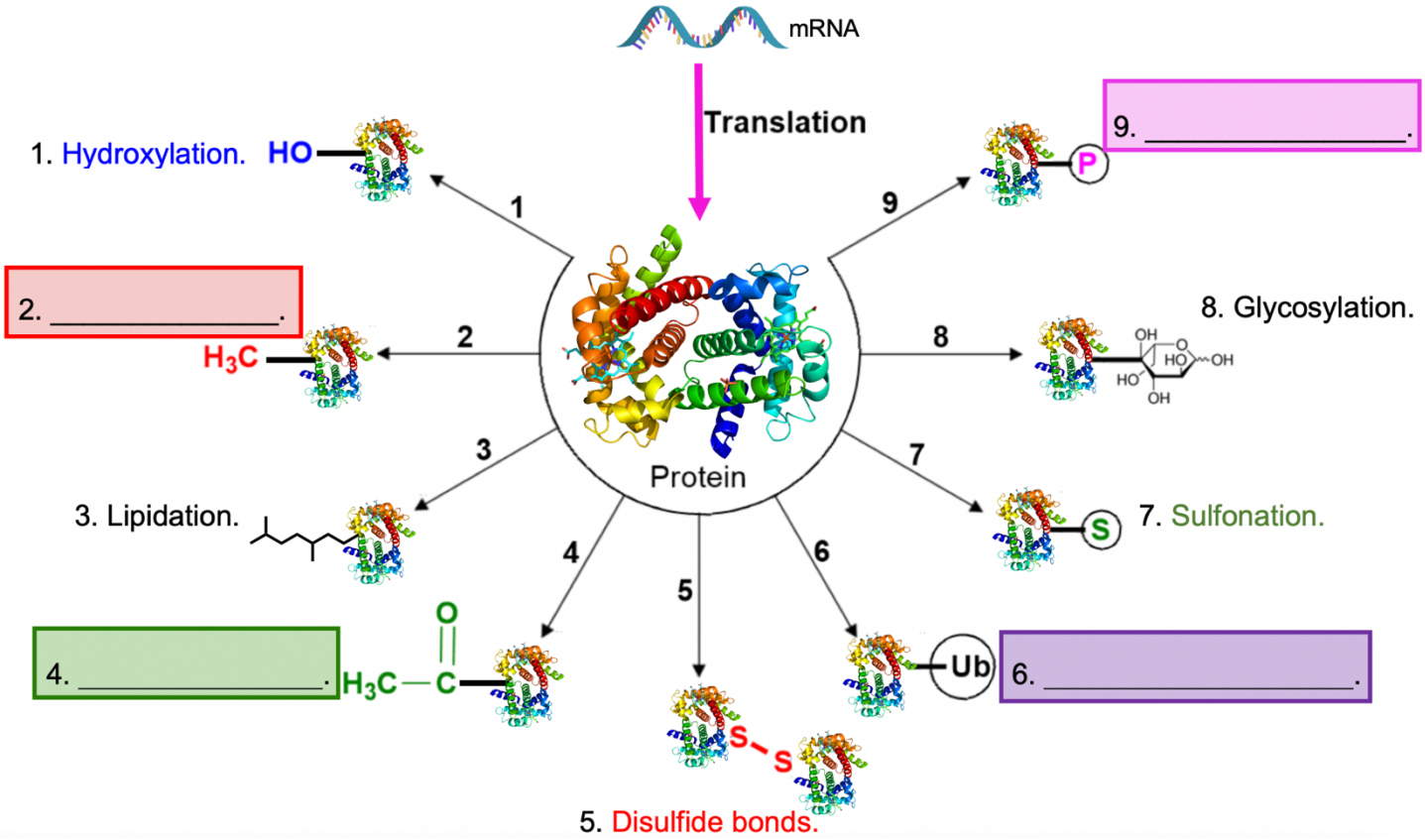
a) Block DNA synthesis in eukaryotic cells.
b) Block protein synthesis in prokaryotes.
c) Block RNA synthesis in prokaryotes.
d) Block viral DNA in prokaryotes.
e) Block protein synthesis in eukaryotes.

CONCEPT: POST TRANSLATIONAL MODIFICATION

- *Recall: Translation* is the cellular process of building _____ using the encoded messages of _____.
- _____**-Translational Modifications** (**PTM**): *covalent* alterations controlling protein activity _____ translation.
- There are *many* types of PTM, but some of the more common types include:

□ Methylation □ Acetylation □ Ubiquitination □ Phosphorylation

EXAMPLE: Post-Translational Modifications.



PRACTICE: Glycosylation is the post-translational addition of _____ to the protein.

a) A carbohydrate.
b) A lipid.
c) A fat.
d) A nucleotide.

PRACTICE: Which of the following is a reversible form of post-translational modification which can activate or deactivate a protein depending on the protein which is being modified?

a) Glycosylation.
b) Ubiquitination.
c) Acetylation.
d) Phosphorylation.

CONCEPT: MUTATIONS

●**Mutations**: permanent _____ in the _____ sequence.

□ Mutations in the DNA, can impact the _____ (via transcription), which can impact proteins (via translation).

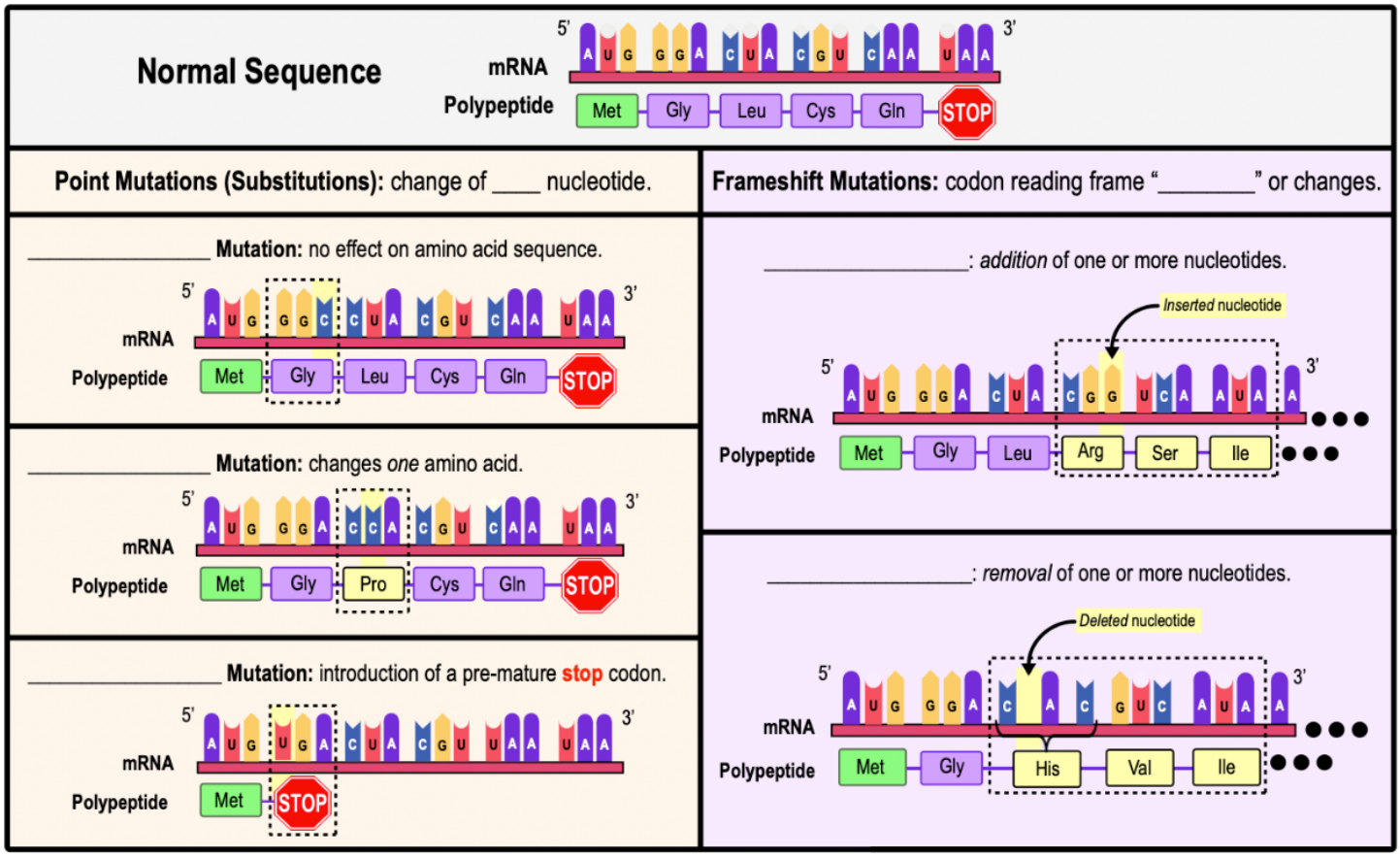
□ Can either be harmful, beneficial or neutral in terms of their impact/result.

□ Can occur _____ or can be *induced* by environmental factors or chemical agents (*mutagens*).

●Mutations are largely responsible for the tremendous _____ found amongst organisms.

Types of Mutations

●There are several types of mutations including the following:



PRACTICE: Which of the following mutations, occurring just after the start codon in the mRNA is likely to have the most serious effects on the polypeptide product?

a) Deletion of one codon.

b) Deletion of one nucleotide.

c) Insertion of three nucleotides.

d) Substitution of one nucleotide.

CONCEPT: MUTATIONS

PRACTICE: A single base substitution is LEAST likely to be deleterious (dangerous) when the change results in _____.

a) Replacement of a codon specifying a hydrophilic amino acid with a codon that specifies a hydrophobic amino acid.
b) Replacement of a codon which codes for an amino acid with a stop codon.
c) The change of a codon specifying a specific amino acid important for the active site of the protein.
d) Replacement of a codon specifying an amino acid with a redundant codon specifying the same amino acid.

PRACTICE: A section of DNA has this base sequence: AGCGTTACCGT. A mutation in this DNA strand results in this base sequence: AGGCGTTACCGT. What type of mutation does this change represent?

a) Frameshift mutation.
b) A missense mutation.
c) A nonsense mutation.
d) A silent mutation.

PRACTICE: A nonsense mutation:

a) Causes an incorrect amino acid to be inserted into a polypeptide chain.
b) Causes synthesis of a polypeptide chain to be terminated prematurely.
c) Prevents the start of translation.
d) Only affects the mRNA code but does not affect the amino acid sequence of the polypeptide.