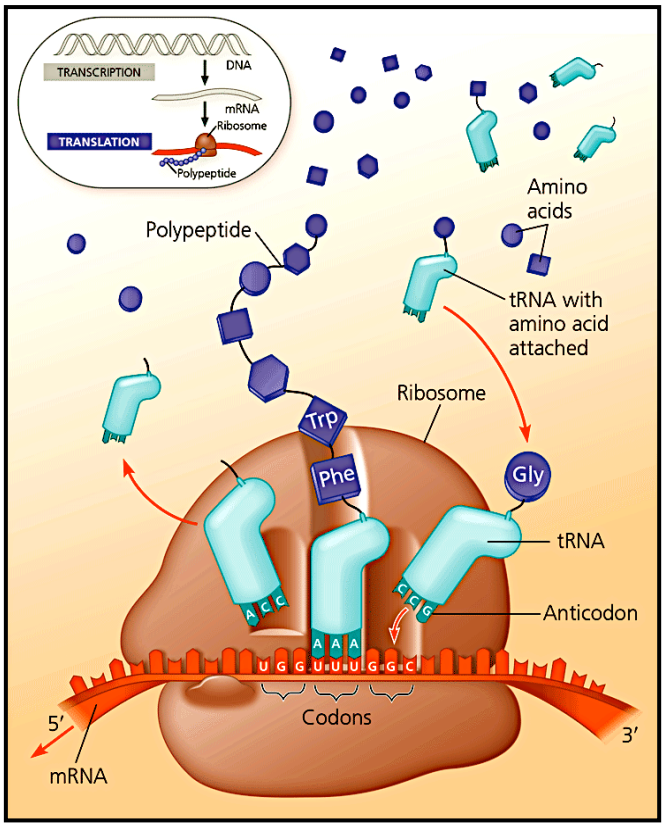
STUDY GUIDE - *Ch. 17.4 - Translation is the RNA-Directed Synthesis of a Polypeptide* **NAME:** _____

- **PHYSICALLY PRINT OUT this PDF and HANDWRITE (with a black or blue pen) your answers directly on this PDF.** *Typed or digitally-written work is **not** accepted. Do **not** answer questions on separate paper.*
- **Importantly, study guides are NOT GROUP PROJECTS!!!** *You, and you alone, are to answer the questions as you **read** your assigned textbook. You are **not** to share answers with other students. You are **not** to copy any answers from any other source, including the internet.*
- **Get in the habit of writing LEGIBLY, neatly, and in a medium-sized font.** *AP essay readers and I will skip grading anything that cannot be easily read so start perfecting your handwriting, and don't write so large you can't add all the relevant details and key elaborations in the space provided.*
- **SCAN physical documents in color and with good resolution. Then, upload your final work as PDFs to Archie.** *Avoid uploading dark, shaded, washed-out, sideways, or upside-down scans of homework. Keep completed physical study guides organized in your biology binder to use as future study and review tools.*
- **READ FOR UNDERSTANDING and not merely to complete an assignment.** ***First**, read a section quickly to get an overview of the topic covered. Then, read it a **second** time slowly, paraphrasing each paragraph **out loud** and analyzing every figure. Finally, read it a **third** time as you answer the study guide questions if assigned and start building your memory. Try to write answers out in your own words, when possible, and try to purposefully and accurately use all new terminology introduced.*

1. Review Figure 17.15 to get a quick overview of **translation**: when the ribosome, with the help of various **tRNA** molecules, builds a **polypeptide (and thus a protein)** from the information encoded in the **mRNA**.

   As you learn from this figure and its legend, describe the **function of transfer RNA**.



2. a. Let's keep reading. Recall from Ch.6 that **ribosomes are the sites of protein synthesis.** They are composed of two subunits: a large and a small ribosomal subunit. What are the subunits of ribosomes composed of?

   1. _____ 2. _____

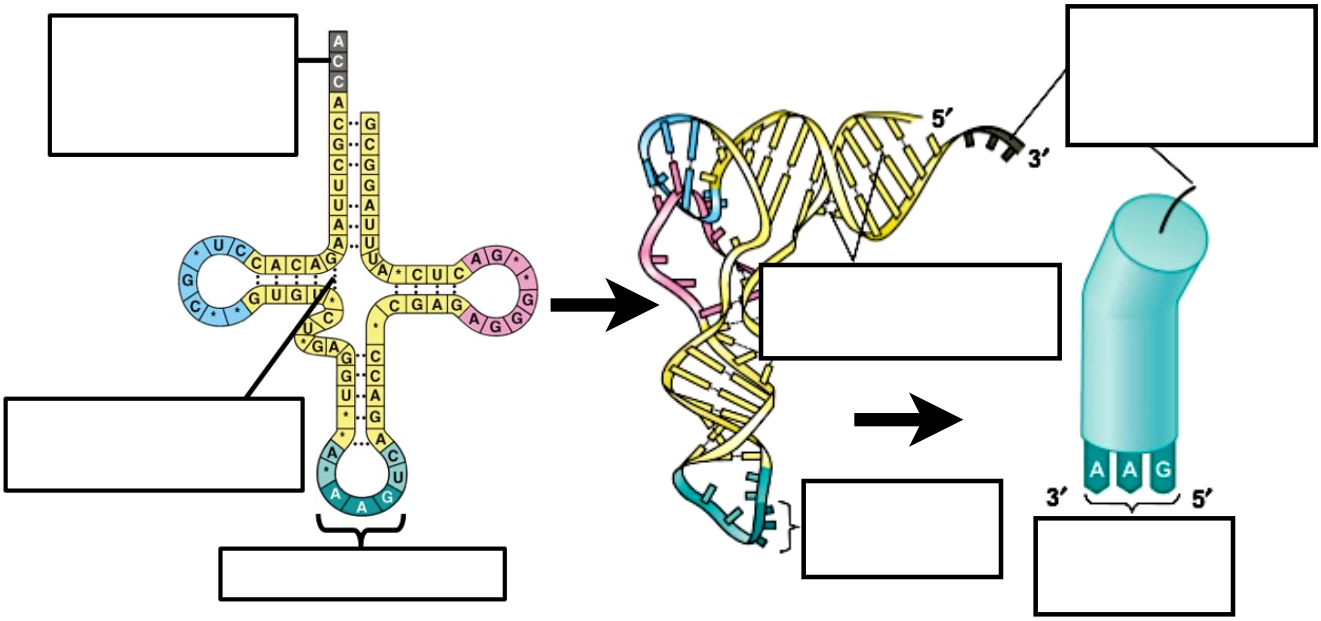
   b. What do ribosomes **build polypeptides (proteins) out of**?

3. a. In terms of the structure of the various **tRNAs, what is their "key" to enable ribosomes to build different polypeptides out of varying orders of amino acids**?

   b. Transfer RNA's are single-stranded molecules that fold up as nucleotides further up in the chain hydrogen bond with nucleotides further down in the chain at various locations. After reading over the section, how do **two different tRNA molecules differ in terms of what is attached to their 3′ ends**?

   c. What is the **anticodon of a tRNA molecule**?

d. Study Figure 17.16. Then, try to **label the tRNA** below from memory before checking your answers for accuracy.



e. How do **two different tRNA molecules differ in terms of their anticodons**?

4. a. Return to Ch.17 Section 1. Where and what was a **codon** again?

b. *Think:* Compare and contrast the **codon and anticodon**? Remember, on the AP Biology exam, this prompt means you must **compare** - *describe the similarities* - and **contrast** - *describe the differences* - between two structures or processes.

Compare *(in what ways are they similar)* =

Contrast *(i what ways are they different)* =

5. How do cells make the **RNA portion of tRNA molecules**?

6. a. Why is the enzyme **aminoacyl-tRNA synthetase** important to translation and protein synthesis?

b. How many different **aminoacyl-tRNA synthetase** enzymes does a cell make and **WHY**?

c. *Think:* **Study Figure 17.17.** What are the **THREE substrates and the FOUR products** of the chemical reaction catalyzed by **aminoacyl-tRNA synthetase** enzymes? *Analyze the figure carefully.*

Substrates: 1. _____ 2. _____ 3. _____

Products: 1. _____ 2. _____ 3. _____ 4. _____

d. Based on what you know from **Ch.8** and after studying carefully the process of **loading empty tRNA's with their corresponding amino acids** as depicted in Figure 17.17, would you say that **making a charged tRNA with a covalently bonded amino acid is an endergonic or exergonic process**? *Justify your answer.*

e. What do we **call a tRNA molecule once its been loaded with its amino acid**?

7. a. How many mRNA **codons exist that specify an amino acid**?

b. How many **types of tRNA** does the cell have?

c. Recall that there are **20** different amino acids that are used to make all proteins, yet there are **61** amino-acid coding codons (and 3 stop codons that do not code for an amino acid) possible in DNA and, thus, mRNA. We say that **there is redundancy in the genetic code** because of this. (Refer back to Ch.17 Section 1). Clarify what is meant by this redundancy in our genetic code?

d. Recall that there are **20** different **aminoacyl-tRNA synthetase** enzymes that load **20** different amino acids onto the **45** tRNA molecules. These **45** tRNA molecules bind to **61** different mRNA codons. What does this mean about the **match between tRNA anticodons and their corresponding mRNA codons**?

e. We say that there exists a wobble when it comes to the **third** nucleotide's base-pairing between the anticodon of a tRNA and the codon in the mRNA (which bind in an antiparallel fashion). What do we mean by **wobble** specifically?

f. How does **wobble** explain that there are fewer tRNAs than codons?

g. Here is a **codon chart**. The codon chart shows you the mRNA codons and the amino acid that a corresponding tRNA molecule would bring to the ribosome as the ribosome translates mRNA.

List all the **codons that code for Proline**.
(Label the 5′ and 3′ ends of each codon)

Note that only one tRNA will be loaded with proline, but that this one tRNA brings proline to the ribosome everyone time one of these four proline codons appear in the mRNA due to the third base wobble between the codons and tRNA anticodon. Find another example of a codon to anticodon pairing in which **third base wobble would allow one type of tRNA to bind to more than one version of a codon coding for the same amino acid**.

First letter	Second letter: U	Second letter: C	Second letter: A	Second letter: G	Third letter
U	UUU, UUC: Phe UUA, UUG: Leu	UCU, UCC, UCA, UCG: Ser	UAU, UAC: Tyr **UAA Stop** **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: Met	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

8. a. You should remember from Ch.6 that, in Eukaryotes, the large and small ribosomal subunits are made from **ribosomal RNA (rRNA)** transcribed from rRNA genes **in the nucleus** and **ribosomal proteins** (built by ribosomes during RNA translation **in the cytoplasm** from ribosomal protein mRNA transcribed in the nucleus from ribosomal protein genes). Where are the **two subunits of ribosomes assembled from the rRNA and proteins** in Eukaryotic cells specifically?

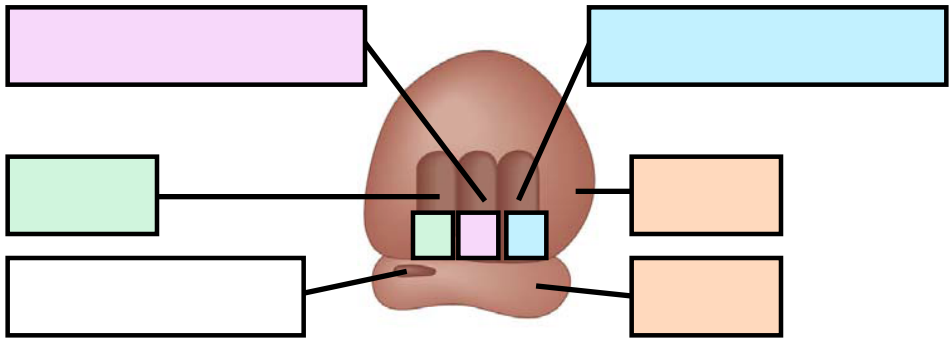
   b. What happens to the **ribosomal subunits after they are made** in Eukaryotes?

   c. **When does a functional ribosome form** from the large and small ribosomal subunits in both Prokaryotes and Eukaryotes?

9. a. How does a **prokaryotic ribosome differ from a eukaryotic ribosome**?

   b. What is the **medial significance** of this difference?

10. a. Study Figure 17.18 in its entirety. Label the main parts of a ribosome.



   b. As you read your text, describe what takes place in the following parts of the ribosome.

      a. **P site =**

      b. **A site =**

      c. **E site =**

      d. **mRNA binding site =**

      e. **Exit tunnel =**

11. Ribosomes catalyze the synthesis of polypeptides *(they help lower the activation energy needed to drive endergonic dehydration synthesis reactions that must occur in order to covalently bond together amino acids into a polypeptide chain).* Which of the two molecules that ribosomal subunits are composed of is the **molecule that catalyzes these dehydration synthesis reactions that build the peptide bonds between amino acids in the polypeptide being constructed**? *Yes, the ribosome contains a ribozyme!*

12. To review, **three types of RNA** are needed for protein synthesis. Complete the chart below with their functions.

Type of RNA	Function of RNA in Cell
rRNA	
mRNA	
tRNA	

13. Much like transcription, we can divide **translation into three stages**. List them below.

    1. _____

    2. _____

    3. _____

14. **Building proteins is a non-spontaneous, endergonic process.** Though **most cellular work** *(mechanical, chemical, and transport)* **uses the RNA-type nucleotide ATP as an energy source**, this isn't the only energy source that can be used in cells. For example, you saw in Ch.16 how when **nucleic acids are built** the **energy comes from the hydrolysis of the four triphosphate nucleoside (the nucleotide) monomers** that themselves will be incorporated into the growing nucleic acid strand strand: for DNA these iared**ATP, dTTP, dGTP, dCTP** (d = deoxy) and for RNA these are **ATP, UTP, GTP, CTP**. Where does **the ribosome get the energy from** used to build polypeptides out of amino acids?

15. Which **four items need to come together in order for translation to be able to start** (to be initiated)?

    1. _____ 2. _____

    3. _____ 4. _____

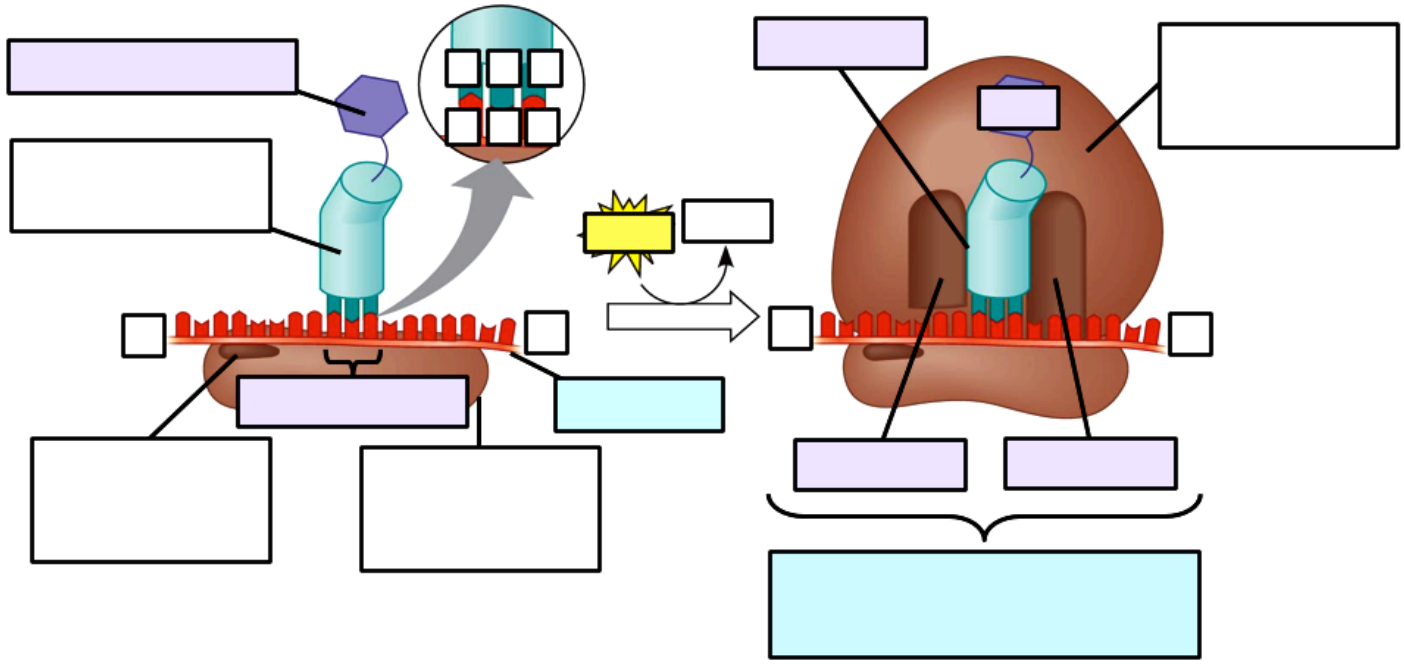
16. a. What is **always the first amino acid in every new polypeptide constructed by ribosomes** *(at least initially since polypeptides can undergo post-translational modifications in which the initial amino acid may be removed as needed for proper protein folding and function)*?

    b. This first amino acid is attached to an initiator tRNA (the first tRNA to assemble on the mRNA) along with the two ribosomal subunits. What is **the START codon this initiator tRNA binds to**? Make sure you label the 5′ and 3′ ends of this START codon. **Remember, mRNA are always translated in the 5′ to 3′ direction.**

    c. Is this 5′ AUG 3′ Start Codon, where translation of the mRNA transcript begins, found at the very beginning of the mRNA strand or are there some mRNA nucleotides upstream (in the 5′ direction) of this Start Codon that are not translated into the amino acids of a polypeptide by the ribosome? R**efer back to Ch.17.3 Figure 17.11 as well.**

d. If the start codon is the one you listed above, what is the **anticodon** (in the antiparallel configuration: 3′ to 5′) that is found on the **complimentary section of the initiator tRNA carrying that initial Methionine amino acid** you listed in 16.a.?

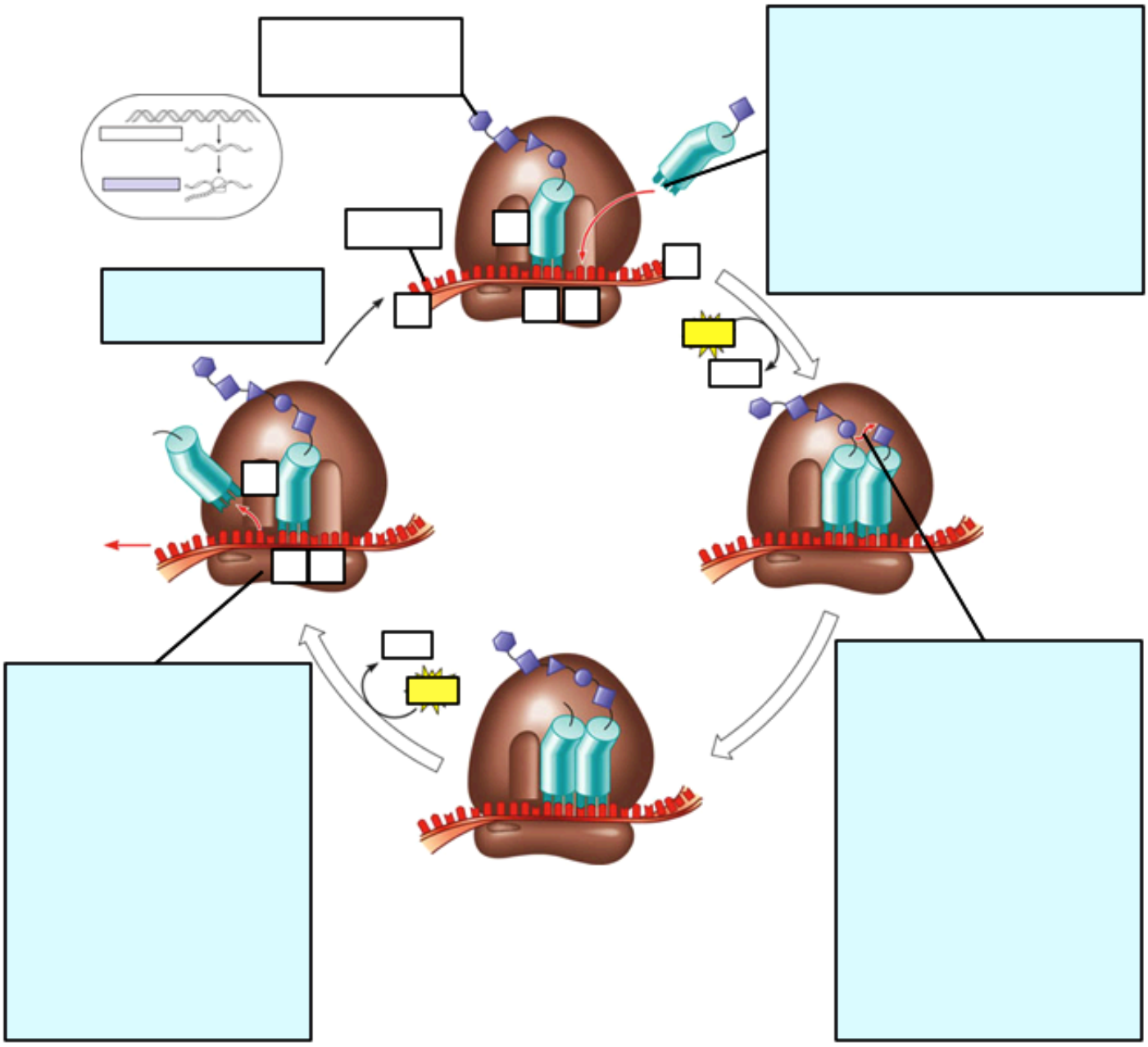
17. **Study Figure 17.19.** When you feel you have the information mastered, describe accurately and clearly the first and second steps related to the **initiation of translation** while labeling the diagram below.



1.

2.

18. **Study Figure 17.20.** When you feel you have the information mastered, describe accurately and clearly the three main steps that repeat during the **elongation cycle of translation** while labeling the diagram below.



19. a. How does the mRNA signal to the ribosome **when to stop translating the rest of the mRNA**?

b. List the **three stop codons** below you could find in mRNA. Make sure you label the 5′ and 3′ ends of these stop codons.

c. *Think:* What would be the DNA sequence of these three stop codons in the complimentary template DNA template strand that was transcribed into the mRNA? Make sure you label the 5′ and 3′ ends of these stop codons in the DNA (remember the DNA template strand would be antiparallel to the mRNA).

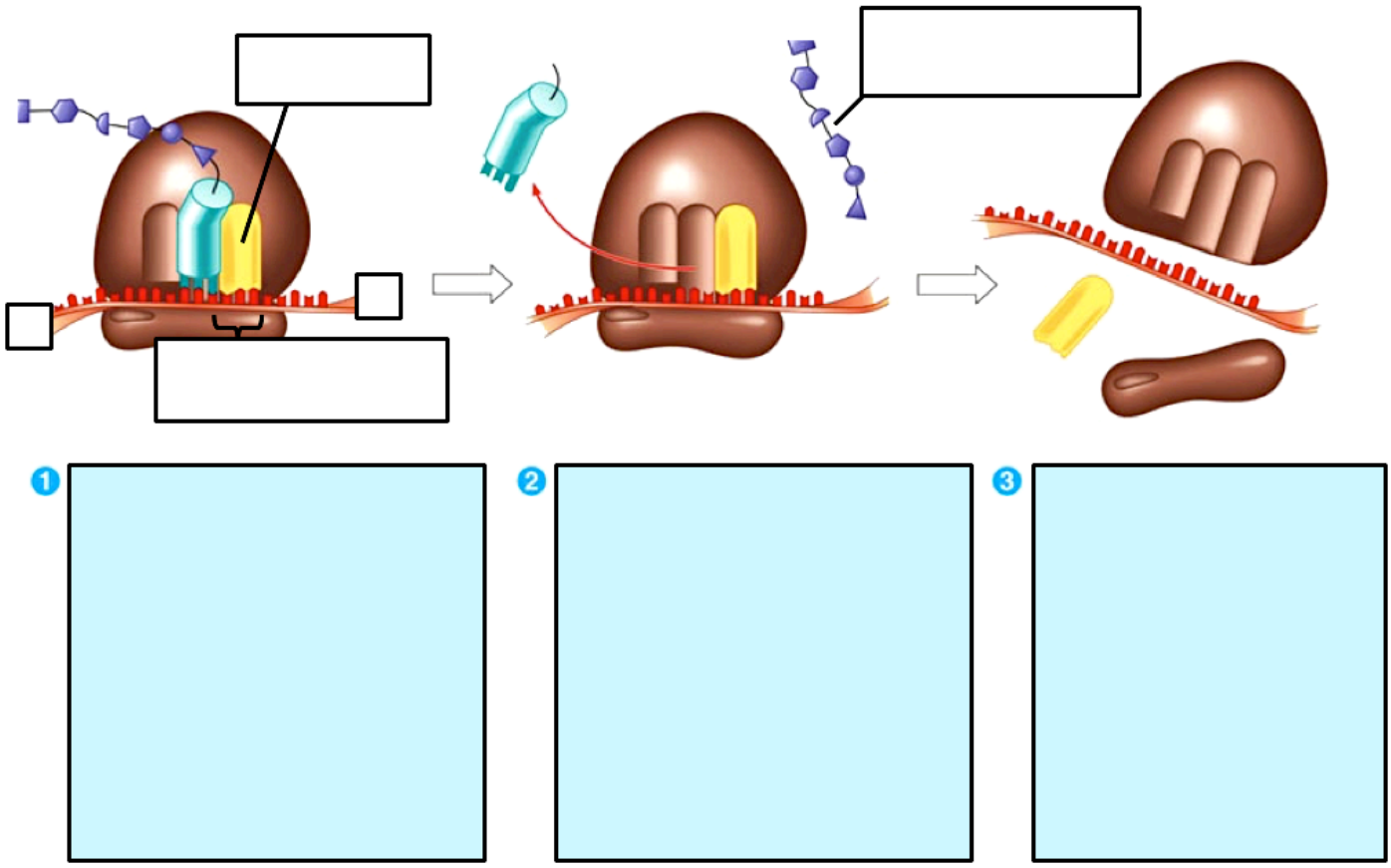
d. Do these mRNA **stop codons** attract a tRNA in order to bring a new amino acid to the ribosome to add to the growing polypeptide of the protein? Said differently, *do any tRNA's have anticodons to match these stop codons or do stop codons code for an amino acid?*

e. What **enters the ribosome's A site when the stop codon triplet on the mRNA enters in the A site**?

f. What is a **release factor** ?

g. What happens once the release factor enters the A site that causes **translation termination**?

20. **Study Figure 17.19** to mater fully the events involved in terminating translation. When you feel you have the information memorized, test yourself by practicing describing accurately and clearly the three stages of **translation termination** while labeling the diagram below.



21. a. Let's perform a quick translation of a mRNA transcript. Refer back to the codon chart in question 7.g. and determine the **primary protein structure** (the sequence of **amino acids** in the polypeptide) that will be constructed by the ribosome using the following mRNA sequence. *FYI: **Polypeptides are build from the N -Terminus to the C -Terminus,** as the **ribosome reads the mRNA in the 5' --> 3' direction**, so be sure to include a **"N -"** and a **"- C"** at the start and end of polypeptides you draw).*

mRNA ⟶ **5' - A U G C G G G G G C A U C A A U G A - 3'f**

↓

polypeptide ⟶ **N -**

b. Suppose you were asked to write the DNA gene sequence that encodes the information used by a prokaryotic cell to build the following polypeptide. Remember, **prokaryotic cells have no introns** and do not engage in RNA Processing, including RNA Splicing. Working backwards, what would be the mRNA and then the DNA sequences that correspond to the following polypeptide.. *Make sure you always label your mRNA **AND** your DNA 5′ and 3′ ends.*

polypeptide → **N - Met - Trp - Val - Gly - Ser - Phe - Met - Pro - C**

mRNA → *5′ -*

DNA template strand → ___ -

*Did you remember that RNA uses the nitrogenous base **Uracil** instead of Thymine? Did you remember that your DNA must be complimentary and **antiparallel** to your mRNA? **Did you also remember to include a STOP codon in your mRNA immediately AFTER the codon for proline and, thus, in your complimentary DNA?)***

22. What begins to happen to the **growing polypeptide as it exits the ribosome** as far as protein shape is concerned?

23. List a few examples of a **post-translational modification of a protein**?

1.

2.

3.

4.

24. a. Distinguish between the locations where one would find **free and bound ribosomes**?

Free Ribosomes =

Bound Ribosomes =

b. What are the **two destinations of the proteins made by bound ribosomes**?

1.

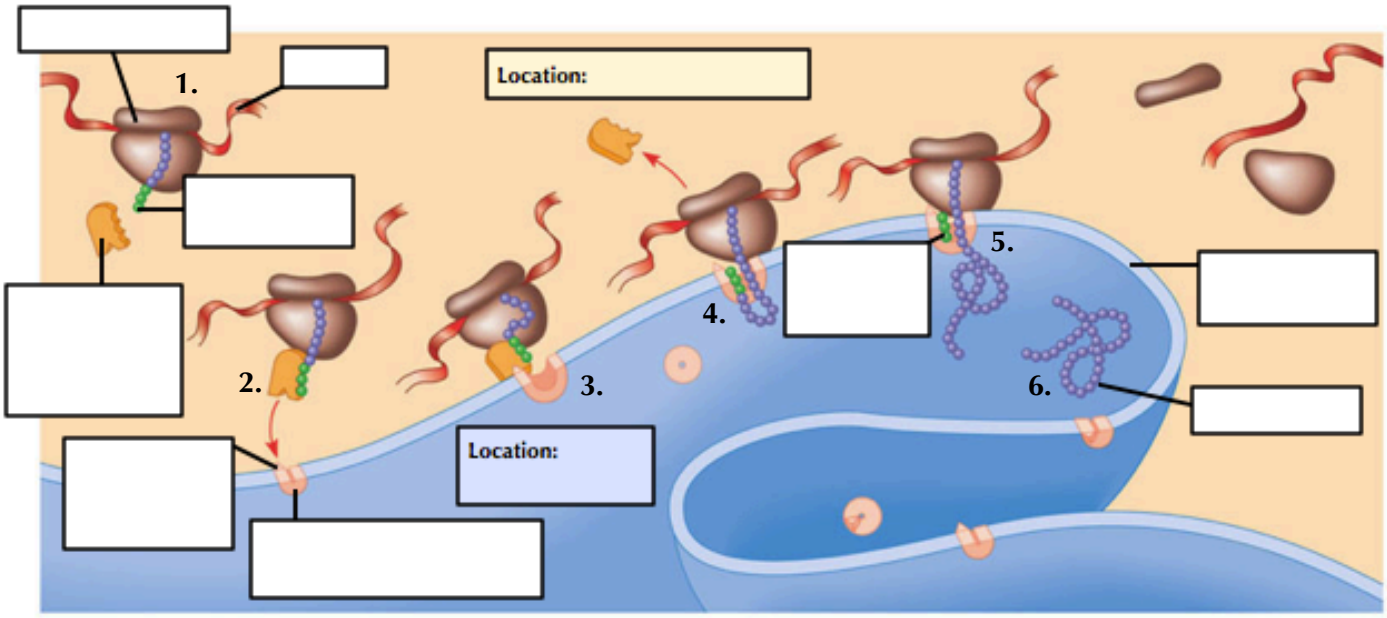
2.

25. a. What is a **signal peptide**?

b. What is a **signal recognition particle**?

c. ***Translation always starts in the cytoplasm on Free Ribosomes*** (See Ch.6). However, **proteins intended to be included in membranes of the endomembrane system, in the lumen of the endomembrane system organelles, or secreted from the cell head to the Rough Endoplasmic Reticulum.** What are the organelles or structures that make up the endomembrane system of a eukaryotic cell? **(Go back to Ch.6 Figure 6.15 and your Ch.6 slides)**

d. Once inside the RER or in the RER membrane, polypeptides fold up and the proteins that fom may be processed further. This processing may even continue in the Golgi. First, however, polypeptides must get to the RER. Label the following illustration showing the **signal mechanism for targeting proteins to the ER** and explain the six steps of the process in the boxes below.



1.

2.

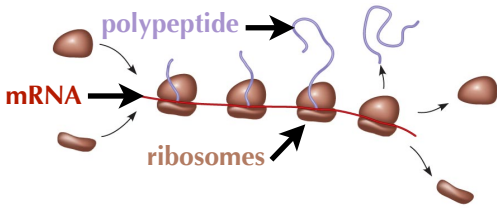
3.

4.

5.

6.

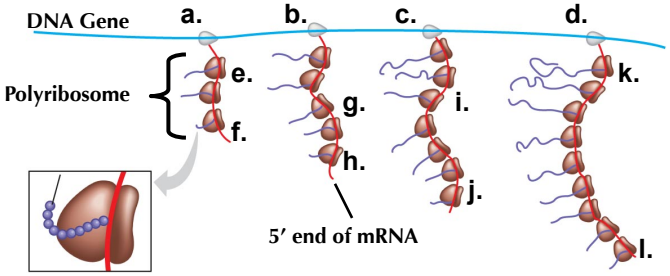
26. a. What are **polyribosomes**?



b. Why are they **beneficial to a BOTH eukaryotic and prokaryotic cell**?

27. a. Review Figure 17.24. Since the DNA is in the cytoplasm where ribosomes are also located, bacterial cells can begin RNA translation while DNA transcription is still taking place. Based on the image below, which one of the mRNA molecules started being transcribed first: a, b, c, or d? The red arrow indicated the direction of transcription on the DNA template strand.

b. On the mRNA you choose in 27.a., which ribosome started translating the mRNA first?



28. Let's review to see if you understood the process of translation. What **two processes ensure that the correct amino acid is added to a growing polypeptide chain**?

1.

2.

*(Check your answers by going to the Ch.17.4 **Concept Check Question #1** in Appendix A of your textbook)*

29. a. Draw a tRNA with the anticodon 3′-CGU-5′.

b. Given wobble (and knowing which nucleotide in the codon is able to be more flexible in base-pairing rules), what two different codons would this anticodon bind to?

c. Draw each codon on an mRNA, labeling all 5′ and 3′ ends, the tRNA, and the amno acid it carries.

*(Check your answers by going to the Ch.17.4 **Concept Check Question #3** in Appendix A of your textbook)*