STUDY GUIDE - *Ch. 17.1 - Genes Specify Proteins via Transcription & Translation* **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.*

This chapter is crucial to your understanding of biology as protein shape and, therefore, function control phenotype. Review often as you work through each section of the chapter, the goal being to understand the processes well.

1. a. What is **gene expression**?

   b. What are the two stages involved in gene expression?

      1. _____ 2. _____

2. a. How did **Archibald Garrod** hypothesize that genes control phenotype?

   b. What did he refer to as **inborn errors of metabolism**?

   c. Describe the example Garrod used to **illustrate his hypothesis**.

3. a. **Beadle and Tatum set out to study if individual genes specify the enzymes that function in biochemical pathways.** Which **organism** did Beadle and Tatum use in their research (it's Latin name is *Neuospora crassa*)?

   b. Why was it beneficial to use *N. crassa* as a research subject since it is a **haploid organism** instead of a diploid organism?!

c. Beadle and Tatum wanted to study the differences between *Neurospora* organisms that had different DNA mutations to try to **pinpoint exactly how changes in DNA change phenotype**. How were *Neurospora* spores treated to **cause various DNA mutations in different spores**?

4. a. In the lab, Beadle and Tatum grew bread mold on different mediums. What is the difference between a **minimal medium** and a **complete growth medium**? **It is important that you understand these terms for this and future chapters.**

Minimal Medium =

Complete Growth Medium =

b. Why could **wild type** (non-mutant) *Neurospora* **survive on minimal medium** even though this minimal medium does not contain all the 20 amino acids, vitamins, and other nutrients the mold cells actually need to live and reproduce?

c. Beadle and Tatum identified **mutants** that could not survive when grown on minimal medium, but which **could survive on complete medium**. Why could these particular mutant *Neurospora* **not** survive on minimum medium?

d. Study Figure 17.2. After identifying metabolic mutants (mutants that, due to damage to a particular gene, could no longer synthesize a required biochemical pathway's product needed for survival, **how did Beadle and Tatum try to narrow down which metabolic pathway was unable to work** in each of the different mutants?

e. How did they identify only **mutants incapable of synthesizing arginine** specifically?

f. Among the mutants identified that had a problem synthesizing arginine, variations were found related to which intermediate compound in the arginine-synthesizing biochemical pathway each type of arginine-synthesizing mutant needed in order to not die and be able to continue to survive. What explanation did Beadle and Tatum, and their colleagues Srb and Horowitz, propose to explain **why different biochemical pathway intermediates were necessary in the diet of the different arginine mutants for them to survive**?

5. a. What was the **original name of Beadle and Tatum's hypothesis**, which **explained the role of genes in the DNA** based on their research.

b. What were two later **revisions to Beadle and Tatum's hypothesis** and why were these revisions made? *A critical concept!*

Revision of Hypothesis Name #1: _____

Reason for revision:

Revision of Hypothesis Name #2: _____

Reason for revision:

c. Given what we know today, what are two reasons why even the **One Gene-One Polypeptide hypothesis is no longer considered fully accurate**?

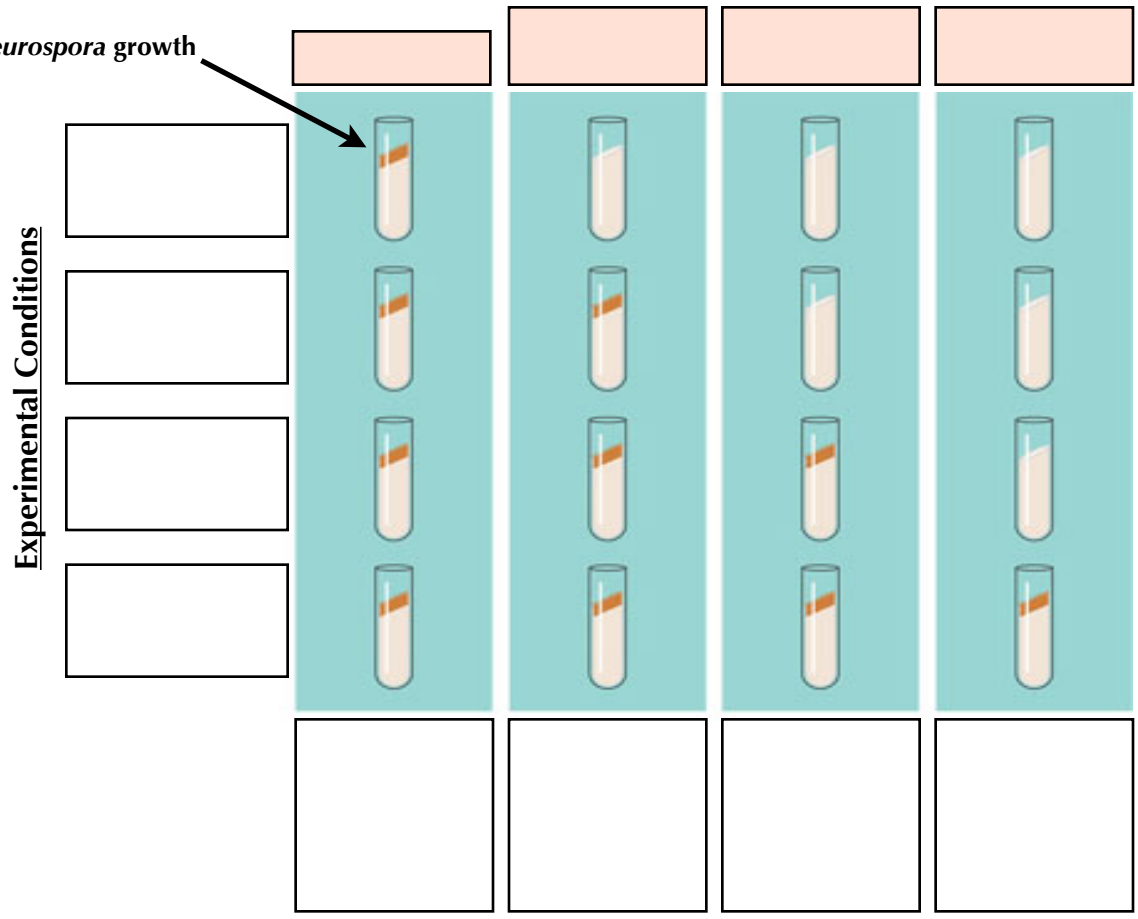
Reason #1:

Reason #2:

6. a. Let's study **Figure 17.3** on the classic experiment conducted by Srb and Horowitz. **Biochemical pathways involve the use of a multiple enzymes, each one helping catalyze one step (chemical reaction) in the multistep pathway.** Draw the **biochemical pathway** (horizontally) that Srb an Horowitz **postulated (hypothesized) allowed *Neurospora* to make arginine** (when arginine was not found in their diet directly)?

_____ → _____ → _____ → _____

b. **Study Figure 17.2** well. This is a classic experiment that you must understand. As you do, fill in the diagram below illustrating Srb an Horowitz's bread mold experimental results. *Understanding the logic behind the experiment, the interpretation of its results, and the conclusion drawn are critical!*



c. Let's review some of Chapter 1 - Experimental Design. What are the **dependent and the independent variables** in this experiment? (*Remember, the D.V. is the variable being measured by the researchers in the experiment while the I.V. is the variable being manipulated by the researchers).*

Independent Variable =

Dependent Variable =

d. Srb and Horowitz's conclusions are visually highlighted in the table below.

Gene (codes for enzyme)	Wild type	Class I mutants (mutation in gene *A*)	Class II mutants (mutation in gene *B*)	Class III mutants (mutation in gene *C*)
Gene *A* → Enzyme A	Precursor → Ornithine	Precursor → ~~Enzyme A~~ → Ornithine	Precursor → Ornithine	Precursor → Ornithine
Gene *B* → Enzyme B	Ornithine → Citrulline	Ornithine → Citrulline	Ornithine → ~~Enzyme B~~ → Citrulline	Ornithine → Citrulline
Gene *C* → Enzyme C	Citrulline → Arginine	Citrulline → Arginine	Citrulline → Arginine	Citrulline → ~~Enzyme C~~ → Arginine

Now, state their **two significant conclusions** in words that resulted from this research?

Finding #1:

Finding #2:

7. a. *Think:* Let's say Srb and Horowitz saw different results than what they did in 6.d. Imagine if they had seen that class I mutants could grow only in MM supplemented with ornithine or with arginine and that class II mutants could grow in MM supplemented with citrulline, with ornithine, or with arginine. Write down what they would have instead concluded is the biochemical pathway for arginine synthesis.

_____ → _____ → _____ → _____

b. *Think:* What would have been their conclusion instead regarding what was the defect in Class I mutants?

c. *Think:* What would have been their conclusion instead regarding what was the defect in Class II mutants?

(Check your answer to 7.a., b., c. by going to the Ch.17 ***Figure Questions*** *for* ***Figure 17.3*** *in Appendix A of your textbook)*

8. a. What are the nucleotide **monomers of DNA**?

b. What are the nucleotide **monomers of RNA**?

c. What are the **monomers of proteins**?

9. Define the following processes that must occur in order to make a protein:

Transcription =

Translation =

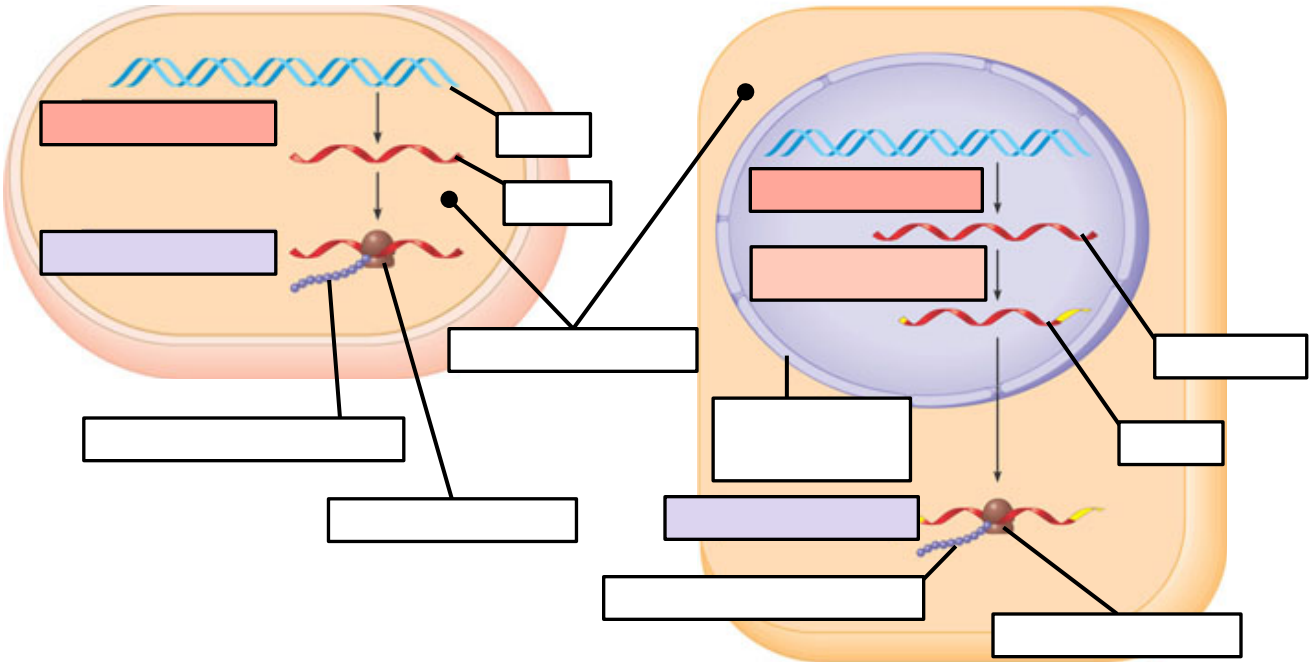
10. During the **transcription of a gene**, **what serves as the template** for the assembly of a complimentary sequence of RNA nucleotides?

11. What is **messenger RNA or mRNA**?

12. What is a **ribosome**?

13. In which of the three **Domains of life** (Eukarya, Archaea, and Bacteria) **do cells conduct transcription** (to make RNA molecules) **and translation** (to construct the primary structure of proteins - polypeptides with a specific amino acid sequence)?

14. a. The **flow of genetic information in a prokaryotic and eukaryotic cell differs**. Label the illustrations below highlighting the differences in the location within the cell where transcription and translation occur in prokaryotes and eukaryotes.



b. What differs in the **timing of transcription and translation in prokaryotes compared to in eukaryotes**?

In Prokaryotes =

In Eukaryotes =

c. Why is the **RNA produced by transcription in a Eukaryote called the Primary Transcript and not mRNA**?

15. What is the **Central Dogma** of molecular genetics, as proclaimed by Francis Crick?

16. a. Let's conduct a quick review to make sure you have this mastered before continuing. Complete the following table to **summarize the processes of transcription and translation in Prokaryotic Cells**.

	Template Molecule Used	Product Synthesized	Location in Prokaryotic Cell of Activity
Transcription			
Translation			

b. Complete the following table to **summarize the processes of transcription and translation in Eukaryotic Cells**.

	Template Molecule Used	Product Synthesized	Location in Eukaryotic Cell of Activity
Transcription			
Translation			

17. a. How many **total nucleotide bases** are there for DNA ?

b. How many **total amino acids** are there?

18. a. The **genetic code is a triplet code of non-overlapping nucleotides**. This allows all amino acids to be coded for. How many **total unique, triplet, non-overlapping codes** can be produced **using the four nucleotides of DNA**?

b. How many amino acids would a cell have been able to code for had the genetic code involved a single base?

c. How many amino acids would a cell have been able to code for had the genetic code involved a two, non-overlapping bases?

19. a. Within a gene, one of the two DNA strands in the DNA double helix is called the **template strand** (also called the antisense strand). What is the **template strand** ?

b. Which nucleotides of RNA do each of the four nucleotides of DNA (A, T, G, C) pair with during DNA transcription? Stated differently, which DNA nucleotides is complimentary to which RNA nucleotides.

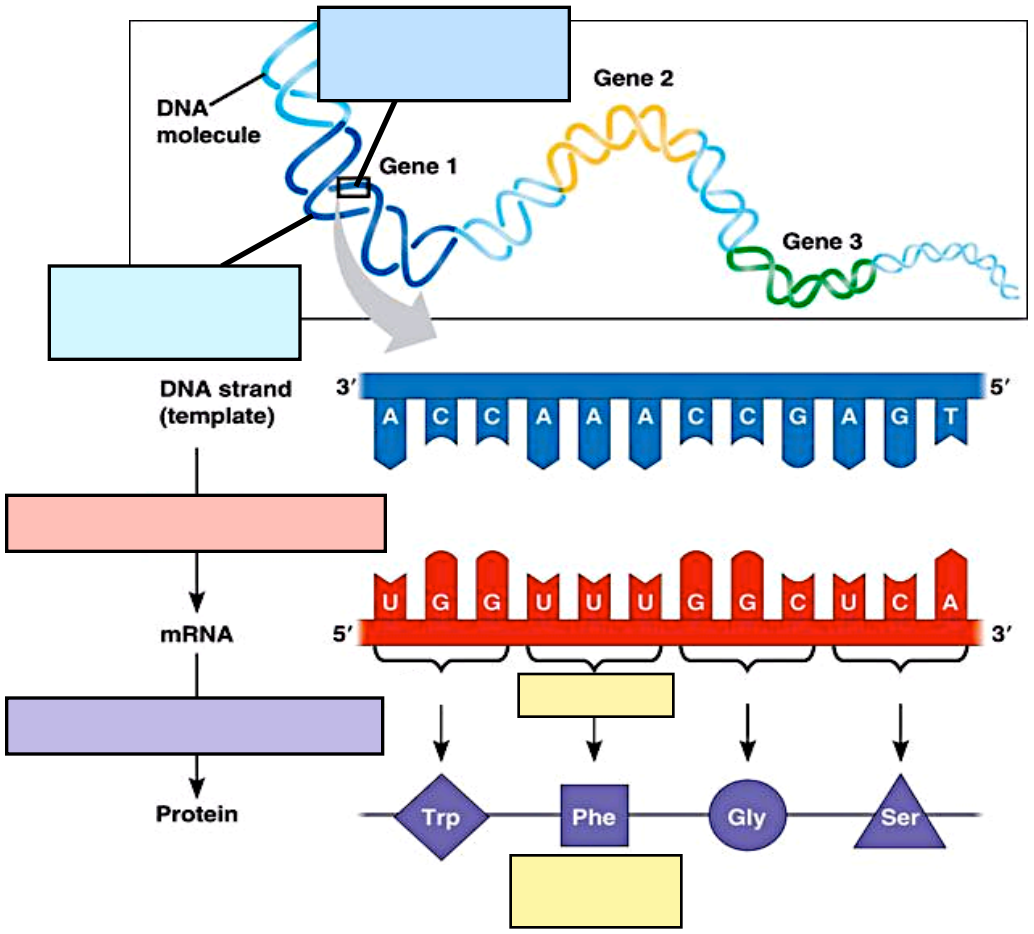
- The **A** in DNA pairs with the _____ in RNA
- The **G** in DNA pairs with the _____ in RNA
- The **C** in DNA pairs with the _____ in RNA
- **The T in DNA pairs with the _____ in RNA**

c. What do we call **each triplet code in mRNA** built complimentary to the template strand?

d. Which of the two DNA stands in the DNA double helix is the **coding strand** (also called the sense strand)?

20. Remember, polymerase enzymes always build nucleotide polymers **antiparallel** to template strands. In what **direction is the RNA molecule itself synthesized (by RNA Polymerase) during DNA transcription**?

21. Study Figure 17.5 and fill in the missing boxes below.



22. a. How did **Nirenberg determine which amino acids was specified by which code**?

b. What was the **first codon-amino acid pair to be identified**?

23. Read over Figure 17.6 . What **polypeptide product (protein primary structure)** would you expect form a **poly-G mRNA** that is **30** nucleotides long? Draw the polypeptide below. *(Check your answers by going to the Ch.17.1 **Concept Check Question #2** in Appendix A of your textbook)*

24. a. What is the mRNA sequence of the **start codon**?

b. What **amino acid does the start codon always code for**?

c. What **role does the start codon play** in translation?

25. a. Of the **64 codons**, how many of the **codons result in an amino acid** being added to a growing polypeptide chain? *Explain.*

b. What are the sequences for the **three stop codons**? 1. _____ 2. _____ 3. _____

c. What happens when the **ribosome hits a stop codon in the mRNA**?

26. What is meant by the statement "**there is redundancy in the genetic code, but no ambiguity**"?

27. What is the **reading frame**?

28. a. Refer to Figure 17.6 as needed. Here is a short DNA template. Below it, **assemble the complimentary mRNA** strand. *(*Note that you **MUST** always identify the 3′ & 5′ ends of any nucleic acid polymer written so label the 3′ & 5′ ends of mRNA too!* Tip: ***First*** *write down the nucleotides complimentary to the template.* ***Then*** *add the 3′ and 5′ labels)*

3′ A C G A C C A A G A G T A A A 5′

b. How many **codons** are there in the stretch of template DNA above above?

c. Draw a labeled box around one of the **codon** on the image above.

d. What would be the **non-template strand of the gene** (the **DNA coding or sense strand**)? *Label the 3′ & 5′ ends!*

e. How does **the non-template DNA strand compare to the mRNA** polymer sequence?

f. **The ribosome reads the mRNA starting from the 5′ (to the 3′) end!** Now **translate the mRNA sequence** you drew in part a.

29. DNA is DNA is DNA. Meaning that **the genetic code is nearly universal.** Because of this jellyfish genes can be inserted into pigs and mosquitos, or firefly genes can make a tobacco plant glow! What conclusions can be drawn from the **near universality of the genetic code** of all living organisms?