Chapter 17: From Gene to Protein

OBJECTIVES:

The Connection between Genes and Proteins

__1. Explain the reasoning that led Archibald Garrod to first suggest that genes dictate phenotypes through enzymes.
__2. Explain Beadle and Tatum's contribution to our understanding of how genes control metabolism.
__3. Distinguish between the "one gene-one enzyme" hypothesis and the "one gene-one polypeptide" hypothesis and explain why the original hypothesis was changed.
__4. Explain how RNA differs from DNA.
__5. Briefly explain how information flows from gene to protein.
__6. Distinguish between transcription and translation.
__7. Compare where transcription and translation occur in prokaryotes and in eukaryotes.
__8. Define "codon" and explain the relationship between the linear sequence of codons on mRNA and the linear sequence of amino acids in a polypeptide.
__9. Explain the early techniques used to identify what amino acids are specified by the triplets UUU, AAA, GGG, and CCC.
__10. Explain why polypeptides begin with methionine when they are synthesized.
__11. Explain in what way the genetic code is redundant and unambiguous.
__12. Explain the significance of the reading frame during translation.
__13. Explain the evolutionary significance of a nearly universal genetic code.

The Synthesis and Processing of RNA

__14. Explain how RNA polymerase recognizes where transcription should begin.
__15. Describe the promoter, the terminator, and the transcription unit.
__16. Explain the general process of transcription, including the three major steps of initiation, elongation, and termination.
__17. Explain how RNA is modified after transcription in eukaryotic cells.
__18. Define and explain the role of ribozymes.
__19. Describe the functional and evolutionary significance of introns.

The Synthesis of Protein

__20. Describe the structure and functions of tRNA.
__21. Describe the structure and functions of ribosomes.
__22. Describe the process of translation (including initiation, elongation, and termination).
__23. Explain what determines the primary structure of a protein and describe how a polypeptide must be modified before it becomes fully functional.
__24. Describe two properties of RNA that allow it to perform so many different functions.
__25. Compare protein synthesis in prokaryotes and eukaryotes.
__26. Define "point mutations." Distinguish between base-pair substitutions and base-pair insertions. Give examples of each and note the significance of such changes.
__27. Describe several examples of mutagens and explain how they cause mutations.

Chapter 18: Viruses

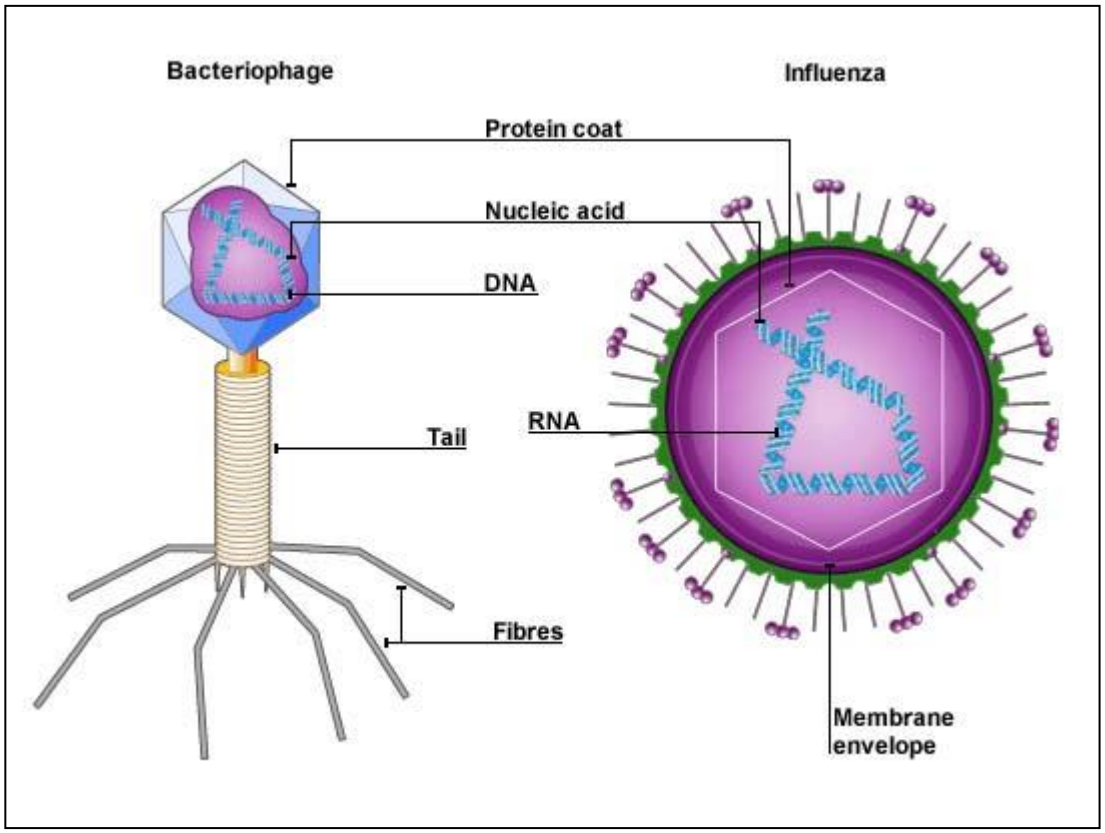
OBJECTIVES:

The Genetics of Viruses

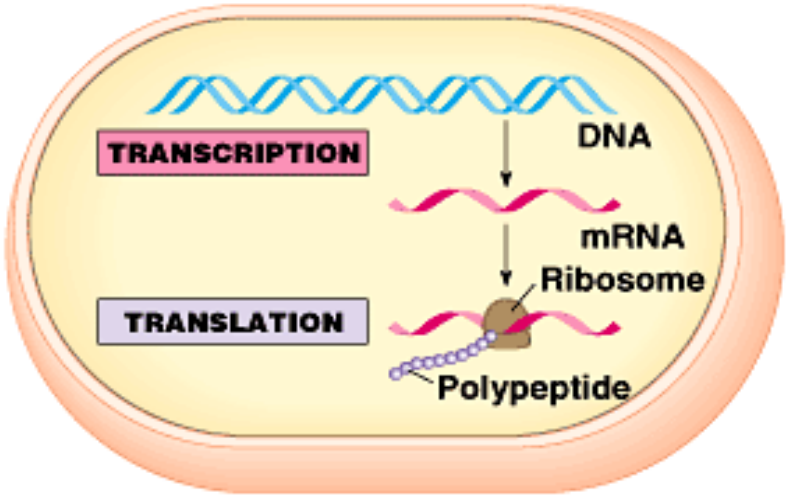
__1. List and describe the structural components of viruses.
__2. Distinguish between the lytic and lysogenic reproductive cycles.
__3. Describe the reproductive cycle of retroviruses.

The Genetics of Bacteria

__4. Describe the structure of a bacterial chromosome.
__5. Distinguish between plasmids and viruses.
__6. Using the lac operon as an example, explain the concept of an operon and the function of the operator, repressor, and co-repressor.
__7. Distinguish between structural and regulatory genes.
__8. Describe how the lac operon functions and explain the role of the inducer, allolactose.

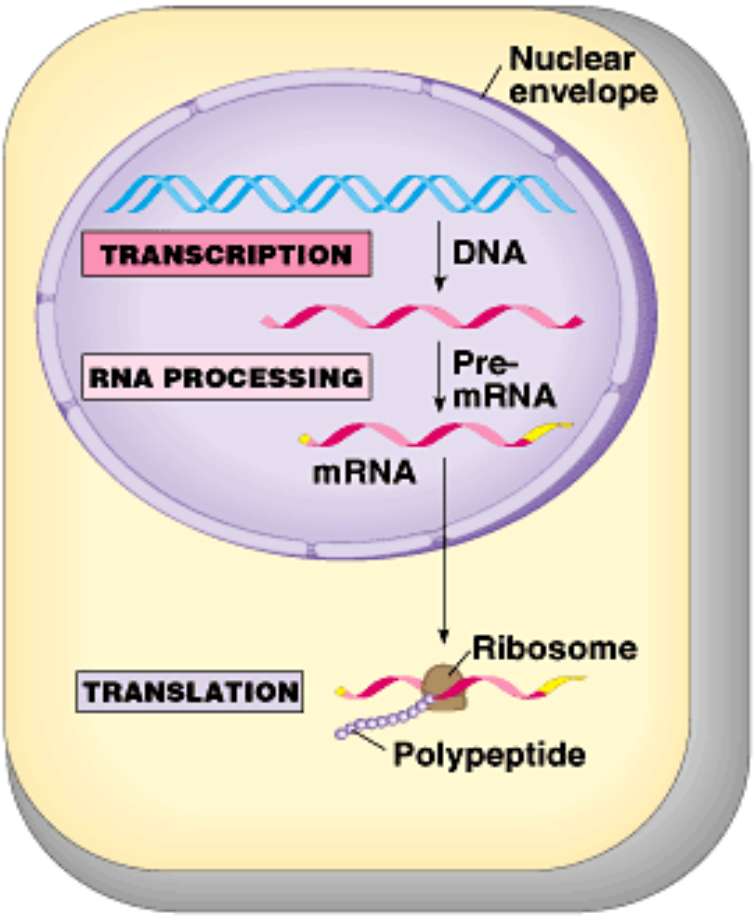


The Central Dogma of Biology



(a) Prokaryotic cell

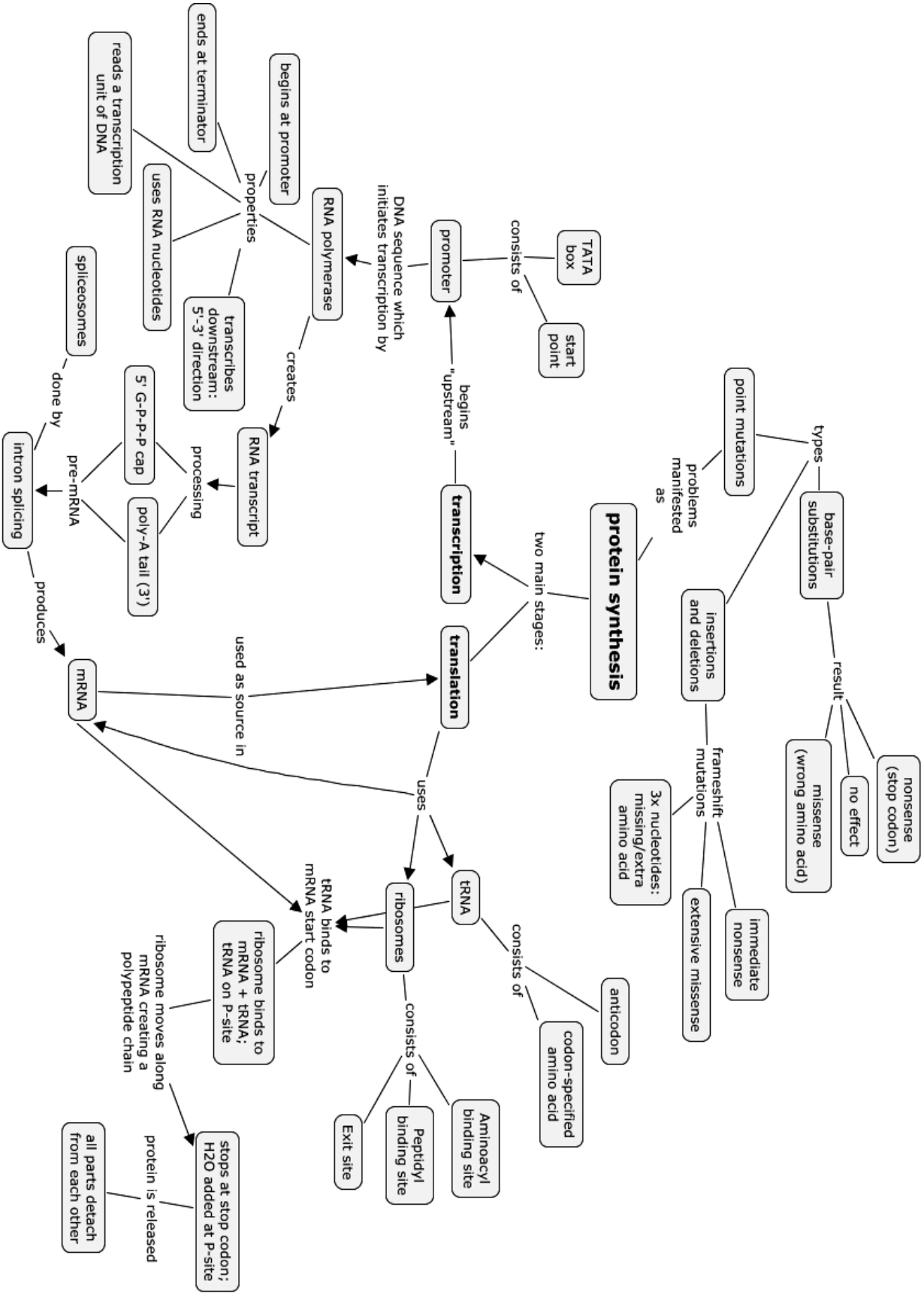
In a cell lacking a nucleus, mRNA produced by transcription is immediately translated without additional processing.



(b) Eukaryotic cell

A membrane-bound nucleus provides a separate compartment for transcription. The original RNA transcript, called pre-mRNA, is processed in various ways before leaving the nucleus.

Chapter 17: Concept Map



THE CONNECTION BETWEEN GENES AND PROTEINS

(p.325) **1.** What is a gene?

A gene is a region of DNA that codes for the production of a specific polypeptide (protein).

(p.325) **2.** What is *gene expression*?

Gene expression is when a gene is actively producing a protein (transcription and translation).

(p.303) **3.** What situation did Archibald Garrod suggest caused inborn errors of metabolism?

Archibald Garrod suggested that genes dictate phenotypes through enzymes that catalyze specific chemical reactions in the cell. Garrod postulated that the symptoms of an inherited disease reflect a person's inability to make a particular enzyme.

(p.304) **4.** Describe one example Garrod used to illustrate his hypothesis.

Garrod used a hereditary condition called alkaptonuria, in which the urine is black because it contains the chemical alkapton, which darkens upon exposure to air. Garrod reasoned that normal individuals have an enzyme that breaks down alkapton whereas individuals with the condition cannot.

(p.304) **5.** State the hypothesis formulated by George Beadle while studying eye color mutations in *Drosophila*.

While studying eye color mutations in Drosophila, George Beadle speculated that each of the various mutations affecting eye color in Drosophila blocks pigment synthesis at specific steps by preventing the production of the enzyme that catalyzes that step.

(p.304) **6.** What revision of detail (*but not of basic principle*) did this hypothesis undergo as more information was gained? Write this restatement and then box or highlight it. This is an important concept and is related to your answer to the previous question!

As more information was gained, the ***one gene - one enzyme hypothesis*** was restated as the ***one gene - one polypeptide (protein) hypothesis***.

(p.304) **7.** Explain the statement, "All enzymes are proteins but not all proteins are enzymes."

Not all proteins are enzymes. There exists many nonenzyme proteins such as keratin and insulin that are nevertheless, gene products.

Basic Principles of Transcription and Translation

This section will introduce you to the processes and associated terminology in the form of an overview. Once you have the big picture, you will take a closer look in the next few concepts.

(p.305) **8.** From the first paragraph in this section, find three ways in which RNA differs from DNA.

(1) RNA contains the sugar ribose instead of deoxyribose.

(2) RNA has the nitrogenous uracil instead of thymine.

(3) RNA is single-stranded while DNA is double-stranded.

(p.305) **9.** What are the monomers of DNA and RNA called?

The monomers of DNA and RNA are the four types nucleotides.

(p.305) **10.** What are the monomers of proteins called?

The monomers of proteins are the 20 amino acids.

11. Define each of these processes that are essential to the formation of a protein:

(p.305) **(1) transcription** - the synthesis of RNA under the direction of DNA

(p.305) **(2) translation** – the actual synthesis of a polypeptide (protein) under the direction of mRNA

(p.307) **12.** Complete the following table to summarize each process:

	Template	Product Synthesized	Location in Eukaryotic Cells
Transcription	DNA	RNA	Nucleus
Translation	mRNA	Protein	Cytoplasm (ribosome)

(p.306) **13.** In eukaryotes, what is the pre-mRNA called?

Pre-mRNA in eukaryotes is called a primary transcript.

(p.306) **14.** How many DNA nucleotide bases are there? 4 How many amino acids are there? 20

(p.306) **15.** How many nucleotides are required to code for these 20 amino acids? 3

(p.307) **16.** So, the language of DNA is a triplet code. How many unique triplets exist? 64

4 x 4 x 4 or 4^3

(p.307) **17.** DNA is double-stranded, but for each protein, only one of these two strands is used to produce an mRNA transcript. What is the coding strand called?

The coding strand is called the TEMPLATE strand.

(p.307) **18.** Here is a short DNA template. Below it, assemble the complementary mRNA strand.

3' A C G A C C A G T A A A 5'

***m*RNA** = 5'UGCUGGUCAUUU 3'

19. How many codons are there above? 4 Put a box around one codon.

(p.307) **20.** What was the first codon–amino acid pair to be identified? UUU = Phenylalanine (Phe)

(p.308) **21.** Of the 64 possible codons, how many code for amino acids? 61

(p.308) **22.** What event is coded for by UAA, UAG and UGA? "stop" signal or termination codons

(UUA = Stop / UAG = Stop / UGA = Stop)

(p.308) **23.** What is the start codon? AUG

(p.308) **24.** Use the table to the left to help you explain why is the genetic code said to be *redundant* but not *ambiguous*?

The genetic code is said to be redundant but not ambiguous because although codons GAA and GAG both specify glutamic acid (redundancy), neither of them specify any other amino acid (no ambiguity).

The Genetic Code

First base (5′ end)	Second base: U	Second base: C	Second base: A	Second base: G	Third base (3′ end)
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