Chapter 16: The Molecular Basis of Inheritance

16.1 Describe the structure of DNA and evidence that it is the genetic material.

16.2 Explain how the Meselson-Stahl experiment contributed to our understanding of DNA replication, and describe this process.

16.3 Distinguish among the levels of chromatin packing in a eukaryotic chromosome.

Genetic information provides for continuity of life. The double-stranded structure of DNA provides a simple and elegant solution for the transmission of heritable information to the next generation. This chapter will guide your study of DNA—how it was determined to be the genetic material, its structure, and how it is faithfully duplicated.

Study Tip: The big picture is shown graphically in Figure 16.1 in your text. Recreate and label the three steps shown to DNA replication in the space below. Simplify your figure by just using the representations of chromosomes rather than DNA strands. Notice the terminology, especially unduplicated chromosome and duplicated chromosome. Be precise with language. Understanding the difference between the two terms will reduce confusion in your thoughts and writing.

DNA replication allows genetic information to be inherited from a parent cell to daughter cells by_____ and from generation to generation by _____.

Concept 16.1 DNA is the genetic material

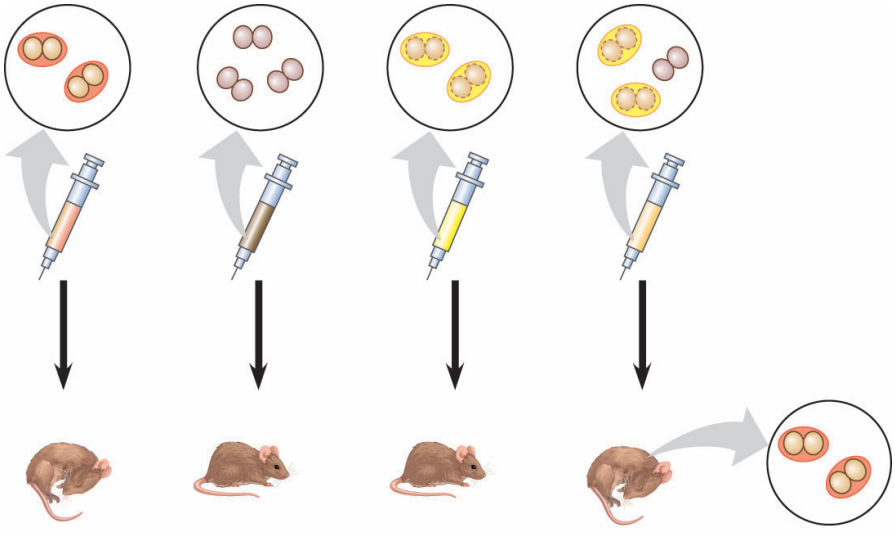
LO 16.1: Describe the structure of DNA and evidence that it is the genetic material.

1. What are the two chemical components of chromosomes?

2. Why did researchers originally think that protein was the genetic material?

3. Distinguish between the virulent and nonvirulent strains of *Streptococcus pneumoniae* studied by Frederick Griffith.

4. Use this figure to summarize the experiment in which Griffith became aware that hereditary information could be transmitted between two organisms in an unusual manner.



5. Define *transformation.*

6. What did Oswald Avery, McCarty, and MacLeod determine to be the *transforming factor*

7. Sketch a *T2 bacteriophage* and label its *head, tail sheath, tail fiber,* and *DNA*.

8. How does a bacteriophage destroy a bacterial cell? Look ahead to Chapter 19, Figure 19.5 in your text, to explain this.

9. How did Hershey and Chase "label" viral DNA and viral protein so that they could be distinguished? Explain why they chose each radioactive tag considering the chemical composition of DNA and protein.

10. Describe the means by which Hershey and Chase established that only the DNA of a phage enters an *E. coli* cell. What conclusions did these scientists draw based on these observations?

11. What are *Chargaff's rules*? How did he arrive at them? Go to the Scientific Skills Exercise on p. 318 and apply these rules to fill in the numbers missing in the chart.

Source of DNA	Base Percentage			
	Adenine	Guanine	Cytosine	Thymine
Sea urchin				
Salmon				
Wheat				
E. coli				
Human				
Ox				

12. List the three components of a nucleotide.

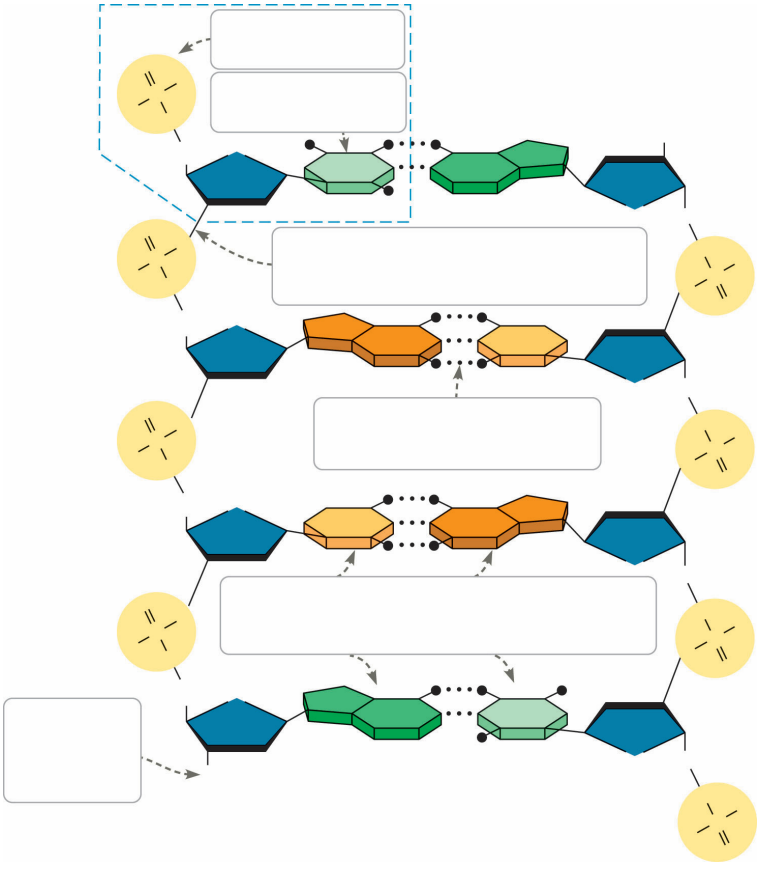
13. Who are the two men who built the first molecular model of DNA and shared the 1962 Nobel Prize for the discovery of its structure?

14. What was Rosalind Franklin's role in the discovery of the *double helix*?

15. Distinguish between the structure of *pyrimidines* and *purines*. Explain why adenine bonds only to thymine.

16. How did Watson and Crick's model explain the basis for Chargaff's rules?

17. This figure shows the DNA double helix untwisted so it is easier to see the chemical details. Label the diagram in detail while noting the antiparallel structure of the molecule.



18. Name the five nitrogenous bases and put a checkmark in the correct column for each base. Also indicate if the base is found in DNA, RNA, or both.

Nitrogenous Base	Purine	Pyrimidine	DNA, RNA or Both?

19. What DNA base is complementary to adenine? _____

What DNA base is complementary to guanine? _____

20. Explain what is meant by *5′ and 3′ ends* of the nucleotide. You can find this information in the legend for Figure 16.5 in your text.

21. What do we mean when we say the two strands of DNA are *antiparallel*?

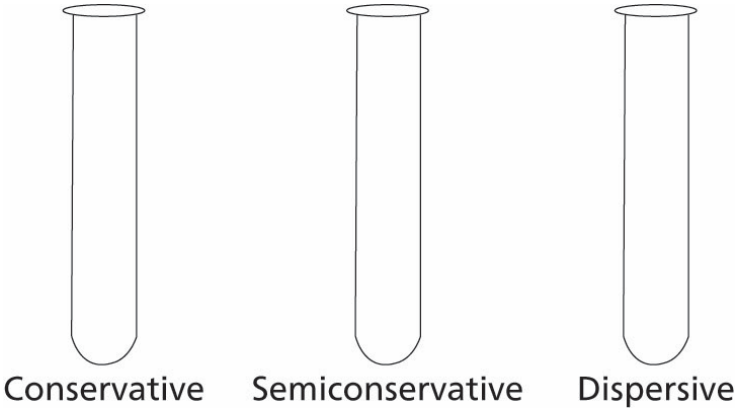
Concept 16.2 Many proteins work together in DNA replication and repair

LO 16.2: Explain how the Meselson-Stahl experiment contributed to our understanding of DNA replication, and describe this process.

22. What is the *semiconservative model of replication*?

23. How did Meselson and Stahl create “heavy” DNA for their experiments?

24. Refer to Figure 16. 11 in your text. Draw and *explain* the three banding patterns Meselson and Stahl predicted might be seen after the second bacterial replication. Which mechanism, conservative, semiconservative, or dispersive matches their data?



25. Define the *origins of replication*.

26. *E. coli* has a single circular chromosome, while eukaryotes have multiple linear chromosomes and much more DNA. How is the replication of eukaryotic DNA speeded up?

27. Distinguish between the *leading* and the *lagging strands* during DNA replication.

28. A new DNA strand can only be synthesized in one direction. Why? What is the direction of synthesis of the new strand?

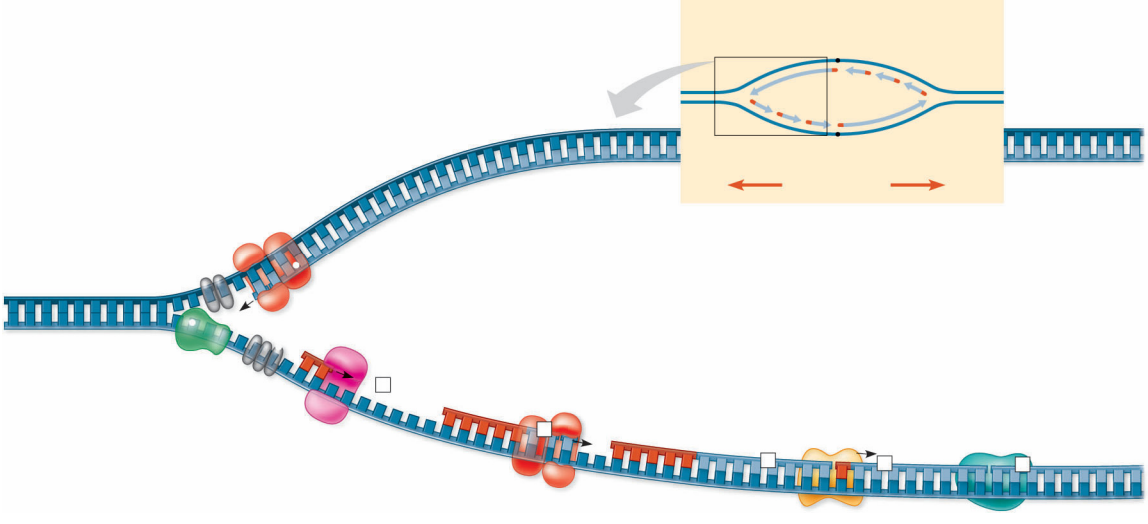
29. What are *Okazaki fragments*? How are they welded together?

30. Which protein does each of the following functions?

Protein	Protein Function
	a. untwists and separates strands
	b. holds DNA strands apart
	c. synthesizes RNA primer
	d. adds DNA nucleotides to new strands
	e. relieves strain caused by unwinding
	f. joins DNA fragments together
	g. removes RNA primer and replaces it with DNA

31. All of the proteins you named above are enzymes *except* _____.

32. Label the following figure. Include *3′* and *5′ strands, RNA primer, primase, SSBP, topoisomerase, helicase, leading strand, lagging strand, DNA pol I, DNA pol III, DNA ligase, parental DNA,* and *new DNA.* Following Figure 16.18 in your text, add the seven notes that explain replication on both the leading and lagging strand.



33. Explain the roles of each of the following enzymes in DNA proofreading and repair.

Enzyme	Role
DNA polymerase	
Nuclease	
Ligase	
Repair enzymes	

34. What is a *thymine dimer*? (See Figure 16.20 in your text.) How might it occur? How is it repaired?

35. What are *telomeres* and what two protective functions do they serve?

36. Explain *telomere erosion* and why it may be related to aging.

37. What types of cells produce *telomerase*? Why is this important?

38. Why are cancer cells able to persist by continuing to divide while most body cells have a limited life span?

Concept 16.3 A chromosome consists of a DNA molecule packed together with proteins

LO 16.3: Distinguish among the levels of chromatin packing in a eukaryotic chromosome.

39. What is a *nucleosome*? Draw and label two nucleosomes including linker DNA.

40. Distinguish between *heterochromatin* and *euchromatin*. How is this important to gene expression?

41. How has our understanding of the arrangement of chromosomes in the nucleus changed from the time when interphase chromosomes were thought to be a tangled mass like a bowl of spaghetti?

Test Your Understanding, p. 333

Now you should be ready to test your knowledge. Place your answers here:

1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____

7. _____ 8. _____