Name_____ **Period**_____

Chapter 16: The Molecular Basis of Inheritance

Concept 16.1 DNA is the genetic material

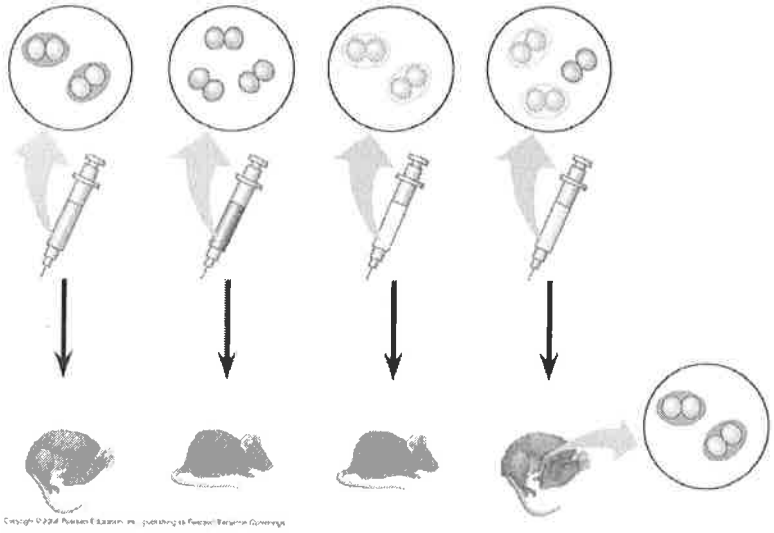
1. What are the two chemical components of chromosomes?

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. What was the purpose of Griffith's studies?

5. 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.



6. Define *transformation.*

7. What did Oswald Avery determine to be the *transforming factor*? _____ Explain his experimental approach.

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

9. How does a bacteriophage destroy a bacterial cell? Look ahead to Chapter 19, Figure 19.5, to explain this.

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

11. 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?

12. What are *Chargaff's rules*? How did he arrive at them?

13. List the three components of a nucleotide.

14. Who built the first model of DNA and shared the 1962 Nobel Prize for discovery of its structure?

15. What was the role of Rosalind Franklin in the discovery of the *double helix*?

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

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

18. Given that the DNA of a certain fly species consists of 27.3% adenine and 22.5% guanine, use Chargaff's rules to deduce the percentages of thymine and cytosine.

19. 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 (D), RNA (R), or both (B).

Nitrogenous Base	**Purine**	**Pyrimidine**	**D, R or B**

20. Explain the base-pairing rule.

21. Describe the structure of DNA relative to each of the following:

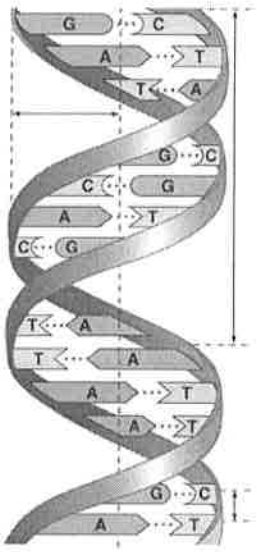
a. distance across molecule _____

b. distance between nucleotides _____

c. distance between turns _____

d. components of the backbone _____

e. components of the "rungs"_____



22. Explain what is meant by 5' and 3' ends of the nucleotide.

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

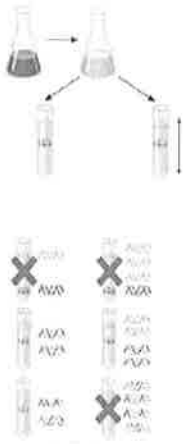
Concept 16.2 Many proteins work together in DNA replication and repair

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

25. Who performed the experiments that elucidated the correct mechanism of DNA replication?

26. How did Meselson and Stahl create "heavy" DNA for their experiments?

27. Use Figure 16.11 to explain how Meselson and Stahl confirmed the semiconservative mechanism of DNA replication.



28. Define the *origins of replication.*

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

30. What is the direction of synthesis of the new strand?

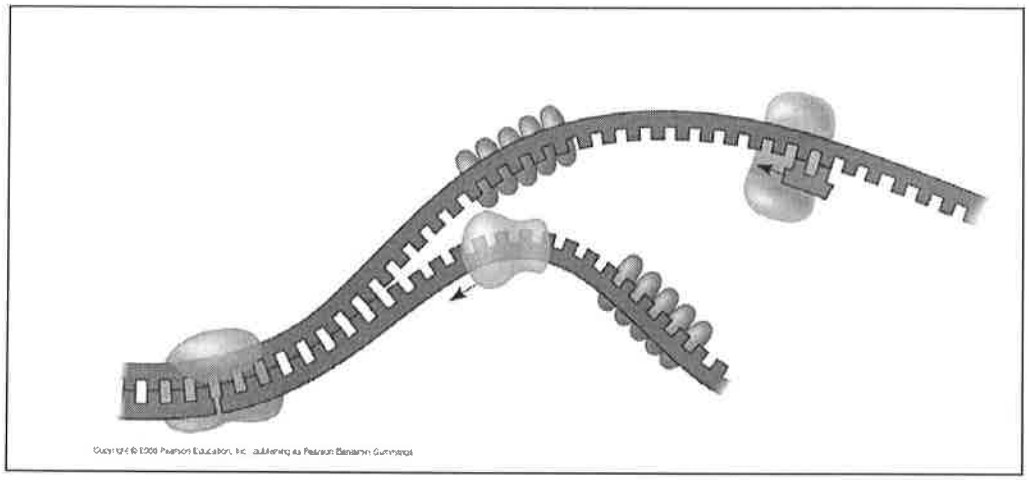
31. What are *Okazaki fragments*? How are they welded together?

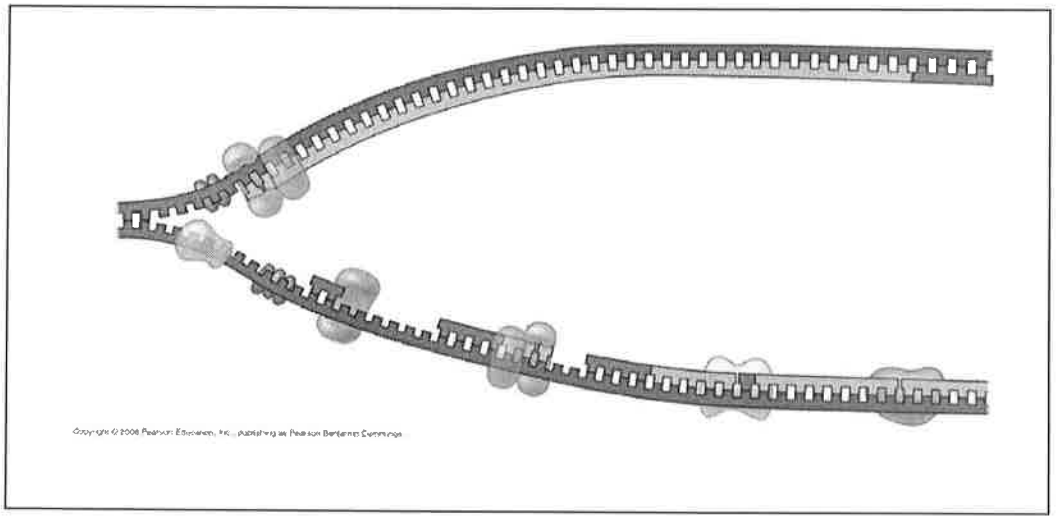
32. Which enzyme . . .?

a. untwists and separates strands	
b. holds DNA strands apart	

c. synthesizes RNA primer	
d. adds DNA nucleotides to new strand	
e. relieves strain caused by unwinding	
f. joins DNA fragments together	
g. removes RNA primer and replaces with DNA	

33. Label the following figures. 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*.





34. *Put it all together!* Make a detailed list of the steps that occur in the synthesis of a new strand.

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

Enzyme	**Role**
DNA polymerase	
Nuclease	
Ligase	
Repair enzymes	

36. What is a *thymine dimer*? How might it occur? How is it repaired?

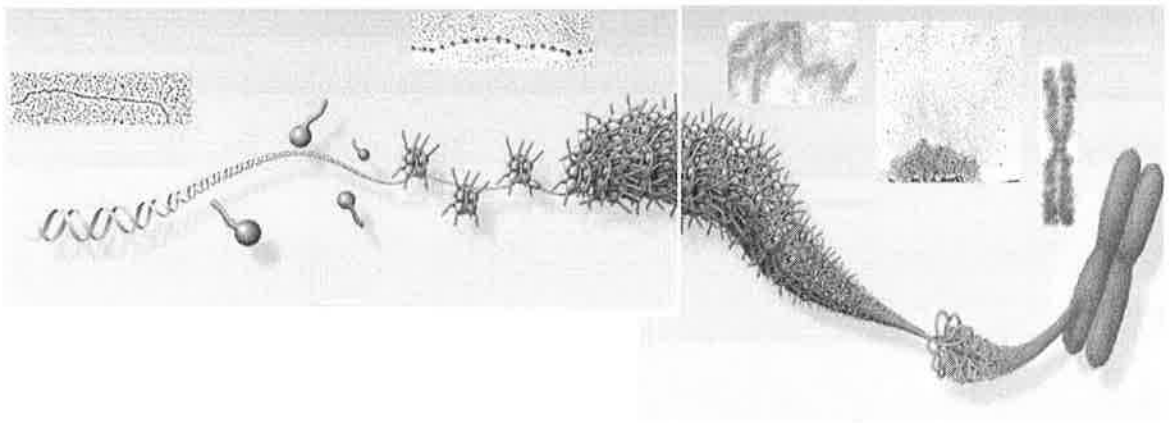
37. Make a sketch of a chromosome and label the *telomeres*.

38. Explain telomere erosion and the role of *telomerase*.

39. Why are cancer cells immortal, but most body cells have a limited life span?

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

40. On the diagrams below, identify the following: *30-nm fiber, metaphase chromosome, double helix, histone proteins, nucleosomes, protein scaffold,* and *looped domains (300-nm fiber).*



41. Distinguish between *heterochromatin* and *euchromatin.*

Testing Your Knowledge: Self-Quiz Answers
Now you should be ready to test your knowledge. Place your answers here:

1._____ 2._____ 3._____ 4._____ 5._____ 6._____ 7._____ 8._____

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

transcription

translation

14. Complete the following table to summarize each process.

	Template	**Product Synthesized**	**Location in Eukaryotic Cell**
Transcription			
Translation			

15. In eukaryotes, what is the *pre-mRNA* called?

16. Write the *central dogma* of molecular genetics, as proclaimed by Francis Crick, in the box below.

17. How many nucleotide bases are there? _____ How many amino acids? _____

18. How many nucleotides are required to code for these 20 amino acids? _____

19. So, the language of DNA is a *triplet code*. How many unique triplets exist? _____

20. 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?

21. 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'

22. How many *codons* are there above? _____ Label one *codon.*

23. Describe Nirenberg's experiment in which he identified the first codon.

24. What was the first codon–amino acid pair to be identified? _____

25. Of the 64 possible codons, how many code for amino acids? _____

26. What event is coded fro by UAA, UAG and UGA? _____

27. What is the *start codon*? _____

28. Why is the genetic code said to be *redundant* but not *ambiguous*?

29. Explain the concept of *reading frame*.

30. Now here is an important idea: **DNA is DNA is DNA**. By this we mean that the code is nearly universal, and because of this, jellyfish genes can be inserted into pigs, or firefly genes can make a tobacco plant glow. Enjoy a look at Figure 17.6 in your text . . . and no question to answer here!

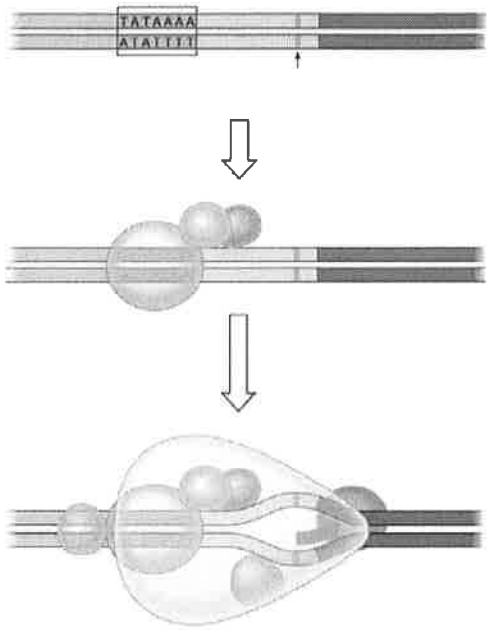
Concept 17.2 Transcription is the DNA-directed synthesis of RNA: A closer look

31. Name the enzyme that uses the DNA template strand to transcribe a new mRNA strand.

32. You will recall from Chapter 16 that *DNA polymerase III* adds new nucleotides to the template DNA strand to assemble each new strand of DNA. Both enzymes can assemble a new polynucleotide only in the 5' → direction. Which enzyme, *DNA polymerase III* or *RNA polymerase*, does not require a primer to begin synthesis?

33. What is a *transcription unit*?

36. Use Figure 17.8 in your text to label the following elements of the figure below: *TATA box, RNA polymerase II, transcription factors, template DNA strand, start point, 5' and 3',* and *mRNA transcript.* To the right of the figure, explain the three stages of initiation that are shown.



37. What is the *TATA* box? How do you think it got this name?

38. What comprises a *transcription initiation complex*?

39. Now it is time to put all of the elements of transcription together. Write an essay below to describe the process by which mRNA is formed. Use these terms correctly in your essay, and underline each one: *TATA box, gene, terminator, promoter, elongation, 5' to 3', termination, initiation RNA, polymerase RNA nucleotides, template, start point, termination signal,* and *transcription factors.* This essay is typical of what you might be asked to write on the AP Biology exam.

Concept 17.3 Eukaryotic cells modify RNA after transcription

40. *RNA processing* occurs only in eukaryotic cells. The primary transcript is altered at both ends, and sections in the middle are removed.

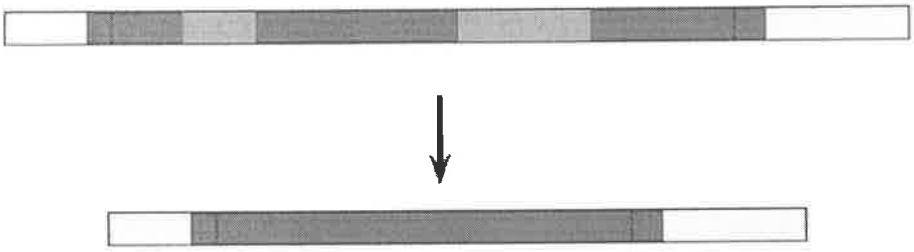
    a. What happens at the 5' end?

    b. What happens at the 3' end?

41. What are three important functions of the *5' cap* and *poly-A tail*?

42. Distinguish between **introns** and **exons**. Perhaps it will help to remember this: *Exons* are *expressed.*

43. On the figure below, label: *pre-mRNA, 5' cap, poly-A tail, introns,* and *exons.*

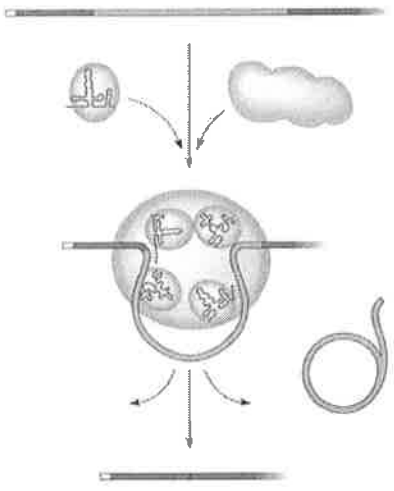


44. What are *snRNPs*? What two types of molecules make up a *snurp*? (We like the word *snurp*! It reminds us of little cartoon characters that wore blue hoods and were called *smurfs*.

45. You will be introduced to a number of *small RNAs* in this course. What type is the RNA in a *snRNP*?

46. *Snurps* band together in little *snurp* groups to form *spliceosomes*. How do spliceosomes work?

47. On the figure below, label the following: *pre-mRNA, snRNPs, snRNA, protein, spliceosomes, intron,* and *other proteins*.



48. Study the figure and text carefully to explain how the splice sites are recognized.

49. What is a *ribozyme*?

50. What commonly held idea was rendered obsolete by the discovery of ribozymes?

51. What are three properties of RNA that allow it to function as an enzyme?

(1)

(2)

(3)

52. What is the consequence of *alternative splicing* of identical mRNA transcripts?

Concept 17.4 Translation is the RNA-directed synthesis of a polypeptide: A closer look

53. You may need to read on in this section in order to answer this question as well as think back to earlier information about mRNA. Come back to this question later if you wish. Three types of RNA are needed for protein synthesis. Complete the chart below.

Type of RNA	Description	Function
mRNA		
tRNA		
rRNA		

54. What is an *anticodon*?

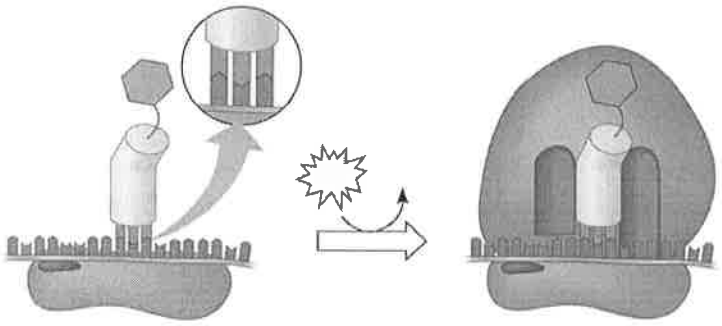
59. Describe the structure of a eukaryotic *ribosome*.

60. How does a prokaryotic ribosome differ from a eukaryotic ribosome? What is the medical significance of this difference?

61. On this figure, label the *large subunit, small subunit, A, P,* and *E sites, mRNA binding site.* To the right of the figure, explain the functions of the A, P, and E sites.

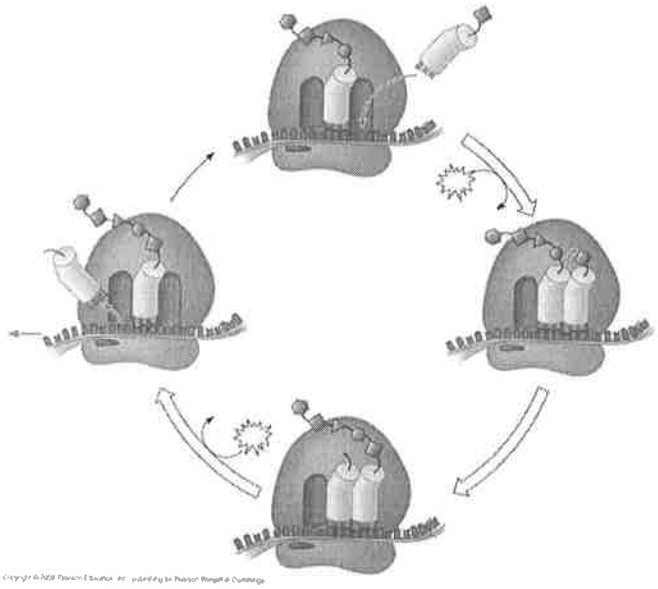
62. Much like transcription, we can divide translation into three stages. List them.

63. Summarize the events of *initiation.* Include these components: *small ribosomal subunit, large ribosomal subunit, mRNA, initiator codon, tRNA, Met, initiation complex, P site,* and *GTP*. The figure below may help you.



64. What is always the first amino acid in the new polypeptide?

65. Now, summarize the events of *elongation*. Include these components: *mRNA, A site, tRNA, codon, anticodon, ribozyme, P site,* and *E site*. Again, the figure may help you.



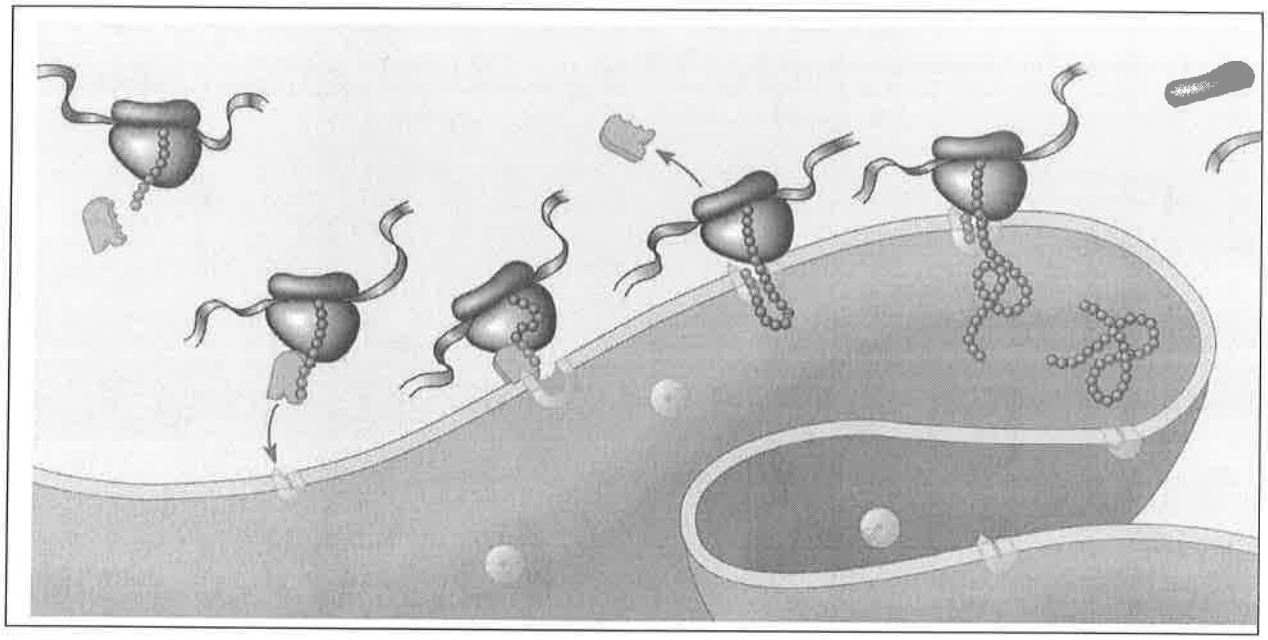
66. What is a *release factor*? By what mechanism is termination accomplished?

67. What is a *polyribosome*?

68. What are some of the things that will result in a final-form functional protein?

69. Describe at least three types of *post-translational modifications*.

70. Use the following figure to explain how proteins are targeted for the ER.



Concept 17.5 Point mutations can affect protein structure and function

71. Define a *mutation* in terms of molecular genetics.

72. Define *point mutations*.

73. What are *frameshift mutations*?

74. Identify two mechanisms by which *frameshifts* may occur.

75. What is the difference between a *nonsense* and *missense mutation*?

76. How can a *base-pair substitution* result in a *silent mutation*?

77. What are the two categories of *mutagens*?

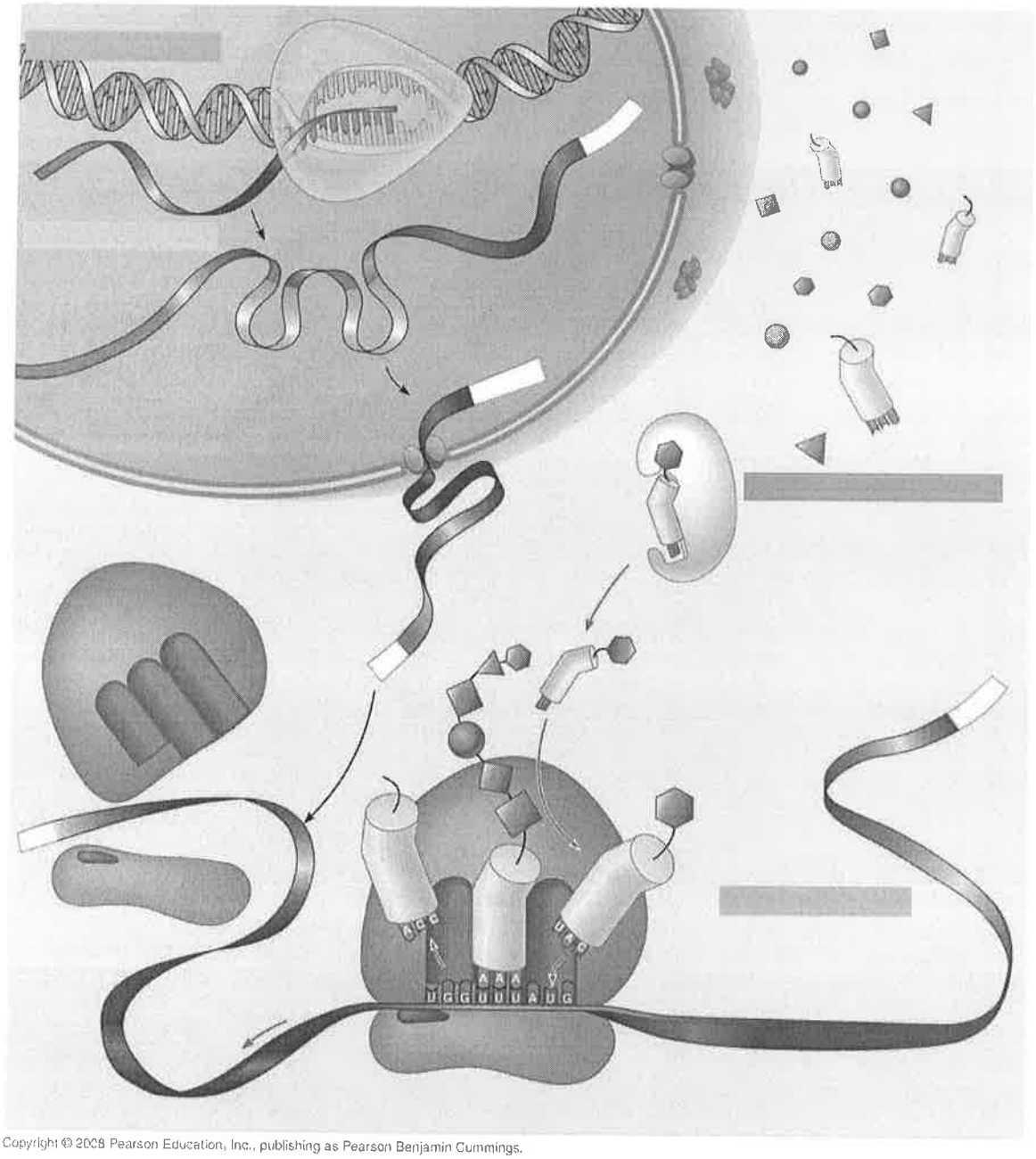
78. Describe the action of difference types of chemical mutagens.

Concept 17.6 Although gene expression differs among the domains of life, the concept of a gene is universal

79. Describe two important ways in which bacterial and eukaryotic gene expression differ.

80. What is a gene? It used to be simply stated that *one gene codes for one polypeptide*. That definition has now been modified. Write below the broader molecular definition in use today.

81. Finally, use this summary figure to put together all that you have learned in this chapter.



Testing Your Knowledge: Self-Quiz Answers
Now you should be ready to test your knowledge. Place your answers here:

1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____

Name_____ **Period**_____

Chapter 18: Regulation of Gene Expression

Overview

The overview for Chapter 18 introduces the idea that while all cells of an organism have all genes in the genome, not all genes are expressed in every cell. What regulates gene expression? Gene expression in prokaryotic cells differs from that in eukaryotic cells. How do disruptions in gene regulation lead to cancer? This chapter gives you a look at how genes are expressed and modulated.

Concept 18.1 Bacteria often respond to environmental change by regulating transcription

1. All genes are not "on" all the time. Using the metabolic needs of *E. coli*, explain why not.

2. What are the two main ways of controlling metabolism in bacterial cells?

3. *Feedback inhibition* is a recurring mechanism throughout biological systems. In the case of *E. coli* regulating tryptophan synthesis, is it *positive* or *negative inhibition*? Explain your choice.

4. What is a *promoter*?

5. What is the *operator*? What does it do?

6. What is an *operon*?

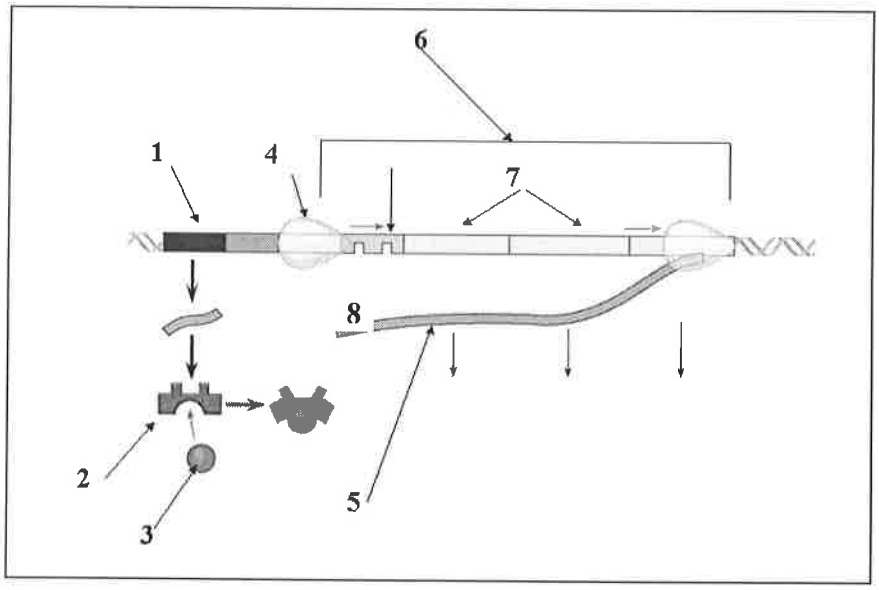
7. List the three components of an *operon*, and explain the role of each one.

8. How does a *repressor* protein work?

9. What are *regulatory genes*?

10. Distinguish between *inducible* and *repressible operons*, and describe one example of each type.

11. Label this sketch of the *lac operon* with the terms at right. Know the function of each structure.



Operon genes

Operon

RNA polymerase

mRNA

Repressor protein

Operator

Repressor

Regulatory gene

Inducer

12. Compare and contrast the *lac* operon and the *trp* operon. (Remember that *compare* means "to tell how they are similar," and *contrast* means "to tell how they are different.")

13. What happens when a repressor is bound to the operator?

14. What is *CAP*? How does *CAP* work?

15. Explain why CAP binding and stimulation of gene expression is *positive regulation.*

16. Describe the relationship between glucose supply, cAMP, and CAP.

17. How can both repressible and inducible operons be *negative regulators*?

Concept 18.2 Eukaryotic gene expression can be regulated at any stage

18. Even though all cells of an organism have the same genes, there is *differential gene expression.* What does this mean?

19. What percentage of the genes of a typical human cell is expressed at any given time?

20. What is the common control point of gene expression for all organisms?

21. Gene expression can be regulated by modifications of the chromatin. Distinguish between *heterochromatin* and *euchromatin* as to their structure and activity.

22. What occurs in *histone acetylation*? How does it affect gene expression?

23. What is *DNA methylation*? What role may it play in gene expression?

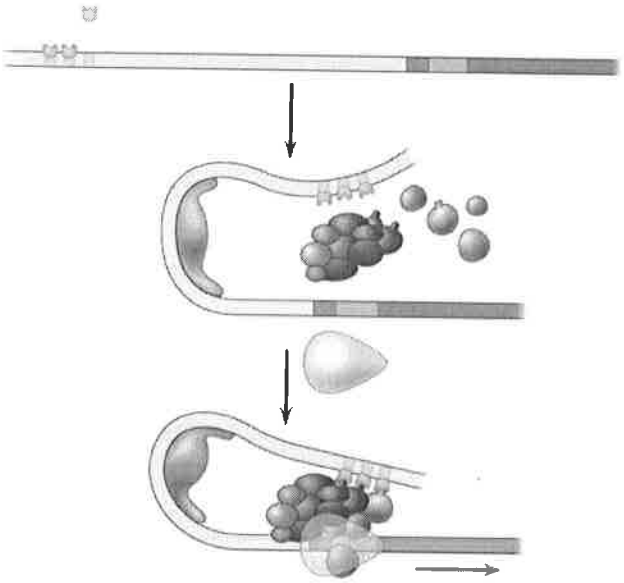
24. The inactive mammalian X chromosome is heavily methylated. What is the result of this methylation?

25. What is *genomic imprinting*, and how is it maintained? Give an example discussed earlier in human genetics.

26. Explain what is meant by *epigenetic inheritance*, and give an example of epigenetic changes discussed in the text or in class.

27. Use the sketch below to explain how enhancers and activators interact with transcription factors to affect gene expression. Label the following elements: *TATA box, promoter, gene, enhancer, activators, transcription factors, transcription initiation complex, RNA polymerase II,* and *DNA.* Then place your explanation to the right of the figure.

EXPLANATION



28. In prokaryotes, functionally related genes are usually clustered in a single operon. What has been found to be the case in eukaryotes?

29. Operons have not been found in eukaryotic cells, and the genes coding for the enzymes of a particular metabolic pathway are often scattered over different chromosomes. What is a plausible mechanism for the *coordination of gene expression*?

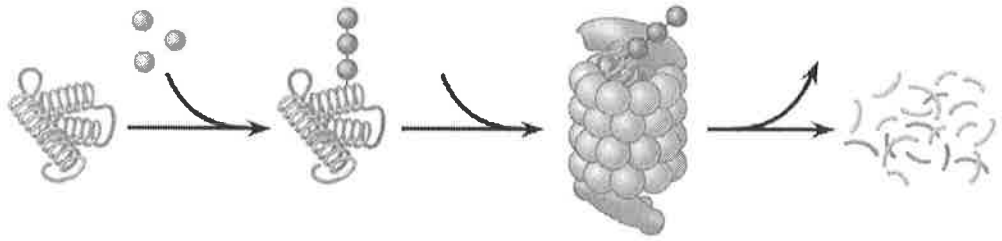
30. How can *alternative RNA splicing* result in different proteins derived from the same initial RNA transcript?

31. *Posttranscriptional control* includes regulation of *mRNA degradation*. Explain how this affects translation.

32. How can proteins be activated, processed, and degraded? Give an example or describe each process.

33. An article in *Scientific American* about *proteasomes* was entitled "Little Chamber of Horrors." Explain how proteins are targeted for degradation, and give a specific example of when this might occur.

34. How do these "little chambers of horrors" function? Annotate the sketch below to describe their action. Then explain their role in regulation of gene expression.

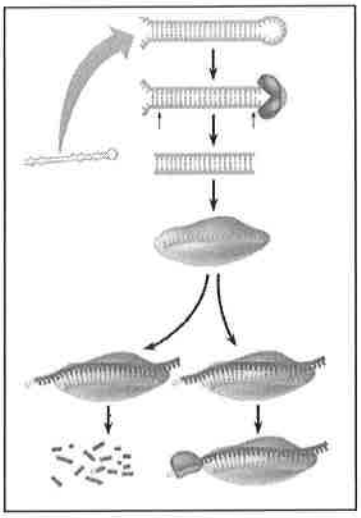


Concept 18.3 Noncoding RNAs play multiple roles in controlling gene expression

35. It is now known that much of the RNA that is transcribed is not translated into protein. these RNAs are called *noncoding RNAs*. Read carefully to discern a crucial role played by these RNAs. What is this role?

36. One of the *noncoding RNAs* that regulate gene expression is *microRNA*. On the sketch below, follow an RNA loop, called a "hairpin," from its creation. Explain the two modes of action of *microRNAs*.

Be sure to label the location of hydrogen bonds and *Dicer*.



Concept 18.4 A program of differential gene expression leads to the different cell types in a multicellular organism

This concept deals with the regulation of gene expression in development. Animal development is also discussed in Chapter 47.

37. What three processes lead to the transformation of a zygote into the organism?

38. Explain what occurs in *cell differentiation* and *morphogenesis*.

39. Differential gene expression results from different activators in different cells. How do different sets of activators come to be present in two cells? Explain how each of these occurs:

    a. distribution of *cytoplasmic determinants*

    b. different *inductive signals*

40. What is meant by *determination*? Explain what this means within an embryonic cell.

41. What process ensures that all the tissues and organs of an organism are in their characteristic places? Where do the molecular cues that control this process arise?

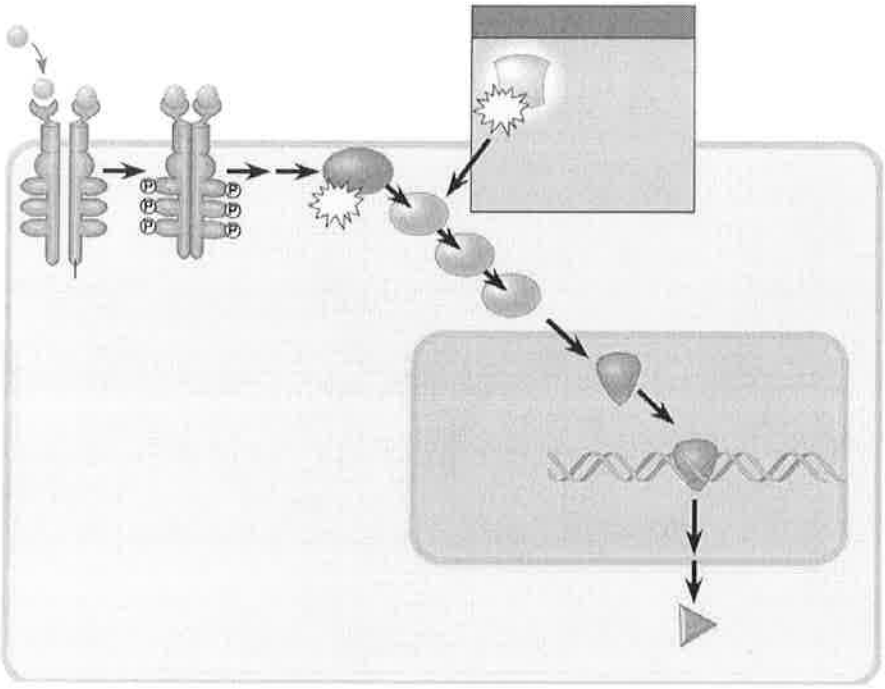
42. What is controlled by *homeotic genes*?

Concept 18.5 Cancer results from genetic changes that affect cell cycle control

43. What mechanism is involved in the beginning of tumor growth? Discuss *oncogenes* and proto-*oncogenes*.

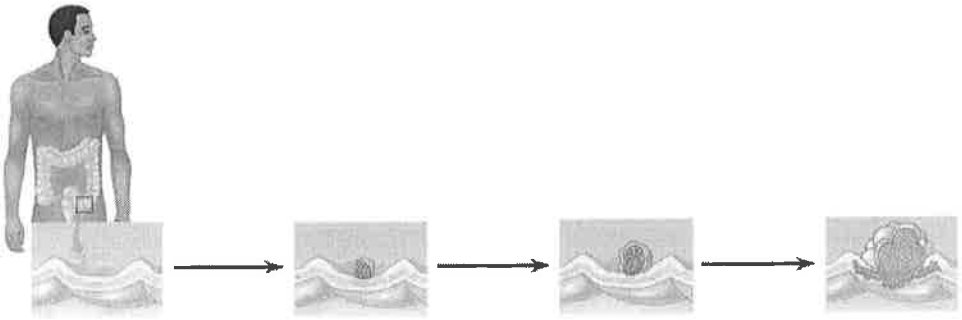
44. What are three mechanisms for converting a proto-oncogene to an oncogene?

45. There seem to be two categories of genes involved in cancer: *oncogenes*, which code for proteins to regulate cell growth, and should not be stuck "on," much like the accelerator in a car; and *tumor-suppressor genes*, which work like the brakes on a car and must function! Let's begin with a look at the *ras gene*, which codes for a G protein and is an *oncogene*. Label the sketch below to explain how a *ras* mutation leads to cancer.



46. *Tumor-suppressor genes* help prevent uncontrolled cell growth. One that is found mutated (and therefore nonfunctional) in more than 50% of human cancer is *p53*. So important is the *p53 gene* that it is sometimes called the "guardian angel of the genome." Describe the double whammy that results from mutation of *p53*.

47. Explain the *multistep model of cancer development* by using the specific example of colorectal cancer. The figure below may be labeled to help in your explanation.



Testing Your Knowledge: Self-Quiz Answers
Now you should be ready to test your knowledge. Place your answers here:

1._____ 2._____ 3._____ 4._____ 5._____ 6._____ 7._____

8._____ 9._____ 10._____