Name: _____

**AP Biology**
*Biology*, **Campbell and Reece, 10th Edition**
Adapted from chapter reading guides originally created by Lynn Miriello

# Unit 6: Molecular Genetics & DNA Technology
## Guided Reading Questions (100 pts total)

**Chapter 16** – The Molecular Basis of Inheritance

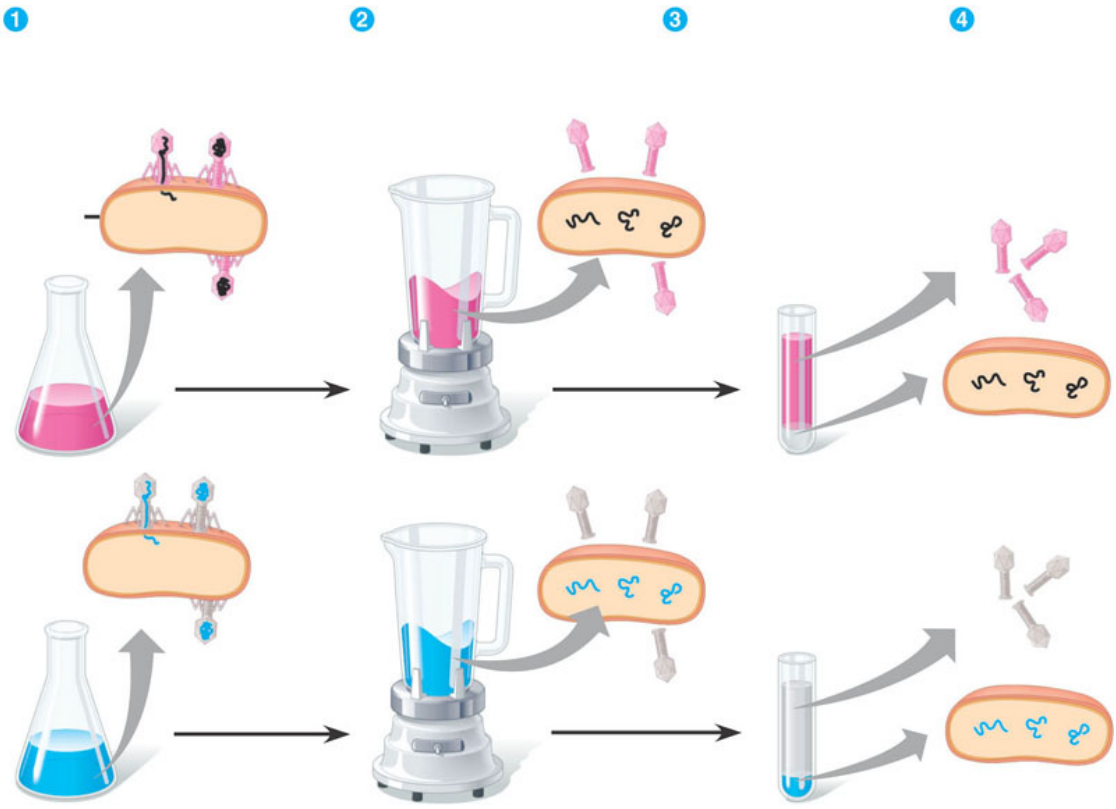
**Concept 16.1** – DNA is the genetic material.

1. Describe Griffith's experiment and the concept of transformation (Figure 16.2).

2. What did Avery, MacLeod, and McCarty contribute to this line of investigation?

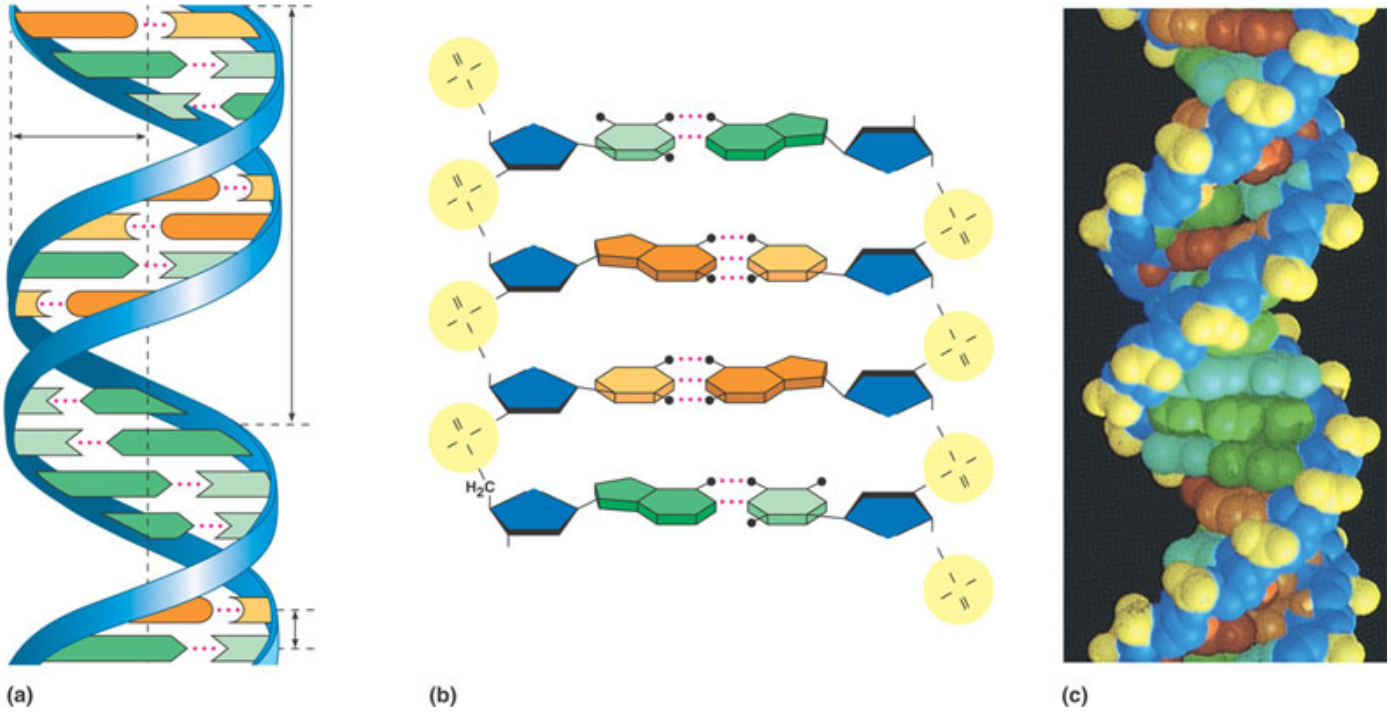
3. What is a bacteriophage? (Figure 16.3)

4. Label the diagram below to describe the Hershey and Chase experiment (Figure 16.4).



5. Why was Rosalind's Franklin's work essential to the understanding of the structure of DNA?

6. Label the diagram below and answer the question that follows (Figure 16.7):




**Question:** Based on your understanding of the diagram above, what is meant by the phrase – "DNA is antiparallel in arrangement"?

7. What causes adenine to always pair with thymine and guanine with cytosine in DNA?

**Concept 16.2** – Many proteins work together in DNA replication and repair.

8. What was the significance of the famous Meselson and Stahl experiment? (Figure 16.11)

9. What does it mean to say that DNA replication is “semiconservative?”

10. Define the following terms:

a. origin of replication –

b. replication fork –

c. primer –

d. leading strand –

e. lagging strand –

f. Okazaki fragments –

g. helicase –

h. single-strand binding protein –

i. topoisomerase –

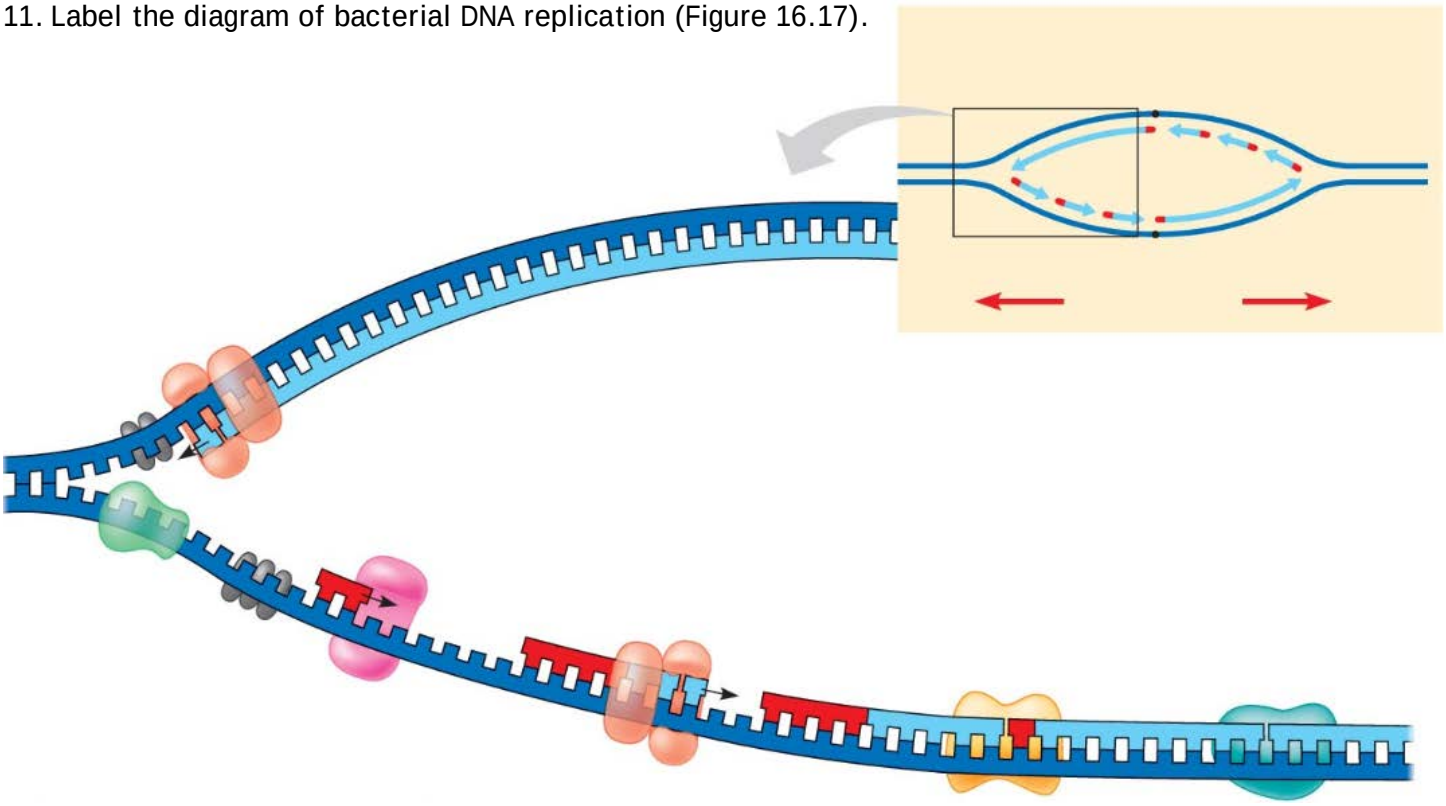
j. primase –

k. DNA polymerase III –

l. DNA polymerase I –

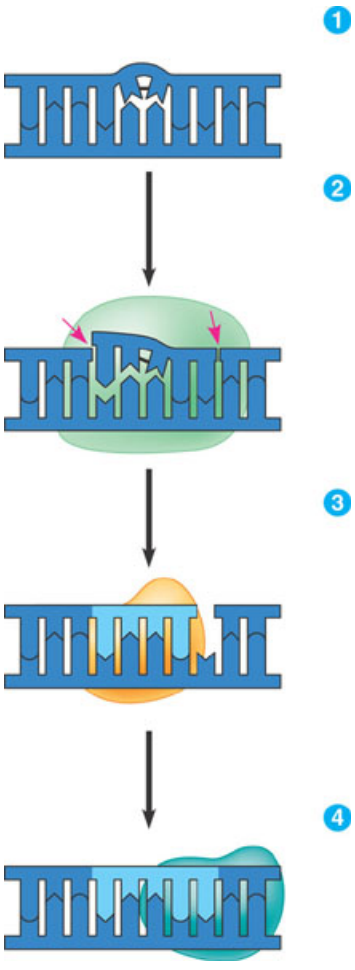
m. DNA ligase -

11. Label the diagram of bacterial DNA replication (Figure 16.17).



12. Label the diagram and answer the question (Figure 16.19).

**Question:** What is the function of the enzymes pictured here?



13. What are telomeres and why are they important? What role does the enzyme telomerase play?

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

14. What two properties distinguish the structure and function of heterochromatin from euchromatin?

**AP Biology Exam Checkpoint:**

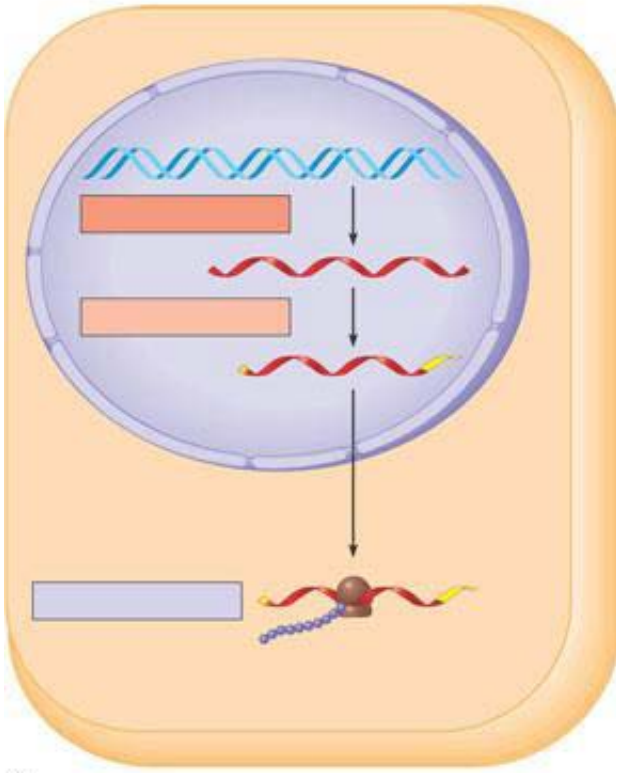
_____ 15. The spontaneous loss of amino groups from adenine results in hypoxanthine, an unnatural base, opposite thymine in DNA. What combination of molecules could repair such damage?

A. nuclease, telomerase, primase
B. telomerase, primase, DNA polymerase
C. nuclease, DNA polymerase, DNA ligase
D. telomerase, helicase, single-strand binding protein

**Chapter 17** – Gene Expression: From Gene to Protein

**Concept 17.1** – Genes specify proteins via transcription and translation.

1. Study the bottom part of Figure 17.3 to note the flow of genetic information in a eukaryotic cell. **Completely label the diagram** with the appropriate terms and provide a definition for each term.



**Terms and Definitions:**

2. Why must the "code of life" exist in triplets and not singles or doubles?

3. Use Figure 17.5 to translate this DNA template strand into a sequence of amino acids.

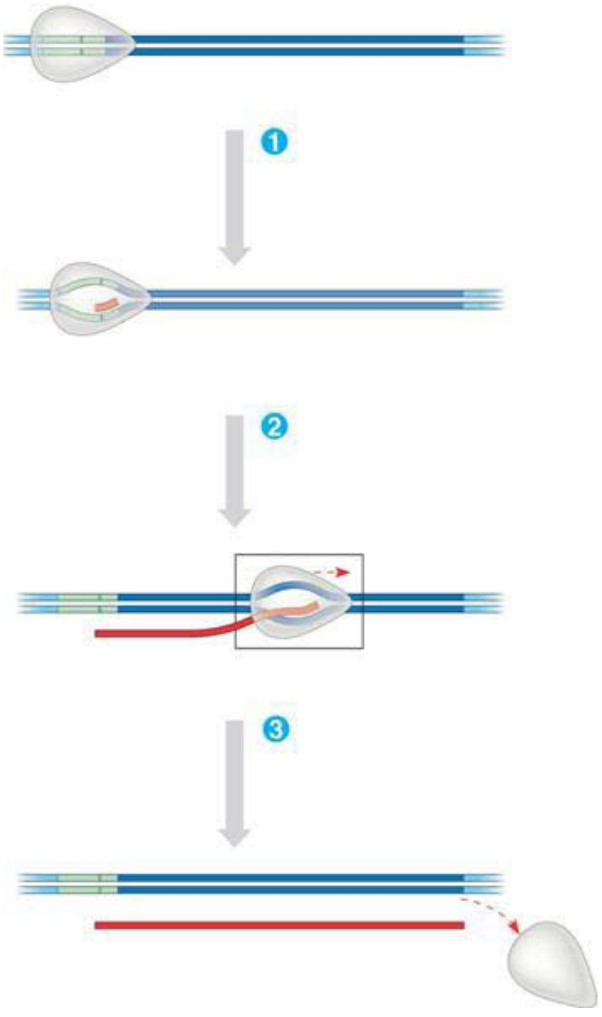

**Amino Acid Sequence:**

4. What does the phrase "reading frame" refer to?

5. What conclusion can be drawn from the alarming similarities of the genetic code among living organisms?

**Concept 17.2** – Transcription is the DNA-directed synthesis of RNA.

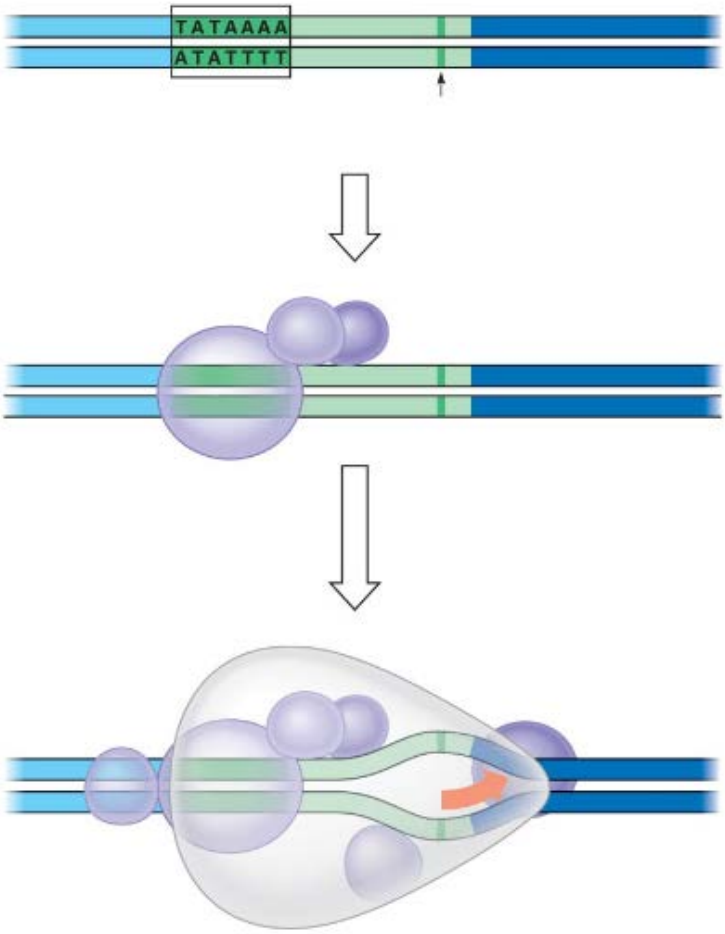
6. Using Figure 17.7, write a summary of transcription. Define all terms used to label the diagram.




**Explanation:**

**Terms and Definitions:**

7. Use Figure 17.8 to demonstrate initiation of transcription at a eukaryotic promoter. Write the definition of each term used to label the diagram.




**Terms and Definitions:**

8. Contrast termination of transcription for prokaryotic versus eukaryotic organisms.

9. Suppose X-rays caused a sequence change in the TATA box of a particular gene's promoter. How would that affect transcription of the gene?

**Concept 17.3** – Eukaryotic cells modify RNA after transcription.

10. Why is RNA processing necessary?

11. Define the following terms:

a. RNA splicing –

b. introns –

c. exons –

d. spliceosome –

e. ribozymes –

f. alternative RNA splicing –

g. domains -

**Concept 17.4** – Translation is the RNA-directed synthesis of a polypeptide.

12. Describe the structure and function of transfer RNA (tRNA).

13. Describe the structure and function of ribosomal RNA (rRNA).

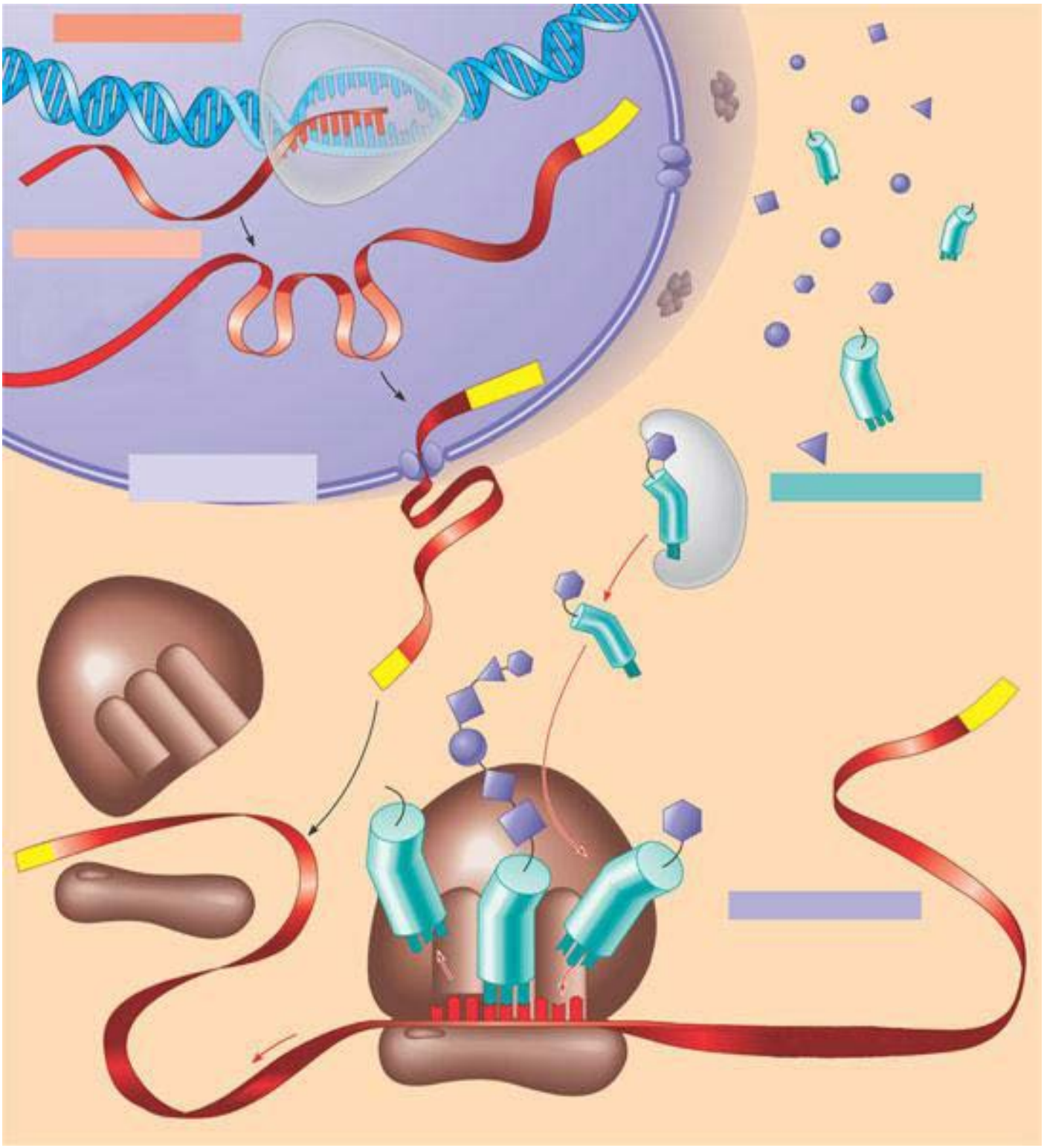
14. Summarize the steps of the initiation of translation (Figure 17.18).

15. Summarize the steps of the elongation cycle of translation (Figure 17.19).

16. Summarize the steps of the termination of translation (Figure 17.20).

17. Describe how a polypeptide to be secreted reaches the endomembrane system (Figure 17.21).

18. Use the figure below to help you reflect on the "whole" picture of going from gene to protein to YOU! See if you can label the empty boxes with the correct terms without using the textbook or referring to previous questions in this reading guide.



**Concept 17.5** – Mutations of one or a few nucleotides can affect protein structure and function.

19. Define the following terms:

a. mutation –

b. point mutation –

c. nucleotide-pair substitution –

d. silent mutation –

e. missense mutation –

f. nonsense mutation –

g. insertion –

h. deletion –

i. frameshift mutation –

j. mutagen –

**AP Biology Exam Checkpoint:**

_____ 20. Which component is not directly involved in translation?
A. DNA
B. tRNA
C. mRNA
D. ribosomes

**Chapter 18** – Regulation of Gene Expression

**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. Define the following terms:

a. operator –

b. operon –

c. repressor –

d. regulatory gene –

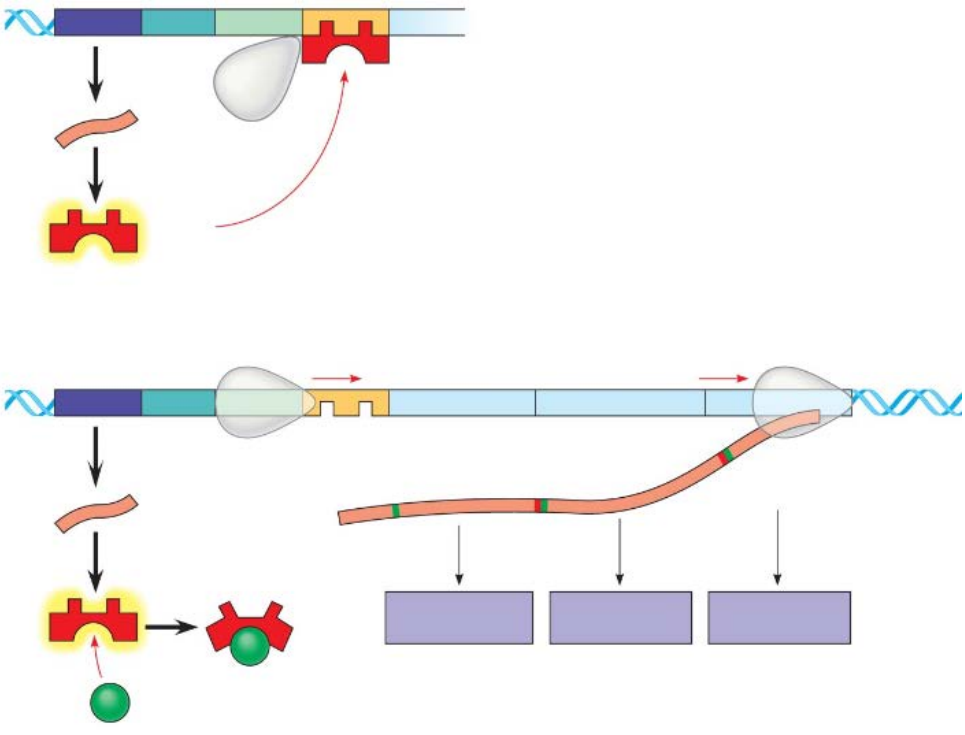
e. corepressor –

f. inducer –

g. activator -

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

6. Label this diagram 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

7. Contrast the *lac* operon with the *trp* operon.

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

**Concept 18.2** - Eukaryotic gene expression can be regulated at many stages.

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

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

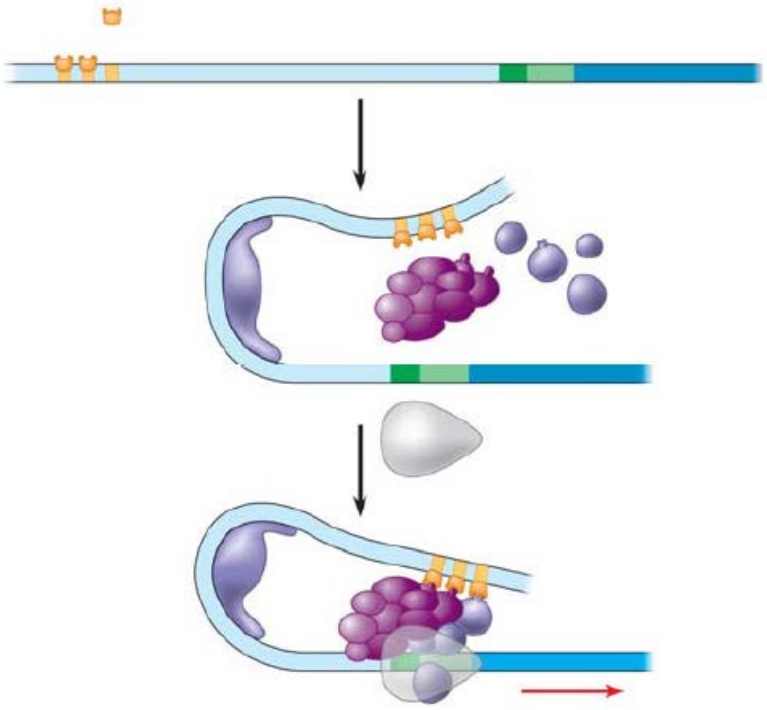
11. What occurs in histone acetylation? How does it affect gene expression?

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

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

14. Use the sketch below to explain how enhancers and activators interact with transcription factors to affect gene expression (Figure 18.10).

    Label the following elements: TATA box, promoter, gene, enhancer, activators, transcription factors, transcription initiation complex, RNA polymerase II, and DNA. Then write an explanation to the right of the figure.



**Explanation:**

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

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

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

**Concept 18.3** - Noncoding RNAs play multiple roles in controlling gene expression.

18. 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?

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

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

20. Explain what occurs in cell differentiation and morphogenesis.

21. What are the two sources of information that instruct a cell to express genes at the appropriate time?

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

23. What is controlled by homeotic genes?

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

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

**AP Biology Exam Checkpoint:**

_____ 25. Which of the following IS NOT a mechanism for converting a proto-oncogene to an oncogene?
A. a point mutation in the promoter of the proto-oncogene
B. a deletion mutation that completely eliminates the proto-oncogene
C. a translocated proto-oncogene ending up near an especially active promoter
D. an increase in the number of copies of the proto-oncogene due to gene duplication

**Chapter 19 –** Viruses

**Concept 19.1** – A virus consists of a nucleic acid surrounded by a protein coat.

1. What are the four forms of viral genomes?

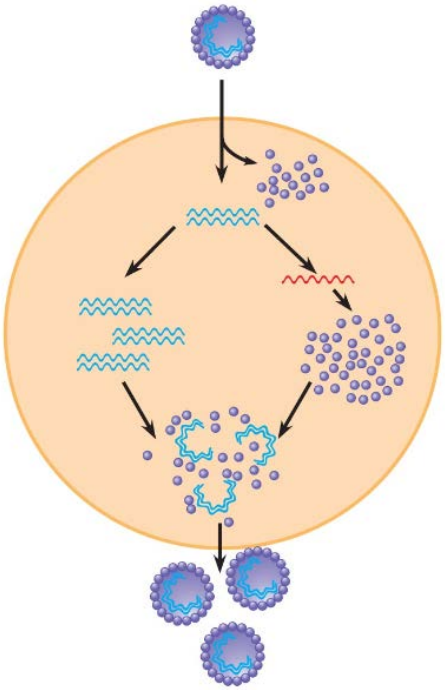
2. What is the role of an envelope in animal viruses?

**Concept 19.2** - Viruses replicate only in host cells.

3. What is meant by host range? Distinguish between a virus with a broad host range and one with an extremely limited host range, and give an example of each.

4. What are bacteriophages (phages)?

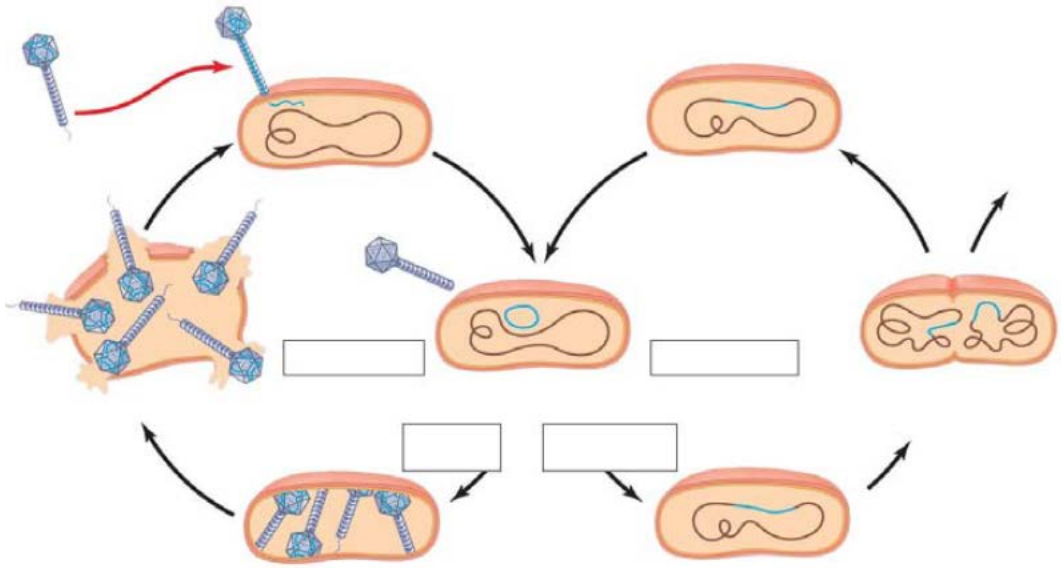
5. Label this figure of a simplified viral reproductive cycle (Figure 19.4). Be sure to label these processes: transcription, translation, infection, replication, and self-assembly.



6. What are restriction enzymes? What is their role in bacteria?

7. Why don't restriction enzymes destroy the DNA of the bacterial cells that produce them?

8. Label the following elements of the figure below: lysogenic phage, lysogenic cycle, lytic cycle, prophage, phage DNA, bacterial chromosome, and self-assembly (See Figure 19.6).



9. What is a prophage? How is this related to a provirus?

10. Distinguish between the lytic and lysogenic modes of bacteriophage reproduction.

11. There are some general differences between bacteriophages and animal viruses. What are two elements that nearly all animal viruses have?

12. What is a retrovirus? How do retroviruses, such as HIV, replicate their genome?

**Concept 19.3** - Viruses, viroids, and prions are formidable pathogens in animals and plants.

13. What is a viroid? What important lesson do they teach? Name one viroid disease.

14. What are prions? How are they transmitted? What do they do?

**AP Biology Exam Checkpoint:**

_____ 15. Cancer cells often have protein receptor molecules on their surfaces that differ from those on normal body cells. Given this fact, how might viruses be used to treat cancer?

A. Viruses sometimes cause cancer. This is a bad idea.
B. Viruses are pathogenic and will infect the host. This treatment will not work.
C. Viruses could be engineered to infect only cancer cells by altering viral surface proteins to recognize only the receptors on cancer cells.
D. Viruses could be used to carry genes exclusively to the normal body cells. These genes could encode proteins that would help destroy the cancer cells.

**Chapter 20** – DNA Tools and Biotechnology

1. It is important to understand the meaning of these three terms to start this chapter.

a. DNA technology –

b. biotechnology –

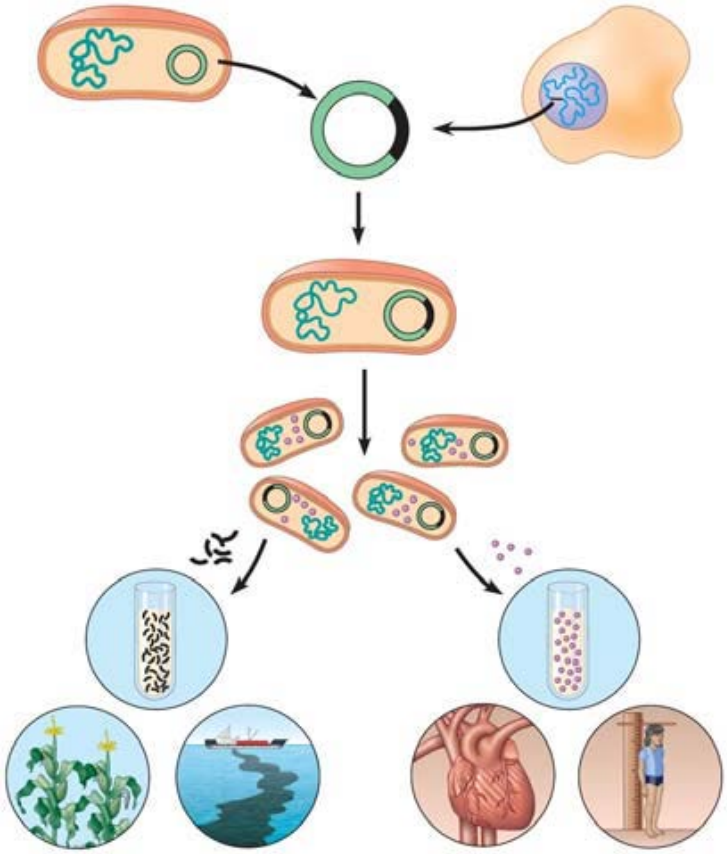
c. genetic engineering -

**Concept 20.1** - DNA cloning yields multiple copies of a gene or other DNA segment.

2. Plasmids are important in biotechnology. Give a full and complete definition of plasmid.

3. What is a cloning vector?

4. Figure 20.5 is a simplified diagram of the gene cloning procedure. Label the major steps illustrated in this diagram.



5. Read the description of restriction enzymes on pages 413-414 carefully. Then study Figure 20.6. When you finish, answer the following question: The restriction enzyme *Hind*III recognizes the sequence 5'-AAGCTT-3', cutting between the two adenine-thymine base pairs. In the space below, draw the double-stranded sequence before and after the enzyme cuts it.

6. The polymerase chain reaction (PCR) is a Nobel Prize–winning idea that is used by scientists to amplify DNA, particularly when the quantity of DNA is very small or contaminated. Explain the three initial steps that occur in one cycle of PCR.

7. What are some potential difficulties in using plasmid vectors and bacterial host cells to produce large quantities of proteins from cloned eukaryotic genes?

**Concept 20.2** – Biologists use DNA technology to study gene expression and function.

8. Study Figure 20.13. Explain how DNA microarrays are used in understanding patterns of gene expression in normal and cancerous tissue.

**Concept 20.4** - The practical applications of DNA-based biotechnology affect our lives in many ways.

9. Explain the idea of gene therapy, and discuss the problems with this technique as demonstrated in the treatment of SCID.

**AP Biology Exam Checkpoint:**

_____ 10. Which of the following tools of DNA technology is INCORRECTLY paired with its use?
A. gel electrophoresis – separation of DNA fragments
B. reverse transcriptase – production of cDNA from mRNA
C. DNA ligase – cutting DNA, creating sticky ends of restriction fragments
D. DNA polymerase – polymerase chain reaction to amplify sections of DNA

**Chapter 21** - Genomes and Their Evolution

**Concept 21.1** – The Human Genome Project fostered development of faster, less expensive sequencing techniques.

1. Craig Venter used an approach to genome sequencing that he termed the whole-genome shotgun approach (Figure 21.2). Explain how this concept can be used to sequence genomes.

**Concept 21.2** - Scientists use bioinformatics to analyze genomes and their functions.

2. What is bioinformatics?

3. How might a human gene microarray chip be of medical importance?

**Concept 21.3** - Genomes vary in size, number of genes, and gene density.

4. What relationship does Chart 21.1 indicate for gene density comparisons between prokaryotes and eukaryotes?

5. What relationship, if any, does a comparison of eukaryotic genomes indicate? Explain your response.

6. How are humans able to successfully compete in nature even though they have about the same number of genes as the nematode *C. elegans*?

**Concept 21.4** - Multicellular eukaryotes have much noncoding DNA and many multigene families.

7. Define the following two terms.

a. pseudogene –

b. repetitive DNA –

c. transposable elements –

d. transposon –

e. retrotransposon –

f. simple sequence DNA –

g. short tandem repeat (STR) –

h. multigene family -

8. What is the significance of the enzyme involved with retrotransposons?

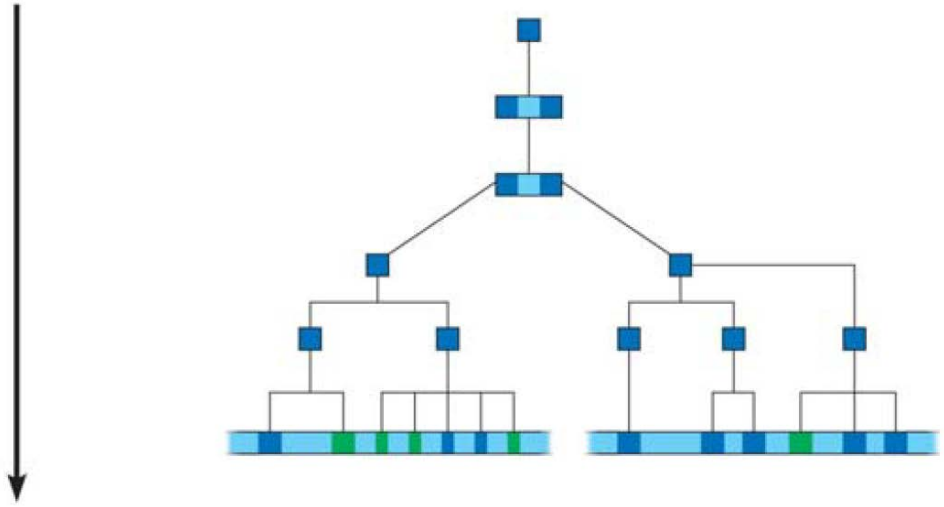
9. Discuss the characteristics of mammalian genomes that make them larger than prokaryotic genomes.

**Concept 21.5** - Duplication, rearrangement, and mutation of DNA contribute to genome evolution.

10. What is the evolutionary significance of the relationship between the genes on human chromosome 16 and those same blocks of genes on mouse chromosomes 7, 8, 16, and 17? (Figure 21.12)

11. Using the concept of a protein domain in your answer, explain why exon shuffling could lead to a novel protein (Figure 21.16).

12. A good summary of several processes involved in genomic evolution can be found in the globin gene families. Label and explain these processes as described in Figure 21.14.



**Concept 21.6** - Comparing genome sequences provides clues to evolution and development.

13. What is evo-devo, and how does it relate to understanding the evolution of genomes?

14. Explain what a homeobox is, and describe how it functions.

**AP Biology Exam Checkpoint:**

_____ 15. Bioinformatics includes all of the following EXCEPT
A. using computer programs to align DNA sequences.
B. developing computer-based tools for genome analysis.
C. using mathematical tools to make sense of biological systems.
D. using DNA technology to combine DNA from two different sources in a test tube.