Name _____ **Period** _____

Chapter 10: Molecular Biology of the Gene

Guided Reading Activities

Big idea: The structure of the genetic material

Answer the following questions as you read modules 10.1–10.3:

1. The study of heredity at the molecular level is called molecular biology.

2. Students are usually surprised to discover that viruses can infect bacteria. What type of virus infects bacteria?
   A bacteriophage

3. Hershey and Chase decided to use radioactively labeled sulfur and phosphorous in their classic experiment. Briefly explain why radioactively labeled carbon would not have worked.
   Because radioactively labeled carbon would have showed up in everything (carbon is the element that the molecules of life are based on)
4. Which of the following is not a component of a nucleotide?

   a. A phosphate group

   b. A pentose (5-carbon sugar)

   c. A nitrogenous base

   d. All of the above are components of a nucleotide.

5. Match the following terms with their proper description: nucleotide, polynucleotide, sugar-phosphate backbone, DNA.

   Contains the nitrogenous base thymine: DNA

   The monomers of nucleic acids: nucleotides

   Formed by covalent bonds between nucleotides: sugar-phosphate backbone

   A polymer of nucleotides: DNA

6. You are a biochemist working for a pharmaceutical company. You have been tasked with identifying a sample of nucleic acid. It is determined that the sample contains the bases cytosine, guanine, adenine, and phosphate groups. Will you be able to determine conclusively whether the sample is RNA or DNA? Briefly explain your answer.
   No, because all of the listed components could be found in a sample of DNA or RNA.

7. A sequence of DNA reads ACTGAGTCA. The next base would have to be

   a. C.

   b. T.

   c. A.

   d. G.

   e. any of those four bases.

8. How were Watson and Crick able to rule out that the bases paired with themselves?
   They were able to rule this out because the X-ray data indicated that a molecule of DNA had a uniform diameter. This would not be possible if the bases paired with themselves.
9. A sample of DNA contains 20% adenine. What percentage of guanine does it contain?
   30%

Big idea: DNA replication

Answer the following questions as you read modules 10.4–10.5:

1. True or false: DNA replication is fully conservative in that you have the original molecule of DNA intact at the end and a brand-new synthesized piece of DNA. If false, make it a correct statement.
   False, DNA replication is semiconservative.

2. You are a molecular biologist working at Johns Hopkins. You are able to create a DNA molecule that was made with radioactively labeled carbon atoms. The radioactively labeled DNA is then allowed to undergo DNA replication using a pool of normal ("unlabeled") nucleotides. Briefly describe the makeup of the two resulting molecules of DNA.
   Each of the new DNA molecules would consist of one radioactively labeled strand and one unlabeled strand.
3. What property of DNA allowed Watson and Crick great insight into the nature of DNA replication?
   Complementary base pairing

4. Complete the following table, which elucidates the components of DNA replication.

	DNA polymerase	DNA ligase	Origin of replication	Replication bubble
Description	Creates DNA by reading a template strand and adding nucleotides with complementary bases	Bonds the DNA fragments of the lagging strand together	The site of the start of DNA replication	The site where DNA replication is occurring

5. Because the two strands of DNA run in opposite directions, only one strand is synthesized continuously. The other strand is sometimes referred to as the lagging strand. Briefly explain why this is an appropriate name for this strand of DNA. Refer to Figure 10.5C on page 189 in your textbook to help you.
The lagging strand has to wait for the double helix to unwind enough for the DNA polymerase to attach and add new nucleotides. Overall, this is due to the fact that DNA polymerase can add nucleotides only to the 3′ end of the strand.

Big idea: The flow of genetic information from DNA to RNA to protein

Answer the following questions as you read modules 10.6–10.16:

1. What process links DNA to RNA?
Transcription

2. "Genotype dictates phenotype" is a common saying. Briefly explain what this means.
This means that an organism's genes (genotype) largely determines the physical outcome of the character.
3. A biochemist identifies a new toxin that closes the nuclear pores of a cell's nucleus. What cellular process would be disrupted by this toxin? Which one would not be? Briefly explain your answer either way. Refer to Figure 10.6A on page 190 in your textbook.
Transcription would not be altered because it occurs in the nucleus, whereas translation would be affected because it occurs on a ribosome in the cytosol of the cytoplasm.
4. True or false: The flow of genetic information goes from RNA → DNA → protein. If false, make it a correct statement.
False, it goes from DNA → RNA → protein.

5. Transcription converts the DNA message into an RNA message.

6. How many codons are illustrated in Figure 10.7 on page 191 of your textbook?

   a. 12

   b. 4

   c. 3

   d. 24

7. Every polypeptide chain synthesized from RNA starts with which amino acid?

   a. Arginine

   b. Phenylalanine

   c. Methionine

   d. Leucine

8. The genetic code is often described as being redundant but not ambiguous. Briefly explain what this means.
   It means that most amino acids have multiple codons that specify them, but no codon specifies more than one amino acid.

9. According to the table of the genetic code (refer to Figure 10.8A on page 192 of your textbook), changing the second base of the codon

   a. always changes the amino acid that is encoded.

   b. never changes the amino acid that is encoded.

   c. sometimes changes the amino acid that is encoded.

   d. All of the above are correct.

   e. None of the above is correct.

10. Match the following terms with their proper description: terminator, promoter, RNA polymerase, and elongation.

    The RNA strand grows one amino acid at a time: elongation

    Creates an RNA copy of a gene: RNA polymerase

    A sequence of bases that determines the end of the gene: terminator

    DNA sequence in front of the gene that determines the start of transcription: promoter

11. A mutation has occurred in the promoter sequence of a gene. Briefly explain what effect that mutation will likely have on transcription of the gene.
    The efficiency of RNA polymerase binding may be affected, and thus the rate of transcription for that gene may decrease or transcription may not occur at all.

12. If a strand of DNA has the sequence AAGCTC, transcription will result in _____.

    a. a single RNA strand with the sequence TTCGAG.

    b. a DNA strand with the sequence TTCGAG.

    c. a single RNA strand with the sequence UUCGAG.

    d. a DNA strand with the sequence AAGCTC.

    e. none of the above.

13. RNA splicing removes ___introns___ from the mRNA while keeping the ___exons___.

14. Which of the following processes occurs in the nucleus of a cell?

    a. RNA splicing

    b. Addition of a 5′ cap

    c. Addition of a 3′ tail

    d. All of the above

15. Briefly explain how one gene could produce multiple polypeptides.
    RNA splicing can put the exons back together in different combinations. This can produce many alternate polypeptides.

16. True or false: A codon reads AUA. The anticodon that recognizes it is TAT. If false, make it a correct statement.
    False, it would be UAU because an anticodon is found on tRNA.

17. Match the description to the molecule(s). Each choice will be used only once.

    a. DNA

    b. mRNA

    c. tRNA

    d. More than one of the above

    e. None of the above

Will always have an equal percentage of A and G, and an equal percentage of C and T:
e. None of the above

Has an anticodon and carries an amino acid: c. tRNA

Serves as a messenger for taking genetic information from the nucleus to the cytoplasm:
b. mRNA

Involved in the process of translation: d. More more than one of the above

Partially unzips/unwinds during the process of transcription: a. DNA

18. Complete the following table, which compares the three different kinds of RNA.

	mRNA	tRNA	rRNA
Description	The RNA copy of the DNA message	The RNA that binds to the amino acid and binds to the mRNA; brings each new amino acid to the growing polypeptide	The RNA that is a component of the ribosomal subunits

19. What organelle is directly responsible for protein synthesis?

a. Nucleus

b. Chloroplast

c. Mitochondria

d. Ribosome

20. True or false: The cap and tail are not part of the message used to construct a polypeptide. If false, make it a correct statement.
True

21. List the key steps of initiation.
The mRNA binds to the small ribosomal subunit, initiator tRNA binds to the start codon, and the large ribosomal subunit binds to the small subunit.

22. A ribosome is formed such that it has a P-site but no A-site. Briefly describe how this would affect translation.
This would essentially stop translation because tRNA could not come and sit in the empty A site.

23. List the three steps of elongation in order.
Codon recognition, peptide bond formation, and translocation

24. True or false: The stop codons specify an amino acid. If false, make it a correct statement.
False, the stop codon does not specify an amino acid.

25. A newly discovered toxin is shown to affect ribosomes such that they are no longer able to translocate during protein synthesis. Briefly explain what effect this would have on protein synthesis.
Protein synthesis would get to the stage of elongation and stop because the ribosome could not translocate down the mRNA.

26. Translation converts the information stored in _____ into _____.

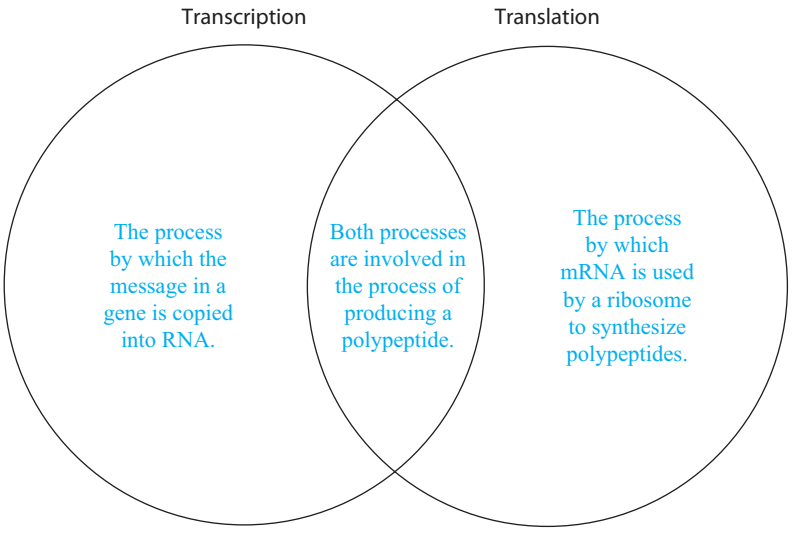
a. DNA; RNA

b. RNA; a polypeptide

c. protein; DNA

d. protein; a polypeptide

27. Complete the Venn diagram that compares transcription to translation.



28. Complete the following table, which compares the different kinds of mutations.

	Silent mutation	Missense mutation	Nonsense mutation	Frameshift mutation
Description	A mutation that does not change the amino acid	A mutation that changes an amino acid	A mutation that changes a codon to a stop codon	A mutation that involves the addition or deletion of a nucleotide that results in a shift in the reading frame

29. Mutation (change) in a gene that altered the original codon to a stop codon would _____.

    a. result in a polypeptide that is one amino acid shorter than the one produced prior to the mutation.

    b. result in a shorter polypeptide chain.

    c. result in an amino acid substitution.

    d. alter the location at which transcription of the next gene begins.

    e. alter the reading frame.

Big idea: The genetics of viruses and bacteria

Answer the following questions as you read modules 10.17–10.23:

1. A(n) ___capsid___ is the protein coat of a virus.

2. Which viral life cycle can be triggered to enter into the other one? What triggers that process?
   The lysogenic cycle can be converted into the lytic cycle. Usually, some kind of external stressor can initiate that process.
3. A human cell has a mutation in a gene, the effect of which is a lack of certain receptor proteins on the surface of the cell. Would a typical enveloped virus be able to infect that cell? Briefly explain your answer.
   The virus would be impeded in entering that particular cell because the virus would have trouble adhering to the cell.
4. List the basic steps in the replication cycle of a typical enveloped RNA virus.
   Entry of the viral genome, uncoating of the protein coat, RNA synthesis by virus, protein and RNA synthesis, and assembly of the new viral components
5. Why do RNA viruses tend to mutate at a fast rate?
   RNA does not have the same proofreading capabilities as DNA.

6. True or false: A retrovirus needs reverse transcriptase to make viral DNA from the host-cell RNA. If false, make it a correct statement.
   False, a retrovirus needs reverse transcriptase to make viral DNA from the viral RNA.

7. How does the flow of genetic information differ in a retrovirus when compared to any cell?
   In a retrovirus the flow is reversed: Instead of DNA → RNA, it's RNA → DNA.

8. Match the following terms with their proper description: reverse transcriptase, viroid, prion, and retrovirus.

   A misfolded protein: ___prion___

   A single circular piece of RNA: ___viroid___

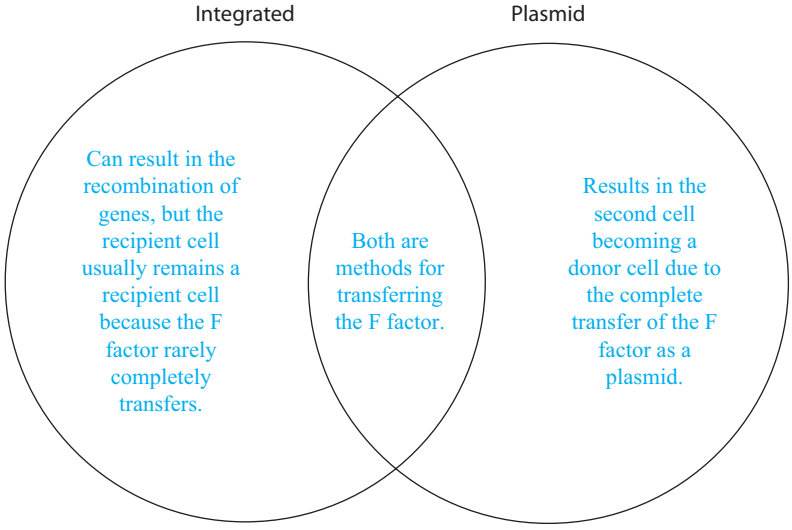
A molecule that makes DNA from RNA: reverse transcriptase

Reverses the flow of genetic information: retrovirus

9. Complete the following table, which compares the mechanisms by which bacteria can transfer DNA.

	Transformation	Transduction	Conjugation
Description	Where a bacterium takes up DNA from its environment	When a bacteria has genes transferred to it from a virus	Where bacteria transfer DNA to each other through conjugation tubes

10. A colony of bacteria is being grown in a liquid medium. A microbiologist adds a chemical that will cause most, but not all, of the bacteria to lyse (split open). Which method of gene transfer is likely to occur at this point? Briefly explain your answer.
Transformation because there will be a large amount of bacterial DNA in the surrounding environment
11. True or false: The F factor can exist as an integrated piece of DNA in the bacterial chromosome or as a plasmid. If false, make it a correct statement.
True
12. Complete the Venn diagram that compares the two mechanisms of transfer for the F factor.



CONNECTING THE BIG IDEAS

Use your knowledge of the information contained within this chapter's "Big Ideas" to answer this question.

Introns vary in number and size from species to species. Prokaryotes do not even have introns in their genes outside of a few genes that code for prokaryotic tRNAs. Propose an explanation as to why prokaryotes don't really have introns and why eukaryotes do have introns.

