Chapter 5

DNA and Genes

Photo credit: Geoff Gallice

End of Chapter Questions

Simple Review Questions

5.1 What Is a Gene?

1. What is a gene?

2. Why do proteins determine many of an organism's traits?

5.2 Chromosomes: Packages of Genetic Information

3. How is DNA packaged into chromosomes?

4. What is the difference between a diploid cell and a haploid cell? What types of cells are haploid?

5.3 The Structure of DNA

5. Why is DNA described as a double helix?

6. How is DNA like a ladder? What are the "sides" of the ladder, and what are the "rungs"?

7. What are the four nucleotides found in DNA? How do they pair?

5.4 How DNA Is Copied

8. How is DNA copied?

9. Is a new molecule of DNA put together using two newly made strands?

5.5 How Proteins Are Built

10. How does RNA differ from DNA?

11. What base-pairing rules are followed in making an RNA transcript from a DNA template?

12. What is a codon?

13. Describe the role of tRNA in translation.

5.6 Genetic Mutations

14. What are the two main causes of genetic mutations?

15. What is a point mutation?

16. What is a frameshift mutation, and what is its effect on a protein?

(CLICK TO CHECK YOUR ANSWERS)

Challenging Review Questions

5.1 What Is a Gene?

17. What is the difference between genotype and phenotype? Is your height part of your genotype or phenotype?

18. How do your genes determine what kinds of chemical reactions occur in your cells?

5.2 Chromosomes: Packages of Genetic Information

19. Is your finger made of diploid cells or haploid cells?

20. Why do some of your cells have only 23 chromosomes rather than 46?

21. What kind of sex chromosomes do you have? Where in your body are sex chromosomes found?

22. Do different types of cells in your body have different genes? If not, what makes them so different from one another?

5.3 The Structure of DNA

23. If you know the nucleotides on one strand of DNA, explain how you can tell what nucleotides are on the other strand of DNA.

24. A DNA nucleotide is made up of a nitrogenous base, a sugar molecule, and a phosphate group. Explain how these three types of molecules form the DNA "ladder."

25. If DNA is made up of nitrogenous bases, sugar molecules, and phosphate groups, why is all the genetic information in a DNA molecule contained in the nitrogenous bases rather than in the sugar molecules or phosphate groups?

5.4 How DNA Is Copied

26. When DNA is copied, why isn't there an "old" molecule and a "new" molecule?

27. Can RNA replicate the way DNA replicates? Why or why not?

5.5 How Proteins Are Built

28. How is transcription similar to DNA replication? How is it different?

29. We compared mRNA processing to editing "aggfr uidosa to be dfjklsdf or rewerwe not to be" to obtain "to be or not to be." In this comparison, is "aggfr" an exon or an intron? Is "not" an exon or an intron?

30. What is the genetic code?

31. Do all codons code for amino acids? If not, what else can a codon code for?

5.6 Genetic Mutations

32. Are point mutations in the first, second, and third positions of a codon equally likely to cause a change in the amino acid sequence of a protein? What type of point mutation is least likely to change the amino acid sequence? Use the genetic code in Table 5.1 to answer these questions.

33. Why is a frameshift mutation more likely to disrupt a protein's function than a point mutation?

34. You are studying two different mutations in a gene that codes for a protein. In the first, a nonsense mutation occurs near the beginning of the gene. In the second, a nonsense mutation occurs near the end of the gene. Which mutation is more likely to disrupt protein function?

35. You are studying two different mutations in a gene that codes for a protein. In one mutation, a single nucleotide is inserted near the beginning of the gene. In the other mutation, three nucleotides are inserted near the beginning of the gene. Which mutation is more likely to disrupt protein function? Why?

(CLICK TO CHECK YOUR ANSWERS)

Apply & Discuss Questions

36. What are the three types of RNA, and what is the function of each type?

37. Your friend Stacie says, "I understand how a point mutation can result in a nonsense mutation, but I don't get how a frameshift mutation can result in a nonsense mutation. Can it?" What do you say? Can you come up with an example of a frameshift mutation that results in a nonsense mutation?

38. "Listen to this," your friend says, reading from a newspaper article. "'Scientists believe that most genetic mutations have no effect on organisms, a small number have a disadvantageous effect, and an even smaller number have an advantageous effect.'" She looks at you. "Do you agree, and if so, why?"

(CLICK TO CHECK YOUR ANSWERS)

End of Chapter Solutions

Simple Review Solutions

1. A gene is a section of DNA that contains the instructions for building a protein.

3. Each chromosome consists of a long DNA molecule wrapped around small proteins called histones.

5. Because DNA is made up of two strands twisted into a spiral or helix, it is called a double helix.

7. The four nucleotides in DNA are adenine (A), guanine (G), cytosine (C), and thymine (T). Adenine always pairs with thymine (A–T), and guanine always pairs with cytosine (G–C).

9. Each new DNA molecule includes one old strand and one new strand.

11. Where DNA has the nucleotides A, C, G, and T, the RNA transcript will have the nucleotides U, G, C, and A respectively.

13. A tRNA molecule includes a sequence of three nucleotides called an anticodon and carries a single, specific amino acid. During translation, the mRNA molecule binds to a ribosome. The codon being translated is positioned at a specific site. A tRNA molecule with the appropriate anticodon binds to the codon. The binding of anticodon to codon follows the usual rules—A binds with U, and G binds with C. The amino acid carried by the tRNA is then added to the growing protein.

15. A point mutation occurs when one nucleotide is substituted for another, such as when a C becomes a G.

Challenging Review Solutions

17. An organism's genes, found in its DNA, make up its genotype. The traits of an organism make up its phenotype. Your height is one of your traits, so it is part of your phenotype.

19. Your finger is made of diploid cells, like most of your body except for your sex cells.

21. Females are XX, males are XY. Sex chromosomes are found in every cell in your body (with the exception of cells that lack nuclei, such as red blood cells).

23. Each nucleotide can best form hydrogen bonds with another specific nucleotide. Because of this, the binding of nucleotides between two strands of DNA occurs in a specific way. Adenine always pairs with thymine (A–T), and guanine always pairs with cytosine (G–C). These base-pairing rules allow the nucleotides of the second strand to be deduced from the nucleotides on the first strand.

25. The sugar molecules and phosphate groups are found in a fixed, constant pattern throughout a single organism's DNA and even from one organism to another. The nitrogenous bases, however, differ and so are able to hold information.

26. Every new DNA molecule has one old strand and one new strand because during DNA replication, the original DNA molecule is unzipped and each strand is used as a template for putting together a new strand.

27. RNA cannot replicate the way DNA replicates—DNA replication relies on the fact that DNA is made up of two complementary strands, so that each can serve as a template for building a new strand. RNA is single-stranded.

29. "aggfr" is an intron that is removed from the mRNA molecule. "not" is an exon that remains in the mRNA molecule.

31. Some codons are stop codons that tell the ribosome there are no more amino acids in the protein being assembled.

33. A frameshift mutation completely changes a protein's amino acid sequence. A point mutation usually changes at most a single amino acid in the protein. For this reason, a frameshift mutation is more likely to disrupt protein function than a point mutation.

35. The insertion of a single nucleotide is more likely to disrupt protein function because it will throw the codon reading frame off—that is, produce a frameshift mutation that drastically affects the amino acid sequence. The insertion of three nucleotides causes the insertion of an extra amino acid, but the rest of the amino acid sequence will not be changed.

Apply & Discuss Solutions

37. A frameshift mutation can result in a nonsense mutation. Suppose mRNA has the sequence CCUAAC. This would code for two amino acids: Proline-Asparagine. Then an insertion between the first two Cs produces the new sequence CC**G**UAAC. The new sequence codes for Proline-STOP. In other words, it results in a nonsense mutation.