Fundamental Molecular Biology, 2nd Edition Instructor Test Bank
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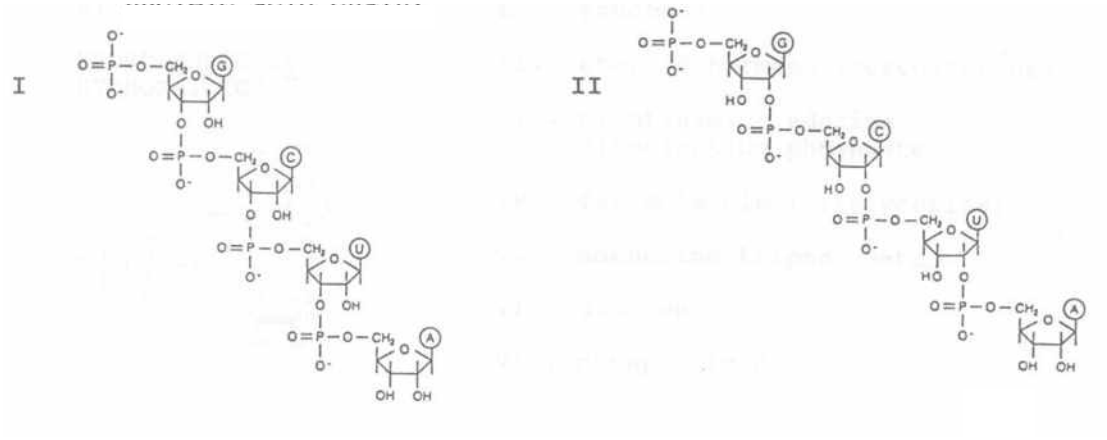
**Chapter 2** The Structure of DNA

**Multiple Choice**

1) Nucleic acids are polymers made up of which of the following monomers?
   A. nucleotides
   B. sugars
   C. amino acids
   D. nitrogenous bases

**Answer: A**

2) Which figure (**I** or **II**) shows the correct structure for a nucleic acid chain?




   A. **I**
   B. **II**

**Answer: A**

3) The phosphodiester linkage between adjacent nucleotides to form a DNA or RNA chain occurs by a _____ reaction involving the removal of _____ and pyrophosphate.
   A. hydrolysis, $H_2O$
   B. hydrolysis, $CO_2$
   C. condensation, $H_2O$
   D. condensation, $CO_2$

**Answer: C**

4) What is the difference between a ribonucleotide and a deoxyribonucleotide?
   A. ribonucleotides contain a phosphate group.
   B. ribonucleotides have a hydroxyl group on the 2′ carbon of their sugar subunit.
   C. ribonucleotides contain a sugar with five carbon atoms.
   D. ribonucleotides have a hydrogen atom on the 1′ carbon of their sugar subunit.

**Answer: B**

5) Which of the following nitrogenous bases is found in RNA, but not DNA?
A. thymine
B. adenine
C. uracil
D. guanine
**Answer: C**

6) Which of the following nitrogenous bases are purines?
A. cytosine and uracil
B. cytosine and thymine
C. cytosine, uracil, and thymine
D. adenine and guanine
**Answer: D**

7) A nucleotide is made up of which of the following subunits?
A. a 5-carbon sugar, a phosphate group, and a nitrogenous base
B. a 5-carbon sugar, a sulfate group, and a nitrogenous base
C. a 5-carbon sugar and a nitrogenous base
D. a 5-carbon sugar, an amino group, and an “R-group”
**Answer: A**

8) What forms the “backbone” of a nucleic acid?
A. a chain of sugar and phosphate groups, linked through phosphodiester bonds
B. purine and pyrimidine pairs, hydrogen-bonded to each other
C. a chain of amino and carboxyl groups, linked via peptide bonds
D. a double helix of antiparallel strands
**Answer: A**

9) By convention, the sequence of bases in a nucleic acid is always written in which direction?
A. amino to carboxyl
B. carboxyl to amino
C. 3′ to 5′
D. 5′ to 3′
**Answer: D**

10) Edwin Chargaff found that the base composition of DNA, defined as the “percent G+C,”
A. differs among species
B. is constant in all cells of an organism within a species
C. is the same among species
D. both A and B
**Answer: D**

11) Which of the following did Watson and Crick know when they were trying to determine the structure of DNA?
A. The number of purines is always larger than the number of pyrimidines.
B. The number of purines is always the same as the number of pyrimidines.
C. The number of cytosines is always the same as the number of adenines.
D. The number of guanines is always the same as the number of thymines.
**Answer: B**

12) The abbreviation dNTP stands for
A. nucleoside 5′-triphosphate.
B. nucleoside 3′-triphosphate.
C. deoxynucleoside 5′-triphosphate.
D. deoxynucleoside 3′-triphosphate.
**Answer: C**

13) In practice, the unit of length used for DNA is the kilobase pair, which corresponds to
A. 10 base pairs
B. 100 base pairs
C. 1000 base pairs
D. 1,000,000 base pairs
**Answer: C**

14) In the two common Watson-Crick base pairs of DNA
A. Adenine (A) is joined to thymine (T) by three hydrogen bonds, while guanine (G) is joined to cytosine (C) by two hydrogen bonds.
B. Adenine (A) is joined to thymine (T) by two hydrogen bonds, while guanine (G) is joined to cytosine (C) by three hydrogen bonds.
C. Adenine (A) is joined to cytosine (C) by three hydrogen bonds, while guanine (G) is joined to thymine (T) by two hydrogen bonds.
D. Adenine (A) is joined to cytosine (C) by two hydrogen bonds, while guanine (G) is joined to thymine (T) by three hydrogen bonds.
**Answer: B**

15) One DNA molecule varies from another by the
A. composition of the sugar-phosphate backbone
B. spacing of the major and minor grooves
C. way in which the bases are attached to the sugars
D. sequence of nitrogenous bases
**Answer: D**

16) The _____ carries a message (the base sequence of DNA) in a form that can be read by DNA-binding proteins; the bases form _____ with the side chains of amino acids of proteins.
A. major groove, hydrogen bonds
B. minor groove, hydrogen bonds
C. major groove, peptide bonds
D. minor groove, peptide bonds
**Answer: A**

17) The predominant form of DNA *in vivo* is
A. A-DNA
B. Z-DNA
C. B-DNA
D. C-DNA
**Answer: C**

18) Which statement about B-DNA is *not true*?
A. B-DNA occurs under conditions of relatively low humidity and relatively low salt.
B. B-DNA forms a right-handed helix.
C. B-DNA has 10.5 bases per turn of the helix.
D. B-DNA has a wide major groove of moderate depth.
**Answer: A**

19) Which statement is *not true* about Z-DNA?
A. Z-DNA forms a left-handed helix
B. Z-DNA is not present in cells
C. Z-DNA may play a role in regulating gene expression
D. At a B-Z junction, one base pair is extruded from the DNA helix
**Answer: B**

20) Watson and Crick noted that DNA's structure is interesting because it suggested a possible copying mechanism. What about DNA's structure facilitates copying?
A. It has the same number of purines and pyrimidines.
B. The nitrogenous bases are located on the *inside* of the double helix.
C. The strands of the double helix are complementary.
D. DNA always goes from 5' to 3'.
**Answer: C**

21) As DNA denatures its absorption of UV light increases, a phenomenon known as:
A. melting
B. reannealing
C. thermal agitation
D. hyperchromicity
**Answer: D**

22) The melting temperature ($T_m$) of DNA is:
A. the temperature at which half the bases in a double-stranded DNA sample have denatured.
B. the temperature at which half the bases in a single-stranded DNA sample have renatured.
C. the temperature at which half the phosphodiester bonds in a double-stranded DNA sample have broken.
D. the temperature at which all the bases in a double-stranded DNA sample have denatured.
**Answer: A**

23) When two strands of DNA from different sources are hybridized in the lab, what provides the chemical stability for holding the two strands of DNA in a double helix structure?
A. hydrophobic interactions (base-stacking) interactions and hydrogen bonds
B. covalent bonds
C. phosphodiester bonds
D. hydrogen bonds only
**Answer: A**

24) Lowering the salt concentration of a DNA solution
A. promotes renaturation.
B. promotes denaturation.
C. promotes formation of hydrogen bonds.

D. removes cations that shield the positive charges on the two strands from each other.
**Answer: B**

25) You determine that a sequence of DNA contains numerous tandem repeats. What unusual DNA secondary structure would this sequence be most likely to form?
A. cruciform
B. triple helix
C. slipped structure
D. tandem helix
**Answer: C**

26) Friedreich's ataxia is a rare inherited neurological disease caused by a
A. trinucleotide repeat expansion in the first intron of the Friedrich's ataxia gene
B. formation of triple helix DNA in the Friedrich's ataxia gene
C. cruciform structures in the frataxin protein
D. both A and B
**Answer: D**

27) A Hoogsteen base pair differs from a Watson-Crick base pair by
A. an altered pattern of hydrogen bonding in the Hoogsteen AT pair
B. the Hoogsteen GC pair only forms two hydrogen bonds
C. Hoogsteen GC pairs are not stable at neutral pH
D. all of the above
**Answer: D**

28) Consider a linear DNA molecule of 20 complete turns (or twists, T=20) with 10.5 base pairs (bp) per turn in solution. If the double helix is underwound by one full turn to the left and then the ends are sealed together, the result is a strained circle with 11.67 bp per turn, where L (linking number) =19 and T=19. If one negative supercoil is spontaneously introduced, the DNA circle will have the following characteristics:
A. L=19, T=20, 11.6 bp/turn
B. L=19, T=20, 10.5 bp/turn
C. L=20, T=20, 10.5 bp/turn
D. L=20, T=20, 11.6 bp/turn
**Answer: B**

29) Topoisomerases are enzymes that
A. relax supercoiled DNA
B. denature double-stranded DNA
C. synthesize a new strand of DNA from a single-stranded DNA template
D. synthesize a strand of DNA from an RNA template
**Answer: A**

30) Which statement is *not true* about DNA supercoiling?
A. Negative supercoiling puts energy into DNA.
B. In bacteriophages, negative supercoiling is associated with decreased activity in replication and transcription.
C. Positive supercoiling occurs ahead of replication forks and transcription complexes.
D. Most DNA within both prokaryotic and eukaryotic cells exists in the negative supercoiled state.
**Answer: B**

31) As genome complexity increases, the time required for reannealing
A. doesn't change
B. increases
C. decreases
D. either B or C depending on the genome
**Answer: B**

32) Supercoiling is a form of DNA
A. primary structure
B. secondary structure
C. tertiary structure
D. quaternary structure
**Answer: C**

33) Most sequence-specific DNA binding proteins interact with
A. the minor groove of Z-DNA
B. the major groove of B-DNA
C. the backbone of A-DNA
D. locally unwound DNA
**Answer: B**

34) DNA loop domains
A. are stabilized by proteins at loop junctions
B. join B-DNA and Z-DNA segments
C. are also known as DNA cruciforms
D. form spontaneously
**Answer: A**

35) The *polarity* of doubled-stranded DNA arises from
A. negative charges on the backbone phosphates
B. the presence of 5' phosphates on one end and 3' hydroxyls on the other
C. base pairing
D. the sequence of bases, which is strand-specific
**Answer: B**

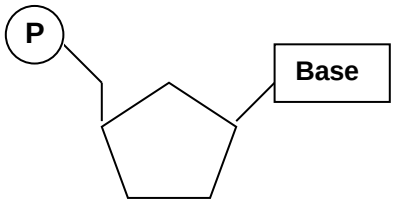
36) DNA-mediated heredity derives from which part of its nucleotide building blocks?
A. the sugars
B. the phosphates
C. the nitrogenous bases
D. none of the above
**Answer: C**

**Short answer/analytical**

37) Distinguish between the terms “nucleoside” and “nucleotide.”
**Answer: Section 2.2, p. 18 and 20**

38) Draw the general structure of a deoxynucleoside monophosphate. Show the sugar structure in detail and indicate the positions of attachment of the base and the phosphate. Also indicate the deoxy position.
**Answer: Section 2.2, Fig. 2.3, p. 20**

39) Starting with the dNTP shown below, draw a clearly labeled diagram showing where the linking bond is between two nucleotides in the same DNA chain. Name the bond. Label the 5′ and 3′ ends of the DNA chain.




**Answer: Section 2.2, Fig. 2.3, p. 20**

40) You have isolated a DNA molecule that is 12,200 base pairs in length. How many kilobase pairs is the DNA molecule?
**Answer: Section 2.2, p. 21**

41) Briefly describe the two main types of interactions that provide chemical stability to the DNA double helix.
**Answer: Section 2.3, p. 22**

42) Which DNA purine forms three H bonds with its partner in the other DNA strand? Which forms two H bonds?
**Answer: Section 2.3, Fig. 2.4, p. 122; Section 2.2, p. 19**

43) Which DNA pyrimidine forms three H bonds with its partner in the other DNA strand? Which forms two H bonds?
**Answer: Section 2.3, Figure 2.4, p. 22; Section 2.2, p. 19**

44) Explain what is meant by the following descriptions of the DNA double helix: “polarity in each strand,” and “the two strands are antiparallel.”
**Answer: Section 2.2, p. 20-21; Section 2.3, p. 25**

45) Which form of DNA is predominant in cells – A, B, or Z DNA? Do other forms ever occur under special circumstances? Explain your answers.
**Answer: Section 2.3, p. 27-28**

46) Use a drawing to illustrate the principles of denaturation, renaturation, and nucleic acid hybridization.
**Answer: Section 2.3, Fig. 2.11, p. 29**

47) Draw a typical DNA denaturation curve. Label the axes and point out the melting temperature ($T_m$). Indicate at what points all of the DNA is double-stranded and all of the DNA is single-stranded.
**Answer: Section 2.3, Fig. 2.12, p. 30**

48) Use a graph to illustrate the relationship between the G + C content of a DNA and its melting temperature. What is the explanation for this relationship?
**Answer: Section 2.3, Figure 2.13, p. 29-30**

49) Use a graph to illustrate the effect of lowering the salt concentration of a solution on the melting temperature ($T_m$) of a DNA sample. What is the explanation for this relationship?
**Answer: Section 2.3, Figure 2.13, p. 29-30**

50) Explain to a patient with Friedreich's ataxia the underlying cause of his disease.
**Answer: Section 2.4, p. 34, Disease Box 2.1**

51) Discuss the significance of DNA supercoiling *in vivo*.
**Answer: Section 2.5, p. 35-36**

52) The DNA duplexes below are denatured and then allowed to reanneal. Which of the two molecules would have the highest $T_m$? Which of the two is least likely to re-form the original structure? Why?

(a) 5′-ATATCATATGATATGTA-3′
3′-TATAGTATACTATACAT-5′

(b) 5′-CGGTACTCGTGCAGGT-3′
3′-GCCATGAGCACGTCCA-5′

**Answer Section 2.3, p. 29; Section 2.4, p. 31-32:** The DNA molecule shown in (b) would have the highest melting temperature ($T_m$) because the sequence is GC-rich. The GC base pair has three hydrogen bonds to every two in an AT base pair. In addition, the base stacking (hydrophobic) interactions of GC base pairs with neighboring base pairs are more favorable energetically than interactions of AT base pairs with their adjacent base pairs. Thus, the higher the GC content in a given molecule of DNA, the higher the temperature required to denature the DNA.

The DNA molecule shown in (a) would be least likely to reform the original structure because it is composed of tandem repeats of "ATAT." These tandem repeats have the potential to form slipped structures, with compensating single-stranded loops in alternate strands.

53) When the base composition of DNA from a grasshopper was determined, 29% of the bases were found to be adenine.
(a) What is the percentage of cytosine?
(b) What is the % composition of each of the four nucleotides in the DNA sequence?
(c) What is the [G] + [C] content?

**Answer:**
**(a)** 21% cytosine
**(b)** 29% adenine, 29% thymine, 21% guanosine, 21% cytosine
**(c)** [G] + [C] content = 42%

**Answer: Section 2.2, p. 19.** The answers were calculated following Chargaff's rules: [A] = [T] and [G] = [C], and [A] + [G] = [T] + [C].
Since the percentage of adenine is 29% and [A] = [T], the percentage of thymine is also 29%, It follows then, that the [A] + [T] content is 29% + 29% = 58%. Accordingly, the [G + C] content must be 100%-58% = 42%. Thus, [C] = 21% and [G] = 21%.

54) Explain why positively supercoiling of genomic DNA might be advantageous for themophilic organisms.

**Answer: Section 2.5, p. 36.** Positive supercoiling makes it more difficult to unwind DNA, because doing do creates further positive supercoiling strain. For an organism that lives at high temperatures, positive supercoils would oppose the effect of heat, which would normally promote DNA melting (i.e., unwinding).

55) Explain how "hydrophobic bonding" stabilizes double-stranded DNA in aqueous solution.

**Answer: Section 2.3, pp. 22-23.** Nitrogenous bases contain nonpolar rings that are hydrophobic. Water tends to exclude these portions of dsDNA, which stack over one other by helical twist, to form a "hydrophobic core" analogous to the hydrophobic cores of proteins or the interior of a lipid bilayer. The hydrophilic sugar-phosphate backbone, on the other hand, freely interacts with water**.**