

## 12.4.E: Nucleic Acids (Exercises)

### 19.1: Nucleotides

#### Concept Review Exercises

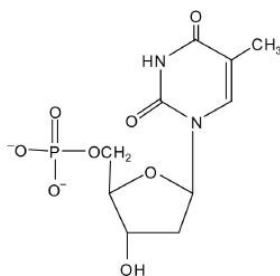
- Identify the three molecules needed to form the nucleotides in each nucleic acid.
  - DNA
  - RNA
- Classify each compound as a pentose sugar, a purine, or a pyrimidine.
  - adenine
  - guanine
  - deoxyribose
  - thymine
  - ribose
  - cytosine

#### Answers

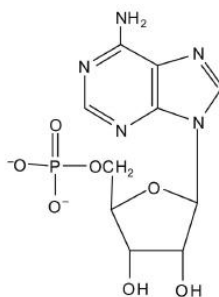
- nitrogenous base (adenine, guanine, cytosine, and thymine), 2-deoxyribose, and  $\text{H}_3\text{PO}_4$
  - nitrogenous base (adenine, guanine, cytosine, and uracil), ribose, and  $\text{H}_3\text{PO}_4$
- purine
  - purine
  - pentose sugar
  - pyrimidine
  - pentose sugar
  - pyrimidine

#### Exercises

- What is the sugar unit in each nucleic acid?
  - RNA
  - DNA
- Identify the major nitrogenous bases in each nucleic acid.
  - DNA
  - RNA
- For each structure, circle the sugar unit and identify the nucleotide as a ribonucleotide or a deoxyribonucleotide.

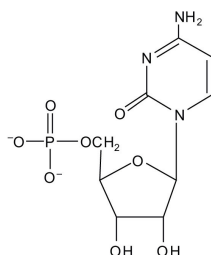


a.

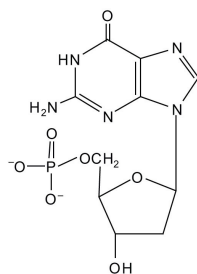


b.

4. For each structure, circle the sugar unit and identify the nucleotide as a ribonucleotide or a deoxyribonucleotide.

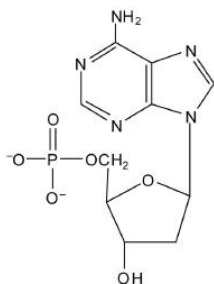


a.

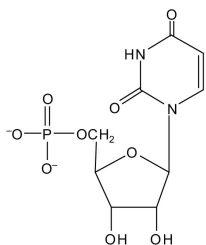


b.

5. For each structure, circle the nitrogenous base and identify it as a purine or pyrimidine.



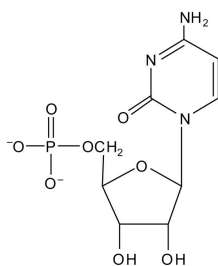
a.



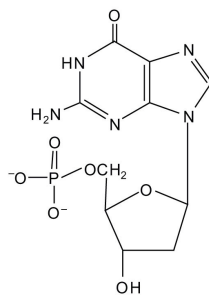
b.

6. For each structure, circle the nitrogenous base and identify it as a purine or pyrimidine.

a.



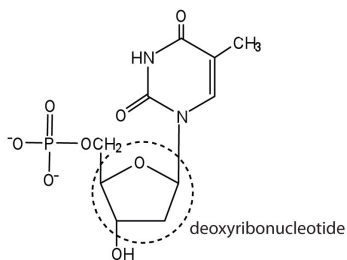
b.



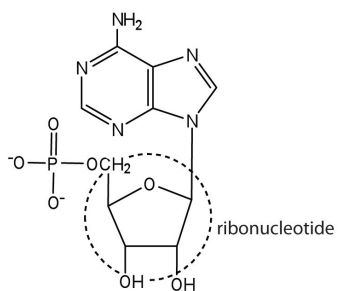
## Answers

1. a. ribose
- b. deoxyribose

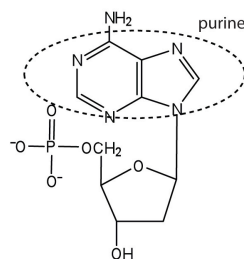
3. a.

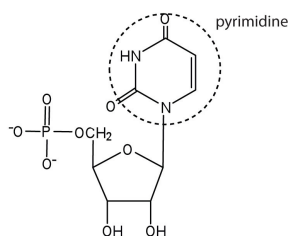


b.



a.





b.

## 19.2: Nucleic Acid Structure

### Concept Review Exercises

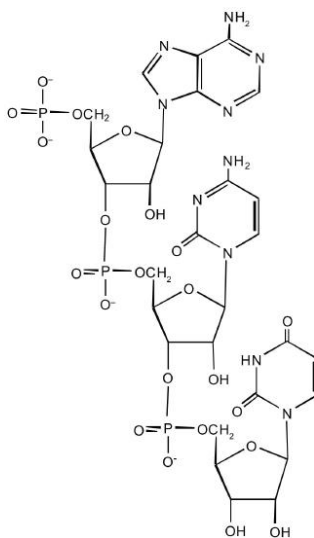
- Name the two kinds of nucleic acids.
  - Which type of nucleic acid stores genetic information in the cell?
- What are complementary bases?
- Why is it structurally important that a purine base always pair with a pyrimidine base in the DNA double helix?

### Answers

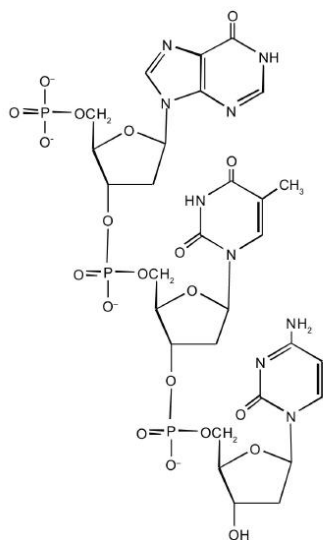
- deoxyribonucleic acid (DNA) and ribonucleic acid (RNA)
  - DNA
- the specific base pairings in the DNA double helix in which guanine is paired with cytosine and adenine is paired with thymine
- The width of the DNA double helix is kept at a constant width, rather than narrowing (if two pyrimidines were across from each other) or widening (if two purines were across from each other).

### Exercises

- For this short RNA segment,
  - identify the 5' end and the 3' end of the molecule.
  - circle the atoms that comprise the backbone of the nucleic acid chain.
  - write the nucleotide sequence of this RNA segment.



- For this short DNA segment,
  - identify the 5' end and the 3' end of the molecule.
  - circle the atoms that comprise the backbone of the nucleic acid chain.
  - write the nucleotide sequence of this DNA segment.

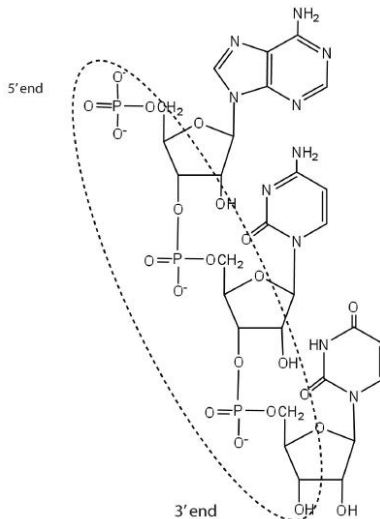


3. Which nitrogenous base in DNA pairs with each nitrogenous base?
  - a. cytosine
  - b. adenine
  - c. guanine
  - d. thymine
4. Which nitrogenous base in RNA pairs with each nitrogenous base?
  - a. cytosine
  - b. adenine
  - c. guanine
  - d. thymine
5. How many hydrogen bonds can form between the two strands in the short DNA segment shown below?
 

5' ATGCGACTA 3' 3' TACGCTGAT 5'
6. How many hydrogen bonds can form between the two strands in the short DNA segment shown below?
 

5' CGATGAGCC 3' 3' GCTACTCGG 5'

## Answers



1.
  - c. ACU

3.
  - a. guanine
  - b. thymine
  - c. cytosine
  - d. adenine
5. 22 (2 between each AT base pair and 3 between each GC base pair)

## 19.3: Replication and Expression of Genetic Information

### Concept Review Exercises

1. In DNA replication, a parent DNA molecule produces two daughter molecules. What is the fate of each strand of the parent DNA double helix?
2. What is the role of DNA in transcription? What is produced in transcription?
3. Which type of RNA contains the codon? Which type of RNA contains the anticodon?

### Answers

1. Each strand of the parent DNA double helix remains associated with the newly synthesized DNA strand.
2. DNA serves as a template for the synthesis of an RNA strand (the product of transcription).
3. codon: mRNA; anticodon: tRNA

### Exercises

1. Describe how replication and transcription are similar.
2. Describe how replication and transcription differ.
3. A portion of the coding strand for a given gene has the sequence 5'-ATGAGCGACTTTGCGGGATTA-3'.
  - a. What is the sequence of complementary template strand?
  - b. What is the sequence of the mRNA that would be produced during transcription from this segment of DNA?
4. A portion of the coding strand for a given gene has the sequence 5'-ATGGCAATCCTCAAACGCTGT-3'.
  - a. What is the sequence of complementary template strand?
  - b. What is the sequence of the mRNA that would be produced during transcription from this segment of DNA?

### Answers

1. Both processes require a template from which a complementary strand is synthesized.
3.
  - a. 3'-TACTCGCTGAAACGCCCTAAT-5'
  - b. 5'-AUGAGCGACUUUGCGGGAUUA-3'

## 19.4: Protein Synthesis and the Genetic Code

### Concept Review Exercises

1. What are the roles of mRNA and tRNA in protein synthesis?
2. What is the initiation codon?
3. What are the termination codons and how are they recognized?

### Answers

1. mRNA provides the code that determines the order of amino acids in the protein; tRNA transports the amino acids to the ribosome to incorporate into the growing protein chain.
2. AUG
3. UAA, UAG, and UGA; they are recognized by special proteins called release factors, which signal the end of the translation process.

## Exercises

- Write the anticodon on tRNA that would pair with each mRNA codon.
  - 5'-UUU-3'
  - 5'-CAU-3'
  - 5'-AGC-3'
  - 5'-CCG-3'
- Write the codon on mRNA that would pair with each tRNA anticodon.
  - 5'-UUG-3'
  - 5'-GAA-3'
  - 5'-UCC-3'
  - 5'-CAC-3'
- The peptide hormone oxytocin contains 9 amino acid units. What is the minimum number of nucleotides needed to code for this peptide?
- Myoglobin, a protein that stores oxygen in muscle cells, has been purified from a number of organisms. The protein from a sperm whale is composed of 153 amino acid units. What is the minimum number of nucleotides that must be present in the mRNA that codes for this protein?
- Use Figure 12.4.E. 3 to identify the amino acids carried by each tRNA molecule in Exercise 1.
- Use Figure 12.4.E. 3 to identify the amino acids carried by each tRNA molecule in Exercise 2.
- Use Figure 12.4.E. 3 to determine the amino acid sequence produced from this mRNA sequence:  
5'-AUGAGCGACUUUGCGGGAUUA-3'.
- Use Figure 12.4.E. 3 to determine the amino acid sequence produced from this mRNA sequence:  
5'-AUGGCAAUCCUCAACGCUGU-3'

## Answers

- 3'-AAA-5'
  - 3'-GUA-5'
  - 3'-UCG-5'
  - 3'-GGC-5'
- 27 nucleotides (3 nucleotides/codon)
- 1a: phenylalanine; 1b: histidine; 1c: serine; 1d: proline
- met-ser-asp-phe-ala-gly-leu

## 19.5: Mutations and Genetic Diseases

### Concept Review Exercises

- What effect can UV radiation have on DNA?
  - Is UV radiation an example of a physical mutagen or a chemical mutagen?
- What causes PKU?
  - How is PKU detected and treated?

## Answers

- It can lead to the formation of a covalent bond between two adjacent thymines on a DNA strand, producing a thymine dimer.
  - physical mutagen
- the absence of the enzyme phenylalanine hydroxylase
  - PKU is diagnosed by assaying a sample of blood or urine for phenylalanine or one of its metabolites; treatment calls for an individual to be placed on a diet containing little or no phenylalanine.

## Exercises

- A portion of the coding strand of a gene was found to have the sequence 5'-ATGAGCGACTTTCGCCCATT-3'. A mutation occurred in the gene, making the sequence 5'-ATGAGCGACCTTCGCCCATT-3'.

- a. Identify the mutation as a substitution, an insertion, or a deletion.
  - b. What effect would the mutation have on the amino acid sequence of the protein obtained from this mutated gene (use Figure 19.14)?
2. A portion of the coding strand of a gene was found to have the sequence 5'-ATGGCAATCCTCAAACGCTGT-3'. A mutation occurred in the gene, making the sequence 5'-ATGGCAATCCTCAACGCTGT-3'.
  - a. Identify the mutation as a substitution, an insertion, or a deletion.
  - b. What effect would the mutation have on the amino acid sequence of the protein obtained from this mutated gene (use Figure 19.14)?
3.
  - a. What is a mutagen?
  - b. Give two examples of mutagens.
4. For each genetic disease, indicate which enzyme is lacking or defective and the characteristic symptoms of the disease.
  - a. PKU
  - b. Tay-Sachs disease

### Answers

1.
  - a. substitution
  - b. Phenylalanine (UUU) would be replaced with leucine (CUU).
3.
  - a. a chemical or physical agent that can cause a mutation
  - b. UV radiation and gamma radiation (answers will vary)

### 19.6: Viruses

#### Questions

1. Describe the general structure of a virus.
2. How does a DNA virus differ from an RNA virus?
3. Why is HIV known as a retrovirus?
4. Describe how a DNA virus invades and destroys a cell.
5.
  - a. Describe how an RNA virus invades and destroys a cell.
  - b. How does this differ from a DNA virus?
6. What HIV enzyme does AZT inhibit?
7. What HIV enzyme does raltegravir inhibit?

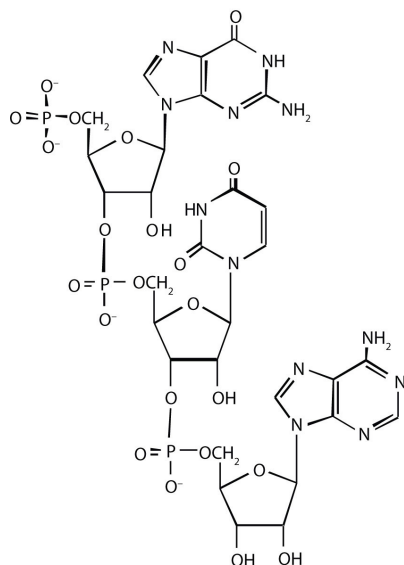
#### Answers

1. A virus consists of a central core of nucleic acid enclosed in a protective shell of proteins. There may be lipid or carbohydrate molecules on the surface.
2. A DNA virus has DNA as its genetic material, while an RNA virus has RNA as its genetic material.
3. In a cell, a retrovirus synthesizes a DNA copy of its RNA genetic material.
4. The DNA virus enters a host cell and induces the cell to replicate the viral DNA and produce viral proteins. These proteins and DNA assemble into new viruses that are released by the host cell, which may die in the process.
5. -
6. reverse transcriptase
7. -

#### Additional Exercises

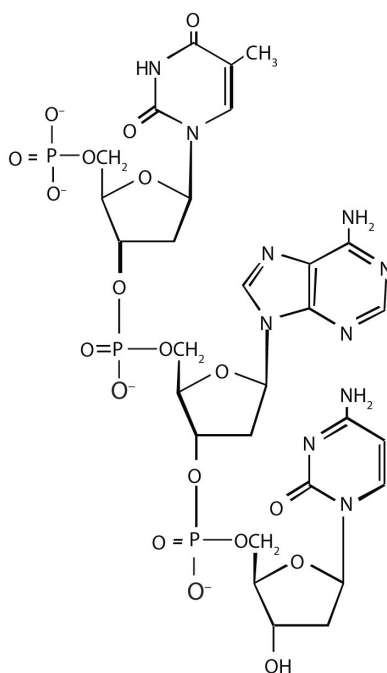
1. For this nucleic acid segment,





- classify this segment as RNA or DNA and justify your choice.
- determine the sequence of this segment, labeling the 5' and 3' ends.

2. For this nucleic acid segment,



- classify this segment as RNA or DNA and justify your choice.
  - determine the sequence of this segment, labeling the 5' and 3' ends.
- One of the key pieces of information that Watson and Crick used in determining the secondary structure of DNA came from experiments done by E. Chargaff, in which he studied the nucleotide composition of DNA from many different species. Chargaff noted that the molar quantity of A was always approximately equal to the molar quantity of T, and the molar quantity of C was always approximately equal to the molar quantity of G. How were Chargaff's results explained by the structural model of DNA proposed by Watson and Crick?
  - Suppose Chargaff (see Exercise 3) had used RNA instead of DNA. Would his results have been the same; that is, would the molar quantity of A approximately equal the molar quantity of T? Explain.
  - In the DNA segment

5'-ATGAGGCATGAGACG-3' (coding strand) 3'-TACTCCGTACTCTGC-5' (template strand)

- What products would be formed from the segment's replication?
- Write the mRNA sequence that would be obtained from the segment's transcription.
- What is the amino acid sequence of the peptide produced from the mRNA in Exercise 5b?

6. In the DNA segment

5'-ATGACGGTTTACTAAGCC-3' (coding strand) 3'-TACTGCCAAATGATTCGG-5' (template strand)

- What products would be formed from the segment's replication?
- Write the mRNA sequence that would be obtained from the segment's transcription.
- What is the amino acid sequence of the peptide produced from the mRNA in Exercise 6b?

7. A hypothetical protein has a molar mass of 23,300 Da. Assume that the average molar mass of an amino acid is 120.

- How many amino acids are present in this hypothetical protein?
- What is the minimum number of codons present in the mRNA that codes for this protein?
- What is the minimum number of nucleotides needed to code for this protein?

8. Bradykinin is a potent peptide hormone composed of nine amino acids that lowers blood pressure.

- The amino acid sequence for bradykinin is arg-pro-pro-gly-phe-ser-pro-phe-arg. Postulate a base sequence in the mRNA that would direct the synthesis of this hormone. Include an initiation codon and a termination codon.
- What is the nucleotide sequence of the DNA that codes for this mRNA?

9. A particular DNA coding segment is ACGTTAGCCCCAGCT.

- Write the sequence of nucleotides in the corresponding mRNA.
- Determine the amino acid sequence formed from the mRNA in Exercise 9a during translation.
- What amino acid sequence results from each of the following mutations?
  - replacement of the underlined guanine by adenine
  - insertion of thymine immediately after the underlined guanine
  - deletion of the underlined guanine

10. A particular DNA coding segment is TACGACGTAACAAGC.

- Write the sequence of nucleotides in the corresponding mRNA.
- Determine the amino acid sequence formed from the mRNA in Exercise 10a during translation.
- What amino acid sequence results from each of the following mutations?
  - replacement of the underlined guanine by adenine
  - replacement of the underlined adenine by thymine

11. Two possible point mutations are the substitution of lysine for leucine *or* the substitution of serine for threonine. Which is likely to be more serious and why?

12. Two possible point mutations are the substitution of valine for leucine *or* the substitution of glutamic acid for histidine. Which is likely to be more serious and why?

## Answers

1.

- RNA; the sugar is ribose, rather than deoxyribose
- 5'-GUA-3'

3. In the DNA structure, because guanine (G) is always paired with cytosine (C) and adenine (A) is always paired with thymine (T), you would expect to have equal amounts of each.

5.

- a. Each strand would be replicated, resulting in two double-stranded segments.
- b. 5'-AUGAGGCAUGAGACG-3'
- c. met-arg-his-glu-thr

7.

- a. 194
- b. 194
- c. 582

9.

- a. 5'-ACGUUAGCCCCAGCU-3'
- b. thr-leu-ala-pro-ala
- c.
  - a. thr-leu-thr-pro-ala
  - b. thr-leu-val-pro-ser
  - c. thr-leu-pro-gin

11. substitution of lysine for leucine because you are changing from an amino acid with a nonpolar side chain to one that has a positively charged side chain; both serine and threonine, on the other hand, have polar side chains containing the OH group.

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