Name _____ Date _____

Molecular structure and duplication of DNA are illustrated. RNA is also constructed and compared to DNA. Students may use this investigation for independent study.

DNA AND RNA

24

Deoxyribonucleic acid (DNA) is a complex molecule found in all living organisms. DNA is the chemical of which genes are composed. An understanding of the organization of this molecule has answered many questions. Scientists now know how chromosomes can duplicate during cell division and transfer their genetic information to new chromosomes. Scientists also understand how chromosomes in the cell nucleus can direct the formation of specific proteins outside the nucleus.

In this investigation, you will

(a) learn the names of the molecules which make up DNA.
(b) use models to construct a molecule of DNA and show how it replicates.
(c) learn the names of the molecules which make up RNA.
(d) use models to show how the base sequence code in DNA is transcribed exactly to RNA.

NOTE: This investigation should be completed before students attempt the tRNA and protein building investigation which follows.

Materials

4 pages of paper models
scissors

Model parts for this investigation are on pages 30T to 32T. Reproduce one copy of each per student.

NOTE: SAVE ALL MODEL PARTS. THEY WILL BE NEEDED FOR INVESTIGATION 25.

Procedure

Part A. Structure of DNA Nucleotides

Two important molecules which make up DNA are deoxyribose and phosphoric acid. Their models and structural formulas are shown in Figure 24-1.

1. Give the molecular formula for

(a) deoxyribose C_H_O_

(b) phosphoric acid H_P_O_

Deoxyribose is a carbohydrate. Phosphoric acid was studied previously as a molecule in ATP.

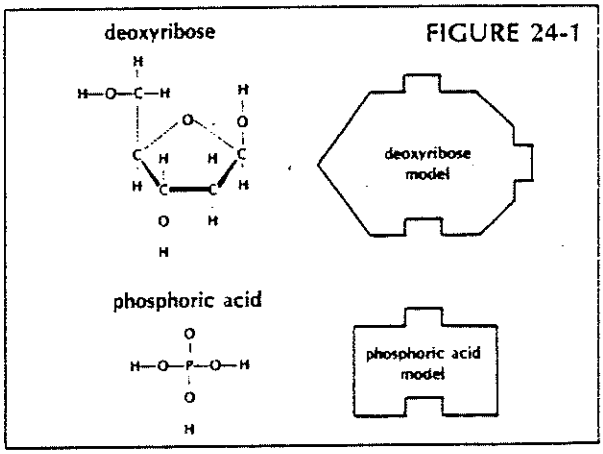
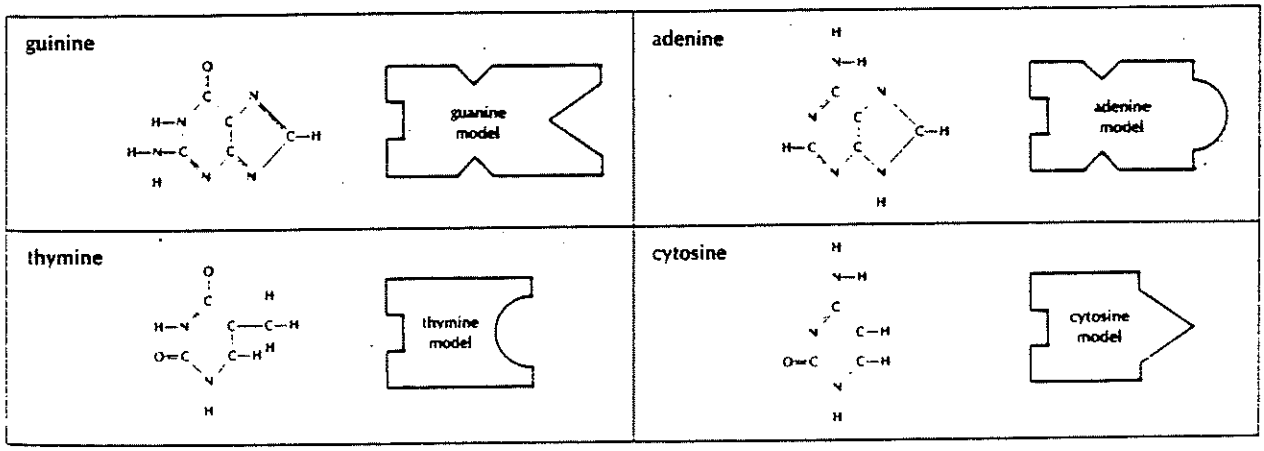


FIGURE 24-1



In addition, there are four different molecules called bases. Their structural formulas and models are shown on page 93.

2. Of the four bases, which other base does

   (a) adenine most resemble in shape? _____

   (b) thymine most resemble in shape? _____

A molecule of deoxyribose joins with phosphoric acid and any one of the four bases to form a chemical compound called a nucleotide. A nucleotide is named for the base that joins with the deoxyribose. For example, if thymine attaches to deoxyribose, the molecule is called a thymine nucleotide.

• Use the pages of nucleotide models to answer questions 3 and 4.

3. List the four different nucleotides. _____

4. (a) How is each nucleotide alike? _____

   (b) How does each nucleotide differ? _____

Note that the phosphoric acid notch fits the projection on deoxyribose to form a bond. In reality, water is lost to form this site.

Part B. Structure of a DNA Molecule

A DNA molecule is "ladderlike" in shape. Deoxyribose and phosphoric acid molecules join to form the sides or uprights of the ladder. Base molecules join to form the rungs of the ladder.

• Cut out the 24 nucleotide models provided by your teacher. *Cut only on solid lines.* **CAUTION:** *Always be careful when using scissors.*

• Fit six nucleotides together in puzzlelike fashion to form a row in the following sequence from top to bottom:

Cytosine nucleotide
Thymine nucleotide
Guanine nucleotide
Adenine nucleotide
Guanine nucleotide
Cytosine nucleotide

Let this arrangement represent the left half of a ladder molecule. It should consist of one side or upright plus six half rungs.

Guanine and cytosine ends match when one molecule is turned upside down. The same is true for thymine and adenine.

5. If DNA is "ladderlike," which two molecules of a nucleotide form the sides, or upright portion of the ladder? _____

6. To which molecule does each base attach? _____

7. Name the molecules of each nucleotide that form part of the ladder's rungs. _____

• Complete the right side of the DNA ladder by matching the bases of other nucleotides to form complete rungs. It may be necessary to turn molecules upside down in order to join certain base combinations. NOTE: The ends of each base will allow only a specifically shaped matching new base to fit exactly.

Your completed model should look like a ladder with matched bases as the rungs. Besides being shaped like a ladder, a DNA molecule is twisted. It looks like a spiral staircase. However, your paper model cannot show this shape.

8. Is the order of half-rung bases exactly the same from top to bottom of each side of your model? _____

9. Only two combinations of base pairings are possible for the rungs. Name these molecule combinations or pairs. _____

10. If four guanine bases appear in a DNA model, how many cytosine bases should there be? _____

11. Your DNA model has four guanine bases.
   (a) Does the number of cytosine bases in your model agree with your prediction? _____
   (b) The following are the bases on the left side of a DNA molecule. List the bases that would make up the right side of a DNA molecule.

   Thymine _____

   Adenine _____

   Guanine _____

   Guanine _____

   Cytosine _____

Name _____ Date _____

FIGURE 24-2

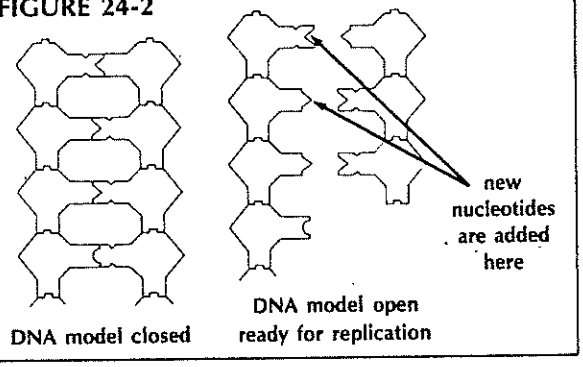
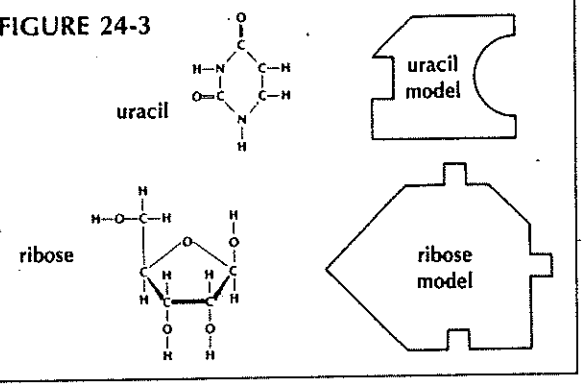


FIGURE 24-3



Part C. DNA Replication

A chromosome contains DNA. Your DNA model represents only a short length of the DNA portion of a chromosome. An entire chromosome has thousands of rungs rather than only six. Although your model is only a small part of a chromosome, its replication is the same as that of an entire chromosome during mitosis and meiosis.

- Open your DNA model along the point of attachment between base pairs (rungs) and separate the two ladder halves. (A chromosome untwists and "unzips" in a similar way prior to replication.) See Figure 24-2 as a guide.

- Using the left half of your model as a pattern, add new nucleotides to form a new right side.

- Build a second DNA model by adding new nucleotides to the right half of the original model.

12. Do the two new molecules contain the same number of rungs? _____

13. Is the order from top to bottom of base pairs (rungs) different or the same for each new DNA molecule? _____

14. How many molecules of adenine and thymine are in each DNA molecule? _____

15. Do the numbers agree? _____

16. Are the two DNA molecules exact copies of each other? _____

The specific order of bases in DNA serves as a code or language. When a chromosome replicates, the code (the order in which the bases occur) is carried over to the new chromosome.

17. What is the code of a chromosome? _____

Part D. RNA Structure

Besides ensuring the exact replication of chromosomes, the sequence (order) and pairings of bases are a genetic code of the instructions for the entire cell. How does a cell "read" the chemical message coded in its DNA in the form of specific base sequences? Part of the answer lies with a second molecule in the nucleus of cells called ribonucleic acid (RNA).

RNA is similar to DNA in that its molecules are also formed from nucleotides. However, deoxyribose and thymine are not found in RNA. Two other molecules, ribose and uracil, are present. Ribose replaces deoxyribose, and uracil replaces thymine. Looking at their structural formulas and models, you will see certain similarities between the molecules that they replace. Formulas and models are shown in Figure 24-3.

18. (a) Which base is replaced in RNA by uracil? _____

(b) What chemical replaces deoxyribose in RNA? _____

19. To which base in DNA do the following RNA bases pair?

(a) guanine _____

(b) adenine _____

(c) cytosine _____

(d) uracil _____

Part E. RNA Transcription

- Cut out the six RNA nucleotide models. *Cut only along solid lines.*
- Open or unzip one of the DNA chromosomes along the base pair points of attachment and separate the two halves.
- Using the left side of your DNA model as a pattern, match RNA nucleotides with the proper nucleotides of the DNA half.

20. Do the RNA half-rung bases pair exactly as they would if this were DNA replication?

_____

- Remove the RNA nucleotide series from the DNA pattern.
- Close the DNA molecule back up with its original right side. (DNA molecules "unzip" temporarily during RNA production.)

RNA is a single-stranded (or ½ ladder) molecule. Thus, the series of RNA nucleotides formed from DNA represents an RNA molecule. After its formation, this RNA leaves the nucleus of the cell and goes to the ribosomes. It carries the DNA message of base sequences in the exact same order. Therefore, the formation of this series of RNA nucleotides is called transcription.

Investigation 25, "tRNA and Protein Building" follows to complete this concept.

Analysis

1. Complete Table 24-1 by using check marks to indicate to which molecule each characteristic applies.

TABLE 24-1. SIMILARITIES AND DIFFERENCES BETWEEN DNA AND RNA

	DNA	RNA
Deoxyribonucleic acid		
Ribonucleic acid		
Ribose present		
Deoxyribose present		
Phosphoric acid present		
Adenine present		
Thymine present		
Uracil present		
Guanine present		
Cytosine present		
Formed from nucleotides		
Double stranded		
Single stranded		
Remains in nucleus		
Moves out of nucleus		
Contains a chemical message or code		