

## UNDERSTANDING GROWTH AND DEVELOPMENT

## CHAPTER 4.1 DNA: THE MOLECULE OF LIFE

**ENGAGE**, page 250

## Group Lab Activity: Extracting DNA

## Advance Preparation:

- Chill 90% isopropyl alcohol in freezer or ice chest. Make sure alcohol remains on ice throughout the investigation.
- Label 100 mL beakers for each lab group: “salt solution,” “detergent solution,” and “alcohol.”
- Prepare a 9% salt solution prior to class. Place 9 grams of NaCl into 100 mL of distilled water. Distribute approximately 10 mL to each lab group.
- Prepare a 25% detergent solution. Pour 25 mL liquid dish detergent into a 250 mL beaker. Add 75 mL of distilled water. Distribute approximately 10 mL to each lab group.
- Prepare a split green pea puree prior to class. Add to blender: 100 mL split green peas and 200 mL cold water. Blend for 15 seconds. Pour through strainer into larger beaker. Distribute approximately 20 mL to each lab group.

## Split Green Pea Puree Materials:

- Blender
- Cold water
- Bag of split green peas
- Large beaker
- Strainer

## Materials (per student):

- |                   |                                   |
|-------------------|-----------------------------------|
| – Safety goggles  | – Test tube stopper               |
| – Small paper cup | – Glass stir rod                  |
| – 2 Test tubes    | – Microcentrifuge tube (optional) |

## Materials (per group):

- |                                |  |
|--------------------------------|--|
| – 4 100 mL Beakers             | – Measuring spoons (mL)                |
| – 3 Plastic transfer pipettes  | – 10 mL Graduated cylinder             |
| – 2 Test tube racks            | – Split green pea puree                |
| – Meat tenderizer              | – 10 mL 9% Salt solution               |
| – Bottled water                | – 10 mL 25% Detergent solution         |
| – BLMs 115–117, Extracting DNA | – 50 mL 90% Isopropyl alcohol, chilled |

## 4.1 DNA: THE MOLECULE OF LIFE

### Procedure:

- Have students read the opening paragraphs on page 250 and ask them to think about what parts of the cell must be opened to release DNA from cells.
- Have them share their ideas with a partner and then the class.
- Explain to students that the cell membrane and nucleus must be opened before DNA can be extracted from cells.
- Direct students to follow the procedures to extract DNA from the split green peas and their own cheek cells.
- Note: You may elect to use BLMs 115–117 for students to use in place of their textbooks.

### EXPLORE, page 253

### Group Lab Activity: Modeling the Structure of DNA

### Advance Preparation:

#### Part A

- Make 15 color copies of BLMs 118–121 on white cardstock paper. If possible, laminate each page before cutting out the shapes.
- Cut out each shape and place three of each shape into a sandwich-size resealable plastic bag for each pair of students.

#### Part B

- Cut the boot lace in half and tie a knot at the cut end.
- Prepare a small bag of plastic beads with 15 beads of each color. Add the two cut pieces of boot laces to each bag.

### Materials:

- 30 Plastic resealable sandwich bags
- Plastic pony beads in four colors (red, blue, green, yellow), approximately 200 beads of each color
- 7 Pairs nylon boot laces (54" cut in half)
- BLM 118, Adenine Nucleotide
- BLM 119, Cytosine Nucleotide
- BLM 120, Guanine Nucleotide
- BLM 121, Thymine Nucleotide
- BLMs 122–123, Modeling the Structure of DNA
- Trans 31, DNA Model

Lab

**Extracting DNA**

**Purpose:**  
Extract your own DNA from cheek cells and compare it to DNA extracted from split green peas.

**Materials (per student):**

Safety goggles	Test tube stopper
Small paper cup	Glass stir rod
2 Test tubes	Microcentrifuge tube (optional)

**Materials (per group):**

4 100 mL Beakers	Split green pea puree
3 Plastic transfer pipettes	10 mL 9% Salt solution
2 Test tube racks	10 mL 25% Detergent solution
Meat tenderizer	50 mL 90% Isopropyl alcohol, chilled
Bottled water	
Measuring spoons (mL)	
10 mL Graduated cylinder	

Wear goggles and lab apron. Use caution when using glassware. Do not taste chemicals. Report all spills. **Warning:** Alcohol is flammable and is an irritant. Avoid skin/eye contact; do not ingest. Do not inhale vapors. If contact occurs, flush affected area with water for 15 minutes. Call the teacher immediately.

**Procedures:**

**Part A—Extracting DNA from Plant Cells**

1. Place 20 drops of the 9% salt solution into a test tube.
2. Use the measuring spoons to measure 5 mL of split green pea puree and add it to the test tube containing salt solution. Salt provides a positive environment for the negatively charged DNA. It neutralizes the electric charge on the DNA molecule. This allows DNA molecules to clump to each other. Salt also helps to break down proteins and carbohydrates inside the cell.

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BLM 115

## 4.1 DNA: THE MOLECULE OF LIFE

## Part A

- Put students into groups of four. Have students work in pairs for Part A and in a foursome for Part B.
- Distribute a bag with nucleotide pieces to each pair of students.
- Facilitate the activity by directing students to open the bag. Ask students the following questions:
  - How many different shapes do you observe? **4**
  - How many subunits does each shape contain? **3**
  - What does each shape have in common? *a subunit labeled “P” and a subunit labeled “D”*
- Introduce the term *nucleotide* to students.
- Direct students to draw a nucleotide in their journals.
- Next, instruct students to manipulate the pieces so that they fit together like pieces of a puzzle.
- Ask students the following questions:
  - What subunits differ between each shape? **A, C, G, T**
  - Do any of the pieces fit together? **yes**
  - What are the letters of the shapes that fit together? **A-T and C-G**
- Direct students to draw their completed model of DNA in their journals.
- Instruct students to draw a diagram of their completed structure in their journals.
- Check for understanding. Use Trans 31 in your class discussion.

## Part B

- Distribute bags filled with beads to each lab group.
- Direct students to follow the procedure on BLM 123.
- Circulate among groups, monitor for understanding, and redirect as needed.
- Conduct a class discussion.

**EXPLAIN**—Part 1, page 254**Materials:**

- BLMs 124–125, DNA WebQuest
- Computers with Internet access

WebQuest

**DNA WebQuest**

**Procedures:**

1. Enter the web address: <http://www.dnai.org>
2. Select **Code** from the menu on the left or along the top.
3. Select **Finding the Structure**.
4. Select **Problem** from the menu along the top.
5. Read through the slide and click on the red forward arrow to move to the next slide.
6. Answer the following questions:
  - With what types of cells did Friedrich Miescher work?
  - From where did he get nuclein?
  - What do we know nuclein as today?
  - What contribution did Phoebus Levene make towards the discovery of DNA's structure?
  - Why were scientists in the 1920s through the early 1940s skeptical that DNA was the molecule of life?
  - Why was Oswald Avery's experiment an important contribution towards the discovery of DNA's structure?
7. Click on **DNA Home** at the top of the slide.
8. Select **Timeline** from the menu.
9. Review the DNA timeline and complete the table below. Click on the icons associated with each scientist's experiment listed in the table on the following page and watch the slide show. Be sure to watch the movie video of each scientist.
10. Click on **DNA Home** at the top of the slide.
11. Select **Code** from the menu. Click on "Finding the Structure."
12. Select **Putting It Together** from the menu.
13. Select **The DNA Double Helix**.

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BLM 124

## 4.1 DNA: THE MOLECULE OF LIFE

- This activity is best suited for each student to have a computer to research and complete the WebQuest. If this is not possible, then pair students together.
- Visit the web page <http://www.dnai.org>.
- Begin class with a discussion of the scientific process as a prereading strategy. Limit discussion to 10 minutes.
- Have students think about the question: Since 1981, scientists have known that HIV causes AIDS. Why would it be such a huge milestone to discover a cure for AIDS?
- Ask students to think about steps scientists have made in the search for a cure for AIDS.
- Distribute BLMs 124–125. Assign students to computers.
- Direct students to record answers to questions in their journals.
- After students complete the WebQuest, relate the importance of discovering DNA's structure to finding a cure for AIDS.

### **EXPLAIN**—Part 2, page 254

#### Reading to Learn

- Have students use their preferred method for note taking.
- Instruct students to record notes in their journals.
- Have students construct a concept map that illustrates the main ideas from the WebQuest and reading.
- Conduct a whole-group discussion. Ask students to share their understanding of the WebQuest and reading.

### **ELABORATE**, page 256

#### Group Activity: Modeling DNA Replication

##### Advance Preparation:

- Cut the zipper off both gallon-size resealable plastic bags. Do not discard the zippers.



## 4.1 DNA: THE MOLECULE OF LIFE



- Cut one zipper into five or six smaller pieces on each side. These will represent free-floating nucleotides.
- Label each smaller plastic piece with the appropriate nucleotide label.
- Leave the other zipper uncut. The uncut zipper represents the template of DNA.
- Use the permanent marker to label the nitrogen base letters on the outside of the DNA template. For example, on one side label “A,” “C,” “G,” “T,” “C.” The other side will then be labeled “T,” “G,” “C,” “A,” “G.”
- Place the zipper and pieces into pint-size resealable plastic bags to ease distribution to students.

**Materials:**

- 15 Gallon-size resealable plastic bags with two-color zipper
- 15 Pint-size resealable plastic bags
- Fine-point permanent marker
- Scissors

**Reading to Learn**

- Put students into groups of two.
- Assign students to read pages 256–258.
- Instruct students to use the QAR reading strategy and answer the questions embedded in the text in their journals.
- Distribute a plastic bag containing model parts to each pair of students.

## 4.1 DNA: THE MOLECULE OF LIFE

**EVALUATE**, page 259**Answers:**

1. Explain how Chargaff's rules and Rosalind Franklin's X-ray diffraction helped Watson and Crick discover the structure of DNA. *Chargaff showed that the DNA nitrogen bases pair following the rule A-T and C-G. Rosalind Franklin's X-ray diffraction showed that DNA was a double helix with the nitrogen bases on the inside of the molecule. The data from these two scientists helped Watson and Crick develop an accurate model of DNA.*
2. Write the steps of replication in your own words. Make sure to use the following words in your explanation. *DNA must be replicated in the nucleus so new cells have the correct amount of DNA to function. Enzymes unzip DNA and break the hydrogen bonds between the nitrogen bases. Free-floating nucleotides attach to the original strand using the base-pairing rule, creating a complementary strand. The result is two exact copies, each containing an original strand and a new strand.*
3. C
4. D
5. C
6. B
7. C
8. A
9. D
10. D

# Understanding Growth and Development

## Introduction

Each multicellular organism begins life as a single cell. Yet, before it dies, the organism may amass millions or even trillions of cells. Growth in multicellular organisms requires the addition of new cells. This means the genetic material, or DNA, must be copied so each new cell has all the instructions necessary to carry out its life functions.

By the end of this unit, you will—

### Know these concepts:

- Structure of DNA
- DNA replication
- Mitosis
- Stem cells are undifferentiated
- Meiosis
- Asexual and sexual reproduction

### Do these things:

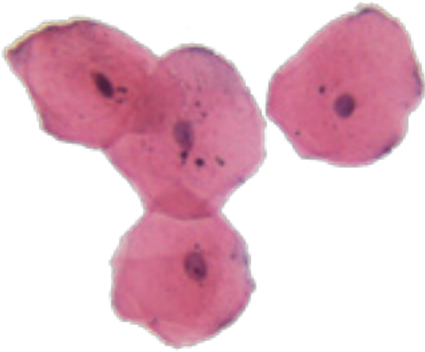
- Demonstrate safe practices
- Collect and organize data
- Analyze patterns in data
- Conduct research
- Draw conclusions based on evidence
- Analyze models and evaluate their limitations
- Use problem-solving skills
- Construct a concept map
- Extract DNA from cells
- Calculate surface area-to-volume ratio
- Dissect a flower

# Understanding Growth and Development

## Unit 4.1 DNA: The Molecule of Life

### ENGAGE

DNA is the molecule of life. It is the heredity material found in every cell that provides instructions for making proteins. Proteins are responsible for most of the structure of cells and are involved with controlling chemical reactions as enzymes. Prokaryotic cells have DNA floating in the cytoplasm, whereas eukaryotic cells have nuclei that contain DNA.



Human cheek cells from saliva

Scientists are able to extract DNA from cells and use it in a variety of ways. DNA can be used to compare organisms at the gene level and shows how organisms are related. This can help scientists observe how organisms have changed over time.

DNA is also used as evidence to connect individuals to a crime. Crime scene investigators collect samples of hair, skin, blood, or other body fluids because they contain cells and thus DNA. A forensic scientist extracts the DNA from cells left behind at the crime scene. After extracting the DNA, the forensic scientist analyzes it against known samples for a match. If a match exists, the individual who committed the crime is identified.

### Journal Entry

#### Think:

Saliva contains cheek cells. What parts of the cell must be opened in order to get DNA out of the cells? What do you think DNA will look like?

#### Pair:

Compare and discuss your responses with a partner. Revise your response after the discussion.

#### Share:

Share your responses with the class. Make further revisions to your responses as needed.



Wear safety goggles and a lab apron. Use care when handling specimens. Do not taste chemicals. Glassware is fragile. Notify the teacher of broken glass or cuts. Wash your hands thoroughly with soap and water before you leave the lab.

### Group Lab Activity

#### Task:

- Extract your own DNA from cheek cells and compare it to DNA extracted from split green peas.



# Understanding Growth and Development

## Materials (per student):

- Safety goggles
- Small paper cup
- 2 Test tube racks
- Test tube stopper
- Glass stir rod
- Microcentrifuge tube (optional)

## Materials (per group):

- 4 100 mL Beakers
- 3 Plastic transfer pipettes
- 2 Test tube racks
- Meat tenderizer
- Bottled water
- Measuring spoons (mL)
- 10 mL Graduated cylinder
- Split green pea puree
- 10 mL 9% Salt solution
- 10 mL 25% Detergent solution
- 50 mL 90% Isopropyl alcohol, chilled

## Procedure:

### Part A—Extracting DNA From Plant Cells

1. Place 20 drops of the 9% salt solution into a test tube.
2. Use the measuring spoons to measure 5 mL of split green pea puree and add it to the test tube containing salt solution. Salt provides a positive environment for the negatively charged DNA. It neutralizes the electric charge on the DNA molecule. This allows DNA molecules to clump to each other. Salt also helps to break down proteins and carbohydrates inside the cell.
3. Add a small pinch of meat tenderizer to the mixture. Meat tenderizer contains an enzyme that helps to break down proteins that support DNA.
4. Place 20 drops of 25% detergent solution into the test tube. Detergent breaks open the cell membrane and nuclear membrane by destroying the lipid bilayer that surrounds the cell and nucleus.
5. Cover with a test tube stopper. Place your thumb over the stopper and gently rotate the test tube side to side for 2 minutes.
6. Use the graduated cylinder to measure 5 mL of chilled isopropyl alcohol. DNA is not soluble in alcohol. The colder the alcohol, the more condensed the DNA molecule becomes, making it more visible.

# Understanding Growth and Development

7. Tilt the test tube 45 degrees and slowly pour the alcohol down the side of the test tube. The alcohol will form a layer on top of the split green pea mixture.
8. Place the test tube into the test tube rack. Wait 2–3 minutes. DNA will precipitate out of the detergent mixture. Watch the DNA float to the surface. DNA that floats to the surface contains millions of strands of DNA. An individual strand is too small to see without the aid of a powerful microscope.
9. In your journal, describe the appearance of the DNA.

## Part B—Extracting DNA From Cheek Cells

1. Place 20 drops of the 9% salt solution into a test tube.
2. Fill the paper cup with about 10 mL of bottled water (~ 1 cm in depth).
3. Put the 10 mL of water into your mouth and swirl the water around for 1 minute. Spit the water back into the paper cup. The water should now contain cells from inside your cheeks. Pour the water into the test tube.
4. Add a pinch of meat tenderizer to the mixture.
5. Place 20 drops of 25% detergent solution into the test tube.
6. Cover with a stopper. Place your thumb over the stopper and gently rotate the test tube side to side for 2 minutes.
7. Use the graduated cylinder and measure 5 mL of chilled isopropyl alcohol.
8. Tilt the test tube 45 degrees and slowly pour the alcohol down the side of the test tube. The alcohol will form a layer on top of the detergent mixture.
9. Place the test tube into the test tube rack. Wait 2–3 minutes. DNA will precipitate out of the detergent mixture. Watch the DNA float to the surface.
10. In your journal, describe the appearance of the DNA.
11. Optional: Place a small amount of alcohol into a microcentrifuge tube. Use a glass stir rod and twirl the DNA around it to form a spool. Transfer the DNA into the microcentrifuge tube.

# Understanding Growth and Development

## Analysis:

1. Describe the appearance of the split green pea DNA. *long, stringy, and snotlike*
2. Describe the appearance of your cheek cell DNA. *long, stringy, and snotlike*
3. Does the appearance of DNA differ between organisms? *no*
4. How do you think scientists tell the difference between the DNA of different organisms? *Answers will vary. Hopefully, some students will suggest that scientists need to analyze the genes of organisms.*
5. What was the purpose of adding detergent to the cell mixture? *Detergent breaks down the cell membranes and nuclear membrane.*

## Group Lab Activity

**EXPLORE**

## Task:

- Identify the basic structure of DNA using models.
- Carefully follow the procedures provided by your teacher.
- Record observations, make drawings, and answer questions as complete sentences in your journal.
- Answer the questions on the following page after completing the lab activity.

## Discussing to Learn

1. What are the three components of a DNA nucleotide? *deoxyribose sugar, phosphate, and a nitrogen base*
2. What nitrogen bases are found in DNA? *adenine, cytosine, guanine, thymine*
3. What does the shape of the DNA molecule look like? *twisted ladder or double helix*
4. What is the backbone of DNA made of? *deoxyribose sugar and phosphate* What makes up the “rungs” of the ladder? *nitrogen bases*
5. Which nitrogen bases always pair together? *Adenine always pairs with thymine, and cytosine always pairs with guanine.*
6. Why are the nitrogen bases specific in their pairing? *The structural shape of each nitrogen base is different and therefore can only fit and chemically bond to its matching base.*
7. Which part of the DNA molecule stores genetic information? *nitrogen bases*
8. What are the benefits of using models? *Models allow us to study structures that are usually too small to see.*
9. How did the paper model and bead model represent the structure of DNA? *The paper model showed the ladder-like shape of DNA. It also showed the sugars and phosphates alternating on the sides and the nitrogen bases in the middle. The bead model showed DNA as a three-dimensional structure. It showed the helical structure of DNA.*

# Understanding Growth and Development

## Individual Activity: DNA WebQuest

### EXPLAIN Part 1

#### Task:

#### Journal Entry

- Think about the following question: Since 1981, scientists have known that HIV causes AIDS. Why would it be such a huge milestone to discover the cure for AIDS?
- Participate in a whole-group discussion about the scientific process.
- Use the Internet to research the DNA Interactive website [www.dnai.org](http://www.dnai.org).
- Follow the directions on the handout provided by your teacher.
- Record answers to questions in your journal.

## Reading to Learn

### EXPLAIN Part 2

#### Journal Entry

#### Task:

- Read and discuss the following passage.
- Construct a concept map in your journal using your notes from the WebQuest and the reading.

## The Structure of DNA

Deoxyribonucleic acid, otherwise known as DNA, is the molecule of life and is found in every living organism. It is the most important organic compound for living organisms because it stores information for cells to properly function.

DNA is a large complex polymer that contains the elements carbon, hydrogen, oxygen, nitrogen, and phosphorus. The molecule is made up of single units, or monomers, called nucleotides. A nucleotide has three components that consist of a 5-carbon sugar called deoxyribose, a phosphate group, and a nitrogen-containing base. There are four different nitrogen bases in DNA; guanine (ghwah-noon), cytosine (sigh-tuh-seen), adenine (ad-uh-noon), and thymine (thy-mean). Nucleotides are often abbreviated with just the letter of the nitrogen base. Individual nucleotides are able to join through covalent bonds to create a very long and complex macromolecule. In DNA, the nucleotide sequence provides the genetic instructions for sequencing amino acids to build proteins.

# Understanding Growth and Development

## Historical Landmarks in the Discovery of DNA

James Watson and Francis Crick are credited with the discovery of the DNA structure. However, the work of other scientists was critical to their understanding of DNA's structure. Their work was heavily influenced by Erwin Chargaff, Linus Pauling, and Rosalind Franklin.

In 1950, Erwin Chargaff found that the nitrogen bases of DNA occur in the same proportion within an organism. For example, if an organism produced 30% cytosine, they would also produce 30% guanine. Likewise, the amount of adenine equaled the amount of thymine. This observation of  $A = T$  and  $C = G$  became known as Chargaff's rules and was the foundation for the base pairing rules for DNA.

The following year, Linus Pauling discovered that a certain group of proteins were shaped in a spiral, or helix. At that time, Watson and Crick were also studying the structure of certain proteins. However, they were more interested in figuring out the puzzle of DNA's structure. Based on their understanding of protein structure and the work of Linus Pauling, Watson and Crick hypothesized that DNA might also be a helix.

Watson and Crick began making three-dimensional models using wire and cardboard to figure out the structure of DNA. They were stumped until they were shown the data produced by Rosalind Franklin. In 1952, Rosalind Franklin and coworker Maurice Wilkins were studying DNA using X-rays. They bombarded the DNA with X-rays and studied the patterns the DNA made on film. Franklin's X-ray photographs of DNA showed an X surrounded by a circle. These photos suggested that DNA is double-stranded and that the strands twist around each other. The photos also suggested that the nitrogen bases were near the center of the molecule.



X-Ray Diffraction of DNA



Artist: Denise Wylie

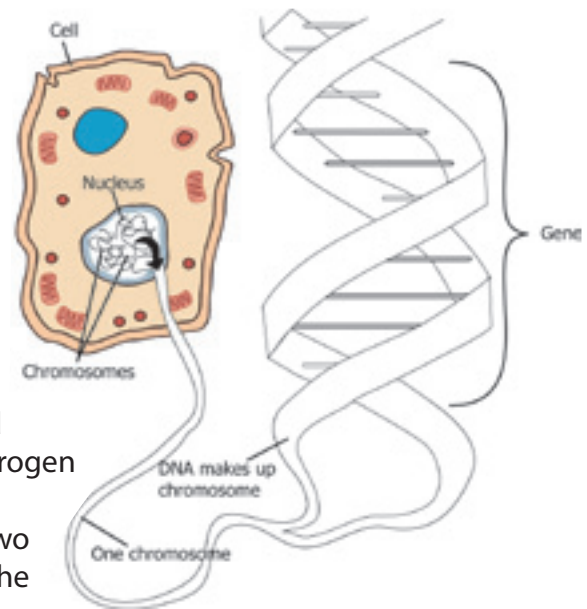
Rosalind Franklin

Rosalind Franklin did not knowingly give her data to Watson and Crick. It was her coworker, Maurice Wilkins, who showed Watson the photos in the spring of 1953. As soon as James Watson observed the photo of the X-shaped pattern of DNA, he immediately knew that DNA was double-stranded and helical. Weeks later, Watson and Crick completed their structural model of DNA and published their paper in the scientific journal *Nature* in April of 1953.

# Understanding Growth and Development

## DNA Is a Double Helix

DNA is shaped like a twisted ladder called a double helix. The backbone, or side of the ladder, is composed of alternating deoxyribose sugar and phosphate groups. The nitrogen-containing base connects to deoxyribose sugar. The two sides of DNA are complementary and are held together at the bases by hydrogen bonds. The hydrogen bonds create a force between the two nitrogen-containing bases. The hydrogen bonds can only form between the bases cytosine and guanine and adenine and thymine. The force from the hydrogen bonds holds the two sides of the DNA molecule together, forming the “rungs” of the ladder.



## Group Activity: Modeling DNA Replication

### ELABORATE

### Journal Entry

#### Task:

- Work with a partner to analyze the process of DNA replication using the QAR strategy.
- Read pages 256–258 and follow the instructions. Discuss answers to the questions with your partner and record your answers and observations in your journal.

## DNA Replication

1. DNA is found in the cytoplasm as a single, circular piece in prokaryotic cells. Eukaryotic cells are more complex. DNA is found in the nucleus of eukaryotic cells in multiple threads called chromosomes. The number of chromosomes varies among organisms. Each human body cell has 46 chromosomes, whereas a fruitfly has eight chromosomes. Each chromosome has sections of DNA, or genes, that code for certain proteins. DNA is the hereditary material that provides instructions for cellular activity.



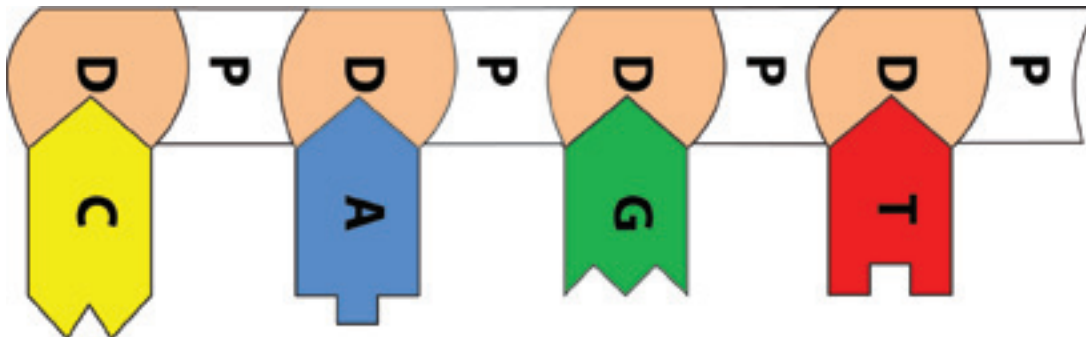
# Understanding Growth and Development

Each cell of an organism, whether prokaryotic or eukaryotic, must have the ability to pass exact copies of DNA to daughter cells for them to function properly. Thus, there must be a way for DNA to replicate, ensuring each new cell has a complete set of genetic material. As a matter of fact, the double helix structure of DNA allows it to replicate or copy itself. Each side of the molecule serves as a template for a new strand. Because each strand can be used to make the other strand, they are referred to as complementary. This is possible through the base pairing rule.

- What is the base pairing rule for DNA? *A-T; C-G*
  - Where in the cell is DNA located? *nucleus* Where in the cell will DNA replication occur? *nucleus*
  - Why is it necessary for DNA to copy itself? *so each new daughter cell will have a complete copy of DNA to carry out cell activities*
2. The DNA molecule is quite long. In fact, if all the DNA was removed from a single human cell, it would measure 3 meters in length. Thus, in order to maximize efficiency in the duplicating process, the molecule is copied in both directions. Each strand of the DNA molecule has a five-prime (5') end and a three-prime (3') end.

One side of the DNA molecule is arranged from 5' to 3'. The complementary strand is antiparallel and is arranged from 3' to 5'.

- Draw the complementary strand of the DNA strand shown below in your journal and label the 3' and 5' ends.



- Examine the plastic zipper model. Describe how each side is complementary. How is the model similar to DNA? *One side complements the other by matching the zipper pattern. One side of the zipper may be blue, while the other is red. The red only fits into the blue side. Likewise, the model has the letters of nitrogen bases. Each side matches the other following the base pairing rule.*
- What are the limitations in using models? *Models are limited by scale.*

# Understanding Growth and Development

3. DNA replication is carried out by a group of proteins that act as enzymes. Some of the enzymes unwind and break open DNA, while others help add new bases to the DNA strands.

- What are enzymes? *Enzymes are proteins that act as catalysts by speeding up chemical reactions.*
- What suffix do most enzymes have? *Most enzymes end with -ase.*

4. Let's look at the steps of DNA replication. The process of replication begins as an enzyme called helicase unwinds and separates the double helix strand of DNA. This process is commonly referred to as "unzipping." The unzipping process breaks the hydrogen bonds that connect the base pairs of the two strands. The points where the DNA is separated into single strands are called replication forks. Replication occurs from the 5' to 3' direction on both strands at replication forks.

- Why is the enzyme called helicase? *DNA is a double helix structure. Helicase unwinds the molecule.*
- Unzip your plastic zipper model of DNA. List the base pairs on the plastic zipper model that are exposed on both sides.

Left side: Answers will vary. A, C, G, T, C

Right side: Answers will vary. T, G, C, A, G

5. Next, free-floating nucleotides pair one at a time to the exposed bases on the strands of the DNA template. Another enzyme called DNA polymerase bonds the new nucleotides together.

- Add the small cut pieces to your opened-zipper model.
- Describe the completed model. *Two exact copies of DNA are produced. Two sides are from the original DNA template. The cut pieces representing nucleotides form new strands of DNA.*

6. Once all of the nucleotides have been added, DNA polymerase proofreads each new strand to make sure each new molecule is a perfect copy of the original. If DNA polymerase detects an error, it removes the incorrect nucleotide and replaces it with the correct one. When proofreading is complete, the result is two identical double-stranded DNA molecules that contain an original strand and one new strand.

- How does your model represent the completion of DNA replication? *There are two complete copies of DNA. Each molecule has an original strand and a new strand.*



# Understanding Growth and Development

## Individual Assessment

### EVALUATE

- 1 Explain how Chargaff's rules and Rosalind Franklin's X-ray diffraction helped Watson and Crick discover the structure of DNA. *Chargaff showed that the DNA nitrogen bases pair following the rule A-T and C-G. Rosalind Franklin's X-ray diffraction showed that DNA was a double helix with the nitrogen bases on the inside of the molecule. The data from these two scientists helped Watson and Crick develop an accurate model of DNA.*
- 2 Write the steps of replication in your own words. Make sure to use the following words in your explanation. *DNA must be replicated in the nucleus so new cells have the correct amount of DNA to function. Enzymes unzip DNA and break the hydrogen bonds between the nitrogen bases. Free-floating nucleotides attach to the original strand using the base pairing rule, creating a complementary strand. The result is two exact copies, each containing an original strand and a new strand.*
- hydrogen bonds
  - nucleus
  - nitrogen bases
  - complementary strand
  - original strand
  - unzip

### Select the best answer for questions 3–10.

- 3 DNA is known as the molecule of life because it –
- A controls the amount of material that enters and exits the cell
  - B directs the process of glycolysis
  - C contains the hereditary material that controls cell activities
  - D is the largest polymer in living organisms
- 4 One of the base pairing rules for DNA is –
- A cytosine pairs with thymine
  - B adenine pairs with cytosine
  - C guanine pairs with adenine
  - D thymine pairs with adenine
- 5 The structure of DNA is a –
- A single helical chain
  - B ring of nitrogen bases
  - C double helix
  - D chain of sugars and phosphates
- 6 The enzyme that links nucleotides to the open strand of DNA is –
- A helicase
  - B DNA polymerase
  - C deoxyribose
  - D pyrimidase

# Understanding Growth and Development

- 7 The backbone of the DNA molecule is composed of –
- A nitrogen bases
  - B nucleotides
  - C sugar and phosphate**
  - D proteins
- 8 Which of the following nucleotide base sequences complements the DNA sequence ATGCCATGC?
- A TACGGTACG**
  - B ATGCCATGC
  - C TACACATGC
  - D TACGGATGC
- 9 DNA unzips and separates into single strands to form two identical copies, ensuring that –
- A each organelle contains the proper amount of DNA
  - B mitochondria can produce enough ATP
  - C the cytoplasm has enough DNA
  - D each new cell has exact copies of genetic material**
- 10 Salt and detergent are necessary to extract DNA from the –
- A cell membrane
  - B cytoplasm
  - C ribosome
  - D nucleus**