CHAPTER 2

From a Cell to an Organism

The BIG Idea

Nearly all the cells in an organism are genetically identical and are organized to work together.

LESSON 1 1.c, 1.e, 7.a

The Cell Cycle and Cell Division

Main Idea The life of a cell usually includes periods of growth and reproduction.

LESSON 2 1.f, 5.a, 7.d, 7.e

Levels of Organization

Main Idea From single-celled to multicellular organisms, all living things are organized.

It's alive! It's alive! The white root growing down into the soil will anchor the new plant that grows from this seed. Once, this seed was just cells in a flower on a California buckeye tree. If the new plant survives, it can grow to be a tree about 12 m tall.

Science Journal Predict what other functions the root might have for the new plant.

Launch Lab

00:10 minutes

When is division not a math problem?

Believe it or not, you started out as one cell. Obviously, you have grown. Cell division is why you grew.

Procedure

1. Obtain a **numbered picture** from your teacher.
2. Use a **microscope** as instructed by your teacher and scan the **provided slide.** Find a cell that matches your numbered picture. Draw the cell in your lab notebook.
3. Move around the room and observe other cells. In your lab notebook, draw cells that are different from your cell.

Think About This

- **Examine** What do your drawings show? Does the process look organized?
- **Predict** Where do you think this process might be happening right now?

1.a, 7.a, 7.d

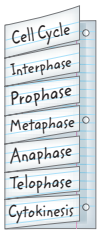
FOLDABLES™ Study Organizer

Cell Cycle Make the following Foldable to organize the phases of the cell cycle.

STEP 1 Fold a sheet of paper in half lengthwise.

STEP 2 Cut along the top line and then every fifth or sixth line of the top flap to form seven tabs.

STEP 3 Label as shown.



Reading Skill

Sequencing
As you read Lesson 1, write a description of what occurs in each phase of the cell cycle under the appropriate tab of your Foldable.

Science Online

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- view Concepts in Motion
- explore Virtual Labs
- access content-related Web links
- take the Standards Check

Get Ready to Read

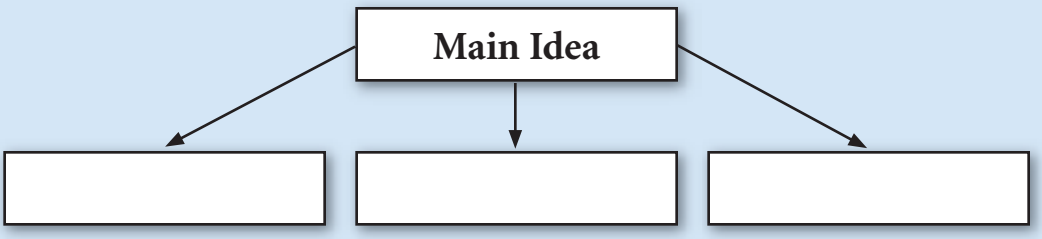
Identify the Main Idea

ELA7: R.2.3

1 Learn It! Main ideas are the most important ideas in a paragraph, a lesson, or a chapter. Supporting details are facts or examples that explain the main idea. Understanding the main idea allows you to grasp the whole picture.

2 Practice It! Read the following paragraph. Draw a graphic organizer like the one below to show the main idea and supporting details.

> Single-celled eukaryotes include protists, like the amoeba shown in **Figure 9,** and some fungi. They are more complex than bacteria. Each single-celled eukaryote has a nucleus and other membrane-bound organelles. Membranes separate organelles and their specialized functions from each other. They also enable organelles to transport substances into and out of a cell.
>
> *—from page 99*



3 Apply It! Pick a paragraph from another section of this chapter and diagram the main idea as you did above.

Reading Tip

The main idea is often the first sentence in a paragraph, but not always.

Target Your Reading

Use this to focus on the main ideas as you read the chapter.

1. **Before you read** the chapter, respond to the statements below on your worksheet or on a numbered sheet of paper.
   - Write an **A** if you **agree** with the statement.
   - Write a **D** if you **disagree** with the statement.
2. **After you read** the chapter, look back to this page to see if you've changed your mind about any of the statements.
   - If any of your answers changed, explain why.
   - Change any false statements into true statements.
   - Use your revised statements as a study guide.

Before You Read A or D	Statement	After You Read A or D
	1 All cell cycles are the same length of time.	
	2 Interphase lasts longer than other phases of a cell's cycle.	
	3 Mitosis produces two daughter cells.	
	4 Chromosomes can be observed using a light microscope.	
	5 A characteristic of all living things is that they grow and develop.	
	6 Single-celled organisms have complex organization.	
	7 Differentiated human cells can become another type of cell.	
	8 Groups of similar cells that work together form tissues.	
	9 Plants have organs that work together to perform functions.	

Science Online

Print a worksheet of this page at ca7.msscience.com.

LESSON 1

Science Content Standards

1.c Students know the nucleus is the repository for genetic information in plant and animal cells.
1.e Students know cells divide to increase their numbers through a process of mitosis, which results in two daughter cells with identical sets of chromosomes.
7.a Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

Reading Guide

What *You'll Learn*

- **Describe** the cell cycle.
- **Identify** the phases of mitosis.
- **Distinguish** among the cell cycle, mitosis, and cell division.
- **Explain** the importance of cell division.

Why *It's Important*

Learning how cells divide and grow will help you understand how all organisms grow.

Vocabulary

cell cycle
interphase
centromere
mitosis
cytokinesis
prophase
metaphase
anaphase
telophase
daughter cell
cell plate
homologous chromosome
sister chromatid

Review Vocabulary

eukaryotic cell: a cell with a nucleus and other organelles (p. 64)

The Cell Cycle and Cell Division

Main Idea The life of a cell usually includes periods of growth and reproduction.

Real-World Reading Connection A multicellular organism like yourself is made of trillions of cells. How are all of these cells made? How long does a cell live?

The Cell Cycle

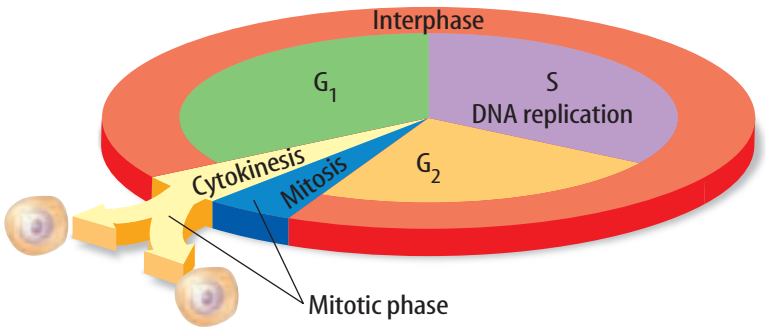
You probably are still growing, but not as fast as when you were younger. You might have entered the phase of development when your reproductive organs mature. All these phases are part of your life cycle. Similarly, cells have a life cycle called the **cell cycle.** The cell cycle, as shown in **Figure 1,** usually includes phases of growth and development and reproduction.

Phases of the Cell Cycle

You'll spend most of your life growing and developing. Only a small portion of a human's life cycle is spent in the reproductive phase. The same is true for cells. The phase of a cell cycle when a cell is preparing to reproduce is called **interphase.** It usually lasts longer than other phases of the cell cycle. The phase when a eukaryotic cell reproduces is called the mitotic (mi TOH tik) phase. During the mitotic phase, the nucleus and cytoplasm of a cell divides, producing two new cells.

Visual Check **Figure 1** What processes are part of the mitotic phase?

Figure 1 Interphase and the mitotic phase make up the cell cycle.



CONTENTS

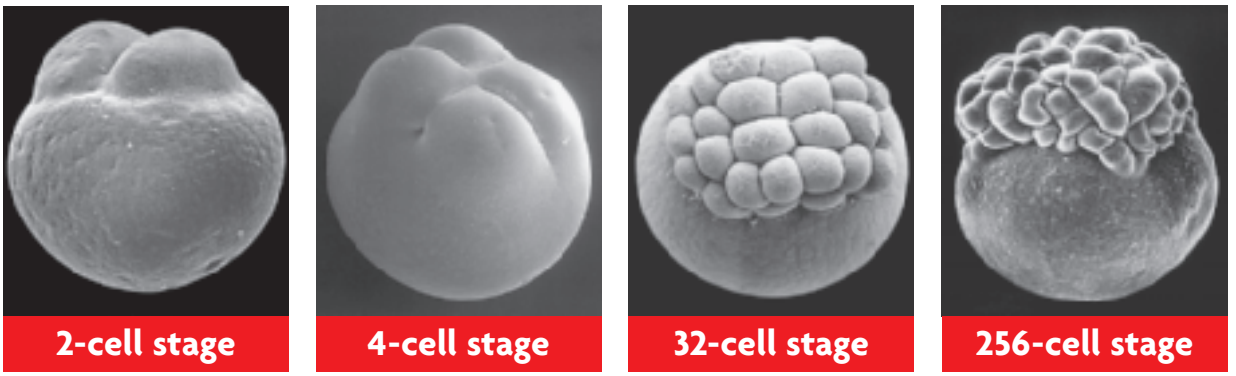


Figure 2 The cell cycle for a newly fertilized zebra fish egg can be as short as 15 min.

Length of a Cell Cycle

The length of time for the cell cycle is different for different types of organisms and cells. During the earliest stages of animal growth, the cell cycle can repeat quickly. For example, a zebra fish grows from a fertilized egg to 256 cells in just 2.5 h, as shown in **Figure 2.**

Characteristics of Interphase

A cell performs specific functions during interphase. For example, a cell in your stomach might produce substances that help digest your food. A plant cell, such as the onion root cell shown in **Figure 3,** might perform cellular respiration during interphase.

Recall from Chapter 1 that a cell's nucleus contains chromosomes. During interphase, the chromosomes in the nucleus are like a bunch of thin spaghetti noodles. Each chromosome is so thin that it cannot be observed with a light microscope.

Also, you read that there are two sets of chromosomes in a nucleus. For each chromosome in one set of chromosomes, there is a similar chromosome in the other set of chromosomes. Scientists call each pair of similar chromosomes a pair of **homologous chromosomes** (huh MAH luh gus • KROH muh sohmz). Humans have 23 pairs of homologous chromosomes.

Reading Check How many sets of chromosomes are in a nucleus?

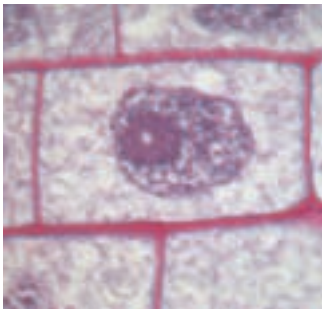
Imagine if you had two sets of instructions for making a pizza. The instructions are similar because they are both for making pizzas. However, they are not identical because the pizzas can have different toppings and crusts. The same is true for your homologous chromosomes; they have similar but not identical instructions.

WORD ORIGIN

homologous
from Greek *homos* (means *same*) and *logos* (means *relation, reasoning*)

Figure 3 This cell is from the root of an onion and is in interphase.

Infer why the chromosomes are not visible in the cell's nucleus.



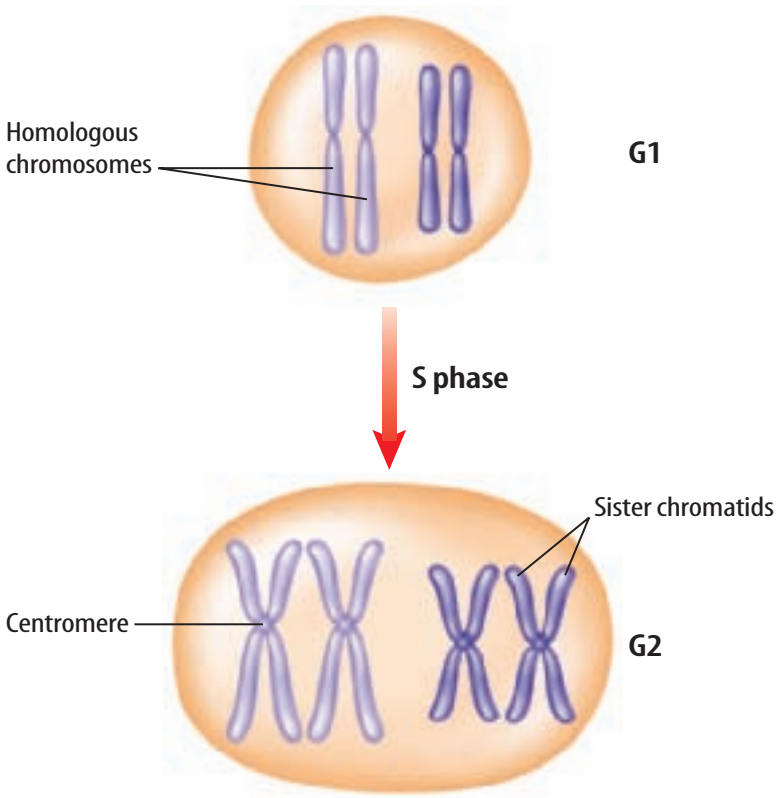
ACADEMIC VOCABULARY
establish (ih STAH blish)
(verb) to put beyond doubt
Her time established that she was the faster runner.

Phases of Interphase Scientists have **established** that interphase consists of three phases—G1, S, and G2. During G1 phase, a cell grows and carries out its usual cellular functions. Some cells remain in G1 and do not reproduce. For example, your muscle cells, some nerve cells, and red blood cells never reproduce. Injuries to nerve and muscle cells can result in a permanent loss of function because they are not replaced. Red blood cells are replaced because they are produced by certain cells in the center of some bones.

Growth continues into S phase. During S, however, the chromosomes inside a cell's nucleus replicate. This means that they make copies of themselves, as the diagram in **Figure 4** shows. The copies of a chromosome made during S phase are called **sister chromatids** (KROH muh tudz). Sister chromatids are held together at a region near the middle of each chromatid called the **centromere.** The replication of chromosomes during S phase ensures that the two new cells formed by cell division are identical.

Visual Check **Figure 4** How many centromeres are there for each replicated chromosome?

Figure 4 A cell in G2 phase has an identical copy of each chromosome.



CONTENTS

Table 1 Phases of the Cell Cycle

Phase	Stages	Description
Interphase	G1	Growth and cellular functions
	S	Growth and chromosome replication
	G2	Growth and cellular functions; organelle replication
Mitotic phase	Mitosis	Nucleus divides.
	Cytokinesis	Cytoplasm divides.

Organelle Replication A cell continues to grow and carry out cellular functions during the final phase of interphase, G2 phase. It also replicates organelles during this phase of interphase. Some organelles, such as mitochondria and chloroplasts, can duplicate themselves because they contain their own DNA. The major events of interphase and the cell cycle are summarized in **Table 1.**

WORD ORIGIN

mitosis
from Greek *mitos* (means *warp thread*) and *osis* (means *act, process*)

Mitosis and Cell Division

You read in Chapter 1 that eukaryotic cells have organelles and other structures. You also read that the control center of the cell is the nucleus. When new cells are made, it is important that the contents of the nucleus be copied correctly. The nucleus divides in a process called **mitosis** (mi TOH sus). The cytoplasm divides in a process called **cytokinesis** (si toh keh NEE sus). These events ensure that each new cell receives all it needs to function normally.

Importance of Mitosis and Cell Division

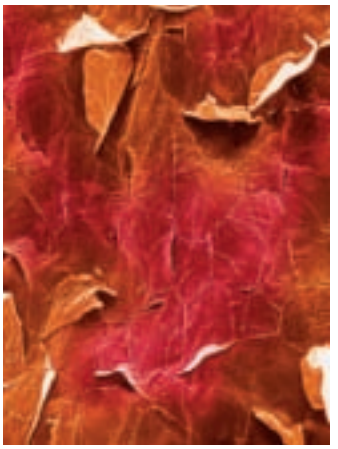
As you read earlier in this lesson, a characteristic of all living things is that they grow and develop. Making more cells is one way multicellular organisms grow. They also grow because some cells increase in size.

Sometimes cells get old, wear out, and die. For example, everyone is constantly shedding old skin cells, as shown in **Figure 5.** New cells formed by mitosis and cell division replace these skin cells. Some cells, such as the ones that line your stomach, live only for a few days. Because of mitosis and cell division, new cells constantly replace these short-lived cells.

Some organisms reproduce by mitosis and cell division. These organisms produce offspring that are identical to the parent. You will read about this kind of reproduction in Chapter 3.

Reading Check How do multicellular organisms grow?

Figure 5 We lose about 30,000–40,000 dead skin cells every minute. Cell divisions replace skin cells.



Color-enhanced SEM Magnification: 1000×

Cell Division Have you ever fallen and scraped your knee? The scrape heals because new cells are made to replace the cells that were damaged or lost. These new cells are made by mitosis and cell division.

It is important to understand that the processes of mitosis and cell division do not produce all cells. For example, a different kind of cell division produces sperm cells or egg cells from reproductive cells. You will read about this kind of cell division in Chapter 3.

Phases of Mitosis

Mitosis is a continuous process. However, mitosis has four recognizable phases or stages, as shown in **Figure 6.**

Prophase The first phase of mitosis is **prophase.** Two major events happen during prophase. First, the DNA that makes up a replicated chromosome twists into tight coils. Have you ever twisted a rubber band so tightly that it coiled around itself? This is similar to what happens to chromosomes during prophase. Once the replicated chromosomes coil, they can be observed with a light microscope. The other major event during prophase is that the membrane around the nucleus breaks apart. After this happens, chromosomes can move to other areas of a cell.

Visual Check **Figure 6** Why can you see the chromosomes in the nucleus of the cell during prophase?

Metaphase During the second stage of mitosis, **metaphase**, the replicated chromosomes move to the middle of the cell. The pairs of sister chromatids line up end-to-end across the center of the cell. How does this happen? Hairlike fibers pull and push the chromosomes to the middle of the cell.

Anaphase In the third stage, **anaphase**, the sister chromatids of each replicated chromosome begin to separate. The hairlike fibers extend from each end of a cell and attach to the centromere of the sister chromatids. These fibers pull the centromere apart and chromatids move away from each other, toward opposite ends of the cell. Now, the chromatids are called chromosomes.

Telophase The final phase of mitosis is **telophase.** During telophase, a new membrane forms around each set of chromosomes. The chromosomes also become less tightly coiled. These two events are nearly the reverse of what happens in prophase. At the end of telophase, there are two new nuclei that are identical to each other and the original nucleus. However, the cell has not divided.

Reading Check What are the four phases of mitosis?

Figure 6 The cell cycle of most eukaryotic cells, like the fish cell shown below, includes mitosis. It is difficult to determine when one phase of mitosis begins and another ends. However, each phase has certain characteristics. At the end of mitosis, two new, genetically identical nuclei form. The original nucleus no longer exists.

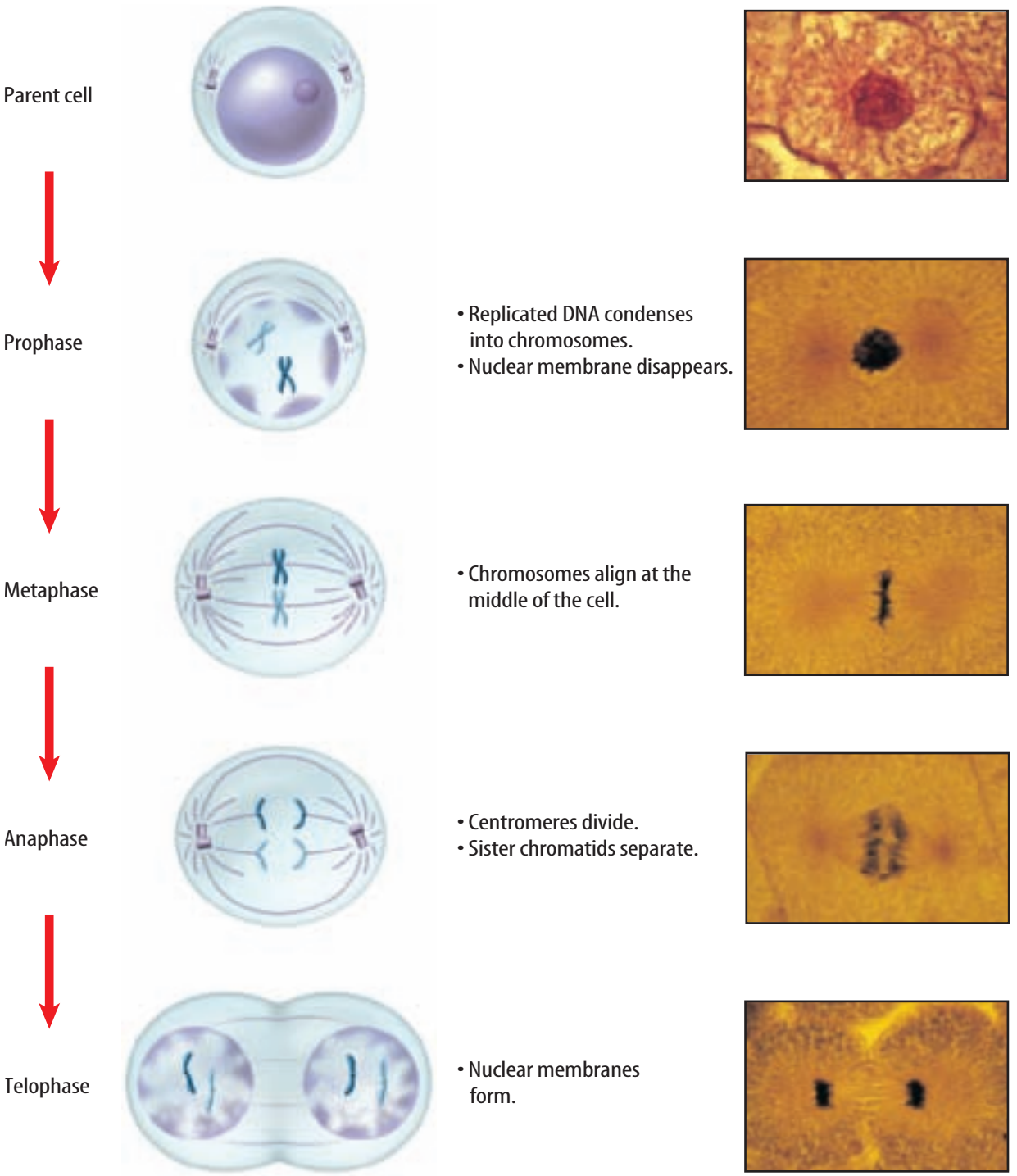


Figure 7 The flexible membrane cell pinches in during cytokinesis. The rigid cell wall of plant cells cannot pinch in.

Identify the stage of cell division shown here.

Color-enhanced SEM Magnification: 125×

Animal Cell

Stained LM Magnification: 1,500×

Plant Cell

WORD ORIGIN

cytokinesis

cyto– from Greek *kytos;* means *a hollow receptacle*

–kinesis from Greek; means *movement, motion*

Dividing the Cell's Components

Cytokinesis is the final stage of cell division. During cytokinesis, the cytoplasm and its components divide to form two identical cells called **daughter cells.** A sign that cytokinesis has begun is when the cell membrane squeezes inward, as shown in **Figure 7.** This is similar to squeezing the middle of a balloon.

During cytokinesis, the appearance of a cell with a cell wall, such as a plant cell also in **Figure 7,** is different from an animal cell that does not have a cell wall. In a cell with a cell wall, a **cell plate** forms between the two new nuclei. The cell plate eventually becomes the cell membrane. The new cell walls of the plant daughter cells are built from molecules released by the cell membrane.

The process of mitosis divides a cell's nucleus. However, the nucleus is just one of many organelles inside a cell. How do daughter cells get organelles? Recall that organelles and other structures are suspended in the cytoplasm of a cell. During cytokinesis, each daughter cell receives half the cytoplasm with organelles that were replicated during G2 of interphase.

Reading Check What is the first sign that cytokinesis has begun?

Results of Cell Division

It is important to realize that after mitosis and cell division, the original cell—called the parent cell—no longer exists. However, daughter cells' chromosomes are identical to those of the parent cell, both in number and type. In other words, the daughter cells are genetically identical to each other and to the original parent cell. All the cells in your body, except sperm and egg cells, have identical chromosomes because of mitosis and cytokinesis.

What have you learned about the cell cycle and cell division?

Cells have periods of growth and reproduction called cell cycles. The cell cycles of different cell types differ in the time that they last. A cell's nucleus divides in a process called mitosis. During mitosis, the DNA that makes up a replicated chromosome is packaged into tight coils. The membrane around the nucleus breaks apart, enabling the chromosomes to move around in the cytoplasm. The replicated chromosomes move to the middle of the cell and the chromatids line up in the center. The sister chromatids in each pair begin to separate and move toward opposite sides of the cell. At the end of mitosis, there are two identical nuclei. Following cytokinesis, two new genetically identical cells form, and the original cell no longer exists.

LESSON 1 Review

Summarize

Create your own lesson summary as you design a **study web.**

1. **Write** the lesson title, number, and page numbers at the top of a sheet of paper.
2. **Scan** the lesson to find the **red** main headings.
3. **Organize** these headings clockwise on branches around the lesson title.
4. **Review** the information under each **red** heading to design a branch for each **blue** subheading.
5. **List** 2–3 details, key terms, and definitions from each **blue** subheading on branches extending from the main heading branches.

ELA7: W 2.5

Standards Check

Using Vocabulary

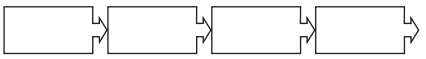
1. In your own words, write a definition of the cell cycle. 1.e
2. Use the word *centromere* in a sentence. 1.e

Understanding Main Ideas

3. **Compare** interphase and the mitotic phase. 1.e
4. Which are copies of a chromosome made during S-phase of the cell cycle? 1.c
   - **A.** centromeres
   - **B.** parent cells
   - **C.** daughter cells
   - **D.** sister chromatids
5. **State** the results of mitosis and cell division. 1.e
6. **Distinguish** between mitosis and cytokinesis. 1.e

Applying Science

7. **Predict** what would happen if a cell completed mitosis, but not cytokinesis. 1.e
8. **Decide** What criteria would you use to decide which phase a cell is in? 1.e
9. **Sequence** Draw a graphic organizer similar to the one below about the phases of mitosis. Begin with the phase that follows interphase and end with the phase that comes before cytokinesis. 1.e



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For more practice, visit **Standards Check** at ca7.msscience.com.

DataLab

00:30 minutes

Try at Home

How does your garden grow?

One of the most common tissues used for observing mitosis and cell division is onion root-tip tissue.

Data Collection

1. Read and complete a lab safety form.
2. Create a data table to record your observations.
3. Use a **microscope** as instructed by your teacher to observe a **prepared slide of stained onion root-tip tissue.** Select the highest magnification to observe the slide.
4. Identify the stage of mitosis and cell division for each cell in your field of view. Record the number of cells in each stage of the cell cycle on your table.
5. Change the field of view twice and repeat step 4 each time.

Data Analysis

1. **Determine** the percentage of cells in each stage of mitosis and cell division.
2. **Construct** a pie chart of your data.

Sample Data Table

	View 1	View 2	View 3
Interphase			
Prophase			
Metaphase			
Anaphase			
Telophase			
Cytokinesis			
Total Cells			

Science Content Standards

1.c Students know the nucleus is the repository for genetic information in plant and animal cells.
7.a Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

Applying Math

Probability and the Cell Cycle

1.e

MA7: NS 1.0, SP 1.0

Using microscopes, several science classes observed plant cells in different stages of the cell cycle. The table shows how many students in each class observed each cell stages.

Stages of the Cell Cycle

Class Period	Interphase	Prophase	Metaphase	Anaphase	Telophase
1	22	4	2	1	1
2	20	5	1	2	2
3	24	2	1	1	2
4	22	3	3	1	1
5	23	3	2	1	1

Example

What is the probability that a first-period student observed a cell in metaphase?

What you know:

- Number of cells observed in metaphase first period: 2
- Total number of cells observed first period: 30

What you need to find:

- Probability of observing a cell in metaphase to total number of cells observed

1. The probability of observing a cell in metaphase to the total number of cells observed is:

$$\frac{\text{Number of cells observed in metaphase}}{\text{Total number of cells observed}} = \frac{2}{30}$$

2. Reduce this fraction to get: $\frac{1}{15}$

Answer: The probability of a first-period student observing a cell in metaphase is 1 out of 15.

Practice Problems

1. What is the probability of a second-period student observing a cell in anaphase?
2. What is the probability of a fifth-period student observing a cell in interphase?

Science Online
For more math practice, visit **Math Practice** at ca7.msscience.com.

LESSON 2

Science Content Standards

1.f Students know that as multicellular organisms develop, their cells differentiate.
5.a Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
7.d Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of Earth's plates and cell structure).
7.e Communicate the steps and results from an investigation in written reports and oral presentations.

Reading Guide

What *You'll Learn*

- **Compare and contrast** a protist to a human skin cell.
- **Distinguish** between differentiation of a plant cell and an animal cell.
- **Sequence** the levels of organization from cell to organism.

Why *It's Important*

Learning how all living things are organized will help you understand how organisms have organized structures and functions.

Vocabulary

cell differentiation
stem cell
tissue
organ
organ system

Review Vocabulary

prokaryotic cell: a cell without a nucleus and other organelles (p. 64)

Levels of Organization

Main Idea From single-celled to multicellular organisms, all living things are organized.

Real-World Reading Connection How do people organize their belongings? They usually place things with similar functions together. For example, things used to cook food are probably in the kitchen. Pots and pans might be in a cabinet and silverware in a drawer. In a similar way, cells and organisms are organized. They have structures that have specialized functions.

Single-Celled Organisms

Why would something that is one cell—a single-celled organism—need to be organized? A single-celled organism carries out all the functions needed for its survival, including obtaining nutrients, waste removal, movement, protection, and reproduction.

Prokaryotes

Recall from Chapter 1 that prokaryotes are single-celled organisms that do not have membrane-bound organelles. For example, bacteria are prokaryotes without nuclei or other organelles. However, bacteria still have structures with specific functions. Some processes that occur in organelles of eukaryotes happen in bacteria along specialized membranes, such as those shown in **Figure 8.**

Figure 8 This cyanobacterium, *Spirulina plantesis,* can perform photosynthesis, making its own food.
Infer how this organism obtains energy.

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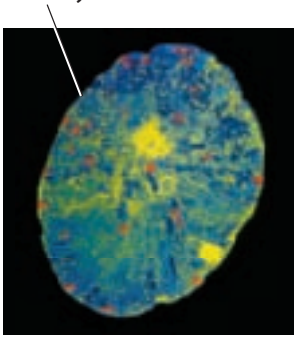
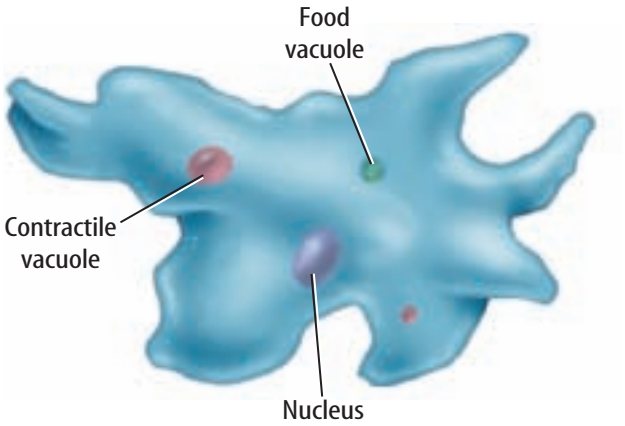


Cross-section Color-enhanced TEM
Magnification: 6600×

CONTENTS



Stained LM Magnification: 160×

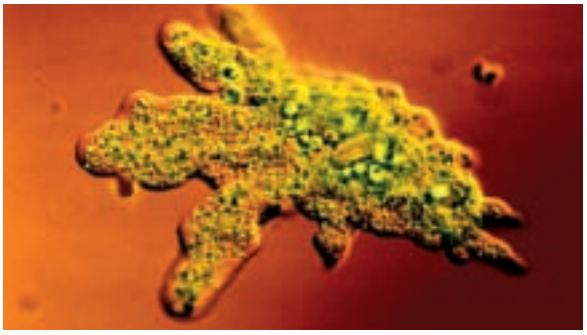


Figure 9 An amoeba, such as this one, lives alone in freshwater.

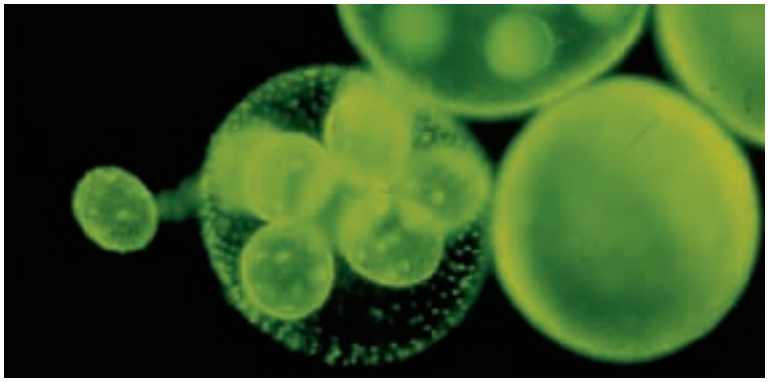
Eukaryotes

Single-celled eukaryotes include protists, such as the amoeba shown in **Figure 9,** and some fungi. They are more complex than bacteria. Each single-celled eukaryote has a nucleus and other membrane-bound organelles. Membranes seperate organelles and their specialized functions from each other. They also enable organelles to transport substances into and out of a cell.

Single-celled eukaryotes are also more complex than cells in multicellular eukaryotes. They usually exist alone and obtain by themselves all the things that they need to survive. Cells in multicellular organisms, however, rely on one another to provide their needs, and cannot survive alone.

Some single-celled eukaryotes, however, live and function together in groups or colonies. After cell division, the daughter cells stay together. The protist colony *Volvox*, as shown in **Figure 10,** is made of specialized eukaryotic green algal cells. Some scientists propose that colonies of single-celled organisms might have led to the development of multicellular organisms.

Reading Check How do cells of a protist colony differ from a single-celled protist?



Darkfield LM Magnification: 100×

Figure 10 Small bridges of cytoplasm connect single-celled organisms in a *Volvox* colony. The flagella on each cell beat in unison with flagella on other cells, propelling the colony through water.

ACADEMIC VOCABULARY
assign (uh SINE)
(verb) to appoint to a duty or task
The play's casting director will assign parts to the actors.

Multicellular Organisms

When doing a group project, someone must organize the group and **assign** tasks. Someone must also make sure everyone does his or her task. The project requires organization to be completed successfully. In a similar way, multicellular organisms require organization. Multicellular organisms have many cells and usually have more than one type of cell. Therefore, they have more complex organization than single-celled organisms.

Cell Differentiation

You started as one fertilized egg. You grew by mitosis and cell division and developed into an organism with many types of cells. How did this happen? It occurred by a process called **cell differentiation** (dih fuh ren chee AY shun) in which cells become different types of cells.

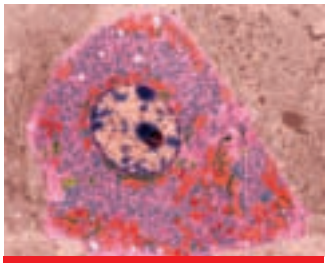
You read in the previous lesson that nearly all the cells of an organism have identical sets of chromosomes. Also, recall that chromosomes contain the instructions of a cell. How can cells be different if they have the identical sets of instructions? Part of the answer is that different cell types use different parts of the instructions on the chromosomes. It's like the actors in a play who only need to memorize the lines in the script for their roles, not the entire script of the play.

Differentiated cells often have specialized structures and shapes for specific functions that are different from other cells. For example, liver cells, like those shown in **Figure 11,** have a greater amount of smooth ER than some other cells. Filtering blood is the main function of liver cells. Recall from Chapter 1 that smooth ER modifies poisons, making them easier to remove from a cell.

Brain cells, also shown in **Figure 11,** are another type of differentiated cell. Brain cells often are highly branched. Branching enables a brain cell to send and receive signals from many directions and over long distances. There are many other differentiated cells in humans, such as the ones shown in **Figure 12.**

Figure 11 Liver cells and brain cells have different structures and functions.
Infer why brain cells are long and branched.

Color-enhanced TEM Magnification: 1240×



Liver Cell

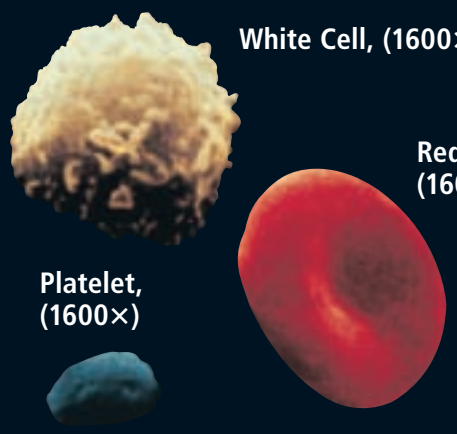
Color-enhanced SEM Magnification: 1,700×

Brain Cell

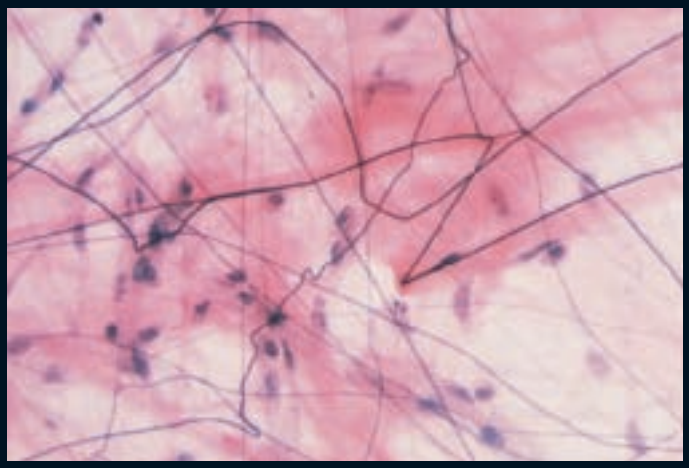
CONTENTS

Visualizing Differentiated Human Cells

Figure 12 Throughout your body, differentiated cells carry out the complex processes that keep you alive and functioning at your best.



▶ **BLOOD CELLS** Red blood cells carry oxygen to your tissues and remove carbon dioxide. White blood cells protect your body from harmful, foreign substances or organisms. Platelets help form blood clots.



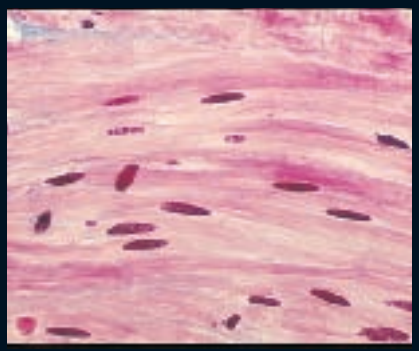
Connective Tissue, (80×)

◀ **CONNECTIVE TISSUE CELLS** Like the cells in blood, some connective tissue cells move about. These connective tissue cells can protect, repair, and transport. Other connective tissue cells are fixed, like those in the photo to the left. These cells can insulate, maintain, store, support, or produce substances.

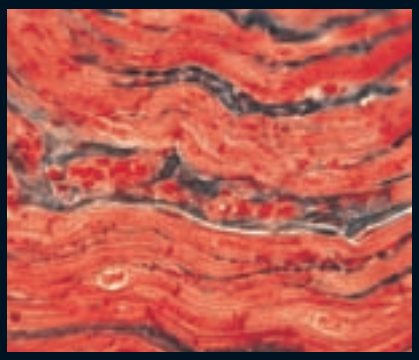
▼ **MUSCLE CELLS** Skeletal muscle cells move body parts such as arms and legs. Smooth muscle cells move substances within or through internal organs and vessels. Cardiac muscle cells are found only in the heart.

Skeletal Muscle, (6000×)

Smooth Muscle, (100×)



Cardiac Muscle, (225×)



Contributed by National Geographic

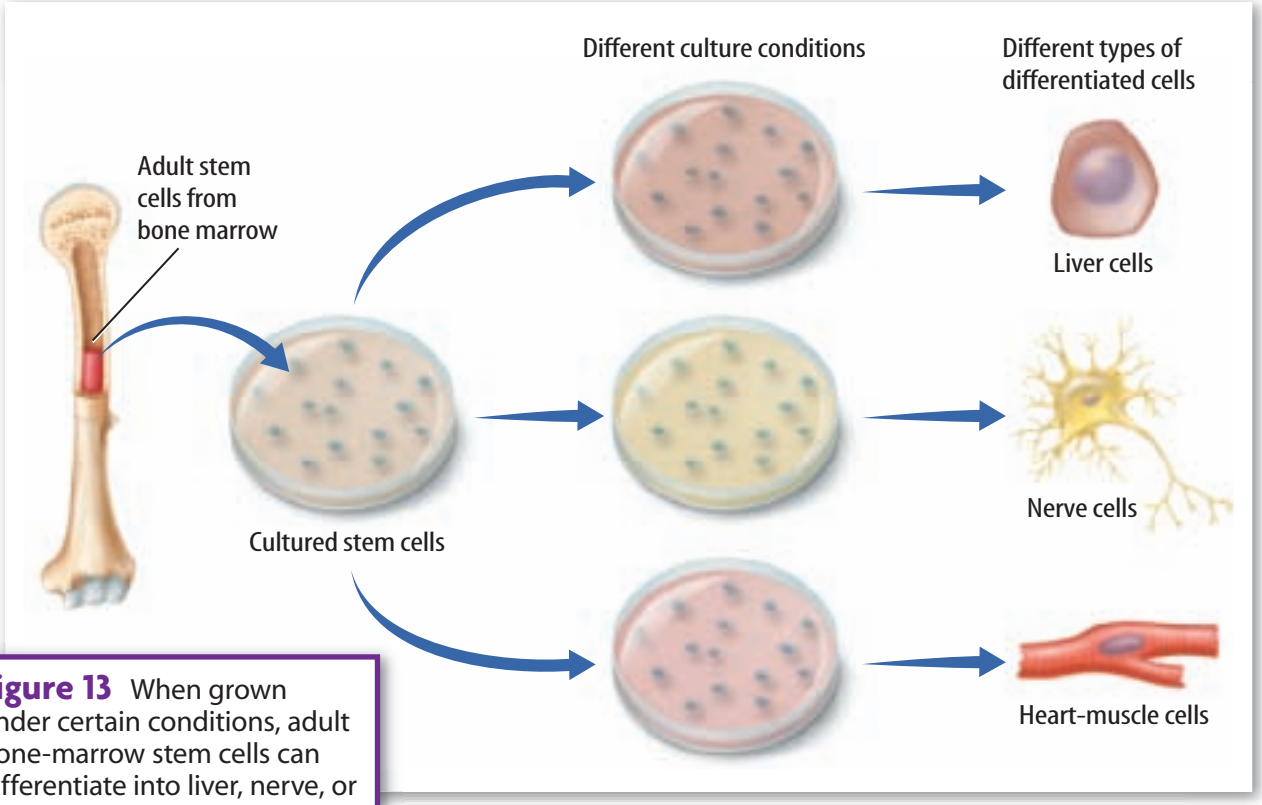


Figure 13 When grown under certain conditions, adult bone-marrow stem cells can differentiate into liver, nerve, or heart-muscle cells.

Infer how stem cells could be important for treating diseases.

Stem Cells Once most human cells differentiate, they cannot become any other type of cell. However, some cells in your body are undifferentiated. These cells, called **stem cells,** can become different types of cells. For example, there are stem cells in the middle of some of your bones. Under the right conditions, these stem cells can become many different types of cells, as shown in **Figure 13.**

Plant Cells Some plant cells can differentiate into another type of cell after they have differentiated into a specific type of cell. For example, the leaf of a begonia plant, as shown in **Figure 14,** contains differentiated cells with specialized functions. However, if you correctly cut a leaf from a begonia plant, place it on soil, and give it proper growing conditions, it can produce new plants.

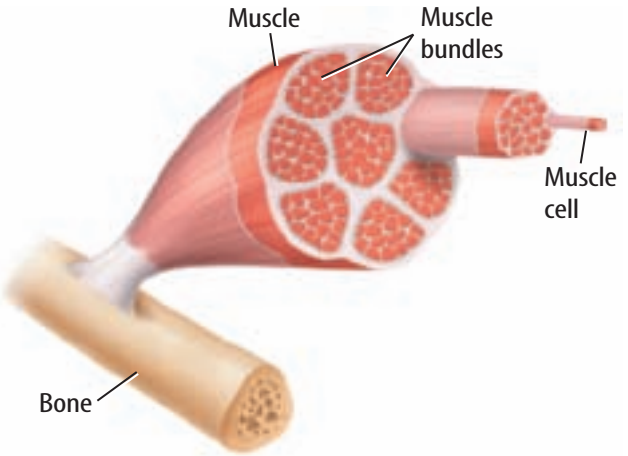
Figure 14 This begonia leaf has differentiated cells. However, the cells can differentiate again into other cell types and produce new begonia plants.

Tissues

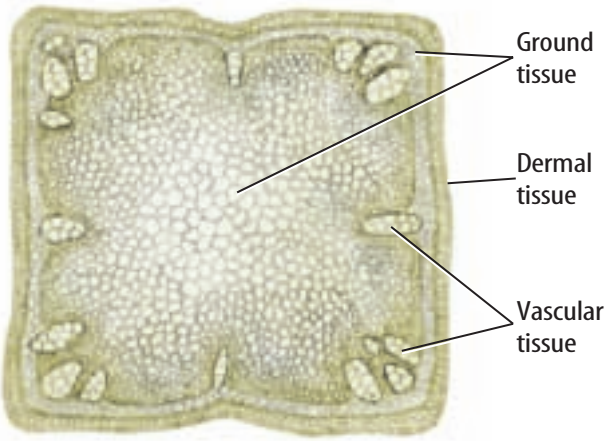
The cast of a play is made of different actors. Each actor must recite his or her lines to tell the play's story. Similarly, most multicellular organisms have groups of similar cells that work together and perform a function. A group of cells that work together and perform a function is a **tissue.** For example, skeletal muscle tissue in your body is made of cells called muscle fibers, as shown in **Figure 15.** The muscle fibers contract and relax and allow your body to move. Plants also have tissues, as also shown in **Figure 15.**

Reading Check What is an example of a tissue?

Figure 15 Tissues are similar cells that work together to perform one or more functions.



Animal Tissue



Plant Tissue

MiniLab 00:20 minutes

What's in a tissue?

You read that different cell types make up tissues. Each cell type in a tissue has a specific function and contributes to the tissue's function.

Procedure

1. Using the **drawings in your text** and the **information provided by your teacher,** organize a tissue that will absorb nutrients.

Analysis

1. **Deduce** whether or not your tissue design is the only possible one. How did other students organize their tissue?
2. **Predict** where in a human body such a tissue might be found.

5.a, 7.d

SCIENCE USE V. COMMON USE

tissue

Science Use a group of cells that work together and perform a function.
Blood is a tissue that contains red blood cells, white blood cells, and platelets.

Common Use a disposable, paper handkerchief.
Please use a tissue to cover your mouth when you sneeze.

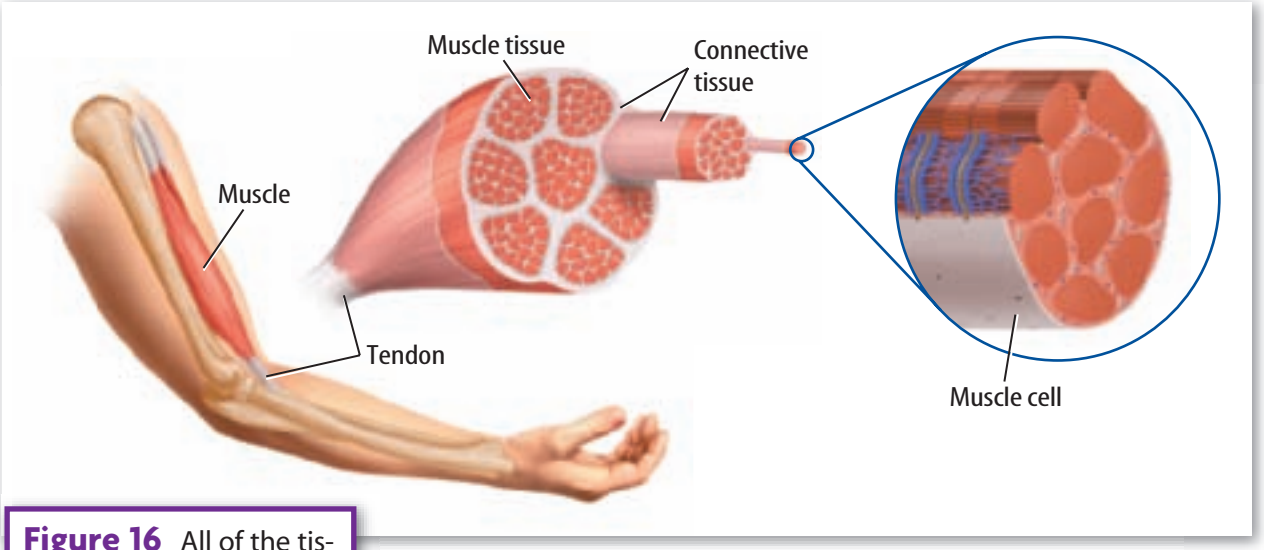


Figure 16 All of the tissues of an organ must work together so that the organ can function. If one of the tissues is not functioning as it should, the organ cannot function.

Organs

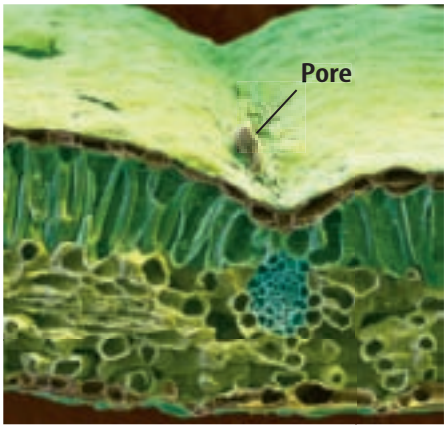
A play's stage crew might include carpenters and electricians. Both groups have specific functions, but work together to create a setting where the actors can perform. In a similar way, an **organ** is a group of similar tissues that work together to perform a function. Each tissue must function properly for the organ to function.

Human Organs Your heart, lungs, brain, stomach, and muscles are some of the organs in your body. A muscle, such as the bicep in your upper arm, is made of different tissues, as shown in **Figure 16.** Besides muscle tissue, a muscle also includes tissues that surround and protect muscle cells and other tissues that connect muscle tissues.

Plant Organs Plants also have organs that perform functions such as storing nutrients, exchanging gases, transporting water or nutrients, or performing photosynthesis. A leaf, as shown in **Figure 17,** is an example of a plant organ. Leaves have tissues that transport substances, provide protection, or are specialized for photosynthesis.

Figure 17 The dark-green tissue is like the skin of a leaf. It has pores that allow gases to enter and exit the leaf. The tissue that looks like blobs is made of cells that perform photosynthesis.

Infer where chlorophyll would be found in this leaf.



Organ Systems

The cast of actors in a play work with makeup and wardrobe specialists, the director, and others in order to perform on stage. In a similar way, some organs in an organism work together. An **organ system** is one or more organs that work together and perform one or more functions. The muscles in your body work together with the bones of your skeleton to allow your body to move. The muscles and bones in your body make up your musculoskeletal system. Your heart, lungs, and digestive system work together to supply your muscles and bones with what they need to work together. Your brain receives and sends signals that coordinate all the organ systems in your body, as listed in **Table 2.**

Reading Check Which organ systems work together to supply the needs of your musculoskeletal system?

Table 2 Human Organ Systems

System Name	Organs	Function
Integumentary (ihn teg yuh MEN tuh ree)	skin	protection and homeostasis
Skeletal	bones, cartilage, ligaments, and joints	protection and support; mineral storage
Muscular	muscles	movement
Nervous	brain, spinal cord, nerves, and sensory receptors	response and regulation
Endocrine (EN duh krun)	pituitary, thyroid, parathyroids, adrenals, thymus, pancreas, pineal, ovaries (females), and testes (male)	produces hormones that control body functions
Cardiovascular (kar dee oh VAS kyuh lur)	heart, blood vessels	transports blood that carries oxygen, nutrients, and wastes
Lymphatic (lihm FA tihk)	lymph nodes, tonsils, spleen, lymphatic vessels	returns fluid to blood and filters blood
Respiratory	nasal passages, pharynx, larynx, trachea, bronchi, and lungs	delivers oxygen to and removes carbon dioxide from blood
Digestive	mouth, esophagus, stomach, small and large intestines, rectum, anus	breakdown food and deliver nutrients and water to the blood
Urinary	kidneys, ureters, bladder, urethra	maintains homeostasis; removes nitrogen-containing substances from blood
Reproductive	• female—fallopian tubes, uterus, vagina, ovaries • male—scrotum, penis, accessory glands, testes	produce offspring

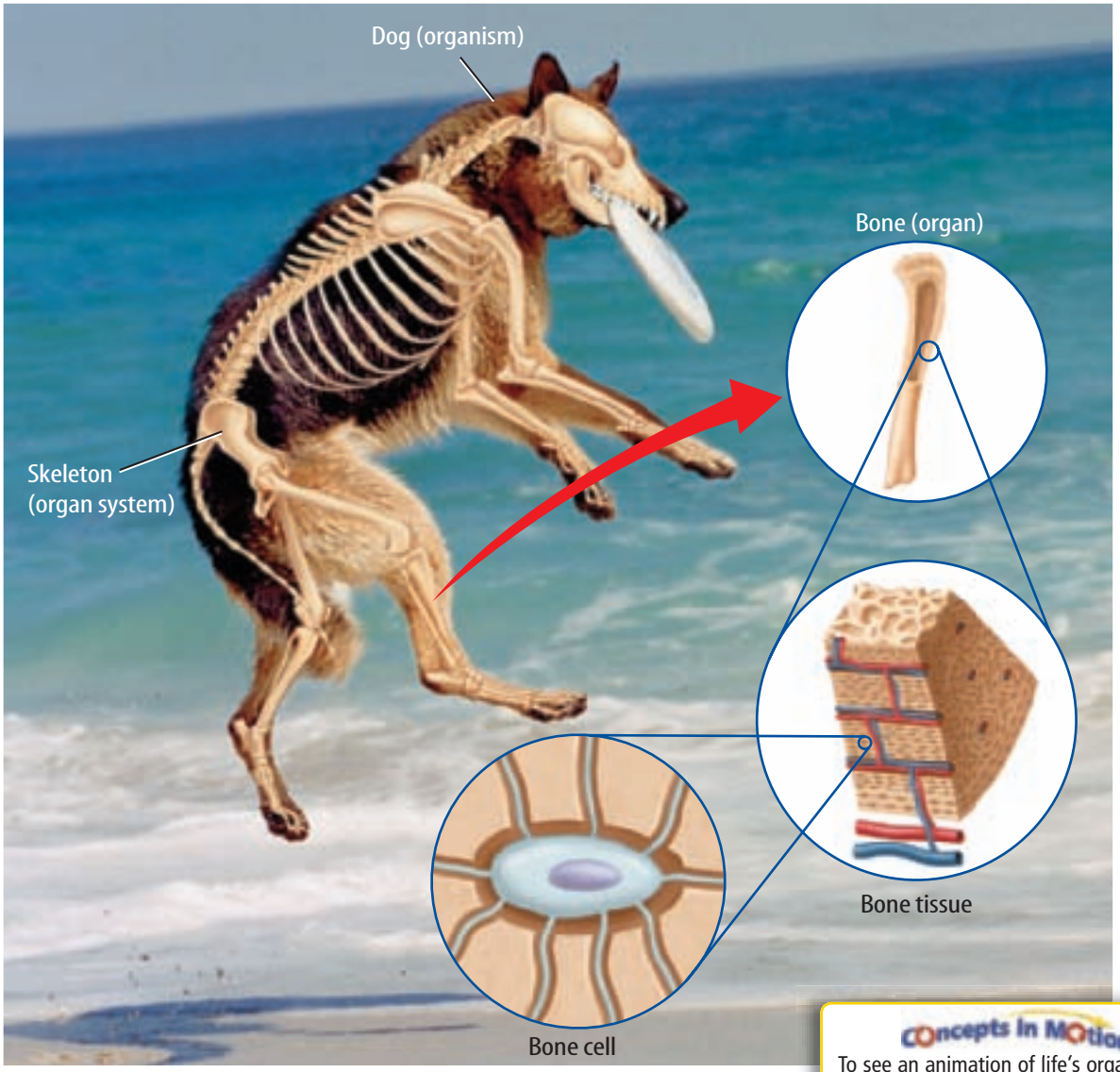
Concepts in Motion

Interactive Table To explore more about human organ systems, visit Tables at ca7.msscience.com.

Organism

The most complex unit of living things is a multicellular organism. Multicellular organisms, such as the dog shown in **Figure 18,** usually have many organ systems. Each organ system has its own function but is dependent on other organ systems. For example, your circulatory system transports nutrients throughout your body. The nutrients come from the breakdown of food in your digestive system. Your organ systems depend on your nervous system. You would not be able to breathe, move, reproduce, or eat without your nervous system. Without all these levels of organization, your body would be like a jumble of food, wastes, gases, and cells.

Figure 18 An organism is made of organ systems, organs, tissues, and cells that all function together and enable the organism's survival.



Concepts in Motion
To see an animation of life's organization, visit ca7.msscience.com .

CONTENTS

What have you learned about levels of organization?

Even the simplest single-celled organisms are organized. Most single-celled organisms perform all the functions they need for life inside one cell. Multicellular organisms have many types of specialized cells. Different types of differentiated cells have different functions.

Multicellular organisms have many levels of organization. They have groups of different cells called tissues that function together. Groups of tissues form an organ that performs a function. Two or more organs that perform a function are an organ system.

LESSON 2 Review

Summarize

Create your own lesson summary as you write a script for a **television news report.**

1. **Review** the text after the **red** main headings and write one sentence about each. These are the headlines of your broadcast.
2. **Review** the text and write 2–3 sentences about each **blue** subheading. These sentences should tell *who, what, when, where,* and *why* information about each **red** heading.
3. **Include** descriptive details in your report, such as names of reporters and local places and events.
4. **Present** your news report to other classmates alone or with a team.

ELA7: LS 2.2

Standards Check

Using Vocabulary

1. Distinguish between stem cells and differentiated cells. 1.f
2. In your own words, write a definition of an organ system. 5.a

Understanding Main Ideas

3. Which is a group of similar tissues that work together to perform a function? 5.a
   - **A.** organism
   - **B.** organ
   - **C.** prokaryote
   - **D.** organ system
4. **Compare** the organization of a single-celled organism to a multicellular organism. 5.a
5. **Give an example** of a differentiated cell and **state** how it is specialized. 1.f
6. **Sequence** the levels of organization from a cell to an organism. 5.a
7. **Compare and Contrast** Copy and fill in the graphic organizer below to compare and contrast a protist and a human skin cell. 5.a

	Similarities	Differences
Protist/ human skin cell		

Applying Science

8. **Predict** why multicellular organisms need levels of organization. 5.a
9. **Assess** What criteria would you use to assess the developmental potential of a cell? 1.f

Science Online

For more practice, visit **Standards Check** at ca7.msscience.com.

Design Your Own Lab

Model and Invent: Design an Organ

Materials

colored pencils
paper
reference materials

Science Content Standards

5.a Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.

7.d Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of Earth's plates and cell structure).

7.e Communicate the steps and results from an investigation in written reports and oral presentations.

Problem

Organs are made up of tissues. Even organs that appear to be made up of only one type of tissue include cardiovascular tissue for oxygen supply and waste removal. Some organs have more than one function, although those functions are related.

Form a Hypothesis

When an organ has more than one function, do the cells and tissues interact differently than in a tissue?

Collect Data and Make Observations

1. Obtain reference materials from your teacher.
2. Using at least two types of tissue, design an organ that will move nutritive substances and absorb nutrients. Remember that the absorbed nutrients have to travel to the rest of the body.
3. Use colored pencils to draw the organ. Include cross sections and label the different tissues.

Analyze and Conclude—Interpret Your Data

1. **Outline** the process you used to design the organ. What types of cells are included in your design?
2. **Describe** the types of tissue you included in your organ design. What is the purpose of each tissue?
3. **Explain** how each tissue supports the organ's function.
4. **Formulate models** for each tissue type that could be combined to model the organ you have designed.
5. **Compare and contrast** the two functions of the organ you have designed. How do the two functions interact?
6. **Summarize** how the tissues in your organ design interact. How did the cells of the tissue you designed in the previous lab interact? Is there a difference between how the tissues interact and how the different tissues interact?

Communicate—Share Your Design

Share your design with your classmates. Explain the different tissues you used and how they interact to support the function of the organ.

Real World Science

Science & Career

David Burgess, PhD

David Burgess is a research scientist and biology professor. His research includes studying the role of a cell's cytoskeleton during cytokinesis—the division of the cytoplasm during cell division. The cytoskeleton plays an important role when the cell membrane pinches in or forms a contractile ring during cytokinesis. A focus of his research is how the formation of the contractile ring is related the timing of the mitotic cycle of cell division.

Write lyrics to a song about mitosis. Include relevant facts about what is occurring to the cell in your song. Visit **Careers** at **ca7.msscience.com** for additional references.

Science & Technology

Healing Burns with Artificial Skin

Serious burns require skin grafts—uninjured pieces of skin collected from the patient's body and transferred to the burned area. What if there isn't enough uninjured skin to provide a graft? Doctors can use artificial skin to temporarily cover the injured skin and promote healing. In the meantime, samples of the patient's healthy skin are removed and grown in the lab. When the new skin has grown large enough to cover the injured area, the artificial skin is surgically removed and replaced with the new skin.

Visit **Technology** at ca7.msscience.com to research treatment options for burns. Use the information to compare and contrast traditional skin grafts with those using artificial and cultured skin.

Science & History

Walther Flemming

Walther Flemming was the founder of cytology, the study of chromosomes. In the late 1800s, he used specific dyes to observe cell division. Flemming saw threadlike structures in a cells' nucleus separate and move into new cells. He called the thread-like structures chromatin and later they were named chromosomes. Flemming was the first person to use the term *mitosis* for the division of a cell's nucleus.

Draw the four stages of mitosis—prophase, metaphase, anaphase and telophase—and present your drawing to the class. Describe what is happening to the cell at each stage.

Science & Society

SIGN UP, SAVE LIVES

Over 90,000 people in the United States wait for organ donations each year, and one in three will die before organs become available. One person can give organs to eight people and his or her tissues can help 50 individuals. Organ donations cannot be made if a person's wishes are not known. Most states, including California, now have state registries of people who are willing to donate their organs at the time of their death. In California, a pink sticker like the one to the left is placed on the driver's license of an organ donor.

Visit Society at ca7.msscience.com to find information about organ donation. Debate the pros and cons of having a national organ donation registry.

ELA7: LS 2.4

Standards Study Guide

The BIG Idea Nearly all the cells in an organism are genetically identical and are organized to work together.

Lesson 1 The Cell Cycle and Cell Division

1.c, 1.e, 7.a

Main Idea **The life of a cell usually includes a period of growth and reproduction.**

- The cell cycle is a eukaryotic cell's period of growth and development and reproduction.
- Different cell types have different cell cycle lengths.
- A cell's nucleus divides in a process called mitosis.
- Mitosis and cell division result in identical daughter cells.

- **anaphase** (p. 92)
- **cell cycle** (p. 88)
- **cell plate** (p. 94)
- **centromere** (p. 90)
- **cytokinesis** (p. 91)
- **daughter cell** (p. 94)
- **homologous chromosome** (p. 89)
- **interphase** (p. 88)
- **metaphase** (p. 92)
- **mitosis** (p. 91)
- **prophase** (p. 92)
- **sister chromatid** (p. 90)
- **telophase** (p. 92)

Lesson 2 Levels of Organization

1.f, 5.a, 7.d, 7.e

Main Idea **From single-celled to multicellular organisms, all living things are organized.**

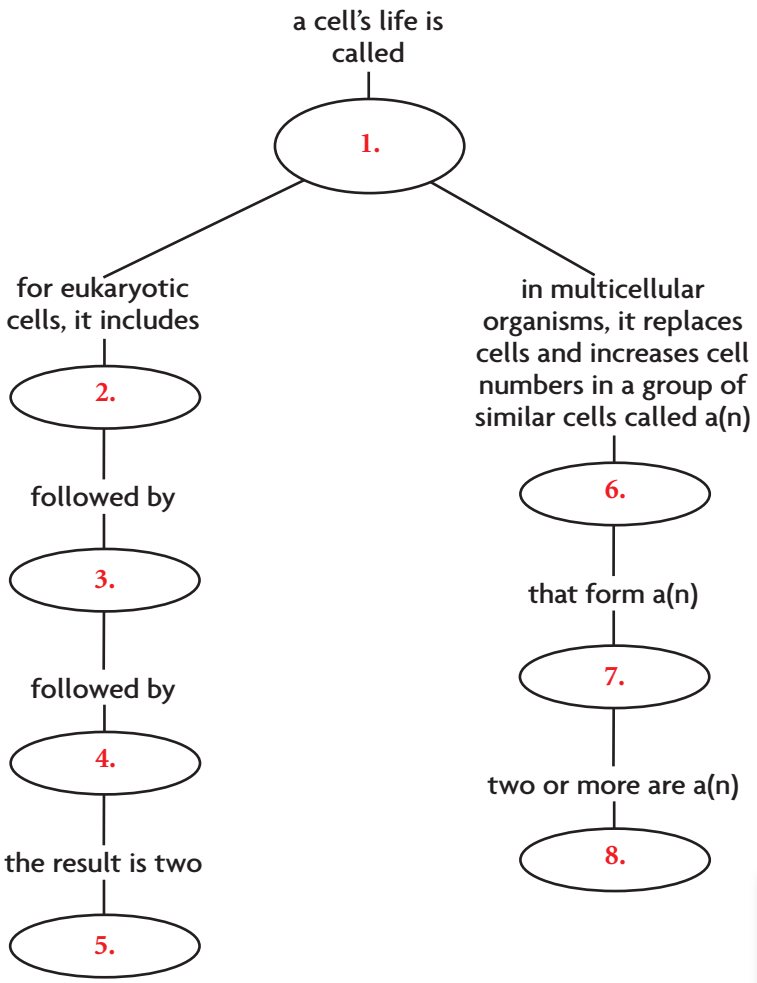
- Even the simplest single-celled organisms are organized.
- Single-celled organisms perform all the functions needed for life in one cell.
- Multicellular organisms have many types of specialized cells.
- Different types of differentiated cells have different functions.
- Multicellular organisms may have many levels of organization.

- **cell differentiation** (p. 100)
- **organ** (p. 104)
- **organ system** (p. 105)
- **stem cell** (p. 102)
- **tissue** (p. 103)

STUDY TO GO Download quizzes, key terms, and flash cards from ca7.msscience.com.

Linking Vocabulary and Main Ideas

Use the vocabulary terms from page 112 to complete this concept map.



Using Vocabulary

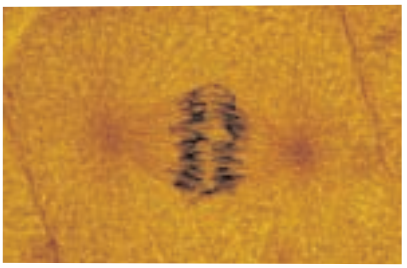
Fill in the blanks with the correct vocabulary words. Then read the paragraph to a partner.

New eukaryotic cells are produced by ___9.___ followed by ___10.___ . Pairs of replicated ___11.___ consist of two ___12.___ attached at a region called a(n) ___13.___ and become visible during ___14.___ . They move to the center of the cell during ___15.___ , and separate and move in opposite directions during ___16.___ . Two new nuclei form during ___17.___ . In plant cells, a(n) ___18.___ forms from the cell membranes of newly formed cells.

Understanding Main Ideas

Choose the word or phrase that best answers the question.

1. Which phase of the cell cycle is shown below?



A. telophase 1.e
B. anaphase
C. metaphase
D. prophase

2. What is usually the longest phase of the cell cycle?
A. interphase 1.e
B. mitosis
C. cytokinesis
D. prophase

3. When are chromosomes replicated?
A. mitosis 1.e
B. G1 phase
C. G2 phase
D. S phase

4. Chromosomes line up in the middle of the cell during which phase of mitosis?
A. telophase 1.e
B. prophase
C. metaphase
D. anaphase

5. When does the cytoplasm divide?
A. interphase 1.e
B. mitosis
C. telophase
D. cytokinesis

6. Which term best describes a muscle fiber?
A. organ 5.a
B. cell
C. organ system
D. tissue

7. Which cells might be used in laboratory to make heart cells?
A. liver cells 1.f
B. bone marrow cells
C. brain cells
D. leaf cells

8. Which is the most complex level of organization?
A. organ system 5.a
B. organ
C. cell
D. tissue

9. How would you best describe the structure at the end of the arrow?

A. cell 5.a
B. organ
C. tissue
D. organ system

10. What level of organization does a leaf represent?
A. cell 5.a
B. organ
C. tissue
D. organ system

Applying Science

11. **Give an example** of a cell type that has a short cell cycle. 1.e

12. **Predict** what would happen if your skin cells were unable to perform mitosis. 1.e

13. **Hypothesize** why the length of the cell cycle is usually short during development from a fertilized egg. 1.e

14. **Compare** the daughter cells formed in mitosis to the original cell that divided to produce them. 1.e

15. **Give an example** of a cell that can make different types of cells. 1.f

16. **Compare** the levels of organization in this textbook to the levels of organization in a multicellular organism. 5.a

Textbook	Organism

17. **Infer** why some single-celled eukaryotes might form a colony. 5.a

18. **Rearrange** the following events that happen during mitosis and cell division in the order that they happen: *chromosomes line up at the center of the cell, nuclear membrane breaks apart, plasma membrane pinches inward, sister chromatids separate.* 1.e

WRITING in Science

19. **Write** a paragraph to explain the following sentence: *It is easier for a begonia leaf to become a new begonia plant than it is for an animal's skin to become a new animal.*

Cumulative Review

20. **Summarize** the phases of mitosis in your own words. 1.e

21. **Explain** why the nucleus is sometimes called the brain of a cell. 1.c

22. **Describe** how a prokaryote is organized. 1.a

Applying Math

Use the table below to answer questions 23–26.

Two Phases of Mitosis

Class Period	Prophase	Telophase
1	4	1
2	5	2
3	2	2
4	3	1
5	3	1

Students in five classes observed cells and identified phases of mitosis. Each class observed 30 cells. The table above lists the number of cells observed in prophase and telophase.

23. What is the probability of a first-period student observing a cell in prophase? MA7: NS 1.0, SP 1.0

24. What is the probability of a second-period student observing a cell in prophase? MA7: NS 1.0, SP 1.0

25. What is the probability of a third-period student observing a cell in telophase? MA7: NS 1.0, SP 1.0

26. What is the probability of a fifth-period student observing a cell in telophase? MA7: NS 1.0, SP 1.0

Standards Assessment

1 **Groups of cells that all do the same sort of work are called**

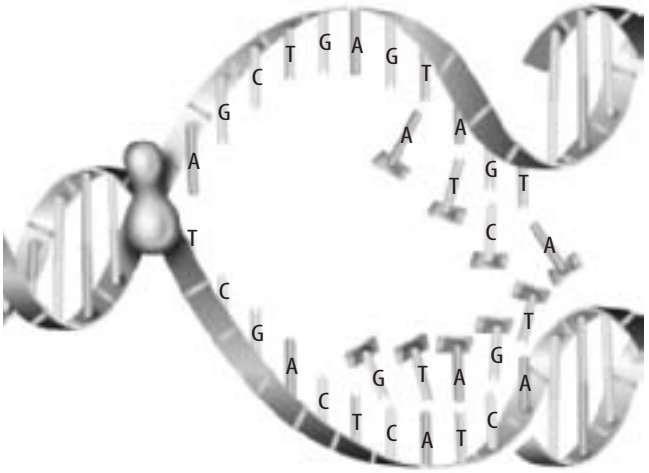
A organs.

B organelles.

C tissues.

D nerves. 5.a

2 **The diagram below shows replication of DNA.**



When does this occur in the cell cycle?

A prophase

B metaphase

C interphase

D anaphase 1.c, 1.e

3 **Following cell division, each new cell's nucleus has**

A half the number of chromosomes as the parent cell.

B identical chromosomes to the parent cell.

C an assortment of the chromosomes from the parent cell.

D all different chromosomes than the parent cell. 1.c, 1.e

4 **Which describes homologous chromosomes in G_1?**

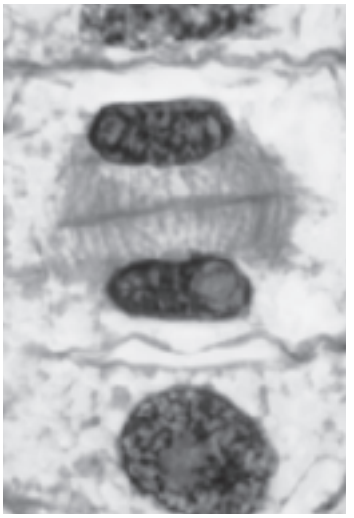
A paired

B duplicated

C tightly coiled as sister chromatids

D in a row at the cell's center 1.e

5 **The photo below shows a plant cell.**



Which phase of this plant's cell cycle is shown?

A cytokinesis

B metaphase

C interphase

D prophase 1.e

6 **What is the main purpose of mitosis?**

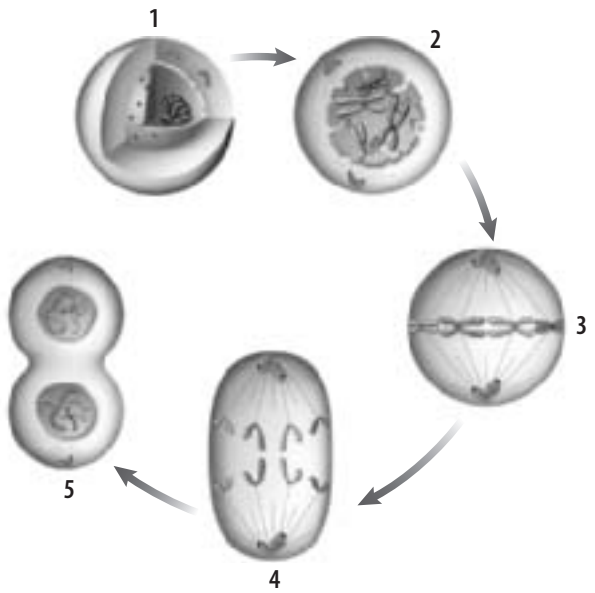
A to produce different cells

B to pair up the chromosomes in a cell

C to reduce the number of chromosomes in a cell in half

D to make a copy of the genetic material in a cell's nucleus 1.e

7 **The figure below shows a cell reproducing.**



Which best describes what happens during step 4?

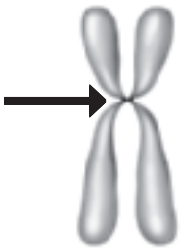
A Each duplicated chromosome pair moves to one end of the cell.

B The genetic material in the cell is duplicated.

C The sister chromatids separate.

D Membranes form around identical nuclei. 1.e

8 **Sister chromatids are shown to the right. What does the arrow point to?**



A Golgi apparatus

B centromere

C ribosome

D cytoplasm 1.c

Use the table below to answer questions 9–11.

Mitosis	
Phase	**Description of Chromosomes**
1	Chromosomes have moved to opposite ends of the cell
2	Chromosomes are clustered near center the cell's center
3	Chromosomes are in a line across the center of the cell
4	Chromosomes are enclosed in two new nuclei

9 **Which phase is number 1?**

A anaphase

B metaphase

C prophase

D telophase 1.e

10 **Which phase is number 2?**

A anaphase

B metaphase

C prophase

D telophase 1.e

11 **Which phase is number 3?**

A anaphase

B metaphase

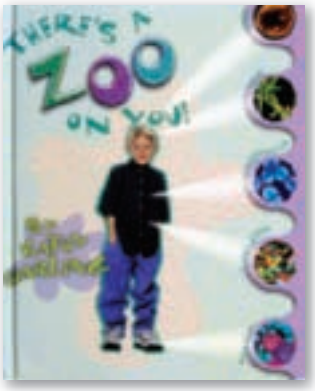
C prophase

D telophase 1.e

Reading on Your Own...

From the Recommended Literature for Science and Math

Are you interested in learning more about cells and multicellular organisms? If so, check out these great books.



Nonfiction

There's a Zoo on You, by Kathy Darling, focuses on symbiotic organisms that live together and share food. The book has numerous color photographs of microorganisms including bacteria, E. coli, dust mites, eyelash mites, staphylococcus aureus, and papoviruses. ***The content of this book is related to Science Standard 7.1.***

Historical Fiction

Fever, 1793, by Laurie Anderson, describes the Yellow Fever epidemic in Philadelphia in 1793 through the eyes of Mattie, a teenage girl. The cause of the disease and possible cures were unknown. The book realistically describes how the citizens responded to the illness. ***The content of this book is related to Science Standard 7.1.***

Essay

101 Things You Don't Know About Science and No One Else Does Either, by James Trefil, contains easy-to-read essays that make science real. This book explores the top ten problems in science. ***The content of this book is related to Science Standard 7.2.***

Nonfiction

Blood, Bones, and Body Bits, by Nick Arnold, provides scientific information about the human body in a humorous way. This book explains the science of things that some would consider gross and disgusting. Cartoonlike drawings help explain the science. ***The content of this book is related to Science Standard 7.5.***
This book should be reviewed by an adult to determine appropriateness for specific readers.

UNIT 1 Unit Test

Choose the word or phrase that best answers the question.

1. Which term would not be used when describing a bacterium?
A. cell membrane
B. mitosis
C. prokaryote
D. single-celled 1.a

2. Which product of cellular respiration is used in photosynthesis?
A. carbon dioxide
B. glucose
C. lactic acid
D. oxygen 1.d

3. The table below includes some cell organelles and their functions.

Organelle	Function
X	Directs all cellular activities
Mitochondrion	Releases energy from molecules following glycolysis
Y	Captures light energy and makes glucose
Ribosome	Makes proteins from amino acids

Which organelle is X?
A. central vacuole
B. endoplasmic reticulum
C. lysosome
D. nucleus 1.c

4. Which organelle is Y?
A. chloroplast
B. Golgi apparatus
C. nucleolus
D. vesicle 1.b

Write your responses on a sheet of paper.

5. **Compare and contrast** a cell wall and a cell membrane. 1.b

6. The table below shows data from an experiment about the rate of photosynthesis.

Container	Distance from light (cm)	Bubbles per min
1	10	45
2	30	30
3	50	19
4	70	6
5	100	1

Conclude Water plants were placed at different distances from a light source. For 5 min, students counted the bubbles that formed on the plants. What conclusion can be made from this experiment? 1.d

7. **Describe** what occurs in a cell's cycle that results in genetically identical cells forming after cytokinesis. 1.e, 2.e

8. **Explain** what might be the result of damage to cells during the early development of organism. 1.f, 5.a

9. The photo below shows cytokinesis in a cell.

Determine if this is cytokinesis of a plant cell or an animal. Explain. 1.b