Section Preview of the Teacher's Edition for

Cell Biology 2nd Edition

Activities 2-4

Suggested student responses and answer keys have been blocked out so that web-savvy students do not find this page and have access to answers.

To experience a complete activity please request a sample found in the footer at lab-aids.com

Issue-Oriented Science

2 Cells and Disease

LABORATORY • 1–2 CLASS SESSIONS

OVERVIEW

Students review the symptoms of two individuals, and compare their blood to normal blood in order to determine a diagnosis. Students are introduced to some of the causes of disease and the roles of abnormal human cells and foreign cells in noninfectious and infectious diseases. A case study describes the *Plasmodium* parasite, a foreign cell that causes malaria, and the sustainability issues associated with malaria.

KEY CONTENT

1. Some human diseases are caused by abnormalities that develop within the body's cells, while others are caused by microbes.
2. Some diseases, including sickle cell disease and malaria, are diagnosed by viewing blood samples from the affected individual through a light microscope.

KEY SCIENCE PRACTICES

1. Students make and record observations.
2. Students develop conclusions based on evidence and reasoning.

MATERIALS AND ADVANCE PREPARATION

For the teacher

Literacy Transparency 2, "Read, Think, and Take Note"
Scoring Guide: UNDERSTANDING CONCEPTS (UC)
Science Skills Transparency 3, "How to Use a Microscope" (optional)

For each group of four students

prepared slide, "Patient A Blood"
prepared slide, "Patient B Blood"

For each pair of students

microscope*
prepared slide, "Typical Human Blood"

For each student

6 Student Sheet 2.1, "Disease Information"
3 sticky notes*
Science Skills Student Sheet 6, "Parts of a Microscope" (optional)
Science Skills Student Sheet 7, "Microscope Magnification" (optional)
Scoring Guide: UNDERSTANDING CONCEPTS (UC) (optional)

**Not supplied in kit*

Each student will need 6 copies of Student Sheet 2.1, "Disease Information," over the course of the unit, one for each case study.

Masters for Science Skills Student Sheets are in Teacher Resources II: Diverse Learners. Masters for Literacy transparencies are in Teacher Resources III: Literacy. Masters for Scoring Guides are in Teacher Resources IV: Assessment.

TEACHING SUMMARY

Getting Started

- Discuss why the study of cells is important to understanding human health.

Doing the Activity

- Students complete the investigation.
- (LITERACY) Introduce the "Read, Think, and Take Note" reading strategy.
- (LITERACY) Students read a case study about malaria.

Follow-up

- Discuss the cellular bases of two diseases.
- Introduce the SEPUP Assessment System.
- (UC ASSESSMENT) Discuss how the structures of cells allow cells to perform their functions.
- Students learn about evidence and trade-offs.

BACKGROUND INFORMATION

Compound light microscopes and electron microscopes are two of the most important tools that have advanced scientists' work in the life sciences and cell biology. The size of an object that can be observed through a microscope depends on its magnification and resolution. Magnification is the ratio of the specimen's image to its actual size. Resolution is a measure of the microscope's ability to clearly distinguish two separate objects, and is inversely related to the wavelength of radiation passing through the specimen.

The Light Microscope

In a compound light microscope two lenses—the ocular lens in the eyepiece and one of the objective lenses—magnify an image when light passes through the specimen. The light is directed upward from below the microscope stage either by way of a mirror or from a built-in light bulb and is usually controlled by a condenser lens below the stage. A modern light microscope magnifies an image up to 1,000 times, a range in which scientists can study tissues, cells and some of their internal structures, and some living organisms. For a viewer to observe a particular level of detail, tissues or cells may have to be fixed and thin-sectioned. Sometimes staining a specimen with a dye allows a viewer to more easily view specific parts of the specimen. The resolution of a light microscope is approximately 200 nanometers, which is the size of a small bacterial cell; this limit is determined by the wavelengths of light that can be passed through the specimen.

The Electron Microscope

An electron microscope magnifies an image by focusing beams of electrons on the image. Electron microscopes can magnify specimens much smaller than a light microscope can, with the most powerful ones magnifying 1,000 times more than a light microscope. Because electron beams have much shorter wavelengths, the resolution is approximately 2 nanometers, which is 100 times higher than a light microscope. For an image to be viewed in an electron microscope, it must be preserved and dehydrated, which means living cells and organisms cannot be viewed with an electron microscope. There are two types of electron microscopes: transmission electron microscopes (TEMs), and scanning electron microscopes (SEMs). Transmission electron microscopes focus a beam of electrons through a thin slice of the specimen, making visible the details of the specimen. Scanning electron microscopes scan a beam of electrons back and forth across the specimen surface and produce a three-dimensional view of the specimen surface.

GETTING STARTED

1 Ask students where they think cells are involved in life processes. Students might know that cells make up skin and are part of what sloughs off when skin is dry. They might also say that cells (sperm and egg) are involved in the reproduction of organisms. Then ask why they think scientists and doctors study cells. Students are likely to say that doctors study cells to see if something is wrong or if someone is sick, and that scientists study cells to understand them and how they work. Some students may have had a medical professional take a throat culture or a blood sample from them. Throat cultures can detect the presence of disease-causing bacteria, such as the *Streptococcus* that causes strep throat. Blood samples are observed under a microscope to detect abnormal numbers or shapes of blood cells or infectious organisms.

2 Cells and Disease

1 In the previous activity, you learned about some of the factors that influence world health and disease. A **disease** is any breakdown in the structure or function of an organism. Scientists who study a particular disease gather information about how that disease affects the organism. They look at all levels of the organism, from molecules and cells to organs and the whole organism. Some scientists, like cell biologists, use microscopes to study the structure and function of cells in the full array of organisms, from humans to plants to insects to microbes. A **microbe** is a microscopic cellular organism or a virus, and some microbes cause infectious diseases. One way to detect and study many diseases is to compare blood from healthy and sick individuals under a microscope. In this activity you will examine samples of blood from healthy and diseased people.

Challenge

How do observations of cells help doctors and scientists diagnose and study diseases?

MATERIALS

FOR EACH GROUP OF FOUR STUDENTS
- prepared slide, "Patient A Blood"
- prepared slide, "Patient B Blood"

FOR EACH PAIR OF STUDENTS
- microscope
- prepared slide, "Typical Human Blood"

FOR EACH STUDENT
- 6 Student Sheet 2.1, "Disease Information"
- 3 sticky notes

DOING THE ACTIVITY

2 Project Science Skills Transparency 3, "How to Use a Microscope." Review the guidelines as necessary with your students. You may also choose to pass out copies of Science Skills Student Sheet 6, "Parts of a Microscope," to review with students. For more information and support for using microscopes, see Teacher Resources II: Diverse Learners.

3 Instruct students to read the patient histories and the table of possible diseases before you pass out the microscope slides. You may wish to have students discuss the disorders so that you make sure they understand that the diseases are difficult to distinguish based on symptoms alone. If necessary, pass out and review copies of Science Skills Student Sheet 7, "Microscope Magnification." Instruct students to refer to the guidelines in the Student Book as they observe the slide of typical human blood.

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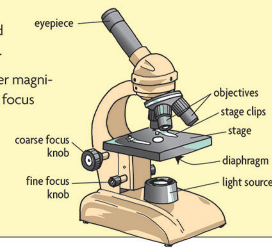
Focusing a Microscope

Be sure that your microscope is set on the lowest power before placing your slide onto the microscope stage. Place the slide on the microscope stage. Center the slide so that the sample is directly over the light opening, and adjust the microscope settings as necessary. If the microscope has stage clips, secure the slide in position so that it does not move.

Observe the sample. Focus first with the coarse-focus knob, and then adjust the fine-focus knob.

After switching to a higher power magnification, be careful to adjust the focus with the fine-focus knob only.

Return to low power before removing the slide from the microscope stage.



Safety

Always carry a microscope properly with both hands—one hand underneath and one holding the microscope arm. Because you are working with live organisms, be sure to wash your hands thoroughly after you finish the laboratory.

Procedure

Part A: Using the Light Microscope

1. Your teacher will demonstrate the different parts of a microscope, as shown in the figure above.

2

2. In your group of four, review the rules for handling a microscope. Demonstrate your knowledge of the parts of a microscope, according to your teacher's instructions.
3. Review the guidelines for focusing a microscope shown above.

3

Part B: Observing Blood

You are a doctor who has recently seen two patients who reported similar symptoms. From your examination of each patient you have gathered more information, which is shown below.

HISTORY FROM PATIENT A:

- Patient reports periods of feeling sick, but feels well most of the time.
- Patient recently returned from working in Africa with the Peace Corps.
- Patient reports frequent fevers, chest pains, and lung infections throughout youth and adulthood.

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4 You may wish to stop the class when they have completed Procedure Step 4, and have the class discuss what they observed. Ask students to describe the typical human red blood cells. They should notice that although the cells vary slightly, they are all round and red. Then ask students how the blood from Patient A compared to the typical human blood. Patient A's sample has fewer cells than the normal blood, and, while some of them are round, others are oblong or boomerang-shaped. Finally ask students how the blood from Patient B compared to the typical human blood. Students should notice that Patient B's red blood cells look normal, but purplish objects with black dots appear among the red blood cells.

- After a two-hour hike a few months ago, she became so tired and out of breath that physical movement was difficult. She experienced joint and muscle pain in her arms and legs.

SYMPTOMS SEEN ON EXAMINATION TODAY:

- Vision problems and yellowing of eyes and skin.
- Abdominal area is tender to the touch.

HISTORY FROM PATIENT B:

- Patient reports becoming sick shortly after returning from a trip to Africa in the past month.
- Patient reports severe headaches and fatigue for the past few weeks.
- Patient reports a fever and muscle and joint pain in the past week.

SYMPTOMS SEEN ON EXAMINATION TODAY:

- Yellowing of the eyes.
- Abdominal area is tender to the touch.

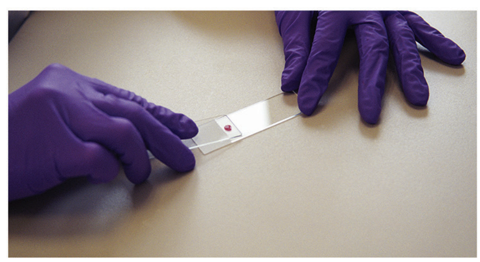
4

4. Prepare a chart with four columns labeled as shown below.

Observations of Blood Samples

Slide	*Shape of cells*	*Color of cells*	*Number of cells in field of view*

With your partner, obtain a slide labeled "Typical Human Blood." This blood sample will serve as your reference. As you observe on medium or high power, record your observations in the chart.



A lab technician prepares a blood sample for viewing under the microscope.

5 5. Based on the patient's report and the examination, the patient's symptoms suggest one of four possible diseases. Read the descriptions of those diseases below. For each disease, draw a sketch of what you predict you would observe in a blood sample under the microscope as compared to the typical human blood you just observed.

Possible Diseases

DISEASE	SYMPTOMS	DESCRIPTION
Polycythemia vera	weakness, disturbed vision, headache, dizziness, enlarged liver, abdominal pain due to an enlarged spleen	An abnormality in the bone marrow causes an overproduction of red blood cells, almost double in some cases. This increases blood volume and thickness, leading to life-threatening blood clots.
Sickle cell disease	joint and muscle pain, anemia, vision problems, abdominal pain, yellowish color of skin and eyes, and frequent infections	An inherited genetic mutation (error) changes the hemoglobin protein, causing the proteins to stack on one another within the red blood cells. This produces a sickle- or banana-shaped blood cell. Sometimes under the microscope the sickle cells appear flattened.
Spherocytosis	yellowish color of skin and eyes, abdominal pain from an enlarged spleen, pale skin, and weakness	A genetic disorder causes the red blood cells to become small, spherically shaped and fragile. These cells are destroyed by the spleen. It is often diagnosed in childhood.
Malaria	fever, headaches, extreme fatigue, mild yellowish color of skin and eyes, abdominal pain, and body aches	An infectious disease, malaria is caused by a single-celled parasite of the genus *Plasmodium* and is carried by mosquitoes. A *Plasmodium* appears as an irregular purple spot containing dark dots when a sample is stained and viewed under a microscope.

6. Decide with your group which pair will first observe Patient A's blood and which will first observe Patient B's.
7. Observe, and draw what you see on the slide sample at medium or high power.
8. Switch patients' slides with the other pair in your group. Repeat Step 7 for the other patient.
9. In your science notebook, write hypotheses for which disease is affecting each patient. Include the information from the slide samples you observed and the "Possible Diseases" table to support your hypotheses.

6 10. Follow your teacher's directions for reading the case study about malaria. As you read, follow the "Read, Think, and Take Note" strategy. To do this:
- Stop at least three times during the reading to mark on a sticky note your thoughts or questions about the reading. Use the list of guidelines below to start your thinking.
- After writing a thought or question on a sticky note, place it next to the passage in the reading that prompted your note.
- Discuss with your partner the thoughts and questions you had while reading.

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5 Students should be able to eliminate polycythemia vera as a possible disease for either of the patients because each patient shows yellowing of the skin and eyes, and yellowing of the skin and eyes is not a symptom of polycythemia vera. Also, students might possibly preliminarily eliminate spherocytosis because it is diagnosed in childhood, and neither patient is a child.

6 (LITERACY) Tell students that they will read six case studies in this unit. The first case study, about malaria, appears in this activity. The literacy strategy "Read, Think, and Take Note" is an opportunity for students to record thoughts, reactions, or questions on sticky notes as they read. The notes serve to make concrete the thoughts arising in their minds and then serve as prompts to generate conversation or write explanations. Throughout this unit and the rest of *Science and Global Issues* you will see multiple opportunities for students to employ and become comfortable with this strategy. Explain to students that through these literacy strategies they are learning the ways in which proficient readers think while reading. Display the guidelines shown on Literacy Transparency 2, "Read, Think, and Take Note," in your classroom for students to refer to. Look for additional occasions for students to apply this strategy when reading text. For more information on "Read, Think, and Take Note," see Teacher Resources III: Literacy.

Distribute six copies of Student Sheet 2.1, "Disease Information" to each student. Review with students the columns of the table on the sheet. Tell them that they will be completing one Student Sheet for each of the six diseases they will read about in the unit. The case studies will provide information about the mechanism of the disease and the various aspects of sustainability—social, economic, and environmental—that pertain to the disease. Tell students that they will need to use the information from the case studies in the last two activities of the unit. If necessary, establish a place for students to store the Student Sheet so they can refer to it throughout the unit. Sample responses for malaria on Student Sheet 2.1, "Disease Information," are at the end of Activity 2 in this guide.

FOLLOW-UP

7 Ask, *What diagnosis did you give to Patient A, and what was your evidence?*

Patient A has sickle cell disease, because some of Patient A's blood cells were the long, thin, banana-shape characteristic of this disease, and the patient's symptoms match those of sickle cell disease. Explain that sickle cell disease is an example of a genetic disease. It results from abnormal hemoglobin proteins caused by an inherited mutation in a gene. Hemoglobin is a protein inside the red blood cells that carries oxygen and is one of a group of proteins called transport proteins, which carry molecules and ions through the body. When blood oxygen levels are low, the abnormal hemoglobin proteins in individuals with sickle cell disease stack on one another into long rods, which causes the normally disc-shaped red blood cells to become irregularly shaped and rigid. These are sickle cells. The sickle cells can clump together in the blood vessels and clog them. Sickle cells have shorter life spans than normal red blood cells, which leads to anemia (a decrease in the number of red blood cells). Since red blood cells carry oxygen through the blood, anemia leads to lowered oxygen, which can damage cells, tissues, and organs. Next ask, *What diagnosis did you give Patient B, and why?*

Patient B has malaria because although her blood cells look normal, among them are irregularly shaped objects with dark dots inside. These objects are most likely malaria parasites. The patient's symptoms also match those for malaria. Explain that malaria is an example of an infectious disease caused by a microbe, or disease-causing microscopic organism.

Read, Think, and Take Note: Guidelines

As you read, from time to time, write one of the following on a sticky note:

- Explain a thought or reaction to something you read.
- Note something in the reading that is confusing or unfamiliar.
- List a word that you do not know.
- Describe a connection to something you learned or read previously.
- Make a statement about the reading.
- Pose a question about the reading.
- Draw a diagram or picture of an idea or connection.

11. Complete the information for malaria on Student Sheet 2.1, "Disease Information" after you read the case study.

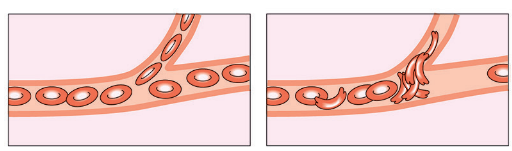
Analysis

1. Compare each patient's blood sample to a normal blood sample. What abnormalities do you observe?

7 2. Based on your observations, which patient has an infectious disease? Explain how you know.

8 3. Observe the diagrams below. Which patient would you diagnose with sickle cell disease? Explain, using evidence from this activity.

Patient 1 *Patient 2*



9 4. How do microscope observations of cells help doctors and scientists diagnose and study diseases? Give specific examples from this activity.

8 Ask, *Based on the diagram, how does the shape of normal red blood cells help them perform their function?*

The flexible disc shape allows them to flow through the blood vessels with the oxygen to carry it through the body. Then ask, *How does the shape of sickled red blood cells prevent them from performing their function?*

The sickled red blood cells are rigid and stack on one another. This causes them to clog the blood vessels, leading to weakness, pain, organ damage, and sometimes paralysis. This clogging is shown in the diagram in Analysis Question 3. Inform students that this is an example of how the structure of a cell helps it perform its function. If the structure is damaged in some way, the cell is no longer able to perform its function as well or at all. Emphasize that people are made of cells and that when they become sick it is often because something has gone wrong at the cellular level.

9 (UC ASSESSMENT) Students' written work from Analysis Question 4 can be scored with the UNDERSTANDING CONCEPTS (UC) Scoring Guide. This is as an opportunity to introduce the SEPUP Assessment System. Provide all students with a UC Scoring Guide, and ask them to keep it with their science notebooks, as they will refer to it several times in this unit and throughout the *Science and Global Issues* course. Explain to the class that you will use the UC Scoring Guide to provide feedback on the quality of their work. Let them know that you will use their writing in Analysis Question 4 to model how the Scoring Guide works.

Begin by pointing out the scoring levels 0–4, and review the criteria for each score. Explain that the scores are based on the quality of their responses and do not correspond to letter grades. A Level-3 response is a complete and correct response. A Level-4 response signifies that the student has both achieved and exceeded the acceptable level of response. Let students know that you would like them to strive to improve by at least one level in later activities. At first, many students will write Level-2 responses, and they should strive to achieve Level-3 and Level-4 responses.

As a class, discuss what a Level-3 response would include. A complete and correct response for Analysis Question 4 will include specific examples from the activity about how scientists and doctors use the microscope to diagnose diseases. You may develop a Level-3 exemplar with the class or share with students the Level-3 response shown in the Sample Responses. Point out the elements that make the example a Level-3 response, and discuss how a Level 1 and a Level 2 are different. Ask students for ideas about how to improve the Level-3 response to make it a Level 4.

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5. From what you learned about malaria in the case study

a. A **trade-off** is an exchange of one thing in return for another, giving up something that is a benefit or advantage, in exchange for something that may be more desirable. What are the trade-offs of using insecticides to kill the mosquitoes?

b. What are the benefits of using insecticides to kill mosquitoes that might be carrying *Plasmodium?*

6. Based on the malaria case study, how does resistance develop in a population of disease-causing microbes?

KEY VOCABULARY	
cell	noninfectious disease
disease	protein
infectious disease	protist
malaria	sickle cell
microbe	**trade-off**
mutation	**vector**

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10 ✓Analysis Question 5b is a Quick Check assessment to ensure that students understand the term, and can identify, trade-offs, which is a component of the EVIDENCE AND TRADE-OFFS scoring variable. One of the goals of *Science and Global Issues* is to teach students that:

1. decisions often involve trade-offs.

2. identifying trade-offs involves analyzing evidence.

Explain to students that in this unit they will make several decisions about world health and sustainability. In this activity students must decide what are the trade-offs of using insecticides to kill mosquitoes. In a decision involving trade-offs, something is given up to gain something else. Since many decisions involve trade-offs, it is important for students to understand that a perfect choice is often not possible. It is possible, however, to recognize and analyze the trade-offs associated with each decision. For example, when asked, “Paper or plastic?” at a store checkout counter, most shoppers make the choice quickly. But there are several trade-offs attached to choosing paper or plastic. A shopper who chooses paper may do so to avoid generating plastic waste or using up petroleum resources. In requesting the paper bag though, the shopper is contributing to other environmental problems, such as increased water and energy usage, and the higher amounts of solid waste and CO_2 emissions associated with making paper bags. Neither choice is particularly beneficial for the environment, and both choices have a downside. Identifying the trade-offs helps clarify the reasoning behind a decision, and the strength of the evidence relevant to making the most informed decision.

To further explore trade-offs, brainstorm with the class a list of decisions they make every day. Choose one, and talk through the associated trade-offs of deciding one way or another. This practice will familiarize students with ways of identifying and considering trade-offs for this and subsequent activities.

CASE STUDY

Malaria

MORE THAN THREE billion people worldwide live in areas where malaria transmission is a risk. Most of the deaths from malaria are in children. In the 1950s and 1960s, world health experts began an effort to wipe out malaria. Although their techniques reduced malaria for a while, they ultimately failed. Today, malaria still exists, and is even spreading to parts of the world where it was thought to have been wiped out or was not a high risk.

Burden of Disease

	NUMBER OF NEW CASES PER YEAR	NUMBER OF DEATHS PER YEAR
Worldwide	200–300 million	450,000
United States	1,500–2,000	0–10

SYMPTOMS AND DISEASE MECHANISM

People once thought that malaria was caused by inhaling the fumes from stagnant water, such as that in swamps. In 1880, a French army doctor first observed parasites inside the red blood cells of malaria patients. It has since been found that the cause of malaria in humans is one of several species of the single-celled parasitic protist *Plasmodium.*

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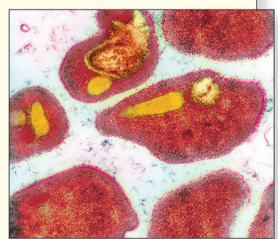

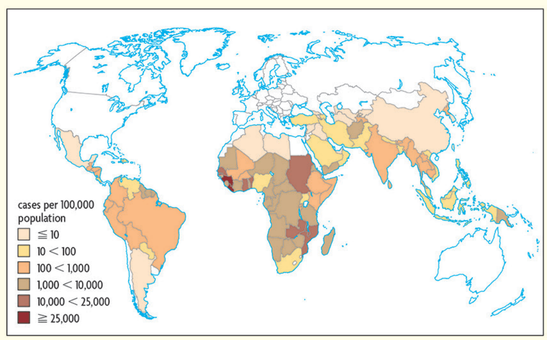

Plasmodium *parasites in the blood (above)*

Locations where malaria occurs (left)

SAMPLE RESPONSES

1. Some cells

2. Patient B probably

Sample Level-3 Response
Sometimes

3. Patient 2 (on the right)

4. (UC ASSESSMENT) A complete and correct response will include

5. a. The benefits are that the insec-

b. ✓The trade-offs of using

6. Antibiotic resistance develops

REVISIT THE CHALLENGE

Discuss responses to Analysis Question 4 to make sure students understand the importance of observing cells in diagnosing and studying diseases.

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Shortly after the discovery of *Plasmodium,* scientists determined that female mosquitoes, which breed in standing water, are the vectors for malaria. A **vector** is an organism that does not cause the disease itself, but spreads disease-causing microbes from one host to another.

The symptoms of malaria can be mild to deadly and include fever, chills, fatigue, an enlarged liver, an enlarged spleen, anemia (reduced number of red blood cells), seizures, coma, and kidney failure.

The following traces the steps of malaria infections:

1. A mosquito becomes infected with *Plasmodium* when it bites and sucks the blood of a human infected with *Plasmodium.*
2. When the infected mosquito bites a person it injects *Plasmodium* in its saliva into that person.
3. The *Plasmodium* travels from the point of the mosquito bite through the bloodstream to the liver and infects liver cells. The *Plasmodium* then begins to reproduce inside the liver cells. Sometimes *Plasmodium* remains in a person's liver and causes no symptoms. Other times the liver cells burst, releasing *Plasmodium.*
4. The *Plasmodium* travels back into the bloodstream from the liver, where it invades red blood cells and then reproduces. The infection is active at this point, and the person experiences symptoms.
5. The red blood cells eventually rupture, which releases the parasites back into the bloodstream where they might be picked up by another mosquito.

MALARIA PREVENTION AND TREATMENT

In the 1950s and 1960s, world health officials hoped to eradicate malaria worldwide with the chemical DDT (dichlorodiphenyltrichloroethane). DDT is a powerful insecticide that kills many insects, including mosquitoes. From 1947 to 1951, in areas where malaria was present in the United States, DDT was applied inside millions of households and over miles of swamps, fields, and forests. Through these DDT applications, malaria protists were effectively wiped out in this country. However, less concentrated efforts in other malaria-ridden parts of the world, and widespread spraying of DDT to kill all sorts of other insects, created *Plasmodium*-carrying mosquito populations that are now resistant to DDT.

Resistance develops if a few mosquitoes in a population are genetically able to withstand

The female Anopheles *mosquito is a vector for malaria.*

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the toxic effects of DDT. When more DDT is applied, more mosquitoes that are sensitive to DDT die. The resistant mosquitoes, however, survive and reproduce greater numbers of resistant mosquitoes until they are a significant proportion of the population, making DDT ineffective.

Scientists also learned that DDT harms other organisms in the environment and is a threat to wildlife, especially birds. One effect of DDT on birds is eggshell thinning, causing the shells to break too soon and the embryo inside to die. Some evidence also suggests that DDT might cause cancer or neurological problems in humans. Today, DDT is banned for agricultural use worldwide, but it still is used in some places to control *Plasmodium*-carrying mosquitoes and prevent them from biting people.

DDT or alternative insecticides are typically sprayed on the inner walls of homes and on protective nets that are draped over sleeping areas, discouraging mosquitoes from coming near.

Studies have shown that insecticide-treated nets are an effective and low-cost tool to control mosquitoes. A large study in Tanzania, where there is a high rate of malarial transmission, investigated the effect of insecticide-treated and untreated nets on infection in children aged one month to four years. The results, summarized below, show that both reduce the risk of death from malarial infection, but that there is greater success with the insecticide-treated nets.

Effectiveness of Mosquito Nets

PREVENTION METHOD	PERCENT REDUCTION IN RISK OF DEATH
Insecticide-treated nets	27
Untreated nets	19

Treatment of malaria infections centers on several drugs that kill the *Plasmodium* parasites that cause malaria. Some drugs attack the parasites when they are present in the blood, while others kill them when they are in the liver. Currently, physicians prescribe combinations of drugs that act together to kill *Plasmodium*.

CHALLENGES TO PREVENTION AND TREATMENT

There are two problems health officials must overcome to make mosquito-net programs more successful in preventing malaria. First, nets that are manufactured and sold pretreated with insecticide must be retreated within

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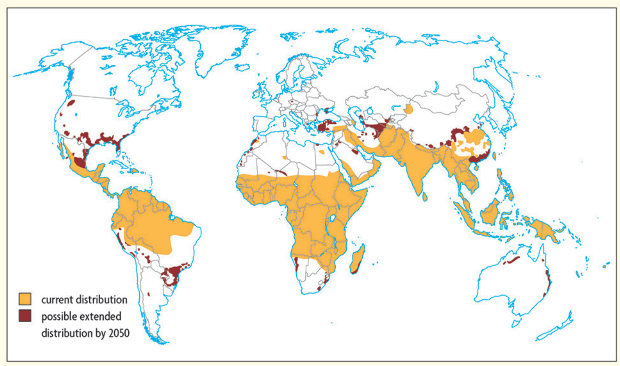
6 to 12 months for them to remain fully effective. Also, the nets, even though relatively low in cost, are still too expensive for some people living in countries with few economic resources. They must rely on programs that donate or reduce the price of the nets and retreatment kits.

There are also major challenges emerging with the drugs that treat malaria. In some areas, two types of *Plasmodium* that cause malaria have become resistant to the medication available for treatment, which means it no longer kills the parasite. The resistance of *Plasmodium* to drugs arises in the same way that mosquitoes acquire resistance to DDT. Since *Plasmodium* is less likely to develop resistance to several drugs at once, a combination of drugs is often given to patients. This approach often succeeds—as long as patients take all of the required doses of the medicine. But multidrug treatment is costly, and health care workers must monitor patients to make sure they complete their courses of treatment. In addition, it is often difficult to get all the right medicines to isolated communities.

Another potential challenge is the movement of malaria to areas with temperatures that were once too cold for the mosquitoes and *Plasmodium*. If the climate of an area changes in a way that favors the breeding and survival of mosquitoes and *Plasmodium*, the risk for malaria in that area increases. Scientists are working with models to predict how climate change could affect the risk of malaria around the world. The model below shows malaria returning to parts of the United States. The effect of climate change on malaria distribution continues to be a point of discussion in the scientific community. ■



A model prediction of the effect of climate change on malaria distribution worldwide

NAME *Sample Student Response* DATE

Disease Information

Disease	*Malaria*
Description of disease and symptoms	*Infectious disease caused by*
Cellular mechanism of disease	Plasmodium
Social factors	*Some don't*
Economic factors	*Some treatments*
Environmental factors	*Plasmodium*

3 What Is a Cell?

LABORATORY • 2–3 CLASS SESSIONS

OVERVIEW

Students begin by drawing and writing their initial ideas about cells. They then observe human, plant, protist, and bacterial cells under a microscope and sketch them. They compare the cells to determine similarities and differences between the cell types. A case study discusses tuberculosis, caused by the single-celled bacterium *Mycobacterium tuberculosis*, and the sustainability issues associated with this disease.

KEY CONTENT

1. Every organism is made of one or more cells.
2. Cells have particular structures that perform specific functions.
3. Every cell is surrounded by a membrane, which separates it from the outside environment.
4. Some plant cells contain chloroplasts.
5. A plant cell has a cell wall.

KEY SCIENCE PRACTICES

1. Students make and record observations.
2. Students develop conclusions based on evidence and reasoning.

MATERIALS AND ADVANCE PREPARATION

For the teacher

Transparency 3.1, "Examples of Cells"
Transparency 3.2, "Venn Diagram of Cells and Microbes"
Science Skills Transparency 3: "How to Use a Microscope"

For each group of four students

prepared slide of human cheek cells
prepared slide of animal sperm cells
prepared slide of typical *Bacillus* bacteria
prepared slide of typical *Coccus* bacteria
prepared slide of plant leaf cells
prepared slide of plant stem cells
prepared slide of plant root cells
piece of onion*
piece of *Elodea* plant
mixed protist culture
dropper bottle of Lugol's solution
cup of water*
dropper
pair of forceps

For each pair of students

microscope slide
microscope slide with a well
coverslip
microscope*
paper towel*
colored pencils

For each student

safety goggles
Student Sheet 2.1, "Disease Information"
Science Skills Transparency 3, "How to Use a Microscope" (optional)
Science Skills Transparency 4, "Microscope Drawing Made Easy" (optional)
3 sticky notes*

**Not supplied in kit*

SAFETY NOTE

Wear safety goggles while working with chemicals. Do not touch the chemicals or bring them into contact with your eyes or mouth. Wash your hands after completing the activity.

Be sure that students are very careful not to grind the microscope lenses into the slides as the slides may crack.

Be sure that students do not wash any plants down the drain. Elodea *is considered an invasive species in many areas worldwide. Check with your county or state agencies on proper disposal methods. In many places, it is sufficient to allow the plants to dry out and then throw them in the trash. You may wish to set up a strainer lined with several layers of cheesecloth or coffee filters, and ask students to filter the materials from their experiments.*

Masters for Science Skills Transparencies are in Teacher Resources II: Diverse Learners.

The mixed protist culture contains Paramecium, Euglena, *and* Amoeba.

TEACHING SUMMARY

Getting Started

- Students discuss their ideas about what cells are and how they are involved in the functions of organisms.

Doing the Activity

- Students observe microscope slides of human, plant, bacterial, and protist cells.

Follow-up

- (LITERACY) The class discusses their groupings of cells on the Venn diagram.
- (LITERACY) Students read a case study about tuberculosis.

BACKGROUND INFORMATION

Protists

Protists are a large kingdom of organisms made up mostly of single-celled eukaryotes. A protist is a living organism that is not a plant, animal, fungus, or prokaryote. Some protists are plantlike because they contain chlorophyll and are able to photosynthesize. Examples of plantlike protists are euglena, diatoms, and red, brown, and green algae. Some protists are heterotrophs (they digest both plant and animal matter) and animal-like. Animal-like protists are classified into four groups based on their mode of movement: some don't move at all, and others have cilia, flagella, or cytoplasmic extensions for movement. Examples of animal-like protists are *Paramecium, Amoeba,* and the parasites in the genus *Plasmodium* that cause malaria. *Plasmodium* is considered a parasitic protist because it requires a host organism for it to reproduce and survive. At one time, animal-like protists were referred to as protozoans and were classified separately from the plantlike protists. Some protists are fungus-like heterotrophs that live in damp environments, and absorb nutrients from dead and decaying matter through their cell membranes. Examples of fungus-like protists are slime molds and water molds.

Bacteria

Bacteria are tiny single-celled prokaryotes with no nucleus or other membrane-bound structures. Instead, the genetic material is in the cytoplasm. The shape of a bacterium—sphere, rod, or spiral—depends on its type. Bacteria sometimes group in chains or clumps, but each cell is enclosed by a cell membrane and cell wall.

Plant Cells

Plant cells have a nucleus that encloses the genetic information. Plants rely on photosynthesis for their nutrition, and many of their cells have organelles called chloroplasts, containing the pigment chlorophyll, which is one of the pigments that make photosynthesis possible. Other plant cells are specialized for transport of water or nutrients. Plant cells are enclosed by a cell membrane and a rigid cell wall that provides structure and support. Cytoplasmic streaming is often visible under a light microscope in plant cells, such as *Elodea.* Cytoplasmic streaming occurs when the chloroplasts and other organelles (not visible with a light microscope) move within the cell in what looks like streams. This allows nutrients and other materials to move throughout the cell, and allows for reorganization of the cell during cellular reproduction.

Animal Cells

Animal cells also have a nucleus that encloses the genetic information. They lack cell walls, but have membranes. The cells are often specialized, with unique shapes and structures that enable each cell to perform a specific function. The several types of organelles within the cell are enclosed by their own membranes.

With stains and an electron microscope or a good light microscope scientists can see the nuclei of animal, plant, and protist cells, and the absence of a nucleus in bacteria. The nucleus, found only in eukaryotes, houses the cell's genetic material, DNA, which is best viewed with an electron microscope. The nucleus is separated from the rest of the cell by a membrane, called the nuclear membrane. Mature red blood cells are an exception. The developing red blood cell ejects its nucleus, and since the mature red blood cell no longer has a nucleus, it does not carry any DNA.

GETTING STARTED

1 Write the following questions on the board or overhead. Use them as prompts for students to think about what they know or have heard about cells and for you to gauge their current knowledge of cells. Ask them to write and/or sketch their ideas in their science notebooks.

- What do cells look like?
- What are cells made of?
- What do cells do?

Ask students, with their groups, to write three analogies that describe cells in terms of common objects. An example is "a cell is like a room because it is separate from its environment." Ask for student volunteers to share their ideas with the class. Discuss the strengths and weaknesses of the everyday objects or ideas that students bring up. For example, one student might say that a cell is like a factory, while another says it is like a balloon. The strength of both analogies is that each is a structure with a boundary like the membrane that separates the inside and outside of a cell. The factory analogy is stronger, however, because it illustrates the structures that exist and the processes that go on within the cell, while the balloon is just filled with air.

Tell students that they will gain more detailed knowledge of cells in this unit.

3 What Is a Cell?

1 ALL LIVING THINGS are made of one or more cells. The **cell** is the basic unit of life and is where many life processes occur. Organisms made up of a single cell are called **single-celled organisms.** Bacteria and protists are examples of single-celled organisms. Other organisms, such as humans, dogs, and plants, are made up of trillions of cells, and therefore, are **multicellular organisms.** In this activity you will observe microscope slides of cells from various single-celled and multicellular organisms.

Challenge

What are the similarities and differences in cells from various living organisms?

A Paramecium, shown above, is a single-celled organism. Grass, dogs, and people, shown at left, are multicellular organisms.

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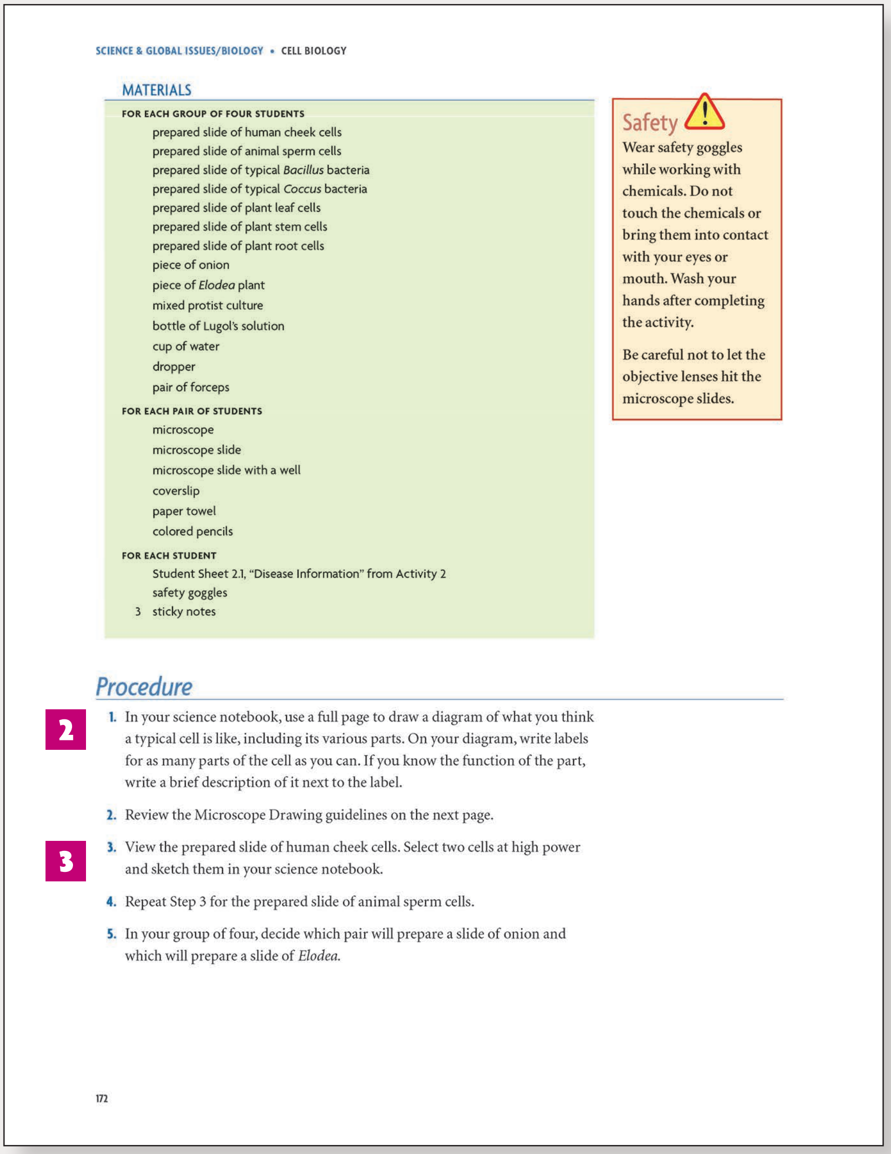
DOING THE ACTIVITY

2 After students have completed Procedure Step 1, project Transparency 3.1, "Examples of Cells," to prompt students' further thinking about cells and cell characteristics. Then review Science Skills Transparency 4, "Microscope Drawing Made Easy." Tell students that in this activity they will observe cells and microbes of various shapes and sizes. They will also observe some of the internal structures of these cells. If necessary, pass out copies of Science Skills Transparency 3, "How to Use a Microscope." Review with students the proper handling of a microscope before they begin the Procedure. Students will likely be able to focus on the slides without assistance. Finding and drawing the protists will be somewhat difficult because it is a live culture of moving organisms. Tell students that in this activity, they should concentrate on what they actually see in the microscope. Remind them that while the light microscope is a very useful tool, there are limits to the level of detail it can reveal. Explain to students that they will gain more detailed information about the internal structures of cells in later activities.



SCIENCE & GLOBAL ISSUES/BIOLOGY • CELL BIOLOGY

MATERIALS

FOR EACH GROUP OF FOUR STUDENTS
- prepared slide of human cheek cells
- prepared slide of animal sperm cells
- prepared slide of typical *Bacillus* bacteria
- prepared slide of typical *Coccus* bacteria
- prepared slide of plant leaf cells
- prepared slide of plant stem cells
- prepared slide of plant root cells
- piece of onion
- piece of *Elodea* plant
- mixed protist culture
- bottle of Lugol's solution
- cup of water
- dropper
- pair of forceps

FOR EACH PAIR OF STUDENTS
- microscope
- microscope slide
- microscope slide with a well
- coverslip
- paper towel
- colored pencils

FOR EACH STUDENT
- Student Sheet 2.1, "Disease Information" from Activity 2
- safety goggles
- 3 sticky notes

Safety
Wear safety goggles while working with chemicals. Do not touch the chemicals or bring them into contact with your eyes or mouth. Wash your hands after completing the activity.

Be careful not to let the objective lenses hit the microscope slides.

Procedure

2
1. In your science notebook, use a full page to draw a diagram of what you think a typical cell is like, including its various parts. On your diagram, write labels for as many parts of the cell as you can. If you know the function of the part, write a brief description of it next to the label.
2. Review the Microscope Drawing guidelines on the next page.

3
3. View the prepared slide of human cheek cells. Select two cells at high power and sketch them in your science notebook.
4. Repeat Step 3 for the prepared slide of animal sperm cells.
5. In your group of four, decide which pair will prepare a slide of onion and which will prepare a slide of *Elodea*.

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3 Encourage students to share the slides efficiently so that each student has a chance to observe and draw every slide provided.

Circulate around the room, assisting students as necessary. As you circulate, question students about what they are seeing in the field of view, and check that they are drawing and labeling accurately. Remind them to think about the similarities and differences they notice in the various types of cells. Some information about each of the cells as viewed in the microscope follows:

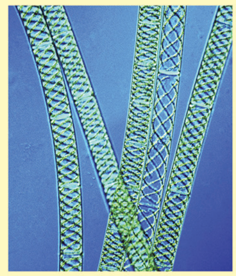
- The human cheek cells are irregular in shape and have a lightly stained cytoplasm and darker nuclei.
- The animal sperm cells are darkly stained round cells with long flagella (whiplike tails).
- The *Bacillus* cells are rod-shaped and have no nuclei.
- The *Coccus* cells are round and have no nuclei.
- The onion cells will be packed together and are fairly rectangular.
- The *Elodea* and prepared plant leaf cells are packed together and are fairly rectangular. There are many round, green objects inside these cells, which are the chloroplasts. It will be difficult to distinguish the nucleus and other organelles among the chloroplasts. If your *Elodea* is healthy, students might see cytoplasmic streaming. If students do not notice this on their own,

you may want to check some of the slides to see if it is occurring.

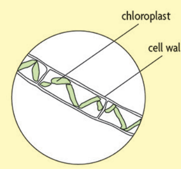
- The plant stem and root cells are shown in transverse section. Many of the stem and root cells are specialized for transport and appear to be empty in the center.
- The *Paramecia* are large, oblong, motile organisms. Their nuclei might be difficult to observe among all of the cell structures that are likely visible. By looking closely, students might observe cilia (hairlike projections) moving around the outside of the cell.
- The *Amoebae* may be difficult to find. They are more irregularly-shaped than any of the other cells students observe. The nucleus might be difficult to see among the cell structures that are likely to be visible.
- The *Euglena* are green, spindle-shaped, motile organisms that move with a flagellum.

Microscope Drawing Made Easy

Below is a picture taken through a microscope of the alga *Spirogyra*. The diagram to the right shows what a biologist or biological illustrator might draw and how he or she would label the drawing.



Spirogyra (algae) x 400



SOME TIPS FOR BETTER DRAWINGS:

- Use a sharp pencil and have a good eraser available.
- Try to relax your eyes when looking through the eyepiece. You can cover one eye or learn to look with both eyes open. Try not to squint.
- Look through your microscope at the same time as you do your drawing. Look through the microscope more than you look at your paper.
- Don't draw every small thing on your slide. Just concentrate on one or two of the most common or interesting things.
- You can draw things larger than you actually see them. This helps you show all of the details you see.
- Keep written words outside the circle.
- Use a ruler to draw the lines for your labels. Keep lines parallel—do not cross one line over another.
- Remember to record the level of magnification next to your drawing.

6. With your partner, follow the instructions below to prepare your slide.

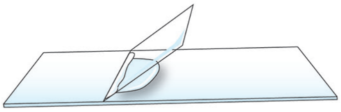
IF YOU ARE PREPARING ONION:

- Place one drop of water and one drop of Lugol's iodine solution on the slide.
- Use forceps or your fingernail to peel off a piece of the very thin inner layer of the onion.
- Place the piece of onion into the drops on the slide.

IF YOU ARE PREPARING *ELODEA*:

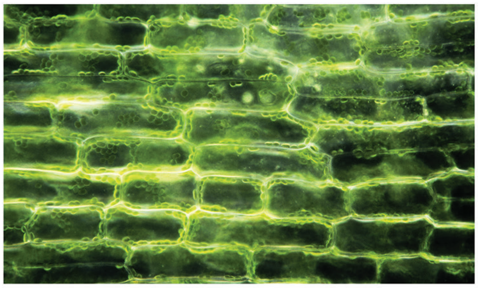
- Place 1–2 drops of water on the slide.
- Select one small, thin, light-green leaf.
- Place the leaf into the drops on the slide.

7. Carefully touch one edge of the coverslip to the water, at an angle. Slowly allow the coverslip to fall into place. This should prevent trapping of air bubbles under the coverslip.



Placing the coverslip

8. Observe the plant cells that you just prepared. Draw what you see at high magnification. Be sure to label your drawing with the name of your plant. When you have finished, do the same for the plant cell slide that was prepared by the other pair in your group.



Plant cells

4 Students will likely relabel structures and add cell structures, and should note what kinds of cells do or do not have certain structures.

9. Observe, and draw at high magnification, the prepared slides of plant leaf, stem, and root cells.
10. With your partner, place 1–2 drops of the mixed protist culture on a clean microscope slide with a well. Observe and draw at high magnification two different types of protists.
11. View the prepared slide of typical *Bacillus* bacteria, focusing on one or two cells at high magnification. Draw one or two of the bacteria cells. Be sure to label your drawings with the name of the sample.
12. Repeat Step 11 for the prepared slide of typical *Coccus* bacteria.
13. Clean up according to your teacher's instructions.

4

14. Go back to the drawing of a cell that you made in Step 1. Add or change any information on that drawing based on your work in this activity.
15. Follow your teacher's directions for reading the case study about tuberculosis (TB). As you read, follow the "Read, Think, and Take Note" strategy.
16. Complete the information for tuberculosis on Student Sheet 2.1, "Disease Information," after you read the case study.

Analysis

1. Compare the four different types of cells (animal, plant, protist, bacteria) you observed. What structures do they have in common?
2. Compare the three types of specialized plant cells (leaf, stem, and root). What similarities and differences did you observe?
3. When you compare the *Plasmodium* protist you observed in Activity 2 and the two protists you observed in this activity, what similarities and differences do you notice?
4. When you compare the two types of bacteria you observed, what similarities and differences do you notice?

FOLLOW-UP

5 ✓(LITERACY) Analysis Question 4 is a quick check assessment to assess students' developing understanding of the unique and shared characteristics of cells of organisms.

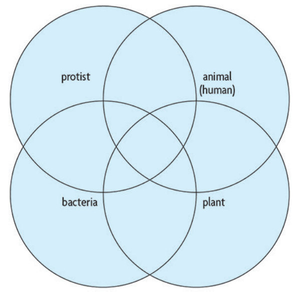
6 After students have drawn their diagrams for Analysis Question 5, Project Transparency 3.2, "Venn Diagram of Cells and Microbes." Discuss the features that students used to classify the cells and microbes on the Venn diagram they created, and write their ideas on the projected Venn diagram. If students do not bring it up, tell them that some cells have a nucleus and others do not. Ask, *Based on your observations, can you conclude for certain which cells do and do not have a nucleus?*

Help students realize that for some cells they can be certain that a nucleus is present because it is clearly visible. But if they cannot see a nucleus, they cannot be certain there is no nucleus. For example, the nucleus may be hard to see if the classroom microscopes are not powerful enough or if it is obscured by other structures in the cell. Note also that, unlike the rectangular cell walls of plants, bacterial cell walls are not visible under a light microscope. Also, bring out the idea that some cells of plants, such as *Elodea* and other producers, contain a structure called a chloroplast, which is green due to the chlorophyll in it. Photosynthesis, the means by which a plant absorbs energy from the sun and produces sugars, takes place in the chloroplasts.

SCIENCE & GLOBAL ISSUES/BIOLOGY • CELL BIOLOGY

5

5. In your science notebook, create a larger version of the Venn diagram shown below. Use what you have learned about cells to record the unique features of the cells of each group of organisms in the appropriate space. Record any common features between groups in the spaces created by overlaps.



6

6. Based on the Venn diagram you created, what features are common to all cells?
7. One focus of TB treatment is ensuring that people who are being treated are closely monitored by health care workers. Explain why this is important, citing evidence from the tuberculosis case study.

KEY VOCABULARY	
antibiotic	**multicellular organism**
bacteria	protist
cell	**single-celled organism**
latent	tuberculosis
macrophage	

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7 (LITERACY) You may choose to assign the case study for homework. If you do, give students the sticky notes they will need to follow the "Read, Think, and Take Note" strategy at home. Begin class the next day by having pairs discuss what they wrote or drew on their sticky notes. Sample responses for tuberculosis on Student Sheet 2.1, "Disease Information" are at the end of Activity 3 in this guide.

SAMPLE RESPONSES

1. They

2. Leaf cells

3. The cells

4. All of

5. ✓ See Venn diagram at right.

7

CASE STUDY

Tuberculosis

Burden of Disease

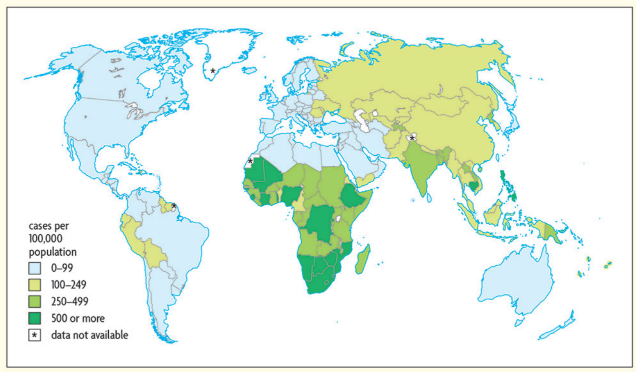
	TOTAL NUMBER INFECTED	ESTIMATED NUMBER OF DEATHS PER YEAR	ESTIMATED NUMBER OF NEW CASES PER YEAR
Worldwide	2 billion	1.5 million	9–10 million
United States	10–15 million	500–600	10,000

TUBERCULOSIS IS A disease that has appeared in the human population for centuries. Evidence of TB infection has been found in the skulls of Egyptian mummies estimated to be at least 3,000 years old. TB is caused by the *Mycobacterium tuberculosis* bacterium and was common in Europe and North America in the 18th and 19th centuries. It declined in those regions as living conditions, nutrition, and treatment improved. Worldwide today, however, it is estimated that at least one-third of the human population is infected with TB bacteria.

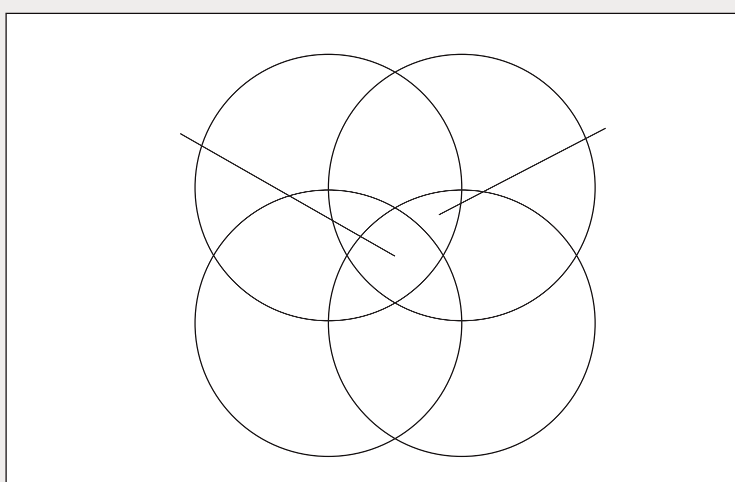
SYMPTOMS AND DISEASE MECHANISM

The physical symptoms of TB include appetite and weight loss, coughing, night sweats, fever, fatigue, and chills. TB usually infects tissue in the lungs, but can also infect other organs in the body, including the brain, kidneys, and spine. Since TB is an extremely infectious disease that can be passed through a cough, sneeze, or even talking with an infected person, people are at higher risk of infection if they live in densely packed urban areas or may be exposed to infected individuals in crowded, closed environments, such as hospitals, prisons, clinics, or airplanes.

(Continued on next page)



Global distribution of tuberculosis cases

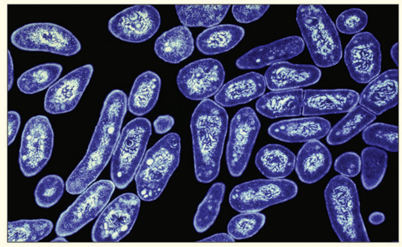


6.

7.

REVISIT THE CHALLENGE

The Venn diagram is a good visual for reviewing the common and unique characteristics of cells.



Mycobacterium tuberculosis *bacteria*

(Continued from previous page)

TB infection is latent or active. In a latent infection, the person has a positive skin or blood test for TB, but a normal chest X-ray. The bacteria are alive inside the body, but they are inactive. A person with a latent infection does not feel sick, has no symptoms, and cannot transmit the TB bacteria to others. Sometimes the latent form becomes active, and symptoms develop. Only 5–10% of people who are infected with TB bacteria, however, ever become sick or infectious. Antibiotic treatments after a person has tested positive for TB reduce the risk of latent TB becoming active, if the person takes the drugs for many months.

The following traces the steps that lead to a tuberculosis infection:

1. An uninfected person inhales TB bacteria in droplets that were released into the air by an infected person, whether minutes or hours earlier.
2. The bacteria enter the lungs, and if they are not immediately killed by the body's immune system, they are ingested by macrophages, a type of white blood cell. The macrophages do not destroy the bacteria.
3. Most of the time, the bacteria are held in check by the immune system. In this case, the infection is referred to as a latent infection.
4. If the infection becomes active, the TB bacteria multiply and travel to the blood. Possible reasons for a latent infection to become active include a weakened immune system, often due to HIV/AIDS infection, malnutrition, cancer, or aging. The bacteria might spread to other organs, but they can only be transmitted out of the body and to other people by the infected person's exhaling them from the lungs.

TUBERCULOSIS PREVENTIONS AND TREATMENTS

While there is a vaccine available to prevent TB, its effectiveness is limited. Worse, the vaccine has caused HIV-positive children to develop a TB infection. Health experts think that being able to accurately detect active TB infections is more beneficial than vaccination to prevent infections.

In 1943, a man critically sick with TB was the first to be given an antibiotic to treat TB. Impressively, the bacteria quickly disappeared, and the man recovered. Now there are a number of antibiotics to treat TB, and they are usually prescribed in combinations of two to four different drugs. Two of the most commonly prescribed today are isoniazid and rifampin. Isoniazid interferes with a bacterium's ability to make a compound needed in its cell walls. Rifampin prevents the bacterial cells from making proteins.

CHALLENGES TO PREVENTION AND TREATMENT

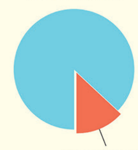
ANTIBIOTIC RESISTANCE

Like *Plasmodium,* TB bacteria have become resistant to many antibiotics. As with malaria, people who do not have access to timely and effective medical care or who don't complete a full course of treatment contribute to the resistance problem. In 2014, the World Health Organization (WHO) was notified of more than 480,000 cases of multidrug-resistant tuberculosis. Multidrug resistance in TB means that the bacteria are resistant specifically to the two main antibiotics, isoniazid and rifampin. Because WHO is not notified of all cases, experts think that there are many more cases. The cost of treating multi-drug-resistant TB infections can be 1,000 times more expensive than treating non-resistant TB infections.

HIV/AIDS AND TB CO-INFECTION

Another reason for the high numbers of TB infections is the relationship between TB and HIV/AIDS. These two diseases are so closely tied to one another that they are often referred to as a co-infection.

HIV weakens the immune system, which then allows latent TB to become active and infectious or makes the patient more vulnerable to TB droplets inhaled from the air. A person who is infected with HIV/AIDS is 50 times more likely to develop active TB in a given year than is an HIV-negative person. Also, the disease progresses more rapidly and deaths are higher in people infected with both HIV and TB than those who are infected only with TB. The primary cause of death in people infected with TB and HIV is the TB. Yet the vast majority of people with HIV worldwide have not been screened for TB. ■



NAME *Sample Student Response* DATE ____________

Disease Information

Disease	*Tuberculosis*
Description of disease and symptoms	*This disease has*
Cellular mechanism of disease	*Bacteria are*
Social factors	*TB is*
Economic factors	*People who*
Environmental factors	

4 What Do Cells Do?

INVESTIGATION • 1–2 CLASS SESSIONS

OVERVIEW

Students work with a computer simulation to match cellular functions to structures found in typical animal, plant, and bacterial cells.

KEY CONTENT

1. Cells have particular structures that underlie their functions, including a cell membrane and a cytoplasm that contain a mixture of thousands of different molecules.
2. All of the molecules in a cell form a variety of specialized structures and organelles, to perform such cell functions as energy production, transport of molecules, waste disposal, synthesis of new molecules, and storage of genetic material.
3. Plant cells contain chloroplasts, the site of photosynthesis.
4. The genetic information stored in DNA directs the synthesis of the thousands of proteins the cell needs.
5. Bacterial cells have neither a nucleus nor other membrane-bound organelles.

KEY SCIENCE PRACTICES

1. Students evaluate and synthesize information from text.

MATERIALS AND ADVANCE PREPARATION

For the teacher

Scoring Guide: UNDERSTANDING CONCEPTS (UC)

For each pair of students

computer with Internet access*

For each student

Student Sheet 4.1, "Structure and Function of Cells"

Scoring Guide: UNDERSTANDING CONCEPTS (UC) (optional)

**Not supplied in kit*

Masters for Scoring Guides are in Teacher Resources IV: Assessment.

TEACHING SUMMARY

Getting Started

- Discuss what all cells need in order to survive, and compare plant and animal cells.

Doing the Activity

- Students match various organelles to typical animal and plant cells according to the organelle's function.
- Students investigate the structures in prokaryotic cells.

Follow-up

- (UC ASSESSMENT) Review the relationship between cell structure and cell function.

GETTING STARTED

1 Ask students to look at the drawing of a cell that they did in Activity 3, "What Is a Cell?" Ask, *What structures must all cells have in order to function and grow?*

Compile a list on the board or overhead. Students are likely to say cell membrane, cytoplasm, and genetic material (DNA). Next ask, *What are some differences between plant and animal cells?*

Students are likely to say that plant cells have a cell wall and chloroplasts. Ask students to think about why plants have a cell wall. Give them time to discuss this briefly with their group. The cell wall provides structure and support for the cells and the plant. Use this example to emphasize the relationship between structure and function. Then, inform students that they will investigate the function of cell structures in more detail in this activity.

DOING THE ACTIVITY

2 All directions for the simulation are on Student Sheet 4.1, "Structure and Function of Cells," which can be downloaded from the *Science and Global Issues* website. A sample Venn diagram for Procedure Step 3 is shown at right.

4 What Do Cells Do?

1 Understanding normal cell structures and their functions helps scientists understand what goes wrong to allow diseases, including the infectious diseases caused by microbes, to progress. Although there are many differences between cells of various organisms, such as plants, animals, and microbes, there are some key similarities in all cells.

One structure common to every cell is a cell membrane that separates it from the outside environment. Similarly, every cell has genetic material in the form of DNA, and a large number of proteins and other molecules that carry out the chemical reactions needed for a cell to live, grow, and reproduce. Some cells contain structures that are surrounded by a membrane, which creates a barrier between the inside of the structure and the rest of the cell. These membrane-bound structures are called **organelles.**

In this activity, you will learn about some common cell structures and their functions in the cell.

Challenge

► What are the functions of the structures in cells?

MATERIALS

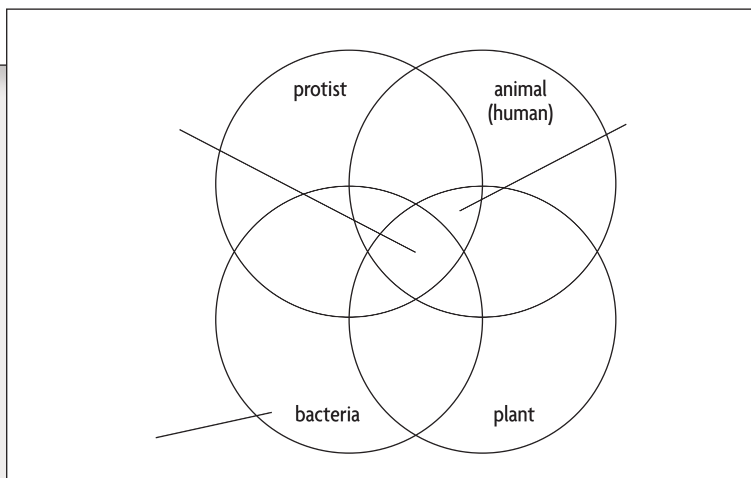
FOR EACH PAIR OF STUDENTS
computer with Internet access

FOR EACH STUDENT
Student Sheet 4.1, "Structure and Function of Cells"

Procedure

Part A: Computer Simulation

2
1. Visit the *Science and Global Issues* page of the SEPUP website at *sepuplhs.org/sgi*. With your partner, go to "What Do Cells Do?" and use Student Sheet 4.1 to guide you through the simulation.



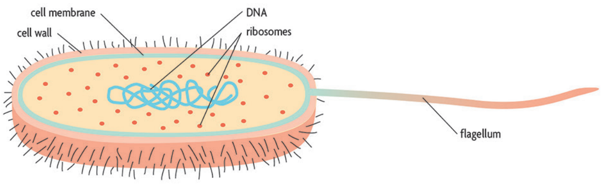
Part B: Comparing Cells

2. Read the following information about bacterial cells. This will prepare you to compare the cells of bacteria with those of animals and plants, which you investigated in Part A.

Reading

Bacterial Cell Structure

A bacterial cell does not have a nucleus or other membrane-bound structures. The genetic information of bacterial cells is stored in a large circular chromosome in the cytoplasm. The cell membrane of a bacterial cell performs the functions of many of the organelles of other organisms' cells. For example, to generate energy, a bacterial cell uses specific enzymes located in its cell membrane. Some bacterial cells can also perform photosynthesis at the cell membrane. The ribosomes in bacteria differ from ribosomes in eukaryotes in size and molecular composition, but like the ribosomes in eukaryotes, they carry out protein synthesis. In bacteria, as in eukaryotes, the cytoplasm also contains numerous enzymes that speed up reactions, such as the ones involved in digestion. Bacteria have an outer cell wall that makes them rigid and gives them shape. The cytoskeleton of prokaryotic cells serves some of the same functions as the eukaryotic cytoskeleton, but is made of different proteins. To move around, some bacteria use long tail-like structures called flagella, or short hair-like fibers called cilia. Although these flagella and cilia may appear similar to those of eukaryotes, they are made of different proteins and produce motion by a different mechanism than that of eukaryotic cilia and flagella.



Antibiotics

There are a number of antibiotics that can treat bacterial infections. The chart below shows how some antibiotics kill bacterial cells or keep them from reproducing.

Four Classes of Antibiotics

ANTIBIOTIC CLASS	MODE OF ACTION IN BACTERIAL CELL
ß-lactams	Interfere with cell wall structure
Tetracyclines	Interfere with protein synthesis
Quinolones	Interfere with the copying of bacterial DNA
Sulphonamides	Interfere with the production of an enzyme needed to copy the bacterial DNA

3. Use your understanding from the simulation and the reading above to make changes and additions to the Venn diagram you created in the simulation

Penicillium mold produces an antibiotic that has saved many lives.

FOLLOW-UP

3 (UC ASSESSMENT) Analysis Question 2 asks students to demonstrate their understanding of the structures needed for a cell to produce a protein and perform its functions, and is an opportunity for you to apply the UNDERSTANDING CONCEPTS (UC) Scoring Guide to assess the progress of their understanding. Tell the class your expectations for satisfactory work.

To begin a review of the activity ask, *What functions do all cells—plant, animal, and bacterial cells—need to perform in order to survive?*

All cells must be able to obtain energy, produce proteins, and store, digest, and excrete materials. Ask, *What structures do all cells have in common in order to perform these functions?*

All cells have a cell membrane, cytoplasm, cytoskeleton, ribosomes, and a specialized area for converting energy to a usable form. Specialized cells are different from one another in the number and kinds of organelles they have. These allow them to perform their specialized functions. Be sure to emphasize that, while many diagrams show typical cells, not all cells are shaped the same, nor do they have the same numbers and kinds of organelles.

WHAT DO CELLS DO? • ACTIVITY 4

Analysis

1. Label each of the following cell types as eukaryotic or prokaryotic:
   - Animal
   - Plant
   - Bacteria

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2. a. Describe the structures an animal cell must have for it to produce a protein.
   b. Explain how these structures work together to produce a protein.

KEY VOCABULARY	
bacteria	Golgi apparatus
cell membrane	lysosome
cell wall	nucleus
cilium, cilia	**organelle**
cytoplasm	prokaryotic cell
cytoskeleton	ribosome
endoplasmic reticulum (ER)	vacuole
eukaryotic cell	vesicle
flagellum, flagella	

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SAMPLE RESPONSES

1. Animal

2. (UC ASSESSMENT) A complete and correct response will include descriptions of

Sample Level-3 Response

a. To make a protein,

b. The nucleus

REVISIT THE CHALLENGE

Tell students to go back to their drawings of a typical cell from Activity 3, "What Is a Cell?" Instruct them to add more details to their drawings and to make any changes based on their learning from the computer simulation. Their drawings should include: