Understanding Cells
A Unit of Study

catalog #2339

Teacher’s Guide

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UNDERSTANDING CELLS
A UNIT OF STUDY
Total Viewing Time: 40:20 minutes
Grades 6-12

GENERAL OVERVIEW OF THE PROGRAM

This three-lesson series, for sixth through twelfth graders, offers a detailed look at the structure and function of cells, how they store and use information, and how they reproduce.

In this Teacher’s Guide, each of the three lessons has its own section, which includes a Summary, Student Objectives, Introducing the Lesson, Follow-Up Activities, Blackline Masters, and Answer Key. Unit Goals, which govern the entire Unit of Study, are included below in the Unit Objectives. A Unit Test, which assesses student comprehension of these Unit Goals, is included as Blackline Masters 16-20. Answers to the Unit Test appear in the Answer Key on page 23 of this guide.

The three lessons, which appear on one videocassette, are as follows:

Lesson One, LIFE AND CELLS, explains the unique characteristics common to all living things and defines cells, the “basic units of life.” In this section, students learn how cells join together to create tissues, organs, organ systems, and whole organisms. The organ systems of the human body are also presented in this lesson.

Lesson Two, HOW CELLS WORK, examines the internal organization of cells and explains the function of each subcellular organelle. In addition, students discover how cells store and use genetic information.

Lesson Three, HOW CELLS REPRODUCE, shows how DNA is replicated and outlines the stages of Mitosis and Meiosis.

INTERACTIVE VIDEO QUIZZES

Each video lesson is followed by a brief interactive video quiz. These quizzes are optional but many teachers have found that students will give more attention to the presentation if they know a video quiz will follow. Answers to Video Quiz questions appear in the Answer Key for each respective lesson.

UNIT OBJECTIVES

The Unit Objectives correlate directly to the National Science Education Standards in Life Science for grades 6-12.

After viewing all three lessons in this Unit of Study, and completing the accompanying Follow-Up Activities, students will be able to…

• Identify that all organisms are composed of cells, the fundamental units of life.

• Identify that most organisms are single cells; other organisms, including humans, are multicellular.
• Identify that cells carry on many functions needed to sustain life: they grow and divide (thereby producing more cells), they take in nutrients (which they use to provide energy for the work that cells do), and they make the materials that a cell or organism needs.

• Describe that specialized cells perform specialized functions in multicellular organisms; groups of specialized cells cooperate to form tissues, different tissues group together to form organs. Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole.

• Identify that the human organism has systems for digestion, respiration, circulation, excretion, movement, control and coordination; these systems interact with one another.

• Define disease as a breakdown in structures or functions of an organism.

• Describe the particular structures that underlie a cell’s functions.

• Describe some of the chemical reactions involved in cell functions.

• Identify that cells store and use genetic information contained in their DNA to direct the synthesis of thousands of proteins that each cell requires.

• Describe that cell functions are regulated through changes in the activity of the functions performed by proteins and through the selective expressions of individual genes; this regulation allows cells to respond to their environment and to control and coordinate cell growth and division.

• Identify that most of the cells in a human contain 23 pairs of chromosomes.

• Identify that transmission of genetic information to offspring occurs through egg and sperm cells that contain only one representative from each chromosome pair.

• Describe that mutations in DNA occur spontaneously at low rates; some of these changes make no difference to the organism, whereas others can change cells and organisms.

UNIT TEST

A unit test, designed to assess student comprehension of the Unit Goals, is included herein as Blackline Masters 16-20. The Unit Test is repeated in this guide beginning on page 20. An Answers Key follows, beginning on page 23.

TEACHER PREPARATION

We suggest that you view this video and review this guide and its accompanying blackline masters before presenting this program to your class.

You may also decide to duplicate some of the blackline masters and distribute copies to your students so they can reference them before they view the video. A different set of blackline masters is provided for each of the three lessons.
As you review these instructional materials, you may choose to make some changes to fit the specific needs of your class. We encourage you to do so, for only by tailoring this program to your students will they obtain the maximum benefits offered by these materials.

Because of the large amount of new material presented in this program, we believe that the greatest educational value would accrue by presenting each lesson on a different day. Each video presentation could be followed by reviews, exercises, and lab work.

STUDENT PREPARATION

Some of the material in this program is complicated, and a considerable amount of unfamiliar terminology will be introduced. For this reason, we feel that it would be wise for students to read selected pages in their science textbooks before viewing these lessons.

INTERNET RESOURCES

The following Internet resources and activities help illustrate some of the salient points of the Unit.

1. Visit IBM’s Higher Ed images at http://ike.engr.washington.edu/software/eduing
   This site contains high quality digital images from basic botany, general electron micrography, histopathy, and human histology. Look at individual images and have students identify the parts and functions of cells. The images are also available with icons.

2. Dennis Kunkel’s Microscopy at http://www.pbrc.hawaii.edu/967Ekunkel
   contains images kids will love: insects, microcosms, and MicroAliens! It also contains information about microscopy and a tour of the PBRC Biological Electron Microscope Facility. There are links to other microscopy sites as well. Have your students think about scale as it relates to the study of very tiny things, such as cells. How does scale affect our access to information?

3. Check out Cells Alive! at http://www.cellsalive.com
   for information on cells’ involvement in the human immune system, bacteria, and parasites. The link to the GALLERY provides great micrographic images of a variety of cells. Have each student or group of students pick a photograph and develop a report on that particular type of cell. What role or roles does the cell play in human existence? How is the function of the cell different from that of a normal blood cell or other cell of the body? There are useful links, containing information about the cell, provided for many of the photographs.
LESSON ONE:
LIFE AND CELLS

SUMMARY OF LESSON ONE: LIFE AND CELLS

The following topics are presented in Lesson One:

1. The characteristics of living things.
2. The definition of a cell.
3. Unicellular versus multicellular organisms.
4. The specialization and organization of cells in a multicellular organism: the human being.

STUDENT OBJECTIVES FOR
LESSON ONE: LIFE AND CELLS

After viewing Lesson One, LIFE AND CELLS, and participating in the lesson activities, students will be able to…

• Compare and contrast living and non–living things.
• Explain what a cell is and how cells are organized inside the body.
• Name the organ systems of the human body.

INTRODUCING LESSON ONE: LIFE AND CELLS

This lesson can be introduced by pointing out some of the facts listed below:
• Living things possess certain characteristics not possessed by non–living things.
• Cells are the building blocks of life: where there is life there are cells.
• Most living things possess only one cell. In multi–celled organisms, cells have become specialized to carry out specific tasks.
• Most cells are so small they can only be viewed under a microscope. Exceptions are certain animal eggs, but the reason they are so large is due to the enormous amount of stored food material (yolk) they contain.

• Present the lesson. The viewing time is 12:20.

FOLLOW–UP ACTIVITIES FOR
LESSON ONE: LIFE AND CELLS

Subjects for Discussion and/or Review

1. Fossil evidence suggests that life first appeared on earth about 3.5 billion years ago. Discuss some of the current views of science regarding the origin of life and the origin of cells.

2. Talk about the disputes that have arisen between Creationism and traditional science. What are the main issues?

3. Viruses survive by taking over living cells and cannot reproduce without them. Are viruses living or nonliving?

4. Review and discuss the organ systems of the human body.
Extended Learning Activities

1. **Microscope Work:** Examine prepared slides of blood and tissues from both plants and animals. Try to identify various cell components, such as the nucleus, cytoplasm, cell membrane, etc.

2. Collect pond water from various locations, add some rice grains to one set of samples, and after a week look at them under a microscope. Make observations regarding the number and behavior of the micro–organisms present with and without the rice. (Rice contains a high percentage of energy rich carbohydrates.) Determine whether any multicellular organisms are present in your samples.

   **BLACKLINE MASTERS FOR
LESSON ONE: LIFE AND CELLS**

**Blackline Master 1, Video Quiz,** is to be used at the end of the video lesson. The narrator will read the questions which are displayed on the screen. Students can use this sheet to record their answers. Answers to the questions are provided below.

**Blackline Master 2, Vocabulary List,** will help students with unfamiliar words used in the lesson, or words pertaining to the subject of the lesson they might encounter in outside reading.

**Blackline Master 3, Crossword Puzzle,** challenges students to use new ideas and vocabulary presented in this lesson. Answers appear on the next page.

**Blackline Master 4, The Characteristics of Living Things Fact Sheet** outlines the basic characters common to all living things.

**Blackline Master 5, The Organ Systems of the Human Body,** is a chart that allows students to identify the organ systems. Answers appear in the Answer Key on page 6 of this guide.

**ANSWER KEY**

**Blackline Master 1, Video Quiz**

1. Cells
2. Reproduce, use energy to live, move, etc.
3. Unicellular
4. Cells
5. Organisms
6. Tissues
7. Specialized
8. Circulatory
9. Respiratory
10. Nervous
LESSON TWO: HOW CELLS WORK

SUMMARY OF LESSON TWO: HOW CELLS WORK

The following topics are presented in Lesson Two:

1. The internal organization of cells.
2. The function of each subcellular organelle.

STUDENT OBJECTIVES FOR
LESSON TWO: HOW CELLS WORK

After viewing Lesson Two, HOW CELLS WORK, and participating in the lesson activities, students will be able to:

- Name and explain the function of each cytoplasmic organelle.
- Explain some of the ways cells obtain and use energy.
- Describe how cells store and use genetic information.
- Explain what a gene is.

INTRODUCING LESSON TWO: HOW CELLS WORK

This lesson can be introduced by pointing out the following facts:

- Cells are like miniature factories whose product is life.
- Only cells that can photosynthesize can trap the sun’s energy. Because human cells cannot trap energy, humans must eat plant products, or animal products from animals that have eaten plants, to obtain energy.
- Being able to understand the Genetic Code has created a revolution in biology and has given birth to a new field called genetic engineering.

- Present the lesson. The viewing time is 14:00

FOLLOW–UP ACTIVITIES FOR
LESSON TWO: HOW CELLS WORK

Subjects for Discussion and/or Review

1. Review and discuss the interrelationships between the different cytoplasmic organelles.

2. Look at electron microscope pictures of plant and animal cells with your students to get a truer, less diagrammatic, concept of cell structure.

3. Discuss the role of proteins in the cell.

4. Review the meaning of the terms chromatin, chromosomes, DNA, and genes.
5. Review and discuss the Genetic Code.

6. Discuss the concept of genetic mutations and genetic diseases.

7. Discuss genetic mapping and the Human Genome Project.

8. What are some of the social and scientific ramifications of knowledge of genetics? How has genetic engineering changed the way that people can control certain genetic features within the human population? What are the ethical implications of genetic engineering?

**Extended Learning Activities**

1. **Microscope Work:** If possible, examine living cells from multicellular organisms under the microscope. Good examples can be obtained by gently scraping the lining of the cheek with a spoon. The plant *Elodea* offers a good subject for observing living plant cells.

2. Examine a slide of the salivary gland chromosomes of the fruit fly, *Drosophila Melanogaster*. These chromosomes are actually polyploid, meaning that many DNA strands exist in each chromosome. This is why they are so large. Look for the bands that may represent genes and the “puffing” that may indicate gene activity.

3. **Cells in the News:** Have each student find three different articles in newspapers or magazines that relate to cells. These could be articles on cloning, cancer studies, antibiotics, genetic mapping, or treatments for genetic diseases, etc. Students could be assigned the task of writing short summaries of each article and/or giving oral presentations.

**BLACKLINE MASTERS FOR LESSON TWO: HOW CELLS WORK**

**Blackline Master 6, Video Quiz,** is to be used at the end of the video lesson. The narrator will read the questions which are displayed on the screen. Students can use this sheet to record their answers. Answers to the questions are provided in the Answer Key on the following page.

**Blackline Master 7, Vocabulary List,** will help students with unfamiliar words used in the lesson, or words pertaining to the subject of the lesson they might encounter in outside reading.

**Blackline Master 8, Crossword Puzzle,** challenges students to use new ideas and vocabulary presented in this lesson. Answers appear in the Answer Key on the following page.

**Blackline Master 9, Diagrams of Cells,** is a sheet containing diagrams of an animal cell and a plant cell that students can reference.
ANSWER KEY
Blackline Master 6, Video Quiz
2. Mitochondria 7. DNA, Deoxyribonucleic acid
3. Ribosomes 8. Reproduce, Divide
4. Ribosomes 9. Four
5. Information, Instructions, 10. Gene
    Plans

Blackline Master 8, Crossword Puzzle

1. MITOCHONDRIA
2. OXYGEN
3. ATP
4. CHROMATIN
5. LYSOSOMES
6. ENDOPLASMIC
7. GENETIC CODE
8. CHLOROPLASTS
LESSON THREE: HOW CELLS REPRODUCE

SUMMARY OF LESSON THREE: HOW CELLS REPRODUCE

Lesson Three, HOW CELLS REPRODUCE, shows how DNA is replicated and outlines the basic stages of mitosis and meiosis.

STUDENT OBJECTIVES FOR LESSON THREE: HOW CELLS REPRODUCE

After viewing Lesson Three, HOW CELLS REPRODUCE, and participating in the lesson activities, students will be able to…

• Explain DNA replication.
• Compare and contrast mitosis and meiosis.

INTRODUCING LESSON THREE: HOW CELLS REPRODUCE

This lesson can be introduced by pointing out the following facts:

• All of us began life as the single cell of a fertilized egg that divided over and over again. As adults, we will have about 100 trillion cells.
• After we grow up, cells divide to maintain and repair worn out cells; otherwise, not a lot of cell division occurs after we mature.
• Cancer is uncontrolled cell division.
• Damage to DNA or chromosomes can cause genetic diseases.

• Present the lesson. The viewing time is 12:00.

FOLLOW–UP ACTIVITIES FOR LESSON THREE: HOW CELLS REPRODUCE

Subjects for Discussion and/or Review

1. Review and discuss mitosis and meiosis.
2. Compare and contrast asexual and sexual reproduction.
3. Discuss cancer from the perspective of genetic damage that results in uncontrolled cell division.
4. Discuss fertilization.
5. Discuss genetic mutations and their role in creating biological diversity.
6. Discuss cloning. What are the social and scientific ramifications of cloning? What will happen if and when scientists can clone human beings?

Extended Learning Activities

1. Microscope Work. Examine a stained and prepared slide showing onion root tip mitosis. Have students identify the stages of mitosis.
2. Examine a stained and prepared slide of a rat testis showing cells undergoing meiosis.
3. Examine a slide showing human metaphase chromosomes in a blood smear.
BLACKLINE MASTERS FOR
LESSON THREE: HOW CELLS REPRODUCE

Blackline Master 10, Video Quiz, is to be used at the end of the video lesson. The narrator will read the questions which are displayed on the screen. Students can use this sheet to record their answers. Answers to the questions are provided below.

Blackline Master 11, Vocabulary List, will help students with unfamiliar words used in the lesson, or words pertaining to the subject of the lesson they might encounter in outside reading.

Blackline Master 12, Crossword Puzzle, challenges students to use new ideas and vocabulary presented in this lesson. Answers appear below.

Blackline Mastera 13a and 13b, Diagrams of Mitosis and Meiosis, contain diagrams of mitosis and meiosis that students can reference.

Blackline Master 14, The Cell Cycle, shows the different cycles of the cell.

Blackline Master 15, Quiz, covers material presented in this lesson. Answers appear in the Answer Key on the following page.

Answer Key

Blackline Master 10, Video Quiz
1. mitosis
2. interphase
3. one half
4. spindle fibers
5. fertilization

Blackline Master 12, Crossword Puzzle

1. DIP
   P
   D
   TELOPHASE
   2. HAPLOID
      A
      L
      E
      S
      I
      3. MEIOSIS
         S
         I
         T
         A
         R
         E
         4. OVUM
            M
            5. REPRODUCTIVE
               M
               6. PROPHASE

5
LESSON ONE: LIFE AND CELLS

The world in which we live can be divided into two very basic parts: things that are alive, such as these microorganisms, and things that are not, such as this rock.

Among living things, there are unbelievable variations. But, as strange as it seems, this sea anemone, this elephant, these tiny rod–shaped bacteria, this crab, and both this butterfly and flowering plant all share certain traits that clearly distinguish them from non–living things.

Scientists call these shared traits the “Characteristics of Life.”

The first characteristic of life is that living things can reproduce. This means that, like these giraffes, they can produce new life that is very similar to themselves.

The second characteristic of life is that, like these young fish, all living things can grow and develop, forming mature organisms that are capable of reproduction.

The third characteristic of living things is that they can respond to the outside world. For example, these striped fish are responding to the much larger white fish by getting out of its way. And this bee has sensed the pollen in this flower and is responding by gathering it to make honey.

Being able to respond to things in the outside world is very useful because it helps living things find food, protect themselves from harm, find mates and perform many other important activities.

The fourth characteristic of life is that living things need to use energy to stay alive. For example, plants, such as these grasses, can trap the energy of sunlight and this energy not only keeps the grasses alive, some of it is chemically stored in their leaves and stems, so that when animals like these cattle graze, they are able to get the energy they need to power their life processes.

The fifth characteristic of life is that living things can change as their environments change, and it is because life has been able to change and adapt over millions of years to meet some very extreme conditions that living things can now be found in almost every imaginable place on earth, such as the algae that live in the boiling water of this hot springs pool, or the dry lichen that cover the surfaces of these rocks, or the bacteria that thrive in the human mouth and digestive tract.

The sixth characteristic of life is that living things can move. This characteristic is obvious when movement is fairly rapid. But it is harder to see when it is slow, such as the movements made by plants as they turn their leaves toward the sun.

When it comes to life some creatures are very complicated, while others are quite simple.

But no matter how simple or how complicated they may be, living things are always very highly organized in the way they are are put together.

In fact, it is because they are so highly organized that scientists usually refer to living things as organisms.

If we look closely at how living things are organized, one fact stands out—they are all made up of cells. For example, the tips of these tiny onion roots, when stained and viewed under a microscope, look like this—a collection of tiny compartments called cells.

Cells are defined as the simplest structures that can carry out all of the activities characteristic of life, that is, can reproduce, grow and develop, use energy, and so on. And because life cannot exist without them, scientists call cells the basic units of life.
The tiny microscopic organisms seen here have only one cell; they are called single celled or unicellular organisms and are examples of some of the simplest living things.

But as we saw in the case of the onion, as living things get bigger, they will always have more cells. In fact, some organisms have hundreds of trillions of cells of many different types. Creatures made up of more than one cell are called multicellular organisms.

Within the bodies of multicellular organisms, cells have become specialized to carry out specific tasks. For example these red blood cells are specialized to carry oxygen to other cells all over the body, while this white blood cell, stained with purple dye, is specialized to kill the harmful bacteria that cause certain diseases.

CELLS WORKING TOGETHER

Multicellular organisms can have hundreds of different types of specialized cells. And yet, it is quite rare to find cells that carry out their tasks alone. That is because in complex organisms cells are almost always found working together in organized groups.

For example, layers of cells that are similar in structure and function are called tissues. Here we see a tissue of cells that makes up the outer layer of a leaf.

Very often, several different types of tissues are found grouped together to form organs, as we can see here in a slice of a disease-fighting organ called a lymph node.

Beyond that, certain organs combine to form organ systems, which, when taken together, create a whole organism.

The human organism has nine basic organ systems.

The first is the skeletal system, which gives the body support and helps protect the delicate internal organs. Bones are the main organ of the skeletal system.

The second is the muscular system, which allows the body to move. The muscles are the main organs of this organ system.

The third is the nervous system, which senses the environment, receives information from the body, helps coordinate physical activities, and makes it possible to think. The brain is the main organ of the nervous system.

Fourth is the circulatory system for carrying blood to cells throughout the body. The heart is the main organ of the circulatory system.

Fifth is the excretory system, which allows the body to rid itself of liquid waste. The kidneys are the main organ of the excretory system.

Sixth is the digestive system, which allows the body to process and absorb food and water. The stomach, small intestine, liver, pancreas, and large intestine are all important digestive organs.

Seventh is the endocrine system, which is made up of different glands that produce the chemical messengers called hormones. Among the organs in the endocrine system are the thyroid, adrenal, and pituitary glands.

Eighth is the respiratory system, which provides the body with oxygen and helps it get rid of the waste product, carbon dioxide. The lungs are the main respiratory organ.

The ninth and last organ system is the reproductive system, which allows us to have children. The female ovaries and male testes are the main organs of the reproductive system.
As we have seen, all nine of these complicated organ systems are made up of organs that are made up of tissue layers of specialized cells.

In the next section of this program, we will look inside a specialized cell and learn how it works.

**LESSON ONE VIDEO QUIZ**

Students may write their answers to the following questions on a separate sheet of paper or on Blackline Master 1, Lesson One Video Quiz.

1. The “basic units of life” are called ________________.
2. Two characteristics of living things are that they can _______ and ________________.
3. The creatures seen here are called ________________ because they have only one cell.
4. Bigger more complicated creatures will have many more ______ than simpler ones.
5. Because they are highly organized in the way they are put together, living things are often called ________________.
6. Similar kinds of cells usually form layers called ________________.
7. In multicellular organisms, cells have become ________________ to perform certain tasks.
8. The organ system used to pump blood is called the ________________ system.
9. The organ system for breathing is called the ________________ system.
10. The brain is the main organ of the ________________ system.

**LESSON TWO: HOW CELLS WORK**

All cells, including the single celled amoeba seen here, are made up of a living jelly–like substance called protoplasm. The protoplasm of a cell is always wrapped in a flexible “skin” called the cell membrane.

The cell membrane helps control what comes into and what goes out of the cell. What comes into the cell are such things as oxygen, water and food; what goes out are wastes and special cell products.

As can be seen in this stained, nonliving nerve cell, the protoplasm inside the cell membrane is made up of two basic parts– a rounded nucleus and the cytoplasm, which is all the protoplasm outside the nucleus.

**THE ORGANELLES OF THE CYTOPLASM**

As you can see by looking at this living cytoplasm, it is very complex. It is always in motion and contains lots of tiny organs, or organelles, plus other structures that carry out a variety of tasks inside the cell.

Now let us look at some simplified diagrams of cells to learn about the components of the cytoplasm and how they function, such as the mitochondria, the powerhouses of the cell where stored energy is released; the lysosomes that contain digestive enzymes; the food vacoules, where large food particles are stored and digested; the centrioles that are important in cell reproduction; the ribosomes where proteins are made; and the network of hollow tubes, upon which most of the ribosomes sit, called the endoplasmic reticulum, or ER, used in transporting proteins inside the cell; the Golgi complex, where proteins are packaged; and in plant cells, the chloroplasts, which are extra–important organelles because they are used to create food.
CHLOROPLASTS AND PHOTOSYNTHESIS

Here we see thousands of green-colored chloroplasts in the cytoplasm of a living cell. These chloroplasts are busy carrying out a process called photosynthesis that is essential to nearly all life on earth.

Inside the chloroplast, light energy is used to combine carbon dioxide gas, CO2, and water, H2O, to make sugar. As a result of photosynthesis, the sun’s energy actually becomes part of the sugar’s chemical structure.

This is why humans can obtain quick energy by eating foods containing sugar.

Now, let us look at how the different parts of a human cell work together to use sugar and other food materials.

After being eaten, food travels down the digestive tract, through the stomach and into the small intestine—the part of the body where food is first taken into cells.

Here the sugar in the food is simply carried across the cell membranes of the cells that line the small intestine. This is possible because sugar is not a very large chemical substance.

However, other materials in the food may be too large to enter the cell in such a simple fashion. They will be surrounded by the cell membrane, which pinches off to form tiny sacs called food vacoules, a process called phagocytosis, or "cell eating."

The food vacuoles will then be entered by lysosomes, which are little more than packages of digestive enzymes. As a result, the food inside the vacuoles will be broken down into useful nutrients.

The lysosomes, you will notice, are created by another organelle called the Golgi complex, which is the place where the digestive enzymes are wrapped in a special membrane. Some cells contain thousands of these organelles.

RELEASING STORED ENERGY

By the time the food in the food vacoules has been broken down into nutrients and released into the cytoplasm, the sugar will have already reached the organelles called mitochondria, the powerhouses of the cells, which can sometimes number up to 2,000 per cell!

Once the sugar gets inside the mitochondria, it will be chemically combined with oxygen to release the sun’s stored energy. This process, called cellular respiration, also creates two waste products—water and carbon dioxide.

It is because our cells need oxygen to release chemically stored energy that humans breathe in oxygen and breathe out carbon dioxide; and the more energy we use up, the faster we must breathe to take in the extra oxygen needed to release more energy.

In these pictures of a living white blood cell, the mitochondria can be seen moving about in the energetic, life supporting, dance that accompanies cellular respiration.

It may not be obvious but cellular respiration is a lot like a burning fire, for when a fire burns, oxygen is used up, carbon dioxide and water are produced, and energy is released—the same thing that happens during cellular respiration.

But it is important to realize that sugar is not actually “burned” inside the cell; instead, the energy stored in sugar is released through a series of complicated steps that produce a special high energy chemical called ATP, or adenosine triphosphate.
Cells use the readily available energy of ATP in much the same way that cars use gasoline, and, without a doubt, one of the most important of the cell’s energy consuming activities is making proteins.

**MAKING PROTEINS**

Proteins are made on the millions of tiny organelles called ribosomes, organelles that themselves are produced in a special part of the nucleus called the **nucleolus**.

And because most ribosomes are found attached to a complicated network of passageways called the **endoplasmic reticulum**, or **ER**, newly made proteins can be easily transported through these passageways from one part of the cell to another. Here we see a picture of the endoplasmic reticulum and ribosomes taken by a powerful electron microscope.

The reason that proteins are so important is that they carry out many different roles. Some are used to **build and repair cells**, some **help fight disease**, others **help transport particles across the cell membrane**, and nearly every time chemicals need to be combined or changed inside cells, the **proteins known as enzymes must be present**, or the chemical reactions will not take place.

Some types of cells, such as those that line the small intestine, even make enzymes that are used **outside the cell**.

These proteins go through the ER to the Golgi complex, where they are specially prepared before being shipped into the digestive tube.

But most of the proteins made on the ribosomes are used **inside the cell**. Some proteins are needed in the nucleus, and to get to the nucleus, these proteins move through the ER until they pass through the **nuclear membrane**.

**THE NUCLEUS: The Control Center of the Cell.**

The nucleus is the control center of the cell and inside the nucleus some of the proteins made in the cytoplasm **help create structures that guide the activities of the cell**.

For example, the living nucleus we see here is composed mostly of a protein containing substance called **chromatin**.

Normally, the chromatin doesn’t look like much; in fact it only begins to really look like something when the cell gets ready to reproduce. Then the chromatin “condenses” into the worm–like structures called **chromosomes** seen here.

And even though part of each chromosome is protein, a lot of it is a very complicated chemical called **DNA**, or **deoxyribonucleic acid**.

Human cells have 23 pairs of chromosomes. Here we can see exactly how the DNA is arranged inside a chromosome; for each tiny human cell contains enough tightly folded DNA inside its chromosomes that if all of it were stretched out, it would be over six feet long!

DNA is the most important chemical in the entire cell because the DNA is where the information on how to run the cell is stored.

The DNA in the chromosomes is made up of two long twisted strands—each of which is built from 4 small sub–units containing the chemicals adenine, guanine, cytosine and thymine, which scientists have abbreviated A, G, T, C.

The cell puts these units together in a definite order to create an amazing chemical language called the **genetic code** that is used by all living things to store information.
In certain ways, the genetic code resembles a written language, but the only letters in its very short alphabet are the chemicals A,G,T,C.

And even odder is the fact that the four letters in its alphabet can only be used to make words that are three letters long, so that the entire genetic code dictionary contains just 64 different words!

Scientists have discovered that, except for three or four “punctuation” words, all the rest of the genetic code words in DNA represent the chemical “building blocks” called **amino acids**, from which proteins are made.

This means that the long chains of DNA in the chromosomes are nothing more than plans that tell the cell how to make different proteins.

And no matter whether the proteins are put to use in a human cell like this one, or in simple one–celled organisms like these, the proteins will do what is needed to keep the cell alive; this means building and repairing old or worn out parts, transporting particles, helping fight disease, or by acting as enzymes that allow chemicals to combine inside the cell.

Each set of genetic code plans for a protein is called a gene and genes, through the proteins they make, help determine physical characteristics, such things as the color of skin, eyes and hair.

Genes are arranged on the DNA one after another inside the chromosomes, and today, scientists working on a huge scientific research project called the **Human Genome Project** are busy mapping the exact location of each of the approximately 100,000 different human genes.

In the next section of this program, we will find out what happens to DNA, genes, and chromosomes when cells reproduce.

**LESSON TWO VIDEO QUIZ**

Students may write their answers to the following questions on a separate sheet of paper or on Blackline Master 6, Video Quiz.

1. Sugar is one of the main sources of __________ for cells.
2. The organelles called ______________ are also known as the powerhouses of the cell.
3. Tens of thousands of tiny “protein factories” called____________ are found on the surface of much of the cell’s endoplasmic reticulum.
4. The organelles called ______________ are made in the nucleus in a special area called the nucleolus.
5. Much of the material in the nucleus is used for storing____________.
6. The language used by cells is known as the______________.
7. Chromosomes contain a long, twisted, thread–like chemical called ________.
8. Chromosomes are not always visible in cells. They can be seen only when cells are getting ready to ____________.
9. The cell’s language uses a chemical alphabet that is only ________ letters long.
10. Each set of protein plans is called a __________.
LESSON THREE: HOW CELLS REPRODUCE

As we learned in the first part of this program, the ability to reproduce is one of the most basic characteristics of living things.

Microscopic one–celled organisms, such as those seen here, usually reproduce by asexual reproduction by simply dividing and making two new cells. With asexual reproduction, only one parent is needed to create offspring.

But large, multicellular, organisms usually have two parents. They develop from the fertilized egg cell created when male and female sex cells join during sexual reproduction.

MITOSIS AND CELL DIVISION

Even though large organisms often require two parents to produce offspring, their individual cells reproduce using a method that is like asexual reproduction in one–celled creatures. Let’s find out how this works in an animal cell.

Before a cell can reproduce, it begins by reproducing its nucleus, a process scientists call mitosis.

The first, and longest, stage of mitosis is called interphase, a period of cell growth when the nucleus is filled with chromatin fibers.

During interphase, a process called DNA replication takes place. The old DNA is copied and two new sets of DNA plans are made –the replication of the DNA results in a duplication of the chromosomes.

But before the duplicated chromosomes appear from the chromatin, the centriole pairs are also duplicated, and early in the next stage of mitosis called prophase, the centrioles move to opposite sides of the nucleus, where tubular structures called spindle fibers form around them as the newly duplicated chromosomes come into view.

During the next stage of mitosis, called metaphase, the duplicated chromosomes line up in the middle of the spindle fibers.

Then, during the fourth stage of mitosis called anaphase, the spindle fibers shorten and each duplicated chromosome is pulled apart creating two separate chromosomes.

During telophase, the last stage of mitosis, two new nuclei form where the chromosomes have gathered, and soon two new “daughter” cells are created after the cytoplasm divides by a process called cytokinesis.

The new daughter cells are now back in interphase and each will grow until it reaches the size of the original parent cell.

Now let us repeat our look at mitosis and cell division without stopping—beginning with interphase, to prophase, to metaphase, to anaphase, and finally to telophase and cytokinesis.

And now let’s follow the cell reproduction process in a living cell—first is interphase, then prophase, then metaphase, anaphase, telophase, and cytokinesis.

In multicellular organisms, new cells are normally only produced when old or damaged cells need to be replaced or when a young organism is growing.

But, it is interesting to note that cells occasionally lose the ability to control how fast they reproduce. These cells, called cancer cells, just keep reproducing over and over again until the organism is finally destroyed.
MEIOSIS: REDUCTION DIVISION

In human cells out of a total of 46 chromosomes, one set of 23 chromosomes comes from the male parent and the other set of 23 comes from the female parent. This means that human cells normally have two complete sets of chromosomes. Having two sets of chromosomes is called the diploid condition of the cell.

But in certain cells called germ cells, found only in the testes of male or the ovaries of females, a process called meiosis takes place that produces haploid cells—cells that have only half the normal diploid number of chromosomes. These cells are called sex cells; the sperm and eggs. Now let us follow the process of meiosis step by step.

Like mitosis, meiosis begins with cells that are in interphase; no chromosomes are visible, but the DNA is replicated during this stage.

The next stage of meiosis, called the first prophase, is quite different from mitosis because the identical pairs of duplicated chromosomes start to group together, and during the first metaphase stage, the duplicated chromosome pairs line up in the center of the cell facing each other.

During the first anaphase of meiosis, the duplicated chromosomes don’t split apart like they did in mitosis; instead they stay stuck together, and one set of each duplicated chromosome pair is pulled in an opposite direction, so that after the first telophase, single duplicated chromosomes remain in each daughter cell.

If this were mitosis, we would be finished at this point, but in meiosis, we have only reached the halfway mark. Now the new cells are in a very brief interphase in which the chromosomes only partially retreat back into chromatin and, very importantly, the DNA is not replicated before the daughter cells enter a second prophase.

From now on out, every thing occurs just as it would during a normal mitosis.

Having reached the end of meiosis, we can see that, compared to mitosis, a big change has taken place because each of the new sex cells has only half the number of chromosomes of the original germ cells.

Now let us look at meiosis from beginning to end without stopping as the germ cell enters the first prophase, the first metaphase, the first anaphase, the first telophase, and the first cytokinesis.

Then the new cells enter the second prophase, the second metaphase, the second anaphase, the second telophase, and the second cytokinesis.

Even though this example demonstrates the typical process of meiosis in multicelled organisms, it should be pointed out that owing to unequal cell divisions in human females, only one functional egg is produced by meiosis.

Nevertheless, if the sex cells produced in this example were human, they would each would contain a haploid number of 23 chromosomes.

So that if the egg and sperm were to join during fertilization, they would create a fertilized egg having 46 chromosomes and from this fertilized egg, through repeated cell divisions, a diploid human embryo would develop.

One further fact to point out is that mistakes sometime occur when germ cell DNA is replicated—mistakes such as the one seen here, in which a genetic code letter is accidentally deleted.

Such mistakes are called genetic mutations. They create inaccurate cell information.
Having the wrong cell information can cause terrible genetic diseases, such as Huntington’s Disease, which has afflicted many members of this family.

This serious genetic disease is not often seen, but the genetic diseases cystic fibrosis and sickle cell anemia are quite common and afflict millions of people worldwide.

Yet, it is important to note that genetic mutations are not always bad; for in extremely rare instances, they actually have positive effects that give an organism a better chance of surviving.

And it is because of these “good” genetic mutations that organisms have been able to adapt and change over the centuries as their environments have changed.

LESSON THREE VIDEO QUIZ

Students may write their answers to the following questions on a separate sheet of paper or on Blackline Master 10, Lesson Three Video Quiz.

1. Before cells divide, the nucleus has to reproduce. This process is called __________.
2. DNA replication takes place during the first stage of nuclear reproduction called ________________.
3. Sex cells have only ________ the number of chromosomes of body cells.
4. Fibers called ___________ ___________ form around the centrioles of animal cells during the reproduction of the nucleus.
5. The process in which male and female sex cells join together is called ________________.

UNIT TEST

(Answer can be found on page 22 of this guide)

True or False (1 point each)
Directions: Mark each of the following statements with “T” if it is true, or “F” if it is false.

1. The large intestine is an organ of the human excretory system.
2. A cell’s mitochondria are where stored energy is released.
3. Proteins are made on the millions of tiny organelles called nucleoli, which are produced in a special part of the nucleus called the ribosome.
4. Human cells have 46 pairs of chromosomes.
5. DNA in chromosomes is made up of two long twisted strands built from four small sub-units containing the chemicals adenine, guanine, thymine, and riboflavin.
6. In asexual reproduction, only one parent is needed to create an offspring.
7. The first, and shortest, stage of mitosis is called interphase.
8. Having two sets of chromosomes is called the diploid condition of the cell.
9. Because human beings have two complete sets of chromosomes, the effect of genetic mutations are usually hidden in the offspring.
10. Living things are always very highly organized in the way in which they are put together.
**Multiple Choice (2 points each)**

**Directions:** Circle the correct answer to the following.

11. The following statements are characteristics of living things EXCEPT:
   (a) All living things can grow and develop.
   (b) All living things must have two parents to reproduce.
   (c) All living things can respond to the outside world.
   (d) All living things need to use energy to power their life processes.
   (e) All living things are highly organized in the way they are put together.

12. The endocrine system produces chemical messengers called
   (a.) Golgi complex
   (b.) hormones
   (c.) chromosomes
   (d.) lysosomes
   (e.) ribosomes

13. The following are roles for proteins EXCEPT:
   (a) Helping fight disease
   (b) Helping transport particles across the cell membrane
   (c) Building and repairing cells
   (d) Acting as enzymes for chemical reactions
   (e) Acting as subunits for DNA

14. The order of the phases, from first to last, involved in cell division are
   (a.) metaphase, anaphase, telophase, cytokinesis, interphase, prophase
   (b.) anaphase, prophase, metaphase, telophase, cytokinesis, interphase
   (c.) interphase, prophase, metaphase, anaphase, telophase, cytokinesis
   (d.) cytokinesis, interphase, prophase, metaphase, telophase, anaphase
   (e.) telophase, cytokinesis, anaphase, interphase, prophase, metaphase

15. The following term means “cell eating;”
   (a.) food vacuole
   (b.) endoplasm
   (c.) enzyme
   (d.) meiosis
   (e.) phagocytosis
### Chart (4 points each)
**Directions:** Complete the chart below; identify the nine organ systems of the human body, their main functions and their main organ(s).

<table>
<thead>
<tr>
<th>ORGAN SYSTEM</th>
<th>FUNCTION</th>
<th>MAIN ORGAN(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.</td>
<td></td>
<td></td>
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<tr>
<td>17.</td>
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<td>23.</td>
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<tr>
<td>24.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Essay Questions (5 points each)
**Directions:** Answer the following questions in the spaces provided; use the back of this sheet if necessary.

25. What are genetic mutations? What role do they play in adaptation, that is, adapting to changes in the environment?

26. What is the unique significance of the letters A, G, T, and C to biologists?

27. Describe the process of photosynthesis. Why is this process important to humans?

28. What role(s) do enzymes play in cellular chemical reactions?

29. Describe the stages of mitosis.

30. What is the significance of the cell’s nucleus? What is the relationship between the nucleus and the cell’s DNA?

### Diagram (14 points)
**Directions:** Label the parts of a cell in the spaces provided.

31. 
Answer Key

Blackline Masters 16-19, Unit Test

True or False (1 point each)
1. F
2. T
3. F
4. F
5. F
6. T
7. F
8. T
9. T
10. T

Multiple Choice (2 points each)
11. d
12. b
13. a
14. c
15. e

Chart (4 points each)

<table>
<thead>
<tr>
<th>ORGAN SYSTEM</th>
<th>FUNCTION</th>
<th>MAIN ORGAN(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. RESPIRATORY</td>
<td>Takes oxygen into the body and gets rid of waste carbon dioxide and water vapor.</td>
<td>lungs</td>
</tr>
<tr>
<td>17. CIRCULATORY</td>
<td>Distributes oxygen, food and hormones to the cells. Carries waste carbon dioxide to the lungs.</td>
<td>heart</td>
</tr>
<tr>
<td>18. DIGESTIVE</td>
<td>Breaks down (digests) food.</td>
<td>Stomach, small intestine, liver, pancreas</td>
</tr>
<tr>
<td>19. SKELETAL</td>
<td>Provides a protective framework for the body.</td>
<td>bones, cartilage</td>
</tr>
<tr>
<td>20. MUSCULAR</td>
<td>Allows the body parts to move.</td>
<td>muscles</td>
</tr>
<tr>
<td>21. EXCRETORY</td>
<td>Removes liquid wastes from the body.</td>
<td>kidneys</td>
</tr>
<tr>
<td>22. NERVOUS</td>
<td>Allows the body to send and respond to the world around it. Oversees all of the other organ systems.</td>
<td>brain</td>
</tr>
<tr>
<td>23. REPRODUCTIVE</td>
<td>Allows us to have children.</td>
<td>ovaries and testes</td>
</tr>
<tr>
<td>24. ENDOCRINE</td>
<td>Produces chemical messengers that travel through the blood to help regulate some of the organs in the body.</td>
<td>endocrine glands</td>
</tr>
</tbody>
</table>
Essay Questions (5 points each)

25. Genetic mutations are mistakes that can sometimes occur during meiosis, either in copying the DNA or in separating the chromosomes into new cells. This means that the sex cells created will contain incomplete or incorrect plans, and the offspring created from mutated sex cells will become carriers of genetic disease. Because humans have two complete sets of chromosomes, the effect of genetic mutations are usually hidden in the offspring because one set of correct plans still exists. However, this genetic information will have become part of the DNA of every cell in the body and will be passed on from generation to generation. If, at some future time, two carriers of a genetic mutation have a child, that child may show the symptoms of the genetic disease. These genetic mutations can, in extremely rare instances, have positive effects that give an organism a better chance of surviving, which allow organisms to adapt and change over time as their environments have changed.

26. DNA is made up of two long, twisted strands, each of which is built from four small sub-units containing the chemicals adenine, guanine, thymine, and cytosine, which scientists have abbreviated A, G, T, and C. The cell puts these units together in a definite order to create a chemical language called the Genetic Code, that is used by all living things to store information. These four letters can only be used to make words that are three letters long, so that the entire genetic code dictionary contains just 64 different words. Except three or four “punctuation” words, all the rest of the genetic code words in DNA represent the chemical building blocks called amino acids, from which proteins are made.

27. A plant has chloroplasts, inside which light energy is used to combine carbon dioxide (CO2) and water (H2O) to make sugar. The sun’s energy actually becomes part of the sugar’s chemical structure. Humans (and other animals) need the energy contained in this sugar. Humans must eat plants, or animals that eat plants, in order survive. The sugar provides stored energy, which is released in a process called cellular respiration.

28. Nearly every time chemicals need to be combined or changed inside of cells, the proteins known as enzymes must be present or the chemical reactions will not take place. Some types of cells, such as those that cover the structures called villi that line the small intestine, make enzymes that are used outside the cell. These proteins go through the endoplasmic reticulum to the Golgi complex, where they are specially prepared before being shipped into the digestive tube. Without enzymes, digestion could not occur.

29. The first, and longest, stage of mitosis is called interphase: a period of cell growth when the nucleus is filled with chromatin fibers. During interphase, a process called DNA replication takes place; the old DNA is copied and two new sets of DNA plans are made. DNA replication will later result in a duplication of the chromosomes. Before the chromosomes appear from the chromatin, the centriole pairs are also duplicated, and early in the next stage of mitosis called prophase, they move to opposite sides of the nucleus, where important tubular structures called spindle fibers will form around them as the newly duplicated chromosomes come into view. During the next stage of mitosis, called metaphase, the duplicated chromosomes line up in the middle of the spindle fibers. Then, during the fourth stage of mitosis called anaphase, the spindle fibers shorten and each duplicated chromosome is pulled apart creating two separate chromosomes. During telophase, the last stage of mitosis, two new nuclei form where the chromosomes have gathered and two new cells are created after the cytoplasm splits by a process called cytokinesis. The new cells are now in interphase and each will grow until it reaches the size of the original parent cell.
30. The nucleus is the control center of the cell; inside the nucleus some of the proteins made in the cytoplasm help create structures that guide the activities of the cell. The nucleus contains the cell’s DNA, or deoxyribonucleic acid. DNA is the most important chemical in the entire cell, because the DNA is where the information on how to run the cell is stored. The long chains of DNA are plans that tell the cell how to make different proteins. The proteins will do what is needed to keep the cell alive; this means building and repairing old or worn out parts, transporting particles, helping fight disease, or by acting as enzymes that allow chemicals to combine inside the cell.

31. Parts of the Cell:
UNDERSTANDING CELLS
A UNIT OF STUDY
Cat. No. 2339

BLACKLINE MASTERS

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1. The “basic units of life” are called ___________________.

2. Two characteristics of living things are that they can ________ and ________________ .

3. The creatures seen here are called ___________________ because they have only one cell.

4. Bigger, more complicated creatures will have many more ________ than simpler ones.

5. Because they are highly organized in the way they are put together, living things are often called _________________.

6. Similar kinds of cells usually form layers called _________________.

7. In multicellular organisms, cells have become _________________ to perform certain tasks.

8. The organ system used to pump blood is called the _________________ system.

9. The organ system for breathing is called the _________________ system.

10. The brain is the main organ of the _________________ system.
UNDERSTANDING CELLS
Lesson One: Life and Cells

Vocabulary List

ALGA: (Plural algae) A primitive plantlike organism.

BACTERIA: (Singular bacterium) The simplest unicellular organisms. Bacterial cells lack a nucleus.

CELLS: The basic units of life. The simplest living structures that can carry out all the activities characteristic of life.

CHARACTERISTICS: Distinctive features.

CIRCULATORY SYSTEM: The organ system that delivers food, hormones, and oxygen to cells and carries away carbon dioxide and other waste products.

DIGESTIVE SYSTEM: The organ system which helps break food down into simpler substances.

DIVISION OF LABOR: The division of work among the different parts of the body.

ENDOCRINE SYSTEM: The organ system of glands which produce the chemicals called hormones that help to run the body.

ENDOCRINE GLANDS: The organs of the endocrine system. They make chemical messengers called hormones that travel through the blood to bring about changes in other organs. The endocrine glands include the pituitary, the thyroid, the parathroids, the adrenals, part of the pancreas, the ovaries, and testes.

ENERGY: The world is made up of matter and energy. Matter has mass (weight) but energy does not. Matter occupies space; energy does not. Energy is the ability to do work, the ability to move matter. Living things need a source of energy to power their life activities.

EXCRETORY SYSTEM: The organ system that removes liquid wastes from the blood stream and eliminates them from the body.

FERTILIZATION: In biology, fertilization refers to the joining of the male and female sex cells.

HORMONES: Chemical messengers that travel through the blood.

LICHEN: A type of organism made of a fungus and an alga that is usually found living on the surface of rocks.

LYMPH NODES: Organs that produce the white blood cells called lymphocytes.

MICRO–ORGANISMS: Organisms that are so small they can only be seen under a microscope.

MULTICELLULAR ORGANISM: An organism made up of many cells.

MUSCULAR SYSTEM: The system of muscles that can contract allowing the body to move.

NERVOUS SYSTEM: The body system that, by sending out and receiving tiny electrical impulses, controls most of the activities of the body.

NUTRIENTS: Food the body can use.

OFFSPRING: Descendants, children.

ORGAN: A group of tissues that work together to perform certain functions. The third level of organization in an organism.

ORGAN SYSTEM: A group of organs that works together to perform certain functions.

ORGANISM: An entire living thing that carries out all the basic functions of life.

PROTOZOA: Unicellular, animal–like organisms of the kingdom Protista.

RED BLOOD CELLS: These cells cause our blood to be red. Their role is to carry oxygen from the lungs to other cells in the body. Although red blood cells have nuclei when they are developing, the mature cells have no nuclei.

REPRODUCE: To produce more members of the same species of organism.

REPRODUCTIVE SYSTEM: The organ system that produces sex cells and that makes it possible for an organism to produce offspring. The ovaries and testes are the main organs of this system. (NOTE: Because they also produce hormones, the ovaries and testes are also included in the endocrine system.)

RESPOND: To make a response. To react to something. Living things respond to stimuli in the world around them.

RESPIRATORY SYSTEM: The organ system that brings oxygen into the body and removes waste carbon dioxide and water vapor.

SEA ANEMONE: A simple multicellular organism that lives in ocean tide pools. Sea anemones resemble flowers.

SKELETAL SYSTEM: The system of bones and cartilage that support the body and help protect the soft internal organs.

SPECIALIZED CELLS: Cells in the bodies of multicellular organisms that carry out special tasks. For example, muscle cells are specialized cells that help move parts of the body.

STIMULI: Plural of stimulus. Something that causes activity. Example: People respond to the stimulus of loud noise by plugging their ears.

TISSUE: Usually tissues are layers of similar cells that perform a certain function. Tissues are the second level of organization in an organism.

TRILLION: A million millions. Adult human beings have around 100 trillion cells.

UNICELLULAR ORGANISM: An organism made up of only one cell.

WHITE BLOOD CELLS: Blood cells that act as a defense system against disease.

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UNDERSTANDING CELLS
Lesson One: Life and Cells
Crossword Puzzle

ACROSS
1. Creatures with only one cell are said to be ____________.
2. Creatures with more than one cell are said to be ____________.
3. Layers of cells that are similar in structure and perform a certain function are called ____________.
4. Because they are so highly organized, living things are often called ________________.
5. One characteristic of living things is that they can ____________ to things that happen in their environments.
6. Another characteristic of living things is that they need a source of ____________ to stay alive.

DOWN
1. The lungs are the main organ of the ______________ system.
2. In complicated living things, such as human beings, cells have become ____________ to perform different tasks.
3. The organ system responsible for removing liquid wastes from the body is called the ______________ system.
4. One of the main characteristics of living things is that they are able to ______________ to create offspring.
5. The organ system of glands that make the chemical messengers called hormones is called the ______________.
6. The brain is the main organ of the ______________ system.
7. Because they are the simplest units of structure and function capable of carrying out all the processes characteristic of life, cells are often called the ____________ of life.
UNDERSTANDING CELLS
Lesson One: Life and Cells
The Characteristics of Living Things Fact Sheet

The following characteristics apply to all living things. Different people have come up with variations on these characteristics, but this list incorporates most points of view.

1. Living things can reproduce to create offspring that are very similar to themselves.

2. Living things can grow and develop.

3. Living things can respond to the outside world.

4. Living things use energy to stay alive.

5. Living things can change as their environments change.

6. Living things can move.

7. Living things are always very highly organized in the way in which they are put together.

8. Living things are always made up of one or more cells.

9. Living things have definite “life spans.”
UNDERSTANDING CELLS  
Lesson One: Life and Cells  
The Organ Systems of the Human Body

Directions: Complete the chart below by identifying the organ systems, functions, and major organ(s) of the human body.

<table>
<thead>
<tr>
<th>ORGAN SYSTEM</th>
<th>FUNCTION</th>
<th>MAIN ORGAN(S)</th>
</tr>
</thead>
</table>


UNDERSTANDING CELLS
Lesson Two: How Cells Work
Video Quiz

Directions: At the end of the video lesson, there is a short quiz. The same quiz appears below; write the answers to the quiz on this sheet.

1. Sugar is one of the main sources of __________ for cells.

2. The organelles called ______________ are also known as the powerhouses of the cell.

3. Tens of thousands of tiny “protein factories” called___________ are found on the surface of much of the cell’s endoplasmic reticulum.

4. The organelles called ______________ are made in the nucleus in a special area called the nucleolus.

5. Much of the material in the nucleus is used for storing______________.

6. The language used by cells is known as the________________.

7. Chromosomes contain a long, twisted, thread–like, chemical called ________.

8. Chromosomes are not always visible in cells. They can be seen only when cells are getting ready to ____________.

9. The cell’s language uses a chemical alphabet that is only __________ letters long.

10. Each set of protein plans is called a __________.
UNDERSTANDING CELLS
Lesson Two: How Cells Work
Vocabulary List

**ADENOSINE TRIPHOSPHATE (ATP):** The major source of readily available energy in cells. ATP is produced in the mitochondria when sugar and oxygen are chemically combined. The energy released is transferred to a chemical known as ADP to make ATP.

**AMOEBA:** A type of unicellular organism that has no definite outer shape.

**CELL DIVISION:** The process that results in two cells being formed from one cell.

**CELL MEMBRANE:** The outer layer of the cell that helps control what comes into and what goes out of the cell. Also called the plasma membrane.

**CELL WALL:** The tough layer outside the cell membrane in plants and bacteria. Wood is little more than the cell walls of trees.

**CENTRIOLES:** Cytoplasmic structures in animal cells that play a role in cell division by aiding spindle formation.

**CHLOROPLASTS:** Organelles in plant and algae cells that contain the green pigment chlorophyll that captures the sun's energy. Chloroplasts are the place where plants make sugar.

**CHLOROPHYLL:** The chemical found in chloroplasts that transfers light energy to chemical energy. Plants get their green color from chlorophyll.

**CHROMATIN:** Chromatin is made up of the tangled, threadlike, coils of chromosomes. Chromatin contains DNA plus certain proteins.

**CHROMOSOMES:** Chromosomes are worm–shaped structures that “condense” from chromatin before cells divide. Chromosomes contain DNA and protein. Human body cells have two full sets of 23 different chromosomes.

**CYTOPLASM:** All the protoplasm located outside the nucleus.

**DEOXYRIBONUCLEIC ACID (DNA):** A long chemical shaped like a twisted ladder. The plans for running and reproducing cells are chemically stored in the DNA. DNA is found mostly in the nucleus but small amounts have also been found in the mitochondria and chloroplasts.

**ENDOPLASMIC RETICULUM:** A complex network of tubular passageways leading out of the nuclear membrane used in transporting proteins.

**ENZYMES:** Proteins that control the rates of chemical reactions in cells. Digestive enzymes such as pepsin and trypsin are produced by specialized cells to break down food in the digestive tract.

**EUKARYOTIC CELLS:** Cells that possess nuclei.

**FOOD VACUOLE:** A small sac created when the cell membrane surrounds a food particle.

**GENETIC CODE:** The chemical language of the cell. DNA stores its plans in the genetic code language.

**GOLGI COMPLEX:** An organelle made up of stacks of membranes that help process, package and deliver proteins from the endoplasmic reticulum.

**LYSOSOMES:** Organelles rarely found in plants that contain digestive enzymes which break down food and digest worn out cell parts.

**MICROTUBULES:** The structural parts that make up the “skeleton” of the cell and that also help move certain organelles in the cell.

**MITOCHONDRIA:** (Singular: Mitochondrion) The organelles where chemically stored energy is released. Known as the “Power-houses of the Cell.”

**NUCLEAR:** Refers to the nucleus.

**NUCLEUS:** (Plural: Nuclei) a rounded structure located in the cytoplasm that acts as the control center for the entire cell.

**NUCLEOLUS:** “Little Nucleus.” The area of the nucleus where ribosomes are made. Cells can have more than one nucleolus.

**ORGANELLES:** “Little Organs.” Certain structures in the cytoplasm where specific tasks are carried out.

**PHAGOCYTOSIS:** “Cell Eating.” Occurs when the cell membrane surrounds food material producing a food vacuole.

**PLASMA MEMBRANE:** Another name for the cell membrane.

**PROKARYOTIC CELLS:** Cells of very primitive organisms such as bacteria and blue–green algae that lack nuclei.

**PROTEINS:** Chemicals made up of long chains of amino acids. Proteins build living material, help carry out chemical reactions, fight disease, and help transport things out of the cell.

**PROTOPLASM:** The living jelly–like substance of cells.

**RIBOSOMES:** The organelles where proteins are made from amino acids.

**VACUOLE:** In plant cells the vacuole is a large sac that contains liquid.
UNDERSTANDING CELLS
Lesson Two: How Cells Work
Crossword Puzzle

ACROSS

1. The________________ are the organelles where the stored energy of sugar is released.
2. The gas called_____________ is usually needed to release the energy stored in sugar.
3. When the energy of sugar is released, it is converted to a chemical abbreviated __________ that is readily available to carry out work inside the cell.
4. During cell reproduction, the chromosomes “condense” from the __________ that is normally found in the nucleus.
5. Tiny packets of digestive enzymes inside of cells are called ____________________.
6. The system of intricate passageways inside of cells is called the________________ reticulum.
7. The chemical language of cells is called _________________________.
8. In plant cells, the organelles called ________________ are where energy of sunlight is converted to stored chemical energy.

DOWN

1. Proteins are made on the organelles called _________________.
2. The living material of both the nucleus and cytoplasm is called by the general name of _________________.
3. All the living material of an animal cell is enclosed in a flexible _________________.
4. Cell products are wrapped in membranes by an organelle called the ______________ complex.
5. Two by–products of cellular respiration are ________________ and water.
UNDERSTANDING CELLS
Lesson Two: How Cells Work
Diagrams of Cells

PLANT CELL

ANIMAL CELL
UNDERSTANDING CELLS
Lesson Three: How Cells Reproduce
Video Quiz

Directions: At the end of the video lesson, there is a short quiz. The same quiz appears below; write the answers to the quiz on this sheet.

1. Before cells divide, the nucleus has to reproduce. This process is called __________.

2. DNA replication takes place during the first stage of nuclear reproduction called ________________.

3. Sex cells have only _______ the number of chromosomes of body cells.

4. Fibers called ___________ ___________ form around the centrioles of animal cells during the reproduction of the nucleus.

5. The process in which male and female sex cells join together is called ________________.
UNDERSTANDING CELLS
Lesson Three: How Cells Reproduce
Vocabulary List

ANAPHASE: The fourth stage of mitosis. During anaphase, the new chromosomes move toward opposite ends of the cell.

CANCER CELLS: Cells that lose the ability to control how fast they reproduce.

CYSTIC FIBROSIS: A serious, often deadly, genetic disease that results in the production of excess secretions especially in the lungs, pancreas, and digestive tract. This disease is most deadly when the lungs become clogged with mucous and breathing becomes difficult.

CYTOKINESIS: The division of the cytoplasm that follows mitosis.

DIPLOID: Having two sets of identical chromosomes.

DNA REPLICATION: The duplication of the DNA. DNA replicates during the interphase stage of mitosis.

FERTILIZATION: The union of female and male sex cells.

GAMETE: Another name for a sex cell.

GENETIC MUTATION: Damage to a chromosome or to the DNA that causes incorrect instructions to be used by a cell. Most mutations result in illness or death but sometimes mutations result in favorable changes.

GENETIC DISEASE: An illness caused by damage to the DNA or the chromosomes that is usually inherited from a parent.

GERM CELLS: The diploid cells of the reproductive system that can undergo meiosis to produce haploid sex cells.

HAPLOID: Having only one set of chromosomes; sex cells, the sperm and egg are haploid. Haploid cells are created from germ cells by meiosis.

HEREDITARY DISEASE: The same as a GENETIC DISEASE.

HOMOLOGOUS CHROMOSOMES: In diploid cells these are the matching chromosomes. Human cells have a total of 46 chromosomes: 23 pairs of homologous chromosomes.

HUNTINGTONS DISEASE: Also called HUNTINGTON’S CHOREA. A genetic disease of that affects the nervous system. Huntington’s Disease results in involuntary jerking movements, mental impairment, speech disturbances, and can cause death.

INTERPHASE: The first stage of mitosis: 90% of a normal cell’s life cycle is spent in this stage. During interphase, the DNA replicates, the centrioles divide, and new organelles are made. Chromosomes are not visible during interphase.

MEIOSIS: The process that takes place in the ovaries and testes when haploid sex cells are created from germ cells. As a result of meiosis, the diploid chromosome number of the parent cell is reduced by half. This occurs because the DNA replicates only once but the cells divide twice. Meiosis is also called REDUCTION DIVISION.

METAPHASE: The third stage of mitosis during which the duplicated chromosomes line up in the center of the mitotic spindle.

MITOSIS: The division of the nucleus that produces the same number of chromosomes as was present in the original cell.

MITOTIC SPINDLE: A system of microtubules that appears during mitosis. The spindle fibers act to separate the chromosomes.

OVUM: (Plural ova) An egg. A female sex cell. Ova are haploid cells produced during meiosis in the ovaries.

OVARY: The main organ of the female reproductive system that produces ova.

POLAR BODIES: The three small structures, little more than haploid nuclei, that along with a single ovum are produced during meiosis in human females. Polar bodies serve no reproductive function.

PROPHASE: The second stage of mitosis. During prophase the duplicated chromosomes make their appearance. During prophase in animal cells, the spindle fibers form around the centrofolds and the nuclear membrane breaks down.

REDUCTION DIVISION: Another term for meiosis.

SEX CELLS: Also called gametes: the sperm and eggs. The haploid male and female sex cells produced during meiosis that join during fertilization to create the single diploid cell called a fertilized egg (zygote).

SICKLE CELL ANEMIA: A genetic disease in which the red blood cells lose their rounded shape and become pointed. As a result of this illness, the cells of the body are unable to obtain enough oxygen.

SISTER CHROMATIDS: The two parts of a duplicated chromosome that are present in prophase. The sister chromatids are pulled apart during anaphase and at that point they are simply called chromosomes.

SPERM: The male sex cell. These haploid cells are created in the testes during meiosis.

SPINDLE FIBERS: The microtubular structures that form the mitotic spindle.

TELOPHASE: The fifth and final stage of mitosis. During telophase, daughter nuclei form as the chromosomes change back into chromatin and new nuclear membranes develop. The division of the cytoplasm, cytokinesis, is usually well underway by telophase.

TESTIS (Plural testes). The male reproductive organ which produces sperm and male sex hormones.

X CHROMOSOMES: One of the human sex chromosomes. These chromosomes carry the genes that determine the sex of the offspring. If a pair of X chromosomes is present, the offspring will be female.

Y CHROMOSOME: The second human sex chromosome. When an Y chromosome is paired with an X chromosome, the offspring will be male.

ZYGOTE: Another name for a fertilized egg.
UNDERSTANDING CELLS
Lesson Three: How Cells Reproduce
Crossword Puzzle

ACROSS
1. The last stage of mitosis is called ____________.
2. Having only one of each chromosome is called the ____________ condition of the cell.
3. Reduction division or ______________ causes the number of chromosomes present in a cell to be reduced by half.
4. The female sex cell or egg is also called an__________.
5. The organ system where meiosis occurs is called the ____________ system.
6. The chromosomes first become visible during the stage of mitosis called _________________.

DOWN
1. Having two complete sets of chromosomes is called the ____________ condition of the cell.
2. The duplicated chromosomes are pulled apart during the fourth stage of mitosis called _________________.
3. The duplicated chromosomes are lined up in the middle of the cell during the stage of mitosis called___________.
4. A structure called the mitotic______________ can be seen between the centrioles of animal cells when the cells are reproducing.
5. Cytokinesis is the division of the cytoplasm during cell reproduction; but the division of the nucleus is called___________.
6. The male sex cells are called______________.
UNDERSTANDING CELLS
Lesson Three: How Cells Reproduce

Mitosis

MITOSIS:
INTERPHASE- • No chromosomes are visible.
• Nucleus is filled with chromatin.
• Period of DNA replication and cell growth.
• Centrioles duplicate.

PROPHASE- • Duplicated chromosome pairs “condense” from chromatin.
• Spindle fibers appear.
• Nuclear membrane breaks up.
• Nucleolus is no longer visible.

METAPHASE- • Duplicated chromosomes line up randomly on the equator of the spindle.

ANAPHASE- • Duplicated chromosomes are pulled apart and the new chromosomes move toward opposite poles of the cell.

TELOPHASE- • New nuclei form.
• The spindle disappears.
• Nucleolus reappear.

CYTOKINESIS- • Cytoplasm divides.
• Two new daughter cells are formed.
UNDERSTANDING CELLS
Lesson Three: How Cells Reproduce

Meiosis:

INTERPHASE:
- Meiosis begins with a diploid germ cell in the ovaries or testes.
- Nucleus is filled with chromatin.
- No chromosomes are visible.
- DNA replication occurs.
- Centrioles duplicate.

PROPHASE I:
- Duplicated chromosome pairs appear.
- Spindle fibers develop.

METAPHASE I:
- The matching pairs of duplicated chromosomes line up on the equator of the spindle facing each other.

ANAPHASE I:
- Each duplicated chromosome of a pair move to an opposite pole of the cell.

TELOPHASE I & CYTOKINESIS I:
- One of each of the diplicated chromosomes of a pair is now in a newly-formed cell.

PROPHASE II:
- Single duplicated chromosomes appear on the new spindle. New chromosomes are NOT FORMED because there was NO DNA REPLICATION beforehand.

METAPHASE II:
- Single duplicated chromosomes line up on the equator of the spindle.

ANAPHASE II:
- The duplicated chromosomes are pulled apart and the new chromosomes move toward opposite poles of the cell.

TELOPHASE II:
- Nuclei begin to develop in the forming daughter cells.

CYTOKINESIS II:
- Cytoplasm divides creating HAPLOID sex cells, either sperm or eggs.
UNDERSTANDING CELLS
Lesson Three: How Cells Reproduce
The Cell Cycle

This diagram shows the percentage of time spent by the cell in each stage of cell reproduction. 90% of a cell’s cycle is spent in Interphase.
UNDERSTANDING CELLS
Lesson Three: How Cells Reproduce
Quiz

1. Directions: Using words, describe what happens to the chromosomes during mitosis in the cell of a diploid organism that only has one chromosome pair. On a separate sheet of paper, diagram the process. (30 points)

A. INTERPHASE
B. PROPHASE
C. METAPHASE
D. ANAPHASE
E. TELOPHASE

2. Directions: Using words, describe what happens to the chromosomes during meiosis in a reproductive cell of a diploid organism that has only one chromosome pair. On a separate sheet of paper, diagram the process. (70 points)

STAGES INVOLVED IN THE FIRST MEIOTIC DIVISION
A. INTERPHASE I
B. PROPHASE I
C. METAPHASE I
D. ANAPHASE I
E. TELOPHASE I
CYTOKINESIS I

STAGES INVOLVED IN THE SECOND MEIOTIC DIVISION
F. PROPHASE II
G. METAPHASE II
H. ANAPHASE II
I. TELOPHASE II

CYTOKINESIS II
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UNDERSTANDING CELLS

Unit Test

True or False (1 point each)
Directions: Mark each of the following statements with “T” if it is true, or “F” if it is false.

____ 1. The large intestine is an organ of the human excretory system.
____ 2. A cell’s mitochondria are where stored energy is released.
____ 3. Proteins are made on the millions of tiny organelles called nucleoli, which are produced in a special part of the nucleus called the ribosome.
____ 4. Human cells have 46 pairs of chromosomes.
____ 5. DNA in chromosomes is made up of two long twisted strands built from four small sub-units containing the chemicals adenine, guanine, thymine, and riboflavin.
____ 6. In asexual reproduction, only one parent is needed to create an offspring.
____ 7. The first, and shortest, stage of mitosis is called interphase.
____ 8. Having two sets of chromosomes is called the diploid condition of the cell.
____ 9. Because human beings have two complete sets of chromosomes, the effect of genetic mutations are usually hidden in the offspring.
____ 10. Living things are always very highly organized in the way in which they are put together.

Multiple Choice (2 points each)
Directions: Circle the correct answer to the following.

11. The following statements are characteristics of living things EXCEPT:
   (a) All living things can grow and develop.
   (b) All living things must have two parents to reproduce.
   (c) All living things can respond to the outside world.
   (d) All living things need to use energy to power their life processes.
   (e) All living things are highly organized in the way they are put together.

12. The endocrine system produces chemical messengers called
   (a.) Golgi complex
   (b.) hormones
   (c.) chromosomes
   (d.) lysosomes
   (e.) ribosomes

13. The following are roles for proteins EXCEPT:
   (a) Helping fight disease
   (b) Helping transport particles across the cell membrane
   (c) Building and repairing cells
   (d) Acting as enzymes for chemical reactions
   (e) Acting as subunits for DNA

14. The order of the phases, from first to last, involved in cell division are
   (a.) metaphase, anaphase, telophase, cytokinesis, interphase, prophase
   (b.) anaphase, prophase, metaphase, telophase, cytokinesis, interphase
   (c.) interphase, prophase, metaphase, anaphase, telophase, cytokinesis
   (d.) cytokinesis, interphase, prophase, metaphase, telophase, anaphase
   (e.) telophase, cytokinesis, anaphase, interphase, prophase, metaphase
15. The following term means “cell eating”
(a.) food vacuole  
(b.) endoplasm  
(c.) enzyme  
(d.) meiosis  
(e.) phagocytosis

**Chart (4 points each)**

**Directions:** Complete the chart below; identify the nine organ systems of the human body, their main functions and their main organ(s).

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<th>ORGAN SYSTEM</th>
<th>FUNCTION</th>
<th>MAIN ORGAN(S)</th>
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Essay Questions (5 points each)
Directions: Answer the following questions in the spaces provided; use the back of this sheet if necessary.

25. What are genetic mutations? What role do they play in adaptation, that is, adapting to changes in the environment?

26. What is the unique significance of the letters A, G, T, and C to biologists?

27. Describe the process of photosynthesis. Why is this process important to humans?

28. What role(s) do enzymes play in cellular chemical reactions?

29. Describe the stages of mitosis.

30. What is the significance of the cell’s nucleus? What is the relationship between the nucleus and the cell’s DNA?
Unit Test (Continued)

Diagram (14 points)
Directions: Label the parts of the animal cell.

31.