074

# Structure of Life



There is exciting variety in nature. Much of this variety is found among Earth's **organisms,** or living things. Each organism has unique structures suited to its particular way of life. Still, all living things have some features in common.

075

## Structure and Function

All living things have structures specially designed to do certain jobs. The eyes of a fly, for example, are made up of several smaller units that allow the fly to see many different images of the same object at once. This helps the fly detect very slight movements, and so escape danger. Many birds, on the other hand, have one eye on either side of their head so that they can see what is happening on both sides of them at once.

SEE ALSO

132 Relationships Between Populations

The two eyes of lions and humans are located on the front of their heads. Each eye sees objects from a slightly different angle. The overlapping views allow the animal to gather information about the objects' depth or distance—information needed for hunting. The flatworm has an eye that can't form an image. It can only detect which direction light is coming from, but this is all the information the flatworm needs to find food and avoid predators.

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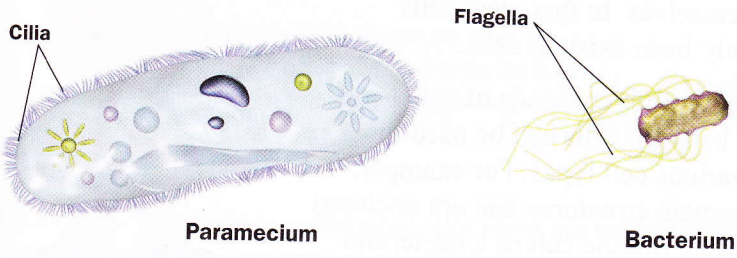
Different organisms may use different structures to do the same job. For example, tiny hair-like cilia surround the microscopic organism known as a paramecium. The cilia move back-and-forth like the oars of a boat to move the paramecium through water. Some bacteria, on the other hand, use whiplike structures called flagella to move through water. The flagella spin rapidly, moving the bacteria much like a propeller moves a boat through water.

**Word Watch!**

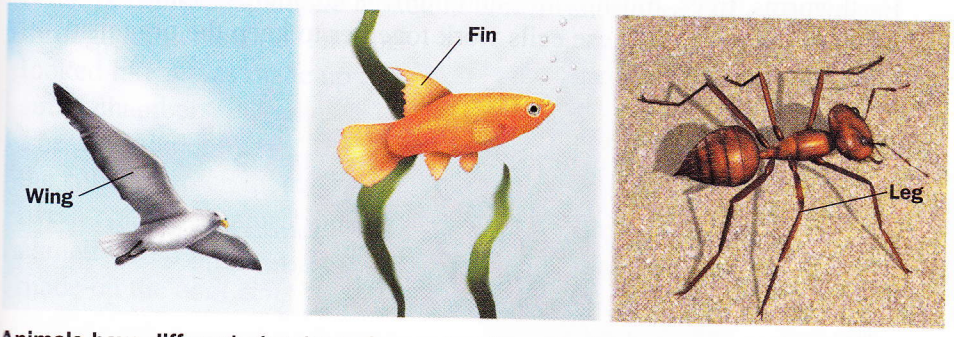
The term *bacteria* is used to refer to members of the kingdom *eubacteria.* A single bacteria is called a *bacterium.*




**Different structures may serve the same function.**

SEE ALSO
156 Protist Kingdom
157 Archaebacteria and Eubacteria Kingdoms

Like microscopic organisms, animals have different kinds of structures to help them move. Birds, bats, and many insects, for example, have wings that allow them to fly through the air. Whales and fish have fins that move them through water. Still other animals, including you, use legs to move from one place to another. Wings, fins, and legs all serve the same function. But each structure is suited to movement in a different type of environment.




**Animals have different structures for moving through air, through water, and on land.**

076

# Cells

All cells have some things in common. For example, all are surrounded by a membrane that holds the contents together, and all use energy to do the work of staying alive.

A feature shared by all organisms is that they are made up of one or more cells. A **cell** is the basic unit of structure and function of life. This is a fancy way of saying that cells make up living things and carry out the activities that keep a living thing alive. A cell is itself a living unit. So, cells are able to make more cells like themselves. In fact, new cells can come only from existing cells.

SEE ALSO
079 Cell Processes
080 Cell Division

There are many different kinds of cells. Differences between cells can be used to categorize various cell types. For example, most cells contain structures that are enclosed by a membrane. But the cell of a bacterium does not have structures surrounded by membranes. Cells that do not have membrane-bound structures are called **prokaryotic** (PRO-care-ee-AH-tic) cells. Cells that have membrane-bound structures are called **eukaryotic** (YOU-care-ee-AH-tic) cells. All organisms except archaebacteria and eubacteria are made up of eukaryotic cells.

SEE ALSO
160 Prokaryotes and Eukaryotes

Many organisms are **unicellular,** or made of only one cell. The cell of a unicellular organism has structures to help the organism move, get food, reproduce, and respond to its surroundings. So, the single cell carries out all the activities that keep the organism alive and allow it to reproduce, or make more of its own kind.

SEE ALSO
113 Reproduction

Earthworms, trees, mushrooms, and humans are **multicellular,** or made of many cells. These cells work together to keep the organism alive and help it reproduce.

**Word Watch!**

*Bacteria* is the plural of *bacterium.*

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Science Alert!

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Many cells in multicellular organisms are specialized to do only certain jobs. For example, the root cells of a plant have tiny hairlike projections that absorb water. Leaf cells do not have these projections. Your nerve cells have long spidery branches that help relay information quickly between your body and your brain. Each specialized cell in a multicellular organism works with other similar cells to carry out a specific job. Having specialized cells for different jobs allows multicellular organisms to perform more functions than unicellular organisms.

SEE ALSO
095 Nervous System

**Science Alert!**

Large organisms have cells that are about the same size as those in small organisms, but large organisms have more cells than small organisms.

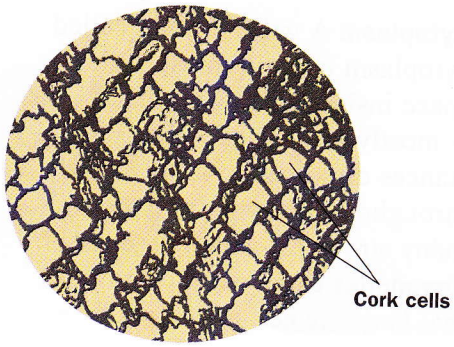
Cells come in all sizes and shapes, but most are **microscopic,** or so tiny you need a microscope to see them.

Your red blood cells are among the smallest cells in your body. About 2000 red blood cells would be needed to form a line across your thumbnail.

**Word Watch!**

The word *cell* comes from the Latin word *cella,* meaning "chamber."

The British scientist Robert Hooke was the first person to observe cells. In the 1660s, Hooke looked at cork from the bark of an oak tree through a microscope. The cork looked like it was made up of small chambers, or rooms. These reminded Hooke of the cells in which monks lived. For this reason, Hooke named the structures that made up the cork *cells.*

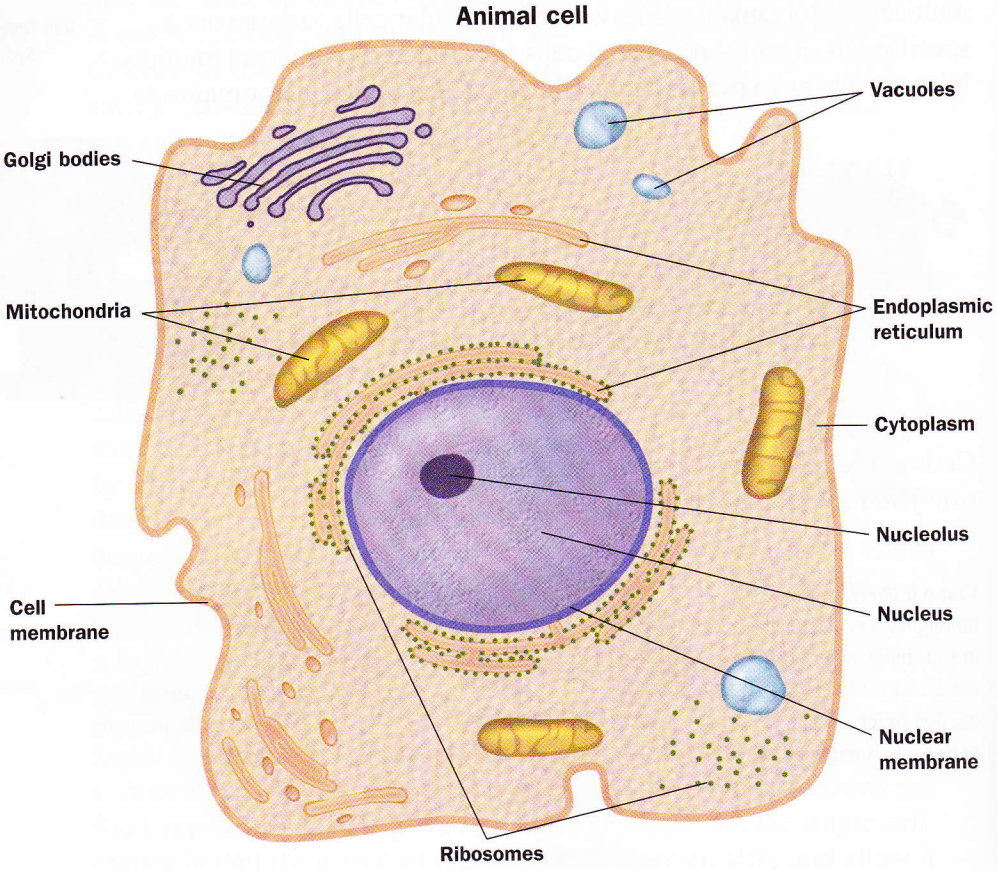


077

## Animal Cell

SEE ALSO
078 Plant Cell

Animals are made up of many different types of cells. The diagram below shows some of the structures found in a typical animal cell. Not all animal cells contain all the structures shown.




**Cell membrane** The cell membrane encloses the cell. It acts like a gatekeeper—allowing some materials to pass through it, but not others.

SEE ALSO
082 Tissues, Organs, and Systems

**Cytoplasm** A gel-like fluid called cytoplasm takes up most of the space inside a cell. Cytoplasm is mostly water, with other substances dissolved in it. Scattered throughout the cytoplasm are many structures called **organelles.** Organelles carry out the activities that keep the cell alive.

**Word Watch!**

*Organelle* means "little organ." Like the organs that make up your body, each kind of organelle is specialized to carry out a specific function within a cell.

**Nucleus** The nucleus
usually located near
animal cell. The nuc
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Chromosomes are m

**Nuclear membrane** T
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**Nucleolus** This struct
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**Vacuoles** These fluid-
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**Science Alert!**

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**Nucleus** The nucleus is a structure usually located near the center of an animal cell. The nucleus is home to the cell's **chromosomes,** genetic structures that contain the information used to direct cell activity and make new cells. Chromosomes are made of **DNA.**

DNA stands for "deoxyribonucleic acid." The traits that make organisms different from one another are coded for in their DNA.

SEE ALSO

080 Cell Division
116 Genes
121 Heredity
115 DNA

**Nuclear membrane** The nuclear membrane surrounds and protects the nucleus.

**Nucleolus** This structure, found inside the nucleus, is responsible for making ribosomes, which are then transported to the cytoplasm.

**Vacuoles** These fluid-filled structures temporarily store different substances needed by the cell. Some are specialized for storing waste products. Animal cells often have many small vacuoles.

**Mitochondria** Mitochondria use oxygen to transform the energy in food to a form the cell can use to carry out its activities. These structures are sometimes called the "powerhouses" of the cell.

Word Watch!

*Mitochondria* is the plural of *mitochondrion.*

**Endoplasmic reticulum** and **Ribosomes** These organelles produce important products for the cell, including proteins and lipids. The endoplasmic reticulum also serves as an internal delivery system for the cell.

**Golgi bodies** Golgi bodies help package products from the endoplasmic reticulum and distribute them around the cell or outside of it.

Science Alert!

Many organelles are too small for you to see using a classroom microscope. But you should be able to find the cell membrane, nucleus, and cytoplasm.

SCILINKS NSTA

Keyword: Cell Structures
www.scilinks.org
Code: GSSM076

078

## Plant Cell

SEE ALSO

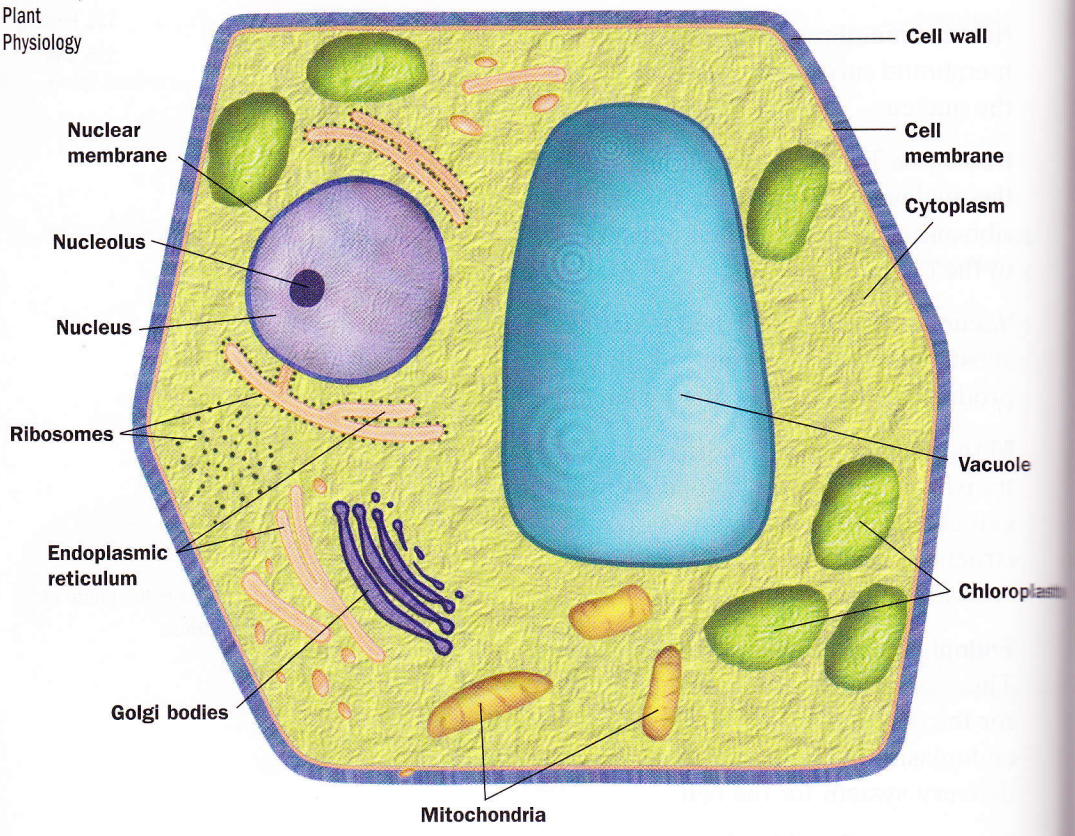
077 Animal Cell

079 Cell Processes

107 Plant Physiology

Plant cells have all the structures animal cells do. But they also have some structures not found in animal cells. These structures include a cell wall and chloroplasts.

**Plant cell**




**Cell wall** This outer barrier provides extra support for the cell and gives it a shape. In plants, the cell wall is made mostly of cellulose, a fiber that is the main component of wood and paper.

**Cell membrane** The cell membrane encloses the cell and controls what materials enter and leave the cell.

**Cytoplasm** This gel-like fluid fills much of the inside of the cell. The **organelles** that carry out the cell's activities are scattered throughout the cytoplasm.

**Nucleus** The nucleus
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**Nuclear membrane** T
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**Nucleolus** This struct
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**Chloroplasts** These
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Science Alert!

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**Vacuole** The vacuole a
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**Nucleus** The nucleus is a structure usually located to one side of a plant cell. The nucleus is home to the cell's **chromosomes,** genetic structures that contain the information used to direct cell activity and make new cells. Chromosomes are made of **DNA.**

**Nuclear membrane** The nuclear membrane surrounds and protects the nucleus.

**Nucleolus** This structure, found inside the nucleus, is responsible for making ribosomes, which are then transported to the cytoplasm.

SEE ALSO
080 Cell Division
116 Genes
121 Heredity
115 DNA

**Chloroplasts** These food-making structures of plant cells contain the green pigment, **chlorophyll.** Chlorophyll captures the energy of sunlight and uses it to drive a chemical reaction that combines water and carbon dioxide to make glucose—the simple sugar plants use as food. This food-making process is called **photosynthesis.**

**Word Watch!**

The word *photosynthesis* is made from the prefix *photo-* meaning "light," and the root *synthesis* meaning "to put together." During photosynthesis, plants use sunlight to put together the atoms that make glucose (their food).

**Science Alert!**

Not all plant cells have chloroplasts. Cells in the roots of plants, for example, are not exposed to sunlight and therefore have no need for chloroplasts.

SEE ALSO
079 Cell Processes
107 Plant Physiology

**Mitochondria** Mitochondria use oxygen to transform the energy in food to a form the cell can use to carry out its activities. These structures are sometimes called the "powerhouses" of the cell.

**Endoplasmic reticulum** and **Ribosomes** These structures produce important products for the cell, including proteins and lipids. The endoplasmic reticulum also serves as an internal delivery system for the cell.

**Golgi bodies** In plant cells, cellulose is made in the Golgi bodies. Cellulose is used in the cell wall.

**Vacuole** The vacuole acts as a storage structure for the cell.

Unlike animal cells, plant cells often have only one large vacuole. It takes up much of the space in the cell.

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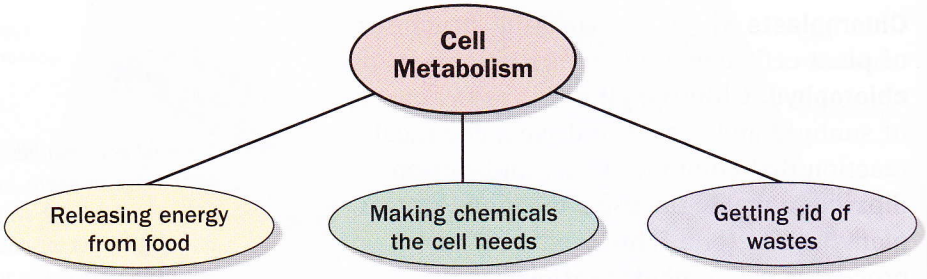
079

## Cell Processes

SEE ALSO

077 Animal Cell
078 Plant Cell
090 Excretory System
093 Circulatory System

Every cell is a busy place in which many chemical activities occur. These activities include releasing energy from food, making chemicals the cell needs, and getting rid of wastes. A cell is well designed to carry out these activities. The fluid cytoplasm, for example, allows materials to move through the cell. A cell also has organelles that make or break down different substances. Together, all the activities carried out by a cell make up its **metabolism.**




**A summary of metabolism**

SEE ALSO

105 Animal Physiology
107 Plant Physiology
267 Chemical Formulas
269 Chemical Reactions

Most chemical activities that take place in a cell need an energy source to drive them. Mitochondria release this energy from food through cellular respiration. **Cellular respiration** is the process in which oxygen ($O_2$) is chemically combined with food molecules (sugar) in the cell to release energy.

Both plant and animal cells get energy in the form they need (**ATP**) through cellular respiration. Because respiration is a chemical process, it can be shown in a chemical equation. The general equation for cellular respiration is written this way:

**glucose (sugar) + $O_2$ → $CO_2$ + $H_2O$ + energy (as ATP)**

Notice that in addition to releasing energy, cellular respiration also produces carbon dioxide ($CO_2$) and water ($H_2O$).

You might also know the term *respiration* as it is commonly used to describe the process of breathing, or bringing oxygen into the body.

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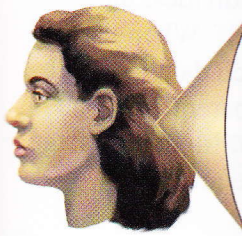

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**Photosynthesis** is the food-making process of plants and some other organisms. Plant cells contain the green pigment **chlorophyll.** Chlorophyll molecules trap energy from the sun and use it to transform carbon dioxide gas ($CO_2$) and water ($H_2O$) into a simple sugar called **glucose.** Plants (and other living things) use glucose as a food source. Oxygen ($O_2$) is also produced during photosynthesis.

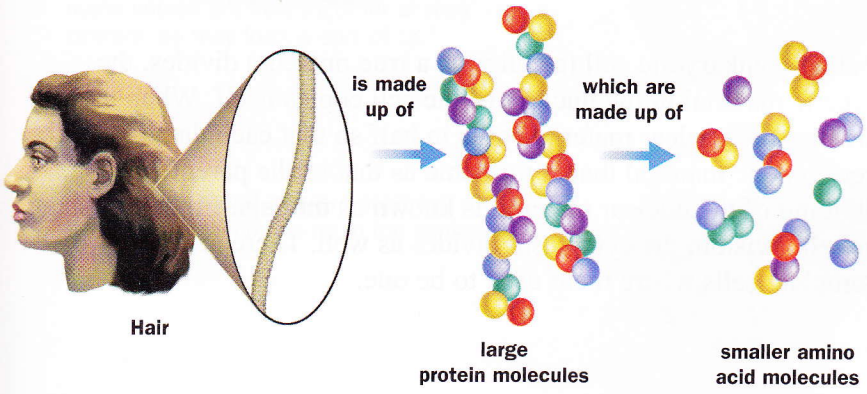
SEE ALSO
078 Plant Cell
156 Protist Kingdom
157 Archaebacteria and Eubacteria Kingdoms

Photosynthesis can be summarized in a chemical equation. The general equation for photosynthesis is written this way:

$$CO_2 + H_2O + \text{energy (sunlight)} \rightarrow \text{glucose (sugar)} + O_2$$

**Proteins** are large molecules of carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur, that are needed by living things. Protein molecules are made up of smaller compounds called **amino acids.** Living things use proteins to build and repair cells, and to control chemical reactions. Special proteins called **enzymes** help direct different chemical reactions in the body.

SEE ALSO
265 Periodic Table
259 Elements, Molecules, and Compounds
089 Digestive System




**Proteins are made up of many amino acids joined together.**

Ribosomes are the protein factories of a cell. An individual cell may have 500,000 ribosomes dotted throughout the membranes of the cell's endoplasmic reticulum and floating freely in the cytoplasm. The endoplasmic reticulum has a lot of surface area to which ribosomes can attach. Once ribosomes get their "work plans" (from the nucleus) to make a specific protein, they combine amino acids to form giant protein molecules. Some proteins are transported to different parts of the cell by the endoplasmic reticulum. Golgi bodies move other proteins to the cell membrane where they can be transported out of the cell.

SEE ALSO
077 Animal Cell
078 Plant Cell

080

## Cell Division

Weeds can grow pretty fast. In fact, the stem and roots of a fast-growing plant seem to get longer over night. Where do the new stem and root parts come from? They are made when existing cells divide to form new cells. This process is called **cell division.** Cell division allows organisms to grow larger. Cell division also helps organisms replace injured cells.

The cells formed through cell division are called *daughter cells*. The daughter cells form from the parent cell.

SEE ALSO

076 Cells
077 Animal Cell
078 Plant Cell
081 Stages of Cell Division

Before a eukaryotic cell (a cell with a true nucleus) divides, the genetic material in the nucleus of the cell copies itself. When the cell divides, the nuclear material splits in half so that each daughter cell gets genetic material that is the same as that of the parent cell. The dividing of the nuclear material is known as **mitosis.** In the last stage of cell division, the cytoplasm divides as well. There are now two complete cells where there used to be one.

Science Alert!

The terms *mitosis* and *cell division* are sometimes used interchangeably. But mitosis really refers only to the dividing of the nuclear material. Cell division is the complete process of copying and dividing the whole cell.

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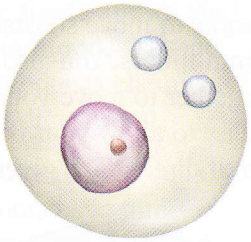
## Stages of Cell Division

081

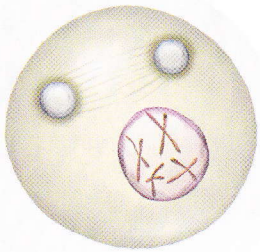
Cell division in eukaryotic cells (cells with a true nucleus) occurs in a predictable set of stages or phases. These steps ensure that the new daughter cells are the same as the cell from which they formed.

SEE ALSO
077 Animal Cell
078 Plant Cell

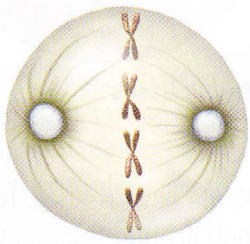
1. **Interphase** is the stage before cell division starts. As a cell prepares to divide, each chromosome in the nucleus makes an exact copy of itself.



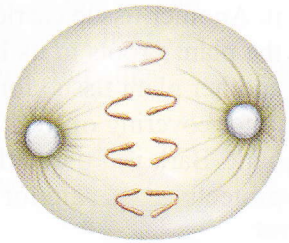
2. During **prophase,** the nucleus prepares for cell division. The genetic material shortens and thickens. The chromosome copies are held together at their centers, so they form a sort of "X."



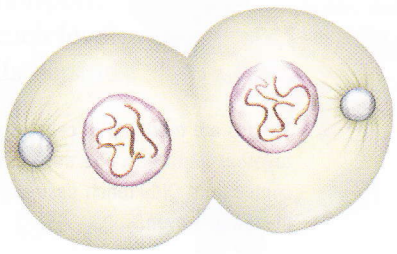
3. During **metaphase,** the two copies of each chromosome line up in the center of the cell.



4. During **anaphase,** the copies separate. One complete set of chromosomes is pulled to one side of the cell. The other complete set is pulled to the other side of the cell.



5. **Telophase** is the final stage of cell division. During this stage, the cytoplasm pinches in at the center of the cell, dividing the original cell in half. When cell division is complete, two new daughter cells are formed. The daughter cells are identical to the parent cell.



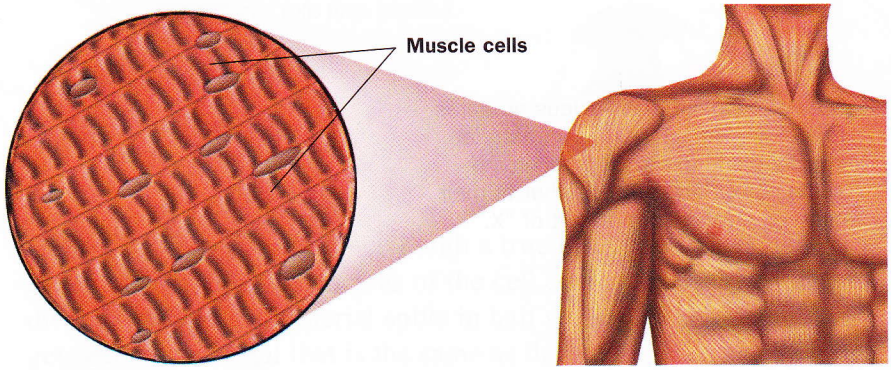
# Tissues, Organs, and Systems

082

Groups of cells that work together to do a specific job are called tissues. Your body, like that of many other animals, is made up of several types of **tissue.** Blood, for example, is a tissue that includes different kinds of blood cells and platelets in a liquid. This tissue works to move substances throughout your body and protect you from illness. You also have muscle tissue and nerve tissue that work together to move your body. Cells of the muscle tissue contract or relax to allow your body to move. But this movement does not occur until direction is given by cells of the nervous tissue.

SEE ALSO

076 Cells
093 Circulatory System
087 Muscular System
095 Nervous System




**Muscle tissue**

Plants have tissues, too. One tissue moves food around the plant to cells that need it. Another tissue carries water up from the plant's roots to its leaves. Still another plant tissue forms the hard outer covering of trees known as bark. Bark is a tissue that acts as a protective covering for woody plants.

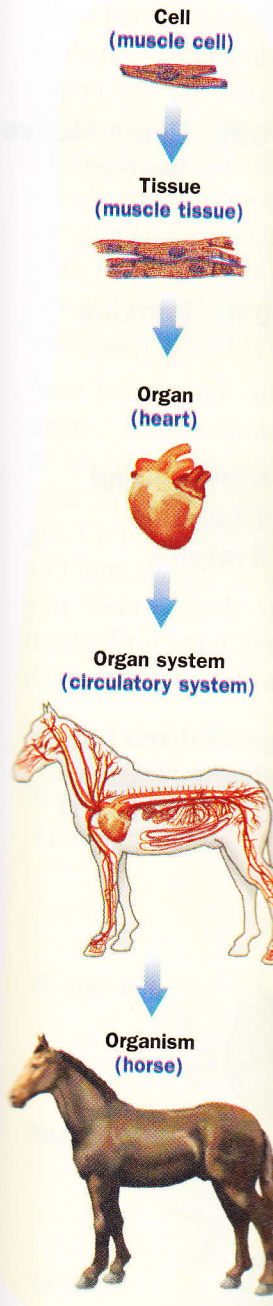
SEE ALSO

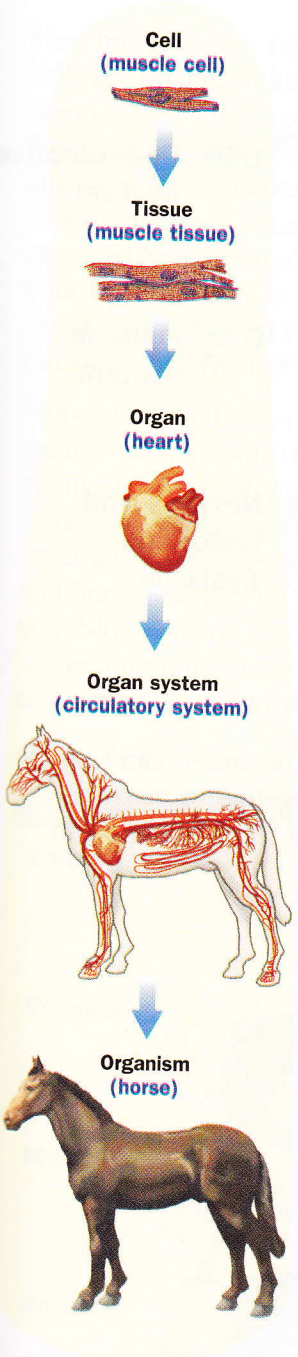
107 Plant Physiology

**A woodpecker must work hard to break through the protective outer tissue, or bark, of a tree.**

**Word Watch!**

Tissues are made up of cells woven together into webs. The word *tissue* comes from Old French *tissu,* meaning "woven."





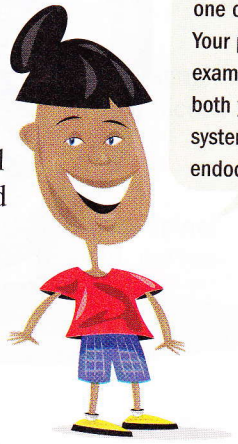

Just as cells join together to form tissues, different tissues join together to form organs. An **organ** is a structure made up of two or more tissues that work together to carry out a specific job. Your stomach is an organ that is made of several types of tissue. For example, muscle tissue allows your stomach to churn and grind food. A tissue that lines your stomach produces chemicals that help break down and digest food.

Roots, stems, and leaves are three organs found in many plants. Roots have three main roles: to absorb water and dissolved minerals, to support and anchor a plant, and to store extra food made by the plant. The different tissues that make up a root carry out these jobs. Other tissues in a plant join together to form leaves. Some of these tissues are specialized to make food. Others are specialized to allow gases to move into and out of the leaf.

SEE ALSO
162 Vascular and Nonvascular Plants

Organs do not usually work alone. Instead, several organs work together as an organ system. An **organ system** is made up of all the organs that work together to do a specific job. One example of an organ system is your digestive system. In this system, your stomach works with your liver, small and large intestines, and other organs to break down food into substances your cells can use. A plant's leaves, stems, and roots work together to make, transport, and store food. At each level of organization, cells depend on other cells to keep the system running smoothly.

SEE ALSO
089 Digestive System
097 Endocrine System



Some organs are part of more than one organ system. Your pancreas, for example, is part of both your digestive system and your endocrine system.

112

# Genes and Heredity

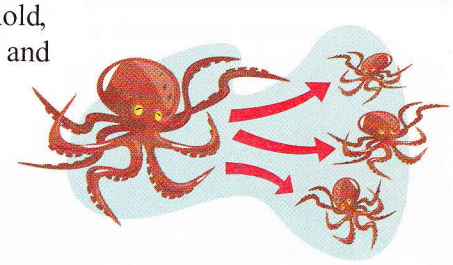


Living things reproduce to make more organisms like themselves. When organisms reproduce, many traits, or characteristics, of the parents are passed to the new organism.

113

## Reproduction

The process of making more of one's own kind is called **reproduction.** Each **species,** or kind, of organism reproduces only its own kind. So, green mold makes only green mold, octopuses make only octopuses, and humans make only humans. Reproduction is essential for the survival of the species.



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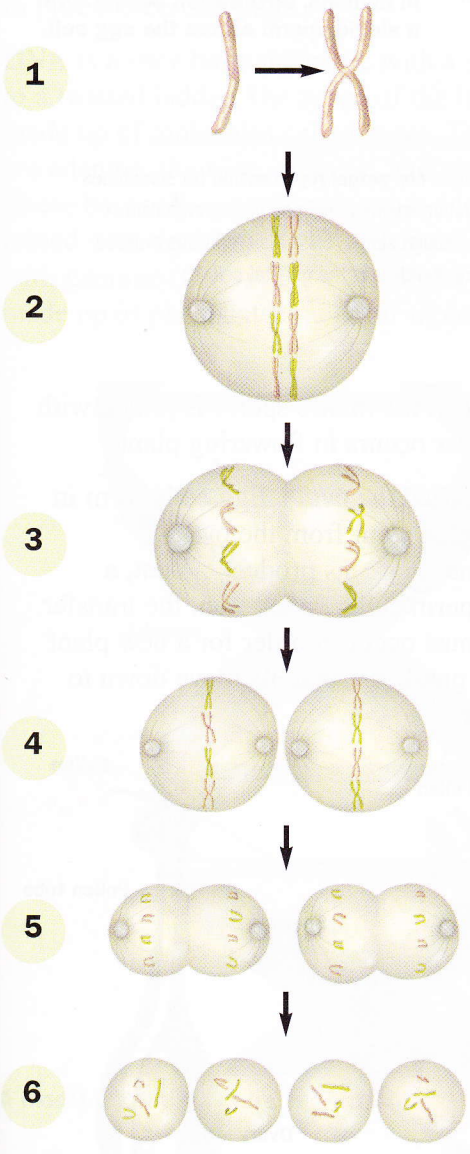
### Sexual Reproduction

Many organisms reproduce by combining cells from two different parents. This type of reproduction is called **sexual reproduction.** In sexual reproduction, the offspring receive genetic material from both parents.

SEE ALSO
116 Genes
121 Heredity

Special cells, called **sperm** and **egg cells,** are used in sexual reproduction. These cells form by a type of cell division called **meiosis.** Cells formed through meiosis have only half the number of **chromosomes,** or genetic material, of the parent cell. For example, most cells of fruit flies have 8 chromosomes (arranged as four **homologous,** or similar, pairs). But the egg or sperm cells of a fruit fly have only 4 chromosomes.

SEE ALSO
077 Animal Cell
078 Plant Cell
116 Genes



1 Before the cell divides, each chromosome copies itself. Held together at their centers, the copies form a sort of "X."

2 Each chromosome in a cell has a homologous, or similar, pair. These pairs now line up two-by-two in the center of the cell.

3 Each pair of homologous chromosomes separates from the other as they move to opposite sides of the cell. The cytoplasm splits and two new cells form. Each new cell has only one of each homologous pair of chromosomes, half the genetic material of the original cell.

4 The chromosomes again line up in the center of the cell, but this time single-file instead of in pairs.

5 The X-shaped chromosomes split and the copies separate. One copy is pulled to one side of the cell. The other copy is pulled to the other side of the cell.

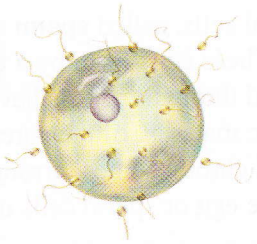
6 Four new cells have formed from the original cell. Each of the four cells has only half the number of chromosomes that the original cell had, and therefore only half the amount of genetic material.

**Stages of meiosis**

MORE ▶

SEE ALSO
099 Reproductive System
102 The Developing Baby

For reproduction to occur, the sperm and egg must join together in a process called **fertilization.** Once fertilized, the egg has a complete set of genetic material. This cell, which is now called a **zygote,** is a unique individual that has some traits of each parent.



**In humans, fertilization occurs after a single sperm enters the egg cell.**

## Did You Know?

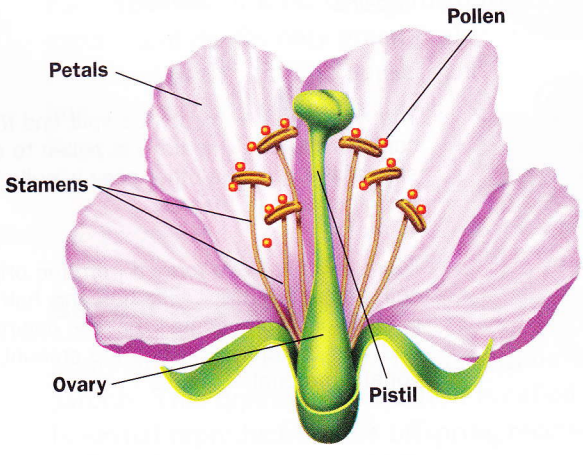
SEE ALSO
080 Cell Division
081 Stages of Cell Division

Reproduction without sperm and eggs is called **non-sexual reproduction** (or sometimes **asexual reproduction**). Non-sexual reproduction involves only one parent organism. Some single-celled living things reproduce through simple cell division. In this process, a cell divides, forming two new cells that are identical to the original cell.

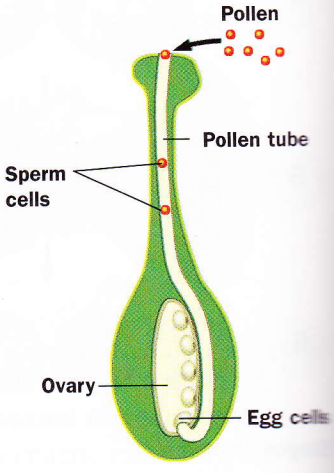
SEE ALSO
099 Reproductive System

Fertilization occurs in animals when the male's sperm is joined with the female's egg. Something similar occurs in flowering plants.

The female part of the flower is called the **ovary.** Egg cells form in the ovary. A long tube, or **pistil,** grows out from the ovary. Surrounding the pistil are **stamens.** Stamens produce **pollen,** a dust-like material that contains sperm cells. **Pollination,** the transfer of pollen from stamen to pistil, must occur in order for a new plant to form. When pollen lands on a pistil, sperm cells move down to the ovary, fertilizing the egg cells.




**Parts of a flower**




**Fertilization**

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# DNA

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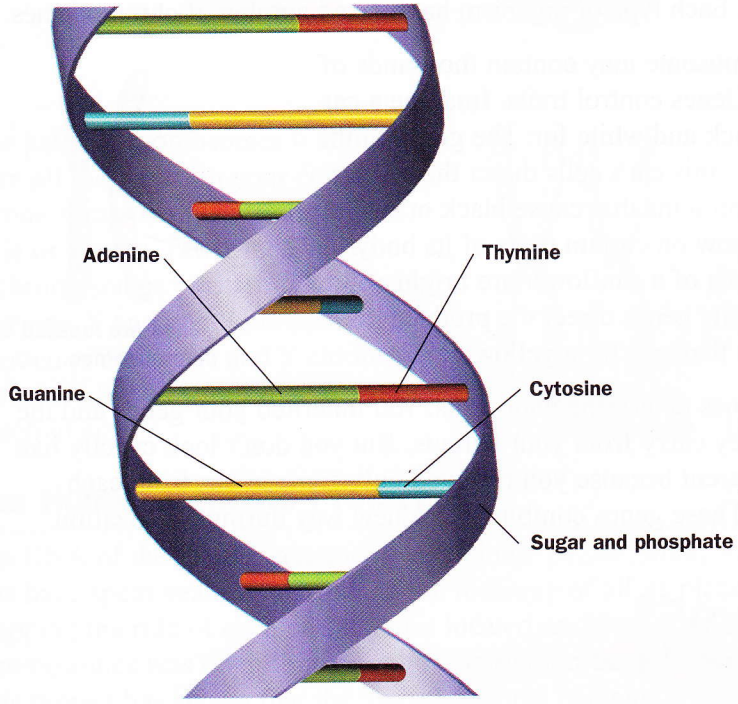
When organisms reproduce, traits are passed from parent to offspring. These traits are carried in **DNA,** the genetic material found in a cell's nucleus. DNA acts like a blueprint for the cells of an organism, instructing them how to put together materials to produce certain traits.

SEE ALSO
077 Animal Cell
078 Plant Cell

DNA is a very large molecule with a shape similar to a twisted ladder. The rungs of the ladder are made up of molecules called bases. The bases are adenine, thymine, guanine, and cytosine. These bases always pair up so that adenine is joined with thymine (A–T) and cytosine is joined with guanine (C–G). The sides of the ladder are made up of phosphate and sugar molecules.

**Word Watch!**

DNA stands for deoxyribonucleic acid.




**A model of DNA structure**

A DNA molecule may contain millions of base pairs. It is the arrangement of these base pairs that determines whether the organism is a rose, a robin, a fish, or a fruit fly.

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