



A HUMAN WHITE BLOOD CELL

Cells and Tissues

CELLS AND TISSUES

Overview of Cells

The cell is the basic structural and functional unit of all known living organisms. It is the smallest unit of life that is classified as a living thing, and is often called the building block of life. Organisms can be classified as unicellular (consisting of a single cell; including most bacteria) or multicellular (including plants and animals). Humans contain about 10 trillion cells.

Prokaryotic Cells

The prokaryote cell is simple and small. There are two kinds of prokaryotes: bacteria and archaea; these share a similar structure. Prokaryotic cells consist of a single chromosome that is in direct contact with cytoplasm, a gel-like substance residing between the cell membrane holding all the cell's internal sub-structures (called organelles), except for the nucleus.

A prokaryotic cell has three architectural regions:

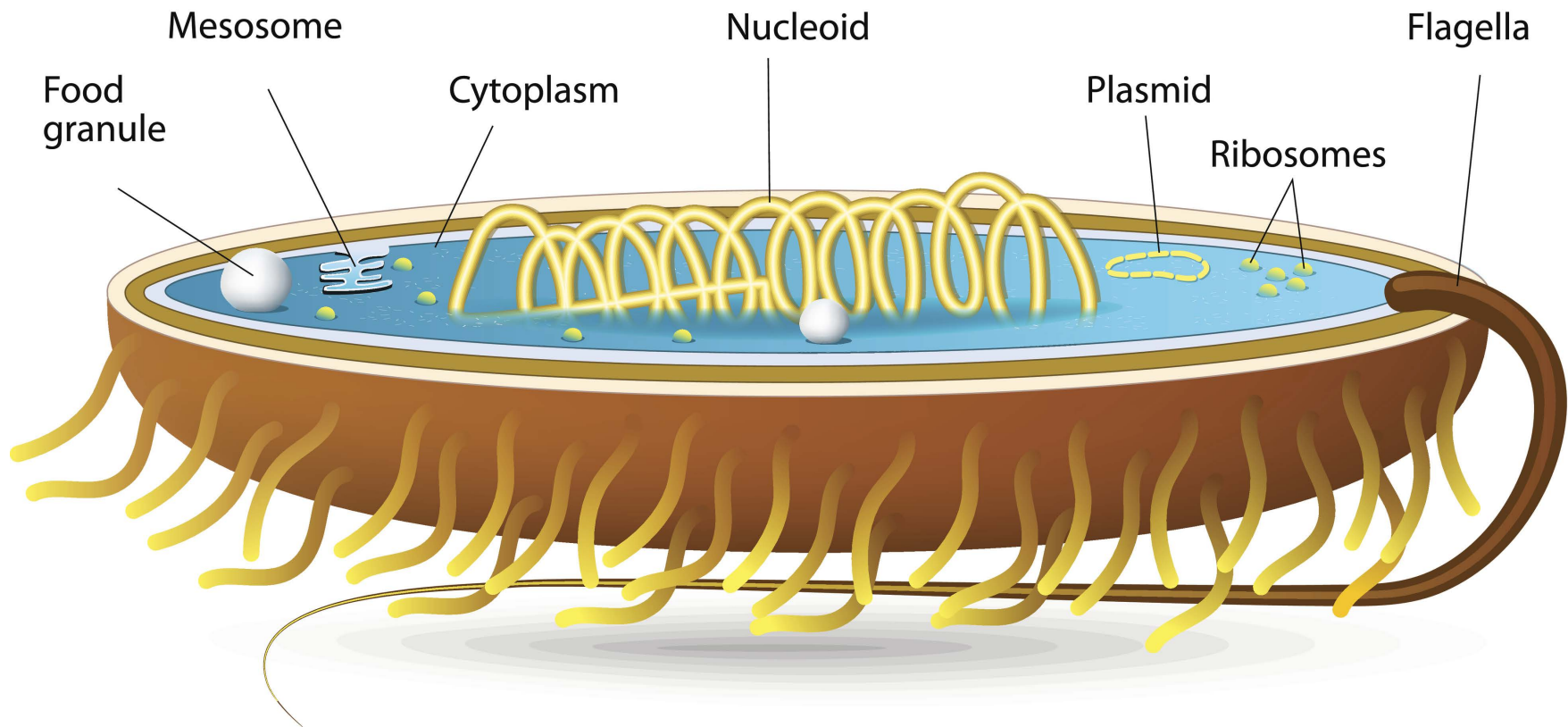
1. On the outside, flagella and pili project from the cell's surface. These are structures (not present in all prokaryotes) made of proteins that facilitate movement and communication between cells;
2. Enclosing the cell is the cell envelope – generally consisting of a cell wall covering a plasma membrane, though some bacteria also have a further covering layer called a capsule. The envelope gives rigidity to the cell and separates the interior of the cell from its environment, serving as a protective filter. Though most prokaryotes have a cell wall, there are exceptions such as *Mycoplasma* (bacteria) and *Thermoplasma* (archaea). The cell wall consists of peptidoglycan in bacteria, and acts as an additional barrier against exterior forces. It also prevents the cell from expanding and finally bursting (cytolysis) from osmotic pressure against a hypotonic environment. Some eukaryote cells (plant cells and fungi cells) also have a cell wall;

3. Inside the cell is the cytoplasmic region that contains the cell genome (DNA) and ribosomes and various sorts of inclusions. A prokaryotic chromosome is usually a circular molecule (an exception is that of the bacterium *Borrelia burgdorferi*, which causes Lyme disease). Though not forming a nucleus, the DNA is condensed in a nucleoid. Prokaryotes can carry extrachromosomal DNA elements called plasmids, which are usually circular. Plasmids enable additional functions, such as antibiotic resistance.

Diagram of a Prokaryotic Cell (Bacteria)



BACTERIA CELL ANATOMY



Eukaryotic Cells

Plants, animals, fungi, slime moulds, protozoa, and algae are all eukaryotic. These cells are about 15 times wider than a typical prokaryote and can be as much as 1000 times greater in volume. The major difference between prokaryotes and eukaryotes is that eukaryotic cells contain membrane-bound compartments in which specific metabolic activities take place.

Most important among these is a cell nucleus, a membrane-delineated compartment that houses the eukaryotic cell's DNA. This nucleus gives the eukaryote its name, which means "true nucleus."

Other differences include:

The plasma membrane resembles that of prokaryotes in function, with minor differences in the setup. Cell walls may or may not be present.

The eukaryotic DNA is organized in one or more linear molecules, called chromosomes, which are associated with histone proteins. All chromosomal DNA is stored in the cell nucleus, separated from the cytoplasm by a membrane. Some eukaryotic organelles such as mitochondria also contain some DNA.

Many eukaryotic cells are ciliated with primary cilia. Primary cilia play important roles in chemosensation, mechanosensation, and thermosensation. Cilia may thus be viewed as sensory cellular antennae that coordinate a large number of cellular signaling pathways, sometimes coupling the signaling to ciliary motility or alternatively to cell division and differentiation.

Eukaryotes can move using motile cilia or flagella. The flagella are more complex than those of prokaryotes.



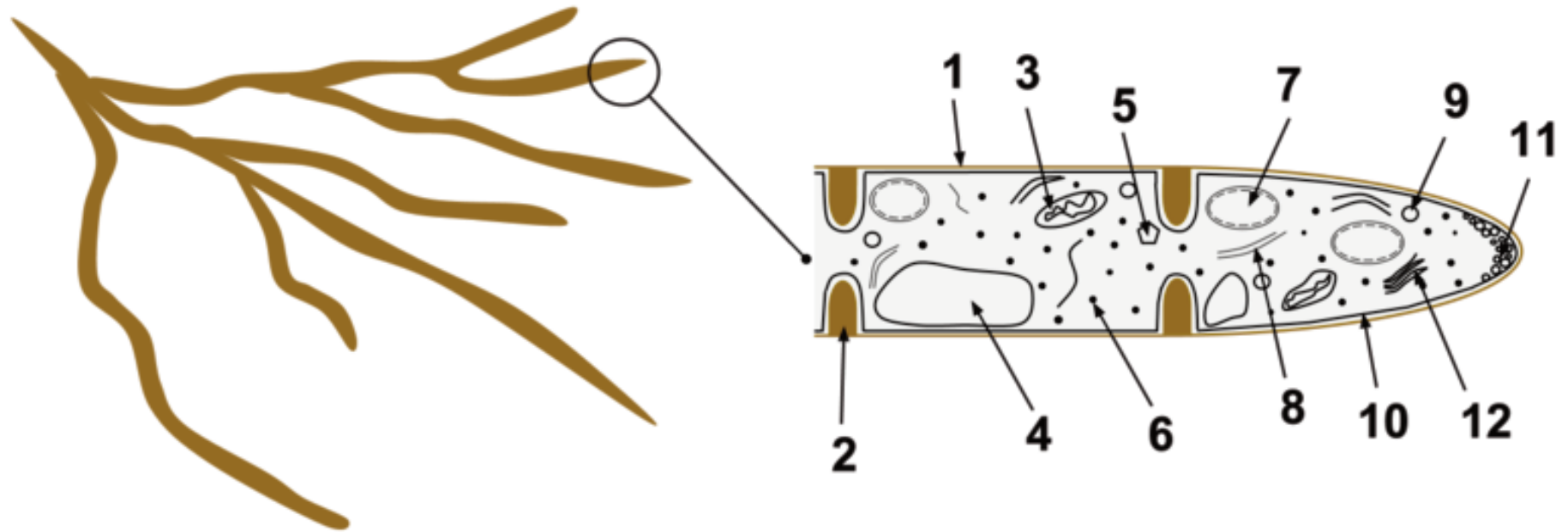
FUNGI CELL STRUCTURE

A fungus, or plural: fungi, is a member of a large group of eukaryotic organisms that includes microorganisms such as yeasts and molds, as well as the more familiar mushrooms. These organisms are classified as a kingdom, Fungi, which is separate from plants, animals, and bacteria. One major difference is that fungal cells have cell walls that contain chitin, unlike the cell walls of plants, which contain cellulose. The discipline of biology devoted to the study of fungi is known as mycology, which is often regarded as a branch of botany, even though genetic studies have shown that fungi are more closely related to animals than to plants.

Abundant worldwide, most fungi are inconspicuous because of the small size of their structures, and their cryptic lifestyles in soil, on dead matter, and as symbionts of plants, animals, or other fungi. They may become noticeable when fruiting, either as mushrooms or molds. Fungi perform an essential role in the decomposition of organic matter and have fundamental roles in nutrient cycling and exchange. They have long been used as a direct source of food, such as mushrooms and truffles, as yeast—a leavening agent for bread, and in fermentation of various food products, such as wine, beer, and soy sauce. Since the 1940s, fungi have been used for the production of antibiotics, and, more recently, various enzymes produced by fungi are used industrially and in detergents. Fungi are also used as biological pesticides to control weeds, plant diseases and insect pests. Many species produce bioactive compounds called mycotoxins, such as alkaloids and polyketides, that are toxic to animals including humans. The fruiting structures of a few species contain psychotropic compounds and are consumed recreationally or in traditional spiritual ceremonies. Fungi can break down manufactured materials and buildings, and become significant pathogens of humans and other animals. Losses of crops due to fungal diseases (e.g. rice blast disease) or food spoilage can have a large impact on human food supplies and local economies.



FUNGI CELL STRUCTURE



1. Hyphal Wall

2. Septum

3. Mitochondrion

4. Vacuole

5. Ergosterol Crystal

6. Ribosome

7. Nucleus

8. Endoplasmic Reticulum

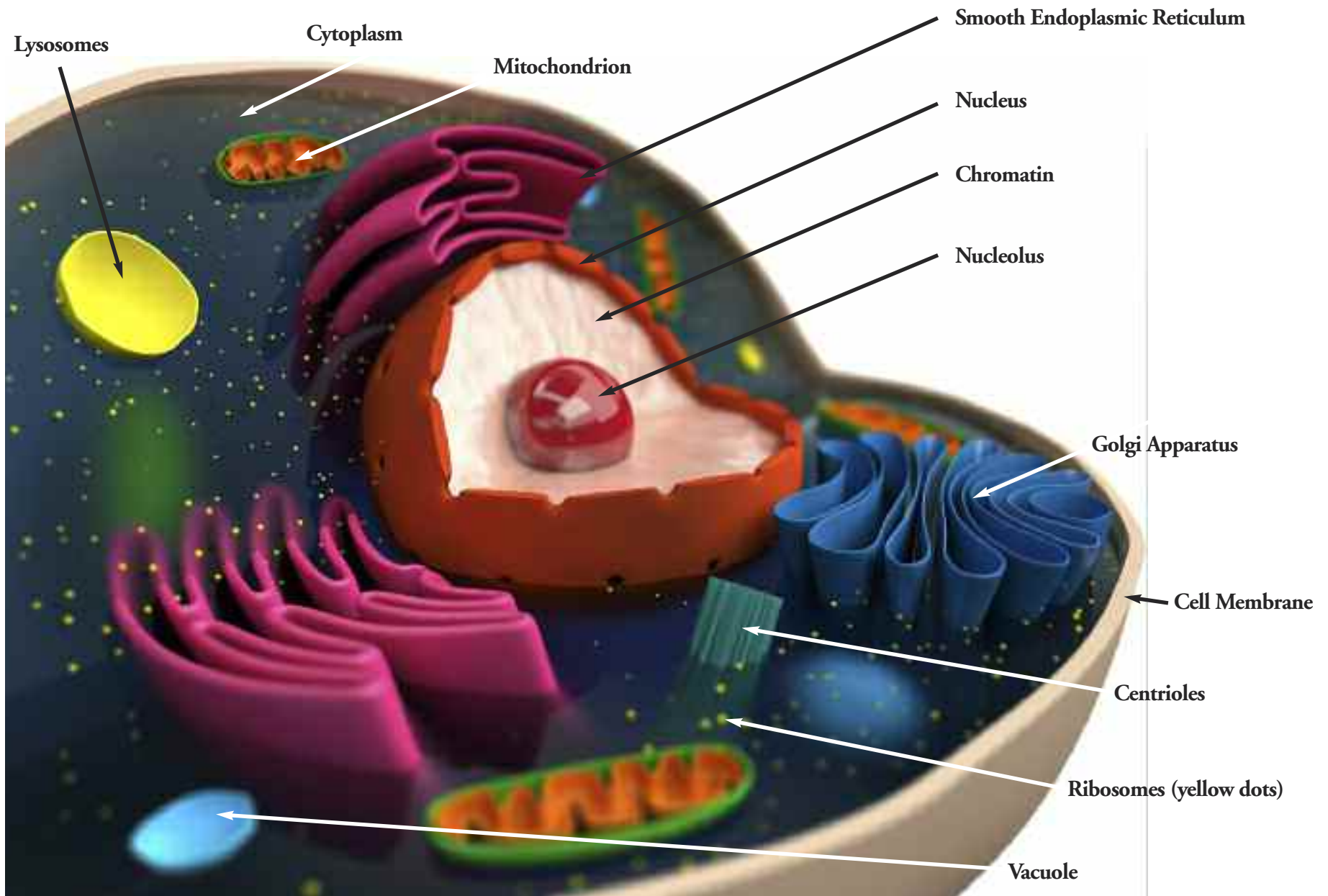
9. Lipid Body

10. Plasma Membrane

11. Spitzenkörper

12. Golgi Apparatus

HUMAN CELL STRUCTURE



Human Cell Glossary

Actin filament (AK-tin) – Part of the cytoskeleton. Actin filaments contract or lengthen to give cells the flexibility to move and change shape. Together with myosin, actin filaments are responsible for muscle contraction.

Adult stem cells – Cells that can renew themselves and differentiate into a limited number of specialized cell types. They replace and renew damaged tissues.

Amino acid (uh-MEE-no) – A chemical building block of proteins. There are 20 standard amino acids. A protein consists of a specific sequence of amino acids.

Anaphase (ANN-uh-faze) – The fourth of six phases of cell division, following metaphase and preceding telophase. In anaphase, the chromosomes separate into two genetically identical groups and move to opposite ends of the spindle.

Aneuploidy (ANN-yoo-PLOY-dee) – The condition of having an abnormal number of chromosomes. See Down syndrome.

Antibody – A protein produced by the immune system in response to a foreign substance such as a virus or bacterium.

Antioxidant (ANN-tee-AWK-si-dunt) – A substance that can neutralize dangerous compounds called reactive oxygen species. Antioxidants are found naturally in our bodies and in foods such as fruits and vegetables.

Apoptosis (ay-PAH-TOE-sis) – Programmed cell death, a normal process in which cells die in a controlled and predictable way. See necrosis.

ATP, adenosine triphosphate (ah-DEH-no-seen try-FOSS-fate) – The major source of energy for biochemical reactions in all organisms.

Bacterium (plural: bacteria) – A one-celled microorganism that contains no nucleus. Some bacteria are helpful, such as those in the intestines that help digest food, while others cause disease. Bacteria are frequently used as model organisms to study basic biological processes. See prokaryotic cell and model organism.

Carbohydrate – A molecule made up of one or more sugars. In the body, carbohydrates can exist independently or be attached to proteins or lipids.

Cell – The basic subunit of any living organism; the simplest unit capable of independent life. Although there are some single-celled organisms, such as bacteria, most organisms consist of many cells that are specialized for particular functions. See prokaryotic cell and eukaryotic cell.

Cell cycle – The sequence of events by which a cell duplicates its contents and divides in two.

Channel protein – A hollow or pore-containing protein that spans a cell membrane and acts as a conduit for small molecules, such as charged particles (ions).

Checkpoint – One of several points in the cell cycle where the cycle can pause if there is a problem such as incomplete DNA synthesis or damaged DNA. See cell cycle.

Chemotaxis (KEE-moh-TACK-sis) – The movement of a cell toward or away from the source of a chemical.

Cholesterol – A waxy lipid produced by animal cells that is a major component of cell membranes. Cholesterol is also used as a building block for some hormones.

Chromosome (KROH-muh-sohm) – A cellular structure containing genes. Excluding sperm and egg cells, humans have 46 chromosomes (23 pairs) in each cell.

Cilium (SILL-ee-um) (plural: cilia) – A hairlike projection from a cell surface. The rhythmic beating of cilia can move fluid or mucus over a cell or can propel single-celled organisms. Cilia are shorter than flagella.

Computational biology – A field of science that uses computers to study complex biological processes that involve many molecular interactions.

Crossing over – A process that occurs during meiosis in which chromosome partners, one inherited from each parent, physically swap sections with one another. This creates hybrid chromosomes that are a patchwork of the original pair. Crossing over occurs in species that reproduce sexually and increases the genetic variety of offspring.

Cytokinesis (SYE-toe-kin-EE-sis) – The last of six phases of cell division. It occurs after the duplicated genetic material has segregated to opposite sides of the cell. During cytokinesis, the cell splits into two daughter cells.

Cytoplasm (SYE-toe-PLAZ-um) – The material found between the cell membrane and the nuclear envelope. It includes the cytosol and all organelles except the nucleus. See cytosol.

Cytoskeleton (SYE-toe-SKEL-uh-tun) – A collection of fibers that gives a cell shape and support and allows movement within the cell and, in some cases, by the cell as a whole. The three main types of cytoskeletal fibers are microtubules, actin filaments, and intermediate filaments.

Cytosol (SYE-tuh-sol) – The semi-fluid portion of the cytoplasm, excluding the organelles. The cytosol is a concentrated solution of proteins, salts, and other molecules. See cytoplasm.

Differentiation – The series of biochemical and structural changes by which an unspecialized cell becomes a specialized cell with a specific function. During development, embryonic stem cells differentiate into the many cell types that make up the human body.

Diploid (DIP-loyd) – Having two sets of chromosomes, one inherited from each parent. All human cells except eggs and sperm are diploid and have 46 chromosomes, 23 from each parent.

DNA, deoxyribonucleic acid (dee-AW-ksee-RYE-bo-new-CLAY-ick) – The substance of heredity. A long, helical, double-stranded molecule that carries the cell's genetic information. See chromosome.

Down syndrome – An inherited condition caused by having an extra copy of chromosome 21. See aneuploidy.

Electron microscope – A powerful microscope that uses beams of fast-moving electrons instead of light to magnify samples. Powerful magnets focus the electrons into an image.

Embryonic stem cell – A cell found in early embryos that can renew itself and differentiate into the many cell types that are found in the human body.

Endocytosis (EN-doe-sye-TOE-sis) – A process cells use to engulf particles or liquid from their surroundings. It occurs when the cell surface membrane puckers inward, encircling the material, then pinches off, producing a vesicle inside the cell.

Endoplasmic reticulum (ER) (EN-doe-PLAZ-mik reh-TIK-yoo-lum) – An organelle made up of interconnected tubes and flattened sacs. There are two kinds of ER: rough (because it is dotted with ribosomes) ER, which processes newly made proteins, and smooth ER, which helps make lipid and neutralizes toxins.

Enzyme – A protein that speeds up a specific chemical reaction without being permanently altered or consumed.

Eukaryotic cell (YOO-kare-ee-AW-tick) – A cell that has a nucleus and other organelles not found in prokaryotes; includes all animal and most plant cells.

Exocytosis (EK-so-sye-TOE-sis) – A process cells use to send substances outside their surface membrane via vesicles.

Extracellular matrix – The material that surrounds and supports cells. It includes structural proteins such as collagen and elastin.

Flagellum (fluh-JELL-um) (plural: flagella) – A long, tail-like structure extending from a cell. Sperm and many microorganisms move using flagella.

G protein – A protein located on the inside of the cell membrane that helps transmit molecular signals into cells.

Gene – A unit of heredity; a segment of DNA that contains the code for making a specific protein or RNA molecule.

Genome (JEE-nome) – All of an organism's genetic material.

Glial cell (GLEE-uhl) – A kind of cell in the nervous system that provides nutrition and support to a nerve cell.

Glycosylation (glye-KAW-sil-AY-shun) – The process of adding specialized chains of sugar molecules to proteins or lipids; occurs in the ER and Golgi.

Golgi (GOLE-jee) – Also called the Golgi apparatus or Golgi complex; an organelle composed of membranous sacs in which many newly made proteins mature and become functional.

Haploid (HAP-loyd) – Having a single set of chromosomes, as in egg or sperm cells. Haploid human cells have 23 chromosomes.

Hormone – A molecule that stimulates specific cellular activity; made in one part of the body and transported via the bloodstream to tissues and organs. Examples include insulin, estrogen, and testosterone.

Intermediate filament – Part of the cytoskeleton that provides strength. Some intermediate filaments form nails, hair, and the outer layer of skin. Others are found in nerves or other organs.

Interphase (IN-tur-faze) – A period in a cell's life cycle when it is not undergoing mitosis.

Lipid (LIP-id) – A fatty, waxy, or oily compound that will not dissolve in water. Lipids are a major part of biological membranes.

Lysosome (LYE-so-sohm) – A bubble-like organelle that contains powerful enzymes that can digest a variety of biological materials.

Meiosis (my-OH-sis) – The type of cell division that makes egg and sperm cells. Meiosis generates cells that are genetically different from one another and contain half the total number of chromosomes in the parent cell. See haploid.

Membrane – A semi-fluid layer of lipids and proteins. Biological membranes enclose cells and organelles and control the passage of materials into and out of them.

Metaphase (MET-uh-faze) – The third phase of cell division, following prometaphase and preceding anaphase. In metaphase, the copied chromosomes align in the middle of the spindle.

Micrometer (MY-kroh-MEE-tur) – One micrometer is one millionth (10⁻⁶) of a meter or one thousandth of a millimeter. The micrometer is frequently used to measure cells and organelles.

Microtubule (MY-kroh-TOO-byool) – Part of the cytoskeleton; a strong, hollow fiber that acts as a structural support for the cell. During cell division, microtubules form the spindle that directs chromosomes to the daughter cells. Microtubules also serve as tracks for transporting vesicles and give structure to flagella and cilia.

Mitochondrion (MITE-oh-KON-dree-un) (plural: mitochondria) – The cell's power plant; the organelle that converts energy from food into ATP, fueling the cell. Mitochondria contain their own small genomes and appear to have descended from free-living bacteria.

Mitosis (my-TOE-sis) – The type of cell division that eukaryotic cells use to make new body cells. Mitosis results in two daughter cells that are genetically identical to the parent cell.

Model system (or Model organism) – A cell type or simple organism – such as a bacterium, yeast, plant, fruit fly, or mouse-used to answer basic questions about biology.

Mutation (myoo-TAY-shun) – A change in a DNA sequence.

Myelin (MY-eh-lin) – A fatty covering that forms a protective sheath around nerve fibers and dramatically speeds the transmission of nerve signals.

Nanometer (NAN-oh-MEE-tur) – One billionth (10^{-9}) of a meter or one thousandth of a micrometer. The nanometer is frequently used to measure organelles and small structures within cells.

Necrosis (neh-CROH-sis) – Unplanned cell death caused by outside circumstances, such as traumatic injury or infection. See apoptosis.

Neuron – A cell in the nervous system that is specialized to carry information through electrical impulses and chemical messengers. Also called a nerve cell.

Neurotransmitter – A chemical messenger that passes signals between nerve cells or between a nerve cell and another type of cell.

Nuclear envelope – A barrier that encloses the nucleus and is made up of two membranes perforated by nuclear pores.

Nuclear pores – An opening in the nuclear envelope that allows the passage of small molecules such as salts, small proteins, and RNA molecules.

Nucleus – The organelle in eukaryotic cells that contains genetic material.

Oocyte (oh-oh-SITE) – The developing female reproductive cell; an immature egg.

Organ – A group of tissues that perform a particular job. Animals have more than a dozen organs, including the heart, brain, eye, liver, and lung.

Organelle (OR-gun-EL) – A specialized, membrane-bounded structure that has a specific function in a cell. Examples include the nucleus, mitochondria, Golgi, ER, and lysosomes.

Prokaryotic cell (PRO-kare-ee-AW-tick) – A cell that lacks a nucleus. Bacteria are prokaryotes. See eukaryotic cell.

Prometaphase (pro-MET-uh-faze) – The second of six phases of cell division, following prophase and preceding metaphase. In prometaphase, the nuclear membrane breaks apart and the spindle starts to interact with the chromosomes.

Prophase (PRO-faze) – The first of six phases of cell division. In prophase, chromosomes condense and become visible and the spindle forms.

Proteasome (PRO-tee-uh-some) – A cellular machine that digests proteins that have been tagged with ubiquitin for destruction.

Protein – A molecule composed of amino acids lined up in a precise order determined by a gene, then folded into a specific three-dimensional shape. Proteins are responsible for countless biological functions and come in a wide range of shapes and sizes.

Reactive oxygen species – One of several types of small molecules containing oxygen with an unstable number of electrons. Reactive oxygen species can damage many kinds of biological molecules.

Ribosome (RYE-bo-sohm) – A molecular complex in which proteins are made. In eukaryotic cells, ribosomes either are free in the cytoplasm or are attached to the rough endoplasmic reticulum.

RNA, ribonucleic acid (RYE-bo-new-CLAY-ick) – A molecule very similar to DNA that plays a key role in making proteins. There are three main types: messenger RNA, ribosomal RNA and transfer RNA.

RNAi (RNA interference) – The process of using small pieces of double-stranded RNA to reduce the activity of specific genes. The process occurs naturally in many organisms and is now commonly used in basic research. It has the potential to be therapeutically useful.

RNA polymerase (puh-LIH-mer-ase) – An enzyme that makes RNA using DNA as a template in a process called transcription.

Spindle – A football-shaped array of fibers made of microtubules and associated proteins that forms before cells divide. Some of the fibers attach to the chromosomes and help draw them to opposite ends of the cell.

Telomerase (tee-LAW-mer-ase) – An enzyme that adds telomeres to the ends of eukaryotic chromosomes, preventing the chromosome from shrinking during each cell division.

Telomere (TEE-lo-meer) – A repetitive segment of DNA at the ends of eukaryotic chromosomes. Telomeres do not contain genes and, in the absence of telomerase, they shorten with each cell division.

Telophase (TEE-lo-faze) – The fifth of six phases of cell division, following anaphase and preceding cytokinesis. In telophase, nuclear membranes form around each of the two sets of chromosomes, the chromosomes begin to spread out, and the spindle begins to break down.

Tissue – A group of cells that act together to carry out a specific function in the body. Examples include muscle tissue, nervous system tissue (including the brain, spinal cord, and nerves), and connective tissue (including ligaments, tendons, bones, and fat). Organs are made up of tissues.

Transcription – The process of copying information from genes (made of DNA) into messenger RNA.

Translation – The process of making proteins based on genetic information encoded in messenger RNA. Translation occurs in ribosomes.

Ubiquitin (yoo-BIH-kwe-tin) – A small protein that attaches to and marks other proteins for destruction by the proteasome.

Vesicle (VEH-sih-kle) – A small, membrane-bounded sac that transports substances between organelles as well as to and from the cell membrane.

Virus – An infectious agent composed of proteins and genetic material (either DNA or RNA) that requires a host cell, such as a plant, animal, or bacterium, in which to reproduce. A virus is neither a cell nor a living organism because it can not reproduce independently.

Zygote (ZYE-gote) – A cell resulting from the fusion of an egg and a sperm.

Overview of Tissue

Tissue is an intermediate level between cells and a complete organism. A tissue is an ensemble of cells, not necessarily identical, but from the same origin, that together carry out a specific function. These are called tissues because of their identical functioning. Organs are then formed by the functional grouping together of multiple tissues.

Human tissues can be grouped into four basic types: connective, muscle, nervous, and epithelial. Multiple tissue types comprise organs and body structures.

Connective Tissue

Connective tissues are fibrous tissues. They are made up of cells separated by non-living material, which is called extracellular matrix. Connective tissue gives shape to organs and holds them in place. Both blood and bone are examples of connective tissue. As the name implies, connective tissue serves a “connecting” function. It supports and binds other tissues. Unlike epithelial tissue, connective tissue typically has cells scattered throughout an extracellular matrix.

Muscle Tissue

Muscle cells form the active contractile tissue of the body known as muscle tissue or muscular tissue. Muscle tissue functions to produce force and cause motion, either locomotion or movement within internal organs. Muscle tissue is separated into three distinct categories: visceral or smooth muscle, which is found in the inner linings of organs; skeletal muscle, in which is found attached to bone providing movement; and cardiac muscle which is found in the heart, allowing it to contract and pump blood throughout an organism.

Nervous Tissue

Cells comprising the central nervous system and peripheral nervous system are classified as neural tissue. In the central nervous system, neural tissue forms the brain and spinal cord and, in the peripheral nervous system forms the cranial nerves and spinal nerves, inclusive of the motor neurons. Nervous tissue functions to transmit messages.

Epithelial Tissue

The epithelial tissues are formed by cells that cover the organ surfaces such as the surface of the skin, the airways, the reproductive tract, and the inner lining of the digestive tract.

The cells comprising an epithelial layer are linked via semi-permeable, tight junctions; hence, this tissue provides a barrier between the external environment and the organ it covers. In addition to this protective function, epithelial tissue may also be specialized to function in secretion and absorption. Epithelial tissue helps to protect organisms from microorganisms, injury, and fluid loss.

Epithelial tissues have four functions:

1. the cells of the body surface form the outer layer of skin.
2. inside the body, epithelial cells form the lining of mouth and alimentary canal and protect these organs.
3. epithelial tissues help in absorption of water and nutrients.
4. epithelial tissues help in elimination of waste products.

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