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As previously mentioned, a cell's cytoplasm is home to numerous functional and structural elements. These elements exist in the form of molecules and organelles — picture them as the tools, appliances, and inner rooms of the cell. Major classes of intracellular organic molecules include nucleic acids, proteins, carbohydrates, and lipids, all of which are essential to the cell's functions. Nucleic acids are the molecules that contain and help express a cell's genetic code. There are two major classes of nucleic acids: deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). DNA is the molecule that contains all of the information required to build and maintain the cell; RNA has several roles associated with expression of the information stored in DNA. Of course, nucleic acids alone aren't responsible for the preservation and expression of genetic material: Cells also use proteins to help replicate the genome and accomplish the profound structural changes that underlie cell division. Proteins are a second type of intracellular organic molecule. These substances are made from chains of smaller molecules called amino acids, and they serve a variety of functions in the cell, both catalytic and structural. For example, proteins called enzymes convert cellular molecules (whether proteins, carbohydrates, lipids, or nucleic acids) into other forms that might help a cell meet its energy needs, build support structures, or pump out wastes. Carbohydrates, the starches and sugars in cells, are another important type of organic molecule. Simple carbohydrates are used for the cell's immediate energy demands, whereas complex carbohydrates serve as intracellular energy stores. Complex carbohydrates are also found on a cell's surface, where they play a crucial role in cell recognition. Finally, lipids or fat molecules are components of cell membranes — both the plasma membrane and various intracellular membranes. They are also involved in energy storage, as well as relaying signals within cells and from the bloodstream to a cell's interior (Figure 2). Some cells also feature orderly arrangements of molecules called organelles. Similar to the rooms in a house, these structures are partitioned off from the rest of a cell's interior by their own intracellular membrane. Organelles contain highly technical equipment required for specific jobs within the cell. One example is the mitochondrion — commonly known as the cell's "power plant" — which is the organelle that holds and maintains the machinery involved in energy-producing chemical reactions (Figure 3). Ayda Basgul Martin At the end of this unit, you should be able to: I. Specify the characteristics associated with life and explain why the cell is the basic unit of life. II. Describe the levels of structural organization in the body. III. Describe the structure and the functions of the major components of a cell. IV. Define metabolism and distinguish between anabolism and catabolism. V. Describe the cellular processes involved in the growth of the human body from a fertilized egg to an adult. VI. Describe the importance of cell differentiation to an organism. VII. Describe the general characteristics of each of the following cell types and relate their characteristics to their functions: nerve cell, muscle cell, red blood cell (erythrocyte), and white blood cell (leukocyte). The different organ systems each have different functions and therefore unique roles to perform in the body. These many functions can be summarized in terms of a few that we might consider definitive of human life: organization, metabolism, exchange of materials, responsiveness, movement, development, growth, and reproduction. Organization A human body consists of trillions of cells organized in a way that maintains distinct internal compartments. These compartments keep body cells separated from external environmental threats and keep the cells moist and nourished. They also separate internal body fluids from the countless microorganisms that grow on body surfaces, including the lining of certain tracts, or passageways. The intestinal tract, for example, is home to even more bacteria cells than the total of all human cells in the body, yet these bacteria are outside the body and cannot circulate freely inside the body. Cells, for example, have a membrane (also referred to as the plasma membrane) that keeps the intracellular environment—the fluids and organelles—separate from the environment outside the cell (the extracellular environment). Blood vessels keep blood inside a closed system, and nerves and muscles are wrapped in tissue sheaths that separate them from surrounding structures. In the chest and abdomen, a variety of internal membranes keep major organs such as the lungs, heart, and kidneys protected and separate from others. The body's largest organ system is the integumentary system, which includes the skin and its associated structures, such as hair and nails. The surface tissue of the skin is a barrier that protects internal structures and fluids from potentially harmful microorganisms, toxins, and the external environment. Metabolism The first law of thermodynamics holds that energy can neither be created nor destroyed—it can only change form. Your basic function as an organism is to consume (ingest) energy and molecules in the foods you eat, convert some of it into fuel for movement, sustain your body functions, and build and maintain your body structures. There are two types of reactions that accomplish this: anabolism and catabolism. Anabolism is the process whereby smaller, simpler molecules are combined into larger, more complex substances. For example, amino acids can be combined together to make proteins. Your body can assemble, by utilizing energy, the complex chemicals it needs by combining small molecules derived from the foods you eat. Catabolism is the process by which larger, more complex substances are broken down into smaller, simpler molecules. For example, sugars are broken down into carbon dioxide and water. Catabolism releases energy. The complex molecules found in foods are broken down so the body can use their parts to assemble the structures and substances needed for life. Taken together, these two processes are called metabolism. Metabolism is the sum of all anabolic and catabolic reactions that take place in the body. Both anabolism and catabolism occur simultaneously and continuously to keep you alive. Every cell in your body makes use of a chemical compound, adenosine triphosphate (ATP), to store and release energy. The cell stores energy in the molecule of ATP and then moves the ATP molecules to the location where energy is needed to fuel cellular activities. Then the ATP is broken down, and a controlled amount of energy is released, which is used by the cell to perform a particular job. QR 6.1. Watch this Crash Course video to learn more about metabolism! Exchange of Material Organisms do not exist solely within their own boundaries but interact with the external environment that surrounds them. One of the ways in which they do this is by exchanging materials with their external environment: taking in materials from their external environment and expelling waste products out into their external environment. These materials and waste products may be anything from very small, relatively simple molecules (e.g., glucose, carbon dioxide) that must cross an individual cell's plasma membrane to whole cells or foods that were ingested but not fully digested and/or absorbed and so must be excreted from the organism. Responsiveness Responsiveness is the ability of an organism to adjust to changes in its internal and external environments. An example of responsiveness to external stimuli could include moving toward sources of food and water and away from perceived dangers. Changes in an organism's internal environment, such as increased body temperature, can cause the responses of sweating and the dilation of blood vessels in the skin in order to decrease body temperature. Movement Human movement includes not only actions at the joints of the body but also the motion of individual organs and even individual cells. As you read these words, red and white blood cells are moving throughout your body, muscle cells are contracting and relaxing to maintain your posture and to focus your vision, and glands are secreting chemicals to regulate body functions. Your body is coordinating the action of entire muscle groups to enable you to move air into and out of your lungs, to push blood throughout your body, and to propel the food you have eaten through your digestive tract. Consciously, of course, you contract your skeletal muscles to move the bones of your skeleton to get from one place to another and to carry out all of the activities of your daily life. Development, Growth, and Reproduction Development is all of the changes the body goes through in life. The development includes the process of cell differentiation, in which unspecialized cells become specialized in structure and function to perform certain tasks in the body. The development also includes the processes of growth and repair, both of which involve cell differentiation. Growth is the increase in body size. Humans, like all multicellular organisms, grow by increasing the number of existing cells, increasing the amount of non-cellular material around cells (such as mineral deposits in bone), and within very narrow limits, increasing the size of existing cells. Reproduction is the formation of a new organism from parent organisms. In humans, reproduction is carried out by the male and female reproductive systems. Because death will come to all complex organisms, without reproduction, the line of organisms would end. I. Specify the characteristics associated with life and explain why the cell is the basic unit of life. List, explain, and provide examples of each of the characteristics of life. In reference to your answer to question #1, above, explain in one sentence why the cell is the basic unit of life. Part 2: Structural Organization of the Human Body Before you begin to study the different structures and functions of the human body, it is helpful to consider its basic architecture; that is, how its smallest parts are assembled into larger structures. It is convenient to consider the structures of the body in terms of fundamental levels of organization that increase in complexity: subatomic particles, atoms, molecules, organelles, cells, tissues, organs, organ systems, and organisms (Figure 1). The Levels of Organization To study the chemical level of organization, scientists consider the simplest building blocks of matter: subatomic particles, atoms, and molecules. All matter in the universe is composed of one or more unique pure substances called elements, familiar examples of which are hydrogen, oxygen, carbon, nitrogen, calcium, and iron. The smallest unit of any of these pure substances (elements) is an atom. Atoms are made up of subatomic particles, such as the proton, electron, and neutron. Two or more atoms combine to form a molecule, such as the water molecules, proteins, and sugars found in living things. Molecules are the chemical building blocks of all body structures. A cell is the smallest independently functioning unit of a living organism. All living structures of human anatomy contain cells, and almost all functions of human physiology are performed in cells or are initiated by cells. Even bacteria, which are extremely small single-celled, independently-living organisms, have a cellular structure. A human cell typically consists of flexible membranes that enclose cytoplasm, a water-based fluid, together with a variety of tiny functioning units called organelles. In humans, as in all organisms, cells perform all functions of life. A tissue is a group of many similar cells (though sometimes composed of a few related types) that work together to perform a specific function. An organ is an anatomically distinct structure of the body composed of two or more tissue types. Each organ performs one or more specific physiological functions. An organ system is a group of organs that work together to perform major functions or meet the physiological needs of the body. Assigning organs to organ systems can be imprecise, since organs that "belong" to one system can also have functions integral to another system. In fact, most organs contribute to more than one system. The organism level is the highest level of organization. An organism is a living being that has a cellular structure and that can independently perform all physiologic functions necessary for life. In multicellular organisms, including humans, all cells, tissues, organs, and organ systems of the body work together to maintain the life and health of the organism. The Cellular Level of Organization You developed from a single fertilized egg cell into a complex organism containing trillions of cells that you see when you look in a mirror. Early during this developmental process, cells differentiate and become specialized in their structure and function. These different cell types form specialized tissues that work in concert to perform all of the functions necessary for the living organism. Cellular and developmental biologists study how the continued division of a single cell leads to such complexity. Figure 6.1. Levels of Structural Organization of the Human Body. The organization of the body often is discussed in terms of six distinct levels of increasing complexity, from the smallest chemical building blocks to a unique human organism. [Image description.] Consider the difference between a cell in the skin and a nerve cell. A skin cell may be shaped like a flat plate (squamous) and live only for a short time before it is shed and replaced. Packed tightly into rows and sheets, the squamous skin cells provide a protective barrier for the cells and tissues that lie beneath. A nerve cell, on the other hand, may be shaped something like a star, sending out long processes up to a meter in length, and may live for the entire lifetime of the organism. With their long winding processes, nerve cells can communicate with one another and with other types of body cells and send rapid signals that inform the organism about its environment and allow it to interact with that environment. These differences illustrate one very important theme that is consistent at all organizational levels of biology: the form of a structure is optimally suited to perform particular functions assigned to that structure. Keep this theme in mind as you tour the inside of a cell and are introduced to the various types of cells in the body. The concept of a cell started with microscopic observations of dead cork tissue by scientist Robert Hooke in 1665. Without realizing their function or importance, Hook coined the term "cell" based on the resemblance of the small subdivisions in the cork to the rooms that monks inhabited, called cells. About ten years later, Antonie van Leeuwenhoek became the first person to observe living and moving cells under a microscope. In the century that followed, the theory that cells represented the basic unit of life would develop. These tiny fluid-filled sacs house components responsible for the thousands of biochemical reactions necessary for an organism to grow and survive. In this chapter, you will learn about the major components and functions of a generalized cell and discover some of the different types of cells in the human body. QR 6.2. Watch this Amoeba Sisters video for an introduction to the cell! Describe the levels of structural organization in the body. Define each of the following levels of organization in the body: Chemical level Cellular level Tissue level Organ level Organ system level Organismal level Write a clear description of the relationships between the chemical, cellular, tissue, organ, organ system, and organismal levels of organization in the body. Part 3: Cell Structure, Cellular Organelles, and Functions General Cell Structure: Plasma Membrane, Cytoplasm, and Nucleus The cell membrane (also known as the plasma membrane) separates the inner contents of a cell from its external environment. This membrane provides a protective barrier around the cell and regulates which materials can pass in or out. It is primarily composed of phospholipids arranged in two layers but also contains cholesterol and a mosaic of different proteins. You will learn more about the structure and function of the plasma membrane in chapter 7. All living cells in multicellular organisms contain an internal cytoplasmic compartment, composed of cytosol and organelles. Cytosol, the jelly-like substance within the cell, provides the fluid medium necessary for biochemical reactions and is mostly composed of water. Eukaryotic cells, including all animal cells, also contain various cellular organelles. An organelle ("little organ") is one of several different types of membrane-enclosed bodies in the cell, each performing a unique function. Figure 6.2. Typical Human Cell. While this image is not indicative of any one particular human cell, it is a typical example of a cell containing the primary organelles and internal structures. [Image description.] Just as the various bodily organs work together in harmony to perform all of a human's functions, the many different cellular organelles work together to keep the cell healthy and perform all of its important functions. The organelles and cytosol, taken together, compose the cell's cytoplasm. The nucleus is a cell's central organelle, which contains the cell's DNA (Figure 2). Organelles of the Endomembrane System Most membranous organelles found in a human cell together form a system within the cell called the endomembrane system. These organelles work together to perform various cellular jobs, including the task of producing, packaging, and exporting certain cellular products. The components of the endomembrane system include the nuclear envelope, endoplasmic reticulum, Golgi apparatus, vesicles, and plasma membrane. Endoplasmic Reticulum: The endoplasmic reticulum (ER) is a system of channels that is continuous with the nuclear membrane (or "envelope") covering the nucleus (see Part 7) and composed of the same lipid bilayer material. The ER can be thought of as a series of winding thoroughfares similar to the waterway canals in Venice. The ER provides passages throughout much of the cell that function in transporting, synthesizing, and storing materials. The winding structure of the ER results in a large membranous surface area that supports its many functions (Figure 3). Endoplasmic reticulum can exist in two forms: rough ER and smooth ER. These two types of ER perform some very different functions and can be found in different amounts depending on the type of cell. Rough ER (RER) is so called because its membrane is dotted with embedded granules—organelles called ribosomes, giving the RER a bumpy appearance. A ribosome is an organelle that serves as the site of protein synthesis, and it is composed of two subunits. Ribosomes can either be bound (attached to ER) or free (floating in the cytosol). Smooth ER (SER) lacks ribosomes. One of the main functions of the smooth ER is in the synthesis of lipids. The smooth ER synthesizes phospholipids, the main component of biological membranes, as well as steroid hormones. Figure 6.3. Endoplasmic Reticulum (ER). (a) The endoplasmic reticulum is a winding network of thin membranous sacs found in close association with the cell nucleus. The smooth and rough endoplasmic reticula are very different in appearance and function. (b) The rough endoplasmic reticulum is studded with numerous ribosomes, which are sites of protein synthesis (source: mouse tissue). EM × 110,000. (c) Smooth endoplasmic reticulum synthesizes phospholipids and steroid hormones regulate the concentration of cellular Ca2+ and break down certain toxins (source: mouse tissue). EM × 110,510. (Micrographs provided by the Regents of the University of Michigan Medical School © 2012.) For this reason, cells that produce large quantities of such hormones, such as those of the female ovaries and male testes, contain large amounts of smooth ER. In addition to lipid synthesis, the smooth ER also sequesters (i.e., stores) and regulates the concentration of cellular calcium (Ca2+), which is extremely important in cells of the nervous system where Ca2+ is the trigger for neurotransmitter release. Additionally, the smooth ER, especially in the liver, performs a detoxification role, breaking down certain toxins. In contrast with the smooth ER, the primary job of the rough ER is the synthesis and modification of proteins destined for the cell membrane or for export from the cell. For this protein synthesis, many ribosomes attach to the ER (giving it the studded appearance of rough ER). Typically, a protein is synthesized within the ribosome and released inside the channel of the rough ER, where sugars can be added to it (by a process called glycosylation) before it is transported within a vesicle (a small fluid-filled sac) to the next stage in the packaging and shipping process: the Golgi apparatus. The Golgi Apparatus: The Golgi apparatus is responsible for sorting, modifying, and shipping off the products that come from the rough ER, much like a post office. The Golgi apparatus looks like stacked flattened discs, almost like stacks of oddly shaped pancakes. Like the ER, these discs are membranous. The Golgi apparatus has two distinct sides, each with a different role. One side (the cis face) of the apparatus receives products in vesicles. These products are sorted through the apparatus, and then they are released from the opposite side (the trans face) after being repackaged into new vesicles. If the product is to be exported from the cell, the vesicle migrates to the cell surface and fuses to the cell membrane, and the cargo is secreted (Figure 4). Figure 6.4. Golgi Apparatus. (a) The Golgi apparatus manipulates products from the rough ER. Proteins and other products of the ER are sent to the Golgi apparatus, which organizes, modifies, packages, and tags them. Some of these products are transported to other areas of the cell, and some are exported from the cell through exocytosis. Enzymatic proteins are packaged as new vesicles called lysosomes. (b) An electron micrograph of the Golgi apparatus. [Image description.] Lysosomes: Some of the protein products from the Golgi include digestive enzymes that are meant to remain inside the cell for use in breaking down certain materials. These enzymes are packaged into vesicles called lysosomes. A lysosome is an organelle that contains enzymes that break down and digest unneeded cellular components, such as a damaged organelle in a process called autophagy ("self-eating"). Lysosomes are also important for breaking down foreign material. For example, when certain immune defense cells, like white blood cells, phagocytize (engulf) bacteria, the bacterial cell is transported to a lysosome and digested by the enzymes inside. Under certain circumstances, lysosomes perform a more grand and dire function. In the case of damaged or unhealthy cells, lysosomes can be triggered to open up and release their digestive enzymes into the cytoplasm of the cell, killing the cell. This "self-destruct" mechanism is called autolysis and makes the process of cell death controlled (a mechanism called "apoptosis"). Organelles for Energy Processing In addition to the jobs performed by the endomembrane system, the cell has many other important functions. Just as you must consume nutrients to provide yourself with energy, so must each of your cells take in nutrients, some of which convert to chemical energy that can be used to power biochemical reactions. Mitochondrion: A mitochondrion (plural = mitochondria) is a membranous, bean-shaped organelle that is the "energy transformer" of the cell. Mitochondria consist of an outer lipid bilayer membrane as well as an additional inner lipid bilayer membrane (Figure 5). The inner membrane is highly folded into winding structures with a great deal of surface area, called cristae. It is along this inner membrane that a series of proteins, enzymes, and other molecules perform the biochemical reactions of cellular respiration. These reactions harvest the energy stored in nutrient molecules (such as glucose) to power the synthesis of ATP, which provides usable energy to the cell. Cells use ATP constantly, so the mitochondria are constantly at work. Oxygen molecules are required during cellular respiration, which is why you must constantly breathe them in. One of the organ systems in the body that uses huge amounts of ATP is the muscular system because ATP is required to sustain muscle contraction. As a result, muscle cells are packed full of mitochondria. Figure 6.5. Mitochondrion. The mitochondria are the energy-conversion factories of the cell. (a) A mitochondrion is composed of two separate lipid bilayer membranes. Along the inner membrane are various molecules that work together to produce ATP, the cell's major energy currency. (b) An electron micrograph of mitochondria. EM × 236,000. (Micrograph provided by the Regents of the University of Michigan Medical School © 2012.) [Image description.] Nerve cells also need large quantities of ATP to run their sodium-potassium pumps, which are used to generate an action potential. Therefore, an individual neuron will be loaded with over a thousand mitochondria. On the other hand, a bone cell, which is not nearly as metabolically active, might only have a couple of hundred mitochondria. The Nucleus: The nucleus is the largest and most prominent of a cell's organelles (Figure 6). The nucleus is generally considered the control center of the cell because it stores all of the genetic instructions for manufacturing proteins. Interestingly, some cells in the body, such as muscle cells, contain more than one nucleus (Figure 7), which is known as multinucleated. Other cells, such as mammalian red blood cells (RBCs), do not contain nuclei at all. RBCs eject their nuclei as they mature, making space for the large numbers of hemoglobin molecules that carry oxygen throughout the body. Inside the nucleus lies the blueprint that dictates everything a cell will do and all of the products it will make. This information is stored within DNA. The nucleus sends "commands" to the cell via molecular messengers that translate the information from DNA. Each cell in your body (with the exception of the cells that produce eggs and sperm) contains the complete set of your DNA. When a cell divides, the DNA must be duplicated so that each new cell receives a full complement of DNA. Figure 6.6. The Nucleus. The nucleus is the control center of the cell. The nucleus of living cells contains the genetic material that determines the entire structure and function of that cell. [Image description.] Organization of the Nucleus and Its DNA: Like most other cellular organelles, the nucleus is surrounded by a membrane called the nuclear envelope. This membranous covering consists of two adjacent lipid bilayers with a thin fluid space in between them. Spanning these two bilayers are nuclear pores. A nuclear pore is a tiny passageway for the passage of proteins, RNA, and solutes between the nucleus and the cytoplasm. Figure 6.7. Multinucleate Muscle Cell. Unlike cardiac muscle cells and smooth muscle cells, which have a single nucleus, a skeletal muscle cell contains many nuclei and is referred to as "multinucleated." (Micrograph provided by the Regents of University of Michigan Medical School © 2012.) Inside the nuclear envelope is a gel-like nucleoplasm with solutes that include the building blocks of nucleic acids. There also can be a dark-staining mass often visible under a simple light microscope, called a nucleolus (plural = nucleoli). The nucleolus is a region of the nucleus that is responsible for manufacturing the RNAs necessary for the construction of ribosomes. Once synthesized, newly made ribosomal subunits exit the cell's nucleus through the nuclear pores. The genetic instructions that are used to build and maintain an organism are arranged in an orderly manner in strands of DNA. Within the nucleus are threads of chromatin composed of DNA and associated proteins (Figure 8). Along the chromatin threads, the DNA is wrapped around a set of histone proteins. When a cell is in the process of division, the chromatin condenses into chromosomes so that the DNA can be safely transported to the "daughter cells." The chromosome is composed of DNA and proteins; it is the condensed form of chromatin. It is estimated that humans have almost 22,000 genes distributed on 46 chromosomes. Describe the structure and the functions of the major components of a cell. Describe the structure (be able to identify them in a diagram) and describe the functions of the following cytoplasmic components: The cell membrane (plasma membrane) Endoplasmic reticulum Ribosomes Golgi apparatus (Golgi complex) Lysosomes Mitochondria Vesicle Describe the structure (be able to identify them in a diagram) and describe the functions of the following nuclear components: Nuclear envelope Chromosomes Nucleolus Use a full page to draw (by hand, and neatly!) an annotated diagram of a cell showing all of the following structures and briefly describing the function of each (a simple, flattened diagram is fine, no need to show 3D structures, but the defining characteristics of each named structure should be clear): Plasma membrane Nuclear envelope Nucleus Nucleolus Smooth endoplasmic reticulum Rough endoplasmic reticulum Bound ribosomes Free ribosomes Golgi apparatus (or Golgi complex) Lysosomes Mitochondria Vesicles Describe the structure (name all the components and describe their relationships to each other) and list the general functions of the "endomembrane system." Part 4: Cellular Processes Involved in Growth. Cell Division, Growth, and Differentiation Cell Division: cells in the body must replace themselves over the lifetime of a person. For example, the cells lining the gastrointestinal tract must be frequently replaced when constantly "worn off" by the movement of food through the gut. But what triggers a cell to divide, and how does it prepare for and complete cell division? The cell cycle is the sequence of events in the life of the cell from the moment it is created at the end of a previous cycle of cell division until it then divides itself, generating two new cells. While there are a few cells in the body that do not undergo cell division (such as gametes, red blood cells, most neurons, and some muscle cells), most somatic cells divide regularly. A somatic cell is a general term for a body cell, and all human cells, except for the cells that produce eggs and sperm (which are referred to as germ cells), are somatic cells. Figure 6.8. DNA Macrostructure. Strands of DNA are wrapped around supporting histones. These proteins are increasingly bundled and condensed into chromatin, which is packed tightly into chromosomes when the cell is ready to divide. Cell Growth: Once cells divide, they grow and increase in size. For example, nerve cells first appear as relatively small cells, but then they elongate to become extremely long cells. Similarly, muscle cells grow to become extremely long cells as muscles are formed. Cell Differentiation: How does a complex organism such as a human develop from a single cell—a fertilized egg—into the vast array of cell types such as nerve cells, muscle cells, and epithelial cells that characterize the adult? Throughout development and adulthood, the process of cellular differentiation leads cells to assume their final morphology and physiology. Differentiation is the process by which unspecialized cells become specialized to carry out distinct functions. A stem cell is an unspecialized cell that can divide without limit as needed and can, under specific conditions, differentiate into specialized cells. Stem cells are unique in that they can also continually divide and regenerate new stem cells instead of further specializing. There are different stem cells present at different stages of a human's life. They include the embryonic stem cells of the embryo, fetal stem cells of the fetus, and adult stem cells in the adult. One type of adult stem cell is the epithelial stem cell, which gives rise to the keratinocytes in the multiple layers of epithelial cells in the epidermis of skin. When a cell differentiates, it becomes specialized; yet if all cells in the body, beginning with the fertilized egg, contain the same DNA, how do the different cell types come to be so different? The answer is analogous to a movie script. The different actors in a movie all read from the same script; however, they are each only reading their own part of the script. Similarly, all cells contain the same full complement of DNA, but each type of cell only "reads" the portions of DNA that are relevant to its own function. In biology, this is referred to as the unique genetic expression of each cell. Cell Specialization As cells specialize, they may undertake major changes in size, shape, metabolic activity, and overall function. The morphology (structure) of a mature cell is closely related to the function it is specialized to serve (Figure 9). Muscle fibers, for example, are far removed in structure and function from the zygote that they ultimately arose from: they are long, slender structures that are well-suited to contracting to produce macroscopic movements over relatively long distances. Some neurons (nerve cells) are exceptionally long and slender in shape, again to act over relatively long distances, although in this case, their function is to transmit information rather than move body structures directly. Erythrocytes (red blood cells) are used to transport oxygen in the blood; their tiny size and lack of a nucleus make them well-suited to squeezing through the smallest of capillaries, and their lack of mitochondria mean they do not themselves use up the oxygen they are supposed to be delivering to other cells. Leukocytes (white blood cells) on the other hand are noticeably larger than erythrocytes and do have mitochondria. The large size of macrophages, for example, means they are capable of physically engulfing relatively large particles or whole cells, such as bacteria by phagocytosis, and their mitochondria allow them access to the chemical energy required to move through body tissues toward invading pathogens. Figure 6.9. Stem Cells. The capacity of stem cells to differentiate into specialized cells makes them potentially valuable in therapeutic applications designed to replace damaged cells of different body tissues. [Image description.] QR 6.3. Watch this Amoeba Sisters video to learn more about how cells become specialized! I. Define metabolism and distinguish between anabolism and catabolism. Define the term "metabolism." Write a single sentence that clearly differentiates between "anabolism" and "catabolism." II. Describe the cellular processes involved in the growth of the human body from a fertilized egg to an adult. Distinguish between cell division, cell growth, and cell differentiation. Provide two examples of cell types in the human body that do not undergo cell division. Define the term "stem cell." Practice For the image below, drag and drop the correct structures to the animal cell. Image Descriptions Figure 6.1. Levels of Structural Organization of the Human Body. The organization of the body often is discussed in terms of six distinct levels of increasing complexity, from the smallest chemical building blocks to a unique human organism. The tip of the pyramid represents the atoms and examples of atoms, the oxygen and hydrogen atoms are given, in the bracket, below shows water molecule to refer to atoms bonding to form molecules with dimensional structures. Next, complexity is shared at the cellular level with the example of a smooth muscle cell represented as an example of a variety of molecules combining to form the fluid and organelles of a body cell. The fourth complexity contains the illustration of smooth muscle tissue to refer to the tissue level of organization, which is defined as a community of similar cells from body tissue. One below in the pyramid organ level is presented to refer to two or more different tissues combined to form an organ, and a urinary bladder illustration is given as an example. The fifth level contains the urinary tract system to refer to the organ system level, which is defined as two or more organs working closely together to perform the functions of a body system. The last and most inclusive level is the organismal level, which is formed by many organ systems working harmoniously together to perform the functions of an independent organism. [Return to image.] Figure 6.2. Typical Human Cell. While this image is not indicative of any one human cell, it is a typical example of an animal cell containing the primary organelles and internal structures. In the illustration, the plasma membrane is labeled as a border, in the cytoplasm; mitochondria, microtubule, centrosome, microfilament, microtubule, lysosome, smooth endoplasmic reticulum (has no ribosome attachment to their membrane), secretory vesicle, peroxisome, vacuole, cytoplasm, Golgi vesicle, Golgi apparatus, rough endoplasmic reticulum (ribosomes attached on their membrane), cytoplasmic ribosomes, which freely floats within the cytosol, intermediate filaments, and nucleus are drawn and labeled. Within the nucleus, chromatin and nucleolus are also drawn and labeled. [Return to image.] Figure 6.4. Golgi Apparatus. (a) The illustration presents RER: transport vesicle carries substances from RER to the Golgi apparatus, and secretory vesicle carries substances from the Golgi apparatus toward the plasma membrane. The Golgi apparatus manipulates products from the rough ER. Proteins and other products of the ER are sent to the Golgi apparatus, which organizes, modifies, packages, and tags them. Some of these products are transported to other areas of the cell, and some are exported from the cell through exocytosis. Enzymatic proteins are packaged as new vesicles called lysosomes. The illustration shows a transport vesicle between the RER and Golgi apparatus and a secretory vesicle between the Golgi apparatus and the plasma membrane. Transport vesicles move materials within the cell, while secretory vesicles store and release materials into the cell or to the extracellular environment. (b) An electron micrograph of the Golgi apparatus is shown with labeled trans face and cis face. The cis face lies near the transitional region of the rough endoplasmic reticulum, while the trans face lies near the cell membrane. These two networks are responsible for the essential task of sorting proteins and lipids that are received (at the cis face) or released (at the trans face) by the organelle. [Return to image.] Figure 6.5. Mitochondrion. The mitochondria are the energy-conversion factories of the cell. (a) Illustration of a mitochondrion shows labels for cristae and intermembrane space. The outer and inner membranes and intermembrane space are labeled within the illustration and the electron micrograph. A mitochondrion is composed of two separate lipid bilayer membranes. Along the inner membrane are various molecules that work together to produce ATP, the cell's major energy currency. The outer mitochondrial membrane fully surrounds the inner membrane, with a small intermembrane space in between. The outer membrane has many protein-based pores that are big enough to allow the passage of ions and molecules as large as a small protein. Cristae are folds in the inner mitochondrial membrane. Mitochondria are organelles in eukaryotic cells. The major function of cristae is to increase the surface area of the mitochondrial membrane. This allows membrane processes to produce more energy at a faster rate. (b) An electron micrograph of mitochondria. EM × 236,000. (Micrograph provided by the Regents of University of Michigan Medical School © 2012). [Return to image]. Figure 6.6. The Nucleus. The nucleus is the control center of the cell. The nucleus of living cells contains the genetic material that determines the entire structure and function of that cell. Illustration of a nucleus contains nucleolus, condensed chromatin, nuclear envelope, and nuclear pores. The nuclear pore is a protein-lined channel in the nuclear envelope that regulates the transportation of molecules between the nucleus and the cytoplasm. In eukaryotic cells, the nucleus is separated from the cytoplasm and surrounded by a nuclear envelope. This envelope safeguards the DNA contained in the nucleus. In spite of this barrier, there is still communication between the nucleus and the cytoplasm. This communication is regulated by the nuclear pores. Next to the nucleus, RER is illustrated, and cisternae of the RER is labeled. The RER is morphologically distinguishable by its series of convoluted, flattened-like membrane sheets (called cisternae) that arise near the nucleus and extend across the cytoplasm. [Return to image.] Figure 6.9. Stem Cells. Stem cells have the remarkable potential to renew themselves. They can develop into many different cell types in the body during early life and growth. The capacity of stem cells to differentiate into specialized cells make them potentially valuable in therapeutic applications designed to replace damaged cells of different body tissues. There are several main categories: the "pluripotent" stem cells (embryonic stem cells and induced pluripotent stem cells) and nonembryonic or somatic stem cells (commonly called "adult" stem cells). The illustration is showing a totipotent embryonic stem cell can divide and differentiate into pluripotent embryonic stem cells such as the endoderm line, which differentiate later into multipotent stem cells to form the cells of the lung and pancreas. The pluripotent mesoderm line differentiates into multipotent stem cells to form the heart muscle and RBC. The pluripotent ectoderm line differentiates into multipotent stem cells to form the cells of the skin and neurons. [Return to image.] definitionSum of all catabolic and anabolic reactions that take place in the body. Any of several different types of membrane-enclosed specialized structures in the cell that perform specific functions for the cell. Skin and its accessory structures. Reactions that build smaller molecules into larger molecules. Chemical reaction that breaks down more complex organic molecules. Building block of proteins; characterized by an amino and carboxyl functional groups and a variable side-chain. Nucleotide containing ribose and an adenine base that is essential in energy transfer. Becoming wider, larger, or more open. Process by which unspecialized cells become more specialized in structure and function. Consisting of more than one cell (as opposed to organisms such as bacteria, which are unicellular). The smallest unit of an element that retains the unique properties of that element. Two or more atoms covalently bonded together. Group of many similar cells (though sometimes composed of a few related types) that work together to perform a specific function. An anatomically distinct structure of the body composed of two or more tissue types. Internal material between the cell membrane and nucleus of a cell, mainly consisting of a water-based fluid called cytosol, within which are all the other organelles and cellular solute and suspended materials. Clear, semi-fluid medium of the cytoplasm, made up mostly of water. One of two major divisions of living things (or their cells) that have membrane-bound nuclei and other organelles and can form large complex organisms (including all animals, plants, fungi). By contrast, bacteria are prokaryotic. Cell's central organelle; contains the cell's DNA. Set of cellular organelles that often work together to produce, package, and export certain products. Cellular organelle that consists of interconnected membrane-bound tubules, which may or may not be associated with ribosomes (rough type or smooth type, respectively). Cellular organelle formed by a series of flattened, membrane-bound sacs that functions in protein modification, tagging, packaging, and transport. Cellular organelle that functions in protein synthesis. Class of organic compounds that are composed of many amino acids linked together by peptide bonds. Class of nonpolar organic compounds built from hydrocarbons and distinguished by the fact that they are not soluble in water. An amphipathic lipid molecule containing a phosphate head (polar) and two fatty acid tails (non-polar). The major molecule comprising plasma membranes. (Also, sterol) lipid compound composed of four hydrocarbon rings bonded to a variety of other atoms and molecules; not to be confused with anabolic steroids, a synthetic supplement Secretion of an endocrine organ that travels via the bloodstream or lymphatics to induce a response in target cells or tissues in another part of the body. Chemical signal that is released from the synaptic end bulb of a neuron to cause a change in the target cell. Membrane-bound structure that contains materials within or outside of the cell. Membrane-bound cellular organelle originating from the Golgi apparatus and containing digestive enzymes. Cell process (a form of endocytosis) in which a cell engulfs and ingests another large particle or cell. One of the cellular organelles bound by a double lipid bilayer that function primarily in the production of cellular energy (ATP). Molecule (usually a protein) that catalyzes chemical reactions. Production of ATP from glucose oxidation via glycolysis, the Krebs cycle, and oxidative phosphorylation. Oxygen-carrying protein in erythrocytes (red blood cells). Deoxyribose-containing nucleic acid that stores genetic information. Membrane that surrounds the nucleus; consisting of a double lipid-bilayer. One of the small, protein-lined openings found scattered throughout the nuclear envelope. Ribose-containing nucleic acid that helps manifest the genetic code as protein. Small region of the nucleus that functions in ribosome synthesis. Substance consisting of DNA and associated proteins. A long DNA molecule, combined with proteins that contains a number of genes. The normal chromosome complement is 23 pairs of homologous chromosomes, one each from mother and father. Life cycle of a single cell, from its birth until its division into two new daughter cells. Haploid reproductive cell (egg or sperm in humans) that contributes genetic material to form an offspring. Excitable neural cell that transfer nerve impulses. A body cell, excluding germ cells. Normally diploid, each cell containing a complete set of genes. Cell that gives rise to a gamete. Type of tissue that serves primarily as a covering or lining of body parts, protecting the body; it also functions in absorption, transport, and secretion. Cell that is oligo-, multi-, or pleuripotent that has the ability to produce additional stem cells rather than becoming further specialized. Developing human during weeks 3–8. Developing human during the time from the end of the embryonic period (week 9) to birth. Cell that produces keratin and is the most predominant type of cell found in the epidermis. outermost tissue layer of the skin Home » Microbiology » Cell Biology The cell, derived from the Latin term "cellula" meaning 'small room', is the foundational and structural unit of all living organisms. Recognized as the cornerstone of life, cells play a pivotal role in the biological framework, providing both structure and function to every living being. The intricate study of these units and their components is termed Cell Biology.Historically, the existence of cells was first unveiled by Robert Hooke in 1665. His observations led him to coin the term "cell" due to their resemblance to the small chambers, or cells, occupied by monks in monasteries. This groundbreaking discovery paved the way for the development of the cell theory in 1839, proposed by Matthias Jakob Schleiden and Theodor Schwann. This theory posits three fundamental tenets: all living organisms are composed of cells, the cell is the primary unit of structure and function in these organisms, and all cells originate from pre-existing cells.Cells are incredibly diverse in their morphology and function. They can range from the minuscule Mycoplasmas, the smallest known cells, to complex multicellular organisms like humans, which comprise an estimated 37 trillion cells. Within this vast array of cells, each possesses specialized organelles that execute distinct functions vital for the organism's survival. These organelles, each with a unique structure, collaborate to perform life-sustaining processes, from DNA replication and repair to protein synthesis.Furthermore, cells are equipped with the capability for specialization and motility. While most plant and animal cells are typically between 1 and 100 micrometres in size and require a light microscope for visualization, electron microscopy offers a higher resolution, revealing intricate cellular details. Organisms can be unicellular, like bacteria, or multicellular, encompassing plants and animals. Notably, the human brain alone houses approximately 80 billion cells.The exploration of cells has not only expanded our understanding of their structure and function but has also catalyzed advancements in related biological domains such as DNA discovery, cancer systems biology, aging, and developmental biology. As we delve deeper into the realm of cell biology, it becomes evident that these microscopic entities, which first appeared on Earth nearly 4 billion years ago, are the very essence of life itself.A cell is the basic structural and functional unit of all living organisms, responsible for various life processes and containing essential biological molecules.Discovery of Cells – Who discovered cells?The journey of cell discovery stands as a testament to the relentless pursuit of knowledge in the realm of science. This exploration unveiled the fundamental building blocks of life, providing profound insights into the intricate tapestry of living organisms.The genesis of cell discovery can be traced back to 1665 when Robert Hooke, utilizing a rudimentary compound microscope, examined a slice of cork. The microscopic cavities he observed bore a resemblance to small chambers or "cells" in monastic settings, leading him to christen them as "cells." However, due to the limited magnification capabilities of his microscope, Hooke perceived these cells as non-living structures.The narrative took a turn when Anton Van Leeuwenhoek, employing a more advanced microscope, discerned cellular entities exhibiting motility, suggesting their living nature. He termed these motile structures "animalcules."Further advancements in the understanding of cellular structure were made by the Scottish botanist, Robert Brown, in 1883. Brown's observations of orchid cells led to the identification and description of the cell nucleus, a pivotal component of cellular function and organization.As microscopy technology evolved, the magnification prowess expanded, enabling more detailed observations. While Hooke's initial discovery laid the foundation, it was the corroborative studies by scientists like Matthias Schleiden and Theodor Schwann that cemented the understanding of cells. Their investigations into plant and animal cells revealed distinct cellular differences, underscoring the universality of cells as the foundational units in both plant and animal life.In essence, the discovery of cells, spearheaded by pioneers like Hooke, Leeuwenhoek, and Brown, illuminated the microscopic world, ushering in the era of cell biology and reshaping our comprehension of life's intricacies.Origins of CellsThe inception of cells is intrinsically linked to the genesis of life, marking the commencement of life's rich tapestry on Earth.Emergence of the Primordial Cell: The ancient remnants of life, stromatolites, are attributed to cyanobacteria, colloquially termed blue-green algae. These oldest known life fossils, dating back a billion years, have been discovered in locations such as the Glacier National Park in the United States.Theories on the Birth of Life's Molecules: The genesis of the minuscule molecules that paved the way for life on early Earth is shrouded in multiple hypotheses. Some postulate that these molecules were transported to Earth via meteorites, as evidenced by the Murchison meteorite. Others advocate for their creation in the depths of the ocean at hydrothermal vents. Yet another theory, stemming from the Miller–Urey experiment, suggests their synthesis through lightning in a primordial reducing atmosphere. The exact nature of the first self-replicating entities remains elusive. While RNA, with its dual capabilities of genetic information storage and chemical reaction catalysis, is a prime candidate (as per the RNA world hypothesis), precursors to RNA like clay or peptide nucleic acid might have existed.The Advent of Cells: Cells made their debut on Earth approximately 3.5 billion years ago. Prevailing scientific consensus posits that these pioneering cells were heterotrophs. Initial cell membranes likely exhibited greater simplicity and permeability compared to their contemporary counterparts, possibly comprising a singular fatty acid chain per lipid. While lipids can autonomously form bilayered vesicles in aqueous environments, potentially predating RNA, the genesis of the first cell membranes might have been facilitated by catalytic RNA or might have necessitated structural proteins for formation.The Rise of Eukaryotic Cells: Eukaryotic cells, with their intricate structure, are believed to have originated from a symbiotic consortium of prokaryotic cells. Organelles within eukaryotic cells, such as mitochondria and chloroplasts, trace their lineage to ancient symbiotic entities – the oxygen-breathing Alphaproteobacteria and Cyanobacteria, respectively. These were endosymbiosed by a primordial archaean prokaryote. The sequence of events leading to the evolution of organelles like the hydrogenosome, in relation to mitochondria, remains a topic of active debate.In summary, the origins of cells provide a fascinating glimpse into the evolutionary processes that shaped life on Earth, offering insights into the intricate dance of molecules that led to the diverse biological entities we observe today.Characteristics of CellsCells, often referred to as the building blocks of life, exhibit a myriad of intricate features that underpin their functionality and structural integrity. These characteristics are quintessential to the sustenance and propagation of life. Herein are the salient features of cells:Structural Framework: Cells confer structural stability and support to an organism, ensuring its form and posture.Organized Interior: Within the cellular confines, there exists a well-orchestrated arrangement of organelles, each enveloped by its distinct membrane. This organization facilitates the compartmentalization of various cellular functions.Genetic Repository: The nucleus, a paramount organelle, serves as the custodian of genetic material. It harbors the vital genetic blueprints essential for cellular reproduction and growth.Presence of Membrane-Bound Organelles: Every cell is equipped with membrane-encased organelles dispersed within the cytoplasm, ensuring the segregation and efficient execution of cellular tasks.Energy Powerhouses – Mitochondria: These double-membraned organelles are the cell's energy hubs. They orchestrate energy transactions crucial for cellular vitality.Lysosomal Function: Lysosomes are cellular custodians that oversee the degradation of superfluous or damaged cellular components, ensuring cellular hygiene and turnover.Endoplasmic Reticulum – The Cellular Factory: This extensive network plays an instrumental role in the cell's internal dynamics. It is pivotal in the synthesis of select molecules and oversees their processing, routing, and localization within the cell.Types of CellsIn the vast realm of biology, cells stand as the fundamental units of life, exhibiting a spectrum of complexities and functionalities. Based on their structural and functional intricacies, cells are primarily classified into two categories: eukaryotic and prokaryotic.Prokaryotic Cell DiagramProkaryotic CellsOverview: Prokaryotic cells, encompassing bacteria and archaea, represent the earliest life forms on Earth. These cells are characterized by the absence of a defined nucleus and are generally smaller and simpler than their eukaryotic counterparts.Structural Features:Cell Envelope: Typically consists of a plasma membrane, often shielded by a cell wall and, in some cases, an additional capsule layer. This envelope provides structural support and acts as a protective barrier.Cytoplasmic Region: Houses the genome (DNA), ribosomes, and various inclusions. The DNA, though not enclosed within a nucleus, is organized in a region termed the nucleoid.Extrachromosomal Elements: Prokaryotes may possess plasmids, circular DNA fragments that encode supplementary genes.External Appendages: Structures like flagella and pili protrude from the cell surface, facilitating movement and intercellular communication.Morphological Diversity: Prokaryotic cells exhibit a range of shapes, including cocci (spherical), bacilli (rod-shaped), and spirochaetes (spiral).Eukaryotic CellsOverview: Eukaryotic cells, found in plants, animals, fungi, and certain protists, are characterized by the presence of a well-defined nucleus and membrane-bound organelles.Structural Features:Nucleus: A membrane-bound organelle that houses the cell's DNA, organized into linear chromosomes associated with histone proteins.Membrane-Bound Organelles: Eukaryotic cells possess specialized compartments, such as mitochondria and chloroplasts, each with distinct functions. Some of these organelles also contain their own DNA.Cilia and Flagella: Eukaryotic cells may possess these structures for movement. Unlike prokaryotic flagella, eukaryotic flagella are structurally more intricate.Compartmentalization: A hallmark of eukaryotic cells is the presence of distinct organelles, facilitating specialized cellular activities in defined spaces.In summary, the cellular world is marked by a dichotomy between prokaryotic and eukaryotic cells, each with its unique set of characteristics and functionalities. This classification underscores the evolutionary intricacies and the diverse strategies adopted by life forms to thrive in myriad environments.Animal CellsPlant Cell Labeled Diagram/Structure of Plant cellFeaturesProkaryotesEukaryotesTypical OrganismsBacteria, ArchaeaProtists, Fungi, Plants, AnimalsSizeApproximately 1–5 µmApproximately 10–100 µmNucleus TypeNucleoid region (lacks a true nucleus)True nucleus enclosed by a double membraneDNA StructureTypically circularLinear chromosomes associated with histone proteinsRNA/Protein

SynthesisCoupled in the cytoplasmRNA synthesis occurs in the nucleus; protein synthesis takes place in the cytoplasmRibosomesComprise 50S and 30S subunitsComprise 60S and 40S subunitsCytoplasmic StructureMinimal structuresHighly organized with endomembranes and a cytoskeletonCell MovementFlagella composed of flagellinFlagella and cilia with microtubules; lamellipodia and filopodia with actinMitochondriaAbsentPresent, ranging from one to several thousandChloroplastsAbsentPresent in algae and plantsOrganizational StructureTypically unicellularUnicellular, colonial, or multicellular with specialized cellsCell DivisionBinary fissionMitosis (via fission or budding); meiosisChromosomesSingle chromosomeMultiple chromosomesMembranesCell membrane onlyCell membrane, often accompanied by various organelle membranesCOMPARISON OF EUKARYOTES VS. PROKARYOTES | IMAGE SOURCE: SCIENCE PRIMER (NATIONAL CENTER FOR BIOTECHNOLOGY INFORMATION). VECTORIZED BY MORTADELO2005., PUBLIC DOMAIN, VIA WIKIMEDIA COMMONSCell StructureCELL STRUCTURE | IMAGE SOURCE: HTTPS://TRAINING.SEER.CANCER.GOV/ANATOMY/CELLS_TISSUES_MEMBRANES/CELLS/STRUCTURE.HTMLCells, the foundational units of life, are intricately designed with specialized components, each playing a pivotal role in ensuring the cell's functionality and vitality. Delving deeper into the cellular architecture, we identify the following key structural elements:PLANT CELL (PLASMA) MEMBRANECell Membrane:Function: Serving as the cell's protective barrier, the cell membrane regulates the ingress and egress of molecules, ensuring a controlled exchange with the external environment.Composition: Often termed the plasma membrane, this semi-permeable structure is equipped with selective pores, facilitating the movement of specific substances.Significance: Beyond its role in substance transport, the cell membrane provides structural integrity, safeguarding the cell's internal components from potential harm and external fluctuations.Cell Wall:Distinctiveness: Exclusively found in plant cells, the cell wall is the outermost protective layer.Composition: Primarily constructed from cellulose, hemicellulose, and pectin, the cell wall exhibits rigidity and robustness.Function: This structural layer imparts shape, offers mechanical protection against external shocks, and provides additional support to the cell, fortifying its stance against environmental challenges.Cytoplasm:Description: Residing within the confines of the cell membrane, the cytoplasm is a viscous, gelatinous matrix.Role: Serving as the cellular arena, the cytoplasm hosts a myriad of biochemical reactions crucial for the cell's sustenance.Inhabitants: Various cell organelles, including the endoplasmic reticulum, mitochondria, ribosomes, and vacuoles, are suspended within this matrix, orchestrating their respective functions.Nucleus:Genetic Repository: The nucleus houses the cell's genetic blueprint, DNA, which dictates cellular activities and inheritance patterns.Regulatory Role: Acting as the cell's command center, the nucleus governs cellular processes, directing growth, maturation, replication, and apoptosis.Structural Features: Encased within a nuclear envelope, the nucleus ensures the safeguarding of DNA, segregating it from the cytoplasmic milieu.In essence, the cellular structure is a marvel of biological engineering, with each component synergistically contributing to the cell's holistic function. This intricate design underscores the complexity and precision inherent in the realm of cellular biology.Cell OrganellesCellular organelles are intricate structures within cells that execute specific functions vital for the cell's survival and operation. Analogous to the organs in multicellular organisms, each organelle has a distinct role, ensuring the cell's optimal functioning.Eukaryotic and prokaryotic cells both possess organelles. However, the organelles in prokaryotic cells are generally simpler and lack a surrounding membrane. The cellular matrix, known as the cytosol, is a gel-like substance that envelops these organelles.Eukaryotic Organelles:Cell Nucleus: The nucleus, the cell's command center, is the most prominent organelle in eukaryotic cells. It safeguards the cell's genetic material and is the hub for DNA replication and RNA synthesis. Encased by the nuclear envelope, the nucleus ensures the DNA's protection from potential external threats. Within the nucleus, the nucleolus is responsible for assembling ribosome subunits.Mitochondria and Chloroplasts: These organelles are pivotal for energy production. Mitochondria, present in all eukaryotic cells, facilitate aerobic respiration, converting nutrients into energy-rich ATP molecules. Chloroplasts, exclusive to plants and algae, harness sunlight to produce carbohydrates via photosynthesis.Endoplasmic Reticulum (ER): The ER is a cellular highway, directing molecules to their destinations. It exists in two forms: the ribosome-studded rough ER and the ribosome-free smooth ER, which plays a role in lipid synthesis and calcium regulation.Golgi Apparatus: This organelle processes and packages macromolecules like proteins and lipids synthesized by the cell.Lysosomes and Peroxisomes: Lysosomes house enzymes that break down waste materials and cellular debris. Peroxisomes neutralize toxic peroxides, ensuring cellular safety.Centrosome: Integral for cytoskeleton organization, the centrosome produces microtubules and oversees transport within the ER and Golgi apparatus.Vacuoles: These membrane-bound sacs isolate waste and, in plants, store water. They play a crucial role in maintaining cellular homeostasis.Eukaryotic and Prokaryotic Organelles:Ribosomes: Comprising RNA and protein complexes, ribosomes are the cellular machinery where protein synthesis occurs using RNA templates.Plastids: Found predominantly in plant cells, plastids are membrane-bound organelles containing specific pigments. They can be classified into chloroplasts (involved in photosynthesis), chromoplasts (involved in pigment synthesis and storage), and leucoplasts (involved in nutrient storage).DIAGRAM OF THE ENDOMEMBRANE SYSTEM | IMAGE CREDIT: LADYOFHATS, PUBLIC DOMAIN, VIA WIKIMEDIA COMMONSOrganelleFunctionDescriptionNucleolusRibosome SynthesisCentral site for ribosome production and plays a role in cellular activities and reproduction.Nuclear MembraneNucleus ProtectionA double-layered boundary that safeguards the nucleus from the rest of the cell's components.ChromosomesGenetic Information StorageEssential for determining an individual's traits. Each human cell contains 23 chromosome pairs.Endoplasmic Reticulum (ER)Substance TransportationA network aiding in substance transport. The rough ER has ribosomes for protein synthesis, while the smooth ER assists in lipid synthesis and metabolism.Golgi ApparatusMacromolecule ProcessingModifies and packages proteins and lipids synthesized by the cell.MitochondriaEnergy ProductionTermed the "cell's powerhouse," it produces ATP, the cell's energy currency, through oxidative phosphorylation.ChloroplastsPhotosynthesisPresent in plants and algae, these organelles harness sunlight to produce carbohydrates.LysosomesWaste ManagementContain enzymes to break down waste materials and foreign invaders.PeroxisomesToxin BreakdownContain enzymes that neutralize toxins, especially peroxides.CentrosomeCytoskeleton OrganizationProduces microtubules, essential for the cytoskeleton, and directs transport through the ER and Golgi apparatus.VacuolesStorageStore nutrients, waste products, and water. In plants, they also maintain turgor pressure.RibosomesProtein SynthesisComplexes of RNA and protein where protein synthesis occurs.PlastidsPigment Storage & Energy CaptureMembrane-bound organelles in plants and euglenoids. They store pigments and participate in photosynthesis. Types include chloroplasts (for photosynthesis), chromoplasts (pigment synthesis and storage), and leucoplasts (nutrient storage).Cells, the fundamental units of life, often possess structures that extend beyond the confines of the cell membrane. These extracellular structures are exposed to the external milieu, lacking the protective shield of the semipermeable cell membrane. The assembly of these structures necessitates the transportation of their components across the cell membrane via specialized export mechanisms.Cell Wall: The cell wall is a prominent extracellular structure found in numerous prokaryotic and eukaryotic cells. It serves as a protective barrier, offering mechanical and chemical defense against external threats, complementing the protective role of the cell membrane. The composition of the cell wall varies among different cell types. While plant cells predominantly contain cellulose-based cell walls, fungal cells have walls composed of chitin, and bacterial cell walls are primarily constituted of peptidoglycan.Prokaryotic Extracellular Structures:Capsule: Certain bacteria are enveloped by a gelatinous capsule that lies outside the cell membrane and cell wall. The composition of the capsule can vary, with some being made of polysaccharides, as seen in pneumococci and meningococci, while others, like Bacillus anthracis, have polypeptide capsules. Some even possess hyaluronic acid-based capsules, such as streptococci. These capsules are not readily stained using conventional methods but can be visualized using techniques involving India ink or methyl blue, enhancing the contrast for observation.Flagella: Flagella are whip-like structures that bestow motility to cells. In bacteria, the flagellum originates from the cytoplasm, traverses the cell membrane(s), and protrudes through the cell wall. These proteinaceous appendages are thick and elongated. It's worth noting that archaea possess a distinct type of flagellum, while eukaryotes have yet another variant.Fimbriae (Pili): Fimbriae, also termed pili, are slender, hair-like projections on bacterial surfaces. Composed of the protein pilin, fimbriae facilitate bacterial attachment to specific receptors on host cells, mediating cell adhesion. Certain specialized pili play a role in bacterial conjugation, a process of genetic material transfer.Cellular processesThe intricate machinery of life operates at the cellular level, where a plethora of processes ensures the sustenance, growth, and reproduction of organisms. These cellular processes are governed by complex biochemical reactions and pathways, ensuring the cell's proper function and survival. Here, we delve into the fundamental cellular processes that dictate the life of a cell:PROKARYOTES DIVIDE BY BINARY FISSION, WHILE EUKARYOTES DIVIDE BY MITOSIS OR MEIOSIS. | IMAGE CREDIT: DOMDOMEGG, CC BY-SA 4.0, VIA WIKIMEDIA COMMONSReplication and Cell Division: Cells reproduce by dividing, a process essential for growth in multicellular organisms and for reproduction in unicellular entities. Prokaryotic cells undergo binary fission, while eukaryotic cells partake in mitosis, followed by cytokinesis. In certain scenarios, a diploid cell undergoes meiosis to produce haploid cells, which act as gametes in multicellular organisms.DNA Replication: Before cell division, a cell's genome is duplicated. This ensures that the daughter cells inherit the complete set of genetic information. DNA replication is a meticulously regulated process, requiring specialized proteins for its execution.DNA Repair: Cells possess enzyme systems that continuously monitor and repair DNA damage. The presence of diverse repair mechanisms, such as nucleotide excision repair and recombinational repair, underscores the importance of maintaining DNA integrity.Growth and Metabolism: Cellular metabolism encompasses the biochemical reactions that facilitate cell growth. It is bifurcated into catabolism, where complex molecules are broken down, and anabolism, where complex molecules are synthesized. For instance, glucose is metabolized to produce adenosine triphosphate (ATP), a molecule central to cellular energy.Protein Synthesis: Proteins, the workhorses of the cell, are synthesized based on the genetic information encoded in DNA. This synthesis involves two primary steps: transcription, where DNA is transcribed into RNA, and translation, where RNA is translated into proteins. The entire process ensures the accurate translation of genetic information into functional protein molecules.Motility: Cellular movement is vital for various processes, from unicellular organisms seeking nutrients to multicellular entities repairing wounds. Mechanisms like flagella and cilia facilitate movement in unicellular organisms, while complex processes drive movement in multicellular organisms, such as during wound healing or immune responses.Navigation, Control, and Communication: Cells exhibit remarkable navigation capabilities, as evidenced by their ability to efficiently traverse complex environments. For instance, certain cells can generate gradients to sense and navigate through mazes, highlighting their sophisticated sensing and communication mechanisms.AN OUTLINE OF THE CATABOLISM OF PROTEINS, CARBOHYDRATES AND FATS | IMAGE CREDIT: TIM VICKERS, VECTORIZED BY FVASCONCELLOS, PUBLIC DOMAIN, VIA WIKIMEDIA COMMONSMulticellularity OrganismMulticellularity, a hallmark of advanced life forms, refers to organisms composed of multiple cells, distinguishing them from unicellular entities. This intricate organization has paved the way for the emergence of diverse life forms with specialized functions and structures.Cellular Differentiation and Specialization: Multicellular organisms exhibit cellular differentiation, where genetically identical cells evolve into distinct cell types tailored for specific roles. For instance, mammals boast a plethora of cell types, including neurons, muscle cells, blood cells, and skin cells, to name a few. Despite sharing the same genetic makeup, these cells manifest different functions and appearances due to the differential gene expression they undergo.Genesis of Multicellularity: The phenomenon of multicellularity is not exclusive to eukaryotes; it has independently emerged at least 25 times across the evolutionary timeline, encompassing certain prokaryotes like cyanobacteria and myxobacteria. However, the intricate multicellular structures are predominantly observed in six eukaryotic groups: animals, fungi, brown algae, red algae, green algae, and plants. The origins of multicellularity can be traced back to various evolutionary pathways, including the formation of interdependent cellular colonies, cellularization, or symbiotic associations between organisms.Historical Evidence: The primordial evidence of multicellularity is found in cyanobacteria-like fossils dating back between 3 to 3.5 billion years. Other ancient multicellular remnants include the debated Grypania spiralis and the fossils discovered in the Palaeoproterozoic Francevillian Group Fossil B Formation in Gabon.Evolutionary Experiments: The transition from unicellularity to multicellularity has been recreated in controlled laboratory settings. Through evolutionary experiments, predation was employed as a selective pressure, leading to the emergence of multicellularity from unicellular progenitors.In conclusion, multicellularity represents a significant evolutionary leap, allowing for the diversification and specialization of life forms. This complex organization has enabled organisms to adapt and thrive in varied environments, showcasing the marvels of evolutionary biology.Cell TheoryThe Cell Theory, a foundational tenet of biology, was pioneered by eminent German researchers: Theodor Schwann, Matthias Schleiden, and Rudolf Virchow. This theory elucidates the fundamental principles governing cellular biology and is summarized as follows:Universality of Cells: Every living organism, irrespective of its complexity, is constituted by cells.Fundamental Life Unit: Cells represent the quintessential structural and functional units that orchestrate the myriad processes vital for life.Cellular Lineage: New cells are not spontaneously generated; they emerge from the division of pre-existing cells.In light of advancing scientific knowledge, the Cell Theory has been refined and expanded to encompass additional principles:Cellular Energetics: Cells are dynamic entities wherein energy is continuously channeled to drive various biochemical reactions.Genetic Continuity: Cells ensure the perpetuation of genetic information by transmitting it during cell division.Biochemical Uniformity: Despite the vast diversity of life, there exists a remarkable consistency in the chemical constituents of cells across all species.Functions of CellCells, the fundamental units of life, execute a myriad of functions pivotal for the sustenance, growth, and development of organisms. Herein, we delineate the principal roles undertaken by cells:Structural Foundation: Cells are the building blocks of all living entities. They confer structural integrity to organisms. Key cellular components, such as the cell wall and cell membrane, bestow support and form to organisms. For instance, human skin comprises myriad cells, while in vascular plants, the xylem, composed of specialized cells, imparts structural robustness.Growth through Cellular Division: Cells proliferate through a process known as mitosis, wherein a parent cell bifurcates into two offspring cells. This cellular multiplication underpins growth in organisms.Substance Transport Mechanisms: Cells orchestrate the import of essential nutrients required for intracellular biochemical reactions. Concurrently, they expel waste products generated from these reactions. Molecular transport across the cell membrane can be:Passive Transport: Small molecules like oxygen and carbon dioxide traverse the cell membrane via diffusion, moving along their concentration gradients.Active Transport: Larger molecules necessitate significant energy for their transport across the cell membrane, a process facilitated by cellular energy.Energy Generation: To fuel their myriad activities, cells necessitate energy. This energy is harnessed through photosynthesis in plants and cellular respiration in animals.Role in Reproduction: Cells play an instrumental role in organismal reproduction. They undergo mitosis, a form of asexual reproduction, where a parent cell divides to yield identical daughter cells. Conversely, meiosis results in daughter cells that are genetically distinct from their parent, ensuring genetic diversity.Synthesis of Biomolecules: Cells are the sites for the synthesis of vital biomolecules, including proteins, nucleic acids, lipids, and carbohydrates. The ribosomes, endoplasmic reticulum, and Golgi apparatus work in tandem to ensure the synthesis, modification, and transport of proteins.Cellular Communication: Cells communicate with each other through signaling pathways. This communication is crucial for processes like tissue repair, immune responses, and coordination of activities in multicellular organisms.Homeostasis: Cells maintain a stable internal environment, ensuring that pH, temperature, and nutrient concentrations are optimal for cellular activities.Waste Management: Lysosomes and peroxisomes in cells break down waste materials and toxins, ensuring that the cell remains unpolluted and functional.Defense and Immunity: Certain cells, especially in animals, play a role in defending the organism against pathogens. White blood cells, for instance, are involved in identifying and destroying foreign invaders.Cell Differentiation: Stem cells have the ability to differentiate into various specialized cell types, ensuring that organisms can develop specialized tissues and organs.Genetic Inheritance: Cells house the genetic material (DNA) that is passed from one generation to the next. This ensures the continuity of genetic traits and the propagation of species.Cell Motility: Some cells, like sperm cells in animals and certain bacteria, exhibit motility. They possess structures like flagella or cilia that enable movement.Storage: Vacuoles in plant cells store nutrients, waste products, and help in maintaining turgor pressure. Similarly, fat cells in animals store lipids that can be used as an energy reserve.Sensory Functions: Certain cells, especially in higher animals, are specialized to detect changes in the environment. For instance, photoreceptor cells in the eyes detect light, while olfactory cells in the nose detect odors.In essence, cells are dynamic entities that not only provide structure but also drive growth, facilitate transport, generate energy, and play a pivotal role in reproduction, underscoring their indispensable nature in the realm of biology.Examples of CellCells are the basic building blocks of all living organisms. Here are examples of different types of cells:Prokaryotic Cells:Bacterial Cells: These are simple cells without a nucleus. Examples include Escherichia coli (E. coli) and Staphylococcus aureus.Eukaryotic Cells:Animal Cells:Red Blood Cells (Erythrocytes): These cells transport oxygen throughout the body.Neurons: These are nerve cells responsible for transmitting electrical signals.Muscle Cells: These cells are responsible for movement. Examples include skeletal muscle cells, cardiac muscle cells, and smooth muscle cells.Sperm Cells: Male reproductive cells.Ovum (Egg Cell): Female reproductive cell.Plant Cells:Leaf Cells (Mesophyll Cells): These cells contain chloroplasts and are responsible for photosynthesis.Root Hair Cells: Specialized for nutrient uptake from the soil.Guard Cells: These cells surround the stomata and regulate the opening and closing of the stomata to control gas exchange.Fungal Cells:Yeast Cells: Single-celled fungi used in baking and brewing.Mycelium Cells: These make up the body of multicellular fungi like mushrooms.Protist Cells:Amoeba: A single-celled organism that moves using pseudopods.Paramecium: A single-celled, ciliated protist.Euglena: A single-celled organism with characteristics of both plants (has chloroplasts) and animals (can move).Specialized Cells:White Blood Cells (Leukocytes): Part of the immune system and help fight infections.Platelets: Involved in blood clotting.Epithelial Cells: These cells line the surfaces of organs and structures in the body.Adipocytes: Fat storage cells.Osteocytes: Bone cells.History of research on CellThe study of cells, the fundamental units of life, has undergone a remarkable transformation over the centuries. This journey, marked by groundbreaking discoveries and technological advancements, has shaped our understanding of the biological world.The Dawn of Microscopy (1632-1723): Antonie van Leeuwenhoek, a self-taught lens maker, pioneered the construction of rudimentary optical microscopes. His meticulous observations led to the documentation of protozoa, like Vorticella from rainwater, and even bacteria from his oral cavity.The Coining of "Cell" (1665): Robert Hooke's exploration of cork and living plant tissue under an early compound microscope revealed tiny structures reminiscent of small rooms. This observation culminated in him introducing the term "cell", derived from the Latin word 'cellula', in his seminal work, "Micrographia".Birth of the Cell Theory (1839): Theodor Schwann and Matthias Jakob Schleiden, through their collaborative efforts, recognized the universal presence of cells in both plants and animals. Their assertion that cells are the foundational unit of structure and development gave rise to the cell theory.The Continuity of Cells (1855): Rudolf Virchow, building on the cell theory, posited that all cells arise from pre-existing cells through the process of cell division, encapsulated in the phrase "omnis cellula ex cellula".Debunking Spontaneous Generation (1859): The age-old belief in spontaneous generation, the idea that life could spontaneously arise from non-living matter, faced a significant challenge. Louis Pasteur, building on the earlier work of Francesco Redi, presented evidence against this notion.Electron Microscopy Revolution (1931): Ernst Ruska's invention of the transmission electron microscope at the University of Berlin marked a turning point in cell research. By 1935, he had enhanced the microscope's resolution twofold, unveiling cellular organelles previously hidden from view.Unraveling the DNA Double Helix (1953): Building on Rosalind Franklin's foundational work, James Watson and Francis Crick unveiled the double helix structure of DNA, a discovery that would revolutionize molecular biology.Endosymbiotic Theory (1981): Lynn Margulis, in her publication "Symbiosis in Cell Evolution", presented the endosymbiotic theory. This theory proposed that certain organelles within eukaryotic cells, such as mitochondria and chloroplasts, originated from ancient symbiotic bacteria.Here are some recent advancements in cell research:ISSCR Guidelines for Stem Cell Research and Clinical Translation: The 2021 updatePublication Date: 2021-05-25Authors: R. Lovell-Badge, Eric Anthony, R. Barker, and others.Abstract: The International Society for Stem Cell Research updated its Guidelines for Stem Cell Research and Clinical Translation to address the advances in stem cell science and associated ethical, social, and policy issues since the last update in 2016. The guidelines serve as the standard for the field, assisting scientists, regulators, funders, physicians, and the public.Read the full paperAdvances in stem cell research and therapeutic developmentPublication Date: 2019-07-01Authors: M. De Luca, A. Aiuti, G. Cossu, M. Parmar, G. Pellegrini, P. Robey.Abstract: This review surveys key advancements in stem cell research and describes the cell types currently being used in the clinic or nearing clinical trials. The authors analyze the scientific rationale, experimental approaches, and results underpinning the clinical use of such stem cells.Read the full paperAnimal mesenchymal stem cell research in cartilage regenerative medicine – a reviewPublication Date: 2019-01-01Authors: M. B. Gugjoo, M. Fazili, M. A. Gayas, R. A. Ahmad, K. Dhama.Abstract: This review discusses the potential of regenerative medicine involving stem cells for cartilage repair. The authors focus on the use of mesenchymal stem cells (MSCs) for articular cartilage repair in animal species, highlighting the achievements and limitations associated with their use.Read the full paperTherapeutic abortion and ectopic pregnancy: alternative sources for fetal stem cell research and therapy in Iran as an Islamic countryPublication Date: 2018-12-07Authors: P. Goodarzi, Khadijeh Falahzadeh, H. Aghayan, and others.Abstract: This paper discusses the challenges of using fetal stem cells for research and therapy in Islamic countries like Iran. The authors suggest the utilization of ectopic pregnancy conceptus and extra-embryonic tissues as potential sources for embryonic or fetal stem cell isolation.Read the full paperProgress in Circulating Tumor Cell Research Using Microfluidic DevicesAuthors: Hogyeong Gwak, Junmoo Kim, Leila Kashefi-Kheyrabadi, B. Kwak, Kyung-A Hyun, H. JungPublication Date: July 2018Abstract: The study focuses on circulating tumor cells (CTCs) which have become a significant topic in cancer research due to their obtainability through liquid biopsy, a minimally invasive procedure. The research has delved into CTC enumeration, profiling, and the correlation between CTC number and patient survival. The paper reviews the trends in isolating and analyzing CTCs using microfluidics, emphasizing the advantages of continuous sample processing and the potential of "do-everything-on-a-chip" approach. The study also touches upon the heterogeneity of tumor cells and the importance of single-CTC analysis after isolation.Read the full paperRecent Advances in CD8+ Regulatory T Cell ResearchAuthors: Yating Yu, Xinbo Ma, R. Gong, Jian-Yang Zhu, Lihua Wei, Jinguang YaoPublication Date: June 2018Abstract: The paper delves into the roles of CD8+ T lymphocytes, particularly CD8+ regulatory T cells (CD8+ Tregs) which possess significant immunosuppressive functions. These cells play a crucial role in blocking overreacting immune responses and maintaining immune homeostasis. The study reviews the origin, functional classification, molecular markers, and mechanisms of action of CD8+ Tregs.Read the full paperAnalysis of Trends and Emerging Technologies in Water Electrolysis Research Based on a Computational MethodAuthors: Takaya Ogawa, Mizutomo Takeuchi, Y. KajikawaPublication Date: February 2018Abstract: The research focuses on water electrolysis for hydrogen production, a topic of increasing importance for accumulating renewable energy. The study provides a comprehensive review of all water electrolysis research areas through computational analysis, using a citation network to detect emerging technologies and forecast trends.Read the full paperFake News Portrayals of Stem Cells and Stem Cell ResearchAuthors: A. Marcon, Blake Murdoch, T. CaulfieldPublication Date: October 2017Abstract: This study delves into how stem cells and stem cell research are portrayed on websites known for disseminating distorted and dubious information. The findings highlight the existence of organized misinformation networks which may mislead the public and polarize public discourse.Read the full paperIn summation, the trajectory of cell research has been marked by persistent inquiry, technological advancements, and paradigm-shifting discoveries. This historical tapestry underscores the relentless human endeavor to unravel the mysteries of the cellular world.MINDMAP ON CELLQuizWhat is the basic structural and functional unit of all living organisms?a) Tissueb) Organc) Celld) Organ systemWhich organelle is known as the powerhouse of the cell?a) Nucleusb) Endoplasmic Reticulumc) Mitochondriad) Golgi ApparatusWhich type of cell lacks a nucleus?a) Eukaryoticb) Prokaryoticc) Animal celld) Plant cellThe cell membrane is primarily composed of:a) Proteinsb) Carbohydratesc) Lipidsd) Nucleic acidsWhich organelle is responsible for photosynthesis in plant cells?a) Lysosomeb) Chloroplastc) Ribosomed) VacuoleWhich of the following is NOT found in animal cells?a) Cell wallb) Mitochondriac) Lysosomesd) CytoplasmThe endoplasmic reticulum (ER) that has ribosomes attached to it is called:a) Smooth ERb) Rough ERc) Granular ERd) Non-granular ERWhich structure is responsible for regulating the transport of substances in and out of the cell?a) Nuclear membraneb) Cell wallc) Cytoplasmd) Cell membraneWhich organelle is responsible for breaking down waste materials in the cell?a) Mitochondriab) Ribosomec) Lysosomed) NucleusDNA is located in which part of the cell?a) Mitochondriab) Cytoplasmc) Nucleusd) Endoplasmic reticulumFAQA cell is the basic structural, functional, and biological unit of all known living organisms. It is the smallest unit of life that can replicate independently.Broadly, there are two main types of cells: Prokaryotic (without a nucleus, like bacteria) and Eukaryotic (with a nucleus, like plant and animal cells).While both plant and animal cells are eukaryotic, plant cells have a cell wall, chloroplasts, and a large central vacuole, which are absent in animal cells.The nucleus acts as the control center of the cell, housing its DNA and directing the synthesis of proteins and ribosomes.Cells are small to maximize the surface area to volume ratio, which allows for efficient exchange of nutrients and waste materials.Often referred to as the "powerhouse" of the cell, mitochondria produce energy in the form of ATP through the process of cellular respiration.Cells reproduce through processes called mitosis (for somatic cells) and meiosis (for reproductive cells or gametes).The cell membrane, also known as the plasma membrane, regulates the transport of substances in and out of the cell and provides protection and support.Stem cells are undifferentiated cells that have the potential to develop into many different cell types. They play a crucial role in development, repair, and regeneration in organisms.Cells communicate through various mechanisms, including chemical signals (like hormones and neurotransmitters), direct cell-to-cell contact, and electrical signals.ReferencesBiology Online. (n.d.). Cell. Retrieved from ––S. (n.d.). Cells. Retrieved from . (n.d.). Cell (biology). Retrieved from biology)Vedantu. (n.d.). Cell structure and function. Retrieved from dia Britannica. (n.d.). Intercellular communication. Retrieved from Training. (n.d.). Cell structure. Retrieved from . (n.d.). Cell structure and function. Retrieved from Liachovitzky)/04%3A_Smallest_Level_of_Complexity_Alive-_Cells_Their_Structures_and_Functions/4.01%3A_Cell_Structure_and_FunctionStudySmarter. (n.d.). Cell structure. Retrieved from . (n.d.). Cellular structure and function. Retrieved from Launcher. (n.d.). CBSE cell structure and functions. Retrieved from . (n.d.). Types of cells in the body. Retrieved from . (n.d.). Exemplar problems. Retrieved from . (n.d.). Science textbook. Retrieved from Generate flashcards, quizzes, and ask questions to deepen your understanding Please login to use this AI.Login here Inside the cellCell divisionTypesSummaryA cell is the smallest living organism and the basic unit of life on earth. Together, trillions of cells make up the human body. Cells have three parts: the membrane, the nucleus, and the cytoplasm.People can think of cells as tiny packages that contain minute factories, warehouses, transport systems, and power plants. They function on their own, creating their own energy and self-replicating — the cell is the smallest unit of life that can replicate. Cells are the basic units of life.The body contains around 50—100 trillion cells, and they vary widely in size, number, structure, and use. Cells also communicate with each other. Whether in plants, humans, or animals, they connect to create a solid, well formed organism. In humans, cells build tissues, tissues form organs, and organs work together to keep the body alive.Robert Hooke first discovered cells in the 1600s. He gave them their name because they resembled the "cella," the Latin term for "small rooms" where monks lived in monasteries.Share on PinterestAlexander Spatari/Getty ImagesExperts estimate that there are around 200 cell types in the human body.Cell types can look different, and carry out distinct roles within the body.For instance, a sperm cell resembles a tadpole, a female egg cell is spherical, and nerve cells are essentially thin tubes.Despite their differences, cells often share certain structures. These are known as organelles or mini-organs. Below are some of the most important:The nucleus represents the cell's headquarters. There is typically one nucleus per cell. However, this is not always the case. Skeletal muscle cells, for instance, have two. The nucleus contains the majority of the cell's DNA, and the mitochondria house a small amount. The nucleus sends out messages to tell the cell to grow, divide, or die.A membrane called the nuclear envelope separates the nucleus from the rest of the cell. Nuclear pores within the membrane allow small molecules and ions to cross back and forth, while larger molecules need to transport proteins to help them through.To ensure each cell remains separate from its neighbor, a special membrane, known as the plasma membrane, envelops the cell. Phospholipids make most of this membrane and prevent water-based substances from entering the cell. The plasma membrane contains a range of receptors, which carry out a number of tasks, including being:Gatekeepers: Some receptors allow certain molecules through and stop others.Markers: These receptors act as name badges, informing the immune system that they are part of the organism and not foreign invaders.Communicators: Some receptors help the cell communicate with other cells and the environment.Fasteners: Some receptors help bind the cell to its neighbors.The cytoplasm is the interior of the cell that surrounds the nucleus. It includes the organelles and a jelly-like fluid called the cytosol. Many of the important reactions that take place in the cell occur in the cytoplasm.The cytoskeleton forms the scaffolding within the cytoplasm of the human cell. It helps the cell maintain the correct shape. However, unlike regular scaffolding, the cytoskeleton is flexible. It plays a role in cell division and cell motility — the ability of some cells to move, such as sperm cells, for instance.The cytoskeleton also helps with cell signaling through the uptake of material from the endocytosis, or the area outside the cell, and moving materials within the cell.The endoplasmic reticulum (ER) processes molecules within the cell and helps transport them to their final destinations. In particular, it synthesizes, folds, modifies, and transports proteins.Cisternae are long sacs that make the ER. The cytoskeleton holds them together. There are two ER types: rough ER and smooth ER.Once the ER processes the molecules, they travel to the Golgi apparatus. People tend to consider the Golgi apparatus the post office of the cell, where items go through packaging and labeling. Once materials leave, they may be useful inside or outside the cell.People may often refer to mitochondria as the powerhouses of cells. They help turn energy from food into energy that the cell can use — adenosine triphosphate. However, mitochondria have a number of other jobs, including calcium storage and a role in cell death.The nucleus transcribes segments of DNA into ribonucleic acid (RNA), a molecule similar to DNA, which directs the translation of RNA into proteins. Ribosomes read the RNA and translate it into proteins by sticking together amino acids in the order the RNA defines.Some ribosomes float freely in the cytoplasm while others attach to the ER.The human body constantly replaces cells. Cells need to divide for a number of reasons, including the growth of an organism and to fill gaps that dead and destroyed cells leave after an injury, for instance.There are two types of cell division: mitosis and meiosis.Mitosis is how most of the cells in the body divide. The "parent" cell splits into two "daughter" cells.Both daughter cells have the same chromosomes as each other and the parent. People refer to them as diploid because they have two complete copies of the chromosomes.In meiosis, the body produces sperm cells and egg cells. In males, meiosis occurs after puberty. Diploid cells within the testes undergo meiosis to produce haploid sperm cells with 23 chromosomes. A single diploid cell yields four haploidsperm cells. They contain one complete set of 23 chromosomes.In females, meiosis begins during the fetal stage, before the individual is born. It happens in stages.A series of diploid future egg cells enter meiosis. At the end of the first stage of meiosis the process stops, and the cells gather in the ovaries. At puberty, one female egg cell resumes meiosis each month. As meiosis completes, it yields a single haploid egg cell each monthly cycle. During human reproduction, the haploid sperm and haploid egg combine. This temporarily doubles the number of chromosomes. A small portion of each chromosome breaks off and reattaches to its partner chromosome before fertilization finishes.More than 200 different types of cells are present in the human body. Below is a small selection of human cell types:Stem cells are cells that must choose what they are going to become. Some differentiate to become a certain cell type, and others divide to produce more stem cells. The embryo and some adult tissues, such as bone marrow, house them.There are at least three main types of bone cells:osteoclasts, which dissolve boneosteoblasts, which form new boneosteocytes, which help communicate with other bone cellsThere are many types of blood cells, including:red blood cells, which carry oxygen around the bodywhite blood cells, which are part of the immune systemplatelets, which help blood clot to prevent blood loss after injuryneutrophils and basophils, and other types of white blood cellsAlso called myocytes, muscle cells are long, tubular cells. Muscle cells are important for a range of functions, including movement, support, and internal functions, such as peristalsis — the movement of food along the gut.These tadpole-shaped cells are the smallest in the human body.They are motile, meaning that they can move. They achieve this movement by using their tail, which contains energy-giving mitochondria.Sperm cells cannot divide. They only carry one haploid, unlike the majority of cells, which carry diploids.Compared with the sperm cell, the female egg cell is a giant. It is the largest human cell. The egg cell is also haploid so that the chromosomes from the sperm and egg can combine to create a diploid cell during the process of fertilization.Fat cells are also called adipocytes, the main adipose tissue constituents. They contain stored fats called triglycerides that the body can use as energy. Once the body uses the triglycerides, the fat cells shrink. Adipocytes also produce some hormones.Nerves cells form the communication system of the body. Also called neurons, they consist of two major parts — the cell body and nerve processes, known as axons and dendrites. The central body contains the nucleus and other organelles, and the nerve processes run like long fingers, carrying messages far and wide. Some of the axons are around 1 meter long.There are various and fascinating cells. In one sense, cells are autonomous cities that function alone, producing their own energy and proteins. In another sense, they are part of the huge network of cells that creates tissues, organs, and us. Science Biology Cells, Organs & Tissues Ask the Chatbot a Question cell, in biology, the basic membrane-bound unit that contains the fundamental molecules of life and of which all living things are composed. A single cell is often a complete organism in itself, such as a bacterium or yeast. Other cells acquire specialized functions as they mature. These cells cooperate with other specialized cells and become the building blocks of large multicellular organisms, such as humans and other animals. Although cells are much larger than atoms, they are still very small. The smallest known cells are a group of tiny bacteria called mycoplasmas; some of these single-celled organisms are spheres as small as 0.2 μm in diameter (1μm = about 0.000039 inch), with a total mass of 10−14 gram—equal to that of 8,000,000,000 hydrogen atoms. Cells of humans typically have a mass 400,000 times larger than the mass of a single mycoplasma bacterium, but even human cells are only about 20 μm across. It would require a sheet of about 10,000 human cells to cover the head of a pin, and each human organism is composed of more than 30,000,000,000,000 cells.This article discusses the cell both as an individual unit and as a contributing part of a larger organism. As an individual unit, the cell is capable of metabolizing its own nutrients, synthesizing many types of molecules, providing its own energy, and replicating itself in order to produce succeeding generations. It can be viewed as an enclosed vessel, within which innumerable chemical reactions take place simultaneously. These reactions are under very precise control so that they contribute to the life and procreation of the cell. In a multicellular organism, cells become specialized to perform different functions through the process of cell differentiation. In order to do this, each cell keeps in constant communication with its neighbors. As it receives nutrients from and expels wastes into its surroundings, it adheres to and cooperates with other cells. Cooperative assemblies of similar cells form tissues, and a cooperation between tissues in turn forms organs, which carry out the functions necessary to sustain the life of an organism.The major parts of an animal cell explainedFrom teeny-tiny ants to 200-ton whales, all members of the animal kingdom are composed of cells.See all videos for this articleSpecial emphasis is given in this article to animal cells, with some discussion of the energy-synthesizing processes and extracellular components peculiar to plants. (For detailed discussion of the biochemistry of plant cells, see photosynthesis. For a full treatment of the genetic events in the cell nucleus, see heredity.) Bruce M. Alberts cellsAnimal cells and plant cells contain membrane-bound organelles, including a distinct nucleus. In contrast, bacterial cells do not contain organelles.A cell is enclosed by a plasma membrane, which forms a selective barrier that allows nutrients to enter and waste products to leave. The interior of the cell is organized into many specialized compartments, or organelles, each surrounded by a separate membrane. One major organelle, the nucleus, contains the genetic information necessary for cell growth and reproduction. Each cell contains only one nucleus, whereas other types of organelles are present in multiple copies in the cellular contents, or cytoplasm. Organelles include mitochondria, which are responsible for the energy transactions necessary for cell survival; lysosomes, which digest unwanted materials within the cell; and the endoplasmic reticulum and the Golgi apparatus, which play important roles in the internal organization of the cell by synthesizing selected molecules and then processing, sorting, and directing them to their proper locations. In addition, plant cells contain chloroplasts, which are responsible for photosynthesis, whereby the energy of sunlight is used to convert molecules of carbon dioxide (CO2) and water (H2O) into carbohydrates. Between all these organelles is the space in the cytoplasm called the cytosol.

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