مبادئ علم الاحياء الطبية

قسم تقنيات البصريات

المرحلى الاولى

اعداد

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Importance of Biology

It is obvious why biology is important for studying medicine: biology is the foundation. It is a field of biology that examines how living things like humans' function. Biology is still far from having all the solutions that scientists need.

Despite recent technical advances, the origin of life on Earth continues to be one of man's biggest mysteries. With an estimated 8.7 million species on the Earth, and just 1.9 million of them have been discovered, there are an infinite number of species to study in biology.

Biology occurs every second when people breathe in and out; each cell receives oxygenated blood and releases carbon dioxide. How do our heart's function and work so hard? What variations exist in how people perceive things? What exactly is awareness? Biology can help in the search for solutions to these questions.

However, biology also must deal with other living things than humans. By examining how it works, scientists can identify potential threats to the environment and explore more environmentally friendly solutions.

Definition of Biology,

Study of living things and their vital processes. The field deals with all the physicochemical aspects of life. The modern tendency toward cross-disciplinary research and the unification of scientific knowledge and investigation from different fields has resulted in significant overlap of the field of biology with other scientific disciplines. Modern principles of other fields—chemistry, medicine, and physics, for example—are integrated with those of biology in areas such as biochemistry, biomedicine, and biophysics.

Biology is subdivided into separate branches for convenience of study, though all the subdivisions are interrelated by basic principles. Thus, while it is custom to separate the study of plants (botany) from that of animals (zoology), and the study of the structure of organisms (morphology) from that of function (physiology), all living things share in common certain biological phenomena—for example, various means of reproduction, cell division, and the transmission of genetic material.

Biology is often approached on the basis of levels that deal with fundamental units of life. At the level of molecular biology, for example, life is regarded as a manifestation of chemical and energy transformations that occur among the many chemical constituents that compose an organism. As a result of the development of increasingly powerful and precise laboratory instruments and techniques, it is possible to understand and define with high precision and accuracy not only the ultimate physiochemical organization (ultrastructure) of the molecules in living matter but also the way living matter reproduces at the molecular level. Especially crucial to those advances was the rise of genomics in the late 20th and early 21st centuries.

Cell biology is the study of cells—the fundamental units of structure and function in living organisms. Cells were first observed in the 17th century, when the compound microscope was invented. Before that time, the individual organism was studied as a whole in a field known as organismic biology; that area of research remains an important component of the biological sciences. Population biology deals with groups or populations of organisms that inhabit a given area or region. Included at that level are studies of the roles that specific kinds of plants and animals play in the complex and self-perpetuating interrelationships that exist between the living and the nonliving world, as well as studies of the built-in controls that maintain those relationships naturally. Those broadly based levels—molecules, cells, whole organisms, and populations—may be further subdivided for study, giving rise to specializations such as morphology, taxonomy, biophysics, biochemistry, genetics, epigenetics, and ecology. A field of biology may be especially concerned with the investigation of one kind of living thing—for example, the study of birds in ornithology, the study of fishes in ichthyology, or the study of microorganisms in microbiology.

Characteristics of living things

All living things share life processes such as growth and reproduction. Most scientists use seven life processes or characteristics to determine whether something is living or non-living.

The table below describes seven characteristics of most living things and contains references to earthworms to explain why we can definitely say that they are 'living'.

Order

Figure 1. A toad represents a highly organized structure consisting of cells, tissues, organs, and organ systems.

Organisms are highly organized, coordinated structures that consist of one or more cells. Even very simple, single-celled organisms are remarkably complex: inside each cell, atoms make up molecules; these in turn make up cell organelles and other cellular inclusions.

In multicellular organisms (Figure 1), similar cells form tissues. Tissues, in turn, collaborate to create organs (body structures with a distinct function). Organs work together to form organ systems.

Sensitivity or Response to Stimuli

Organisms respond to diverse stimuli. For example, plants can bend toward a source of light, climb on fences and walls, or respond to touch (Figure 2).

Figure 2.The leaves of this sensitive plant (*Mimosa pudica*) will instantly droop and fold when touched. After a few minutes, the plant returns to normal. (credit: Alex Lomas)

Even tiny bacteria can move toward or away from chemicals (a process called *chemotaxis*) or light (*phototaxis*). Movement toward a stimulus is considered a positive response, while movement away from a stimulus is considered a negative response.

Watch **this video** to see how plants respond to a stimulus—from opening to light, to wrapping a tendril around a branch, to capturing prey.

Reproduction

Single-celled organisms reproduce by first duplicating their DNA, and then dividing it equally as the cell prepares to divide to form two new cells. Multicellular organisms often produce specialized reproductive germline cells that will form new individuals. When reproduction occurs, genes containing DNA are passed along to an organism's offspring. These genes ensure that the offspring will belong to the same species and will have similar characteristics, such as size and shape.

Growth and Development

Figure 3. Although no two look alike, these puppies have inherited genes from both parents and share many of the same characteristics.

Organisms grow and develop following specific instructions coded for by their genes. These genes provide instructions that will direct cellular growth and development, ensuring that a species' young (Figure 3) will grow up to exhibit many of the same characteristics as its parents.

Regulation

Even the smallest organisms are complex and require multiple regulatory mechanisms to coordinate internal functions, respond to stimuli, and cope with environmental stresses. Two examples of internal functions regulated in an organism are nutrient transport and blood flow. Organs (groups of tissues working together) perform specific functions, such as carrying oxygen throughout the body, removing wastes, delivering nutrients to every cell, and cooling the body.

Homeostasis

Figure 4. Polar bears (*Ursus maritimus*) and other mammals living in ice-covered regions maintain their body temperature by generating heat and reducing heat loss through thick fur and a dense layer of fat under their skin. (credit: "longhorndave"/Flickr)

To function properly, cells need to have appropriate conditions such as proper temperature, pH, and appropriate concentration of diverse chemicals. These conditions may, however, change from one moment to the next. Organisms are able to maintain internal conditions within a narrow range almost constantly, despite environmental changes, through **homeostasis** (literally, "steady state")—the ability of an organism to maintain constant internal conditions. For example, an organism needs to regulate body temperature through a process known as thermoregulation. Organisms that live in cold climates, such as the polar bear (Figure 4), have body structures that help them withstand low temperatures and conserve body heat.

Structures that aid in this type of insulation include fur, feathers, blubber, and fat. In hot climates, organisms have methods (such as perspiration in humans or panting in dogs) that help them to shed excess body heat.

Energy Processing

All organisms use a source of energy for their metabolic activities. Some organisms capture energy from the sun and convert it into chemical energy in food (photosynthesis); others use chemical energy in molecules they take in as food (cellular respiration).

What are the current kingdoms of life?

The 5 Kingdoms of life that scientists use to classify organisms are Kingdom Animalia, Kingdom Plantae, Kingdom Fungi, Kingdom Monera and Kingdom Protista

What are the 5 kingdoms and examples of each?

The 5 Kingdoms of life are:

Kingdom **Animalia**- Eg. Polar Bears

Kingdom **Plantae**- Eg. Coconut trees

Kingdom **Fungi**- Eg. Button Mushrooms

Kingdom **Monera**- Eg. Lactobacillus bacteria

Kingdom **Protista**- Eg. Seaweed

Are there 5 or 6 kingdoms of life?

There are 5 kingdoms of life. The five kingdoms are Kingdom Animalia, Kingdom Plantae, Kingdom Fungi, Kingdom Protista and Kingdom Monera.

Scientific Kingdoms of Living Things

The **Scientific Kingdoms of living things** are one of the largest categories used in the taxonomic classification of living things. Taxonomic classification refers to the system used by scientists to name, identify, and group together living organisms based on their ancestry and characteristics.

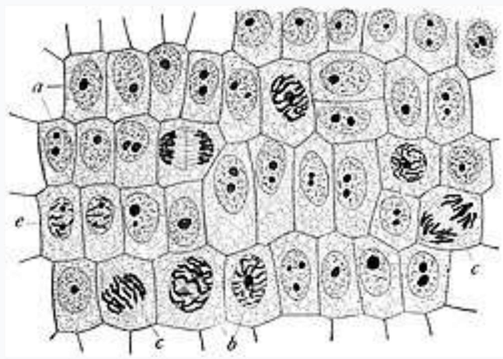
All **living organisms** are divided into 5 kingdoms, which are defined as groups of living organisms with similar characteristics and shared evolutionary lineages. The term Animals, for example, refers to all the living organisms in the Kingdom Animalia, which is one of the 5 scientific kingdoms of organisms. All animals have similar traits, which include being multicellular and heterotrophic, and are descendants of the same evolutionary ancestor.

While kingdoms are one of the largest categories of taxonomic classification in science, they are one step below the largest category, the Domains. All living organisms are organized into three domains, based on their cell types. The three domains are: **Bacteria, Archaea, and Eukaryota.** Domains are considered to be the very first branches on the tree of life, and all three domains are considered descendants of a single common ancestor called the Last Common Universal ancestor (LUCA). These three domains further branch out into the 5 kingdoms of living things. Bacteria and Archaea were originally considered kingdoms, united under the domain prokaryote, however as scientists better understood the biology of both groups, it became clear that they were distinct branches on the tree of life and deserved to be categorized in their own domains.

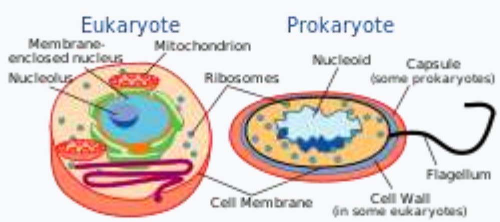
Cell (biology)

This article is about the basic unit of lifeforms. For the branch of biology that studies them, see Cell biology.

Cell



Onion (*Allium cepa*) root cells in different phases of the cell cycle (drawn by E. B. Wilson, 1900)



A eukaryotic cell (left) and prokaryotic cell (right)

Identifiers

MeSH	D002477
TH	H1.00.01.0.00001
FMA	686465

The **cell** is the basic structural and functional unit of all forms of life. Every cell consists of cytoplasm enclosed within a membrane, and contains many macromolecules such as proteins, DNA and RNA, as well as many small molecules of nutrients and metabolites. The term comes from the Latin word *cellula* meaning 'small room'.

Cells can acquire specified function and carry out various tasks within the cell such as replication, DNA repair, protein synthesis, and motility. Cells are capable of specialization and mobility within the cell.

Most plant and animal cells are only visible under a light microscope, with dimensions between 1 and 100 micrometres. Electron microscopy gives a much higher resolution showing greatly detailed cell structure. Organisms can be classified as unicellular (consisting of a single cell such as bacteria) or multicellular (including plants and animals). Most unicellular organisms are classed as microorganisms.

The study of cells and how they work has led to many other studies in related areas of biology, including: discovery of DNA, cancer systems biology, aging and developmental biology.

Cell biology is the study of cells, which were discovered by Robert Hooke in 1665, who named them for their resemblance to cells inhabited by Christian monks in a monastery. Cell theory, first developed in 1839 by Matthias Jakob Schleiden and Theodor Schwann, states that all organisms are composed of one or more cells, that cells are the fundamental unit of structure and function in all living organisms, and that all cells come from pre-existing cells. Cells emerged on Earth about 4 billion years ago.

Discovery

Cell theory

With continual improvements made to microscopes over time, magnification technology became advanced enough to discover cells. This discovery is largely attributed to Robert Hooke, and began the scientific study of cells, known as cell biology. When observing a piece of cork under the scope, he was able to see pores. This was shocking at the time as it was believed no one else had seen these. To further support his theory, Matthias Schleiden and Theodor Schwann both also studied cells of both animal and plants. What they discovered were significant differences between the two types of cells. This put forth the idea that cells were not only fundamental to plants, but animals as well.

Cell Theory

This was a major advance in the field of biology since little was known about animal structure up to this point compared to plants. From these conclusions about plants and animals, two of the three tenets of cell theory were postulated.

1. All living organisms are composed of one or more cells
2. The cell is the most basic unit of life

Schleiden's theory of free cell formation through crystallization was refuted in the 1850s by Robert Remak, Rudolf Virchow, and Albert Kolliker.[4] In

1855, Rudolf Virchow added the third tenet to cell theory. In Latin, this tenet states *Omnis cellula e cellula*. This translated to:

3. All cells arise only from pre-existing cells

Modern interpretation

The generally accepted parts of modern cell theory include:

1. All known living things are made up of one or more cells.
2. All living cells arise from pre-existing cells by division.
3. The cell is the fundamental unit of structure and function in all living organisms.
4. The activity of an organism depends on the total activity of independent cells.
5. Energy flow (metabolism and biochemistry) occurs within cells.
6. Cells contain DNA which is found specifically in the chromosome and RNA found in the cell nucleus and cytoplasm.
7. All cells are basically the same in chemical composition in organisms of similar species.

Number of cells

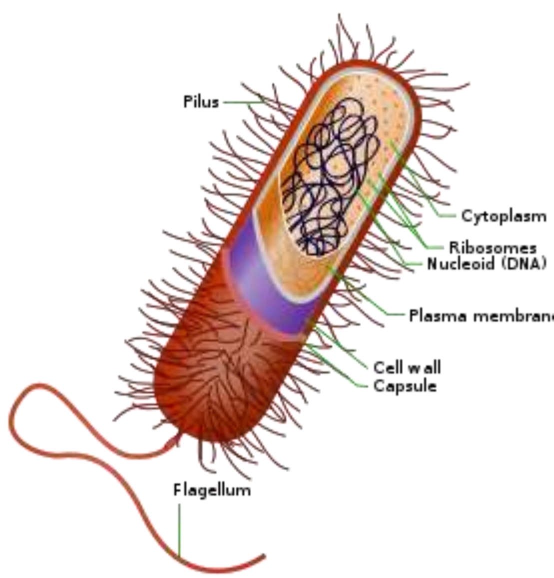
The number of cells in plants and animals varies from species to species; it has been estimated that the human body contains around 37 trillion (3.72×10^{13}) cells, and more recent studies put this number at around 30 trillion (~36 trillion cells in the male, ~28 trillion in the female). The human brain accounts for around 80 billion of these cells. Hatton et al. provide numbers for most other human organs.

Cell types

Cells are broadly categorized into two types: eukaryotic cells, which possesses a nucleus, and prokaryotic cells, which lack a nucleus but still has a nucleoid region. Prokaryotes are single-celled organisms, whereas eukaryotes can be either single-celled or multicellular.

Prokaryotic cells

Prokaryote



Structure of a typical prokaryotic cell

Prokaryotes include bacteria and archaea, two of the three domains of life. Prokaryotic cells were the first form of life on Earth, characterized by having vital biological processes including cell signaling. They are simpler and smaller than eukaryotic cells, and lack a nucleus, and other membrane-bound organelles. The DNA of a prokaryotic cell consists of a single circular chromosome that is in direct contact with the cytoplasm. The nuclear region in the cytoplasm is called the nucleoid. Most prokaryotes are the smallest of all organisms ranging from 0.5 to 2.0 µm in diameter.

A prokaryotic cell has three regions:

- Enclosing the cell is the cell envelope, generally consisting of a plasma membrane covered by a cell wall which, for some bacteria, may be further covered by a third layer called a capsule. Though most prokaryotes have both a cell membrane and a cell wall, there are exceptions such as *Mycoplasma* (bacteria) and *Thermoplasma* (archaea) which only possess the cell membrane layer. The envelope gives rigidity to the cell and separates the interior of the cell from its environment, serving as a protective filter. The cell wall consists of peptidoglycan in bacteria and acts as an additional barrier against exterior forces. It also prevents the cell from expanding and bursting (cytolysis) from osmotic pressure due to a hypotonic environment. Some eukaryotic cells (plant cells and fungal cells) also have a cell wall.

- Inside the cell is the cytoplasmic region that contains the genome (DNA), ribosomes and various sorts of inclusions. The genetic material is freely found in the cytoplasm. Prokaryotes can carry extrachromosomal DNA elements called plasmids, which are usually circular. Linear bacterial plasmids have been identified in several species of spirochete bacteria, including members of the genus *Borrelia* notably *Borrelia burgdorferi*, which causes Lyme disease. Though not forming a nucleus, the DNA is condensed in a nucleoid. Plasmids encode additional genes, such as antibiotic resistance genes.
- On the outside, some prokaryotes have flagella and pili that project from the cell's surface. These are structures made of proteins that facilitate movement and communication between cells.

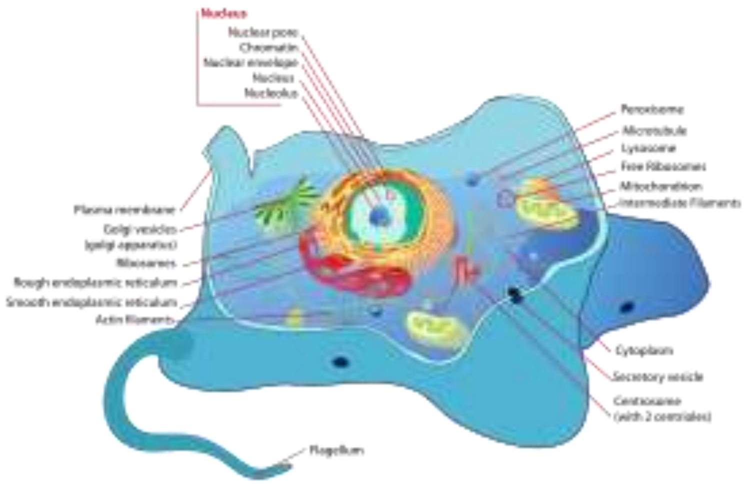
Bacterial shapes

Bacteria § Morphology

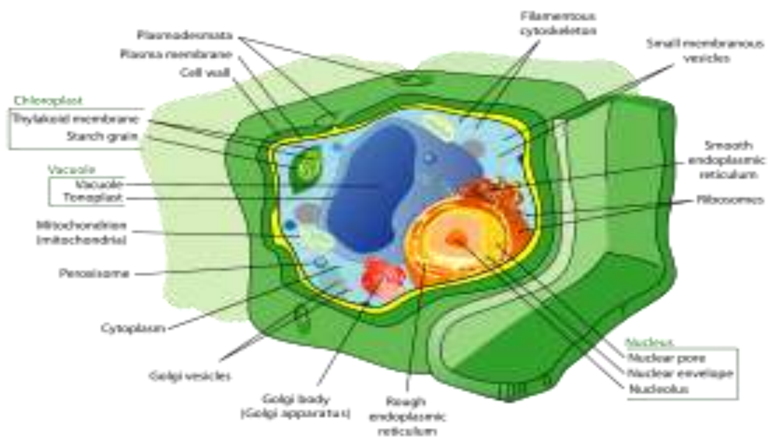
Cell shape, also called cell morphology, has been hypothesized to form from the arrangement and movement of the cytoskeleton. Many advancements in the study of cell morphology come from studying simple bacteria such as *Staphylococcus aureus*, *E. coli*, and *B. subtilis*. Different cell shapes have been found and described, but how and why cells form different shapes is still widely unknown. Some cell shapes that have been identified include rods, cocci and spirochaetes. Cocci are circular, bacilli are elongated rods, and spirochaetes are spiral in form.

Eukaryotic cells

<u>Eukaryote</u>



Structure of a typical animal cell



Structure of a typical <u>plant cell</u>

Plants, animals, fungi, slime moulds, protozoa, and algae are all eukaryotic. These cells are about fifteen times wider than a typical prokaryote and can be as much as a thousand times greater in volume. The main distinguishing feature of eukaryotes as compared to prokaryotes is compartmentalization: the presence of membrane-bound organelles (compartments) in which specific activities take place. Most important among these is a cell nucleus,[4] an organelle that houses the cell's DNA. This nucleus gives the eukaryote its name, which means "true kernel (nucleus)". Some of the other differences are:

- The plasma membrane resembles that of prokaryotes in function, with minor differences in the setup. Cell walls may or may not be present.
- The eukaryotic DNA is organized in one or more linear molecules, called chromosomes, which are associated with histone proteins. All chromosomal DNA is stored in the cell nucleus, separated from the cytoplasm by a membrane.[4] Some eukaryotic organelles such as mitochondria also contain some DNA.
- Many eukaryotic cells are ciliated with primary cilia. Primary cilia play important roles in chemosensation, mechanosensation, and thermosensation. Each cilium may thus be "viewed as a sensory cellular antennae that coordinates a large number of cellular signaling pathways, sometimes coupling the signaling to ciliary motility or alternatively to cell division and differentiation."[20]

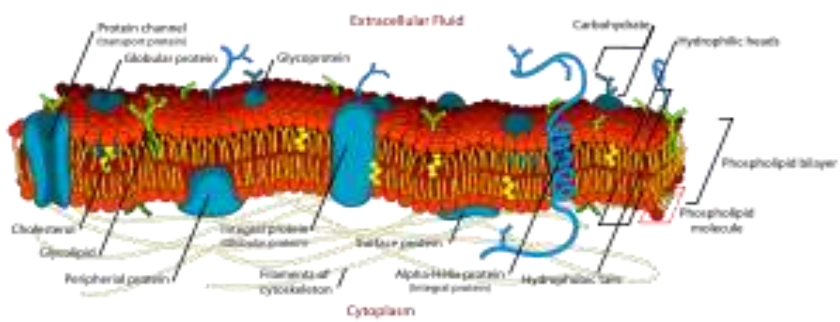
- Motile eukaryotes can move using motile cilia or flagella. Motile cells are absent in conifers and flowering plants.[citation needed] Eukaryotic flagella are more complex than those of prokaryotes.[21]

Subcellular components

All cells, whether prokaryotic or eukaryotic, have a membrane that envelops the cell, regulates what moves in and out (selectively permeable), and maintains the electric potential of the cell. Inside the membrane, the cytoplasm takes up most of the cell's volume. Except red blood cells, which lack a cell nucleus and most organelles to accommodate maximum space for hemoglobin, all cells possess DNA, the hereditary material of genes, and RNA, containing the information necessary to build various proteins such as enzymes, the cell's primary machinery. There are also other kinds of biomolecules in cells. This article lists these primary cellular components, then briefly describes their function.

Cell membrane

Main article: Cell membrane



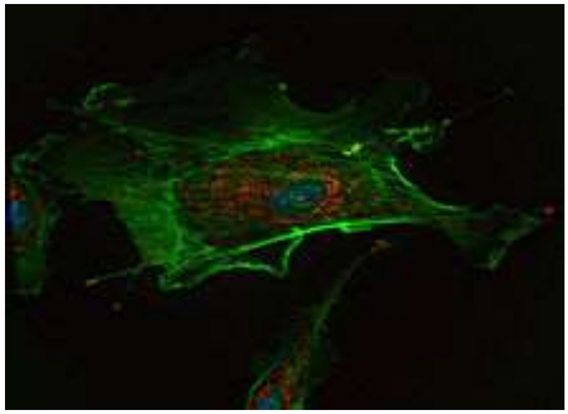
Detailed diagram of lipid bilayer of cell membrane

The cell membrane, or plasma membrane, is a selectively permeable biological membrane that surrounds the cytoplasm of a cell. In animals, the plasma membrane is the outer boundary of the cell, while in plants and prokaryotes it is usually covered by a cell wall. This membrane serves to separate and protect a cell from its surrounding environment and is made mostly from a double layer of phospholipids, which are amphiphilic (partly hydrophobic and partly hydrophilic). Hence, the layer is called a phospholipid bilayer, or sometimes a fluid mosaic membrane. Embedded within this membrane is a macromolecular structure called the porosome the universal secretory portal in cells and a variety of protein molecules that act as channels and pumps that move different molecules into and out of the cell. The membrane is semi-permeable, and selectively permeable, in that it can either let a substance (molecule or ion) pass through freely, to a limited extent or not at all. Cell surface membranes also contain receptor proteins that allow cells to detect external signaling molecules such as hormones.

Cytoskeleton

Cytoskeleton

Morphogenesis

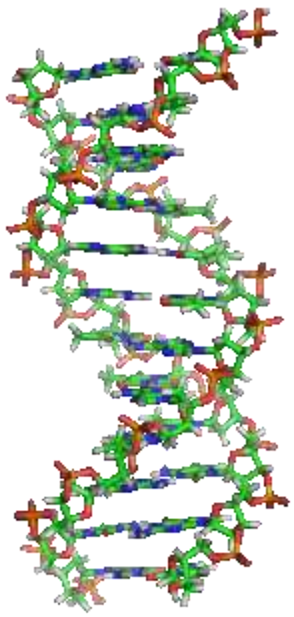


A fluorescent image of an endothelial cell. Nuclei are stained blue, mitochondria are stained red, and microfilaments are stained green.

The cytoskeleton acts to organize and maintain the cell's shape; anchors organelles in place; helps during endocytosis, the uptake of external materials by a cell, and cytokinesis, the separation of daughter cells after cell division; and moves parts of the cell in processes of growth and mobility. The eukaryotic cytoskeleton is composed of microtubules, intermediate filaments and microfilaments. In the cytoskeleton of a neuron the intermediate filaments are known as neurofilaments. There are a great number of proteins associated with them, each controlling a cell's structure by directing, bundling, and aligning filaments. The prokaryotic cytoskeleton is less well-studied but is involved in the maintenance of cell shape, polarity and cytokinesis. The subunit protein of microfilaments is a small, monomeric protein called actin. The subunit of microtubules is a dimeric molecule called tubulin. Intermediate filaments are heteropolymers whose subunits vary among the cell types in different tissues. Some of the subunit proteins of intermediate filaments include vimentin, desmin, lamin (lamins A, B and C), keratin (multiple acidic and basic keratins), and neurofilament proteins (NF–L, NF–M).

Genetic material

DNA and RNA



Deoxyribonucleic acid (DNA)

Two different kinds of genetic material exist: deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Cells use DNA for their long-term information storage. The biological information contained in an organism is encoded in its DNA sequence.[4] RNA is used for information transport (e.g., mRNA) and enzymatic functions (e.g., ribosomal RNA). Transfer RNA (tRNA) molecules are used to add amino acids during protein translation.

Prokaryotic genetic material is organized in a simple circular bacterial chromosome in the nucleoid region of the cytoplasm. Eukaryotic genetic material is divided into different,[4] linear molecules called chromosomes inside a discrete nucleus, usually with additional genetic material in some organelles like mitochondria and chloroplasts (see endosymbiotic theory).

A human cell has genetic material contained in the cell nucleus (the nuclear genome) and in the mitochondria (the mitochondrial genome). In humans, the nuclear genome is divided into 46 linear DNA molecules called chromosomes, including 22 homologous chromosome pairs and a pair of sex chromosomes. The mitochondrial genome is a circular DNA molecule distinct from nuclear DNA. Although the mitochondrial DNA is very small compared to nuclear chromosomes,[4] it codes for 13 proteins involved in mitochondrial energy production and specific tRNAs.

Foreign genetic material (most commonly DNA) can also be artificially introduced into the cell by a process called transfection. This can be transient, if the DNA is not inserted into the cell's genome, or stable, if it is. Certain viruses also insert their genetic material into the genome.

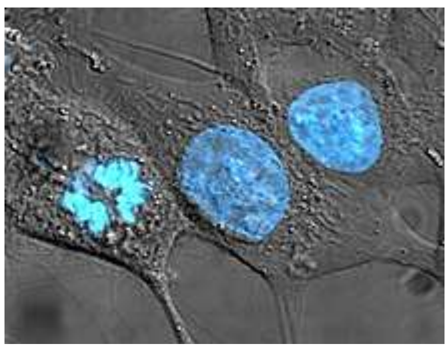
Organelles

Organelle

Organelles are parts of the cell that are adapted and/or specialized for carrying out one or more vital functions, analogous to the organs of the human body (such as the heart, lung, and kidney, with each organ performing a different function).[4] Both eukaryotic and prokaryotic cells have organelles, but prokaryotic organelles are generally simpler and are not membrane-bound.

There are several types of organelles in a cell. Some (such as the nucleus and Golgi apparatus) are typically solitary, while others (such as mitochondria, chloroplasts, peroxisomes and lysosomes) can be numerous (hundreds to thousands). The cytosol is the gelatinous fluid that fills the cell and surrounds the organelles.

Eukaryotic



Human cancer cells, specifically HeLa cells, with DNA stained blue. The central and rightmost cell are in interphase, so their DNA is diffuse and the entire nuclei are labelled. The cell on the left is going through mitosis and its chromosomes have condensed.

- **Cell nucleus**: A cell's information center, the cell nucleus is the most conspicuous organelle found in a eukaryotic cell. It houses the cell's chromosomes, and is the place where almost all DNA replication and RNA synthesis (transcription) occur. The nucleus is spherical and separated from the cytoplasm by a double membrane called the nuclear envelope, space between these two membrane is called perinuclear space. The nuclear envelope isolates and protects a cell's DNA from various molecules that could accidentally damage its structure or interfere with its processing. During processing, DNA is transcribed, or copied into a special RNA, called messenger RNA (mRNA). This mRNA is then transported out of the nucleus, where it is translated into a specific protein molecule. The nucleolus is a specialized region within the nucleus where ribosome subunits are assembled. In prokaryotes, DNA processing takes place in the cytoplasm.[4]

- **Mitochondria and chloroplasts**: generate energy for the cell. Mitochondria are self-replicating double membrane-bound organelles that occur in various numbers, shapes, and sizes in the cytoplasm of all eukaryotic cells.[4] Respiration occurs in the cell mitochondria, which generate the cell's energy by oxidative phosphorylation, using oxygen to release energy stored in cellular nutrients (typically pertaining to glucose) to generate ATP (aerobic respiration). Mitochondria multiply by binary fission, like prokaryotes. Chloroplasts can only be found in plants and algae, and they capture the sun's energy to make carbohydrates through photosynthesis.

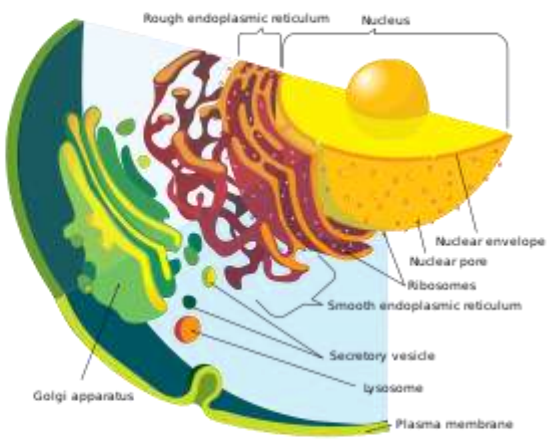


Diagram of the endomembrane system

- **Endoplasmic reticulum**: The endoplasmic reticulum (ER) is a transport network for molecules targeted for certain modifications and specific destinations, as compared to molecules that float freely in the cytoplasm. The ER has two forms: the rough ER, which has ribosomes on its surface that secrete proteins into the ER, and the smooth ER, which lacks ribosomes.[4] The smooth ER plays a role in calcium sequestration and release and also helps in synthesis of lipid.
- **Golgi apparatus**: The primary function of the Golgi apparatus is to process and package the macromolecules such as proteins and lipids that are synthesized by the cell.
- **Lysosomes and peroxisomes**: Lysosomes contain digestive enzymes (acid hydrolases). They digest excess or worn-out organelles, food particles, and engulfed viruses or bacteria. Peroxisomes have enzymes that rid the cell of toxic peroxides, Lysosomes are optimally active in an acidic environment. The cell could not house these destructive enzymes if they were not contained in a membrane-bound system.[4]
- **Centrosome**: the cytoskeleton organizer: The centrosome produces the microtubules of a cell—a key component of the cytoskeleton. It directs the transport through the ER and the Golgi apparatus. Centrosomes are composed of two centrioles which lie perpendicular to each other in which each has an organization like a cartwheel, which separate during cell division and help in the formation of the mitotic spindle. A single

centrosome is present in the animal cells. They are also found in some fungi and algae cells.

- **Vacuoles**: Vacuoles sequester waste products and in plant cells store water. They are often described as liquid filled spaces and are surrounded by a membrane. Some cells, most notably *Amoeba*, have contractile vacuoles, which can pump water out of the cell if there is too much water. The vacuoles of plant cells and fungal cells are usually larger than those of animal cells. Vacuoles of plant cells are surrounded by a membrane which transports ions against concentration gradients.

Eukaryotic and prokaryotic

- **Ribosomes**: The ribosome is a large complex of RNA and protein molecules.[4] They each consist of two subunits, and act as an assembly line where RNA from the nucleus is used to synthesise proteins from amino acids. Ribosomes can be found either floating freely or bound to a membrane (the rough endoplasmatic reticulum in eukaryotes, or the cell membrane in prokaryotes).[26]
- **Plastids**: Plastid are membrane-bound organelle generally found in plant cells and euglenoids and contain specific *pigments*, thus affecting the colour of the plant and organism. And these pigments also helps in food storage and tapping of light energy. There are three types of plastids based upon the specific pigments. Chloroplasts contain chlorophyll and some carotenoid pigments which helps in the tapping of light energy during photosynthesis. Chromoplasts contain fat-soluble carotenoid pigments

like orange carotene and yellow xanthophylls which helps in synthesis and storage. Leucoplasts are non-pigmented plastids and helps in storage of nutrients.[27]

Structures outside the cell membrane

Many cells also have structures which exist wholly or partially outside the cell membrane. These structures are notable because they are not protected from the external environment by the cell membrane. To assemble these structures, their components must be carried across the cell membrane by export processes.

Cell wall

Further information: Cell wall

Many types of prokaryotic and eukaryotic cells have a cell wall. The cell wall acts to protect the cell mechanically and chemically from its environment, and is an additional layer of protection to the cell membrane. Different types of cell have cell walls made up of different materials; plant cell walls are primarily made up of cellulose, fungi cell walls are made up of chitin and bacteria cell walls are made up of peptidoglycan.

Prokaryotic

Capsule

A gelatinous capsule is present in some bacteria outside the cell membrane and cell wall. The capsule may be polysaccharide as in pneumococci, meningococci or polypeptide as *Bacillus anthracis* or hyaluronic acid as in streptococci. Capsules are not marked by normal staining protocols and can be detected by India ink or methyl blue, which allows for higher contrast between the cells for observation.[28]: 87

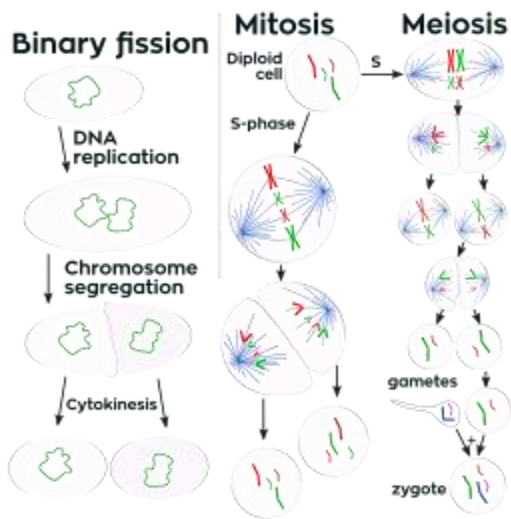
Flagella

Flagella are organelles for cellular mobility. The bacterial flagellum stretches from cytoplasm through the cell membrane(s) and extrudes through the cell wall. They are long and thick thread-like appendages, protein in nature. A different type of flagellum is found in archaea and a different type is found in eukaryotes.

Fimbriae

A fimbria (plural fimbriae also known as a pilus, plural pili) is a short, thin, hair-like filament found on the surface of bacteria. Fimbriae are formed of a protein called pilin (antigenic) and are responsible for the attachment of bacteria to specific receptors on human cells (cell adhesion). There are special types of pili involved in bacterial conjugation.

Cellular processes



Prokaryotes divide by binary fission, while eukaryotes divide by mitosis or meiosis.

Replication

Cell division

Cell division involves a single cell (called a *mother cell*) dividing into two daughter cells. This leads to growth in multicellular organisms (the growth of tissue) and to procreation (vegetative reproduction) in unicellular organisms. Prokaryotic cells divide by binary fission, while eukaryotic cells usually undergo a process of nuclear division, called mitosis, followed by division of the cell, called cytokinesis. A diploid cell may also undergo meiosis to produce haploid cells, usually four. Haploid cells serve as gametes in multicellular organisms, fusing to form new diploid cells.

DNA replication, or the process of duplicating a cell's genome,[4] always happens when a cell divides through mitosis or binary fission. This occurs during the S phase of the cell cycle.

In meiosis, the DNA is replicated only once, while the cell divides twice. DNA replication only occurs before meiosis I. DNA replication does not occur when the cells divide the second time, in meiosis II.[29] Replication, like all cellular activities, requires specialized proteins for carrying out the job.[4]

DNA repair

DNA repair

Cells of all organisms contain enzyme systems that scan their DNA for DNA damage and carry out repair processes when damage is detected.[30] Diverse repair processes have evolved in organisms ranging from bacteria to humans. The widespread prevalence of these repair processes indicates the importance of maintaining cellular DNA in an undamaged state in order to avoid cell death or errors of replication due to damage that could lead to mutation. *E. coli* bacteria are a well-studied example of a cellular organism with diverse well-defined DNA repair processes. These include: nucleotide excision repair, DNA mismatch repair, non-homologous end joining of double-strand breaks, recombinational repair and light-dependent repair (photoreactivation).

Growth and metabolism

Cell growth and Metabolism

Between successive cell divisions, cells grow through the functioning of cellular metabolism. Cell metabolism is the process by which individual cells process nutrient molecules. Metabolism has two distinct divisions: catabolism, in which the cell breaks down complex molecules to produce energy and reducing power, and anabolism, in which the cell uses energy and reducing power to construct complex molecules and perform other biological functions. Complex sugars consumed by the organism can be broken down into simpler sugar molecules called monosaccharides such as glucose. Once inside the cell, glucose is broken down to make adenosine triphosphate (ATP), a molecule that possesses readily available energy, through two different pathways.

Protein synthesis

Protein biosynthesis

Cells are capable of synthesizing new proteins, which are essential for the modulation and maintenance of cellular activities. This process involves the formation of new protein molecules from amino acid building blocks based on information encoded in DNA/RNA. Protein synthesis generally consists of two major steps: transcription and translation.

Transcription is the process where genetic information in DNA is used to produce a complementary RNA strand. This RNA strand is then processed to give messenger RNA (mRNA), which is free to migrate through the cell. mRNA molecules bind to protein-RNA complexes called ribosomes located in the cytosol, where they are translated into polypeptide sequences. The ribosome mediates the formation of a polypeptide sequence based on the mRNA sequence. The mRNA sequence directly relates to the polypeptide sequence by binding to transfer RNA (tRNA) adapter molecules in binding pockets within the ribosome. The new polypeptide then folds into a functional three-dimensional protein molecule.

Motility

Motility

Unicellular organisms can move to find food or escape predators. Common mechanisms of motion include flagella and cilia.

In multicellular organisms, cells can move during processes such as wound healing, the immune response and cancer metastasis. For example, in wound healing in animals, white blood cells move to the wound site to kill the microorganisms that cause infection. Cell motility involves many receptors, crosslinking, bundling, binding, adhesion, motor, and other proteins. The process is divided into three steps: protrusion of the leading edge of the cell, adhesion of the leading edge and de-adhesion at the cell body and rear, and cytoskeletal contraction to pull the cell forward. Each step is driven by physical forces generated by unique segments of the cytoskeleton.

Navigation, control, and communication

Cybernetics § In biology

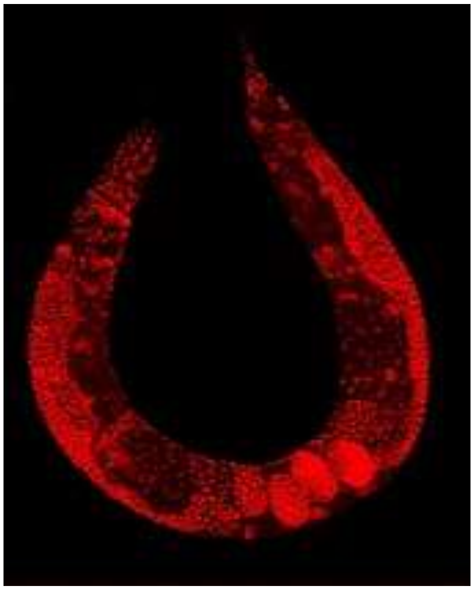
In August 2020, scientists described one way cells—in particular cells of a slime mold and mouse pancreatic cancer-derived cells—are able to navigate efficiently through a body and identify the best routes through complex mazes: generating gradients after breaking down diffused chemoattractants which enable them to sense upcoming maze junctions before reaching them, including around corners.

Multicellularity

Main article: Multicellular organism

Cell specialization/differentiation

Cellular differentiation



Staining of a *Caenorhabditis elegans* highlights the nuclei of its cells.

Multicellular organisms are organisms that consist of more than one cell, in contrast to single-celled organisms.

In complex multicellular organisms, cells specialize into different cell types that are adapted to particular functions. In mammals, major cell types include skin cells, muscle cells, neurons, blood cells, fibroblasts, stem cells, and others. Cell types differ both in appearance and function, yet are genetically identical. Cells are able to be of the same genotype but of different cell type due to the differential expression of the genes they contain.

Most distinct cell types arise from a single totipotent cell, called a zygote, that differentiates into hundreds of different cell types during the course of development. Differentiation of cells is driven by different environmental cues (such as cell–cell interaction) and intrinsic differences (such as those caused by the uneven distribution of molecules during division).