

# Structural organization of the cell - overview of cell components

Cells are the basic structural and functional units of all multicellular organisms. Cell theory (basic statements): 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. specific functions are identified with specific structural components and domains within the cell, some developed this characteristic to such extent that they are identified by their function (e.g. although all cells contain contractile proteins, muscle cells contain the largest amounts of them contractile function is their identifying function). ... cells are divided into 2 major compartments cytoplasm + nucleus. Protoplasm is the living content of a cell that is surrounded by a plasma membrane.

\*Cytoplasm is a part of cell located outside the nucleus. It contains organelles and inclusions in an aqueous gel called the cytoplasmic matrix.

Cytoplasmic matrix/cytosol consists of a variety of solutes, including inorganic ions ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ) and organic molecules, such as intermediate metabolites, carbohydrates, lipids, proteins and RNAs. It's the site of physiologic processes that are fundamental to cell's existence (protein synthesis, breakdown of nutrients). The concentration of solutes is controlled by the cell and influences the metabolic activity within the cytoplasmic compartments.

Organelles are described as membranous(membrane-limited) and non-membranous. All cells have the basic set of intracellular organells, which can be more or less developed depending on the cell function. In addition, each type of organelle contains a set of unique proteins (in membranous organelles these proteins are either incorporated into the cell membrane, or sequestered within the lumen; in non-membranous organelles they usually form polymeres)

Membranous organelles – constitute the plasma membrane (1 or 2) that separates the internal organelle environment from the cytoplasm: nucleus, mitochondria, endoplasmic reticulum (sER/rER), Golgi apparatus, endosomes, lysosomes, transport vesicles, peroxisomes, melanosomes (+ plasmolemma) Plasma membrane (= plasmolemma for the cell membrane) is a lipid bilayer that forms the cell boundary as well as the boundaries of many organelles within the cell Mitochondria are double membrane organelles that provide most of the energy to the cell by producing ATP (adenosine triphosphate) in the process of oxidated phosphori Rough endoplasmic reticulum (rER) a region of endoplasmic reticulum associated with ribosomes and the site of protein synthesis and modification of newly synthesized proteins Smooth endoplasmic reticulum (sER) is a region of the endoplasmic reticulum involved in lipid and steroid synthesis but is not associated with ribosomes Golgi apparatus is a membranous organelle, composed of multiple flattened cisternae responsible for modifying, sorting and packaging proteins and lipids for intracellular or extracellular transport Endosomes are membrane-bounded compartments interposed within endocytotic pathways that have the major function of sorting proteins delivered to them via the endocytotic vesicles and redirecting them to different cellular compartments for their final destination Lysosomes are small organelles containing digestive enzymes that are formed from endosomes by targeted delivery of unique lysosomal membrane proteins and lysosomal enzymes Peroxisomes are small organelles involved in the production and degradation of  $\text{H}_2\text{O}_2$  (hydrogen peroxide) and degradation of fatty acids Transport vesicles are membrane-bounded vesicles, involved in both endocytosis and exocytosis and vary in shape and the material that they transport, include pinocytotic vesicles, endocytotic vesicles, and coated vesicles.

Non-membranous organelles – do not have any plasma membrane: ribosomes, microtubules, intermediate filaments, actin filaments, centrioles. Microtubules are parts of the cytoskeleton, which they form together with actin and intermediate filaments, they continuous elongate and shorten (by adding and removing tubulin dimers) showing the dynamic instability Filaments are another part of the cytoskeleton and can be classified in 2 groups – actin filaments, which are flexible chains of actin molecules, and intermediate filaments, which are ropelike fibers formed from a variety of proteins. Both groups provide the tensile strength to withstand tension and support the cell Centrioles are short paired cylindrical structures found in the center of the microtubule organizing center (=centrosome), their derivatives give rise to the basal bodies of cilia Ribosomes are structures essential for protein synthesis and compose of ribosomal RNA and ribosomal proteins (including proteins attached to the membranes of the rER and proteins free in the cytoplasm)

Inclusions are not usually surrounded by plasma membrane and contain the products of the metabolic activity of the cell, which consists of such materials, as crystals, pigment granules, lipids, glycogen, and other stored waste products. They obtain the characteristic staining properties and are considered nonmoving, nonliving components of the cell. Lipofuscin. Brownish-gold pigment visible in routine HE staining, easily seen in non-dividing cells (neurons, skeletal and cardiac muscle). Often called the "wear-and-tear" pigment, because accumulates as a result of oxidative degradation of mitochondria with aging (senescence) of the cell + residual bodies (lysosomal digestion) + digestion in macrophages after the phagocytosis. Lipofuscin accumulations can also be an indicator of cellular stress. Hemosiderin. An iron-storage complex, visible as deep brown granules, associated with the indigested residues of the hemoglobin and found within the cytoplasm of the cells in the spleen (cemetery of erythrocytes – by phagocytosis), lungs (alveolar macrophages, especially after pulmonary infections with little hemorrhage into alveoli). Glycogen. Highly branched polymer used for the storage of glucose. Stored in granules.

Not stained by HE, but with PAS or toluidine blue. Most abundant in liver and striated muscles. Lipid inclusions/fat droplets. Nutritive inclusions, which provide energy for cellular metabolism. May appear temporarily (intestinal absorptive cells) or constantly (adipocytes). Are usually extracted by the organic tissue solvents use for the preparations of the slides not visible. Crystalline inclusions. In humans found in Sertolli (sustentacular) and Leydig (interstitial) cells of testes. The significance is not clear yet.

\*Nucleus

The nucleus is a membrane-limited compartment that contains the genome (genetic information) in eukaryotic cells. The nucleus contains genetic information, together with the machinery for DNA replication and RNA transcription and processing. The nucleus of a nondividing cell, also called an interphase cell, consists of the following components: Chromatin, is nuclear material organized as euchromatin or heterochromatin. It contains DNA associated with roughly an equal mass of various nuclear proteins (e.g., histones) that are necessary for DNA to function. The nucleolus is a small area within the nucleus that contains DNA in the form of transcriptionally active ribosomal RNA (rRNA) genes, RNA, and proteins. The nucleolus is the site of rRNA synthesis and contains regulatory cell-cycle proteins. The nuclear envelope is the membrane system that surrounds the nucleus of the cell. It consists of an inner and an outer membrane separated by a perinuclear cisternal space and perforated by nuclear pores. The outer membrane of the nuclear envelope is continuous with that of the rough-surfaced endoplasmic reticulum (rER) and is often studded with ribosomes. The nucleoplasm is nuclear content other than the chromatin and nucleolus.