...going one step further

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The Animal Cell

Introduction

Cells in animal multicellular organisms principally only occur in groups of similar cells or together with other differentiated cells, or embedded in the intercellular substrate (intercellular substance, extracellular matrix). The surrounding environment of the unicellular and primitive multicellular organisms (the "primordial soup", so to speak) also surrounds the cells of more complex highly organized animal (human) organisms, and ensures its nutrition via the blood vessels that penetrate throughout the tissues (down to the capillaries).

The following basic characteristics distinguish the cells of living organisms: they possess higher complexity of organization than their surroundings, they can react to stimuli from within and from their environment, and they have the ability to reproduce (reduplication).

Overview of the construction and function of cells

The cell membrane (plasma membrane) encloses the cell and also provides a barrier to the external environment allowing the maintenance of its own internal environment. Within the cell, certain structures and small organs (organelles, see list below) are also enclosed by a plasma membrane. The plasma membrane itself consists of polar lipids that form a semi-permeable membrane. Thus the individual compartments and organelles are separated from one another and from the specific molecules and ions they contain. The plasma membrane is also connected to a fine framework of structural proteins, the filaments of the cell skeleton (cytoskeleton). This cytoskeleton consists of fine actin filaments (7 nm diameter), hollow microtubules (25 nm diameter) and, lying in between in diameter, the intermediary filaments. The microtubules develop from an organization centre, usually the centriole. They are also responsible for transport processes along their length, to and from the organization centre (directional active transport, which also occurs in the axons of nerve cells). The centriole itself is an organelle consisting of two groups of tubes perpendicular to one another, from which the microtubules extend – this also occurs in newly formed cells. During cell division the separation of the chromosomes is carried out by the "marionette threads", the microtubules emanating from the centriole.

As the name implies, the cytoskeleton ensures overall stability for the cell along with a corresponding degree of flexibility. Furthermore the cytoskeleton enables extreme versatility in the active movements of the cell: from stretching out foot-like appendages (e.g. filopodia) to make major changes in shape of the entire cell (also the basis of active muscle contraction for example) to active movement of the cell (cell migration). Moreover, the elements of the cytoskeleton propagate the tension lines within a cell via the so-called cell-cell connections (e.g. desmosomes, see below) to the neighbouring cells and so mechanically connect different areas of cells e.g. in the epidermis of the skin – particularly clear in the prickle cells.

Within the cell-cell connections (intercellular contact) structures with predominantly mechanical function (contact adhesion: zonula; punctum; fascia adhaerens; macula adhaerens = desmosome) can be distinguished from those with an active metabolic and electro-coupling function (nexus, macula communicans = gap junction; synapse). Finally, there are cell connections that seal off the intercellular area (contact barrier: zonula occludens). Connections to the extracellular membrane form focal contacts and to the basal membrane the hemidesmosome.

All proteins, which make up the components of the cytoskeleton, are made by the "sewing machine" of the proteins, the ribosomes. These can be suspended in the cytoplasm or may be bound onto the vacuole system of the rough endoplasmic reticulum (rough ER). Information is carried to the ribosomes from the cell nucleus, where genetic information is stored on the chromosomes by means of the mRNA. The ribosome couples amino acid to amino acid to order and "sews" them onto a peptide or protein. Peptides and proteins are further modified by auxiliary proteins within the ER, e.g. sugar groups may be added to the protein (glycosylation). The smooth ER can synthesize lipids (cholesterol, triglycerides, steroid hormones), lipoproteins and phospholipids. Furthermore the smooth ER makes fat-soluble compounds water-soluble

and thus detoxifies them. In certain types of cell (e.g. muscle cells) the smooth ER also serves as a store for calcium ions.

The Golgi apparatus (GA) consists of groups of flat sac-like membranes (sacculi) und numerous small vesicles. Here proteins newly synthesized in the ER are further modified. Specific sugar groups are synthesized and coupled onto proteins, and also some proteins are cleaved. In addition polysaccharides with appropriate sulfatization are synthesized and glycolipids are synthesized and joined together. These mature proteins are packed into vesicles in the GA and made ready for transport. Thus the GA plays an important role in the sorting and delivery of proteins ("Post Office of the cell").

The GA is also connected with exocytotic events (release of vesicles) and fagocytosis (protrusion of the plasma membrane with subsequent "pinching off" of the membrane together with the components that it surrounds). Vesicles can also be actively enveloped and captured (endocytosis) and also receptors acting as mediators can be brought in (pinocytosis). Membrane protrusions such as the microvilli (small finger-like protrusions with little mobility), stereocilia (larger protrusions with relatively little mobility) and kinocilia (flagellum-shaped protrusions for active cilia movement) will only be discussed in the course reading.

Vacuoles can be formed both endocytotically and by cell components that digest the contents of vesicles (lysosomes).
Alongside the lysosomes in a cell are small organelles (peroxisomes), which principally oxidize fatty acids, amino acids and uric acid and can detoxify potentially cytotoxic organic compounds.

Mitochondria are bacteria that entered unicellular organisms in primeval times and developed into so-called symbionts. They possess their own genetic material and also ribosomes for the synthesis of their own proteins. They have however become so intertwined with the genome of the host cell that they can no longer live independently. The benefit of this symbiosis is that the mitochondria can utilize oxygen (a principle toxic substance for living cells, that first arose in the primeval atmosphere from the evolution of plants). Thus carbohydrates, fatty acids and amino acids are oxidized to CO_2 and H_2O by consumption of elemental oxygen. In this way ATP, the universal energy carrier, is obtained for the cell. The mitochondrion possesses a double membrane wall. ATP synthesis and the processes of the respiratory chain take place on the internal wall itself. Fatty acid oxidation and the citric acid cycle take place within the mitochondria matrix. Thus the mitochondria can be described as the powerhouse of the cell.

The cell nucleus is the information centre for the cell. The information itself is distributed over 46 deoxyribonucleic acid molecules (DNA). They are accommodated in the cell nucleus together with the histones (capping proteins). The nucleus is typically more densely packed than the cytoplasm and is surrounded by a nuclear double membrane (cistern of the ER) with defined channels (nuclear pores). The information for protein synthesis is taken to the ribosomes by the messenger ribonucleic acid (mRNA), which is synthesized on the gene segments of the DNA. This process is called transcription and produces copies of the DNA. The ribosomal RNA is synthesized on specialized segments in the nucleoli (aggregations in the cell nucleus). In addition there is close communication between the cytoplasm and the membrane receptors, so the cell nucleus represents the central information and control unit of the cell.

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English

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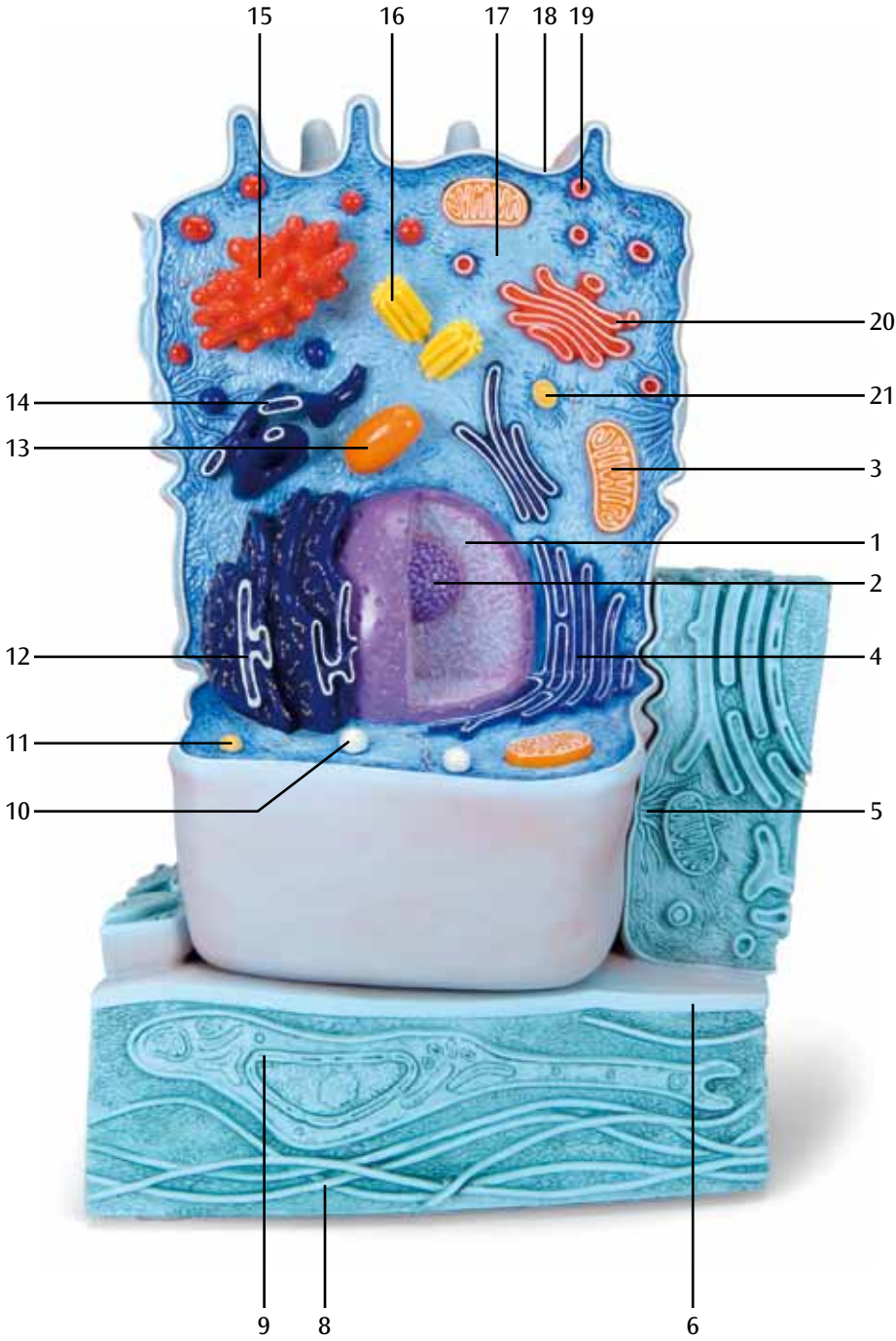
1 Cell nucleus
2 Nucleolus
3 Mitochondrion
4 Smooth endoplasmic reticulum (ER)
5 Desmosome (Macula adhaerens)
6 Basal membrane
7 Hemidesmosome
8 Collagen fibres
9 Fibroblast
10 Peroxisome
11 Lysosome
12 Rough endoplasmic reticulum (ER)
13 Mitochondrion
14 Smooth endoplasmic reticulum (ER)
15 Golgi Apparatus
16 Centriole
17 Cytosol with embedded filament of the cytoskeleton
18 Microvilli
19 Secretion vesicle
20 Golgi Apparatus
21 Lysosome
22 Zonula occludens
23 Zonula adhaerens
24 Desmosome (Macula adhaerens)
25 Microplica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