Al-Farabi Kazakh National University

Faculty of Biology and Biotechnology

Laboratory work

Education program of specialty 5B060700 – Biology

«Cell biology»

Spring semester 2021-2022 academic year

Lecturer

Faleyev Dmitry Gennadievich

Candidate of Biological Sciences,

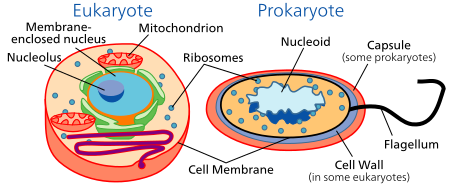
senior teacher, department of biodiversity and bioresources

Almaty 2021

Laboratory work 1. Comparison of features of prokaryotic and eukaryotic cells

Examine available materials. Sketch diagrams and drawings.

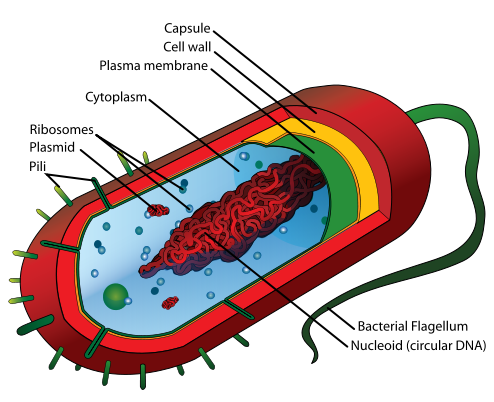
|  |  |  |
| --- | --- | --- |
| **Comparison of features of prokaryotic and eukaryotic cells** | | |
|  | [**Prokaryotes**](https://en.wikipedia.org/wiki/Prokaryote) | [**Eukaryotes**](https://en.wikipedia.org/wiki/Eukaryote) |
| **Typical organisms** | [bacteria](https://en.wikipedia.org/wiki/Bacterium), [archaea](https://en.wikipedia.org/wiki/Archaea" \o "Archaea) | [protists](https://en.wikipedia.org/wiki/Protist), [fungi](https://en.wikipedia.org/wiki/Fungus" \o "Fungus), [plants](https://en.wikipedia.org/wiki/Plant" \o "Plant), [animals](https://en.wikipedia.org/wiki/Animal" \o "Animal) |
| **Typical size** | ~ 1–5 [µm](https://en.wikipedia.org/wiki/Micrometre)[[17]](https://en.wikipedia.org/wiki/Cell_(biology)#cite_note-CampbellBiology320-18) | ~ 10–100 µm[[17]](https://en.wikipedia.org/wiki/Cell_(biology)#cite_note-CampbellBiology320-18) |
| **Type of [nucleus](https://en.wikipedia.org/wiki/Cell_nucleus" \o "Cell nucleus)** | [nucleoid region](https://en.wikipedia.org/wiki/Nucleoid_region); no true nucleus | true nucleus with double membrane |
| [**DNA**](https://en.wikipedia.org/wiki/DNA) | [circular](https://en.wikipedia.org/wiki/Circular_prokaryote_chromosome) (usually) | linear molecules ([chromosomes](https://en.wikipedia.org/wiki/Chromosome)) with [histone](https://en.wikipedia.org/wiki/Histone) [proteins](https://en.wikipedia.org/wiki/Protein) |
| [**RNA**](https://en.wikipedia.org/wiki/RNA)**/[protein](https://en.wikipedia.org/wiki/Protein" \o "Protein) synthesis** | coupled in the [cytoplasm](https://en.wikipedia.org/wiki/Cytoplasm" \o "Cytoplasm) | [RNA synthesis](https://en.wikipedia.org/wiki/Transcription_(genetics)) in the nucleus [protein synthesis](https://en.wikipedia.org/wiki/Translation_(biology)) in the cytoplasm |
| [**Ribosomes**](https://en.wikipedia.org/wiki/Ribosome) | [50S](https://en.wikipedia.org/wiki/50S) and [30S](https://en.wikipedia.org/wiki/30S) | [60S](https://en.wikipedia.org/wiki/60S) and [40S](https://en.wikipedia.org/wiki/40S) |
| **Cytoplasmic structure** | very few structures | highly structured by [endomembranes](https://en.wikipedia.org/wiki/Endomembrane_system) and a [cytoskeleton](https://en.wikipedia.org/wiki/Cytoskeleton) |
| [**Cell movement**](https://en.wikipedia.org/wiki/Chemotaxis) | [flagella](https://en.wikipedia.org/wiki/Flagellum) made of [flagellin](https://en.wikipedia.org/wiki/Flagellin" \o "Flagellin) | flagella and [cilia](https://en.wikipedia.org/wiki/Cilium) containing [microtubules](https://en.wikipedia.org/wiki/Microtubule); [lamellipodia](https://en.wikipedia.org/wiki/Lamellipodia) and [filopodia](https://en.wikipedia.org/wiki/Filopodia) containing [actin](https://en.wikipedia.org/wiki/Actin) |
| [**Mitochondria**](https://en.wikipedia.org/wiki/Mitochondrion) | none | one to several thousand |
| [**Chloroplasts**](https://en.wikipedia.org/wiki/Chloroplast) | none | in [algae](https://en.wikipedia.org/wiki/Algae" \o "Algae) and [plants](https://en.wikipedia.org/wiki/Plant" \o "Plant) |
| **Organization** | usually single cells | single cells, colonies, higher multicellular organisms with specialized cells |
| [**Cell division**](https://en.wikipedia.org/wiki/Cell_division) | [binary fission](https://en.wikipedia.org/wiki/Binary_fission) (simple division) | [mitosis](https://en.wikipedia.org/wiki/Mitosis) (fission or budding) [meiosis](https://en.wikipedia.org/wiki/Meiosis) |
| [**Chromosomes**](https://en.wikipedia.org/wiki/Chromosome) | single chromosome | more than one chromosome |
| [**Membranes**](https://en.wikipedia.org/wiki/Membrane) | [cell membrane](https://en.wikipedia.org/wiki/Cell_membrane) | Cell membrane and membrane-bound organelles |



Comparison of features of prokaryotic and eukaryotic cells

Laboratory work 2. Structure of a typical prokaryotic cell

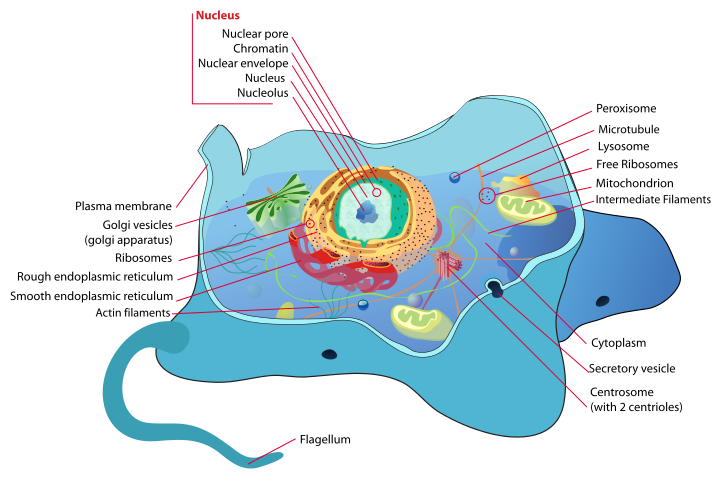
Examine available materials. Sketch diagrams and drawings.



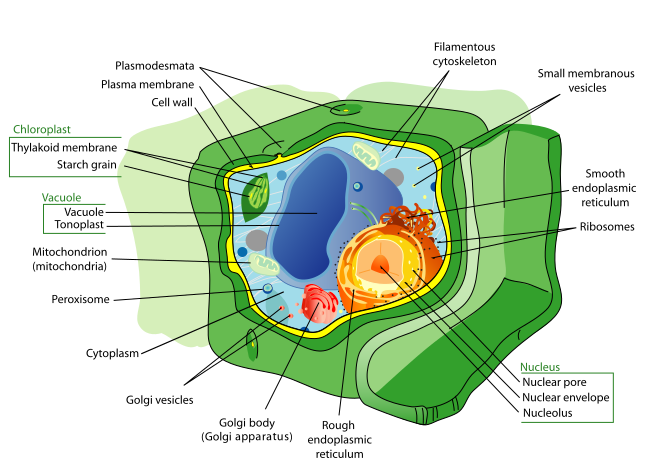
Structure of a typical prokaryotic cell

Laboratory work 3. Structure of a typical plant animal cell

Examine available materials. Sketch diagrams and drawings.



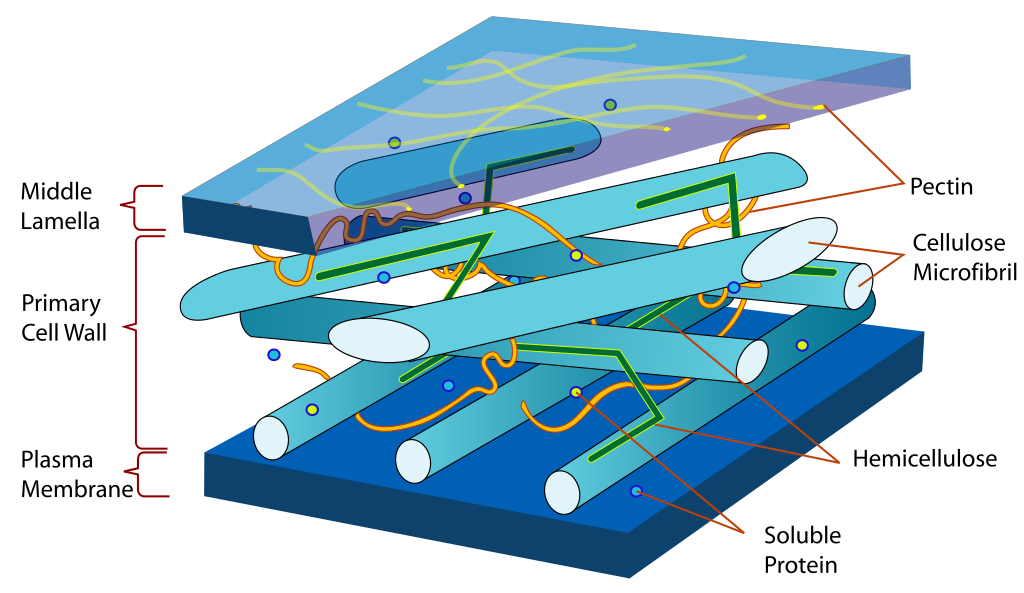
Structure of a typical animal cell



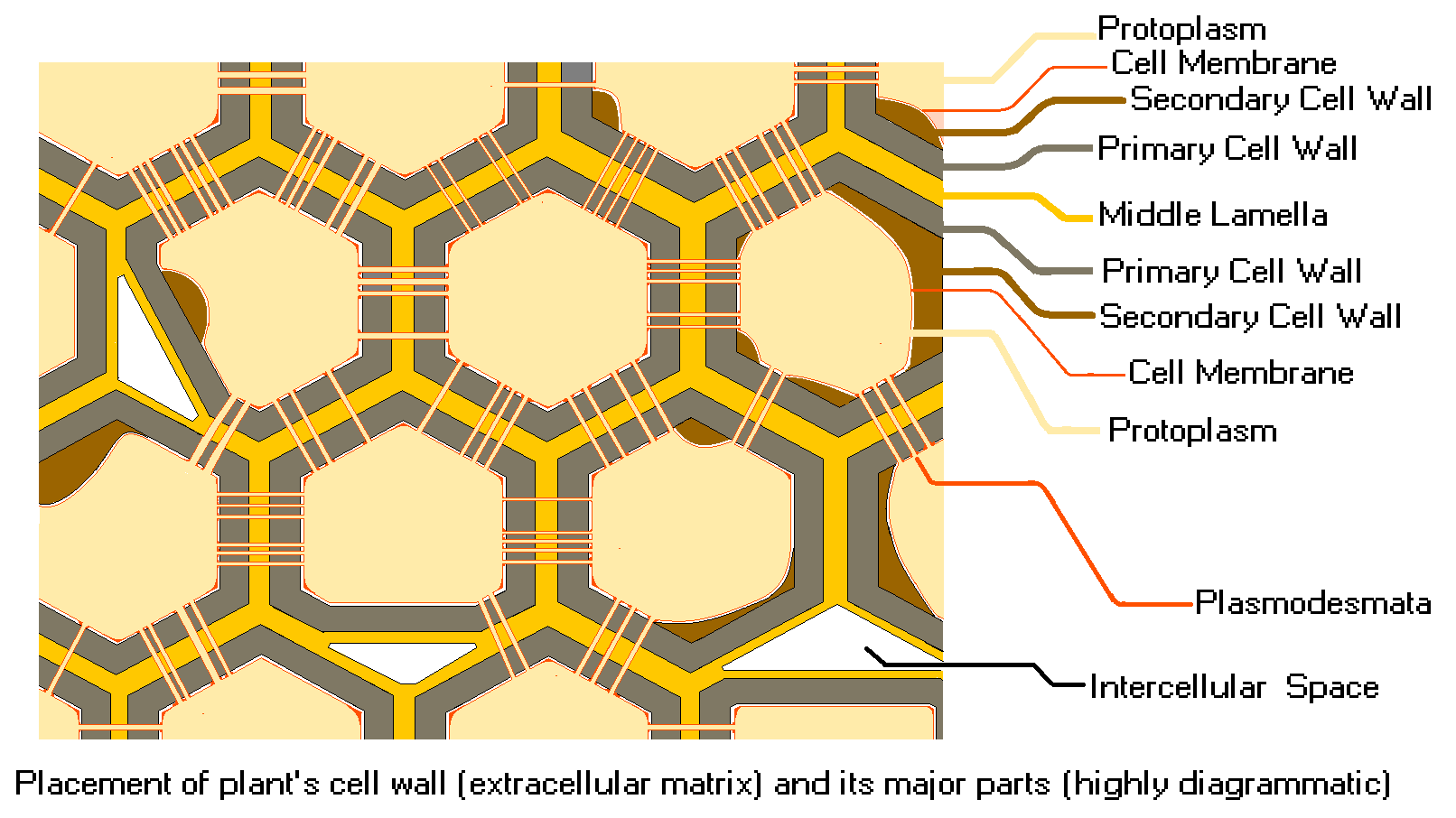
Structure of a typical plant cell

Laboratory work 4. Molecular structure of the primary cell wall in plants

Examine available materials. Sketch diagrams and drawings.



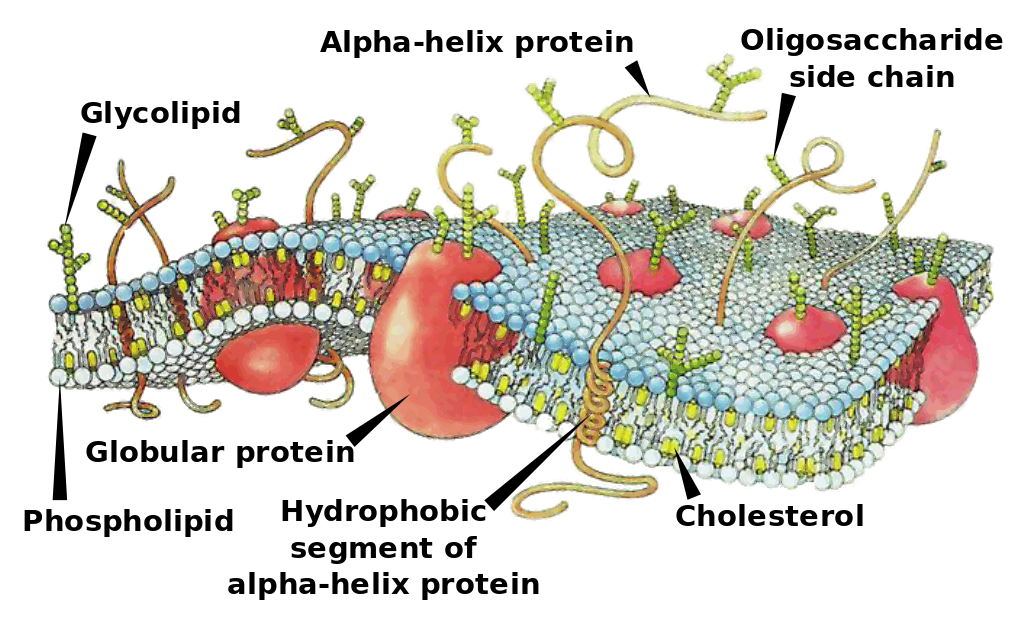
Molecular structure of the primary cell wall in plants



Cell wall in multicellular plants – its different layers and their placement with respect to protoplasm (highly diagrammatic)

Laboratory work 5. Cell membrane

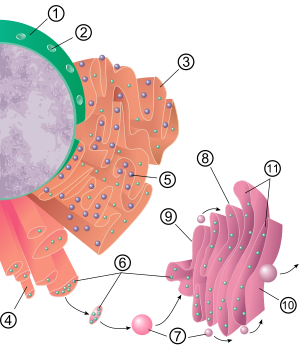
Examine available materials. Sketch diagrams and drawings.



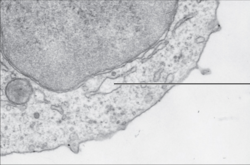
Cell membrane

Laboratory work 6 Organelles of the cell. Endoplasmic reticulum, Golgi apparatus: structure, purpose, biology, biochemical aspects.

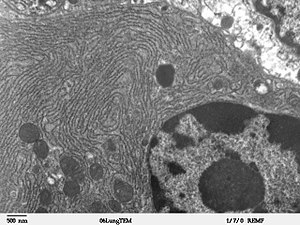
Examine available materials. Sketch diagrams and drawings.



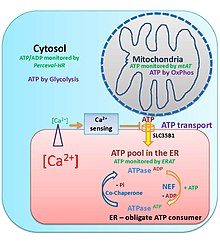
1 Nucleus 2 Nuclear pore 3 Rough endoplasmic reticulum (RER) 4 Smooth endoplasmic reticulum (SER) 5 Ribosome on the rough ER 6 Proteins that are transported 7 Transport vesicle 8 Golgi apparatus 9 Cis face of the Golgi apparatus 10 Trans face of the Golgi apparatus 11 Cisternae of the Golgi apparatus



Electromicrograph showing smooth ER (arrow) in mouse tissue, at 110,510 x magnification.



Micrograph of rough endoplasmic reticulum network around the nucleus (shown in lower right-hand side of the picture). Dark small circles in the network are mitochondria.



CaATiER model



Micrograph of Golgi apparatus, visible as a stack of semicircular black rings near the bottom. Numerous circular vesicles can be seen in proximity to the organelle.

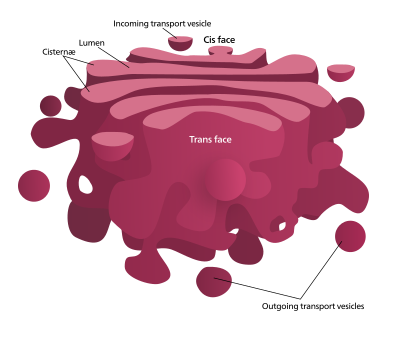
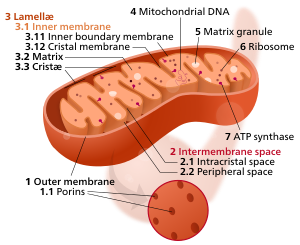


Diagram of a single "stack" of Golgi

Laboratory work 7 Cell Organelles. Mitochondria and plastids: structure.

Examine available materials. Sketch diagrams and drawings.



Components of a typical mitochondrion

1 Outer membrane

1.1 Porin

2 Intermembrane space

2.1 Intracristal space

2.2 Peripheral space

3 Lamella

3.1 Inner membrane

3.11 Inner boundary membrane

3.12 Cristal membrane

3.2 Matrix

3.3 Cristæ

4 Mitochondrial DNA

5 Matrix granule

6 Ribosome

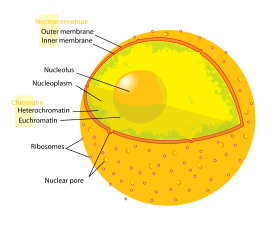
7 ATP synthase



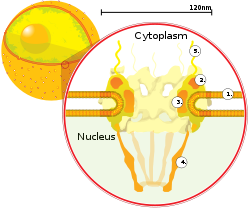
Two mitochondria from mammalian lung tissue displaying their matrix and membranes as shown by electron microscopy

Laboratory work 8 Organelles cells. Cellular nucleus: structure.

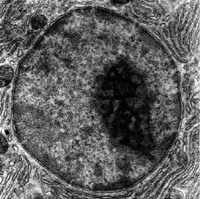
Examine available materials. Sketch diagrams and drawings.



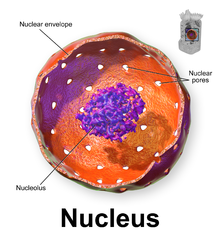
The eukaryotic cell nucleus. Visible in this diagram are the ribosome-studded double membranes of the nuclear envelope, the DNA (complexed as chromatin), and the nucleolus. Within the cell nucleus is a viscous liquid called nucleoplasm, similar to the cytoplasm found outside the nucleus.



A cross section of a nuclear pore on the surface of the nuclear envelope (1). Other diagram labels show (2) the outer ring, (3) spokes, (4) basket, and (5) filaments.



An electron micrograph of a cell nucleus, showing the darkly stained nucleolus



3D rendering of nucleus with location of nucleolus

Laboratory work 9. Organelles of the cell. Ribosomes: structure, purpose, biology, biochemical aspects.

Examine available materials. Sketch diagrams and drawings.



Figure 1 - Ribosomes assemble polymeric protein molecules whose sequence is controlled by the sequence of messenger RNA molecules. This is required by all living cells and associated viruses.

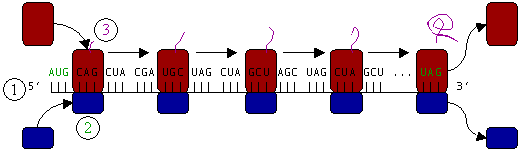
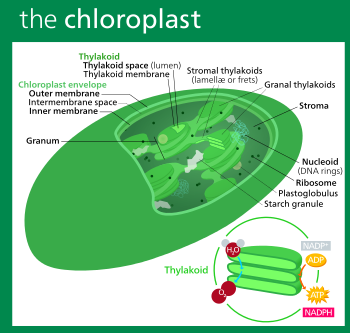
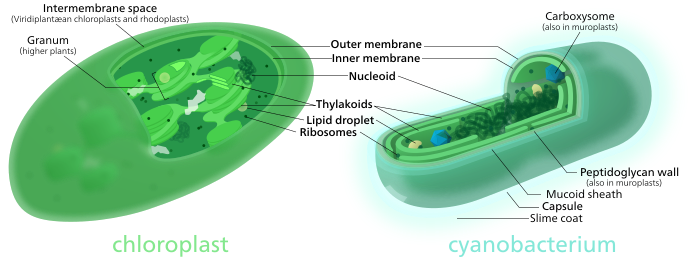


Figure 2 - Translation of mRNA (1) by a ribosome (2)(shown as small and large subunits) into a polypeptide chain (3). The ribosome begins at the start codon of RNA (AUG) and ends at the stop codon (UAG).

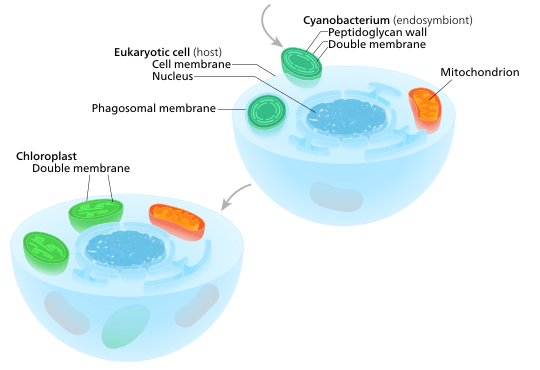
Laboratory work 10 Organelles of the cell. Chloroplasts: structure, purpose, biology, biochemical aspects.



Structure of a typical higher-plant chloroplast

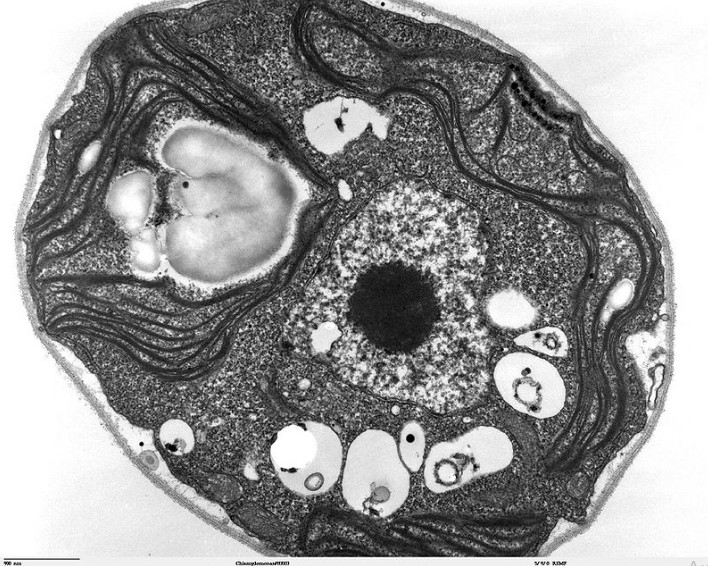


Both chloroplasts and cyanobacteria have a double membrane, DNA, ribosomes, and thylakoids. Both the chloroplast and cyanobacterium depicted are idealized versions (the chloroplast is that of a higher plant)—a lot of diversity exists among chloroplasts and cyanobacteria.

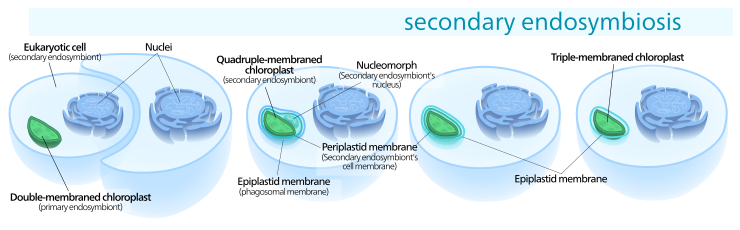


Primary endosymbiosis

A eukaryote with mitochondria engulfed a cyanobacterium in an event of serial primary endosymbiosis, creating a lineage of cells with both organelles. It is important to note that the cyanobacterial endosymbiont already had a double membrane—the phagosomal vacuole-derived membrane was lost.



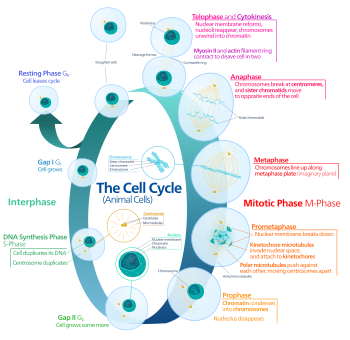
Transmission electron micrograph of *Chlamydomonas reinhardtii*, a green alga that contains a pyrenoid surrounded by starch.



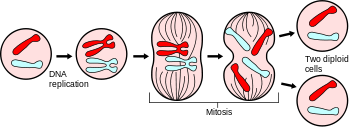
Secondary endosymbiosis consisted of a eukaryotic alga being engulfed by another eukaryote, forming a chloroplast with three or four membranes.

Laboratory work 11 Cell division: mitosis, meiosis.

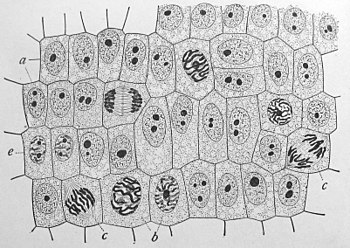
Examine available materials. Sketch diagrams and drawings.



Mitosis in an animal cell (phases ordered counter-clockwise).



Mitosis divides the chromosomes in a cell nucleus.



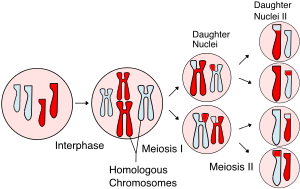
Onion (Allium) cells in different phases of the cell cycle enlarged 800 diameters.

a. non-dividing cells

b. nuclei preparing for division (spireme-stage)

c. dividing cells showing mitotic figures

e. pair of daughter-cells shortly after division



In meiosis, the chromosome or chromosomes duplicate (during interphase) and homologous chromosomes exchange genetic information (chromosomal crossover) during the first division, called meiosis I. The daughter cells divide again in meiosis II, splitting up sister chromatids to form haploid gametes. Two gametes fuse during fertilization, creating a diploid cell with a complete set of paired chromosomes.

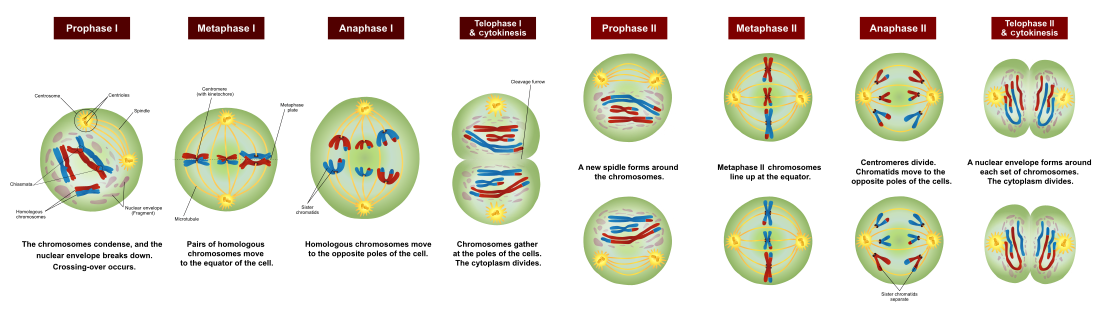
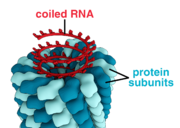


Diagram of the meiotic phases

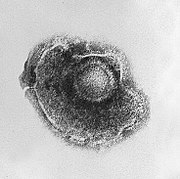
|  |  |  |
| --- | --- | --- |
|  | **Meiosis** | **Mitosis** |
| End result | Normally four cells, each with half the number of chromosomes as the parent | Two cells, having the same number of chromosomes as the parent |
| Function | Production of gametes (sex cells) in sexually reproducing eukaryotes with diplont life cycle | Cellular reproduction, growth, repair, asexual reproduction |
| Where does it happen? | Almost all eukaryotes (animals, plants, fungi, and [protists](https://en.wikipedia.org/wiki/Protist));  In gonads, before gametes (in diplontic life cycles); After zygotes (in haplontic); Before spores (in haplodiplontic) | All proliferating cells in all eukaryotes |
| Steps | Prophase I, Metaphase I, Anaphase I, Telophase I, Prophase II, Metaphase II, Anaphase II, Telophase II | Prophase, Prometaphase, Metaphase, Anaphase, Telophase |
| Genetically same as parent? | No | Yes |
| Crossing over happens? | Yes, normally occurs between each pair of homologous chromosomes | Very rarely |
| Pairing of homologous chromosomes? | Yes | No |
| Cytokinesis | Occurs in Telophase I and Telophase II | Occurs in Telophase |
| Centromeres split | Does not occur in Anaphase I, but occurs in Anaphase II | Occurs in Anaphase |

Laboratory work 12 The structure of viruses. Cell theory.

Examine available materials. Sketch diagrams and drawings.



Structure of tobacco mosaic virus: RNA coiled in a helix of repeating protein sub-units

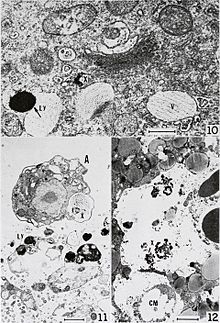


Structure of chickenpox virus. They have a lipid envelope

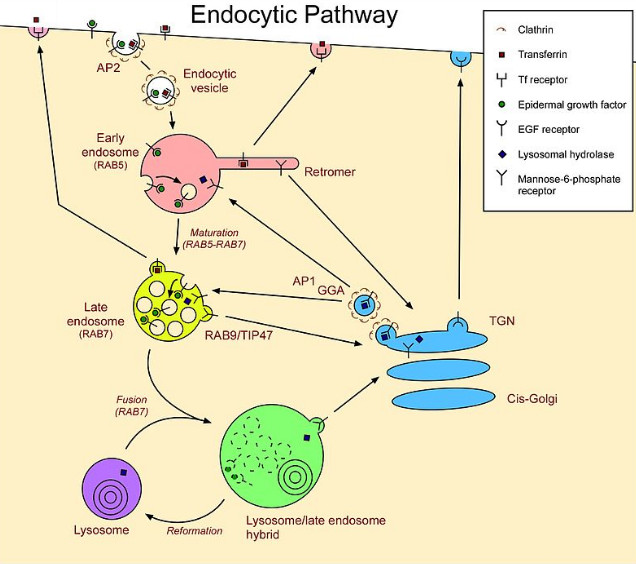


Some bacteriophages inject their genomes into bacterial cells (not to scale)

Laboratory work 13 Cellular inclusions. Lysosomes.



TEM views of various vesicular compartments. Lysosomes are denoted by "Ly". They are dyed dark due to their acidity; in the center of the top image, a Golgi Apparatus can be seen, distal from the cell membrane relative to the lysosomes.



The lysosome is shown in purple, as an endpoint in Endocytotic sorting. AP2 is necessary for vesicle formation, whereas the Mannose-6-receptor is necessary for sorting Hydrolase into the Lysosome's lumen.

Laboratory work 14 Methods of cell research.

Microscopy is the technical field of using microscopes to view objects and areas of objects that cannot be seen with the naked eye (objects that are not within the resolution range of the normal eye). There are three well-known branches of microscopy: optical, electron, and scanning probe microscopy, along with the emerging field of X-ray microscopy.

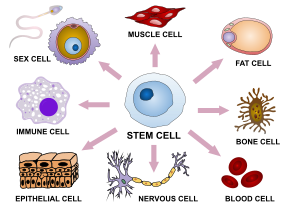
Optical microscopy and electron microscopy involve the diffraction, reflection, or refraction of electromagnetic radiation/electron beams interacting with the specimen, and the collection of the scattered radiation or another signal in order to create an image. This process may be carried out by wide-field irradiation of the sample (for example standard light microscopy and transmission electron microscopy) or by scanning a fine beam over the sample (for example confocal laser scanning microscopy and scanning electron microscopy). Scanning probe microscopy involves the interaction of a scanning probe with the surface of the object of interest. The development of microscopy revolutionized biology, gave rise to the field of histology and so remains an essential technique in the life and physical sciences. X-ray microscopy is three-dimensional and non-destructive, allowing for repeated imaging of the same sample for in situ or 4D studies, and providing the ability to "see inside" the sample being studied before sacrificing it to higher resolution techniques. A 3D X-ray microscope uses the technique of computed tomography (microCT), rotating the sample 360 degrees and reconstructing the images. CT is typically carried out with a flat panel display. A 3D X-ray microscope employs a range of objectives, e.g., from 4X to 40X, and can also include a flat panel.

Cell culture is the process by which cells are grown under controlled conditions, generally outside their natural environment. After the cells of interest have been isolated from living tissue, they can subsequently be maintained under carefully controlled conditions. These conditions vary for each cell type, but generally consist of a suitable vessel with a substrate or medium that supplies the essential nutrients (amino acids, carbohydrates, vitamins, minerals), growth factors, hormones, and gases (CO2, O2), and regulates the physio-chemical environment (pH buffer, osmotic pressure, temperature). Most cells require a surface or an artificial substrate (adherent or monolayer culture) whereas others can be grown free floating in culture medium (suspension culture). The lifespan of most cells is genetically determined, but some cell culturing cells have been “transformed” into immortal cells which will reproduce indefinitely if the optimal conditions are provided.

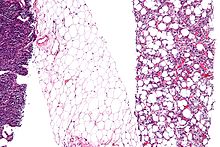
In practice, the term "cell culture" now refers to the culturing of cells derived from multicellular eukaryotes, especially animal cells, in contrast with other types of culture that also grow cells, such as plant tissue culture, fungal culture, and microbiological culture (of microbes). The historical development and methods of cell culture are closely interrelated to those of tissue culture and organ culture. Viral culture is also related, with cells as hosts for the viruses.

The laboratory technique of maintaining live cell lines (a population of cells descended from a single cell and containing the same genetic makeup) separated from their original tissue source became more robust in the middle 20th century.

Laboratory work 15 Applied aspects of cell biology. Cell differentiation. Cell pathology.



Stem cell differentiation into various tissue types.



Micrograph of a liposarcoma with some dedifferentiation, that is not identifiable as a liposarcoma, (left edge of image) and a differentiated component (with lipoblasts and increased vascularity (right of image)). Fully differentiated (morphologically benign) adipose tissue (center of the image) has few blood vessels. H&E stain.

Examine available materials. Sketch diagrams and drawings.