Introductory lecture on botany
for students of the specialty “Pharmacy”

The subject of botany. Botany is the science of plants. A plant is a living organism. Features of the structure of plant cells.

Plan

Предмет ботаники. Ботаника – наука о растениях.
Растения и человек
Разделы ботаники и их связь с системной организацией в живой природе.
Современное представление о строении клетки.
Клеточная теория.
Эукариотическая клетка, ее структура.
Принципиальные отличия между растительной, грибной и животной клетками.
Растительная клетка, ее строение.

The subject of botany. Botany is the science of plants.
Plants and humans
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Modern understanding of the structure of the cell.
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Botany is the science of plants.

Botany is the science of plants.

Botany as a science has a history of more than two and a half thousand years. Its development is closely connected not only with the development of individual special sciences about wildlife, but also with the history of mankind as a whole.

The original knowledge of plants was associated with their use in the household and the economy of man, for food, clothing, medicine, etc. The most ancient cultivated plants are wheat, barley, rice, flax, soybeans, cotton, and corn. Their cultivation began in prehistoric times. The second group of plants – rye, oats, peas and some other types of plants began to be cultivated later. The study of plants for the purpose of treatment also began in prehistoric times.

Heraclitus, Empedocles, Anaxagoras, Virgil and other scientists of antiquity wrote about plants in their philosophical works. But the works of Aristotle, Theophrastus, Pliny, Dioscorides and Columella were the most important for botany.

Theophrastus (371-286 BC) – a student of Aristotle, is rightly considered in the history of science as the "father of botany". Along with the description of the use of plants in agriculture and medicine, Theophrastus considered questions of a purely theoretical nature: the structure and physiological functions of plants, geographical distribution, the influence of soil and climatic conditions, tried to systematize plants. From his works, "The Natural History of Plants" and in a few fragments "On the causes of plants" have been preserved. In them, he gives a classification of plants, which was adhered to almost until the XIX century, correctly identifies plant organs, describes various ways of feeding plants and describes in detail about 500 plants.

The works of Theophrastus are the first in the history of botany to form a unified system of knowledge, observations of agricultural practitioners and the works of scientists. The influence of Theophrastus'works on the subsequent development of botany for many centuries was enormous.

The main figure in botany of the XVIII century is Carl Linnaeus. Modern botanists almost canonized K. Linnaeus. His merit in the history of botany lies in the fact that he was able to generalize, classify and reform all the material accumulated by science before him.

His main works: "Systema Naturae", "Fundamenta Botanica", "Philosophia Botanica" and "Species Plantarum", have not lost their relevance to this day. Here described and applied double names for all plant species known to him (about 10 thousand). In addition, in his work "Philosophia Botanica", he created a kind of concept of botany as a science and outlined its history briefly and clearly. The period of development that preceded him, Carl Linnaeus called "the period of the empirical development of science".

Darwin's evolutionary theory introduced a new content to botanical research, combining them with a common task – to identify the history of the development of organisms, their kinship relationships. During this period, new sciences emerged: plant genetics, plant geography, plant biochemistry, geobotany, plant cytology.

The twentieth century was marked by huge progress in biological knowledge, a relative and absolute increase in the role of biology among other branches of science. In the twentieth century, biology was transformed from a predominantly descriptive science into a predominantly experimental and accurate one, armed with the latest methods and technical means of research, closely related to the achievements of chemistry, physics, mathematics, and technology. The same is applying to botany.

Currently, botany is a major multidisciplinary science. Its general task is the study of individual plants and their complexes – plant communities. One of the main tasks of botany is the development of scientific basis for nature and natural resources protection. Botany works closely with agronomy, medicine, soil science, forestry, chemistry, geology, zoology, and mathematics. The branches of botanical science use a variety of experimental research methods and technical means.

The importance of plants in nature and human life. The entire landmass of our planet, excluding the icy deserts of the Arctic and Antarctic, is covered by plants. Plant organisms are also widely represented in the seas and oceans. They can be both microscopic and enormous. One thing they have in common is that they all contain the green pigment – chlorophyll, which is concentrated in special organelles of plant cells – plastids. A unique property of chlorophyll is its participation in the complex process of photosynthesis, during which carbon dioxide is absorbed, oxygen is released, and organic substances are synthesized from inorganic ones. The process of photosynthesis occurs on a colossal scale. The multi-layered green screen created by plants greatly exceeds the surface area of our planet. According to a very rough estimate, plants in photosynthesis produce about 400 billion tons of organic matter each year, and in doing so they sequester about 175 billion tons of carbon.

Vegetation plays a primary regulatory role in the overall gas exchange and water balance of the Earth, it protects the soil from destruction, enriches it with nutrients, it creates a food and energy base for the entire animal world.

Human life is unthinkable without the use of plants. It is food, building material, raw materials for various industries. The basis of energy is products of plant origin – coal, peat, oil. Green spaces reduce dust and air pollution, noise levels, and thus improve the living conditions of the urban population.

Sections of botany and their connection with the system organization in wildlife.

Botany, as part of a more general science, biology, is in turn divided into a number of special sciences whose tasks include the study of certain regularities in the structure and life of plants or vegetation.

Morphology of plants is one of the largest and earliest formed branches of botany. It is the science of the regularities of formation and development of various plant life forms and their individual organs. The formation and development of plant organs is considered both in the course of individual development of an individual from seed germination to the end of life (ontogenesis) and in the course of historical development (evolution) of the entire species or any other systematic group to which the individual belongs (phylogeny).

In the course of development of morphology even more specialized sciences were formed: cytology (studies of the law of structure and development of the main structural unit of plants – the cell); histology and anatomy of plants (the origin, development, and structure of different tissues forming organs); embryology (the law of development and structure of the embryo); organography of plants (origin, development, and structure of plant organs – root, stem, leaf, flower, fruit, etc.); palynology (structure of pollen and spores).

Florography - the task of this science is to recognize and describe species, that is, to make their diagnoses. Species described (diagnosed) by florographers are classified by taxonomists into groups based on similarities reflecting relatedness. Often, however, the work of a florographers and a taxonomist is combined in the person of one scientist. Taxonomy is the science of diversity of species and causes of this diversity. The task of taxonomy is to bring all our knowledge of the species described by florists into an easily observable scientific system. Plant geography (phytogeography) is the largest branch of botany, the main task of which is to study the distribution patterns of plants and their communities (cenoses) on land (Earth) and in the world's oceans.

Ecology of plants. Plant life depends on the environment (climate, soil, etc.), but plants, in turn, affect the creation of this environment – participate in the soil-formation process, change the climate. The task of ecology of plants is to study the structure and vital activity of plants in relation to the environment. This science is of great importance to practical agriculture.

Plant physiology is the science of plant life processes, mainly metabolism, movement, growth, development rhythms, reproduction, etc.

Microbiology is the science of the peculiarities of life processes occurring in microscopic organisms, the predominant part of which are bacteria and some fungi. Achievements of soil microbiology are widely used in agricultural practice.

Paleobotany is the science of fossil plants of past geological periods.

Other branches of botany have become so isolated due to the special tasks and methods of work used that they have long ago become special sciences, such as biophysics, biochemistry, radiobiology, genetics, etc.

The structure of the plant cell.

The main structural and functional unit of the body of a living organism is the cell (cellulus). Only viruses are devoid of cellular structure. A cell can exist either as a separate (unicellular) organism (bacteria, many algae, and fungi) or as part of the body of animals, plants, and fungi.

The study of the cell became possible after the invention of the first light microscope by the Jansen brothers in 1590. The light, or optical, microscope remained virtually the only instrument for studying the cell for 350 years. Only in the 40s of the last (20th) century did scientists get a new powerful tool for the study of the cell – the electron microscope, which allowed them to make a number of important discoveries. The electron microscope has almost unlimited resolution.

For the first time, the cell structure of plants was observed and described by the Englishman Robert Hooke (1665), looking under a microscope at a slice of cork. The discovery of the nucleus and organoids of the cell, the elucidation of the main functions and structural features of the protoplast - the living content of the cell – was made mainly in the XIX and the first half of the XX century by the efforts of many scientists. As a result, a special science on the cell arose, called cytology (from the Greek words “kitos”- vessel and logos-learning).

At the turn of the 1930s-40s, the German zoologist Theodor Schwann and the botanist Mathias Schleiden formulated the cell theory. The main thesis of the cell theory is the recognition of the principle of cellular structure and growth common to all organisms. In 1858, the German scientist Rudolf Virchow justified the principle of cell inheritance by division: “every cell originates from a cell.

The modern cell theory considers the multicellular organism as a complexly organized, integrated system consisting of functioning and interacting cells. The unity of the cellular structure is confirmed both by the similarity of the structure of different cells and by the similarity of their chemical composition and metabolic processes.

The main points of the modern cell theory:

1. The cells of all living organisms are similar to each other in structure and chemical composition, basic manifestations of life and metabolism.

2. Cells of all organisms have a membrane structure.

3. Cells reproduce by dividing; each new cell is formed by dividing the original mother cell.

4. In multicellular organisms cells specialize in their functions and form tissues, organs are composed of tissues, tissues are closely interconnected, forming a single organism.

5. The cellular structure of all living organisms testifies to the unity of origin.

THE STRUCTURE OF THE PLANT CELL

Cell sizes of most plants range from 10 to 100 microns. Only some specialized elongated cells reach gigantic sizes. For example, unicellular seed hairs of some cotton varieties reach 5 cm in length, and unicellular fibers of the ramie plant – even 55 cm. However, the diameter of these cells is only 50-100 µm. The number of cells in the body of higher plants is very large. It has been reported that one large tree leaf contains more than 100 million cells.

There are two main types of plant cells in terms of shape: parenchymal and prosenchymal. Parenchymal cells are more or less isodiametric, i.e., their size is approximately the same in all three dimensions. Prozenchymal cells are elongated in length, which exceeds their width by 5-6 times or more.

A somatic plant cell is usually surrounded by a cell wall consisting mainly of cellulose. The living contents of the cells are called protoplasts. In many mature plant cells, the central part is occupied by a large vacuole filled with cell sap, the main content of which is water with minerals and organic substances dissolved in it. The cell wall and vacuole are the products of the protoplast.

In botany, a plant cell is treated as a protoplast and its derivatives.

Protoplast

The protoplast is the active living content of the cell. All major processes of cellular metabolism are carried out in the protoplast. The main classes of compounds included in the protoplast are proteins, nucleic acids, lipids, and carbohydrates. The protoplast consists of the cytoplasm and the nucleus.

In the process of protoplast life, various substances are formed, which are collectively called ergastic substances. They are formed directly in the protoplast and partially accumulate there in a dissolved form or as inclusions. In much larger amounts, ergastic substances are concentrated outside the protoplast, forming the cell wall and the vacuole. Products of the protoplast are called protoplast derivatives. They are divided into primary and secondary. Primary ones include the cell wall and vacuole, which are present in almost all plant cells. Secondary protoplast derivatives do not usually accumulate in all plant cells and are related to their functions.

The nucleus is an obligatory and essential part of the living cell of all eukaryotic organisms. It is the place of storage and reproduction of genetic information that determines the characteristics of a given cell and, ultimately, of the organism as a whole. The nucleus also serves as the control center for metabolism and almost all processes occurring in the cell. Cells with the nucleus removed tend to die quickly. In living cells, the nucleus is normally absent only in mature segments of the phloem sieve tubes.

In young, especially meristematic cells, it occupies the central position, but later it is usually shifted to the cell wall, attached to the growing vacuole.

The general plan of the nucleus structure is similar in most eukaryotic organisms. On the outside, it is surrounded by a double membrane, a nuclear envelope pierced with pores. The nucleoplasm (or nuclear juice) is the content of the interphase nucleus. Chromatin (the dense substance of the nucleus (DNA)) and nucleoli are immersed in the nucleoplasm: as well as ribosomes. As the cell divides, the chromatin becomes denser and denser and eventually assembles into chromosomes.

Nucleolus have no membrane and lie freely in the nucleoplasm. The main function of nucleolus is the synthesis of some forms of RNA (mainly ribosomal RNA) and the formation of ribosome precursors (subunits).

The cytoplasm is the part of the protoplast enclosed between the cell wall and the nucleus. Most cellular metabolic processes are carried out in the cytoplasm, except for nucleic acid synthesis. The basis of cytoplasm is its matrix or hyaloplasm, a complex colorless, optically transparent colloidal system capable of reversible transitions from hydrosol to hydrogel. The most important role of hyaloplasm is to unite all cellular structures into a single system and ensure interaction between them in the processes of cellular metabolism.

The cytoplasm of plant cells contains small bodies, or organoids (organelles), which have special functions. These are plastids, Golgi complex, mitochondria, etc.

A third important component of the cytoplasm is cytoplasmic membranes. Biological membranes are thin films constructed mainly of phospholipids and lipoproteins. According to modern concepts, they are a lipid bilayer “stuffed” with protein molecules and enclosed in an openwork framework consisting of glycoproteins with branched carbon and glycolipids with unbranched chains. One of the main properties of cell membranes is their selective permeability (semi-permeability): some substances pass through with difficulty or do not pass through at all, others penetrate easily. Selective membrane permeability makes it possible for various biochemical reactions, often opposite in direction, to proceed simultaneously and independently in isolated compartments (reservoirs) formed by the endoplasmic network.

Membranes primarily separate the cytoplasm from the cell wall and vacuoles, and inside the cytoplasm, as already mentioned, they form an endoplasmic network – a system of small vacuoles and tubules connected with each other. This system is three-dimensional, and its shape and extent depend on the cell type, its metabolic activity and differentiation stage. For example, in protein-synthesizing cells, the cisterns of the endoplasmic network look like flat sacs with numerous ribosomes connected to its outer surface. Such a network with fixed groups of ribosomes, or polysomes, is called a rough (granular) network. Polysomes (polyribosomes) and the rough endoplasmic network are the main sites of protein synthesis. Lipid-secreting cells have a large system of tubular cisterns devoid of ribosomes (agranular, smooth endoplasmic network). The endoplasmic network functions as a communication system of the cell and is used for the transport of substances. Endoplasmic networks of neighboring cells are connected through cytoplasmic filaments-plasmodesmata. The endoplasmic network is the main site of synthesis of other cell membranes.

Ribosomes are macromolecular organelles, found within all living cells, that perform biological protein synthesis (mRNA translation). Ribosomes link amino acids together in the order specified by the codons of messenger RNA (mRNA) molecules to form polypeptide chains. Ribosomes consist of two major components: the small and large ribosomal subunits. Each subunit consists of one or more ribosomal RNA (rRNA) molecules and many ribosomal proteins (RPs or r-proteins). The ribosomes and associated molecules are also known as the translational apparatus.

The Golgi apparatus, also known as the Golgi complex, Golgi body, or simply Golgi, is an organelle found in most eukaryotic cells. Part of the endomembrane system in the cytoplasm, it packs proteins into membrane-bound vesicles inside the cell before the vesicles are sent to their destination. It is believed that in a plant cell, it also synthesizes macromolecules that make up the cell wall and the contents of the vacuole.

The Golgi complex consists of individual dictyosomes and Golgi vesicles. Dictyosomes are a stack of flat, disc-shaped cisterns that do not touch each other, bounded by membranes. Often, dictyosomes change along the edges into a system of thin branching tubes. The number of dictyosomes in a plant cell usually ranges from one to several dozen. The Golgi vesicles detach from the edges of the dictyosomal plates or the ends of the tubes and are usually directed towards the plasmalemma or vacuole.

Spherosomes are small vesicles between 0.2 and 1.3 μm in size, initially surrounded by a biological membrane and containing specific enzymes. The function of spherosomes is to accumulate fat. A mature spherosome is usually a blob of fat surrounded by a biological membrane or protein sheath.

Mitochondria and plastids. Both types of these organoids are bimembranous. All or almost all living eukaryotes contain mitochondria in their cells, and all autotrophic eukaryotes also contain plastids. Both plastids and mitochondria are capable of synthesizing their own protein molecules because they have their own DNA.

Mitochondria are an integral part of almost all living eukaryotic cells. Their shape, size, and number are constantly changing. The number of mitochondria varies from a few to hundreds of thousands. They are especially numerous in the secretory tissues of plants. The length of these organoids does not exceed 10 microns. Most often they are elliptical or rounded, but may resemble sticks, small grains, etc. On the outside, mitochondria are surrounded by a membrane consisting of two membranes, which are not connected to the endoplasmic network of the cytoplasm. The inner membrane forms outgrowths into the mitochondrial cavity in the form of leaf-like plates (cristae) or tubes. There are different types of cristae and tubes. The space between the cristae and tubes is filled with a homogeneous transparent substance, the mitochondrial matrix. The matrix contains ribosomes, similar in size to ribosomes of prokaryotic cells, and mitochondrial DNA, which is not bound to histones, unlike DNA of the nucleus, and is visible under an electron microscope as thin circular strands.

Mitochondria are able to synthesize their proteins independently of the nucleus on their own ribosomes under the control of mitochondrial DNA. Mitochondria are apparently formed only by independent fission, although under the control of the nucleus.

The main function of mitochondria is to provide the energy needs of the cell during respiration. Energy-rich ATP molecules are synthesized from ADP during the oxidative phosphorylation reaction. The energy stored in ATP comes from the oxidation of various energy-rich substances, mainly sugars, in the mitochondria.

The plastid is a membrane-bound organelle found in the cells of plants, algae, and some other eukaryotic organisms. They are considered to be intracellular endosymbiotic Cyanobacteria. Examples include chloroplasts (used for photosynthesis), chromoplasts (used for pigment synthesis and storage), and leucoplasts (non-pigmented plastids that can sometimes differentiate).

Plastids were discovered and named by Ernst Haeckel, but A. F. W. Schimper was the first to provide a clear definition. They often contain pigments used in photosynthesis, and the types of pigments in a plastid determine the cell's color. They are also the site of manufacture and storage of important chemical compounds used by the cells of autotrophic eukaryotes. They possess a double-stranded DNA molecule that is circular, like that of the circular chromosome of prokaryotic cells.

The precursors of plastids are the proplastids, small usually colorless formations located in the meristematical cells of roots and shoots.

Plant proplastids (undifferentiated plastids) may differentiate into several forms, depending upon which function they perform in the cell. They may develop into any of the following variants:

Etioplasts are the precursors of chloroplasts Chloroplasts: typically green plastids used for photosynthesis.

Chromoplasts: coloured plastids for pigment synthesis and storage

Leucoplasts: colourless plastids for monoterpene synthesis; leucoplasts sometimes differentiate into more specialized plastids:

Amyloplasts: for starch storage and detecting gravity (for geotropism)

Elaioplasts: for storing fat

Proteinoplasts: for storing and modifying protein

Depending on their morphology and function, plastids have the potential to change between the listed forms.

Plastids are relatively large cell formations. The largest of them — chloroplasts reach a length of 4-10 microns and 2-4 microns in width and are clearly distinguishable in a light microscope. The shape of chloroplasts is most often lenticular or ellipsoidal. Leucoplasts and chromoplasts can have different shapes. As a rule, there are several dozens of plastids in the cells. Chloroplasts are found in all green organs of plants, as well as in the embryos of some plants, leucoplasts are very common in the cells of organs hidden from sunlight — roots, rhizomes, tubers, as well as in the sieve-like elements of some angiosperms. Chromoplasts are found in the cells of the leaves of many plants, mature colored fruits (tomatoes, rosehip, mountain ash, etc.), sometimes in root crops (carrots).

A chloroplast is a type of organelle known as a plastid, characterized by its two membranes and a high concentration of chlorophyll. Other plastid types, such as the leucoplast and the chromoplast, contain little chlorophyll and do not carry out photosynthesis.

Chloroplasts are roughly 1–2 μm (1 μm = 0.001 mm) thick and 5–7 μm in diameter. They are enclosed in a chloroplast envelope, which consists of a double membrane with outer and inner layers, between which is a gap called the intermembrane space. A third, internal membrane, extensively folded and characterized by the presence of closed disks (or thylakoids), is known as the thylakoid membrane. In most higher plants, the thylakoids are arranged in tight stacks called grana (singular granum). Grana are connected by stromal lamellae, extensions that run from one granum, through the stroma, into a neighbouring granum. The thylakoid membrane envelops a central aqueous region known as the thylakoid lumen. The space between the inner membrane and the thylakoid membrane is filled with stroma, a matrix containing dissolved enzymes, starch granules, and copies of the chloroplast genome.

The main function of chloroplasts is photosynthesis. The central role in this process belongs to the pigment chlorophyll. In addition to photosynthesis, the synthesis of ATP from ADP, the synthesis and hydrolysis of lipids, assimilative starch and proteins deposited in the stroma are carried out in chloroplasts.

The internal structure of chromoplasts and leukoplasts is simpler. There are no granas in them.

There are no pigments in the leucoplasts, but the synthesis and accumulation of spare nutrients, primarily starch, sometimes proteins, rarely fats, can be carried out here. Very often, grains of secondary spare starch are formed in the leukoplasts.

Leucoplasts, where secondary starch is synthesized and accumulated, are called Amyloplasts, protein - Proteinoplasts, lipids — Elaioplasts.

Лейкопласты на свету могут превращаться в хлоропласты.

Leucoplasts can change into chloroplasts in the light.

Chromoplasts are plastids, heterogeneous organelles responsible for pigment synthesis and storage in specific photosynthetic eukaryotes.

Chromoplasts are found in fruits, flowers, roots, and stressed and aging leaves, and are responsible for their distinctive colors. This is always associated with a massive increase in the accumulation of carotenoid pigments.

Chromoplasts synthesize and store pigments such as orange carotene, yellow xanthophylls, and various other red pigments. As such, their color varies depending on what pigment they contain. The main evolutionary purpose of chromoplasts is probably to attract pollinators or eaters of colored fruits, which help disperse seeds. However, they are also found in roots such as carrots and sweet potatoes. They allow the accumulation of large quantities of water-insoluble compounds in otherwise watery parts of plants.

Protoplast waste products. In the process of vital activity of the protoplast, various substances arise, which have received the generalized name of ergastic substances. They are formed directly in the protoplast and are partially preserved in it in a dissolved form or in the form of inclusions. In much larger quantities, ergastic substances are concentrated outside the protoplast, forming a cell wall. The other part accumulates in the cell juice of the vacuole in the form of solutions or is deposited in the cytoplasm in the form of various inclusions. The nature and main functions of ergastic substances are different. The most important of these substances are simple proteins, some carbohydrates, in particular glucose, sucrose and starch or inulin close to it, as well as cellulose, spare fats and fat-like substances-compounds of primary metabolism; products of secondary metabolism-tannides, polyphenolic compounds, alkaloids, isoprene derivatives, etc. The ergastic substances also include calcium oxalate, which is common in many plants. Almost all ergastic substances, regardless of their nature, can be re-involved in the processes of active cell metabolism to some extent. Therefore, the division of these substances into a numerous group according to their main function is to a certain extent conditional.

The most important group of ergastic substances is spare substances. These are proteins, carbohydrates listed above, excluding cellulose, and fats.

Most ergastic substances are physiologically active. Many of them accumulate in significant quantities and are of exceptional importance in human economic activity and in medicine. The diverse use of cellulose, or fiber, is well known, starch, glucose, and sucrose are widely used in engineering, the food industry and medicine. Tannides, or tannins, polyphenolic compounds are the basis for obtaining a numerous medicinal product. Pectin substances are widely used in the confectionery industry, as well as in medicine.

Some ergastic substances are extremely toxic. Most often these are alcaloids, some glycosides, polypeptides (in the pale grebe).

A vacuole is a membrane-bound organelle which is present in plant and fungal cells and some protist, animal, and bacterial cells. Vacuoles are essentially enclosed compartments which are filled with water containing inorganic and organic molecules including enzymes in solution, though in certain cases they may contain solids which have been engulfed. Vacuoles are formed by the fusion of multiple membrane vesicles and are effectively just larger forms of these. The organelle has no basic shape or size; its structure varies according to the requirements of the cell.

The contents of the vacuole – cell juice is an acidic (pH 3-5) aqueous solution of various organic and non-organic substances. The chemical composition and consistency of the cell juice differs significantly from the protoplast. These differences are related to the selective permeability of the tonoplast performing the barrier function. Most of the organic substances contained in cell juice belong to the group of ergastic products of protoplast metabolism. Depending on the needs of the cell, they can accumulate in significant quantities in the vacuole or completely disappear. The most common are various carbohydrates, which play the role of spare energy substances, as well as organic acids. Vacuoles of seeds often contain proteins. Plant vacuoles often serve as a place of concentration of various secondary metabolites - polyphenolic compounds: flavonoids, anthocyanins, tannides and nitrogen — containing substances-alkaloids. Many inorganic compounds are also dissolved in the cell juice.

The functions of vacuoles are diverse. They form the internal water environment of the cell, and with their help, water-salt metabolism is regulated. In this regard, the role of the tonoplast involved in the active transport and accumulation of certain ions in vacuoles is important.

Another important role of vacuoles is to maintain the turgor hydro statistical pressure of the intracellular fluid in the cell. Their third function is the accumulation of spare substances and also waste, i.e., the end products of cell metabolism. Sometimes, vacuoles destroy toxic or unnecessary substances in the cell. This is usually performed by special small vacuoles containing the corresponding enzymes. Such vacuoles are called lysosomal.

Turgor pressure in plant cells contributes to the maintenance of the shape of the non-woody parts of plants. It also serves as one of the growth factors, providing cell growth by stretching. The loss of turgor causes the plants to wither. Turgors pressure is associated with the selective permeability of the tonoplast for water and the phenomenon of osmosis. Osmosis is a one-way diffusion of water through a semipermeable partition towards an aqueous solution of salts of a higher concentration. The water entering the cell juice exerts pressure on the cytoplasm, and through it-on the cell wall, causing its elastic state, i.e., providing turgor. The lack of water in the plant and thus in a separate cell leads to plasmolysis, i.e., to a reduction in the volume of the vacuole and the separation of the protoplast from the shell. Plasmolysis can be induced artificially by immersing the cell in a hypertonic solution of any salt or sugar. Plasmolysis is usually reversible, and can serve as an indicator of the living state of the protoplast.

Cell wall

The cell wall in plants is a structural formation located on the periphery of the cell, outside the plasmalemma, giving the cell strength, preserving its shape and mechanically protecting its protoplast.

The plant cell wall resists the high osmotic pressure of the large central vacuole and prevents cell fracture. In addition, the set of strong cell walls serves as a kind of external skeleton that supports the shape of the plant and gives it mechanical strength. The cell wall, having great strength, is at the same time capable of growth by stretching. These two, to a certain extent, opposite requirements are met due to the peculiarities of its structure and chemical composition.

The cell wall is usually transparent and transmits sunlight well. Water and low molecular substances can easily pass through it, but it is completely or partially impermeable to high molecular weight substances. In multicellular organisms, the walls of neighboring cells are held together by pectin substances that form a median plate.

The cell wall is a product of the vital activity of its protoplast. Therefore, the cell wall can grow only by being in contact with protoplast. However, when the protoplast dies, the wall remains, and the dead cell can continue to perform the functions of carrying water or play the role of a mechanical support.

The basis of the cell wall is made up of high-polymer carbohydrates, cellulose (fiber) molecules assembled into complex bundles — fibrils forming a framework immersed in a matrix — base consisting of hemicelluloses, pectins and glycoproteins. Cellulose molecules consist of numerous linearly arranged monomers — glucose residues. Cellulose is very resistant, does not dissolve in dilute acids and even in concentrated alkalis. The elastic cellulose skeleton gives the adhesive wall mechanical strength.

Upon completion of the growth of the wall of some cells, lignin is deposited in the wall. The process of lignin deposition is called lignification. The cell wall impregnated with lignin is strong and hard. Most often, the walls of cells subjected to mechanical loads are lignified. Such cells usually die off.

The walls of some cell types may include layers of lipids: wax, cutin and suberin. Cutin and wax usually cover the outer walls of the epidermis cells. The cutin layer creates a water – and airtight cuticle layer on the surface of the plant. Suberine impregnates the cell walls. It makes the cell wall impermeable to water and gases, so a cell with such a shell usually dies.

The cell wall is layered and consists of one or more shells. During the division of meristematic cells, a middle lamella (median plate) is initially formed, formed mainly by amorphous pectin substances. The protoplast of each cell forming its own primary shell, consisting mainly of pectin substances and hemicelluloses, on its side on the median plate. At the same time, the cell grows by stretching under the action of turgor pressure. The shells of dividing and growing cells are called primary. They are rich in water, and the cellulose content in them is relatively small (no more than 30 %). Thin sections of the primary shell are called primary pore fields.

For many cells, the deposition of new layers of the shell stops with the cessation of cell growth. In other cells, the deposition of the shell from the inside continues even after reaching the final size. The thickness of the cell wall increases due to forming of new layers, and the volume of the cell cavity decreases. This process is called secondary thickening of the cell wall, and the shell itself is called secondary. The secondary shell performs mainly a mechanical function. It is most often found in the cells of supporting tissues. The chemical composition of the secondary shell differs from the chemical composition of the primary. It contains less water and more cellulose.

Generally, secondary walls are usually formed after a cell has completed its elongation and therefore, do not normally extend as it is deposited on the inner side of the existing primary wall, next to the cell lumen. Secondary calls are present in cells which are non-living at maturity, such as sclereids, fibres, and vessel elements. The secondary wall consists of three layers, so that a cell wall way consists of five layers, the middle lamella, the primary wall and threes of secondary wall. In the majority of tracheids and fibres, secondary walls are made up of the three layers (s1, s2, s3), the central layer is usually the thickest. In some cells, however, the number of layers may be more.

The secondary shell is sometimes forming unevenly. In some vessels, it has the form of separate rings or spirals. This allows the cells to retain the ability to stretch in length. Cell walls with secondary thickenings often become lignified due to the deposition of lignin in their matrix.

Secondary cell walls are commonly characterized by the presence of cavities called pits. A pit in a cell wall usually occurs opposite a pit in the wall of an adjoining cell, and the two opposing pits constitute a pit-pair. The middle lamella and the two primary walls between the two pit cavities are called the pit membrane. Pits arise during ontogeny of the cell and result from differential deposition of secondary wall material. Pits are the areas on the cell wall on which the secondary wall is not laid down, so the pits are actual discontinuities in the secondary wall.

Pits vary in size and detailed structure, but two principal types are recognized in cells with secondary walls: simple pits and bordered pits. The basic difference between the two kinds of pit is that, in the bordered pit, the secondary wall arches over the pit cavity and narrows down its opening to the lumen of the cell. The overarching secondary wall constitutes the border. In simple pits, no such overarching occurs. In bordered pits, the part of the cavity enclosed by the border is called the pit chamber, and the opening in the border is the aperture. A combination of simple pits is termed a simple pit-pair, and of two opposing bordered pits a bordered pit-pair. Combinations of simple pits and bordered pits, called half-bordered pit-pairs, are found in the xylem. A pit may have no complementary structure, for example, as when it occurs opposite an intercellular space. Such pits are called blind pits. In addition, two or more pits may oppose a single pit in an adjoining cell, a combination that has been named unilaterally compound pitting.

The contents of neighboring cells are connected to each other through special cytoplasmic strands – plasmodesmata.

Plasmodesmata are microscopic channels that connect the cytoplasm of neighbouring plant cells with each other. They form intercellular cytoplasmic bridges called symplast. It consists of a canal, lined by plasma membrane. It has a simple or branched tubule known as desmotubule. Desmotubule is an extension of endoplasmic reticulum. Structurally, plasmodesmata are tube-like structures. There are desmotubules in space of plasmodesmata.

Desmotubules consist of a tightly packed endoplasmic reticulum. Moreover, there is a cytoplasmic sleeve between the membrane and the desmotubules. It is an extension of the cytosol.

By means of plasmodesmas, the active movement of certain substances from cell to cell is carried out.

Cystolith are outgrowths of the epidermal cell wall, usually of calcium carbonate, formed in a cellulose matrix in special cells called lithocysts, generally in the leaf of plants.

Cystolith are outgrowths of the epidermal cell wall, usually of calcium carbonate, formed in a cellulose matrix in special cells called lithocysts, generally in the leaf of plants.The cystolith is a spindle-shaped body composed of concentric layers of longitudinally oriented cellulose microfibrils associated with pectins and other cell wall polysaccharides. At maturity, it is heavily impregnated with calcium carbonate. Some cystoliths also contain silicon and are covered in a sheath of siliceous material.

Inclusions. Inclusions are components of the cell, which are deposits of substances temporarily removed from the metabolism, or its final products. Most inclusions are visible in a light microscope and are located either in the hyaloplasm and organoids, or in vacuoles. There are liquid and solid inclusions.

Very often, spare nutrients are deposited in the form of inclusions. The main and most common of them is the starch granules. The growth of starch granules occurs by superimposing new layers of starch on the old ones, so they have a layered structure. If there is one centre around which layers of starch are deposited, then a simple grain appears, if two or more, then a complex granule is formed, consisting of several simple ones. A semi-complex granule is formed in cases when starch is initially deposited around several points, and then after the contact of simple granules, common layers appear around them. The arrangement of the layers can be concentric (for example, in wheat) or eccentric (in potatoes).

Lipid drops are usually located in the hyaloplasm and are found in almost all plant cells. This is the main type of spare of nutrients of many plants, as well as of algae. In the seeds of some angiosperms (sunflower, cotton, peanuts, soy), oil makes up to 40% of the dry matter weight.

Spare proteins belong to the category of simple proteins, in contrast to complex protein - proteids that form the basis of the protoplast. Usually, spare proteins are deposited in seeds. More often, spare proteins accumulate in vacuoles and precipitate when moisture is lost during seed maturation. Usually, the deposited proteins form granules of a rounded or elliptical shape, called aleurone. If aleurone granules do not have a noticeable internal structure, they are called simple. Sometimes, in aleurone granules, one or more crystal-like structures (crystalloids) are noticeable among the amorphous protein, which, unlike real crystals, can swell in water. In addition to crystalloids, brilliant colorless round — shaped corpuscles-globoids are found in aleurone granules. Aleurone granules containing crystalloids and globoids are called complex. In each plant species, they, like starch granules, have a certain structure.

Plants, unlike animals, do not have special excretory organs and often accumulate the final products of the protoplast's vital activity in the form of oxalate or calcium carbonate salts. Crystalline inclusions of this type accumulate in significant quantities in the tissues and organs that plants periodically shed (leaves, bark). They are deposited exclusively in vacuoles. The shape of these inclusions is quite diverse: single polyhedra, rod-shaped crystals, bundles of needle-shaped crystals — raphides, clusters of many small crystals — “crystal sand”, clusters of crystals — druses. The shape of crystals is often specific to certain taxa and is sometimes used for their microdiagnosis.

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