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INTRODUCTION INTO THE HUMAN BODY

Human anatomy (from the Gk. *anatemno* — dissect) is the science of the structure of organs, organ systems and parts of the human body, considered from the standpoint of development, functionality and constant interaction with the surrounding environment.

Human anatomy corresponds to the Morphology, which is one of the most important departments of Biological Sciences. Morphology is a complex science of the form and structure of the human body in normal and pathological conditions. Morphological sciences include the descriptive (normal) anatomy, functional anatomy, age anatomy, experimental anatomy, histology, cytology, topographical (regional) anatomy for surgery, plastic (relief) anatomy for artists, comparative anatomy, radiographic anatomy, cross-sectional anatomy and pathological anatomy. As a science, the anatomy has objectives like studying of a shape, an internal structure, a position of organs and their relations based on age, sex and individual characteristics.

The process of fetal development of a human body is a study of **embryology**, detailing the mechanisms of organ formation and the body as a whole; identifying ways of improving the structure of living beings. The study of the complete life cycle of an organism from fertilization to death is known as *ontogeny* (*onthos* — individual).

The human body continues to develop after birth: changing the structure and shape of organs, their position and relations. The age anatomy includes the studying of laws of the anatomical structure of the human body after birth. Significant differences in the structure of the male and female bodies require the research of signs of sexual dimorphism (gender peculiarities).

There are individual differences in the structure, shape, and position of organs between people of the same age group. On the one hand, the individual characteristics of the body structure are related to the fact that embryos develop at different rates and attain different final weights and sizes. On the other hand, individual differences in the structure of the human body caused by the development of organs after birth which depends on life conditions. It's necessary to take into account the influence of social factors, which is the subject of anthropology, that studies man in their evolutionary development. Human anatomy should be studies from the point of view of the functional characteristics of individual organs (functional anatomy) because the function relates to the structure.

Anatomy, like a science, is linked by common scientific interests with other sciences, such as histology, molecular biology, embryology, comparative anatomy, anthropology, etc. It is a fundamental discipline in the system of a medical education, forming the base for further study of theoretical and clinical disciplines.

Human anatomy and physiology (the study of the functional characteristics of a living organism) are the theoretical base of the medicine because the knowledge of the structure and function of the human body is necessary for understanding the changes caused by the disease. In this regard, one of the important directions is the applied or clinical anatomy which develops the anatomical problems of theoretical and practical medicine. **Applied anatomy** has surgical, dental, neurosurgery directions, etc.

Depending on the task, studying the anatomy is divided into systemic, topographic, and plastic disciplines.

The **systemic anatomy** describes the structure, shape, position, relationships and the development of the system of organs. The systemic anatomy includes the *osteology* (the doctrine of the bones which make up the skeleton), *arthro-syndesmology* (the doctrine of the connection of the bones), *myology* (the doctrine of the muscles), *splanhnology* (the doctrine of the internal organs), *angiology* (the doctrine of the vascular system), *neurology* (the doctrine of the nervous system), *endocrinology* (the doctrine of the internal secretion's organs), *esthesiology* (the doctrine of the sense organs).

The **topographic anatomy** studies the structure, shape, position and the relationship of organs with each other by the areas of the body and layers.

The **plastic anatomy** studies the statics and dynamics of external forms of the human body. Plastic is the anatomy of the visual arts: painting, drawing, sculpture.

The **radiographic anatomy** involves the study of anatomical structures as they are visualized by x-rays, ultrasound scans, or other specialized procedures performed on an intact body.

The **cross-sectional anatomy** has emerged as a new subspecialty of gross anatomy as new advances in radiographic anatomy, such as CT (computerized tomography) and spiral scans, have emerged.

HISTORY

Anatomy is one of the oldest sciences. Tangible cultural monuments testify about the early appearance of anatomical details. Some organs, their position in the body and their functions were described through the ritual embalming of corpses (cadavers) even in ancient Egypt.

The scientists of Ancient Greece who created anatomical terminology had a big influence on development of the medicine and anatomy. Prominent representatives of Greek medicine and anatomy were Hippocrates, Aristotle and Herophilus.

Hippocrates (Hippokrates) (460–377 BC) was a Greek physician, traditionally regarded as the father of medicine. He received a medical education on the island Kos where the famous medical school was. His name is associated with the medical profession's Hippocratic oath from his attachment to a body of ancient Greek medical writings, some of which was written by him.

Aristotle (384–322 BC) was the great Greek philosopher and scientist. His works include "History of Animals", "On the parts of Animals", "On the generation of Animals "and others.

Herophilus (4th–3rd centuries BC) was a Greek anatomist who practiced medicine in Alexandria. He combined the existing anatomical details and described unknown before him the ventricles of the brain and its meninges, vascular plexus, venous sinuses of the cranial dura mater, duodenum, prostate, seminal vesicles, and others. He was regarded as the father of human anatomy.

The most prominent representative of Roman medicine and anatomy was Galen.

Claudius Galen (131–201 AD), full name Claudios Galenos, was a Greek physician. He attempted to systematize the whole of medicine, making important discoveries in anatomy and physiology. His works became influential in Europe when retranslated from Arabic in the 12th century. Medicine issues included more than 100 tractates ("Anatomical studies", "On the Usefulness of the Parts of the Body" etc.). Galen advocated the need for knowledge of anatomy and physiology in the practice of medicine. He contributed a lot of new information into the anatomy (described the muscles of the spine, three tunicae of artery, quadrigeminal plate of the mesencephalon, seven pairs of cranial nerves, the largest vein of the brain). Galen's anatomical works formed the base of anatomy (till the end of the Middle Ages).

Avicenna (980–1037 AD) was a Persian-born Islamic philosopher and physician; Arabic name ibn-Sina. He was educated and began to practice medicine in Bukhara. Then he was the court physician in Khorezm and Iran. His Canon of Medicine was a standard medieval medical text which had been reprinted 40 times in different countries (from 20 years of the XI century). The Avicenna's work was a handbook for the doctors during several centuries. Avicenna was the greatest physician and scientist of the East.

The following century entered into history as the Renaissance was marked by great scientific discoveries, increased attention to the literature and the arts. In this era many scientists had made a significant contribution to the anatomy, especially the major figures of the Renaissance whose names are Leonardo da Vinci and Andreas Vesalius.

Leonardo da Vinci (1452–1519) was an Italian painter, scientist, and engineer. He devoted himself to a wide range of other subjects, from anatomy and biology to mechanics and hydraulics. He made a lot of anatomical drawings with explanatory notes. Da Vinci presented the classification of muscles and analyzed their work using the laws of mechanics, discovered and described the thyroid gland, and curves of the vertebral column.

Andreas Vesalius (1514–1564) was a Flemish anatomist, the founder of modern anatomy. He dissected and prepared corpses, made pictures of bones, muscles, organs, blood vessels, nerves. In 1538 Vesalius published the "Anatomical tables", a small anatomical atlas. He drew and transcribed notes during the autopsy and dissection of corpses. The result of many years of the hard work was his famous work "Structure of the human body" ("De Humani Corporis Fabrica") published in Basel in 1543, contained accurate descriptions of human anatomy, but owed much of its great historical impact to the woodcuts of his dissections. This essay dealt the devastating blow to the scholastic anatomy and determined the direction of anatomy in the next century.

Several major discoveries in the anatomy were made in the XVII century. In 1628 **W. Harvey** (1578–1657) described the greater and lesser circles; moreover the basic laws of blood flow through the vessels ("De Motu Cordis" 1628) which became the beginning of the functional anatomy.

G. Aselli (1581–1626) described the lymphatic vessels of the intestine, **J. Van Horn** (1621–1670) discovered the thoracic duct, **M. Malpighi** (1628–1694) discovered the alveoli and capillaries in the lungs and demonstrated the pathway of blood from arteries to veins.

In the same century, scientists began to use a microscope to investigate the internal structure of organs.

Medicine was rapidly developed in Russia in the XVIII century. In 1706 in Moscow, the first surgeon's ("lekarskaya") school was established at the military hospital. Its leader was Dr. **Nicholaas Bidloo**. The similar schools were opened in other cities (in 1715 in St. Petersburg in the land and naval hospitals, in 1717 — in Kronshtadt at the Naval Hospital, in 1733 — in Tavrov and Arkhangelsk). Moscow University was founded in 1755 by the request of M.V. Lomonosov, and the Medical Surgical Academy was established in St. Petersburg in 1798.

The teaching of anatomy was supplied well at these schools.

M.I. Shein (1712–1762) was the chief doctor of St. Petersburg Admiralty Hospital. He developed the first Russian anatomical terminology. He published an anatomical atlas in 1744, and the first anatomy textbook translated into Russian in 1757. Students dissected corpses during their learning of the anatomy.

N.M. Maksimovich-Ambodik (1744–1812) was the school teacher at Kronshtadt Admiralty Hospital, Honorary Member of the Medicine Collegium, in 1793 he issued "Anatomical and physiological Dictionary", where he described the structure and functions of the human body.

The outstanding Russian anatomist of the first half of the XIX century was **P.A. Zagorskiy** (1764–1846), he was the head of the physiological anatomy at the Medical Surgical Academy. P.A. Zagorskiy created the first original Russian anatomy textbook in 1802. He continued Shein's work for establishing Russian anatomical terminology, researched objects of the comparative anatomy. P.A. Zagorskiy expressed materialistic views on the development of organisms, similar to the theory of evolution. He created the first Russian anatomic school.

The famous anatomist and surgeon was the professor of the Medical Surgical Academy **I.V. Buyalskiy** (1789–1866) who researched problems of the surgical anatomy. He prepared and issued "Anatomical surgical tables" (1828, 1835, 1852). He was the founder of the topographical anatomy in Russia.

N.I. Pirogov (1810–1881) was the head of the Department of Surgery and the clinic of Hospital

Surgery (the 2nd Military Land Hospital), the prominent surgeon, anatomist and public figure. He introduced the new anatomy research methods to cut frozen corpses and «ice sculpture» which allowed precise and clear identifying of relative positions of organs. N.I. Pirogov wrote a number of anatomical books, "Surgical anatomy of the arterial trunks and fascia" (1837), "Full course of applied anatomy of the human body" (1843–1844), "Illustrated Topographic Anatomy of Dissections Made in Three Dimensions across the Frozen Human Body" (1851–1859) and others. He was one of the first who began to carry out experiments on animals and cadavers to solve clinical problems.

By the end of the XIX century, the gathering of facts was basically finished in the anatomy. Scientists began to generalize and formulate the laws of the structure of the human body, influences of the environment, living conditions, physical exercises. They began to identify the individual, gender and age differences, to study the anatomical changes of the relationship of organs during the pathological processes.

P.F. Lesgaft (1837–1909) was the professor of Kazan University; he studied the environmental effects on the development, structure and shape of the body. He summarized his research in the writings "Bases of theoretical anatomy" (1892) and "Human Anatomy" (1895–1896). P.F. Lesgaft was the founder of the science of physical training and sport medicine, the founder of the functional anatomy in Russia.

D.N. Zernov (1843–1917) was the professor at Moscow University; he published a study of the brain structure and an anatomy textbook.

There were many outstanding scientists who had made great contributions to the science in the first half of the XX century.

V.P. Vorobiev (1876–1937) was the professor of Kharkov Medical Institute; he offered an original method of macro- and microscopic examination of the nervous system and received new information about the anatomy of the autonomic nervous system plexus. He created Russian human anatomy atlas.

V.N. Shevkunenko (1872–1952) was the professor of the Military Medical Academy; he developed the doctrine of the individual anatomical variability of organs and systems of the human body which has the great importance in the surgery. He owned the original works "Typical human Anatomy" (with A.M. Geselevich, 1935), "Atlas of peripheral nervous and venous system" (with A.N. Maximenkov and A.S. Vishnevsky, 1949) which was awarded the State Prize. V.N. Shevkunenko produced a number of topographic anatomy books and manuals; he created a large school of topographic anatomists.

V.N. Tonkov (1872–1954) was the founder of the collateral circulation doctrine, the author of the first Russian anatomy textbook.

Basic researches in the field of the lymphatic system anatomy were made by **G.M. Josiphov** (1870–1933) and his disciple **D.A. Zhdanov** (1902–1971).

B.A. Dolgo-Saburov (1900–1960) devoted his studies to learning the innervation and blood supply of vessels and internal organs.

M.G. Prives (1904–2000) was the researcher of an influence of the labour activity on the structure of the musculoskeletal system and cardiovascular system, circulatory system adaptation to the gravitational stress. He made a lot for the introduction of X-rays to the human anatomy studying. He was the co-author of the anatomy textbook which repeatedly published in Russian and foreign languages, and so far is used to study the human anatomy.

S.S. Mikhailov (1919–1993) introduced a significant contribution to the anatomy. He was the author and editor of monographs "Arterio-venous carotid-cavernous aneurysms" (1965), "The innervation of intra- and extracranial venous structures" (1964), "Clinical Anatomy of the Heart" (1987), moreover the author of a textbook "Human Anatomy" for stomatologists (1973).

V.V. Kupriyanov (1912–2006) was the academician of the Academy of Medical Sciences, the head of a large school of anatomists in Russia and abroad. His main works are devoted to the study of organs' microcirculation in normal, pathological and experimental conditions. He developed no-injection techniques to identify the vessels of the microcirculatory system, formulated the scientific direction of transcapillary and juxtacapillary bloodstreams. Researches of peripheral and autonomic nervous systems were carried out under the direction of V.V. Kupriyanov.

HUMAN DEVELOPMENT

Two main periods are distinguished in the development of an individual organism which is termed the ontogeny (prenatal and postnatal development). Prenatal development is the period from the time of fertilisation until birth. This period of time required for full development of a fetus in utero is referred to as gestation (*gestare* "to carry" or "to bear"). Embryo refers to the developing zygote from the third week of development to the end of the eighth week. During this period all the major organs, systems and placenta are developed. During the first two week after fertilization implantation occurs. This period is referred to as the *germinal or pre-embryonic period*. Fetus refers to the developing zygote from the ninth week until birth. Birth usually occurs at the end of the ninth lunar/month (40 weeks). The fetus has a human appearance. Postnatal development extends from birth to death.

The central feature of reproduction is the fusion of two gamete pronuclei at fertilization. In humans the male gametes are spermatozoa, which are produced from puberty onwards. Female gametes are released as secondary oocytes in the second meiotic metaphase; the oocyte has become an ovum. Fertilization involves the transport of spermatozoa and ovum, capacitation, approximation and fusion of gametes. Fertilization usually occurs in the ampulla or lateral third of the fallopian tube. Because each of these reproductive cells is a haploid cell; they combine a diploid cell. This new single cell, called a **zygote** (Fig. 1), contains all of the genetic material needed to form a human (half from the mother and half from the father). Two haploid nuclei derived from the sperm and oocyte are referred to as pronuclei. Two pronuclei make contact, lying side by side (syngamy). They decondense, expand, and replicate their DNA in preparation for mitosis. Then the pronuclei migrate toward each other, their nuclear envelopes disintegrate, and the male- and female-derived genetic material intermingles. This step completes the process of fertilization and results in a single-celled diploid zygote with all the genetic instructions it needs to develop into a human. Cleavage is defined as repeated mitotic division or segmentation of the zygote resulting in a ball of cells termed the **morula** (*morula* — "little mulberry"). The first cleavage begins 30 hours after fertilization. Cleavage lasts four days. The resultant 12 to 16 individual cells of the morula are known as **blastomeres** (*blastos* — "germ" in the sense of a seed or sprout). As cleavage proceeds the morula is moved along the uterine tube towards the uterine cavity. by peristalsis and beating cilia of the uterine tubes. Four days after fertilization, when the morula enters the uterus, fluid-filled spaces between the blastomeres appear and fuse into a central cavity called the **blastocoele**. Cleavage is said to be completed, when the morula becomes a **blastocyst.** The morula consists of two groups of cells: the **outer cell mass** and **inner cell mass**. The inner cell mass occupy the inner part of the morula. They will later develop into the **embryo proper**. The outer cell mass cells reside in the peripheral part of the morula and will give rise to the nourishing and protective membranes which surround the embryo; it is termed the trophoblast (*trophe* "to feed" or "to nourish"). As the blastocyst forms, the trophoblast excretes enzymes that begin to degrade the zona pellucida. In a process called "hatching", the conceptus breaks free of the zona pellucida in preparation for implantation. At the end of the first week, the blastocyst comes in contact with the uterine wall and adheres to it, embedding itself in the uterine lining via the trophoblast cells. The blastocyst typically implants in the fundus of the uterus or on the posterior wall. When implantation succeeds the superficial cells of the trophoblast fuse with each other, forming the syncytiotrophoblast, a multinucleated body that digests endometrial cells to firmly secure the blastocyst to the uterine wall. The underlying cells of the trophoblast are termed cytotrophoblast cells. At the beginning of the second week, the cells of the inner cell mass form into a two-layered disc of embryonic cells, and a space, the amniotic cavity, opens up between it and the trophoblast (Fig. 2). Cells from the upper layer of the disc (the epiblast or ectoderm) extend around the amniotic cavity, creating a membranous sac. On the ventral side of the embryonic disc, opposite the amnion, cells in the lower layer of the embryonic disk (the hypoblast or endoderm) expand into the blastocyst cavity and compose a

yolk sac. Endoderm and ectoderm form the germ disc or bilaminar disc. This disc will develop into the embryo. The amniotic cavity is roofed by amnion. The layer of flattened cells is termed the exocoelomic or Heuser's membrane. A loose network of cells develops between Heuser's membrane and the cytotrophoblast. This is termed the extraembryonic mesoderm. Fluid filled spaces develop in the extraembrynic mesoderm. These become confluent and give rise to a large cavity which surrounds the yolk sac and the amniotics sac except at one end. This linking bridge of extraembrynic mesoderm is the connecting or body stalk. The large cavity is known as the extraembryonic coelom. It splits the extraembryonic mesoderm into an inner layer around the amniotic and yolk sacs and an outer layer next to the cytotrophoblast. The extraembryonic mesoderm around the yolk sac is termed splanchnopleuric mesoderm. The outer layer of the extraembryonic mesoderm and the part of the inner layer covering the amniotic sac is termed somatopleuric mesoderm. The somatopleuric mesoderm and the overlying trophoblast form the chorion. By the end of the second week the blastocyst is called the chorionic vesicle because it is surrounded by chorion. At about the thirteenth day the conceptus is completely embedded. As the above changes are occurring in the embryoblast, the trophoblast differentiates further so as to establish a haemotrophic mode of nutrition.

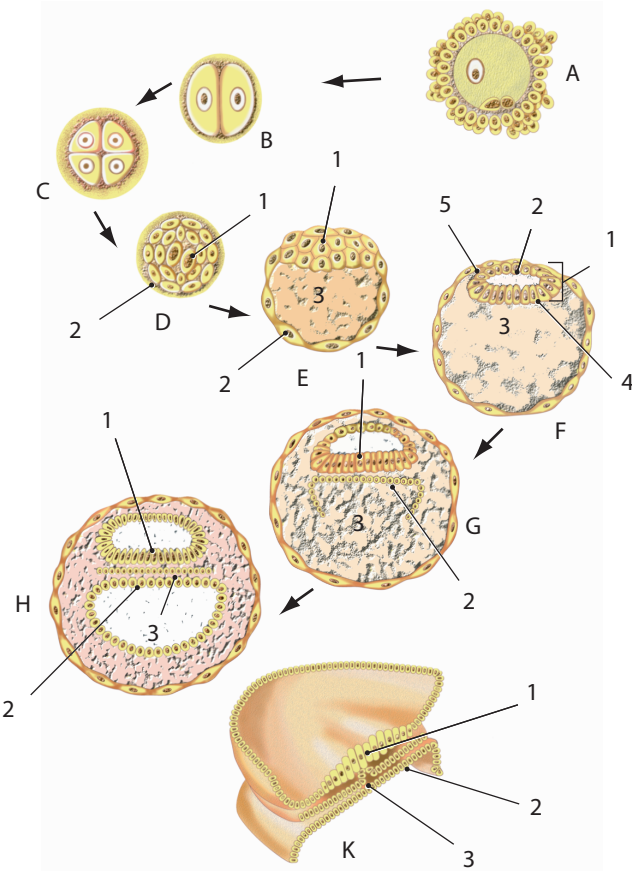


Fig. 1. The zygote division and the process of formation of germ layers: A — zygote; B, C — zygote division; D — blastula: 1 — embryoblast; 2 — trophoblast; E — blastocyst: 1 — embryoblast; 2 — trophoblast; F — blastocyst: 1 — embryoblast; 2 — amniotic cavity; 3 — blastocel; 4 — embryonic endoderm; 5 — amniotic epithelium; G, H, K — process of formation of germ layers: 1 — ectoderm; 2 — endoderm; 3 — mesoderm

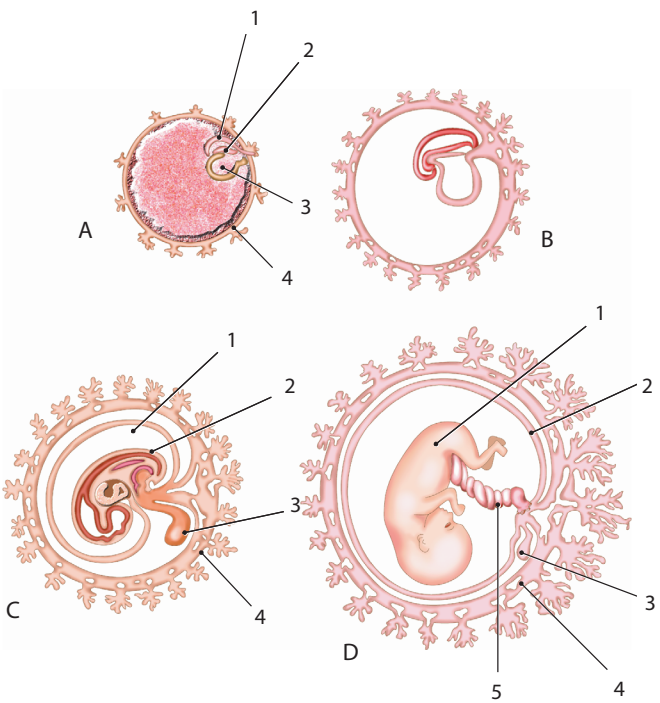


Fig. 2. The development of embryo and fetal extraembryonic membranes in the early stages of ontogenesis (scheme): A — 2–3 week embryo; B — 4-week embryo; C — 6-week embryo; 1 — amniotic cavity; 2 — body; 3 — yolk sac; 4 — trophoblast; D — 4–5 month fetus: 1 — body; 2 — amnion; 3 — yolk sac; 4 — chorion; 5 — umbilical cord

At about the 15th day after fertilization a midline ridge of ectodermal cells develops in the caudal part of the embryo just cranial to the cloacal membrane. This is the primitive streak. Cells spread laterally between the ectoderm and endoderm and form a new third layer, the intraembryonic mesoderm. The cranial mesoderm is the cardiogenic mesoderm and gives rise to the heart and part of the diaphragm in the adult. As a result of the insinuation of mesoderm between ectoderm and endoderm the embryonic disc becomes three layered or trilaminar. This process is known as gastrulation and the embryo during this phase of development is known as a gastrula. At the completion of gastrulation at about the end of the fourth week the primitive streak regresses and degenerates. The primitive streak has a bulbous cranial end termed the primitive knot (also known as primitive node or Hensen's node). As the primitive streak elongates to its caudal end, its cranial end elongates to form a primitive knot. Caudal to the primitive knot the primitive streak has a midline groove termed the primitive groove. The primitive knot has a depression called the primitive pit. From the primitive pit and proceeding cranially towards the prochordal plate there grows a solid cord of the cells termed the notochordal process. The notochordal process insinuates itself between ectoderm and endoderm. The notochordal canal becomes a solid cord of the cells termed the notochord (Fig. 3). The intraembryonic mesoderm on either side of the notochord becomes thickened to form two longitudinal columns which are named paraxial mesoderm. This is the intermediate cell mass or intermediate mesoderm. External to it the lateral plate mesoderm is continuous with extra-embyonic mesoderm at the periphery of the disc. Fluid-filled spaces appear in the lateral plate mesoderm. This eventually fuse to form an intraembryonic coelom. This is a horseshoe shaped cavity with its lateral arms being continuous cranially in the cardiogenic mesoderm. The part of the coelom within the cardiogenic mesoderm will develop into the pericardial cavity. The arms of the coelom are called pleuroperitoneal canals. The caudal ends of the canals break through the peripheral mesoderm and communicate with extraembryonic coelom on either side.

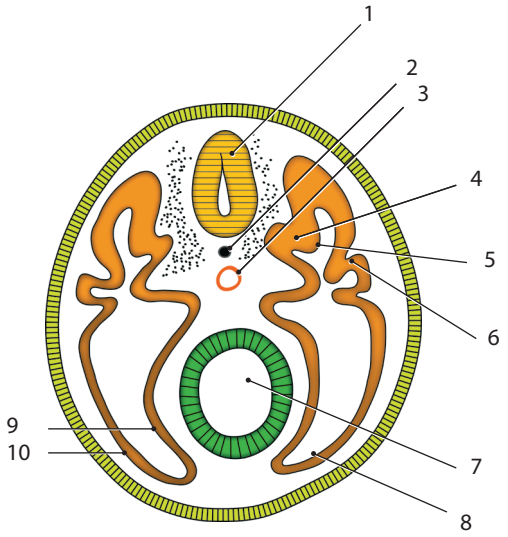


Fig. 3. The somite structure (transverse section): 1 — neural tube; 2 — notochord; 3 — aorta; 4 — sclerotome; 5 — myotome; 6 — dermatome; 7 — gastrocele; 8 — secondary body cavity (coelom); 9 — splanchnopleura; 10 — somatopleura

At the same time there is increased secretion of amniotic fluid. A head fold, a tail fold and two lateral folds are formed as a result of folding-under of the cranial, caudal and lateral parts of the embryo respectively. These foldings convert the flat embryonic disc into a cylindrical embryo. Rapid growth of the cranial end of the neural tube is also associated with its differentiation into forebrain, midbrain and hindbrain. The rapid growth results in the bending ventrally of the embrynonic disc. After folding of the embryo endoderm forms a hollow tube, the primitive gut, which contributes to the development of the parts of the gastrointestinal, respiratory, urogenital and urinary systems.

During the third week the allantois develops as a small diverticulum which projects outward from the caudal part of the yolk sac into the mesoderm of the connecting stalk. Chorion develops in the second week of gestation. At first it consists of three layers: extraembryonic mesoderm, cytotrophoblast and syncytiotrophoblast. The implanted embryo is surrounded by chorion which has villous stems with numerous side branches and terminal villi. With continued growth of the implanted embryo the deciduas capsularis approaches and

finally fuses with deciduas parietalis during the third to fifth month of gestation. Further growth of the embryo results in compression and subsequent atrophy and disappearance of chorionic villi in the desidua capsularis. The bald chorion that results is known as chorion leave. In the deciduas basalis chorionic filli persist and form the chorion frondosum. Fetal membranes are extraembryonic tissues necessary for the nourishment, protection and support of the embryo. These tissues are widely believed to be of trophoblastic origin and include: yolk sac, allantois, amnion, chorion and umbilical cord (Fig. 4). This endodermal evagination, allantois is rudimentary in human beings. Within the extraembryonic mesoderm surrounding the vestigial allantois there are developing umbilical blood vessels and "forming" blood in the third and fourth weeks. The human placenta at term, is flat and circular or oval in shape with an average volume of 500 ml; average weight of 500 gm. The diameter is 250 mm while the average thickness is about 25 mm. The placenta is thickest in the middle and thin at the periphery where it is continuous with the chorion leave. The placenta has a smooth shiny fetal surface and the rough and granular maternal surface.

During the fourth week the embryo enters into the process of body building. A process involves differentiation and growth of the individual germ layers into tissues and organs and folding of the embryo to form a tubular body. By the end of the eighth week, all the major organ systems have begun to develop, but the functioning of most organs is minimal. Within the first eight weeks of gestation, a developing embryo establishes the rudimentary structures of all of its organs and tissues from the ectoderm, mesoderm, and endoderm. Like the central nervous system, the heart also begins its development in the embryo as a tube-like structure. The heart begins beating in the beginning of the fourth week. During weeks four–five, the eye pits form, limb buds become apparent, and the rudiments of the pulmonary system are formed. By week seven, the facial structure is more complex and includes nostrils, external ears, and lenses. By the eighth week, the head is nearly as large as the rest of the embryo's body, and all major brain structures are in place. By the end of the embryonic period, the embryo is approximately 3 cm from crown to rump and weighs approximately 8 g.

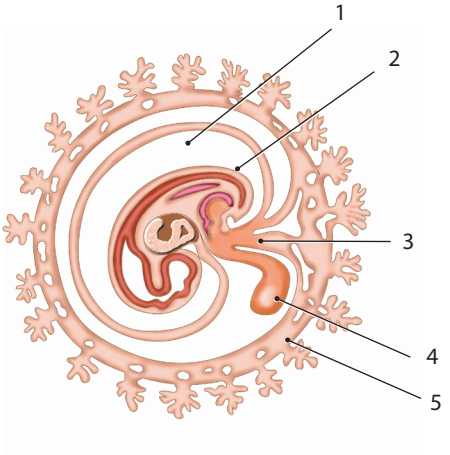


Fig. 4. The human embryo, sixth week of development: 1 — amniotic cavity; 2 — body of an embryo; 3 — umbilical cord; 4 — yolk sac; 5 — trophoblast

The histogenesis is formation of different tissues from undifferentiated cells, which are constituents of three primary germ layers; organogenesis is period of human development during which the embryo is becoming a fully functional organism capable of independent survivia; systemogenesis is formation of the functional systems.

During the third week, as the notochord is developing, ectodermal cells in the region between the prochordal plate and the primitive node thicken and form the neural plate. The neural plate folds into a midline, neural groove flanked on each side by elevated ridges called neural folds. The ectoderm medial to the neural folds is known as neuroectoderm. The ectoderm peripheral to the neural folds is known as surface or skin ectoderm. Two neural folds approach each other and ultimately fuse in the midline. The groove of neuroectoderm is now converted into a neural tube. Skin or surface ectoderm of one side joins the skin ectoderm of the other side so that the neural tube lies below the surface. Just prior to fusion of the neural folds the neuroectodermal cells at the summit of the neural fold (i.e,. adjacent to skin ectoderm) separate from the folds, sink into the underlying mesoderm and come to

lie dorsolateral to the neural tube. They form the neural crest. Under the influence of the segmenting paraxial mesoderm the neural crest breaks into cell groups that correspond to the mesodermal somites. Cranial to the somites the neural crest forms irregular non-segmented masses on either side of the neural tube. The completely closed neural tube detaches from surface ectoderm and becomes surrounded by mesoderm. The neural tube will give rise to the brain, spinal cord and some peripheral nerves. Neural crest cells in the non-segmented (cranial) and segmented (caudal) parts of the neural crest give rise to sensory ganglia, sympathetic ganglia, adrenal medulla, odontoblasts, pia-arachnoid and Schwann cells. The surface ectoderm largely contributes to the protective covering i.e. epidermis, hair, nails, sweat and sebaceous glands.

Towards the end of the third week (20th day) the paraxial mesoderm becomes segmented into a series of blocks. Each block is known as a somite and the interval from the 20th to 30th day is known as the somite period. Segmentation of the paraxial mesoderm proceeds up to the thirtieth day when the embryo attains the full complement of 44 somites. The four to five pairs of the most cranial somites are known as occipital somites. They are situated on either side of the hindbrain and notochord. They contribute to the formation of the base of the skull. Structurally each somite is a block of mesoderm which at first contains a cavity known as a myocoele. The myocoele is later obliterated by the proliferation of surrounding cells. The resultant solid block of mesoderm differentiates into a ventromedial part called the sclerotome and a dorsolateral part called the dermomyotome. The cells of the sclerotome migrate ventromedially and become organized around the notochord and neural tube. Here they give rise to primitive vertebrae. The dermomyotome is a composite structure consisting of a lateral dermal plate and a medial muscle plate or myotome. The dermal plate gives rise to the dermis while the myotome differentiates into skeletal muscle. Intermediate mesoderm is a longitudinal tract of mesoderm just lateral to the somites. It connects the paraxial mesoderm to the lateral plate mesoderm. Intermediate mesoderm will give rise to organs of the urinary and genital systems.

Lateral plate mesoderm is intraembyonic mesoderm extending from intermediate mesoderm to the edge of the embryonic disc. Cranially the lateral plate mesoderm of one side is continuous with that of the other side by means of a bar of mesoderm lying proximal to the buccopharyngeal membrane. The bar of mesoderm is known as the pericardial bar or cardiogenic mesoderm. The appearance of the intraembyonic coelon during the third and fourth weeks divides the lateral plate mesoderm into two layers: somatic or parietal and splanchinic or visceral. Somatic intraembryonic mesoderm is also known as somatopleure. It lies between the coelom and ectoderm. Splanchnic mesoderm is also known as splanchnopleure. It lies between the coelom and endoderm. The somatopleure will develop into to the skeletal and muscle elements of the limbs. The splanchnopleure develops into the visceral layer of the pericardial, pleural and peritoneal sacs; and the musculature of the heart respiratory and gastrointestinal systems.

A tube-like gut gives rise to the epithelial lining of the gastrointestinal system, respiratory system, urinary bladder and urethra, and the parenchyme of the tonsils, thyroid, parathyroid, thymus, liver and pancreas.

The fetal period extends from the ninth week to 38th week inclusive (after ovulation). It is a period of extensive growth of the fetus with relatively less tissue differentiation. The latter attribute makes the fetus less sensitive to teratogenic agents during the period. Organs which were formed during the second month now undergo extensive growth and functional maturation so that by the end of gestation the fetus will be capable of surviving outside the uterus. This period is also characterized by the complete development of the placenta and fetal membranes to meet the increased metabolic needs of the growing fetus. As a result of growth and differentiation the embryo at the eight week has a distinct human appearance with a face, eye, ear and a limb bud. The head is large with respect to the rest of the body but it is no longer such a prominent feature of the body. The face has eyes which have migrated into the frontal plane. In the limbs the different parts of the adult limb (arm, elbow, forearm, wrist and hand; thigh, knee, leg ankle and foot)

have developed. The distal parts of the limbs which were once paddle shaped now have developed fingers and toes. At 20 to 24 weeks the head is about 30% of the crown-heel length. Fetal or crown-heel length at 20 weeks is about 25 cm and doubles (to 50 cm) at term. Fetal weight at 20 weeks is one sixth of the birth weight. The normal birth weight is 2.5–3.5 kg. From the 20th week onwards movements of the limbs and trunk (fetal movements) are strong enough to be detected by the mother. The phenomenon is known as "quickening". During the sixth month of gestation (24 weeks onwards) the fetal lungs begin to secrete surfactant. Surfactant reduces the surface tension of the thin film of fluid coating the surfaces of the pulmonary alveoli. In this way surfactant assists in the expansion and inflation of the lungs. During the seventh month the fetal lungs have alveoli surrounded by blood capillaries and pulmonary maturity is reached. If pregnancy is terminated after the seventh month, the fetus can exist (respire) independently. The seventh month is therefore called the viable age of the fetus. In practice survival of such a fetus is ensured by giving it medical and technological assistance in the field of neonatology. The age of embryos can be determined by using several criteria. These include the estimated date of conception, the size of the embryo, and the degree of development of the embryo.

After birth the body and organs are growing. Proportions exchange, differentiation of tissues continues.

The gradations of postnatal period of ontogeny include the neonatal stage (newborns, 1–28 days), first postnatal year (28 day — 1 year), infancy (1–3 years), early childhood (4–7 years), later childhood (8–12 years), juvenile stage (13–16 years), youthful (17–21 years), young adults of college age (22–35 years), middle-aged, mature adults (36 to 60 years), elderly people (61–74 years); people of old age (75 years of age and older). People 90 years of age and older form the longevity group.

QUESTIONS FOR SELF-CONTROL

1. What are the objectives of the anatomy as a science? What does it study?
2. Who dissected corpses for research of the human body at the first time?
3. Who is considered the reformer of anatomy? What works did he write?
4. What are the most prominent anatomists in the XVII–XIX centuries? List their works and contribution to the development of the anatomy.
5. Which stages of the embryonic development of the fetus do you know?
6. Name the age periods of a human life.

STRUCTURAL ORGANIZATION OF THE HUMAN BODY

The human body is composed of cells and noncellular structures which consistently united in tissues, organs, organs' systems and the human body as a whole during the process of philo- and ontogenesis. A *cell* (*cellula*) is an elementary genetic, structural and functional unit, the main structural element of all living organisms (Fig. 5). A surface apparatus, cytoplasm and nucleus are the components of a human body cell.

The surface apparatus of a cell includes the cell membrane, *surface specializations* (*specialisationes superficiales*) or the supramembrane complex and submembrane structures. The *cell membrane*, *plasmalemma* (*membrana cellularis*, *plasmalemma*) is composed of the biphospholipid layer and protein molecules which are either on its surface or penetrate it (Fig. 6). Intracellular membranes have a similar structure. A supramembrane layer is termed the *glycocalyx* (*glycocalyx*) consisting of carbohydrate molecules (residue) associated with the proteins. This is a receptor unit of a cell. A submembrane complex is formed by an *ectocytoplasm*, *cortical cytoplasm* (*ectocytoplasma*) which contains microtubules and microfilaments composed of protein structures that act as the cytoskeleton. The surface apparatus of a cell provides the transmembrane transport of substances into and out of the cell.

The *cytoplasm* (*cytoplasma*) contains the *cytosol* (*cytosol*, *matrix cytoplasmatica*), *organelles and cytoplasmic inclusions* (*organella et inclusiones cytoplasmicae*). The cytosol is a colloidal solution, the internal environment of the cell where all metabolic reactions occur. The organelles are permanent struc-

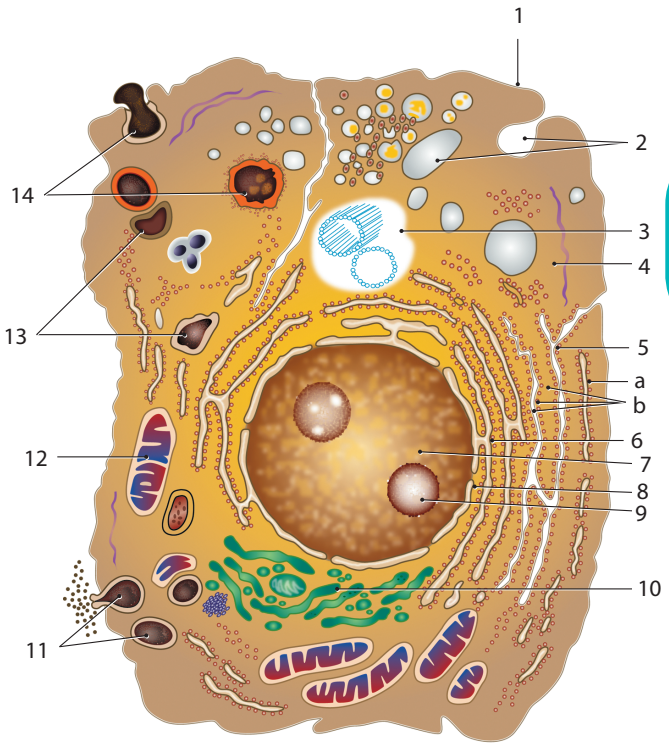


Fig. 5. Structural organization and some principal organelles of a typical cell: 1 — cell membrane (plasmalemma); 2 — pinocytotic vesicles; 3 — centrosome (cytocentre); 4 — cytoplasm; 5 — endoplasmic reticulum: a — membrane of a rough endoplasmic reticulum, b — ribosomes; 6 — connection of the perinuclear space with endoplasmic cavities; 7 — nucleus; 8 — nuclear pores; 9 — nucleolus; 10 — Golgi apparatus (complex); 11 — secretory vacuoles; 12 — mitochondrion; 13 — lysosomes; 14 — stages of phagocytosis

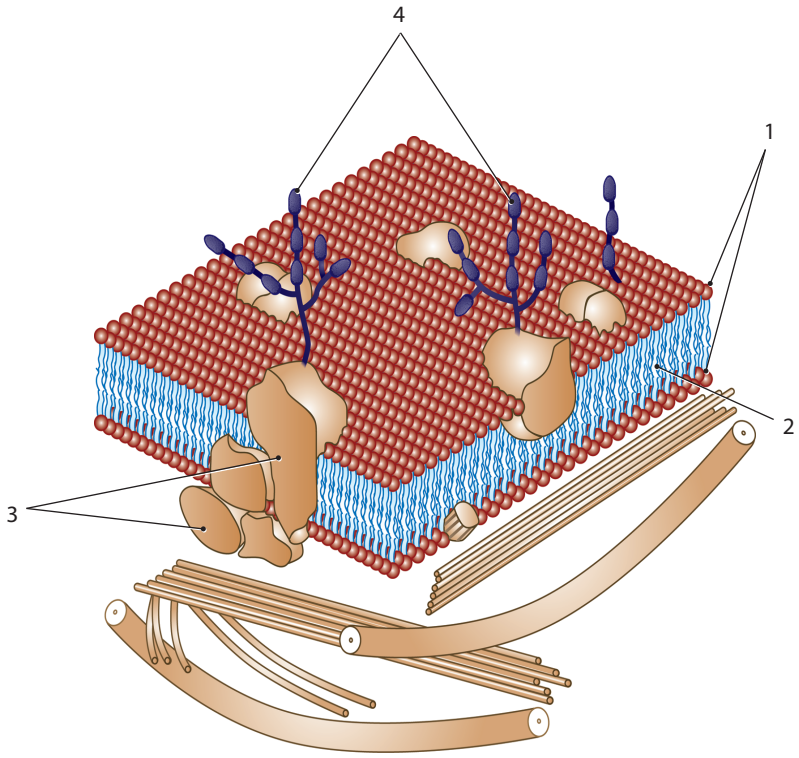


Fig. 6. Molecular organization of a cell membrane (plasmalemma): 1 — phospholipids; 2 — hydrophobic tails of phospholipids; 3 — proteins; 4 — glycolipids of glycocalix

tures of a cell; they have a specific structure and perform certain functions. They include the ribosomes, endoplasmic reticulum, Golgi complex, lysosomes, peroxysomes, mitochondria, cytocentre (centrosome).

Ribosomes (*ribosomae*) are the organelles carrying out protein synthesis. Large groups of the ribosomes are called *polysomes* (*polyribosomae*). Ribosomes are joined with the walls of the endoplasmic reticulum which are formed by membranes and receive synthesized proteins.

An *endoplasmic reticulum* (*reticulum endoplasmicum*) is the main highway of the intracellular transport. The part with the ribosomes is called the *rough endoplasmic reticulum* (*reticulum endoplasmicum granulosum*). The other part which is free from ribosomes is named the smooth endoplasmic reticulum (*reticulum endoplasmicum non granulosum*). It synthesizes carbohydrates and lipids. A tubular content comes into the Golgi complex.

The *Golgi complex*, *Golgi apparatus* (*complexus golgiensis*, *apparatus golgiensis*) is composed of vesicles, saccules and tubules, their walls are formed by the membrane. Synthesis products are «packaged» there and then go into the cytoplasm and are used by a cell or are evacuated from it.

The cell membrane, endoplasmic reticulum and Golgi complex constitute a common cell membrane system.

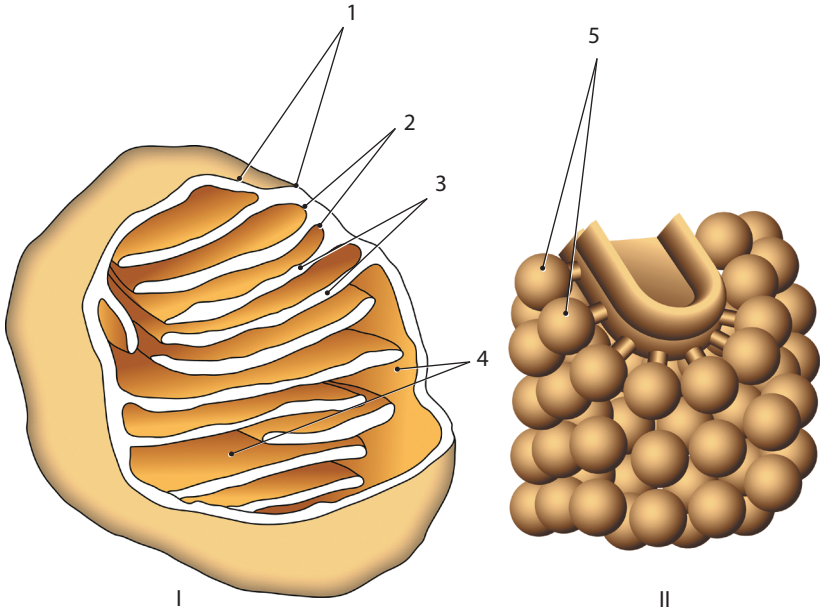


Fig. 7. The Mitochondrion: I — principal scheme: 1 — external mitochondrial membrane; 2 — internal mitochondrial membrane; 3 — cristae; 4 — mitochondrial matrix; II — the scheme of a mitochondrial crista: 5 — elementary particles (particula fungiformis)

Lysosomes (*lysosomae*) are separated from Golgi complex and contain up to 60 hydrolytic enzymes. *Peroxysomes* (*peroxysomae*) are similar to lysosomes and hold about 40 enzymes transforming peroxydes, particularly hydrogen peroxide.

Metabolic processes are provided with the energy of adenosine triphosphate (ATP) which is synthesized in the *mitochondria* (*mitochondria*) (Fig. 7). The *mitochondrion* (*mitochondrion*) is the energy plant of the cell.

Cell division involves *centrioles* (*centriola*) of a cytocentre (centrosome). These two cylindrical structures form the centres of the daughter cells and compose a *mitotic spindle* (*fusus mitoticus*) of the cell division apparatus.

Cytoplasmic inclusions are not always present in the cytoplasm, yet are considered a normal part of the cell. There are stored food (carbohydrates, lipids) and cell pigments (exogenous, endogenous) inclusions.

The *nucleus* (*nucleus*) has a different shape and is comprised of the nuclear envelope, nucleoplasm, nucleolus (Fig. 8).

The *nuclear envelope* (*tegumentum nucleare*) is the limited structure that compartmentalizes the contents of the nucleus, segregating them from the cytoplasm. It consists of the *outer* and *inner nuclear membranes* (*membranae nucleares externa* et *interna*) with unique bidirectional access sites called *nuclear pores* (*porus nuclearis*).

The *nucleoplasm*, *karyoplasm* (*nucleoplasma*) is composed of the *fibrous lamina* (*lamina fibrosa nuclearis*), *chromatin* (*chromatinum*), *nuclear body* (*corpusculum nucleare*).

A *nucleolus* (*nucleolus*) has got the *nucleolonema* (*nucleolonema*) with the *amorphous part* (*pars*

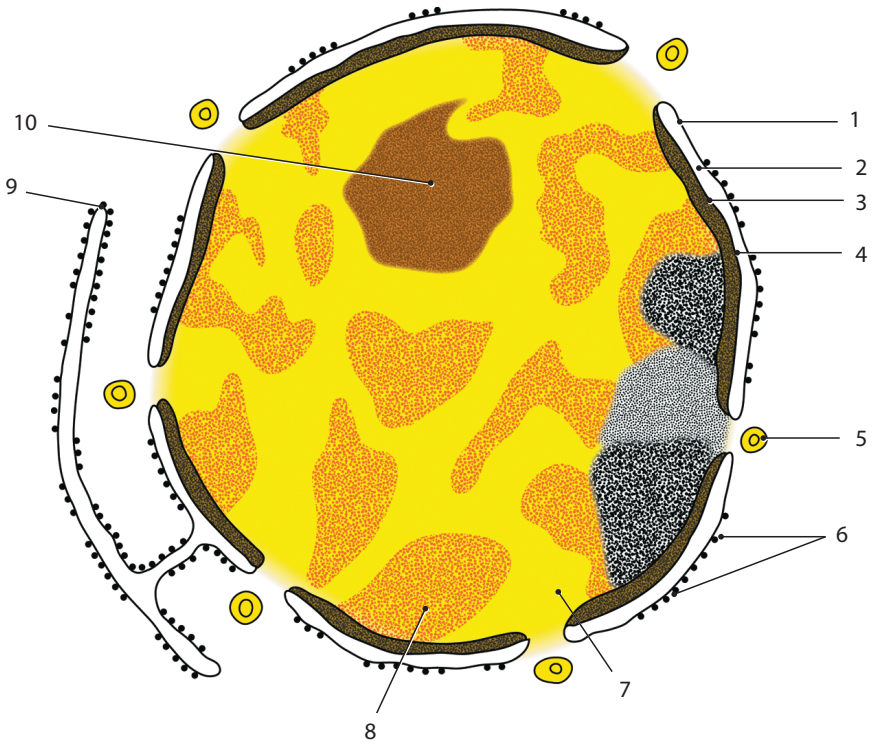


Fig. 8. The nucleus: 1 — outer nuclear membrane (of a nuclear envelope); 2 — perinuclear space; 3 — inner nuclear membrane (of a nuclear envelope); 4 — nuclear lamina (fibrous lamina); 5 — nuclear pore complex; 6 — ribosomes; 7 — nucleoplasm (karyoplasm); 8 — chromatin; 9 — cistern of a granular endoplasmic network; 10 — nucleolus

amorpha), *nucleolar chromatin* (*pars chromatoidea*), *fibrous region* (*pars fibrosa*), *granular component* (*pars granulosa*).

The nucleus contains almost all the cell's deoxyribonucleic acid (DNA). The DNA stored within the nucleus is essential to the cell because its genes encode the amoni acid sequences of the various proteins that the cell must produce to stay alive. Each DNA molecule is coiled, supercoiled, and looped in an elaborate manner so as to constitute a thread-shaped structure called a chromosome. During mitosis (Gr., *mitosis*, thread-like condition), each chromosome becomes microscopically visible as an individual thread that stains intensely with hematoxylin (Gr., *chroma*, color; *soma*, body) (Fig. 9). During the greater part of the cell's lifespan, chromosomes are typically indistinguishable as separate entities because they exist in a partly

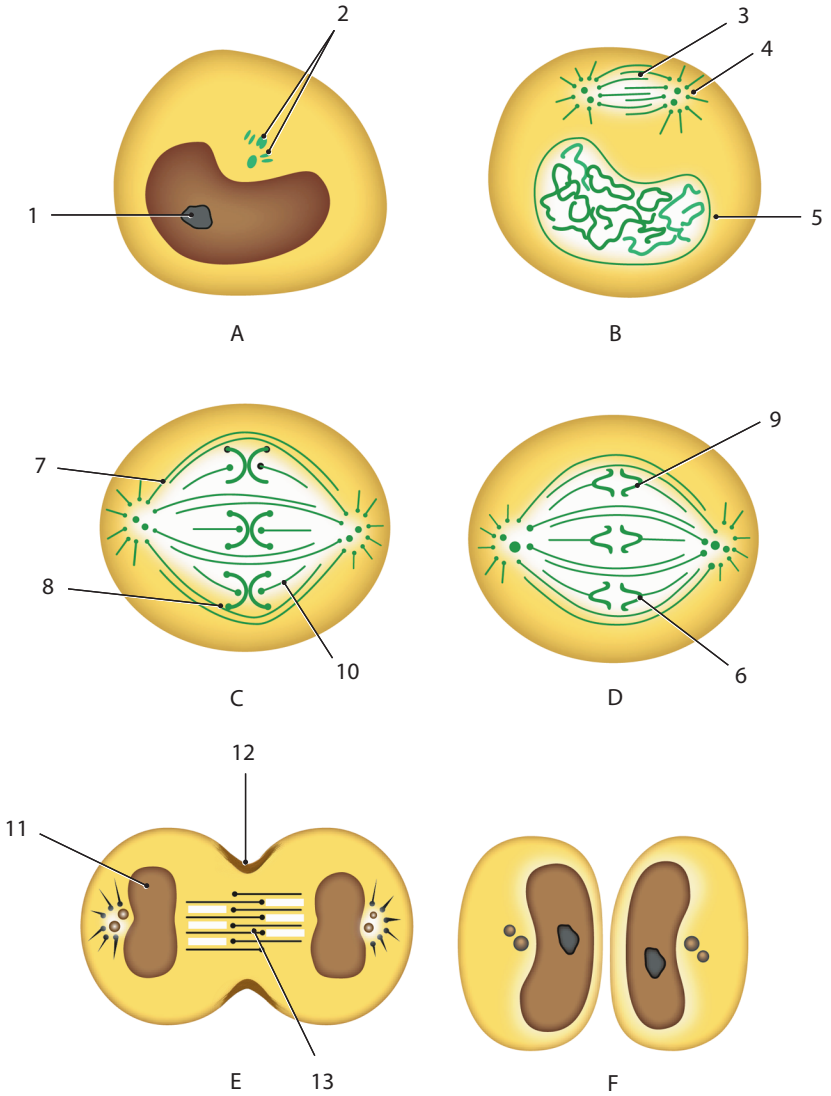


Fig. 9. The scheme of mitosis: A — interphase; B — prophase; C — metaphase; D — anaphase; E — telophase; F — two new cells; 1 — nucleolus; 2 — centrioles; 3 — cell division spindle (mitotic spindle); 4 — aster (centrioles); 5 — nuclear envelope; 6 — kinetochore; 7 — polar fibres (microtubules); 8, 9 — chromosomes; 10 — centriolo-centromeric fibres (microtubules); 11 — the formation of the nucleus; 12 — cleavage furrow; 13 — midbody

condensed and partly extended state that gives them the collective appearance of chromatin granules instead of individual threads. Most extended regions of chromosomes represent sites where genetic instructions are being used for protein synthesis. *Chromatin* (*chromatin*) is a macromolecular complex composed mostly of DNA together with histones, gene-regulatory proteins, and a small, variable proportion of RNA.

Multinucleate cells are called a *syncytium* (*syncytium*).

Tissue (histos) is the phylogenetically developed integration (interaction) of cells and non-cellular structures. It specializes in performing of certain functions.

1. ***Epithelial tissue*** (*textus epithelialis*) develops from all three germ layers. This tissue is highly cellular, with little or no extracellular substance between cells. The epithelial tissue, or epithelium (plural = epithelia) provides the body's first line of protection from physical, chemical, and biological wear and tear. Many epithelial cells are capable of secretion and release mucous and specific chemical components onto their apical surfaces. Sloughing off of damaged or dead cells is a characteristic of a surface epithelium and allows airways and digestive tracts to rapidly replace damaged cells with new cells.

There are two types of this tissue; the *surface epithelium* (*epithelium superficiale*) forming the lining of the body, serous membranes, the inner coats of the tubular organs (Fig. 10), and the *glandular epithelium* (*epithelium glandulare*) which is presented by small and large glands (Fig. 11). The sur-

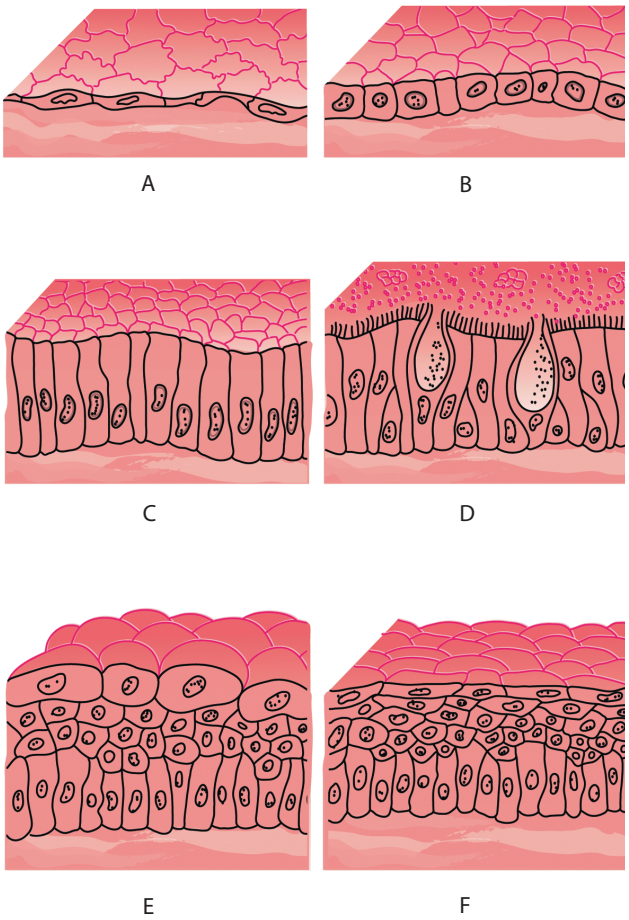


Fig. 10. Construction of epithelia [surface epithelia]: A — simple squamous epithelium (mesothelium); B — simple cuboidal epithelium; C — simple columnar epithelium; D — ciliated epithelium (pseudostratified columnar epithelium); E — transitional epithelium; F — non-keratinized stratified squamous epithelium

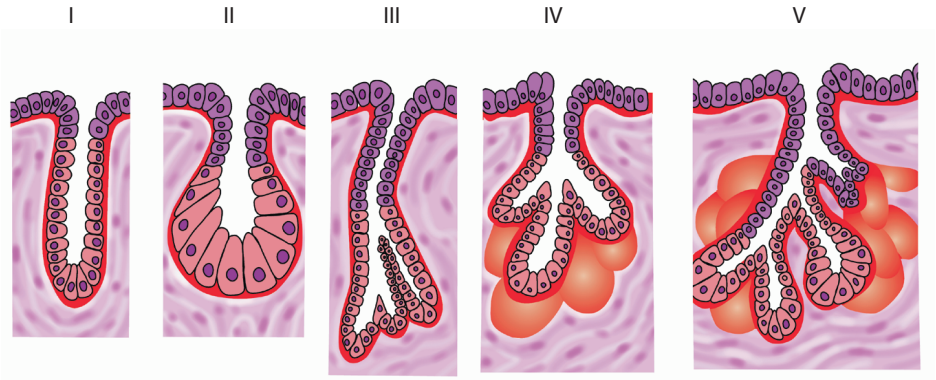


Fig. 11. Classification of multicellular glands: I — simple tubular gland; II — simple acinar gland; III — branched tubular gland; IV — branched acinar gland; V — compound tubulo-acinar gland

face epithelium is classified according to the shape of the cells and number of the cell layers formed. Cell shapes can be squamous (flattened and thin), cuboidal (boxy, as wide as it is tall), or columnar (rectangular, taller than it is wide). The number of cell layers in the tissue can be one if every cell rests on the basement membrane; it is the *simple epithelium* (*epithelium simplex*). Two and more layers of cells compose the *stratified epithelium* (*epithelium stratificatum*), and only the basal layer of cells is on the membrane. The *pseudostratified epithelium* (*epithelium pseudostratificatum*) (pseudo- means "false") consists of a single layer of irregularly shaped cells that give the appearance of more than one layer. Transitional kind of a specialized stratified epithelium contains cells the shape of which can be varied.

The *epithelial cells* (*cellulae epitheliales seu epitheliiocyti*) are typically characterized by the polarized distribution of organelles and membrane-bound proteins between their basal and apical surfaces. Adjoining cells constitute *intercellular junctions* (*junctiones intercellulares*) between their cell membranes. They are *simple* (*denticulate*, *digitiform*) or *complex junctions* (*desmosomes*, etc.). The *basement membrane* (*membrana basalis*) provides an attachment site for the epithelium and separates it from underlying connective tissue.

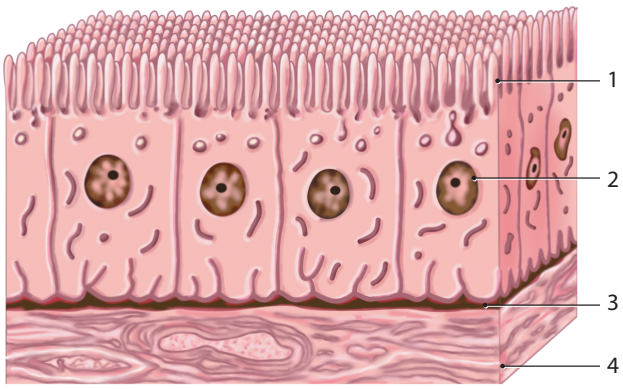


Fig. 12. The epithelial cells with cilia: 1 — microvilli; 2 — nucleus of the epitheliocyte; 3 — basal membrane; 4 — connective tissue proper

Epithelial cells can have got special structures: the microvilli, brush border, cilia, flagella, and tonofibrills.

The simple squamous epithelium includes the *mesothelium* (*mesothelium*) and *endothelium* (*endothelium*). It is present where rapid passage of chemical compounds is observed. The alveoli of lungs where gases diffuse, segments of kidney tubules, and the lining of capillaries are also made of it. The mesothelium forms the surface of the peritoneum, pleura, pericardium and internal organs. The simple cuboidal epithelium is in kidney tubules, ducts of the glands. The simple columnar epithelium covers the inner surface of the stomach, intestines, and female reproductive organs. Columnar cells of the epithelium have the cilia on their surface which are able to beat, so it is called ciliated epithelium (Fig. 12). It lines airways and uterine tubes. The *keratinized epithelium*, or *epidermis* (*epithelium stratificatum squamosum cornificatum* seu *epidermis*), covers the surface of the skin; the *non-keratinized epithelium* (*epithelium stratificatum squamosum non cornificatum*) lines the surface of the cornea, the inner surfaces of the oral cavity and esophagus. The *stratified cuboidal epithelium* and *stratified columnar epithelium* can be found in certain glands and ducts. The *transitional epithelium*, or *urothelium* (*epithelium transitionale* seu *urothelium*) is in the urinary system.

A gland is made up of one or more cells modified to synthesize and secrete chemical substances. Most glands consist of groups of epithelial cells. A gland can be classified as an *endocrine gland* (*glandula endocrina*), a ductless gland that releases secretions directly into surrounding tissues and fluids (endo- = "inside"), or an *exocrine gland* (*glandula exocrina*) whose secretions leave through a duct (exo- = "outside") that leads to the epithelial surface. Exocrine glands are classified as either unicellular or multicellular. The *unicellular exocrine glands* (*glandulae exocrinae unicellulares*) are composed by scattered single cells, such as a *goblet cell* (*epitheliocytus caliciformis*), found in the mucosa of the small and large intestine (Fig. 13). The duct of a multicellular exocrine gland is single in a *simple gland* (*glandula simplex*) but in *compound*

glands (*glandulae compositae*) it is divided into one or more branches.

2. ***Connective and supporting tissues*** (*textus connective atque sustinentes*) has a mesenchymal origin. These tissues typically have in common three characteristic components: *connective tissue cells* (*cellulae textuum connectivorum*), *extracellular matrix* (*matrix extracellularis*), and *fibres of connective tissues* (*fibrae textuum connectivorum*).

It is a multifunctional structure. It performs trophic (regulation of the cellular nutrition and participation in phagocytosis), mechanical (formation of organs' stroma, fascias, aponeuroses, cartilages, bones, creation the soft and bony skeletons of the body), reparative (participation in wound healing) functions.

There are several kinds of these tissues: the *connective tissue proper*, *mucoid or gelatinous connective tissue*, *reticular tissue*, *adipose tissue*, *cartilage tissue*, *bone or osseous tissue*.

The *connective tissue proper* (*textus connectivus proprius*; *textus conjunctivus*) includes the *loose* (*laxus*), *dense* (*compactus*) and *fusocellular* (*fusocellularis*) *connective tissues* (Figs. 14, 15).

The *cartilage tissue* (*textus cartilagineus*) (Fig. 16) is composed of *chondrocytes* (*chondrocyti*), *collagen and elastic fibres* (*fibrae collageni et fibrae elasticae*) in the *cartilage matrix* (*matrix cartilaginea*).

Three main kinds of cartilage tissue are *hyaline cartilage* (*cartilago hyalinea*), *fibrocartilage* (*cartilago fibrosa*), and *elastic cartilage* (*cartilago elastica*). Hyaline cartilage, the most common type of cartilage in the body, consists of short and dispersed collagen fibres and contains large amounts of proteoglycans. Both strong and flexible, it is found in the ribs and nose, covers articular surfaces of bones, and forms metaphyses. It makes up a template of the embryonic skeleton before bone formation. Fibrocartilage is tough because it has thick bundles of collagen fibres dispersed through its matrix. The knee and temporomandibular joints (discs and meniscus) and the intervertebral discs are composed of fibrocartilage. Elastic cartilage contains elastic fibers as well as collagen and proteoglycans. This tissue gives rigid support as well as elasticity. The external ear and

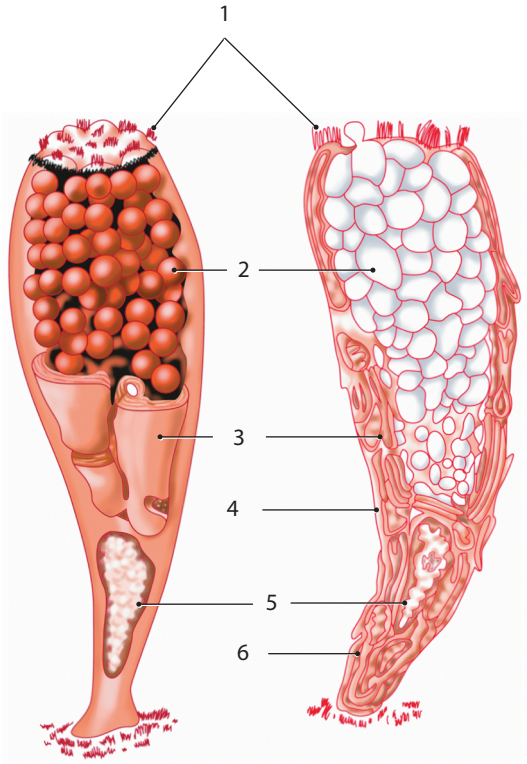


Fig. 13. The structure of a glandular cell — goblet exocrinocyte: 1 — microvilli; 2 — granules with mucous substance; 3 — Golgi apparatus; 4 — mitochondrion; 5 — nucleus; 6 — rough endoplasmic reticulum

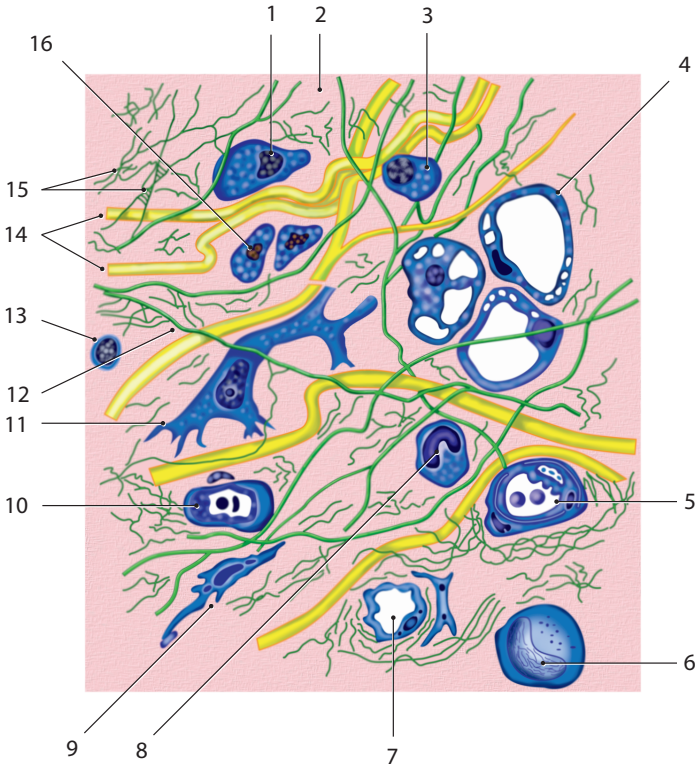
cartilages of the larynx are constituted by elastic cartilage.

The *bone tissue* (*textus osseus*) (Fig. 17) is a kind of connective tissue in which the *ground substance* (*substantia fundamentalis*) of the *bone matrix* (*matrix ossea*) contains collagen fibres and *hydroxyapatite cristalls* (*cristallum hydroxyapatiti*).

3. ***Haematolymphoid complex*** (*structurae haematolymphoideae*) consists of *blood cells* (*haemocyti*) and *plasma* (*plasma*). Blood cells are *red blood cells*, *erythrocytes* (*erythrocyti*), *white blood cells*, *leukocytes* (*leucocyti*) and *platelets*, *thrombocytes* (*thrombocyti*) (Fig. 18). The blood plasma, lymph plasma, chylomicron are kinds of plasma.

4. ***Muscle tissue*** (*textus muscularis*) is composed of the structures with contractile apparatus, and can change the length and shape of the organ. The different types of muscle tissue depend on their

Fig. 14. The loose connective tissue: 1 — macrophage; 2 — amorphous ground substance (extracellular matrix); 3 — plasma cell; 4 — adipocyte; 5 — blood vessel; 6 — monocyte; 7 — lymphatic capillary; 8 — eosinophilic granulocyte; 9 — fibrocyte; 10 — blood capillary; 11 — fibroblast; 12 — elastic fibre; 13 — lymphocyte; 14 — collagen fibres; 15 — reticular fibres; 16 — basophilic granulocyte



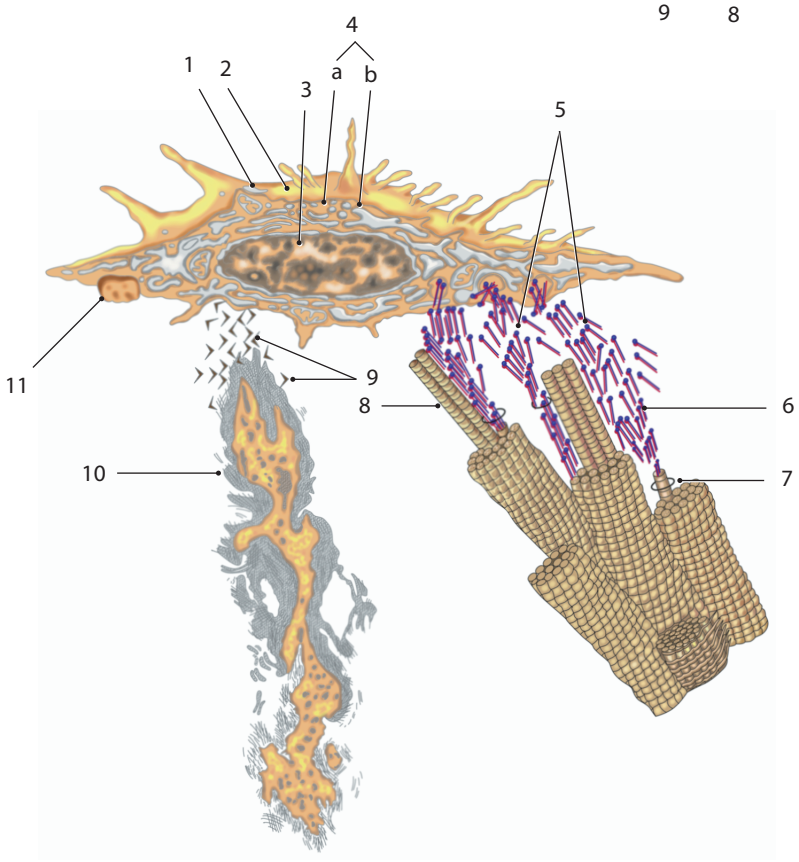
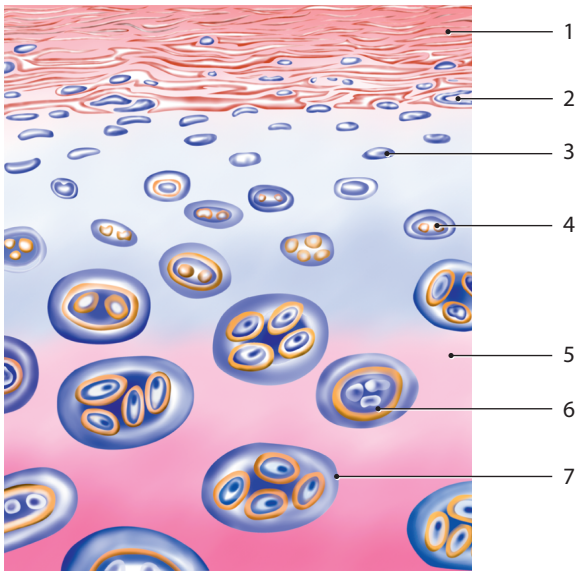


Fig. 15. The scheme of the fibroblast construction and the extracellular matrix: 1 — fibroblast; 2 — Golgi apparatus; 3 — nucleus; 4 — endoplasmic reticulum (a — smooth, b — rough); 5 — tropocollagen molecules that release from the cell; 6 — the process of polymerization of tropocollagen to the protofibrils; 7 — microfibrils; 8 — fibrils; 9 — elastin molecules; 10 — microfibrillar structural glycoprotein; 11 — elastic fiber into the fibroblast plasmalemma

Fig. 16. The cartilage tissue (hyaline cartilage): 1 — fibrous layer of perichondrium; 2 — chondrogenic layer of perichondrium; 3 — chondroblasts; 4 — chondrocytes in lacunae; 5 — interterritorial cartilage matrix (extracellular matrix); 6 — territorial cartilage matrix; 7 — isogenous aggregates



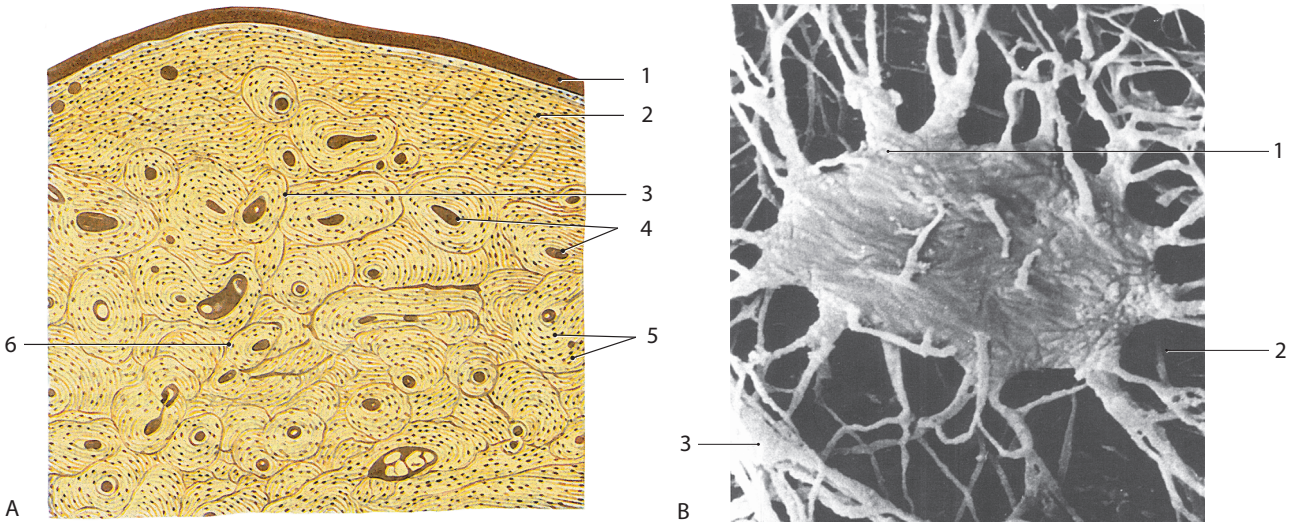


Fig. 17. The osseous tissue (A): 1 — periosteum; 2 — external circumferential lamellae; 3 — osteon concentric lamellae; 4 — central (osteonic) canals; 5 — osteocytes; 6 — interstitial lamellae. Osteocyte (B): 1 — osteocyte; 2 — osteocyte lacuna; 3 — wall of osteocyte lacuna

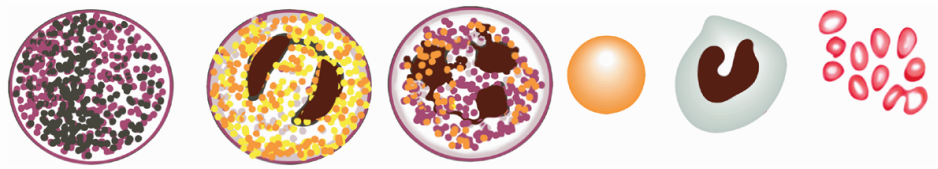


Fig. 18. The blood cells: 1 — basophilic granulocyte; 2 — eosinophilic granulocyte; 3 — segmented neutrophilic granulocyte; 4 — erythrocyte; 5 — monocyte; 6 — thrombocytes

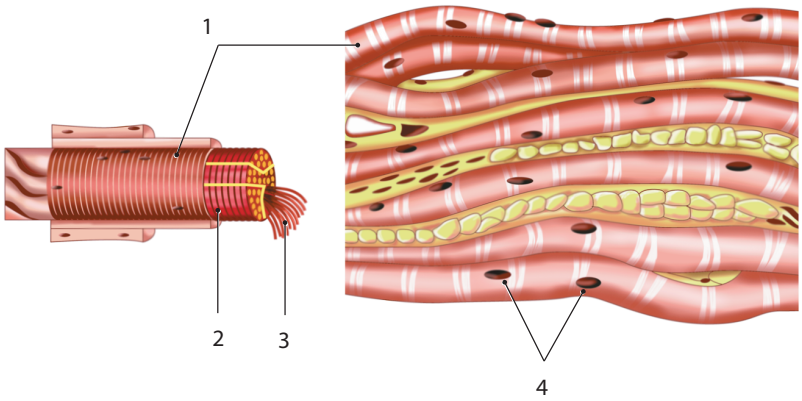


Fig. 19. The skeletal striated muscle: 1 — muscle fiber; 2 — sarcolemma; 3 — myofibrils; 4 — nuclei

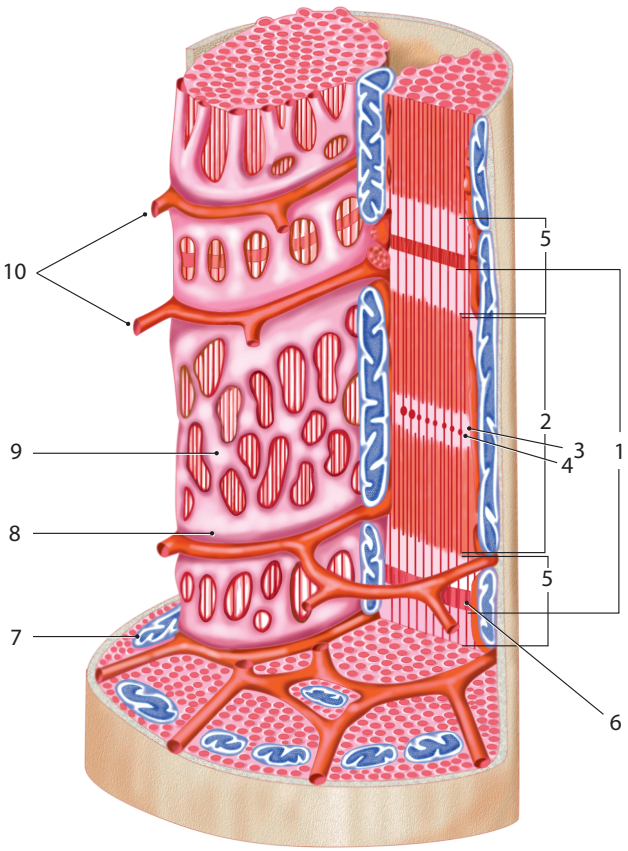


Fig. 20. Two myofibrils of muscle fibre (scheme): 1 — sarcomere; 2 — anisotropic band (A band); 3 — H band (pale zone); 4 — M line (mesophragma); 5 — isotropic band (I band); 6 — Z line, Z disc (telophragma); 7 — mitochondrion; 8 — terminal cistern; 9 — sarcoplasmic reticulum; 10 — transverse tubules, T tubules

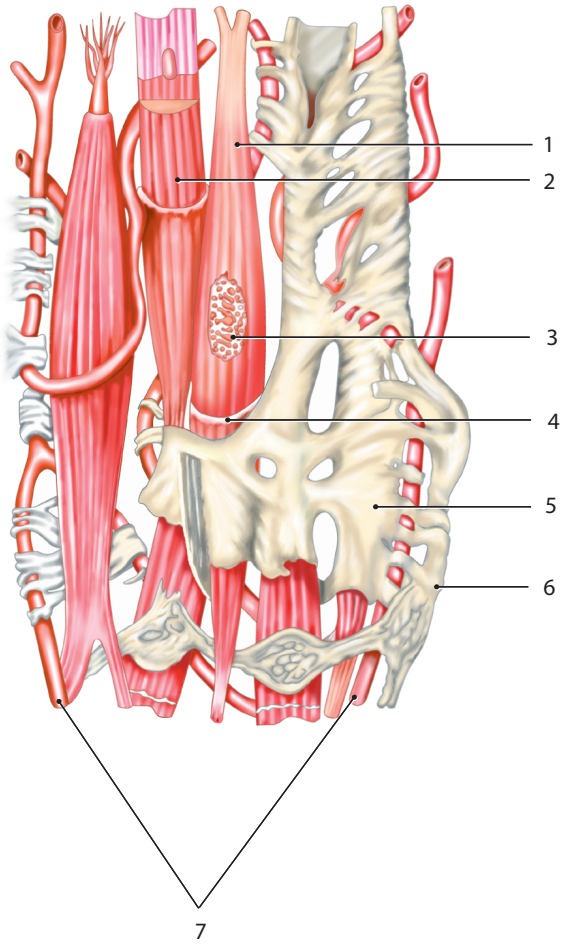


Fig. 21. The smooth muscle tissue (scheme): 1 — myocyte; 2 — myofibrils; 3 — nucleus; 4 — sarcolemma; 5 — endomysium; 6 — nerve; 7 — blood capillaries

origin. *Smooth tissue* (*textus muscularis nonstriatus* seu *textus muscularis levis*) develops from the mesenchyme. *Striated tissue* (*textus muscularis striatus*) derives from the segmented mesoderm or visceral mesoderm. Last is subdivided into the *skeletal striated muscle* (*textus muscularis striatus skeletalis*) and *visceral striated muscle* (*textus muscularis striatus visceralis*). The visceral muscle includes the *cardiac striated muscle* (*textus muscularis striatus cardiacus*) and *non-cardiac visceral striated muscle* (*textus muscularis striatus visceralis non cardiacus*).

Muscle tissue is formed by *muscle cells*, *myocytes* (*myocyti*) which are capable of contraction, and the support apparatus composed of collagen and elastic fibers connected groups of cells and organized a soft framework around them.

Myocytes differ in size, speed of the excitement and the contraction, periods of fatigue in the contracted state, also the areas of distribution. Smooth muscle tissue (Fig. 19) forms the media of arterial, venous and lymph vessels, ducts of glands, muscular layer of intestines, etc. It is innervated by the autonomous (vegetative) nervous system. Striated muscle tissue organizes skeletal muscles which are innervated by the somatic part of the nervous system (Figs. 20, 21). Striated cardiac muscle tissue forms the myocardium; it is innervated by the autonomic nervous system.

5. ***Nerve tissue*** (*textus nervosus*) has an ectodermal origin; it's composed of *neurons* (*neuroni*) and *neuroglia* (*neuroglia*) (Fig. 22). Glia surrounds the neurons, carrying out demarcation, supporting, trophic and protective functions. Neuroglia cells are varied in shape, size and relationship with neurons.

Each neuron has the *body* (*perikaryon*; *neurosoma*; *soma*; *corpus neuronis*), *axon* (*axon*), and *dendrite* (*dendritum*). Dendrites branch off the cell body and appear as thin extensions. A long process, the axon, protracts from the body and can be wrapped in myelin (Fig. 23) which is formed by *Schwann cell*, *neurolemmocyte* (*Schwannocytus*; *neurolemmocytus*). Processes of neurocytes with shells form the nerve fibers (neurofibrae). The totality of nerve fibers and connective tissue shells make a *nerve* (*nervus*).

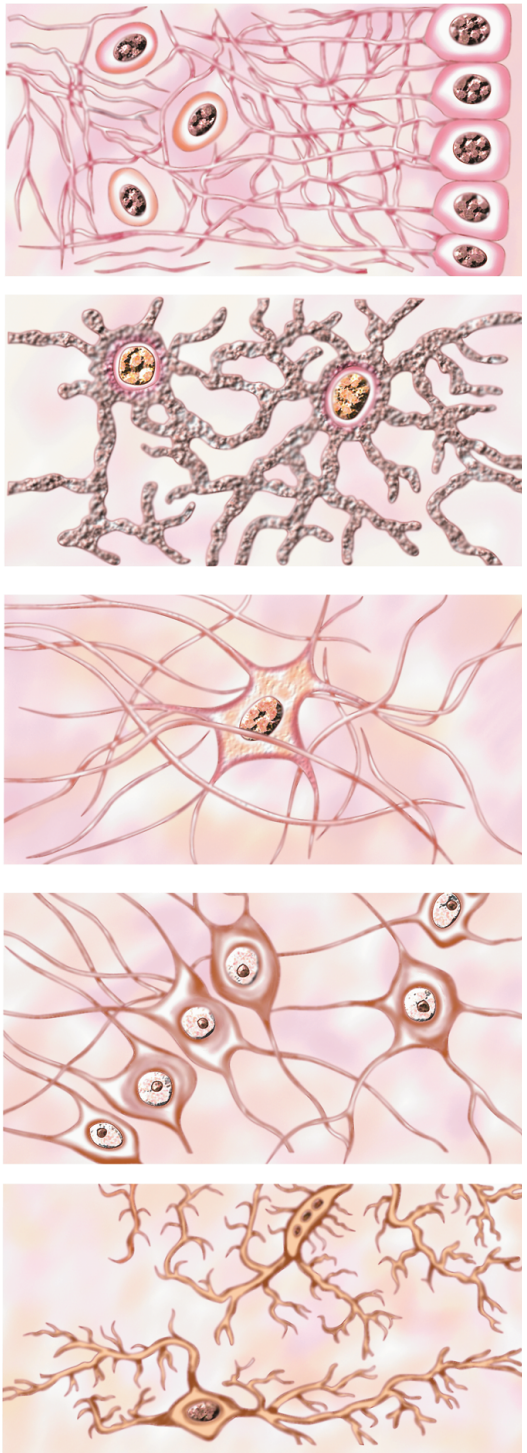


Fig. 22. The different types of central glial cells (scheme): 1 — ependymal cells; 2 — protoplasmic astrocytes; 3 — fibrous astrocytes; 4 — oligodendrocytes; 5 — microglial cells

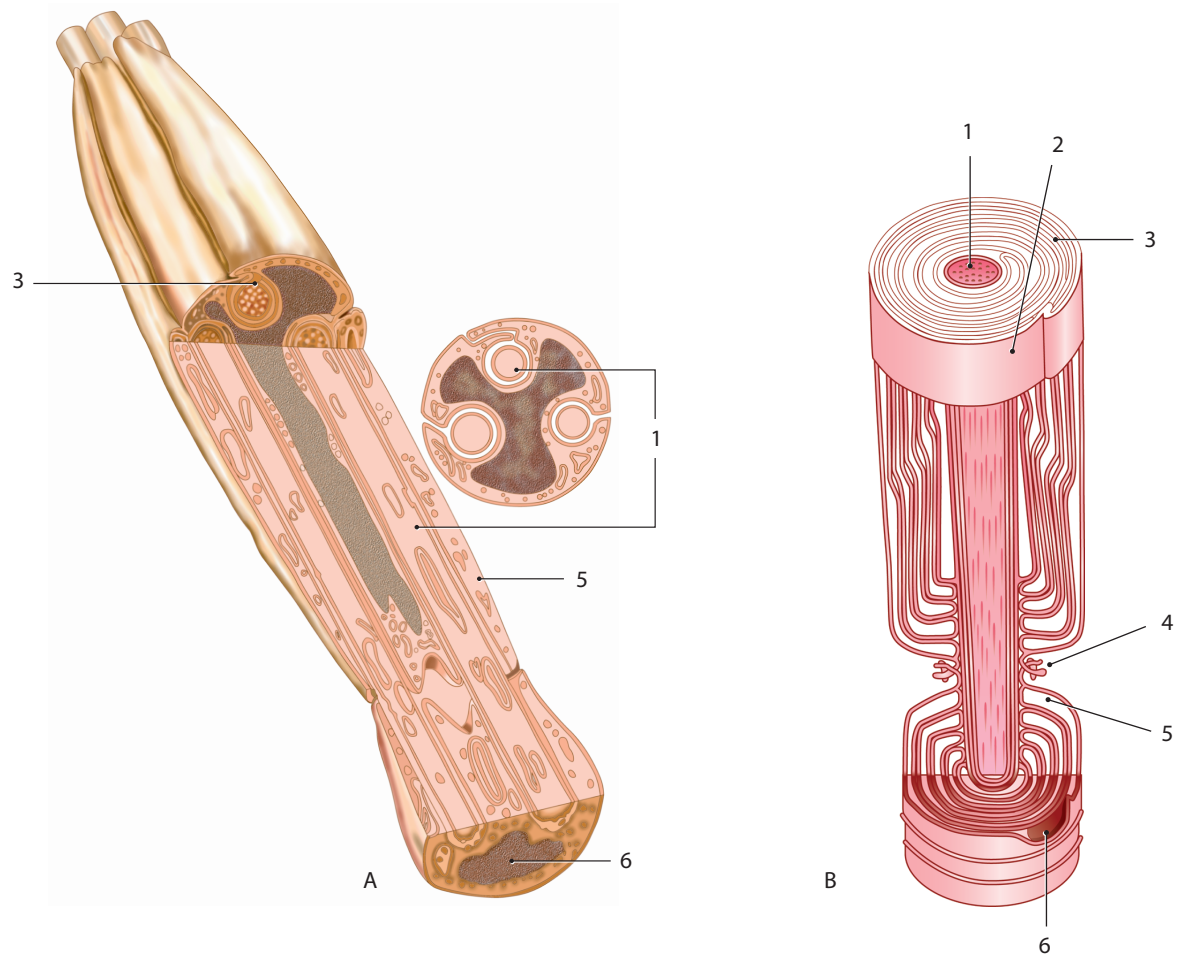


Fig. 23. The scheme of nonmyelinated (A) and myelinated (B) nerve fibers: 1 — axon; 2 — axolemma; 3 — mesaxon; 4 — myelin sheath gaps (node of Ranvier); 5 — cytoplasm of a neurolemmocyte (Schwann cell); 6 — nucleus of a neurolemmocyte

Multipolar neurons include several dendrites and a single axon; *unipolar neurons* have only a single process extending out from the nerve cell body. *Bipolar and pseudounipolar neurons* contain a single dendrite and axon (Fig. 24). According to functions neurons are divided into *motor*, *sensory*, *internuncial*, *secretory*, *pigmented* (Fig. 25). The *synapses* (*synapses*) are distinguished as *neuroneuronal*, *neuromuscular*, *neuroglial*, *neuroglandular*, *neurovascular*, *neurohaemal* (Figs. 26, 27).

The organ is the evolutionarily developed integration of tissues forming the compound organized coherent structure with a comparative autonomy. Organs in the anatomy are a part of the human body, a component of a particular system, which has its intrinsic shape, structure and position in the body, a characteristic architecture of the blood vessels and nerves, consisting of several types of tissues that performs a specific function or functions. We can consider any organ from this perspective (liver, heart, stomach, muscle, and so on). For example, the liver consists of different types of tissues, but the main one is epithelial, which provides clearance substances released to the liver from the gastrointestinal tract and bile formation.