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# DIGESTIVE SYSTEM
# ПИЩЕВАРИТЕЛЬНАЯ СИСТЕМА

## The manual for medical students

*Учебное пособие для медицинских вузов
(специальность «Лечебное дело»)*

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# LIST OF ABBREVIATIONS

Art., art. — articulatio
Artt., artt. — articulationes
For., for. — foramen
Lig., lig. — ligamentum
Ligg., ligg. — ligamenta
M., m. — musculus
Mm., mm. — musculi
N., n. — nervus
Nn., nn. — nervi
R., r. — ramus
Rr., rr. — rami
S., s. — sulcus

# PREFACE

The creation of the manual «Alimentary System» in English meets the requirement of modern Russian medicine and education. Nowadays many English-speaking oversea students study in Medical Universities of Russia. Besides, many Russian school leavers have a good command of the English language so they will be able to use this manual taking into consideration the fact that many Russian specialists in medicine work abroad after graduating from the universities or take part in different international conferences and symposiums.

The English version of the manual is based on the Russian manual by professor Gayvoronskiy I. V. «Normal Human Anatomy» which has been published in Russia 9 times and is approved by the Ministry of education of Russia.

This manual introduces the main principles of Russian Anatomy School such as: detailed study of the general aspects and items of Anatomy including the development of organs and anomalies of the development. If we compare theoretical approaches to Anatomy in Russia and in other countries we`ll see that our approach is based on the system descriptions of organs, i.e. we describe separately Skeletal system, Articulations, Muscular system etc. Moreover, we use Latin terminology while describing the organs and discuss clinicoanatomical and functional problems. As for the manuals in other countries many of them describe Anatomical systems in accordance with the regional and topographical principles.

The structure of our manual meets the requirements of modern standards of medical education in Russia which in their turn correspond to the major European standards. After each chapter we give test questions and clinicoanatomical problems. The English and Latin terminology is given in accordance with International Anatomical Nomenclature.

The authors strongly believe that the manual will allow future doctors to form the morphological foundation for the further study of theoretical and clinical disciplines. We also hope that it will be of great help to Anatomy teachers.

# ПРЕДИСЛОВИЕ

Создание учебного пособия «Пищеварительная система» на английском языке является требованием современной системы медицинского образования в России. В настоящее время в медицинских университетах нашей страны обучаются студенты из различных регионов дальнего зарубежья. Кроме того, многие выпускники российских школ хорошо владеют английским языком, поэтому они также смогут пользоваться данным пособием, принимая во внимание, что зачастую русские специалисты в медицине после окончания университета уезжают работать за рубеж или принимают участие в различных международных конференциях и симпозиумах.

Английская версия пособия базируется на русском учебнике профессора И. В. Гайворонского «Нормальная анатомия человека», который был издан в России 9 раз и одобрен Министерством образования Российской Федерации.

Данное пособие познакомит читателей с главными принципами Русской анатомической школы, которые заключаются в подробном изучении общих вопросов, в том числе развития органов и аномалий развития. В России преподавание анатомии ведется с функционально-клинических позиций и основано на описании органов по системам, т. е. отдельно изучается опорно-двигательная система, артросиндесмология, миология и другие системы. Также при описании строения органов акцентируется внимание на латинской терминологии. Что касается зарубежных руководств по анатомии человека, многие из них основываются на регионально-топографическом принципе без использования латинской терминологии.

Структура данного пособия соответствует современным стандартам медицинского образования в России, которые, в свою очередь, соответствуют важнейшим европейским стандартам. После каждой главы мы приводим контрольные вопросы и ситуационные клинические задачи. Английская и латинская терминология приведена в соответствии с Международной анатомической номенклатурой.

Авторы выражают уверенность, что данное пособие позволит будущим докторам сформировать морфологический фундамент для последующего изучения теоретических и клинических дисциплин. Мы также надеемся, что оно принесет определенную пользу и преподавателям анатомии человека.

# 1. GENERAL SPLANCHNOLOGY

Splanchnology is the science of viscera. The viscera, *viscera seu splancha*, are the internal organs, mainly located within the thoracic and abdominal cavities of the human body (fig. 1.1). The thoracic cavity contains the heart, lungs, thymus, oesophagus. The abdominal cavity contains most viscera: the stomach, liver, pancreas, small and large intestine, spleen, kidneys, adrenal glands, ureters, urinary bladder, prostate (in males), uterus, ovaries, uterine tubes (in females). But not all the internal organs are inside the cavities, some of them are outside (e. g. the external reproductive organs in males and females). Some organs are in the head and neck. The larynx, pharynx, thyroid gland, parathyroid glands and also the part of the oesophagus are in the neck. The tongue, teeth, salivary glands are organs of the head.

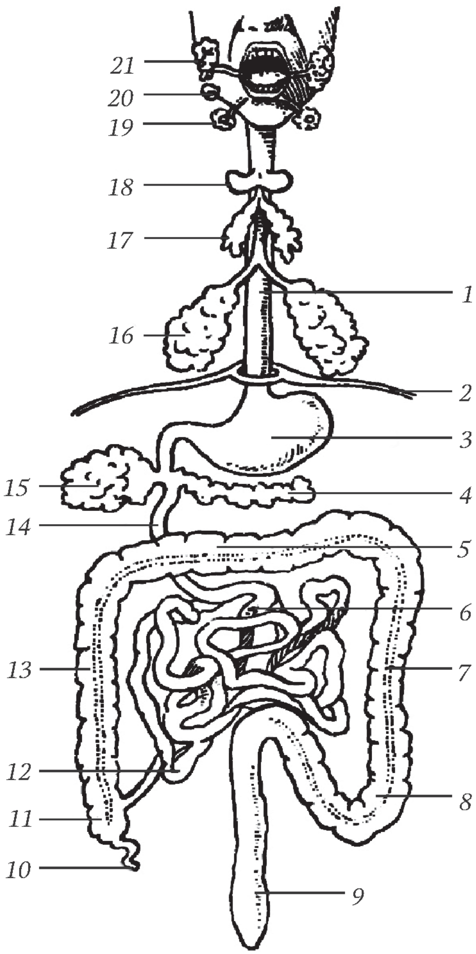


Fig. 1.1. The organs of neck, thoracic and abdominal cavities (scheme):

*1* — oesophagus; *2* — diaphragm; *3* — stomach; *4* — pancreas; *5* — transverse colon; *6* — jejunum; *7* — descending colon; *8* — sigmoid colon; *9* — rectum; *10* — vermiform appendix; *11* — caecum; *12* — ileum; *13* — ascending colon; *14* — duodenum; *15* — liver; *16* — lungs; *17* — thymus; *18* — thyroid gland; *19* — submandibular gland; *20* — sublingual gland; *21* — parotid gland

Thus, the viscera form the alimentary, respiratory, urogenital systems; they partly form the endocrine system. The heart, as the central organ of the cardiovascular system, also belongs to the internal organs. The brain and the spinal cord do not belong to the viscera.

The listed organs have various forms, sizes and certain functions. According to the structure, most organs can be divided into two groups: hollow and parenchymatous. The hollow, or tubular, organs are similar in the structure of the wall and have a cavity inside. Such organs are the oesophagus, stomach, intestine, ureter etc. The parenchymatous organs are structured from homogenous mass termed the parenchyma (e. g. the liver, kidneys, pancreas etc.). Only few organs have specific structure: the tongue (muscular organ), the teeth (comprised of solid tissues), the prostate (organ having a mixed structure (muscular-parenchymatous-tubular).

Taking into account the complex structure of the viscera, we suggest an indicative plan for the study and description of the organs:

1) general description of an organ (shape, configuration, sizes, weight); 2) external structure of an organ (parts, surfaces, borders, grooves and so on); 3) internal

structure of an organ (tissular architecture) and structural units; 4) topography of an organ; 5) data of radiographic, tomographic, ultrasonic examination of an organ; 6) function of an organ; 7) blood and lymphatic vessels of an organ; 8) innervation of an organ.

The form, external structure and position of the viscera are various. Also it is necessary to take into account the age changes of the viscera. The sexual differences of the organs are not significant (certainly except the reproductive organs).

For the doctors it is especially important to know the topography of the organs: holotopy, skeletotopy and syntopy. The holotopy is the relations of the viscera to the body regions (regions of head, neck, chest, back, abdomen and perineum): it means the projection of the organ to the body surface. The skeletotopy is the relation of the organ to the parts of the skeleton or to the certain bony projections which can be easily palpated in a living person or can be seen in radiograph. The syntopy is the relation of the organ to the adjacent viscera, vessels and nerves.

The position of the organs is mainly determined by the body type physique. For example, in normosthenic body type physique, the stomach is hook-shaped; in asthenic body type physique, it is like an elongated hook; in hypersthenic body type physique, the stomach lies horizontally, like a horn.

## 1.1. Principles of Structure of Hollow Organs

The wall of the hollow (tubular) organs is a series of layers, arranged from inside outwards as follows: mucous membrane, muscular coat and adventitia (or serous membrane).

**Mucous membrane**, *tunica mucosa*, lines the inner surface of the hollow organs of the alimentary, respiratoty and urogenital systems. The mucosa of the different hollow organs is similar in structure (fig. 1.2). It consists of the epithelial layer, the basement membrane called the lamina propria, lamina muscularis and submucous layer. The structure of the mucous epithelium, *epithelium mucosae*, is specific for each organ. It can be multi-layered, as in the oral cavity, or single-layered, as in the stomach and intestine. Owing to small thickness and transparency of the epithelial layer, the mucous membrane has a certain color (from pale pink to vermilion). The color depends on the depth of localization and quantity of the blood vessels in the lamina propria. The epithelium itself has no vessels.

The lamina propria of mucous membrane, *lamina propria mucosae*, is under the

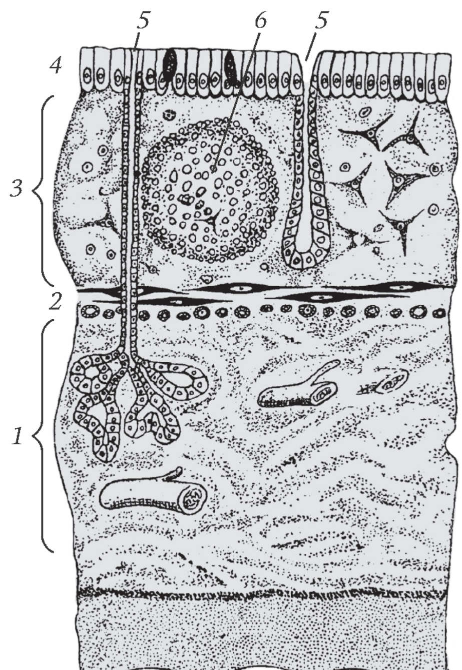


Fig. 1.2. Scheme of the structure of mucosa:

*1* — tela submucosa; *2* — lamina muscularis mucosae; *3* — lamina propria mucosae; *4* — epithelium; *5* — glands; *6* — solitary lymphatic follicle

epithelium; it bulges into the epithelium like tiny projects termed papillae, *papillae*. Loose connective tissue of the lamina propria contains the branches of the blood and lymphatic vessels, the nerves, glands and lymphoid tissue.

The glands of the mucous membrane are formed by the aggregation of the epithelial cells which penetrate into the underlying tissue.

It should be noted, that they penetrate not only the lamina propria of mucous membrane but even the submucous layer. The glandular cells elaborate the mucus or the secretion for the chemical digestion of food. The glands may be unicellular or multicellular. For example, the goblet cells of the mucous of the large intestine, producing the mucus, are unicellular. The multicellular glands produce the special secretion: saliva, gastric and intestinal juice. The terminal parts of the glands deeply penetrate the mucosa; this provides their abundant blood supply. The multicellular glands of the mucous layer differ in form; they may be tubular (in the form of a tube), alveolar (like a vesicle) and tubulo-alveolar (combined) glands.

The lymphoid tissue of the lamina propria mucosae is comprised of the reticular tissue which is rich in lymphocytes. It may be diffuse, or may collect in small masses, termed the lymphoid follicles (nodules). The lymphoid follicles may be solitary, *noduli lymphoidei solitarii*, (their diameter is about 0,5—3 mm), or aggregated, *noduli lymphoidei aggregate* (their diameter is about 10—15 mm).

The lamina muscularis mucosae, *lamina muscularis mucosae*, adjoins the submucosa and consists of 1—3 layers of smooth muscle cells. The mucosa of the tongue, palate, gum, tonsils has no lamina muscularis.

The submucosa lies between the mucous and muscular layers. It is well- developed in most viscera; rarely the mucous membrane lies immediately over the muscular layer. The submucous layer provides the firm fixation of the mucous membrane. It is formed by loose connective-tissue containing the submucous vascular (arterial, venous, lymphatic) and nerve plexuses. Hence it contains the main intraorganic vessels and nerves. The submucous layer possesses a high mechanical durability. It is firmly linked with the lamina propria and muscularis of mucous membrane and loosely linked with the muscular layer. Due to this, the mucous membrane is able to displace relatively to the muscular layer.

The role of the mucous membrane is multifarious. First of all the epithelium provides the mechanical and chemical protection of the organs. The contraction of the mucous membrane itself and the mucus facilitates the transport of the content of the hollow organs. The aggregation of the lymphoid tissue in the lymphoid follicles or lymphoid tonsils plays the important role in biological protection of the body. The secretions of the glands (mucus, enzymes, digestive juices) work as catalysts or the components of the metabolic processes. At last, the mucous membrane of some digestive organs absorbs the nutrients and liquids. In these organs the area of the mucous membrane is greatly increased due to the folds and microvilli.

**Muscular coat**, *tunica muscularis*, is a middle layer in the wall of a hollow organ. Most commonly it is formed by two layers of smooth muscle tissue, having the different orientation. The circular layer, *stratum circulare*, is internal; it immediately surrounds the submucous layer. The longitudinal layer, *stratum longitudinale*, is external. The architecture of the muscular layer is specific for each viscus. The different organs have certain structure of muscle fibers, number of muscular layers, arrangement and degree of development of muscle fibers. Most commonly the muscle fibers of the wall of a hollow organ

are smooth but they also may be striated. The number of muscular layers varies from one to three. In last case the muscular layers also include the layer of the oblique muscle fibers, apart from longitudinal and circular. In some places the smooth muscle fibers concentrate to form the sphincters which regulate the passage of the content from one organ to another (e. g. the sphincter of common bile duct, the pyloric sphincter, internal sphincter of anus, internal sphincter of urethra etc.). The smooth muscle tissue, forming the muscular layer of the hollow organs, functionally differs from the striated muscle tissue. It is autonomic, contracts involuntary and slowly. The smooth muscle fibers have rich innervation and blood supply. There are intermuscular plexuses (arterial, venous, lymphatic and nervous) between the circular and longitudinal muscle layers. Each layer also has own vessels, nerves and nerve endings. It should be noted, that in the commencement of the alimentary and respiratory systems and in the terminal parts of the alimentary and urogenital systems, the smooth muscle tissue is replaced by the striated muscle tissue. The latter allows to perform the voluntary actions.

The muscular layer of the hollow organs provides the tone of their walls, the passage and mixing of their content, the contraction and relaxation of sphincters.

**Adventitia or serous layer.** The external layer in the wall of the hollow organs is formed by the adventitia or serous layer. If the organs are fused with surrounding tissues, they are covered by the adventitia, *tunica adventitia*, (e.g. the pharynx, oesophagus, duodenum, trachea, bronchi, ureter etc.). These organs can not displace because of their fixation to surrounding tissues. The adventitia is made of fibrous connective-tissue containing the vessels and nerves. The hollow organs, which possess mobility and are able to change their position in the body and their volume, are covered by the serous layer, *tunica serosa*.

The serosa is a thin transparent membrane formed by fibrous connective-tissue and covered from outside by one layer of flat cells, termed mesothelium. The serosa is connected to the muscular coat by means of the subserous layer, *tela subserosa*, which is formed by loose connective tissue. The subserosa contains the vascular and nervous plexuses. In normal, the free surface of the serous layer is smooth, shiny, lubricated by serous fluid. The serous fluid is produced by transudation from the capillaries of the subserous vascular plexus. The serous layer covers the stomach, small intestine, partly the large intestine, urinary bladder etc. The serous layer of the hollow organ separates the viscera, preventing the adhesion of organs during the close contact; also it provides the mobility and gliding of viscera and their regeneration in case of injury.

## 1.2. Principles of Structure of Parenchymatous Organs

Most commonly the parenchymatous organs are the large glands. They are liver, pancreas, lungs, adrenal glands etc. The term ‘parenchymatous’ is from Greek term *parenchyma* (flesh). The parenchyma is formed by the glandular tissue of the organs. The glandular tissue itself is surrounded by connective-tissue, called stroma, containing the vessels and nerves. The smallest parts of the parenchymatous organs, bounded by the connective-tissue frame with own vascular bed, form the structural and functional units of the parenchymatous organs (e. g. lobule in the salivary glands, acinus in the lung, nephron in the kidney, follicle in the thyroid gland etc.). Apart from the structural and functional units, the segments are distinguished in the parenchymatous organs.

The segment is a macroscopically visible part of the organ, having the relatively autonomic innervation, blood and lymph circulation and bounded by the connective-tissue septa. These septa are used for separation of the segment during surgical operation. The function of the parenchymatous organs is to provide the most important metabolic processes in the body (gas exchange, secretion of the enzymes and hormones, evacuation of harmful subtances etc.)

Each organ will be described in details in the chapters of special splanchnology.

## TEST QUESTIONS

1. What systems of the internal organs do you know?
2. What organs are situated in the head, neck, thoracic cavity and abdominal cavity?
3. What layers have the hollow organs? How are they arranged in the wall of the organ?
4. Describe the structure of the mucous membrane.
5. Decsribe the structure of the muscular coat.
6. Describe the structure of serous layer and adventitia. What is the difference between the serous layer and adventitia?
7. Describe the structure of the parenchymatous organs.
8. What are the differences between the hollow and parenchymatous organs?

# 2. ALIMENTARY SYSTEM

The alimentary (digestive) system, *systema digestorium*, includes the complex of functionally interrelated organs providing the mechanical and chemical digestion of food, the absorption of nutrients into the blood and lymphatic stream, the formation of fecal masses and their excretion. The main purpose of the alimentary system is to supply the body with energetic and nutritive materials. Besides, the alimentary system neutralizes the toxic substances, which pass with the food or are produced during the digestion of food; also it secretes the biologic active substances (hormons, vitamins, enzymes etc.).

The alimentary system includes the oral cavity, salivary glands, pharynx, oesophagus, small intestine, large intestine, liver and pancreas. The digestive organs are placed in the head, neck, thoracic and abdominal cavities. In the oral cavity the food is grinded by the teeth, mixes with saliva coming from the salivary glands, and mixed with the help of tongue. Thus, the process of digestion begins in the oral cavity. The masticated food (bolus) then comes through the oesophagus into the stomach, where it undergoes the effect of the gastric juice (detoxification, stir, digestion of proteins). The digestion continues in the small intestine: the partly digested food, termed the chyme, undergoes the effect of the bile, produced by the liver, and the effect of the pancreatic and intestinal juices, and the nutrients are actively absorbed. Further the chyme passes to the large intestine, where the water is absorbed and the fecal masses are formed; finally the faeces are excreted. In general the alimentary system is a tube 7—8 m long, commencing from the mouth and ending at the anus. Along this tube there are many large and small digestive glands (salivary glands, liver, pancreas).

## 2.1. Oral Cavity

The oral cavity, *cavitas oris*, is the beginning of the alimentary system. Here the food undergoes the mechanical and chemical digestion (mastication, moistening with saliva and desinfection). The enzymes of the saliva split the carbohydrates.

The oral cavity is divided into two parts: the vestibule, *vestibulum oris,* and oral cavity proper, *cavitas oris propria* (fig. 2.1). The oral vestibule is framed by the lips and cheeks. It is separated from the oral cavity proper by the alveolar processes of the maxilla and mandible, by the gums and teeth.

In the mucosa of the oral vestibule, opposite the upper second molar tooth, there is a small papilla, where the parotid duct, *ductus parotideus*, opens.

The oral cavity proper has a roof and floor. The roof is formed by the hard and soft palate; the floor is formed by the root of the tongue and the muscular diaphragm of the oral cavity, which is composed of the mylohyoid and genoihyoid. The oral cavity proper and the vestibule are communicated by the slit bounded by the posterior molar tooth anteriorly and by the anterior border of the mandibular ramus posteriorly. Behind, the oral cavity communicates with the pharynx through the fauces, *fauces.*

The food passes to the oral cavity through the oral fissure, *rima oris*, which is framed by the upper and lower lips, *labium superius* et *labium inferius*. Laterally the lips are connected by the labial commissures, *commissura labiorum*.

Externally the upper lip is bounded by an oblique skin fold termed the nasolabial sulcus, *sulcus nasolabialis*. In the center of the upper lip there is a groove called philtrum,

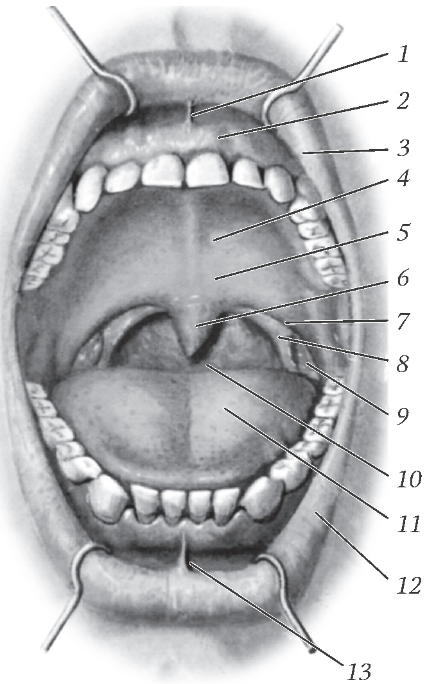


Fig. 2.1. Oral cavity (frontal aspect):
*1* – frenulum of upper lip (*frenulum labii superioris*); *2* – gum (*gingiva*); *3* – upper lip (*labium superius*); *4* – hard palate (*palatum durum*); *5* – soft palate (*palatum molle*); *6* – uvula (*uvula palatina*); *7* – palatoglossal arch (*arcus palatoglossus*); *8* – palatopharyngeal arch (*arcus palatopharyngeus*); *9* – palatine tonsil (*tonsilla palatina*); *10* – fauces (*fauces*); *11* – dorsum of tongue (*dorsum linguae*); *12* – inferior lip (*labium inferius*); *13* – frenulum of lower lip (*frenulum labii inferioris*)

*philtrum*. At the lower end of the philtrum, especially in children, there is a slightly prominent tubercle, *tuberculum*.

The base of the lips is formed of the striated muscle surrounding the mouth. The lips have three parts: cutaneous, transitional and mucous. The cutaneous part has a typical skin structure. It is covered by keratinized stratified squamous epithelium, contains the sebaceous and sweat glands, and also hairs (moustache, beard in males). The transitional part of the lips also has a stratified squamous epithelium, however, here it is significantly thinner, does not have hairs and sweat glands but has the sebaceous glands. The blood capillaries lie superficially under the epithelium, giving the red color to the transitional part of the lip. The mucous part of the lip is covered by non-keratinized stratified squamous epithelium; its submucous layer contains numerous mucous glands. Some of them reach 3–4 mm in size and can be easily palpated from the side of the mucous membrane. The mucous membrane of the lips is connected to the gum by the median folds known as the frenulum of upper lip, *frenulum labii superioris*, and the frenulum of lower lip, *frenulum labii inferioris*. Prolongating from the lips to the cheeks, the mucous membrane keeps the same structure, but the buccal mucous glands, *glandulae buccales*, are slightly smaller than the labial mucous glands.

The cheeks, like the lips, are formed externally by the skin. Some mimic muscles lie between the skin and mucous membrane. Under the skin there is a layer of adipose tissue. Between the skin and buccinators there is a buccal fat pad, *corpus adiposum buccae*; it is especially well- developed in children. The buccal fat pad spreads backwards between the buccinator and masticatory muscles. It thickens the cheeks, making them rounded, and contributes to decrease of the volume of the oral cavity. This has a particular importance for the act of suction in newborns and infants.

The mucous membrane of the oral cavity, which immediately surrounds the alveolar processes of maxillae and alveolar part of the mandible, is termed the gum, *gingiva*. The gums are continuos with the alveolar mucosa which covers the external surfaces of the alveolar processes of maxillae and mandible`s alveolar part and has a brighter color. From inside the gum is continuous with the mucosa of the hard palate and the oral floor. The gum includes three parts: attached, free and gingival (interdental papilla) (fig. 2.2). The attached part is firmly fixed to the periosteum of the alveolar processes of the maxillae

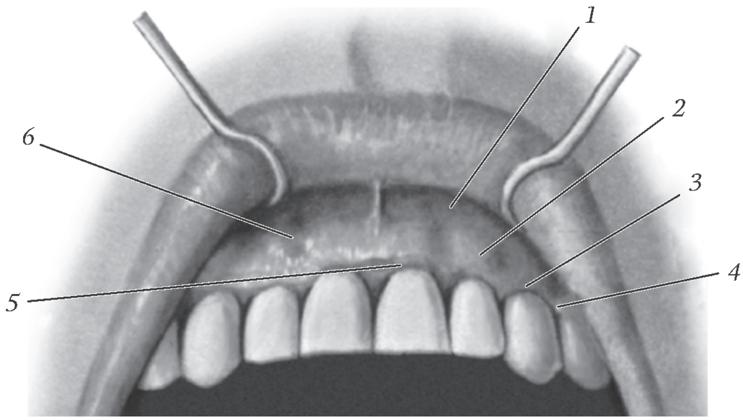


Fig. 2.2. Structure of gum:
*1* — alveolar mucosa; *2* — attached part of gum; *3* — free part of gum; *4* — gingival part of gum (interdental papilla); *5* — gingival margin (*margo gingivalis*); *6* — alveolar yoke (*jugum alveolare*)

and alveolar part of the mandible. This part has a wavy surface because of the alternation of the prominent areas corresponding to the alveolar yokes. Between the prominents there are gingival interdental grooves. The free part of the gum adjoins the neck of each tooth and is separated from it by a narrow gingival groove, *sulcus gingivalis*. The gingival (interdental) papillae, *papillae gingivales*, triangular, fill the intervals between the teeth. The gingival margin, *margo gingivalis*, sharp, forms an oval contour in the area of each tooth.

The oral cavity contains the important organs participating in the initial stages of the digestion. Here belong the teeth, tongue, salivary glands. The tonsils of the oral cavity are the parts of the Pirogoff-Waldeyers lymphoepithelial oropharyngeal ring, which is described below.

The mucosa of the oral floor is loosely connected with the upper surface of the muscles and with the capsules of the sublingual glands; it easily displaces owing to a well-developed submucous layer. On either side of the tongue a sublingual fold, *plica sublingualis*, is situated. The folds converge anteriorly; on the end of each fold there is a prominence called the sublingual caruncle, *caruncula sublingualis*, where the excretory ducts of both submandibular and sublingual salivary glands open. In the anterior part of the oral cavity along the midline, the mucosa forms the fold connecting the inferior surface of the tongue to the oral floor and called the frenulum, *frenulum linguae*. On the upper wall of the oral cavity, in the region of the hard palate, there is a small ridge called the palatine raphe, *raphae palate*, which is clearly distinct in children. A small incisive papilla, *papilla incisiva*, corresponding to the incisive foramen, is at the anterior end of the palatine raphe. The surface of the hard palate is rough because of the dense thickenings of mucosa, called the transverse palatine folds, *plicae palatinae transversae*.

The oral mucosa can be morphofunctionally divided into three types:

1) masticatory mucous membrane (lines the gums and hard palate);

2) cover mucous membrane (lines the lips, cheeks, floor of the oral cavity, alveolar processes of the maxillae and alveolar part of the mandible, inferior surface of the soft palate and inferior surface of the tongue;

3) specialized (lines the dorsal surface of the tongue).

The epithelium of the cover mucous membrane is non-keratinized stratified squamous; the epithelium of the masticatory and specialized mucous membrane is keratinized stratified squamous. The oral mucosa performs the protective, secretory, sensory, absorbing and immune functions.

According to the size, the glands of the oral cavity can be divided into two groups: minor salivary glands, located in the thickness of the mucosa: labial, buccal, palatine, molar, lingual; and the major salivary glands: parotid, submandibular and sublingual.

According to the type of secretion, the salivary glands are divided into three groups: 1) serous glands elaborating the fluid which is rich in proteins: the parotid gland and the minor glands located in the area of the lingual vallate papillae; 2) mucous glands: palatine and lingual glands; 3) mixed: submandibular, sublingual and minor labial, buccal and anterior lingual glands.

According to the form of the terminal parts, the parotid and sublingual glands are tubulo-alveolar; the submandibular gland is mixed (partly tubulo-alveolar, partly alveolar).

The minor glands of the oral cavity disseminate over almost the entire surface of the oral mucosa; their size varies from 1 to 5 mm. The smallest among the minor glands lie immediately in the fibrous layer of the mucous membrane. Sometimes they lie in the submucous layer as the lobular, a little flattened glands, which can be easily palpated from the side of the oral cavity. The labial glands, *glandulae labiales*, are numerous; they are between the orbicularis oris and mucosa. They form almost complete ring around the oral opening (they are absent only at the angles of the mouth. The buccal glands, *glandulae buccales*, are inward to the buccinator; the greatest quantity of the buccal glands is around the excretory duct of the parotid gland. The glands, lying opposite the molars, are called the molar glands, *glandulae molares*. The palatine glands, *glandulae palatinae*, spread unevenly. The area of the hard palate has few minor glands. The soft palate contains the larger glands which form a thick layer. The lingual glands, *glandulae linguales*, lie on the superior surface of the tongue; they are divided into anterior glands, located in the apex, and posterior glands, located in the root. The anterior glands are mucous; the posterior glands are serous.

## 2.2. Teeth

The teeth, *dentes*, are situated at the border between the oral vestibule and oral cavity proper. The function of the teeth is to bite and shred (chew) the food. Besides, they make the speech clear, and play aesthetic role.

The teeth are held in the dental alveoli of the maxilla and mandible (fig. 2.3).

Human teeth have two generations: deciduous teeth, *dentes decidui* and permanent teeth, *dentes permanentes*. The number of the deciduous teeth is 20; they appear between 6 months to 2 years of age and are changed by the permanent teeth between 6 and 14 years of age. The deciduous teeth are smaller than the permanent teeth and differ from them in structure. The number of the permanent teeth is 32. Each tooth consists of:

1) crown, *corona dentis*; it is a thick part of a tooth, protruding from the dental alveola;

2) root, *radix dentis*; it is the part of a tooth, placed in the dental alveola. The root of the tooth ends by apex, *apex radicis dentis*;

3) neck, *cervix dentis*; it is a narrow part of a tooth between the crown and root.

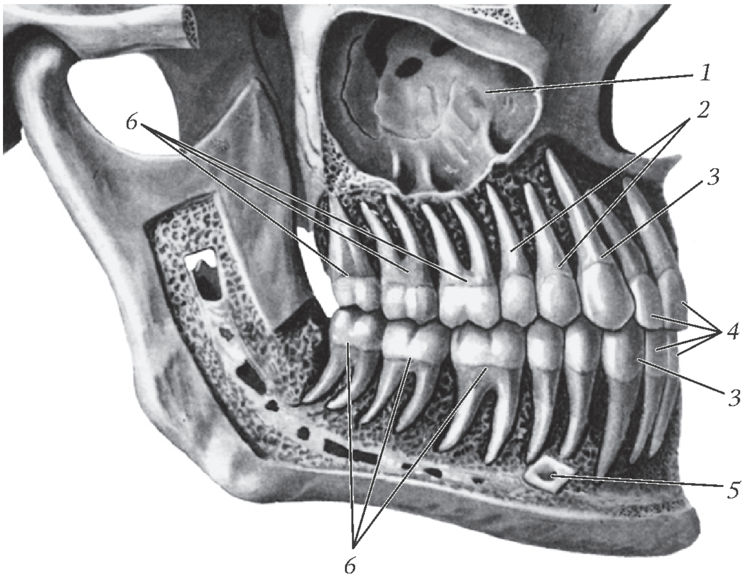


Fig. 2.3. Permanent teeth (right aspect):
*1* — maxillary sinus (*sinus maxillaris*); *2* — premolar teeth (*dentes premolares*); *3* — canine tooth (*dens caninus*); *4* — incisor teeth (*dentes incisivi*); *5* — mental foramen (*foramen mentale*); *6* — molar teeth (*dentes molares*)

Inside the tooth there is a small dental cavity, *cavitas dentis*, (pulp cavity, *cavitas pulparis*); its form is various in different teeth. The part of the dental cavity, situated within the crown, is termed the crown cavity, *cavitas coronalis*. The latter is continuous with the root canal, *canalis radicis dentis*, terminating by the apical foramen, *foramen apicis dentis*, on the root apex. The dental cavity is filled with the pulp, *pulpa dentis*, formed by loose connective tissue, which is rich in cellular elements, vessels and nerves. In accordance with the parts of the dental cavity, the pulp is divided into crown pulp and root pulp. The pulp plays trophic, sensory and protective roles; also it produces the dentine.

The tooth is mainly formed by the dentine, *dentinum*. It is a bone-like tissue. The dentine is comprised of intercellular matrix, lacking of the lime and perforated by the dentine tubules. The dentine tubules contain the cytoplasmic processes of odontoblasts, the bodies of which are in the peripheral area of the pulp. The dentine, which forms the crown, is covered by the layer of the enamel, *enamelum*, but the dentine of the root is covered by the cement, *cementum*. The junction between the enamel and cement is at the root of a tooth.

The root is connected to the dental alveola by connective-tissue called the periodontium, *periodontium*. The latter is composed of the collagen fibers and ground substance of connective-tissue and is highly-innervated. It connects the wall of the dental alveola with cement of the root. The periodontium plays the shock-absorbing, protective and sensory functions.

The collection of the structures, providing the attachment of the tooth to the dental alveola, makes the supporting apparatus known as the parodontium, which consists of the root cement, periodontium, the wall of the dental alveola and adjacent gum.

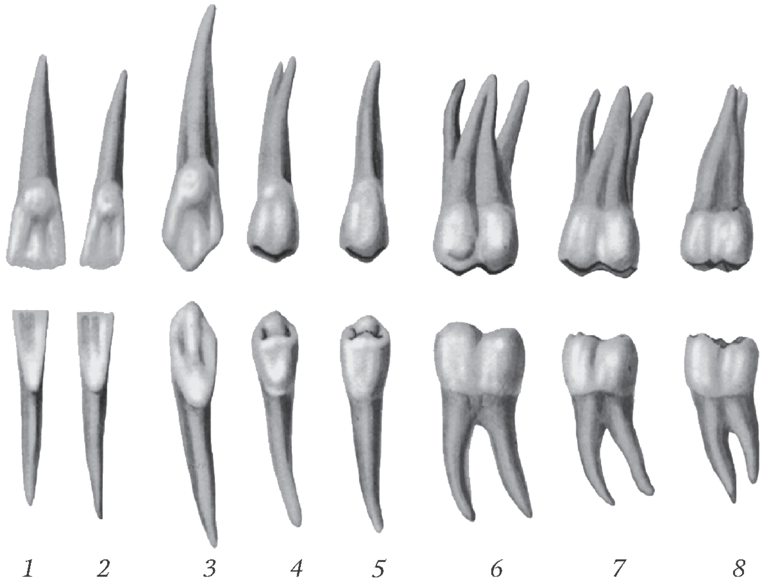


Fig. 2.4. Permanent teeth of the right side (lingual surface):
*1* — medial incisor tooth (*dens incisivus medialis*); *2* — lateral incisor tooth (*dens incisivus lateralis*); *3* — canine tooth (*dens caninus*); *4—5* — premolar teeth (*dentes premolares*); *6, 7, 8* — molar teeth (*dentes molares*)

In humans, like in all mammals, there are four types of teeth: incisors, canines, premolars and molars. The incisor and canine teeth are used for grasping and gnawing the food; the premolar and molar teeth grind the food (fig 2.4). The dental formula in adults (i.e. abridged digital expression of the arrangement of teeth in one half of upper and lower jaw (or quadrant)) is the following: 2.1.2.3 (fig. 2.5). The first number denotes the number of incisor teeth, the second number denotes the number of canine teeth, the third number denotes the number of premolar teeth, and the fourth number denotes the number of molar teeth. Thus, in humans the number of teeth in upper and lower jaw is equal. In each half there are 2 incisor teeth, 1 canine tooth, 2 premolar teeth and 3 molar teeth. The incisor and canine teeth form the frontal group of teeth, and the premolar and molar teeth form the distal group of teeth.

The formula of deciduous teeth is 2.1.0.2. Zero means that there are no premolar teeth among the deciduous teeth. It should be noted, that the molar teeth (two from each side) are situated in the place of the premolar teeth.

Besides, each tooth, beginning from the median plane, has own serial number. For the permanent teeth, the incisor teeth are denoted by the numbers 1 and 2; the canine tooth — by 3; the premolar teeth — by 4 and 5, the molar teeth — by 6, 7 and 8. The deciduous teeth have the following denotation: the incisor teeth — 1 and 2, the canine tooth — 3, the premolar teeth — 5 and 6.

Sometimes dentists use the binary digital formula of teeth. It means that for the permanent teeth before the serial number of a tooth we should add the number 1 (for the teeth of the right quadrant of the upper jaw), number 2 (for the teeth of the left quadrant of the upper jaw), number 3 (for the teeth of the left quadrant of the lower jaw), and num-

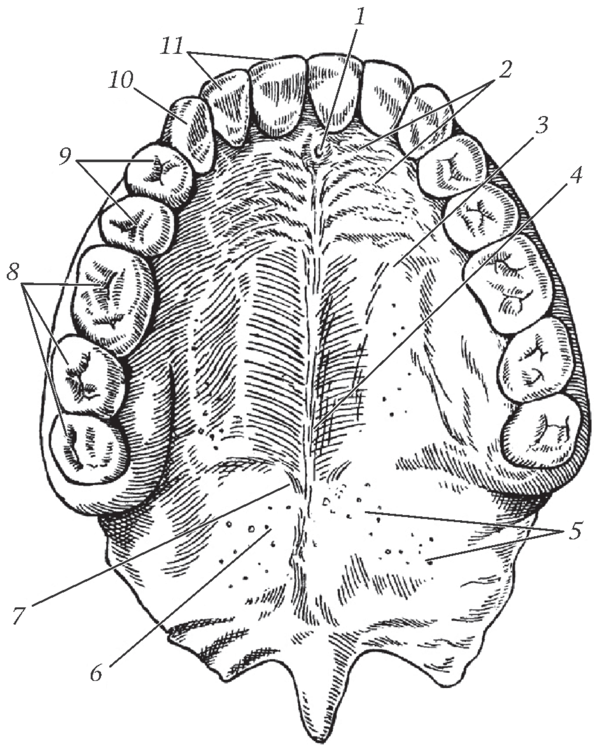


Fig. 2.5. Permanent teeth of upper dental arch, mucosa of palate (inferior aspect):

*1* — incisive papilla (*papilla incisiva*); *2* — transverse palatine folds (*plicae palatinae transversae*); *3* — hard palate (*palatum durum*); *4* — palatine raphe (*raphe palati*); *5* — openings of palatine glands; *6* — soft palate (*palatum molle*); *7* — palatine foveola (*foveola palatina*); *8* — molar teeth (*dentes molares*); *9* — premolar teeth (*dentes premolares*); *10* — canine tooth (*dens caninus*); *11* — incisive teeth (*dentes incisivi*)

ber 4 (for the teeth of the right quadrant of the lower jaw). Thus, the canine tooth of the left quadrant of the upper jaw is denoted by number 23, and the last molar tooth is denoted by number 48. For the deciduous teeth before the serial number of the tooth, number 5 is added (for the teeth of the right quadrant of the upper jaw), number 6 (for the teeth of the left quadrant of the upper jaw), number 7 (for the teeth of the left quadrant of the lower jaw), and number 8 (for the teeth of the right quadrant of the lower jaw). Thus, the lateral incisor tooth of the right quadrant of the upper jaw is denoted by number 52, and the first molar tooth of the left quadrant of the lower jaw — by number 74.

The crown (anatomical crown) is a part of the tooth covered by the enamel. The latter consists of the enamel prisms (one layer of the large prismatic cells) and represents the hardest and highly mineralized (containing up to 95 % of minerals) tissue of the body. In spite of this, it reduces with age and further it can not regenerate. The part of the crown, protruding above the gum, is called the clinical crown, *corona clinica*. In children the clinical crown is smaller than anatomical; in elderly vise versa because the parts of the teeth, which are not covered by the enamel, may protrude into the oral cavity. The surface of the enamel is covered by the membrane containing the proteins and called the cuticle of enamel.

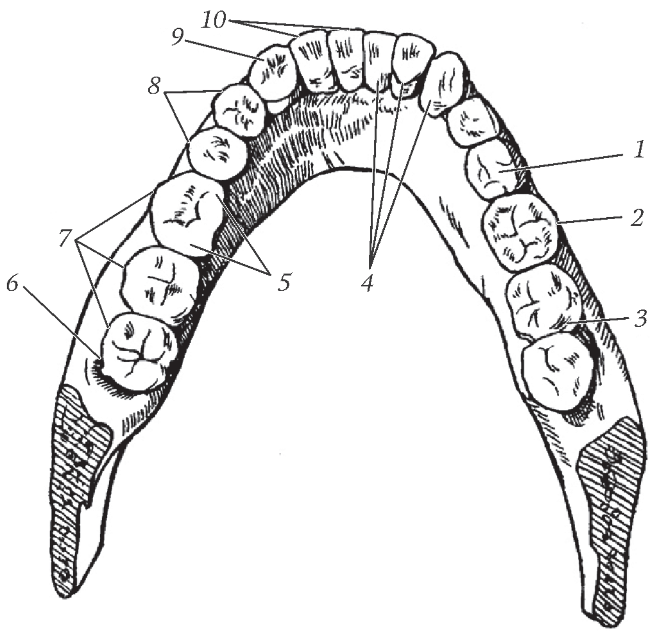


Fig. 2.6. Permanent teeth of lower dental arch (superior aspect):

*1* — occlusal surface (*facies occlusalis*); *2* — vestibular surface (*facies vestibularis*); *3* — contact surface (*facies contacta*); *4* — lingual surface (*facies lingualis*); *5* — tubercles of dental crown (*tubercula (coronae) dentis*); *6* — wisdom tooth (*dens serotinus*); *7* — molar teeth (*dentes molares*); *8* — premolar teeth (*dentes premolares*); *9* — canine tooth (*dens caninus*); *10* — incisive teeth (*dentes incisivi*)

The crown of each tooth has several separate surfaces, or sides (fig. 2.6):

The surface of the crown, facing the oral cavity, is termed the lingual surface, *facies lingualis* (for the teeth of the lower jaw), and the palatine surface, *facies palatine* (for the teeth of upper jaw).

The surface, situated opposite the lingual surface and facing the oral vestibule, is called the vestibular surface, *facies vestibularis*: this surface of the frontal teeth is in contact with the lips and therefore termed the labial surface, *facies labialis*); the vestibular surfaces of the distal teeth are adjacent to the cheeks and therefore called the buccal surface, *facies buccalis*.

The surfaces, adjacent to the crowns of the teeth of one jaw, are the contact surfaces, *facies contacta*. Among the contact surfaces the mesial surface, *facies mesialis*, (medial to the center of the dental arcade) and distal surface, *facies distalis*, (distal to the center of the dental arcade) are distinguished. These surfaces are approximal, *facies approximales*, relatively to each other.

The surface of the crown, which contacts with the same surface of a tooth of the other jaw when the jaws bring together, is the occlusal (chewing) surface, *facies occlusalis*; this surface of the lower jaw is directed upwards, of the upper jaw is directed downwards. In the molar teeth it is wide and has a various number of the tubercles. The incisor teeth have no occlusal surface but they have the incisal margin, *margo incisalis*, instead of it. Hence, each tooth has the certain form of the crown.

The number of roots varies from one (incisor and canine teeth) to three (upper molar teeth). Respectively the form of the dental cavity varies. The form of the crown of incisor teeth resembles a chisel; the form of canine teeth is like a cone; the form of premolar and molar teeth is like an irregular cube with several tubercles.

***Incisor teeth***, *dentes incisivi*, are the frontal teeth, four in upper and four in lower jaws. They are divided into lateral and central incisor teeth. The crown of the incisor tooth is like a chisel; its free end narrows into a sharp incisal margin. The root is simple and cone-shaped. The root of the lower incisor teeth is much flattened from the sides. The upper central incisor teeth have the widest crown; the lower incisor teeth are the smallest.

***Canine teeth***, *dentes canini*, are lateral to the incisor teeth, one in each quadrant of the upper and lower jaws. They are long and have a massive crown (especially upper canine teeth). The crown is like a cone with sharp end which is less distinct in the lower canine teeth. The roots of the upper canine teeth are longer than those of the lower canine teeth; sometimes they reach the floor of the maxillary sinus.

***Premolar teeth***, *dentes premolares*, are lateral to the canine teeth, two in each quadrant of the upper and lower jaws. The crown of the upper premolar teeth is oval in cross-section; the crown of the lower premolar teeth is almost round. The occlusal surface consists of two conical tubercles: vestibular and lingual. The root of the lower premolar teeth is simple and cone-shaped; the root of the upper premolar teeth is flattened from the sides. The root of the first upper premolar tooth splits into the buccal and lingual parts in 50 % of the cases.

***Molar teeth***, *dentes molares*, are lateral to the premolar teeth, three from each side. They are counted from front to back (first, second and third). The occlusal surface of the molar teeth is extensive. They are firmly fixed by several roots and they are the most important in the chewing.

The crown of the molar teeth resembles an elongated cube. The occlusal surface is separated into four tubercles (two buccal and two lingual) by two grooves running at a right angle. Most commonly the crown of the first molar tooth has five tubercles. The crown of the second molar tooth is a little smaller, has a regular form and mostly four tubercles on the occlusal surface. The lower third molar tooth (wisdom tooth, *dens serotinus*) is highly variable. Usually it is smaller and bears three or four tubercles on its crown. The occlusal surface of the molar teeth resembles a rhombus with rounded angles. It has three grooves resembling the letter H and separating this surface into four tubercles. The lower molar teeth have two roots: anterior and posterior; they are flattened from front to back. The upper molar teeth have three roots: lingual, conical in shape, and two buccal, flat in shape. The form and size of the third molar teeth (wisdom teeth) are variable. Usually these teeth are the smallest and have short roots which often merge into a common cone. Sometimes the wisdom tooth remains rudimentary and hence, is called a pin tooth (small tooth with one root).

The deciduous teeth are similar to the constant teeth in the structure of the crown, but they are much smaller. The crown of the deciduous teeth is matte white; the crown of the constant teeth has yellowish tint. The roots of the deciduous teeth are less-developed in comparison to the crown, their walls are thin, and the dental cavity is large and opens on the root apex by a wide opening.

**Dental eruption**. The time of the dental eruption varies depending on nourishment and other factors. Usually it begins in the middle of the first year of life and ends

by the third year. The teeth erupt in the following sequence: first of all the lower incisor teeth appear, then the upper incisor teeth, then the medial molar teeth, canine teeth and finally the lateral molar teeth (fig. 2.7).

The time and sequence of the dental eruption are individual. The teeth may appear before the usual time (sometimes a baby is born already with erupted incisor teeth). Often the teeth appear later than usual time, or appear in another order.

The period from the beginning of the third year of life to the end of the seventh year (i.e. the period between the eruption of the last milk tooth and the appearance of the first constant tooth) can be called the rest period. In this period only milk teeth function.

The change of the deciduous teeth begins at 6—7 years and ends at 13—15 years of age. The constant teeth appear in following order: the first lower molar teeth, then the central incisor teeth and the first upper molar teeth and then the lateral incisor teeth. The wisdom teeth appear between 17 and 25 years of age (sometimes later, often they are absolutely absent).

If the teeth were not affected by diseases, they remain until old age. The teeth fall out in the elderly because of the general metabolic disorders: the blood supply of the pulp and periodontium worsens that leads to the disorder of the nutrition of the teeth; the teeth become loose and fall out. Teeth loss, in its turn, causes the atrophy of the alveolar processes. Rarely the teeth remain until extremely old age.

When the jaws draw together, the upper and lower teeth meet, that is called the occlusion. In normal occlusion the posterior ends of the upper and lower dental arcades set in the frontal plane; the upper incisor teeth bite against the vestibular surfaces of the lower incisor teeth, obscuring $^{1}/_{3}$ of their crowns. The buccal tubercles of the upper

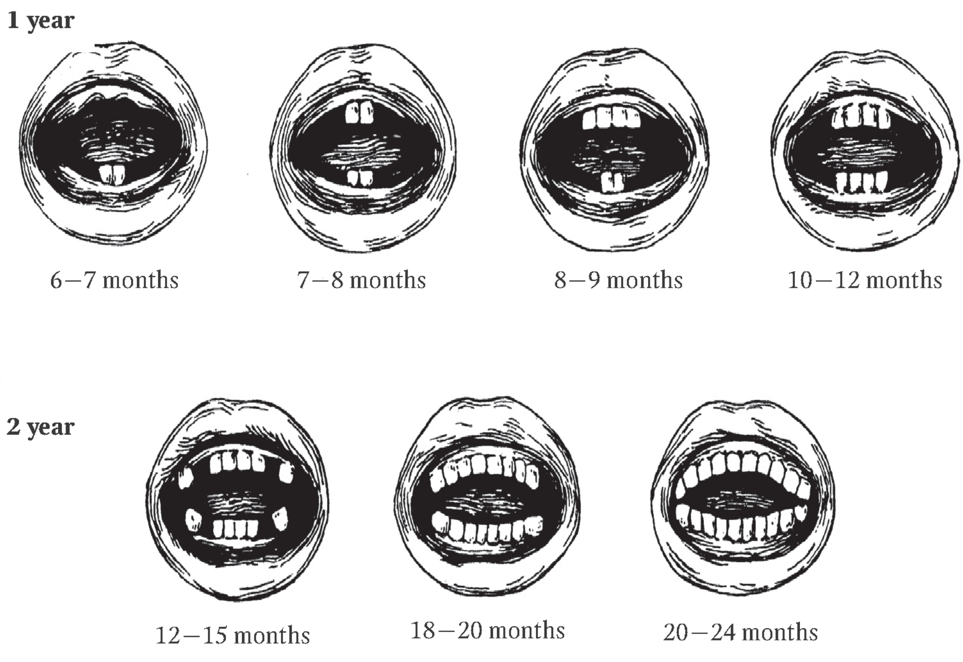


Fig. 2.7. Time of eruption of deciduous teeth (scheme)

molar teeth lie outside the buccal tubercles of the lower molar teeth. In normal occlusion the upper and lower teeth do not coincide exactly because the crowns of the upper incisor teeth are much larger than the crowns of their lower equivalents. Therefore, the upper molar teeth are situated half of tubercle posterior to the lower molar teeth. And each upper tooth mostly contacts the crown of its lower equivalent, which is termed the main antagonist, and in less degree contacts the crown of the next lower tooth, which is the accessory antagonist. The posterior surfaces of the crowns of the last upper and lower molar teeth lie in the same plane because the crowns of the upper wisdom teeth are smaller than the crowns of their lower equivalents.

Between the teeth there are spaces termed diastemae, *diastemae*. During chewing the parts of the crown, protruding towards each other, contact and are subjected to friction therefore they wear with age.

## 2.3. Tongue

The tongue, *lingua* (in Greek — *glossus*), is a muscular organ covered by the mucous membrane and having the rich blood supply and innervation (fig. 2.8). It participates in the mixing of food, in the act of swallowing, in taste and tactile perception and speech production.

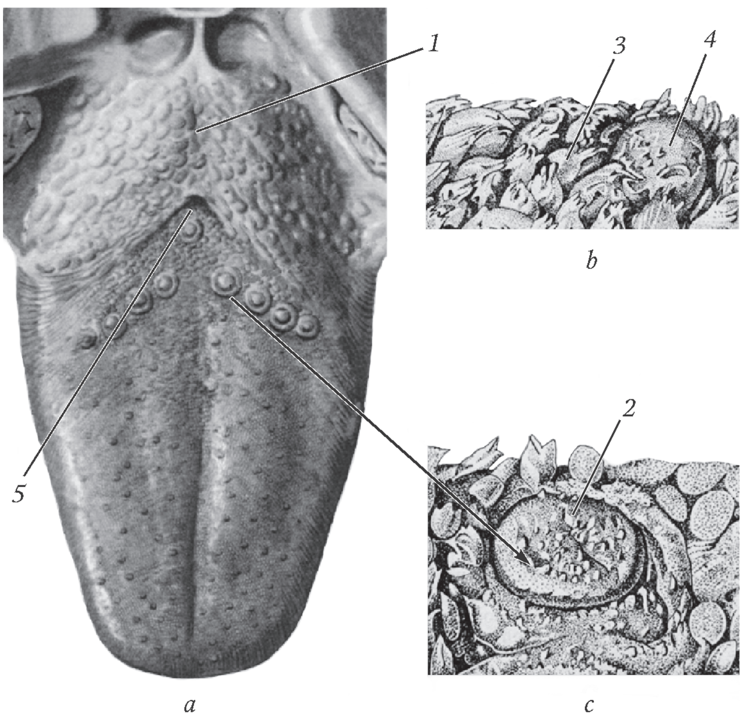


Fig. 2.8. Tongue:

*a* — superior surface; *b* — fungiform and filiform papillae; *c* — vallate papilla (magnified);
1 — lingual tonsil (*tonsilla lingualis*); 2 — vallate papilla (*papilla vallata*); 3 — filiform papilla (*papilla filiformis*); 4 — fungiform papilla (*papilla fungiformis*); 5 — foramen caecum of tongue (*foramen caecum linguae*)

When the jaws occlude, the tongue fills the oral cavity entirely. Its dorsum adjoins the hard and soft palate, its edges and apex touch the inner surface of the alveolar processes. The skeletal muscles connect the tongue to the mandible, hyoid bone and styloid process of the temporal bone. The tongue is fleshy; its form and sizes are changeable. The tongue is flattened and slightly elongated at rest; it narrows forwards to form the apex, *apex linguae*. Posteriorly and inferiorly the tongue is attached to the hyoid bone by the wide base. This part of the tongue is called the root, *radix linguae*. The basic mass of the tongue (between the apex and root) is the body, *corpus linguae*. The superior surface of the tongue, or dorsum, *dorsum linguae*, has a longitudinal groove passing along the midline and called the median sulcus, *sulcus medianus linguae*. The margins of the tongue, *margo linguae*, separate the superior and inferior surfaces. The inferior surface of the tongue, *facies inferior linguae*, is free only in the area of the apex and anterior part of the body. The mucosa covering the inferior surface of the tongue is much thinner, softer and smoother than that covering the superior surface. It forms two elongated fimbriated folds, *plicae fimbriatae*, converging anteriorly near the apex of the tongue (fig. 2.9).

The lingual mucosa, like the mucosa of the whole oral cavity, is comprised of fibrous connective tissue, lined by stratified squamous epithelium. The dorsum of the tongue is covered by numerous small lingual papillae, *papillae linguales*, which are closely adjacent to each other and impart a velvety texture to the surface of the dorsum. In the area of the root the mucosa is devoid of the papillae. Here it is smooth and has the lymphoid structures looking like chaotically spreading elevations and collectively forming the lingual tonsil, *tonsilla lingualis*.

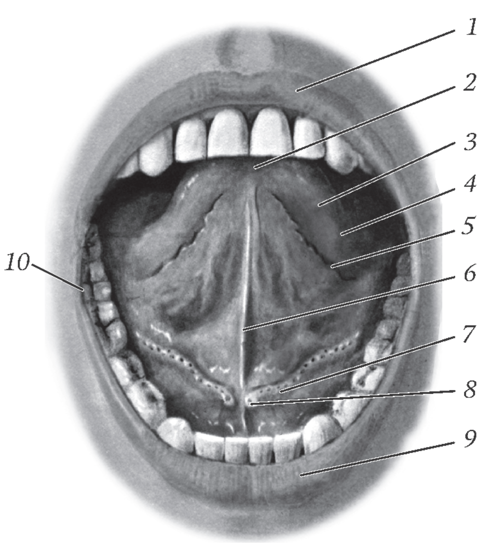


Fig. 2.9. Inferior surface of tongue; sublingual region:

*1* — upper lip (*labium superius*); *2* — apex of tongue (*apex linguae*); *3* — inferior surface of tongue (*facies inferior linguae*); *4* — margin of tongue (*margo linguae*); *5* — fimbriated folds (*plicae fimbriatae*); *6* — frenulum of tongue (*frenulum linguae*); *7* — sublingual fold (*plica sublingualis*); *8* — sublingual caruncle (*caruncula sublingualis*); *9* — lower lip (*labium inferius*); *10* — labial commissure (*commissura labiorum*)

***Lingual papillae*** are projections of lamina propria which elevate the epithelium above the general level, reaching more or less significant size (fig. 2.10). Five types of the papillae are distinguished: filiform, conical, fungiform, vallate and foliate.

The filiform, *papillae filiformes*, and conical papillae, *papillae conicae*, are the most numerous and cover the anterior two thirds of the tongue, producting its characteristic texture. They are the smallest; their height is about 1mm. They bear many secondary papillae. Their epithelium splits into fine processes, each being the apex of a secondary papilla. The epithelium is keratinized therefore the surface of the tongue is whitish. The connective-tissue base of the papillae contains the vessels and nerves. These papillae do not have the taste buds; they provide the general sensitivity of the tongue (tactile, temperature and pain).

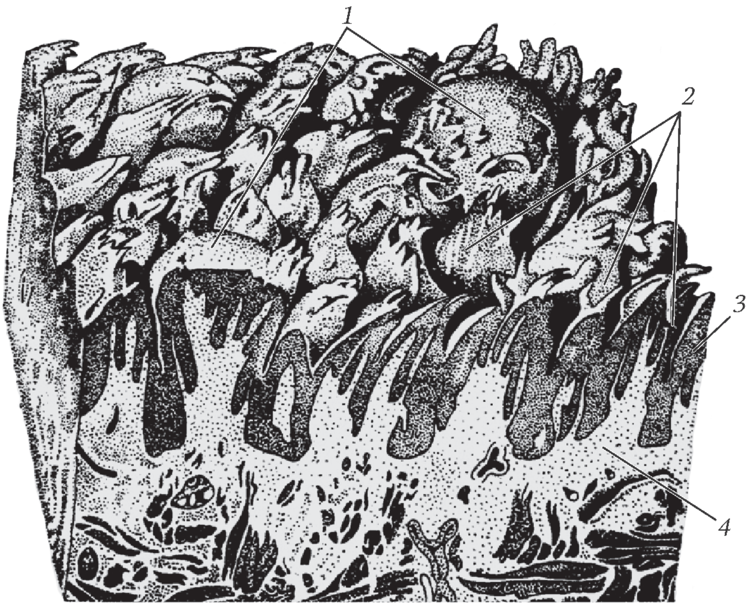


Fig. 2.10. Mucous membrane of tongue (magnification × 16):
*1* — fungiform papillae (*papillae fungiformes*); *2* — filiform papillae (*papillae filiformes*); *3* — epithelium; *4* — lamina propria mucosae

The fungiform papillae, *papillae fungiformes*, are less numerous than filiform but larger in diameter. They are clearly visible to the unaided eye. They are sited between the filiform papillae, mainly on the apex, body and along the edges of the tongue. The fungiform papillae are round; they narrow towards their bases. Their free surfaces are absolutely smooth. The epithelium of the papilla is thin, transparent, non-keratinezed therefore the blood passing through the vessels of the papillae`s connective-tissue base gives them red color. On the tongue of a living person the fungiform papillae look like red prominences on the pale field of the velvety surface, made by the filiform papillae. The fungiform papillae contain the gustatory nerve endings.

The vallate papillae, *papillae vallatae*, are much less in number but larger in diameter (about 2—3 mm); they have a peculiar shape and certain position. Their number varies: usually 7—9, more rarely — 10—12. They are placed at the root, forming a V-shaped row immediately in front of the terminal sulcus, *sulcus terminalis linguae*. The latter, also V-shaped, separates the dorsum of the tongue from the root; its limbs run anterolaterally from a median depression termed foramen caecum, *foramen caecum linguae*. In 50 % of the cases in the foramen caecum there is an unpaired larger vallate papilla.

The vallate papillae are like fungiform papillae in shape, but their superior surface is flattened, and they are encompassed by a narrow deep groove which is surrounded, in its turn, by a roll of the mucous membrane. Each vallate papilla has secondary subepithelial papillae and bears taste buds. The taste buds lie on the papilla`s lateral surface in the thickness of the keratinized epithelium. The total number of the taste buds in the tongue`s epithelium is 2000, and half of them is in the vallate papillae. The taste buds are microscopic structures which include the specialized gustatory (sensory) cells ac-

cepting the taste sensation. Less number of the taste buds is in the epithelium of fungiform papillae and even less number of those is in the foliate papillae and in the area of the soft palate.

The foliate papillae, *papillae foliatae*, are located along the lateral edges of the tongue near its root; they are developed only in children, in adult they are rudimentary and look like parallel folds separated by deep grooves.

In the area of the lingual root, behind the vallate papillae in the thickness of the mucosa there is an aggregation of lymphoid tissue, which forms the lingual tonsil, *tonsilla lingualis* (fig. 2.11). The latter consists of the round tuberles, lingual follicles, having 2—4 mm in diameter. The tubercles are made up of the lymphoid tissue concentrated as lymphoid follicles (nodules). In the center of each follicle there is a minute opening, called the crypt, leading to a cavity, in which the excretory ducts of the mucous salivary glands open. The surfaces of the lingual follicles and of the crypts are covered by stratified squamous epithelium. The crypt, surrounding lymphoid follicle and its thin connective-tissue capsule together form the structural and functional unit of the tonsil, termed cryptolymphon.

Behind the lingual tonsil, the mucosa of the root continues to the lateral and median glossoepiglottic folds, *plica glossoepiglottica mediana* et *plicae glossoepiglotticae laterals*, connecting the anterior surface of the epiglottic cartilage to the tongue. Between the folds there are depressions termed the epiglottic valleculae, *valleculae epiglotticae*.

***The muscles of tongue*** form its general mass and they are divided into two groups:

1) extrinsic muscles (skeletal), which start from the bony points and end in the tongue;

2) intrinsic muscles, which lie only inside the tongue and do not leave it. The extrinsic muscles change the position of the tongue. The intrinsic muscles change the shape of the tongue.

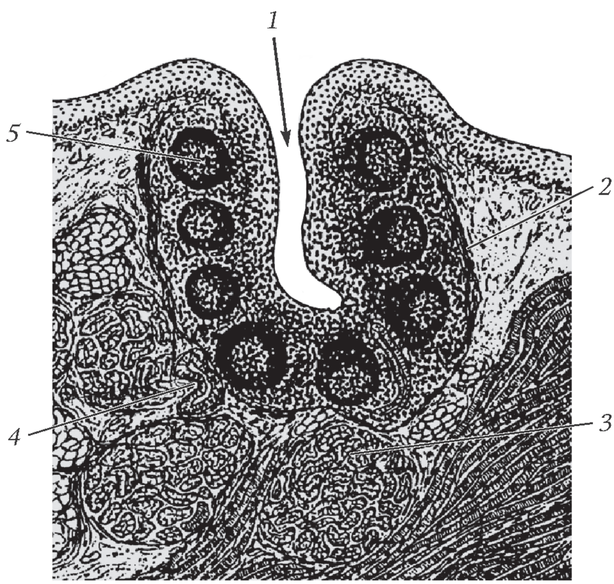


Fig. 2.11. Lingual tonsil:
*1* — crypt; *2* — connective-tissue capsule; *3* — mucous gland; *4* — excretory duct of mucous gland; *5* — lymphoid follicle

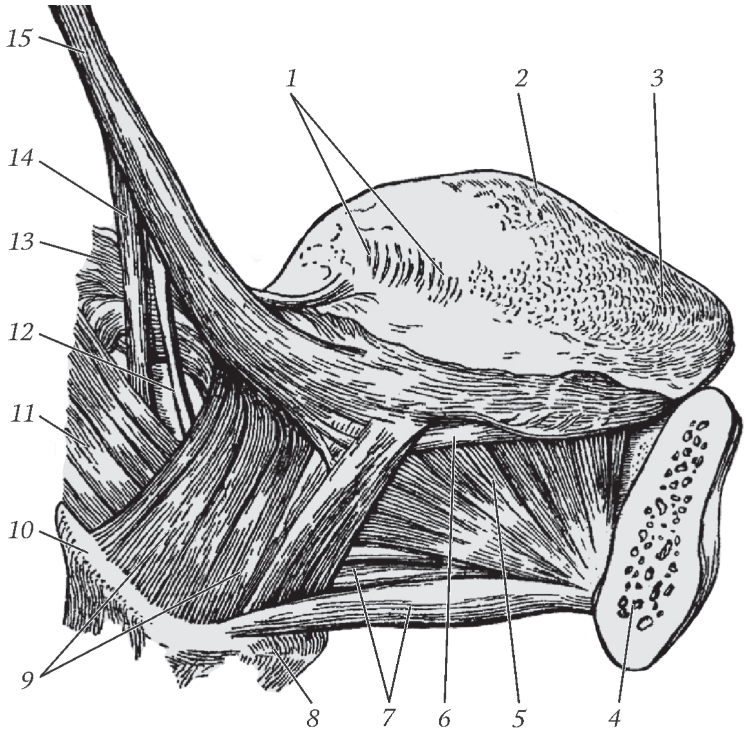


Fig. 2.12. Extrinsic muscles of tongue:

*1* — foliate papillae (*papillae foliatae*); *2* — dorsum of tongue (*dorsum linguae*); *3* — margin of tongue (*margo linguae*); *4* — mandible (*mandibula*); *5* — genioglossus (*m. genioglossus*); *6* — inferior longitudinal muscle (*m. longitudinalis inferior*); *7* — geniohyoid (*m. geniohyoideus*); *8* — body of hyoid bone (*corpus ossis hyoidei*); *9* — hyoglossus (*m. hyoglossus*); *10* — greater horn of hyoid bone (*cornu majus ossis hyoidei*); *11* — middle pharyngeal constrictor (*m. constrictor pharyngis medius*); *12* — stylohyoid ligament (*ligamentum stylohyoideum*); *13* — superior pharyngeal constrictor (*m. constrictor pharyngis superior*); *14* — stylopharyngeus (*m. stylopharyngeus*); *15* — styloglossus (*m. styloglossus*)

The extrinsic muscles (fig. 2.12):

1. Genioglossus, *m. genioglossus*, is the strongest of the lingual muscles; it arises by the short tendon from the mental spine of the mandible immediately above the origin of the geniohyoid and fans out upwards and backwards to end in the thickness of the tongue. During contraction it moves the tongue forwards and down to protrude its apex from the mouth.

2. Hyoglossus, *m. hyoglossus*, quadrilateral, is lateral to genioglossus; it arises from the greater horns of the hyoid bone and also from the lesser horns and body and ends in the lateral parts of the tongue. It pulls the tongue backwards and down.

3. Styloglossus, *m. styloglossus*, long and thin, lies medial and superior to the stylohyoid. It arises from the styloid process of the temporal bone and from the stylomandibular ligament; it then passes, making an arch, forwards and down, adjoining the hyoglossus and enters the tongue from the lateral side. Acting bilaterally, the two muscles pull the tongue backwards and up. Acting unilaterally, it pulls the tongue to the side.

4. Palatoglossus, *m. palatoglossus*, arises from the palatine aponeurosis, passes in the palatoglossal arch to blend with transverse muscle of the tongue. The muscle pulls the root of the tongue upwards, depresses the soft palate and narrows the fauces.

The intrinsic muscles of the tongue (fig. 2.13) are thin fascicles, passing within the tongue along three mutually perpendicular directions.

The following intrinsic muscles of the tongue are distinguished:

1. Inferior longitudinal muscle, *m. longitudinalis inferior*, paired, is only one muscle among the intrinsic lingual muscles, which can be isolated anatomically. It is deep to the mucosa of the lower lingual surface, between the genioglossus and hyoglossus. It extends longitudinally from the lingual root to the apex.

2. Superior longitudinal muscle, *m. longitudinalis superior*, consists of several thin fascicles, which lie immediately deep to the mucosa of the upper lingual surface, extending from the root of the tongue to its apex.

3. Transverse muscle, *m. transversus linguae*, is a complex of muscle fascicles which arise from both sides of the lingual septum, *septum linguae*, run transversely and end in the mucous membrane of the lingual margins and dorsum. These fascicles intersect with the fascicles of the genioglossus.

4. Vertical muscle, *m. verticalis linguae*, is weaker than the preceding muscles; it is more marked in the lateral part. Its fascicles pass almost vertically form the dorsum of the tongue to its lower surface.

The fascicles of all the intrinsic lingual muscles are intertwined with each other and with the fascicles of the skeletal muscles, due to which the tongue has a very complex structure. This provides a great mobility of the tongue and large changeability of its form: the contraction of the longitudinal muscles shortens the tongue and curves it to all sides; the contraction of the transverse muscle decreases the width of the tongue; the contraction of the vertical muscle flattens the tongue and makes it wider.

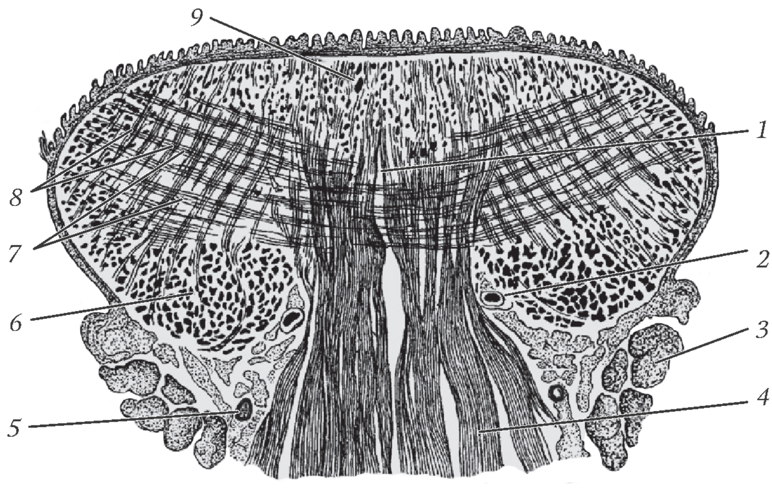


Fig. 2.13. Intrinsic muscles of tongue (frontal section of lingual body):

*1* — lingual septum (*septum linguae*); *2* — deep lingual artery (*arteria profunda linguae*); *3* — sublingual gland (*glandula sublingualis*); *4* — genioglossus (*m. genioglossus*); *5* — lingual nerve (*n. lingualis*); *6* — inferior longitudinal muscle (*m. longitudinalis inferior*); *7* — transverse muscle (*m. transversus linguae*); *8* — vertical muscle (*m. verticalis linguae*); *9* — superior longitudinal muscle (*m. longitudinalis superior*)

The lingual septum, *septum linguae*, is a vertical, thin and somewhere perforated fibrous partition passing in the muscular mass of the tongue along the median plane. It divides the tongue into two symmetrical halfs. Its height is about 1 cm and decreases forwards; in the area of the lingual apex it becomes sharp. The upper edge of the lingual septum slightly does not reach the mucosa of the lingual dorsum. The median sulcus, *sulcus medianus linguae*, of the lingual dorsum corresponds to the lingual septum.

## 2.4. Salivary Glands

The major salivary glands, *glandulae salivariae majores*, (parotid, sublingual, submandibular) have the same genesis as the minor glands. They are developed from the epithelium of the oral cavity but keep the connection with the mucosa only by means of the excretory ducts.

The salivary glands elaborate the protein or mixed secretion called saliva. The saliva is a peculiar digestive juice containing the enzymes which split carbohydrates. Besides, the saliva contains the lysozyme and Ig A, which possess antibacterial action. The salivary glands also have the endocrine function, producing such hormones as parotin, serotonin, nerve growth factor, epithelium-derived growth factor etc. The saliva is saturated with the ions of calcium, phosphorus, magnesium etc, which play the important mineralizing role for maintaining of the normal chemical composition of the dental enamel. In humans the salivary glands produce about 0,5—2 liters of the saliva per 24 hours.

**Parotid gland**, *glandula parotidea* (fig. 2.14) is the largest compound acinar gland which elaborates the protein saliva; its weight is 20—30 g. It is pulpy, grayish-pink and consists of clearly distinct lobules. The lobules are formed by the numerous connective-tissue septa penetraiting the gland from its capsule. The parotid gland is irregular in form. Its narrow part enters the retromandibular fossa. The tissue of the gland is traversed by the external carotid artery, retromandibular vein and by the facial and auriculotemporal nerves. The small lymphatic follicles are between its lobules. The lateral surface of the parotid gland, covered by the parotid fascia, contacts the skin. The parotid gland superiorly adjoins the external acoustic meatus, almost reaching the zygomatic arch; inferiorly it is related to the angle of the mandible. Posteriorly, the parotid gland is moulded to the mastoid process and sternocleidomastoid. Anteriorly, it becomes thin and covers the posterior third of the masseter. On the anterior margin of the gland, almost opposite the middle of the mandibular ramus, the excretory duct of the parotid gland, *ductus parotideus*, comes out. It passes along the external surface of the masseter and enters the tissues of the cheek, perforating the buccinator. The parotid duct opens on the mucous membrane of the cheek into the oral vestibule upon a small papilla opposite the second upper molar crown.

The parotid gland often has an accessory lobule termed the accessory parotid gland, *glandula parotidea accessoria*, which lies on the masseter.

**Submandibular gland**, *glandula submandibularis* (fig. 2.14) is the second gland in size next to the parotid gland; its weight is 15 g. It is a compound tubulo-alveolar gland, which elaborates the mixed (protein-mucous) saliva with the prevalence of the protein component. This gland produces 75—80 % of the total volume of the saliva. It is egg-shaped and slightly flattened from the lateral sides. The gland lies in the submandibular triangle. Its lateral surface is related to the inner surface of the mandibule`s body, the

medial surface adjoins the hyoglossus and styloglossus. Its external surface is separated from the skin by only subcutaneous fat, platysma and the superficial layer of the proper cervical fascia. The anterior part of the submandibular gland lies on the superior surface of the mylohyoid; from this part the excretory duct of the submandibular gland, *ductus submandibularis*, comes out. It then runs along the medial side of the sublingual gland to the frenulum of the tongue, *frenulum linguae*, and opens by a small opening on the sublingual caruncle, *caruncula sublingualis.* The submandibular gland is covered by a thick capsule which is formed by the proper cervical fascia.

**Sublingual gland**, *glandula sublingualis* (fig. 2.14), is the smallest of three major salivary glands; its weight is about 5 g. It is a compound tubulo-alveolar gland which elaborates the mixed saliva with the prevalence of the mucous component. The gland is narrow and elongated; it lies immediately deep to the mucosa of the oral floor, on the superior surface of the mylohyoid. Medially, it adjoins the genioglossus and hyoglossus; laterally, it adjoins the medial surface of the mandibule`s body. The gland consists of several lobules and has a main duct, *ductus sublingualis major*, which opens on the sublingual caruncle independently or together with the submandibular duct. Several smaller ducts, *ductus sublinguales minores*, open on the sublingual fold independently.

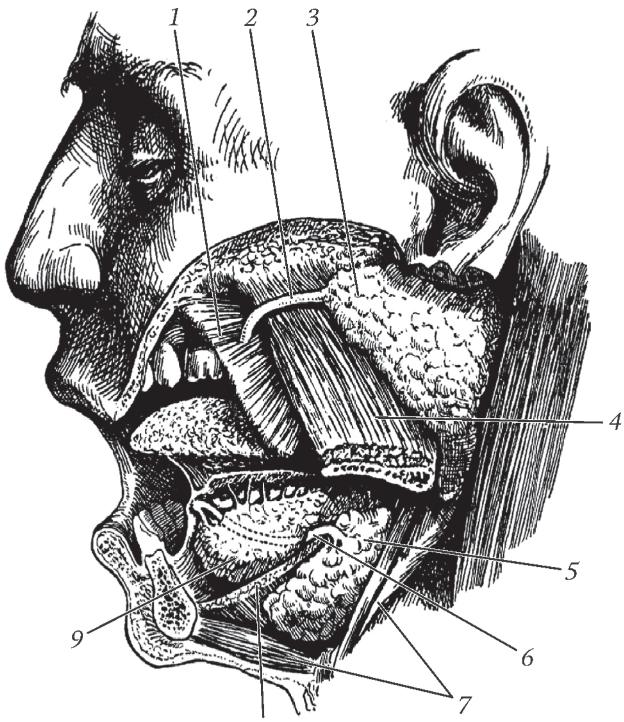


Fig. 2.14. Salivary glands (left half of mandible has been removed):

*1* — buccinator (*m. buccinator*); *2* — parotid duct (*ductus parotideus*); *3* — parotid gland (*glandula parotidea*); *4* — masseter (*m. masseter*); *5* — submundibular gland (*glandula submandibularis*); *6* — submandibular duct (*ductus submandibularis*); *7* — digastric (*m. digastricus*); *8* — mylohyoid (*m. mylohyoideus*); *9* — sublingual gland (*glandula sublingualis*)

## 2.5. Palate

The palate, *palatum*, forms the roof of the oral cavity. It has the form of a vault and is divided into the hard palate (anterior two thirds) and soft palate (posterior third).

The base of the hard palate, *palatum durum*, is formed by the palatine processes of maxillae and the horizontal plates of the palatine bones, which are covered by the mucous membrane from the side of the nasal cavity and the side of the oral cavity. The mucous membrane is firmly linked with the periosteum and has a pale pink color because it is covered by keratinized stratified squamous epithelium. The mucosa is thick and forms two-three transverse palatine folds, *plicae palatinae transversae* (fig. 2.5). Anteriorly and laterally the hard palate is continuous with the gums.

According to the morphofunctional structural features the hard palate`s mucosa is divided into four zones (fig. 2.15):

1) adipose zone is in the anterior third of the hard palate`s mucosa; its submucous layer contains the fat;

2) glandular zone occupies posterior two thirds of the hard palate`s mucosa; it contains the terminal ends of the mucous and salivary glands;

3) marginal zone corresponds to the place where the mucosa of the hard palate is continuous with the gum;

4) zone of the palatine raphe is at the area of the palatine raphe, *raphe palati*.

Last two zones do not have the submucosa.

**Soft palate**, *palatum molle*, is a continuation of the hard palate. Its anterior part is almost horizontal, while the posterior part, called the palatine velum, *velum palatinum*, hangs down ending by a free thin margin. A median rounded process termed the palatine uvula, *uvula palatine*, projects from it. Laterally, the palatine velum prolongates into two fold (arches). The posterior arch is called palatopharyngeal; it descends to the posterior wall of the pharynx. The anterior arch is palatoglossal, *arcus palatoglossus*; it runs to the lateral edge of the lingual root (fig. 2.1).

The anterior and posterior arches limit a depression, called the tonsillar fossa, *fossa tonsillaris*, on either side of the fauces; it contains the palatine tonsil, *tonsilla palatina*. The latter is a paired mass of lymphoid tissue in the shape of a flattened egg. The medial surface of the tonsil is free and faces the oral cavity. The lateral surface adjoins the superior constrictor of pharynx, being separated from it by the tonsillar capsule, *capsula tonsillaris*, the thickness of which reaches 1 mm. Outside the capsule there is a layer of loose paratonsillar fat where the

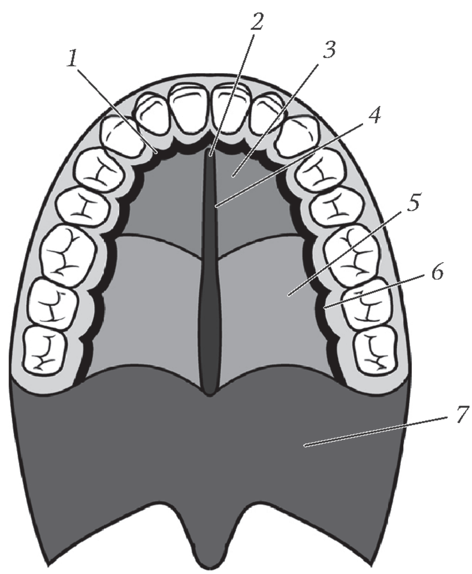


Fig. 2.15. Zones of mucous membrane of hard palate (scheme):

*1* — marginal zone; *2* — incisive papilla; *3* — adipose zone; *4* — zone of palatine raphe; *5* — glandular zone; *6* — marginal zone; *7* — soft palate

paratonsillar abscesses may be formed. This fat descends to the lingual root and connects with the fat of the palatoglossal arch.

The internal carotid artery passes 1—1,5 cm behind the palatine tonsil. The tonsils are variable in size: they can be hidden by the palatoglossal arches or can protrude out. The medial surfaces of tonsils are covered by the mucous membrane with small openings where the ducts of small mucous glands open. The tissue of the palatine tonsil is penetrated by the deep invaginations of mucous membrane, called the tonsillar crypts, *cryptae tonsillares*. The crypts 5—7 mm immerse into the tonsil; their total number is 10—20. They increase the area of the palatine tonsil to 300 $cm^2$. During swallowing the palatine tonsils are slightly compressed, due to which the crypts are emptied from their content.

Thus, the palatine tonsil is a lymphoepithelial organ. The microscopic sections of it show the alternation of the epithelium with lymphoid tissue (follicles) surrounded by a thin connective-tissue capsule (fig. 2.16). As mentioned above, the complex of these structures forms a structural and functional unit of the tonsil, called cryptolymphon.

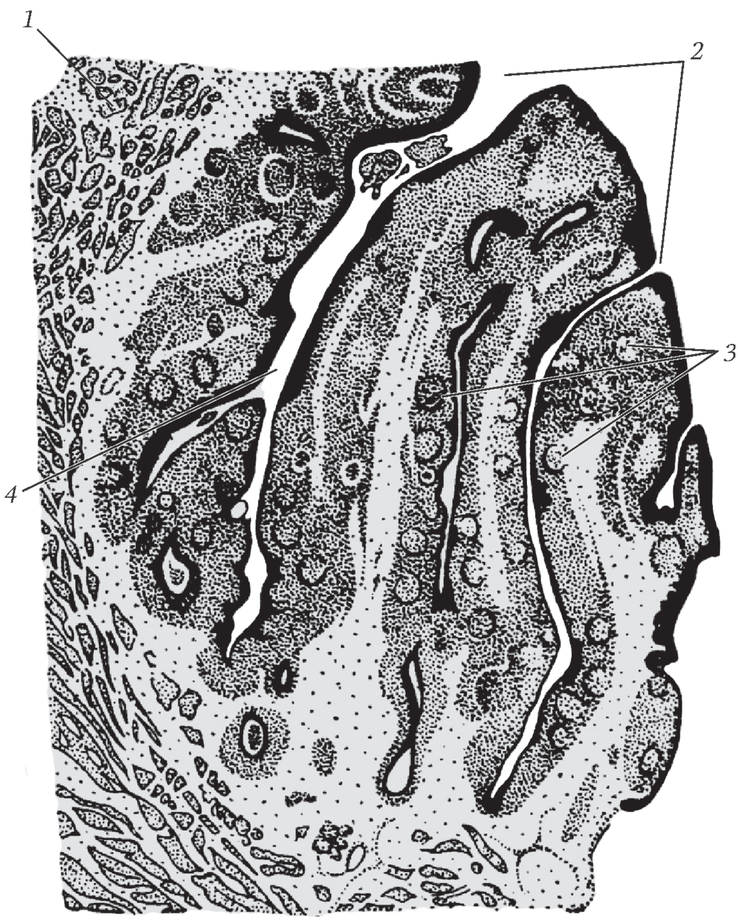


Fig. 2.16. Palatine tonsil (frontal section):
*1* — superior pharyngeal cosnstrictor; *2* — openings of crypts; *3* — lymphoid nodules; *4* — tonsillar crypt

In the upper part of the tonsillar fossa there is a triangular supratonsillar fossa, *fossa supratonsillaris*, filled with the accessory lobule of the palatine tonsil. Sometimes this lobule enters the soft palate deeply, ramifies and do not have a direct connection with the main palatine tonsil. Such a lobule is called the accessory intrapalatine tonsil, *tonsilla intrapalatina accessoria*; it usually contains a deep branchy crypt known as Tourtual sinus, *sinus Turtuali*, playing a great role in the pathology of the tonsils. The tonsils provide humoral and cellular defence against infection.

The mucosa of the hard palate`s posterior part and of the soft palate contains numerous mucous glands. The soft palate is the double fold of mucosa. Its upper layer is directed to the nasal cavity and forms the posterior, or nasopharyngeal, surface covered by ciliated columnar epithelium. Such an epithelium is typical for airways. The lower layer is a continuation of the hard palate`s mucosa and forms the anterior, or oropharyngeal, surface. It is lined by non-keratinezed stratified squamous epithelium. The blood capillaries are visible through it therefore, the soft palate has a pink color.

The soft palate contains the muscles, glands and the fibrous plate known as palatine aponeurosis, *aponeurosis palatina*, which is attached to the posterior border of the palatine bones` horizontal plates. All the muscular fibers of the soft palate are attached to the aponeurosis.

***Muscles of soft palate*** (fig. 2.17) are striated; they are small.

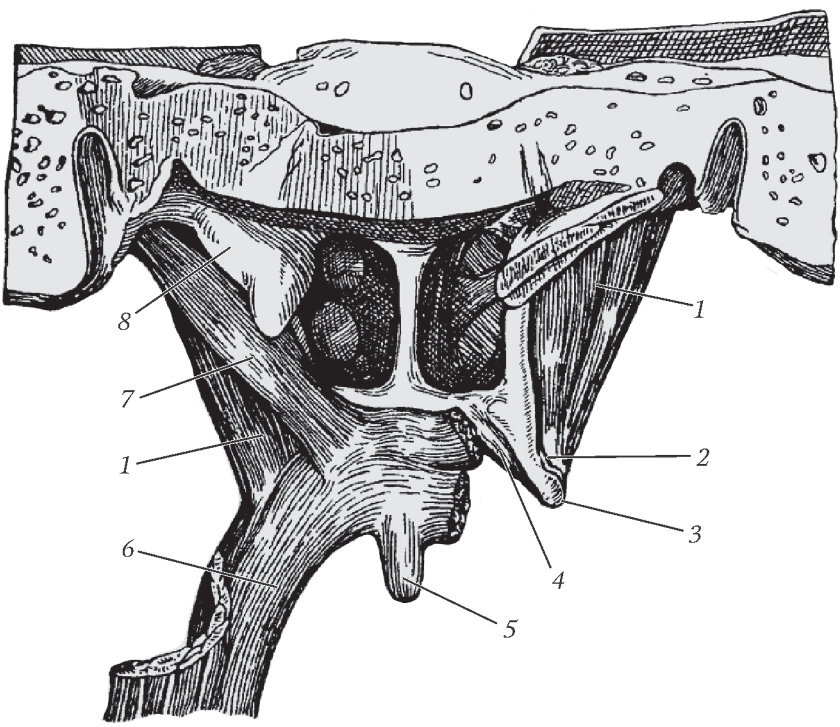


Fig. 2.17. Muscles of soft palate (posterior aspect (on the right, levator veli palatine and palatopharyngeus have been removed):

*1* — tensor veli palatini; *2* — bursa of tensor veli palatini; *3* — pterygoid hamulus; *4* — tendon of tensor veli palatini; *5* — musculus uvulae; *6* — palatopharyngeus; *7* — levator veli palatini; *8* — cartilage of auditory tube

The tensor veli palatini, *m. tensor veli palatini*, triangular, is medial to the medial pterygoid. It arises from the base of the sphenoidal pterygoid process, descends vertically, its fibers converge into a tendon turning medially round the pterygoid hamulus to pass to the palatine aponeurosis; between the tendon and hamulus there is a small mucous bursa. In the midline it connects with its fellow. The muscle tenses the palatine velum and opens the auditory tube.

The levator veli palatini, *m. levator veli palatini*, is medial and posterior to the preceding muscle; it arises from the inferior surface of the temporal bone`s pyramid (in front of the external opening of the carotid canal), and partially from the cartilage and membranous lamina of the auditory tube. It then descends forwards and medially to end in the palatine aponeurosis. The muscle elevates the soft palate.

The musculus uvulae, *m. uvulae*, is a small paired fasciculus which arises from the posterior nasal spine of the palatine bone`s horizontal plate and from the palatine aponeurosis, passes along the midline and ends in the uvula. The muscle elevates and shortens the uvula.

The palatoglossus, *m. palatoglossus*, belongs both to the lingual muscles and muscles of the soft palate. It arises from the palatine aponeurosis, forms, with the mucosa over it, the palatoglossal arch and blends with the transverse muscle of the tongue. The muscle pulls the root of the tongue upwards, depresses the soft palate and narrows the fauces.

The palatopharyngeus, *m. palatopharyngeus*, is stronger than the previous muscle. It arises from the palatine aponeurosis and pterygoid hamulus, forms, with the mucosa over it, the palatopharyngeal arch and ends in the wall of the pharynx near the posterior edge of the thyroid cartilage. The muscle tenses the palatopharyngeal arch, drawing it closer to the opposite arch. Acting bilaterally, the two muscles pull the palatine velum down and backwards. When the soft palate is fixed, the muscle assists in the elevation of the pharynx. Thus, the upper part of the pharynx (nasopharynx) becomes isolated from the rest of the pharynx during swallowing. Also a so-called Passavant`s ridge, which is formed by the contraction of the circular fibers of the superior pharyngeal constrictor, helps to isolate the nasopharynx during swalloing.

## TEST QUESTIONS

1. Describe the bony structure of the walls of the oral cavity. Describe the structure of the lateral, inferior and superior walls. What muscles form the inferior wall (floor) of the oral cavity? What is the action of these muscles?
2. Define the vestibule and the oral cavity proper.
3. Describe the parts and structure (layers) of the lips.
4. Give the characteristic of the mucous of the oral cavity.
5. Name and classify the salivary glands. Describe the localization of the major salivary glands.
6. Where do the major salivary glands` ducts open?
7. Which of the salivary gland are serous (mucous, mixed)? Which of them are alveolar (tubulo-alveolar)?

8. Describe the components of the saliva and its function.
9. Describe the structure of a tooth.
10. Write the formula of the constant and milk teeth. What is the difference between milk and constant teeth in number and types?
11. Describe the surfaces of the crown.
12. Describe the distinctive features of the incisors, canine, premolars and molars.
13. Describe the distinctive features of the milk teeth.
14. Describe the time of the dental eruption (milk and constant).
15. Describe the external structure of the tongue (its parts, grooves, papillae).
16. Describe the function of different types of papillae.
17. Where is the lingual tonsil located? What is its function?
18. Describe the muscles of the tongue (name, attachment, action of each muscle). What muscles change the shape of the tongue? What muscles change the position of the tongue? Which muscles move the tongue forward (backward, up, down, to the sides)?
19. What is the function of frenulum of the lips and of the tongue? What is the function of the sublingual fold and caruncle?
20. Which bones form the hard palate?
21. Describe the structure of the soft palate. Name the muscles of the soft palate, their attachment and action.
22. What muscles depress the soft palate, which of them elevate the soft palate? Which muscle acts on the soft palate and together on the tongue (pharynx)? Which of the muscles arise from the auditory tubes and what is the practical importance of such attachment?
23. Describe the structure of the palatoglossal and palatopharyngeal arches.
24. Describe the localization of the palatine tonsils. What is the function of the palatine tonsils?
25. What structures frame the fauces? What is the function of the fauces?

## CLINICOANATOMICAL PROBLEMS

1. A gunshot wound of the mental region and of the floor of the oral cavity occured: which parts of the oral cavity and which muscles can be damaged? Which functions of the digestive organs are disordered?
2. After a chemical burn of the oral cavity a patient lost the ability to distinguish the taste of food. Which papillae of the lingual mucosa were damaged?
3. A patient came to a doctor-medical examiner and said that he has been hit in face, and the right sixth tooth of the upper jaw has been knocked out. As evidence he showed the crown of the knocked out tooth which had two tubercles on the occlusal surface. What conclusion should the doctor give?
4. The parotid gland was inflamed, and paralysis of the mimic musculature occurred in a child. Why did it happen?
5. During the attack of stenocardia it is recommended to put a tablet of nitroglycerin under the tongue. How can you explain the rapid effect of the absorption of the medicine in sublingual application?

## 2.6. Pharynx

The pharynx, *pharynx*, is an unpaired funnel-shaped organ. It starts from the base of the skull and is continuous with the oesophagus at the level of the intervertebral disc between the VI and VII cervical vertebrae. In front of the pharynx there are the nasal cavity, oral cavity and larynx; behind — the deep cervical muscles covered by the prevertebral lamina of proper cervical fascia; lateral to the pharynx there are the neurovascular bundles of the neck. The pharynx conducts the food, which passes from the oral cavity to the oesophagus through the fauces, and it also transmits the air, which passes from the nasal cavity to the laryngeal cavity through the choanae, or from the oral cavity through the fauces. Hence, the alimentary and respiratory tracts cross in the pharyngeal cavity.

Relatively to the organs located in front of the pharynx, the pharyngeal cavity is divided into three parts: the nasal part (superior), or nasopharynx; the oral part (middle), or oropharynx; and the laryngeal part (inferior), or laryngopharynx (fig. 2.18).

During swallowing the nasopharynx is isolated from the rest of the pharynx by the soft palate. Due to this, the food can not pass to the nasopharynx (and thence through the choanae to the nasal cavity), but is directed down, to the oesophagus. During swallowing the larynx is rised up, the tongue is moved backwards and the epiglottis closes the laryngeal inlet.

The pharynx has the superior wall, which is fused with the skull base, the posterior wall and two laterals. The posterior wall is the most extensive; it adjoins the deep cervical muscles, which are covered by the prevertebral lamina of the proper cervical fascia. The superior pharyngeal wall is termed the vault, *fornix pharyngis*. The nasal and oral parts of the pharynx do not have the anterior wall because here the pharynx is connected with the nasal and oral cavities by means of the choanae and fauces respectively. Only the inferior pharyngeal part has an anterior wall which is formed by the mucous membrane covering the posterior wall of the larynx.

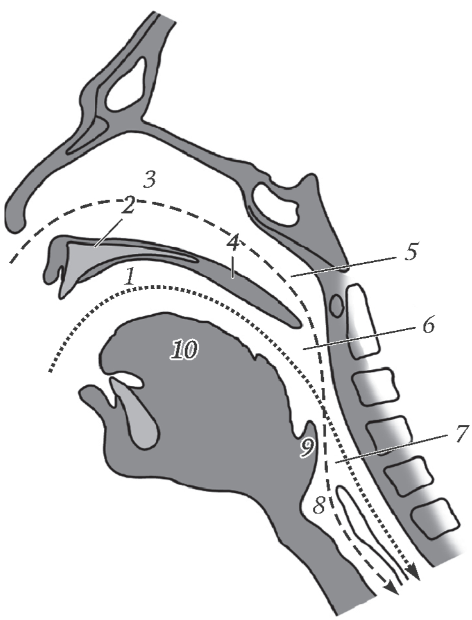


Fig. 2.18. Scheme of respiratory (– – – –) and digestive (………..) tracts:

*1* — oral cavity; *2* — hard palate; *3* — nasal cavity; *4* — soft palate; *5* — nasal part of pharynx; *6* — oral part of pharynx; *7* — laryngeal part of pharynx; *8* — laryngeal cavity; *9* — epiglottis; *10* — tongue

Now we will describe the structure of the pharyngeal parts individually.

***Nasal part of pharynx***, *pars nasalis pharyngis*, is behind the choanae which limit the nasal cavity posteriorly. The mucosa of only this part of the pharynx has a ciliated epithelium. In the area of the vault it is thickened by the aggregation of lymphoid tissue forming the pharyngeal tonsil, *tonsilla pharyngealis*. The latter is well-developed in newborns (it has 8 mm in length and 3 mm in width), and then begins to atrophy.

On the lateral wall of the nasopharynx, opposite the posterior end of the inferior nasal concha, there is a pharyngeal opening of auditory tube, *ostium pharyngeum tubae auditivae*. It is bounded by an elevation termed the torus tubarius, *torus tubarius*, the posterior part of which bulges greater and descends as a salpingopharyngeal fold, *plica salpingopharyngea*, containing the muscle of the same name.

Behind and above the salpingopharyngeal fold there is a depression called the pharyngeal recess, *recessus pharyngeus*. The salpingopalatine fold, *plica salpingopalatina*, containing the muscle of the same name, passes from the torus tubarius to the pharyngeal recess. Between the pharyngeal opening of auditory tube and the palatine velum (close to the opening) on either side there is a paired aggregation of lymphoid tissue termed the tubal tonsil, *tonsilla tubaria*, which is much smaller than an unpaired pharyngeal tonsil.

***Oral part of pharynx***, *pars oralis pharyngis*, is at the level of the fauces and occupies the interval between the palatine velum and laryngeal inlet. Between the oropharynx and oral cavity there is a paired palatine tonsil, *tonsilla palatina*. It is placed in the tonsillar fossa, *fossa tonsillaris*, between the palatoglossal and palatopharyngeal arches.

The floor of the tonsillar fossa is formed by the superior pharyngeal constrictor and pharyngeal fascia. Each tonsil consists of the lymphoid follicles, having 1—2 mm in diameter and surrounded by connective-tissue tonsillar capsule, *capsula tonsillaris*.

Thus, at the entrance to the pharynx from the nasal and oral cavities there is a collection of the lymphoid tonsils: the lingual tonsil, two palatine tonsils, the pharyngeal and two tubal tonsil, which all together form the lymphoepithelial Pirogov-Waldeyer`s ring (fig. 2.19). The mucous membrane of the posterior pharyngeal wall may be examined through the fauces. For examination it needs to open the mouth wide and to depress the root of the tongue.

***Laryngeal part of pharynx***, *pars laryngea pharyngis*, is the lowest and the narrowest part of the pharynx, situated behind the larynx (fig. 2.20). It extends from the level of the laryngeal inlet to the level of the lower edge of the cricoid cartilage, where the pharynx is continuous with the oesophagus. The anterior wall of the laryngopharynx is formed by the posterior wall of the larynx,

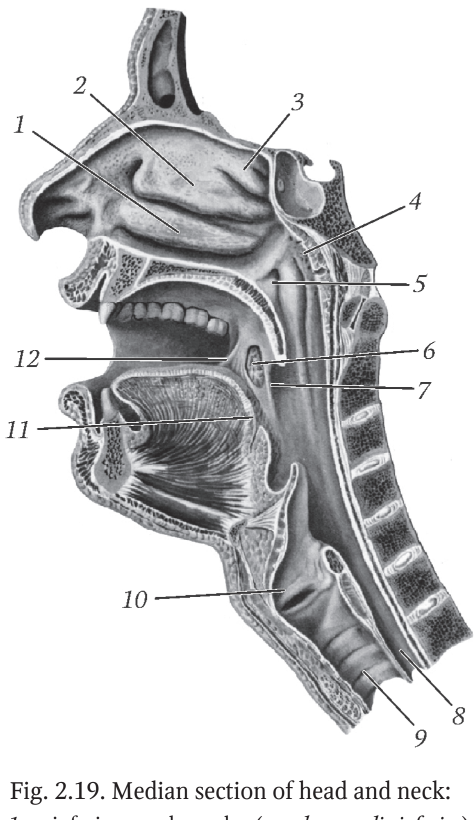


Fig. 2.19. Median section of head and neck:

*1* — inferior nasal concha (*concha nasalis inferior*); *2* — middle nasal concha (*concha nasalis media*); *3* — superior nasal concha (*concha nasalis superior*); *4* — pharyngeal tonsil (*tonsilla pharyngealis*); *5* — pharyngeal opening of auditory tube (*ostium pharyngeum tubae auditivae*); *6* — palatine tonsil (*tonsilla palatina*); *7* — palatopharyngeal arch (*arcus palatopharyngeus*); *8* — oesophagus (*oesophagus*); *9* — trachea (*trachea*); *10* — larynx (*larynx*); *11* — lingual tonsil (*tonsilla lingualis*); *12* — palatoglossal arch (*arcus palatoglossus*)

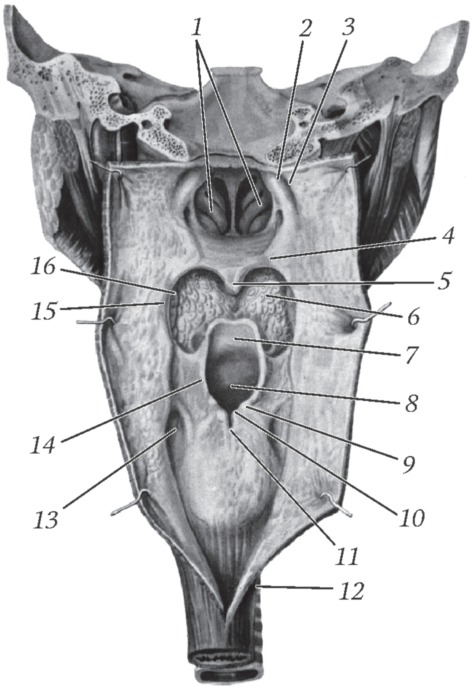


Fig. 2.20. Pharyngeal cavity (posterior aspect (posterior wall is opened)):

*1* — choanae (*choanae*); *2* — torus tubarius (*torus tubarius*); *3* — pharyngeal recess (*recessus pharyngeus*); *4* — palatine velum (*velum palatinum*); *5* — palatine uvula (*uvula palatina*); *6* — root of tongue (*radix linguae*); *7* — epiglottis (*epiglottis*); *8* — laryngeal inlet (*aditus laryngis*); *9* — cuneiform tubercle (*tuberculum cuneiforme*); *10* — corniculate tubercle (*tuberculum corniculatum*); *11* — interarytenoid notch (*incisura interarytenoidea*); *12* — oesophagus (*oesophagus*); *13* — piriform recess (*recessus piriformis*); *14* — aryepiglottic fold (*plica aryepiglottica*); *15* — palatopharyngeal arch (*arcus palatopharyngeus*); *16* — palatine tonsil (*tonsilla palatina*)

covered by the mucous membrane. Above the anterior wall there is an opening called the laryngeal inlet, *aditus laryngis*, which is bounded anteriorly by the epiglottis and laterally by the aryepiglottic folds. On the sides of the larynx protruding into the pharyngeal cavity there is a deep depression termed the piriform recess, *recessus piriformis*. It is bounded medially by the lateral wall of the larynx and laterally by the lateral wall of the pharynx, which contains the posterior edge of the thyroid cartilage`s lamina at this level. The medial and lateral walls converge with each other at an acute angle. The medial wall of the piriform recess is divided into the upper (smaller) and lower (larger) parts by the mucosal fold covering the superior laryngeal nerve and called the fold of superior laryngeal nerve, *plica nervi laryngei superioris*. Posterior to the laryngeal prominence is a constriction leading to the oesophagus. Thus, below, the pharynx ends with a clearly distinct constriction being the entrance into the oesophagus.

The pharyngeal wall consists of the mucous membrane, muscular layer and adventitia.

The mucous membrane of the pharynx resembles the oral mucosa. It is composed of stritified squamous epithelium and lamina propria. The mucous membrane of nasopharynx is ciliated like in the respiratory tract. In the area of the pharyngeal vault the mucous membrane is thickened by the aggregation of lymphoid tissue that forms the pharyngeal tonsil.

The mucous membrane of the pharynx has a lot of mucous and mixed glands. The mucous glands are structurally similar to the mucous glands of the lingual root but they are located deeper, sometimes penetrating the muscle layer. The mixed glands lie more superficially and resemble those of the oral cavity and larynx.

Beneath the mucous membrane of the pharynx there is a well-developed connective-tissue layer, which is formed by elastic fibers and called pharyngobasilar fascia, *fascia pharyngobasilaris*. This layer of elastic fibers corresponds to submucosa of other hollow digestive organs. Near the oesophagus the pharyngobasilar fascia diminishes in thickness and gradually transforms into usual submucous layer.

The pharyngobasilar fascia is attached to the following structures of the skull base: from the pharyngeal tubercle it passes along the occipital bone`s basilar part to the petro-occipital synchondrosis and continues along the inferior surface of the pyramid (in front of the external opening of the carotid canal); it then directs forwards and medially along the sphenopetrosal synchondrosis to the base of the medial pterygoid plate and descends along its posterior edge to the fibrous strip called the pterygomandibular raphe, *raphae pterygomandibularis* (it is between the pterygoid hamulus of sphenoid bone and the mandible); it then passes along the mandibular ramus to reach the mylohyoid line.

The muscular layer of the pharynx is formed by striated muscles. This layer is external to the pharyngeobasilar fascia and includes two muscle groups: 1) contstrictor muscles (their fibers have transverse and oblique direction); 2) muscles elevating the pharynx (they are longitudinal) (fig. 2.21).

The pharynx has three constrictor muscles. The superior constrictor, *m. constrictor pharyngis superior*, arises from the lower part of the medial plate and hamulus of the sphenoidal pterygoid process, from the pterygomandibular raphe, mylohyoid line of mandible and from the tongue as a continuation of its transverse muscle. The fibers of the superior constrictor run mainly horizontally to form a single muscle plate which meets its fellow in the midline. The part of the pharyngeobasilar fascia between the upper edge of the superior constrictor and the base of skull is not covered by the muscular layer.

The middle constrictor, *m. constrictor pharyngis medius*, is fan-shaped sheet arising from the lesser and greater horns of the hyoid bone and from the stylohyoid ligament. Its upper fibers partially cover the superior constrictor, the middle fibers run horizon-

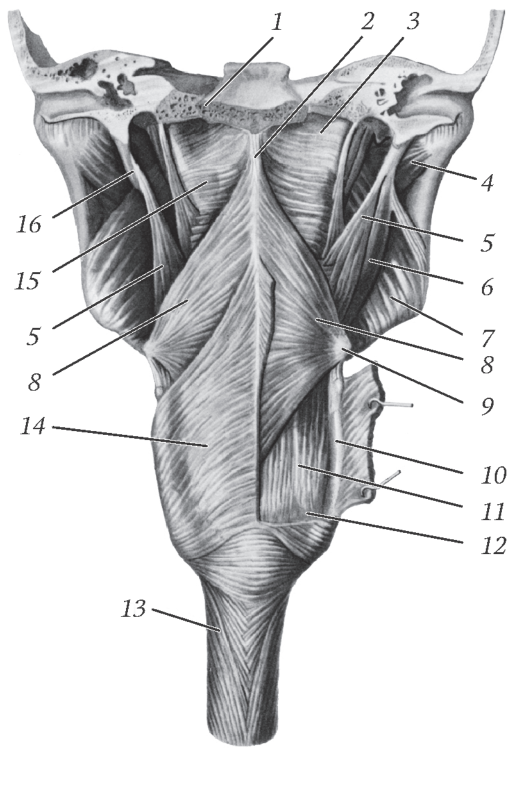


Fig. 2.21. Muscles of pharynx (posterior aspect (inferior pharyngeal constrictor has been resected and turned outward)):

*1* — basilar part of occipital bone (*pars basilaris ossis occipitalis*); *2* — pharyngeal raphe (*raphe pharyngis*); *3* — pharyngobasilar fascia (*fascia pharyngobasilaris*); *4* — lateral pterygoid muscle (*m. pterygoideus lateralis*); *5* — stylopharyngeus (*m. stylopharyngeus*); *6* — stylohyoid (*m. stylohyoideus*); *7* — medial pterygoid muscle (*m. pterygoideus medialis*); *8* — middle pharyngeal constrictor (*m. constrictor pharyngis medius*); *9* — greater horn of hyoid bone (*cornu majus ossis hyoidei*); *10* — superior horn of thyroid cartilage (*cornu superius cartilaginis thyroideae*); *11* — palatopharyngeus (*m. palatopharyngeus*); *12* — the area of inferior horn of thyroid cartilage (*cornu inferius cartilaginis thyroideae*); *13* — muscular layer of oesophagus (*tunica muscularis oesophagus*); *14* — inferior pharyngeal constrictor (*m. constrictor pharyngis inferior*); *15* — superior pharyngeal constrictor (*m. constrictor pharyngis superior*); *16* — styloid process (*processus styloideus*)

tally, and the lower fibers descend to be inserted into the median pharyngeal raphe with its opposite fellow.

The inferior constrictor, *m. constrictor pharyngis inferior*, is much stronger than the middle constrictor and overlaps its most part. It arises from the oblique line of the thyroid cartilage and external surface of the cricoid cartilage. Its fibers run like rays to join the opposite muscle in the median pharyngeal raphe, and the lowermost fibers blend with the musular fibers of the oesophagus.

The longitudinal pharyngeal muscles are internal to the constrictors, closer to the pharyngeobasilar fascia. They are much weaker. Here belong: the stylopharyngeus, *m. stylopharyngeus*, which start from the styloid process of the temporal bone; the palatopharyngeus, *m. palatopharyngeus*, situated in the palatopharyngeal arch; the salpinopharyngeus, *m. salpingopharyngeus*, situated in the salpingopharyngeal fold.

Thus, the muscular layer of the pharynx is chiefly formed by the constrictors, which overlap each other like a tile (the superior constrictor is the deepest and the inferior one is the most superficial hence is visible entirely). The fibers of the constrictors converge with their fellows to form the pharyngeal raphe, *raphe pharyngis*, along the midline of the posterior pharyngeal wall. During swallowing, the constrictors contract sequentially from above downwards, pushing the food bolus into the oesophagus. The longitudinal muscles elevate the pharynx during the swallowing.

The adventitia covers the pharyngeal muscles from outside. It is loosely linked with the adjacent organs and with the prevertebral lamina of the proper cervical fascia. Due to this, the pharynx is almost immobile. Posterior and lateral to the pharynx there is a peripharyngeal space, *spatium peripharyngeum*. It is divided into retropharyngeal space, *spatium retropharyngeum*, and lateropharyngeal space, *spatium lateropharyngeum*, respectively. The peripharyngeal space contains the adipose tissue and also the vessels, nerves and lymph nodes.

## 2.7. Oesophagus

The oesophagus, *oesophagus*, is a direct continuation of the pharynx; it is a tube 25—30 cm long, flattened from front to back. It starts at the level of the VII cervical vertebra and ends opposite the XI thoracic vertebra. In accordance with the position in the body, the oesophagus can be divided as follows:

1) cervical part, *pars cervicalis*, equal to the height of the VII cervical body;

2) thoracic part, *pars thoracica*, extending throughout the thoracic cavity;

3) abdominal part, *pars abdominalis*, the shortest, 1—1,5 cm long.

The oesophagus is linked with the adjacent organs by areolar tissue therefore, it is quite mobile. It distinctly deviates from the midline, especially in the neck. The cervical part of the oesophagus is behind the trachea and in front of the vertebral column and the prevertebral lamina of the proper cervical fascia. Where the pharynx is continuous with the oesophagus, the muscular layer is a little thickened. Between the cervical and thoracic parts the oesophagus deviates to the left which should be used by surgeons to choose a surgical approach. In the thorax, opposite the III thoracic vertebra, the aortic arch lies in front of the oesophagus. At the level of the IV and V thoracic vertebrae the oesophagus crosses the left bronchus, passing behind it (fig. 2.22). Then the oesophagus slightly deviates to the right.

The vagus nerves adjoin the oesophagus on both sides; their branches, connecting together, form the plexuses. The vertebral column is behind the oesophagus, and only opposite the IX thoracic vertebra the oesophagus is pushed forwards by the aorta. Before passing through the diaphragm, the oesophagus deviates to the left of the midline again.

Thus, the aorta and oesophagus go around each other like a gently sloping spiral. The oesophagus together with the vagus nerves passes through the oesophageal hiatus of the diaphragm, situated to the left of the median plane, into the abdominal cavity.

The oesophageal lumen has three anatomical constrictions: pharyngeal, bronchial and diaphragmatic. The pharyngeal (paryngo-oesophageal) constriction, *constrictio pharyngooesophagealis*, is at the commencement of the oesophagus opposite the laryngeal cricoid cartilage, which is at the level between the VI and VII cervical vertebrae. The bronchial (thoracic) constriction, *constrictio partis thoracicae*, is where the oesophagus is crossed by the left main bronchus; it is at the level between the IV and V thoracic vertebrae. The diaphragmatic constriction, *constrictio phrenica*, corresponds to the oesophageal hiatus of the diaphragm, which is situated at the level of the X—XI thoracic vertebrae.

The oesophagus of a living person has two physiological constrictions: aortic and cardial; they are visible in radiological examination. The aortic constriction, *constrictio aortalis,* is formed by the adjoining aortic arch. It is at the level of the III thoracic vertebre. The cardial constriction, *constrictio cardialis*, is opposite the XI thoracic vertebra and corresponds to the place where the oesophagus is continuous with the stomach.

In endoscopic and surgical practice 9 segments of the oesophagus are distinguished: tracheal; aortic; aorto-bronchial;

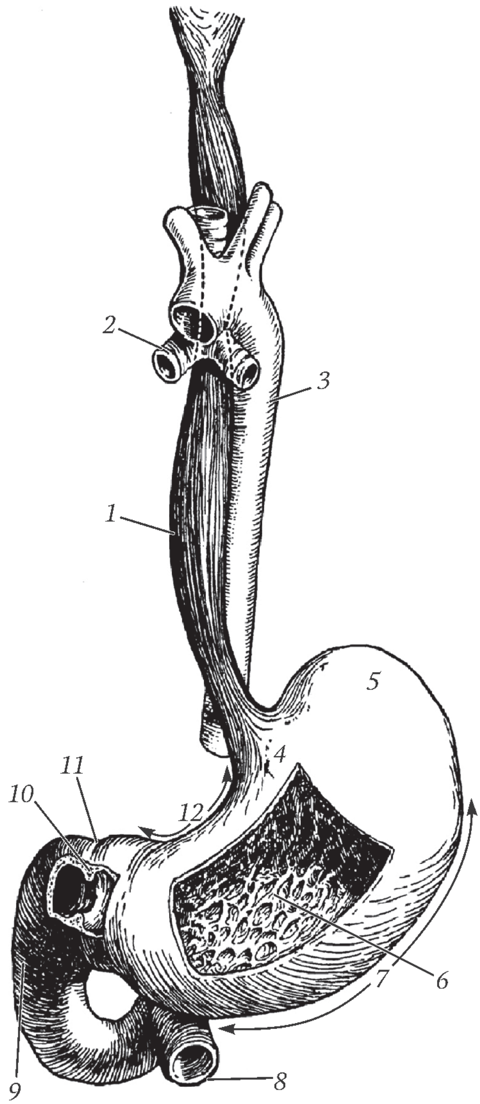


Fig. 2.22. Syntopy of thoracic part of oesophagus:

*1* — oesophagus (*oesophagus*); *2* — right principal bronchus (*bronchus principalis dexter*); *3* — descending aorta (*aorta descendens*); *4* — cardiac part of stomach (*pars cardiaca gastricus*); *5* — fundus of stomach (*fundus gastricus*); *6* — gastric folds (*plicae gastricae*); *7* — greater curvature (*curvatura major*); *8* — jejunum (*jejunum*); *9* — duodenum (*duodenum*); *10* — pyloric valve (*valvula pylori*); *11* — pyloric part (*pars pylorica*); *12* — lesser curvature (*curvatura minor*)

bronchial; subbronchial; retropericardial; supradiaphragmatic; intradiaphragmatic; infradiaphragmatic.

The wall of the oesophagus is about 4 mm thick and constructed from the following layers (fig. 2.23): the mucous, submucous, muscular and adventitious layers.

The mucous membrane, lining the oesophagus from inside, has well marked longitudinal folds. The epithelium of the mucous layer is non- keratinized stratified squamous. The mucosa is traversed by the ducts of the small numerous oesophageal glands, *glandulae oesophageae*, the bodies of which lie in the submucosa. Apart from these glands, the mucous layer has the cardiac glands and solitary lymphoid follicles. The cardiac glands of the oesophagus are placed in its tracheal and infradiaphragmatic segments; they resemble the gastric cardiac glands and secrete the mucin.

The submucous layer is formed by areolar tissue containing the blood and lymphatic vessels and nerves. This tissue loosely connects the mucous and muscular layers, due to which the oesophageal mucosa is folded into relatively high longitudinal folds. When the oesophagus is not distended, its lumen is star-shaped in a cross-section.

The muscular layer of the upper part of the oesophagus is constructed from the striated muscle tissue, like in the pharynx. In the middle part the striated muscle fibers are gradually replaced by smooth muscle cells. In the lower part the muscular layer is fully formed by smooth muscles. The muscular layer consists of outer longitudinal, thicker, and inner circular strata.

The oesophagus is covered by a dense connective-tissue, which forms its external sheath called adventitia. In certain places the oesophagus is covered by the serous layer: above the root of the lung, where the left mediastinal pleura adjoins the oesophagus, and below the root of the lung, where the right mediastinal pleura adjoins it. The pericardium is anterior to the lower portion of the thoracic part of the oesophagus. Below the diaphragm the oesophagus is enveloped by the peritoneum from all sides.

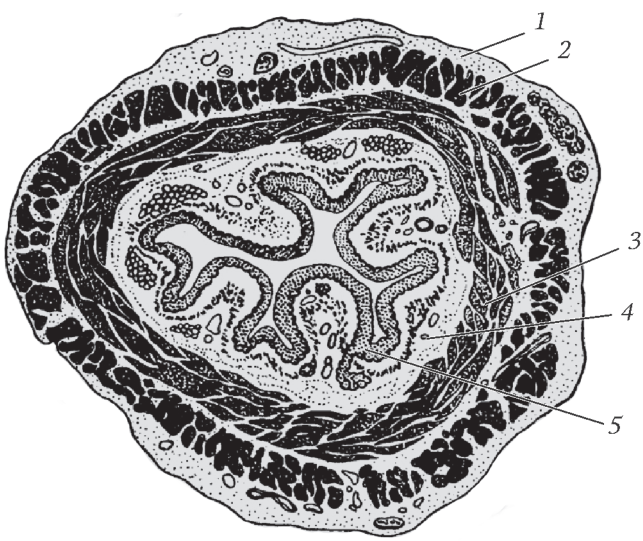


Fig. 2.23. Transverse section of oesophagus (magnification × 4):
*1* — tunica adventitia; *2* — longitudinal stratum of muscular layer; *3* — circular stratum of muscular layer; *4* — tela submucosa; *5* — epithelium

## 2.8. Stomach

The stomach, *gaster* (*ventriculus*), carries out the following important functions: 1) accumulation the food passing from the oesophagus; 2) splitting of proteins and fats, coagulation of the casein of milk; 3) mixing and moving the chyme to the intestine. The main function of the stomach is a secretion of the gastric juice, which contains the enzymes (pepsin, chymosin) and hydrochloric acid. Pepsin splits the complex proteins, and chymosin coagulates the casein of milk. Chymosin is present in the gastric juice only in children. Besides, the stomach plays the endocrine function (produces local tissue hormones) and excretory function (excretion of the metabolic products from the body).

The capacity of the stomach varies from 1,2 to 4 liters; the average capacity in adults is about 1200 ml. Its sizes alter depending on the contained food and especially liquid. A greatly distended stomach descends to the level of the umbilicus and even below. If it is empty and contracted (for example, at starvation), its sizes are considerably decreased.

The shape of the stomach is peculiar (fig. 2.24). It has anterior wall, *paries anterior*, directed forwards and slightly up, and the posterior wall, *paries posterior*, directed backwards and a little down. Both surfaces are continuous with each other along the margins. The shorter margin, directed upwards, is called the lesser curvature, *curvatura minor*. The longer, convex, margin, directed down, is the greater curvature, *curvatura*

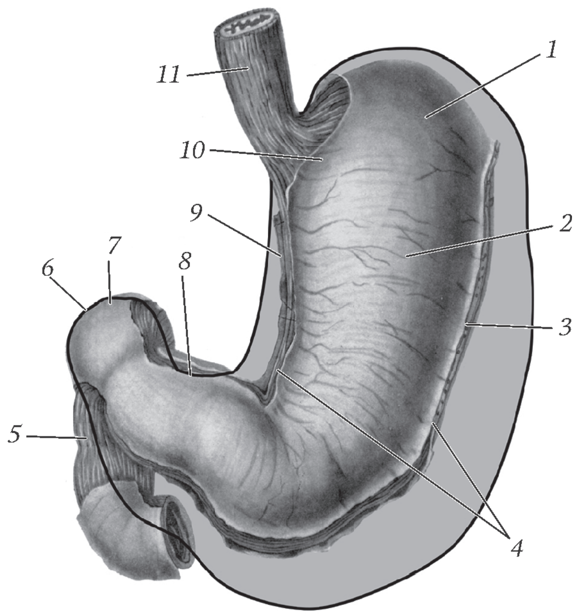


Fig. 2.24. Stomach (anterior aspect). Black line shows shape and position of full stomach:
*1* — fundus of stomach (*fundus gastricus*); *2* — body of stomach (*corpus gastricum*); *3* — greater curvature (*curvatura major*); *4* — lines of attachment of greater and lesser omenta; *5* — descending part of duodenum (*pars descendens duodeni*); *6* — superior duodenal flexure (*flexura duodeni superior*); *7* — superior part of duodenum (*pars superior duodeni*); *8* — pyloric part (*pars pylorica*); *9* — lesser curvature (*curvatura minor*); *10* — cardiac part (*pars cardiaca); 11* — oesophagus (*oesophagus*)

*major*. At the upper end of the lesser curvature there is an opening leading from the oeosphagus into the stomach and termed the cardiac orifice, *ostium cardiacum*; the part of the stomach, adjoining it, is called the cardiac part, *pars cardiaca* (or cardia, *cardia*). The oesophagus opens into the stomach not immediately on its top but a little on right the side therefore, the left side of the oesophagus joins the greater curvature at an acute angle called the cardiac notch, *incisura cardiaca*. The size of the cardiac notch (angle of His) may be different, depending on the shape of the stomach. From the side of the stomach the cardiac orifice is shielded by the fold of the mucous layer, playing the role of the valve (fold of Gubarev). A blind protrusion of the stomach, directed up and to the left of the cardiac part, is called the fundus of stomach, *fundus gastricus*.

The middle part of the stomach is named the body, *corpus gastricum*, and the terminal part, near the opening into the duodenum, is called the pyloric part, *pars pylorica*. The latter, in its turn, is divided into a wider pyloric antrum, *antrum pyloricum*, and narrower pyloric canal, *canalis pyloricus*. The stomach opens into the duodenum by means of the pyloric orifice, *ostium pyloricum*. It is indicated by a clearly visible pyloric constriction on the surface of the organ, which shows the exact border between the stomach and duodenum. A circular pyloric valve, *valvula pylori*, corresponds to the pyloric orifice from the inside.

When the stomach is filled moderately, it is situated mainly in the left hypochondriac region and partially in the epigastrium. The fundus of stomach occupies the concavity of the diaphragm in the left hypochondriac region, the cardiac orifice is to the left side of the XI or X thoracic vertebral body, and the pyloric orifice is to the right of the intervertebral disc between the bodies of the XII thoracic and I lumbar vertebrae. When the stomach is filled moderately, the greater curvature forms an arch connecting the lowest points of the IX or X pairs of the ribs. The area of the anterior gastric surface, immediately adjoining the inner surface of the anterior abdominal wall, is triangle-shaped. It is bounded on the left by the left costal cartilages (from VII to IX), on the right by the inferior border of the liver, below by the transverse colon. The rest of the anterior gastric surface is in contact with the liver (the area of the lesser curvature and of the cardiac orifice) and with the diaphragm (the fundus, body and the part of the greater curvature). The posterior surface of the stomach is adjacent to the spleen, pancreas, left kidney with the adrenal gland and the transverse colon (below, in the area of the greater curvature).

Certainly, the given data is arbitrary because the shape and size of the stomach are constantly modified by intrinsic changes and by the state of surrounding viscera. An empty stomach displaces backwards, its wall does not contact the anterior abdominal wall, and in this case the transverse colon is anterior to the stomach. When the stomach is full, it expands and the greater curvature mainly displaces down and to the left. The lesser curvature is less mobile because the stomach is fixed in the area of the cardiac and pyloric orifices.

The mucous membrane, *tunica mucosa*, differs by its grayish-pink color (in young people the color is brighter). It is separated from the oesophageal mucosa by a serrated whitish line, *ora serrata*. If the stomach is not distended or distended a little, its mucosa is folded into the gastric folds, *plicae gastricae* (fig. 2.25). They cross each other in different directions, and only in the cardiac and pyloric parts they run radially. Along the lesser and greater curvatures there are longitudinal folds. At the junction of the stomach and duodenum the mucosa forms a circular pyloric valve bound-

ing an oval-shaped pyloroc orifice and corresponding to the pyloric sphincter. The latter is closed during the contraction of the sphincter, absolutely separating the lumen of the stomach and duodenum. The gastric folds are more numerous and well marked during the strong contraction of the stomach musculature. When the stomach is distended, the folding decreases and the mucosa becomes thinner (its average thickness is 2—3 mm).

The surface of the mucosa is honeycombed by the small elevations bounded by the constant grooves of different sizes and directions and called the gastric areas, *areae gastricae*. The gastric areas are studded with minute depressions, the gastric pits, *foveolae gastricae*, which denote entrances to the gastric glands. The number of the gastric glands, *glandulae gastricae*, is 35—40 millions.

Three types of the gastric glands are distinguished: proper (main) gastric glands, cardiac and pyloric. The proper gastric glands are in the body and fundus; they are the most numerous, and their secretory surface reaches 4 $m^2$. They include five types of cells: 1) chief (secrete pepsinogen); 2) oxyntic, or parietal (produce hydrochloric acid); 3) mucous and 4) mucous ('neck') cells (secrete the mucus); 5) endocrine (produce the biological active substances: gastrin, serotonin, histamine, somatostatin etc; these substances are the tissue hormones, which influence the local and general processes of the regulation of the body functions).

The cardiac glands (situated in the cardiac part of stomach) consist of mainly mucous and chief cells. The pyloric glands contain mainly parietal cells, producing the mucus, and endocrine cells, producing the hormones. It should be noted that the mucus provides not only mechanical protection of the mucous membrane but contains the antipepsin, which protects the gastric wall from autodigestion.

The gastric mucosa is covered by simple columnar epithelium. Its loose connective-tissue contains the bodies of the glands and also the solitary lymphatic follicles.

The submucous layer, *tela submucosa*, is well-developed throughout the stomach therefore, the mucous membrane is quite mobile and forms the folds.

The muscular layer, *tunica muscularis*, is comprised of smooth muscles arranged in three layers (fig. 2.26). The external longitudinal layer, *stratum longitudinale*, is a continuation of the same layer of the oesophageal muscular coat; it is better developed near the greater and lesser curvatures. In the area of the pyloric part it becomes thicker and is developed uniformly.

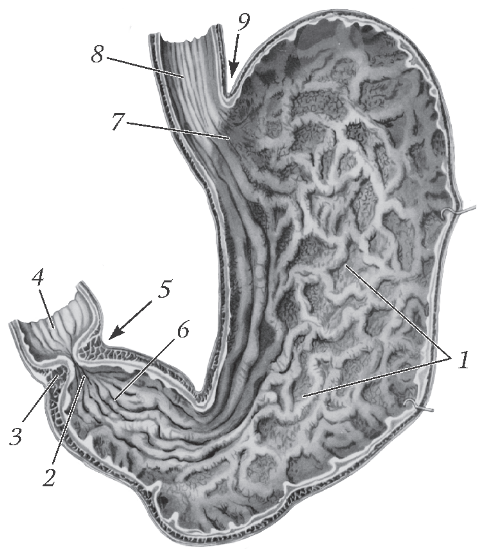


Fig. 2.25. Relief of mucous membrane of posterior gastric wall:

*1* — gastric folds (*plicae gastricae*); *2* — pyloric valve (*valvula pylorica*); *3* — pyloric sphincter (*m. sphincter pylori*); *4* — mucous membrane of duodenum (*tunica mucosa duodeni*); *5* — pylorus (*pylorus*); *6* — mucous membrane (*tunica mucosa*); *7* — cardiac orifice (*ostium cardiacum*); *8* — mucous membrane of oesophagus (*tunica mucosa oesophagei*); *9* — cardiac notch (*incisura cardiaca*)

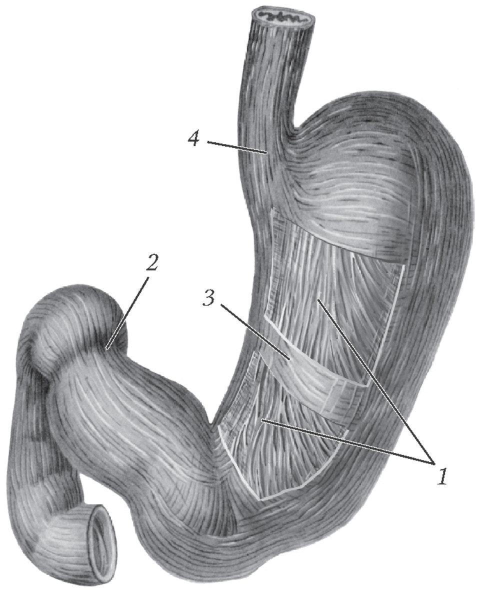


Fig. 2.26. Muscular layer of stomach (superficial longitudinal and middle strata have been partially removed):

*1* — oblique fibers; *2* — longitudinal stratum of muscular layer at junction of stomach and duodenum; *3* — circular stratum; *4* — longitudinal stratum of muscular layer of oesophagus

The middle layer, thicker, is circular, *stratum circulare*; its fibers are also continuous with the circular oesophageal and duodenal fibers. It spreads throughout the stomach in the shape of rings which concentrate at the junction between the pylorus and duodenum to form the pyloric sphincter, *m. sphincter pylori*, included into the pyloric valve. The third, or deep, layer is formed by oblique fibers, *fibrae obliquae*. They also connect with the circular oesophageal fibers and consist of the separate fascicles, which round the cardiac orifice and spread along the anterior and posterior walls of the stomach. The oblique fibers form the base of the Gubarev`s fold in the cardiac part. There is no special muscle sphincter in the cardiac part however this fold contains a well-developed submucous venous plexus. When the stomach contracts during the digestion of food, the cardiac orifice is closed.

The stomach is covered by the peritoneum from all sides (intraperitoneal position) and is connected with the liver, spleen, transverse colon and diaphragm by the ligaments of the peritoneum (*lig. hepatogastricum, lig. gastrosplenicum, lig. gastrocolicum, lig. gastrophrenicum*). The peritoneal covering is absent along the lesser curvature (the line of the attachment of the hepatogastric ligament) and along the greater curvature (the line of the attachment of the greater omentum). The subserous layer is formed by a thin layer of areolar tissue.

## TEST QUESTIONS

1. Describe the skeletotopy of the pharynx: where does it start (relatively to the skull) and end (relatively to the vertebral column)?

2. What parts of the pharynx are distinguished?

3. Describe the localization of the nasopharynx. Why this part of the pharynx has such a name? Describe its walls. What epithelium covers it? What is the function of this part? What structure separates the nasopharynx from oropharynx? What organs are opened into the nasopharynx? What are the names of their openings?

4. Where is the oropharynx located? Why it has such a name? What are its boundaries? What epithelium covers it? What is its function? Explain how the alimentary tract crosses the respiratory tract in the oropharynx. Where is the boundary between the nasopharynx and oropharynx?

5. Where is the laryngopharynx located? Why it has such a name? Describe its walls. What epithelium covers it? What is its function? Describe its interrelations with other organs.

6. Describe the localization of the tonsils in the nasopharynx. What is their function? Where is the adenoid located? What is its practical importance?

7. What tonsils are included into the Pirogov`s ring?

8. What is the salpingopharyngeal fold? What muscle does it contain?

9. Describe the layers of the pharynx in sequence. How many muscular layers does it have? Which of them is inner (outer)? Describe the names of the pharyngeal mucles, their attachment and action.

10. Describe the position of the pharyngeobasilar fascia. Describe its attachment to the base of the skull. How does it transform near the oesophagus?

11. What fascial spaces exist near the laryngopharynx? What is their practical importance?

12. Describe the commencement and the end of the oesophagus. Describe the skeletotopy of the oesophagus. What is its total length? What is the length of the alimentary tract from the oral vestibule to the beginning of stomach?

13. What parts of the oesophagus are distinguished according to their localization?

14. Describe the relations of each part of the oesophagus to other organs (especially to aorta and trachea).

15. What nerves accompany the oesophagus and pass through the oesophageal hiatus of the diaphragm together with the oesophagus?

16. Describe the layers of the oesophagus in sequence.

17. Describe the mucosa of the oesophagus: type of the epithelium, folds, glands.

18. How many muscular layers does the oesophagus have? Which of them is inner (outer)?

19. What anatomical and physiological constrictions does the oesophagus have? What are the differences between them? Describe the skeletotopy of each constriction. What is their practical importance?

20. Describe the position of the stomach in the abdominal cavity and the place of the stomach projection to the anterior abdominal wall of a living person.

21. Describe the parts of the stomach: which of them is superior (inferior); how will you differentiate the anterior and posterior walls of the stomach, superior and inferior parts on the anatomical preparation of the stomach? What part of the stomach (superior or inferior) is the fundus? Describe the pyloric part in details.

22. Describe the localization of the pyloric valve and sphincter; of the cardial sphincter. Explain their practical importance.

23. Describe the skeletotopy of the stomach (relatively to the vertebral column and to the ribs) and skeletotopy of its different parts: cardiac and pyloric orifices, fundus, greater and lesser curvatures. Describe the borders of the area of the stomach, which directly adjoins the anterior abdominal wall.

24. Describe the relations of the stomach to the neighboring organs: what organs adjoin the stomach posteriorly, superiorly, inferiorly, from the right and left sides.

25. Describe the layers of the gastric walls in sequence.

26. Describe the features of the gastric mucosa: folds, gastric areas, gastric foveolae and so on.

27. Describe the types and localization of the gastric glands. How do they differ in function? What kinds of cells does each of these types of glands contain? What substances does each kind of the cells secrete?

28. How is the stomach covered by the peritoneum? What ligaments connect the stomach to the surrounding organs?

29. Describe the functions of the stomach. How long food can be situated in the stomach?

30. Describe the shapes of the stomach depending on the constitutional features.

### CLINICOANATOMICAL PROBLEMS

1. In 7-year old children the nasal breath is disturbed and the hearing is decreased. The hypertrophy of which tonsils may lead to such symptoms?

2. A patient complains of a pain behind the sternum when the food bolus passes down. The radiological examination shows that the food bolus is delayed at the level of the V thoracic vertebra. Which organ may have the tumor?

3. An endoscopist is examining the oesophageal mucosa. What view does he observe throughout the oesophagus?

4. An endoscopist has to do fibrogastroscopy and PH-measurment in the different parts of the stomach. At what depth does he need to enter the optical fiber? What form do the folds of the gastric mucosa have in the cardiac part, on the curvatures, walls and in the pyloric part?

5. The ptosis of the stomach was diagnosed in a patient. Which ligaments were lengthened?

## 2.9. Small intestine

The small intestine, *intestinum tenue* (in Greek — *enteron*), is the part of the alimentary canal, in which the digestion of the chyme by the intestinal juice, bile and pancreatic juice occurs. Due to the influence of these secretions all nutritive substances undergo chemical digestion. The proteins are splitted by such enzymes as enterokinase, trypsin, chymotrypsin, erepsin and nuclease; the fats — by lipase; the carbohydrates — by amylase, sacharase, lactase etc.

The absorption of the products of digestion into the blood and lymphatic capillaries occurs through the mucous membrane of the small intestine. Besides, the intestine performs the mechanical function (possesses peristalsis), pushing the chyme to the caudal direction. The mucous membrane of the small intestine contains the endocrine cells, which produce the biological active substances (histamine, serotonin, cholecystokinin — pancreozimin etc).

The small intestine starts directly from the stomach and opens into the large intestine (fig. 2.27). The small intestine is a coiled tube 5—6 metres long. The diameter of its commencement is about 4—4,5 cm, then it gradually decreases to 2,5—3,0 cm. The small intestine consists of three parts: duodenum, jejunum and ileum. The jejunum and ileum, located intraperitoneally and having a mesentery, are united into the mesenteric small intestine, *intestinum tenue mesenteriale*. The most part of the duodenum lies extraperitoneally hence it is non-mesenteric and sessile.

The wall of the small intestine is comprised of the mucous, submucous, muscular and serous layers (or adventitia). The mucous membrane has a typical relief, including such structures as the circular folds, intestinal villi and crypts. All these structures increase the surface of the mucosa (to 20—30 m$^2$) and contribute to the performance of the main functions of the intestine. The circular folds, *plicae circulares*, are formed by the mucous and submucous layers. The intestinal villi, *villi intestinales*, are the microscopic digitate processes projected into the intestinal lumen (fig. 2.28). The number of the villi is from 20 to 40 per 1 mm$^2$. The connective-tissue base of each villus contains smooth muscle cells, the plexus of blood capillaries, nerves and the central lacteal (lymphatic) vessel. Directly from the chyme the proteins and carbohydrates are absorbed into the blood capillaries of the villi, and the fats are absorbed into the lymphatic vessel. The contraction of the myocytes contributes to the processes of the absorption and emptying of the vessels.

The numerous solitary lymphatic follicles, *noduli lymphoidei solitari*, (10—15 thousands) are scattered throughout the intestinal mucosa. They reach 0,5—3 mm in the diameter and often penetrate the submucous layer. The larger accumulations of the lymphoid tissue, called the aggregated lymphoid follicles, *noduli lymphoidei aggregati*, are typical of the terminal part of the ileum. Their number is 30—100, and the diameter is 5—12 mm. The lamina muscularis mucosae is well developed and made up of the bundles of myocytes, arranged longitudinally and circularly.

The submucous layer is formed by areolar tissue containing the largest vascular and nervous (submucous) plexuses and also the terminal parts of the intestinal glands.

The muscular layer consists of two strata of smooth muscle tissue: inner (circular) and outer (longitudinal), between which

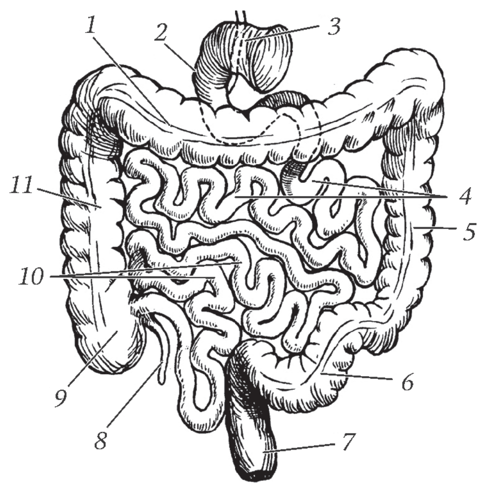


Fig. 2.27. Parts of small and large intestine:

*1* — transverse colon (*colon transversum*); *2* — duodenum (*duodenum*); *3* — bulb of duodenum (*bulbus duodeni*); *4* — jejunum (*jejunum*); *5* — descending colon (*colon descendens*); *6* — sigmoid colon (*colon sigmoideum*); *7* — rectum (*rectum*); *8* — vermiform appendix (*appendix vermiformis*); *9* — caecum (*caecum*); *10* — ileum (*ileum*); *11* — ascending colon (*colon ascendens*)

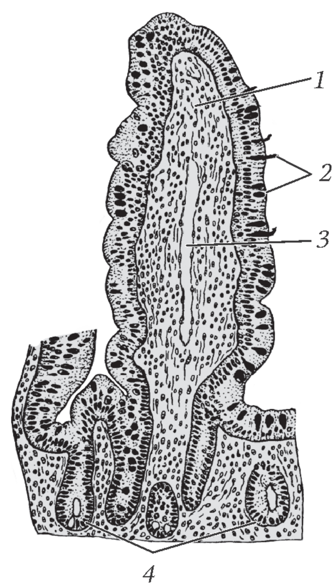


Fig. 2.28. Villus of small intestine (longitudinal section (magnification × 120)):

*1* — connective-tissue; *2* — epithelium; *3* — lacteal vessel; *4* — tubular glands

there is a vascular plexus and nervous muscular-intestinal plexus. The serous layer covers the small intestine from all sides, except the duodenum, the most part of which has a peritoneal cover only from the anterior side.

### 2.9.1. Duodenum

The duodenum, *duodenum*, has a relatively small length (in adult from 25 to 30 cm), but it is essentially important. It is the direct continuation of the stomach; the excretory ducts of the liver and pancreas open into its lumen. The process of the gastric digestion stops in the duodenum and the change of chyme under the influence of the bile and pancreatic juice begins.

The duodenum adjoins the lumbar part of the vertebral column and is fixed motionlessly, except its commencement and terminal part. It has a peculiar horseshoe shape and lies in the frontal plane (fig. 2.29).

The duodenum consists of four parts. The superior (first) part, *pars superior*, starts from the pyloric sphincter at the level of the disc between the XII and I lumbar vertebral bodies, runs horizontally backwards and to the right. The commencement of the superior part expands into so called duodenal cap, or ampulla (bulb), *bulbus duodeni*. Then the duodenum curves abruptly, forming the superior duodenal flexure, *flexura duodeni superior*, and then passes down as the descending (second) part, *pars descendens*, situated

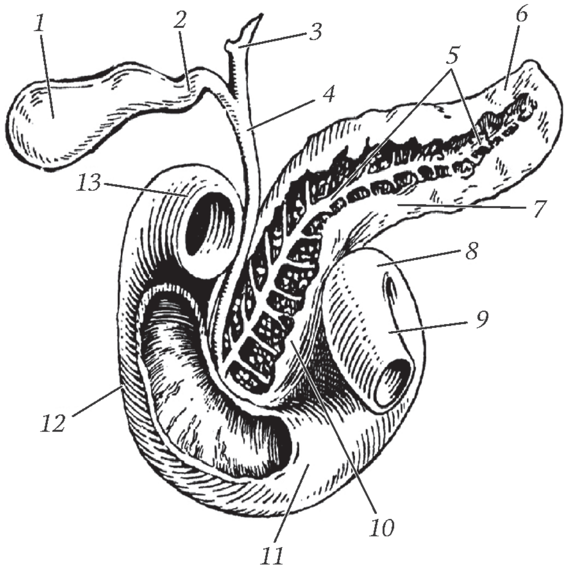


Fig. 2.29. Duodenum and pancreas. Excretory duct of pancreas is visible; anterior wall of duodenum has been opened:

*1* — gallbladder (*vesica biliaris*); *2* — cystic duct (*ductus cysticus*); *3* — common hepatic duct (*ductus hepaticus communis*); *4* — common bile duct (*ductus choledochus*); *5* — pancreatic duct (*ductus pancreaticus*); *6* — tail of pancreas (*cauda pancreatis*); *7* — body of pancreas (*corpus pancreatis*); *8* — duodenojejunal flexure (*flexura duodenojejunalis*); *9* — jejunum (*jejunum*); *10* — head of pancreas (*caput pancreatis*); *11* — horizontal part of duodenum (*pars horizontalis duodeni*); *12* — descending part of duodenum (*pars descendens duodeni*); *13* — superior part of duodenum (*pars superior duodeni*)

on the right side of the I, II and partially III lumbar vertebral bodies. At a second bend, termed the inferior duodenal flexure, *flexura duodeni inferior*, the duodenum, turns horizontally as the horizontal (third) part, *pars horizontalis*. The inferior duodenal flexure is at the level of the III lumbar vertebra. The horizontal part turns up as an ascending part, *pars ascendens*, which ends opposite the left side of the II lumbar vertebra in the jejunum. At this union the duodenum turns abruptly forwards to form the duodenojejunal flexure, *flexura duodenojejunalis*. Here the duodenum is fixed to the left intermediate crus of the diaphragm by means the bundle of smooth muscle fibers, which form the suspensory muscle of duodenum, *m. suspensorius duodeni*. The latter, surrounded by the fascia and peritoneum, constitutes the suspensory ligament of duodenum, *lig. suspensorium duodeni* (ligament of Treitz).

The superior part of the duodenum adjoins the neck of the gallbladder above and the transverse colon below. The descending part is in contact with the right kidney and anteriorly is crossed by the mesentery of the transverse colon. In the groove between the head of pancreas and the descending part of duodenum the common bile duct passes. Medial to the descending part, within its horseshoe, is the head of pancreas.

The duodenal mucosa is covered by columnar epithelium. The relief of the mucous membrane is characterized by the presence of the circular folds occupying about one-half or two-thirds of the luminal circumference. The folds are absent only at the commencement of the duodenum, but they are especially large and numerous in its ascending part.

On the posterior wall of the descending part together with the circular folds the longitudinal fold of duodenum, *plica longitudinalis duodeni*, is present. Below, it becomes taller and ends with the major duodenal papilla, *papilla duodeni major*. On its top the common bile duct, *ductus choledochus*, opens. Before the common bile duct opens, the pancreatic duct, *ductus pancreaticus*, joins it. The longitudinal fold is formed by the common bile duct, which gradually, in oblique direction, pierces the layers of the duodenum, raising the mucous membrane.

The union of the common bile and pancreatic ducts forms a common channel called the hepatopancreatic ampulla, *ampulla hepatopancreatica*. Its terminal part is surrounded by the sphincter of hepatopancreatic ampulla, *m. sphincter ampullae hepatopancreaticae* (sphincter of Oddi). Before the merger, the common bile duct and the pancreatic duct also have sphincters: the sphincter of common bile duct, *m. sphincter ductus choledochi*, and the sphincter of pancreatic duct, *m. sphincter ductus pancreatici*.

Rarely the accessory pancreatic duct is observed. It opens on the top of the minor (accessory) duodenal papilla, *papilla duodeni minor*.

The duodenal mucosa (mainly of the upper part of the duodenum) contains the branched tubular duodenal glands, *glandulae duodenales*, the bodies of which lie in the submucosa.

The major part of the duodenum is covered by the serous layer only from anterior side. Hence this part of the duodenum is extraperitoneal. It is a hidden part of duodenum, *pars tecta duodeni*; it is invisible when the abdominal cavity is opened. The commencement of the duodenum is entirely surrounded by the peritoneum and has a ventral mesentery, which connects the duodenum to the liver as a hepatoduodenal ligament, *lig. hepatoduodenale*. The distal part of duodenum also lies intraperitoneally, and in the area of the duodenojejunal flexure there is a small dorsal mesentery. The surface of the duodenum, which is not covered by the peritoneum, has an adventitia as the outer layer.

Under the serous layer and adventitia there is a muscular coat consisting of the external longitudinal and internal circular layers of smooth muscle cells.

### 2.9.2. Mesenteric Part of Small Intestine

The mesenteric part of the small intestine, *intestinum tenuae mesenteriale*, includes the jejunum and ileum, which lie intraperitoneally and have a mesentery. The general length of the intestine is about 5,5—6 metres. There is no clearly defined boundary between the jejunum and ileum: the proximal $^2/_5$ of the mesenteric part is the jejunum, the distal $^3/_5$ is the ileum.

***Jejunum***, *jejunum*, begins from the duodenojejunal flexure as the continuation of the duodenum, opposite the left side of the II lumbar vertebral body. Its coils lie in the upper left part of the abdominal cavity.

***Ileum***, *ileum*, is the continuation of the jejunum. It occupies the lower right part of the abdominal cavity and ends in the region of the right inguinal fossa, opening into the caecum which is the first part of the large intestine.

The diameter of the mesenteric part of small intestine at the commencement is about 45 mm, and it then gradually decreases to 30 mm.

The small intestine has two borders: mesenteric, *margo mesenterialis*, and free, *margo liber*. The mesenteric border is the place of the attachment of the mesentery and is not covered by the peritoneum; the free border, opposite to it, is directed to the anterior abdominal wall. The mesenteric part of small intestine is arranged in a series of coils, the location of which is various and individual. The presence of the mesentery provides the great mobility of the jejunum and ileum. Between the two mesenteric layers there are the arteries, veins, nerves and lymphatic vessels.

The intestinal wall is 1—2 mm thick and consists of the mucous, submucous, muscular and serous layers. The circular folds, *plicae circulares*, of the mucous membrane are especially numerous at the beginning of the jejunum. They gradually become lower and shorter. In the terminal part of the ileum the folds completely disappear. The whole surface of the mucous membrane is covered by the numerous intestinal villi which give to it a velvety texture (fig. 2.30). The jejunum has much more villi then the ileum; their approximate number is from 12 to 14 per 1 mm$^2$.

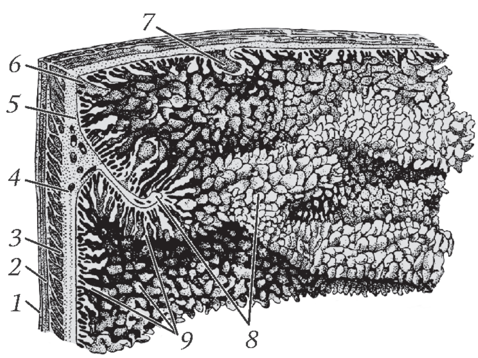


Fig. 2.30. Mucous membrane of small intestine:
*1* — tunica serosa; *2* — longitudinal stratum of muscular layer; *3* — circular stratum of muscular layer; *4* — tela submucosa; *5* — lamina muscularis mucosae; *6* — tunica mucosa; *7* — solitary lymphoid nodule; *8* — circular folds; *9* — intestinal villi

The epithelium of the intestinal mucosa is composed mainly of columnar cells but it also has columnar absorptive cells, undifferentiated cells, goblet and special endocrine epitheliocytes.

The mucous membrane of the jejunum and ileum contains the tubular intestinal glands, *glandulae intestinales*. Their terminal parts lie in the submucosa. They secrete the intestinal juice. The numerous solitary lymphatic follicles, *noduli lymphoidei solitari*, are scattered throughout the intestinal mu-

cosa. Along the free border of the ileum the solitary follicles are grouped into the aggregated lymphoid follicles (Peyer`s patches), elongated or oval in shape and varying in length from 2 to 6 cm (fig. 2.31).

The circular stratum of the muscular layer, *stratum circulare*, is much more developed than the outer longitudinal layer, *stratum longitudinale*. The jejunum and ileum are completely covered by the serous layer (peritoneum). Hence the mesenteric part of small intestine is intraperitoneal and has a long mesentery. The root of the jejunal and ileal mesentery, *radix mesenterii jejuni* et *ilei*, fixates to the posterior abdominal wall. It is attached along the line running obliquely from the II lumbar vertebra to the right sacroiliac joint. The length of the mesenteric root is 18—20 cm; the length of the mesentery along the intestinal border is 5—6 metres.

Thus, the mesentery of small intestine is fan-shaped. Its length is the shortest at the beginning and at the end of the mesenteric part of small intestine (3—5 cm) and the longest in the middle (10—15 cm).

## 2.10. Large Intestine

The large intestine, *intestinum crassum* (in Greek — *colon*), is a continuation of the small intestine and the last part of the alimentary canal. It is placed in the abdominal cavity as a rim fraiming the coils of the small intestine. It descends into the pelvis and ends by the anus. The large intestine perform the following important functions: 1) intensive absorption of water from the chyme; 2) digestion of cellulose with the help of bacterias; 3) excretion of the metabolic products; 4) production of vitamins K and B; 5) secretion of the great volume of the mucus; 6) formation, accumulation and excretion of fecal masses.

The large intestine differs from the small intestine in the calibre, exterior view and some structural features of its wall. These features are:

1) taeniae coli, *taeniae coli*, are the ribbons of the concentrated longitudinal smooth muscles, visible through the peritoneal covering and having the width about 1 cm;

2) haustrae coli, *haustrae coli*, are the small pouches, formed by a colon sacculation and caused by the shorter length of the longitudinal muscle layer in comparison with the total length of the intestine;

3) omental appendices, *appendices epiploicae*, are small adipose projections of the peritoneum covering of the large intestine. They are various in size and form. More often they are elongated, sharpened or rounded in the form. Their average sizes are $2 \times 1 \times 0{,}5$ cm.

The large intestine has three parts:

1) caecum with the vermiform appendix;

2) colon;

3) rectum.

The structure of the caecal and colonic wall has some features. From outside, in certain places, the colon is covered by the serous layer, under which the omental appendices are observed. Beneath the serous layer is the subserous and then muscular layers. The muscular layer consists of two strata: external longitudinal and internal circular. The longitudinal stratum concentrates to form the taeniae coli having about 1 cm in width and located at an equal distance from each other. One taenia extends along the

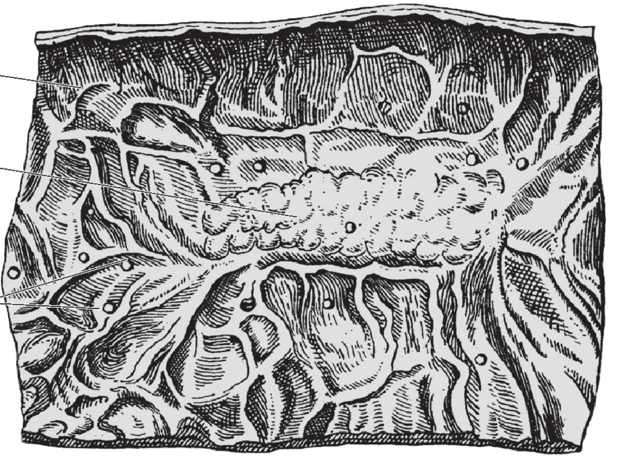


Fig. 2.31. Mucous membrane of ileum:
*1* — tunica mucosa; *2* — aggregated lymphoid nodules; *3* — solitary lymphoid nodules

anterior surface of the colon (in the transverse colon it extends along the attachment of the greater omentum hence it is called the omental taenia, *taenia omentalis*); the second taenia extends along the free surface of the colon (in the transverse colon it passes along the inferior border, in the ascending and descending colons it runs along the medial border) and called the free taenia, *taenia libera*; the third taenia extends along the fixed border (in the transverse colon it is at the attachment of the mesentery, in the ascending and descending colons it is where the intestine is fused with the abdominal wall) and termed the mesocolic taenia, *taenia mesocolica*.

In general, the circular muscle fibers of the caecum and colon form a complete, uniformly thick layer; it is a little thickened only at the bases of the semicircular folds. Deep to the muscular layer are the submucosa and mucous membrane. The latter forms well marked semilunar folds, *plicae semilunares coli*, arranged in three rows. They correspond to the transverse grooves, which separate the haustrae and are visible on the exterior surface of the large intestine. The mucosa has no villi and aggregated lymphoid follicles, which are typical of the small intestine. Here only solitary lymphoid follicles are observed. The tubular glands of the colonic mucosa are numerous. They form the deep and wide depressions called the crypts that give the cribriform appearance to the mucosa. The crypts are lined by columnar epithelium, consisting mostly of goblet cells between which there are columnar absorptive and undifferentiated cells (fig. 2.32).

**Caecum**, *caecum* (in Greek — *typhlon*), with the vermiform appendix, *appendix vermiformis*, commences the large intestine. It is situated below the place where the ileum opens into the large intestine. Primarily (in embryo) the caecum and vermiform appendix have an equal diameter, but further, due to uneven growth they become different. The part of the intestine, which develops into the caecum, grows intensively, while the vermiform appendix is behind in growth. In a newborn the border between the caecum and vermiform appendix is not clearly distinct: the caecum has the shape of a funnel, the top of which is gradually continuous with the vermiform process. After birth the lateral wall of the caecum becomes longer than the medial wall therefore, the vermiform process dis-

places medially and opens not into the end of the caecum but a little below the ileal orifice.

In an adult person the caecum has a form of a hemispherical sac situated in the right inguinal fossa. Its length is from 6 to 12 cm; its capacity is 250—350 ml. The caecum is completely covered by the serous layer (peritoneum). The external longitudinal stratum of the caecal muscular layer already forms three taeniae extending throughout the colon. They arise from the orifice of vermiform appendix and diverge, ascending one along the anterior surface, other two along the posterior surface of the caecum. The inner surface of the caecum has semilunar folds, and the outer surface has transverse grooves, *sulci transverse*, corresponding to the folds. The grooves delineate the haustrae coli.

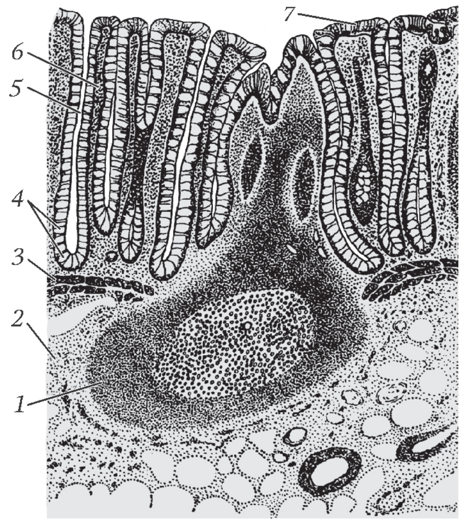

Fig. 2.32. Mucous membrane of transverse colon (longitudinal section (magnification × 70)):

*1* — solitary lymphoid nodule; *2* — tela submucosa; *3* — lamina muscularis mucosae; *4* — goblet cells; *5* — lumen of tubular gland; *6* — lamina propria mucosae; 7 — epithelium

On the left wall of the caecum there is an ileal orifice, *ostium ileale*, (it is also called the ileocaecal orifice, *ostium ileocaecale*), having the form of a horizontal slit bounded by two folds of the mucous membrane with the circular muscle fibers in their base. These folds are termed the superior, or ileocolic, lip, *labium ileocolicum*, and inferior, or ileocaecal lip, *labium ileocaecale*. The lips form the ileocaecal valve, *valva ileocaecalis* (fig. 2.33), which regulates the passage of the chyme from the ileum to the caecum. The valve has the shape of a funnel directed to the caecum by its sharp end. In normal peristalsis the slit expands and freely transmits the content of the small intestine into the caecum. If the pressure in the caecum is increased, the edges of the folds draw together and close the ileal orifice to prevent the back flow of the chyme from the caecum to the ileum. Slightly below the ileocaecal orifice there is a small orifice, *ostium appendicis vermiformis*, leading into the vermiform appendix.

***Vermiform appendix*** may have various forms: cylindrical, fusiform and even spherical. Rarely, it has a straight direction, like in embryo; more often it is curved like a loop or spiral because of a small length of its mesentery. The average length of the vermiform appendix is about 9 cm, but it may be just several millimeters in length or increase to 20—23 cm. The diameter of the vermiform appendix is about 7 mm. Its position is related with the position of the caecum and ileum and may be diverse. Most commonly the vermiform appendix is behind and below the end of the caecum. In this case it is usually free, mobile and connects to the ileum by a long peritoneal ligament which permits it to move in different directions. In some cases it is fixed to the abdominal wall or to the nearest internal organ. Rarely the vermiform appendix is posterior to the cupula of caecum (retrocaecal position). If the caecum lies mesoperitoneally, the vermiform appendix may be situated in the retroperitoneal space, i.e. to be retroperitoneally. Sometimes it is placed under the liver or in the lesser pelvis independently or together with the caecum.

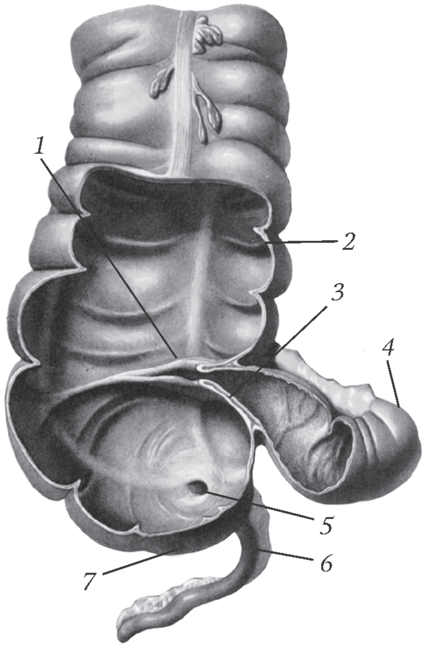


Fig. 2.33. Junction of ileum and caecum (frontal section):

*1* — ileocolic lip (*labium ileocolicum*); *2* — ascending colon (*colon asendens*); *3* — ileocaecal lip (*labium ileocaecale*); *4* — ileum (*ileum*); *5* — orifice of vermiform appendix (*ostium appendicis vermiformis*); *6* — vermiform appendix (*appendix vermiformis*); *7* — caecum (*caecum*)

The vermiform appendix opens into the caecum by a round funnel-shaped opening surrounded by the folds of the mucous membrane, which are called the valve of the vermiform appendix, though they do not work as a valve. The cavity of the vermiform appendix may have the form of an equable cylinder or may consist of the expansions alternating with constrictions. The cavity may be partially or fully obliterated. In normal it is filled with the mucus.

Usually the vermiform appendix is completely covered by the serous layer, i.e. lies intraperitoneally. Under a thin connective-tissue subserous layer there is a muscular coat consisting of two layers of smooth muscle cells (outer longitudinal and inner circular). Deep to the muscular coat are the submucosa and mucosa which is rich in lymphoid tissue. The lymphoid follicles unite into the groups surrounding the lumen of the vermiform appendix as a complete ring and called the aggregated lymphoid follicles of vermiform appendix, *noduli lymphoidei aggregati appendicis vermiformis.*

The colon is divided into: 1) ascending colon; 2) transverse colon; 3) descending colon; 4) sigmoid colon.

***Ascending colon***, *colon ascendens*, lies in the right half of the abdominal cavity; it ascends from the caecum vertically, reaches the right hypochondriac region and then it abruptly turns to the left to be continuous with the transverse colon at the right colic flexure. The ascending colon adjoins the quadratus lumborum and transversus abdominis and is related to the inferomedial part of the right kidney. The average length of the ascending colon is 20 cm, but if the caecum lies higher, it may be significantly shorter. When the ascending colon is distended, it may immediately adjoin the lateral abdominal wall or may be shielded by the coils of the small intestine. The ascending colon is covered by the peritoneum from anterior and lateral sides; its posterior surface is fused with the posterior abdominal wall hence it lies mesoperitoneally.

***Transverse colon***, *colon transversum*, starts from the right colic flexure, *flexura coli dextra (flexura coli hepatica)*, in the right hypochondriac region. More often the right colic flexure is antetior to the lower third of the right kidney and adjoins the liver. In the left hypochondriac region the transverse colon abruptly curves down as the left colic flexure, *flexura coli sinistra (flexura coli splenica seu lienalis)*, which adjoins the spleen and the left kidney. The left colic flexure lies higher than the right one and is fixed by the phrenicocolic ligament, *ligamentum phrenicocolicum.* After the formation of the left colic flexure, the transverse colon is continuous with the descending colon.

The transverse colon, about 50 cm long, forms an arch facing up by its concavity. Sometimes the transverse colon is so long that it descends to the pelvic inlet. Due to the presence of the mesentery the transverse colon is very mobile. The transverse colon is related to the neighboring viscera as follows: superiorly it adjoins the liver and stomach; inferiorly — the coils of the small intestine; posteriorly — the pancreas and duodenum. If the stomach is empty, the transverse colon adjoins the anterior abdominal wall. When the stomach is distended, it pushes the transverse colon to the depth of the abdominal cavity. The position of the transverse colon is very changeable and depends on the individual features and functional state.

***Descending colon***, *colon descendens*, is situated in the left half of the abdominal cavity, adjoining the abdominal wall. When the descending colon is contracted significantly, the coils of the small intestine are in front of it. Like the ascending colon, the descending colon is covered by the peritoneum only from anterior and lateral sides, i. e. lies mesoperitoneally. Rarely the descending colon has a mesentery.

***Sigmoid colon***, *colon sigmoideum* (in Greek — *romanum*), starts from the descending colon at the level of the iliac crest and ends in the rectum at the level of the left sacroiliac joint. The length of the mesentery and of the intestine is various. The root of the mesentery is fixed to the posterior abdominal wall opposite the left side of the IV—V lumbar vertebra. The sigmoid colon may rise up or descend to the lesser pelvis. Sometimes it displaces to the right and adjoins the coils of the small intestine and the organs of the lesser pelvis.

***Rectum***, *rectum* (in Greek — *proctos*), 15—20 cm long, is in the cavity of the lesser pelvis. It extends from the level of the left sacroiliac joint`s upper edge to the inferior surface of the perineum. The rectum is not straight but has two curves located in sagittal plane: 1) sacral flexure, *flexura sacralis*, directed backwards by its convexity; 2) anorectal flexure, *flexura anorectalis* (perineal flexure, *flexura perinealis*), which rounds the apex of the coccyx and is directed forwards by its convexity). Sometimes the rectum is curved in the frontal plane however, this curve is inconstant.

At the level of the II—III sacral vertebrae the human rectum gradually loses the mesentery hence becomes less mobile, and its terminal part is firmly fixed to the pelvic diaphragm. The rectum itself is its upper part (*pars pelvina*), which is situated in the cavity of the lesser pelvic; the lower part, placed under the levator ani, is called the anal canal, *canalis analis* (fig. 2.34). These two parts are different in origin and function.

The lumen of the rectum is uneven. Throughout the first 3—4 cm its diameter is about 3 cm. This part of the rectum is termed supraampullar, *pars supraampullaris*. Then it expands into an egg-shaped or pear-shaped rectal ampulla, *ampulla recti*. Its length reaches 8—10 cm, and the diameter of a moderately distended rectum is 5,5 cm. The next to the ampulla is a narrow part of the rectum, termed the anal canal, *canalis analis*. Its length is about 3—4 cm, and diameter is about 3 cm. The rectum ends by the anus, *anus*. Anterior to the rectum are the urinary bladder, seminal vesicles and prostate in males, and the uterus and vagina in females; posterior to the rectum is the sacrum.

The structure of the rectum wall significantly differs from other parts of the large intestine. The upper third of the rectum is entirely covered by the serous layer (peritoneum), i. e. lies intraperitoneally, and has a mesentery called mesorectum. The middle part of the rectum is covered by the peritoneum from anterior and lateral sides (meso-

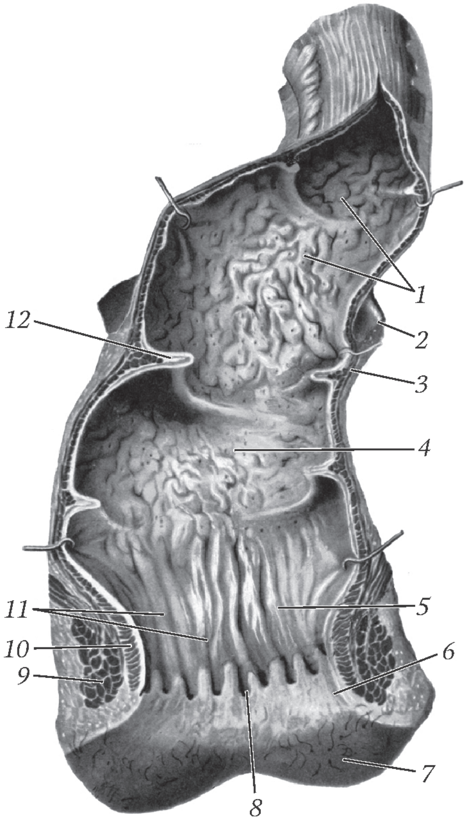


Fig. 2.34. Rectum (dissected along the anterior wall):

*1* — solitary lymphoid nodules (*noduli lymphoidei solitarii*); *2* — parietal peritoneum (*peritoneum parietale*); *3* — visceral peritoneum (*peritoneum viscerale*); *4* — rectal ampulla (*ampulla recti*); *5* — anal canal (*canalis analis*); *6* — haemorrhoidal zone (*zona haemorrhoidalis*); *7* — skin; *8* — anal sinus (*sinus analis*); *9* — external anal sphincter (*m. sphincter ani externus*); *10* — internal anal sphincter (*m. sphincter ani internus*); *11* — anal columns (*columnae anales*); *12* — transverse fold of rectum (*plica transversalis recti*)

peritoneally); the lower third is outside the peritoneum hence, is covered by the adventitia.

The taeniae and haustrae, typical of other parts of the large intestine, disappear in the rectum. The inner, circular muscle fibers of the rectum form a complete, uniformly thick layer; it is a little thickened only at the bases of the transverse folds of the mucosa. Around the anus the rectal circular muscle is greatly thickened as non-striated sphincter ani internus, *m. sphincter ani internus*. The sphincter ani externus, *m. sphincter ani externus*, formed by striated musculature, surrounds the anal canal and belongs to the perineal muscles. The muscle fibers from the adjacent organs (urinary bladder, ureter and coccyx) blend with the muscular coat of the rectum. They form the rectovesical, rectourettral and rectococcygeal muscles, *m. rectovesicalis*, *m. rectouretralis* et *m. rectococcygeus*.

Deep to the muscular coat are the submucosa and mucous membrane. The relief of the mucous membrane in the supraampullar part is characterized by clearly distinct transverse folds, *plicae transversae recti*. They are semilunar in shape, and placed on the lateral walls of the rectum alternatively on the right and on the left sides. Each fold occupies half or three thirds of the circumference. The ampulla has two transverse folds: the inferior fold, which is located on the left, 7—8 cm above the anus, and the superior fold, which is on the right, 2 cm above the inferior one. The folds are formed by the mucous membrane, submucosa and circular layer of the muscle fibers. The mucous membrane in the supraampullar part and in the ampulla of the rectum is lined by simple columnar epithelium.

In the anal canal, approximately 1,5 cm above the anus, 5—8 longitudinal folds are formed; they are called the anal columns, *columnae anales*. They are 7—14 long and protrude 1—2 mm above the total level of the mucous membrane. Directing upwards they become thinner; below they are taller. Between their lower ends there are transverse mucous folds, the anal valves, *valvulae anales*, which form, together with the other layers of the rectal wall and the nearest anal columns, the anal sinuses, *sinus anales*. The sinuses have the shape of the swallow nests, opened upwards. They play an important role in

the control of gases and rectal content, working as the particular locking mechanism of the mucous membrane. Often in adults the veins of the submucous rectal venous plexus enlarge and form the protrusions covered by the mucosa and bulging into the lumen of the anal canal. This area of the anal canal is termed the hemorrhoidal zone, *zona haemorrhoidalis*.

At the junction between the ampulla and anal canal there is a fold termed the anorectal line, *linea anorectalis*. It passes above the anal columns and corresponds to the place where the puborectal muscle envelopes the posterior rectal wall. Below the anal valves there is a circular fold formed by protruding part of the sphincter ani internus and called the anal pecten, *pecten analis*. Here the submucosa is constructed from a dense connective-tissue and provides a firm fixation of the mucous membrane to the muscular layer (sphincter ani internus).

Along the superior border of the anal pecten the anocutaneal line, *linea anocutanea*, passes. It is at the level of the inferior edge of the sphincter ani internus. At this site columnar epithelium is continuous with stratified squamous epithelium. Below the anocutaneal line there is a zone of thin white color skin,'white line', or linea alba, having 5—7 mm in width. The skin of the linea alba is devoid of the folds, sebaceous and sweat glands and hairs. It is firmly linked with the fibers of the sphincter ani internus. Below the linea alba, the terminal part of the anal canal is lined by true skin, pigmented, folded and containing sweat and sebaceous glands.

## TEST QUESTIONS

1. Describe the parts of the small intestine in sequence. Where does the duodenum begin?
2. What is the length of the whole small intestine and of the duodenum specifically?
3. What parts of the duodenum are distinguished? What is the bulb (ampulla) of duodenum?
4. Describe the skeletotopy of the each part of the duodenum.
5. Describe the syntopy of each part of the duodenum.
6. Describe the layers of the duodenum`s wall in sequence.
7. Describe the features of the duodenal mucosa: types of its folds, glands. Describe the localization of the longitudinal fold of duodenum.
8. Describe the localization of the major and minor duodenal papillae. What ducts open here?
9. What is the common bile duct, how is it formed?
10. What is the hepatopancreatic ampulla, how is it formed?
11. How are different parts of the duodenum covered by the peritoneum? What is the hidden part of the duodenum?
12. What is the duodenojejunal flexure? Describe its skeletotopy and practical importance.
13. What is the Treitz ligament? What is its clinical importance?
14. Describe the function of the duodenum.
15. Name the parts of the small and large intestine in sequence beginning from the stomach. What is the length of the small and large intestine?

16. How do the jejunum and ileum project to the anterior abdominal wall of a living person?

17. Describe the position of the jejunum and ileum in the abdominal cavity. Where is the beginning of the jejunum, where does the jejunum continue into the ileum, where is the end of the ileum?

18. Describe the syntopy of the small intestine.

19. Describe the layers of the wall of the jejunum and ileum in order.

20. Describe the features of the mucous layer of the jejunum and ileum. How many muscular layers do they have? Describe the types and function of these layers.

21. Describe the function of the small intestine.

22. Describe the differences between the jejunum and ileum in external and in internal structure.

23. Describe the relations of the small intestine to the peritoneum.

24. Describe the beginning of each part of the large intestine.

25. Where is the caecum located? What is the length of the caecum?

26. Where is the projection of the caecum and of the vermiform process to the anterior abdominal wall of a living person?

27. Describe the variants of the positions of the vermiform appendix.

28. Describe the place where the ileum opens into the caecum (externally and internally): ileocaecal angle, orifice, valve and so on.

29. Where does the ascending colon project to the anterior abdominal wall of a living person?

30. What is the right colic flexure?

31. Where does the transverse colon project to the anterior abdominal wall of a living person?

32. What is the left colic flexure?

33. Where does the descending colon project to the anterior abdominal wall of a living person?

34. Where does the sigmoid colon project to the anterior abdominal wall of a living person?

35. Describe the level of the beginning and end of the sigmoid colon.

36. Describe the localization of the rectum.

37. Describe the relation of the different parts of the large intestine to surrounding organs and to the peritoneum.

38. Describe the layers of the wall of the large intestine in order.

39. Describe the features of the mucous layer of the large intestine. How many muscular layers does it have? Describe the types and function of these layers.

40. Describe the function of the large intestine.

41. Describe the features of the large intestine relatively to the small intestine in the structure and in the function. Describe the differences between the small and large intestine.

42. What is the function of the epiploic appendices? How do the teniae and haustrae formed?

43. What types of teniae do you know? Describe their localization in different parts of the large intestine.

44. Describe the features of the rectum, its parts. What features does its mucosa have? Describe the sphincters of the rectum: localization, features of functioning. Where

is the hemorroidal zone of the rectum? Give the definition of it and describe its practical importance.

## CLINICOANATOMICAL PROBLEMS

1. An endoscopist has to examine the duodenal mucosa with a fibroscope. What length should the optic fiber have? Along which anatomical structures will the endoscope pass? What structures can be observed on the duodenal mucosa?

2. The radiological examination of a patient with the healed ulcer of the duodenum showed the delay of the barium at the level of the I lumbar vertebra on the right. Which part of the intestine is stenosed?

3. A patient has a gunshot wound of the abdomen. During the surgical operation a doctor needs to examine the small intestine. How should it be done correctly?

4. During operation for appendicitis a surgeon needs to find the vermiform process through the small cut in the anterior abdominal wall. What signs should the doctor use?

5. A doctor has to do the digital examination of the rectum in a patient with hemorrhoids. Which parts of the rectum are possible to palpate? In which parts of the rectum can the hemorrhoidal nodes be observed?

6. A doctor has to do the rectoscopy and sigmoidoscopy in a patient with dysentery. Which curves of the rectum should an endoscopist take into account during the examination? At what depth should the doctor put in the endoscope?

## 2.11. Liver

The liver, *hepar* (in Greek — *jecor*), is the largest gland in the human body; its average weight is 1500 g. Due to the great vascularization its parenchyma is red-brown. The liver performs the following essential functions: 1) neutralization of toxic substances contained in food, formed in the metabolic processes or injected into the blood (detoxification function); 2) inactivation of hormones and biological active substances; 3) production of bile, which is necessary for digestion and absorption of fats and for stimulation of peristalsis; 4) synthesis of proteins; 5) formation of glycogen (trophic function); 6) accumulation of fat-soluble vitamins A, D, K, E etc; 7) phagocytosis and destruction of foreign substances (immune function); 8) hemopoesis (in embryonic period). Hence the liver is a vitally important organ.

The liver has two surfaces: diaphragmatic and visceral, and two borders: inferior and posterior.

The diaphragmatic surface, *facies diaphragmatica*, directed forwards and up, fits the concavity of the diaphragm hence, is greatly convex (fig. 2.35). This surface is divided into the superior, anterior, right and posterior parts and also the bare area, *area nuda*, in the limits of which the liver is fused with the diaphragm. The peritoneum, covering the diaphragmatic surface, forms a fold called the falciform ligament, *ligamentum falciforme*. The latter divides the surface into two unequal lobes: right lobe of liver, *lobus hepatis dexter*, larger, and left lobe of liver, *lobus hepatis sinister*. The left lobe differs from the right lobe not only by smaller sizes but also by much less thickness. In the direction from the right to the left, the liver becomes thinner (its vertical size decreases).

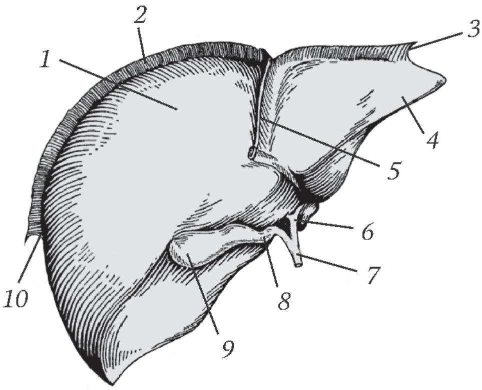


Fig. 2.35. Liver (diaphragmatic surface):

*1* — right hepatic lobe (*lobus hepaticus dexter*); *2* — coronary ligament (*ligamentum coronarium hepatis*); *3* — left triangular ligament (*ligamentum triangulare sinistrum*); *4* — left hepatic lobe (*lobus hepatis sinister*); *5* — falciform ligament (*ligamentum falciforme hepatis*); *6* — common hepatic duct (*ductus hepaticus communis*); *7* — common bile duct (*ductus choledochus*); *8* — cystic duct (*ductus cysticus*); *9* — gallbladder (*vesica biliaris*); *10* — right triangular ligament (*ligamentum triangulare dextrum*)

The visceral surface, *facies visceralis*, facing down and backwards, bears three grooves resembling in whole the letter H (fig. 2.36). One of them runs in the frontal plane: it is a transverse fissure, *sulcus transversus*, or porta hepatis, *porta hepatis*. Other two grooves are arranged sagittaly; they are called the right and left longitudinal grooves, *sulcus longitudinalis dexter et sulcus longitudinalis sinister*.

At the porta hepatis the portal vein, proper hepatic artery and nerves enter and the common hepatic duct and lymphatic vessels emerge. The anterior portion of the left longitudinal groove is deeper and called the fissure for ligamentum teres, *fissura ligamenti teretis*. It contains the obliterated vestige of the umbilical vein, which transforms into the ligamentum teres, *ligamentum teres hepatis*, after birth. The posterior portion of the left longitudinal groove is called the fissure for ligamentum venosum, *fissura ligamenti venosi*); it contains the ligamentum venosum, *ligamentum venosum*, which represents an obliterated ductus venosus (Arantii), which is the connection of the umbilical vein with inferior vena cava in a fetus. The right longitudinal groove is divided by the caudate process of liver, *processus caudatus*, into two parts: anterior and posterior. The anterior part is a fossa for gallbladder, *fossa vesicae biliaris*; here the gallbladder lies. The posterior part is a groove for inferior vena cava, *sulcus venae cavae*, containing the inferior vena cava.

The mentioned grooves divide the liver into four lobes: left, right, quadrate and caudate. The left lobe of liver, *lobus hepatis sinister*, corresponds to the left lobe on the diaphragmatic surface. Other three lobes, all together, are equal to the right lobe of liver, which therefore includes the right lobe of liver, *lobus hepatis dexter*, itself, quadrate lobe, *lobus quadratus*, and caudate lobe, *lobus caudatus*. The latter has a rounded tubercle termed the papillary process, *processus papillaris*. The limits of the quadrate lobe are formed by the transverse fissure, right and left longitudinal grooves and inferior border of liver. The caudate lobe is bounded by the same grooves and the posterior border of liver. It is connected to the right lobe by the caudate process, *processus caudatus*.

The inferior border of liver, *margo inferior*, sharp, has two notches: right and left. The right notch, *incisura vesicalis*, is slight, sometimes is absent. The left notch, *incisura ligamenti teretis*, is deeper. The posterior border of liver, *margo posterior*, is obtuse and has a deep concavity corresponding to the projection of the vertebral column.

On the diaphragmatic surface there is a shallow cardiac impression, *impressio cardiaca*, formed by the ajoining heart. The visceral surface (fig. 2.36) of liver bears the following imprints of the adjacent viscera:

1) the area of the anterior gastric wall is related to the left lobe of liver (gastric impression, *impressio gastrica*);

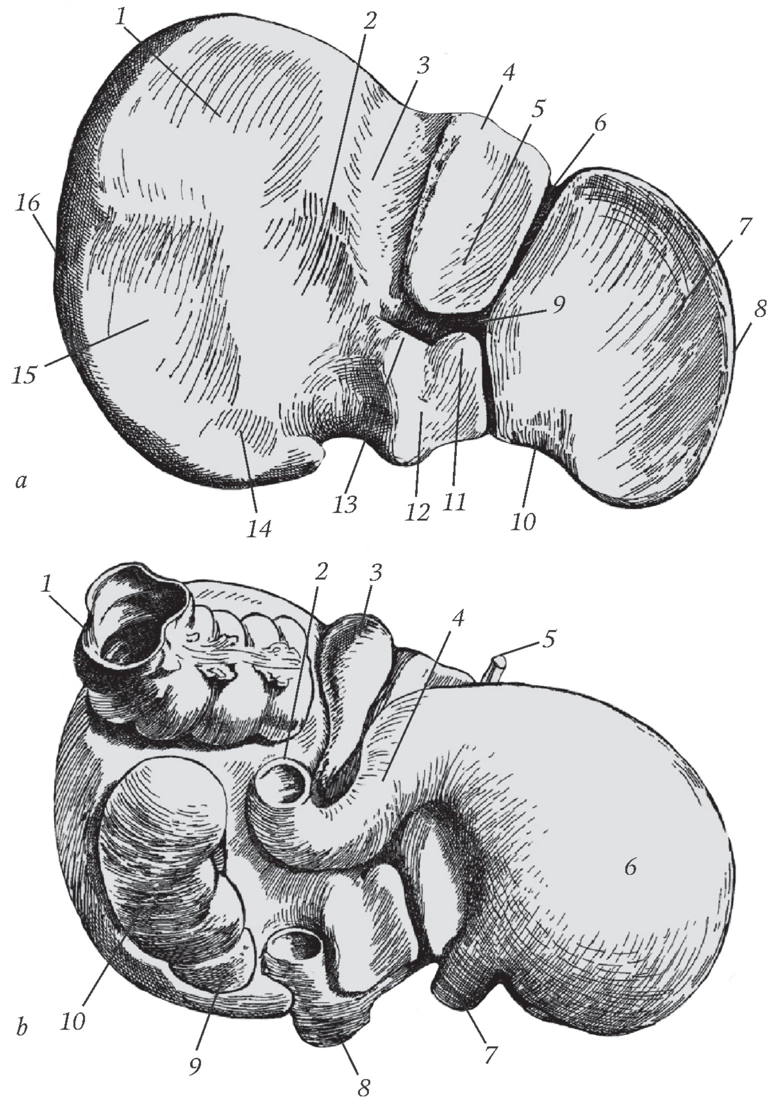


Fig. 2.36. Liver (visceral surface):

*a* — gallbladder, ligamentum teres hepatic and inferior vena cava have been removed, and the impressions, formed by the adjoining organs, are showed: *1* — colic impression (*impressio colica*); *2* — duodenal impression (*impressio duodenalis*); *3* — right longitudinal groove (*sulcus longitudinalis dexter*); *4* — quadrate lobe (*lobus quadratus*); *5* — pyloric impression (*impressio pylorica*); *6* — left longitudinal groove (*sulcus longitudinalis sinister*); *7* — gastric impression (*impressio gastrica*); *8* — left hepatic lobe (*lobus hepatis sinister*); *9* — porta heaptis (*porta hepatis*); *10* — oesophageal impression (*impressio oesophageale*); *11* — papillary process (*processus papillaris*); *12* — caudate lobe (*lobus caudatus*); *13* — caudate process (*processus caudatus*); *14* — suprarenal impression (*impressio suprarenalis*); *15* — renal impression (*impressio renalis*); *16* — left hepatic lobe (*lobus hepatis sinister*).

*b* — organs adjoining the liver are preserved: *1* — transverse colon (*colon transversus*); *2* — duodenum (*duodenum*); *3* — gallbladder (*vesica biliaris*); *4* — pylorus (*pylorus*); *5* — ligamentum teres hepatis (*ligamentum teres hepatis*); *6* — stomach (*gaster*); *7* — oesophagus (*oesophagus*); *8* — inferior vena cava (*vena cava inferior*); *9* — right suprarenal gland (*glandula suprarenalis dextra*); *10* — right kidney (*ren dexter*)

2) on the posterior border, near the left longitudinal groove, there is an impression formed by the adjoining abdominal part of oesophagus (oesophageal impression, *impressio esophageale*);

3) the pylorus adjoins the quadrate lobe (pyloric impression, *impressio pylorica*);

4) on the right lobe, at the region of the anterior edge, there is an imprint of the right colic flexure and the nearest portion of the transverse colon (colic impression, *impressio colica*);

5) posterior to the preceding impression there is an impression formed by the adjoining right kidney (renal impression, *impressio renalis*);

6) to the left of the renal impression there is a duodenal impression, *impressio duodenalis*, which prolongates to the area of the caudate lobe;

7) more dorsal, near the posterior edge of the liver, to the right of the inferior vena cava there is a suprarenal impression, *impressio suprarenalis*.

The liver lies mesoperitoneally; it is devoid of the peritoneal covering only in the areas of the grooves (porta hepatis, fossa for gallbladder, groove for inferior vena cava etc) and also in the site of the fusion with the diaphragm. The latter area has a name the bare area, *area nuda*. The peritoneum is firmly fused with the liver by means of a thin layer of connective tissue, which forms a fibrous capsule of liver (Glisson`s capsule), *tunica fibrosa*. The latter prolongates through the porta hepatis inside the liver parenchyma, accompanying the branching of the portal vein. Where the peritoneum passes from the liver to the diaphragm, it reflexes to form the following ligaments: falciform ligament, *ligamentum falciforme*; coronary, *ligamentum coronarium*; right and left triangular ligaments, *ligamenta triangularia dextrum et sinistrum*. Where the peritoneum passes from the liver to the neighboring organs, it forms the following ligaments: hepatorenal ligament, *ligamentum hepatorenale*; hepatogastric ligament, *ligamentum hepatogastricum*; hepatoduodenal ligament, *ligamentum hepatoduodenale*.

The position of the liver is maintained by the following mechanisms: 1) connective-tissue connecting the liver with the inferior surface of the diaphragm (in that place where the peritoneal covering is absent); 2) inferior vena cava, which tightly fused with the liver together with the hepatic veins which open into the inferior vena cava; 3) intra-abdominal pressure transfering from the tonus of the abdominal muscles to the viscera lying below the liver; 4) coronary ligament of liver. The liver, adjoining the concavity of the diaphragm by its superior surface, follows the movements of the diaphragm during inspiration and expiration; in quiet respiration the liver moves 2—3 cm up and down.

**Topography of liver.** The liver is placed in the right upper part of the abdominal cavity (epigastrium, *epigastrium*) immediately under the diaphragm. It occupies the whole right hypochondriac region, *regio hypochondriaca dextra*, the part of the epigastric region, *regio epigastrica* and the part of the left hypochondriac region, *regio hypochondriaca sinistra*. The superior border of the liver corresponds to the height of the diaphragmatic dome which rises higher on the right, to the level of the attachment of the V costal cartilage to the sternum; on the left, the superior border of liver corresponds to the level of the attachment of the VI costal cartilage to the sternum. This border is arch-shaped and anteriorly projects as follows: along the right midaxillary line at the level of the X intercostal space; along the right midclavicular and parasternal lines at the level of the V costal cartilage; along the anterior median line at the level of the xi-

phoid process` base; along the left parasternal line at the level of the VI rib. Posteriorly the superior border of liver projects as follows: along the right posterior axillary line at the level of the VII intercostal space; along the right paravertebral line at the level of the X intercostal space; along the posterior median line at the level of the IX thoracic vertebral body.

The inferior border of liver anteriorly projects as follows: on the right it coincides with the costal arch, then, at the junction of the VII and IX right costal cartilages, it descends less obliquely than the costal arch and runs to the left and up to the place of the junction of the VIII and VII left costal cartilages. Thus, only small area of the liver surface immediately adjoins the abdominal wall in the epigastrium. Here it is easy to palpate the inferior border of liver, if the muscles of the abdominal wall are not tensed. The inferior border of liver posteriorly projects as follows: along the right posterior axillary line to the inferior edge of the XI rib; along the right paravertebral line at the level of the XII rib; along the posterior median line to the body of the XI thoracic vertebra.

The liver is divided into a series of subdivisions associated with the branching patterns of the hepatic artery, portal vein and accompanying hepatic ducts. In accordance with the primary division of the portal vein, the right lobe, *lobus hepatis dexter*, and the left lobe, *lobus hepatis sinister*, are distinguished. Further ramification of the portal vein into the branches of the second and third orders determines the division of the liver parenchyma into the sectors and segments. The sector is a part of the liver, in the limits of which the second order branches of the portal vein and of the hepatic artery ramify. The sectoral bile duct emerges from the sector. The segment is a part of the sector, in the limits of which the third order branches of the portal vein and of the hepatic artery ramify. The division of the liver into the relatively autonomously vascularized areas is applied to the most sparing liver resections. However, the problem of the segmental structure of the liver has not been fully solved yet. In International Anatomical Terminology the scheme of C. Couinand is accepted as basical (table 1). According to it, the liver is divided into two lobes, five sectors and eight segments.

*Table 1*

**Hepatic segmentation**

| Lobe | Sector | Segment |
|---|---|---|
| Left | Left dorsal | I ($C_1$) |
| | Left lateral | II ($C_2$) |
| | Left paramedian | III ($C_3$) |
| Right | Right paramedian | IV ($C_4$) |
| | Right lateral | V ($C_5$) |
| | | VIII ($C_8$) |
| | | VI ($C_6$) |
| | | VII ($C_7$) |

In practice it is advisable to distinguish four segments of the liver: anterior, posterior, medial, located within the right lobe; and lateral, located within the left lobe

(fig. 2.37). The medial segment includes the quadrate area, corresponding to the quadrate lobe of liver.

The parenchyma of the liver is divided by the connective-tissue septa (termed interlobular septa) into a multitude of equal hepatic lobules, *lobuli hepatis*. The human liver consists of about 500 000 hepatic lobules, which are the structural and functional units of the liver.

Each hepatic lobule has the shape of a hexagonal prism, the diameter of which is 1—1,5 mm and the height is 1,5—2 mm. The lobule consists of the hepatic plates which are constructed from the hepatocytes and have the radiate direction in the form of beams. The central vein is in the center of the lobule.

The blood capillaries penetrate the hepatic lobule from the periphery; they are the branches of the interlobular veins (from the system of portal vein) and of the interlobular arteries passing in the interlobular connective-tissue septa. Inside the lobule the venous and arterial capillary bed unite into the sinusoids which are placed between the beams of hepatocytes and have a close contact with them. The intralobular capillaries of the liver differ from the capillaries of other organs in larger diameter; their walls are very closely adjacent to the surfaces of the hepatocytes. These and some other features permit to refer the interlobular capillaries to the category of sinusoids. The vessels, which flow out from the capillary network, drain into the central vein of the lobule and then into the interlobular collecting veins. Further the collecting veins unite as the hepatic veins draining into the inferior vena cava. The mentioned features of the liver vascularization (it receives 70 % of blood from the portal system and 30 % from arterial system) permits to define it as a 'wonderful net' of liver, rete mirabile hepatis.

The surface of each hepatocyte is grooved; the grooves of adjacent hepatocytes join to form the fine canaliculi having 1 micron in diameter. These canaliculi are the bile canaliculi, or bile capillaries, *ductuli biliferi*. They do not have own walls and terminate blindly in the center of the lobule. In the periphery, the bile canaliculi join to form the interlobular bile ductules, *ductuli biliferi interlobulares*. Beginning from the interlobular bile ductules, the biliary ducts merge to form sequentially the segmental, sectoral, right and left lobar hepatic ducts and finally the common hepatic duct. The interlobular arteries, veins and interlobular bile ductules, lying parallely to each other in the interlobular connective-tissue septa, form the hepatic (portal) triads. Thus, from one side the he-

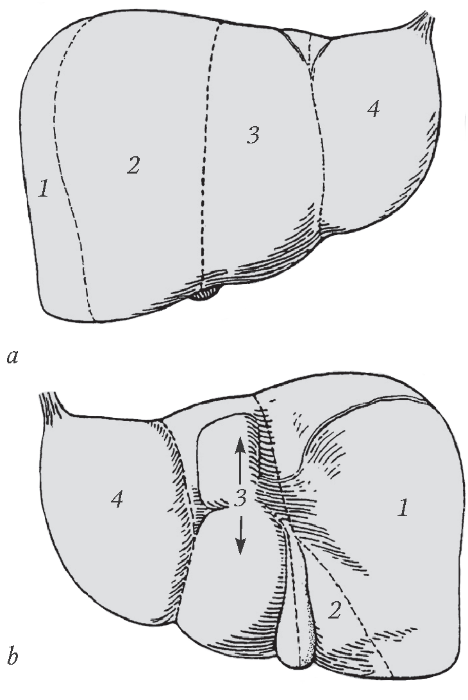


Fig. 2.37. Segments of liver (scheme):

*a* — projection to the diaphragmatic surface; *b* — projection to the visceral surface; *1* — posterior segment; *2* — anterior segment; *3* — medial segment; *4* — lateral segment

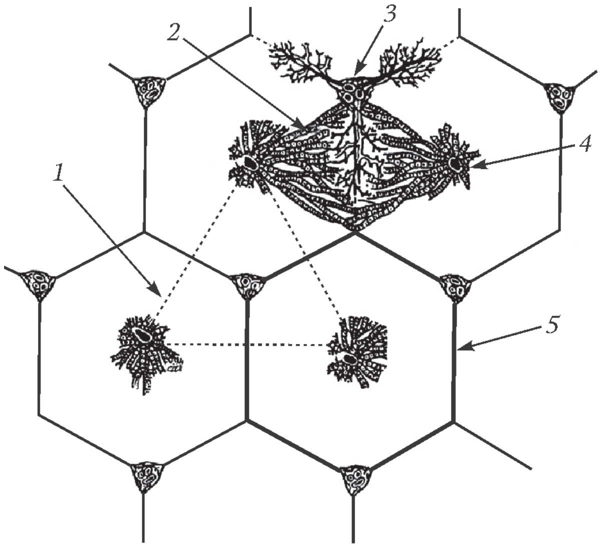


Fig. 2.38. Structural and functional unit of liver (scheme):
*1* — portal lobule; *2* — acinus; *3* — hepatic triad; *4* — central vein; *5* — classic hepatic lobule

patocytes of the hepatic lobule are in contact with the blood capillary, and from another side they are in contact with the bile canaliculus. The hepatocytes receive the carbohydrates, lipids, molecules of proteins and oxygen from the blood capillaries. The hepatocytes accumulate the glycogen and produce the bile, which passes into the bile canaliculi.

The modern concept of the structural and functional unit of liver proposes to distinguish, besides a classic hepatic lobule, the portal lobule and the portal acinus. The portal lobule consists of the adjoining parts of three adjacent hepatic lobules; it is a triangular territory centred on a portal triad, its boundary passes through adjacent central veins. The portal acinus consists of the adjoining parts of two adjacent hepatic lobules (fig. 2.38). The acinus is a rhomboid territory centred on a preterminal branch of hepatic arteriole; its boundary passes through the portal triads (they are at the obtuse angles of the acinus) and through the central veins (they are at its sharp angles). In contrast with the hepatic lobule, the vascularization in the portal lobule and in the acinus occurs from the center of the lobule to the periphery.

## 2.12. Gallbladder

The gallbladder, *vesica biliaris seu vesica fellea* (in Greek — *cholecystis*), is an elongated sac (fig. 2.39). Its blind rounded end is a fundus, *fundus vesicae biliaris*; it is directed forwards and down, extending beyond the inferior border of liver to contact the anterior abdominal wall behind the junction of the VIII and IX right costal cartilages. The fundus is gradually continuous into with body of gallbladder, *corpus vesicae biliaris*, which narrows at the opposite end to form the neck, *collum vesicae biliaris*. The latter curves up and forwards and abruptly back and downwards to become the cystic duct, *ductus cysticus*. The cystic duct is greatly curved; it passes down, joining the common hepatic duct,

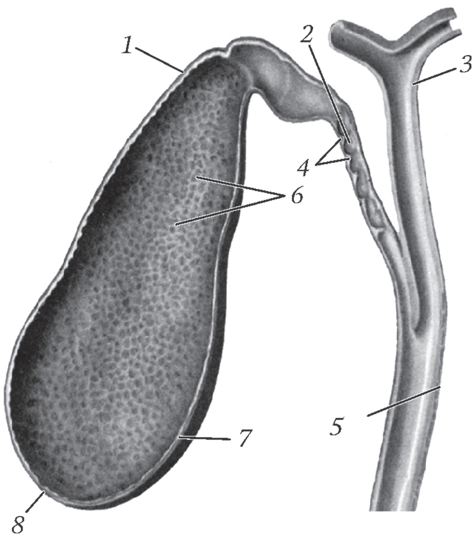


Fig. 2.39. Gallbladder and extraorganic bile ducts (longitudinal section):

*1* — neck of gallbladder (*colum vesicae biliaris*); *2* — cystic duct (*ductus cysticus*); *3* — common hepatic duct (*ductus hepaticus communis*); *4* — spiral fold (*plica spiralis*); *5* — common bile duct (*ductus choledochus*); *6* — mucous membrane of gallbladder (*tunica mucosa vesicae biliaris*); *7* — body of gallbladder (*corpus vesicae biliaris*); *8* — fundus of gallbladder (*fundus vesicae biliaris*)

*ductus hepaticus communis*, to form a common bile duct, *ductus choledochus*, situated to the right of the portal vein between the layers of the hepatoduodenal ligament. The common bile duct crosses the superior part of duodenum, passing along its posterior surface. Then the duct runs down between the descending part of duodenum and the head of pancreas to reach the pancreatic duct; together they enter the duodenal wall where they unite into the hepatopancreatic ampulla, the distal end of which opens onto the descending part of the duodenum on the top of the major duodenal papilla. According to the topography, the common bile duct is divided into 4 parts: supraduodenal, retroduodenal, pancreatic and intramural.

The capacity of the gallbladder is 40—60 $cm^3$, its length is 80—120 mm and width is 30—50 mm. In the fossa for gallbladder the wall of the gallbladder is firmly linked with the liver parenchyma by the fibrous tissue. Its other surfaces (including the fundus) are free and covered by the peritoneum. Thus, the gallbladder is mesoperitoneal. Rarely the gallbladder deeply penetrates the liver parenchyma and lies extraperitoneally.

The external layer of the gallbladder`s wall is formed by adventitia in the place of the fusion with the liver, and by the serosa in the rest part. Beneath the external layer there is a thin muscular layer and then the mucous membrane. In the neck of the gallbladder and in the cystic duct the mucosa forms a spiral fold, *plica spiralis*, which directs the bile from the common hepatic duct to the gallbladder, when the duodenum does not contain chyme. The bile, passing from the liver, may retain in the gallbladder for a long time and may be accumulated as a concentrate because the mucous membrane of the gallbladder is able to absorb about 80 % of water from the bile.

## 2.13. Pancreas

The pancreas, *pancreas* (fig. 2.40), is the second in size gland of the alimentary tract; its weight in an adult person is 70—80 g. It consists of two parts: exocrine, forming 97 % of the total weight, and endocrine. The exocrine part produces the pancreatic juice which is rich in the digestive enzymes: trypsin, chymotrypsin, lipase, amylase. The endocrine part secretes the hormones: insulin, glucagon, somatostatin etc.

The pancreas is placed mainly in the epigastric and left hypochondriac regions. Its two thirds are to the left of the median plane. The pancreas is grayish-pink, has a soft consistency and well marked lobular structure.

The pancreas is described as having a head, neck and tail. An elongated body of the pancreas, *corpus pancreatis*, is situated at the level of the I lumbar vertebra. The head of the pancreas, *caput pancreatic*, is a thickening lying to the right of the vertebral column opposite the II lumbar vertebra. The opposite narrow end of the pancreas is its tail, *cauda pancreatis*, which extends to the left hypochondriac region and reaches the left kidney, suprarenal gland and spleen. The length of the pancreas is 16—22 cm, the width (the vertical size of the body) is 4 cm, thickness is about 2 cm.

The head of pancreas, *caput pancreatis*, is a little thickened below to be continuous with the uncinate process, *processus uncinatus*. The head lies at the level of the I—II lumbar vertebrae within the duodenal curve, closely adjoining its concave surface. The anterior surface of the head is related to the body of the stomach, pylorus and the superior part of duodenum. Posteriorly, the head adjoins the lumbar part of the diaphragm, portal vein, common bile duct and abdominal aorta. At the junction of the head and body there is a pancreatic notch, *incisura pancreatica*.

The neck of pancreas, *collum pancreatis*, is a slightly narrowed part between the head and body.

The body of the pancreas is trihedral. It has three surfaces: posterior, anterosuperior and anteroinferior. The posterior surface, *facies posterior*, adjoins the I lumbar vertebral body and great vessels (abdominal aorta and inferior vena cava). The anterosuperior surface, *facies anterosuperior,* is slightly concave and in contact with the stomach. The anteroinferior surface, *facies anteroinferior*, narrow, is related to the coils of the small intestine and the transverse colon. The body of pancreas has three clearly distinct bordes: superior, anterior and inferior, *margo superior*, *margo anterior et margo inferior*. Often the superior blunt border forms the omental eminence, *tuber omentale*, directed to the omental bursa.

The peritoneum covers only anterosuperior and anteroinferior surfaces of the pancreas; the tail is absolutely devoid of the serous covering. Along the anterior border of the pancreas the root of transverse mesocolon is attached.

The exocrine part of the pancreas, *pars exocrina pancreatis*, is a compound tubuloalveolar gland. It produces the pancreatic juice. The structural and functional unit of this part is an acinus which includes the secretory cells and excretory duct, surrounded by the blood capillaries. The collection of the acinuses, opened into the interlobular excretory duct, form the pancreatic lobule, *lobulus pancreatis*.

The small ducts of the pancreas, starting from the lobules inside the parenchyma, join one another to form the larger ducts which open into the pancreatic duct, *ductus pancreaticus* (fig. 2.40). The latter lies inside the pancreatic parenchyma (closer to the posterior surface of pancreas) and extends throughout the pancreas from its left to the right ends. Mostly the pancreatic duct joins the common bile duct to form the hepatopancreatic ampulla in the major duodenal papilla. The opening of the ampulla is surrounded by the sphincter of the hepatoduodenal ampulla, *sphincter ampullae hepatopancreaticae*, formed by smooth muscle cells. More rarely the pancreatic duct opens into the descending part of duodenum independently. Sometimes the accessory pancreas, *pancreas accessorium*, is observed; it has an independent duct, *ductus pancreaticus accessorius*.

The feature of the pancreatic structure is determined by the presence of the pancreatic islets or insulae (of Langerhans). These are the collections of the epithelial cells, surrounded by thick capillary network. They are most numerous in the pancreatic tail.

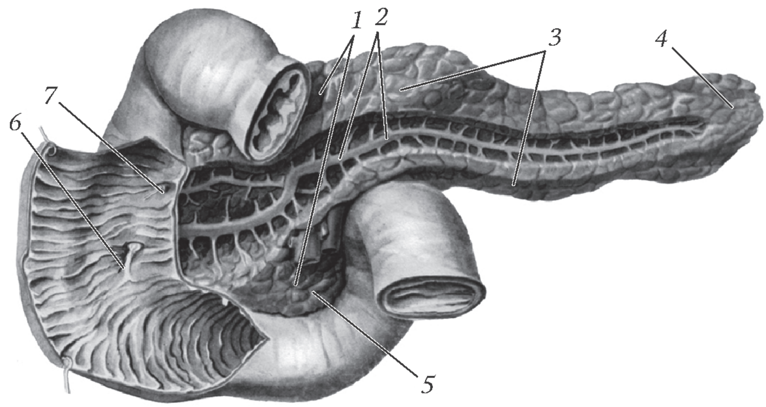


Fig. 2.40. Pancreas and duodenum; pancreatic duct is visible:

*1* — head of pancreas (*caput pancreatis*); *2* — pancreatic duct (*ductus pancreaticus*); *3* — body of pancreas (*corpus pancreatis*); *4* — tail of pancreas (*cauda pancreatis*); *5* — uncinate process (*processus uncinatus*); *6* — major duodenal papilla (*papilla duodeni major*); *7* — minor duodenal papilla (*papilla duodeni minor*)

The islets of Langerhans form an endocrine part of the pancreas, *pars endocrina pancreatis*. Their number varies from 250 thousands to 2,5 millions, their weight is 2,4 g. The major types of islet cells are B-insulocytes, producing the insulin (70 %); A-insulocytes, secreting the glucagon (20 %); C-, D-, PP-insulocytes, producing the somatostatin, pancreatic polypeptides etc.

## TEST QUESTIONS

1. Describe the position of the liver in the abdominal cavity and its projection to the anterior abdominal wall of a living person.
2. Describe the surfaces of the liver. Describe the liver`s borders.
3. How will you differentiate the anterior and posterior sides of the liver on an isolated preparation?
4. Describe the skeletotopy of the liver (relatively to the vertebral column and to the ribs), the projection of its borders to the anterior and posterior sides of the body according to the topographical lines of the thorax.
5. Describe the relations of the liver to the peritoneum and to the neighboring organs: what organs adjoin the liver posteriorly, superiorly, inferiorly, from the right and left sides.
6. Describe the lobes of the liver. What fissures (grooves) separate them?
7. What is the porta hepatis? What does it transmits? Describe the position and relations of the structures which enter and leave the liver through the porta hepatis.
8. Where is the gallbladder located?
9. Describe the position of the ligamenta teres and venosum. What vessels of a fetus transform into these ligaments after birth?
10. Describe the relations between the liver and inferior vena cava.
11. Describe the position of the coronary, falciform, triangular ligaments of the liver.
12. What is the Glisson`s capsule?

13. Describe the functions of the liver.

14. Describe the subdivisions of the liver: lobes, sectors, segments, lobules, and relations between them. What is the practical importance of the liver segmentation?

15. Describe the subdivisions (orders) of the hepatic artery and portal vein. How the branching of the vessels relate to subdivisions of the liver?

16. Define the segment of the liver. How many segments are distinguished anatomically and clinically?

17. Describe the structural and functional units of the liver: hepatic lobule, portal lobule, hepatic acinus.

18. Describe the structure of the hepatic lobule. What is its shape, size? Around which structure are the hepatocytes grouped?

19. What is the composition of the hepatic triad?

20. Describe the flow of the blood to the liver and from the liver. Why does the liver receive two types of the blood? Describe the blood supply of the liver, beginning from the hepatic artery. How does the deoxygenated blood flow from the liver into the inferior vena cava?

21. What is the rete mirabile of the liver?

22. What is the function of the bile? Where is the bile formed? Describe all the bile ducts in order, beginning from beliferous ductules.

23. What parts has the gallbladder? Describe its function, relation to the peritoneum and adjacent viscera. Where does it project to anterior abdominal wall? Describe its skeletotopy. What duct arises from the gallbladder?

24. Describe the formation of the common bile duct. Where does it open?

25. Describe the position of the pancreas in the abdominal cavity and its projection to the anterior abdominal wall of a living person.

26. Describe the parts of the pancreas.

27. Describe the relations of the pancreas to the surrounding organs and to the peritoneum.

28. Describe the skeletotopy of the pancreas relatively to the vertebral column.

29. Describe the borders and surfaces of the pancreas.

30. How do the ducts of the pancreas open into the duodenum?

31. Describe the endocrine and exocrine functions of the pancreas.

## CLINICOANATOMICAL PROBLEMS

1. In a patient with leukemia the liver is increased 3 cm below the right costal arch. On the left, the liver reaches the lateral border of the rectus abdominis. How is the liver increased in comparison with the normal?

2. The hepatoptosis is observed in a patient. Which mechanism of the fixation of the liver is failed?

3. During cholecystectomy many small stones are found in the gallbladder. Which bile ducts should a doctor examine to exclude the presence of the stones in them?

4. The radiological examination of a patient with cholelithiasis shows that the stone closed the cystic duct. In this case, can the bile pass into the duodenum?

5. A patient with acute pancreatitis needs a surgical operation. Which surgical approach may the doctor use, taking into account the topographical features of the pancreas?

6. In a patient with the disease of the stomach the fibrogastroscopy was done and the biopsy was taken. In the biopsy of the gastric wall the pancreatic tissue was observed. What can the doctor think about?

## 2.14. Morphofunctional Features of Peritoneum

***Peritoneum***, *peritoneum*, is a serous membrane which lines the walls of the abdominal cavity and covers the viscera situated in the abdominal cavity.

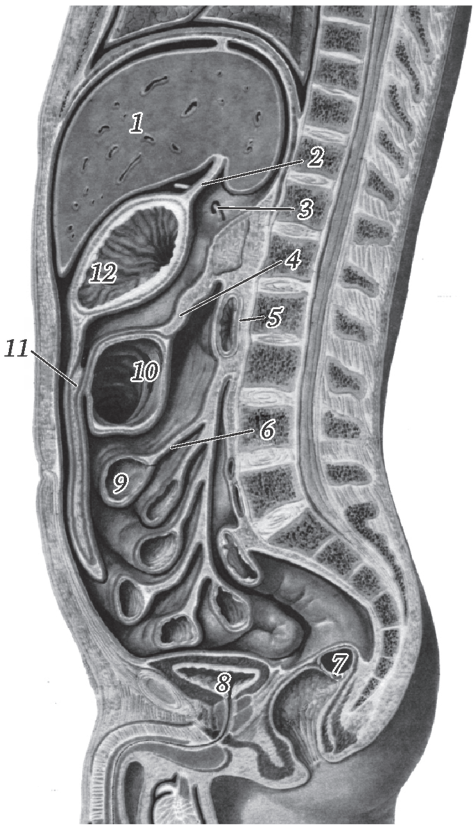


Fig. 2.41. Median section of body; relations of the organs to peritoneum:

*1* — liver (*hepar*); *2* — lesser omentum (*omentum minus*); *3* — vestibule of omental bursa (*vestibulum bursae omentalis*); *4* — transverse mesocolon (*mesocolon transversum*); *5* — duodenum (*duodenum*); *6* — mesentery (*mesenterium*); *7* — rectum (*rectum*); *8* — urinary bladder (*vesica urinaria*); *9* — jejunum (*jejunum*); *10* — transverse colon (*colon transversum*); *11* — omental bursa (*bursa omentalis*); *12* — stomach (*gaster*); *13* — gastropancreatic foramen (*foramen gastropancreaticum*); *14* — pancreas (*pancreas*)

The peritoneum, lining the inner surface of the abdomen, is called the parietal peritoneum, *peritoneum parietale*. It is a component of the abdominal cavity, *cavitas abdominalis*.

***The abdominal cavity*** is the largest body cavity, which represents the space bounded by the endoabdominal, *fascia endoabdominalis*. Apart from the endoabdominal fascia, the walls of the abdominal cavity are formed by the following structures: superiorly — the diaphragm; anteriorly and laterally — anterolateral abdominal muscles; posteriorly — the lumbar part of the vertebral column with quadtratus lumborum and psoas major; inferiorly — the walls of the greater and lesser pelvis. Thus, the term 'abdominal cavity' includes the abdominal cavity itself and also both hypochondriac regions and pelvic cavity, *cavitas pelvis*.

It should be noted that in certain sites the parietal peritoneum does not closely adjoin the endoabdominal fascia. (fig. 2.41). Thus, between the endoabdominal fascia of the posterior abdominal wall and the peritoneum there is a space filled with the fat and the organs: duodenum, pancreas, adrenal glands, kidneys, aorta, inferior vena cava etc. This space is termed the retroperitoneal space. Such a space is in the area of the urinary bladder (on the anterior wall of the lesser pelvis). It is termed the anteperitoneal space, *spatium anteperitoneale*. It includes the retropubic space, *spatium retropubicum*, and retroinguinal space, *spatium retroinguinale*. On the bottom of the lesser pelvis between the parietal peritoneum and pelvic

fascia there is a subperitoneal space, *spatium subperitoneale*, containing the fat and the organs: prostate, seminal vesicles in males, and the cervix of the uterus and the part of the vagina in females.

The peritoneum, covering the viscera situated in the abdominal cavity, is called visceral, *peritoneum viscerale*. It is a component of the wall of the certain organ.

The visceral peritoneum covers the organs differently. Therefore, three kinds of the relations between the viscera and peritoneum are distinguished: intraperitoneal, mesoperitoneal and extraperitoneal (fig. 2.42).

An intraperitoneal organ is covered by the peritoneum completely (from all sides), except a narrow area, along which the mesentery is attached. Hence the intraperitoneal organs have a mesentery, which helps to fixate the organs to the abdominal wall. Such organs are the stomach, small intestine (except the duodenum), vermiform appendix, transverse colon, sigmoid colon, the superior part of the rectum, spleen. Only one organ is intraperitoneal but has no mesentery. This is the caecum, which has the form of a sac, fixed to the ascending colon.

A mesoperitoneal organ is covered by the peritoneum from three sides, and one its side is fused with the abdominal wall. This side has an adventitia instead of the peritoneum in the composition of its wall. The mesoperitoneal organs are sessile (immobile). Here belong the ascending colon, descending colon, the middle part of the rectum, liver, the filled urinary bladder, uterus.

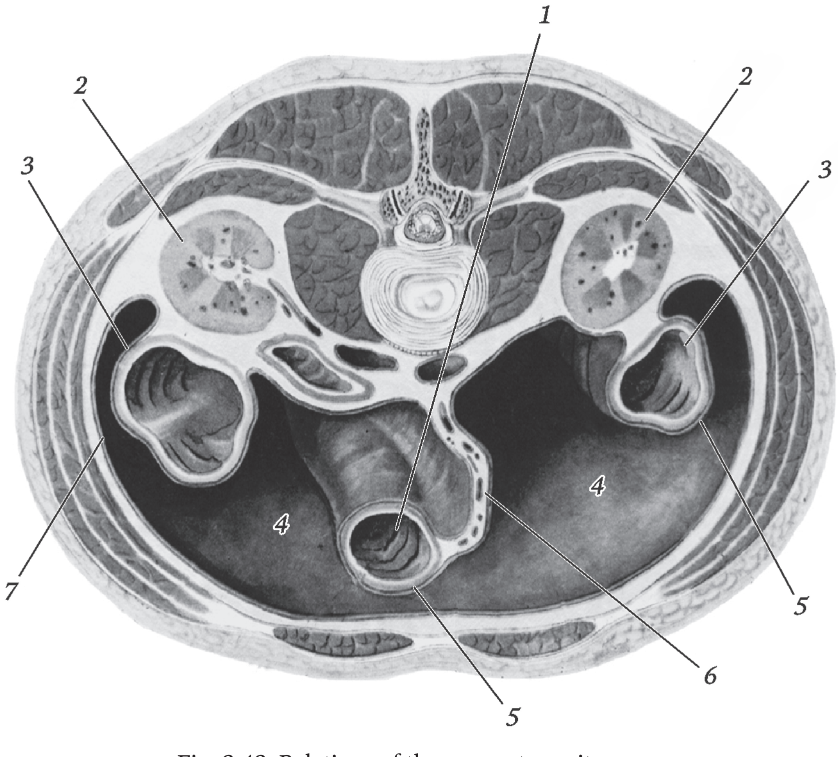


Fig. 2.42. Relations of the organs to peritoneum:
*1* — intraperitoneal position; *2* — extraperitoneal position; *3* — mesoperitoneal position; *4* — peritoneal cavity; *5* — visceral peritoneum; *6* — mesentery; *7* — parietal peritoneum

The extraperitoneal organs (located in the retroperitoneal, anteperitoneal or subperitoneal spaces) are covered by the peritoneum only from one side, while other sides have an adventitia. With the help of the advenditia the organ is fixed to surrounding tissues therefore, such organs are immobile. They are duodenum, pancreas, adrenal glands, kidneys, ureters, inferior part of the rectum. Only one organ has a particular relation to the peritoneum. This is the ovary. It is covered by a single layer of the embryonic mesothelium and situated inside the peritoneal cavity, *intra cavum peritonei*.

The relations of the viscera to the peritoneum should be taken into account in surgical practice. If the organ is extraperitoneal or mesoperitoneal, the extraperitoneal surgical approaches may be used (for example, in operations on the kidneys, adrenal glands, urinary bladder, the uterine cervix, ureter and so on). For the intraperitoneal organs all the surgical approaches are made only through the peritoneum, i.e. with the opening of the peritoneal cavity.

The parietal peritoneum is continuous with the visceral peritoneum without an interruption, and as a result a single slit-like cavity is formed; it is termed the peritoneal cavity.

***The peritoneal cavity***, *cavitas peritonealis*, is a slit-like space between the parietal and visceral peritoneum or between some areas of the visceral peritoneum, having an undefined shape and filled with serous fluid. The undefiniteness of the peritoneal cavity`s shape is caused by the inconstancy of the size, position and volume of the viscera covered by the peritoneum.

The peritoneal cavity of males is completely closed and is not communicated with the exterior. In females the peritoneal cavity is communicated with the exterior through the uterine tubes, uterine cavity and vagina. It should be noted that in normal the lumen of the uterine tubes is closed by a thin layer of the mucus. Just in some cases they may become the ways for the distribution of infection from the vagina or uterus into the peritoneal cavity.

You should pay attention that in some manuals of operative surgery the terms ‘abdominal cavity’ and ‘cavity of abdomen’ are not identical. The term ‘abdominal cavity’ is a space bounded by the parietal peritoneum. And the term ‘cavity of abdomen’ is a space bounded by the endoabdominal fascia. Hence, with this point of view the cavity of abdomen includes three parts: 1 — abdominal cavity; 2 — peritoneal cavity; 3 — retroperitoneal, anteperitoneal and subperitoneal spaces.

**Peritoneum and its derivatives**. The total square of the peritoneum is about 20 500 $cm^2$. However, it fits within the abdominal cavity due to its great folding and complex arrangement. The peritoneum is a thin transparent elastic sheath covered by a thin layer of the serous fluid. In a healthy person it has grayish-pink opalescent color.

The peritoneum has the following layers: the mesothelial layer, basement membrane, connective-tissue stroma, formed by the collagen and elastic fibers, and the layer of the blood and lymphatic vessels, rich in the periadventitial cells.

The parietal peritoneum has local structural features (the different sizes of mesotheliocytes, the size of intercellular spaces, thickness of connective-tissue stroma and the degree of the development of capillary plexuses).

The structural specificity of the visceral peritoneum depends on the viscera. Therefore, the peritoneum is functionally divided into the following parts: 1) the areas, which produce a transudate (serous fluid); 2) the areas, which absorb the serous fluid; 3) in-

different areas. The serous fluid is produced mainly by the visceral peritoneum because the plexuses of blood capillaries prevail in it. The serous fluid is derived from the plasma of these capillaries. It is similar to the blood plasma in composition and provides the trophicity and moisture of the mesothelium. Hence the viscera glide freely and are fixed relatively to each other and to the parietal peritoneum. The total volume of the serous fluid in the peritoneal cavity is 20—25 ml.

The resorption is performed mainly by the parietal peritoneum in the area of the diaphragm and perineum. Here are the plexuses of lymphatic capillaries which absorb the serous fluid. In other areas the peritoneum both produces serous fluid and absorbs it.

One more essential property of the peritoneum is its high regenerative ability. If the peritoneum is damaged by some mechanical, chemical or temperature effects, it produces an adhesive fibrinous exudate, providing the adherence of the injured areas. Thus, the peritoneum may limit peritoneal infection (especially the peritoneum of the greater omentum).

In the peritoneum of the greater omentum the collagen fibers are almost absent, and immediately under the basement membrane there are elastic fibers and the plexuses of blood capillaries. Such a structure permits the greater omentum to displace to the inflammatory focus to limit it and to provide the phagocytosis of microflora.

The following derivatives of the peritoneum are distinguished:

1) ligaments of peritoneum, *ligamenta peritonei*;
2) mesenteries, *mesenteria*;
3) omenta, *omenta*;
4) folds, *plicae*.

***The ligaments of peritoneum*** are the folds of the peritoneum where the parietal peritoneum is continuous with the visceral one, passing from the abdominal wall to the viscus, or where the visceral peritoneum is reflected from one viscus to another.

The ligaments may be single-layered or double-layered. The single-layered ligament has only one free surface lined by the mesothelium (non fused). The other surface of the single-layered ligament is fused with the abdominal wall or with viscus. Therefore, you can not take the single-layered ligament by your fingers, you can just palpate it. The single-layered ligaments are absolutely immobile. The examples of such ligaments: hepatorenal ligament, *ligamentum hepatorenale*; duodenorenal ligament, *ligamentum duodenorenale*; coronary ligament, *ligamentum coronarium*, etc.

The double-layered ligaments represent the double sheet of the peritoneum. Both surfaces of such a ligament are free and lined by mesothelium. The layers of the peritoneum may enclose the vessels, nerves, ducts or fat. You can take the double-layered ligament by your fingers, palpate its content, displace it or change its form.

The examples of such ligaments: falciform ligament, *ligamentum falciforme*; right and left triangular ligaments, *ligamentum triangulare dextrum et ligamentum triangulare sinistrum*; hepatogastric ligament, *ligamentum hepatogastricum*; hepatoduodenal ligament, *ligamentum hepatoduodenale*; gastrosplenic ligament, *ligamentum gastrosplenicum* (*gastrolienale*); gastrophrenic ligament, *ligamentum gastrophrenicum*; gastrocolic ligament, *ligamentum gastrocolicum*; broad ligament of uterus, *ligamentum latum uteri*, etc.

According to genesis, the ligaments of the peritoneum can be divided into four groups:

— the derivatives of the ventral mesentery (falciform ligament, coronary ligament, right and left triangular ligaments, hepatogastric ligament, hepatoduodenal ligament);

— the derivatives of the dorsal mesentery (gastrophrenic ligament, gastrocolic ligament etc.);

— the derivatives of the parietal peritoneum (hepatorenal ligament, duodenoranal ligament, phrenicocolic ligament, broad ligament of uterus);

— obliterated vestiges of vessels and ducts, enveloped by the peritoneum (ligamentum teres of liver, median and medial umbilical ligaments).

***Mesenteries*** are double-layered ligaments, formed by the reflexion of the peritoneum from the abdominal wall to the viscera, which fixate the viscera and transmit the vessels and nerves. Between the layers of the mesentery the connective-tissue, fat, vessels, nerves, lymph nodes are situated.

A viscus, having a mesentery, is always intrapitoneal and more or less mobile. The longer the mesentery, the greater the mobility of a viscus.

The mesenteries may be ventral or dorsal in development. However, the ventral mesentery of the primitive gut reduces almost on all its extent and partially remains as the ligaments (e.g. hepatogastric and hepatoduodenal ligaments).

Hence the remaining mesenteries are dorsal in genesis. The names of the mesenteries are formed by the word '*meso*' and the name of the organ (e.g. *mesogastrium*, *mesocolon*, *mesoappendix* etc).

It is important for the abdominal surgery to know the level of the fixation of the mesenteric roots to the posterior abdominal wall and their length (fig. 2.43).

The root of the transverse mesocolon, *radix mesocolon transversi*, 22—25 long, arises from the right side of the II lumbar vertebra in the right hypochondriac region, adjoning the liver and crossing the right kidney and vertebral column. It ends at the level of the left side of the I lumbar vertebra, crossing the left kidney and adjoning the spleen.

The root of the jejunal and ileal mesentery, *radix mesenterii*, 18—20 cm long, is attached along a line running diagonally from the left side of the II lumbar vertebra to the right sacroiliac joint. Along the intestinal margin the length of the mesentery is from 3,5 to 5 m.

The root of the sigmoid mesocolon, *radix mesocolon sigmoidei*, 4—6 cm long, is attached to the posterior abdominal wall to the left side of the vertebral column at the level of the IV—V lumbar vertebare.

The root of the mesentery of the rectum`s superior part (mesorectum), *radix mesorecti*, is attached at the level of the I—III sacral vertebrae. Its length is 5—7 cm.

The root of the mesoappendix, *radix mesoappendicis*, 3—5 cm long, is near the ileocaecal angle; it is attached to the terminal part of the ileum.

The uterus, uterine tubes and ovaries also have mesenteries, but they are not associated with the mesenteries of the primitive gut. They are the parts of the uterine broad ligament (*mesometrium*, *mesosalpinx*, *mesoovarium*).

***Omentum*** is an elongated mesentery of the stomach, which encloses the fat in shape of lobules and plexuses of blood vessels.

The lesser and greater omenta are distinguished.

The lesser omentum, *omentum minus*, is a double sheet of the peritoneum, stretched between the diaphragm, lesser gastric curvature and superior part of duodenum (fig. 2.43). It consists of two ligaments: hepatogastric and hepatoduodenal, which are the continuation of each other. The hepatogastric ligament, *ligamentum hepatogastricum*, is very thin, transparent and may be fenestrated. The vessels, passing to the lesser

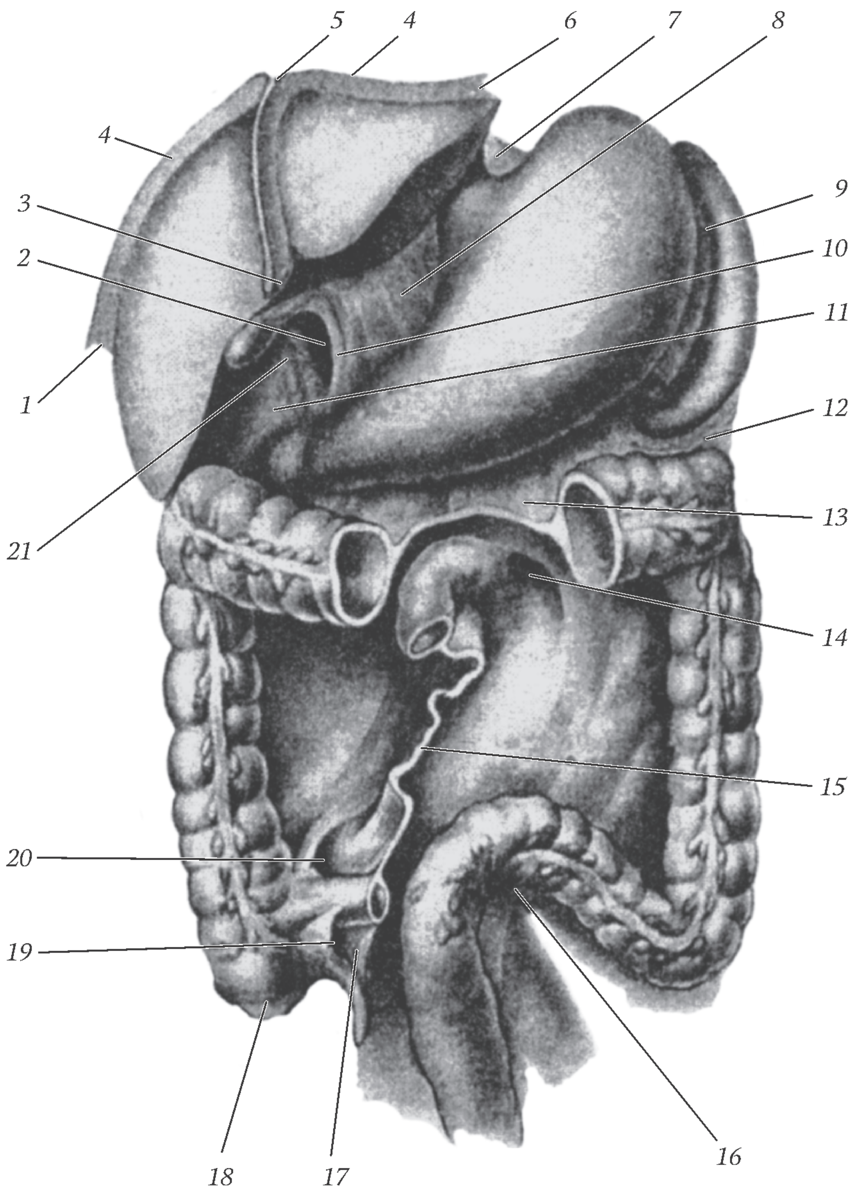


Fig. 2.43. Abdominal viscera (anterior aspect (the small intestine and the middle part of the transverse colon have been removed; the liver, stomach, large intestine, the peritoneal ligaments and fossae are visible)):

*1* — right triangular ligament; *2* — epiploic foramen; *3* — ligamentum teres hepatis; *4* — coronary ligament; *5* — falciform ligament; *6* — left triangular ligament; *7* — gastrophrenic ligament; *8* — hepatogastric ligament; *9* — gastrosplenic ligament; *10* — hepatoduodenal ligament; *11* — duodenorenal ligament; *12* — phrenicocolic ligament; *13* — transverse mesocolon; *14* — superior duodenal recess; *15* — root of mesentery; *16* — intersigmoid recess; *17* — mesoappendix; *18* — retrocaecal recess; *19* — inferior ileocaecal recess; *20* — superior ileocaecal recess; *21* — hepatorenal ligament

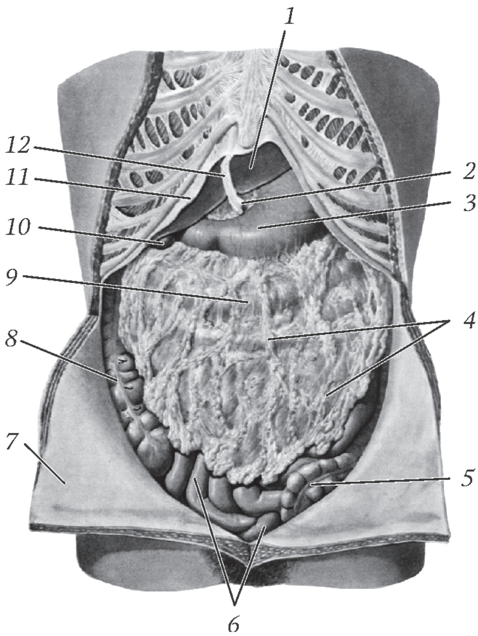


Fig. 2.44. Abdominal viscera (anterior aspect (anterior abdominal wall is dissected; in the upper part it has been removed, in the lower part it is turned outward)):

*1* — liver (left lobe); *2* — ligamentum teres hepatis; *3* — stomach; *4* — greater omentum (anterior layer); *5* — sigmoid colon; *6* — small intestine; *7* — parietal peritoneum; *8* — ascending colon; *9* — transverse colon (relief); *10* — fundus of gallbladder; *11* — diaphragm; *12* — falciform ligament

curvature, are contained between its two layers. The hepatoduodenal ligament, *ligamentum hepatoduodenale*, encloses the large vessels (portal vein and proper hepatic artery), common hepatic duct, nerves, lymph vessels and connective-tissue therefore, it is 1—1,5 cm thick. The lesser omentum is anterior to the vestibule of the omental bursa.

The greater omentum, *omentum majus*, is an elongated dorsal mesentery of the stomach (fig. 2.44); it is a double sheet, folded on itself to make four layers. The anterior double-layered fold starts from the greater gastric curvature, descends between the anterior abdominal wall and the intestine almost to the pubic bones; it then reflexes and ascends as the posterior double-layered fold, adhering to the anterior fold. The greater omentum is attached to the transverse colon and fixates above it to the posterior abdominal wall.

The greater omentum consists of three ligaments, which sequentially continue with each other from the right to the left. The part of the greater omentum from the stomach to the transverse colon forms the gastrocolic ligament, *ligamentum gastrocolicum*. The part of the greater omentum, passing from the gastric fundus to the spleen, is named the gastrosplenic ligament, *ligamentum gastrosplenicum* (*gastrolienale*). And the shortest part of the greater omentum between the cardiac part of stomach and the diaphragm is the gastrophrenic ligament, *ligamentum gastrophrenicum*.

It should be noted that in newborns and during the first year of life the descending and ascending folds of the greater omentum are not fused together, and between them there is an omental bursa, *bursa omentalis*. In adults the bursa is absent because the folds of the greater omentum are fused.

***Fold*** is a double sheet of the parietal peritoneum, formed by underlying vessels, ducts, ligaments or accumulation of fat. The folds are situated on the inner surface of the anterior abdominal wall below the umbilicus, and in the lesser pelvis.

On the anterior abdominal wall there are five vertical and two almost horizontal folds (fig. 2.45). Along the midline from the apex of the urinary bladder to the umbilicus an unpaired peritoneal fold passes; this is the median umbilical fold, *plica umbilicalis mediana*. It contains a fibrous cord called the median umbilical ligament, *ligamentum umbilicale medianum*, representing an obliterated urachus (a duct that drains the urinary bladder of the fetus). On the sides of this fold a paired medial umbilical fold, *plica*

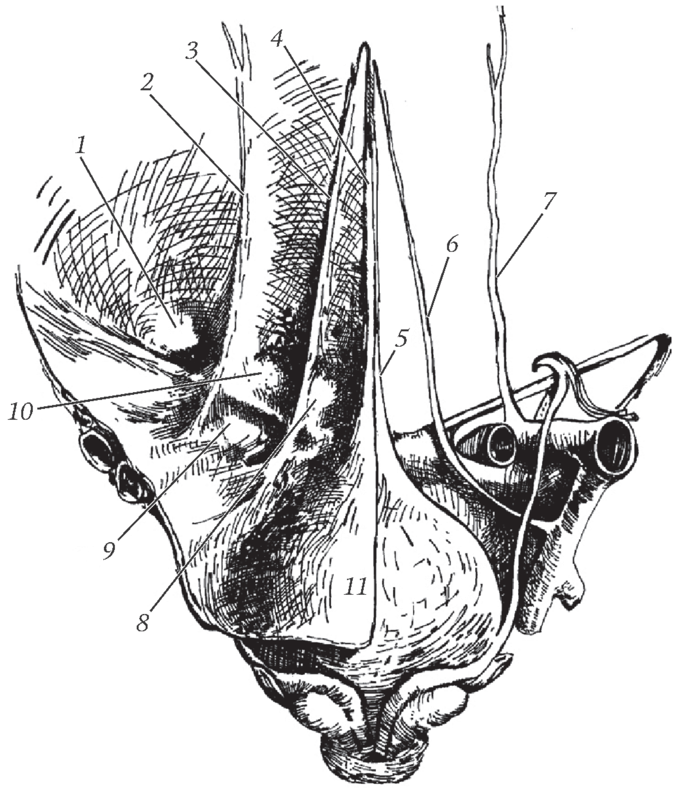


Fig. 2.45. Folds and fossae on the posterior surface of the anterior abdominal wall (on the right, the parietal peritoneum has been removed):

*1* — lateral inguinal fossa (*fossa inguinalis lateralis*); *2* — lateral umbilical fold (*plica umbilicalis lateralis*); *3* — medial umbilical fold (*plica umbilicalis medialis*); *4* — median umbilical fold (*plica umbilicalis mediana*); *5* — median umbilical ligament (*ligamentum umbilicale medianum*); *6* — medial umbilical ligament (*ligamentum umbilicale mediale*); *7* — inferior epigastric artery (*a. umbilicalis inferior*); *8* — supravesical fossa (*fossa supravesicalis*); *9* — femoral fovea (*fovea femoralis*); *10* — medial inguinal fossa (*fossa inguinalis medialis*); *11* — peritoneum (*peritoneum*)

*umbilicalis medialis*, runs down and laterally. It also contains a fibrous cord named the medial umbilical ligament, *ligamentum umbilicale mediale*, which is an obliterated umbilical artery. Lateral to it, is a less-defined lateral umbilical fold, *plica umbilicalis lateralis*. It passes 1,5 cm lateral to the umbilicus and contains the functioning blood vessels: inferior epigastric artery and veins, *a. et vv. epigastricae inferiores*. The almost horizontal folds correspond to the inguinal ligaments.

Between the mentioned folds, immediately above the inguinal ligament there are three pairs of fossae. The closest to the midline is a paired supravesical fossa, *fossa supravesicalis*. The lateral umbilical fold separates two practically important fossae: the medial inguinal fossa, *fossa inguinalis medialis*, corresponding to the superficial inguinal ring, and the lateral inguinal fossa, *fossa inguinalis lateralis*, corresponding to the deep inguinal ring.

Under the inguinal ligament one more paired fossa exists; this is a femoral fossa, *fossa femoralis*. It corresponds to the inner opening of the femoral canal, *anulus femoralis*, and is situated below the medial inguinal fossa.

In the male lesser pelvis there is a rectovesical fold, *plica rectovesicalis*. It is formed by the accumulation of fat and areolar tissue. In females this ligament consists of two separate parts: rectouterine and vesicouterine folds, *plica rectouterina et plica vesicouterina*.

## 2.15. Review of Abdominal Viscera

The abdominal cavity contains the digestive and urogenital organs, and also the spleen, which is an organ of the immune system, and adrenal glands, which are the endocrine organs.

The digestive organs contained in the abdominal cavity are: the abdominal part of the oesophagus, stomach, small intestine, large intestine, liver with gallbladder and pancreas (fig. 2.46). The abdominal part of oesophagus is short (2—3 cm). Passing through

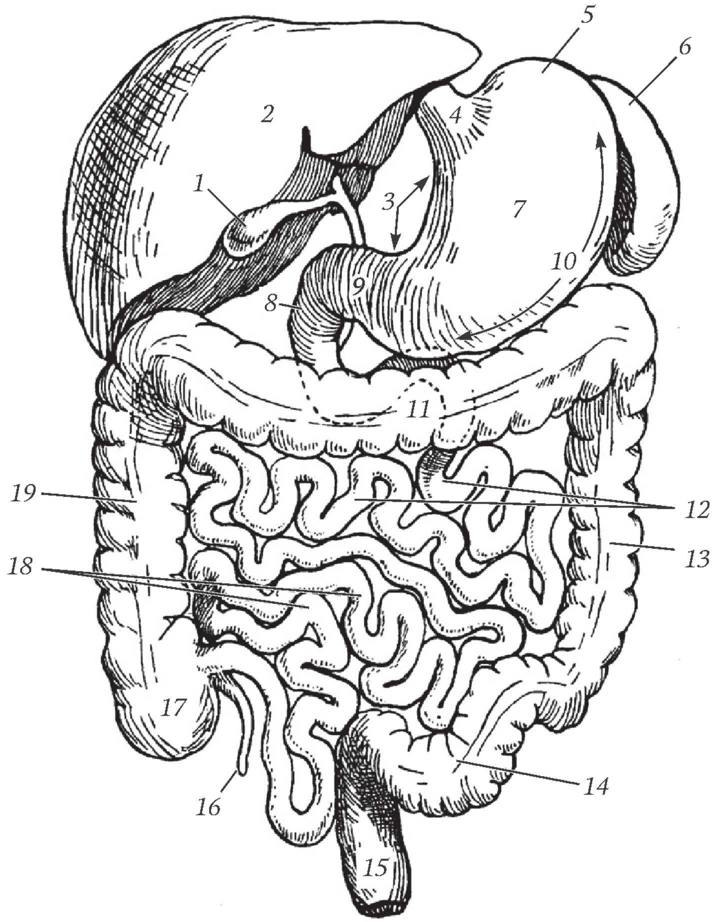


Fig. 2.46. Disposition of the organs of alimentary system in the abdominal cavity):
*1* — gallbladder; *2* — liver; *3* — lesser curvature; *4* — cardiac part; *5* — fundus of stomach; *6* — spleen; *7* — stomach; *8* — duodenum; *9* — pyloric part; *10* — greater curvature; *11* — transverse colon; *12* — jejunum; *13* — descending colon; *14* — sigmoid colon; *15* — rectum; *16* — vermiform appendix; *17* — caecum; *18* — ileum; *19* — ascending colon

the oesophageal hiatus, the oesophagus opens into the stomach, *gaster*. The stomach has two walls (surfaces): anterior and posterior. In examination, only anterior gastric wall and both curvatures (lesser and greater) are visible. The stomach is conventionally divided into the cardiac part, *pars cardiaca*, situated near the oesophagus; the fundus, *fundus*, which is the superior dome-shaped part of the stomach; the body, *corpus*; the pyloric part, *pars pylorica*, which is continuous with the duodenum, *duodenum*. The stomach occupies the epigastrium and the part of the left hypohondriac region. The gastric fundus and partially the greater curvature adjoin the spleen situated in the left hypochondriac region. The right hypochondriac region and partially epigastrium are occupied by the liver, *hepar*. It has a convex diaphragmatic surface and uneven visceral surface. The visceral surface carries two longitudinal and one transverse fissures. The right longitudinal fissure contains the gallbladder, *vesica biliaris*, the fundus of which slightly extends beyond the inferior border of the liver. In the anterior part of the left longitudinal fissure there is a ligamentum teres of liver, *ligamentum teres hepatis*, passing from the umbilicus in the edge of the falciform ligament. The transverse fissure is the porta hepatis.

If you pull the liver down, you will see the falciform ligament, *ligamentum falciforme,* on its diaphragmatic surface (fig. 2.35). It divides the liver`s diaphragmatic surface into two unequal parts: right (larger) and left (smaller) lobes.

If you put your hand into the depth between the costal arch and liver, you will feel the coronary ligament, *ligamentum coronarium*. It is a reflexion of the parietal peritoneum from the diaphragm to the visceral peritoneum of the liver. At the right and left borders of the liver the coronary ligament is continuous with the right and left triangular ligaments formed by two layers of the peritoneum.

From the lesser gastric curvature to the liver the hepatogastric ligament, *ligamentum hepatogastricum*, extends; it is thin, gentle and often fenestrated. Following to the right, this ligament is immediately continuous with the hepatoduodenal ligament, *ligamentum hepatoduodenale*, connecting the porta hepatis with the commencement of the duodenum. The layers of the hepatoduodenal ligament envelop the portal vein, *v. portae*, proper hepatic artery, *a. hepatica propria*, common bile duct, *ductus choledochus*, nerves, lymph vessels and nodes, connective-tissue and fat.

The free margin of the hepatoduodenal ligament is anterior to the epiploic foramen, *foramen epiploicum* (*omentale*). Superiorly this foramen is bounded by the visceral surface of the liver; posteriorly — by the hepatorenal ligament, *ligamentum hepatorenale*, being the reflexion of the peritoneum from the visceral hepatic surface to the right kidney; inferiorly — by the duodenorenal ligament, *ligamentum duodenorenale*, representing the reflexion of the peritoneum from the superior part of the duodenum to the right kidney.

The epiploic foramen (foramen of Winslow) leads into the vestibule of the omental bursa, *vestibulum bursae omentalis*, situated behind the lesser omentum.

When you pull the stomach down and to the right, you will see the gastric ligaments that form the greater omentum. The gastrophrenic ligament, *ligamentum gastrophrenicum*, passes from the diaphragm to the cardiac orifice of the stomach; the gastrosplenic ligament, *ligamentum gastrosplenicum* (*gastrolienale*), runs from the gastric fundus to the splenic hilum; the gastrocolic ligament, *ligamentum gastrocolicum*, extends from the gastric greater curvature to the transverse colon. The gastrocolic ligament composes the major part of the greater omentum therefore, it is often named the greater omentum, *omentum majus*.

Immediately under the right lobe of the liver there is a superior part of duodenum, *pars superior duodeni*, 3—4 cm long. Other parts of the duodenum are invisible from the side of the peritoneal cavity because they are shielded together with the pancreas by the parietal peritoneum covering the posterior abdominal wall, i.e. are situated retroperitoneally.

To examine other abdominal viscera you should lift and turn the greater omentum, which descends from the greater gastric curvature, and you will see the large and small intestine (fig. 2.47).

The coiled small intestine is framed by the colon from the right, left and from above. Because of the peristaltic movements the coils of the small intestine change their position however, the coils situated above and on the left belong to the jejunum, and coils situated below and on the right belong to the ileum. Approximately two thirds of the coils of the small intestine`s mesenteric part lie superficially, and the rest is in the depth; thus, to see this one third, you should shift the superficial coils.

To define the commencement of the mesenteric part of the small intestine you need to find the duodenojejunal ligament, *ligamentum duodenojejunale*, (ligament of Treitz, *ligamentum Treizi*). It is in the region of the duodenojejunal flexure, *flexura duodenojejunalis*. You may find the ligament of Treitz by the displacement of all the coils of the small intestine down and to the right. After this you may examine the mesenteric root of the small intestine, which descends obliquely, passing from level of the II lumbar vertebral body to the level of the right sacroiliac joint. The mesenteric root of the small intestine starts from the ligament of Treitz.

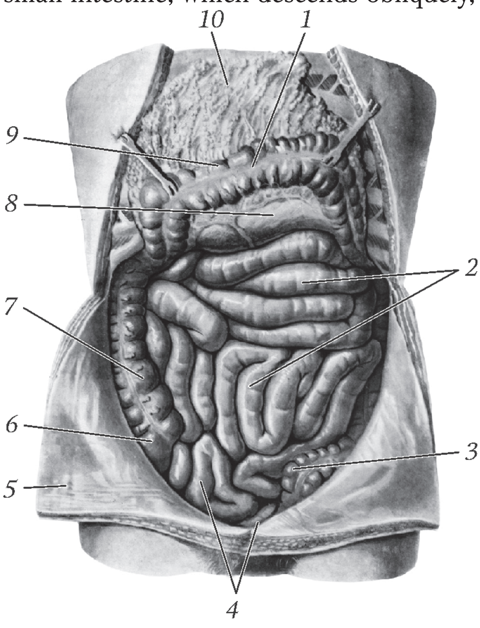


Fig. 2.47. Abdominal viscera (anterior aspect). Greater omentum and transverse colon are turned upward:

*1* — free taenia; *2* — jejunum; *3* — sigmoid colon; *4* — ileum; *5* — parietal peritoneum; *6* — caecum; *7* — ascending colon; *8* — transverse mesocolon; *9* — transverse colon; *10* — greater omentum (posterior layer)

Moving along the coils of the small intestine from the duodenojejunal flexure to the right iliac fossa, you will reach the ileocaecal angle where the ileum is continuous with the large intestine. The large intestine, *intestinum crassum*, includes the following parts: caecum, *caecum*, with the vermiform appendix, *appendix vermiformis*; ascending colon, *colon ascendens*; transverse colon, *colon transversum*; descending colon, *colon descendens*; sigmoid colon, *colon sigmoideum*; rectum, *rectum*.

To examine the caecum and ascending colon you need to move the small intestine up and to the left. The caecum is placed in the right inguinal fossa. It is enveloped by the peritoneum from all sides, but it has no mesentery. However, the intraperitoneal position of the caecum is observed in 80—85 % of cases. Rarely the posterior wall of the caecal cupola is fused with the posterior abdominal wall and has no peritoneal covering. In this case the caecum has a mesoperitoneal position.

Usually from the medial caecal wall, in the inferior part of the ileocaecal angle the vermiform appendix arises. It lies intraperitoneally and has a small mesentery. Rarely the appendix is behind the caecal cupola; such a position is called retrocaecal. Very rarely when the caecum has a mesoperitoneal position, the appendix is not observed from the side of the peritoneal cavity because it lies in retroperitoneal space. To see the appendix, lying retroperitoneally, it needs to cut the peritoneum and separate the caecal cupola from the abdominal wall.

Directing upwards from the caecum, you will find the ascending colon having a typical mesoperitoneal position. On all extent it is fused with the posterior abdominal wall therefore, it is almost immobile. Mostly it is able to change its form and volume.

The ascending colon reaches the right hypochondriac region, where it abruptly turns to the left at the right colic flexure, *flexura coli dextra*, to be continuous with the transverse colon. The right colic flexure is also named the hepatic flexure, *flexura hepatica*, because it adjoins the liver.

The transverse colon is intraperitoneal. The transverse mesocolon, 7—10 cm long, is fixed to the posterior abdominal wall obliquely from the right side of the II lumbar vertebra to the left side of the I lumbar vertebra. If the transverse mesocolon is longer than in average, the transverse colon sags. The transverse colon sharply curves down as the left colic flexure, which is the junction of the transverse colon and descending colon. It should be noted that the left colic flexure (or splenic flexure because it is in contact with the spleen), *flexura coli sinistra seu flexura lienalis*, is attached to the diaphragm by the phrenicocolic ligament, *ligamentum phrenicocolicum*. To examine the left colic flexure and the descending colon you need to displace the coils of the small intestine to the right.

The descending colon has a mesoperitoneal position, i.e. is fixed to the posterior abdominal wall. In the region of the left inguinal fossa the descending colon ends in the sigmoid colon. The latter is covered by the peritoneum from all sides and has a mesentery, which is 3—5 long. The form, size and position of the sigmoid colon are changeable. Most commonly the sigmoid colon forms a single loop of 15—20 cm, which descends to the lesser pelvis. More rarely the elongated sigmoid colon (35—40 cm), forming 2—3 loops, is observed. Also rarely you may observe the short sigmoid colon (about 10 cm). As usual such a sigmoid colon has a short mesentery or is absolutely devoid of a mesentery and lies mesoperitoneally. At the level of the I sacral vertebra the sigmoid colon is continuous with the rectum. To examine the rectum you need to raise the coils of the small intestine and sigmoid colon.

The superior (supraampullar) part of the rectum is completely covered by the peritoneum and has a proper mesentery, like the sigmoid colon. The middle (ampullar) part lies mesoperitoneally, the inferior part lies extraperitoneally hence the anal canal is covered by adventitia.

Besides the rectum, the lesser pelvic cavity contains the urinary bladder, *vesica urinaria*; it is behind the pubic symphysis. A distended bladder is convex and lifts the peritoneum, becoming mesopertoneal. An empty bladder is flattened, its lateral walls significantly contracts, and it becomes extraperitoneal.

In females between the rectum and urinary bladder is the uterus, *uterus*, covered by the peritoneum from three sides. The peritoneum leaves the uterus to reach the lateral pelvic walls as the broad ligaments of the uterus, each consisting of two layers continuous at the upper border of the ligament; between them at this border is the uterine tube,

*tuba uterina*. On the posterior surface of the uterine broad ligament is the female reproductive gland, the ovary, *ovarium*.

In males the deferent duct, *ductus deferens*, runs from the ingunal canal`s deep ring to the lesser pelvis. Behind the urinary bladder, under the peritoneum lining the floor of the lesser pelvis, there are the seminal vesicles, *vesiculae seminales*, and adjoining ampullae of deferent ducts, *ampullae ductus deferentis*. Deep to them, in the lesser pelvic cavity under the urinary bladder is the prostate, *prostata*.

In the retroperitoneal space, besides the duodenum and pancreas, there are the kidneys, *renes*, suprarenal glands, *glandulae suprarenales*, and ureters, *ureteres*. The kidneys are placed in the lumbar region on the sides of the vertebral column at the level of the XII thoracic and upper two lumbar vertebrae. The abdominal part of the descending aorta, *pars abdominalis aortae descendens*, and inferior vena cava, *v. cava inferior*, pass in the retroperitoneal space along the posterior abdominal wall in front of the vertebral bodies.

## 2.16. Anatomical and Topographical Features of Peritoneal Cavity

The peritoneal cavity has a very complex form determined by the structural features and disposition of the abdominal viscera, by the position of the ligaments, mesenteries, omenta and folds (fig. 2.43). In spite of the inconstancy of the peritoneal cavity`s slit-like spaces, it is possible to distinguish in the peritoneal cavity the following parts: storeys, bursae, openings, canals, pouches and recesses. These areas are important in clinical practice, because the inflammatory exudate may accumulate here to form abscesses.

The transverse mesocolon divides the peritoneal cavity into two storeys: upper and lower. The upper storey extends to the diaphragmatic dome, and the lower one extends to the floor of the lesser pelvic cavity.

***The upper storey*** includes the liver with the gallbladder (mesoperitoneal), the stomach, spleen and the superior part of duodenum (intraperitoneal), the descending, horizontal and ascending parts of duodenum and pancreas (extraperitoneal). The upper storey has several important slit-like spaces, which are like labyrinths between the abdominal walls and viscera. These spaces are limited by the ligaments. Let`s consider the main spaces of the upper storey.

1. Right subphrenic recess, *recessus subphrenicus dexter*, is also called the hepatic bursa. This is a slit between the diaphragmatic surface of the hepatic right lobe below and the diaphragm above, the right part of the coronary ligament and right triangular ligament posteriorly and falciform ligament on the left. The recess is rather deep and communicates with the right paracolic groove (the right lateral canal of the lower storey of the peritoneal cavity).

2. Left subphrenic recess, *recessus subphrenicus sinister*. It is less limited than the right subphrenic recess and consists of two parts extensively communicating with each other: 1) the left hepatic bursa, situated between the left hepatic lobe below and the diaphragm above, the falciform ligament on the right, the left part of the coronary ligament and the left triangular ligament posteriorly; 2) the pregastric bursa, situated between the anterior gastric wall and the lesser omentun anteriorly and inferiorly and the diaphragm above. The left subphrenic recess is deep but less narrow than the right subphrenic recess. Usually the serous fluid is not retained here and flows down and laterally into the splenic recess.

3. Splenic recess, *recessus lienalis*, is also named the splenic blind sac, *saccus caecus lienis*. This recess is limited: on the left and posteriorly by the phrenicolienal ligament; superiorly — by the diaphragm and gastrosplenic ligament; inferiorly and on the left — by the phrenicocolic ligament. The left subphrenic and splenic recesses do not communicate with the left paracolic groove (the left lateral canal of the lower storey of the peritoneal cavity).

4. Subhepatic recess, *recessus subhepaticus*, or subhepatic bursa, is between the hepatic visceral surface above, transverse mesocolon and transverse colon below. Followed to the left, the recess extends to the porta hepatic and hepatoduodenal ligament. It is quite deep recess, where the abscesses may be formed in the case of the inflammation of the gallbladder or duodenum. The subhepatic recess communicates with the hepatorenal recess, *recessus hepatorenalis*, and then with the right paracolic groove (with the right lateral canal of the peritoneal cavity).

5. The vestibule of the omental bursa, *vestibulum bursae omentalis*, is a slit-like space. It is the most isolated among the spaces of the peritoneal cavity`s upper storey. You can enter freely into it only through the epiploic foramen, *foramen epiploicum* (*omentale*). As mentioned above, the epiploic foramen is bounded anteriorly by the hepatoduodenal ligament; superiorly by the liver; posteriorly by the hepatorenal ligament; inferiorly by duodenorenal ligament. Sometimes after the inflammatory diseases the epiploic foramen becomes very narrow or fully closed. In normal it admits the index finger. To insert the index finger you need to place the finger immediately at the porta hepatic and then move it under the hepatoduodenal ligament.

The vestibule of the omental bursa is bounded anteriorly by the lesser omentum and partially by the posterior gastric wall; posteriorly by the parietal layer of the peritoneum; superiorly by the liver`s caudate lobe and by the area of the diaphragm near the oesophagus.

The vestibule of the omental bursa leads to a slit-like gastropancreatic foramen, *foramen gastropancreaticum*, situated behind the stomach and leading, in its turn, into the omental bursa. The foramen is bounded anteriorly by the posterior gastric wall; posteriorly by the peritoneum covering the pancreas; from the sides by the medial and lateral gastropancreatic folds, *plicae gastropancreaticae mediale et laterale*.

In adults the cavity of the omental bursa is closed, but sometimes between the double folds of the greater omentum the small spaces remain.

***Lower storey*** of the peritoneal cavity extends from the transverse mesocolon to the floor of the lesser pelvis. It includes the small and large intestine, urinary bladder. In females here are the uterus, uterine tubes and ovaries. The lower storey has the two mesenteric sinuses, two paracolic grooves and several recesses formed by the peritoneum where it passes from one organ to another.

1. Right mesenteric sinus, *sinus mesentericus dexter*, triangular, is bounded superiorly by the transverse mesocolon; on the right by the caecum and ascending colon; inferiorly by the mesenteric root of the small intestine and the terminal part of the ileum, which separates the right mesenteris sinus from the cavity of the lesser pelvis. The sinus contains the coils of the small intestine. The right mesenteric sinus communicates with the left mesenteric sinus in the upper left angle above the duodenojejunal flexure.

2. Left mesenteric sinus *sinus mesentericus sinister*, is to the left and down of the mesenteric root of the small intestine. It is framed on the left by the descending colon and

sigmoid mesocolon; on the right by the mesentery of the small intestine. Below, the left mesenteric sinus communicates with the cavity of the lesser pelvis. The sinus is also filled with the coils of the small intestine.

3. Right paracolic groove, *sulcus paracolicus dexter* (right lateral abdominal canal, *canalis abdominis lateralis dexter*), is between the right lateral abdominal wall and ascending colon. Above, it communicates with the right subphrenic recess, and below, it opens into the right inguinal fossa. The depth of the groove varies and depends on the form and sizes of the ascending colon. When the body is in the horizontal position, the upper part of the groove is deeper; in the vertical position of the body the serous fluid flows down into the right inguinal fossa.

4. Left paracolic groove, *sulcus paracolicus sinister* (left lateral abdominal canal, *canalis abdominis lateralis sinister*), is between the left lateral abdominal wall and descending colon. In vertical position of the body the upper part of the groove (the level of the XI rib) is deeper. The left paracolic groove is separated from the left subphrenic recess by the phrenicocolic ligament therefore, they do not communicate. Below, the left paracolic groove prolongates into the left inguinal fossa and further into the lesser pelvis.

Where the peritomeum passes from one organ to another, it creates the recesses which can be sites where the limited inflammatory processes are localized.

1. Superior duodenal recess, *recessus duodenalis superior*, is to the left of the II vertebral body under the root of the transverse mesocolon. It is bounded anteriorly by the duodenojejunal fold; posteriorly by the parietal peritoneum covering the posterior abdominal wall; superiorly by the transverse mesocolon; inferiorly by the upper margin of the duodenojejunal flexure. Sometimes this recess penetrates deeply into the retroperitoneal space and may cause the formation of the retroperitoneal hernia (hernia of Treitz), which may contain the coils of the small intestine.

2. Inferior duodenal recess, *recessus duodenalis inferior*, is a shallow fossa on the posterior abdominal wall, situated under the duodenojejunal flexure. Frequently the recess penetrates the ligament of Treitz.

3. Superior ileocaecal recess, *recessus ileocaecalis superior*, is a shallow fossa between the upper margin of the terminal part of the ileum and ascending colon.

4. Inferior ileocaecal recess, *recessus ileocaecalis inferior*, is between the inferior surface of the terminal part of the ileum and the caecal wall. Usually in this recess the appendix lies.

5. Retrocaecal recess, *recessus retrocaecalis*, is behind the caecal cupola. It may be a site of the internal hernia of the ileocaecal angle.

6. Intersigmoid recess, *recessus intersigmoideus*, is a narrow funnel-shaped deep (3—4 cm) fossa situated to the left of the root of the sigmoid mesocolon. It is bounded anteriorly by the sigmoid mesocolon, and posteriorly by the parietal peritoneum covering the posterior abdominal wall. The recess opens into the left paracolic groove. The left ureter passes at the level of this recess.

7. Rectovesical pouch, *exavatio rectovesicalis*, is in the cavity of the lesser pelvis in males, below the rectovesical folds. In females in the lesser pelvis there are two pouches: recto-uterine, *excavatio rectouterina* (pouch of Douglas), and vesico-uterine, *excavatio vesicouterina*. They are between the corresponding organs. The pouch of Douglas has especially important clinical value; if the uterine tube ruptures in ectopic pregnancy, the blood accumulates here. In this case the puncture of Douglas pouch through the pos-

terior vaginal fornix is performed for diagnostic reasons. The purulent diseases in the pouches of the lesser pelvis may lead to the formation of inflammatory focuses giving the clinical presentation of the pelvic peritonitis.

## 2.17. Development of Digestive Organs

The most digestive organs have a single origin, i.e. are developed from a common source. This source is the embryonic, or primitive, gut. It is formed by two embryonic layers: ectoderm and visceral mesoderm.

Further the endoderm (inner embryonic layer) gives the origin to the digestive glands and epithelium of the mucous membrane of the viscera. All other layers of the alimentay tract (lamina propria and muscularis of the mucous membrane, submucosa and adventitia) are developed from the mesoderm.

The mesothelium is developed from the visceral layer of splanchnotom. The epithelium of the stomatodeum and proctodeum, the dental enamel organ are developed from the ectoderm; the salivary glands, epithelium of the tongue`s mucous membrane are developed from entoderm. Other dental tissues (dentine, pulp, cement, periodontium) are developed from the mesenchyme.

The primitive gut appears very early, already at 4-th week of fetal development. In this period it has an uniform diameter; it is closed by the pharyngeal and cloacal membranes from both ends, and its length does not exceed the size of the body. The embryonic gut widely communicates with yolk sac by means of yolk stalk (also known as omphaloenteric duct, *ductus omphaloentericus*). The gut protrudes as diverticula into the rostral (cranial) and caudal ends of embryo.

The cranial diverticulum is divided into cephalic, or pharyngeal, gut and the foregut. They are separated by the entodermal diverticulum of future respiratory organs, trachea and lungs. The deep parts of the oral cavity and the pharynx are developed from the pharyngeal gut. The oesophagus is developed from the foregut. The part of the embryonic gut, which widely communicates with the yolk stalk, is named the midgut. It gives rise to the stomach, small intestine, liver, pancreas and the most part of the large intestine. The caudal diverticulum is called the hindgut, which develops into the rest of the large intestine.

The parts of the embryonic gut and the organs, developing from it, are given in the table 2.

*Table 2*

**Development of Digestive Organs**

| **Embryonic gut** | | | |
|---|---|---|---|
| Cephalic (pharyngeal) gut | Caudal gut | | |
| Deep parts of oral cavity<br>Pharynx | Foregut | Midgut | Hindgut |
| | Oesophagus | Stomach<br>Small intestine<br>Liver<br>Pancreas<br>Large intestine ($^2/_3$) | Large intestine ($^1/_3$) |

The development of the face and associated anomalies, the development of the peritoneum and of the digestive organs and their developmental anomalies are the most essential problems regarded clinically.

## 2.18. Development of Face

By the end of the forth week in the cranial end of the embryo a depression of the ectoderm appears; it reaches the cranial diverticulum of the embryonic gut. This depression is the stomatodeum. The stomatodeum is separated from the cavity of the pharyngeal gut by the double-layered septum called the pharyngeal membrane. It disappears during the fifth week, and a communication is established between the stomatodeum and the pharyngeal gut. The pharyngeal gut develops into the oral cavity: the entoderm gives rise to the epithelium of the tongue and to the salivary glands; the mesenchyme of the branchial arches gives rise to the muscles of the tongue and dental pulp; the ectoderm of the stomatodeum gives rise to the epithelium of the oral cavity`s walls.

In the same period the branchial arches are formed. This occurs as follows. The ectoderm on the cranial end of the embryo forms the depressions known as the branchial clefts. Five pairs of the branchial clefts appear in the human embryo. Towards the clefts the entoderm of the cranial (pharyngeal) gut protrudes as the branchial sacculi which reach the ectoderm. Thus, the branchial membranes, made up of the ectoderm and entoderm, are formed. In fishes the membranes break down to form the 'true' branchial clefts. In humans the branchial membranes do not rupture in normal. If the development fails and the branchial membranes are ruptured, the born child will have a congenital branchial fistula of the neck, *fistula colli congenita*.

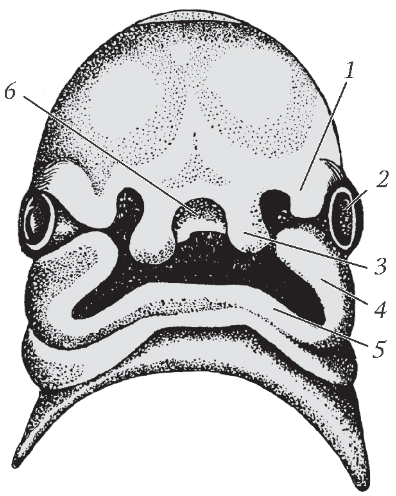


Fig. 2.48. Head of human embryo. 5 weeks (anterior aspect):

*1* — lateral nasal prominence; *2* — optic rudiment; *3* — middle nasal prominence; *4* — maxillary prominence; *5* — mandibular prominence; *6* — area infranasalis

The major element of the face development is the I branchial arch. It is also named the mandibular arch. In the process of the development it bifurcates into paired maxillary and mandibular prominences, which limit the opening of the stomatodeum from the lateral sides. Superiorly the stomatodeum is bounded by the frontal prominence, formed due to the development of the cerebral vesicle.

In the process of further development during the fifth week the paired elevations appear on the frontal prominence; they are termed the nasal prominences. Two of them lie closer to the midline (these are the medial nasal prominences), the other are situated lateral to the previous and called the lateral nasal prominences. Thus, now the opening of the stomatodeum is limited superiorly by an unpaired frontal prominence, lying along the midline and by the paired medial and lateral nasal prominences, lying on each side of the frontal prominence; laterally by the paired maxillary prominences; inferiorly by the mandibular prominences (fig. 2.48).

Further, at the 7—8-th week of the fetal life the medial nasal prominences grow intensively (fig. 2.49). They are drawn together and then are fused along the midline, covering the frontal prominence. The medial nasal prominences wedge between the maxillary prominences growing towards each other, and then they are fused with them. Besides, the mandibular prominences are fused to form the mandibular acrh. Further the maxillary and mandibular prominences merge together, that limits the sizes of the future oral fissure and forms the angles of mouth.

The medial and lateral nasal prominences create the external nose, and between them the nostrils are formed. On the side of the lateral nasal prominences the rudiment of the visual organ appears. By the fusion of the lateral nasal prominences with the maxillary prominences the nasolacrimal duct is formed.

In this periord the stomatodeum is limited superiorly by the fused medial nasal prominences; laterally by the fused maxillary and mandibular prominences; inferiorly by the arch which is formed by the fusion of the mandibular prominences.

The creation of the face consists of the merger of the prominences surrounding the stomatodeum.

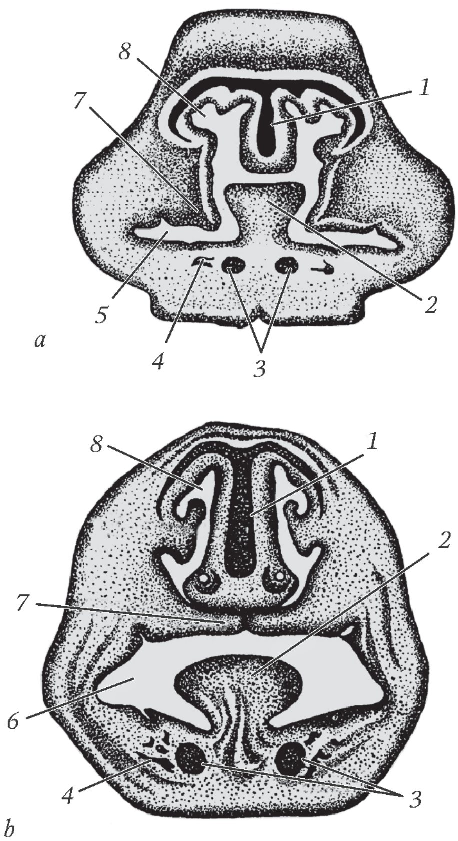


Fig. 2.49. Head of human embryo (frontal section):
*a* — 7 weeks; *b* — 8 weeks;
*1* — nasal septum; *2* — tongue; *3* — Meckel`s cartilage; *4* — rudiment of mandible; *5* — primary oral cavity; *6* — secondary oral cavity; *7* — palatine processes; *8* — nasal cavity

1. The paired mandibullar prominences fusing along the midline form the lower jaw and corresponding part of the face, including the lower lip.
2. The maxillary prominences form the major part of the upper jaw and the lateral part of the upper lip.
3. The medial nasal prominences form the dorsum of the nose, nasal septum and the middle part of the upper lip.
4. The fused maxillary and mandibular prominences form the angles of mouth.
5. During the 7-th week the stomatodeum is divided into two floors: future oral and nasal cavities. Also the formation of the palate occurs. The palate is formed by the merger of the palatine processes passing from the internal aspect of the maxillary prominences. They are complited by the horizontal plates of the palatine bones.

The impairment of these processes (they occur during 1st-2d months of pregnancy) leads to the different anomalies of the facial development.

## 2.19. Developmental Anomalies of Face

Most often developmental anomaly of face is a cleft lip, *labium leporinum seu cheilochisis*. This is the lateral fissure cutting the upper lip where the medial nasal prominence is fused with the maxillary prominences. The cleft lip may be incomplete, cutting only the red part of lips, skin, mucous membrane and muscle. But this kind is obsereved rarely. Most commonly the complete cleft is observed. In this case the cleft cuts not only lip but also the maxilla`s alveolar process. The cleft lip may be unilateral or bilateral.

If the fusion of the lateral nasal prominences with the maxillary prominences is disordered, the oblique facial fissure occurs; it is called the cloloboma. This is severe defect which damages the deep structures of the face; frequently it is incompatible with life.

During the formation of the oral fissure the macrostomia and microstomia may occur. ***Macrostomia*** is a great increase of the oral opening because the maxillary and mandibular prominences are not fused together. In ***microstomia*** these prominences are fused excessively, and the oral opening becomes extremelly small.

One of the severe defets is a cleft palate, *palatum fissum seu faux lupina*. It occurs if the maxillary prominences are not fused. The severity of this defect may be different: it may separate the hard and soft palate completely or may cut only soft palate or just uvula. If an infant has such a hole in the palate, the food or milk come from the oral cavity to the nasal cavity that may cause the aspiration pneumonia. In the past, an infant having this defect died. Currently, such defects are successfully treated with plastic surgery. To liquidate the cleft palate in the early stages the palatal obturators are used. These are the prothesis making the imitation septum and stimulating the growth of the maxilla`s palatine processes. The surgical treatment is used only when the processes of the facial skull formation finish.

Besides the abnormalities of the face, it is important to describe the most often anomalies of the dental occlusion.

Anomalies of Dental Occlusion

1. Stegodontia, *stegodontia*. The upper incisors significantly protrude forward and cover the lower incisors.
2. Hiatodontia, *hiatodontia*. The incisal margins of the upper teeth do not touch the incisal margins of the lower teeth (opened occlusion).
3. Progenia, *progenia*. The lower incisors significantly protrude forward.

## 2.20. Development of Peritoneum

To understand the arrangement of the peritoneum: its relationships with the organs, the position of the peritoneal ligaments and the structure of the peritoneal cavity, you need to know the development of the peritoneum.

The peritoneum is developed from the middle embryonic layer, mesoderm. At the earliest stages of development on either side of the gut tube the ventral (non-segmented) part of the mesoderm is situated; it is called the splanchnotom. It includes the cavity bounded by the medial and lateral plates and named the coelom. The lateral plate gives rise to the peritoneal peritoneum; the medial one develops into the visceral peritoneum. The mesoderm of the gut tube transforms into the muscular coat, connective-tissue layer and mesothelium; the epithelium of the mucous membrane and glandular structures are developed from the entoderm.

To understand the abnormalities of the development, let`s consider the peritoneal development in stages (fig. 2.50, 2.51).

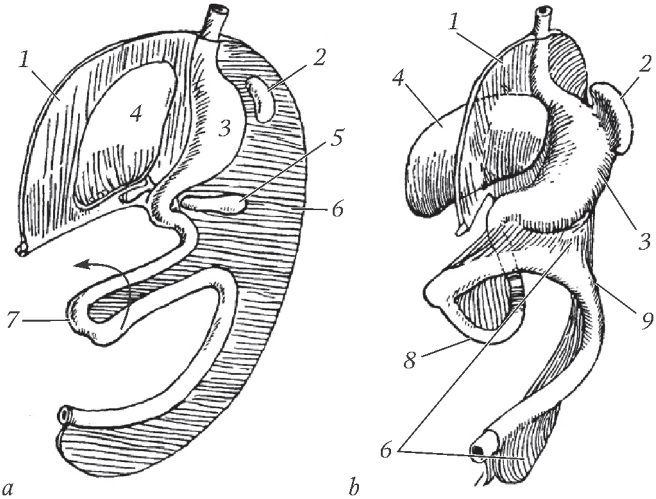


Fig. 2.50. Scheme of the development of the stomach, intestine and mesentery:

*a* — 7 weeks (left lateral aspect); *b* — 8 weeks (left anterolateral aspect); *1* — ventral mesentery; *2* — spleen; *3* — stomach; *4* — liver; *5* — pancreas; *6* — dorsal mesentery; *7* — intestine; *8* — small intestine; *9* — large intestine

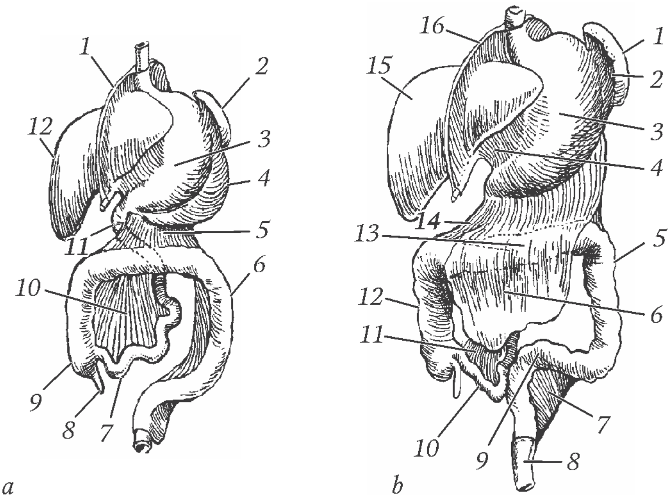


Fig. 2.51. Scheme of the development of the peritoneum and intestine (anterior aspect):

*a* — 16 weeks: *1* — ventral mesentery; *2* — spleen; *3* — stomach; *4* — dorsal mesentery; *5* — transverse mesocolon; *6* — large intestine; *7* — ileum; *8* — vermiform appendix; *9* — caecum; *10* — mesentery; *11* — duodenum; *12* — liver;

*b* — 20 weeks: *1* — spleen; *2* — gastrosplenic ligament; *3* — stomach; *4* — lesser omentum; *5* — descending colon; *6* — greater omentum; *7* — sigmoid mesocolon; *8* — rectum; *9* — sigmoid colon; *10* — ileum; *11* — mesentery; *12* — ascending colon; *13* — transverse colon; *14* — transverse mesocolon; *15* — liver; *16* — falciform ligament of liver

I stage. The 4th week of the embryonic development. The length of the embryonic gut is equal to the body length. The embryonic gut extends as a straight tube from the rostral to caudal end of embryo in the median plane. The medial plates of the splanchnotom, drawing together and enveloping the gut tube, form the dorsal and ventral mesenteries. In this stage the ventral mesentery is present only from the rostral end to the level of umbilicus; below umbilicus it has been already reduced.

II stage. The 5—6th weeks of the embryonic development. The gut tube starts to differentiate. Firstly, in the area of the stomach the fusiform expansion appears. At the same time the dorsal gastric mesentery (in the region of the greater curvature) intensively grows. The omental bursa starts to form.

The epithelial lining of the commencement of the midgut gives rise to the rudiments of the pancreas. One of them protrudes between the layers of the dorsal mesentery, the other — between the layers of the ventral mesentery.

Besides, the rudiment of the liver protrudes in the ventral wall. It grows very rapidly and displaces the rudiment of the pancreas to the dorsal surface. In the mesenchym of the dorsal mesentery the rudiment of the spleen appears.

III stage. The 7th week of the embryonic development. The caudal end of the foregut, which has been expanded in the area of the stomach, perfoms rotations: around the vertical axis from the left to the right (as a result the right wall becomes the posterior wall, and the left wall becomes the anterior wall); around the sagittal axis from down to up (as a result the lesser curvature is directed above, greater curvature is directed below; the duodenum is to the right of the future vertebral column). Respectively the ventral mesentery of the stomach and of the duodenum is also directed above, while the dorsal mesentery is directed below, i. e. the mesenteries pass from the sagittal to the frontal planes. Due to the rotations of the mesentery the liver, developing in it, also deviates upward. The sizes of the liver continue to increase rapidly. Moving apart the layers of the ventral mesentery, the superior surface of the liver adjoins the diaphragm and is fused with it, and the peritoneum covers the superior and inferior surfaces of the liver. The ligaments, extending from the lesser gastric curvature and duodenum to the liver and further prolongating to the diaphragm and the anterior abdominal wall (hepatogastric, heaptoduodenal, coronary, triangular), are derivatives of the ventral mesentery. The rotation of the stomach around the longitudinal axis (from the left to the right) leads to the fact that its left wall becomes anterior, and the right wall becomes posterior. The lower part of the oesophagus also rotates.

IV stage. The 12th week of the embryonic development. The gut tube intensively grows, resulting in the formation of the loop, facing by its convexity forward and down. The loop has two segments: descending (jejunoileal, or cranial) and ascending (ileocolic, or caudal). The commencement of the ascending segment has a thickening corresponding to the caecum.

During 13th week the ascending segment rises and makes a turn, covering the descending segment and duodenum. The thickening, corresponding to the caecum, is under the liver. The colon takes the transverse postion. The yolk stalk is reduced. Already in this period the dorsal mesentery in the area of the duodenum and descending colon is reduced.

V stage. After 16th week of the fetal development. This stage is characterized by the intensive growth of the certain parts of the gut tube. Such a growth is observed mainly

in three places:

1) in the region of the future small intestine, below the decussation with the ascending segment, approximate 7 loops of the mesenteric part of the small intestine are formed;

2) the descent of the caecum and the formation of the ascending colon, the reduction of the mesentery of the ascending colon and its fusion with the abdominal wall. Descending to the right inguinal fossa, the caecum becomes disproportionately long. Further, its terminal part does not increase in diameter and remains in rudimentary state. This part of the caecum corresponds to the future vermiform process;

3) the part of the ascending segment in the area of the sigmoid colon.

## 2.21. Developmental Anomalies of Digestive Organs

In the process of organogenesis the different variations (anomalies) in development may occur, which do not lead to the functional disorders after the birth and need not the surgical treatment. More rarely the developmental defects are observed, which are manifested immediately after the birth by the functional disorders, sometimes incompatible with life of a newborn therefore, to liquidate them the surgical treatment is used.

1. Malformations of oesophagus. More often the oesophageotracheal fistulae occur. They appear as a result of an incomplete separation of the gut tube and trachea. Three main variants of this defect exist: narrow and long fistula, short and wide fistula and common oesophageotracheal wall. As usual the fistula is at the level of the VII cervical and the I thoracic vertebrae, i.e. where the rudiments of the respiratory organs appear, at the junction between the pharyngeal gut and the foregut. The presence of the fistula is accompanied by the aspiration of the food and liquid into the respiratory tract that leads to aspiration pneumonia. More rarely aplasia and atresia of the oesophagus are observed. Aplasia is a full or partial absence of the oesophagus. Atresia is a partial or full (on all extent) obliteration of the oesophagus, when instead of the tube the fibromuscular cord is formed.

2. Meckel`s diverticulum, or ileal diverticulum. It is a remnant of the omphaloenteric duct, which arises from the embryonic gut cranial to the future caecum and passes to the yolk sac. In normal during the first week of the embryonic development it obliterates and atrophies. But if it closure does not occur, it remains as a digitate bulge directing from the intestine to the anterior abdominal wall. Usually its length is 50—70 cm from the ileocaecal angle. The coils of the small intestine may twine around the diverticulum and cause the intestinal volvulus. Sometimes it does not manifistate during life and is observed in posthumous dissection.

3. Common dorsal mesentery, *mesenterium commune dorsale*. On all extent the embryonic gut has a common dorsal mesentery until 2d months of the embryonic development. In dogs and cats it remains throughout life because the ascending segment of the gut tube does not rotate. In humans the mesentery in the region of the duodenum, ascending and descending colon is reduced. This occurs in humans because of the vertical body position to limit the mobility of the intestine. In animals the abdominal wall is not anterior but inferior therefore, the viscera are not so mobile. The common dorsal mesentery, remaining in humans, may cause the intestinal volvulus which may lead to the intestinal obstruction.

4. Two extreme positions of the caecum: subhepatic and pelvic. The rotation of the ascending segment of the gut loop leads to the fact that the caecal dilatation lies in the right hypochondriac region near the liver. Further, the caecal dilatation descends. If this process decelerates, the caecum and vermiform appendix may be situated near the liver. In this case, if the appendix is inflamed, it is difficult to make a correct diagnosis because the doctors first think about the inflammation of the gallbladder. If the caecum grows too rapidly, the caecum with the vermiform process descends into the cavity of the lesser pelvis. In this case to make the diagnosis of appendicitis in females the doctors have to differentiate it with the inflammation of the ovaries.

5. Two extreme forms of the vermiform appendix: very long (the cases of 20—25 cm long have been described) and its full absence.

6. Two extreme forms of the length of the sigmoid mesocolon: megamesosigma and micromesosigma (or its full absence).

7. Two extreme forms of the jejunoileal loop of the small intestine: too short and too long. In the first case the absorption of nutrients is decreased, and a person, even having a normal nutrition, remains very thin. If the small intestine is too long, there is a tendency to overweight.

8. The rudiments of the pancreas are not fused. The cases have been described, when besides the main pancreas, located retroperitoneally, the lobules between the layers of the ventral mesentery or immediately in the wall of the stomach are observed.

9. Inverse position of the viscera (abdominal or total), *situs viscerum inversus abdominalis seu situs viscerum inversus totalis*. This anomaly is rare. It occurs owing to the rotation of the gut tube not from the left to right but in opposite direction. As a result all the digestive organs are mirror. As usual the function of the organs is not disturbed, but in pathology it is difficult to make a correct diagnosis.

10. The absence or narrowing of the anus. This defect needs the surgical treatment immediately after the birth. During operation the surgeons preserve or create the sphincters of the rectum.

## TEST QUESTIONS

1. Give the definition of the peritoneum. What layers of the peritoneum do you know? Describe the function of the parietal and visceral peritoneum.

2. Give the definition of the abdominal and peritoneal cavities. What are the differences between them?

3. Describe the derivatives of the peritoneum.

4. Where are the retroperitoneal, anteperitoneal, retropubic, retroinguinal and subperitoneal spaces located? Describe their walls.

5. What types of the organs relatively to the peritoneum are distinguished?

6. What are the differences between the extra-, meso- and intraperitoneal organs? Which of them have a mesentery? Which of them are mobile? Name the organs which belong to each of these groups. Describe the specific relation of the ovaries to the peritoneum.

7. Name the derivatives of the peritoneum. What types of the ligaments are distinguished?

8. What is the root of the mesentery? Describe the position and attachment of the roots of the transverse mesocolon, of the jejunum and ileum mesentery, of the sigmoid mesocolon, of the mesorectum, of the mesoappendix.

9. What is the omentum? Give the definition of the greater and lesser omentum. Describe their components, functions and localization.

10. Describe the umbilical folds of the anterior abdominal wall. Describe the content of each of these folds. What fossae are formed between these folds? Describe the relations of the fossae to the rings of the inguinal canal.

11. What storeys are distinguished in the peritoneal cavity? Describe their borders.

12. Describe the upper storey: what organs, ligaments and bursae are located here?

13. Describe the walls of the hepatic, omental and pregastric bursae. Describe the relations between them and their communications. Describe the borders of the epiploic foramen and omental vestibule.

14. What is the clinical importance of the bursae and of their communications?

15. Describe the lower storey: what organs, mesenteries, ligaments, recesses, canals and sinuses are located here?

16. Describe the borders of the right and left mesenteric sinuses. Describe their communications.

17. Describe the borders of the right and left paracolic canals and their communications.

18. Describe the borders of the superior and inferior duodenal recesses. What is their clinical importance?

19. What is the Treitz ligament? What is its clinical importance?

20. Describe the borders of the superior and inferior ileocaecal, and retrocaecal recesses. What is their clinical importance?

21. Describe the borders of the intersigmoid recesses. What is its clinical importance?

22. Describe the differences between the male and female lower storey.

23. Give the definition of the rectouterine and vesicouterine recesses, and of the rectovesical recess. What is the Douglas pouch? Describe its clinical importance.

24. Describe the development of digestive organs.

25. Describe the development of the face.

26. What developmental anomalies of the face do you know?

27. Describe the development of the peritoneum in stages.

28. What developmental anomalies of the digestive organs do you know?

## CLINICOANATOMICAL PROBLEMS

1. When performing an appendectomy a doctor found a gangrenous appendix. Into which recesses and pouches can the pus spread in the case of the perforation of a gangrenous appendix?

2. A patient needs an operation on the kidney. Is it possible to perform this operation without entering into the peritoneal cavity?

3. A surgeon has to sew the perforated ulcer situated on the posterior gastric wall. How can a doctor approach this wall to make sutures?

*Учебное пособие*

# DIGESTIVE SYSTEM
# ПИЩЕВАРИТЕЛЬНАЯ СИСТЕМА

**The manual for medical students**

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