



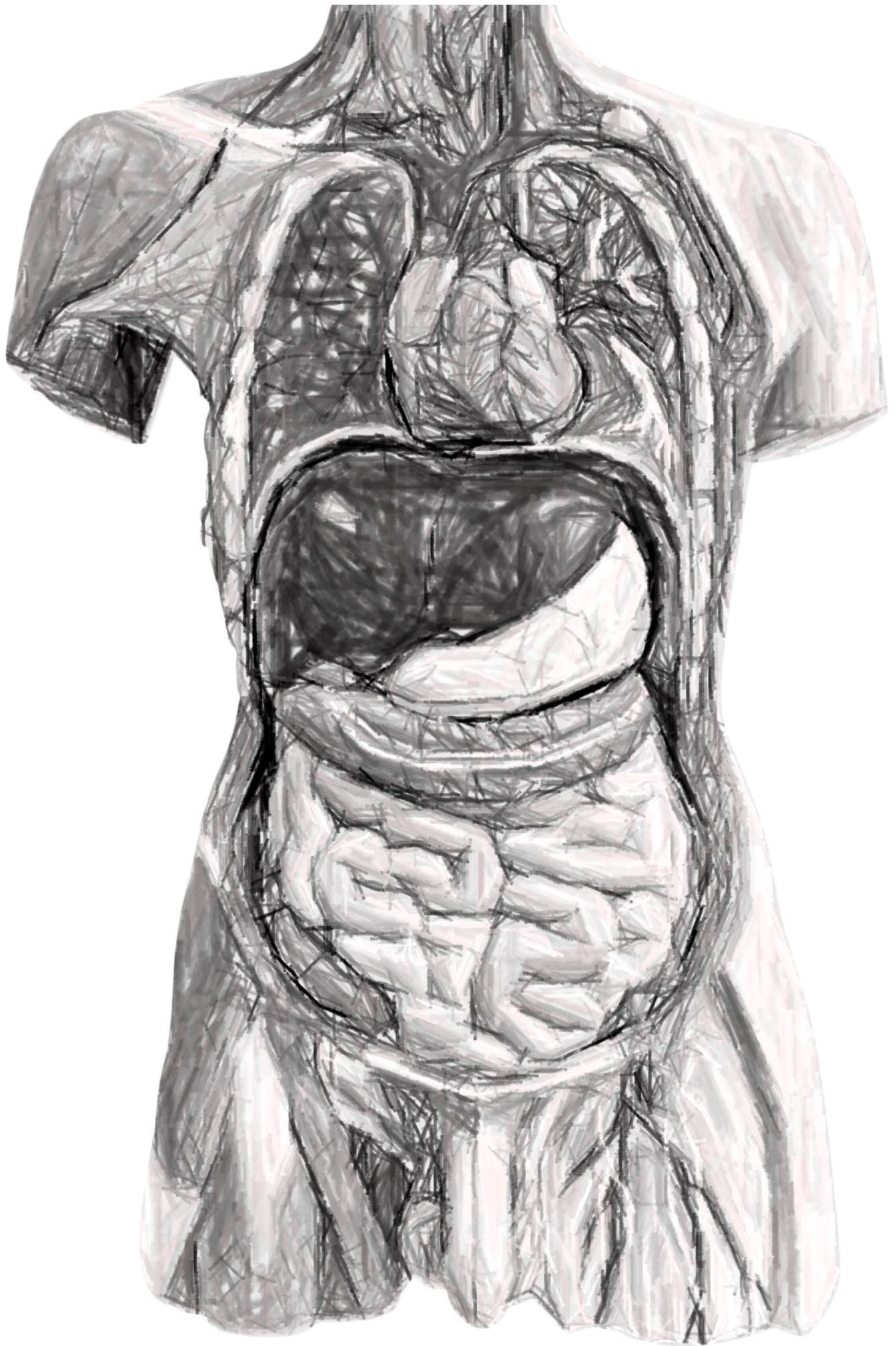
**Comenius University in Bratislava
Jessenius Faculty of Medicine in Martin
Department of Anatomy**



ANATOMY OF THE ALIMENTARY SYSTEM

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PREFACE

This textbook has been prepared for pre-graduate medical students as educational material. It focuses on the theoretical basis of the anatomy of the alimentary system but is also supplemented with relevant clinical correlations.

The material is arranged into 12 chapters. The first two chapters deal with the structures of the oral cavity, including the teeth, salivary glands and tongue. Subsequent chapters focus in turn on the different parts of the alimentary canal from the pharynx to the rectum. Separate chapters focus on accessory organs such as the liver, gallbladder and pancreas, and finally on the peritoneum. The last chapter contains a set of review questions that, allow you to check your knowledge.

The individual organs are described in terms of their location, external description, their relationship to neighbouring structures and their vascular supply, lymphatic drainage and innervation are also described in detail. A partial description of the internal structures is also given, but more in terms of macroscopic anatomy.

For better understanding and imagination, the text section is supplemented with schematic figures, photographs of formalin-fixed cadaveric specimens and summary tables. Although the textbook contains many illustrations, it is necessary to combine study with the use of anatomical atlases.

Photographs of formalin-fixed specimens were obtained during dissection exercises in the Department of Anatomy, Jessenius Faculty of Medicine in Martin, Comenius University Bratislava. Thanks are due to all the teachers of the Department of Anatomy who participated in the dissection exercises and guided the students professionally.

We hope you will find this textbook useful for individual study and review of anatomy.

Authors

INTRODUCTION TO THE ALIMENTARY SYSTEM

The alimentary system (also called the gastrointestinal tract) is composed of:

- series of hollow organs that are responsible for processing food and converting it into energy and essential nutrients to nourish the entire body – swallowing food, secreting fluids and digestive enzymes, mixing and moving food, absorbing nutrients, and excreting remaining waste (feces). The organs are connected in a long, twisting tube from the oral cavity to the anus – **oral cavity (mouth), pharynx, esophagus, stomach, small and large intestine, rectum and anal canal**;
- accessory organs that help the body digest food, but food does not pass through them – **salivary glands, liver, pancreas and gallbladder**. In the broader context of this function, we also include here **teeth and tongue**, which are part of the oral cavity.

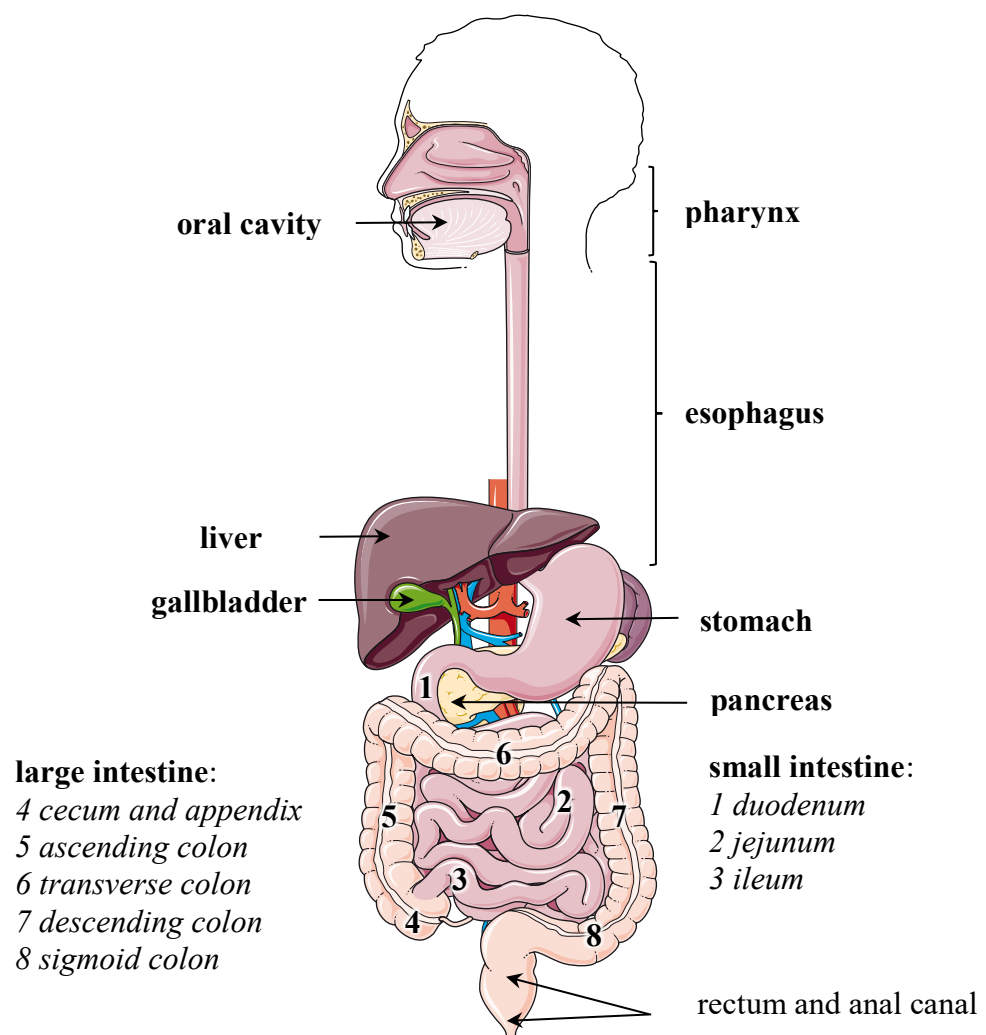


Fig. 1
Organs of the alimentary system

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1 ORAL CAVITY (Cavitas oris in Latin)

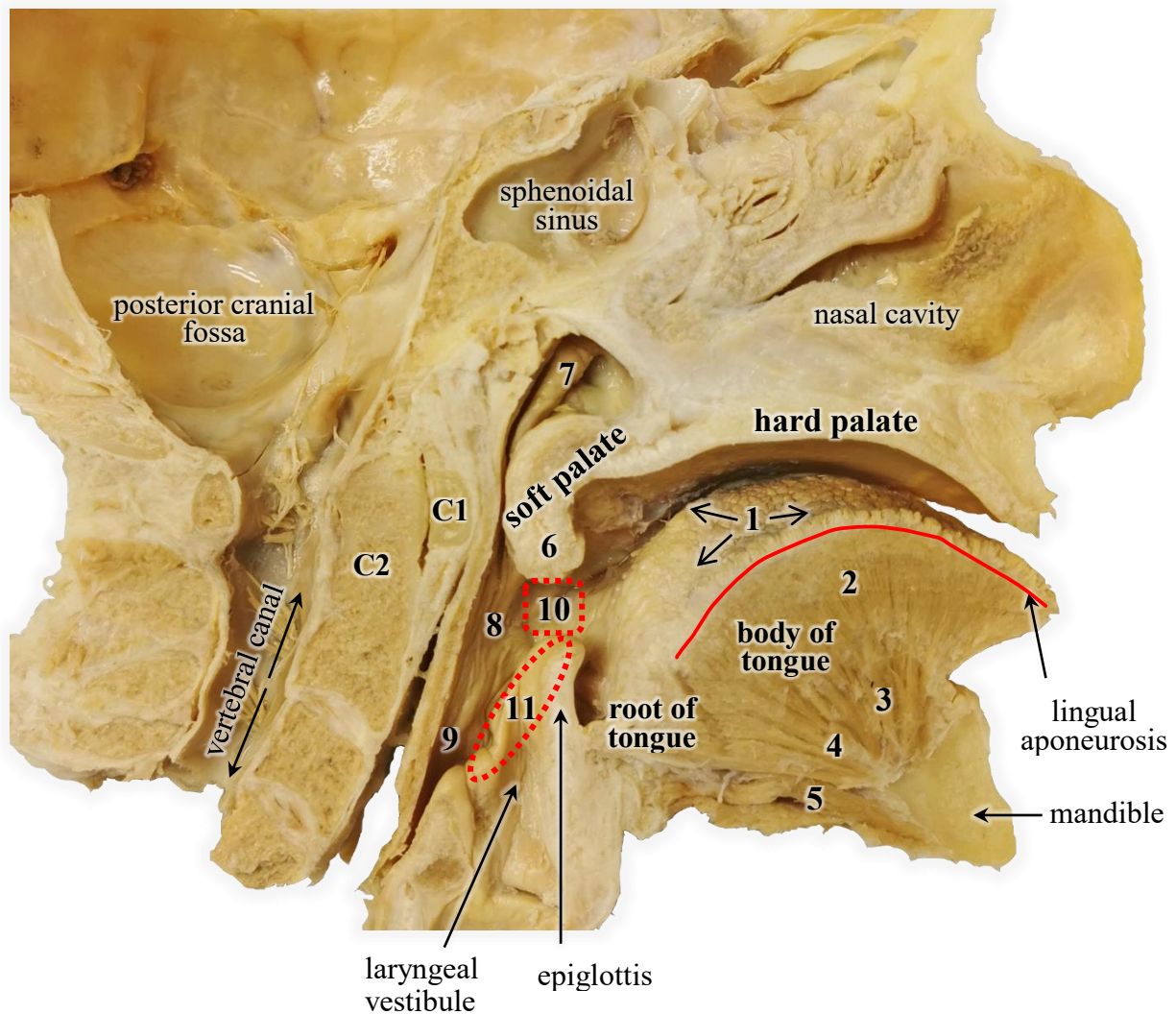
The oral cavity, better known as the mouth, represents the beginning of the alimentary system. Its primary function is the initiation of mechanical and chemical digestion processes. It also serves as a secondary respiratory conduit and has an important function for sound modification for the production of speech.

The oral cavity is bordered by the lips ventrally and by the cheeks laterally. Its roof is formed by the hard and soft palate that separates it from the nasal cavity. The flexible floor is formed by the muscular diaphragm and is occupied mainly by the tongue. It also includes the teeth, gingiva (gum), tongue, salivary glands and palatine tonsils. The oral cavity communicates with the exterior through the anterior opening between lips, the **oral fissure**. Posteriorly it communicates with the oral part of the pharynx through the **oropharyngeal isthmus (isthmus of fauces)**.

The oral cavity consists of an outer, smaller portion, the oral vestibule and an inner, larger portion, the oral cavity proper. These two parts are separated by the teeth and alveolar processes of the upper and lower jaws, which are covered by the gums. When the teeth are clenched, the vestibule communicates with the oral cavity proper through the retromolar space (space behind the third molar tooth) on either side and through the gaps between the teeth.

The spaces behind the molars provide access for the administration of nutrients to a patient who has a temporarily immobilized mandible due to a fracture.

- **Oral vestibule** is a narrow slit-like space between the lips and cheeks externally and upper and lower dental arches with the gums internally. Superiorly and inferiorly, it is limited by the groove, the **superior** and **inferior vestibular fornix** (Fig. 3 and 5), where the labial and buccal mucosa turns to become the alveolar mucosa. The **frenulum of the upper and lower lip** (Fig. 3 and 5), is a midline free-edged mucosal fold in the oral vestibule. The frenulum is extended between the gingiva and mucosa of the upper or lower lip. The parotid gland, one of the major salivary glands, empties saliva through the parotid duct into the oral vestibule. The vestibule is also moisturized by several other small minor buccal and labial salivary glands.
- **Oral cavity proper** lies posterior to the oral vestibule. It is bounded anteriorly and laterally by the teeth embedded in the alveolar processes and extends posteriorly to the isthmus of fauces.



- 1 mucous membrane of the tongue with papillae
- 2 intrinsic muscles of the tongue
- 3 genioglossus muscle
- 4 geniohyoid muscle
- 5 mylohyoid muscle
- 6 uvula
- 7 nasal part of the pharynx
- 8 oral part of the pharynx
- 9 laryngeal part of the pharynx
- 10 oropharyngeal isthmus
- 11 laryngeal inlet

Fig. 2

Head with the oral and nasal cavities, pharynx and larynx
Sagittal plane - section of the head with adjacent areas

Formalin-fixed cadaveric specimen, Department of the Anatomy,
 Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

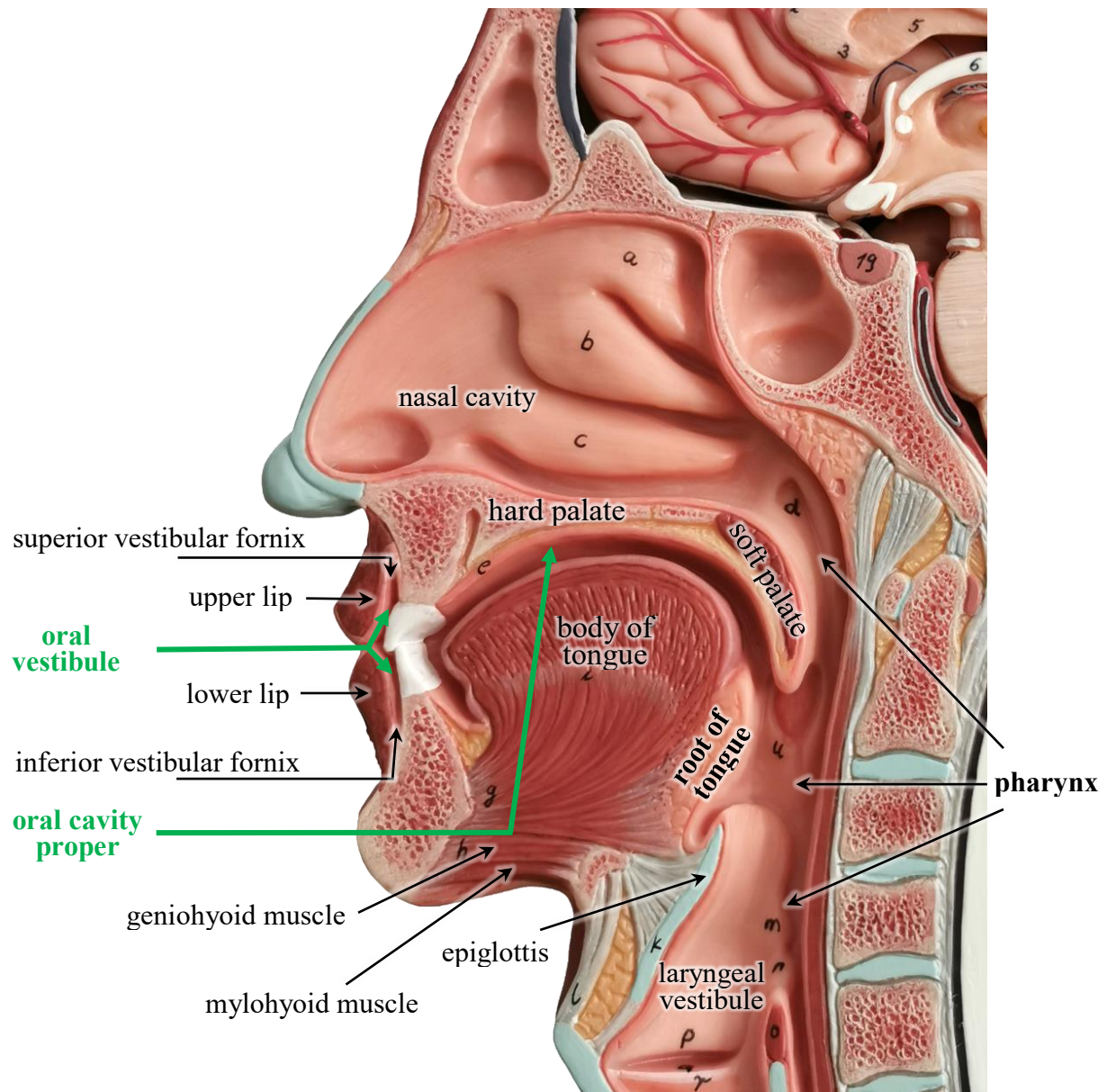


Fig. 3
Oral cavity – oral vestibule and oral cavity proper
Sagittal plane - section of the head with the oral and nasal cavities, pharynx and larynx
 Photography of SOMSO model
 Modified by additional drawing and labeling

1.1 ORAL VESTIBULE (Vestibulum oris in Latin)

1.1.1 LIPS (Labium superius and labium inferius in Latin)

The upper and lower lips are pliable, mobile musculofibrous structures that surround the anterior opening of the mouth, the **oral fissure (oral cleft, rima oris)**. On each side of the lips, the **labial commissure** forms the **angle of the mouth**.

- The **upper lip** extends from the nares of the nose above to the oral fissure below. Laterally it is separated from the cheeks by the **nasolabial sulci**. These grooves pass from the ala of the nose approximately 1 cm lateral to the angle of the mouth. The upper lip has a shallow, vertical groove, the **philtrum**, which extends from the nasal septum to the vermilion border. Philtrum ends below at a small protuberance, the **labial tubercle**.
- The **lower lip** is bordered inferiorly by the **mentolabial sulcus**, which separates it from the chin.

The lips are entirely composed of soft tissue based on the muscles of the facial expression (mainly orbicularis oris muscle), vessels and nerves, superficial and deep compartments of the fat and numerous small labial glands. From the external to internal side, the surface of the lip is comprised of four zones: skin, vermilion border, vermilion and oral mucosa.

- **Skin** of the lips contains sweat and sebaceous glands and hairs (beard in adult men). **Vermilion border** is the sharp line that separates the skin from the vermilion.
- **Vermilion** (red portion of the lip) is the transitional zone on the edge of the lip located between the skin and the inner mucous membrane. The surface of this zone is covered by the skin, which is thinner and has no pigment (that's why it is translucent) and contains a rich vascular network. It has no sweat and sebaceous glands and hairs. The vermilion itself is also often referred to as "lips".
Dilatation of vessels, the thickness of the epithelium, degree of keratinization and amount of melanin pigments cause vermilion to range in color from reddish-pink to brown.
- **Oral mucosa** covers the inner aspect of the lips. In the midline, the mucous membrane of each lip is connected with the vestibular gingiva by the **frenulum**

of the upper lip (it is the most prominent) and the **frenulum of the lower lip**. Labial frenula contain loose connective tissue.

Most of the substance of each lip is based on the **orbicularis oris muscle**. It surrounds the oral fissure from both sides, acts as a sphincter and controls the diameter of the oral fissure. Several other muscles of the facial expression blend into this muscle and they change the shape of the lips.

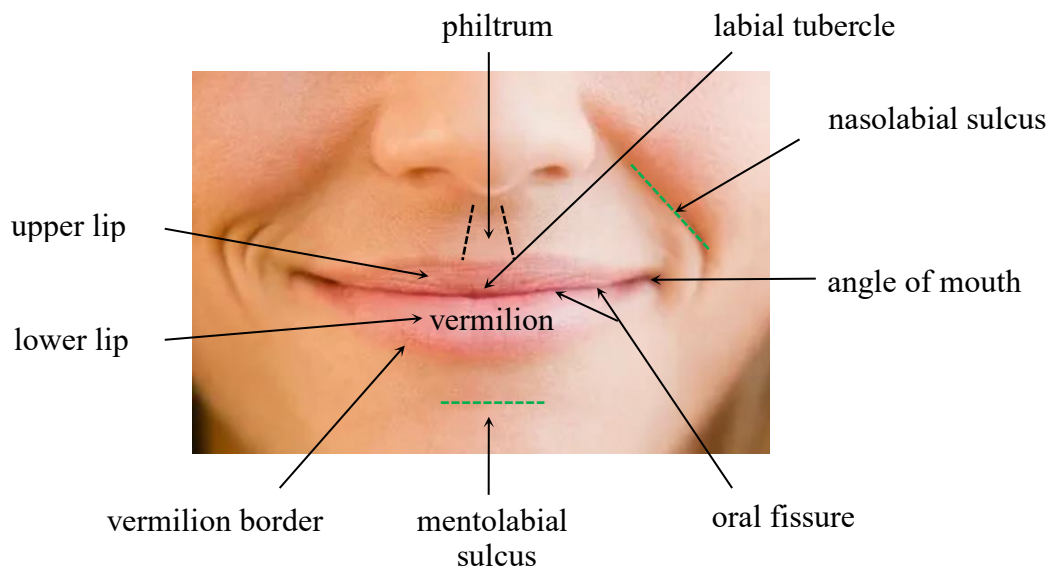


Fig. 4

Anatomy of the lips and adjacent area

Available online at: <https://www.labello.com/labello-magazine/anatomy-of-the-lips-k194?>; 2022

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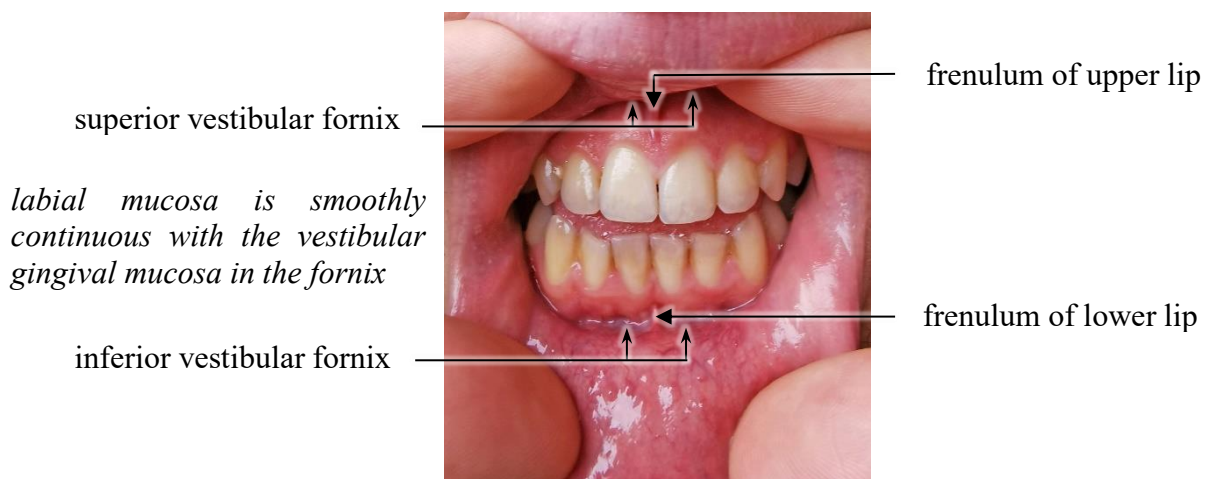


Fig. 5

Oral vestibule, frenula of the lips

Photo from the authors' archive

1.1.1.1 Vessels and nerves of the lips

- **Arterial supply** to the upper and lower lip comes from the superior and inferior labial arteries (both are branches of the facial artery). Superior and inferior labial arteries anastomose with the arteries from the opposite side and form an arterial network around the lips.
- **Venous blood** is drained through the superior and inferior labial veins directly into the ipsilateral facial vein. The facial vein empties into the internal jugular vein.
- **Lymph** from the upper lip and lateral sides of the lower lip drains into the submandibular lymph nodes at the same side and also into the lymph nodes at the contralateral side. The medial portion of the lower lip is drained primarily into the submental lymph nodes.
- **Innervation for muscles** of the facial expression is by the facial nerve [CN VII].
- **General sensory innervation** is carried by the branches of the maxillary (V2) and mandibular nerves (V3) – both are divisions of the trigeminal nerve [CN V]. The upper lip is innervated by the infraorbital nerve (branch of the maxillary nerve) and the lower lip is innervated by the branches of the inferior alveolar nerve (branch of the mandibular nerve).

Infection from the lips spreads rapidly due to their mobility and the abundance of blood and lymphatic vessels.

*The area of the face from the root of the nose to the corners of the mouth, including the upper lip, is sometimes known as the **danger triangle of the face**. The superficial veins of this area have extensive connections with the deep veins of the head and intracranial cavernous sinus. These superficial veins are valveless and therefore there is the possibility of retrograde venous drainage. Infection of this triangle can thus spread to the intracranial cavernous sinus and can result in sinus thrombosis (thrombus is the formation of a blood clot). It can also progress into meningitis or sepsis. Some cranial nerves [CN III, IV, VI and V - V1, V2]* that are closely related to the sinus may also be affected. Practically, this can lead to several clinical symptoms due to the loss of function of these nerves.*

**CN III – oculomotor nerve; CN IV = trochlear nerve; CN VI = abducens nerve;*

CN V – trigeminal nerve and its main divisions: V1 – ophthalmic nerve and V2 – maxillary nerve.

1.1.2 CHEEK (Bucca in Latin)

The cheeks form the lateral movable wall of the oral cavity. Anatomically, the buccal region extends from the zygomatic arch above to the mandible below and from the nasolabial sulcus ventrally to the masseter muscle dorsally. Externally, the cheek is covered by thin richly vascularised skin. Internally, the surface is lined with the mucous membrane, which is firmly connected to the muscles of the face. The buccal mucous membrane is continuous above and below with labial mucosa and gums and dorsally with the mucosa of the soft palate. On the mucous membrane of the cheek, the parotid duct opens through the small orifice, **papilla of the parotid duct**. The submucous tissue contains numerous small buccal glands.

The cheek is formed by the muscles of the facial expression. The principal muscle of the cheek is the **buccinator muscle**. It lies deeper than other muscles of the facial expression and it is separated from them by the buccopharyngeal fascia and buccal fat pad. The buccinator muscle acts to press mucosa of the cheek against the teeth and helps during mastication and deglutination.

Superficial to the buccinator muscle, between buccinator and masseter muscles, there is an encapsulated collection of the fat, the **buccal fat pad** (Bichat's fat pad). It extends dorsally to the inner surface of the mandibular ramus into the infratemporal fossa. It is proportionally much larger in infants. The buccinator muscle and the buccal fat pad are pierced by the parotid duct, which opens into the oral vestibule.

1.1.2.1 Vessels and nerves of the cheek

- **Arterial supply** comes from the facial artery and the transverse facial artery, which arises from the superficial temporal artery.
- **Venous blood** is drained into the facial vein and also through the transverse facial vein into the retromandibular vein.

Another way is drainage into the pterygoid plexus via the deep facial vein. This venous network has numerous connections with the intracranial cavernous sinus and therefore represents a dangerous route for the spread of infection into the intracranium (see veins of the lips).

- **Lymph** drains into the submandibular lymph nodes.

- **Motor nerve supply** to the muscles of the facial expression, including the buccinator muscle, is provided by the facial nerve [CN VII].
- **General sensory innervation** is carried by the branches of the maxillary nerve (V2) and the branches of the mandibular nerve (V3) – both are divisions of the trigeminal nerve [CN V].
- *A brief note: The cheeks are innervated by the buccal nerves. The sensory buccal nerve arises from the mandibular nerve – a division of the trigeminal nerve, and the motor buccal nerve arises from the facial nerve.*

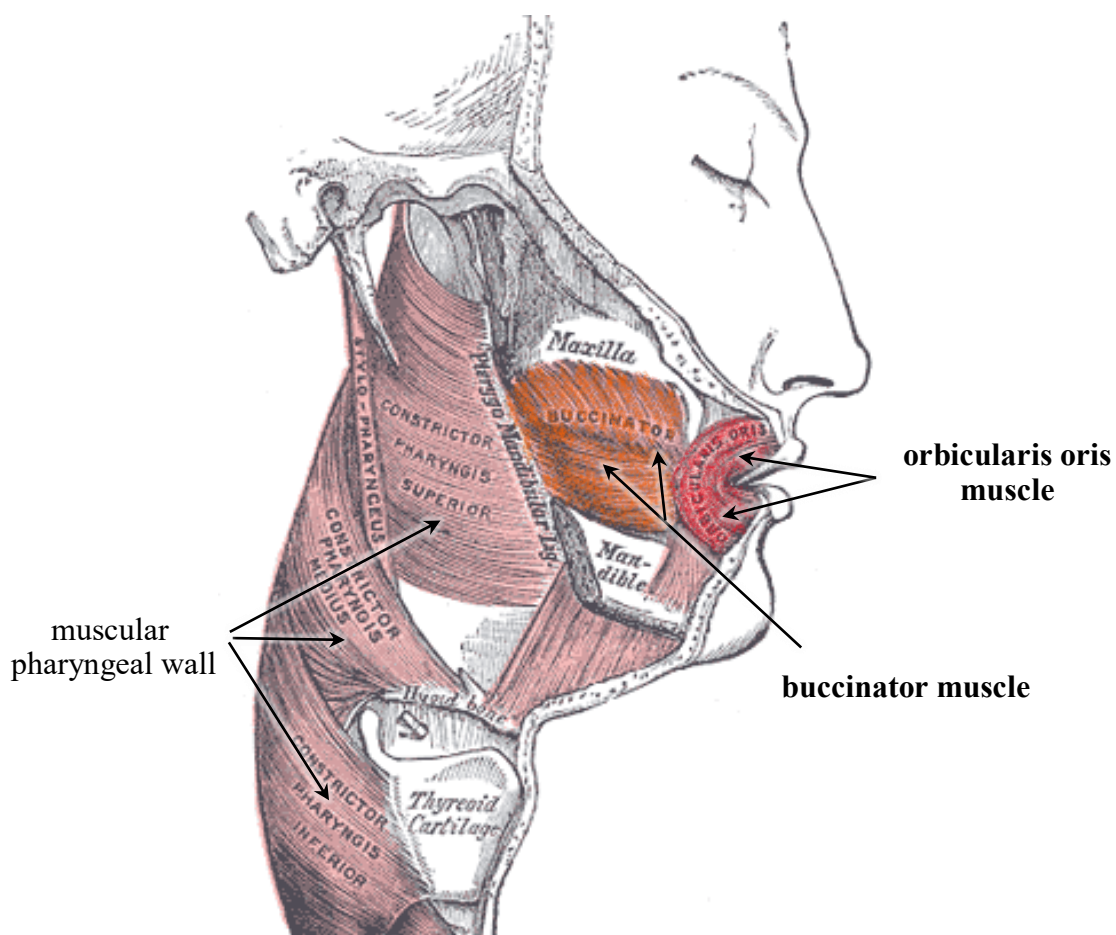


Fig. 6

Muscles of the mouth and cheek: the orbicularis oris and the buccinator muscle

Sagittal plane, right side

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1.1.3 GINGIVA (gum)

The gingiva (also called the gum) is specialized dense fibrous tissue. It is closely connected to the periosteum of the underlying bone. This firm attachment is called the *mucoperiosteum*. Gingiva does not have submucous and elastic tissue or small salivary glands.

The gums cover the alveolar processes of the maxilla and mandible and surround and support the teeth in their position. Thus, they provide the seal around the necks of the teeth in the dental alveoli. The gums protrude around the teeth by a raised edge, the *gingival margin*. The gingival margin surrounds the teeth in a (cuff) collar-like fashion. Between the gingival margin and the tooth, there is a slight *gingival sulcus* (gingival groove) where the gum is fixed to the tooth in a special closure, the *gingivodental junction*. This fixation protects the tooth from infection entering its neck and root area. Between adjacent necks of teeth, the gingiva forms a protrusion, the *gingival papilla (interdental papilla)*.

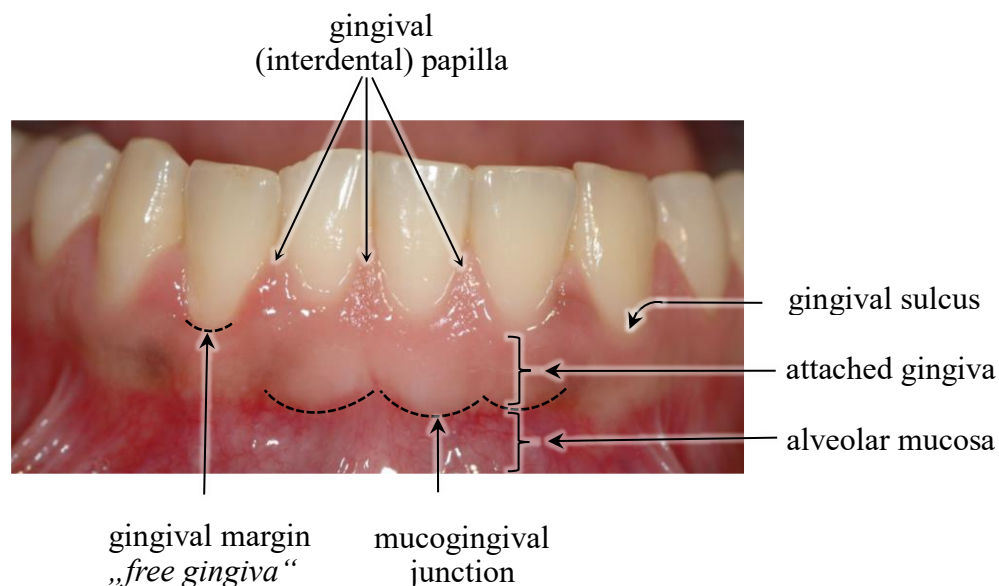


Fig. 7

Oral vestibule and lower jaw, including healthy gingiva and mucosa of the region of the mandible

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https://www.wikiskripta.eu/w/Gingiva#/media/Soubor:Healthy_gingiva.jpg; 2022

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1.1.3.1 Vessels and nerves of the gingiva

- **Arterial supply** comes from the arterial network of the teeth and of the palate for gingiva around the maxilla and from the arteries supplying the floor of the oral cavity for gingiva around the mandible. There are branches of the maxillary artery (posterior superior alveolar artery, infraorbital and inferior alveolar artery), the facial and lingual arteries.
- **Venous blood** is drained independently on the arteries – anteriorly into the facial vein, posteriorly into the pterygoid plexus within the infratemporal fossa. Venous blood from the gingival area of the mandible also drains to the veins of the tongue.
- **Lymph** drains into the submandibular lymph nodes.
- **Innervation** is carried by the branches of the maxillary nerve (V2) for the gingiva, which covers the alveolar process of the maxilla. The branches of the mandibular nerve (V3) supply the gingiva, which covers the alveolar process of the mandible.

The maxillary nerve and mandibular nerve is the division of the trigeminal nerve [CN V].

1.2 ORAL CAVITY PROPER (Cavitas oris propria in Latin)

1.2.1 TEETH (Dentes or in sing. dens in Latin; *odōn* / *odous* in Greek)

The teeth are embedded and fixed in the dental alveoli (tooth sockets) of the alveolar processes of the maxilla and mandible. They are arranged in the upper **maxillary dental arch** and lower **mandibular dental arch**. Each dental arch has 16 permanent teeth or 10 milk teeth. For practical purposes, each arch is further divided into two symmetrical halves. This division creates 2 upper and 2 lower quadrants. In each quadrant, there are a total of 8 permanent teeth or 5 milk teeth.

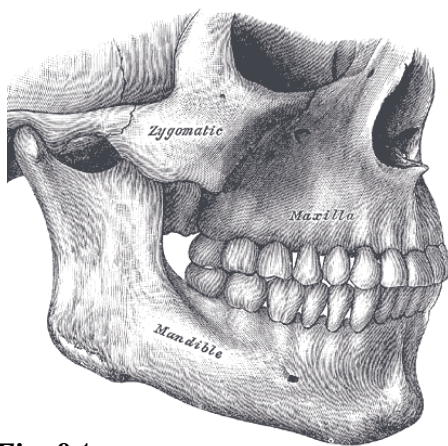


Fig. 8A
Permanent teeth and jaws

Fig. 8A + 8B

Viewed from the right side

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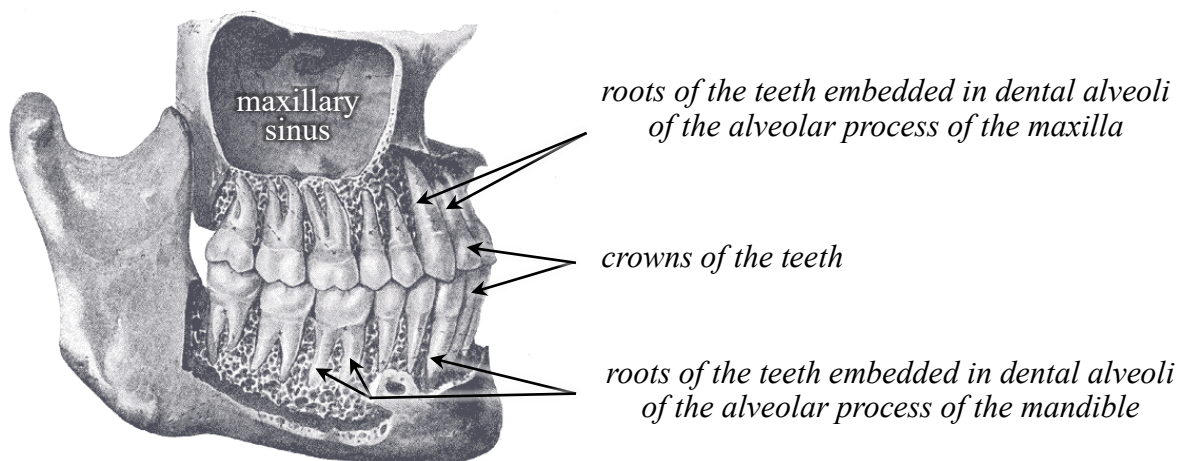


Fig. 8B
Permanent teeth; external layer of the maxilla and mandible has been partly removed and the maxillary sinus has been opened

Human dentition is composed of two sets of teeth during a lifetime.

- The **primary dentition – deciduous teeth:**

It is also called the milk teeth or baby teeth. There are a total of 20 deciduous teeth. Each of the 4 quadrants of the oral cavity contains: 2 incisors, 1 canine and 2 molars. There are no premolars or third molars in the primary dentition.

- The **secondary dentition – permanent teeth:**

There are a total of 32 permanent teeth. Each of the 4 quadrants of the oral cavity contains: 2 incisors, 1 canine, 2 premolars and 3 molars.

Differences between deciduous (milk) and permanent teeth:

There are a total of 20 deciduous teeth. They are less regular, weaker and smaller, but have a larger pulp cavity than the permanent teeth. The root canal is more tortuous and branching. They look whiter with a bluish tinge. The enamel and dentine of deciduous teeth are thinner and less mineralized, so dental caries (tooth decay) progresses more quickly.

1.2.1.1 Basic anatomy of the tooth – dental parts and tissue

- **Dental parts**

Each tooth consists of three parts:

- **Dental crown** projects from the gingiva and is exposed within the oral cavity. It is covered by enamel.
- **Root of the tooth** is anchored by the periodontal ligaments in the dental alveolus and is not exposed to the oral cavity. It is the longest part of the tooth. It is covered by cement. The number of roots in different teeth varies.
- **Neck of the tooth** is a part between the crown and root where the enamel and cement meet at the cementoenamel junction. This part is connected with the gingiva by the gingivodental junction.

Inside each tooth is a chamber, the **pulp cavity** which is filled with the *dental pulp*. The chamber consists of a wider *pulp cavity of the crown* and narrowed one or more *root canal(s)* / *pulp canal(s)*. The end of the root is called the *apex*. It is perforated by the *apical foramen*.

The apical foramen is the opening through which the blood vessels and nerves enter the dental pulp and through which the infection of the pulp may enter the dental alveolus and surrounding soft tissues.

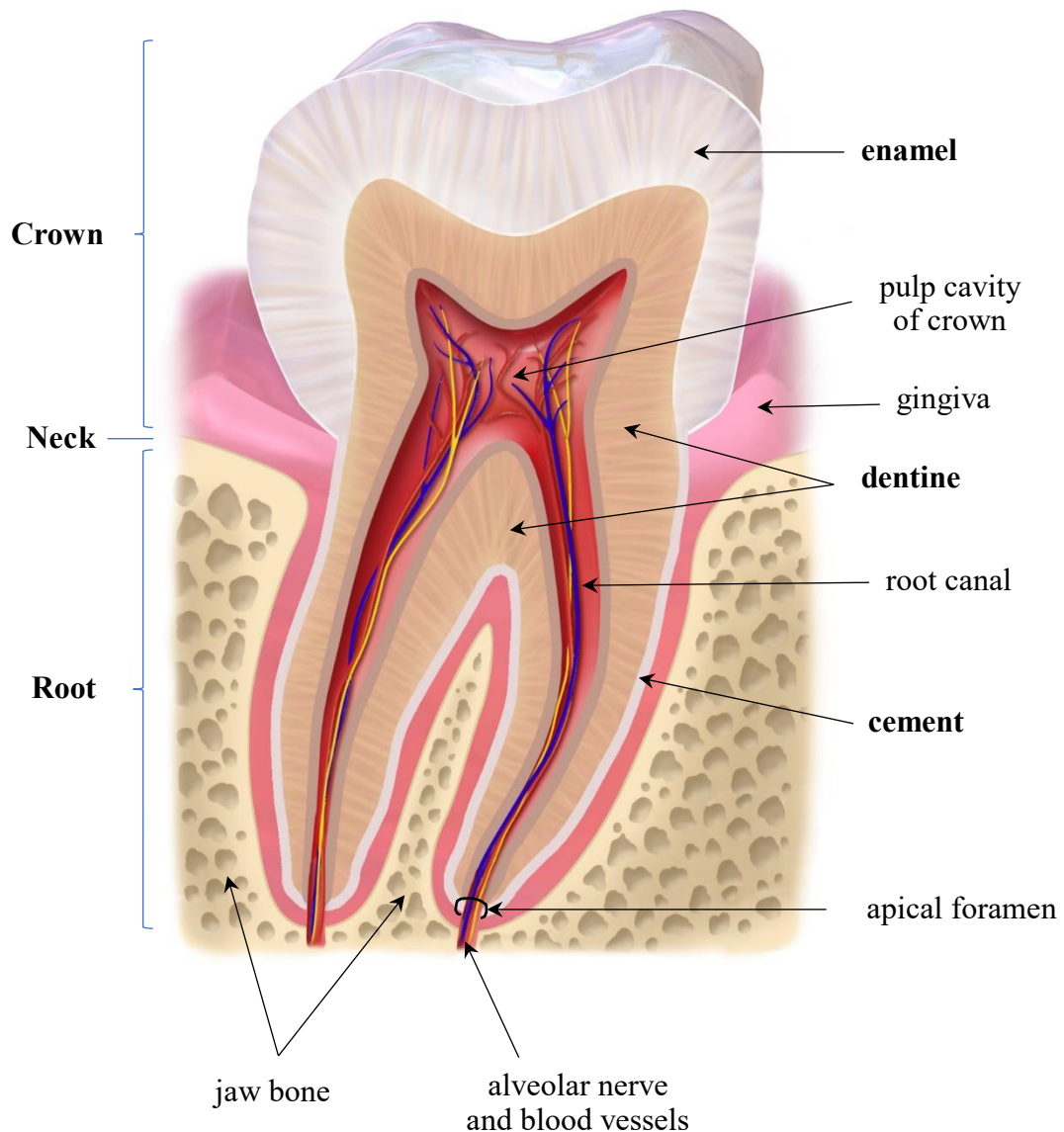


Fig. 9
Cross section of the tooth
Schematic figure

Blausen.com staff (2014). "Medical gallery of Blausen Medical 2014". WikiJournal of Medicine 1 (2). DOI:10.15347/wjm/2014.010. ISSN 2002-4436. Available at: https://en.wikipedia.org/wiki/Tooth_enamel#/media/File:Blausen_0863_ToothAnatomy_02.png
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- **Dental tissue**

The teeth are the hardest substances in the human body. They consist of three calcified tissues – dentine, enamel and cement. The soft tissues of the teeth include the dental pulp and periodontium. These tissues are richly vascularized and have a high level of metabolism and therefore have a good potential for healing.

- **Dentine (dentin)** is the main component of the tooth (in terms of volume, dentine has the largest proportion in the tooth structure). It forms a layer from the dental crown to the root and it underlies both enamel and cement.

Dentine is a vital, innervated but avascular hard tissue. It is penetrated by minute canals, the dental tubules. They connect the underlying pulp cavity to the overlying tissue. Dentine is a modification of the osseous tissue, but unlike it, it does not remodel during life.

Dentine is the layer that surrounds the pulp cavity and plays a key role in transmitting sensations from the outer surface of the teeth to the inside. Due to the extensive innervation of the dental pulp, the exposed dentine is extremely sensitive.

- **Enamel** forms the outermost layer of the crown of the tooth. The enamel covering meets cement at the neck.

It is avascular, the hardest and most mineralized substance in the body. It does not contain nerves. The thickness and density of enamel vary over the surface of the tooth. It is hardest at the biting edges, or cusps.

Enamel is responsible for protecting the underlying tooth dentine. It provides thermal insulation of the tooth and protects the internal vital tissues from destruction. Over time, if the enamel begins to wear away, it exposes the dentine, causing tooth pain and increased sensitivity to pressure, heat and cold, or acidic or sticky foods.

- **Cement (cementum)** is a specialized bone-like tissue covering the root and neck of the tooth. At the neck, cement forms only a thin layer. The main role of cement is to serve as a structure by which the periodontal ligaments can attach to the tooth, thus ensuring its stability in the dental alveolus.

During life, cement is capable of remodeling, by which it responds to changes in the periodontium and on the tooth surface, and thus ensures a secure attachment of the tooth. With age, cement increases in thickness.

- **Dental pulp** is the innermost and softest layer of the teeth which occupies the pulp cavity of the tooth. It is formed by the loose gelatinous connective tissue, blood and nerves. Neurovascular structures enter the apical foramen at the apex of the root.

The fixation of the tooth within the dental alveolus is by the fibrous joint. It is dento-alveolar syndesmosis that is called **gomphosis**. However, the tooth is not completely embedded in the dental alveolus but is suspended and fixed by the special ligaments and tissue of the periodontium.

- **Periodontium** includes several types of tissues that support and attach the teeth to the dental alveoli and allow sensations of touch and pressure. These include: periodontal ligaments, gingiva, cement, alveolar bone and periosteum of the tooth socket.

1.2.1.2 Designation of the tooth surfaces

The following surfaces are described on the crown of the tooth:

- **Occlusal surface** is used for chewing with the back teeth. On the molar and premolar teeth, this surface has the *cusps* (humps). On the incisor teeth, there is a sharp cutting edge, which is called the *incisal margin*. The canine teeth have a single, pointed cusp;
- **Vestibular surface** of the teeth faces the oral vestibule. Can also be used the terms: *labial surface* at the incisor and canine teeth, which is closest to the lip and *buccal surface* at the premolar and molar teeth, which is closest to the cheek;
- **Palatal surface** of the teeth of the maxillary dental arch faces the hard palate and **lingual surface** of the teeth of the mandibular dental arch faces the tongue;
- **Mesial surface** is closest to the midline of the face and **distal surface** is farthest from the midline.

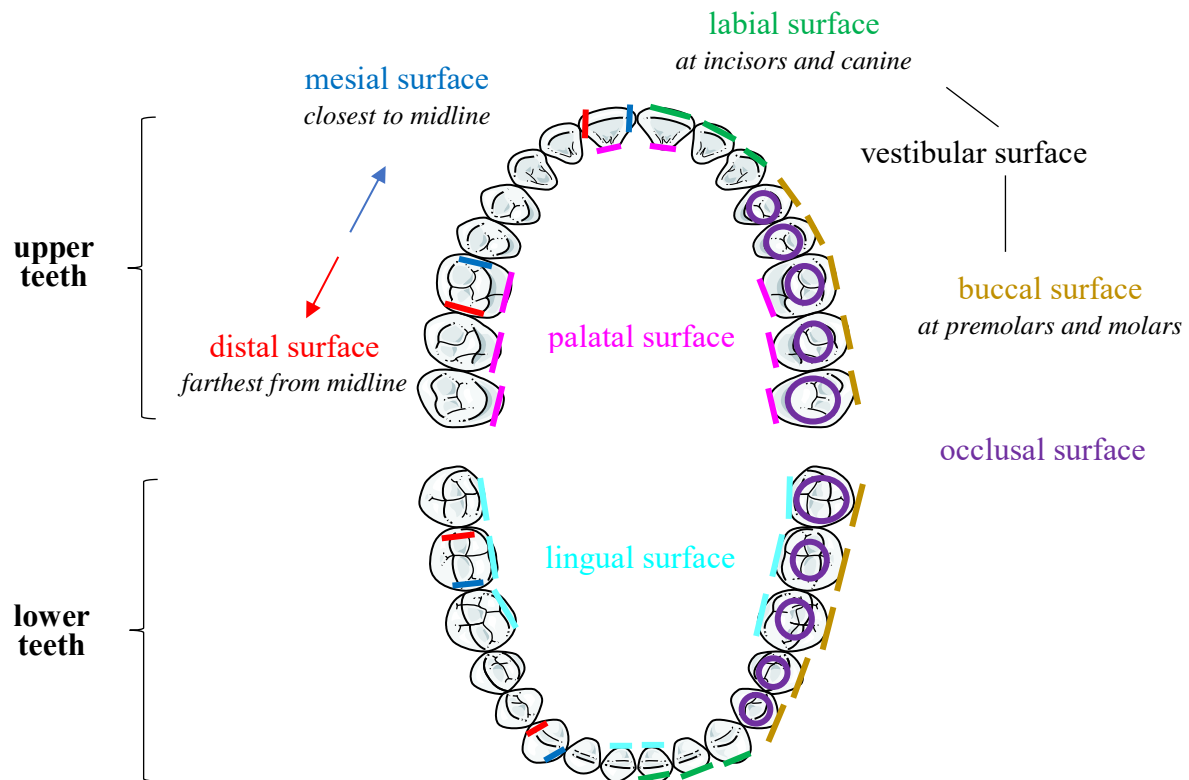


Fig. 10

Designation of the tooth surface

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1.2.1.3 Types of the teeth

The types of the teeth are identified by their characteristics. There are 4 main types:

- **Incisor tooth**

There are total of 8 incisors in both the upper and lower jaws – two incisors on either side of the midline are known as the **central incisors** and two adjacent teeth to the central incisors are known as the **lateral incisors**. *The upper central incisor is the widest of the anterior teeth and it is also larger than the lower central incisor.*

The incisor teeth are the front teeth that help bite and cut food due to their shape - they are chisel-shaped with sharp edges. This is why they are also called the *cutting teeth*. They are single-rooted.

- **Canine tooth**

Canines are located behind (farther from the midline) and adjacent to the lateral incisors and they support them. They are in the third position of the dental arches. There are 4 canines in the oral cavity, one in each quadrant of the mouth. Their main function is to tear food.

The crown of the canine teeth emerges into a single sharp cusp, that is why the canines are also called the *cuspid teeth*. The canine teeth have one long root. They have the longest root of all teeth.

- **Premolar tooth**

Premolars are located between the canines and molars. They are in the fourth and fifth positions of the dental arches. Thus, there are a total of eight premolars in the oral cavity (but only in the permanent dentition, deciduous teeth do not have premolars). Four in the maxillary dental arch and four in the mandibular dental arch. The one closer to the midline is the *first premolar* and the one farther from the midline is the *second premolar*. They are more important for tearing and crushing food and the 2nd maxillary premolar also complements the molars in their function.

Premolars usually have 2 – 3 cusps (humps) separated by the fissures on the occlusal surfaces of their crowns. Therefore, they are often referred to as the *bicuspid teeth*.

- Maxillary premolars: they have the buccal and palatal cusps separated by the central fissure.
- Mandibular premolars: the 1st premolar tooth has buccal and lingual cusps. The 2nd premolar tooth can have 2 – 3 cusps. There is the 2-cusp form with the buccal and smaller lingual cusps or the predominant 3-cusp form with 2 smaller lingual and single buccal cusps separated by the mesiodistal fissure.
- Premolars are single-rooted teeth except for the 1st maxillary premolar, which has usually 2 roots (buccal and palatal).

- **Molar tooth**

The most posterior teeth in the mouth are the molars, the largest of the permanent teeth. They are in the sixth, seventh and eighth positions of the dental arches. In permanent dentition,

there are a total of 12 molars in both dental arches with three in each quadrant of the mouth. The primary dentition contains only eight molars. Molars are named starting with the closest to the midline as the *first molar*, *second molar* and *third molar teeth*.

The third molars are often referred to as wisdom teeth. In some people, however, the third molars do not develop fully and so they may vary in size and shape or may even be absent. They are often extracted as a preventive measure.

Molars have the largest crown of any other teeth and they have multiple cusps and roots. There are also referred to as the *multicuspid teeth*. Their main function is to grind and chew food.

- Maxillary molars: the 1st molar tooth usually has 4 – 5 cusps (it is the largest of the molar teeth). The 2nd molar tooth has 4 cusps (1 at each corner of its occlusal surface) and the 3rd molar has 3 cusps. Occlusal surface of the crown is rhomboidal in form. The cusps are separated by the H-shaped fissure. All three upper molars have 3 roots – two buccal and one palatal.

The tips of the roots of the maxillary molars are located in close proximity to the floor of the maxillary sinus, which may lead to the risk of oroantral communication when performing any surgical or endodontic procedure in this area.

- Mandibular molars: the 1st molar tooth usually has 5 cusps (three buccal and two lingual), all of which are separated. The 2nd molar has 4 cusps (two buccal and two lingual). The 3rd molar tooth may resemble either the 1st or 2nd molar. Occlusal surface of the crown is rectangular in form. The cusps are separated by the cross-shaped fissure. Lower molars have 2 roots – one mesial and one distal. The roots of the 3rd molar are often fused.

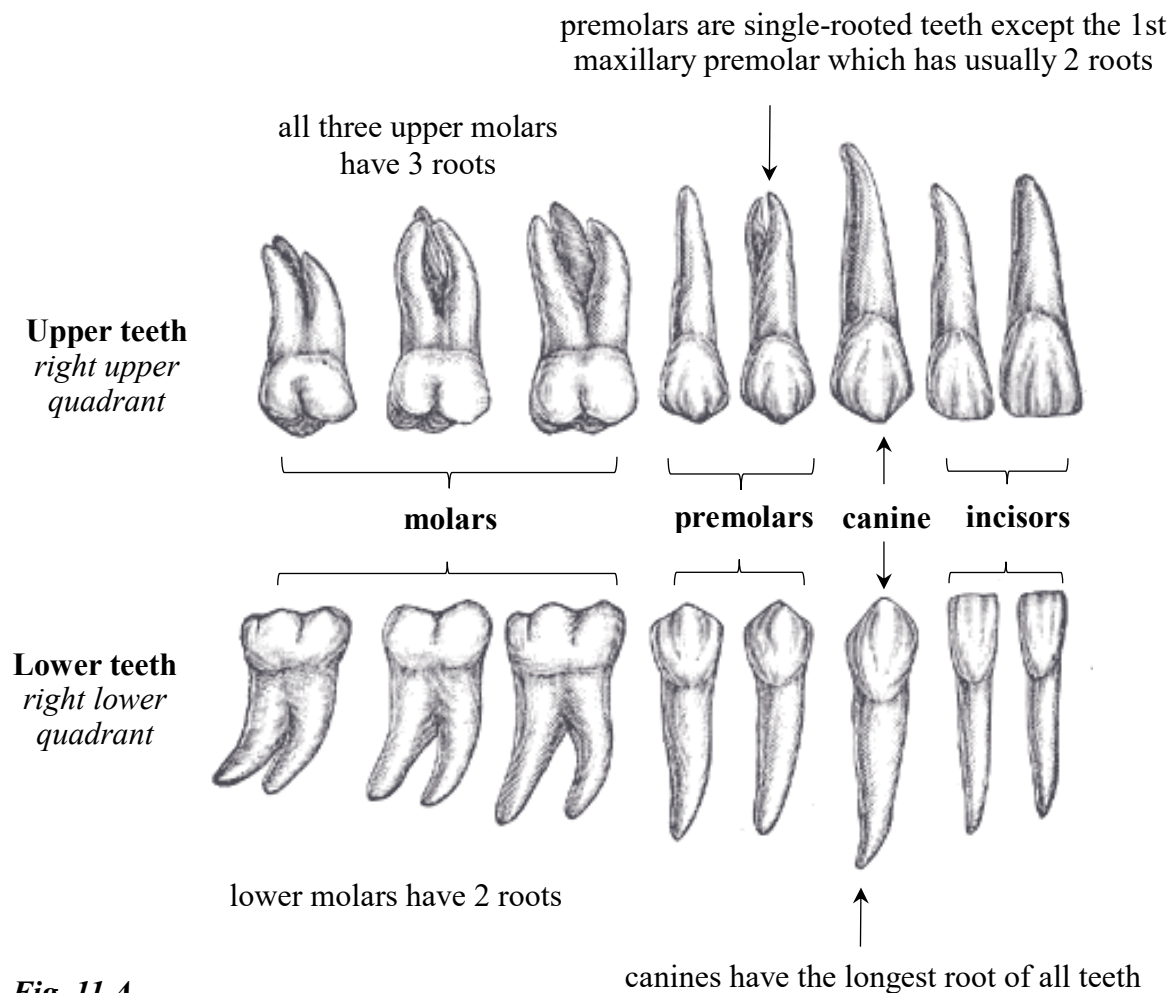


Fig. 11 A
Types of the permanent teeth; right side

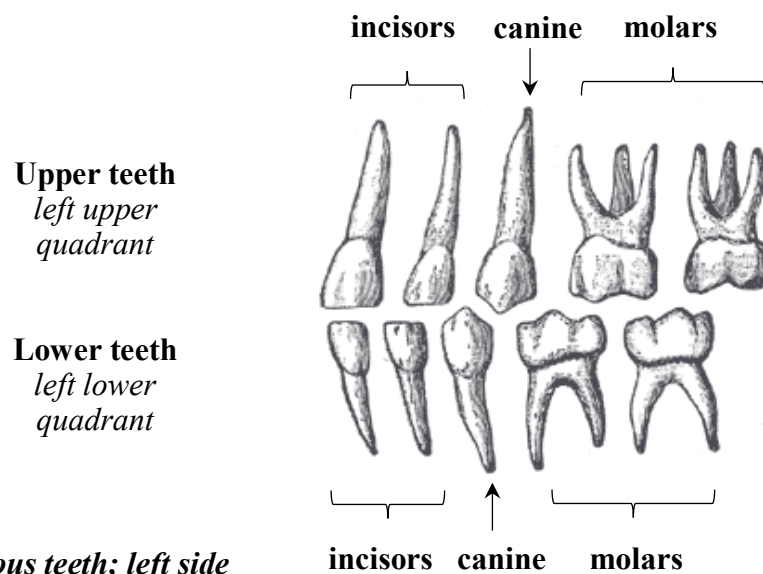


Fig 11 B
Types of the deciduous teeth; left side

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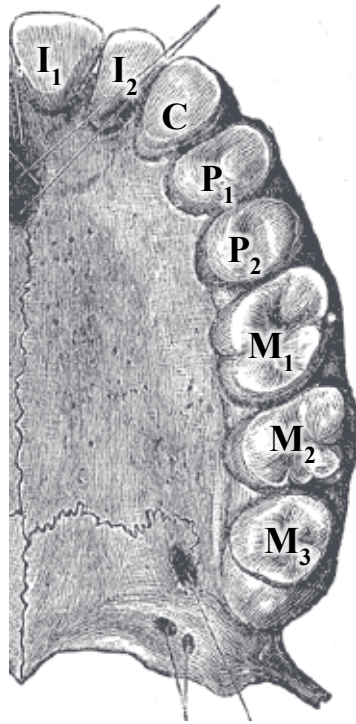


Fig. 12 A

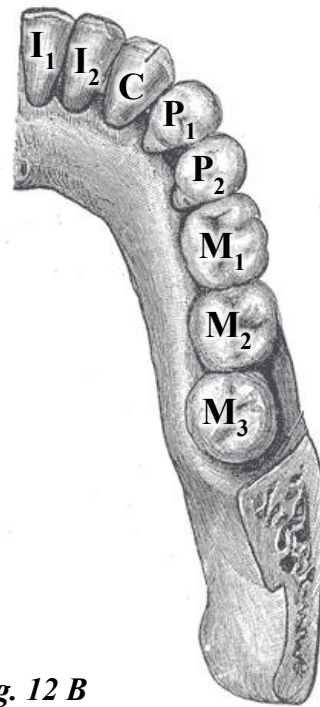


Fig. 12 B

I₁ central incisor
I₂ lateral incisor
C canine
P₁ first premolar
P₂ second premolar

M₁ first molar
M₂ second molar
M₃ third molar

Fig. 12

Permanent teeth of the upper and lower dental arch

12 A – Permanent teeth of the left half of the upper dental arch; seen from below

12 B – Permanent teeth of the right half of the lower dental arch; seen from above

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1.2.1.4 Coding of the teeth

The tooth numbering system allows quick and clear indication of the number and position of the teeth in the upper and lower jaw. Different types of tooth notation are used around the world.

- Based on the international agreement on the location and naming of the individual teeth a **two-digit numbering system** is commonly used according to FDI - World Dental Federation (FDI = Fédération Dentaire Internationale).

In this numbering system, the **first number** represents the quadrant of the dentition from 1 to 4. Quadrant 1 is the upper right dental quadrant of the patient and from there we proceed clockwise (from the dentist's perspective), so quadrant 4 is the lower right quadrant. The **second number** represents the number of the tooth in a particular quadrant from the midline of the face.

Example: the notation „14" would therefore refer to the permanent right upper first premolar tooth and „37" would refer to the permanent left lower second molar tooth. The numeral reads as "one" "four", not fourteen.

For deciduous teeth, the system is similar, but when describing the quadrants, the numbers 5 to 8 are used instead of the numbers 1 to 4. Similarly, due to the absence of premolars in the milk dentition, only numbers 1 to 5 are used for the second number.

Example: the notation „84" would therefore refer to the deciduous right lower first molar tooth.

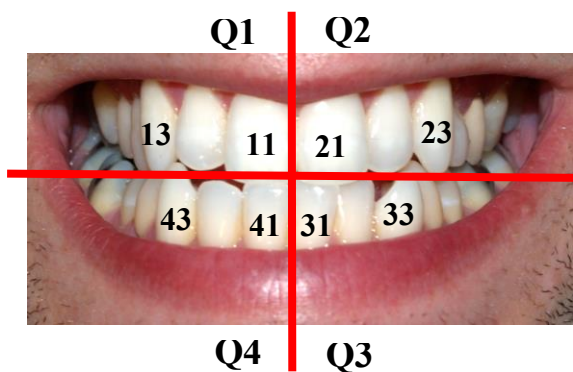


Fig. 13
Coding of the permanent teeth according to the FDI - World Dental Federation

Author: David Shankbone, 2007. Available online at: https://commons.wikimedia.org/wiki/File:Teeth_by_David_Shankbone.jpg; 2022
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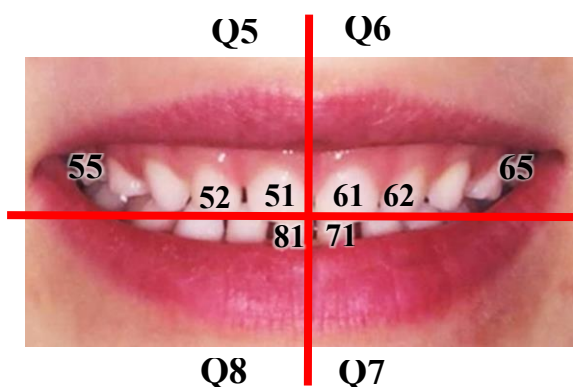










Fig. 14
Coding of the deciduous teeth according to the FDI - World Dental Federation

Available online at: <https://www.healthbenefitstimes.com/glossary/deciduous-teeth/>; 2022
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- The **Palmer notation** is a nomenclature for the numbering and naming of the teeth, primarily used in the United Kingdom.

Similar to the World Dental Federation notation, individual teeth within each quadrant of the dental arches are numbered from the midline to distal. For the permanent teeth, a number from 1 to 8 is used, with 1 indicating the central incisor and 8 indicating the third molar. The deciduous teeth are lettered A through E from the midline to distal in each quadrant, with A indicating the central incisor and E indicating the second molar.

The tooth number is associated with symbols     that indicate the dental quadrant in the patient. The symbol  indicates the right upper maxillary quadrant,  the left upper maxillary quadrant,  the right lower mandibular quadrant and  the left lower mandibular quadrant.

Example: the notation „6[┘] " would therefore refer to the permanent right upper first molar tooth and „┐ C " would therefore refer to the deciduous left lower canine tooth.

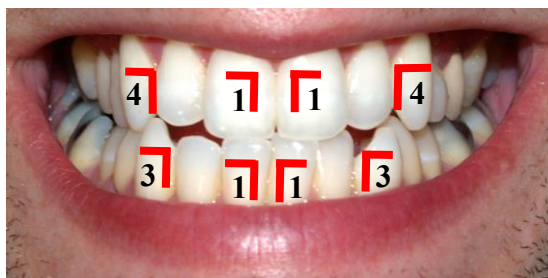


Fig. 15
Coding of the permanent teeth according to the Palmer system

Author: David Shankbone, 2007. Available online at: https://commons.wikimedia.org/wiki/File:Teeth_by_David_Shankbone.jpg; 2022
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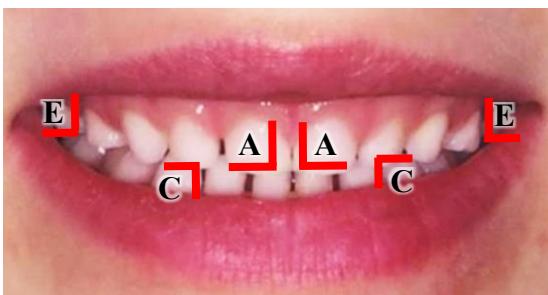



Fig. 16
Coding of the deciduous teeth according to the Palmer system

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- Another way of numbering the teeth is to use the **Latin names of the teeth**.

The initial letter of the Latin name of the tooth is used for the designation (I = incisor, C = canine, P = premolar and M = molar). It is numbered medio-distally. The permanent tooth is denoted by a capital letter, the deciduous tooth by a lowercase letter. Similar to the Palmer system, this numbering uses the symbols  for each quadrant of the patient.

Example: the notation of the permanent dentition „M₂┐" would therefore refer to the permanent right upper second molar tooth and „└ I₂" would therefore refer to the permanent left lower lateral incisor. The milk teeth would be numbered as follows - e.g.: „m₂┐" would thus refer to the deciduous right upper second molar.

M ₃ M ₂ M ₁ P ₂ P ₁ C I ₂ I ₁	I ₁ I ₂ C P ₁ P ₂ M ₁ M ₂ M ₃
M ₃ M ₂ M ₁ P ₂ P ₁ C I ₂ I ₁	I ₁ I ₂ C P ₁ P ₂ M ₁ M ₂ M ₃

Fig. 17 A
Coding of the permanent teeth using Latin tooth names

m ₂ m ₁ c i ₂ i ₁	i ₁ i ₂ c m ₁ m ₂
m ₂ m ₁ c i ₂ i ₁	i ₁ i ₂ c m ₁ m ₂

Fig. 17 B
Coding of the deciduous teeth using Latin tooth names

1.2.1.5 Eruption of the teeth

Eruption of the teeth (teething) is a process in tooth development where the teeth are brought into the mouth and become visible.

At birth, no milk teeth are present, but by the third year of life, all 20 milk teeth have erupted. The deciduous teeth usually start erupting around the 6th month of life and the permanent teeth erupt around the 6th year of life. Mixed dentition, in which both deciduous and

permanent teeth are present in the oral cavity at the same time, occurs between the ages of 6 and 12 years. The first milk tooth to erupt is the mandibular central incisor and the eruption continues with other incisors erupted in a clockwise direction with an interval of 2 months. Teething continues with the first molar. The lower and upper canines and the second molars erupt at approximately the same time.



Fig. 18
Maxilla and mandible; dental panoramic tomogram of a 9-year-old child with mixed dentition; wisdom tooth buds are visible distal to the unerupted second molars

Original diagram from Wikipedia; Author: Coronation Dental Specialty Group which is a owner and authorize use of the image; 2013. Available online at:

https://commons.wikimedia.org/wiki/File:Mixed_dentition_pan.jpg; 2022



Fig. 19
Maxilla and mandible; panoramic radiograph showing impacted wisdom teeth in a 16-year-old patient

Original diagram from Wikipedia; Author: Coronation Dental Specialty Group which is a owner and authorize use of the image, 2013. Available online at:

https://commons.wikimedia.org/wiki/File:Basic_panoramic_radiograph.jpg; 2022

Milk teeth are replaced by the permanent teeth which are called the **replacement teeth** and are erupted *distal* to the primary teeth. The teeth that have not replaced the milk teeth are called the **additional teeth**. Eruption of the permanent teeth occurs sequentially at a difference of 1 year except for the 3rd molar tooth which erupts between 13 – 25 (30) years. The first permanent tooth that normally erupts into the oral cavity is the mandibular first molar. This is followed by the incisors. The premolars sometimes erupt before the canines. The age of completion of calcification is approximately 3 years after the eruption of a particular tooth.

The teeth erupt in a specific order and time sequence that depends on a number of factors – gender, nutrition, health status, civilization and geographical factors, ... For these reasons, there may be some variability in the order of the eruption and the period of teething is not the same in all children. This also explains the different timing data in the literature.

The teeth of the lower jaw ordinarily erupt slightly earlier than the teeth of the upper jaw in both deciduous and permanent dentition. Also, the eruption of the permanent teeth is usually faster in girls than in boys, by up to a year.

The usual age of eruption for the primary dentition is listed in the *Table 1* and for the secondary dentition in the *Table 2*.

Eruption of deciduous teeth		Months
Central incisors	i ₁	6 - 8
Lateral incisors	i ₂	7 - 10
First molars	m ₁	12 - 16
Canines	c	16 - 20
Second molars	m ₂	20 - 24

Table 1: Usual age of eruption of the deciduous teeth according to Moore K.L., Dalley A.F., Agur A.M.: Clinically Oriented Anatomy. Wolters Kluwer, 2018

Eruption of permanent teeth		Years
First molars	M ₁	6 - 7
Central incisors	I ₁	7 - 8
Lateral incisors	I ₂	8 - 9
Canines	C	10 - 12
First and second premolars	P ₁ + P ₂	10 - 12
Second molars	M ₂	12
Third molars	M ₃	13 – 25

Table 2: Usual age of eruption of the permanent teeth according to Moore K.L., Dalley A.F., Agur A.M.: Clinically Oriented Anatomy. Wolters Kluwer, 2018

1.2.1.6 Vessels and nerves of the teeth

- **Arterial supply** is derived from the direct or indirect branches of the maxillary artery which arises from the external carotid artery.

Upper teeth are supplied by the anterior and posterior superior alveolar artery. The anterior superior alveolar artery originates from the infraorbital artery which is a direct branch of the maxillary artery. It supplies the incisor and canine teeth. The posterior superior alveolar artery originates from the maxillary artery and supplies the premolar and molar teeth.

All lower teeth are supplied by the inferior alveolar artery, a direct branch of the maxillary artery.

- **Veins** generally follow the arteries. A substantial portion of the venous blood is drained into the pterygoid plexus. Venous blood from the anterior teeth can also drain into the facial vein.
- **Lymph** drains mainly into the submandibular, submental and deep cervical lymph nodes.
- **Nerve supply** to all upper teeth is via the branches of the maxillary nerve (V2) and to lower teeth via the branches of the mandibular nerve (V3). Both nerves originate from the trigeminal nerve [CN V].
 - The upper teeth are innervated by the group of the superior alveolar branches of the infraorbital nerve, a branch of the maxillary nerve. The posterior superior alveolar nerve innervates the molar teeth, the middle superior alveolar nerve the premolar teeth and the anterior superior alveolar nerve the canine and incisor teeth. These alveolar nerves form the superior dental plexus which supplies not only the teeth (the nerves enter apical foramina on the roots of teeth), but also the adjacent gingiva.
 - The lower teeth are innervated by the inferior alveolar nerve, a branch of the mandibular nerve. It forms the inferior dental arch for the nerve supply of the teeth and also for the adjacent gingiva.

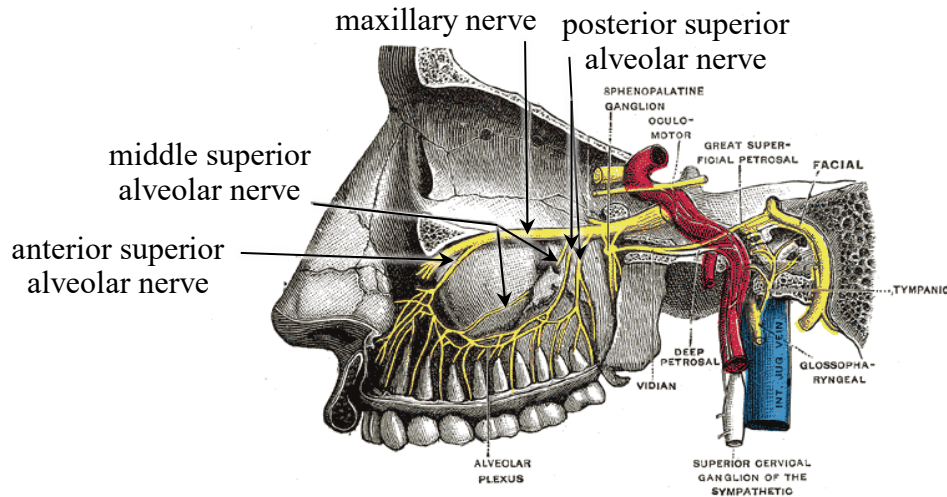


Fig. 20

Innervation of the upper teeth, superior alveolar branches of the maxillary nerve and superior dental plexus

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Modified by additional drawing and labeling

All lower teeth can be anesthetized simultaneously using block anesthesia in one quadrant. However, the upper teeth are sensory nerve supplied by the different individual branches. Due to this different innervation, block anesthesia is not possible and anesthesia of individual teeth is preferred.

1.2.2 TONGUE (Lingua in Latin; glossa in Greek)

The tongue is a highly muscular organ of mastication, deglutition, taste and articulation. It is located partly in the oral cavity and partly in the oropharynx and is attached by its external muscles to the hyoid bone, mandible, styloid process and soft palate.

1.2.2.1 External description of the tongue

The tongue is divided by the terminal sulcus into the **oral** and **pharyngeal parts** and it presents an **apex** and **margins**, **dorsum** and **inferior surface**.

- Anterior two-thirds of the length of the tongue located in the oral cavity is called the **oral part** or the **body of the tongue**. It is oriented more horizontally and faces upwards

to the hard and soft palate. The body of the tongue ends ventrally into the **apex** (tip) touching the lower incisor teeth. The apex continues on each side into the **margins** which are in contact with the gingiva and teeth.

- Posterior one-third of the tongue is oriented more in the vertical plane and faces posteriorly into the oropharynx. This is the **pharyngeal part** or **root of the tongue**.
The root of the tongue is movably connected with the epiglottis by the **median glossoepiglottic fold** in the midline and the **lateral glossoepiglottic folds** on the sides. These folds border two mucosal pouches, the **epiglottic valleculae**.

The oral and pharyngeal parts of the tongue differ anatomically and functionally in the mucosa, innervation and developmental origin.

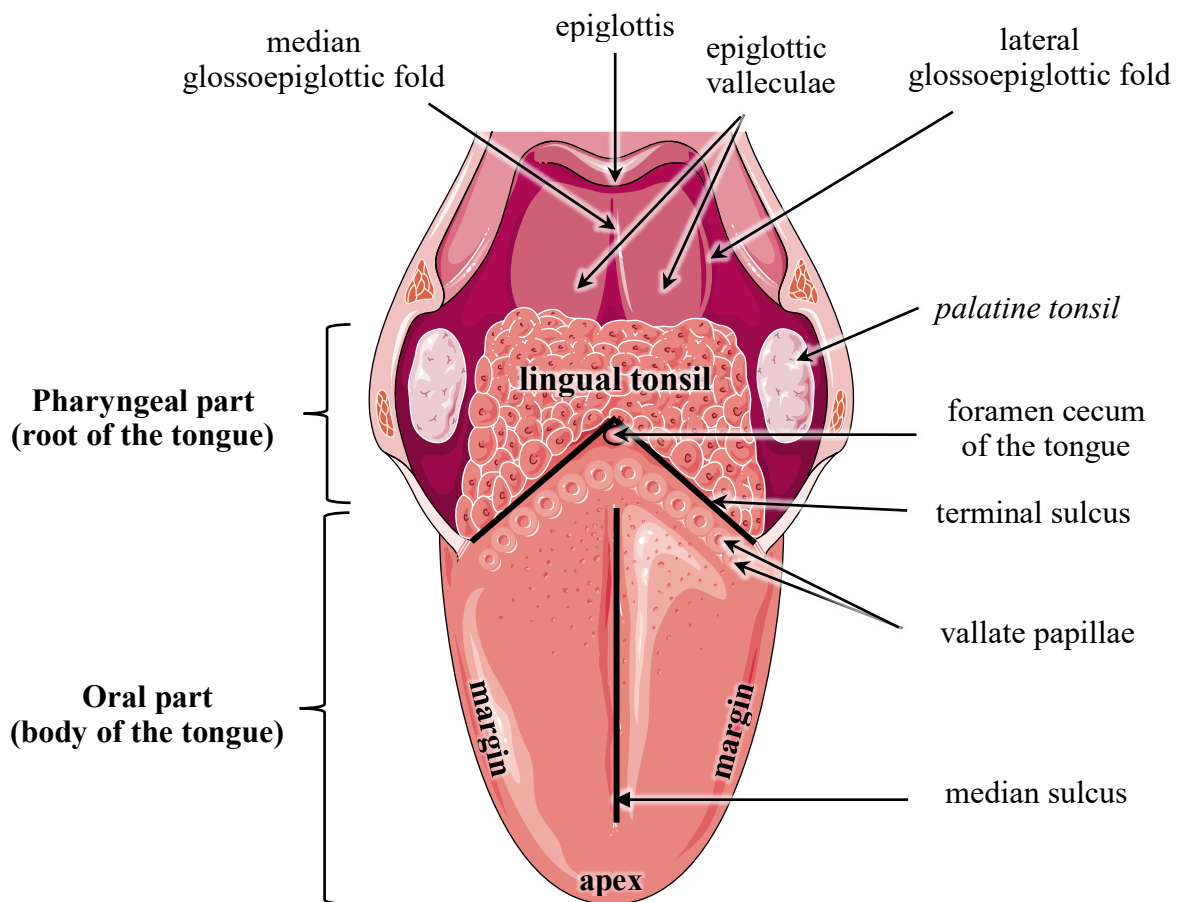


Fig. 21
Tongue, dorsum of the tongue

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Modified by additional drawing and labeling

The tongue has two surfaces. The **dorsum** („top“ of the tongue), which faces the palate and the **inferior surface** („undersurface“), which rests against the floor of the mouth. The **dorsum of the tongue** is characterized by a V-shaped **terminal sulcus**. This groove separates the tongue into the oral part and pharyngeal part. The terminal sulcus of the tongue runs from the center anteriorly on either side to the margins of the tongue. *A small median depression, the foramen cecum, is located at the top of „V“.* It is a nonfunctional remnant of the embryonic thyroglossal duct. In the middle, the dorsum of the oral part of the tongue is divided into the right and left halves by a visible shallow longitudinal **median sulcus**.

1.2.2.2 Mucosa of the tongue

The tongue is covered with the mucous membrane, which has some differences on the **dorsum** and on the **inferior surface** of the tongue.

- **Dorsum of the tongue:**

The mucosa of the oral part is normally pink and moist. The submucosa is absent and mucosa is firmly attached to the **lingual aponeurosis**. It is a plate of connective tissue that is the attachment site for the muscles of the tongue. The dorsal mucosa in this part has a rough texture because it is covered by numerous small **lingual papillae**. It also contains a number of small salivary glands. The lingual papillae generally increase the contact area between the surface of the tongue and the contents of the oral cavity. The lingual papillae are divided into four morphologically distinct types – filiform, fungiform, vallate and foliate. All, except the filiform papillae, have taste buds on their surfaces.

The mucosa of the pharyngeal part has no lingual papillae. It is thick and irregular due to the presence of many small lymphoid nodules embedded in the submucosa. Lymphoid nodules are collectively termed the **lingual tonsil**.

Lingual papillae:

- **Filiform papillae** are the most common thread-shaped papillae that cover most of the body of the tongue. They are sensitive to tactile stimuli and are the only lingual papillae without taste buds.
- **Fungiform papillae** occur mainly on the tip and lingual margins. They are deep red in color, mushroom-shaped and larger than filiform papillae. They contain mechanical and thermal receptors and taste buds.
- **Vallate (circumvallate) papillae** lie immediately anterior to the terminal sulcus and are arranged in a V-shaped row. They are the largest blunt-ended cylindrical papillae of which there are approximately 8 – 12. They contain taste buds.

- **Foliate papillae** are linear folds of the mucosa at the margins of the tongue. They are poorly developed in human. They contain taste buds.

Taste buds (caliculi gustatorii) are located in the epithelium of papillae and they form the taste organ.

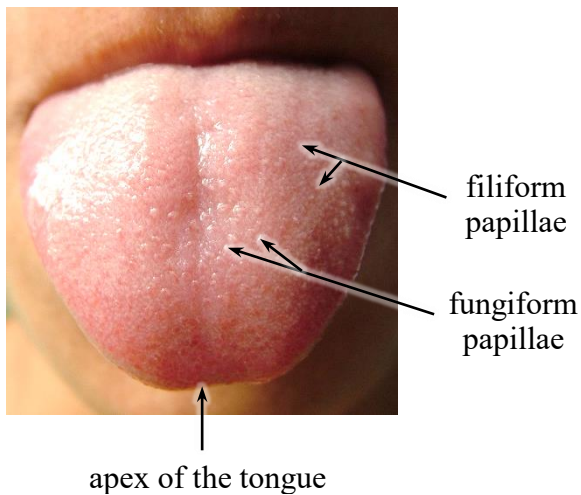


Fig. 22
Oral part of the tongue (body): dorsum with the papillae

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Available online at

<https://www.freeimages.com/photo/tongue-1550970>; 2022

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- **Inferior surface of the tongue:**

Its mucosa is thin, transparent and lacks lingual papillae. In the midline, this surface is connected to the floor of the oral cavity by the vertical fold, the **frenulum of the tongue** (lingual frenulum). On each side of the frenulum, the deep lingual vein is visible and lateral to each vein is the fimbriated fold. A small mucosal projection, the sublingual caruncle, is located at both sides of the lingual frenulum. The submandibular and major sublingual ducts open here.

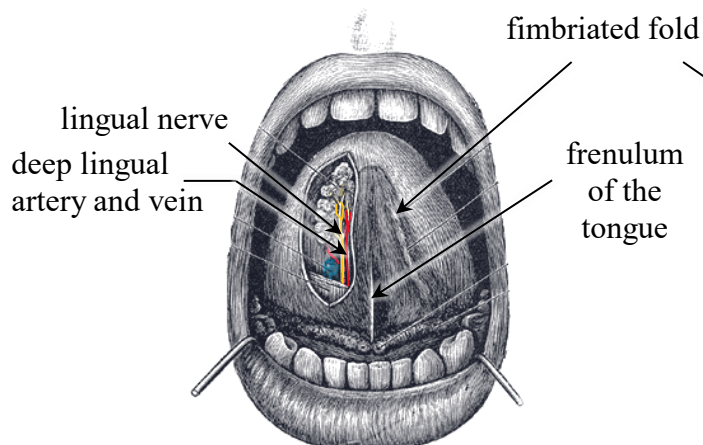


Fig. 23A
Inferior surface of the tongue

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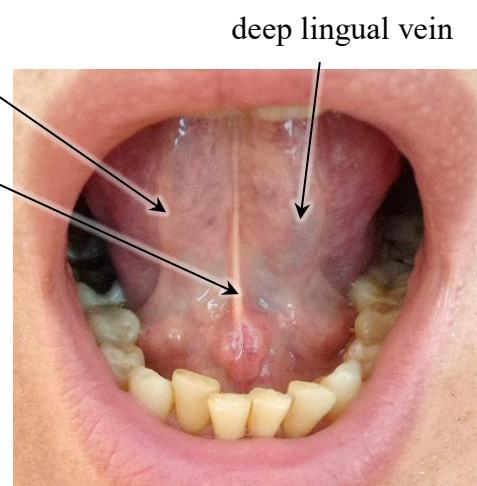


Fig. 23B
Inferior surface of the tongue
Photo from the authors' archive

1.2.2.3 Muscles of the tongue

Extrinsic are the muscles of the tongue that change the position of the tongue and **intrinsic** (own) that change its shape. The muscle mass of the tongue is completely divided into two symmetrical halves by the median fibrous **lingual septum**. This means, that there are four intrinsic and four extrinsic muscles in each half of the tongue.

The **intrinsic (own) muscles** (Table 3) are not attached to any bone and have no fascia of their own. They originate and insert into the substance of the tongue and intertwine with each other. Intrinsic muscles are arranged in three mutually perpendicular directions and are named according to these directions: the **superior** and **inferior longitudinal muscles**, the **transverse** and **vertical muscles**.

intrinsic muscle of the tongue	position / origin - insertion	function	innervation
superior longitudinal	<i>muscle fibers pass immediately beneath the aponeurosis linguae along the entire length of the tongue</i> O + I: aponeurosis linguae	shortens tongue, curls apex and sides of the tongue	hypoglossal nerve
inferior longitudinal	<i>muscle fibers pass near the inferior surface of the tongue</i> O: root of the tongue I: apex of the tongue	shortens tongue, uncurls apex and turns it downward	hypoglossal nerve
transverse	<i>muscle fibers are intertwined with other muscle fibers</i> O: lingual septum I: submucosal connective tissue of lateral margins of tongue	narrows and elongates tongue	hypoglossal nerve
vertical	<i>muscle fibers form vertical bundles</i> O: aponeurosis linguae I: inferior surface	flattens and broadens tongue	hypoglossal nerve

Table 3: Intrinsic muscles of the tongue

The **extrinsic muscles** (Table 4) originate outside the tongue and insert into it. Muscles attach the tongue to the hyoid bone and mandible below and to the styloid process and soft palate above. They are paired: **hyoglossus**, **genioglossus**, **styloglossus** and **palatoglossus**. Palatoglossus belongs to the muscles of the tongue and also to the muscles of the soft palate.

Attaching the tongue to the mandible is clinically important because pulling the mandible forward during anesthesia prevents the tongue from falling backward and obstructing breathing.

extrinsic muscle of the tongue	origin	insertion	function	innervation
hyoglossus	hyoid bone	inferior aspect of lateral side of the tongue	depresses and retracts the tongue	hypoglossal nerve
genioglossus	mental spine of mandible	fanlike insertion on the lingual aponeurosis from the apex to the posterior part of the tongue	protrudes tongue, bilateral activity depresses center of tongue, unilateral activity deviates tongue to the contralateral side	hypoglossal nerve
styloglossus	styloid process of temporal bone	lateral side of the tongue posteriorly	retracts and elevates the tongue	hypoglossal nerve
palatoglossus	palatine aponeurosis of soft palate	lateral side of tongue	elevates the root of tongue	glossopharyngeus nerve via pharyngeal plexus

Table 4: Extrinsic muscles of the tongue

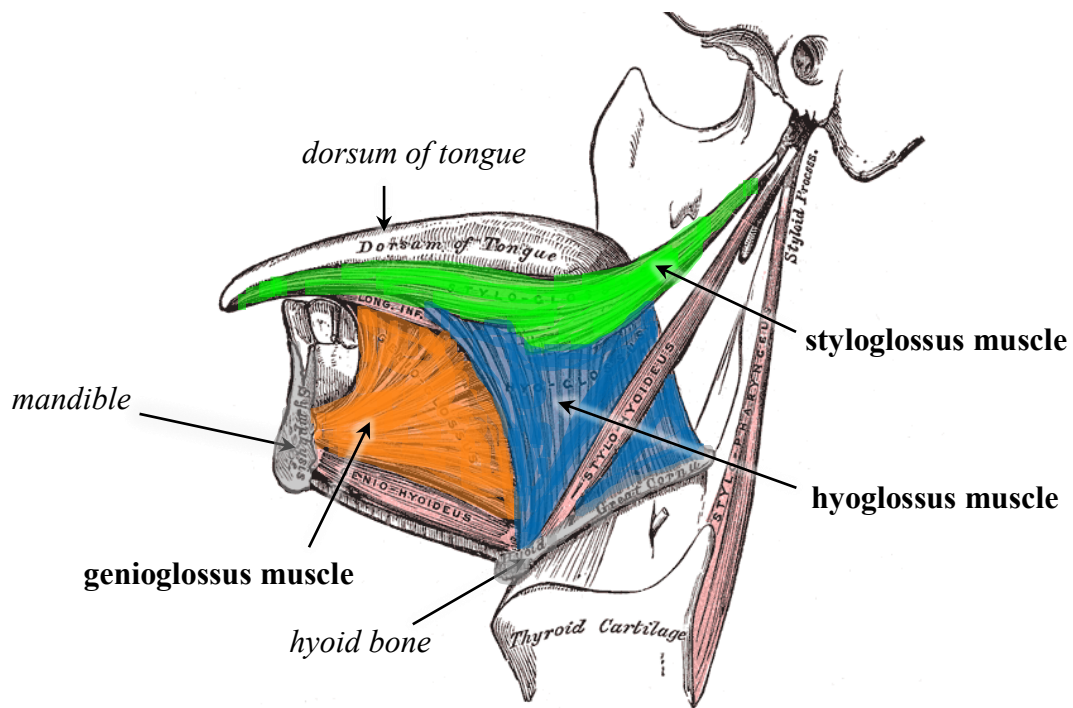


Fig. 24

***Extrinsic muscles of the tongue in addition to the palatoglossus, which is not shown
Sagittal plane***

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Lea & Febiger, 1918. Available online at Bartleby.com, 2022. www.bartleby.com

Modified by additional drawing, labeling and colorization

Intrinsic muscles are arranged in three mutually perpendicular directions and are named according to these directions:

- vertical muscle
- transverse muscle
- longitudinal muscle

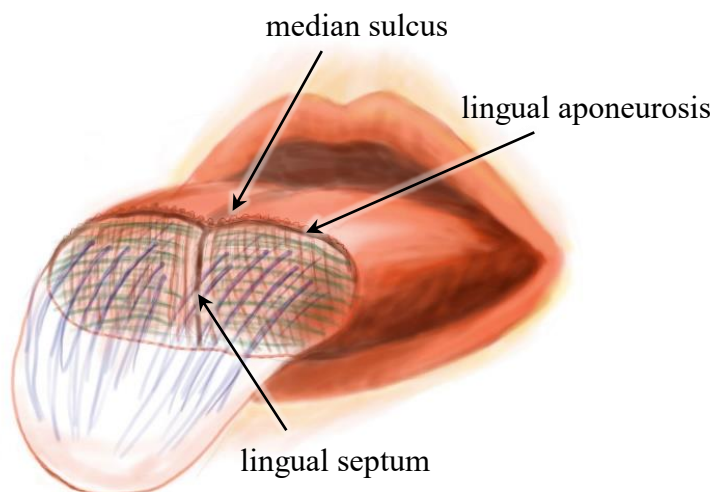


Fig. 25

Intrinsic muscles of the tongue

Schematic figure from the authors' archive

1.2.2.4 Vessels and nerves of the tongue

- **Arterial supply** to the tongue comes from the lingual artery (branch of the external carotid artery) and its branches – the deep lingual artery that supplies the body and apex of the tongue and the dorsal lingual artery for the root of the tongue. The branches of the lingual artery anastomose with the contralateral arterial branches.
- **Venous blood** is basically drained into the internal jugular vein through the lingual veins and their tributaries.
- **Lymphatic drainage** is very specific. Most of the lymphatic vessels follow the venous drainage, however, some of the vessels run an independent course.
 - *Root of the tongue drains bilaterally into the jugulo-digastric lymph node (conspicuous node at the junction of the internal jugular vein and posterior belly of the digastric muscle).*
 - *Medial portion of the body drains bilaterally into the jugulo-omohyoid node (conspicuous node at the junction of the internal jugular vein and omohyoid muscle).*
 - *Lateral portions of the body drain ipsilaterally into the submandibular lymph nodes.*
 - *Apex and frenulum drain bilaterally into submental lymph nodes.*

All lymph from the tongue is ultimately drained via the deep cervical lymph nodes into the jugular venous trunk.

Malignant tumors of the tongue spread rapidly through the lymphatic vessels, partly because the high mobility of the tongue facilitates the release of tumor cells and partly because the lymph drains from both halves of the tongue to both right-sided and left-sided lymph nodes.

- **Innervation** for all muscles, except the palatoglossus, arises from the hypoglossal nerve [CN XII]. Palatoglossus muscle is also classified as a muscle of the soft palate and fauces and it is nerve supplied by the pharyngeal plexus, specifically mainly by the glossopharyngeal nerve [CN IX].
- **General sensory innervation** (touch and temperature) from the mucosa of the body of the tongue is carried by the lingual nerve which is a branch of the mandibular nerve (V3) – division of the trigeminal nerve [CN V]. The root of the tongue is nerve supplied

by the sensory fibers of the glossopharyngeal nerve [CN IX]. The mucosa at the transition to the epiglottis is nerve supplied by the vagus nerve [CN X].

- **Special sensory innervation** (taste) from the body of the tongue is carried by the chorda tympani which is a branch of the facial nerve [CN VII]. Chorda tympani joins the lingual nerve in the infratemporal fossa and runs within its sheath. Special sensation from the root of the tongue is carried by the glossopharyngeal nerve [CN IX] and from the small area of the tongue just anterior to the epiglottis is carried by the vagus nerve [CN X].
There are five universally accepted basic tastes that stimulate and are perceived by our taste buds: sweet, salty, sour, bitter and umami.
- **Parasympathetic innervation** to glands of the body of the tongue is carried by the chorda tympani running in the sheath of the lingual nerve. The root of the tongue is nerve supplied by the parasympathetic fibers of the glossopharyngeal nerve [CN IX].

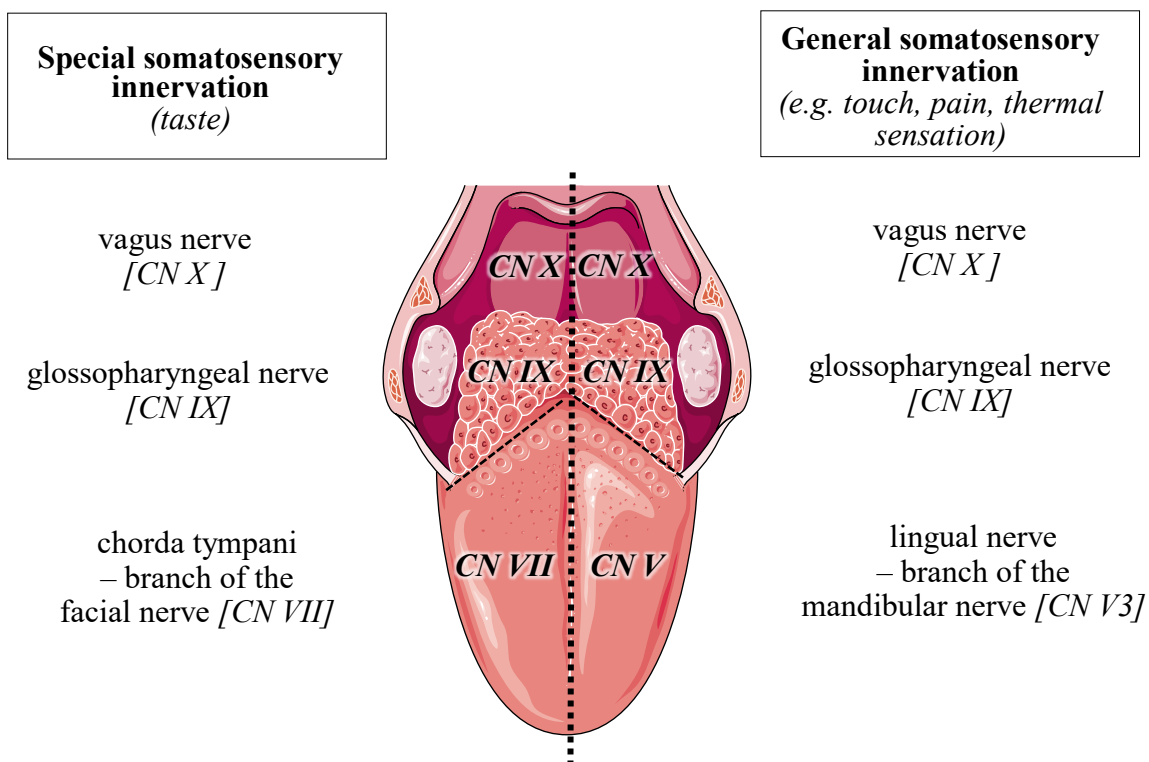


Fig. 26

Innervation of the tongue

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Modified by additional drawing and labeling

Loss of taste involving the anterior 2/3 of the tongue indicates the presence of a facial nerve lesion, while loss of tactile, pain, thermal sensation indicates a trigeminal nerve lesion.

1.2.3 PALATE (Palatum in Latin)

The palate forms the roof of the oral cavity and separates it from the nasal cavity. It consists of two parts, a hard and a soft palate.

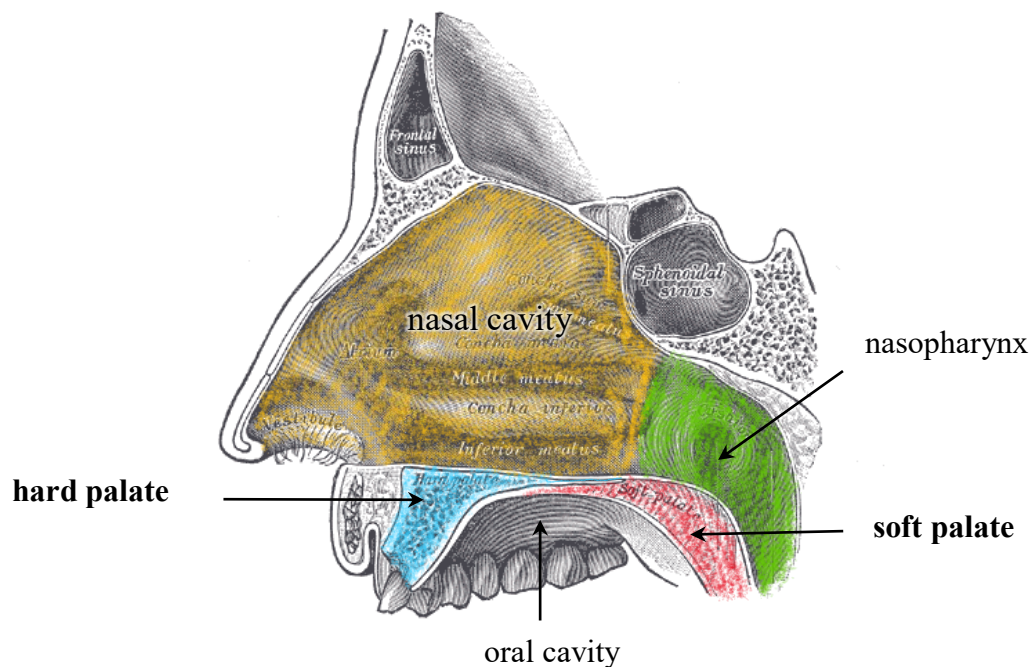


Fig. 27

Hard and soft palate

Sagittal plane, left side

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1.2.3.1 Hard palate (Palatum durum in Latin)

The hard palate is an anterior immovable bony part of the palate. It is mostly filled by the tongue when it is at rest. The hard palate consists of two bones - the anterior two-thirds are formed by the *palatine processes of the right and left maxilla* and the posterior third is formed by the *horizontal plates of the palatine bones*. The hard palate is covered with a mucous membrane, which is firmly attached to the periosteum. It forms a mucoperiosteum and is therefore immobile to the base. The **palatine raphe** is a midline mucosal ridge at the union of the right and left palatine processes. At its anterior end, just behind the upper incisor teeth, there

is a small mucosal eminence, the **incisive papilla** overlying the incisive fossa. The transverse mucosal ridges, **palatine folds (palatine rugae)**, extend on either side across the anterior part of the hard palate. Beneath the mucous membrane of the hard palate, there are some taste buds and numerous palatine glands. Posteriorly, the hard palate is continuous with the soft palate.

The incisive fossa is a small depression covered with epithelium into which the incisive canal opens by the incisive foramina. The incisive canal allows the passage of small blood vessels and nerves between the nasal and oral cavities. The incisive foramen is used as an anatomical landmark for defining the severity of cleft lip and cleft palate.

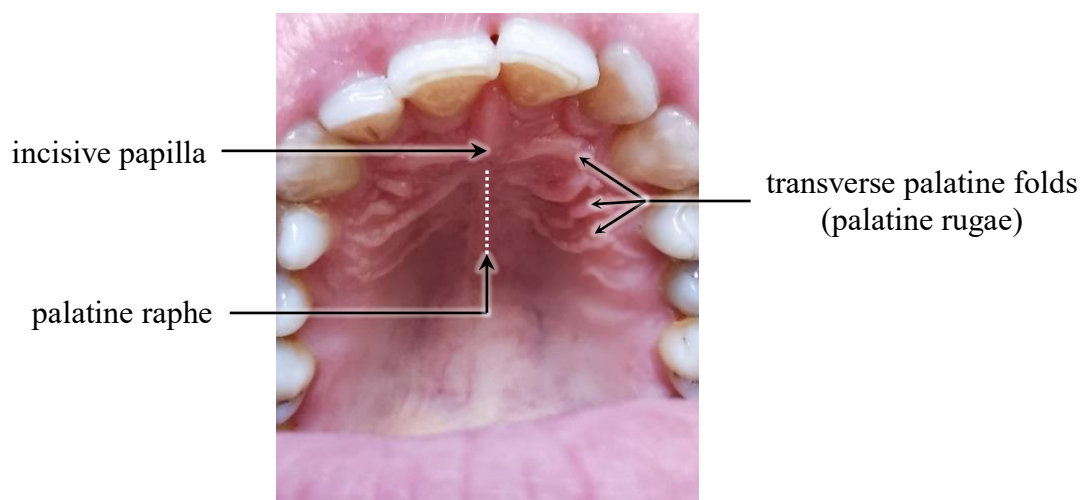


Fig. 28
Hard palate with the transverse palatine folds and incisive papilla
Photo from the authors' archive

1.2.3.2 Soft palate (Palatum molle in Latin)

The soft palate forms the posterior flexible part of the palate. It hangs from the back of the hard palate and in front of the posterior pharyngeal wall like a movable valve. Movements of the palate are essential to swallowing, speech and breathing. It is angled downward to help close the oropharyngeal isthmus, or rises to a horizontal position during swallowing to help close the nasopharynx.

In its usual position (at rest), the soft palate is sloped downward and its anterior (oral) surface is concave and the posterior surface is continuous with the nasal floor. The inferior

margin is free and extends into a median small tear-shaped muscular projection, the **uvula**. Laterally, the soft palate is joined to the tongue and pharynx by two folds:

- the **palatoglossal arch**, which overlies the palatoglossal muscle and forms the anterior pillar of the oropharyngeal isthmus. It extends in front of the tonsillar fossa (tonsillar sinus) in which the palatine tonsil is placed.
- the **palatopharyngeal arch**, which overlies the palatopharyngeal muscle and forms the posterior pillar of the oropharyngeal isthmus. It is situated behind the tonsillar fossa.

The soft palate is supported by the fibrous **palatine aponeurosis**. It is formed by the flat expanded tendons of the tensor veli palatini muscles and is also the site of attachment of the other muscles of the soft palate and fauces. Anteriorly, the palatine aponeurosis is continuous with the periosteum of the palatine bones. Posteriorly, it is unattached and ended in a thinner free margin.

The mucosa covering the soft palate is continuous with the pharyngeal mucosa and the mucosa of the oral and nasal cavity. The small palatine glands are under the mucous membrane on both surfaces of the soft palate, and the taste buds are only on the surface of the oral cavity.

The soft palate is also known as the muscular palate or the velum. The posterior edge of the soft palate is sensitive to touch and may induce vomiting on tactile stimulation.

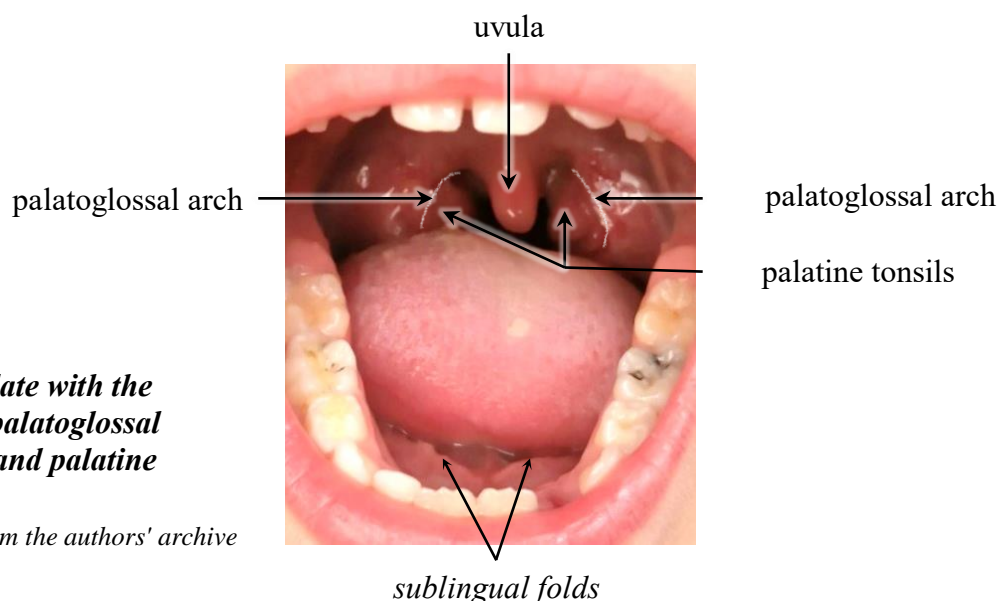


Fig. 29
Soft palate with the
uvula, palatoglossal
arches and palatine
tonsils

Photo from the authors' archive

1.2.3.3 Muscles of the soft palate and fauces

Palatine muscles are important in swallowing, breathing and speaking. There are two bilateral muscles, tensor veli palatini and levator veli palatini, which originate from the base of the skull and descend to the soft palate. The other two bilateral muscles, palatoglossus and palatopharyngeus, originate from the soft palate and insert into the tongue and pharynx. The last muscle of this group is unpaired musculus uvulae. *Table 5* describes an overview of the muscles of the soft palate and fauces.

- **Tensor veli palatini muscle** has two parts – vertical and horizontal. The vertical part is the muscular part, which originates from the base of the skull. It descends towards the pterygoid hamulus of the sphenoid bone and changes direction at its level, wrapping around it and continuing medially as a horizontal part. The horizontal part expands and forms palatine aponeurosis. The horizontal parts of both tensor veli palatini muscles meet in the midline and interpenetrate each other.

Function: Tensor veli palatini muscle tenses the soft palate, which becomes firm, allowing the other muscles attached to it to work more efficiently. During swallowing and yawning, it fortifies the lumen of the auditory tube.

- **Levator veli palatini muscle** runs from its origin from the petrous part of the temporal bone obliquely anterior and inferior to the upper surface of the palatine aponeurosis. The muscle interdigitates in the midline with muscle from the opposite side.

Function: Levator veli palatini muscle is the only muscle that elevates the soft palate during swallowing and yawning, thus separating the nasopharynx from the oropharynx.

- **Palatoglossus muscle** originates from the palatine aponeurosis and descends anterolaterally towards the side of the tongue. It elevates mucosa to form the palatoglossal arch in the oropharyngeal isthmus (*Fig. 31*).

Function: Palatoglossus muscle pulls the soft palate towards the tongue and moves the palatoglossal arch downward to the midline, helping to narrow the oropharyngeal isthmus. This muscle elevates the root of the tongue during swallowing.

- **Palatopharyngeus muscle** originates from the palatine aponeurosis and descends posterolaterally towards the pharynx. Muscle fibers radiate into the lateral

pharyngeal wall. Muscle underlies the palatopharyngeal arch in the oropharyngeal isthmus.

Function: Palatopharyngeus muscle depresses the soft palate and moves the palatopharyngeal arch downward to the midline, helping to narrow the oropharyngeal isthmus. This muscle pulls the pharyngeal wall superiorly, anteriorly and medially during swallowing.

- **Musculus uvulae** originates from the posterior margin of the hard palate and runs posteriorly, where it is inserted into the connective tissue of the uvula.

Function: Musculus uvulae elevates and shortens uvula making the central region of the soft palate thicker.

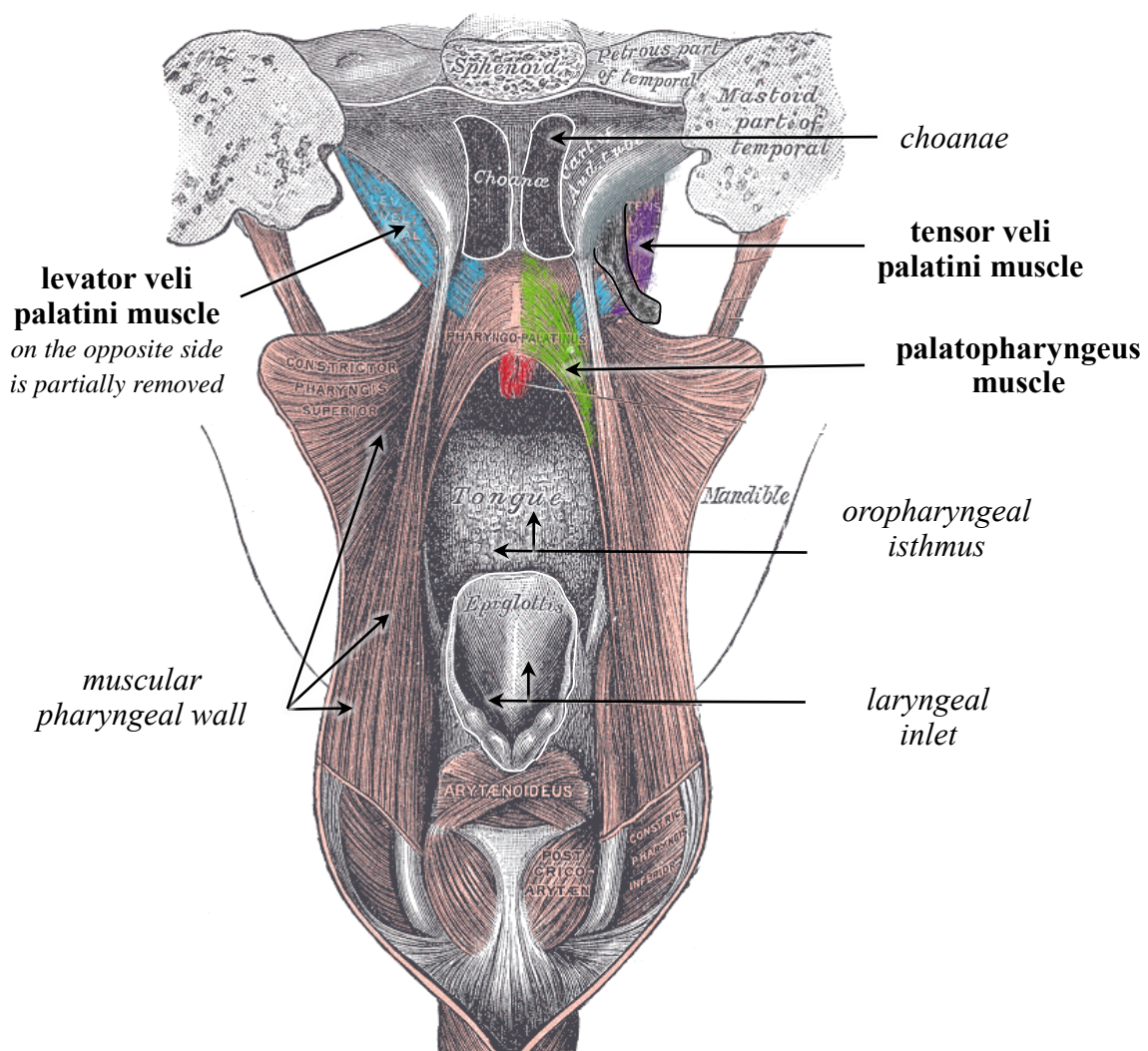


Fig. 30

Muscles of the soft palate in addition to palatoglossus, which is not shown
Posterior view; pharynx is cut through the pharyngeal raphe and the walls of the pharynx are diverted laterally

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Modified by additional redrawing, labeling and colorization

muscles of the soft palate and fauces	origin	insertion	function	innervation
tensor veli palatini	spine and pterygoid process of the sphenoid bone and cartilaginous wall of the auditory tube	palatine aponeurosis	tenses the soft palate and fortifies the wall of the auditory tube	mandibular nerve – division of the trigeminal nerve [CN V]
levator veli palatini	petrous part of the temporal bone anterior to the external opening of the carotid canal and cartilaginous wall of the auditory tube	palatine aponeurosis	elevates the soft palate	vagus nerve [CN X] via pharyngeal plexus
palatoglossus	palatine aponeurosis	side of the tongue	depresses the soft palate and moves the palatoglossal arch downward to the midline and elevates the root of the tongue	
palatopharyngeus*	hard palate and palatine aponeurosis	muscular coat of the pharynx	depresses the soft palate and moves the palatopharyngeal arch downward to the midline and elevates the pharynx	
musculus uvulae	posterior nasal spine of the hard palate and palatine aponeurosis	connective tissue of the uvula	shortens uvula and pulls it superiorly	

Table 5: Muscles of the soft palate and fauces

** Palatopharyngeus muscle belongs to the levators of the pharynx according to its function.*

1.2.3.4 Vessels and nerves of the hard and soft palate

- **Arterial supply** comes from the descending palatine artery (branch of the maxillary artery) and from the ascending palatine artery (branch of the facial artery). Branches from the ascending pharyngeal artery also participate in the vascular supply to the palate.
- **Veins** drain into the pterygoid plexus and via the pharyngeal venous network into the internal jugular vein.
- **Lymph** drains into the submandibular and deep cervical lymph nodes.
- The palate receives the **sensory innervation** from the branches of the maxillary nerve (V2) – division of the trigeminal nerve [CN V].
- **Motor innervation** for the muscles of the soft palate and fauces, except the tensor veli palatini muscle, arises from the vagus nerve [CN X] via the pharyngeal plexus. The tensor veli palatini muscle is innervated by the mandibular nerve – division of the trigeminal nerve [CN V].
- **Parasympathetic innervation** is carried by the facial nerve [CN VII].

1.2.4 OROPHARYNGEAL ISTHMUS (Isthmus faucium in Latin)

The oropharyngeal isthmus (isthmus of fauces) is a narrow space between the oral cavity and the oral part of the pharynx. It is bounded superiorly by the **soft palate** and inferiorly by the **root of the tongue**. On either side are the **palatoglossal** and **palatopharyngeal arches**, which form the pillars of the fauces and border the tonsillar fossa with the **palatine tonsil**.

An adult and a child, with the exception of an infant, cannot breathe and swallow at the same time. Thus, when swallowing, the oropharyngeal isthmus widens due to the elevation of the soft palate. Horizontal position of the soft palate separates the nasopharynx from the oropharynx and closes the airway. The laryngeal inlet is also closed, so fluids and solids are directed into the esophagus.

When chewing, the oropharyngeal isthmus narrows and keeps the bite in the oral cavity while breathing is allowed.

The narrowing of the oropharyngeal isthmus is the result of the interplay of several structures – the root of the tongue is elevated, the soft palate is depressed and palatoglossal and palatopharyngeal arches move toward the midline.

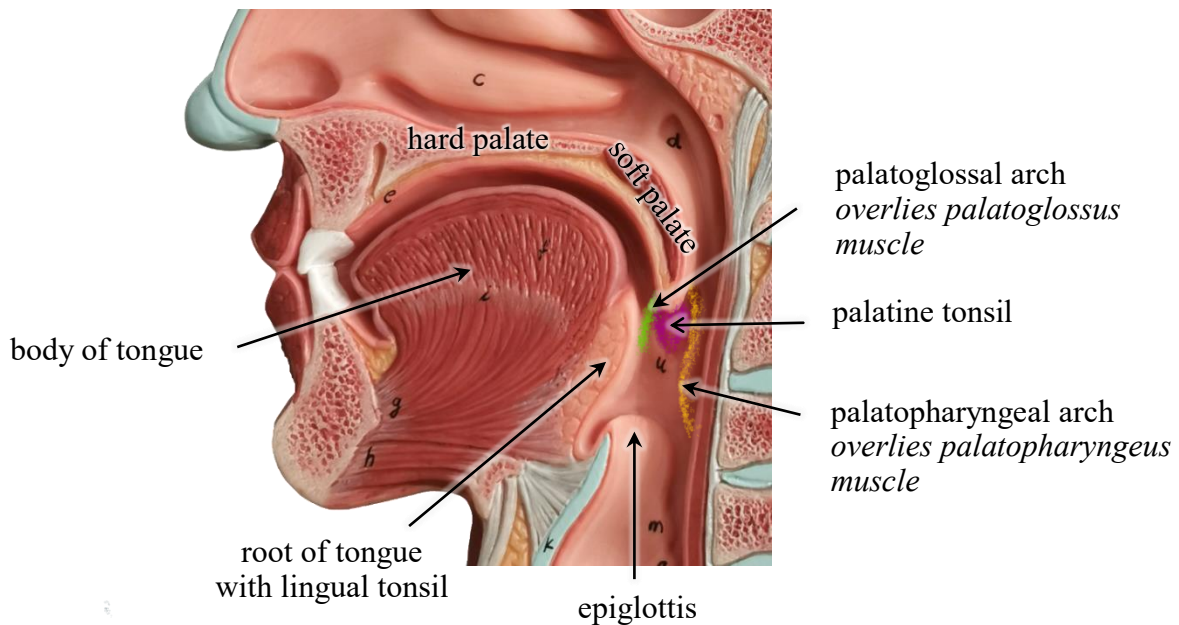


Fig. 31
Borders of the oropharyngeal isthmus
Sagittal plane - section of the head
Photography of SOMSO model
Modified by additional drawing and labeling

1.2.5 PALATINE TONSIL (*Tonsilla palatina* in Latin)

The **palatine tonsil** is a lymphoepithelial organ, which is located between the palatoglossal and palatopharyngeal arches. It is lodged in recess, which is called the **tonsillar fossa (tonsillar sinus)**. The lateral surface of the palatine tonsil is covered by the fibrous **tonsillar capsule**. The peritonsillar space, which is located between the tonsillar capsule and pharyngeal wall, is filled with soft tissue and contains the venous **tonsillar plexus**. The medial (inner) surface of the palatine tonsil is lined by the mucosa and it is uneven with numerous **tonsillar pits** that extend into epithelial recesses, the **tonsillar crypts**.

Tonsillectomy (surgical removal of the palatine tonsil) or opening of a peritonsillar abscess can lead to complications such as postoperative bleeding. The source of bleeding may be damage to the external palatine vein (also called the paratonsillar vein) of the tonsillar plexus. The second source of bleeding may be arterial. The internal carotid artery is closely related to the palatine tonsil. It usually lies 1 – 1.5 cm behind the tonsillar fossa. Injury to this artery may lead to fatal bleeding.

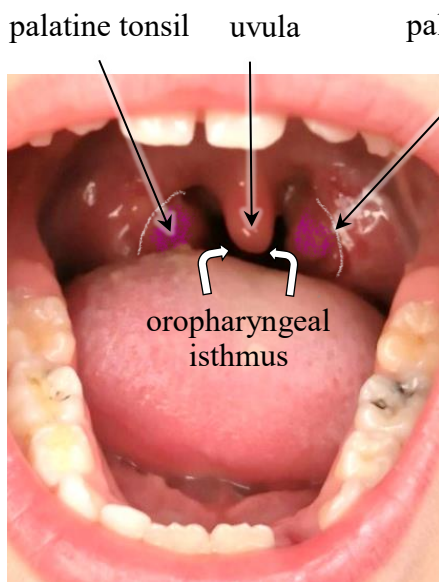


Fig. 32 A

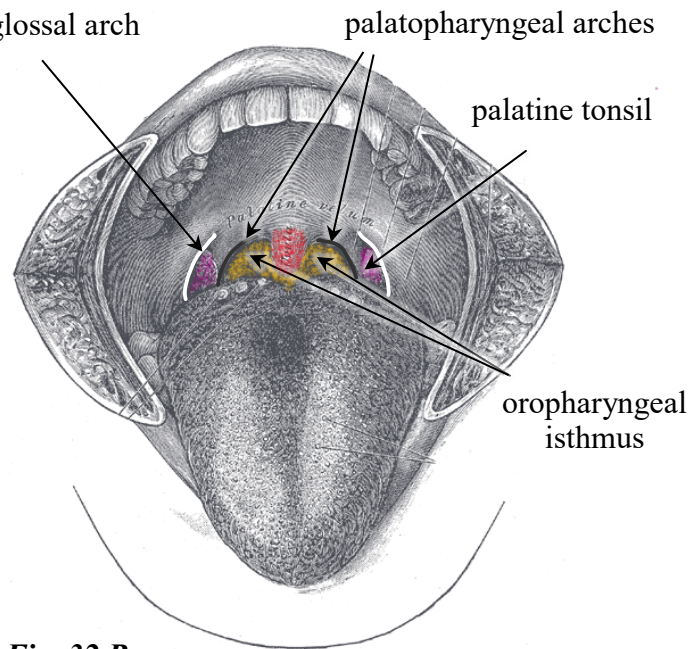


Fig. 32 B

The palatine tonsil and its inner surface is visible through the open mouth when the tongue is depressed.

Fig. 32
Oropharyngeal isthmus and palatine tonsils

32 A – Photo from the authors' archive

32 B – Original diagram from Gray's Anatomy, 20th US edition which has now lapsed into the public domain (out of copyright). Gray H.: Anatomy of the human Body. Philadelphia: Lea & Febiger, 1918.

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1.2.5.1 Vessels and nerves of the palatine tonsil

- **Arterial supply** comes from multiple sources. The palatine tonsil is blood supplied by the ascending palatine artery (branch of the facial artery), ascending pharyngeal artery (branch of the external carotid artery), descending palatine artery (branch of the maxillary artery) and the dorsal lingual artery (branch of the lingual artery).
- **Veins** drain via the tonsillar plexus into the facial, lingual and pharyngeal veins.
- **Lymph** drains into the deep cervical lymph nodes.
- **General sensory innervation** is carried by the branches of the maxillary nerve (V2) – division of the trigeminal nerve [CN V].
- **Sensory innervation** is carried by the branches of the glossopharyngeal nerve [CN IX] and also by the minor palatine nerves, which are branches of the maxillary nerve (V2).

1.2.6 FLOOR OF THE MOUTH

The floor of the mouth includes the soft tissues between the medial aspect of the mandibular body and the hyoid bone. It represents the inferior border of the oral cavity. The floor of the mouth is formed by several structures:

- **Muscular diaphragm** which is a flexible horizontal U-shaped plate extending between the medial aspects of the mandibular body. The principal muscles of this diaphragm are bilateral **mylohyoid muscles**. They are flat, thin, triangular-shaped muscles originating from the mandible and inserted to the median fibrous raphe and to the body of the hyoid bone. Their posterior margin is free. Muscles raise the floor of the mouth and support the tongue. They pull the larynx forward during swallowing.
- **Geniohyoid muscles** – paired narrow cord-like muscles situated superior to the mylohyoid muscles and inferior to the tongue. They aid the mylohyoid muscles.
- **Body of the tongue** (anterior two-thirds / oral part of the tongue) is attached to the floor of the mouth by the midline mucosal fold, the **frenulum of the tongue** (lingual frenulum).

Other important structures of the floor of the mouth include bilaterally: the sublingual fold, which overlies the sublingual gland, the sublingual caruncle (papilla), the deep part of the submandibular gland and the submandibular duct.

1.2.6.1 Vessels and nerves of the floor of the mouth

- **Arterial supply** comes from the sublingual artery, which is a branch of the lingual artery, and from the branches of the facial artery.
- **Veins** accompany the arteries and basically drain venous blood into the internal jugular vein.
- **Lymph** drains into the upper group of the deep cervical lymph nodes and from the posterior part also into the submandibular lymph nodes.
- The floor of the oral cavity receives the **sensory innervation** from the lingual nerve, which is a branch of the mandibular nerve (V3) – division of the trigeminal nerve [CN V].
- The mylohyoid muscle is nerve supplied by the mylohyoid nerve, which is the branch of the mandibular nerve (V3). The geniohyoid muscle is innervated by the cervical spinal nerves, via the hypoglossal nerve [CN XII].

2 SALIVARY GLANDS (Glandulae oris in Latin)

The salivary glands are numerous exocrine glands, that produce saliva through their ducts directly into the oral cavity.

- **Minor salivary glands** secrete saliva continuously, permanently. They are scattered in the submucosa or mucosa of the oral epithelium lining the lips, cheeks, tongue and palate. They are referred to by their position as:

- **labial glands** – on the inner side of the lips;
- **buccal glands** – on the inner side of the cheeks; the buccal glands underneath the mucous membrane of the mouth at the level of the molar teeth are called the **molar glands**;
- **lingual glands** – on the tongue;
- **palatine glands** – located beneath the mucous membrane of the palate; there are two larger masses, one on each side of the midline of the palate.

Minor salivary glands produce only 5 to 8% of the total production of saliva, but this amount is enough to keep the mouth moist, when the major salivary glands are not working.

- **Major salivary glands** secrete saliva on the basis of a nerve stimulus. They drain saliva into the oral cavity through longer excretory ducts. The major salivary glands include the paired:

- **parotid gland** – it is located on the side of the face and in the retromandibular space; the parotid duct opens out into the oral vestibule at the orifice opposite the second upper molar tooth;
- **submandibular gland** – it is located mostly within the submandibular triangle and it lies also on the floor of the mouth; the submandibular duct opens at the sublingual caruncle (papilla);
- **sublingual gland** – it is located on the floor of the mouth; the major sublingual duct opens at the sublingual caruncle (papilla) and the minor sublingual ducts open on the surface of the sublingual folds.

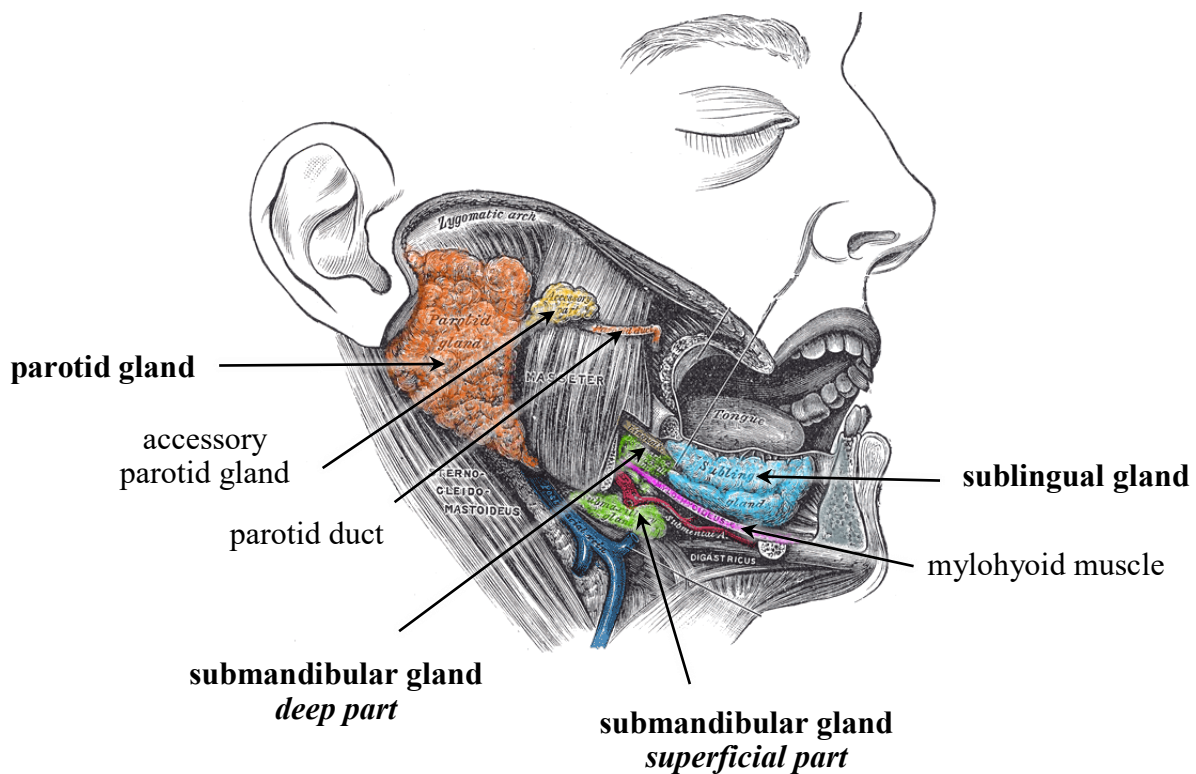


Fig. 33

Major salivary glands – parotid, submandibular and sublingual gland

The right side

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2.1 PAROTID GLAND (Glandula parotis in Latin)

The parotid gland is the largest of the major salivary glands. It lies on the side of the face, immediately below and in front of the external ear. Anatomically, it occupies the parotid region and the retromandibular fossa. About 75% or more of the gland overlies the masseter muscle. The rest is located retromandibular.

The parotid gland overlaps the ramus of the mandible and extends to the temporomandibular joint and the external auditory canal. Cranially, it extends up to the zygomatic arch. Caudally, it overlaps the upper portion of the sternocleidomastoid muscle and the posterior belly of the digastric muscle. At the front, it lies on the masseter muscle. It is completely enclosed in the tough **parotid fascia** (parotid capsule).

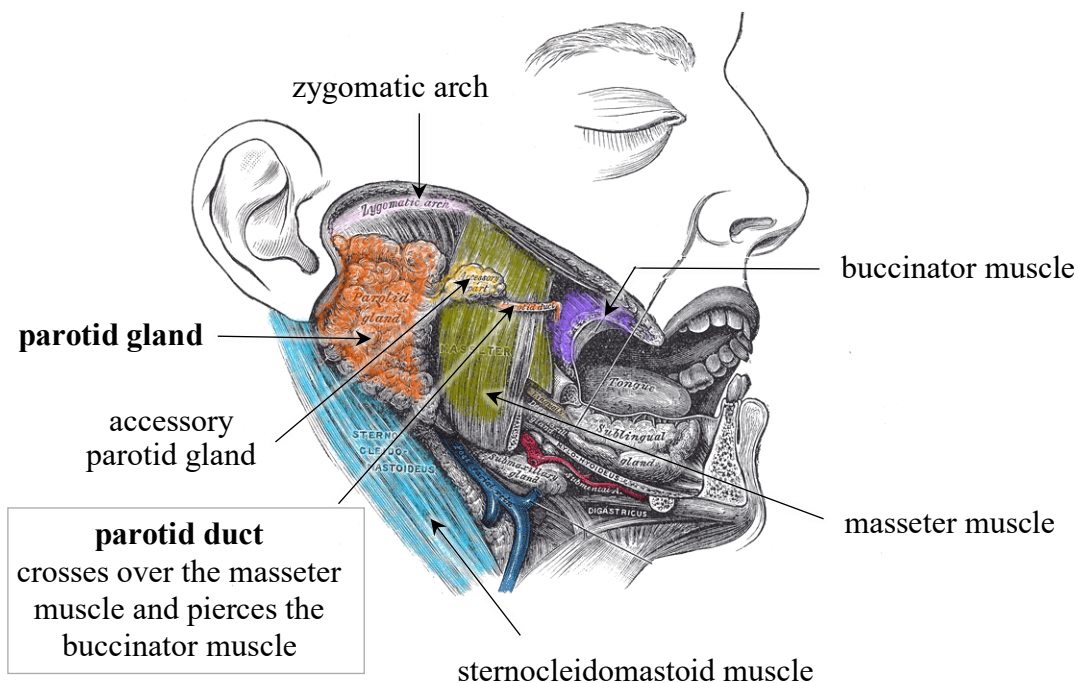


Fig. 34

Parotid gland – location

The right side

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Inside the gland, the branches of the facial nerve [CN VII] form the parotid plexus. This nerve plexus divides the gland into:

- **superficial part**, which lies superficial to the parotid plexus;
- **deep part**, which lies deep to the parotid plexus.

Although the facial nerve passes through the gland, the facial nerve does not provide any innervation to it!

The other several neurovascular structures pass through the substance of the parotid gland and they are important, especially during parotid gland surgery – Table 6.

The **parotid duct** (*Stensen's duct*) is about 5 – 7 cm long. It runs horizontally and most of its course is usually located at the junction between the tragus of the auricle and the upper lip. It crosses over the masseter muscle, usually passes through the buccal fat pad (corpus adiposum) and pierces the buccinator muscle. It opens out into the oral vestibule on the mucous membrane of the cheek through a small orifice, the **papilla of the parotid duct**, opposite the second upper molar tooth.

The **accessory parotid gland** usually lies on the masseter muscle and often follows the parotid duct.

Facial nerve and its branches	It runs within the substance of the parotid gland and gives off five motor branches that innervate the muscles of the facial expression (<i>see Fig. 35</i>).
External carotid artery and its branches	It ascends through the parotid gland and after giving off the posterior auricular artery, it divides into its two terminal branches, the superficial temporal artery and maxillary artery .
Retromandibular vein and its tributaries	It is formed within the parotid gland by the confluence of the maxillary veins and superficial temporal vein.
Auriculotemporal nerve	It is a branch of the mandibular division (V3) of the trigeminal nerve [CN V], that accompanies the superficial temporal vessels.

Table 6: Relationship of the parotid gland to surrounding neurovascular structures

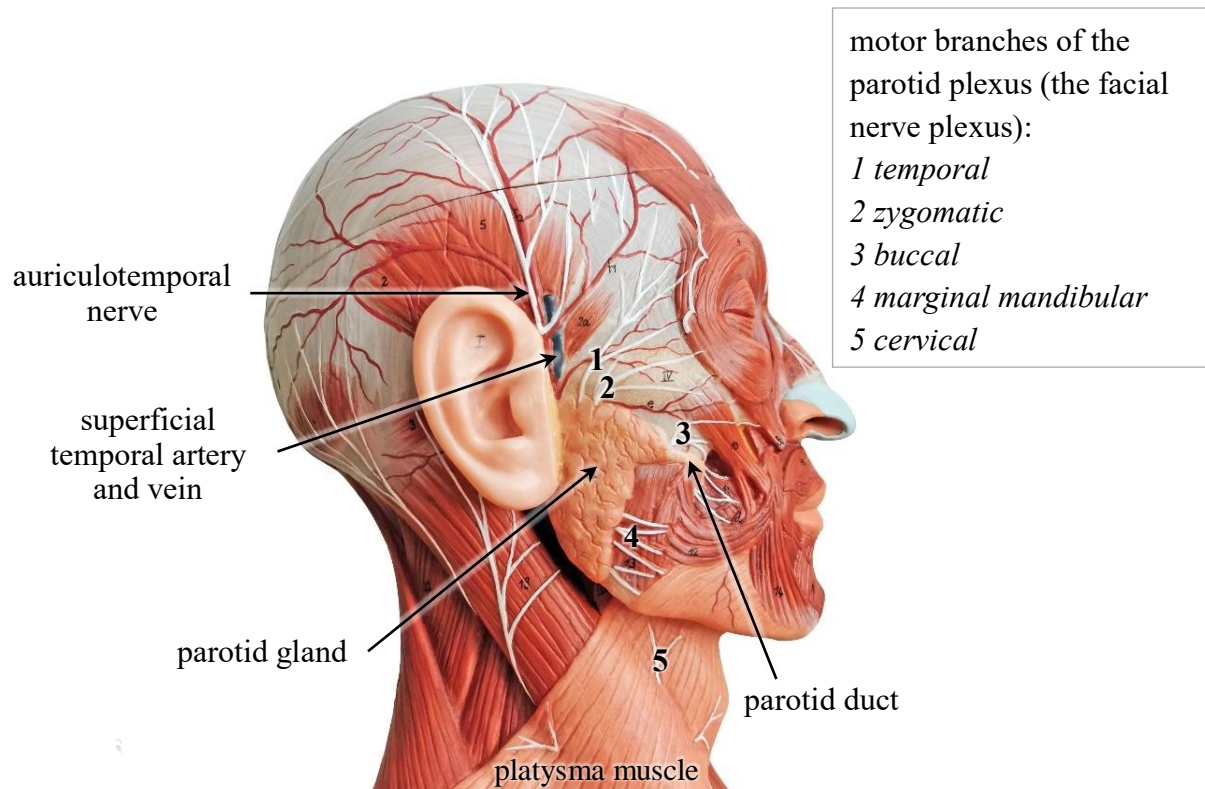


Fig. 35

Relation of the parotid gland to surrounding neurovascular structures

Photography of SOMSO model

Modified by additional drawing and labeling

2.1.1 Vessels and nerves of the parotid gland

- **Arterial supply** to the parotid gland comes from the numerous arteries that pass through its substance – from the superficial temporal artery and also from its branch, the transverse facial artery, maxillary artery and posterior auricular artery.
- **Venous blood** is drained into the retromandibular vein.
- **Lymph** drains into the superficial and deep cervical lymph nodes.
- **Sensory innervation** of the parotid gland is by the auriculotemporal nerve, which is a branch of the mandibular nerve (V3) – division of the trigeminal nerve [CN V].
- **Parasympathetic innervation** is carried by the glossopharyngeal nerve [CN IX].
- **Sympathetic innervation** to the greater salivary glands arises from the superior cervical ganglion and follows the branches of the external carotid artery. The autonomic innervation controls the rate of saliva production.

2.2 SUBMANDIBULAR GLAND (*Glandula submandibularis* in Latin)

The submandibular gland lies along the inner surface of the mandible. The gland wraps around the posterior margin of the mylohyoid muscle, therefore it has a greater, superficial part and a smaller, deep part.

- **Superficial part of the submandibular gland** lies inferior to the mylohyoid muscle on the inner surface of the mandible in its submandibular fossa. It is located outside the oral cavity in the submandibular triangle (also referred to as the digastric triangle). Superficially, it is covered by the skin, platysma and investing fascia.
- **Deep part of the submandibular gland** lies on the superior surface of the mylohyoid muscle within the oral cavity. It is located lateral to the hyoglossus muscle.

The **submandibular duct** (*Wharton's duct*) is approximately 5 cm in length and emerges from the deep part of the gland. It runs forward on the mylohyoid muscle to open into the floor of the mouth at the small mucosal projection, the **sublingual caruncle** (*papilla*). The caruncle is located just lateral to the base of the frenulum of the tongue. The submandibular duct crosses the lingual nerve, which passes anteromedially through the floor of the mouth.

The submandibular gland and duct are related to the facial vessels, lingual and mylohyoid nerves (both nerves are branches of the mandibular nerve (V3), division of the

trigeminal nerve [CN V]), the hypoglossal nerve [CN XII] and the motor mandibular branch of the facial nerve [CN VII] – Table 7.

The submandibular lymph nodes lie in contact with the surface of the gland and within its substance, so it is necessary to remove both the gland and the nodes during the radical neck dissection.

Facial vessels	Facial artery runs medial to the superficial part of the submandibular gland or passes through its substance, whereas the facial vein usually runs superficial to the gland.
Facial nerve	Mandibular branch of the facial nerve is a motor branch, which supplies muscles of the lower lip and chin. <i>Injuries of this nerve result in paresis or paralysis of the muscles of this region and are present as drooping of the lower lip.</i>
Hypoglossal nerve	Hypoglossal nerve gives off the branches to innervate the muscles of the tongue (except palatoglossus muscles). <i>Injuries can lead to dysarthria and tongue deviation to the side of the lesion. However, injury to this nerve is rare to such an extent as to cause visible disability.</i>
Lingual nerve	Lingual nerve carries sensory innervation from the anterior two-thirds of the tongue. It also stores the special sensory fibers for the taste of the anterior two-thirds of the tongue (belonging to the chorda tympani). <i>Immediate postoperative ipsilateral paresthesia and loss of taste from the anterior two-thirds of the tongue are usually temporary and rarely permanent.</i>

Table 7: Relationship of the submandibular gland and submandibular duct to surrounding neurovascular structures

2.2.1 Vessels and nerves of the submandibular gland

- **Arterial supply** to the submandibular gland comes from the branches of the facial and lingual artery.
- **Veins** accompany the arteries and basically drain venous blood into the internal jugular vein.

- **Lymph** drains into the submandibular lymph nodes and sequentially into the superficial and the deep cervical lymph nodes.
- **Sensory innervation** of the gland is by the lingual nerve through the mandibular nerve (V3), division of the trigeminal nerve [CN V].
- **Parasympathetic innervation** is carried by the chorda tympani, which is a branch of the facial nerve [CN VII]. The chorda tympani joins the lingual nerve – branch of mandibular nerve (V3).
- **Sympathetic innervation** to the greater salivary glands arises from the superior cervical ganglion and follows the branches of the external carotid artery.

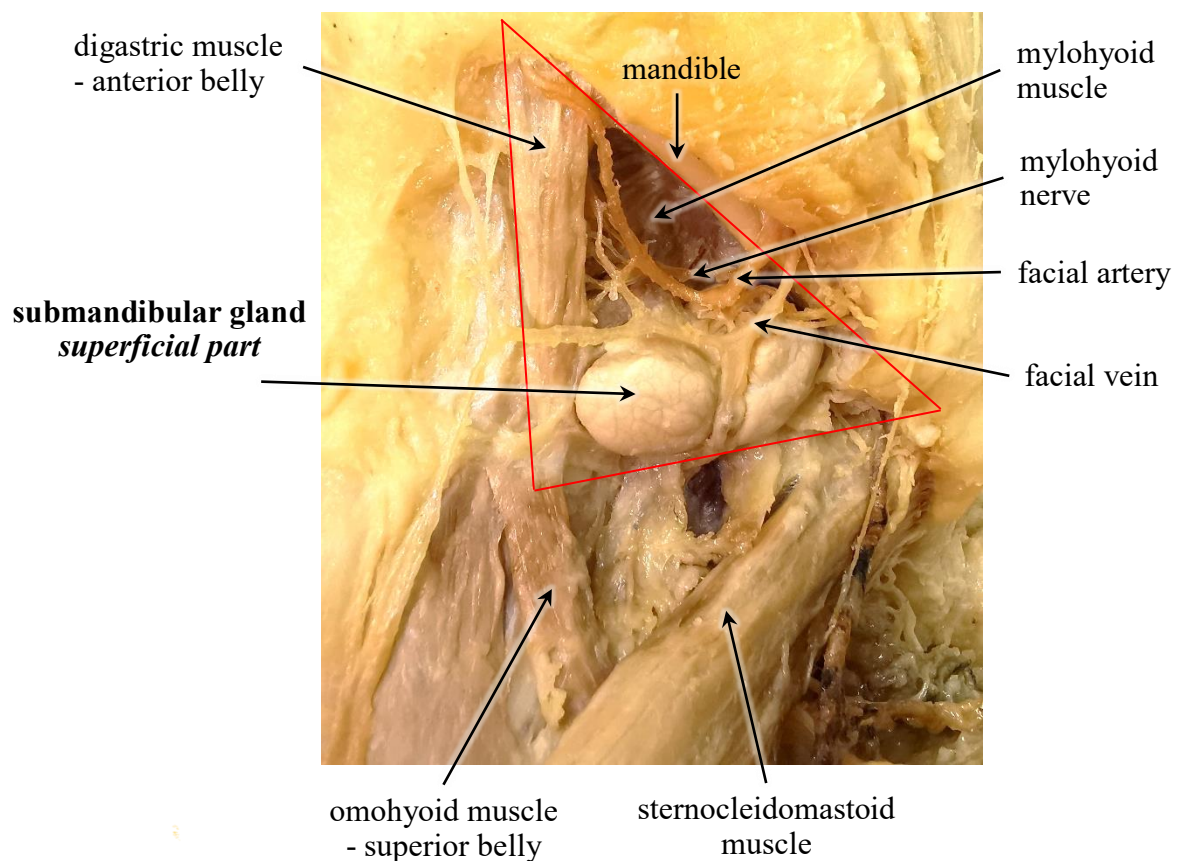


Fig. 36

***Superficial part of the left submandibular gland within the submandibular triangle
The posteroinferior border of the submandibular triangle, formed by the posterior belly of the digastric muscle and the stylohyoid muscle, is not visible***

*Formalin-fixed cadaveric specimen, Department of Anatomy,
Jessenius Faculty of Medicine, Comenius University*

2.3 SUBLINGUAL GLAND (*Glandula sublingualis* in Latin)

The sublingual gland is the smallest of the major salivary glands. The entire sublingual gland is located immediately beneath the mucous membrane of the floor of the mouth and superior to the mylohyoid muscle. The gland elevates the mucosa to form the elongated **sublingual fold**. It extends obliquely from the sublingual caruncle posterolaterally.

Laterally, the gland is bounded by the inner surface of the mandible and lies in the shallow mandibular depression, the sublingual fossa. Along its medial side, the submandibular duct and the lingual nerve run. At the front, two sublingual glands almost meet each other.

The **major sublingual duct** opens together with the submandibular duct on the **sublingual caruncle (papilla)**. Numerous **minor sublingual ducts** open on the surface of the **sublingual fold**.

2.3.1 Vessels and nerves of the sublingual gland

The vascular and nerve supply to this gland is the same as for the submandibular gland.

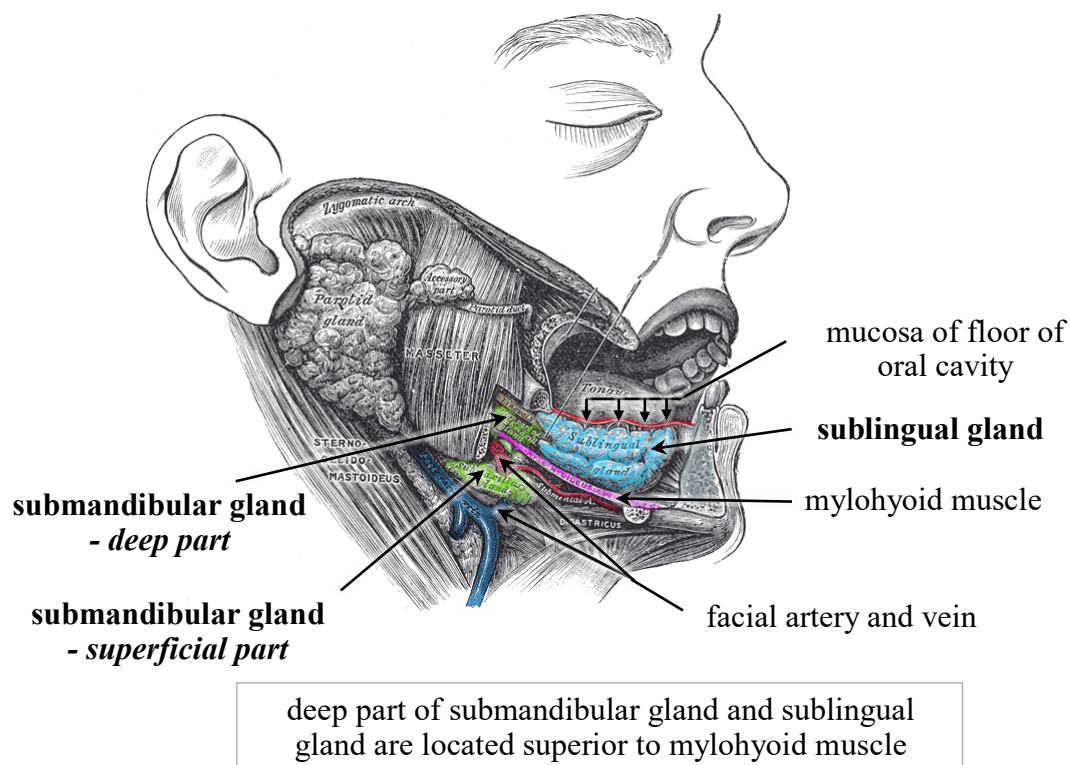


Fig. 37

Submandibular and sublingual gland

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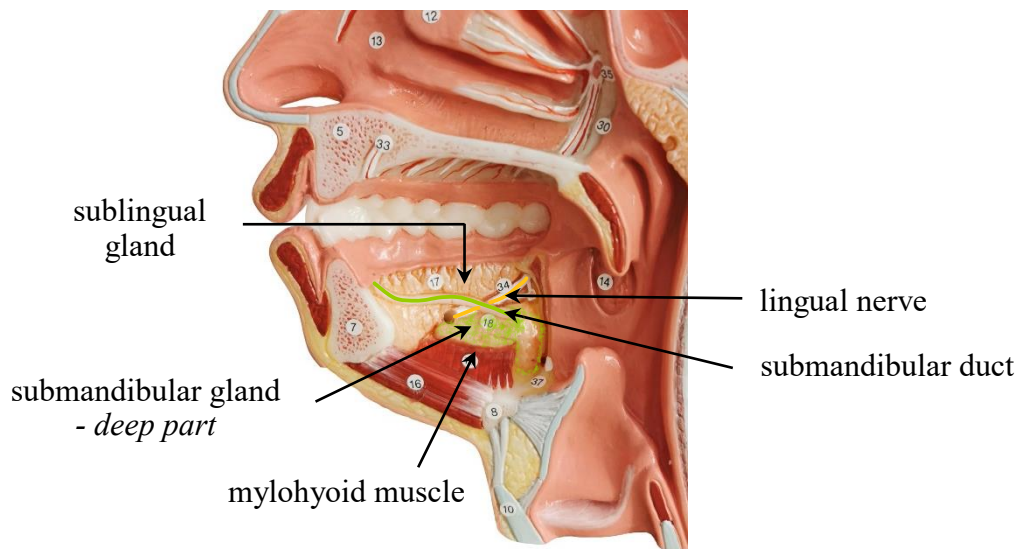


Fig. 38
Relation of the sublingual gland to surrounding structures
 Photography of SOMSO model
 Modified by additional drawing and labeling

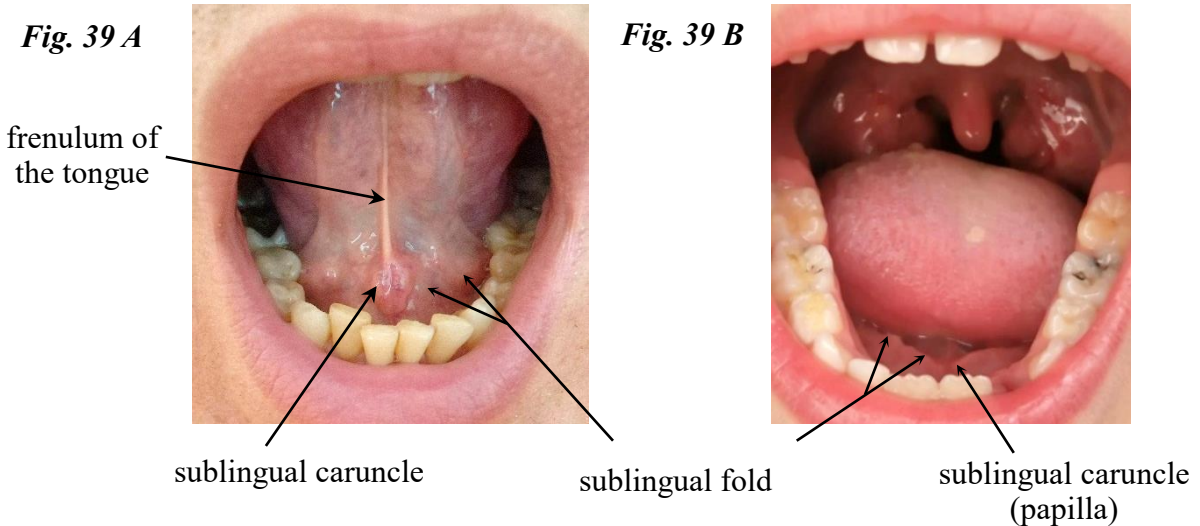


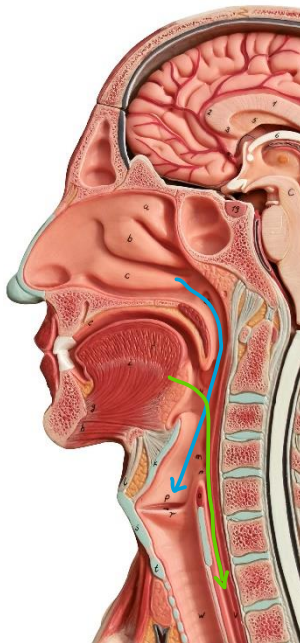
Fig. 39 A + 39 B
Sublingual caruncle (papilla) and sublingual fold
39 A – elevated tongue; 39 B – tongue at rest
 Photo from the authors' archive

The sublingual caruncle (sublingual papilla) is a small mucosal projection that is one on either side of the frenulum of the tongue. It indicates the point where the submandibular and major sublingual ducts empty into the oral cavity.

The sublingual fold is a mucosal prominence overlying the sublingual gland that extends obliquely from the caruncle posterolaterally.

3 PHARYNX

The pharynx is a musculofascial tube, which has roles in both the respiratory and alimentary systems. It is a common pathway for air and food. The pharynx transmits air from the nasal cavity to the larynx and it permits the passage of swallowed solids and liquid from the oral cavity into the esophagus. These two pathways cross at the oropharynx and then diverge at the level of the laryngopharynx. The pharynx also plays a role in immune defense.



The blue arrow indicates flow of air from the nasal cavity to the larynx and the green arrow indicates passage of food from the oral cavity to the esophagus. Both pathways cross at the oropharynx.

Fig. 40
Midsagittal section of the head

Photography of SOMSO model
Modified by additional drawing

3.1 Anatomical position and relations of the pharynx to neighbouring structures and organs

The pharynx is situated **behind the nasal and oral cavities** and **behind the larynx**. Cranially it is blindly terminated and fixed at the base of the cranium, caudally it continues directly into the esophagus. It begins at the external surface of the **cranial base** and ends at the **inferior border of the cricoid cartilage of the larynx**. This is approximately at the level of the **6th cervical vertebra**. Posteriorly, the retropharyngeal space, which contains loose connective tissue, separates the pharynx from the cervical part of the vertebral column and prevertebral muscles. On the sides of the pharynx, there are **internal jugular veins, vagus nerves** and **lobes of the thyroid gland**. Laterally, the pharynx is also related to the **carotid**

arteries - the laryngeal part of the pharynx to the common carotid artery and the other parts of the pharynx to the external and internal carotid arteries.

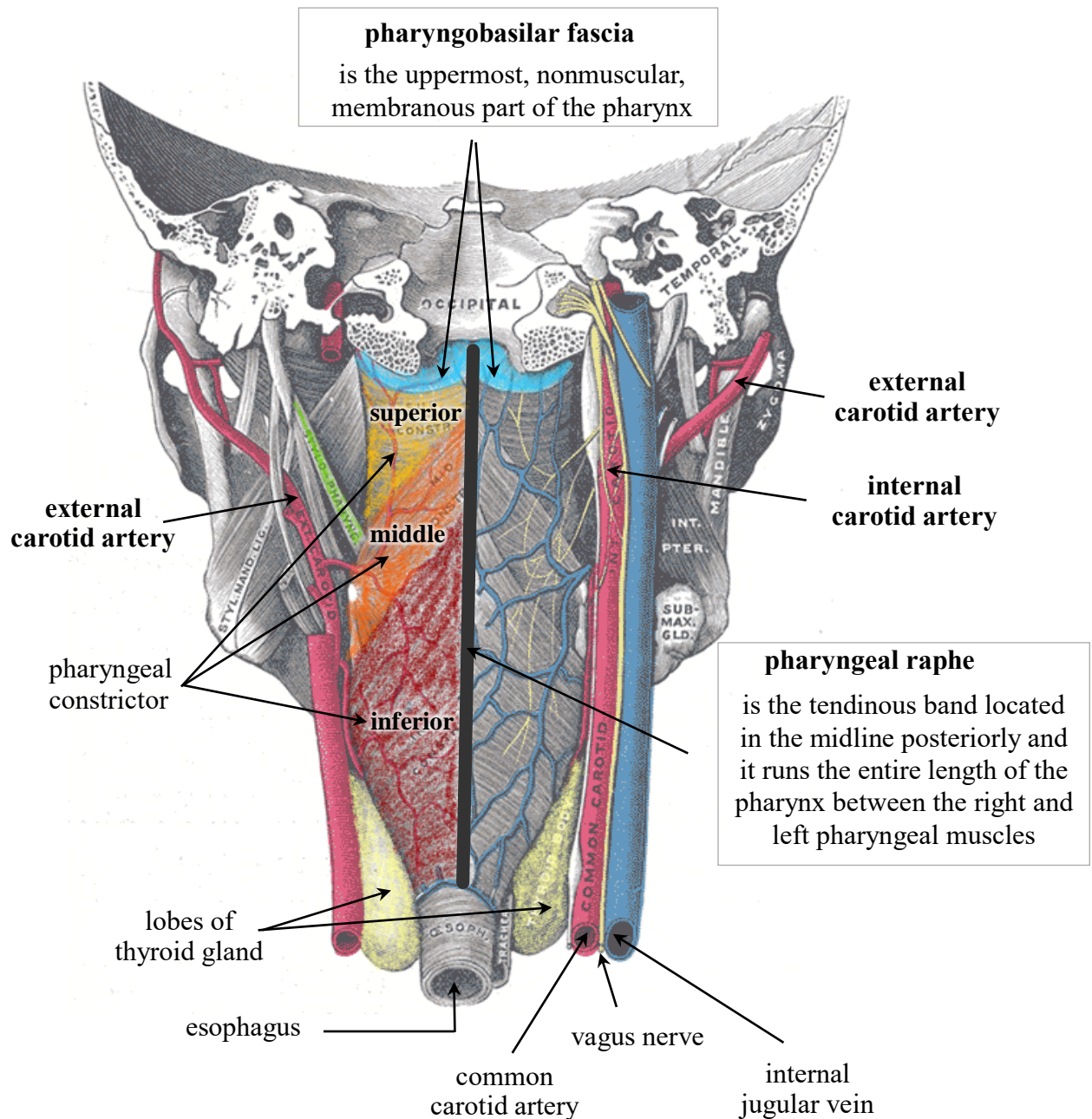


Fig. 41
Relations of the pharynx to the neurovascular structures
Posterior view

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3.2 Fixation of the pharynx

The pharynx is firmly connected only to the base of the skull. Further connection to the surrounding structures is through loose connective tissues that allow pharyngeal movements during swallowing. Fixation of the pharynx to the skull base runs in a line from the pharyngeal tubercle of the occipital bone laterally to the external opening of the carotid canal and then anteriorly to the medial plate of the pterygoid process of the sphenoid bone. The tendinous band, **pharyngeal raphe** begins from the pharyngeal tuberculum and runs the entire length of the pharynx to the esophagus. The pharyngeal raphe fixes the pharynx and is also the site of attachment of the pharyngeal constrictor muscles.

3.3 Parts of the pharynx

The pharynx is divided according to its anterior relations into the nasal, oral and laryngeal parts.

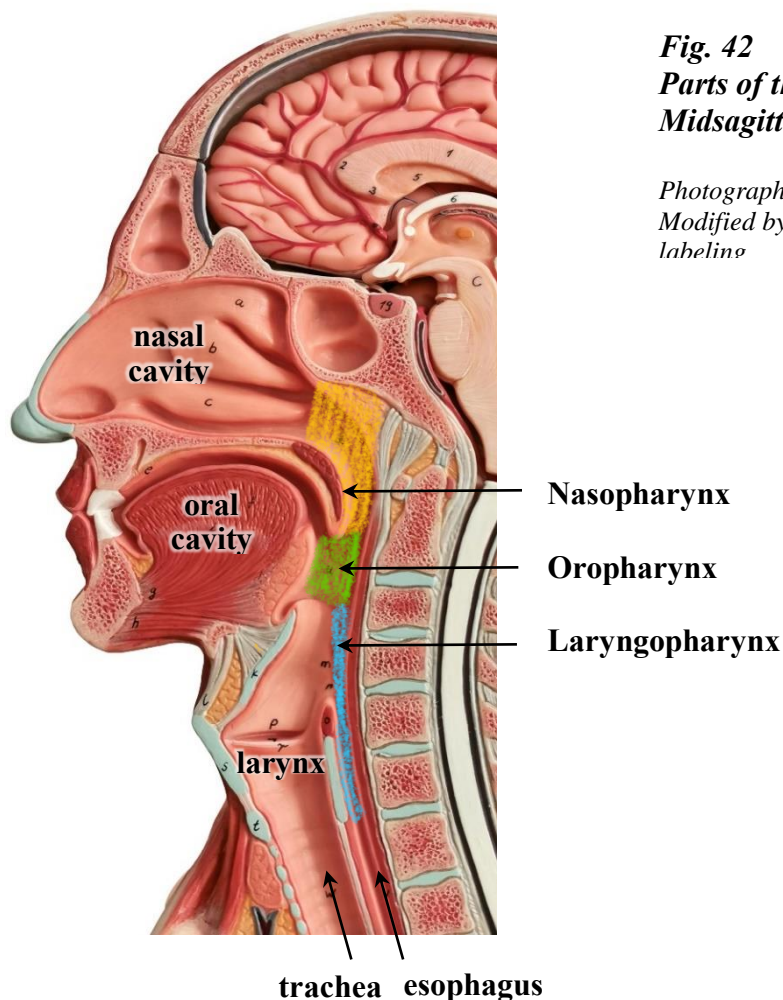


Fig. 42
Parts of the pharynx
Midsagittal section of the head

*Photography of SOMSO model
Modified by additional drawing and
labeling*

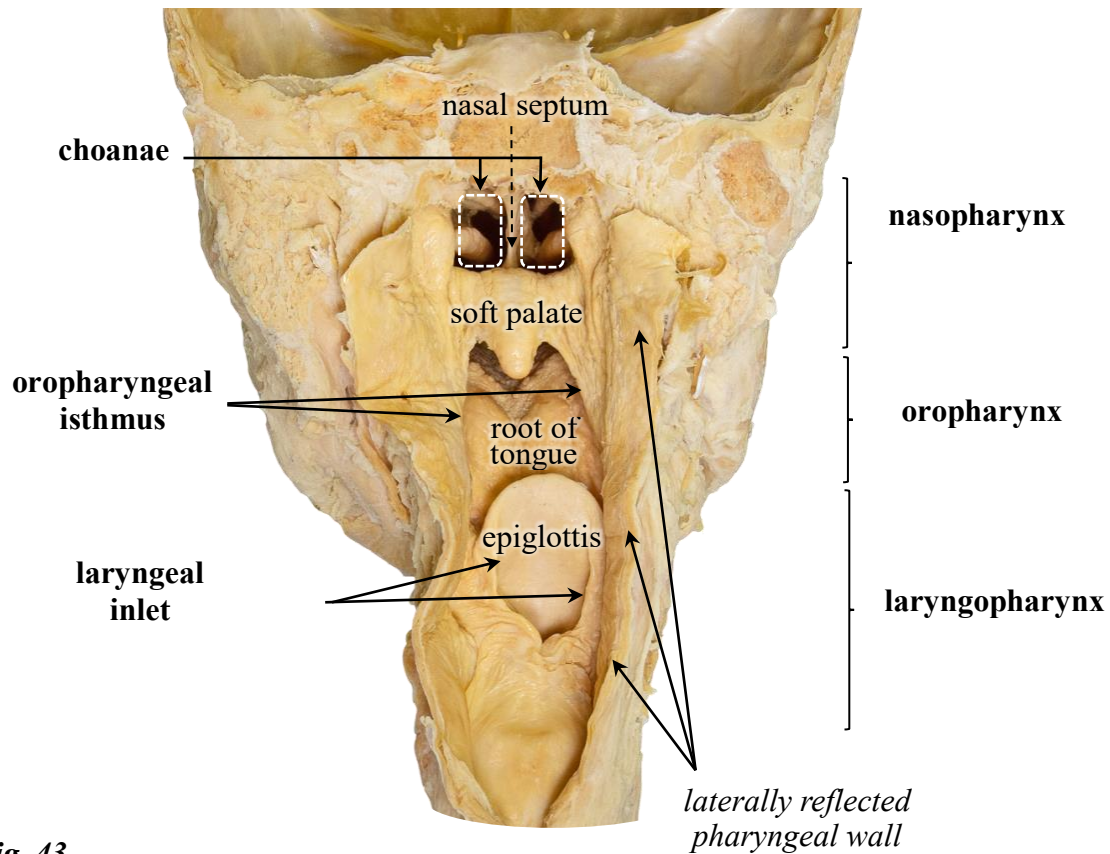


Fig. 43
Head – anterior relation of the pharynx
Posterior view with the pharyngeal wall open

*Formalin-fixed cadaveric specimen, Department of Anatomy,
 Jessenius Faculty of Medicine, Comenius University*

- **Nasal part of the pharynx**

It is the uppermost and largest part of the pharynx. It lies behind the nasal cavity and is connected to it through the **posterior nasal apertures (choanae)**. The nasopharynx extends from the cranium to the level of the soft palate. The pharyngeal wall is attached to the base of the skull only by the stretched, nonmuscular, membranous **pharyngobasilar fascia**, because the muscular layer is absent here. The vault of the pharynx, below the sphenoid bone, is inclined dorsocaudally, forming a **pharyngeal fornix**. A large collection of lymphoid tissue, known as the **pharyngeal tonsil**, is located under the mucosa of the fornix.

On each side of the pharyngeal wall, there is a **pharyngeal opening of the auditory tube**. Through this opening, the nasopharynx is connected to the middle ear. **Torus tubarius** is a prominence above and behind the opening of the auditory tube formed by its cartilaginous part. The **tubal tonsil** is submucosal lymphatic tissue near this opening.

There are two other folds associated with the pharyngeal opening of the pharyngotympanic tube:

- ***salpingopharyngeal fold***, which extends inferiorly from the *torus tubarius* and overlies the *salpingopharyngeal muscle*;
- ***torus levatorius***, which is just beneath the opening and is directed to the soft palate; it overlies the *levator veli palatini muscle*.

Enlargement of the pharyngeal tonsil, especially in children, known as adenoids or adenoid vegetations, can lead to narrowing of the nasopharynx and blockage of air passage during breathing. Breathing is therefore only possible through the oral cavity, which is not physiological. Adenoids can also lead to recurrent inflammatory diseases of the middle ear. The treatment of choice may be tonsillectomy (adenectomy), in which the pharyngeal tonsil is removed.

- **Oral part of the pharynx – oropharynx**

It is the middle part of the pharynx. It extends superiorly to the soft palate and inferiorly to the upper margin of the epiglottis. The oropharynx lies behind the oral cavity and is connected to it through the ***oropharyngeal isthmus (isthmus faucium)***. Isthmus with two lateral pillars – palatoglossal and palatopharyngeal folds, forms the border between the oral cavity and oropharynx. It includes the palatine tonsil embedded in the tonsillar fossa between the two named folds. The root of the tongue forms an anterior and inferior boundary of the oropharynx. The collection of the lymphoid tissue, the **lingual tonsil**, is embedded in the mucosa lining this part of the tongue.

Lymphatic pharyngeal ring – Waldeyer's tonsillar ring

It is a ringed arrangement of both larger and smaller collections of lymphoid tissue scattered in the mucous membrane lining the nasal and oral part of the pharynx. The lymphoid tissue of this ring belongs to the mucosa-associated lymphoid tissue (MALT) and serves the immune system. The largest collection of this ring is formed by distinct tonsils:

- unpaired **pharyngeal tonsil** and **lingual tonsil**
- paired **palatine tonsils** and **tubal tonsils**.

The lymphoid tissue of the Waldeyer's ring is located at the gateway of the respiratory and alimentary system and so it has an important protective role in the first line of defense against inhaled and ingested pathogens that enter the body.

- **Laryngeal part of the pharynx – laryngopharynx**

It is the lowermost part of the pharynx. It extends from the upper margin of the epiglottis to the level of the 6th cervical vertebra and the inferior border of the cricoid cartilage. The laryngopharynx lies behind the larynx and is connected to it through the ***laryngeal inlet***. A small pear-shaped depression, **piriform fossa** (recess), is located on each side of the laryngeal inlet. The mucous membrane of the piriform fossa is marked by the low fold, which is formed by the course of the internal laryngeal nerve, a branch of the superior laryngeal nerve.

Liquids and solids pass through the piriform fossa inferiorly to the esophageal inlet. Swallowed foreign bodies (e.g., small fish bones) may lodge in the fossa and irritate the delicate neuronal network. During their removal, the internal laryngeal nerve may be damaged, which results in anesthesia of the laryngeal mucosa down to the vocal folds.

3.4 Muscles of the pharynx

Unlike other organs of the digestive system, which have a muscular layer composed of smooth muscle, the pharyngeal wall has a muscular layer composed entirely of the striated muscles.

The pharyngeal muscular wall consists of the external circular layer formed by three pharyngeal constrictors and the internal longitudinal layer formed by three pharyngeal levators. All muscles are paired. Pharyngeal muscles function during swallowing and speaking.

Superior, middle and inferior pharyngeal constrictors (Table 8) originate anteriorly on either side of the wall of the nasal cavity, oral cavity and larynx. The muscles circularly enclose the lumen of the pharyngeal wall and overlap each other like roof tiles. They join dorsally and attach to the tendinous band, the **pharyngeal raphe**. During swallowing, these muscles constrict or narrow the pharyngeal cavity to move the food bolus downward into the esophagus (an involuntary process).

The internal longitudinal layer consists of the **pharyngeal levators** – **palatopharyngeus, salpingopharyngeus and stylopharyngeus muscles** (Table 9). These muscles descend from their origins to the wall formed by the constrictors and penetrate and attach to the muscular layer. They are named according to their origins. Levators shorten and widen the pharynx during swallowing and speaking. They elevate the larynx and also the soft palate to prevent the food from entering the nasopharynx.

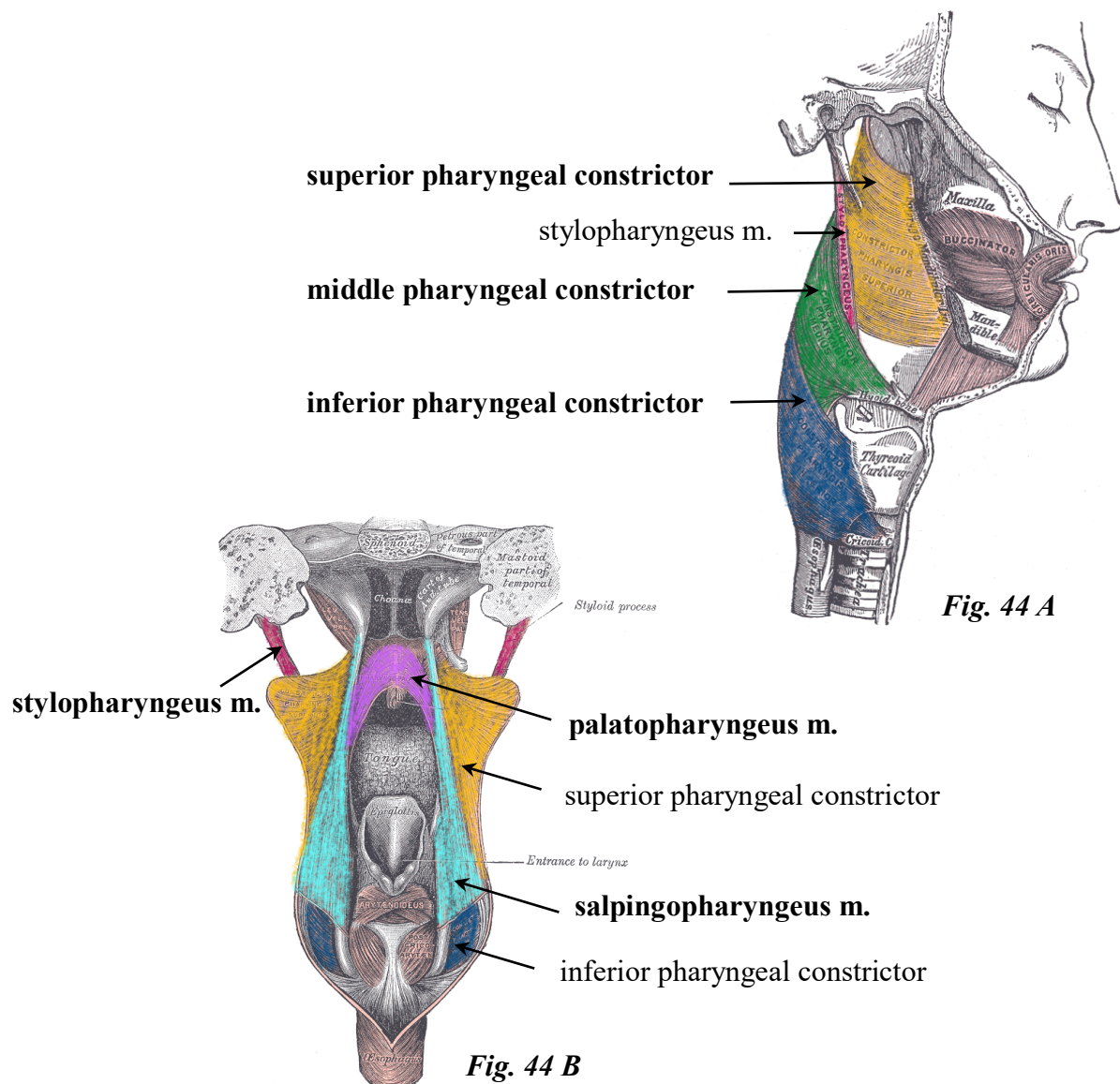


Fig. 44

Muscles of the pharynx

44 A – pharyngeal constrictors, sagittal plane

44 B – pharyngeal levators, posterior view

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constrictor muscles of the pharynx	origin	insertion	function	innervation
superior pharyngeal constrictor	<ul style="list-style-type: none"> - pterygoid process - pterygomandibular raphe - mandible - muscles of the tongue 	pharyngeal raphe	constricts pharyngeal wall during swallowing	vagus nerve [CN X] via pharyngeal plexus
middle pharyngeal constrictor	<ul style="list-style-type: none"> - greater and lesser horns of the hyoid bone 			
inferior pharyngeal constrictor	<ul style="list-style-type: none"> - thyroid cartilage - cricoid cartilage 			

Table 8: Pharyngeal constrictors

levator muscles of the pharynx	origin	insertion	function	innervation
palatopharyngeus	hard palate and palatine aponeurosis of the soft palate	muscular coat of the pharynx	elevates (shortens and widens) the pharynx during swallowing and speaking	vagus nerve [CN X] via pharyngeal plexus
salpingopharyngeus*	cartilaginous part of the auditory tube			
stylopharyngeus	styloid process of the temporal bone			glossopharyngeal nerve [CN IX]

Table 9: Pharyngeal levators

* Levators are named according to their origins. Salpingopharyngeus – salpinx is Greek for a tube.

3.5 Vessels and nerves of the pharynx

- Numerous direct and indirect branches of the external carotid **artery supply** the pharynx. These include: the ascending pharyngeal artery, ascending palatine artery which arises from the facial artery, descending palatine and sphenopalatine arteries which arise from the maxillary artery. The lower part of the pharynx is blood supplied by the inferior thyroid artery which originates from the thyrocervical trunk of the subclavian artery.
- The **pharyngeal veins** form the venous pharyngeal plexus, which drains into the pterygoid plexus in the infratemporal fossa and into the internal jugular vein either directly or via the facial vein.
- **Lymph** drains via the retropharyngeal and parapharyngeal nodes into the deep cervical lymph nodes.
- **Nerve supply** for the pharynx is via the neural pharyngeal plexus. This plexus is formed by the sensory fibers of the glossopharyngeal nerve [CN IX] and sensory and motor fibers of the vagus nerves [CN X]. The neural pharyngeal plexus also includes sympathetic fibers from the superior cervical ganglion.
- The vagus nerve [CN X] and its branches give off **motor nerve supply** for all pharyngeal muscles except the stylopharyngeus muscle, which is motor nerve supplied by the glossopharyngeal nerve [CN IX]. These two cranial nerves also provide **parasympathetic innervation** of the pharyngeal glands.
- **Sensory innervation** comes from the vagus [CN X] and glossopharyngeal nerves [CN IX]. Fibers from the maxillary division of the trigeminal nerve [CN V] also contribute to innervation for the anterior and superior nasopharynx.

4 ESOPHAGUS (Oesophagus in Latin)

The esophagus is a muscular tube about 25 cm long, that is responsible for the passage of food from the pharynx to the stomach. It has a star-shaped lumen with a diameter of 1.5 – 2 cm. However, it is flexible and expandable, so it can double its diameter when swallowed.

4.1 Anatomical position and curvatures of the esophagus

The esophagus begins in the neck as a direct continuation of the pharynx at the level of the **inferior border of the cricoid cartilage**, in front of the **6th cervical vertebra**. It continues downward and enters the thoracic cavity and passes through the mediastinum. The esophagus traverses the **diaphragm** through the **esophageal hiatus**, level with the **10th thoracic vertebra**. Its last part is located in the abdominal cavity, where ends at the cardia of the stomach, near the **11th thoracic vertebra**.

The esophagus descends anterior to vertebrae, generally in the midline position, and follows the curvature of the spine in the sagittal plane. As it passes through the thorax, the esophagus curves slightly three times. In the upper portion of the thorax, it first curves slightly to the left, in the middle portion it curves to the right and forms a groove on the right lung, and in the lower portion of the thorax, it curves again to the left forming an impression on the left lung. Below the diaphragm, in the abdominal cavity, it runs left to the spine and forms the impression on the left lobe of the liver.

4.2 Parts and relations of the esophagus to neighbouring structures and organs

According to the course, the esophagus is divided into three **parts** – **cervical** (CVI – TI), **thoracic** (TI – TX) from the superior thoracic aperture to the esophageal hiatus of diaphragm and **abdominal**, which is a short part between diaphragm and cardiac orifice of the stomach (TXI).

- **Cervical part of the esophagus**

In the beginning, level with the cricoid cartilage, the cervical part of the esophagus is narrowed by the **pharyngo-esophageal constriction**. The esophagus lies directly posterior to the cervical part of the **trachea**. It forms with the trachea bilateral grooves in which the

recurrent laryngeal nerves run. On either side of the esophagus, there is a **lobe of the thyroid gland** and in the carotid sheath, the **common carotid artery**, **internal jugular vein** and **vagus nerve**.

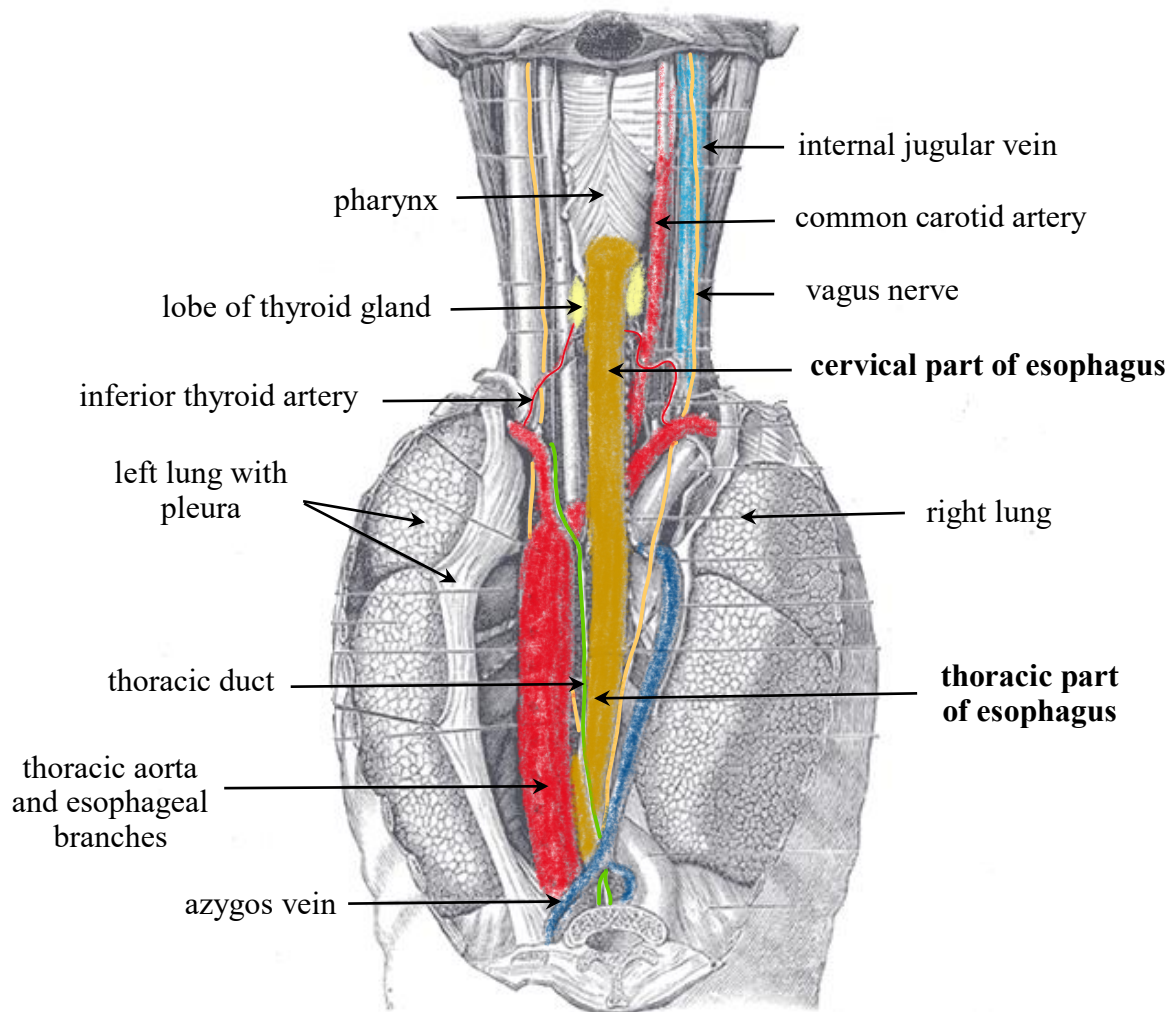


Fig. 45
Cervical and thoracic parts of the esophagus; some adjacent neurovascular structures are noted

Posterior view

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- **Thoracic part of the esophagus**

It is the longest part of the esophagus. It passes slightly to the right of the **thoracic aorta** and just above the diaphragm passes from the right to the left side, crossing the aorta anteriorly. The thoracic aorta comes into position just behind the esophagus.

Anterior to the thoracic part of the esophagus, there are (from above downward): **thoracic part of the trachea, principal bronchi** (in close relation it is mainly the **left principal bronchus**), and **heart** in the pericardium. Posterior to the esophagus, there are **vertebral column, posterior intercostal arteries, thoracic duct** (main lymphatic duct), **azygos vein**, terminal portion of the **hemiazygos** and **accessory hemiazygos veins**, near the diaphragm **thoracic aorta**.

On the left side, there are **aortic arch**, which continues into the **thoracic aorta**, **left subclavian artery, thoracic duct, left vagus nerve** and **left pleural cavity with the lung**. Anterolaterally, but only on the left side, the esophagus is related to the **left recurrent laryngeal nerve**.

On the right side, there is the arch of the **azygos vein**, the **right vagus nerve** and the **right pleural cavity with the lung**.

- **Abdominal part of the esophagus**

It is the shortest part, 1 – 2 cm long. Anterior to the esophagus, there is the **left lobe of the liver**, on which it forms the esophageal impression. Posterior to the esophagus, there is the **diaphragm**. The abdominal part of the esophagus is **intraperitoneal in position**.

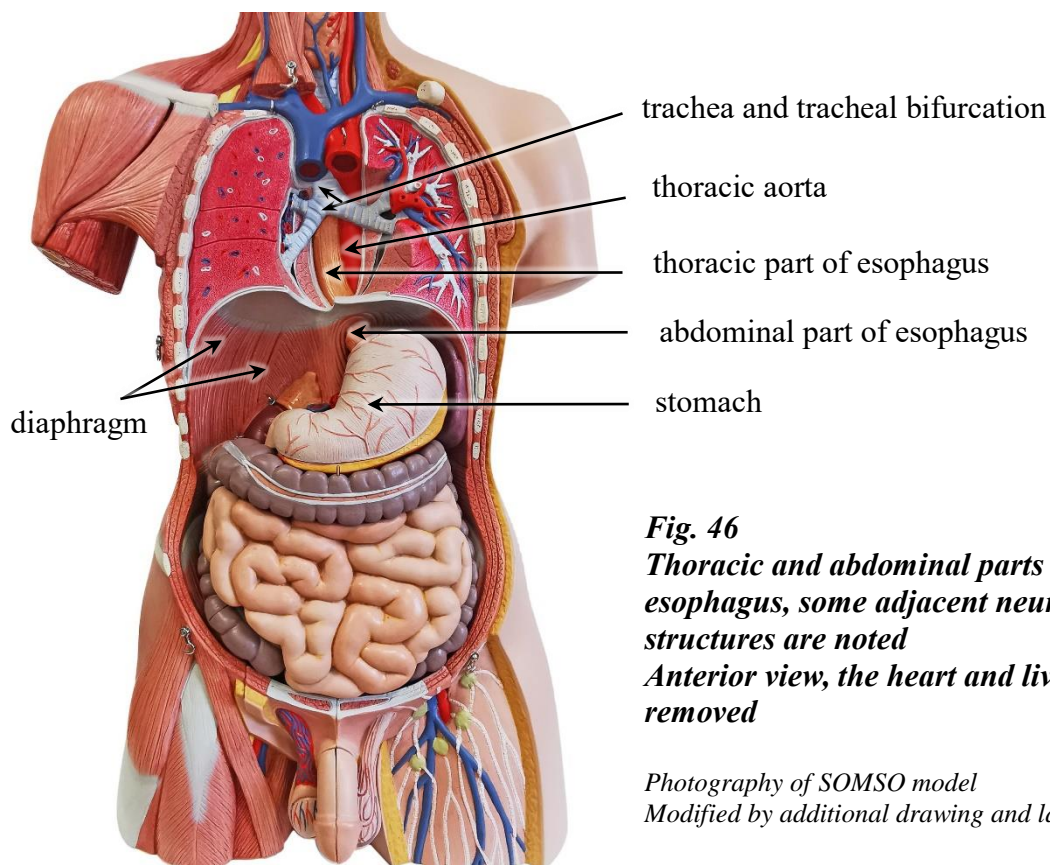


Fig. 46
Thoracic and abdominal parts of the
esophagus, some adjacent neurovascular
structures are noted
Anterior view, the heart and liver are
removed

Photography of SOMSO model
Modified by additional drawing and labeling

4.3 Muscular coat of the esophagus

The wall of the esophagus consists of the striated muscle in the upper third, a mixture of the striated and smooth muscle in the middle third (from the junction with the left main bronchus), and only smooth muscle in the lower third. The external layer is formed by the longitudinally oriented muscular fibers and the internal layer is circular. The circular layer at the distal end of the esophagus forms only a "functional" sphincter (not anatomical), that controls the passage of contents into the stomach and prevents backward progression into the esophagus.

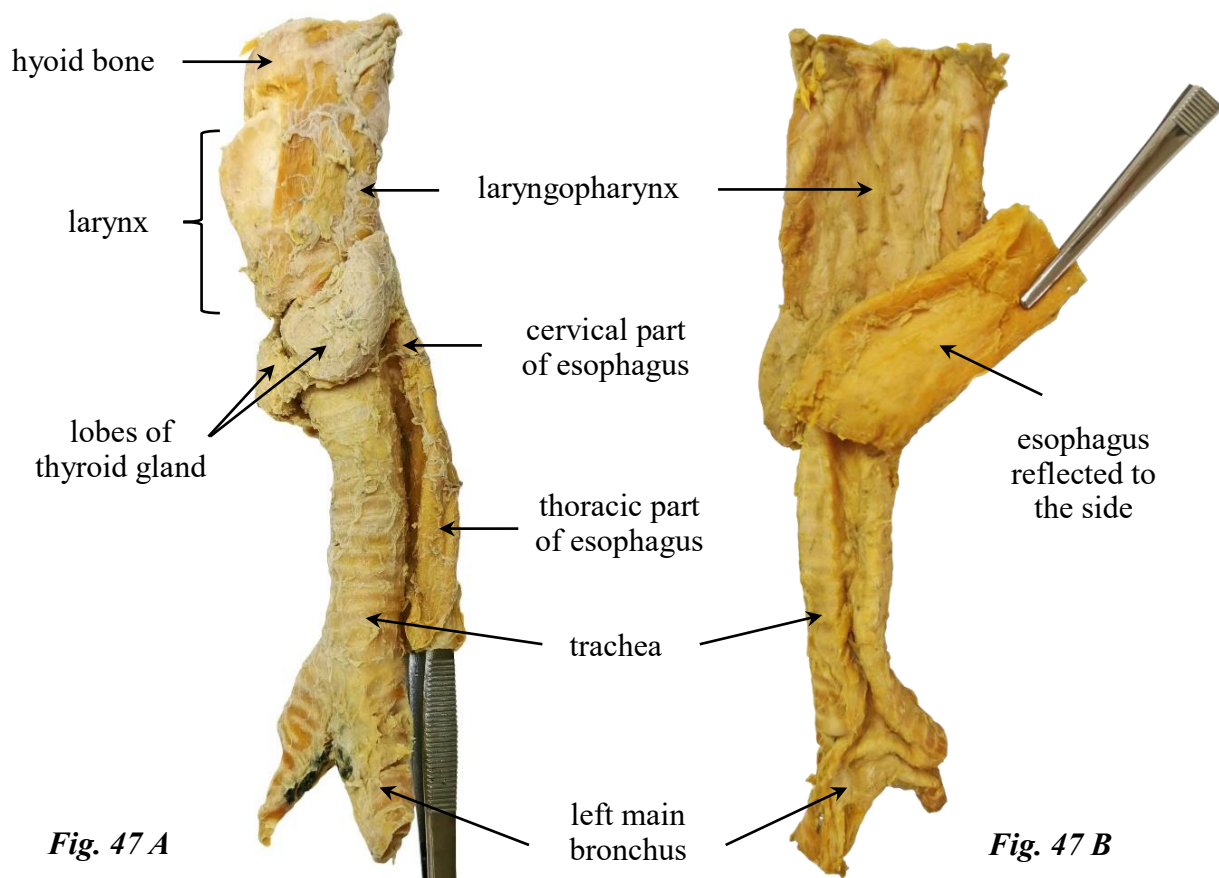


Fig. 47
Laryngeal part of the pharynx and cervical esophagus and proximal portion of the thoracic esophagus

47 A – Anterolateral view

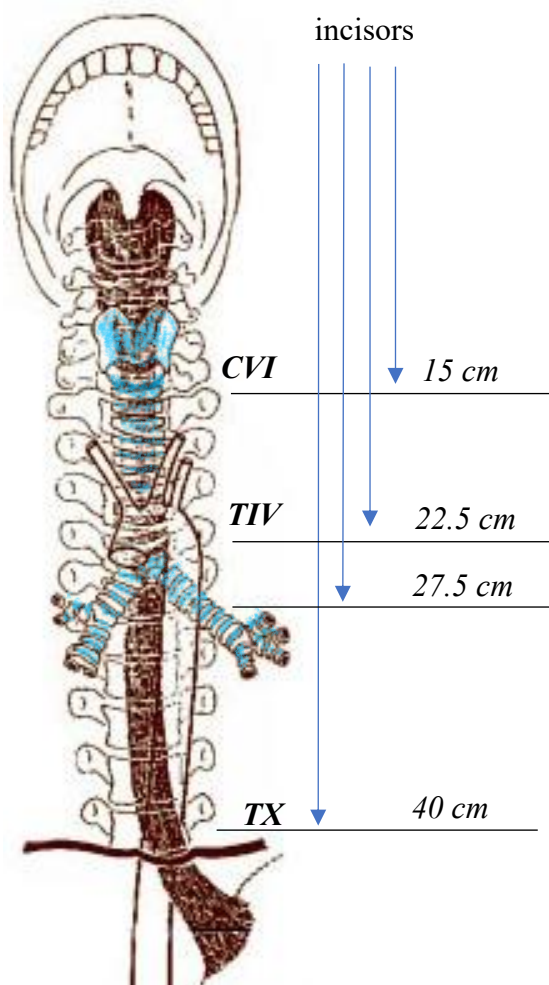
47 B – Posterior view

*Formalin-fixed cadaveric specimen, Department of Anatomy,
Jessenius Faculty of Medicine, Comenius University*

4.4 Constrictions of the esophagus

The esophagus has four points, where it is narrowed. These constrictions arise from adjacent structures, that compress the esophagus:

- The uppermost **pharyngo-esophageal constriction** is at the beginning of the esophagus, at the level of the inferior border of the **cricoid cartilage** in front of **CVI**.
- The middle two constrictions are located in the thorax – where the esophagus is crossed in the front by the **aortic arch**, the level with **TIV** and where it is constricted by the course of the **left principal bronchus**.
- The lowermost **diaphragmatic constriction** lies at the passage of the esophagus through the diaphragm, at the level of **TX**.



During endoscopic examination, the distance of each constriction is measured from the upper incisors with the patient's head tilted.

Fig. 48
Constrictions of the esophagus
Frontal view

Original diagram from Wikimedia; Author: training.seer.cancer.gov; 2008. Available online at the public domein:

https://commons.wikimedia.org/wiki/File:Illu_esophagus.jpg; 2022

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From a clinical point of view, knowledge of esophageal constrictions is important. These are the places, where swallowed foreign bodies are most commonly lodged. Also, unwanted ingested chemical substances move more slowly through the strictures, which can also cause damage to the esophageal wall in these places.

From a practical point of view, esophageal constrictions require attention when inserting medical instruments. The distance of each constriction is measured from the upper incisors with the patient's head tilted.

4.5 Vessels and nerves of the esophagus

- The esophagus does not have its own arteries. It is **blood supplied** by the esophageal branches of the surrounding arteries:
 - the **cervical part** is supplied by the inferior thyroid artery, which originates from the thyrocervical trunk of the subclavian artery;
 - the **thoracic part** is supplied by the esophageal branches of the thoracic aorta and posterior intercostal arteries;
 - the **abdominal part** is supplied mainly by the branches of the left gastric artery, partly by the branches of the inferior phrenic artery.
- The **venous blood** flows via the venous esophageal plexus into the esophageal veins:
 - the veins of the **cervical part** drain into the inferior thyroid vein;
 - the veins of the **thoracic part** drain into the azygos and hemiazygos veins;
 - the veins of the **abdominal part** drain into the gastric veins.

The veins basically drain venous blood via the tributaries into the superior vena cava and also into the hepatic portal vein.

*When the pressure in the hepatic portal venous system increases (**portal hypertension**), blood from the hepatic portal vein is diverted through the venous anastomoses (shunts) and flows into the superior and inferior vena cava by different (alternative) routes. The hepatic portal vein and its tributaries are valveless, so blood can also flow in them in a reverse direction.*

*One such route is the diversion of the blood from the hepatic portal vein via the gastric veins into the esophageal veins and then via the azygos and hemiazygos veins into the superior vena cava. Esophageal veins can therefore play an important role as **portocaval anastomoses**.*

- **Lymphatic drainage:**
 - from the **cervical part**, the lymph drains into the deep cervical lymph nodes;
 - from the **thoracic part**, the lymph drains into the paratracheal, tracheobronchial and posterior mediastinal lymph nodes;
 - from the **abdominal part**, the lymph drains into the gastric and inferior phrenic lymph nodes.
- Esophageal muscles are **motor nerve supplied** by the vagus nerve [*CN X*].
- **Sensory innervation** of the esophagus occurs via the vagus nerve [*CN X*], which carries information about the normal physiological processes and reflex activities. Information as stretch and pain is carried by the afferents, that pass via the sympathetic trunks and splanchnic nerves.
- The **parasympathetic nervous system** represented by the vagus nerve [*CN X*] promotes peristalsis and secretion of the glands and the **sympathetic nervous system**, via the fibers of the cervical and thoracic sympathetic ganglia, inhibits both processes.

ABDOMINOPELVIC CAVITY

The **abdomen** is the part of the trunk, that lies between the thorax above and the pelvis below. It contains the **abdominal cavity**. Its superior border, level with inferior thoracic aperture, is formed by the diaphragm. The diaphragm separates the abdominal and thoracic cavities. The abdominal cavity has no floor of its own, physically, but conventionally the upper plane of the pelvic cavity, formed by the sacrum, the upper margin of the ala ilium, the inguinal ligament, and the pubic symphysis, is considered to be its lower limit. The abdominal cavity thus continues freely into the pelvic cavity, which is why it is also referred to as the **abdominopelvic cavity**.

The abdominal cavity is lined with a serous peritoneal membrane, which encloses the **peritoneal cavity**. The peritoneal cavity also continues freely into the pelvis. Thus, the abdominal and pelvic cavities contain a common peritoneal cavity, and pathological processes in one cavity can spread freely to the other one.

The **pelvic cavity** itself is divided into the greater and lesser pelvis by the terminal line. The terminal line marks the plane of the pelvic inlet, too. The greater pelvis is generally considered a part of the abdominal cavity. It houses e.g. small intestine (ileum), cecum and sigmoid colon. The lesser pelvis contains some organs of the urogenital system and also from the gastrointestinal system, the rectum and anal canal.

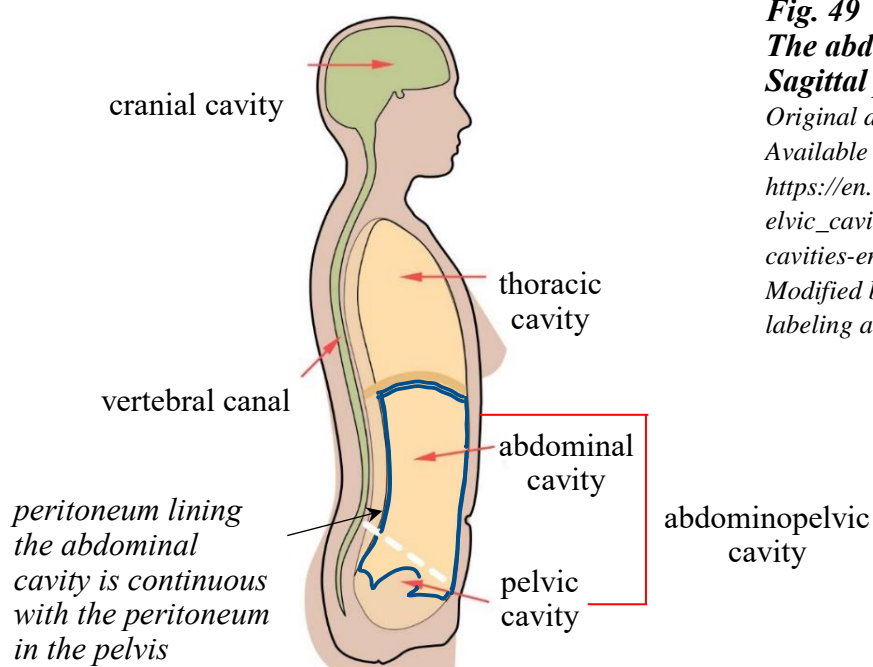


Fig. 49
The abdominopelvic cavity
Sagittal plane

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https://en.wikipedia.org/wiki/Abdominopelvic_cavity#/media/File:Scheme_body_cavities-en.svg; 2022

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Knowledge of the anatomical position and relationships between abdominal organs is essential for the correct evaluation of the patient's examination results and also for the interpretation of symptoms such as pain associated with abdominal problems, as well as for diagnosis and determination of treatment.

The position of the abdominal organs is determined in relation to the skeleton and as a projection onto the anterior abdominal wall.

For these descriptive purposes, the anterior abdominal wall is topographically divided by the imaginary lines into **four quadrants** or, in more detail, into **nine regions**.

- Dividing the anterior abdominal wall by two mutually perpendicular lines, which intersect at the level of the umbilicus, the right upper, right lower, left upper and left lower quadrants are formed.
- Dividing the anterior abdominal wall by two horizontal and two vertical lines, nine regions are formed. The upper horizontal line (subcostal) passes through the inferior margin at the 10th costal cartilage and the lower horizontal line (intertubercular) connects the tubercles of the iliac crests. Two vertical lines are the right and left midclavicular lines.

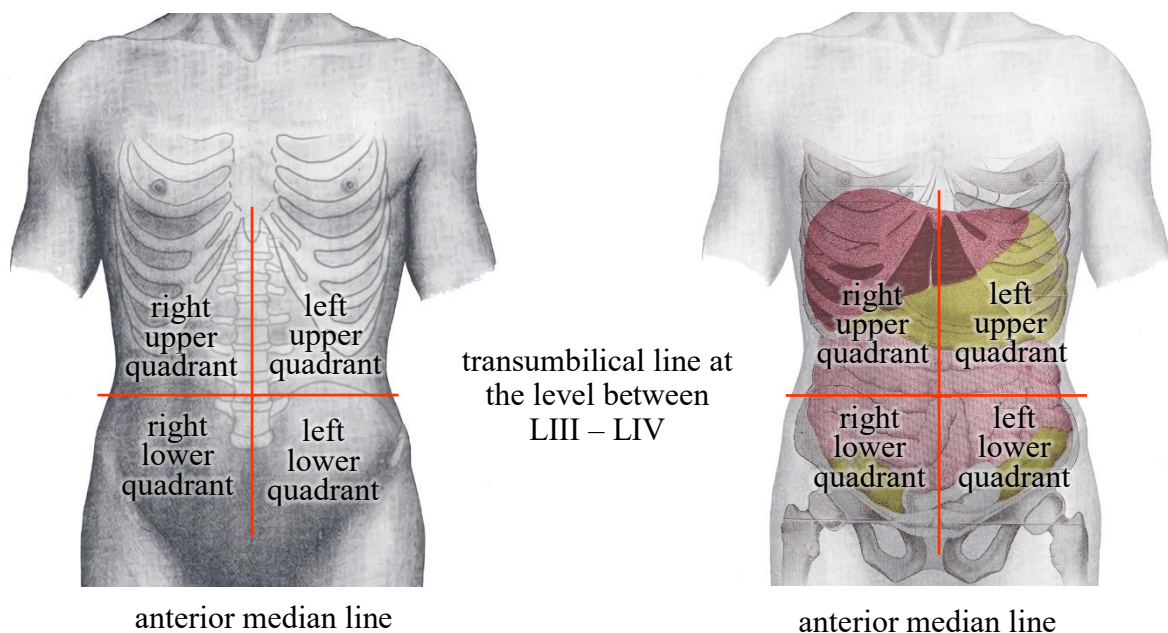
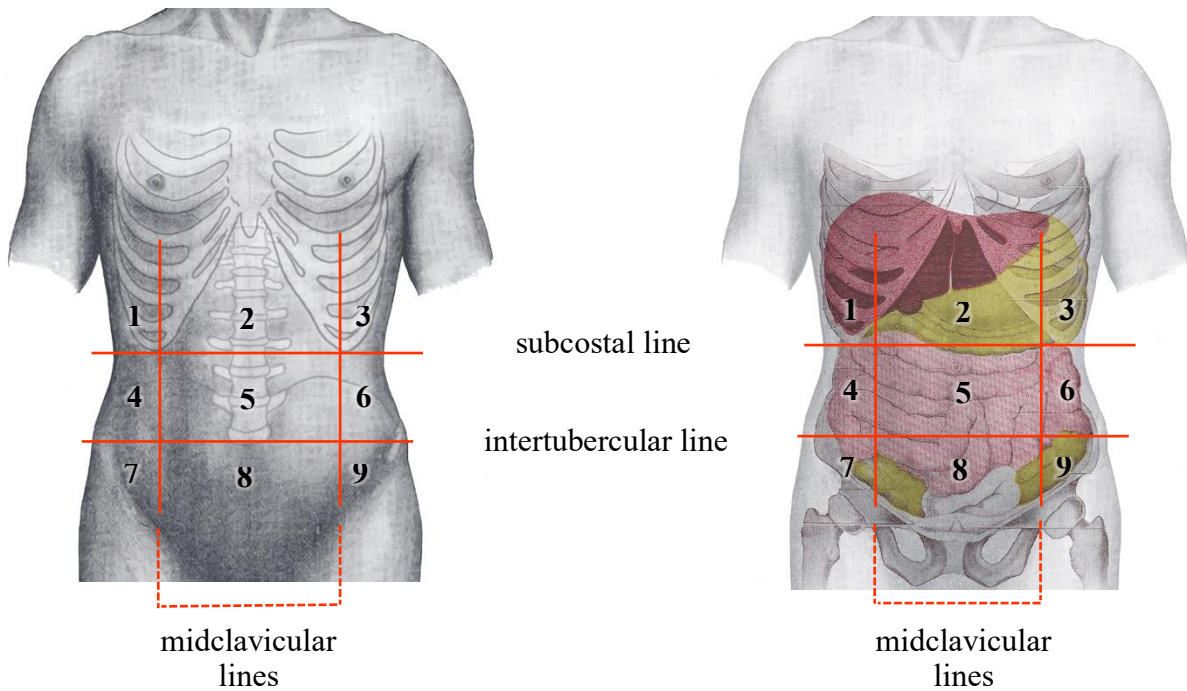


Fig. 50
Four-quadrant topographical pattern
Frontal plane, schematic figure

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- 1 right hypochondrium
- 2 epigastric region
- 3 left hypochondrium
- 4 right flank; right lateral region
- 5 umbilical region
- 6 left flank; left lateral region
- 7 right inguinal region; right groin
- 8 pubic region
- 9 left inguinal region; left groin

Fig. 51
Nine-region pattern
Frontal plane, schematic figure

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The division of the anterior abdominal wall into four quadrants or nine regions allows, among other things, clear communication between physicians, e.g. about the location of a patient's abdominal pain or a suspicious mass.

5 STOMACH (Gaster; ventriculus in Latin)

The stomach is a hollow organ that extends between the abdominal esophagus and the beginning of the small intestine. It is the widest part of the alimentary system that serves as a reservoir of food and is responsible for the process of food breakdown due to its enzymes. It can take in a considerable amount of food in a short time (its capacity is about 1 – 1.5 l), but after processing it can move its contents in small doses into the duodenum over a long period of time.

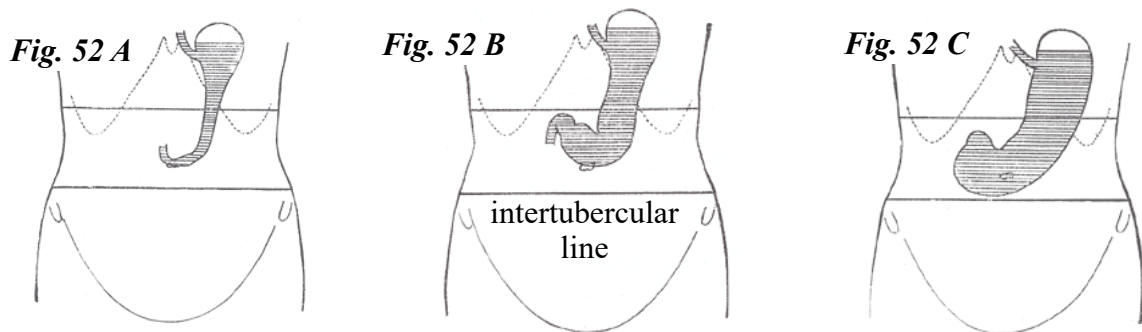


Fig. 52
Differences in the shape and size of the stomach depending on its filling in the standing position

Fig. 52 A – empty stomach; Fig. 52 B – slightly full stomach; Fig. 52 C – distended stomach

Frontal plane

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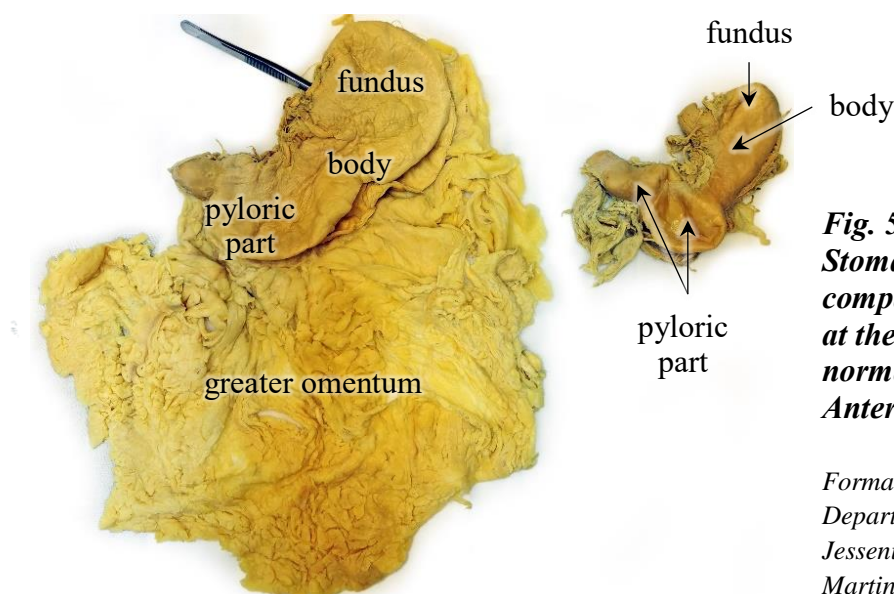


Fig. 53
Stomach (anterior wall) – comparison of the stomach – at the left dilated, at the right normal size
Anterior wall of the stomach

Formalin-fixed cadaveric specimen,
Department of the Anatomy,
Jessenius Faculty of Medicine in
Martin, Comenius University
Bratislava

5.1 Anatomical position and relations of the stomach to neighbouring structures and organs

The stomach is located just below the diaphragm. Although its $\frac{3}{4}$ is located to the left of the vertebral column in the **left hypochondrium**, it also extends into the **epigastric** and **umbilical regions**. Its size, shape and projection onto the skeleton are variable and vary according to its filling and to the position of the person. The stomach is usually J-shaped and its most fixed part is the **cardia**, the beginning of the stomach, which is located to the left of the vertebral column at the level of the **TXI vertebra**. The distal end of the stomach, the **pylorus**, is located to the right of the spine. Its position is more variable and in the standing position, it is approximately at the level of **LI vertebra**. Similarly, the position of the lower margin of the stomach varies and can range from **LIII – LIV** to **LIV – LV vertebrae** (when examining the filled stomach in the standing position).

The anterior wall of the stomach is related to the **liver** and **diaphragm** and a small area of the stomach is directly related to the **anterior abdominal wall**. The posterior wall of the stomach is related to the **left kidney**, **left suprarenal gland**, **spleen**, **pancreas**, **transverse mesocolon** and **diaphragm**. Inferior to the greater curvature of the stomach, the **transverse colon** is situated.

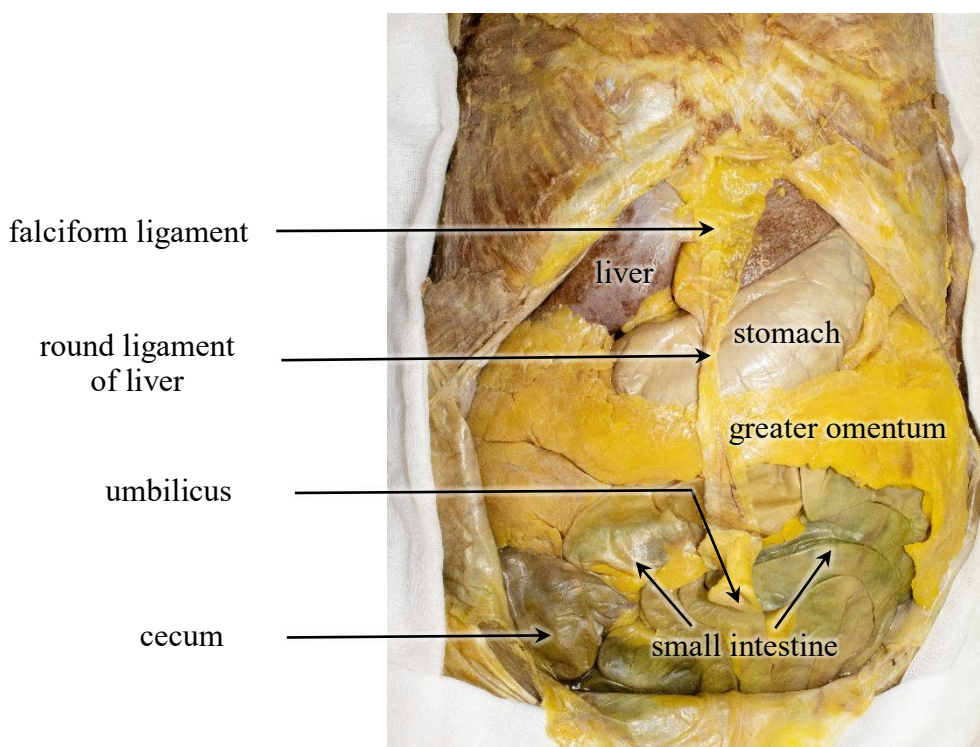


Fig. 54

Abdominal cavity – abdominal organs in situ („In situ“ means „in its original place“)

Anterior wall of the stomach

Formalin-fixed cadaver, Department of the Anatomy,

Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

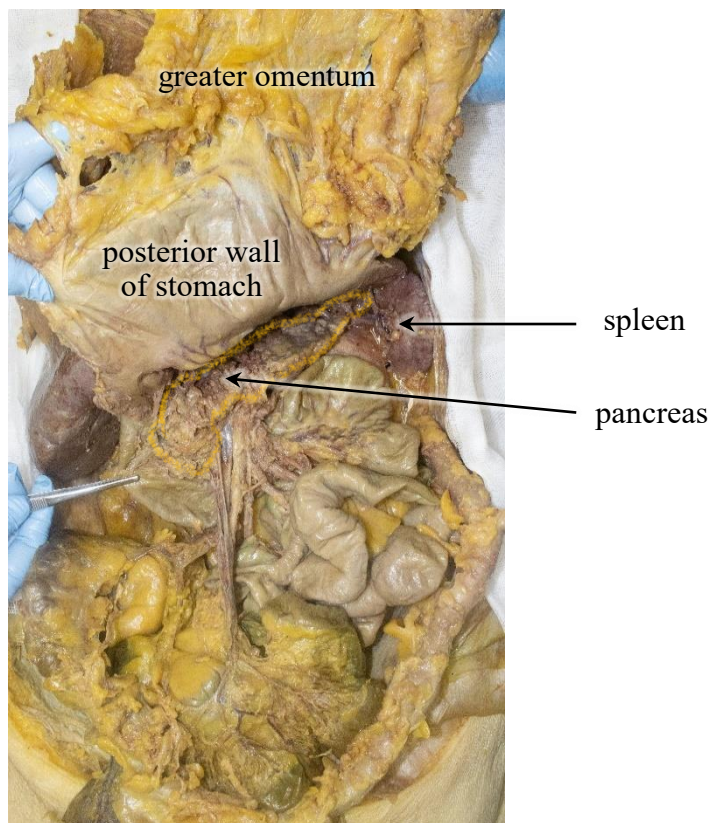


Fig. 55
Posterior relation of the stomach to the pancreas and spleen
The stomach and greater omentum are turned upward

Formalin-fixed cadaveric specimen, Department of the Anatomy, Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

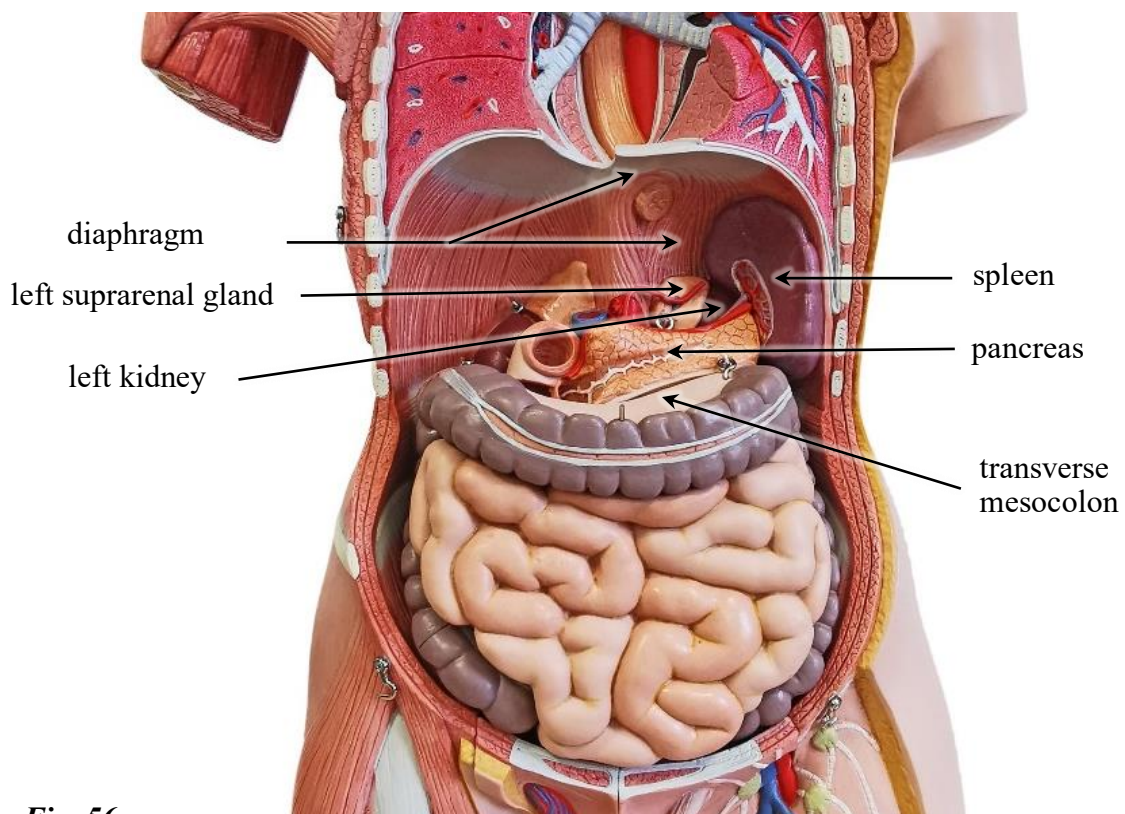


Fig. 56
Posterior relations of the stomach to the neighbouring structures and organs
The stomach is removed

Photography of SOMSO model
 Modified by additional drawing and labeling

5.2 Description of the stomach

The parts and openings of the stomach:

- **Cardia / cardinal part** of the stomach is the area near the opening of the esophagus into the stomach.
- **Fundus** of the stomach is the rounded widest and often the gas-filled part of the stomach above and to the left of the cardia. It is located beneath the diaphragm. The upper border of the fundus is called the *fornix of the stomach*.
- **Body** of the stomach is the largest, central part bounded superiorly by the cardia and fundus and inferiorly by the pyloric part.
- **Pyloric part** of the stomach is a distal part, which begins with an angular notch and extends into the pylorus. It is divided into a larger initial segment, the *pyloric antrum*, that narrows into the *pyloric canal*.
- **Pylorus** is the most distal area of the stomach, which is reinforced by the thickened ring of the muscle fibers, the **pyloric sphincter**.
- **Cardial orifice** is the proximal opening of the stomach. It is between the esophagus and stomach and it is surrounded by the cardia.
- **Pyloric orifice** is a distal opening, which connects the stomach with the beginning of the duodenum. It is surrounded by the gastric circular muscle – the **pyloric sphincter**.

Other features of the stomach include:

- **Greater curvature** is a larger, convex curvature in the contour of the stomach. It is directed to the left.
- **Lesser curvature** is a shorter, concave curvature in the contour of the stomach. It is directed to the right.
- **Cardial notch** (incisure) is a sharp angle formed by the esophagus and the wall of the stomach.
- **Angular notch** (incisure) is located at the lowermost point of the lesser curvature. It indicates the junction of the body and the pyloric part.

An empty or poorly filled stomach is anteroposteriorly flattened and has an **anterior wall** and **posterior wall**. More precisely, since the greater curvature is more anteriorly oriented than the lesser curvature, the anterior wall is oriented ventrocranially and the posterior wall dorsocaudally.

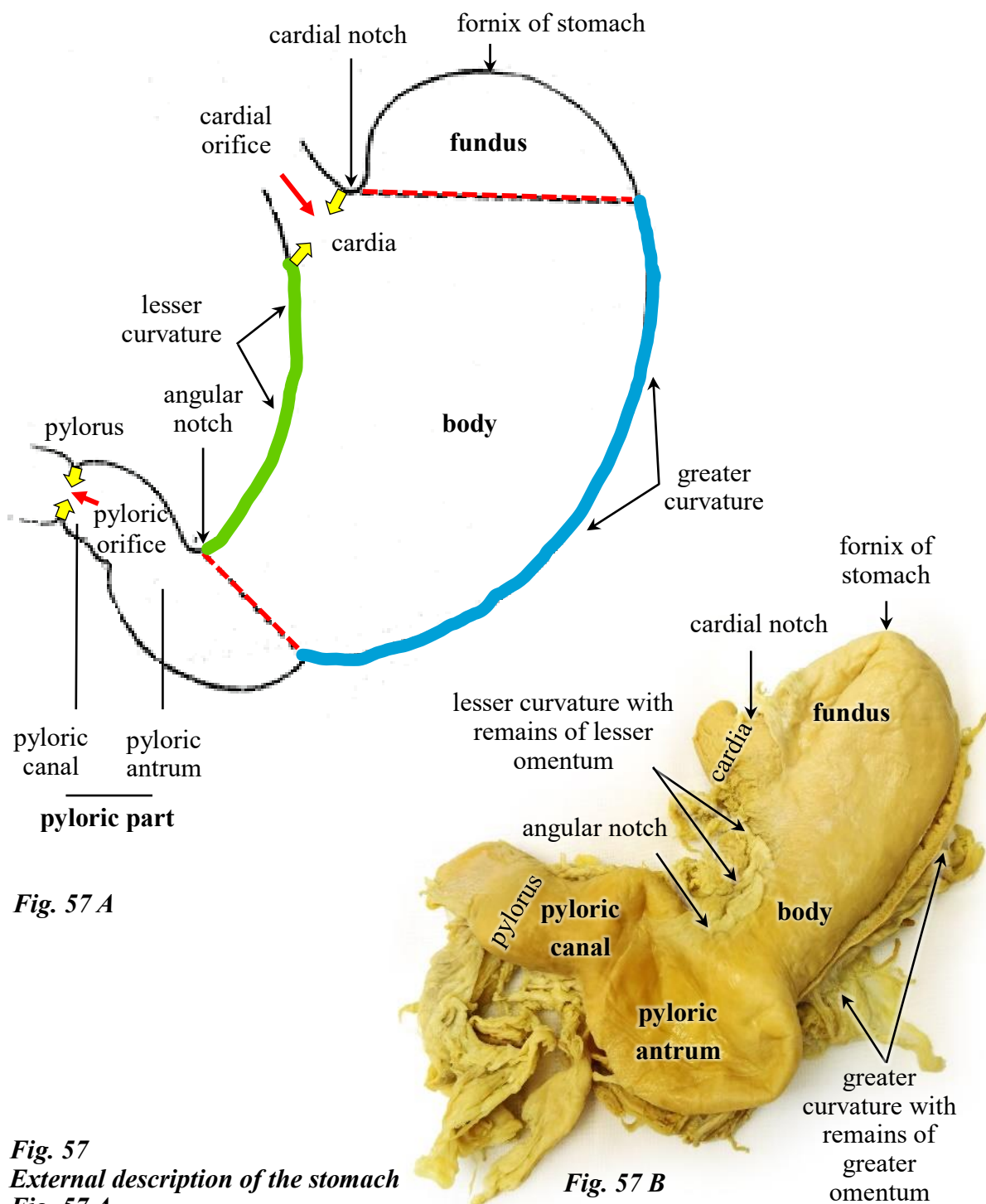


Fig. 57

External description of the stomach

Fig. 57 A

Schematic figure of the stomach, anterior wall

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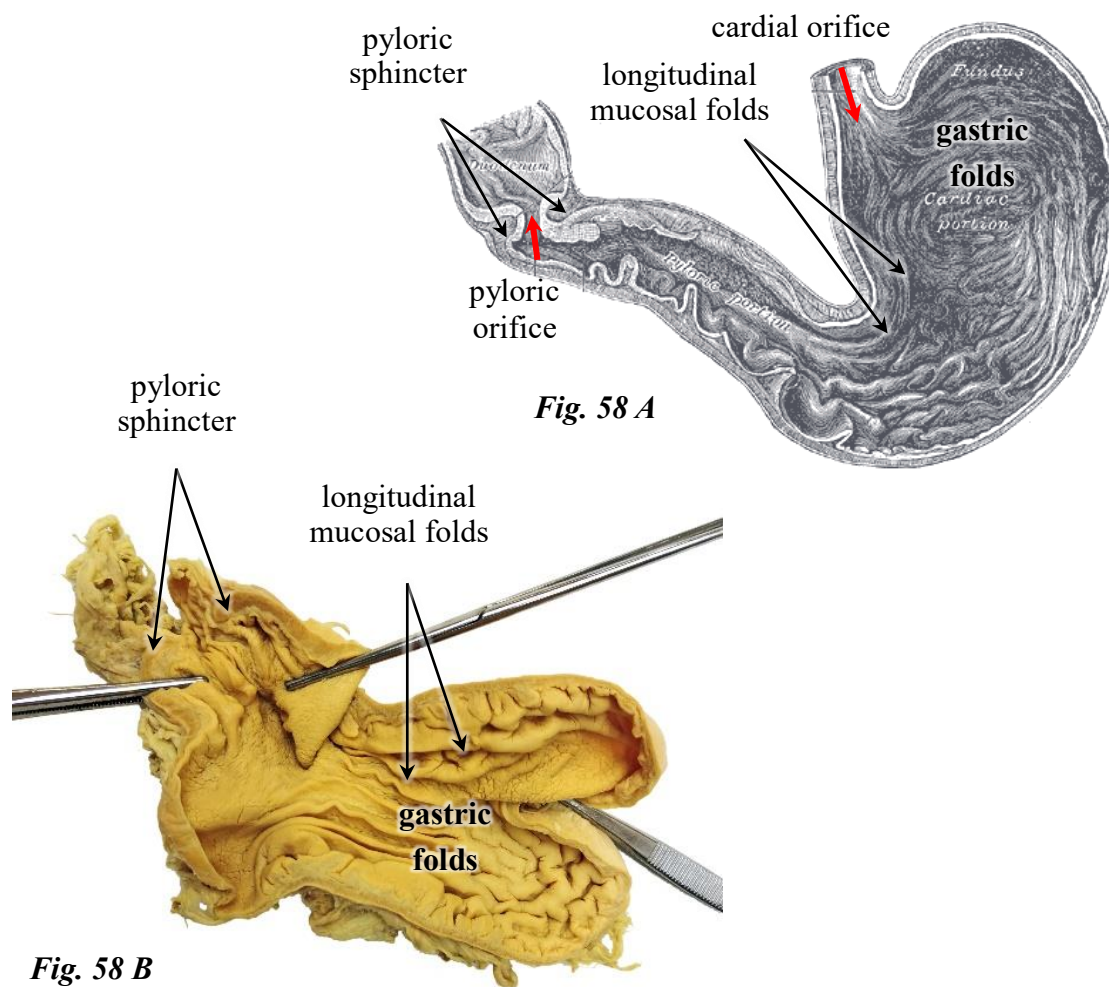
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Fig. 57 B

Anterior wall of the stomach, the greater and lesser omenta are removed

Formalin-fixed cadaveric specimen, Department of the Anatomy,

Jessenius Faculty of Medicine in Martin, Comenius University Bratislava



The inner surface of the stomach is lined with a mucous membrane, that contains the stomach glands. The gastric mucosa forms the gastric folds. Typical longitudinal gastric folds are found along both curvatures of the stomach. They form the passageway, the gastric canal for the passage of the contents of stomach. The folds become smaller when the stomach is filled.

Fig. 58

Inner surface of the stomach

Fig. 58 A – Original diagram from Gray's Anatomy, 20th US edition which has now lapsed into the public domain (out of copyright). Gray H.: *Anatomy of the human Body*. Philadelphia: Lea & Febiger, 1918.

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Fig. 58 B – Formalin-fixed cadaveric specimen, Department of the Anatomy, Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

5.3 Position of the stomach to the peritoneum

The stomach is positioned **intraperitoneally** (i.e. in the peritoneal cavity of the abdominal cavity). The layers of the visceral peritoneum from the anterior and posterior walls of the stomach join along the lesser curvature of the stomach to form the double-layered fold, the **lesser omentum**, and along the greater curvature of the stomach they form the **greater omentum**. The omenta connect the stomach to surrounding structures and they contain blood and lymph vessels and nerves for supplying the stomach. *For more on the lesser and greater omentum, see the chapter "Peritoneum".*

5.4 Vessels and nerves of the stomach

- The **arterial supply** of the stomach is involved in all three main branches of the celiac trunk – the left gastric, common hepatic and splenic arteries.

Two anastomotic arterial arches are formed on the curvatures of the stomach. The arteries of these arches are adapted by their tortuous course to the changes in the size of the stomach, and give off numerous small branches which supply the adjacent areas of both walls of the stomach.

On the lesser curvature of the stomach, the arterial arch is formed by an anastomosis between the left gastric and the right gastric arteries, which arise from the proper hepatic artery of the common hepatic artery. On the greater curvature of the stomach, the arterial arch is formed by an anastomosis between the left gastro-omental (gastro-epiploic) artery, which arises from the splenic artery, and the right gastro-omental (gastro-epiploic) artery, which arises from the gastroduodenal artery, from the common hepatic artery.

The fundus of the stomach is also blood supplied by the short gastric arteries, which are the branches of the splenic artery.

Gastric ulcers are open lesions, that develop on the lining of the stomach. They can lead to perforation of the stomach wall and cause bleeding into the abdominal cavity if they erode into the gastric artery. Ulcers located on the posterior wall of the stomach may erode into the pancreas or splenic artery.

- The **veins** accompany the arteries and finally drain the venous blood from the stomach to the hepatic portal vein either directly or via its tributaries.
The left gastric vein drains directly into the portal vein. It also has smaller connections with the esophageal veins, which enlarge and become important in portal hypertension (see the esophageal veins).
- **Lymph** is drained by the lymph nodes sequentially in three levels:
 - the first level consists of the regional lymph nodes – the right and left gastric, the right and left gastro-omental, splenic and pyloric lymph nodes;
 - the second level consists of the lymph nodes along the celiac trunk;
 - the third level consists of the intestinal trunks, which drain the lymph into the thoracic duct.
- **Nerve supply** is by the autonomic gastric plexuses. They are formed by both parasympathetic and sympathetic nervous systems and also carry sensory information. The parasympathetic nervous system promotes peristalsis, blood flow, glandular secretion and gastric emptying, and has essentially opposite effects to the sympathetic nervous system. The exception is the pyloric sphincter, which is activated by the sympathetic nervous system (it increases its tension).
- **Parasympathetic** fibers originate from the vagus nerves [CN X]. Vagus nerves also carry chemical **sensory information**, that is related to a change in acidity in the stomach, for example, a burning sensation (pyrosis).
- **Sympathetic** innervation is via the greater and lesser splanchnic nerves, which arise from the ganglia of the thoracic sympathetic trunk. The splanchnic nerves synapse in the celiac plexus and continue to the periphery along the arteries. The sympathetic nervous system also carries **sensory information** such as sensations of pain, pressure and temperature changes.

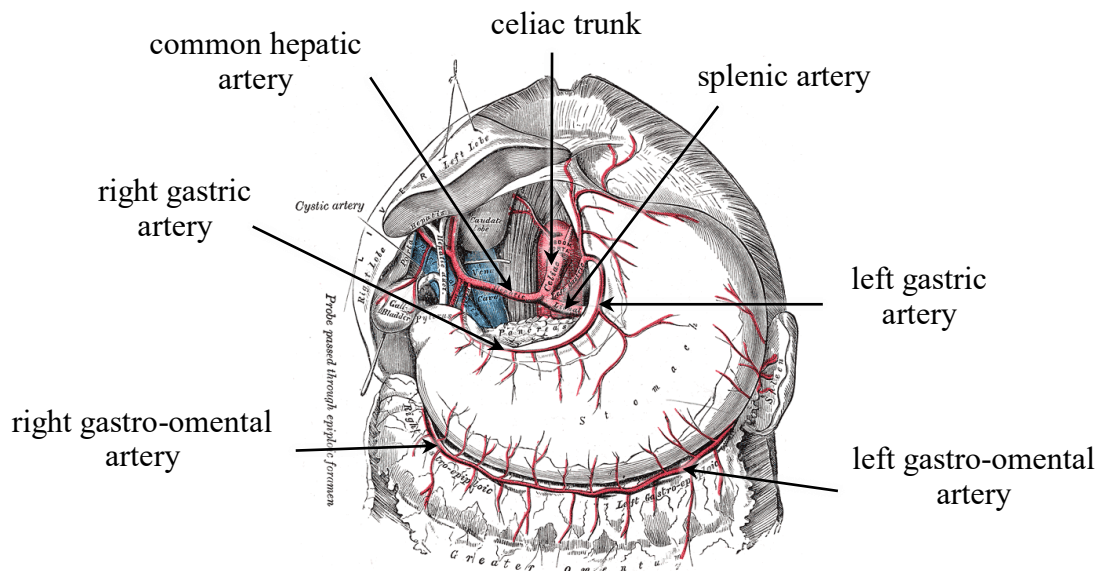


Fig. 59
Blood supply of the stomach

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NOTE:

The autonomic plexus situated in the wall of the digestive tract is collectively referred to as the **enteric system (enteric plexus)** because of its relative independence and many important physiological functions. It consists of the nerve plexuses and nerve ganglia, which are found in the wall of the organs from the cardia of the stomach to the internal anal sphincter of rectum. It also affects and innervates the gallbladder and pancreas.

The enteric system is a highly integrated system, which is able to function relatively independently of the central nervous system although it can be influenced by it. It regulates many important physiological functions of the gastrointestinal tract (e.g., coordinated gastric and intestinal motility, intestinal peristalsis, secretomotor activity, vascular tone).

6 SMALL INTESTINE (*Intestinum tenue* in Latin)

The small intestine is the longest part of the alimentary system between the stomach and large intestine. It consists of three parts (listed in order from the stomach towards the large intestine) – **duodenum**, **jejunum** and **ileum**.

During life, its length is approximately 3 to 5 m, but after death, when muscle tone does not act, its length can be as long as 5 to 7 m. Its diameter varies from 2 to 5 cm. It is wider at the beginning and narrows toward its end, i.e. aborally. *Although it is longer than the large intestine, it is called the small intestine because it has a narrower diameter.*

The small intestine receives the bile and pancreatic juice and is therefore the primary site of digestion. It is responsible for the absorption of nutrients and water and the thickening of food. The small intestine is also involved in the immune defense system and distributes messenger substances and hormones to regulate digestion.

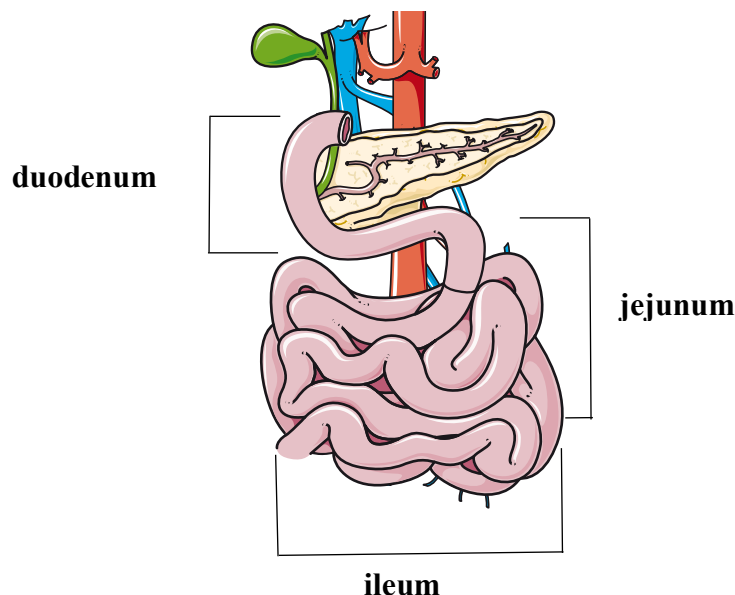


Fig. 60
Parts of the small intestine

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6.1 Anatomical position of the small intestine

The small intestine is a continuation of the pylorus of the stomach and its beginning is located to **the right of the vertebral column at the level of the LI vertebra**. Its end exits into

the large intestine through the **ileocecal orifice (ileal orifice)** within the **right iliac fossa**. Most of the **duodenum** is located near the posterior abdominal wall and the entire duodenum usually lies above the level of the umbilicus. However, this position may change with age.

The course of the **jejunum** and **ileum** is twisted into numerous coils, which fill a substantial portion of the abdominal cavity and are surrounded from above and from the sides by the large intestine. The jejunum represents the proximal two-fifths of the jejunoileum and it lies more in the left upper quadrant of the abdominal cavity. The ileum forms distal three-fifths and is mostly in the right lower quadrant. The terminal portion of the ileum usually lies in the pelvis, from which it ascends and ends on the medial side of the large intestine.

6.2 Parts and relations of the small intestine to neighbouring structures and organs

The first part, the **duodenum** extends between the pylorus and the **duodenojejunal flexure**. The jejunum and ileum form the last two parts of the small intestine. The **jejunum** is a middle part of the small intestine and begins from the duodenojejunal flexure. It continues smoothly into the ileum. The third part, the **ileum** opens into the medial wall of the beginning of the large intestine within the right iliac fossa.

- **Duodenum**

The duodenum is the shortest, widest and most fixed part of the small intestine. It is approximately 25 – 30 cm long. Its course forms a C-shaped curve around the **head of the pancreas**. It begins at the pylorus to the right of the vertebral column, at the level of the **LI** vertebra and crosses the midline to open into the jejunum at the **duodenojejunal flexure**. This flexure is located to the **left of the LII** vertebra. The duodenum has four parts:

- **Superior part** extends from the pylorus of the stomach and passes to the **right** toward the **gallbladder**. This part is located anterior to the **bile duct, hepatic portal vein, gastroduodenal artery** and **inferior vena cava** and superior to the head of the **pancreas**. The **liver** is located ventrocranially from this part.

The beginning of the superior part of the duodenum (immediately distal to the pylorus) is slightly dilated and is therefore called the **ampulla** or **duodenal cup**. This portion is more mobile than the other parts of the duodenum because only this portion is located intraperitoneally and is connected with the liver by the **hepatoduodenal ligament** (*it is a part of the lesser omentum*).

Clinically, the ampulla is the site where duodenal ulcers occur more frequently. Erosion of the duodenal wall can manifest itself in painful conditions in the patient, but it can be treated medically.

However, if the ulcer progresses, the erosion of the wall can lead to complete perforation of the duodenal wall, and then it is already a critical condition that requires surgical intervention. Perforation can be complicated by the inflammation of the peritoneum, which spreads and irritates the surrounding viscera such as the liver, pancreas and gallbladder. Another complication may be also damaging to the gastroduodenal artery (located behind the ampulla), which can cause serious bleeding and possible shock from hypovolaemia.

- **Superior duodenal flexure** is flexure between the superior and descending part of the duodenum.
- o **Descending part** extends along the **right side** of the vertebral column from the **LI** to **LIII** vertebra. Its anterior surface is crossed by the **transverse colon** and **transverse mesocolon**. Anteriorly, it is also in relation to the **liver** (*it forms a duodenal impression on the right lobe of the liver*) and **jejunum**. Posteriorly, there are the **right kidney** and other right kidney-related structures (*renal pelvis, ureter, renal vessels*). At the lateral side of the descending part is the **right colic flexure** and at its medial side is the head of the **pancreas**.

Two ducts come from the medial side into the descending part of the duodenum – the **bile duct** and **pancreatic duct**. By joining these ducts, a **hepatopancreatic ampulla** is formed. The hepatopancreatic ampulla enters the duodenum at the **major duodenal papilla**. Above this, there is the **minor duodenal papilla** (present in most people) which is the opening of the **accessory pancreatic duct**.

- **Inferior duodenal flexure** is a flexure between the descending and inferior (horizontal) part of the duodenum.
- o **Inferior part (horizontal part)** is the longest part of the duodenum. It passes **from the right to the left** at the level of the **LIII** vertebra, anterior to the **vertebral column**, **inferior vena cava**, **abdominal aorta** and the **right gonadal vessels**. Its anterior surface is crossed by the **superior mesenteric vessels** and it is related to the **jejunum** with the mesentery. It lies inferior to the head of the **pancreas**.

- **Ascending part** passes upward along the left side of the aorta to the level of the **LII** vertebra and terminates at the **duodenojejunal flexure**. It is related to the **left kidney** (and the left ureter and left renal vessels), the **left gonadal vessels**, the **jejunum** with the mesentery and also to the **pancreas**.

The duodenojejunal flexure is supported at its position by the band of muscle and connective tissue, which is referred to as the suspensory muscle (ligament) of the duodenum (*ligament of Treitz*).

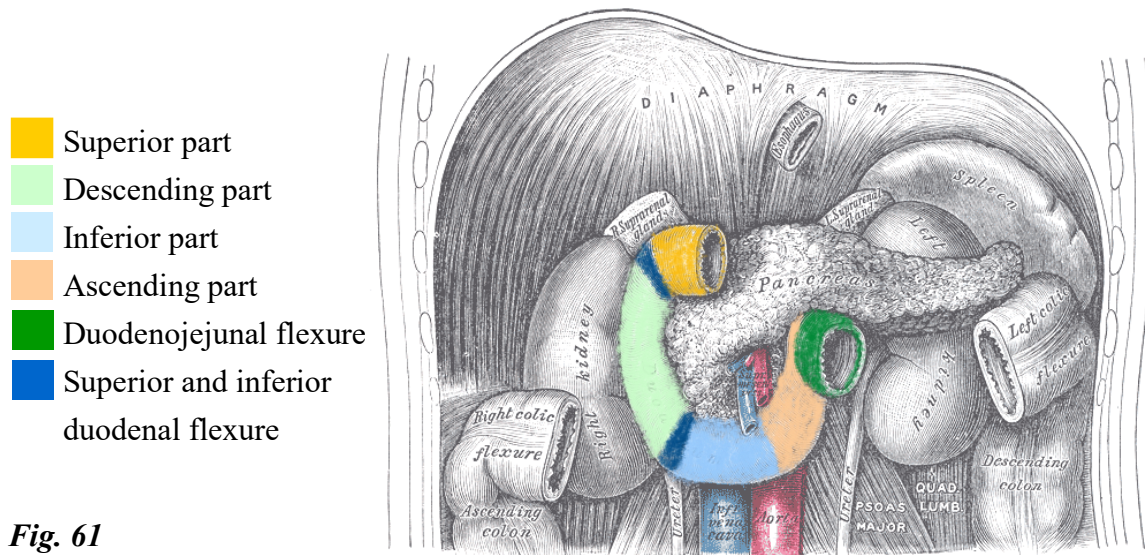


Fig. 61
Parts of the duodenum
Anterior view

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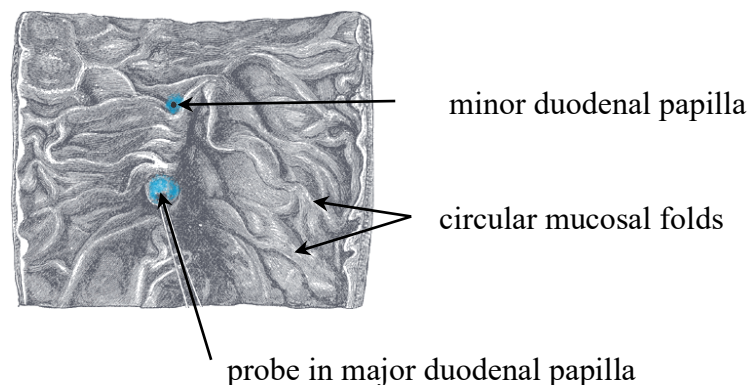


Fig. 62
Major and minor duodenal papilla
Medial wall of the descending part of the duodenum

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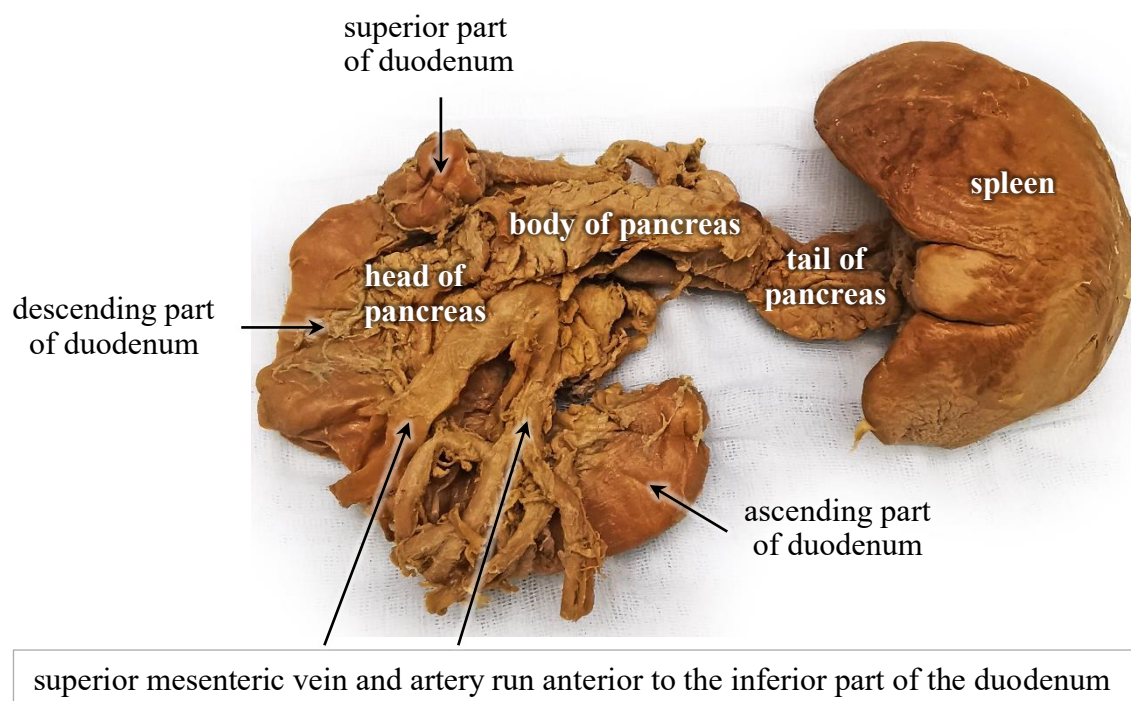


Fig. 63

Duodenum, pancreas and spleen

Anterior view

*Formalin-fixed cadaveric specimen, Department of the Anatomy,
Jessenius Faculty of Medicine in Martin, Comenius University Bratislava*

- **Jejunum and ileum**

The jejunum and ileum are the other two parts of the small intestine. The jejunum begins from the **duodenojejunal flexure**, which is located to the **left of the vertebral column at the level of the LII** and passes smoothly into the ileum. The ileum ends **in the right iliac fossa** and enters the large intestine through the **ileocecal orifice (ileal orifice)**.

Anterior to the jejunum and ileum, there is the **greater omentum** and **anterior abdominal wall**. Posteriorly, there are the large vessels – the **abdominal aorta, inferior vena cava, gonadal vessels** and **ureters**. Laterally and superiorly, there is the **large intestine**. Inferior to the ileum is the **sigmoid colon, urinary bladder, uterus, the right uterine tube** and the **right ovary**.

Since the jejunum passes into the ileum without a sharp boundary and their common feature is attachment to the posterior abdominal wall via the peritoneal fold, called the **mesentery**, they are sometimes referred to as the **jejunoileum**.

As already stated, although there is no morphologically distinct boundary between the jejunum and ileum, there are certain features characteristic of each part that change gradually

from the beginning of the jejunum to the end of the ileum. These differences are surgically important (*Table 10*).

The jejunum is shorter than the ileum. It has a larger diameter and its wall is thicker and more vascular. The arteries of the jejunum and ileum form the anastomotic arcades (arches) within the mesentery. From the arcades come straight arteries, the vasa recta, which supply the intestine. The jejunum contains fewer arterial arcades (1 – 2) than the ileum and its vasa recta (straight arteries) are longer. The mucosal circular folds, plicae circulares, of the jejunal wall are more numerous, thicker and deeper than ileal mucosal circular folds, where they are small and even absent in the terminal ileum. The mucosa of the jejunum contains isolated lymphoid nodules everywhere in the mucosa compared to the ileum where more prominent aggregations of the lymphoid follicles are present. The mesentery associated with the jejunum contains less fat.



Fig. 64 A
Arterial arcades within the mesentery of the jejunum and ileum
The coils of the intestine are stretched
 Formalin-fixed cadaveric specimen,
 Department of the Anatomy, Jessenius Faculty
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Fig. 64 B
 longer
 vasa recta

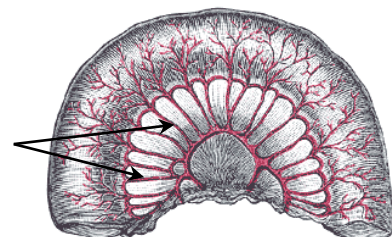
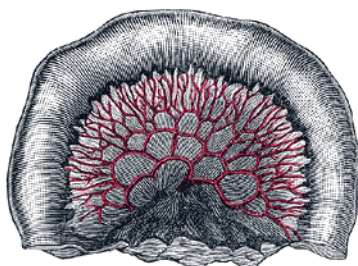


Fig. 64 C
 shorter
 vasa recta



jejunum contains fewer
 arterial arcades (1 – 2) than
 the ileum and its vasa recta
 (straight arteries) are longer

Fig. 64 B + 64 C
64 B – Arterial arcades within the mesentery of the jejunum
64 C – Arterial arcades within the mesentery of the ileum

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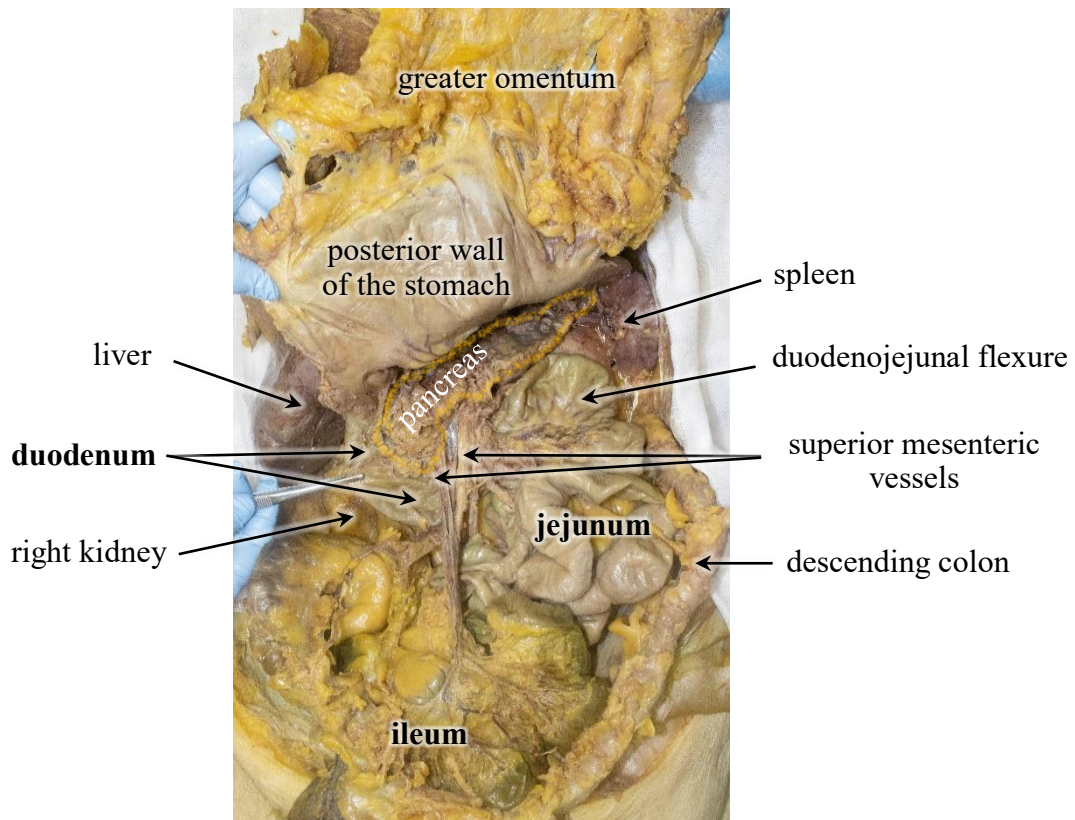


Fig. 65

Parts of the small intestine and some adjacent organs are noted

The stomach and greater omentum are turned upward

*Formalin-fixed cadaveric specimen, Department of the Anatomy,
Jessenius Faculty of Medicine in Martin, Comenius University Bratislava*

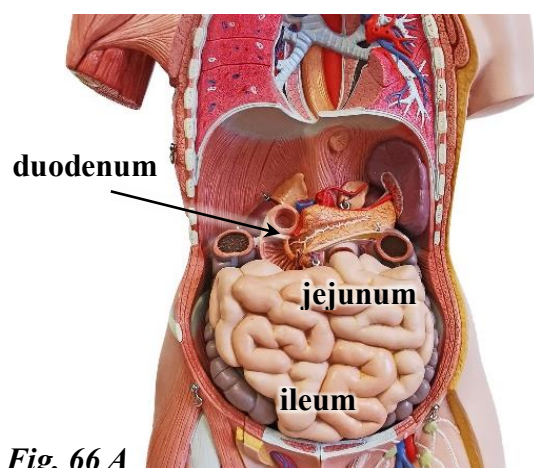


Fig. 66 A

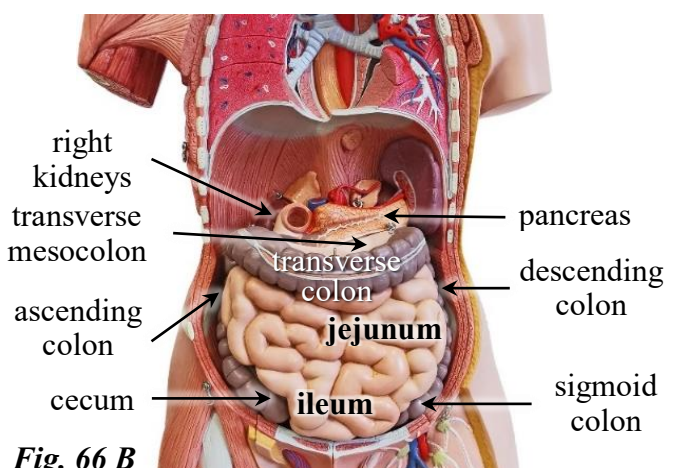


Fig. 66 B

Fig. 66

Fig. 66 A – Parts of the small intestine

Fig. 66 B – Small intestine and some adjacent organs are noted

Anterior view, the stomach and liver are removed

Photography of SOMSO model

Modified by additional drawing and labeling

characteristic	jejunum	ileum
location	ULQ* of the abdominal cavity	LRQ* of the abdominal cavity + pelvis
length	approx. 2/5	approx. 3/5
diameter	approx. 3 cm	approx. 2 cm
intestinal wall	thick	thin
vascularity of the wall	more vascular	less vascular
arterial arcades	less arterial arcades	more arterial arcades
vasa recta	long and few	short and numerous
mucosal circular folds	more numerous, thicker and deeper	low and sparse
lymphoid nodules	few	many
fat in mesentery	less	more

Table 10: Different characteristics of the jejunum and ileum in a living body

**ULQ = upper left quadrant; LRQ = lower right quadrant*

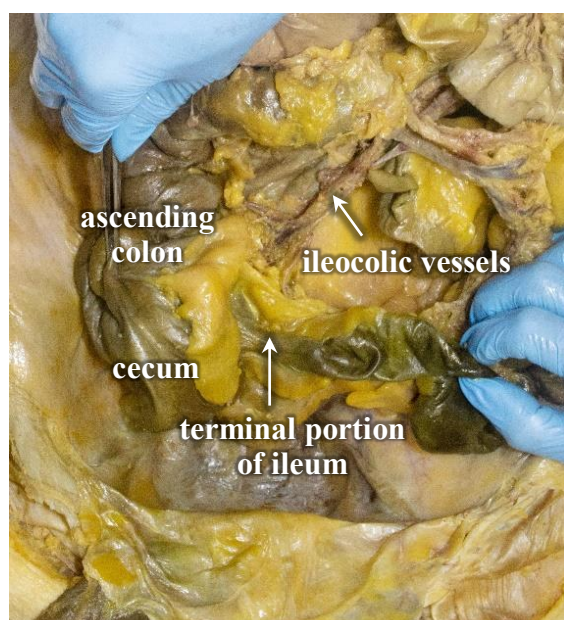


Fig. 67

Terminal portion of the ileum and beginning of the large intestine

Formalin-fixed cadaveric specimen, Department of the Anatomy, Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

6.3 Position of the small intestine to the peritoneum

The **duodenum** is secondary **retroperitoneal**, except for its beginning. It has no mesentery and its anterior surface is covered by the peritoneum which fixes it to the structures of the posterior abdominal wall (therefore, it is the most fixed part of the small intestine). The beginning of the duodenum is intraperitoneal and it is connected with the liver by the hepatoduodenal ligament.

The **jejunum** and **ileum** are **intraperitoneal organs**. They are attached to the posterior abdominal wall by the peritoneal fold, the **mesentery**. The mesentery allows both parts of the small intestine a relatively large range of movements. Between two layers of the mesentery, there are the nerves, blood and lymphatic vessels, that supply the jejunum and ileum, together with a variable amount of fat.

6.4 Vessels and nerves of the small intestine

- The **arterial supply** of the duodenum comes from the branches of the celiac trunk and also from the superior mesenteric artery, both arise from the abdominal aorta. The jejunum and ileum are blood supplied only by the branches of the superior mesenteric artery.
- Portions of the **duodenum** located above the level of the major duodenal papilla are supplied by the superior pancreaticoduodenal arteries, which come from the gastroduodenal artery (branch of the celiac trunk). Portions of the **duodenum** located below the level of the major duodenal papilla are supplied by the inferior pancreaticoduodenal arteries, which come from the superior mesenteric artery. The superior and inferior pancreaticoduodenal arteries anastomose together.
- The **jejunum** and **ileum** are supplied by the jejunal and ileal arteries, which are branches of the superior mesenteric artery.
- The **veins** of the **duodenum** follow the arteries and basically drain venous blood via the tributaries into the hepatic portal vein, some directly, others indirectly via the superior mesenteric vein. The superior mesenteric vein also drains the **jejunum** and **ileum**.
- **Lymphatic vessels of the duodenum** follow the arteries. The lymph drains mainly via the celiac lymph nodes into the intestinal trunk.

- The lymph from the **jejunum** and **ileum** drains sequentially through three groups of the lymph nodes located in the mesentery and then drains mainly into the superior mesenteric lymph nodes (and from them into the celiac lymph nodes) or also into the lumbar lymph nodes.
- The small intestine is **nerve supplied** by the nerves of the celiac plexus (which gives origin to the superior mesenteric plexus). The celiac plexus contains the parasympathetic and sympathetic fibers as well as the viscerosensory fibers. This plexus receives:
 - The **parasympathetic** and **sensory fibers** from the vagus nerves [*CN X*].
 - The pre-ganglionic **sympathetic fibers** from the splanchnic thoracic nerves. The sympathetic nervous system also carries the **sensory information**.

7 LARGE INTESTINE (*Intestinum crassum* in Latin)

The large intestine is the last part of the alimentary system. It extends from the cecum to the anal canal with the anus. The large intestine directly follows the terminal ileum and receives content from it through the **ileal orifice (ileocecal opening)**.

In adults, it measures 1.5 – 1.8 m. Its diameter varies between 7.5 – 4 cm and decreases toward the anus. It consists of the **cecum** associated with the **vermiform appendix**, **colon – ascending, transverse, descending and sigmoid**, **rectum** and **anal canal** (listed in order from its beginning to the anus).

The large intestine receives mushy to liquid contents from the ileum, which are thickened in the large intestine by the absorption of water and electrolytes. The remaining waste matter is temporarily deposited in the rectum in the form of feces before being removed by defecation. The modification of the contents in the large intestine is due to the fermentation and putrefactive processes of the microorganisms, which are part of the intestinal contents, some of which also produce vitamin K.

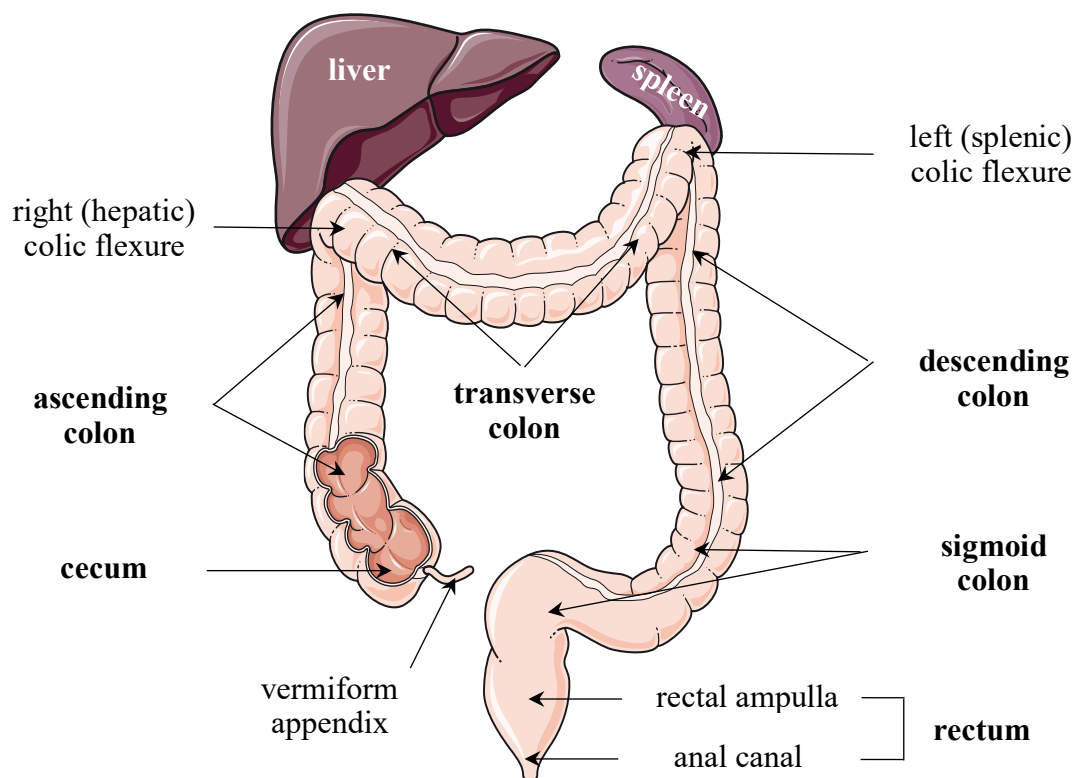


Fig. 68
Parts of the large intestine

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Modified by additional drawing and labeling

7.1 Anatomical position of the large intestine

Most of the large intestine is situated in the **abdominal**, resp. **abdominopelvic cavity**, where it surrounds the small intestine from above, below and also on both sides of the flanks. The last parts, the rectum and anal canal are located in the **lesser pelvis**.

The initial part of the large intestine, the **cecum**, lies in the **right iliac fossa**, then ascends as the **ascending colon** into the **right hypochondriac region**, where it bends as the **right colic flexure** just below the liver. Its continuation passes as the **transverse colon** through the abdominal cavity, forming an arch that extends to the **umbilical region** and continues into the **left hypochondriac region**, where it again bends as the **left colic flexure**, just below the spleen. From this position, it descends as the **descending colon** downward into the **left iliac fossa**, where the descending colon is continuous with the **sigmoid colon**. The sigmoid colon begins within the greater pelvis, above the pelvic inlet and it extends into the **lesser pelvis**, where it continues into the **rectum** at the level of the **SIII vertebra**. The terminal part of the large intestine, the **anal canal** penetrates the **pelvic floor** and ends as the anus.

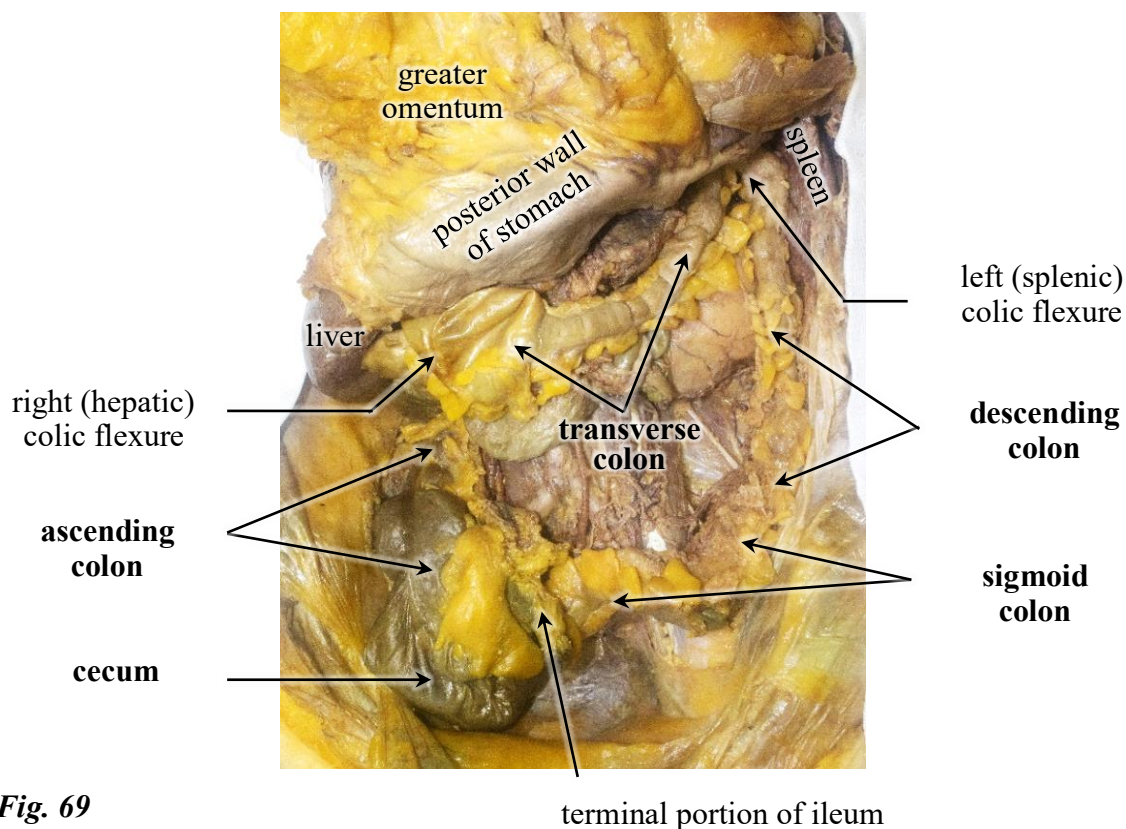


Fig. 69

Parts of the large intestine

The greater omentum is separated from the transverse colon; the stomach and greater omentum are turned upward

*Formalin-fixed cadaveric specimen, Department of the Anatomy,
Jessenius Faculty of Medicine in Martin, Comenius University Bratislava*

7.2 General characteristics of the large intestine

The large intestine is widest at its beginning and gradually, toward the rectum, its caliber (diameter) narrows. It is much wider, but shorter than the small intestine. *The large intestine is called large because it has a larger lumen (diameter), not because it is longer.*

Most of the large intestine has several distinct anatomical characteristics:

- **Teniae coli** are thickened longitudinal bands of smooth muscle, about 1 cm wide. They are located at the outer surface of the intestinal wall. Their contractions facilitate the peristaltic activity of the colon and form outwardly bulging areas of the colon, the haustra.

There are three distinct longitudinal bands which are designated by their position on the colon transversum:

- ***mesocolic tenia** is located dorsally, at the attachment of the transverse mesocolon;*
 - ***omental tenia** is located ventrocranially, at the attachment of the transverse colon to the greater omentum;*
 - ***free tenia (tenia libera)** is located ventrocaudally and there are no structures attached to it.*
- **Haustra of the colon** are the sacculations (pouches) of the colon that give it its typical "baggy" appearance. They are separated on the inner side by semilunar folds.
The **semilunar folds** are crescent-shaped folds between two haustra. The folds are composed of all intestinal wall layers and are produced by the contractions of the muscular layer.
Haustra are a manifestation of the function of the musculature of the intestine. The longitudinal muscles (teniae) shorten the intestine and the circular muscles constrict the wall of the intestine. The location and size of the haustra are constantly changing due to muscle movements.
- **Omental appendices (appendices epiploicae)** are fat-filled pouches of the peritoneum, that are attached externally to the teniae.

Teniae coli, haustra of the colon and omental appendices are not found on the appendix vermiformis and rectum. In the appendix, all three teniae converge toward the origin of the appendix and form a continuous layer of longitudinal musculature around its wall. Similarly, in the rectum, the teniae coli from the sigmoid colon broaden to form a continuous outer longitudinal layer of the smooth muscle around its wall.

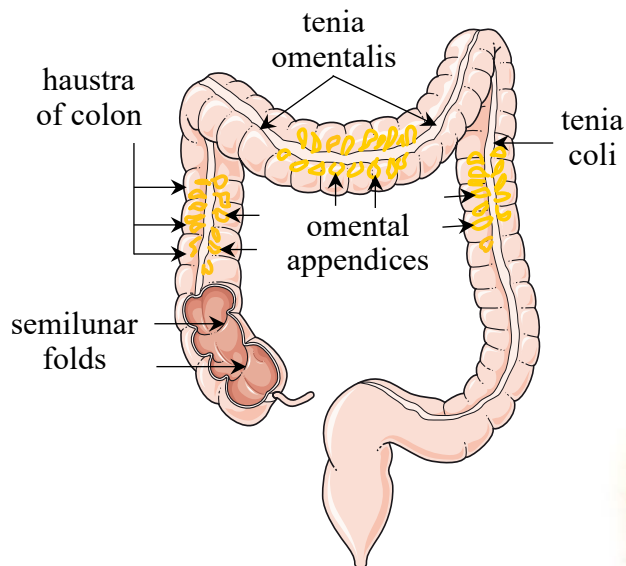


Fig. 70 A
Characteristic features of the large intestine

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Modified by additional drawing and labeling

The teniae coli, haustra of the colon and omental appendices are not usually found on the rectum and vermiform appendix. However, this cadaveric specimen shows atypically present omental appendices on the vermiform appendix.

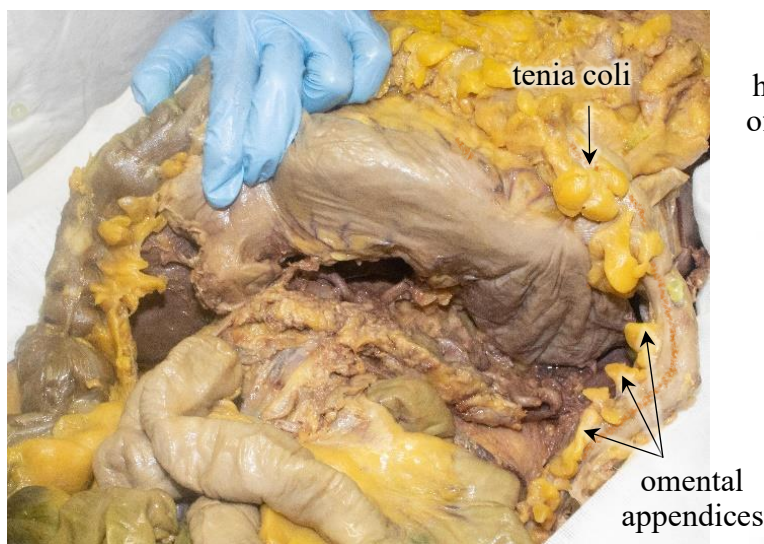


Fig. 70 C

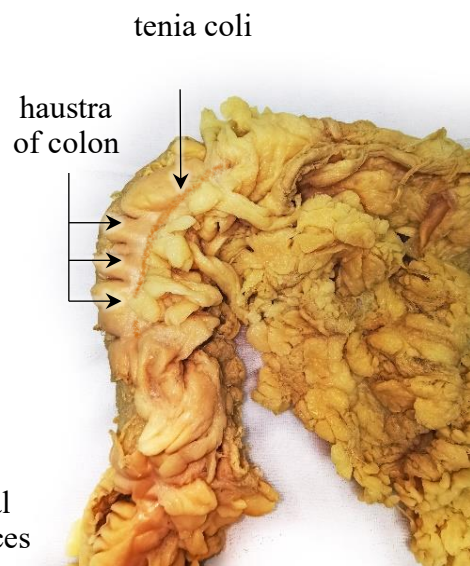


Fig. 70 D

Fig. 70

Characteristic features of the large intestine

70 B – The cecum and all parts of the colon. The greater omentum is attached to the transverse colon

70 C – The stomach, transverse colon and greater omentum are turned upward

70 D – Enlarged detail on the right colic flexure

Formalin-fixed cadaveric specimen, Department of the Anatomy,
Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

7.3 Parts and relations of the large intestine to neighbouring structures and organs

- **Cecum**

The cecum is the first part of the large intestine. It is a blind, sac-like part, which is approximately 6 – 8 cm in length and also in width. The cecum lies in the **right iliac fossa**, below the opening of the terminal ileum. Superiorly, it is continuous with the ascending colon. The terminal ileum opens through an opening into the large intestine, where the cecum and ascending colon join together. This opening, the **ileal orifice (ileocecocolic orifice)** is surrounded by the upper and lower lips, which project into the lumen of the large intestine. The opening is also referred to as the ileocecal valve, but there is no anatomical muscular sphincter around the opening, so it serves as a relatively passive flap that regulates the unidirectional passage of contents from the small intestine to the large intestine. Inferior to the ileal orifice, there is the **orifice of the vermiform appendix**.

Posterior to the cecum are the **iliacus muscle** and **lateral cutaneous nerve**. The anterior and medial walls of the cecum are related to the coils of the **small intestine**, possibly also to the **greater omentum**. The cecum is usually in contact with the **anterior abdominal wall**.

Fig. 71 A

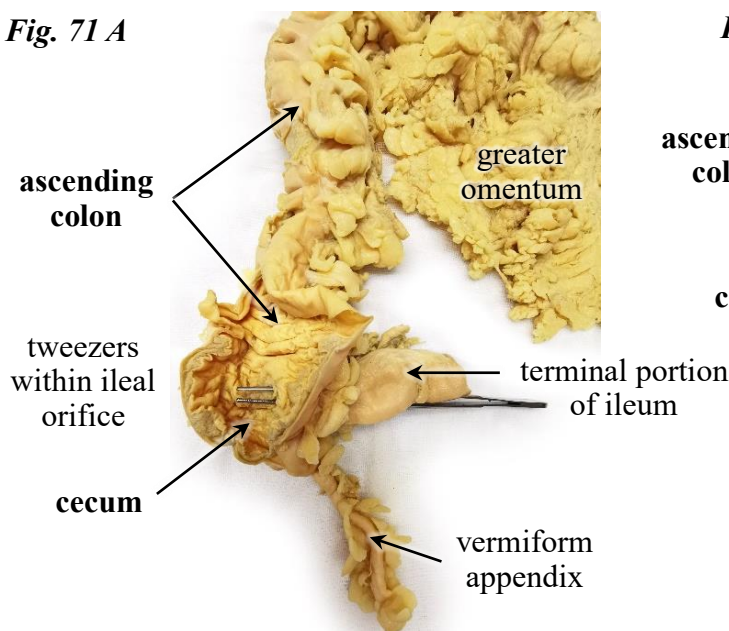


Fig. 71 B

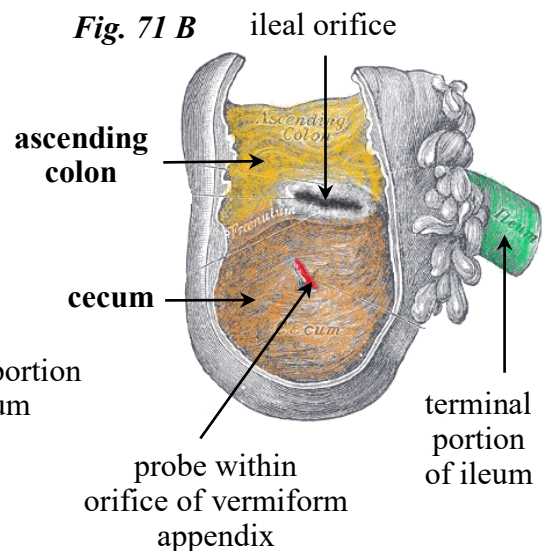


Fig. 71

Cecum, ileal orifice and orifice of the vermiform appendix

71 A – Formalin-fixed cadaveric specimen, Department of the Anatomy, Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

71 B – Original diagram from Gray's Anatomy, 20th US edition which has now lapsed into the public domain (out of copyright). Gray H.: Anatomy of the human Body. Philadelphia: Lea & Febiger, 1918. Available online at Bartleby.com, 2022. www.bartleby.com

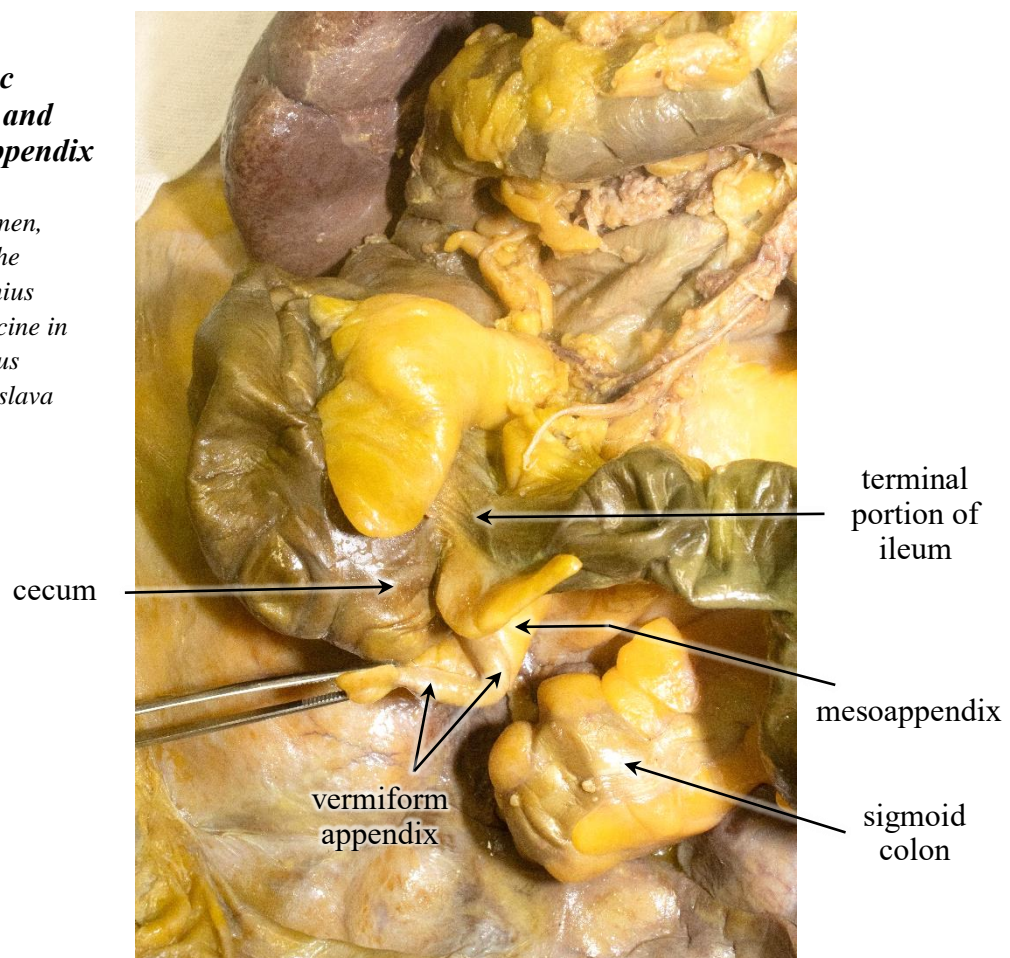
Modified by additional drawing, labeling and colorization

- **Appendix, vermiform appendix**

The cecum is associated with the **appendix, vermiform appendix** (*vermis – worm-like in Latin*). It is a narrow, blind-ended muscular tube. It varies in length and is usually 5 – 10 cm long and 0.5 – 1 cm in diameter (like a pencil). Its wall contains a large amount of lymphoid tissue, so it is also called the abdominal tonsil but is not thought to have any vital functions in the human body.

The position and relations of the appendix to neighbouring structures and organs are clinically very significant but individually very variable, especially with regard to its free end. It may be in different positions depending on its relations to the cecum, ascending colon, ileum or pelvis: in **retrocecal**, **prececal**, **subcecal**, **retrocolic position**, **pre-ileal**, **post-ileal** and **sub-ileal position**. A relatively common variant is the **pelvic position**, in which the appendix extends into the lesser pelvis and, in women, lies in close proximity to the **right ovary** and **uterine tube**.

Fig. 72
The right iliac fossa, cecum and vermiform appendix
Formalin-fixed cadaveric specimen, Department of the Anatomy, Jessenius Faculty of Medicine in Martin, Comenius University Bratislava



The base (beginning) of the appendix, has a relatively stable position. It arises from the posteromedial surface of the cecum below the ileal orifice and opens to the cecum through the **orifice of the vermiform appendix**. The base is projected onto the anterior abdominal wall to **McBurney's point**. It is located at the junction of the lateral and middle one-third of the line connecting the anterior superior iliac spine and umbilicus.

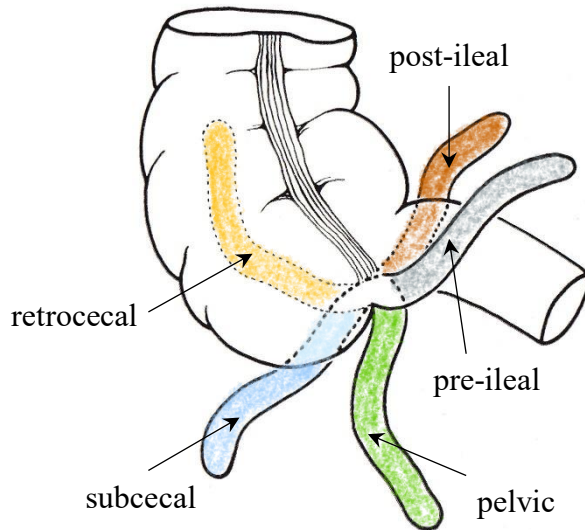


Fig. 73
The most common variations in anatomical position of the vermiform appendix

Author: Grant, John Charles Boileau.
Public domain.

An anatomical illustration from An atlas of anatomy/by regions.1962

Available online at:

https://commons.wikimedia.org/wiki/File:Grant_1962_172a.png

Modified by additional drawing, labeling and colorization

*Appendicitis is an acute inflammation of the appendix and is a common cause of acute abdomen requiring urgent surgical intervention. Most patients with acute appendicitis have localized maximal abdominal tenderness around **McBurney's point** on palpation. The treatment for appendicitis is an appendectomy, which is the surgical removal of the appendix.*

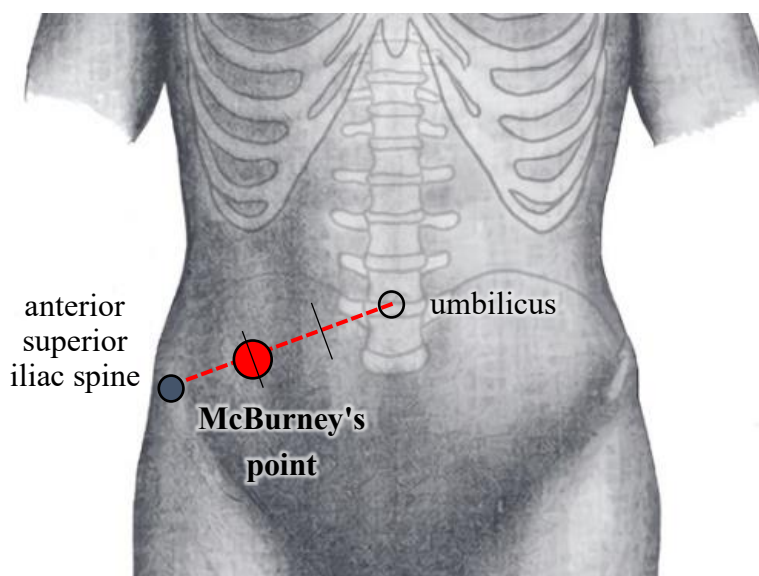


Fig. 74
McBurney's point

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- **Ascending colon**

The cecum continues without borders into ascending colon. The ascending colon is narrower than the cecum and is approximately 12 – 16 cm long. It ascends on the right side of the abdominal cavity toward the visceral surface of the liver. Here, in the **right hypochondriac region**, it turns to the left at the right colic flexure (hepatic flexure).

Posterior to the ascending colon are the **muscles – quadratus lumborum** and **transverse abdominal**, and there are also some nerves of the lumbar plexus: the **iliohypogastric**, **ilioinguinal** and **lateral cutaneous femoral nerves**. Anteriorly, the ascending colon is related to the **abdominal wall** and to the coils of the **small intestine**, which are also located on its medial side. Laterally, it is separated from the adjacent abdominal wall by the deep vertical groove lined by the peritoneum (peritoneal recess). It is the **right paracolic gutter** (*see the chapter: "Peritoneum"*).

- **Right colic flexure (hepatic flexure)**

The right colic flexure is a bend in the colon between ascending and transverse colon, located in the **right hypochondriac region**. It is also referred to as the hepatic flexure because of its close relation to the visceral surface of the **liver** on which it forms an impression. Posterior to the right colic flexure lies the **right kidney**, anteromedially is located **gallbladder** and medially **descending part of the duodenum**. It lies at the level of the cartilages of the 10th and 11th ribs.

- **Transverse colon**

The transverse colon is about 50 – 60 cm long, making it twice as long as the transverse diameter of the abdominal cavity. Because of its length, its course makes the arch which reaches the umbilical region. The transverse colon thus passes from the **right hypochondriac region** through the **umbilical region** to the **left hypochondriac region**, where it turns inferiorly and becomes the descending colon.

The transverse colon is the intraperitoneal part of the colon, and its peritoneal fold is called the **transverse mesocolon**. It attaches the transverse colon to the posterior abdominal wall and allows its mobility. This makes the transverse colon the most mobile part of the colon and therefore its position is variable.

Superior to the transverse colon is the **liver** with the **gallbladder** and the greater curvature of the **stomach**. Inferiorly and partly posteriorly, there are the **coils of the small**

intestine and ventrally it is related to the **greater omentum** and **anterior abdominal wall**. Posterior to the transverse colon is descending part of the **duodenum**, **pancreas**, **mesentery** and **duodenojejunal flexure**.

- **Left colic flexure (splenic flexure)**

The left colic flexure is a bend in the colon between the transverse and descending colon, located in the **left hypochondriac region**. It is also referred to as the splenic flexure because of its close relation to the **spleen**. Posterior to the left colic flexure lies the **left kidney** and the **tail of the pancreas**. It lies at the level of the cartilage of the 8th rib. It is fixed to the diaphragm by the phrenicocolic ligament.

- **Descending colon**

The descending colon runs from the **left hypochondriac region** inferiorly through the left side of the abdominal cavity toward the **left iliac fossa**. It is approximately 20 – 30 cm long. It continues into the sigmoid colon.

The relations of the descending colon to the surrounding structures are analogous to the relations of the ascending colon on the right side.

- **Sigmoid colon**

The sigmoid colon follows the descending colon. The pelvic brim (iliac crest) is considered to be the conventional boundary between the descending and sigmoid colon. The sigmoid colon occupies the **left iliac fossa** and then enters the **lesser pelvis**, where it becomes continuous with the rectum in front of the **SIII vertebra**.

The sigmoid colon is approximately 30 – 40 cm long and its course resembles the letter „S“ (hence its name). The wall of the sigmoid colon is marked by the long omental appendices, which disappear when the peritoneal fold, the sigmoid mesocolon, terminates. The termination of teniae coli is at the rectosigmoid junction, where the longitudinal muscle bands from the sigmoid colon broaden to form a complete outer longitudinal layer of smooth muscle around the wall of the rectum.

Posterior to the sigmoid colon and behind the parietal peritoneum, there is the **iliacus muscle**, **left common iliac vessels** (*at its lower position in the pelvis, it is related to the external and internal iliac vessels*), **left ureter** and **left gonadal vessels**. Inferiorly is the **urinary**

bladder in male, and the **uterus, left uterine tube** and **left ovary** in female. Superiorly, there are the coils of the **small intestine**.

Fig. 75 A

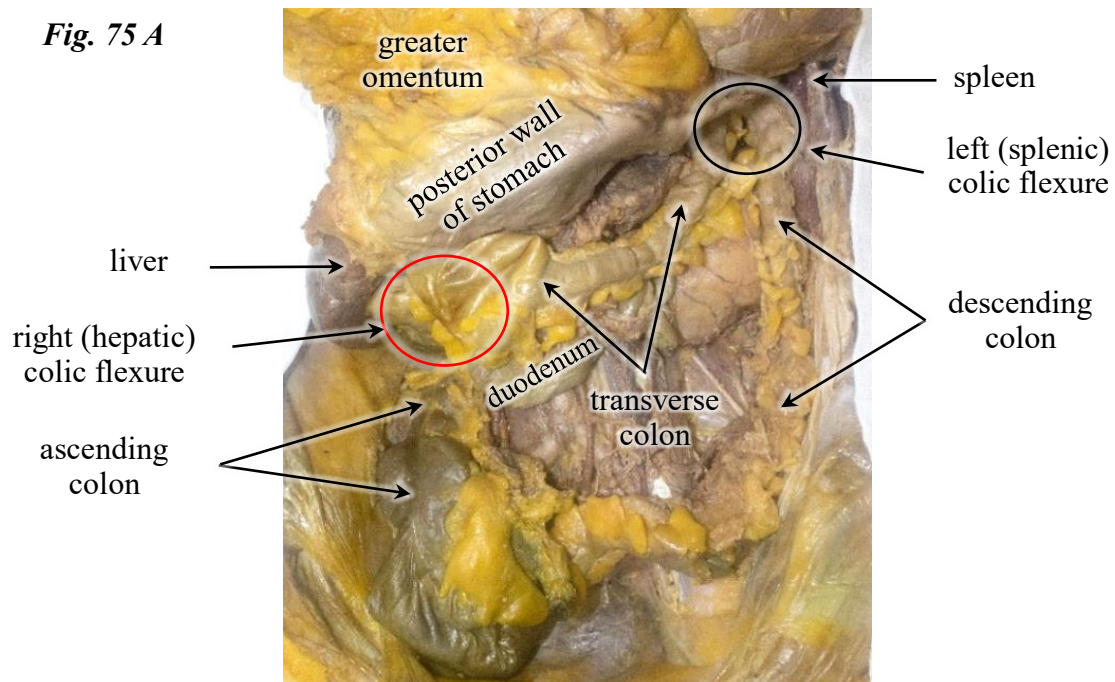
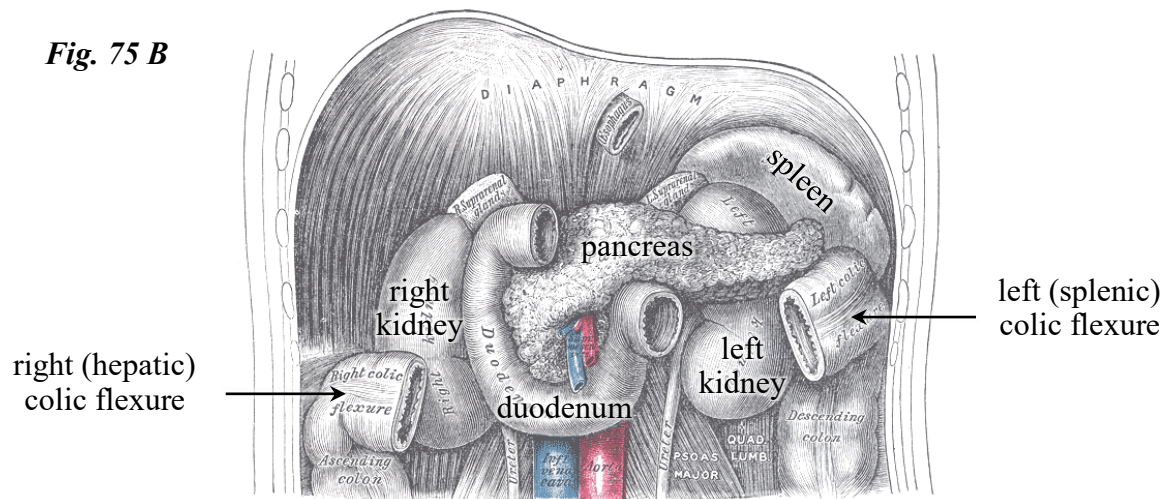


Fig. 75 B



left colic flexure is more acute, less mobile and located higher and also more posteriorly than right colic flexure

Fig. 75

Differences between the right and left colic flexure

75 A – The greater omentum is separated from the transverse colon; the stomach and greater omentum are turned upward

Formalin-fixed cadaveric specimen, Department of the Anatomy,
Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

75 B – Original diagram from Gray's Anatomy, 20th US edition which has now lapsed into the public domain (out of copyright). Gray H.: Anatomy of the human Body. Philadelphia: Lea & Febiger, 1918. Available online at Bartleby.com, 2022. www.bartleby.com

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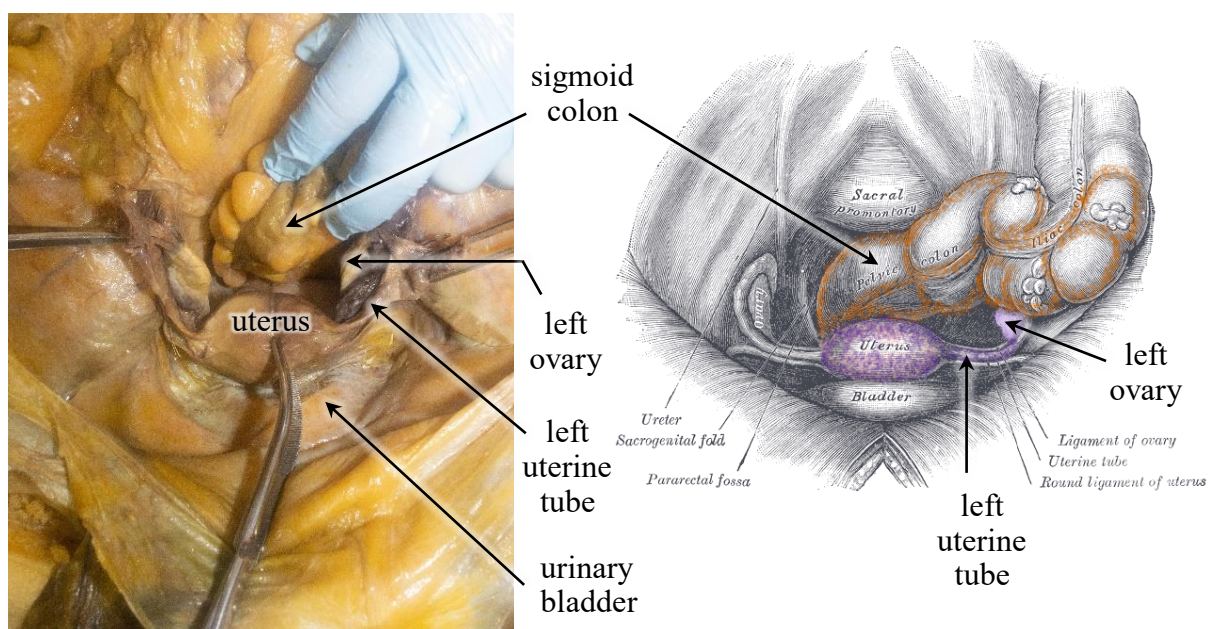


Fig. 76

Relation of the sigmoid colon to the uterus, left uterine tube and left ovary in female pelvis

76 A – Formalin-fixed cadaveric specimen, Department of the Anatomy, Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

76 B – Original diagram from Gray's Anatomy, 20th US edition which has now lapsed into the public domain (out of copyright). Gray H.: Anatomy of the human Body. Philadelphia: Lea & Febiger, 1918. Available online at Bartleby.com, 2022. www.bartleby.com
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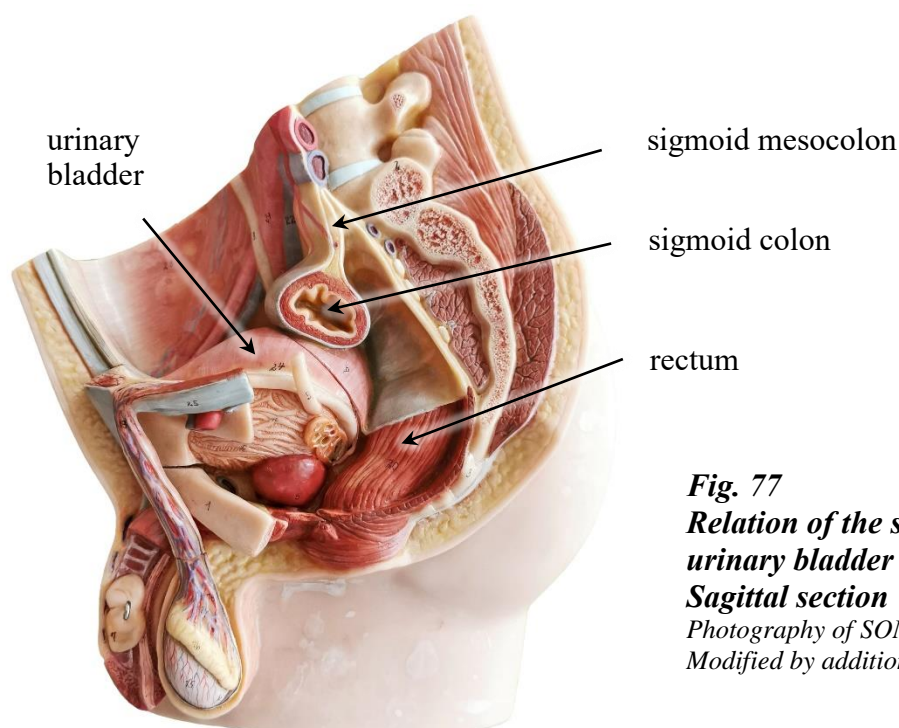


Fig. 77

Relation of the sigmoid colon to the urinary bladder in male pelvis
Sagittal section

Photography of SOMSO model
Modified by additional labeling

- **Position of the cecum and colon to the peritoneum**

The cecum and parts of the colon alternate in relation to their position to the peritoneum:

- **intraperitoneal positioned:** the cecum with the vermiform appendix, transverse colon and sigmoid colon.
- **retroperitoneal positioned:** ascending colon and descending colon.

The **cecum** is enveloped by the peritoneum, but usually, it has no mesentery. If a peritoneal fold is present, it is called a **mesocecum**. It is highly mobile and may be displaced from the iliac fossa superiorly. Its inferior blind end is not dorsally fixed, so that a **retrocecal recess** is formed between it and the posterior wall of the abdominal cavity.

The **vermiform appendix** is completely covered by the peritoneum and it is connected to the mesentery of the small intestine (ileum) by its own peritoneal fold, the **mesoappendix**. The mesoappendix contains the appendicular vessels and nerves.

The anterior wall and sides of the **ascending/descending colon** are covered by the peritoneum. Laterally, the ascending/descending colon is separated from the adjacent abdominal wall by the deep vertical groove lined by the peritoneum. It is the peritoneal recess, the **right/left paracolic gutter** (*see the chapter: "Peritoneum"*). The ascending/descending colon has no peritoneal fold and is attached directly to the posterior abdominal wall by its posterior surface. The ascending colon and descending colon are in a secondary **retroperitoneal position**.

The **sigmoid colon** is **intraperitoneally positioned**. Its peritoneal fold, the **sigmoid mesocolon**, attaches it to the posterior pelvic wall. The long, fan-shaped sigmoid mesocolon allows for relatively large mobility of the sigmoid colon and thus variability of the relations to the surrounding structures.

7.4 Vessels and nerves of the cecum and colon

- The **arterial supply** of the cecum and all parts of the colon comes from two sources – the superior and inferior mesenteric arteries, both arise from the abdominal aorta. The left colic flexure forms a border between the organs, which are supplied by the branches of the superior or inferior mesenteric artery.
- The cecum with the vermiform appendix, ascending colon, right colic flexure and transverse colon are supplied by the branches of the superior mesenteric artery

(gradually from the cecum up to the left colic flexure) – the ileocolic artery, which gives the appendicular artery to supply the appendix, right colic artery, middle colic artery.

- The descending and sigmoid colon are supplied by the left colic and sigmoid arteries, which arise from the inferior mesenteric artery.
- The left colic flexure and the adjacent portion of the transverse and descending colon are supplied by the branches of both mesenteric arteries via anastomoses between them.
- The **veins** follow the arteries and basically drain venous blood via the tributaries into the portal vein. The inferior mesenteric vein is drained into the splenic vein. The splenic vein joins the superior mesenteric vein to form the portal vein.
- **Lymphatic vessels** of the cecum and colon follow the arteries. The lymph vessels drain gradually via the superior and inferior mesenteric lymph nodes into the celiac lymph nodes and then into the intestinal trunk.
- The cecum and colon are **nerve supplied** by the celiac plexus (which gives origin to the superior mesenteric plexus) and by the abdominal aortic plexus (which gives origin to the inferior mesenteric plexus). The celiac and abdominal aortic plexuses contain parasympathetic and sympathetic fibers as well as viscerosensory fibers.

These plexuses receive:

- The **parasympathetic fibers** from the vagus nerve [*CN X*] and from the sacral parasympathicus. The left colic flexure also represents the boundary between the cranial (vagal) and sacral (pelvic) parasympathetic innervation. The cecum, ascending and transverse colon are nerve supplied by the parasympathetic fibers from the vagus nerve [*CN X*]. The descending and sigmoid colon are nerve supplied from the sacral (pelvic) parasympathetic fibers.
- The pre-ganglionic **sympathetic fibers** from the splanchnic thoracic nerves, which join the celiac plexus and the lumbar splanchnic nerves which join the abdominal aortic plexus.

Fig. 78 A

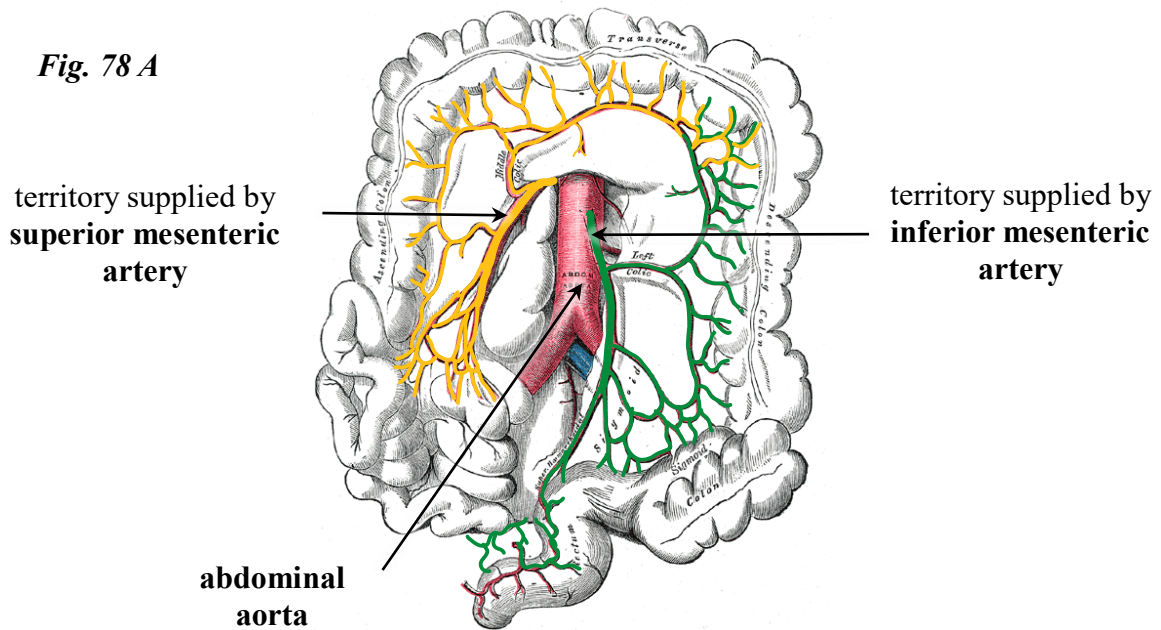


Fig. 78 B

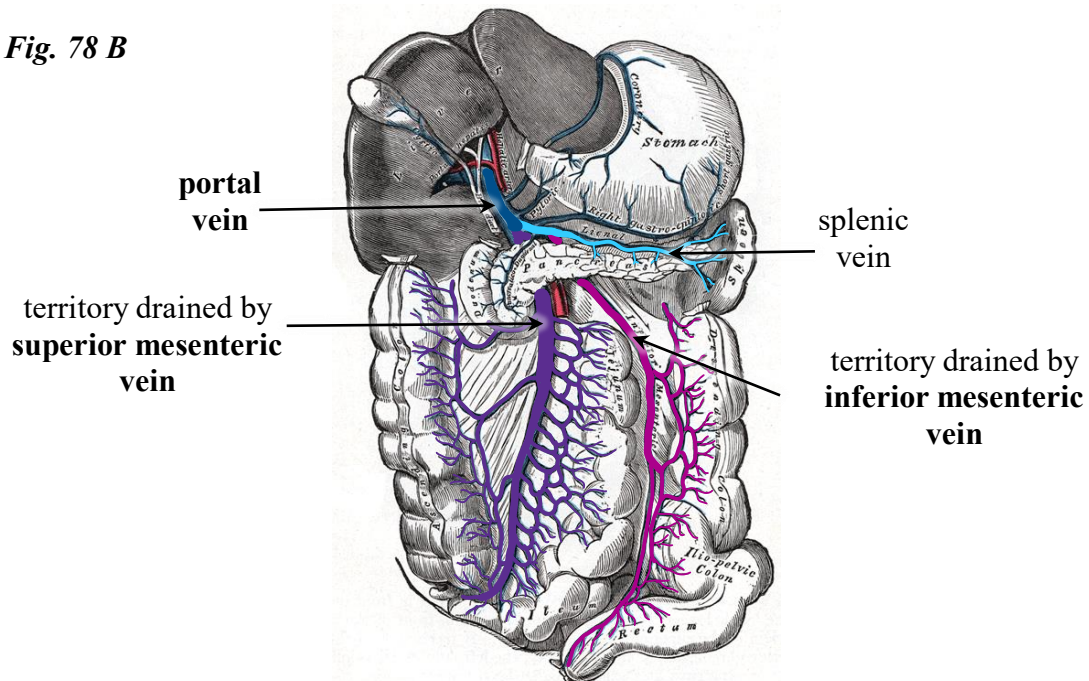


Fig. 78

Vessels of the cecum and colon

78 A – Arterial supply

78 B – Venous drainage

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- **Rectum and anal canal**

The **rectum** extends between the sigmoid colon and the anal canal. It starts from the **rectosigmoid junction**, anterior to the **SIII vertebra** or at the end of the sigmoid mesocolon, because the rectum is positioned retroperitoneally. In passing the **pelvic diaphragm**, the rectum is continuous with the **anal canal** and ends as the **anus**.

*The rectum differs from the other parts of the colon in that its wall does not have the typical features of the colon - it **does not have teniae coli, colonic haustra and omental appendices**. Thus, when operating in this area, the border between the colon sigmoideum and the rectum can be recognized by the naked eye.*

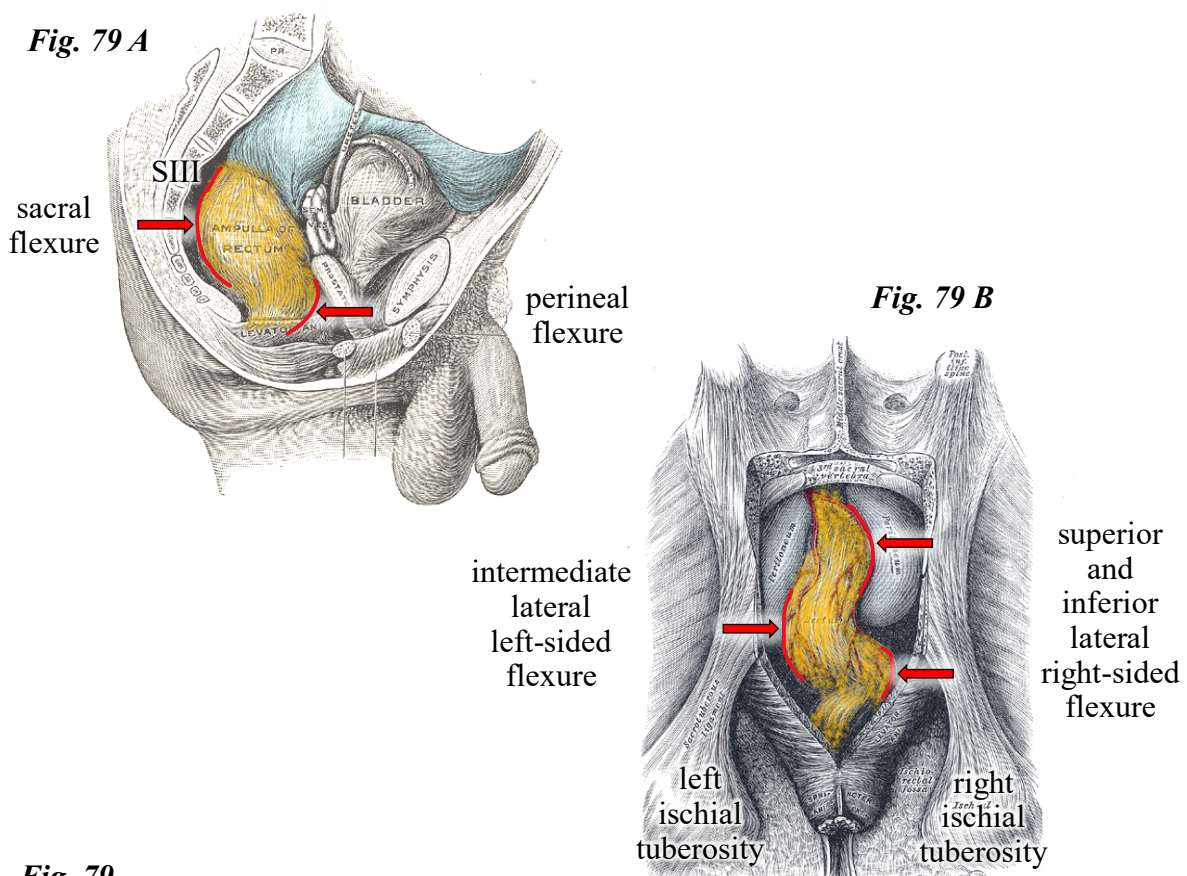


Fig. 79

Flexures of the rectum

79 A – Flexures of the rectum in the sagittal plane

79 B – Flexures of the rectum in the frontal plane

Posterior view; the lower part of the sacrum and coccyx have been removed

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The rectum is approximately 15 cm long. It lies within the lesser pelvis, where it is the most posterior organ of the pelvic viscera. It passes downward and follows the curve of the sacrum and coccyx. So, in the **sagittal plane**, the course of the rectum is marked by two flexures:

- The **sacral flexure**, which is an anteriorly concave curvature that conforms to the sacrum.
- The **perineal (anorectal) flexure**, at the transitory area between the rectum and the anal canal, which is an anteriorly convex bend, just above the anus.

In the **frontal plane**, the filled rectum is curved to the sides and forms lateral curvatures. They are conditioned by the transverse folds on the inner surface of the rectum.

- The **superior lateral flexure** is the upper curvature with a right-sided convexity of the rectal wall;
- The **intermediate lateral flexure** is the middle curvature with a left-sided convexity;
- The **inferior lateral flexure** is the lower curvature again with a right-sided convexity of the rectal wall.

Parts and relations of the rectum to neighbouring structures and organs

- The **rectal ampulla** is a dilated part immediately above the pelvic diaphragm and lies in the range of the sacral flexure. Its length is 10 – 12 cm. It passes through the perineal flexure into the anal canal.

The **mucosa of the rectal ampulla** is marked by the **transverse folds**. They are usually 1 – 2 cm thick folds, which consist of the mucosa, submucosa and the circular muscular layer. There are usually three folds. The middle fold, Kohlrausch's fold, is the largest and most constant. It projects into the rectal ampulla from the right wall and is palpable on the right side of the rectum 6 – 8 cm above the anus. The other two folds project into the rectum from the left side.

The **anorectal junction** is a point, where the dilated rectal ampulla narrows as it traverses the pelvic diaphragm and continues into the anal canal. It is situated approximately below the tip of the coccyx and above the anal columns. Internally, its level is indicated by the superior ends of the anal columns.

- The **anal canal** begins at the anorectal junction. It is a narrowed part, its length is approximately 2.5 – 3.8 cm. Its mucosa differs from the mucosa of the rectal ampulla.

The **mucosa of the anal canal** is marked by the **longitudinal folds**, the **anal columns**. There are 6 to 10 folds around the circumference of the wall. The **anal sinuses** are small recesses (niches) between the anal columns. The **anal valves** are small transverse folds that form the inferior boundary of the anal sinuses.

The anal valves together form a circle around the anal canal at the **pectinate line (dentate line)**. It is the inferior line of demarcation of the anal valves. Inferior to the pectinate line is a lighter strip about 15 mm wide, the **anal pecten**. It is an anal transition zone between the columnar epithelium above and stratified, nonkeratinized squamous epithelium below. The anal pecten ends inferiorly at the **anocutaneous line (white line)**. It is the beginning of the external skin composed of the stratified, nonkeratinized squamous epithelium.

The internal **rectal venous plexus** is a thickened vascular submucous tissue, that surrounds the level of the anal columns and sinuses.

*The area around the internal rectal venous plexus is also called the **hemorrhoidal zone**. It acquires clinical significance in pathological circumstances, when the veins become more congested, greatly enlarged and tortuous. The dilated veins of the internal rectal venous plexus, the anorectal varices (hemorrhoids), protrude into the lumen of the anal canal and contribute to its narrowing. They have a tendency to bleed and bleeding of them is characteristically bright (fresh) red and it may be associated with the portocaval anastomosis. They are viscerally innervated, so they are painless.*

The external hemorrhoids are enlarged veins, which are commonly associated with e.g. chronic obstipation or pregnancy. They are somatically innervated, so they are more painful than the internal hemorrhoids.

The **longitudinal muscular layer** forms a complete layer around the anal canal into which all three teniae of the sigmoid colon extend. The **circular muscular layer** of the anal canal forms thickened ring around the superior two-thirds of the anal canal. It is an involuntary sphincter, the **internal anal sphincter muscle**. It ends at the level of the anocutaneous line (white line).

The voluntary **external anal sphincter muscle** is a muscular ring composed of the transversely striated fibers overlying the internal anal sphincter muscle. It consists of three parts – deep, superficial and subcutaneous, arranged sequentially along the anal canal from superior to inferior. The deep part blends with the fibers of the levator ani muscle from the **pelvic**

diaphragm. The lowermost subcutaneous part is like a horizontally flattened disc of the muscle and it lies caudal to the internal anal sphincter muscle.

The **anus** is the inferior opening of the anal canal, encircled by the subcutaneous and superficial parts of the **external anal sphincter muscle**. Its skin contains sweat glands and hair follicles.

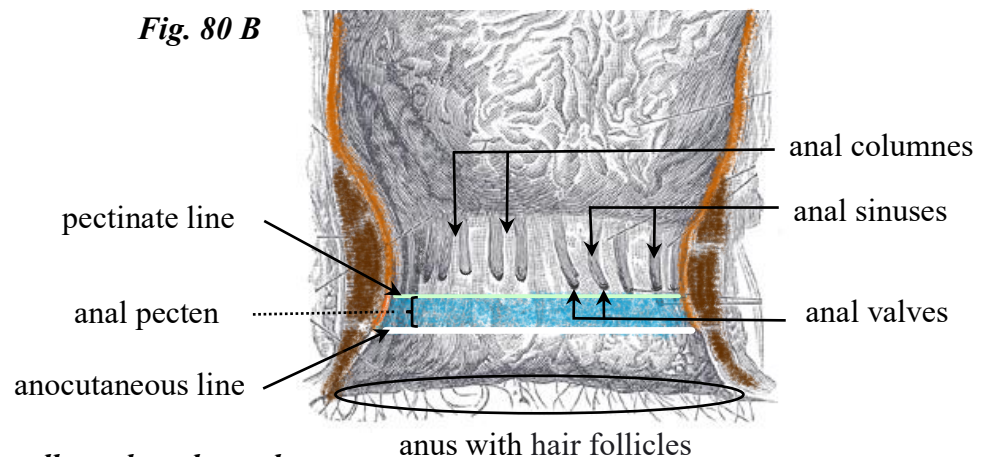
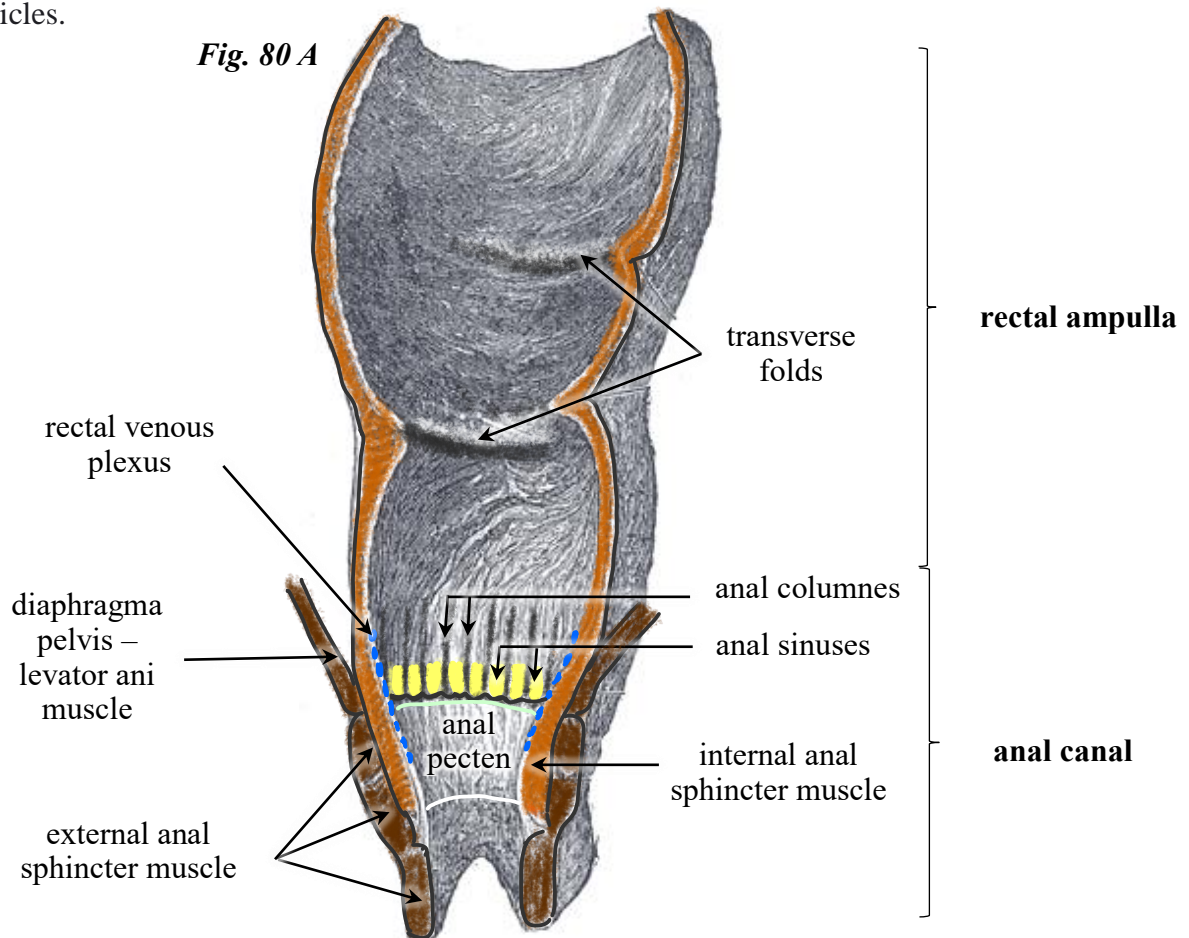


Fig. 80 Rectum

80 A – Rectal ampulla and anal canal

80 B – Anal canal

Original diagram from Gray's Anatomy, 20th US edition which has now lapsed into the public domain (out of copyright). Gray H.: Anatomy of the human Body. Philadelphia: Lea & Febiger, 1918. Available online at Bartleby.com, 2022. www.bartleby.com

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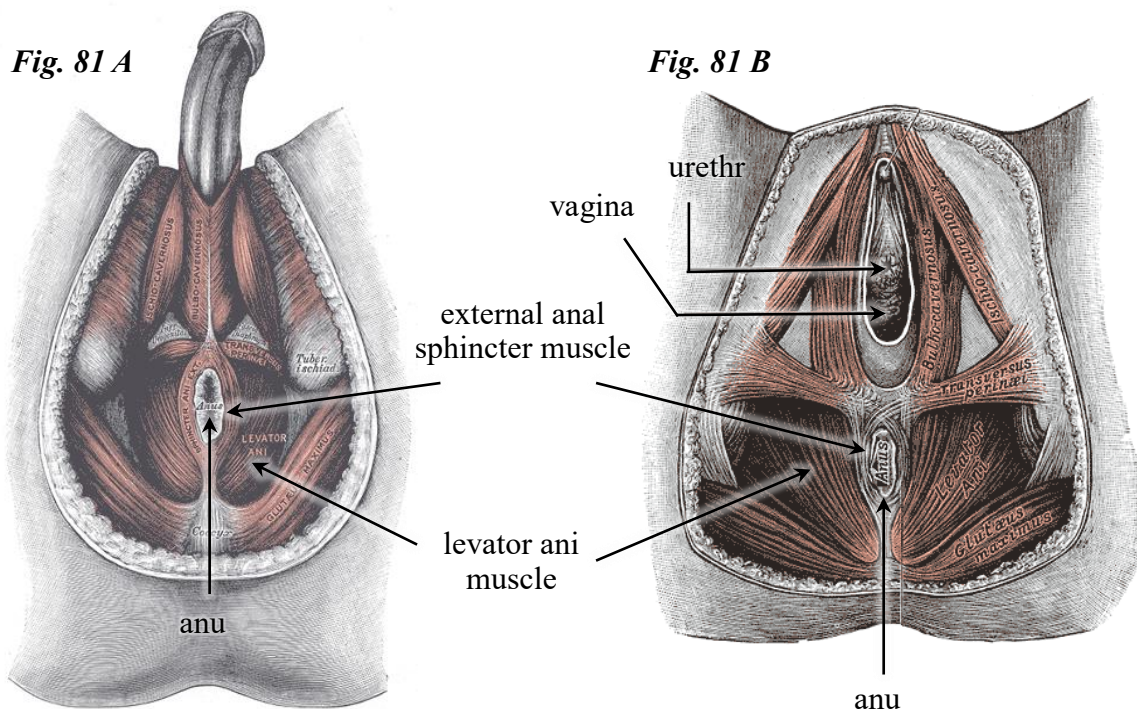


Fig. 81 Anus and external anal sphincter

81 A – Anus, muscles of the male perineum

81 B – Anus, muscles of the female perineum

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Modified by additional labeling

Relations of the rectum to neighbouring structures and organs

Posterior to the rectum are the sacrum and the coccyx. They are connected with the rectum by the **rectococcygeal muscle** and **anococcygeal ligament**. Inferolaterally, there is the **pelvic diaphragm** (levator ani muscle). Inferior to the pelvic diaphragm and lateral to the anal canal, there is the right and left **ischio-anal fossa**. Anteriorly, the **rectovesical muscle** extends between the rectum and the urinary bladder.

Anterior to the rectum in male, there is the **urinary bladder, prostate, and rectovesical septum** with the **seminal vesicles** and **deferent duct**. The rectum is separated from the urinary bladder by the peritoneal pouch, the **recto-vesical pouch**.

Anterior to the rectum in female, there is the uterus and **rectovaginal septum** with the **vagina**. The rectum is separated from the uterus by the peritoneal pouch, the **recto-uterine pouch**.

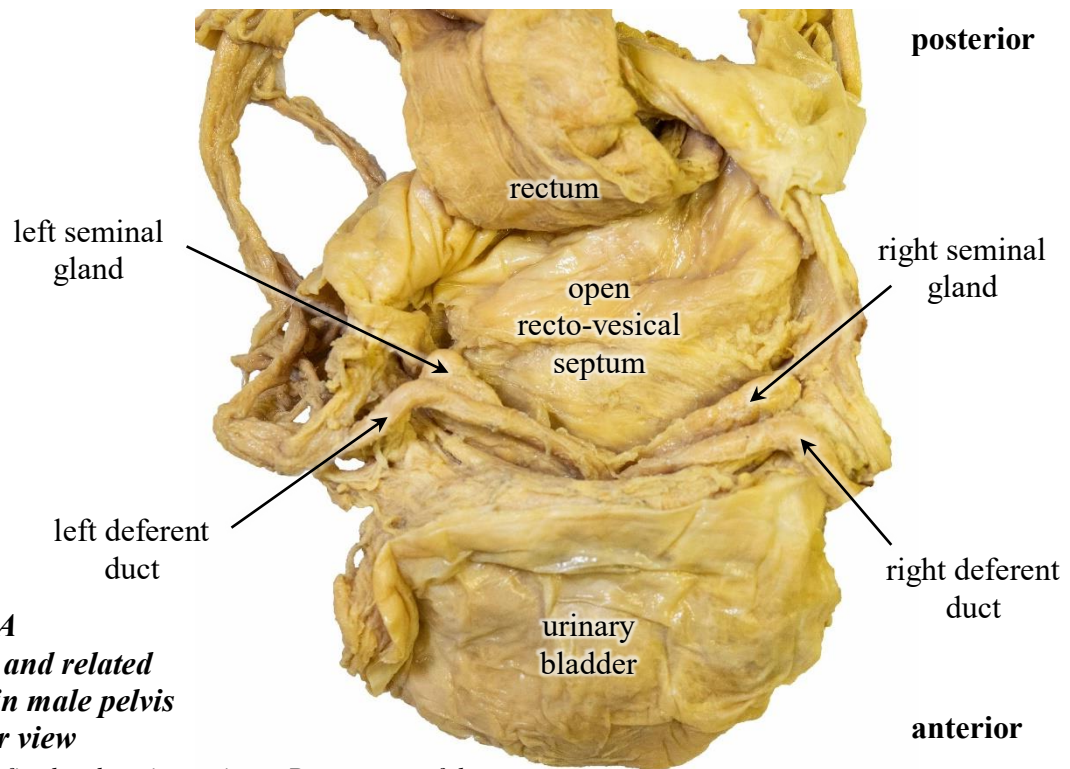


Fig. 82 A
Rectum and related
organs in male pelvis
Superior view

*Formalin-fixed cadaveric specimen, Department of the
 Anatomy, Jessenius Faculty of Medicine in Martin,
 Comenius University Bratislava*

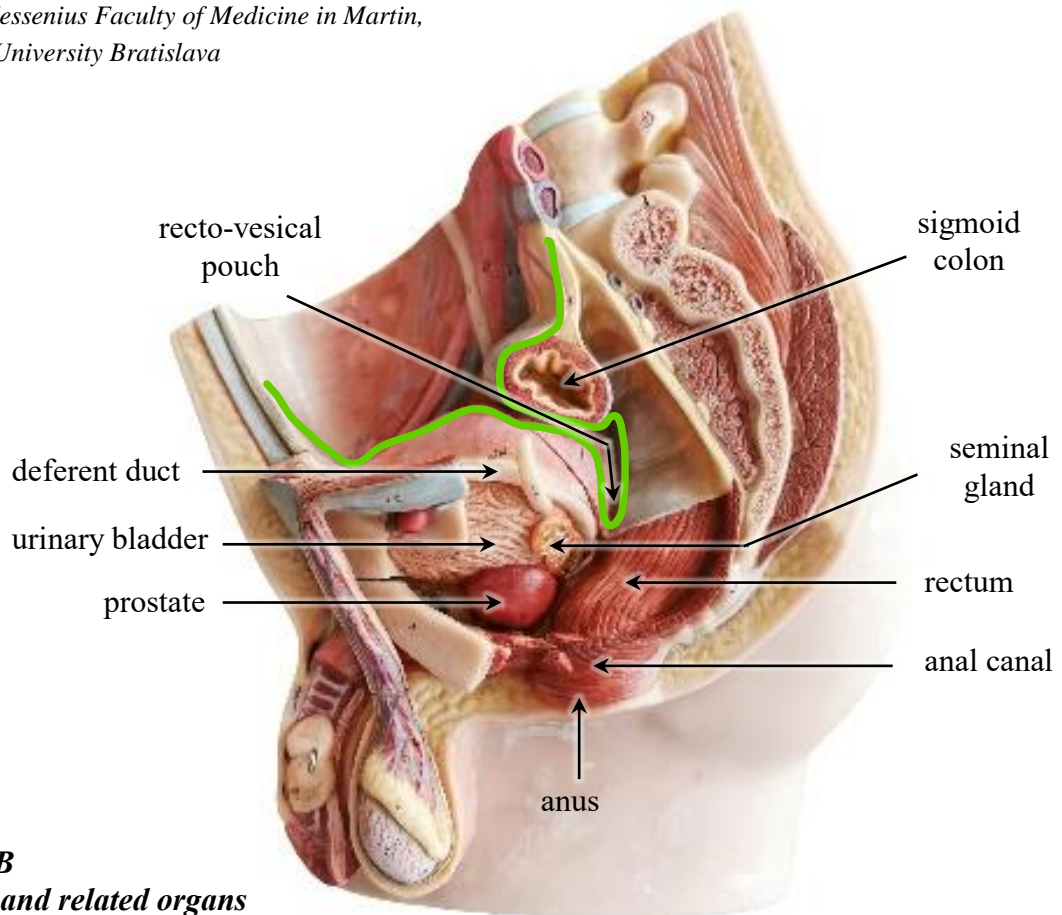


Fig. 82 B
Rectum and related organs
in male pelvis; peritoneal pouch
Sagittal plane

*Photography of SOMSO model
 Modified by additional drawing and labeling*

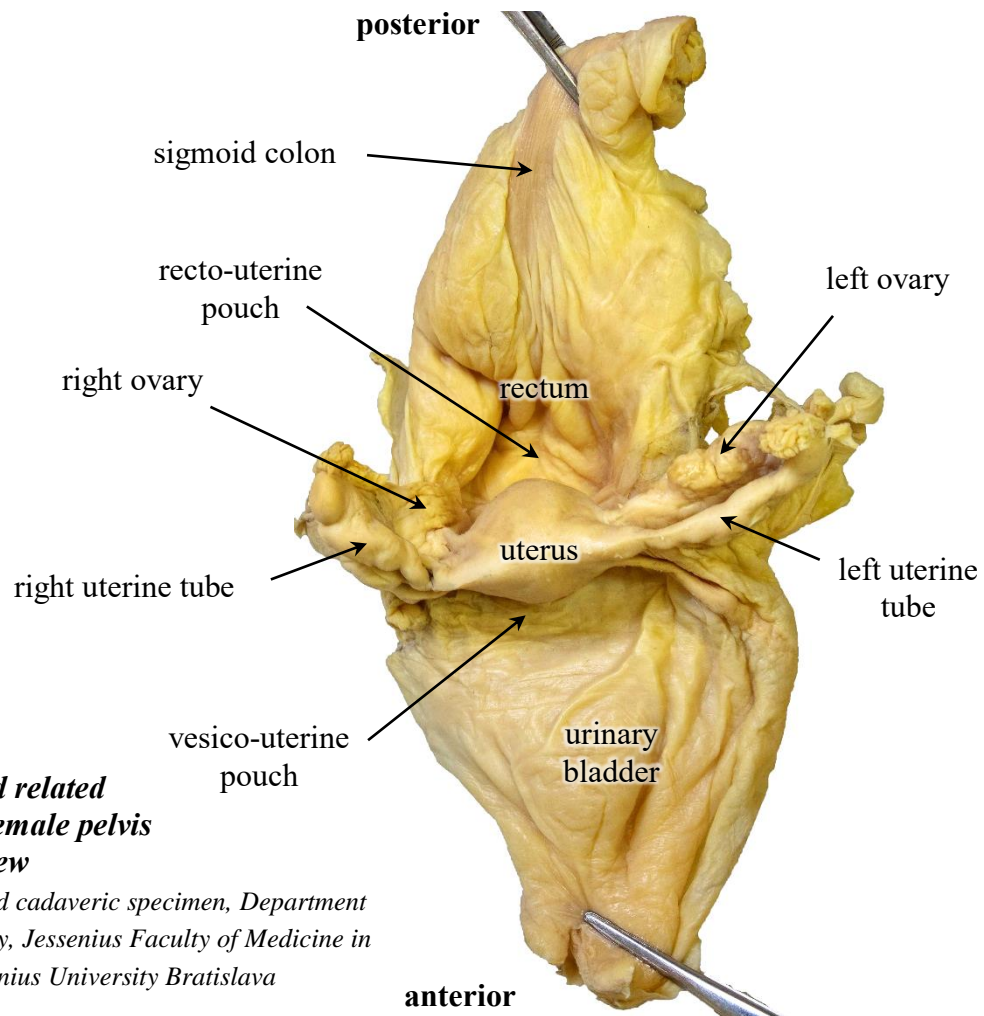


Fig. 83 A
Rectum and related
organs in female pelvis
Superior view

Formalin-fixed cadaveric specimen, Department of the Anatomy, Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

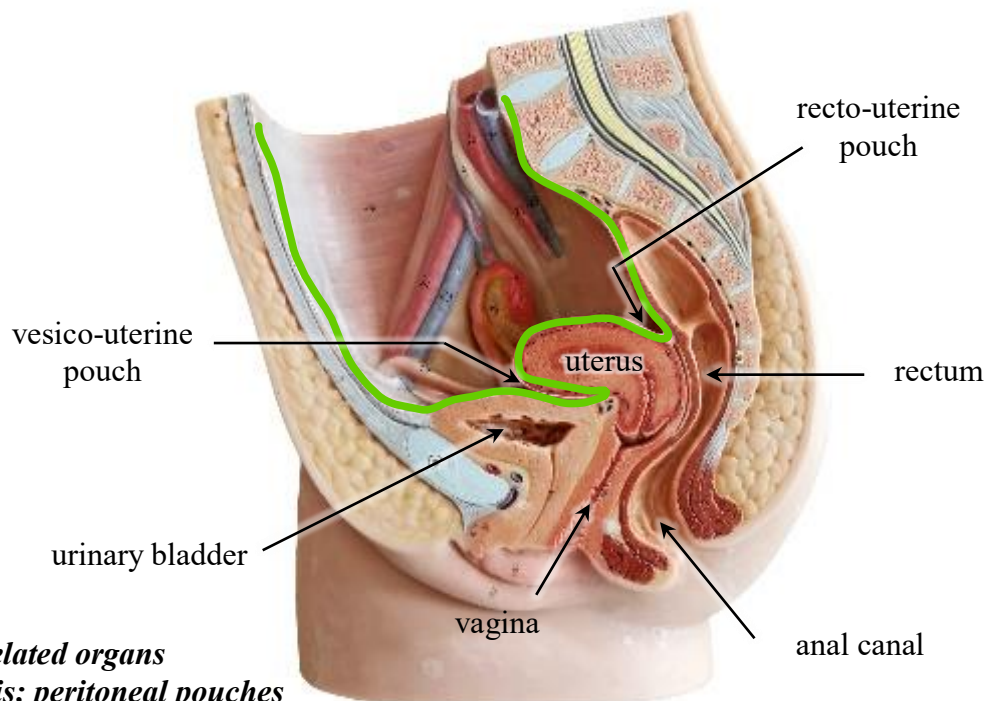


Fig. 83 B
Rectum and related organs
in female pelvis; peritoneal pouches
Sagittal plane

*Photography of SOMSO model
 Modified by additional drawing and labeling*

Per rectum examination is a very important but often neglected examination. The examination can detect, for example, colorectal cancer. Through the anterior wall of the rectum, the prostate is palpable in men and the cervix of the uterus in women. In females, the examination is limited for the gynecological palpations of internal organs when you are unable to access the vaginal vault or the examination is too painful (vaginal atrophy).

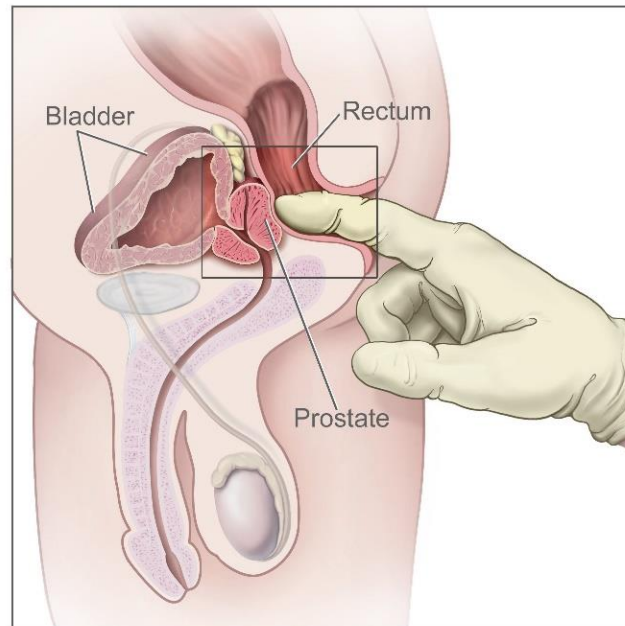


Fig. 84

Examination of the prostate per rectum

Original diagram from Wikipedia.org. Public domain. Unknown author - This image was released by the National Cancer Institute, an agency part of the National Institutes of Health, with the ID 7136. 2008. Available at: https://en.wikipedia.org/wiki/Rectal_examination

7.5 Vessels and nerves of the rectum

- The **arterial supply** of the rectum and anal canal comes from two sources – from the inferior mesenteric artery and from the internal iliac artery.
- The upper portion of the rectum is blood supplied by the superior rectal artery, which arises from the inferior mesenteric artery. The portion of the rectum, just above the pectinate line, is supplied by the middle rectal artery, which arises from the internal iliac artery. The most inferior portion, including the anal canal below the pectinate line, both sphincters as well as peri-anal skin, is supplied by the inferior rectal artery, which arises from the internal pudendal artery. The internal pudendal artery is a branch of the internal iliac artery. The rectal arteries anastomose each other and also the superior rectal artery forms anastomoses with the sigmoid arteries.

- The **venous blood** is drained via the rectal venous plexus. It drains in both directions from the level of the pectinate line. Superior to the pectinate line, the rectal venous plexus is drained via the superior rectal vein into the inferior mesenteric vein and finally into the portal venous system. Inferior to the pectinate line, the rectal venous plexus is drained via the inferior rectal vein into the internal pudendal vein, which drains the blood via the internal iliac into the caval venous system (represented by the inferior vena cava). The middle rectal vein drains the blood via the internal iliac vein into the caval venous system and it forms anastomoses with both the superior rectal and inferior rectal vein.

During pathological conditions, when portal pressure is elevated and venous drainage through the portal venous system is restricted, the rectal veins form important alternative routes. These are the portocaval anastomoses, that allow blood to drain from the portal venous system through the inferior vena cava to the heart.

- **Lymphatic vessels** drain lymph from the rectum in several directions. Along the superior rectal artery, the lymphatic vessels drain via the inferior mesenteric lymph nodes into the celiac lymph nodes. The portion just above the pectinate line is drained by the lymphatic vessels along the middle rectal artery into the internal iliac lymph nodes. The lymph is drained directly and also indirectly – from the sides of the rectum via the pararectal lymph nodes into the internal iliac lymph nodes. The anal canal inferior to the pectinate line and anus are drained by the lymphatic vessels via the superficial inguinal lymph nodes into the external iliac lymph nodes.
- The rectum superior to the anal canal has a **visceral innervation**. It is nerve supplied by the inferior hypogastric plexus, which contains **sympathetic, sacral parasympathetic and visceral afferent fibers**. The sympathetic fibers maintain the tonus of the internal anal sphincter muscle and the parasympathetic fibers inhibit its tonus and induce the peristaltic contractions necessary for defecation.
- The anal canal below the pectinate line and the anus have a **somatic innervation**. The nerve supply arises from the pudendal nerve. Therefore, this part of the anal canal and anus are sensitive to pain, touch and temperature. Somatic efferent fibers stimulate the contraction of the external anal sphincter muscle, which is a voluntary muscle.

8 LIVER (Hepar in Latin)

The liver is the largest visceral organ in the abdominal cavity and also the largest gland in the human body with both external and internal secretions. It is an essential organ that is responsible for many vital life functions. The liver serves primarily as a nutrient processing center for food, a metabolic and detoxification center, and a reservoir of glycogen, protein, lipids and hormones. Its exocrine function ensures the secretion of bile, which aids in the digestion of fats. In the embryonic period, it is also the seat of hematopoiesis.

The liver is a richly vascularised organ, reddish-brown in color, with fragile consistency. Injuries to the liver bleed intensely and surgical suturing of the wound is difficult. The weight of the liver of an adult human is approximately 1.5 kg (with a range of 1.0 – 2.5 kg). Its shape is approximately that of a cone or a wedge with a larger right lobe and a smaller and narrower left lobe.

8.1 Anatomical position and fixation of the liver

The liver lies in the **right hypochondrium, epigastrium** and it extends into the **left hypochondrium**. It is located just below the diaphragm and its larger portion mainly under its right vault. In a healthy person, the inferior margin of the liver is covered by the right costal arch up to the right midclavicular line and does not reach below the costal margin. From the point where the right midclavicular line intersects the right costal arch, the liver continues to the left, crossing the midline and reaching the left hypochondrium. When breathing, it moves along with the excursions of the diaphragm.

The **fixation of the liver** in its position is ensured in several ways:

- by the direct connection with the diaphragm in the bare area;
- by the ligamentous structures (falciform ligament, round ligament of the liver - ligamentum teres hepatis, lesser omentum);
- by the position of the inferior vena cava, which is embedded in the parenchyma of the liver within the groove for the vena cava;
- by the support of the surrounding organs;
- by the atmospheric pressure which fixes the liver to the vault of the diaphragm.

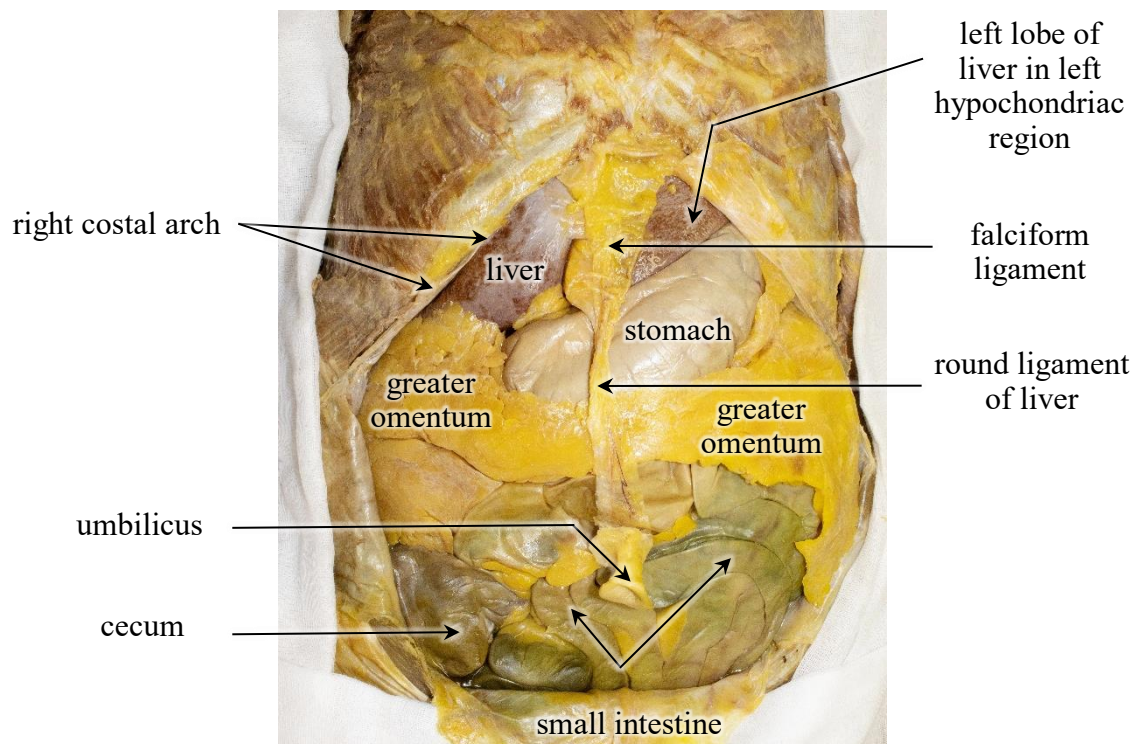


Fig. 85

Abdominal cavity – liver and other abdominal organs in situ („In situ“ means „in its original place“)

Anterior view

Formalin-fixed cadaver, Department of the Anatomy,
Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

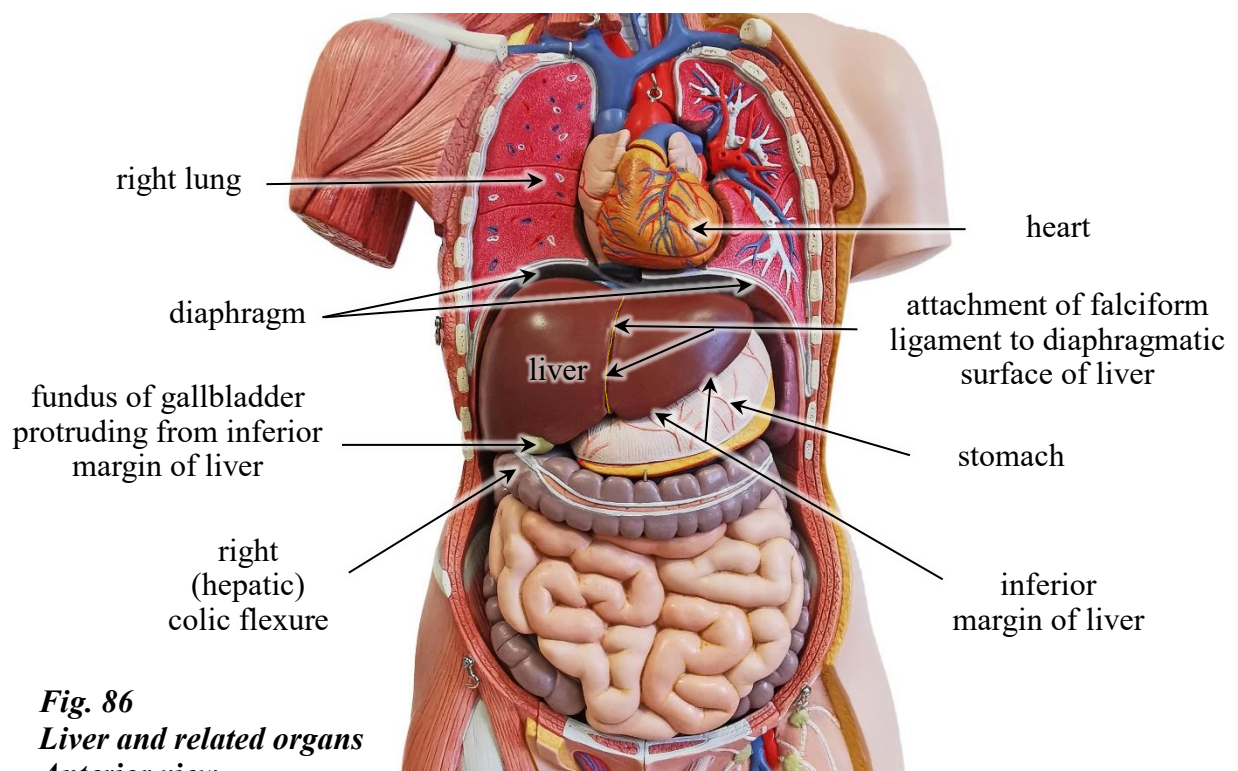


Fig. 86

Liver and related organs

Anterior view

Photography of SOMSO model
Modified by additional drawing and labeling

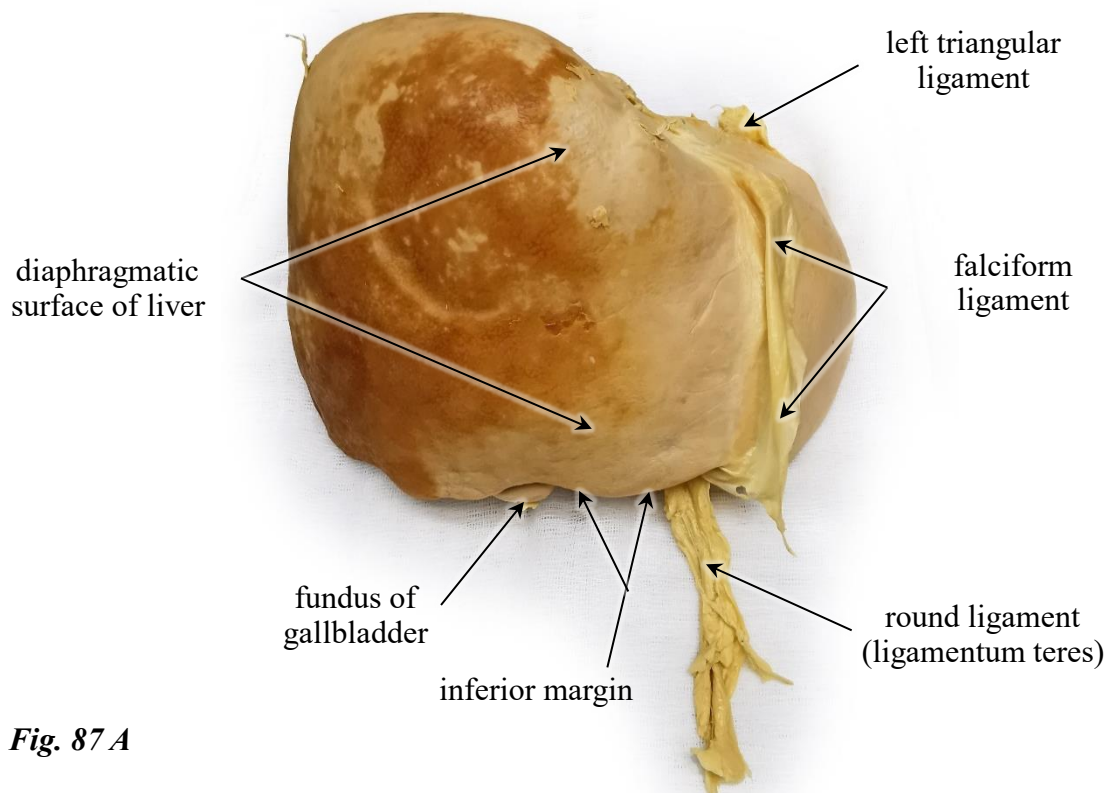


Fig. 87 A

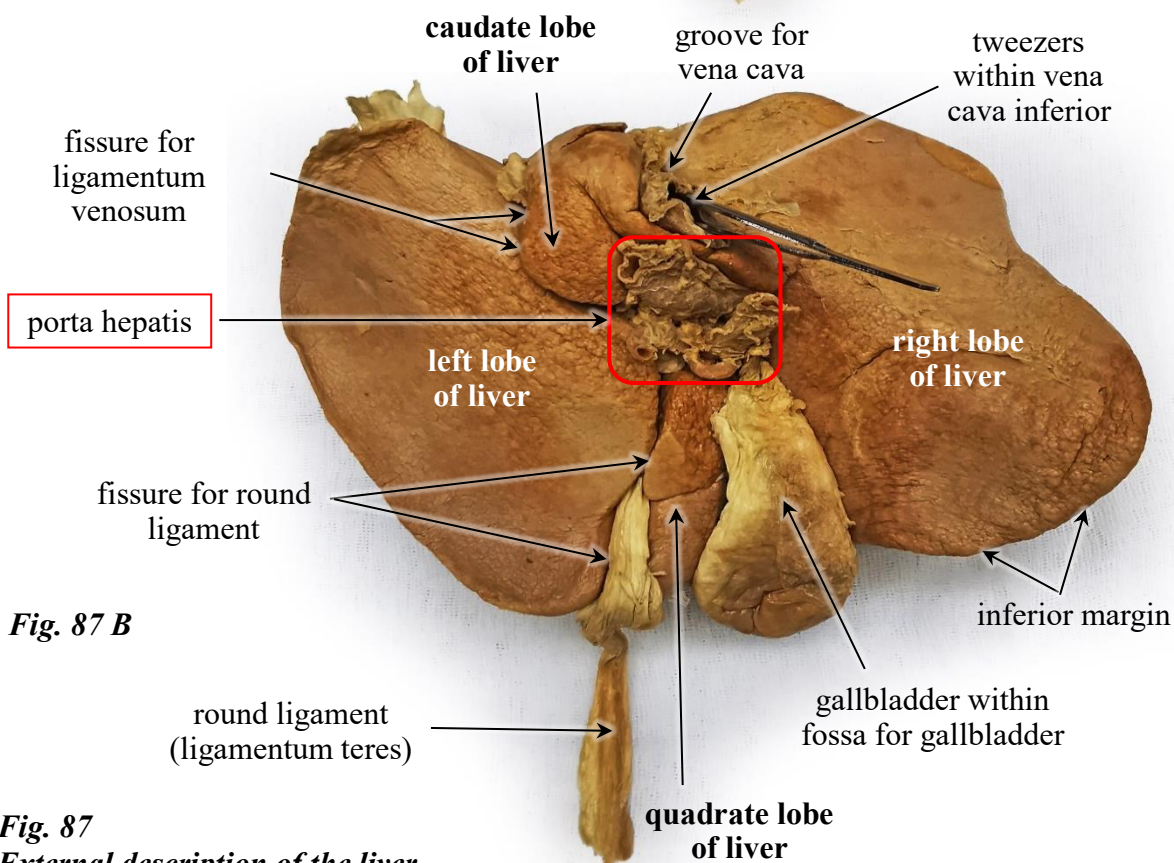


Fig. 87 B

Fig. 87

External description of the liver

Fig. 87 A – Diaphragmatic surface of the liver

Fig. 87 B – Visceral surface of the liver

Formalin-fixed cadaver, Department of the Anatomy,
Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

8.2 Description of the liver and relations to neighbouring organs

The liver has two **surfaces** – **diaphragmatic** and **visceral**. Anteriorly, the surfaces are separated by the sharp **inferior margin**. Posteriorly, one surface flows seamlessly into the other via a rounded **posterior margin**.

- **Diaphragmatic surface**

The smooth and convex diaphragmatic surface faces the diaphragm and follows the diaphragmatic vault. The diaphragm separates the liver from the **heart** and **pericardium**, **lungs** and **pleurae** (*and costodiaphragmatic recesses*).

The diaphragmatic surface has anterior, superior and posterior parts. The diaphragmatic surface is covered by the visceral peritoneum, except for its posterior and partly superior part, which is called the **bare area** (*area nuda*). The bare area of the liver lacks a peritoneal covering and in this location, the liver lies in direct contact with the diaphragm and inferior vena cava. The bare area is demarcated by the **coronary ligament**. The anterior and superior part of the diaphragmatic surface is attached to the diaphragm and the anterior abdominal wall by the **falciform ligament**. Its free inferior edge contains the obliterated umbilical vein (the **round ligament of the liver**/**ligamentum teres hepatis**).

- **Visceral surface**

In the anatomical position, the visceral surface of the liver is directed inferiorly, toward the abdominal viscera, and posteriorly. This surface, unlike the diaphragmatic, is uneven, slightly concave and bears multiple fissures, structures and impressions of adjacent organs.

Two sagittally oriented fissures and one transverse fissure – the **porta hepatis**, centrally located between the sagittal fissures, are arranged in the form of the letter „H“ on the visceral surface of the liver. This arrangement divides the surface into four lobes – **the right and left lobe of the liver**, the **quadrate** and **caudate lobe**.

- The **right sagittal fissure** is formed anteriorly by the **fossa for the gallbladder** and posteriorly by the **groove for the vena cava**. It separates the right lobe of the liver from the quadrate lobe anteriorly and from the caudate lobe posteriorly.

- ***Fossa for gallbladder** is a depression in which the gallbladder is situated.*
- ***Groove for vena cava** is a deep furrow, in which the inferior vena cava is embedded. In this groove, the hepatic veins drain into the inferior vena cava. The ligament of the vena cava may also be present – it bridges the margins of the groove and thus fixes the vein in the groove.*

- The **left sagittal fissure** is formed anteriorly by the **fissure for the ligamentum teres (fissure for the round ligament)** and posteriorly by the **fissure for the ligamentum venosum**. It separates the left lobe of the liver from the quadrate lobe anteriorly and from the caudate lobe posteriorly.
- ***Fissure for ligamentum teres** is a groove that lodges the round ligament of the liver (ligamentum teres hepatis) – the ligamentum is a remnant of the umbilical vein.*
- ***Fissure for ligamentum venosum** is a groove that lodges the ligamentum venosum. This ligament is a remnant of the ductus venosus (Arantii).*
- The **porta hepatis** (hilum of the liver) is a transverse fissure through which all vessels (except the hepatic veins), the nerves and also hepatic ducts enter or leave the liver.

*The porta hepatis contains the **triad of important structures**: the **proper hepatic artery** and **hepatic portal vein** that enter the liver and the **right and left hepatic ducts** that leave the liver. It also transmits the lymphatics and sympathetic nerves from the celiac plexus, and the parasympathetic hepatic branches of the vagus nerve.*

The visceral surface is covered by the visceral peritoneum, in addition to the porta hepatis and the fossa for the gallbladder.

- The visceral surface is in direct contact with some abdominal organs. The right lobe of the liver is closely related to the **right kidney, right suprarenal gland, the right colic flexure and duodenum**. The left lobe of the liver is related to the **abdominal part of the esophagus and stomach**. This lobe is also marked by the omental tuberosity. It is projection left to the fissure for the ligamentum venosum, which is directed to the lesser sac/omental bursa.

Fig. 88 A
Visceral surface of
the liver;
porta hepatis and
portal triad

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and labeling

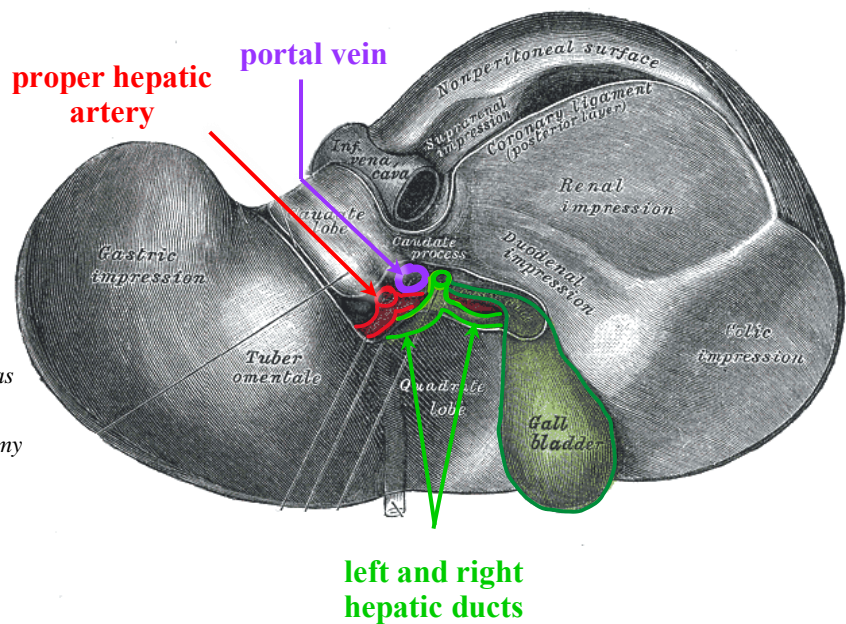


Fig. 88 B
Visceral surface of
the liver;
porta hepatis and
portal triad

Formalin-fixed cadaveric
specimen, Department of
the Anatomy,
Jessenius Faculty of
Medicine in Martin,
Comenius University
Bratislava

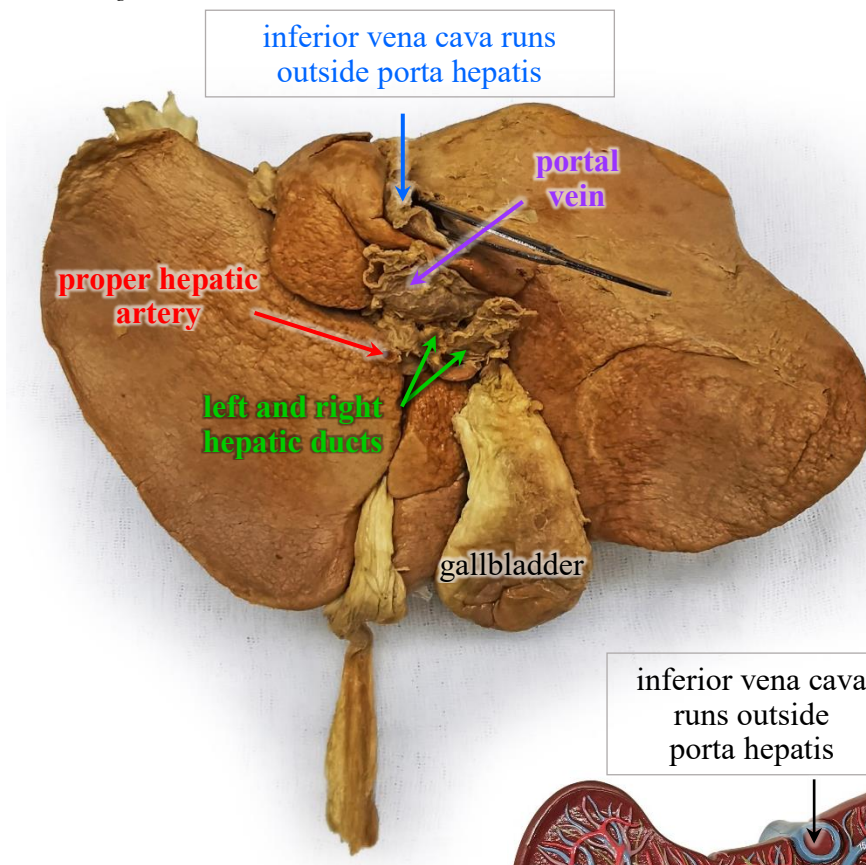
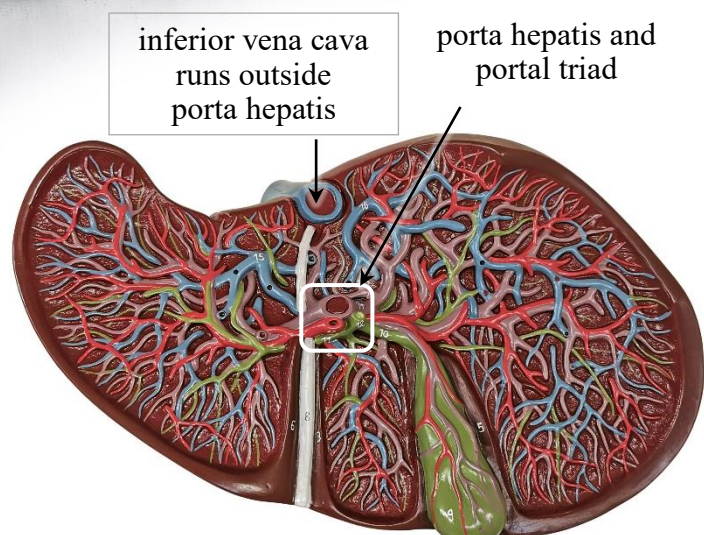


Fig. 89
Internal structures of the liver and
porta hepatis;
Horizontal section

Photography of model

Modified by additional drawing and labeling



8.3 Impressions on the liver

The liver is a relatively soft organ, so its shape is also the result of contact with surrounding organs. These organs form impressions on the visceral surface of the liver.

- On the right lobe of the liver we can distinguish from posterior to anterior:
 - **Suprarenal impression** – it extends also on the bare area of the liver
 - **Renal impression** – it extends also on the bare area of the liver
 - **Duodenal impression**
 - **Colic impression**
- On the left lobe of the liver, we can distinguish from posterior to anterior:
 - **Esophageal impression**
 - **Gastric impression**

8.4 Anatomical lobes and functional (surgical) subdivision of the liver

The external surface of the liver is divided by the ligaments and fissures into four anatomic (topographic) lobes. The diaphragmatic surface of the liver is subdivided by the attachment of the falciform ligament into two asymmetrical lobes:

- the large **right lobe**
- much smaller **left lobe**.

On the visceral surface, there are visible four lobes, which are separated by two sagittal and one transverse fissure. In addition to the two above-mentioned, these are: the quadrate lobe, which is anterior and inferior, and the caudate lobe, which is posterior and superior.

- The **quadrate lobe** is located between the fossa for the gallbladder on the right side and the fissure for the ligamentum teres on the left side.
- The **caudate lobe** is located between the groove for the vena cava on the right side and the fissure for the ligamentum venosum on the left side.

The porta hepatis is located between the quadrate and caudate lobes.

The anatomic, macroscopic division of the liver into lobes is descriptive and facilitates orientation with respect to the surrounding organs. However, it does not correspond to the internal, functional division of the liver that is according to the branching of the hepatic vessels and bile ducts.

The organisation of the internal division into eight functional segments is based on the internal distribution of the vessels and hepatic ducts. Each segment receives its own primary

branch of the hepatic artery, the branch of the hepatic portal vein and is drained by its own hepatic ducts. Segmentation of the liver is important for surgical anatomy because it facilitates resection of only individual affected segments.

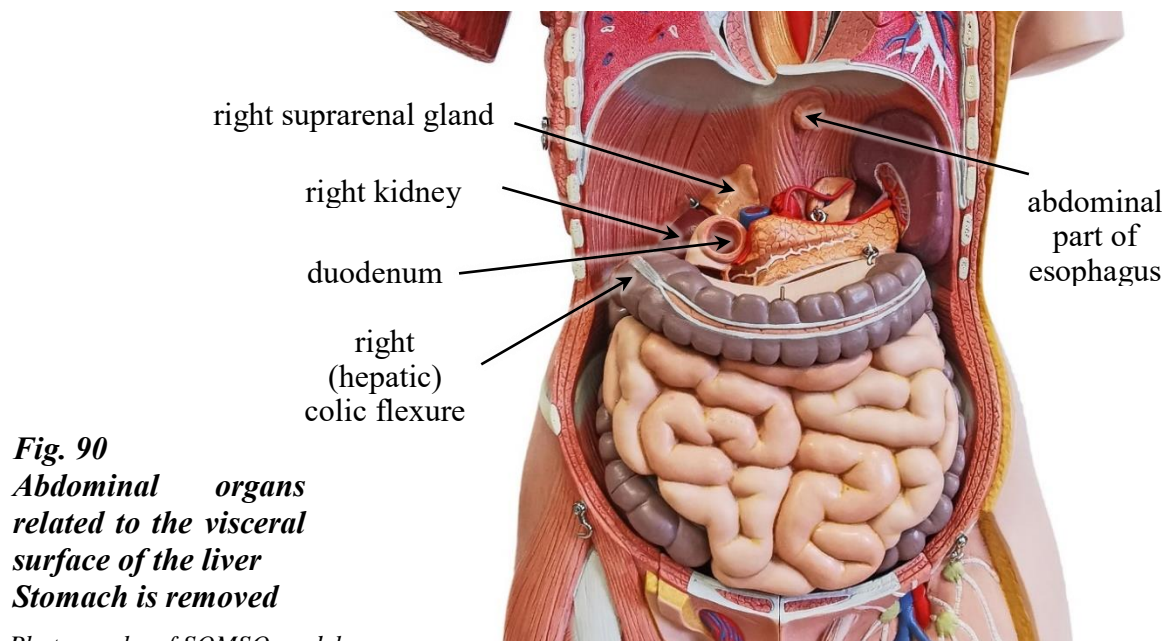


Fig. 90
Abdominal organs
related to the visceral
surface of the liver
Stomach is removed

Photography of SOMSO model
Modified by additional drawing and labeling

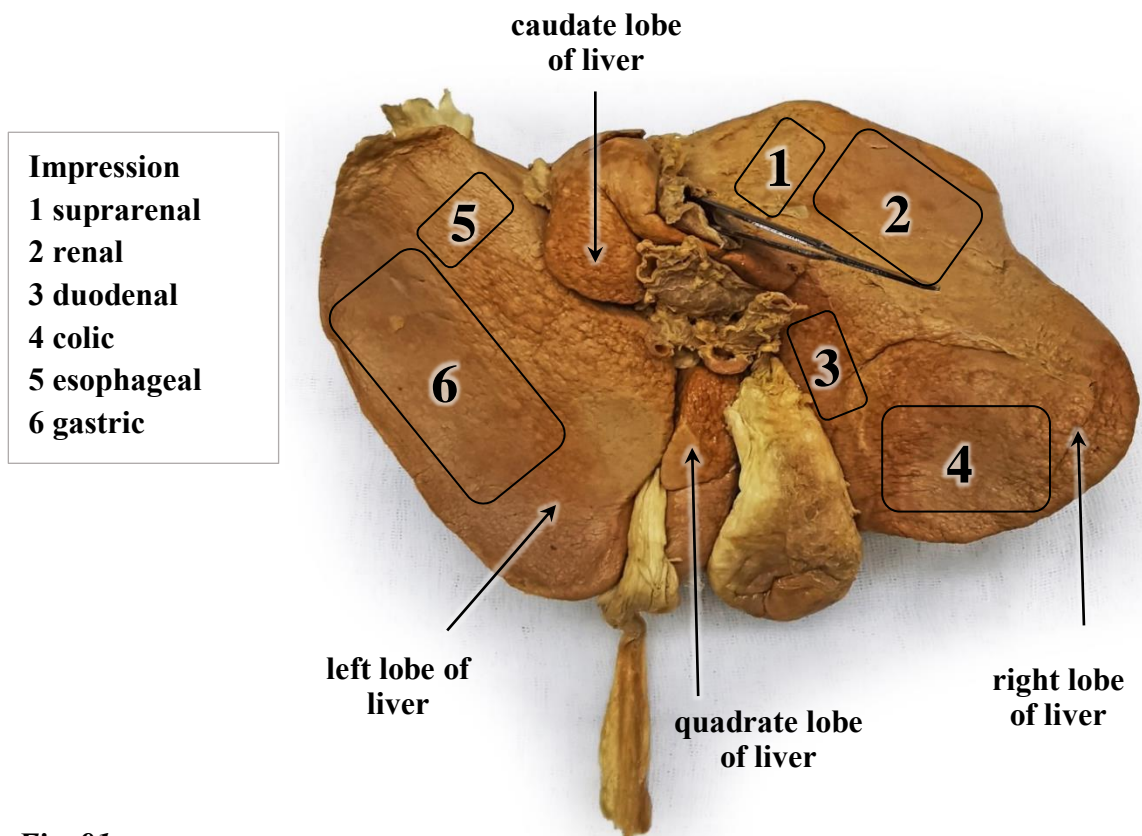


Fig. 91
Impressions of the liver at the visceral surface and lobes of the liver
Formalin-fixed cadaveric specimen, Department of the Anatomy,
Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

8.5 Relation of the liver to the peritoneum and associated ligaments

The liver is an **intraperitoneal** organ. The visceral peritoneum covers the liver except for the following areas:

- Bare area (area nuda)
- Porta hepatis
- Fossa for the gallbladder
- Groove of the inferior vena cava.

Beneath the serous peritoneal covering, there is the immobile fibrous capsule (Glisson's capsule), which is especially thick in the bare area.

The liver is connected by the **peritoneal folds**, which are referred to as the ligaments, to the diaphragm, anterior abdominal wall and to neighbouring organs.

- The **coronary ligament** is a single-layered reflection of the peritoneum that passes between the diaphragm, which is covered by the parietal peritoneum, and the liver, which is covered by the visceral peritoneum. It surrounds the bare area by its anterior (upper) layer and posterior (lower) layer. These two layers of the coronary ligament fuse laterally at the liver to form the triangular ligaments.

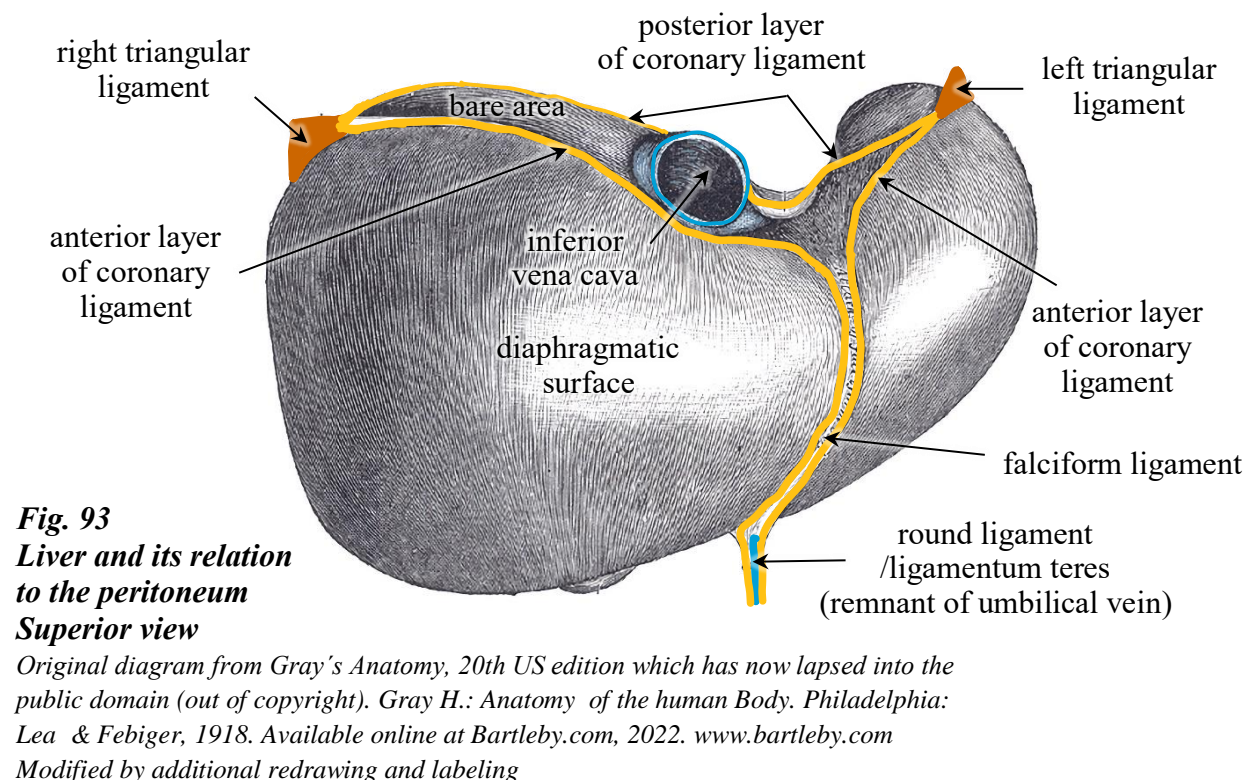
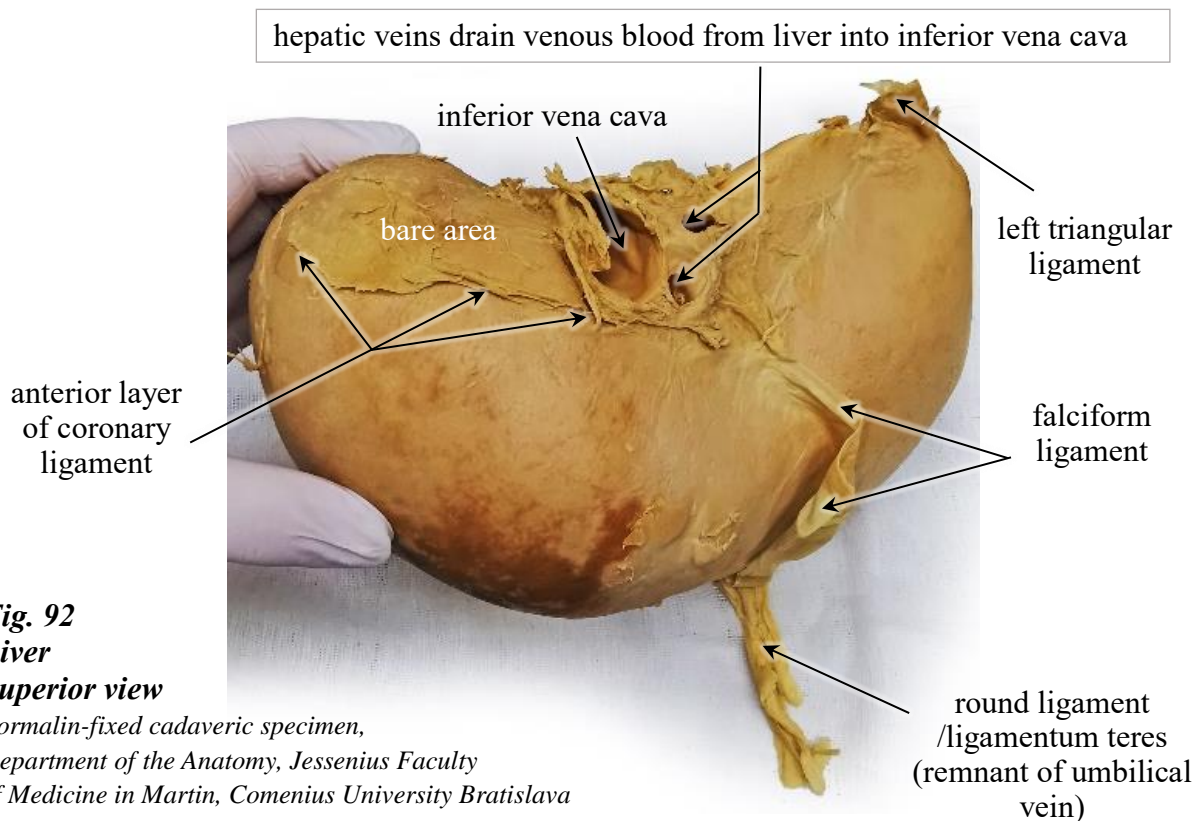
- The right and left **triangular ligaments** are double-layered folds. They are formed by the connections of the right and left portions of the anterior and posterior coronary ligaments. The triangular ligaments connect the liver to the diaphragm.

- The **falciform ligament** is a sagittally oriented double-layered fold, which attaches the liver up and forward to the parietal peritoneum of the diaphragm and down to the anterior abdominal wall. Its free edge, which is extended between the umbilicus and the inferior margin of the liver and the fissure for the ligamentum teres, contains the **round ligament of the liver** (the remnant of the umbilical vein).

- The **lesser omentum** connects the visceral surface of the liver to the beginning of the superior part of the duodenum by its **hepatoduodenal ligament** and to the lesser curvature of the stomach by its **hepatogastric ligament**. The small portion of the lesser omentum is extended between the liver and the abdominal part of the esophagus as the **hepatoesophageal ligament**. The hepatoduodenal ligament borders anteriorly the entrance (**omental foramen/epiploic foramen**) to the small space of the peritoneal cavity, the **lesser sac/omental bursa**.

- The **hepatoduodenal ligament** encloses the structures, which pass to or from the porta hepatis in the following arrangement:

The **proper hepatic artery** is located anteriorly and to the left, the **bile duct** is located anteriorly and to the right and the **hepatic portal vein** is located posterior to the proper hepatic artery and bile duct. In addition: lymph vessels and autonomic nerves.



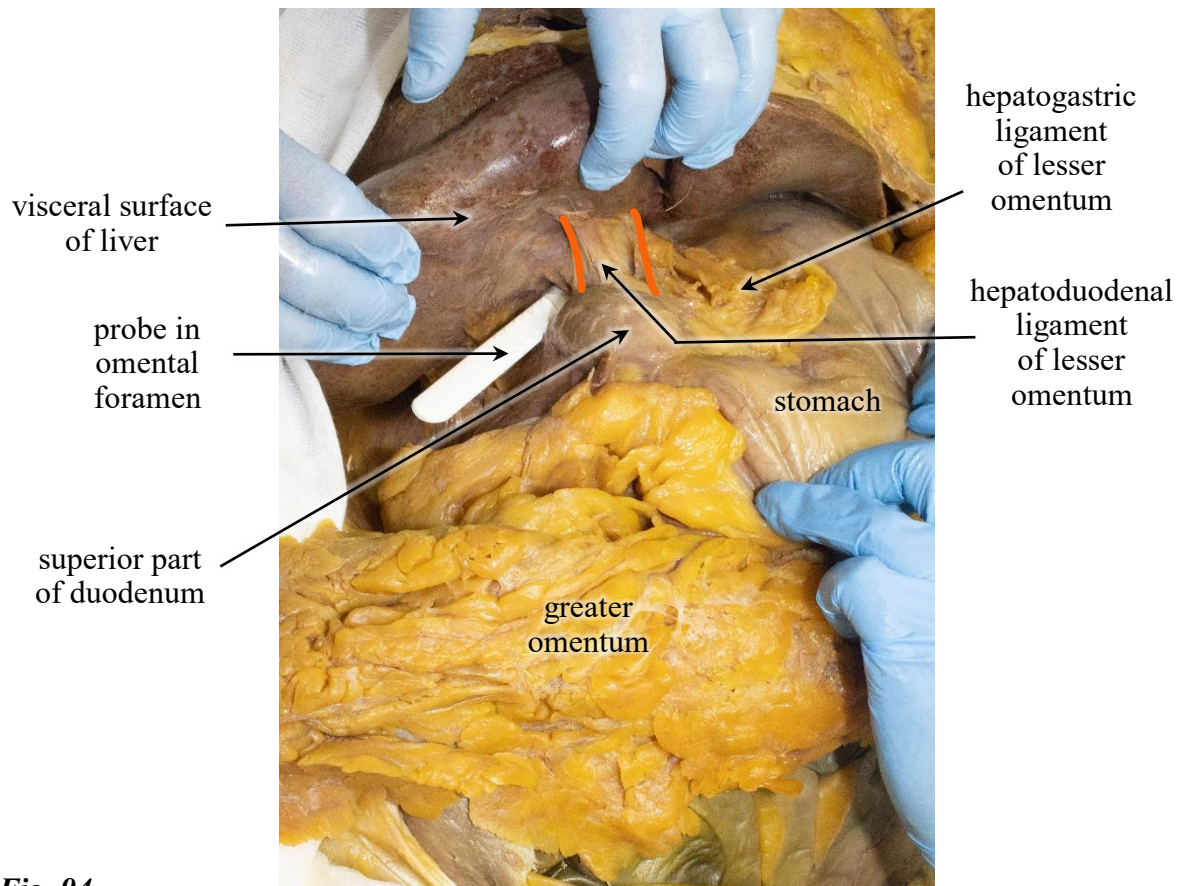


Fig. 94

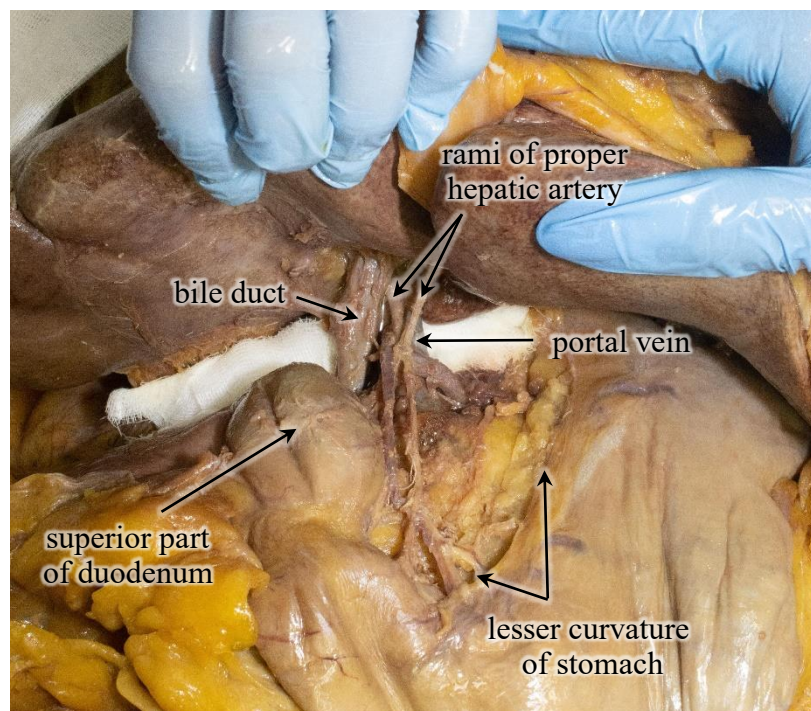
The lesser omentum and the hepatoduodenal ligament

Formalin-fixed cadaveric specimen, Department of the Anatomy, Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

Fig. 95

***Portal triad;
the lesser omentum is partially removed and the hepatoduodenal ligament is cleared***

*Formalin-fixed cadaveric specimen,
Department of the Anatomy,
Jessenius Faculty
of Medicine in Martin,
Comenius University
Bratislava*



8.6 Vessels and nerves of the liver

- The liver has a **dual blood supply** – by the hepatic portal vein and proper hepatic artery, but single venous drainage – by the hepatic veins.
- The **hepatic portal vein** collects the venous blood from the abdominal organs of the alimentary system including the upper portion of the rectum, gallbladder and pancreas, as well as the spleen.

The hepatic portal vein is formed by the union of the splenic vein and superior mesenteric vein, posterior to the pancreas at the level of the 2nd lumbar vertebra. It runs behind the superior duodenum, then enters the hepatoduodenal ligament and ascends to the liver.

The vein provides 75 – 80 % of blood flow to the liver. The portal blood is rich in nutrients (absorbed from the digestive tract and passed to the liver for processing) and relatively high in oxygen. It contains about 40 % more oxygen than blood which returns to the heart from systemic circulation. This is the dominant blood supply to the liver parenchyma.

The hepatic portal venous system is a special system in which the hepatic portal vein connects two capillary beds - one representing the capillary network in the organ (e.g., the intestine, stomach, ...) and the other one representing the hepatic sinusoids. Thus, blood is drained from the **capillary bed of one organ** by tributaries **first to the hepatic portal vein** and through it to the **hepatic sinusoids**, and only then it does flow through the **hepatic veins into the inferior vena cava** and from it into the heart.

If blood flow through the hepatic portal vein is restricted by a pathological process and the pressure in the vein increases (portal hypertension), a portocaval anastomosis allows reverse blood flow into the systemic venous circulation. The hepatic portal vein forms such important anastomoses with the esophageal veins, the rectal venous plexus, and the superficial veins of the abdominal skin in the umbilical region.

- The **proper hepatic artery** carries the oxygenated blood to the liver from general circulation. Artery arises from the common hepatic artery, which is a branch of the celiac trunk.

Since the blood in the portal vein still has a rather high oxygen content, the proper hepatic artery is relatively thin (with a smaller diameter) in relation to the volume of the whole liver. It provides 20 – 25 % of blood flow to the liver. It supplies non-parenchymal structures, particularly the intrahepatic duct system for bile. Poorly is involved in the nutrition of the liver cells.

When blood flow through the portal vein increases, flow through the hepatic artery decreases and vice versa (it is a response of the hepatic artery). This dual, reciprocally compensating blood supply provides healthy people with some protection from liver ischemia.

- Venous drainage:

Blood from the hepatic portal vein and proper hepatic artery mixes together in the hepatic sinusoids and from these collects progressively into the hepatic veins. The **hepatic veins** subsequently drain into the inferior vena cava.

- o **Lymph** of the liver has a superficial and deep lymphatic vascular system. Lymph is drained either caudally via the hepatic lymph nodes (within the porta hepatis and along the hepatic arteries) into the celiac lymph nodes and from there into the intestinal trunks or cranially via the inferior and superior phrenic lymph nodes into the mediastinal nodes and then into the bronchomediastinal trunk.

Lymph drainage by the cranial route may also lead to form metastases of liver cancer in the thoracic lymph nodes.

- The liver is **nerve supplied** by the hepatic plexus, which is a continuation of the celiac plexus. The celiac plexus contains the autonomic nerve fibers – the pre-ganglionic **sympathetic fibers** from the splanchnic thoracic nerves and it is also joined by the **parasympathetic fibers** from the vagus nerves [CN X].
- o **Sensory innervation** of the visceral peritoneum, which covers the diaphragmatic surface of the liver, is provided by the right phrenic nerve. *This explains the hiccups (contractions of the diaphragm) in liver injury, as well as the projection of pain from the liver to the right scapula or shoulder.* The fibrous Glisson's capsule is innervated by branches of the lower intercostal nerves. *Distension of the capsule results in sharp, well-localized pain.*

9 BILIARY SYSTEM

The biliary system drains waste products from the liver into the duodenum and it helps in digestion with the controlled release of bile. Bile is greenish-yellow fluid, that consists of water, cholesterol, bile pigments (bilirubin, ...), bile salts and fats. Its main function is to aid in the digestion of fats and to carry away waste.

Bile is produced continuously by the liver and from the hepatocytes is collected by a system of the intrahepatic and extrahepatic ducts. Bile is transported into the descending part of the duodenum or stored and concentrated in the gallbladder.

9.1 EXTRAHEPATIC BILIARY SYSTEM

The extrahepatic biliary ducts begin in the porta hepatis by the **right and left hepatic ducts**. These drain the respective lobes of the liver. After a short course, the right and left hepatic ducts unite to form the **common hepatic duct**, which is joined on the right side with the **cystic duct** from the gallbladder to form the **bile duct/common bile duct** (*see Fig. 97*).

9.1.1 Bile duct (common bile duct)

The **bile duct** is formed by the union of the common hepatic and cystic ducts. Its length varies from 5 – 15 cm.

It runs within the **hepatoduodenal ligament** (a free edge of the lesser omentum) and it lies to the right of the proper hepatic artery and anterior to the hepatic portal vein. Then the bile duct continues to descend and lies **posterior to the superior part of the duodenum** and **posterior to the head of the pancreas**. Near the left wall of the descending part of the duodenum, it meets the pancreatic duct. Both ducts pass obliquely through the wall of the duodenum to form a dilatation, the **hepatopancreatic ampulla** (*commonly known as the ampulla of Vater*). The ampulla opens into the duodenum through the **major duodenal papilla**.

The hepatopancreatic ampulla is regulated by the **sphincter of the ampulla** (sphincter of Oddi). The sphincter muscle complex consists of circular and spiral smooth-muscle fibers. The spiral muscle fibers continue separately around the terminal portion of the bile duct and also around the termination of the pancreatic duct, where they form autonomous muscle rings, the **sphincter of the bile duct** and the **sphincter of the pancreatic duct**. When there is no content in the duodenum, the sphincters are contracted and bile is returned and passes through

the cystic duct into the gallbladder, where it is concentrated and stored. Shortly after food is taken, the gallbladder contracts, releasing stored bile. The sphincter of the bile duct opens and allows bile to enter the duodenum.

The sphincters prevent the re-entry of contents from the duodenum into the ducts and especially the entry of bile into the pancreatic duct, which would activate pancreatic enzymes and lead to severe damage to the pancreas.

9.1.2 Gallbladder (Vesica biliaris or vesica fellea in Latin)

The gallbladder receives, concentrates and stores bile. It is a pear-shaped organ, which is located within the **fossa for the gallbladder on the visceral surface of the liver**. Its position separates the right lobe of the liver from the quadrate lobe (*see Figs. 86, 87, 96 and 97*).

The gallbladder is divided into the fundus, body and neck.

- **Fundus** is a rounded blunt end of the gallbladder. It directs caudally and projects from the inferior margin of the liver approximately 1 – 1.5 cm. The fundus comes in contact with the anterior abdominal wall at the point, where the right costal arch intersects the right midclavicular line. *At this point, the fundus is accessible to palpation, but is palpable only when it is enlarged due to bile accumulation.*
- **Body** is the main part and it is attached to the liver.
- **Neck** is a narrow part opposite the fundus. It runs dorsally toward the porta hepatis and continues smoothly into the cystic duct.

The **cystic duct** drains the gallbladder. It joins the common hepatic duct to form the bile duct.

The cystic duct is lined with a mucous membrane that forms a spiral fold. This arrangement allows bile to flow in both directions - on the basis of higher pressure on one side or the other. Thus, bile can flow into the gallbladder when the sphincter of the bile duct or the sphincter of the ampulla is retracted, or out of the gallbladder when the gallbladder is retracted and bile flows into the duodenum.

Relation of the gallbladder to neighbouring organs and peritoneum

The gallbladder has close relation with the duodenum and colon. It is located anterior and superior to the **duodenum** and superior to the **transverse colon**, the body is also related to **right colic flexure**. *Its very close contact with the liver and its projection onto the anterior abdominal wall should not be forgotten.*

The gallbladder is an **intraperitoneal organ**. Peritoneum completely surrounds the fundus and covers the external surface of the body and neck, while their hepatic surface is attached to the fossa for the gallbladder by the connective tissue of the fibrous capsule of the liver.

Blockage of the bile ducts by gallstones prevents the transport of bile into the duodenum. Bile is returned in the opposite direction and bilirubin from bile accumulates in the blood. This condition results in jaundice.

Jaundice is also commonly caused by diseases such as pancreatic head cancer, which blocks the passage of bile in the bile duct passing through the cancerous part of the pancreas.

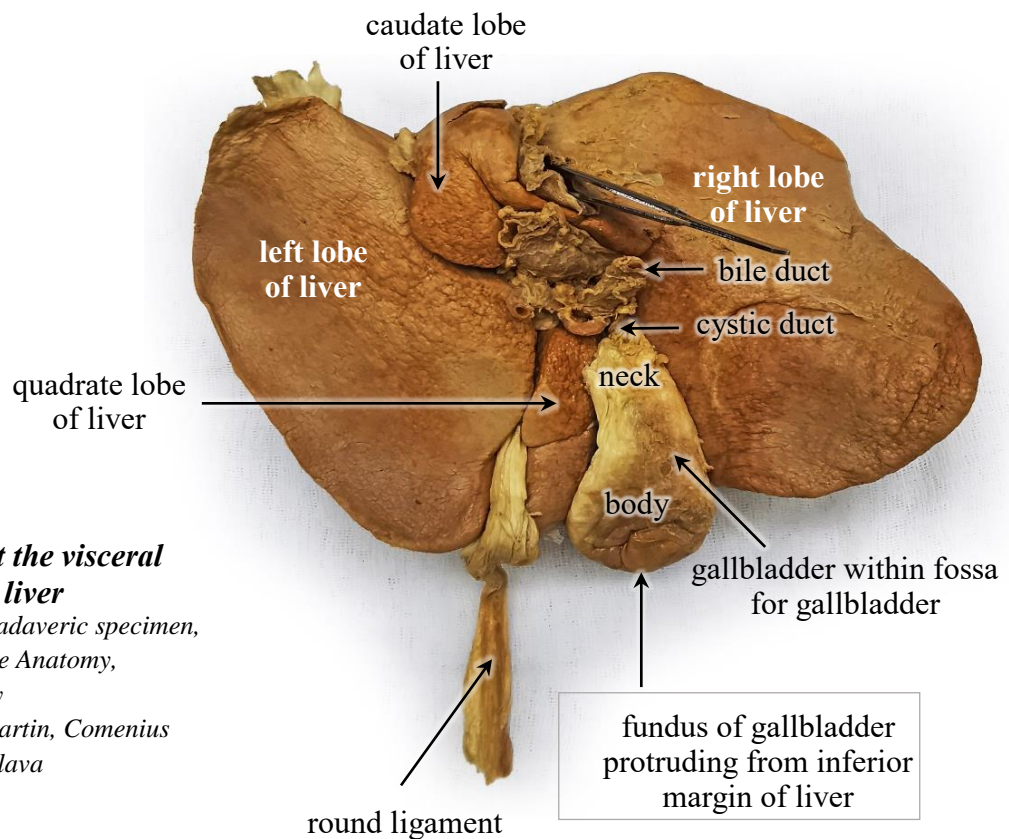


Fig. 96
Gallbladder at the visceral surface of the liver
*Formalin-fixed cadaveric specimen,
Department of the Anatomy,
Jessenius Faculty
of Medicine in Martin, Comenius
University Bratislava*

9.1.3 Vessels and nerves of the biliary system and gallbladder

- The **arterial supply** of the **gallbladder** and **cystic duct** comes from the cystic artery, which is a branch of the proper hepatic artery.
- The **hepatic ducts and bile duct** are supplied by various arteries. Proximally, the supply is provided by the cystic artery and the right branch of the proper hepatic artery. The retroduodenal portion of the **bile duct** is supplied by the posterior superior pancreaticoduodenal artery and gastroduodenal artery.
- **The veins** accompany arteries and, principally, the venous blood is drained by the hepatic portal vein. Small veins from the gallbladder and hepatic ducts can also enter directly into the liver and drain into the hepatic sinusoids.
- **Lymph** is drained via the hepatic lymph nodes (see more in the chapter on lymphatic drainage of the liver).
- The **nerve supply** to the gallbladder and biliary system is provided by sympathetic fibers (which originate from pre-ganglionic sympathetic fibers from the splanchnic thoracic nerves), visceral afferent (pain) fibers, and parasympathetic fibers from the vagus nerve. The nerves enter the celiac plexus, and this continues as the hepatic plexus along the arteries to the organs. The right phrenic nerve (somatic afferent fibers) may carry pain caused by gallbladder inflammation.

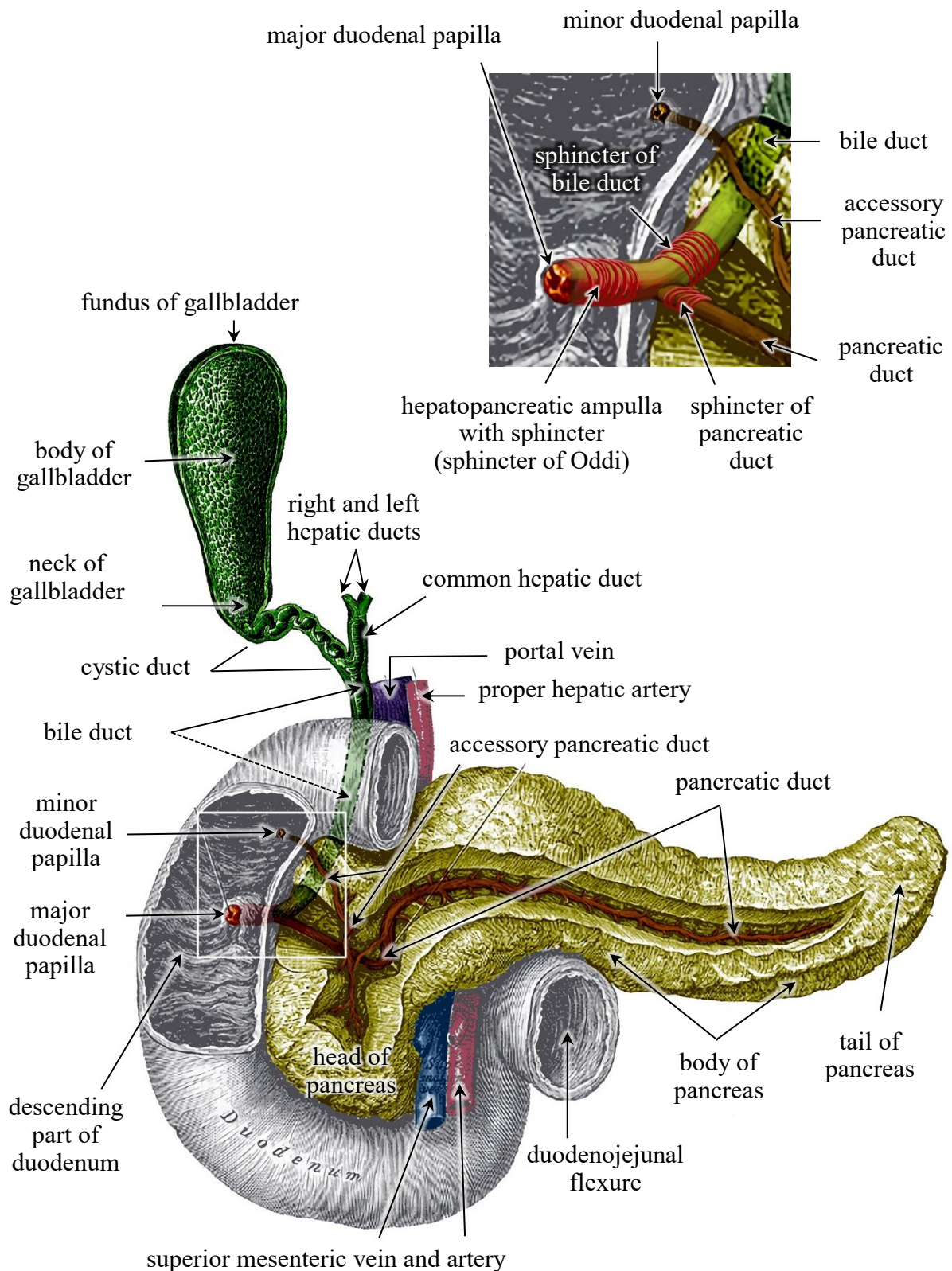


Fig. 97

Gallbladder and biliary system; pancreas and pancreatic ducts

Anterior view

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10 PANCREAS

The pancreas is an accessory digestive gland. It is a combined exocrine and endocrine gland. Its exocrine parts are responsible for the production of pancreatic juice with digestive enzymes, which are drained by a system of smaller ducts into the pancreatic duct and accessory pancreatic duct. The pancreatic ducts exit into the duodenum. Its endocrine parts are represented by 1 – 2 million endocrine cells (islets of Langerhans), which are scattered in the exocrine tissue. The endocrine portions are responsible for the production of hormones, (e.g., insulin and glucagon) that enter the blood. Their function is mainly to regulate blood sugar levels. Due to its functions, the pancreas is an essential and vital organ.

The pancreas has the appearance of a gland with a visible drawing of the lobules. It is a parenchymatous, soft, elongated organ measuring 13 – 15 cm in length, grey-pink in color. Its weight is approximately 60 – 90 g.

10.1 Anatomical position of the pancreas

The pancreas lies on the posterior abdominal wall, at the back of the **epigastric** and **left hypochondriac regions**. It is a secondary **retroperitoneal** organ. The pancreas is located behind the **stomach**, separated from it by the lesser sac and in front of the large abdominal vessels – the **abdominal aorta** and **inferior vena cava**. It passes almost horizontally from the **duodenum** on the right toward the **spleen** on the left and runs anterior to the bodies of the **LI – LII vertebra**.

10.2 Parts and relations of the pancreas to neighbouring structures and organs

The pancreas is divided into the head, neck, body and tail.

- The **head of the pancreas** is an enlarged part, anteroposteriorly flattened, projected at the level of the LI – LIII vertebra. It is located in the C-shaped concavity of the duodenum and is firmly attached to its descending part. The pancreatic head extends into the **uncinate process**, the hooked process, that projects inferiorly and to the left, behind the superior mesenteric vessels. The **pancreatic notch** separates the uncinate process from the rest of the pancreatic head and also from the other parts of the pancreas. The superior mesenteric vessels run within this notch.

Anteriorly, the pancreatic head is crossed by the attachment of the **root of the transverse mesocolon** and it is also in contact with the **stomach** and the coils of the **jejunum**. Posteriorly, the pancreatic head is related to the **inferior vena cava, bile duct, right renal vessels** and **hepatic portal vein**.

- The **neck of the pancreas** is a short strip (about 2 cm) between the head and body of the pancreas. Posteriorly of the neck, there are the **superior mesenteric vessels** and the beginning of the **hepatic portal vein**, which is formed by the junctions of the splenic vein and superior mesenteric vein. The neck of the pancreas is a surgical landmark.
- The **body of the pancreas** is an elongated part, which overlies the LII vertebra and runs to the left kidney. The body has three surfaces:
 - **Anterior surface** is covered with the parietal peritoneum. This surface faces the posterior wall of the stomach and the organs are separated by the **lesser sac** (omental bursa). The root of the **transverse mesocolon** is attached to its inferior margin. *Omental eminence* (tuber omentale) is a bulge on the anterior surface resulting from the position of the aorta resp. vertebral column behind the pancreas.
 - **Posterior surface** lies in front of the **abdominal aorta, left renal vessels, inferior mesenteric vein, splenic vein, left suprarenal gland** and the **hilum of the left kidney**. The **splenic artery runs on the superior margin**, which is the boundary between the anterior and posterior surfaces.
 - **Inferior surface** is very narrow and is in contact with the **duodenojejunal flexure** and **jejunum**.
- The **tail of the pancreas** is a narrow, short part with a rounded end. It reaches the **spleen**. It lies anterior to the **left kidney** and is also related to the **left colic flexure**.

Cancer of the head of the pancreas can cause obstruction of the bile duct with subsequent development of jaundice. An expansively growing tumor may also compress both the hepatic portal vein and inferior vena cava with subsequent hypertension of these veins.

10.3 Pancreatic ducts

- The **pancreatic duct** is the main excretory duct of the pancreas. It begins at the tail of the pancreas and runs transversely through the body and turns inferiorly at the head of the pancreas. The main pancreatic duct connects with the **bile duct** to form the **hepatopancreatic ampulla** (*ampulla of Vater*), which enters the descending part of the duodenum at the **major duodenal papilla**. The hepatopancreatic ampulla is surrounded by the **sphincter of the ampulla** and the circular muscle fibers continue separately around the terminal portions of the pancreatic duct and the bile duct, forming the **sphincter of the pancreatic duct** and **sphincter of the bile duct** (*see chapter – Extrahepatic biliary system and Fig. 97*).
- The **accessory pancreatic duct** is an additional duct. It drains the head of the pancreas and empties into the duodenum at the **minor duodenal papilla** (it is located above the major duodenal papilla).

The main and accessory pancreatic ducts usually communicate with each other.

10.4 Relation of the pancreas to peritoneum

The pancreas is a secondary **retroperitoneal** organ.

10.5 Vessels and nerves of the pancreas

- The **arterial supply** of the pancreas comes from the branches of the celiac trunk and also from the superior mesenteric artery, both arise from the abdominal aorta.
- The head of the pancreas is blood supplied by the superior and inferior pancreaticoduodenal (P-D) arteries. The superior P-D arteries are the branches of the gastroduodenal artery (from the common hepatic artery) – thus the supply area of the celiac trunk, and the inferior P-D arteries are the branches of the superior mesenteric artery.
- The body and tail of the pancreas are supplied by the multiple pancreatic arteries, which are branches of the splenic artery (from the celiac trunk).
- The **veins** correspond to arteries and the venous blood from the pancreas is drained either directly or via tributaries (splenic vein and superior mesenteric vein) into the hepatic portal vein.

- The **lymphatic vessels** follow the arteries. The lymph is drained via the celiac lymph nodes and superior mesenteric lymph nodes into the intestinal trunk. Due to the retroperitoneal position of the pancreas, the lymph may be also drained into the lumbar lymphatic nodes.
- The pancreas is **nerve supplied** by the nerves of the celiac plexus and superior mesenteric plexus. The plexuses contain parasympathetic and sympathetic fibers as well as viscerosensory fibers.
 - The **parasympathetic fibers** derive from the vagus nerves [CN X].
 - The pre-ganglionic **sympathetic fibers** derive from the splanchnic thoracic nerves.

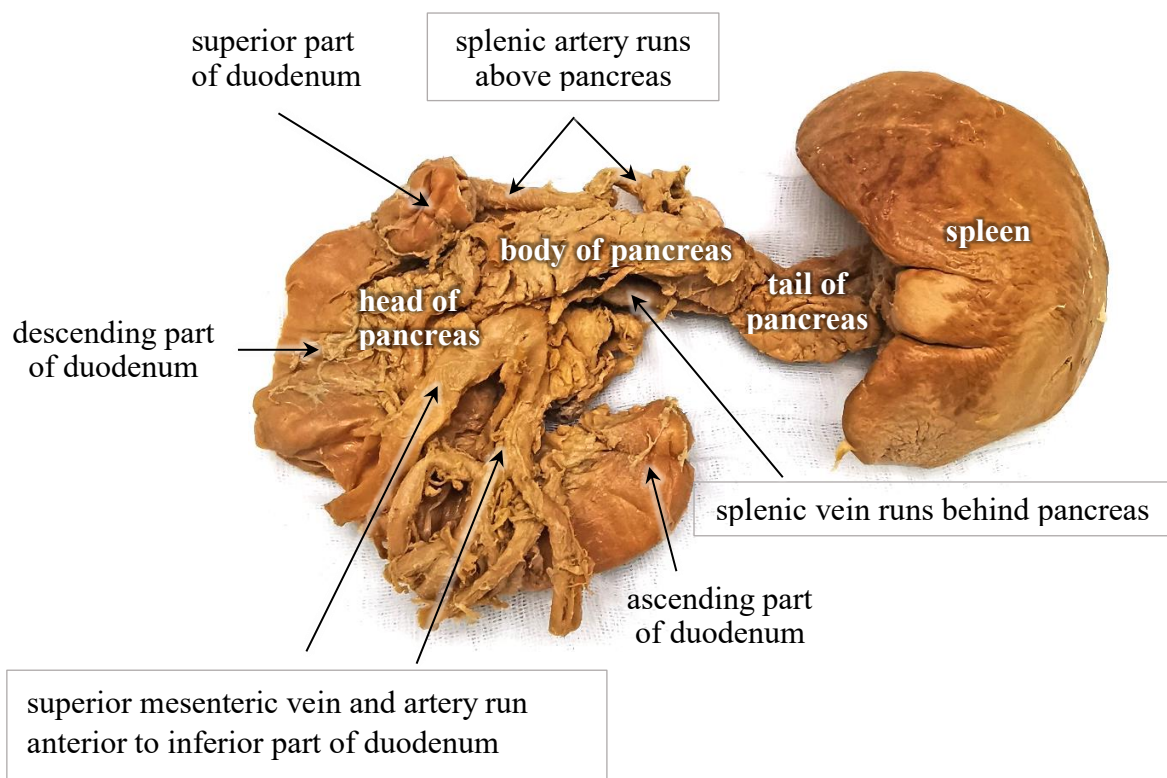


Fig. 98

Duodenum, pancreas and spleen

Anterior view, inferior margin of the pancreas slightly tilted upward

Formalin-fixed cadaveric specimen, Department of the Anatomy, Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

Fig. 99 A

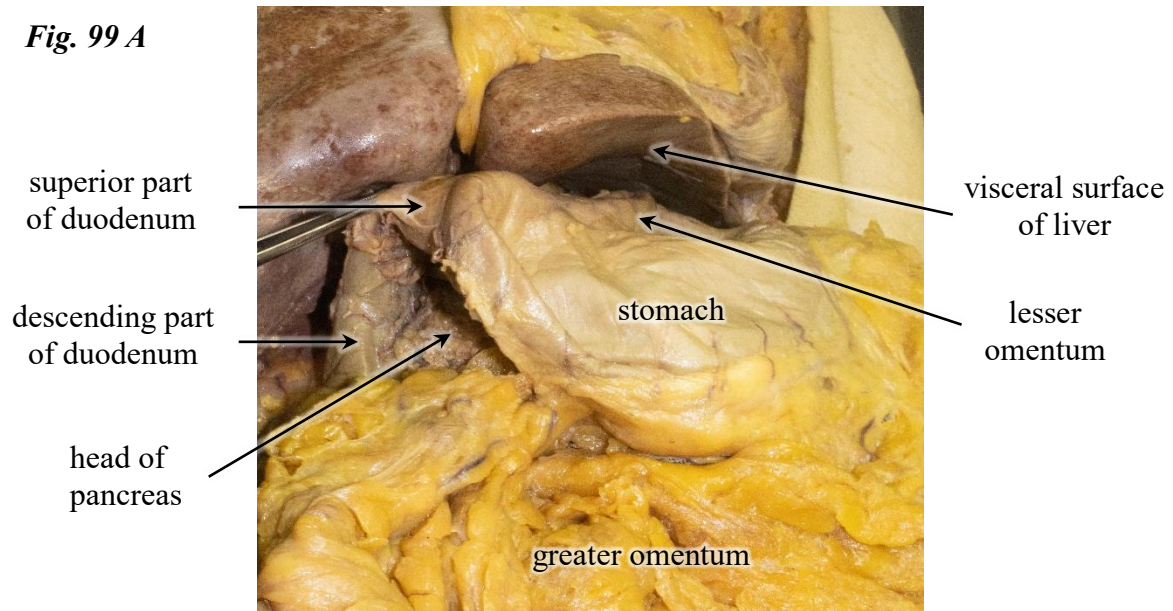


Fig. 99 B

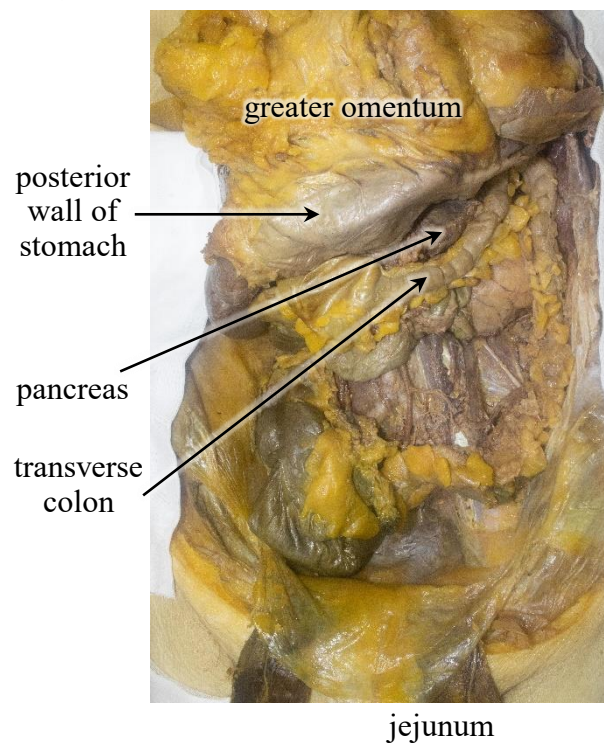


Fig. 99 C

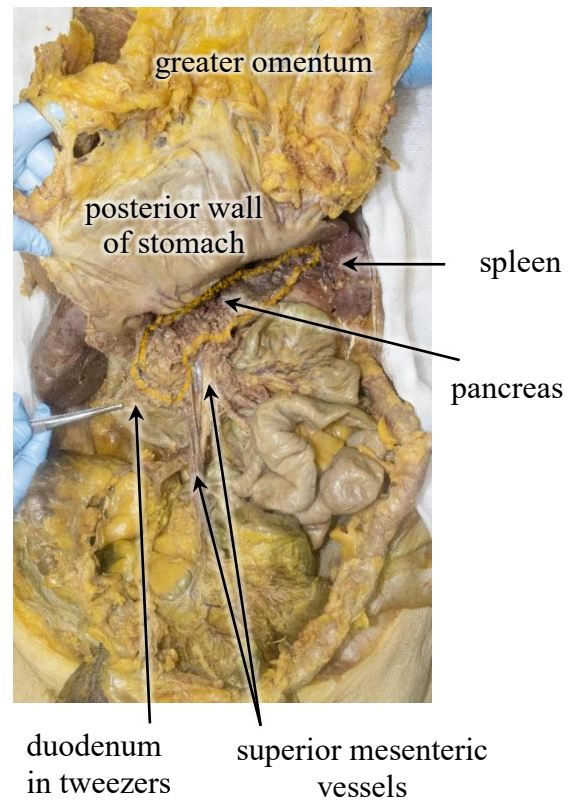


Fig. 99

Pancreas in situ („*In situ*“ means „in its original place“)

99 A – The stomach and duodenum are slightly tilted upward

99 B – The stomach and greater omentum are turned upward, transverse colon in situ

99 C – The stomach and greater omentum are turned upward, transverse colon is removed

*Formalin-fixed cadaveric specimen, Department of the Anatomy,
Jessenius Faculty of Medicine in Martin, Comenius University Bratislava*

11 PERITONEUM

The peritoneum is a slippery, transparent serous membrane, which lines the abdominopelvic cavity and covers many of the abdominal and pelvic organs. *It is similar to the pleura and pericardium.*

The peritoneum consists of two layers – the **parietal peritoneum** lines the inner surface of the abdominopelvic wall, as well as the diaphragm (*wall – paries in Latin*) and, at various points, reflects onto the abdominal viscera as the **visceral peritoneum**, which covers the viscera (*internal organ – viscus sg, viscera pl. in Latin*). Two layers of the peritoneum are continuous with each other – the parietal peritoneum reflects (turns sharply and continues) into the visceral peritoneum. These reflections – **omenta**, **mesenteries** and **peritoneal ligaments**, have different names depending on which organ they are associated with.

The peritoneum is formed by a single layer of flat mesothelial cells (mesothelium) supported by submesothelial connective tissue. The parietal peritoneum is loosely connected to the abdominal and pelvic walls by subserous tissue – it allows alteration in the size of some viscera. It is firmly fused only with the diaphragm. The visceral peritoneum is firmly attached to the surface of the organs - it forms the serous coat (tunica serosa) of the organs – it cannot be easily separated from it.

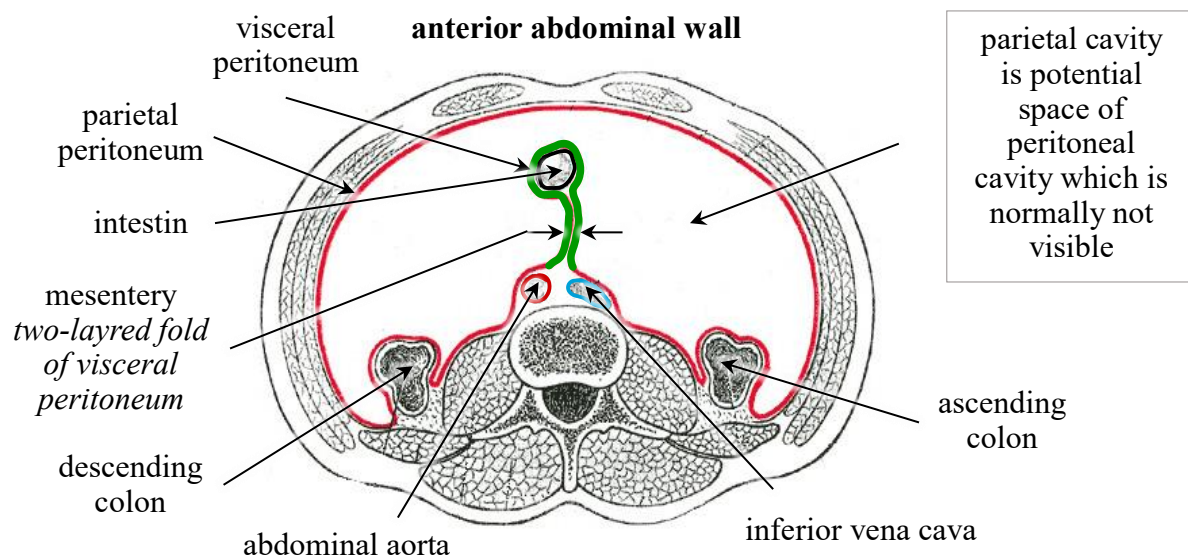


Fig. 100
Parietal and visceral peritoneum and peritoneal cavity
Transversal section, schematic figure

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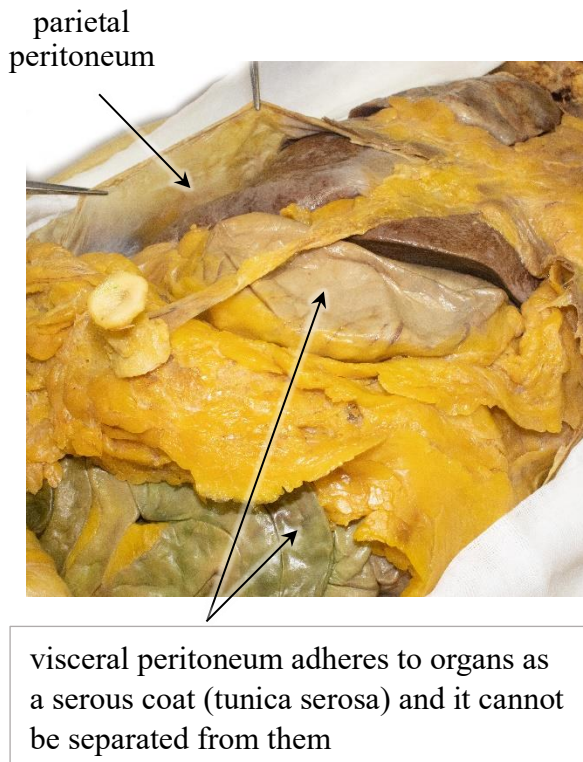


Fig. 101

Parietal and visceral peritoneum

*Formalin-fixed cadaveric specimen, Department of the Anatomy,
Jessenius Faculty of Medicine in Martin, Comenius University Bratislava*

The potential space between the parietal and visceral peritoneum is called the **peritoneal cavity**. There are no organs in the peritoneal cavity. The potential space of the peritoneal cavity is normally not visible. It contains a small amount of **peritoneal (serous) fluid**, which consists of water, electrolytes, immune cells (e.g., white blood cells) and other substances derived from the interstitial fluid in the adjacent tissue. Peritoneal fluid lubricates the peritoneal surface and allows the two layers to slide freely over each other and thus facilitating free movement between viscera. The shape and size of the space vary according to the filling of the organs and their function, e.g., intestinal peristalsis.

In men, the peritoneal cavity is an enclosed space, but in women, it communicates with the exterior through the openings of the uterine tubes, uterus and vagina. This communication constitutes a potential pathway of infection from the outside.

The amount of the peritoneal fluid may be increased e.g., in inflammatory conditions of the viscera, tumors, metabolic disorders...

The peritoneal space has a large surface area – its surface area is about 1.8 m², so it can facilitate the spread of disease throughout the peritoneal cavity and over the visceral surfaces. On the other hand, it can be used for the administration of some types of medicaments and a number of procedures (e.g., peritoneal dialysis - purification of blood in case of kidney failure by repeated regular filling of dialysis fluid into the peritoneal cavity).

11.1 Positions of the abdominopelvic viscera to the peritoneum

The viscera, which are covered by the peritoneum and are suspended from the abdominal wall by the peritoneal folds are classified as **intraperitoneal**.

Intraperitoneal does not mean really situated in the peritoneal cavity. The peritoneal cavity can be thought of as a balloon into which an organ, e.g., the stomach or intestine, is pushed from the back. As a result, a layer of peritoneum envelops, e.g., the stomach or intestine and is called the visceral peritoneum.

- **Intraperitoneal organs:** the abdominal part of the esophagus, stomach, only the beginning of the duodenum (associated with the hepatoduodenal ligament), jejunum, ileum, cecum, vermiform appendix, transverse colon, sigmoid colon, liver, gallbladder, spleen, tail of the pancreas and as well as the pelvic organs – uterus, uterine tube and ovaries.

The viscera, that are not suspended by the peritoneal folds and are located between the parietal peritoneum and the abdominal wall (*they are outside of the peritoneal cavity and are not completely covered by the peritoneum*) are classified as **extraperitoneal**, namely: retroperitoneal, subperitoneal and preperitoneal

- **Primary retroperitoneal organs and structures** are positioned posterior to the peritoneal cavity and they were retroperitoneal throughout development:

- the kidneys, ureters and the suprarenal glands. These structures are also primary retroperitoneal: the abdominal aorta, inferior vena cava, autonomic plexuses and ganglia, lymph vessels and nodes.

- **Secondary retroperitoneal organs** are positioned posterior to the peritoneal cavity and were initially intraperitoneal, suspended by the mesentery. During intrauterine development, they became retroperitoneal when their peritoneal folds fused with the posterior abdominal wall. Thus, in adults, only their anterior surface is covered by the peritoneum:

- a substantial part of the duodenum, pancreas (excluding the tail of the pancreas), ascending colon and descending colon.

- **Subperitoneal organs** are situated within the lesser pelvis, inferior to the peritoneal cavity:

- the rectum, empty urinary bladder, as well as the seminal vesicles, prostate, and urethra in men, and vagina and urethra in women.

- **Preperitoneal organ** is positioned anterior to the peritoneal cavity:

- the full urinary bladder.

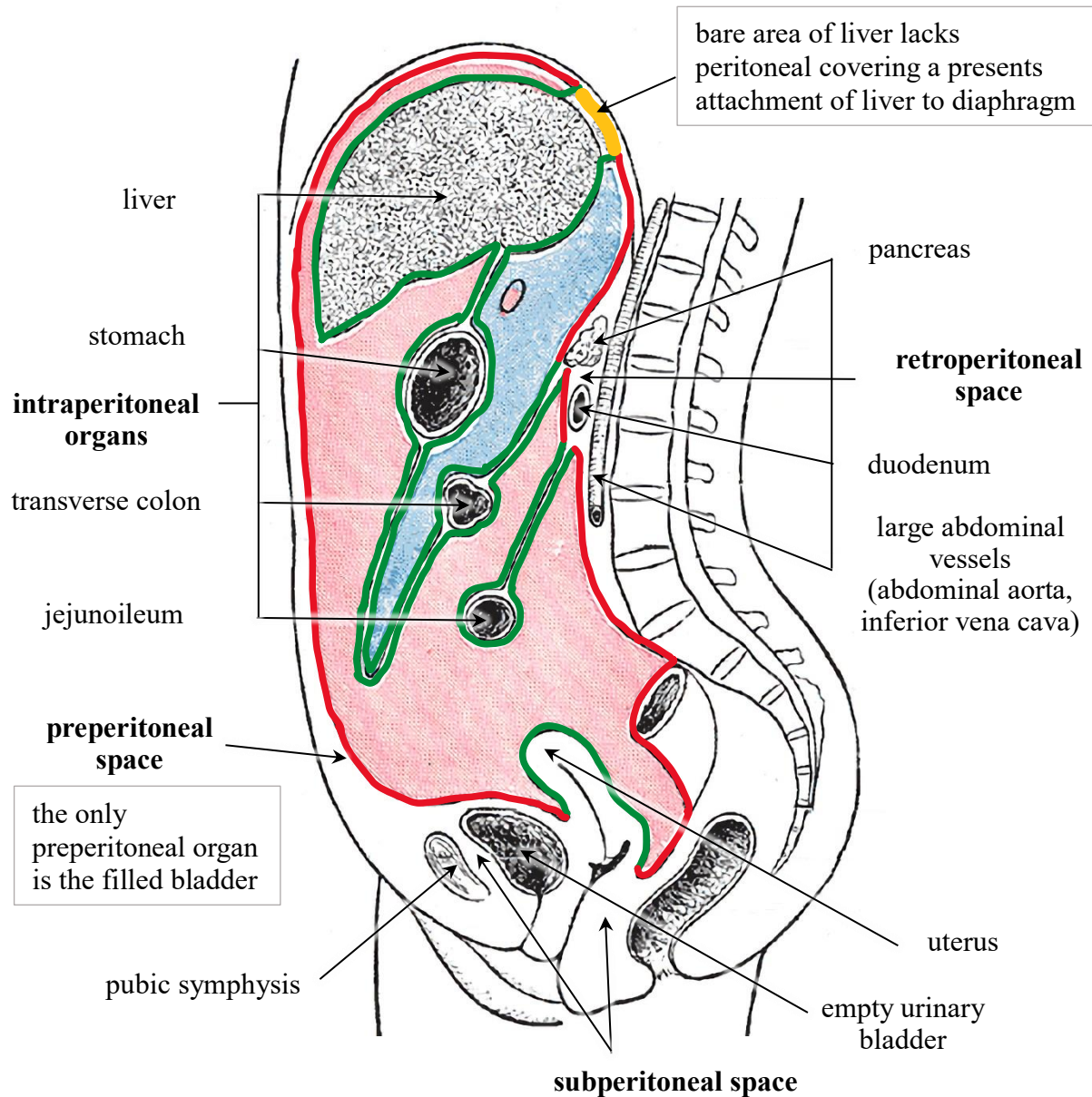


Fig. 102
Position of abdominopelvic viscera to peritoneum
Sagittal section, schematic figure

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11.2 Peritoneal folds – mesenteries, omenta and ligaments

The peritoneal reflections, **peritoneal folds – omenta, mesenteries and ligaments**, constitute a continuity of the visceral and parietal peritoneum. They connect organs to each other or to the abdominal wall, thus they serve to support the intraperitoneal organs and act as

a conduit for the passage of the blood vessels, lymphatics and nerves. Some of them convey ducts of the accessory organs to and from the viscera.

- **Omenta**

The omenta are **two-layered peritoneal folds**, which are associated with the stomach. They connect the stomach with the adjacent organs.

- The **greater omentum** is the largest fold of the visceral peritoneum with an area of approximately 1 m². It arises from the greater curvature of the stomach and descends caudally. The greater omentum overlaps ventrally the transverse colon and hangs freely like an apron in front of the coils of the jejunum for a variable distance. Then it folds back, ascends toward the transverse colon and adheres to the omental tenia of the transverse colon and to the transverse mesocolon. Finally, it reaches the posterior abdominal wall. Thus, the greater omentum consists of two peritoneal duplications (four layers of the peritoneum in total). It contains the right and left gastroepiploic vessels.

The upper part of the greater omentum, which passes between the greater curvature of the stomach and the omental tenia of the transverse colon is called the **gastrocolic ligament**.

The greater omentum increases the absorptive surface area of the peritoneum. It has the ability to migrate (due to intestinal peristalsis) to any inflamed area and wrap itself around the diseased organ to enclose the inflammation and participate in stopping the spread of inflammation by releasing lymphocytes. The greater omentum can also provide a source of well-vascularized tissue that participates in the early reparative process. For these reasons, the greater omentum is often referred to as the policeman of the abdomen

- The **lesser omentum** is the peritoneal fold, which connects the stomach, duodenum and esophagus to the visceral surface of the liver. It participates in the delimitation of the lesser sac/omental bursa. The lesser omentum can be subdivided into its parts:
 - **Hepatoduodenal ligament**, which forms the right thicker part of the lesser omentum. It passes between the beginning of the duodenum and the liver. It conveys the **portal vein, proper hepatic artery and bile duct**, as well as lymph vessels and autonomic nerves.
 - **Hepatogastric ligament**, which passes between the lesser curvature of the stomach and liver.

- **Hepato-esophageal ligament**, which passes between the abdominal esophagus and liver. *More about the lesser omentum in the chapter "Liver".*

Fig. 103 A

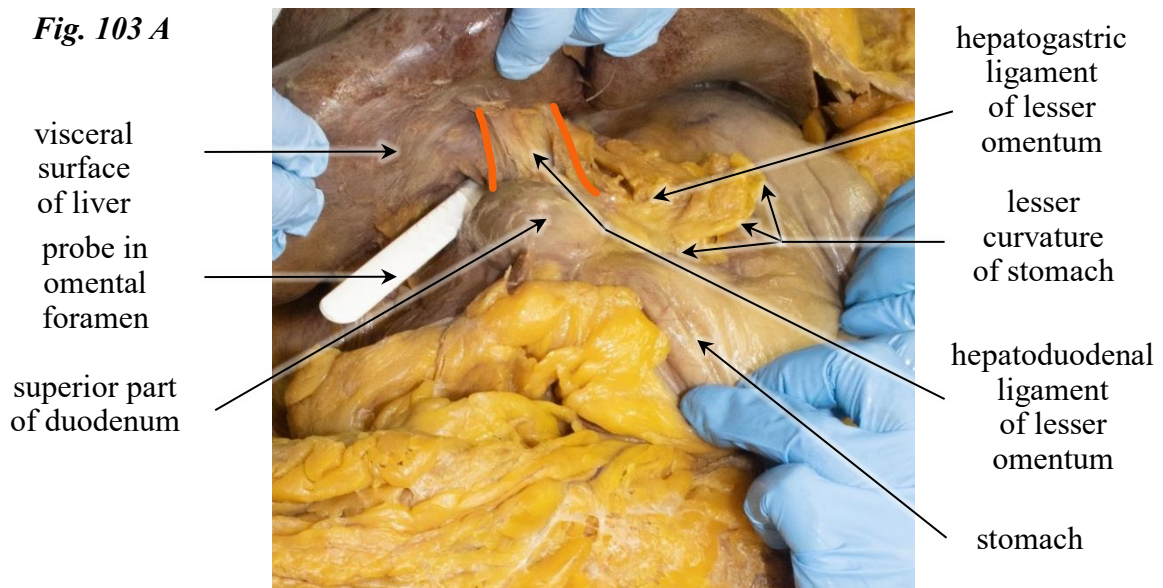


Fig. 103 B

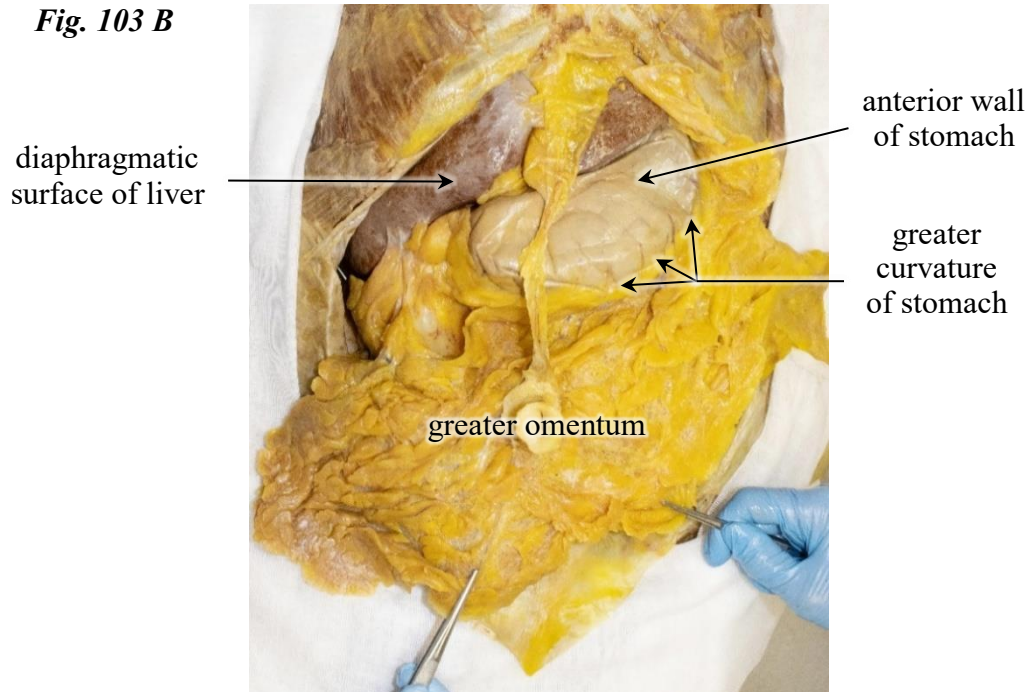


Fig. 103

Greater and lesser omentum

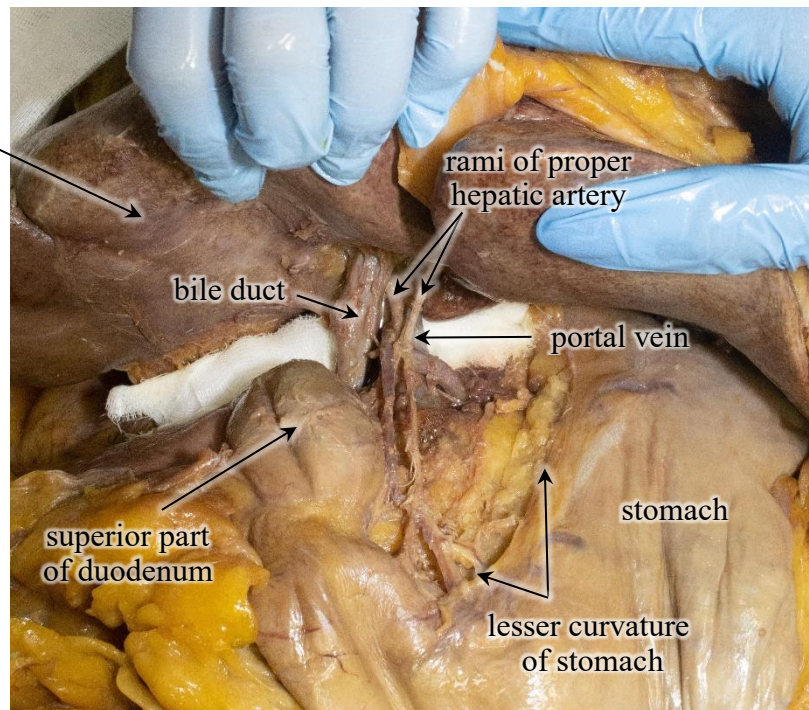
Fig. 103 A – lesser omentum

Fig. 103 B – spread greater omentum

*Formalin-fixed cadaveric specimen, Department of the Anatomy,
Jessenius Faculty of Medicine in Martin, Comenius University Bratislava*

visceral surface
of liver

Fig. 104
Portal triad;
the lesser omentum is
partially removed and
hepatoduodenal
ligament is cleared
Formalin-fixed cadaveric
specimen,
Department of the Anatomy,
Jessenius Faculty
of Medicine in Martin,
Comenius University
Bratislava



○ Mesenteries

The mesenteries are **two-layered peritoneal folds** that connect the intraperitoneal viscera to the posterior abdominopelvic wall or to another structure. They contain adipose tissue, arteries, veins, lymphatic vessels, nodes and the nerves, that supply the viscera with which they are associated (e.g., the transverse **mesocolon** contains the vessels, nerves, and lymphatics supplying the transverse **colon**).

When we speak generally of „a“ mesentery, we mean the two-layered peritoneal fold associated with any viscera that are located intraperitoneally. For clarity, however, when we specify, we use the name of the viscera with the prefix "meso...". The mesentery associated with the jejunum and ileum does not have a compound term containing the jejunum and ileum, but is simply named „the“ mesentery.

English term	Latin term	Mesentery associated with
mesentery	mesenterium	jejunioileum
transverse mesocolon	mesocolon transversum	transverse colon
sigmoid mesocolon	mesocolon sigmoideum	sigmoid colon
mesocecum	mesocaecum	cecum
mesoappendix	mesoappendix	vermiform appendix
mesosalpinx	mesosalpinx	uterine tube
mesovarium	mesovarium	ovary

Table 11: Terminology of two-layered peritoneal folds associated with the intraperitoneal positioned viscera

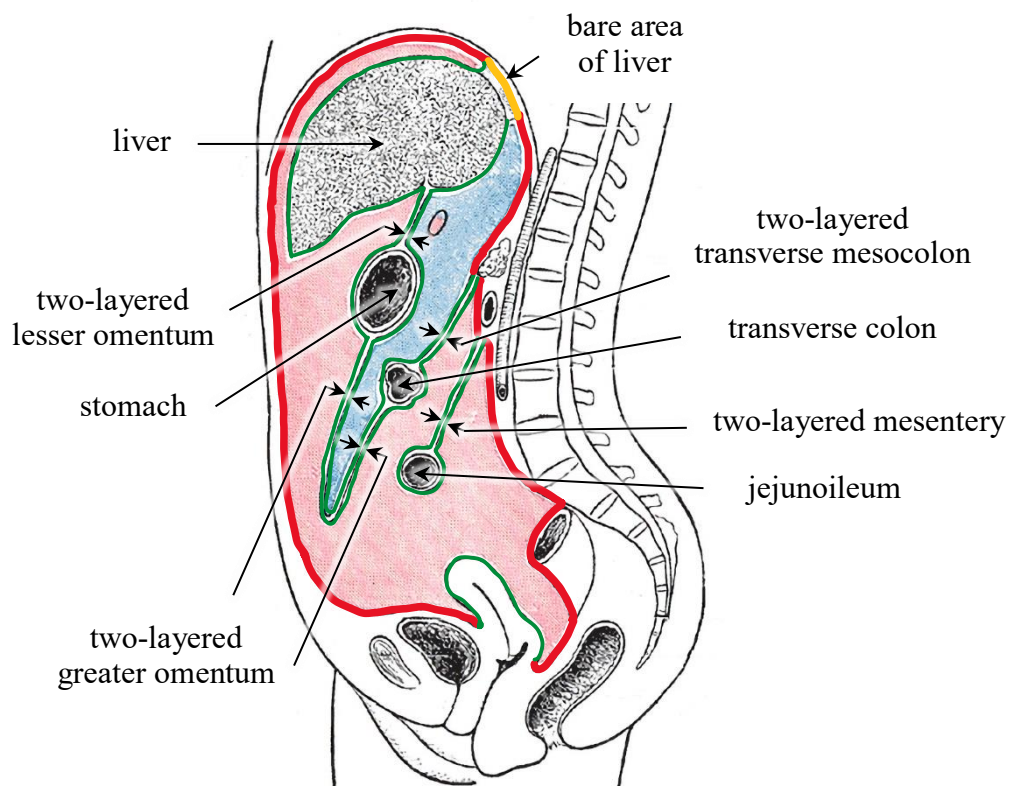


Fig. 105

Mesenteries and omenta

Sagittal section, schematic figure

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Fig. 106 A

mesentery

adipose tissue, arteries, veins, lymphatic vessels and nerves supplying the jejunum are sandwiched between two layers of peritoneum

coils of jejunum

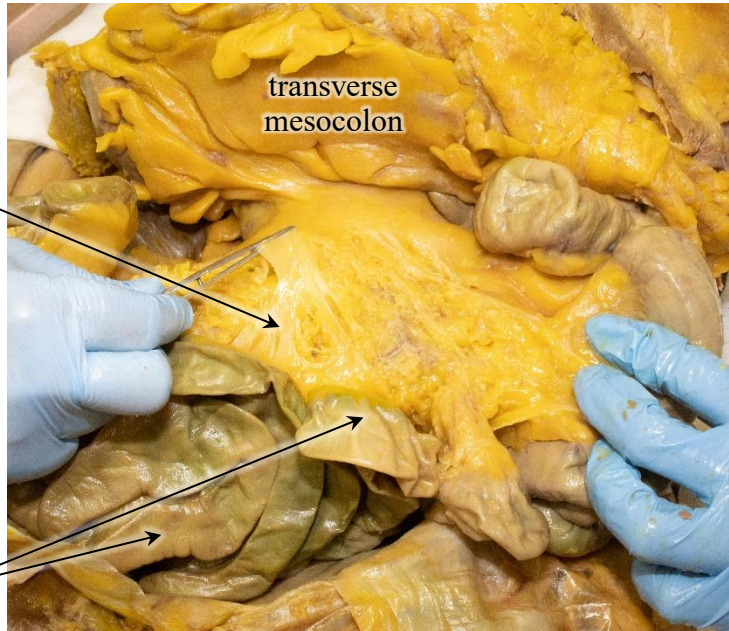


Fig. 106 C

Fig. 106 B

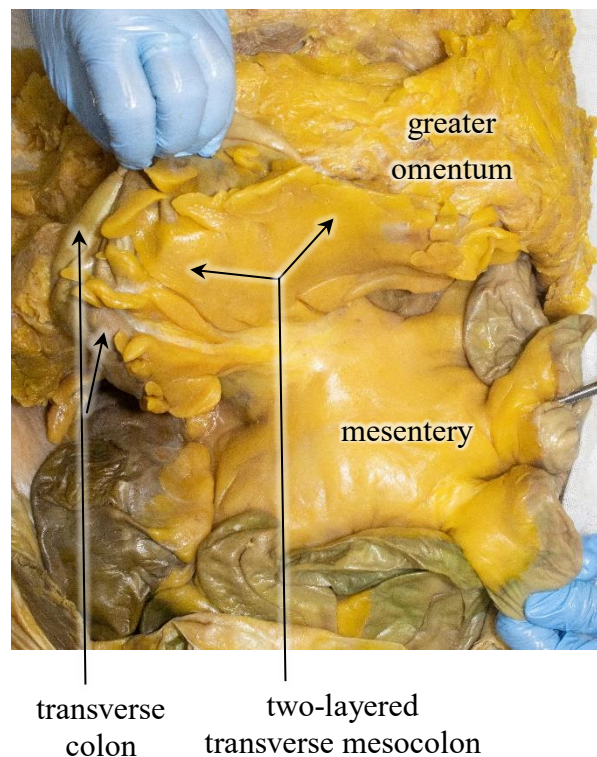
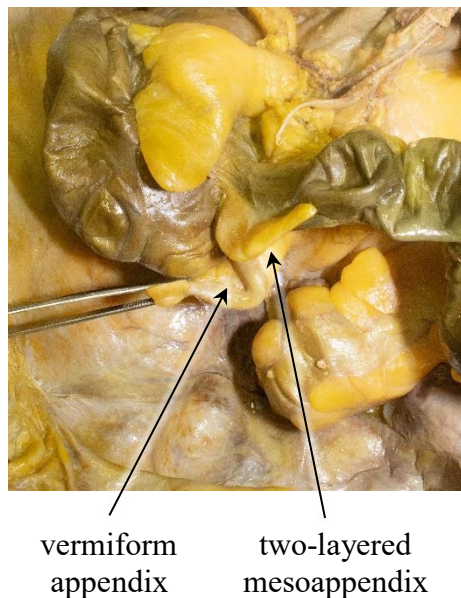


Fig. 106

Mesenteries

106 A – Mesentery associated with the jejunum

106 B – Mesoappendix associated with the vermiform appendix

106 C – Transverse mesocolon associated with the transverse colon (it is turned upward)

Formalin-fixed cadaveric specimen, Department of the Anatomy,
Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

- **Mesentery** is a large, fan-shaped peritoneal fold associated with the jejunum and ileum. Mesentery connects the jejunum and ileum to the posterior wall of the abdominal cavity by the **root of the mesentery**. It extends from the duodenojejunal flexure, just to left of the LII vertebra and passes obliquely downward and to the right iliac fossa, where it ends at the ileocecal junction. It crosses the inferior (horizontal) part of the duodenum, abdominal aorta, inferior vena cava and the right ureter.

- **Transverse mesocolon** is a peritoneal fold associated with the transverse colon. It connects the transverse colon to the posterior wall of the abdominal cavity by the **root of the transverse mesocolon**. The root of the transverse mesocolon extends from the right kidney to the left kidney. It is attached to the anterior surface of descending part of the duodenum, the head of the pancreas and continues along the lower edge of the body and tail of the pancreas. It is located above the duodenojejunal flexure.

- **Sigmoid mesocolon** is an inverted V-shaped double-layered peritoneal fold associated with the sigmoid colon. The sigmoid mesocolon connects the sigmoid colon to the pelvic wall by the **root of the sigmoid mesocolon**. The root of the sigmoid mesocolon crosses the left iliac vessels, left gonadal vessels and left ureter.

- **Mesocecum** and **mesoappendix** are peritoneal folds associated with the cecum and vermiform appendix.

- **Peritoneal ligaments**

The peritoneal ligaments differ from those of the musculoskeletal system. They are usually (not all) two-layered peritoneal folds that connect an organ to another organ or to the abdominal wall, e.g., gastrocolic (between stomach and transverse colon), gastrosplenic (between stomach and spleen), hepatoduodenal ligament (superior part of duodenum and porta hepatis), ... or the falciform ligament of the liver passing between the liver and the abdominal wall., the broad ligament of the uterus passing between the margin of the uterus and the lateral pelvic wall.

The peritoneal ligaments associated with the liver are as follow: the **coronary, triangular, falciform** and **round ligament of the liver**. *These ligaments are described in more detail in the chapter "Liver".*

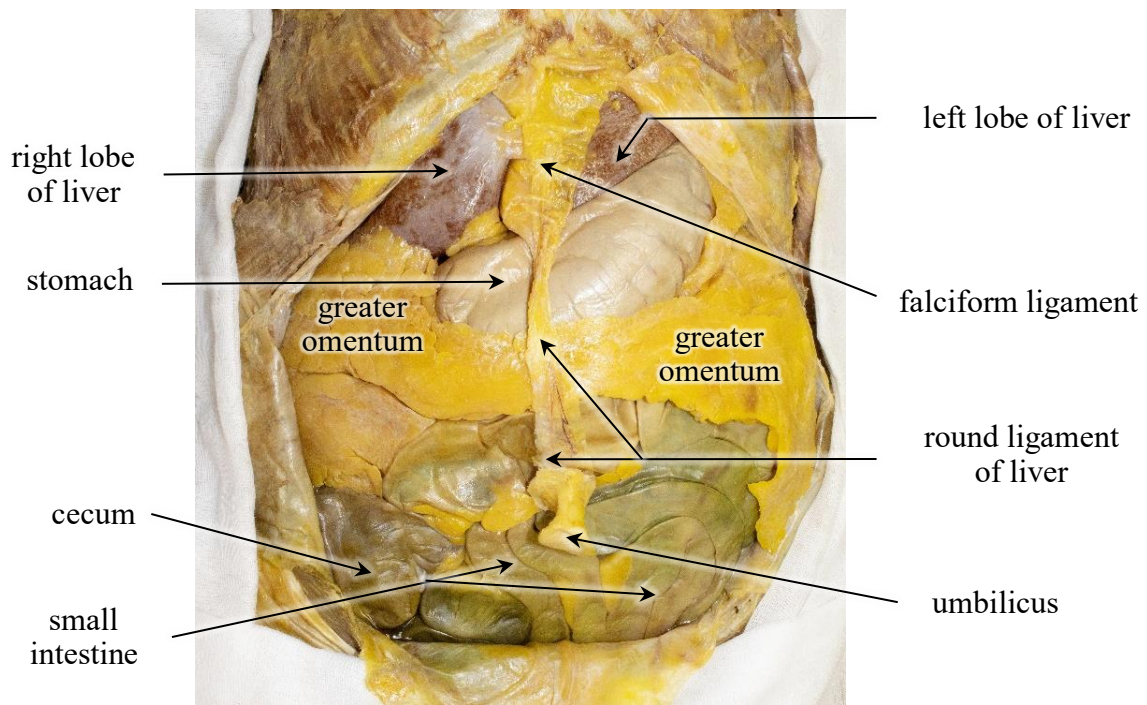


Fig. 107 A

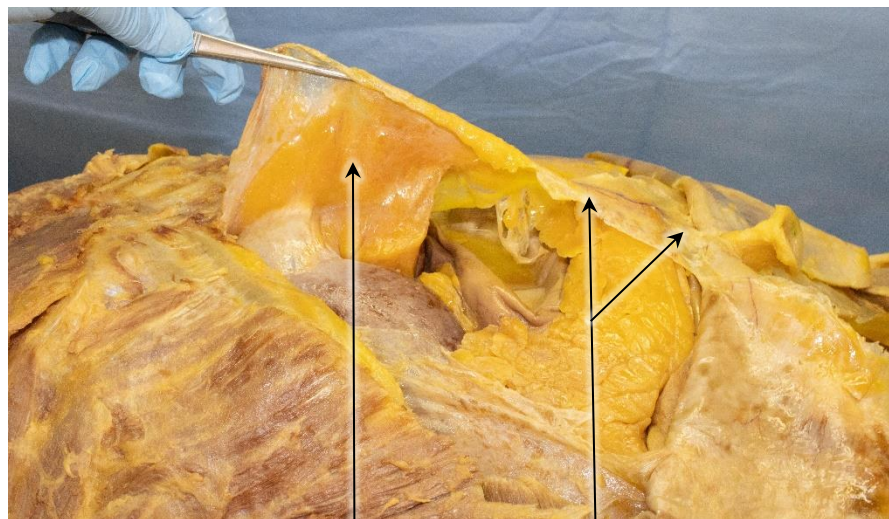


Fig. 107 B

Fig. 107

Falciform ligament and round ligament (ligamentum teres hepatis) – peritoneal ligaments associated with the liver

107 A – Anterior view

107 B – Lateral view

Formalin-fixed cadaver, Department of the Anatomy, Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

11.3 Peritoneum associated with the anterior abdominal wall

- The parietal peritoneum on the inner (posterior) surface of the **supraumbilical part** of the anterior abdominal wall is characterized by the sagittally oriented peritoneal fold, the **falciform ligament of the liver**. It extends between the diaphragmatic surface of the liver and the anterior abdominal wall. The **round ligament of the liver** (ligamentum teres hepatis) is the embryonic remnant of the umbilical vein. It forms the free edge of the falciform ligament. It passes between the visceral surface of the liver and the umbilicus. It is a fibrous remnant of the umbilical vein (*see Fig. 107*).

- The parietal peritoneum on the inner (posterior) surface of the **infraumbilical part** of the anterior abdominal wall is characterized by the folds elevated either by the ligaments, which are embryonic remnants or by the course of blood vessels.

- The **median umbilical fold** is a single midline fold that passes from the apex of the urinary bladder to the umbilicus. The fold covers the median umbilical ligament, which is a fibrous *remnant of the urachus* (*see also Fig. 111 B*).

- The **medial umbilical folds** are bilateral folds situated lateral to the median umbilical fold running from the pelvis to the umbilicus. They cover the medial umbilical ligaments, which are the embryonic remnants of the *obliterated umbilical arteries*.

- The **lateral umbilical folds** are bilateral folds situated lateral to the medial umbilical folds. They begin medial to the deep inguinal ring and ascend toward the arcuate line at the posterior surface of the rectus abdominis muscle. They cover the *inferior epigastric vessels*.

Between the umbilical folds, there are the peritoneal depressions, each of which is a potential site of the inguinal hernia. The localization of the hernia determines how the hernia is classified and treated.

- The **supravesical fossae** are shallow depressions in front of the urinary bladder between the median and medial umbilical folds.

- The **medial inguinal fossae** are situated opposite to the *superficial inguinal ring* between the medial and lateral umbilical folds. They are also called the inguinal triangles and are potential sites of the less common direct inguinal hernias.

- The **lateral inguinal fossae** are situated lateral to the lateral umbilical folds and correspond to the **deep inguinal ring**. They are potential sites of the most common indirect inguinal hernias.

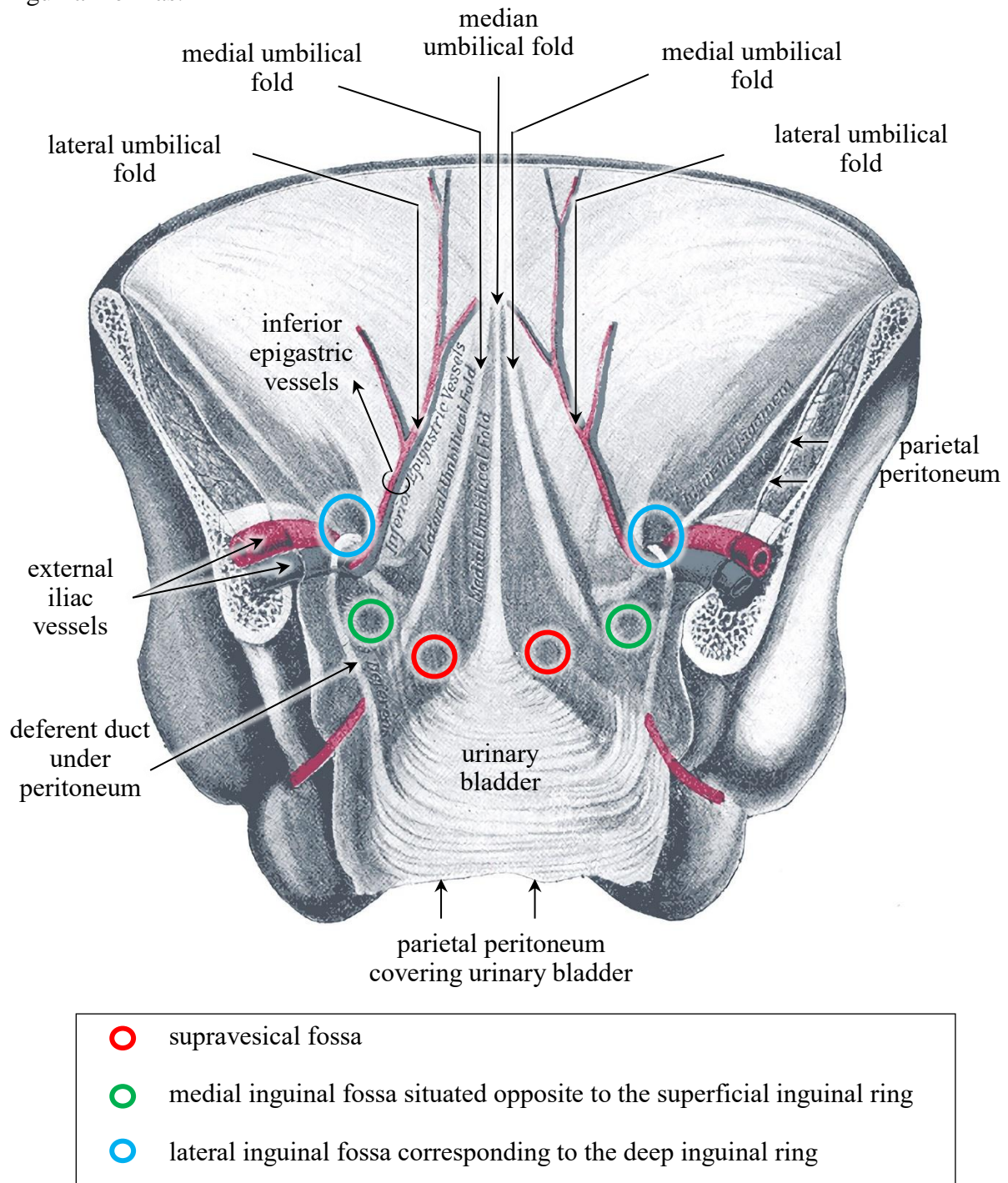


Fig. 108

Peritoneum associated with the anterior abdominal wall

Posterior view to inner surface of the anterior abdominal wall

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Modified by additional redrawing, labeling and colorization

11.4 Peritoneum associated with the posterior abdominopelvic wall

The parietal peritoneum that covers the posterior abdominopelvic wall is interrupted by some attachments e.g., attachment of the **root of the transverse mesocolon**, **root of the mesentery** and **root of the sigmoid mesocolon**. On the sides, the area of adhesion of the colon ascendens and descendens to the posterior abdominal wall is visible. This area is not covered by the peritoneum.

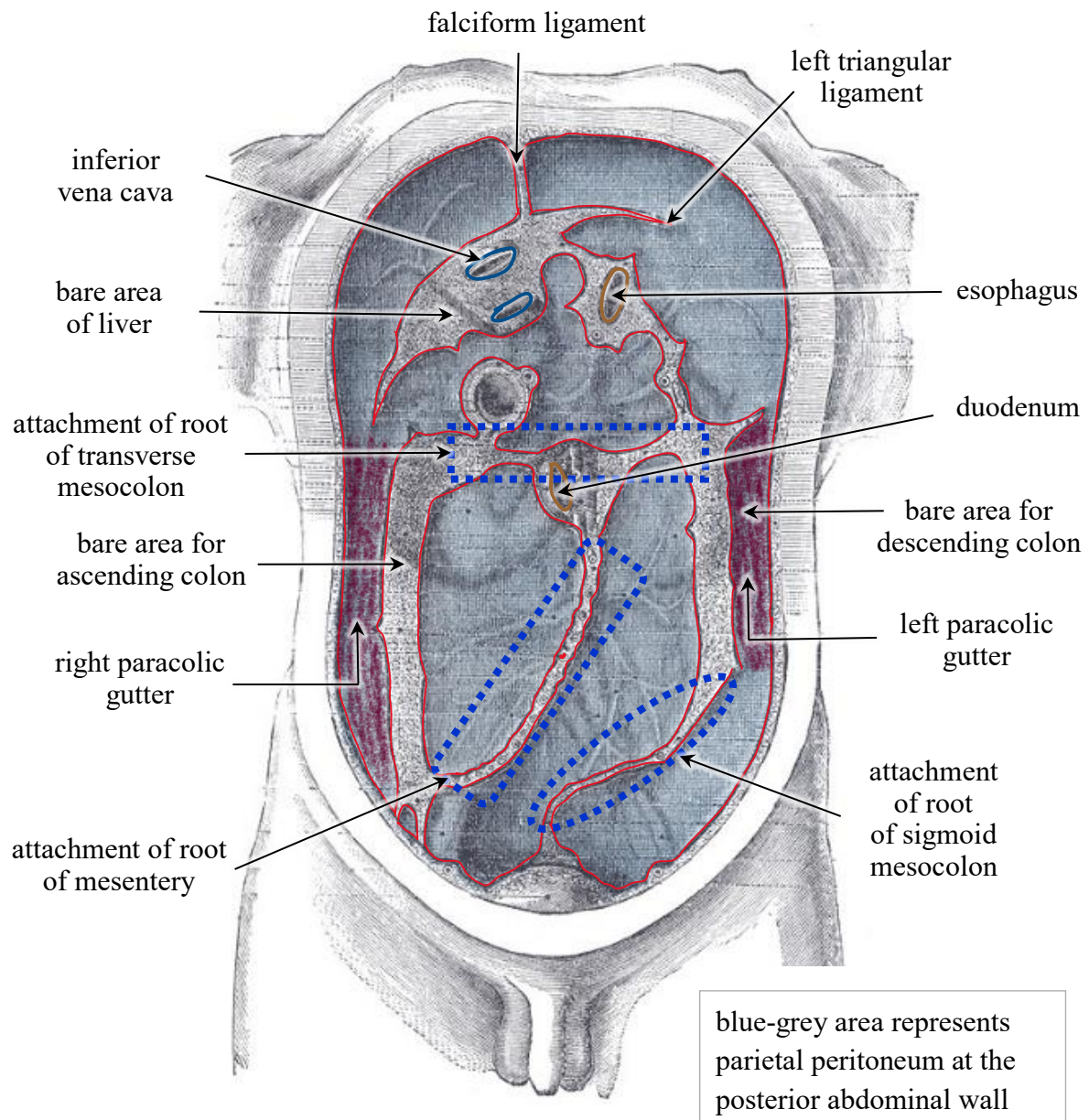


Fig. 109

Parietal peritoneum associated with the posterior abdominopelvic wall

Anterior view to inner surface of the posterior abdominal wall

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Modified by additional redrawing, labeling and colorization

11.5 Peritoneum in pelvis

The peritoneal membrane from the abdominal cavity continues freely into the pelvis but does not reach the pelvic floor. It reflects onto some pelvic viscera and forms the pouches (recesses) between the pelvic organs.

- **Peritoneum in the male pelvis:** The peritoneum of the anterior abdominal wall continues into the lesser pelvis and covers the upper part of the urinary bladder and upper part of the seminal vesicles and then reflects onto the anterior and lateral surfaces of the rectum. The **recto-vesical pouch** occurs between the urinary bladder and rectum and it is **the lowermost point of the peritoneal cavity in male**.

- **Peritoneum in the female pelvis:** The peritoneum of the anterior abdominal wall continues into the lesser pelvis and covers the upper part of the urinary bladder. Then it encloses the uterus (it is intraperitoneal), overlies the posterior fornix of the vagina (the anterior is not related to the peritoneum), and finally reflects onto the anterior and lateral surfaces of the rectum. The **vesico-uterine pouch** occurs between the urinary bladder and uterus and also the **recto-uterine pouch (pouch of Douglas)** between the rectum and uterus. The **recto-uterine pouch** is **the lowermost point of the peritoneal cavity in female**.

The lowermost points of the peritoneal cavity represent recesses, where the pathological fluid may preferentially collect in a standing position (e.g., abscess, haemoperitoneum, intraperitoneal metastases). In female, the rectouterine pouch is easily accessible externally for the puncture through the posterior vaginal fornix.

Fig. 110 A

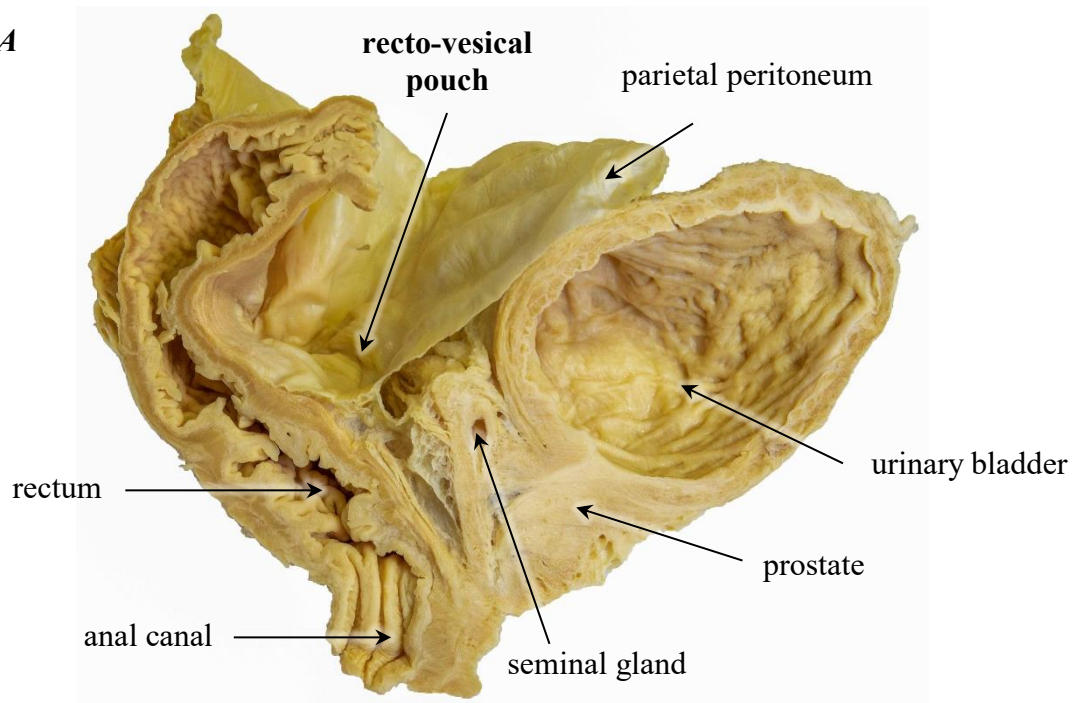


Fig. 110 B

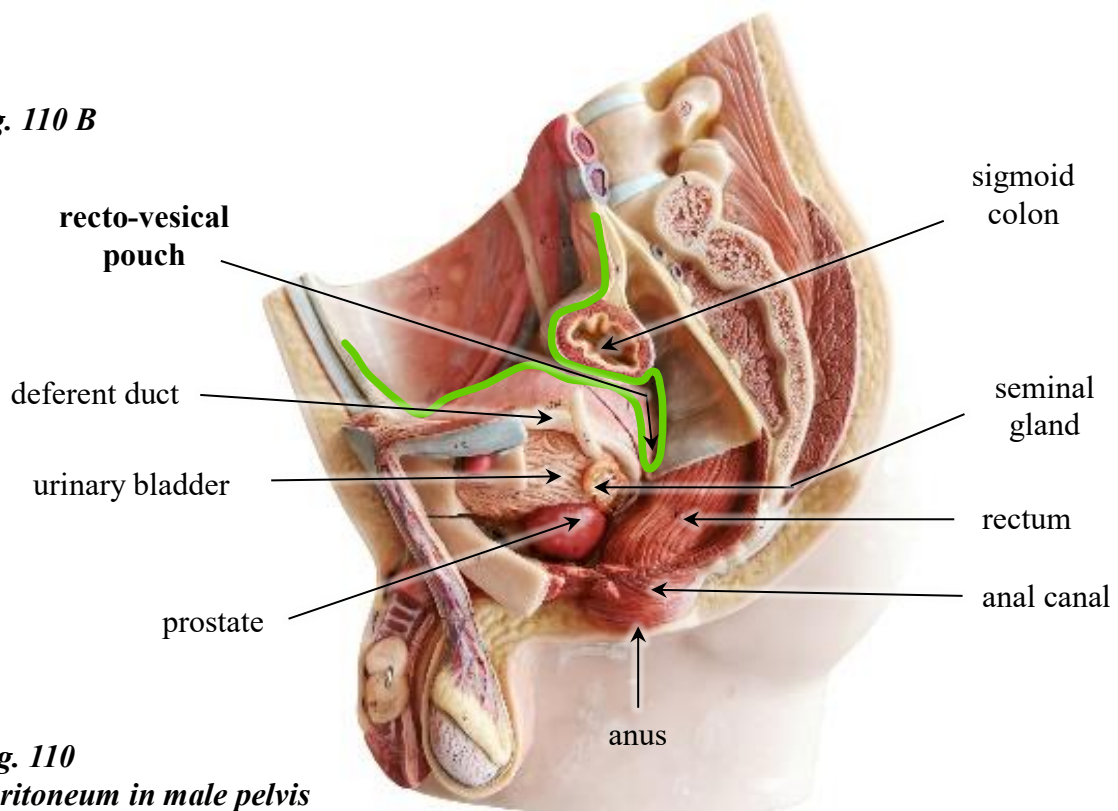


Fig. 110

Peritoneum in male pelvis

Sagittal plane

110 A – Recto-vesical pouch; open recto-vesical septum; subperitoneal structures and organs

Formalin-fixed cadaveric specimen, Department of the Anatomy, Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

110 B – Recto-vesical pouch

Photography of SOMSO model

Modified by additional drawing and labeling

Fig. 111 A

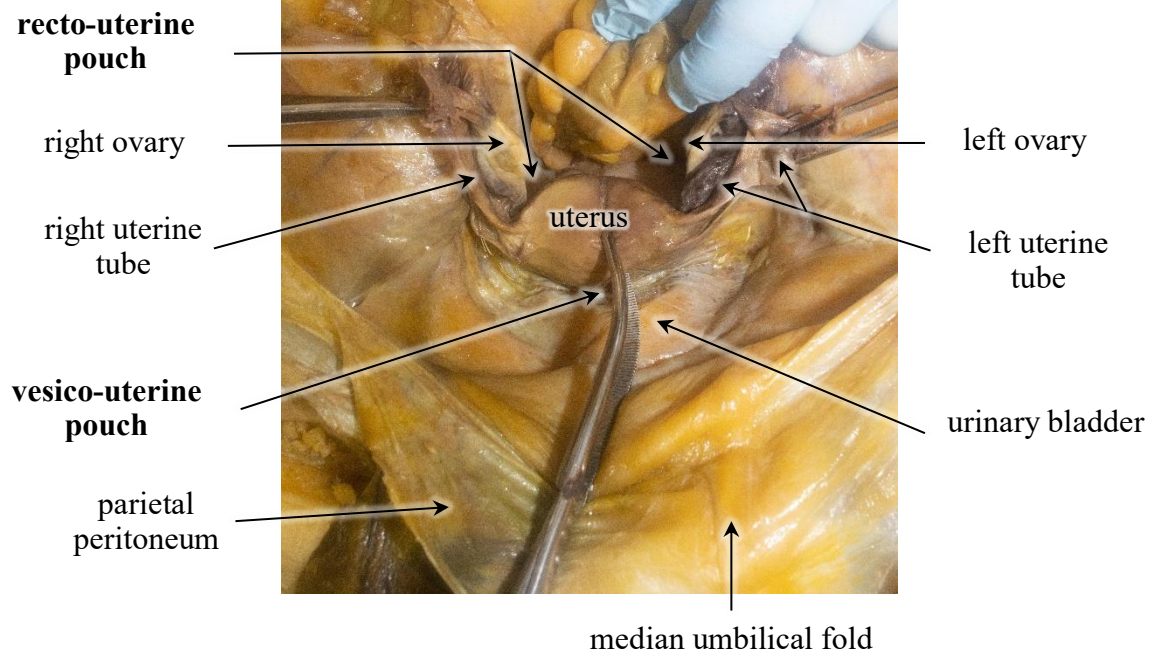


Fig. 111 B

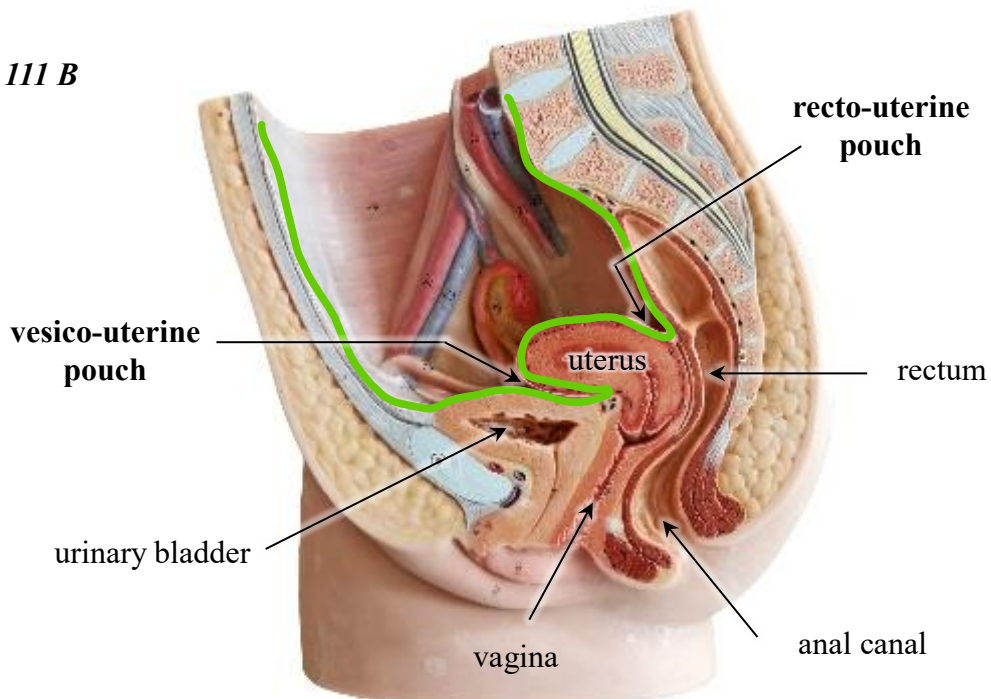


Fig. 111

Peritoneum in female pelvis and peritoneal pouches

111 A – Superior view

Formalin-fixed cadaveric specimen, Department of the Anatomy, Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

111 B – Sagittal plane

Photography of SOMSO model

Modified by additional drawing and labeling

11.6 Subdivision of the peritoneal cavity

The peritoneal cavity can be divided into the **greater** and **lesser peritoneal sacs**. The greater sac is the main and larger part of the peritoneal cavity and lies outside the lesser sac. The greater and lesser sacs communicate with each other through the **omental foramen/epiploic foramen**.

The greater sac is further subdivided by the root of the transverse mesocolon into the upper **supramesocolic compartment** and lower **inframesocolic compartment**. Both compartments of the peritoneal cavity differ topographically and according to the vascular supply. The viscera located in the **supramesocolic compartment** are blood supplied by the branches of the **celiac trunk**. The viscera located in the **inframesocolic compartment** are blood supplied by the branches from both – the **superior** and **inferior mesenteric arteries**. As the root of the transverse mesocolon passes in front of the duodenum and pancreas, superior portions of these organs are in the supramesocolic compartment and inferior portions in the inframesocolic compartment. The duodenum and pancreas thus receive the vascular supply from both, the celiac trunk and from the superior mesenteric artery.

These compartments communicate with each other ventrally, through the space between the transverse colon, and greater omentum and the anterior abdominal wall, and also laterally, through the **paracolic gutters**. They are spaces between the lateral surface of the ascending/descending colon and the posterolateral abdominal wall. Paracolic gutters are clinically important because they represent the spaces through which pathological processes in the peritoneal cavity can spread.

The inframesocolic compartment is further subdivided by the root of the mesentery into the **right** and **left paracolic spaces**. Also, these two spaces have different sources of blood supply. The viscera located in the **right paracolic space** of the inframesocolic compartment are blood supplied by the branches of the **superior mesenteric artery**. The viscera located in the **left paracolic space** are blood supplied by the branches of the **inferior mesenteric artery**.

Fig. 112 A

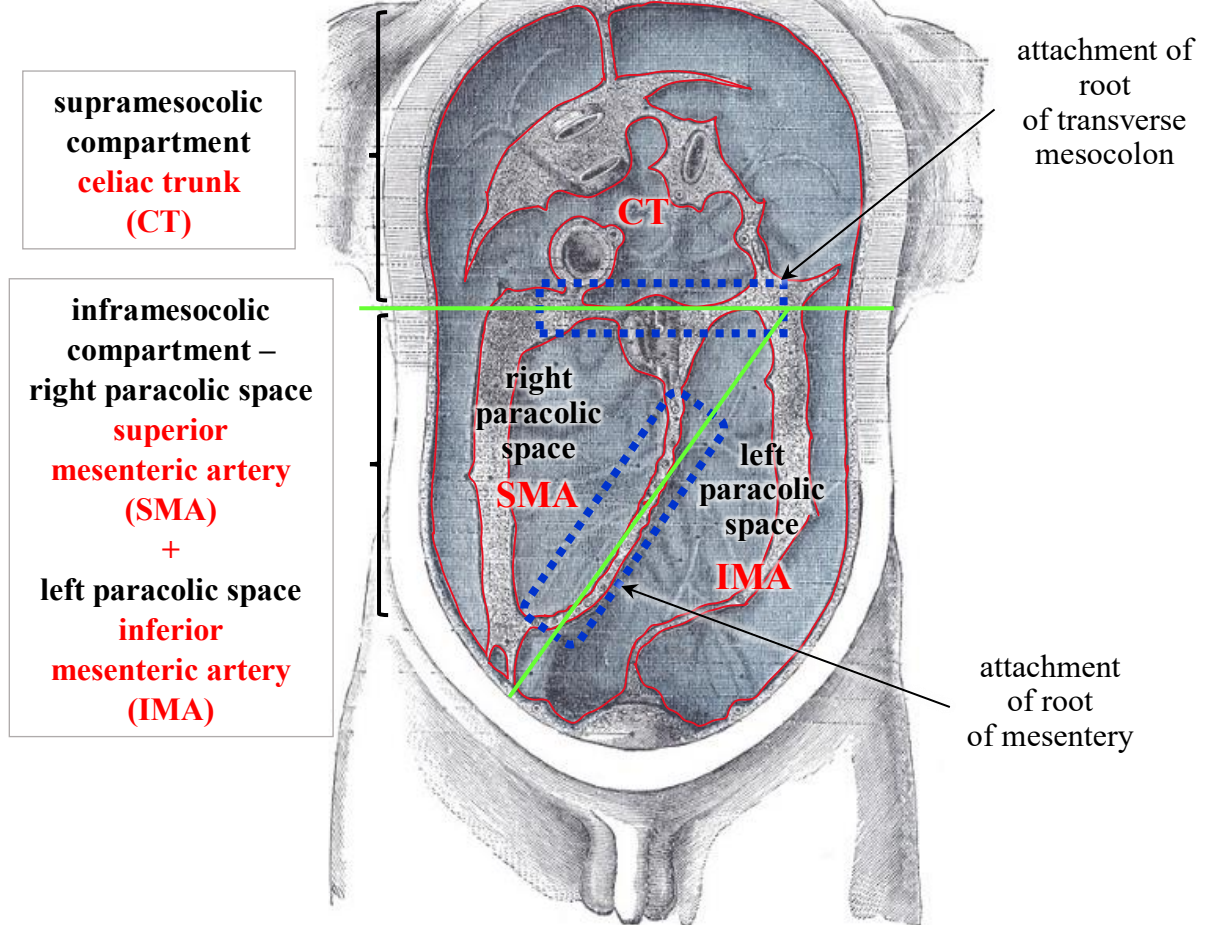


Fig. 112
Blood supply according to the
subdivision of the peritoneal cavity

112 A – Anterior view
to inner surface of
the posterior
abdominal wall

112 B – Sagittal
section

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Gray H.: Anatomy of the
human Body.

Philadelphia: Lea &
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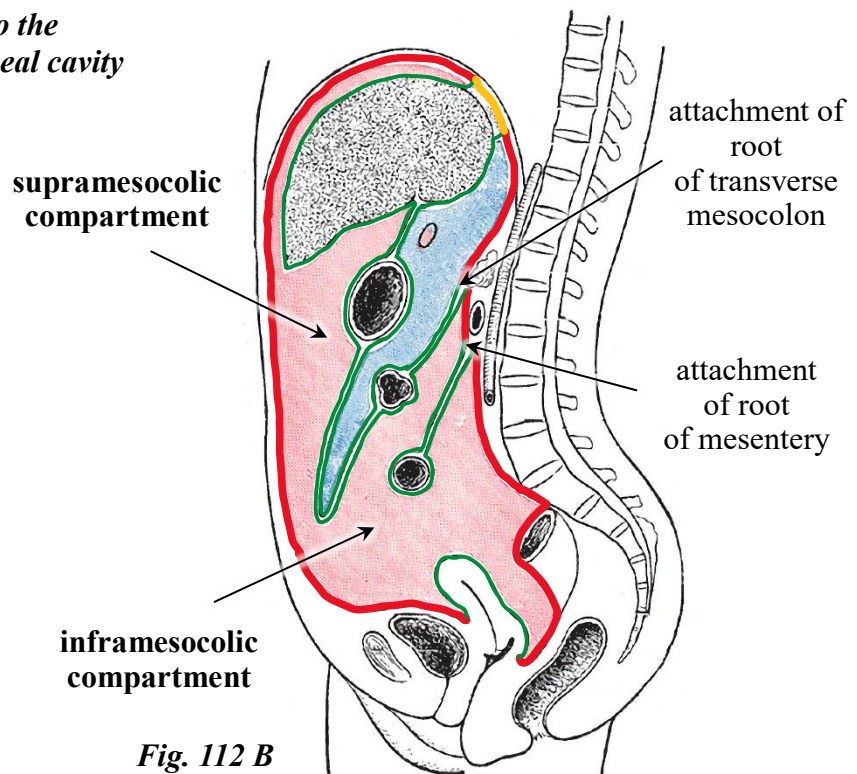


Fig. 112 B

Division of peritoneal cavity		Source of blood supply	Viscera
supramesocolic compartment		celiac trunk	liver, gallbladder, stomach, abdominal part of esophagus, spleen, superior portions of duodenum and pancreas
inframesocolic compartment	right paracolic spaces	superior mesenteric artery	inferior portions of duodenum and pancreas, jejunum, ileum, vermiform appendix, cecum, ascending colon, transverse colon
	left paracolic spaces	inferior mesenteric artery	descending colon, sigmoid colon, upper portion of the rectum

Table 12: Division of the peritoneal cavity according to the source of blood supply

11.7 Recesses of the peritoneal cavity

As the peritoneum surrounds the viscera, various sacs or spaces called recesses are formed in the peritoneal cavity. The supramesocolic compartment contains a recess, which is called the **lesser sac/omental bursa**. The **lesser sac is bounded** by the following organs and structures:

Anteriorly: stomach and its peritoneal folds – the lesser omentum and gastrocolic ligament (the upper portion of the greater omentum).

- **Posteriorly:** parietal peritoneum that covers the anterior surface of pancreas and duodenum.
- **Superiorly:** liver and the left portion of the diaphragm.
- **Inferiorly:** transverse colon and transverse mesocolon.
- **On the left:** spleen, gastrosplenic, phrenicosplenic and splenorenal ligaments (splenorenal ligament contains splenic vessels).
- **On the right:** the lesser sac communicates with the greater sac through the **omental foramen/epiploic foramen**.

Boundaries of the **omental foramen/epiploic foramen** are as follows:

- **Anteriorly:** hepatoduodenal ligament (free edge of the lesser omentum), that contains the portal vein, bile duct and proper hepatic artery.
- **Posteriorly:** peritoneum, hepatorenal ligament and inferior vena cava.
- **Superiorly:** caudate lobe of the liver.
- **Inferiorly:** superior part of the duodenum.

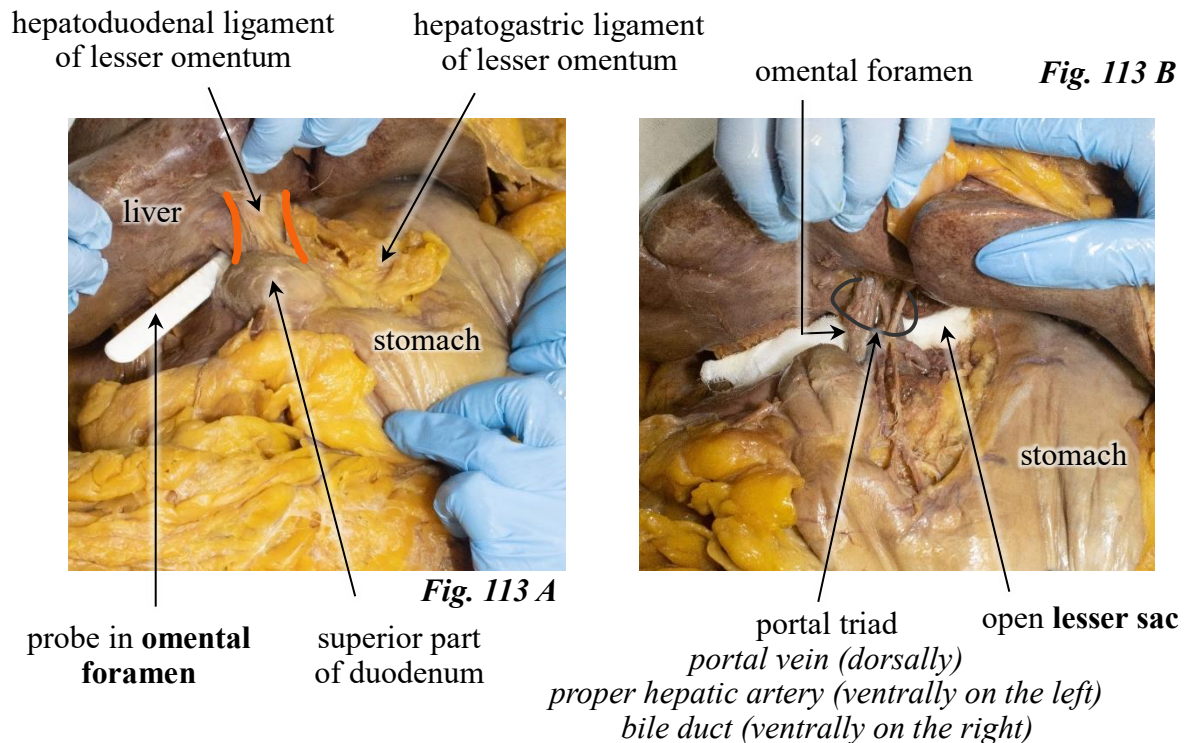


Fig. 113

113 A – Omental foramen and lesser omentum; 113 B – Open lesser sac (omental bursa)

Formalin-fixed cadaveric specimen, Department of the Anatomy, Jessenius Faculty of Medicine in Martin, Comenius University Bratislava

Fig. 114

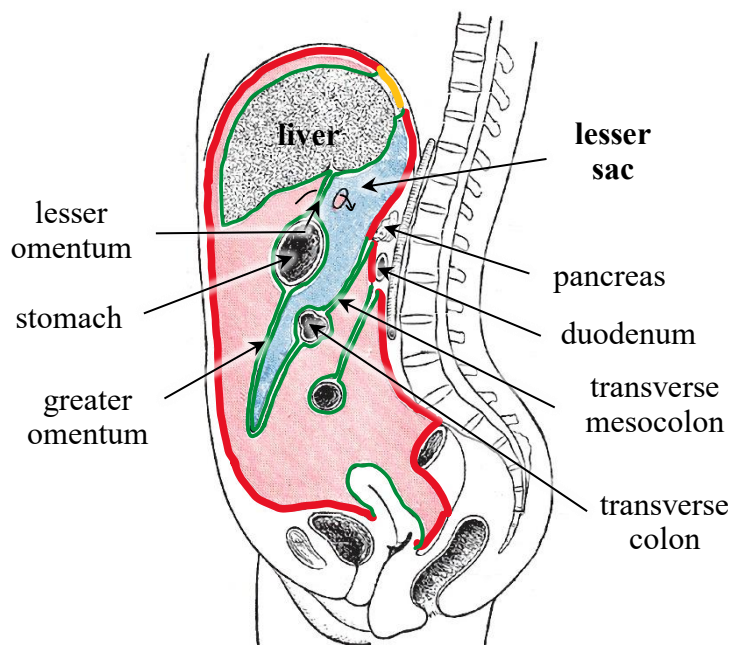
**Borders of the lesser sac
Sagittal section**

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Some other clinically significant peritoneal recesses

- The **right** and **left subphrenic recesses** form the superior extensions of the greater sac. They are situated between the diaphragm and the liver and are separated from each other by the falciform ligament.
- The **right** and **left subhepatic spaces** are located below the liver. The left subhepatic space is actually the lesser sac/omental bursa. The right subhepatic space communicates with the right subphrenic recess. The right subhepatic space extends into the hepatorenal recess, which separates the liver from the right kidney.

The hepatorenal recess (Morison's pouch) is the deepest pouch in a patient in the supine position (horizontal position). It is a potential space, which can be filled when some pathological fluid (ascites, blood,) enters this area. When it is not present, there is no space between the liver and the right kidney.

- The **duodenal recesses** (retro-, para-, superior, inferior) are located near the duodenojejunal flexure.
- The **retrocecal recess** is often present on the right side of the body behind the cecum or ascending colon.
- The **intersigmoid recess** on the left side of the body at the angle of the root of the sigmoid mesocolon. The ureter can be palpated here.

These recesses are clinically important because they can be the site of internal herniations and also the site of abscesses or accumulation of various pathological fluids. They communicate with each other and the pathological process from one site can thus spread to any other site in the peritoneal cavity.

11.8 Vessels and nerves of the peritoneum

The parietal peritoneum is supplied by blood vessels and nerves that supply the abdominal wall. The visceral peritoneum is supplied by vessels and nerves that supply the individual viscera enclosed by the adjacent peritoneum. The parietal peritoneum has a rich

sensory innervation, which is highly sensitive to pain, while the visceral peritoneum are not, due to its lack of sensory innervation.

- **Arterial supply** of the parietal peritoneum adjacent to the abdominal wall comes from the branches of the internal thoracic artery and branches of the femoral artery (superficial epigastric and superficial circumflex iliac arteries). The deeper level is blood supplied by the superior epigastric artery and the last two posterior intercostal and subcostal arteries. The inferior region is supplied by the branches of the external iliac artery (inferior epigastric and deep circumflex iliac arteries).
- The **veins** of the parietal peritoneum adjacent to the abdominal wall follow the arteries.
- The **lymph** from the supraumbilical part drains into the axillary lymph nodes and from the infraumbilical part into the superficial inguinal nodes. Deep lymphatic vessels follow the arteries – along the internal thoracic are drained into the parasternal lymph nodes, along the abdominal aorta into the lumbar lymph nodes, and along the external iliac artery into the external iliac lymph nodes.
- The **parietal peritoneum** is nerve supplied by the lower six thoracic spinal nerves and the first lumbar – iliohypogastric and ilioinguinal nerves. They are the somatic nerves arranged in segmental areas that innervate the abdominal wall. The parietal peritoneum in the pelvis is mainly supplied by the obturator nerve. The pain is well localized and sensitive to the pain, temperature, touch and pressure.
- The **visceral peritoneum** is nerve supplied by the autonomic nerves that innervate various organs. The visceral type of pain is diffuse and hard to localize. It is sensitive to distension of viscera and chemical irritation.

Any injury or inflammation of the parietal peritoneum is felt as acute localized pain. When the parietal peritoneum is irritated, the muscles over it tend to contract reflexively. The tensing of the muscles of the abdominal wall is referred to as abdominal guarding (it is also known as 'défense musculaire'). It is a characteristic finding on physical examination in acute abdomen (inflammation of the inner surface of the abdomen + peritoneum due to appendicitis, diverticulitis ...).

12 REVIEW QUESTIONS

12.1 Oral cavity, tongue, teeth, salivary glands

Multiple choice questions

Oral cavity:

- a/ upper and lower lips meet laterally in the nasolabial sulcus (fold)
- b/ internally each lip is connected to the adjacent gum by the philtrum
- c/ gingival glands are opened into the vestibule
- d/ floor of the oral cavity is formed by the mylohyoid and geniohyoid muscles
- e/ palatopharyngeus muscle originates from the palatine aponeurosis

Oral cavity:

- a/ philtrum of the lip ends in the labial frenulum
- b/ the gum (gingiva) contains no salivary glands
- c/ the floor of the oral cavity is formed by the mylohyoid muscle
- d/ the soft palate of the oral cavity consists of the palatine aponeurosis
- e/ all major salivary glands are opened into the proper oral cavity

Palate:

- a/ palatine aponeurosis continues anteriorly into the periosteum of the palatine process of the maxilla
- b/ tensor veli palatini muscle originates from the palatine aponeurosis
- c/ median palatine raphe of the hard palate ends anteriorly at the papilla incisiva
- d/ palatine aponeurosis continues downwards into the lingual aponeurosis
- e/ palatine tonsil is situated in front of the palatoglossal arch

Soft palate and palatine aponeurosis:

- a/ soft palate can be depressed to help close the oropharyngeal isthmus
- b/ soft palate can be elevated to separate the nasopharynx from the oropharynx
- c/ palatine aponeurosis gives attachment for the superior pharyngeal constrictor
- d/ palatine aponeurosis gives attachment for the levator veli palatini muscle
- e/ palatine aponeurosis continues anteriorly directly into the periosteum of the palatine bones

Palate:

- a/ periosteum of the hard palate posteriorly continues into the palatine aponeurosis
- b/ tensor veli palatini muscle originates from the palatine aponeurosis
- c/ soft palate forms the superior border of the isthmus faucium (oropharyngeal orifice)
- d/ mucous membrane of the hard palate contains minor salivary glands
- e/ it is blood supplied also by the branches of the maxillary artery

Tongue:

- a/ lingual mucosa of the dorsum of the tongue contains the lymphoid nodules
- b/ lingual mucosa of the dorsum of the tongue contains the lingual glands
- c/ vallate papillae are located immediately anterior to the terminal sulcus
- d/ body and root of the tongue are separated by the terminal sulcus
- e/ palatoglossus muscle elevates the root of the tongue

Mucosa at the dorsum of the oral part of the tongue:

- a/ it is firmly attached to the lingual aponeurosis
- b/ it is papillated
- c/ it contains lingual glands
- d/ submucosa contains lingual tonsil
- e/ it contains gustatory cells (taste buds)

Tongue:

- a/ inferior surface of the tongue is connected to the floor of the mouth by the labial frenulum
- b/ lingual septum separates the oral and pharyngeal part of the tongue
- c/ lingual papillae are situated behind the terminal sulcus of the tongue
- d/ lingual glands produce saliva continuously
- e/ one from extrinsic muscles of the tongue originates from the temporal bone

Permanent teeth:

- a/ occlusal surface of the premolar teeth are bicusped
- b/ gingiva (gum) around molars of the permanent teeth contains minor salivary glands
- c/ mesial surface of the canine tooth is directed toward the first premolar tooth
- d/ molars teeth with two roots are attached into the alveolar process of the mandible
- e/ pulp infection may enter the alveolus and surrounding soft tissues through the apical foramen at the root

Teeth:

- a/ crown and neck of the tooth are covered by the cementum
- b/ canine tooth has the longest root of all teeth
- c/ first molar and central incisor are first erupted of the permanent teeth
- d/ lower molars teeth have 3 roots
- e/ molars are also called multicuspid teeth

Teeth:

- a/ cementum covers the neck and root of the tooth
- b/ mesial surface of the canine tooth directs toward the first premolar tooth
- c/ in both upper quadrants of the permanent teeth, there are 4 premolars together
- d/ molars teeth with two roots are attached into the alveolar process of the mandible
- e/ first molar tooth is erupted as the first of the deciduous teeth

Major salivary glands:

- a/ submandibular gland is related to the facial nerve
- b/ sublingual gland is located above the mylohyoid muscle
- c/ parotid duct penetrates the masseter muscle of the cheek
- d/ submandibular duct runs closely to the medial surface of the sublingual gland
- e/ major sublingual duct is opened on the sublingual fold

Submandibular gland:

- a/ deep part of the submandibular gland is situated below the mylohyoid muscle
- b/ superficial part of the submandibular gland lies within the proper oral cavity
- c/ duct of the submandibular gland runs on the medial side of the sublingual gland
- d/ duct of the submandibular gland is crossed by the lingual nerve
- e/ duct of the submandibular gland is opened on the sublingual fold

Which nerve lies deep to the submandibular gland?

- a/ facial
- b/ glossopharyngeal
- c/ trigeminal
- d/ hypoglossal
- e/ vagus

Sublingual salivary gland:

- a/ its secretions empty on the sublingual fold
- b/ its secretions empty on the sublingual caruncle (papilla)
- c/ lingual nerve runs at its medial surface
- d/ it is located above the mylohyoid muscle
- e/ sublingual papilla (caruncle) lies next to the base of the frenulum of the tongue

Which of the following structures passes through the parotid gland:

- a/ external carotid artery
- b/ vagus nerve
- c/ facial nerve
- d/ facial artery
- e/ retromandibular vein

Parotid gland and duct:

- a/ a substantial part of the parenchyma of the glandula parotis overlies the musculus masseter
- b/ the nervous parotid plexus of the facial nerve is located in the parenchyma of the parotid gland
- c/ the retromandibular vein runs through the parenchyma of the parotid gland
- d/ parotid duct pierces the masseter muscle
- e/ parotid duct opens and produces saliva into the proper oral cavity

Open questions with short answer

- **Name the openings at the beginning and the end of the alimentary system:**
- **Name the groove in the middle part of the upper lip:**
- **Name the structure which connects the lip to the gum:**
- **Which muscle largely controls the diameter of the oral fissure?**
- **Name muscles of the floor of the oral cavity:**
- **Name types of the teeth in the deciduous dentition:**
- **Name dental tissues:**
- **Name the parts of the tooth:**
- **Name the part of the tooth which is formed by the dentine and enamel:**
- **Name the surface of the canine tooth which is directed towards lateral incisor:**
- **Name the layer of the tooth which is situated immediately deep to the enamel:**
- **Name the opening through which the neurovascular structures enter or leave the tooth:**
- **Which tooth is called bicuspid?**
- **Name the part of the tooth which is visible and protrudes through the gingiva:**
- **Name the hard, white material which covers the crown portion of the tooth:**
- **Name extrinsic muscles of the tongue:**
- **Name muscle which pulls tongue down and backwards:**
- **Which structure separates oral and pharyngeal parts of the tongue**
- **What attaches the inferior aspect of tongue to oral mucosa?**
- **Name the surfaces of the tongue:**
- **Name mucosal pouches (depressions) between the tongue and epiglottis:**
- **Where are the sublingual ducts opened into oral cavity? Write exactly.**

- Which duct(s) of salivary gland is/are opened into sublingual papilla (caruncle):
- Which muscle is pierced by parotid duct?
- Which nerve branches within the parotid gland?
- Which muscle separated the submandibular gland into its superficial and deep portions?
- Which salivary gland (s) is (are) opened into vestibule of the oral cavity:

12.2 Pharynx, esophagus, stomach

Multiple choice questions

Mark the levators of the pharynx:

- a/ stylopharyngeus m.
- b/ musculus uvulae
- c/ palatopharyngeus m.
- d/ salpingopharyngeus m.
- e/ levator veli palatini m.

Mark the muscle which narrows the oropharyngeal isthmus:

- a/ palatoglossus m.
- b/ styloglossus m.
- c/ palatopharyngeus m.
- d/ salpingopharyngeus m.
- e/ stylopharyngeus

Mark the structure which is located in the nasal part of the pharynx:

- a/ pharyngeal fornix
- b/ piriform fossa
- c/ palatine tonsil
- d/ tubal tonsil
- e/ pharyngeal opening of the auditory tube

Pharynx:

- a/ pharyngeal tonsil is located in front of the palatopharyngeal arch
- b/ pharyngeal opening of the auditory tube is situated in the pharyngeal fornix
- c/ tubal elevation is elevated by the cartilage of the auditory tube
- d/ superior laryngeal nerve runs under the mucosa of the piriform fossa of its laryngeal part
- e/ trachea is situated in front of the pharynx

Pharynx:

- a/ tubal tonsil is situated behind the palatopharyngeal arch
- b/ palatopharyngeus muscle belongs to the levators of the pharynx
- c/ it extends from cranial base to the 6th cervical vertebra
- d/ the levators of the pharynx are inserted to the pharyngeal raphe
- e/ constrictors of the pharynx are covered by the pharyngobasilar fascia

Nasal part of the pharynx:

- a/ it communicates with the nasal cavity through the conchae
- b/ pharyngeal fornix contains tubal tonsil
- c/ inflammation of this part can spread into the middle ear
- d/ it extends between the cranial base and soft palate
- e/ it is inserted to the cranial base by the superior pharyngeal constrictor muscle

Which structure / organ is situated on the right side of the oral part of the pharynx?

- a/ lobe of the thyroid gland
- b/ laryngeal recurrent nerve
- c/ internal jugular vein
- d/ vagus nerve
- e/ common carotid artery

Esophagus:

- a/ laryngeal recurrent nerves are related to the cervical part of the esophagus
- b/ internal carotid arteries are situated on the sides of the cervical part of the esophagus
- c/ azygos vein is located at the right side of the thoracic part of the esophagus
- d/ thoracic part of the esophagus is situated in front of the thoracic duct
- e/ abdominal part of the esophagus is related to the liver

Esophagus:

- a/ its beginning is constricted
- b/ thoracic part of the esophagus is closely related to both lungs
- d/ it is surrounded by sphincter (circular muscular ring) at the level of the esophageal opening of the diaphragm
- e/ main lymphatic duct runs behind the thoracic part of the esophagus
- c/ abdominal part of the esophagus is intraperitoneal in position

Cervical part of the esophagus:

- a/ its commencement (beginning) is projected to C6
- b/ internal jugular veins are located on the sides of the cervical part of the esophagus
- c/ it is situated behind the larynx
- d/ its commencement (beginning) is constricted
- e/ communicates with the larynx through the laryngeal inlet

Mark the structures which are situated on the right side of the thoracic part of the esophagus:

- a/ right vagus nerve
- b/ right laryngeal recurrent nerve
- c/ thoracic duct
- d/ azygos vein
- e/ thoracic aorta

Stomach:

- a/ anterior wall of the stomach is related to the diaphragm
- b/ it is situated in front of the lesser sac (omental bursa)
- c/ it is situated in front of the transverse colon
- d/ the cardiac orifice is distal opening of the stomach
- e/ upper wider part of the stomach is named fundus

Stomach:

- a/ cardiac incisure (notch) separates the esophagus from the fundus of the stomach
- b/ the narrowest part of the stomach is the pyloric antrum
- c/ it is intraperitoneal in position
- d/ pyloric orifice is surrounded by the circular muscular ring (sphincter)
- e/ transverse colon is situated behind the stomach

Which of the following structure / organ is situated behind the stomach:

- a/ left suprarenal gland
- b/ diaphragm
- c/ pancreas
- d/ duodenum
- e/ transverse colon

Which of the following structure / organ is situated in front of the stomach:

- a/ spleen
- b/ jejunum
- c/ diaphragm
- d/ liver
- e/ transverse mesocolon

Open questions with short answer

- Which muscles narrow the isthmus faucium?
- Where are constrictors of the pharynx inserted?

- **Name the levators of the pharynx:**
- **Write the origin and function of the salpingopharyngeus muscle:**
- **Name the structure which is located within the pharyngeal fornix:**
- **Name the opening between the proper oral cavity and the oral part of the pharynx:**
- **Name the opening between the nasal cavity and the nasal part of the pharynx:**
- **Name the opening between laryngeal cavity and the laryngeal part of the pharynx:**
- **Name the openings between the nasal part of the pharynx and adjacent spaces:**
- **Name the tonsils that belong to the Waldeyer's (pharyngeal lymphatic) ring:**
- **Which part of Waldeyer's (pharyngeal) lymphatic ring is most closely associated with the epiglottis?**
- **Name the opening in the diaphragm through which the esophagus enters the abdominal cavity:**
- **Which structure separates wall of the esophagus from the upper portion of the stomach:**
- **Name the right margin of the stomach:**
- **Which structure separates the body and pyloric part of the stomach:**
- **Name opening between stomach and duodenum:**
- **Write the position of the stomach to the peritoneum:**
- **Name parts of the stomach:**
- **Which part of the stomach is the widest?**
- **Name the orifices of the stomach:**
- **Name the sphincter located between the stomach and duodenum:**
- **Where (to which regions) does the stomach project onto the anterior abdominal wall?**

12.3 Intestine

Multiple choice questions

Duodenum:

- a/ it is situated in front of the right kidney
- b/ ventral surface of its horizontal part is crossed by the inferior mesenteric vessels
- c/ its beginning is connected to the liver by small portion of the lesser omentum
- d/ duodenojejunal flexure is projected to the 2nd lumbar vertebra on the right side of the vertebral column
- e/ it is retroperitoneal in position

Duodenum:

- a/ visceral surface of the left lobe of the liver is marked by the duodenal impression
- b/ bile duct opens into the minor duodenal papilla in descending part of the duodenum
- c/ inferior vena cava is situated behind the duodenum
- d/ inferior mesenteric vessels run in front of the horizontal (inferior) part of the duodenum
- e/ it is retroperitoneal in position

Duodenum:

- a/ its beginning is connected to the liver by the right portion of the lesser omentum
- b/ it is related to the left kidney
- c/ it is related to the right kidney
- d/ duodenal impression is visible on the visceral surface of the right lobe of the liver
- e/ duodenojejunal flexure is projected to the 2nd lumbar vertebra on the right side of the vertebral column

Duodenum:

- a/ the superior part of the duodenum is situated in front of the bile duct
- b/ the superior part of the duodenum is situated in front of the portal vein
- c/ it is closely related to the head of the pancreas
- d/ its superior part is located just to the right of LI
- e/ it is entirely situated in inframesocolic part of the peritoneal cavity

Which structure / organ is located just behind the jejunum:

- a/ abdominal aorta
- b/ portal vein
- c/ inferior vena cava
- d/ ureters
- e/ left suprarenal gland

Small intestine:

- a/ ileum is situated above the sigmoid colon
- b/ all parts of the small intestine are intraperitoneal in position
- c/ mucosal circular folds are more frequent in the ileum than in jejunum
- d/ it terminates as ileocaecal orifice in the right iliac fossa
- e/ coils of ileum extend into pelvis

Small intestine:

- a/ wall of jejunum is thin and light than in ileum
- b/ the coils of the jejunum protrude upwards into the lesser sac (behind the stomach)
- c/ jejunum is located in front of the inferior vena cava
- d/ duodenojejunal flexure is situated in front of the body of pancreas
- e/ duodenojejunal flexure is located on the left side of the abdominal aorta

Compare the features about the jejunum and ileum:

- a/ diameter of the jejunum is narrower than diameter of the ileum
- b/ jejunum is longer than the ileum
- c/ the wall of the jejunum is less vascular than the ileal wall
- d/ the wall of the jejunum is thicker than the ileal wall
- e/ the circular mucosal folds in the jejunum are less frequent and smaller than in the ileum

Colon:

- a/ upper portion of the greater omentum is attached to the transverse colon
- b/ ileocecal orifice is projected onto the anterior abdominal wall in Mcburney's point
- c/ all parts of the colon are retroperitoneal in position
- d/ right colic flexure is situated on the medial side of the duodenum
- e/ left colic flexure is related to the tail of the pancreas

Sigmoid colon:

- a/ it enters the lesser pelvis
- b/ posterior cutaneous femoral nerve runs behind the sigmoid colon
- c/ its wall contains the bands of longitudinal muscles which are called taeniae coli
- d/ it is intraperitoneal in position
- e/ the rectosigmoid junction is situated in front of the SIII

Vermiform appendix:

- a/ it is also called the abdominal tonsil
- b/ its base (beginning) in the caecum is located at the point where all taeniae coli meet
- c/ its blind end is projected onto the anterior abdominal wall at Mcburney's point
- d/ it is suspended from the terminal ileum by the mesoappendix
- e/ in pelvic position, it is closely related to the right ovary

Rectum and anal canal:

- a/ lateral flexures of the rectum are formed by the internal transverse folds
- b/ rectum is separated from the prostate by the rectovesical septum
- c/ anal canal passes through the pelvic diaphragm
- d/ anal columns are united inferiorly by the anal valves
- e/ superior to each anal valve is the anal sinus

Rectum and anal canal:

- a/ rectum begins at the level of first sacral vertebra
- b/ internal rectal venous plexus is situated beneath the mucosa of the rectal ampulla
- c/ rectal ampulla and anal canal are separated by the anal valves
- d/ internal anal sphincter is involuntary muscle
- e/ external anal sphincter is derived from the pelvic diaphragm

Rectum and anal canal:

- a/ anal canal passes through the pelvic diaphragm
- b/ dilated part of the rectum is called ampulla
- c/ in female, the rectum is closely related to the urinary bladder
- d/ in male, the rectum is closely related to the prostate
- e/ anus is encircled by the internal anal sphincter

Which organ is situated in front of the rectum in male:

- a/ prostate
- b/ urinary bladder
- c/ seminal vesicles
- d/ deferent duct
- e/ cecum

Which of the following structures is found in the anal canal?

- a/ internal rectal venous plexus
- b/ muscular circular rings
- c/ transverse folds
- d/ taeniae coli
- e/ pectinate line (dentate line)

Open questions with short answer

- **Name the parts of the duodenum:**
- **Name the part of the duodenum to which the bile duct is opened:**
- **Name the part of the duodenum to which the pancreatic duct is opened:**

- **Name the structure which is opened into the descending part of the duodenum?
(Write exactly).**
- **Name the opening between small and large intestine:**
- **Write the position of the small intestine to the peritoneum:**
- **Write the relation of the vermiform appendix in pelvic position:**
- **What is projected onto anterior abdominal wall at Mcburney's point?**
- **Name the longitudinal muscle layer of the large intestine which forms distinct muscle bands:**
- **What are the omental appendices (appendices epiploicae)? Briefly describe:**
- **On which parts of the large intestine can haustration be seen?**
- **Name the nerves of the lumbar plexus that run behind the ascending colon:**
- **Which sphincter(s) of the alimentary system is (are) involuntary?**
- **Which part of the colon is intraperitoneal?**
- **Which part of the colon is retroperitoneal?**
- **Name the flexure of the colon which is located higher, backward and is more acute than other one. Write both names of the flexure:**
- **Which external characteristics distinguish the large intestine from the small intestine? Write at least 2:**
- **Name the parts of the rectum:**
- **Name the flexures of the rectum in sagittal plane:**
- **Write ventral relations of the rectum in female:**
- **Write ventral relations of the rectum in male:**
- **Name the muscular ring (sphincter) of the anal canal which is derived from the pelvic diaphragm:**
- **Describe the structures that are typical of the mucosa of the anal canal:**

12.4 Liver, biliary system and pancreas

Multiple choice questions

Which of following impressions are situated at the visceral surface of the right lobe of the liver:

- a/ duodenal impression
- b/ gastric impression
- c/ renal impression
- d/ splenic impression
- e/ oesophageal impression

Mark the organs which are related to visceral surface of the liver:

- a/ right lobe of the liver is related to the duodenum
- b/ right lobe of the liver is related to the right colic flexure
- c/ right lobe of the liver is related to the right kidney
- d/ left lobe of the liver is related to the left kidney
- e/ left lobe of the liver is related to the oesophagus

Liver:

- a/ bile duct leaves the liver through the porta hepatis
- e/ hepatic veins leave the liver through the porta hepatis
- b/ it is firmly attached to diaphragm by bare area
- c/ visceral surface of the left lobe of liver is related to left kidney
- d/ quadrate lobe is bounded on the left by the fissure for ligamentum teres
- e/ caudate lobe is bounded on the right by the groove for the vena cava

Which ligament(s) of the liver is/are remnant of foetal circulation?

- a/ round ligament of the liver
- b/ triangular ligaments
- c/ ligamentum venosum
- d/ coronary ligament
- e/ hepatorenal ligament

Gallbladder:

- a/ it is intraperitoneal in position
- b/ it is closely related to the right kidney
- c/ its blind part is called fornix
- d/ its duct connects to the common hepatic duct and forms the bile duct
- e/ gall bladder is projected onto anterior abdominal wall at the point where right midclavicular line crosses costal arch on the right side

Excretory apparatus of the liver and the gallbladder:

- a/ common hepatic duct forms the beginning of the excretory apparatus of the liver
- b/ bile duct runs behind the body of the pancreas
- c/ bile duct runs behind the superior part of the duodenum
- d/ bile duct is runs within the hepatoduodenal ligament
- e/ the end of the bile duct is surrounded by a circular muscular ring (sphincter)

Pancreas:

- a/ it is projected to anterior abdominal wall into the epigastrium and left hypochondriac region
- b/ it is situated above the duodenojejunal flexure
- c/ it is situated in front of the superior mesenteric vessels
- d/ it is situated in front of the right kidney
- e/ it is intraperitoneal in position

Pancreas:

- a/ body of pancreas is situated above duodenojejunal flexure
- b/ anterior surface the head of the pancreas is crossed by the root of the transverse mesocolon
- c/ the head of the pancreas is situated in front of the portal vein
- d/ it is closely related to liver
- e/ main pancreatic duct empties into the descending part of duodenum

Pancreas:

- a/ it is projected to anterior abdominal wall into umbilical region
- b/ splenic artery runs behind the pancreas
- c/ splenic vein runs behind the pancreas
- d/ it is situated in front of the abdominal aorta
- e/ it is situated behind the lesser sac

Pancreas:

- a/ it extends from L1 to L3
- b/ it is situated behind the stomach
- c/ the tail of the pancreas attaches the spleen
- d/ it is situated above the duodenojejunal flexure
- e/ it is retroperitoneal in position

Which structure / organ is situated in front of the pancreas:

- a/ mesocolon transversum
- b/ inferior vena cava
- c/ jejunum
- d/ liver
- e/ stomach

Which blood vessel is located behind the pancreas:

- a/ splenic vein
- b/ splenic artery
- c/ inferior vena cava
- d/ portal vein
- e/ abdominal aorta

Open questions with short answer

- **Which ligament of the liver borders the bare area?**
- **Name the part of the lesser omentum which contains the portal vein:**
- **Write structures which run within hepatoduodenal ligament and write precisely their arrangement (position) in this ligament:**
- **Where does the excretory apparatus of the liver begin?(write exactly):**
- **Name the area of the liver which is border by the coronary ligaments:**
- **Name the surface of the liver by which it is attached directly to the diaphragm:**
- **Which structures enter and exit the liver in porta hepatis?**
- **What separates the caudate and quadrate lobes from the right lobe of the liver on the visceral surface?**
- **What separates the caudate and quadrate lobes from the left lobe of the liver on the visceral surface?**
- **Name the lobes of the liver which are separated by the fossa of the gallbladder:**
- **Which organs are closely related to the visceral surface of the right lobe of the liver?**
- **Which organs are closely related to the visceral surface of the left lobe of the liver?**
- **Name the ligaments of the liver which are remnants of the foetal circulation:**
- **Which organs are closely related to the bile duct:**

- Write the name of rounded end of the gallbladder:
- Write the parts of the gallbladder and duct which arises from it:
- Name the parts of the pancreas:
- Write the projection of the pancreas to the vertebral column: You can use abbreviations for example: TXII
- Write the position of the pancreas to the peritoneum:

12.5 Peritoneum

MULTIPLE CHOICE QUESTIONS

Which organ is intraperitoneal in position?

- a/ ureters
- b/ uterus
- c/ urinary bladder
- d/ spleen
- e/ suprarenal glands

Which organ / structure is retroperitoneal in position?

- a/ stomach
- b/ abdominal aorta
- c/ pancreas
- d/ kidney
- e/ liver

Peritoneal cavity:

- a/ rectoprostatic pouch is the lowermost part of peritoneal cavity in male
- b/ rectouterine pouch is the lowermost part of the peritoneal cavity in female
- c/ spleen is retroperitoneal in position
- d/ uterus is intraperitoneal in position
- e/ liver is intraperitoneal in position

Peritoneal cavity:

- a/ empty urinary bladder is only one preperitoneal organ
- b/ lateral umbilical folds are elevated by the inferior mesenteric vessels
- c/ lesser sac communicates with the greater sac through the epiploic foramen
- d/ in both men and women, the peritoneal cavity is an enclosed space
- e/ it is separated by the attachment of the root of the mesentery into the supramesocolic part and inframesocolic part

The most inferior portion of the peritoneal cavity in the female is:

- a/ pararectal fossa
- b/ paravesical fossa
- c/ rectouterine pouch
- d/ rectovesical pouch
- e/ vesicouterine pouch

Mark the structur / organ that form anterior border of the lesser sac:

- a/ liver
- b/ greater omentum
- c/ spleen
- d/ stomach
- e/ transverse colon

Lesser sac (omental bursa) and epiploic (epiploic) foramen:

- a/ lesser sac separates the stomach from the pancreas
- b/ at the left, the lesser sac is bounded by the spleen
- c/ lesser sac communicates with the greater sac through the omental (epiploic) foramen
- d/ hepatoduodenal ligament forms anterior border of the omental (epiploic) foramen
- e/ duodenum forms inferior border of the omental (epiploic) foramen

Greater omentum:

- a/ it forms anterior wall of the lesser sac (omental bursa)
- b/ separates coils of the jejunum from the anterior abdominal wall
- c/ it is also called a policeman of the abdomen
- d/ contains vessels which blood supply the transverse colon
- e/ its upper part is called the gastrocolic ligament

Mesentery:

- a/ it forms inferior border of the lesser sac (omental bursa)
- b/ root of mesentery crosses the pancreas
- c/ root of mesentery crosses the left ureter
- d/ root of mesentery crosses the inferior vena cava
- e/ it contains arteries, veins, nerves and lymphatics that supply the jejunum and ileum

Mesentery:

- a/ its superior attachment is projected at the duodenojejunal flexure to the right of 2nd lumbar vertebra
- b/ root of the mesentery crosses common iliac vessels
- c/ root of the mesentery crosses the right ureter
- d/ root of the mesentery crosses the abdominal aorta
- e/ it ends in the right iliac fossa

Open questions with short answer

- Name the lowermost part of the peritoneal cavity in male:
- Name the lowermost part of the peritoneal cavity in female:
- Name the attachment of double-layered fold of the peritoneum that connects the jejunum to the posterior abdominal wall:
- Name part of the peritoneal cavity which separates the stomach from the pancreas:
- Name double-layered fold of the peritoneum associated with the jejunum and ileum:
- Name two-layered peritoneal fold which is associated with the stomach:
- Which organs are crossed by the root of the transverse mesocolon?
- Which structures are crossed by the root of the sigmoid mesocolon
- Name the upper portion of the greater omentum:
- Name the opening between the greater sac and the lesser sac:

12.6 Blood supply, venous and lymphatic drainage, and nerve supply of the organs of the alimentary system

Multiple choice questions

Oral cavity:

- a/ soft and hard palate are supplied by the branches of the maxillary artery
- b/ upper lip is supplied by the branches of the maxillary artery
- c/ mylohyoid muscle of the floor of the oral cavity is supplied by the facial nerve
- d/ lower lip is nerve supplied by the sensory fibers of the mandibular nerve
- e/ the main muscle of the lips is nerve supplied by the motor fibers of the mandibular nerve

Mark artery (*arteries*) which give (*s*) branch (*es*) for blood supply of palate:

- a/ ascending pharyngeal artery
- b/ lingual artery
- c/ maxillary artery
- d/ posterior auricular artery
- e/ facial artery

Blood and nerve supply of the tongue:

- a/ lingual glands on the anterior 2/3 of the tongue are supplied by the parasympathetic fibers of the facial nerve
- b/ all intrinsic muscles are nerve supplied by the hypoglossal nerve
- c/ loss of the general sensation over the posterior 1/3 of the tongue indicates damage to the trigeminal nerve
- d/ tongue is blood supplied mainly by the branches arising from the facial artery
- e/ blood from the tongue is mainly drained into the internal jugular vein

Tongue:

- a/ tongue is blood supplied mainly by the branches arising from the lingual artery
- b/ mucosa of the inferior surface of the tongue is supplied by the hypoglossal nerve
- c/ lingual glands on the root of the tongue are supplied by parasympathetic fibers of the facial nerve
- d/ mucosa of the body of the tongue is supplied by the sensory fibers of the mandibular nerve
- e/ all lymph from the tongue is ultimately drained into the deep cervical lymph nodes

Tongue:

- a/ extrinsic muscles of the tongue are nerve supplied by both hypoglossal and glossopharyngeal nerves
- b/ intrinsic muscles of the tongue are nerve supplied by the glossopharyngeal nerve
- c/ special sensory innervation (taste) from the anterior 2/3 of the tongue is carried by the facial nerve
- d/ special sensory innervation (taste) from the posterior 1/3 of the tongue is carried by the glossopharyngeal nerve
- e/ loss of general sensation over the anterior 2/3 of the tongue indicates damage to the trigeminal nerve

Parotid gland:

- a/ it is closely related to the facial nerve
- b/ facial nerve provides the parasympathetic innervation of the parotid gland
- c/ trigeminal nerve provides the sensory innervation of the parotid gland
- d/ venous blood is mainly drained into the facial vein
- e/ it is supplied with blood from the various arteries that arise from the external carotid artery

Major salivary glands:

- a/ submandibular gland is supplied by the parasympathetic fibers of the facial nerve
- b/ sublingual gland is supplied by the parasympathetic fibers of the facial nerve
- c/ submandibular gland is supplied by the sensory fibers of the trigeminal nerve
- c/ parotid gland is supplied by the sensory branches of the facial nerve
- d/ parotid gland is supplied by parasympathetic fibres of the glossopharyngeal nerve

Pharynx:

- a/ branches of the internal carotid artery supply the nasal part of the pharynx
- b/ pharyngeal constrictors are inserted to the pharyngeal raphe
- c/ pharyngeal veins are drained into internal jugular vein
- d/ pharyngeal constrictors are supplied by vagus nerve
- e/ mucosal pharyngeal glands are supplied by parasympathetic fibers of glossopharyngeal nerve

Esophagus:

- a/ mucosal oesophageal glands are supplied by the parasympathetic fibers of the vagus nerve
- b/ striated muscles of its cervical part are supplied by motor fibers of the glossopharyngeal nerve
- c/ venous blood of the cervical part of the esophagus is drained into the superior thyroid veins
- d/ venous blood of the thoracic part of the esophagus is drained into azygos vein
- e/ in pathological condition with elevated portal vein pressure, the esophageal veins become important portocaval anastomosis between the portal vein and inferior vena cava

A patient was diagnosed with bleeding ulcer of the lesser curvature of the stomach.

Which artery is most likely involved?

- a/ gastroduodenal
- b/ left gastric
- c/ left gastro-omental (epiploic)
- d/ right gastro-omental (epiploic)
- e/ short gastrics

Stomach:

- a/ perforated gastric ulcer on its posterior wall may result in erosion (damage) of splenic vein
- b/ in pathological condition with elevated portal vein pressure, the gastroomental veins become important portocaval anastomosis between portal vein and inferior vena cava
- c/ pylorus of stomach is blood supplies by left gastric artery and left gastroomental artery
- d/ mucosal gastric glands are supplied by parasympathetic fibres of vagus nerve
- e/ venous blood from greater curvature of stomach is drained into splenic vein

The fundus of the stomach receives its arterial supply from the:

- a/ common hepatic
- b/ inferior phrenic
- c/ left gastroepiploic
- d/ right gastric
- e/ splenic

Which of the following organ of the alimentary system drains venous blood directly into the inferior vena cava:

- a/ sigmoid colon
- b/ liver
- c/ abdominal part of the esophagus
- d/ duodenum
- e/ gallbladder

Which organ(s) is(are) supplied by arteries and their branches that run(s) within lesser omentum:

- a/ stomach
- b/ oesophagus
- c/ pancreas
- d/ duodenum
- e/ liver

Rectum:

- a/ external anal sphincter muscle is nerve supplied by the pelvic splanchnic nerves
- b/ superior rectal veins are drained via the other veins into the portal venous system
- c/ middle rectal veins are drained via the other veins into the caval venous system
- d/ lymph from the rectal ampulla is also drained into the inferior mesenteric lymph nodes
- e/ lymph from the lower part of the anal canal is also drained into the superficial inguinal lymph nodes

Peritoneum:

- a/ peritoneal cavity is subdivided into the supramesocolic and inframesocolic part by the attachment of the root of the transverse colon
- b/ organs located in the supramesocolic part of the peritoneal cavity are supplied by the branches of the superior mesenteric artery
- d/ all retroperitoneal organs in the inframesocolic part of the abdominal cavity are supplied by the branches of the inferior mesenteric artery
- c/ visceral peritoneum is highly sensitive to pain, temperature, touch and pressure
- e/ sigmoid mesocolon contains arteries that supply the upper portion of the rectum

Open questions with short answer

- Which nerve provides motor innervation to the mylohyoid muscle?
- Which nerve provides motor innervation to the orbicularis oris muscle?
- Which nerves provide motor innervation to the muscles that make up the floor of the mouth?
- Which branch of the trigeminal nerve carries sensory information from the upper lip?
- Which branch of the trigeminal nerve carries sensory information from the lower lip?
- Where is drained blood from the lateral wall and roof of the oral cavity?
- Which branch of the trigeminal nerve carries the pain from the tooth number 22?
- Which nerve is responsible for taste sensation from the body of the tongue?
- Which nerve is responsible for taste sensation from the root of the tongue?
- Which nerve is responsible for general sensation from the body of the tongue?
- Which nerve is responsible for general sensation from the root of the tongue?
- Which nerve(s) innervate(s) mucosa and mucosal glands of palate?
- Which nerve carries postganglionic parasympathetic fibers to the parotid / submandibular / sublingual gland?
- Name the cranial nerve that provides the general sensory nerve supply to the parotid / submandibular / sublingual gland:
- Into which veins do pharyngeal veins open?
- Which organs are supplied by the celiac trunk and its branches?
- Which organs are supplied by the superior mesenteric artery and its branches?
- Which organs are supplied by the inferior mesenteric artery and its branches?

- **Name artery (arteries) which supplies (supply) the fundus of the stomach:**
- **Name artery (arteries) which supplies (supply) the greater curvature / lesser curvature of the stomach:**
- **Which branch(es) of the abdominal aorta supplies (supply) the duodenum?**
- **Which branch(es) of the abdominal aorta supplies (supply) the small intestine?**
- **Which branch(es) of the abdominal aorta supplies (supply) the cecum and colon:**
- **Into which veins do esophageal veins directly open?**
- **Into which veins do rectal veins directly open?**
- **Which veins drain the venous blood from the liver?**

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