Dentistry - Practical classes 8: Placenta, Urinary System

EARLY PLACENTA

The **placenta** is a temporary organ that in the course of pregnancy allows to exchange substances between the maternal and foetal blood to support development of the foetus. In structure of the placenta both foetal and maternal tissues participate (foetomaternal organ). **Foetal part** consists of the chorionic plate (membrana chorii) and chorionic villi (a part of the frondosum). **Maternal part** is formed by the decidua basalis (blue): functional zone of the pregnant endometrium forms a bottom of the intervillous space (I). Edges of the placenta are continuous with the foetal membranes (amniochorion). The **intervillous space** can be found between the foetal and maternal parts and it is filled in with the maternal blood. Principal **chorionic villi** that are anchored to the basal plate are called the **anchoring** villi; these villi not reaching the basal plate are called the **free** villi. Chorionic villi ramify extensively; their ramification and numbers are related to a foetus growth. An area of the placenta including a large anchoring villus and surrounding free villi is referred to as the **kotyledon**; kotyledons are separated incompletely by the **placental septa** arising from the decidua basalis.

The **basal plate** consists of decidual cells (derived from decidual transformation of endometrial fibroblasts). **Decidual cells** are oval to polygonal, their cytoplasm is light (due to a large amount of glycogen) or pink; their nucleus is oval and contains a well apparent nucleolus. The blood from the spiral arteries comes in contact with the chorionic villi. The myometrium is situated under the endometrium. Hyaline degeneration of cells gives rise to the **fibrinoid** that covers the structures in the intervillous space. With time a fibrin can be deposited on the fibrinoid. In full term placenta the fibrinoid can also covers large areas of the villi.

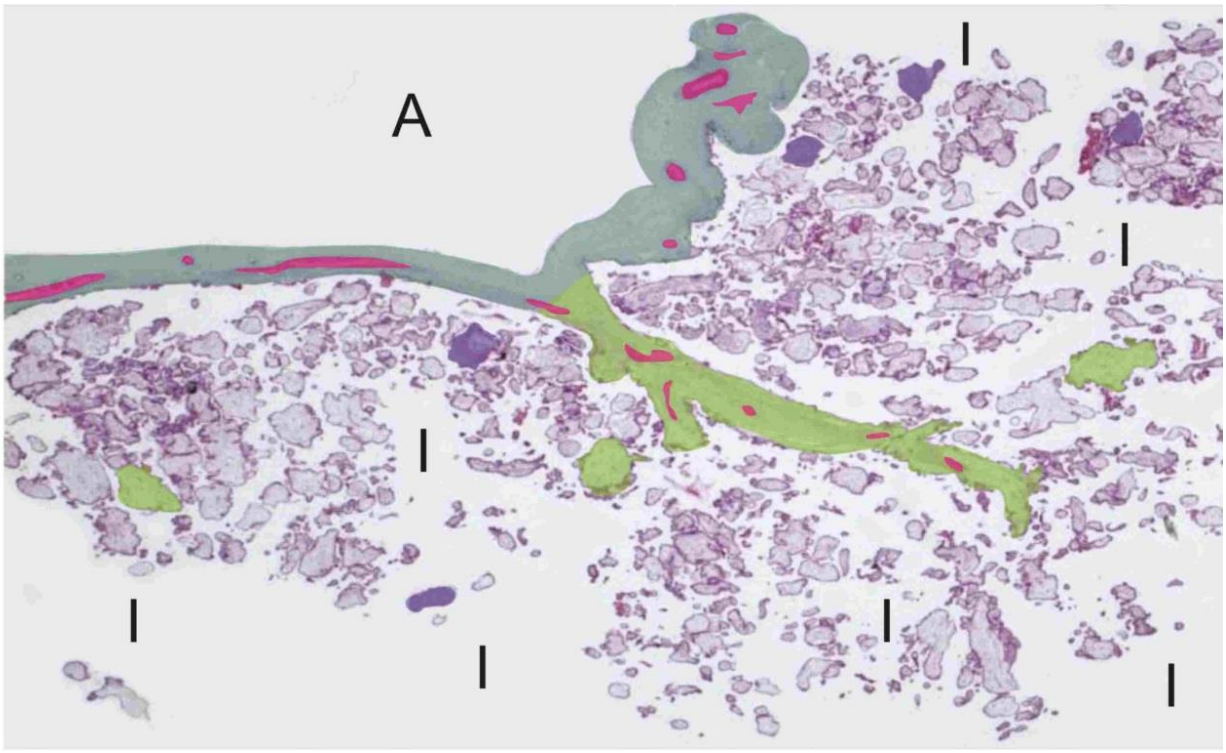
An outer and smooth surface of the **chorionic plate** is lined by a layer of low cuboidal **amniotic cells**. The umbilical cord is also attached to the plate from this aspect. Two umbilical arteries and one vein branch in the chorionic plate into **chorionic vessels** that supply chorionic villi with the blood. The chorionic plate contains the **mesenchymal connective tissue** that also enters the chorionic villi. The inner surface facing the

intervillous space is covered with the trophoblast; an outer layer contains the **syncytiotrophoblast** under which lies a layer of pale **cytotrophoblast** cells.

The most important functional structure of the placenta is the **chorionic villus**. Differential diagnosis of the early and full-term placenta is based on microscopic structure of the chorionic villus. In the early placenta the terminal villi are relatively large and are covered by two layers of the trophoblast. An inner layer, the **cytotrophoblast** is formed by pale cells whose numbers decline after month 5. The cytotrophoblast lies on the basal lamina that separates it from the underlying mesenchyme. An outer layer is formed by the **syncytiotrophoblast**; it is a typical syncytium, i.e. their cytoplasm contains a large number of nuclei. This trophoblast layer is continuous during the whole pregnancy. By accumulation of cell nuclei the syncytial knots are formed. A surface of the syncytiotrophoblast that is in contact with the maternal blood is increased by many microvilli (brush border). Inside of the villus there is the **mesenchymal connective tissue** and **blood vessels**; the vessels are not abundant and occur in the centre of the villus. In some slides of the early placenta the nucleated red blood cells (erythroblasts); maternal erythrocytes in the intervillous space do not contain the nucleus. The connective tissue contains oval macrophages the so called Hofbauer cells – their number increases with placenta maturation; they likely participate in remodelling chorionic villi.

ORIENTATION IN THE SLIDE

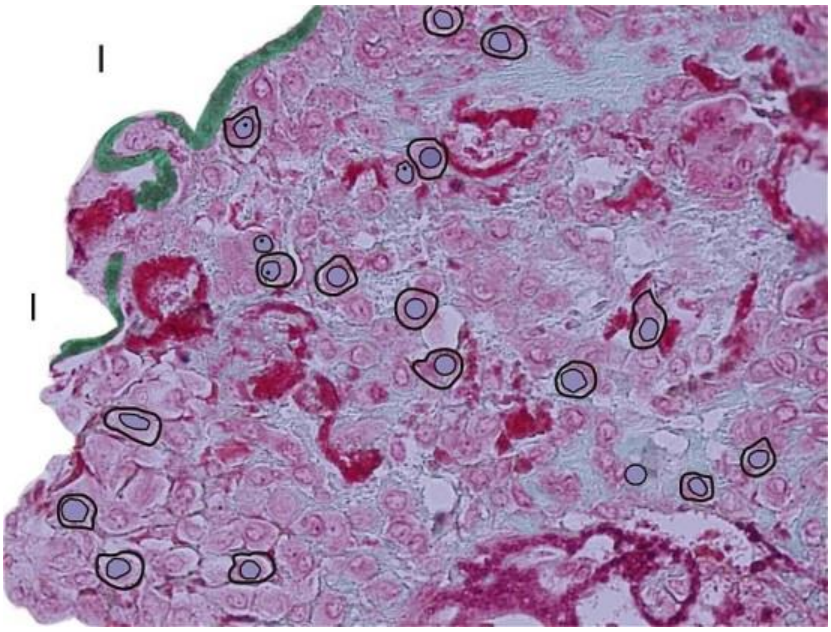
Placenta is a large organ and for that treason the slide often contains only one plate and the **intervillous space** (in an interactive slide indicated by a letter „I“). In the figure the chorionic plate is indicated in dark green; the chorionic villi (some are indicated in light green) emanate from the **chorionic plate**. **Chorionic villi** ramify extensively and enter the space between the chorionic and basal plates (intervillous space - I). Inside of the chorionic plate and inside of the villi the blood vessels (red) pass through and contain the foetal blood. Among the chorionic villi that look pale because of the mesenchymal connective tissue, the rare **placental** (**decidual**) **septa** (purple) can be found. A smooth surface of the chorionic plate that does not contain the villi is facing the amniotic cavity (A).



CHORIONIC PLATE

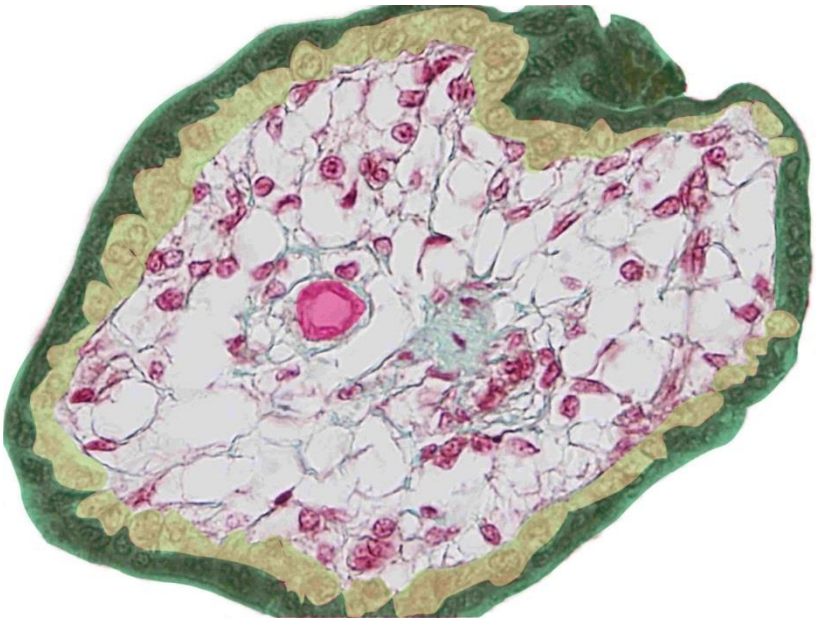
In a longitudinal section the chorionic plate shows both surfaces. An outer one is lined by a simple **amniotic epithelium** (brown) that is flattened to cuboidal – the amniotic cavity (A) is situated above. The core of the **mesenchymal connective tissue** is formed by mesenchymal cells and a rich extracellular matrix; the **chorionic blood vessels** (red) pass through. From an inner surface facing the intervillous space (I) the chorionic villi emanate (Fig. shows the part of the chorionic plate between the villi). This surface is covered by two layers of the trophoblast - the **cytotrophoblast** (light green) and by the **syncytiotrophoblast** (dark green).

Decidual (**placental**) **septa** (purple) emanate from the maternal part of the placenta, enter the intervillous space (I). In their microscopic structure they differ from chorionic villi. Septa contain the **decidual cells**; boundaries between the cells are well apparent (the cell borders of some cells are labelled in black). The pink cytoplasm of decidual cells contains one oval nucleus (grey); in some sections the nucleolus is visible (black). A space left among the decidual cells contains the extracellular matrix that is rich in glycoproteins and collagen (stained in green); rarely the first tiny deposits of fibrinoid can be found in the early placenta (red). An outer surface of placental septs is covered by the **trophoblast**; in the image on left the syncytiotrofoblast can be seen (green).



A detailed view of a transverse section of the **chorionic villus** allows to identify the early placenta. An outer surface of the villus is covered by two layers of the trophoblast. The outer **syncytiotrophoblast** (dark green) is in contact with the maternal blood in the intervillous space; to increase a transport of substances its surface is increased with the brush border. The cytoplasm of the syncytiotrophoblast is dark and contains many aggregated dark cell nuclei - a typical example of the syncytium. In some places the nuclei are accumulated to form syncytial knots (in upper right corner). On the contrary to the syncytiotrophoblast the inner layer, the **cytotrophoblast** (light green), consists of a single cell layer (Langhans cells). The cytoplasm of the cytotrophoblast is light and the cell borders between adjacent cells are well visible; each cell has the nucleus with a pale chromatin. A core of the villus contains a mesenchymal connective tissue; its extracellular matrix is rich in a ground substance; fibres are reduced (collagen inside of the villi is labelled in

green). The connective tissue contains rare **blood vessels** situated in the central part of each villus.



SUMMARY

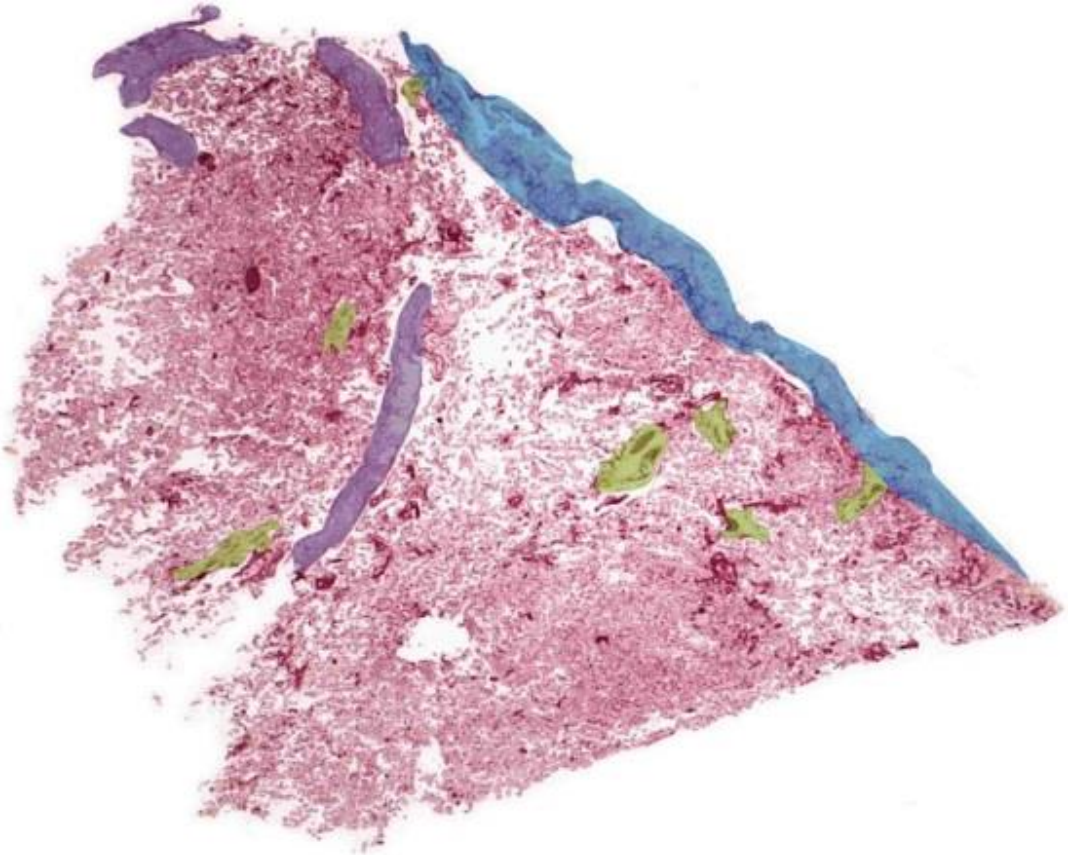
Placenta can be identified from recognition of structures of its maternal and foetal parts (most slides show at least one of these components, the **chorionic plate** or decidua basalis) and of structures of the **intervillous space**. This space is hidden between both plates, contains the maternal blood, chorionic villi and rare decidual septa. **Decidual septa** consist of relatively large polygonal **decidual cells** with a pale cytoplasm. **Chorionic villi** have specific structure. Their placental barrier in the early placenta is formed by the **syncytiotrophoblast**, almost continuous **cytotrophoblast**, **mesenchymal connective tissue** and endothelium of blood vessels (blood vessels are not numerous and occur in the central part of each villus).

FULL-TERM PLACENTA

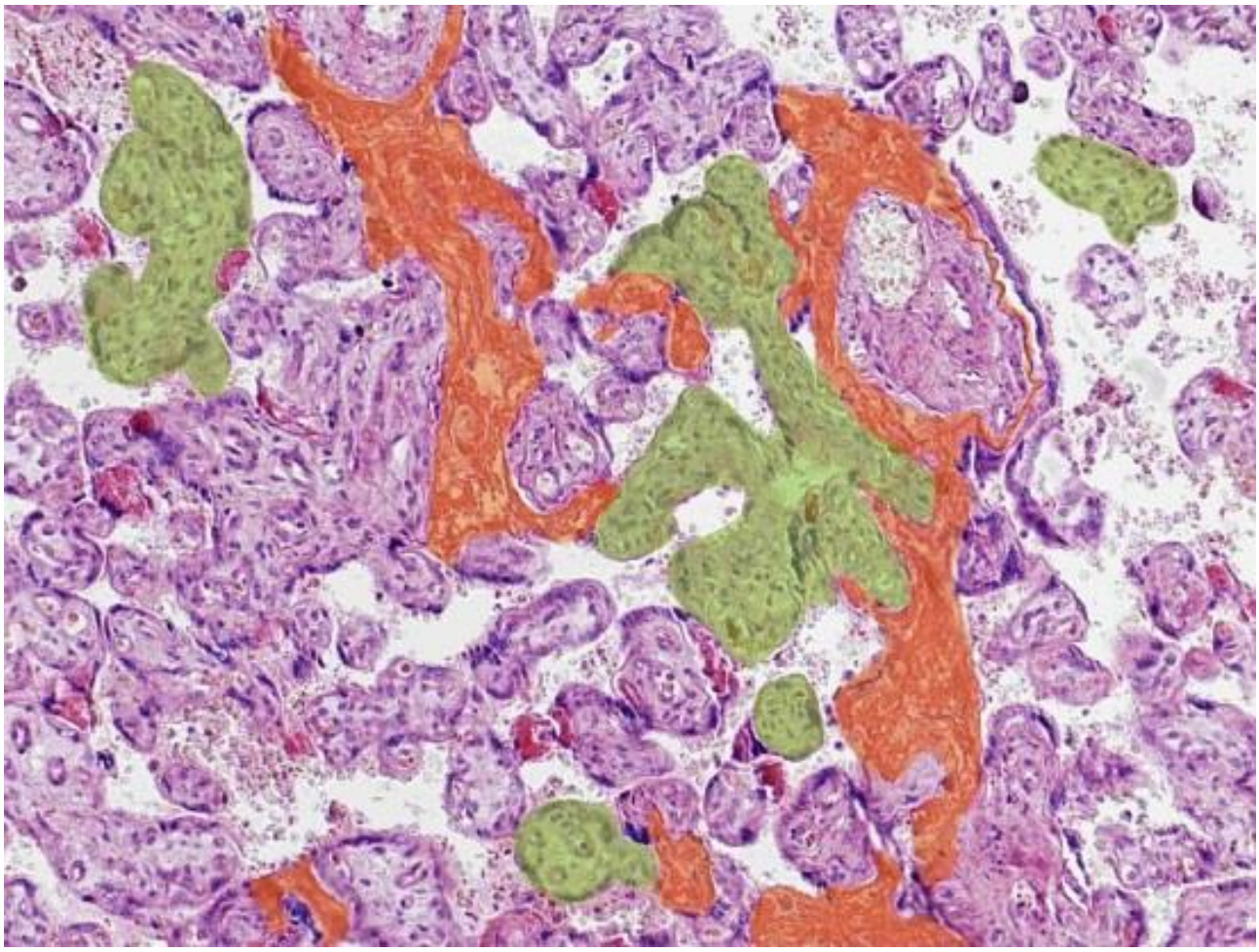
General structure of the **placenta** and is parts was described in a topic „Early placenta“. Full-term placenta differs from the early one by the structure of their **chorionic villi**. **Intervillous space** of the full-term placenta is filled in with a high number of tiny terminal villi. Their surface is covered with a thin but continuous layer of the **syncytiotrophoblast**. Redistribution of cell nuclei of the syncytiotrophoblast gives rise to syncytial knots while the other parts can become very thin. The **cytotrophoblast** is reduced and usually there are only few rare cells left. Under the basal lamina of the trophoblast there is the **mesenchymal connective tissue** the amount of which is reduced.

It contains **Hofbauer cells**. Inside of the villi there are many **blood capillaries** reaching the trophoblast (i.e., they appear at the edges of the villi). Endothelium contacting the syncytiotrophoblast reduces the distance for diffusion and exchange of gases and nutrients between the foetal and maternal blood. Foetomaternal barrier is in some places reduced to syncytiotrophoblast and endothelium. Foetal erythrocytes (inside of the capillaries of chorionic villi) have the same morphology as maternal erythrocytes in the intervillous space. A typical feature of the full-term placenta is presence of **fibrinoid** (fibrin, tissue debris, placental secretion) that covers partially the chorionic villi (but also the chorionic plate and decidua basalis). Fibrinoid hinders a transport of nutrients across the placental barrier.

ORIENTATION IN THE SLIDE



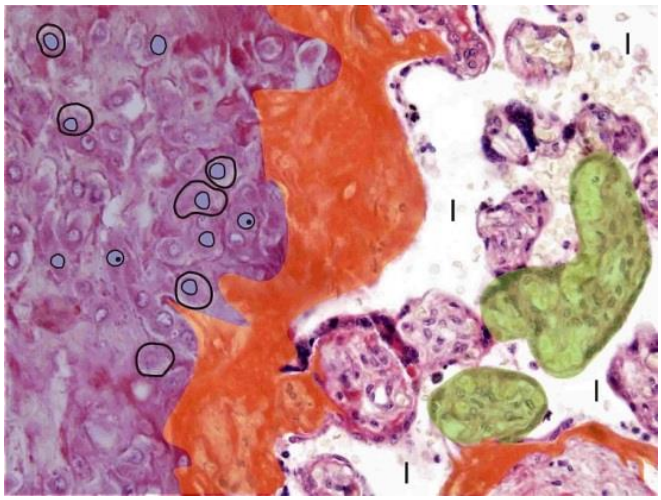
A part of the **placenta** that is visible in the slide includes the **basal plate** (in an interactive slide indicated in blue), which represents the maternal part. An outer part of the basal plate looks straight as it is cut off the myometrium. An inner part is facing the **intervillous space**; it is a site where anchoring villi are inserted. The principal **chorionic villi** are relatively large, and they can be found in longitudinal or transverse



sections. Villi ramify extensively and tiny terminal villi almost completely fill in the intervillous space. Some chorionic villi are labelled in light green colour; two of them are anchored to the basal plate (the so called anchoring villi). The intervillous space also contains the **decidual** (placental) **septa** (purple) emanating from the decidua basalis.

Intervillous space left among chorionic villi is narrow; it contains the maternal blood, which is removed from the slide in the course of tissue fixation - as a result only few red blood cells can be seen here. **Chorionic villi** are labelled in green. A surface of chorionic villi is covered by many deposits of the **fibrinoid** (orange) of different sizes (some are tiny, but others can cover several villi).

Placental or **decidual septum** belongs to the maternal part of the placenta as it is derived from the decidua basalis. Like other structures of the basal plate this septum also contains decidual cells.



Decidual cells are relatively large and of polygonal or oval shape. Some decidual cells are lined by a black colour; oval nuclei are grey, they often contain the nucleolus. A surface of the septum can be also covered by the **fibrinoid** (orange). Next to the septum the **chorionic villi** can be seen (two villi are indicated in green). Cleft-like space left between the villi, the so called **intervillous space** (indicated by letter "I") is filled in with the maternal blood. The foetal blood occurs in the blood capillaries inside of the chorionic villi.

Chorionic villus in the mature placenta can be distinguished from the villus of the early placenta in a transverse section. An outer surface is covered by the continuous **syncytiotrophoblast** (in an interactive slide it is indicated in dark green colour). **Cytotrophoblast** is reduced so that single cells (5 cells are indicated in light green). A connective tissue of the villus contains many blood **capillaries** (red) that reach the edges of the villi - some contact the syncytio-trophoblast. Inside of blood capillaries, foetal blood cells can be seen; the maternal blood occurs in the intervillous space.

SUMMARY

Placenta can be identified from recognition of structures of its maternal and foetal parts (most slides show at least one of these components,

the **chorionic plate** or decidua basalis) and of structures of the **intervillous space**. This space is hidden between both plates, contains the maternal blood, chorionic villi and rare decidual septa. **Decidual septa** consist of relatively large polygonal **decidual cells** with a pale cytoplasm; these cells occur mainly in the decidua basalis. **Chorionic villi** have a specific structure. Their placental barrier in the full-term placenta is formed by the continuous **syncytiotrophoblast**, **mesenchymal connective tissue** and **endothelium** of blood vessels (blood vessels are numerous and touch the edges of villi - in such areas the barrier is reduced to syncytiotrophoblast and endothelium. Cytotrophoblast is discontinuous - only rare (Langhans) cells are left in the villi.

KIDNEY

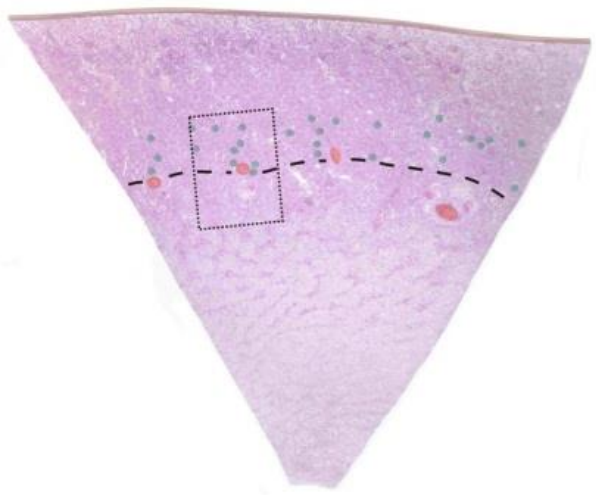
Kidney (its exocrine portion) has a structure of compound tubular gland; main function is to produce the urine. Principal structure is composed of renal tubules. Nephrons (approx. two millions) form the initial part of tubules, which produce the urine. **Nephron** is formed by: Bowman's capsule, proximal tubule, Henle's loop, distal tubule and very short connecting piece. These parts have the same origin; they are derived from metanephrogenic blastema. Other parts of renal tubules, which participate in concentration of the urine include collecting and papillary ducts.

Kidney parenchyma is divided in cortex and medulla. Principal components of the **cortex** include: **Renal corpuscle** (*corpusculum renis Malpighi*) is the most conspicuous structure of the kidney composed of the **glomerulus** (tuft of fenestrated capillaries) invested by a double-layered **Bowman's capsule**. The layers of Bowman's capsule are separated by the urinary Bowman's space, which collects a primary urine that is drained in the proximal tubule. **Proximal tubule** occurs in the cortex in the vicinity to renal corpuscles. It is lined by simple columnar epithelium called **nephrocytes**. Nephrocytes are relatively large. A luminal surface contains a brush border formed by high microvilli of irregular lengths; as a result the lumen is irregular and narrow. **Distal**

tubule is lined by smaller **nephrocytes** with rare short microvilli. For that reason, the lumen is a broad and of a regular shape. A site that comes in contact with a vascular pole of the corresponding renal corpuscle forms the ***macula densa***, which is a component of the **juxtaglomerular apparatus** responsible for a major endocrine function of the kidney (see ELC „Endocrine system“).

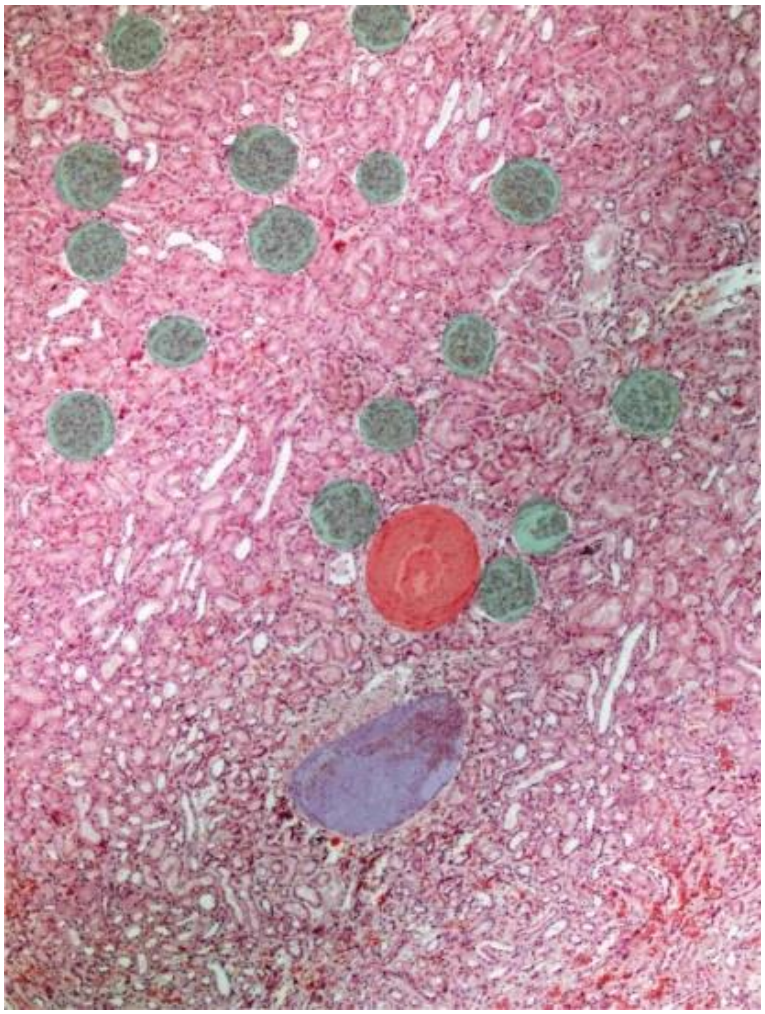
Henle's loop enters the medulla as a descending loop and then turns up as an ascending loop. In a microscope we can distinguish a **thin segment** (15 μm) lined by a simple squamous epithelium and a thick **segment** (30 μm) lined by simple cuboidal epithelium that is continuous with a distal tubule. The other tubules that are derived from the ureteric bud include collecting and papillary ducts. **Collecting duct** is lined by a simple cuboidal to columnar epithelium; the cytoplasm is very pale and boundaries between the cells are well visible and apical cytoplasm bulges into the lumen. Papillary ducts (of ***Bellini***) lined by simple columnar epithelium collect the urine from 5-7 collecting tubules; however, in our sides these structures are not included.

ORIENTATION IN THE SLIDE



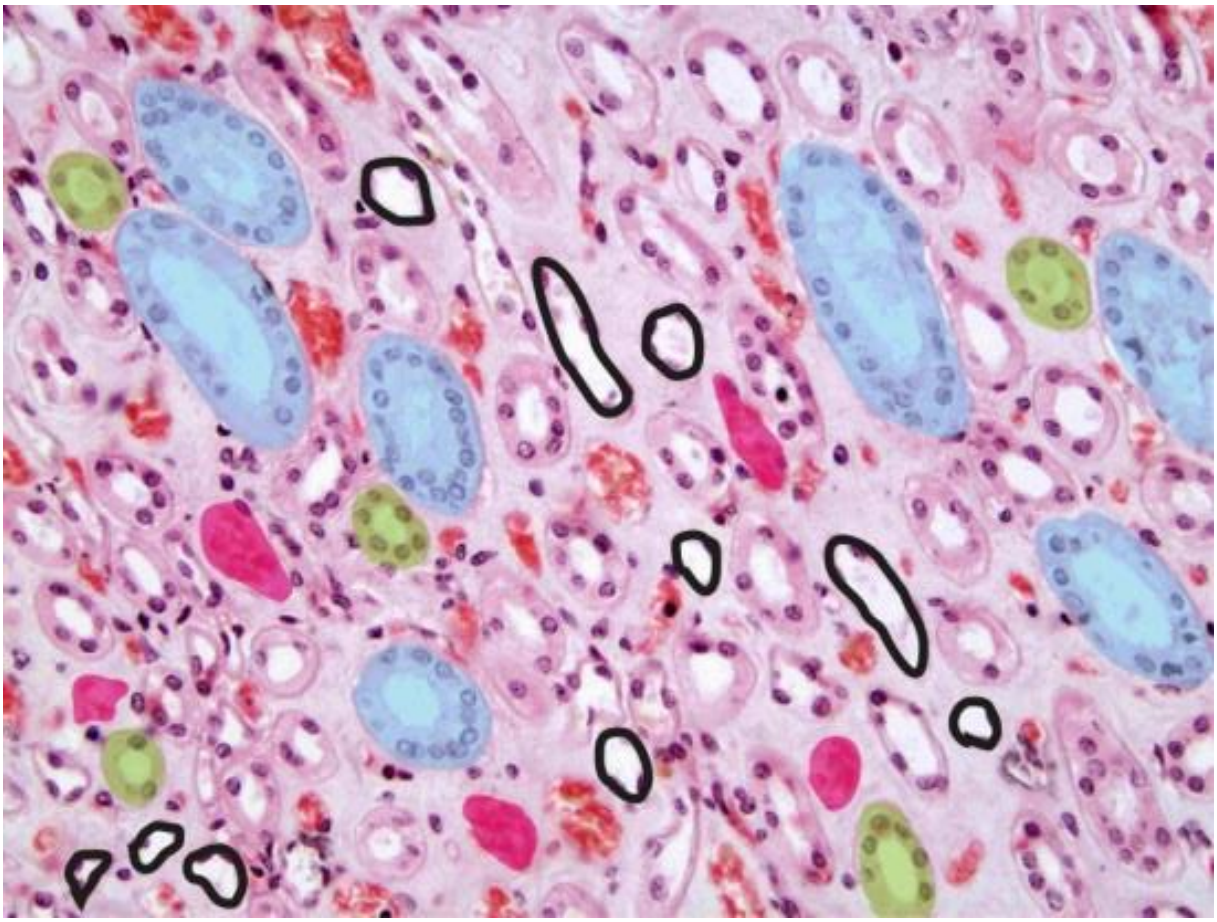
Kidney is a large organ and for that reason a slide contains only a small part of its parenchyma. Outer surface is covered by a **capsule** from a dense connective tissue. Both lateral edges follow to a deep medulla. A superficial part of the parenchyma under the capsule is called the **cortex**. the cortex contains **renal corpuscles** (depicted in green), which are well visible even at the lowest magnification. A boundary between cortex and medulla (dashed line) contains relatively large transverse sections of **arcuate arteries** (red). **Medulla** is a little bit lighter; there are no renal corpuscles, but it contains many renal tubules. A tissue covered by a rectangle at the interface between the cortex and the medulla is shown at higher magnification in the next image.

Parenchyma of the kidney is divided in **cortex** and **medulla**. The most conspicuous structure is **renal corpuscle** (green) that occurs only in the renal cortex. Renal corpuscles are of spherical shape; because of their large size (200 μm) they are well visible at low magnification. Corpuscles in the vicinity to cortico-medullary boundary belong to the so called juxtamedullary nephrons - their glomerulus is of large size. In the renal corpuscle here are two types of tubules: proximal and distal tubules. The amount of interstitial tissue comprises less than 5% parenchyma. At border between cortex and medulla, large blood vessels can be found: arcuate arteries and veins. Arcuate artery (red) belongs to muscular arteries; in Fig. a vein is depicted in blue. The medulla contains many tubules, mainly loops of Henle and collecting ducts. **Renal corpuscle** is the most conspicuous structure of the renal cortex. It is composed of Bowman's capsule and glomerulus. In the **Bowman's capsule**, the **parietal layer** is best visible: it is lined by simple squamous epithelium (indicated in grey line). The visceral layer covers the glomerulus. **Glomerulus** (red) is formed by a tuft of fenestrated capillaries; it contains erythrocytes, endothelial cells, podocytes and intraglomerular mesangial cells. The urinary space (of Bowman; in white) occurs between parietal and visceral layers. An area with a thickest urinary space is called the **urinary pole**; here a squamous epithelium of the parietal layer is continuous with the epithelial lining of the proximal tubule (light blue). An opposite area is called the **vascular pole** - here the urinary



space become narrow and disappears and parietal layer is continuous with a visceral layer. In the vascular pole, the afferent arteriole enters the Bowman capsule and efferent arteriole leaves it. In the vicinity to renal corpuscle, renal parenchyma contains proximal and distal tubules (visible in transverse and longitudinal sections). **Proximal convoluted tubules** (purple) have irregular lumen (in some it is indicated by a black line). Epithelium is formed by voluminous columnar **nephrocytes** – as a result a cross section reveals only few nuclei. **Distal tubules** have a regular lumen (asterisk); nephrocytes are smaller (these tubules contain more cell nuclei) = simple cuboidal epithelium. The cytoplasm is paler than in proximal tubules. In both tubules, cell boundaries are not well visible. The site where a loop of distal tubule comes in a contact with a vascular pole constitutes the ***macula densa*** (green): cell nuclei are densely packed, and the cells assume a columnar shape.

Renal medulla contains tubules of different sizes seen in transverse, oblique or longitudinal sections. Identification of particular tubules is facilitated after classification of a lining epithelium and by comparison of tubules diameters. The smallest lumen has the **loop of Henle**; its **thin segment** is lined with simple squamous epithelium (some thin segments are indicated by a black line).

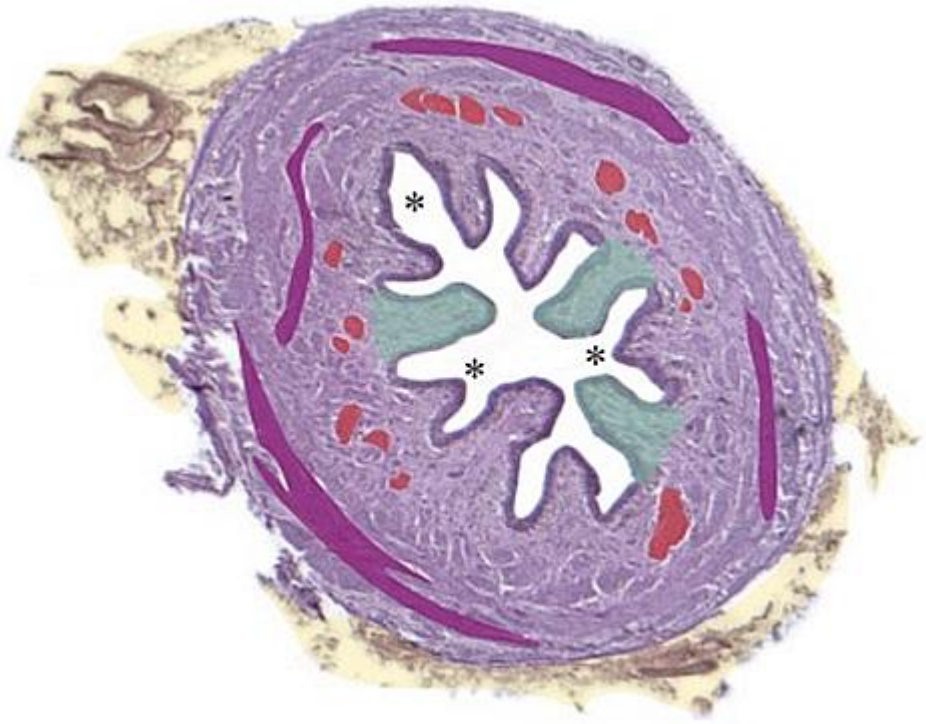


Thick segment of loop of Henle is lined by simple cuboidal epithelium (green); size of lumen and of tubule can be compared to thin segments. Thin segments look similar to thin-walled blood vessels ***vasa recta*** (red) – they can be distinguished according to red blood cells in their lumen. **Collecting ducts** have a larger lumen lined by a simple cuboidal to columnar epithelium (blue). Their epithelial cells are very pale with well visible boundaries; apical cytoplasm is convex (bulges in the lumen).

URETER

Ureter is a tubular organ of urinary passages with length over 25 cm that transports urine form the renal pelvis to the urinary bladder. A wall of the ureter consists of three layers: i) ***Tunica mucosa***, ii) ***Tunica muscularis*** and iii) ***Tunica adventitia***.

The **mucosa** is lined by the **urothelium** (classified as a pseudostratified cuboidal epithelium). This epithelium is also referred as to transitional epithelium. *Lamina propria mucosae* is formed by a loose connective tissue with many elastic fibres, which permits a formation of



longitudinal mucosal folds well visible in a transverse section.

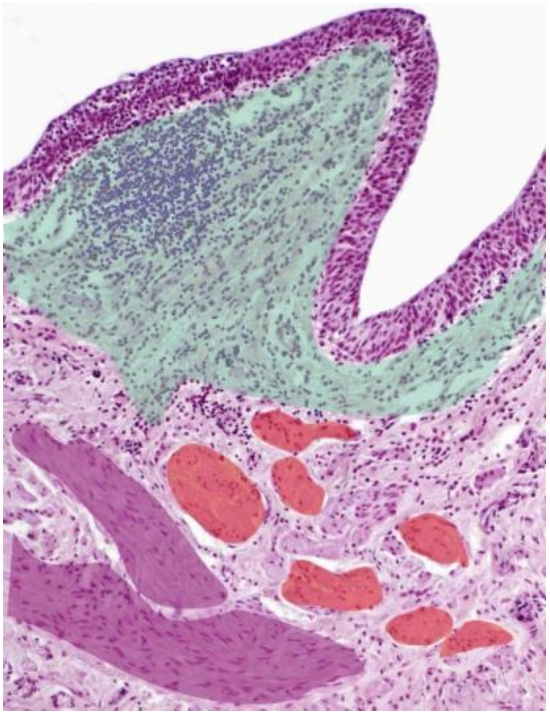
T. muscularis is formed by a smooth muscle. In upper two thirds t. muscularis consists of inner longitudinal and outer circular layers. In the lower third of the ureter, an additional longitudinal outer layer is apposed. Layers of smooth muscle are responsible for peristaltic movement.

An outer layer is formed by **t. adventitia** of loose connective tissue (ureter is located retroperitoneally).

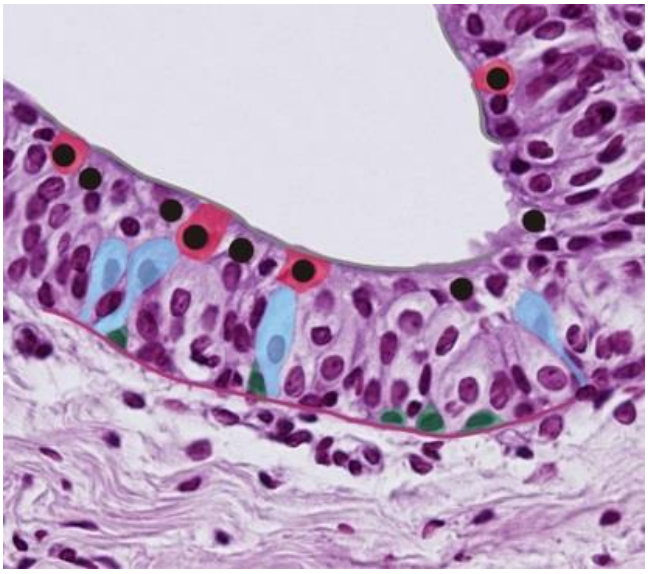
A general structure of the ureter was described on previous page. In a transverse section it appears as a tine tubular organ (thickness of the wall is approx. 1 mm). A wall consists of three layers: i) ***T. mucosa*** is lined with the urothelium; a loose connective tissue in the lamina propria allows formation of longitudinal foldings (three **mucosal folds** are shown in green). Presence of foldings gives rise to a stellate-like lumen (indicated by asterisks). ii) A middle layer is ***t. muscularis*** of smooth muscle. The

upper portion consists of two layers; in a low third the third layer is added). An inner layer is oriented longitudinally (indicated in red); another layer is circular (purple). The third layer is formed by longitudinally running cells. iii) The outermost layer, ***t. adventitia*** (yellow), contains a loose connective tissue with blood vessels, nerves and adipocytes.

Ureter wall



Longitudinal **mucosal folds** of the ureter are lined by the **urothelium**. A core of the folds is formed by a loose connective tissue constituting the ***lamina propria mucosae*** (in green). A mucosal connective tissue is locally infiltrated by lymphocytes (purple) that can form rare lymphatic nodules. Under the mucosa there is the ***tunica muscularis*** consisting of the smooth muscle. An inner layer is oriented longitudinally; in a transverse section, the bundles of this layer are oval (red) – only he largest spherical diameters of myocytes reveal the nucleus. In a next layer, the smooth muscle is arranged circularly; in a transverse section, spindle-shapes myocytes can be seen containing elongated rod-like nucleus in the central part.



The covering epithelium lining the ureteral mucosa (urothelium or **pseudostratified cuboidal epithelium**) has a characteristic appearance. The epithelium is relatively thick and consists of several rows of cells. The basal cells are most often triangular (shown in green) and are attached to the basal lamina (its course is shown in purple). Other cells are longer, and their nuclei are located higher up. Most typical are the tennis racket-

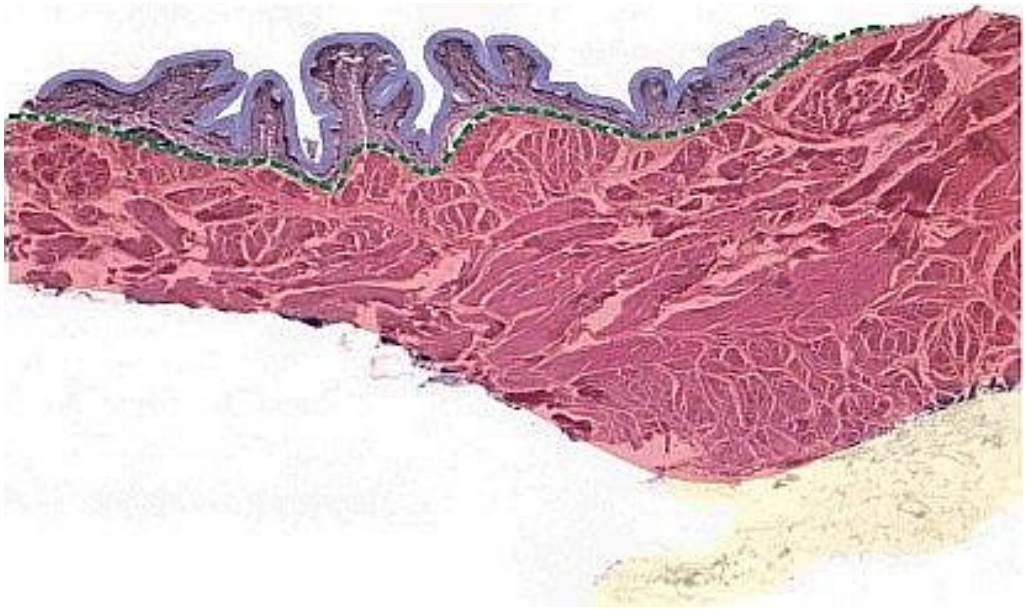
shaped cells (blue), which do not reach the surface with their apical pole. The most differentiated cells line the surface (red); these cells are roughly cuboidal in shape and therefore have a round nucleus. Some surface cell nuclei are shown in black. The apical membrane of the surface cells of the urothelium is thickened to resist the action of urine. The apical cytoplasm contains discoid vesicles; these structures are visible in light microscopy as the crusta, which is visible as a dark line, the course of which is shown as a grey line.

URINARY BLADDER

A wall of the urinary bladder consists of i) ***Tunica mucosa***, ii) ***Tunica muscularis*** and iii) ***Tunica adventitia / serosa***. The **mucosa** is lined with the **urothelium** (classified as a pseudostratified cuboidal epithelium). This epithelium is also called as the transitory epithelium because its structure changes according to its content: an empty bladder has 6-8 cell rows while a full one has only 2-3 cell rows. The *lamina propria mucosae* under the basal lamina is formed by a loose connective tissue and permits to form mucosal folds. A smooth mucosa in the *trigonum vesicae* facilitates removal of urine into the urethra. The **t. muscularis** consists of a smooth muscle, which is arranged in three layers: an inner layer is plexiform, middle circular (the thickest part constitutes the *musculus sphincter vesicae*) and outer is longitudinal. A musculature of all three layers functions as the *musculus detrusor*, i.e. it is important in emptying the bladder. From outside the bladder is covered mostly by **t. adventitia** of a loose connective tissue; a posterior aspect is covered by the **serosa**.

ORIENTATION IN THE SLIDE

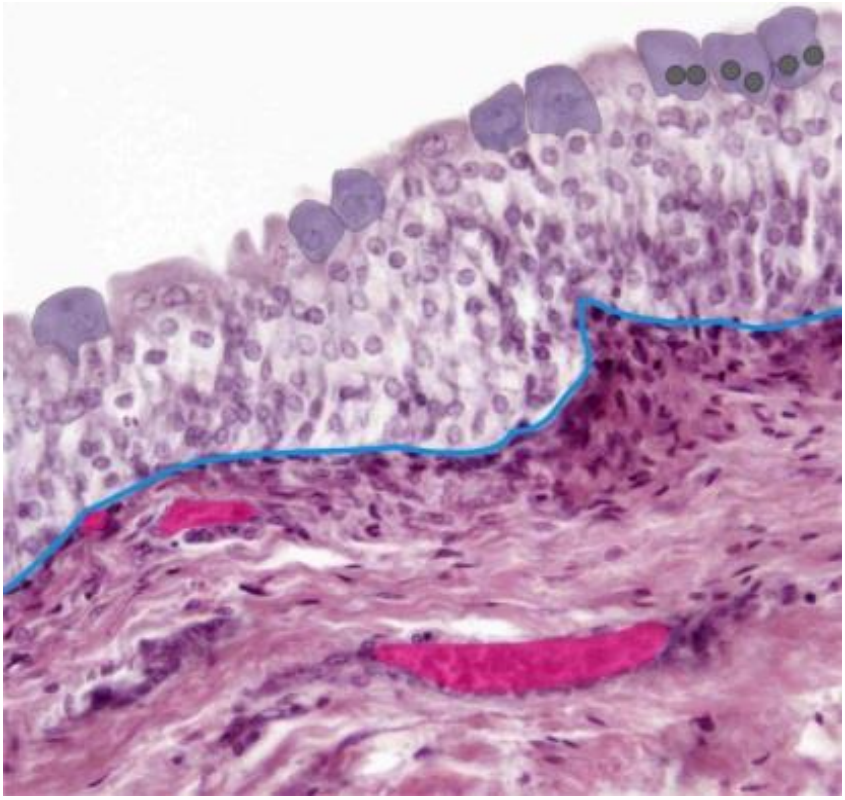
Preparation shows a part of the urinary bladder wall. The thickest is a muscle layer (**t. muscularis** composed of three layers of smooth muscle arranged as a plexiform, circular and longitudinal layers; in an interactive slide it is indicated in red). In some slides a tissue in this layer is cut so that the outer **t. adventitia** is not shown (this layer is indicated in yellow). *T. adventitia* is formed by a loose connective tissue with adipocytes, blood vessels and nerves. *T. serosa* covers only upper



posterior aspect of the bladder (not seen in our slides). The most important layer for a slide identification is the **t. mucosa**.

Its short part can be seen in some slides (light purple). The mucosa is folded; inside of foldings there is a loose connective tissue which is a part of *lamina propria mucosae*. A border between t, mucosa and *t. muscularis* is labelled in a dashed green line.

Urothelium



A lining layer of the urinary bladder is formed by the urothelium also known as a transitory epithelium (because of its ability to change its thickness depending on a content of the bladder). This covering epithelium is classified as a pseudostratified cuboidal epithelium. Superficial cell are very large; their

cytoplasm is voluminous and assumes a shape that in a light microscopy looks like cuboidal (characteristic superficial cells are labelled in purple). Some superficial cells are binucleated (their nuclei are indicated in green). A cytoplasmic process that attaches these cuboidal cells to the basal lamina is not well seen in the light microscope. Nuclei of middle cells are located at several levels or rows because these cells are smaller. The basal lamina is indicated as a blue line. The lamina propria of a loose connective tissue with blood vessels (red) occurs under the basal lamina.

The **tunica muscularis** is the thickest layer of the urinary bladder. It is formed by a **smooth muscle**, which is arranged in a very complex manner. In a microscope, three layers with differently oriented myocytes can be distinguished. Those portions of the musculature that are seen in a transverse section (examples in an interactive image are indicated in grey) show circular diameters of myocytes (nucleus is visible only in the largest); nuclei in a transverse section look spherical. In a longitudinal section, the cells are spindle-shaped, and their nucleus is rod-like (example of the muscle with such orientation is indicated in orange). A small amount of connective tissue with nerves, blood vessels (incl. arterioles - red) is seen between islands of a muscle tissue.