• The urinary system functions to remove the waste products of metabolism from the blood and to regulate the concentration of many constituents of the body fluids. This system consists of the kidney, which produces the urine, and the ureter, urinary bladder, and urethra, that convey the urine to outside of the body.
The human kidneys are paired organs situated retroperitoneally on the posterior wall of the abdominal cavity on either side of the vertebral column. They are roughly broad bean-shaped with the concavity on the medial side. From this concavity, hilus, emerges a large excretory duct, ureter, and courses downward to the urinary bladder, which stores the urine for some hours.

The kidney is tightly enclosed by a thin but strong capsule of dense collagen fibers and further together with the adrenal gland by an adipose tissue capsule.

Interior to the hilus there is a large cavity surrounded by the kidney substance, the renal sinus, containing the renal pelvis which divides into 8 to 12 renal calyces, accepting each the renal papilla. The remainder of the sinus around these structures is occupied by loose connective tissue and adipose tissue, through which the blood vessels and nerves pass into the renal tissue.
• This is to show the macroscopic organization of the kidney. On the left side, in the middle, is the hilus and its inward extension, the renal sinus, containing the renal pelvis and calyces. On the section surface, viewed with the naked eye, an outer darker reddish brown cortex is distinguishable from an inner lighter gray medulla, which is made up of 8 to 12 conical structures called renal pyramids, having their base toward the cortex and their apex or papilla projecting each into the lumen of a renal calyx. The lateral boundaries of each pyramid are defined by inward extensions of the darker cortical tissue forming the renal columns. A renal pyramid together with the cortical tissue overlying its base and covering its sides, constitutes a renal lobe.

• The parenchyma of the kidney is made up of countless minute uriniferous tubules that are its functional units. Along the length of these tubules, successive segments are specialized for different roles in the formation of the urine. Corresponding segments of the many parallel tubules are in register at the same level of the renal medulla, resulting in transverse zones that differ slightly in color or pattern. There are an inner and an outer zone of the medulla and the outer zone is further subdivided into a darker and thicker inner layer or band and a lighter and thinner outer band.

• From the bases of the medullary pyramids thin radially directed striations extend into the cortical substance, but they do not extend through the entire thickness of the cortex. They are called the medullary ray and represent
continuation of bundles of tubules from the pyramid into the cortex. Between the medullary rays, the substance of the cortex shows granular appearance; this portion is called the **renal labyrinth**.

- At the tip of each papilla, about 25 pores are seen, that are openings of the terminal segments of the uriniferous tubules into the calyx. This area is called area cribrosa.
This figure shows a human renal lobe as a whole. The cortex and medulla, and renal column covering the lateral sides of renal pyramid are clearly recognized. The renal calyx covering the tip of the papilla is also evident.
• This figure consists of the upper half, the cortex, and the lower half, the medulla. The surface of the cortex is covered by a thin but strong capsule of dense collagen fibers. In the cortex, stained dark reddish violet, four striations, medullary rays, continuing with the medulla are recognized; between the medullary rays tissue appears granular, that is the labyrinth.

• The medulla, appearing light greenish violet, consists exclusively of the tubules.
• This figure is downward continuation of 15-03. The medulla consists mainly of longitudinally sectioned tubules. The tip of the renal papilla is covered by a double walled cap, renal calyx.

In this figure three medullary rays and two labyrinths between them are recognized. In the labyrinth large round structures are numerously seen; they are renal corpuscles. Otherwise the labyrinth consists of innumerable sections of the uriniferous tubules, stained dark red.
• The uriniferous tubule consists of two functionally distinct portions.

• The first portion, called the nephron, collects a filtrate of the blood, created in a spherical mass of tortuous capillaries, at its proximal end, and modifies the composition of this fluid by adding nitrogenous water to it and by reabsorbing from it certain components that need to be conserved. This portion is the so-called glandular portion, derived from the metanephrogenic tissue.

• The second portion, the collecting tubule, absorbs water from the filtrate to concentrate its solutes resulting in a hypertonic urine which is conveyed to the renal pelvis. This portion is the excretory duct system in usual glands, derived from the ureteric bud, a diverticulum from the Wolfian duct.

• There are approximately 1.5 million uriniferous tubules in a human kidney. Along the length of the nephron in each of these, traditionally there are six morphologically distinguishable segments, each occurring at a particular level in the cortex or medulla. The epithelium lining of each segment has a characteristic microscopic structure related to its specialization for specific function in the formation of urine.

• The terminology of these segments has been long time very complicated and the origin of confusions of beginners for understanding of the renal functions. Following descriptions are adopted the terminology of Renal Commission of the International Union of Physiological Sciences.

• Four major subdivisions of the uriniferous tubule are now recognized: the proximal tubule, intermediate tubule, distal tubule, and the collecting system. Each of these is further subdivided into two or more segments.

• At the proximal end of each nephron, there is a closed, thin-walled expansion of the tubule that is deeply invaginated to form a cup-shaped hollow structure called Bowman's capsule. The concavity of this blind end of the nephron is occupied by a globular tuft of highly convoluted capillaries, glomerulus. This mass of capillaries and its surrounding chalice-shaped epithelial capsule, together, constitute the renal corpuscle. It has a vascular pole where the afferent and efferent vessels enter and leave the glomerulus, and a urinary pole where the slit-like cavity between the layers of the invaginated Bowman's capsule (urinary space or Bowman's space) is continuous with the lumen of the proximal tubule.

• Two segments of the proximal tubule are distinguished: the proximal convoluted tubule (PCT, pars convoluta), situated in the cortex, and the proximal straight tubule (PST, pars recta), extending from the cortex into the outer stripe of the medulla. This is followed by the intermediate tubule which forms a long loop which is subdivided into the descending thin limb (DTL, pars descendens), traversing the inner stripe of the outer medulla and extending deep into the inner medulla, and recurrent portion, the ascending thin limb (ATL, pars ascendens).

• At the junction of the inner and outer medulla, the ascending thin limb is continuous with the distal straight tubule (DST, thick ascending limb) which traverses the outer medulla and continues into the cortex, where it becomes the distal convoluted tubule (DCT). In the cortex, the distal convoluted tubule is joined by a collecting tubule (CT), to a collecting duct (CD), which passes downward through the cortex and medulla to the area cribrosa of the renal papilla, where it opens into a calyx.

• The portion of the nephron, traditionally called the loop of Henle, includes the segments now called the thick descending limb of the proximal tubule (PST), the thin descending (DTL) and ascending (ATL) limbs of the intermediate tubule, and the thick ascending limb (DST) of the distal tubule. These several segments are represented in

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15-06

Scheme of uriniferous tubules
the same sequence in all nephrons, but the length of the loop of Henle varies. In addition to long-looped nephrons described above, there are short-looped nephrons, in which the loop turns back in the outer medulla, and cortical nephrons, which have very short loop that does not extend into the medulla but turns back in the inner cortex. The renal corpuscles also vary in their location. Some may be near the renal capsule, others midcortical, and still others are juxtamedullary.

- The intermingling of the serpentine convoluted tubules within the cortex makes it impossible, in histological sections, to relate their cross sections to a particular renal corpuscle.


- This scheme and above descriptions are indebted to “A Textbook of Histology” by Dr. D. W. Fawcett, 1994.
Bowman’s capsule around a glomerulus is a double-walled cup composed of squamous epithelial cells. The glomerulus pushes into and deeply indents a blind terminal expansion of the uriniferous tubule. Therefore, a visceral layer of epithelium, glomerular epithelium, called podocyte, is closely applied to the capillaries, and a parietal layer, capsular epithelium, encloses a narrow cavity, capsular space or Bowman’s space. At the vascular pole of the renal corpuscle, the visceral layer turns over around the afferent and efferent arterioles and continues with the parietal layer of the epithelium. At the urinary pole the squamous epithelium of the parietal layer is continuous with the cuboidal epithelium lining the neck of the proximal convoluted tubule.
• In the development of the renal corpuscle, the cells of visceral layer become so extensively modified that they are no longer imagined as epithelial cells. The individual cell is called podocyte, and is stellate in form with several radiating primary processes that embrace the underlying capillaries and give rise to very numerous secondary branches called foot-processes or pedicles. These interdigitate with corresponding processes of neighboring podocytes but are not closely adherent to them. An extra-ordinarily elaborate system of intercellular clefts is thus formed, through that a filtrate of the blood plasma can enter the capsular space. Thus formed filtration slits are 25～35 nm wide.

• The endothelium of the glomerular capillaries is thin and perforated by pores of 70～90 nm in diameter. The basal lamina between the glomerular epithelium and endothelium of the capillaries is 0.1～0.15 µm in thickness.

• The continuous filtration of the blood plasma in the renal glomeruli is a process that is essential for the elimination of nitrogenous wastes and control of the extracellular fluid composition and of blood volume. The structural components of the filter are ① the fenestrated endothelium, ② the basal lamina, and ③ the filtration slits between the foot-processes of the podocytes.

• The spaces between the glomerular capillaries are occupied by mesangium, a connective tissue consisting of mesangial cells in an extracellular matrix that is relatively free of fibrous elements. The mesangial cells are considered to be a specialized type of pericyte providing structural support for the capillary
loops. They show the phagocytic activity and may participate in the continuous turnover of the basal lamina.
• This is a longitudinal section of a human renal cortex, showing the renal labyrinth and medullary ray. The left two thirds of this figure is the renal labyrinth and through its axial portion runs an arteria radiata, which gives rise afferent arterioles at intervals for about eight renal corpuscles. Around them the field is densely filled by the sections of the renal tubules. The right one third is the medullary ray consisting of longitudinally sectioned renal tubules. In this specimen collagen fibers stain deep blue.

• Specimen of figures of 15-09 and 15-10 were made by Prof. Dr. I. Asami.
This is a transverse section of the renal labyrinth, showing a radiate artery (A), two radiate veins (V) and four renal corpuscles, that may accept the afferent arteriole from this radiate artery. Around these the field is occupied, almost exclusively, by the sections of proximal convoluted tubules, stained deep red. Only a few sections of distal convoluted tubules and collecting tubules are intermingled.
This is also a transverse section of the human renal labyrinth, showing four renal corpuscles and innumerable sections of renal tubules, that are mainly of the proximal convoluted tubules, intermingled by several sections of distal convoluted tubules and connecting tubules. In this specimen collagen fibers stain green.
• This is a human renal corpuscle surrounded by sections of the proximal convoluted tubules. In this renal corpuscle the afferent and efferent arterioles, glomerulus, and urinary pole opening into the proximal convoluted tubule are all recognized, and further the macula densa at the vascular pole is also seen. This section is 3µm thick.
• Higher magnifications of this renal corpuscle are shown in 15-13～15-15.
At upper middle is the section of the macula densa (double arrows). Adjacent to its lower right side enters the afferent arteriole left-downward (long arrow) into the glomerulus and to its left side leaves the efferent arteriole upward (long arrow with double arrow heads) from the glomerulus. The afferent arteriole has circular smooth muscle fibers in its wall but the efferent arteriole does not. A round cell with lucent cytoplasm (small arrow) is recognized between the afferent arteriole and the macula densa; this is the juxtaglomerular cell. Small elongated nuclei seen between the macula densa and the afferent and efferent arterioles are called the cells of Goormaghtigh.

The afferent arteriole divides into the glomerular capillaries and they put together in the efferent arteriole. BS indicates the space of Bowman.
• This figure shows the urinary pole of the glomerulus. The space of Bowman (BS) continues here with that of the proximal convoluted tubule (long arrow). The simple squamous epithelial cells of the Bowman’s capsule (parietal layer, arrow heads) continue here with the simple cuboidal epithelial cells of the proximal convoluted tubule. This change of epithelial cells is quite abrupt. The epithelial cells lining the proximal convoluted tubule (P) are simple cuboidal and provided with very distinct brush border on the free surface. Their cytoplasm stains dark red and basal striation is evident but the cell border between the adjacent cells is not perceived. The podocytes embracing the capillaries (visceral layer) are indicated by arrows. Collagen fibers stain deep green.
This figure shows the glomerulus, in detail. At about one fourth of the right side runs vertically the collagen fibers of the Bowman’s capsule, staining deep green and on its left side cover the simple squamous epithelial cells (parietal layer, arrow heads). Left side to it is the cavity of the Bowman’s capsule (BS) which is occupied by the highly convoluted capillaries, glomrulus, embraced by the podocytes (visceral layer, arrows). As this specimen was freshly fixed, thin sectioned, and adequately stained, the podocytes, having large round nucleus and light violet stained cytoplasm, are evidently distinguishable. The space between the podocytes and the capsular epithelium is the space of Bowman (BS). Double arrows indicate the mesangial cells.

- P: proximal convoluted tubule, C: collecting tubule.
In this field there are three renal corpuscles and around them numerous sections of the proximal convoluted tubules, stained deep red. At center located corpuscle, both the vascular pole and urinary pole are recognized. Above the vascular pole, the macula densa and three sections of the distal convoluted tubule are seen. In this specimen capillaries are filled by blood corpuscles.
• Higher magnification of 15-16. From the top left enters the afferent arteriole into the corpuscle and from the right side adjacent to this leaves the efferent arteriole. Upper to them locates the macula densa (arrow) and in the triangular space limited by these three is filled by small elongated nuclei of the Goormaghtigh cells.

At right adjacent to the efferent arteriole is a section of the distal convoluted tubule. As this specimen is not enough thin (about 7 μm), identification of podocytes (arrow) in the glomerulus is not easy. The epithelial cells of the proximal convoluted tubules stain deep red and are provided with conspicuous brush border on their free surface. The spaces between the proximal convoluted tubules and the renal corpuscle are filled by capillaries containing blood corpuscles.
• This figure shows a portion of the renal labyrinth. At center is a renal corpuscle providing with afferent arteriole and urinary pole. Left side adjacent to this run vertically the radiate artery and vein. Around these, space is filled up by sections of the proximal and distal convoluted tubules. In this specimen collagen fibers stain blue.

• Specimen of figures 15-18 and 15-19 was prepared by Prof. Dr. I. Asami.
• Higher magnification of 15-18. From the upper left corner runs the afferent arteriole right downward and enters into the renal corpuscle; from the opposite pole begins the proximal convoluted tubule, staining deep red, with a narrow beginning. Right side adjacent to the afferent arteriole is the macula densa (arrow). At lower left runs the radiate vein, containing some erythlocytes. In the glomerulus the podocytes are distinguishable.

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• In the middle is a renal corpuscle with the vascular pole at its top. A thick ascending limb of the intermediate urinary tubule runs along the left edge of this corpuscle arriving at its tip where the conspicuous macula densa (arrow) is recognized on the lower wall. Along the lower edge of this field three sections of proximal convoluted tubule (P) and a collecting tubule (C) are seen.
• From the top of this renal corpuscle the afferent arteriole enters into the corpuscle and divides into the glomerular capillaries. Right side to the afferent arteriole is a section of the distal convoluted tubule with the macula densa on its lower wall (arrow).
The afferent arteriole enters into this corpuscle at its top and then divides into the glomerular capillaries. As the section is very thin, about $0.1 \mu m$, nuclei of the endothelial cells and the erythrocytes in the capillary lumen are evidently distinguished. Arrows indicate the mesangial cells. The space of Bowman (BS) is very narrow in this specimen.
At lower middle are two transverse sections of distal convoluted tubules (D) and upper to them is a longitudinal section of connecting tubule (C). At upper left corner is a transverse section of connecting tubule. All others are sections of the proximal convoluted tubules (P), stained deep red and provided with the prominent brush border on their free surface. All of the tubules are encircled by a distinct basement membrane stained green. Spaces among these tubules are filled by blood capillaries.

The proximal tubule starts as a tubule lined by the cuboidal epithelial cells at the urinary pole, where it continues with the squamous epithelium of the Bowman’s capsule. After numerous convolutions near the renal corpuscle, this tubule enters into the medullary ray and runs straight toward the tip of the renal papilla.

The proximal tubules are the longest segment of the nephron, and together they make up the greatest part of the renal cortex.

The epithelium of the proximal tubule has the prominent brush border which is covered by a glycocalix staining faint green. The cells have a single spherical nucleus, and numerous long mitochondria in the basal half of cells, oriented parallel to the cell axis. This orientation of mitochondria results in a faint vertical striation of the cytoplasm in the histological sections. The cytoplasm stains intensely with acid dyes, as eosin or azocarmine. The lateral boundaries of cells are not resolved with the light microscope, due to, in part,
their intensive interdigitation.

- The proximal tubule reabsorbs nearly all of the glucose and amino acids in the glomerular filtrate, while allows other substances of no nutritional value to be excreted in the urine.
Higher magnification of 15-23. At center left is a transverse section of connecting tubule (C), consisting of nine epithelial cells. Their cytoplasm stains less red and the lateral boundary of each cell is distinct. Around this there are five sections of the proximal convoluted tubule (P), 50〜60μm in diameter, consisting of tall epithelial cells. They contain a spherical nucleus and are provided with a distinct brush border on the free surface, covered by faint green glicocalix. Their cytoplasm stains intensely red with azocarmine and shows granular appearance. The number of nuclei in one section is less numerous. The lateral boundary of each cell is not perceived. At upper right corner is a section of the distal convoluted tubule (D). All of these sections are encircled by a distinct basement membrane, stained deep green. Spaces among the tubules are occupied by the capillaries containing blood corpuscles.
• In the middle runs vertically the medullary ray limited on both side by the renal labyrinth. The medullary ray in this figure consists of the longitudinal sections of pars recta of proximal tubule, thick ascending limbs of intermediate tubule, and collecting tubule.
In the middle runs vertically a collecting tubule (C), consisting of simple cuboidal epithelial cells with distinct cell boundary. Their cytoplasm appears almost colorless. Upper left to this is a thick ascending limb of intermediate tubule (D) consisting of simple low cuboidal epithelial cells. They have a spherical nucleus protruding half into the lumen and the cytoplasm stains moderately red. On the right and left sides to them runs each a pars recta of proximal tubule (P) consisting of simple cuboidal epithelial cells, staining deep red and providing with distinct brush border covered by faintly green stained glycocalix on the free surface. The lateral boundary of each cell is not perceived.
• This figure shows the transverse section of the outer layer of the outer zone, consisting of the descending straight portions of the proximal tubule (PST), the descending thin limbs of the intermediate tubule (DTL), the thick ascending limbs of the intermediate tubule (DST), and the collecting tubules (CT).

• The descending straight portion (pars recta, PST) of the proximal tubule, about 60μm in diameter, abruptly narrows in the outer layer of the outer medulla and continues as descending thin limb (DTL) of the loop of Henle, with a diameter of 15μm. Therefore further downward, in the inner layer of the outer medulla, no proximal straight tubule is encountered. In the lower one third of this figure, there are only a few PST are observed.
Higher magnification of 15-27.

Here the descending straight portions of the proximal tubule (P), the thick ascending limbs of the intermediate tubule (D), and the collecting tubules (C) are recognized. A descending thin limb is indicated by arrow, which is very alike with a capillary or venule in size as well as in form. Spaces among the tubules are filled by abundant connective tissues.
At center a descending straight portion of the proximal tubule continues with a descending thin limb of the intermediate tubule (DTL). At this transition, indicated by an arrow, the prominent brush border ends and deeply red stained cuboidal epithelium turns abruptly into the simple squamous epithelium.

- P: descending straight portions of the proximal tubule (PST), C: collecting tubule, D: thick ascending limb of the intermediate tubule (DST)
This is the longitudinal section of the inner layer of the outer zone of medulla. No proximal tubule is seen. There are descending thin limbs, ascending thin limbs of the intermediate tubule, and ascending thick limbs of the distal tubule, and collecting tubules. The connective tissue, stained green, is abundant among these tubules.
• In the green stained connective tissue, the descending and ascending thin limbs (arrows) of the intermediate tubule, ascending thick limbs (D), and the collecting tubules (C) are recognized. The descending and ascending thin limbs (indicated with arrows) are 10～20 μm in diameter and the epithelium is only 0.5～2.0 μm thick, and the central portion of the cells containing the nucleus bulges into the lumen. The shape of the cells and the small caliber of the tubule result in a very alike appearance with that of capillary or venule in the histological sections.

• The descending thin limb is continuous at the bend of the loop with the straight ascending limb of the tubule.

• The distal tubule begins in the inner layer of the outer zone of the medulla at an abrupt transition from the thin limb of the loop of Henle to its thick ascending limb. Its initial portion is called the medullary thick ascending limb and its continuation becomes the cortical thick ascending limb. Where the latter contacts the vascular pole of the renal corpuscle of the same nephron, its epithelium contains a plaque of specialized cells called macula densa. Distal to this point, the tubule pursues a tortuous course and called the distal convoluted tubule.

• The epithelium of the thick ascending limb consists of simple low cuboidal cells containing a spherical nucleus. As they lack the brush border on the free surface, the contour of the lumen is smooth. The cytoplasm stains red but
much lighter than that of the proximal tubule.
In the abundant connective tissue, stained green, the thin limbs (arrows) of the intermediate tubule, ascending thick limbs (D) and collecting tubules (C) are seen.
• A long thin limb traverses in the middle of figure. Except for three collecting tubules (C), remaining tubules are the ascending thick limbs of intermediate tubules.
From lower left to upper right one large tubule, ascending thick limb (D), traverses the figure. Parallel to this runs a thin limb of the intermediate tubule (TL). In the uppermost region traverses a capillary (arrow). At middle right is a collecting tubule (C), consisting of the simple columnar epithelial cells, with distinct cell boundary.
This shows the apical portion of a renal papilla and renal calyx covering the tip of it. The papilla consists of the longitudinally sectioned collecting ducts and descending as well as ascending thin limbs of the loop of Henle. The surface of the papilla is covered by the double walled calyx, the epithelium of which is the transitional epithelium.
• Higher magnification of 15-35. In the abundant connective tissue, stained deep green, longitudinally or obliquely sectioned ductus papillares and descending as well as ascending thin limbs of the loop of Henle are seen.
• In the middle traverse two large collecting ducts (C) and parallel to them two very thin tubules (arrows), thin limbs of loop of Henle, one above, the other down to them, are seen.

• The collecting duct system, consisting of connecting tubule, collecting tubule and collecting duct, is the same as the excretory duct system of the usual excretory glands.

• The connecting tubule is a short transitional segment joining the distal convoluted tubule to the collecting tubule, which enters into the nearest medullary ray and courses inward through the cortex and medulla. When the collecting tubules reach the inner zone of the medulla, pairs of them approach at an acute angle and become confluent. About seven such convergences, in the inner zone of the medulla, results in the formation of larger straight ducts 100~200μm in diameter, called papillary ducts, that open into a calyx of the renal pelvis on the area cribrosa.

• The morphological features of the epithelial cells of this system are roughly common in the histological specimen. The epithelium consists of simple cuboidal or simple columnar cells with distinct cell boundary. Each of them contains a spherical nucleus in the middle of the cell body. The cytoplasm appears colorless or faintly pink in H-E preparations.
• This is a longitudinal section of a renal papilla. In the middle two collecting tubules or collecting ducts are confluent and become a larger duct. Among the longitudinally sectioned collecting tubules the connective tissue is abundant.
15-39.
Renal papilla.
U-turn of a thin portion of Henle’s loop.
Human,
MG stain,
x 64.

- This figure shows the U-turn of a thin limb of loop of Henle in the renal papilla. In this field three collecting ducts are seen. Others are thin limbs of loop of Henle and capillaries filled by red stained plasm.
A thin transitional epithelium covers the surface of the papilla and turns over at the right end of the figure to the inner surface of the renal calyx becoming a thick transitional epithelium. In the upper half of the field there are several sections of distended urinary tubules.
• The excretory passages of the urinary tract are lined by transitional epithelium throughout, but there are regional differences in its thickness. The connective tissue of the lamina propria is abundant and rich in meshwork of elastic fibers.

The walls of the renal calyces, pelvis, and ureter are all provided with a well-developed layer of smooth muscle, which is made up of anastomosing bundles of muscle fibers of various orientation.
This is a transverse section of a human ureter. The lumen is lined by the transitional epithelium, underlain by the connective tissue of lamina propria and tela submucosa. Further outside there are layers of smooth muscle fiber bundles, inner longitudinal and outer circular. Because of the post mortem contraction of the muscle fiber bundles the mucous membrane is thrown up into the lumen, resulting in several longitudinal folds.
• This is the transitional epithelium of a human ureter, underlain by the loose connective tissue of lamina propria which contains numerous capillaries.
• This is a general view of the wall of a human urinary bladder. The epithelium appears relatively thick, underlain by the thick connective tissue of lamina propria and tela submucosa. The muscle layer is very thick consisting of sizable strands of smooth muscle cells and is roughly divided into three layers. These intermingle at their interface so that the layers cannot be clearly separated from one another. These muscles act as a whole to minimize the lumen of the bladder to discharge the urine.
• This is the transitional epithelium of a human urinary bladder, moderately distended. The epithelium is five to seven cells thick and cells at surface are rounded and lightly elevated into the lumen. Some of these have two nuclei.
• (The three conditions of the transitional epithelium are shown in 02-22, 02-23, and 02-24.)
This is the whole view of a transverse section of a human penis. The penis is a cylindrical body covered with skin, 15~20 cm long and 3~4 cm in diameter, and is the male copulative organ. The core of the penis consists of three cavernous erectile bodies, namely two dorsally located paired corpora cavernosa penis and ventrally located unpaired corpus spongiosum penis (corpus cavernosum urethrae), which is penetrated by the urethra throughout the length.

- The corpora cavernosa penis are enclosed by a common thick collagenous tissue, tunica albuginea, and the corpus cavernosum urethrae is also enclosed by a much thinner tunica albuginea. At the distal end the corpus cavernosum urethrae makes an expansion, the glans penis, which caps the distal ends of the corpora cavernosa penis. The three corpora cavernosa, are enveloped in the lump by very loose connective tissue and further on the surface by the thin skin.

- The erectile tissue of the corpora cavernosa is a sponge-like system of irregularly shaped vascular spaces fed by afferent arteries and drained by efferent veins. In the flaccid penis these cavernous spaces contain very little blood and appear as irregular narrow clefts. During erection, they expand as they become engorged with blood under pressure. The increased inflow of blood and relative restriction of outflow results in enlargement and rigidity of the erect penis.
The male urethra serves as the terminal portion of both the urinary tract and the reproductive tract. The lining of the penile urethra, 12～14 cm in length, is stratified columnar epithelium. At its most distal portion the lining becomes into stratified squamous epithelium, which is alike to that covering the glans penis.

• Higher magnification of 15-45. At center is the male urethra penetrating the axial portion of the corpus cavernosum urethrae. The blood spaces composing the cavernous body are much narrower than that of the corpora cavernosa penis. Several very small glands are scattered in the upper region.
- The female urethra is short, 30 to 40 mm long, and lined with stratified squamous epithelium. Numerous invaginations are formed by the epithelium. The lamina propria is a loose connective tissue containing numerous veins.