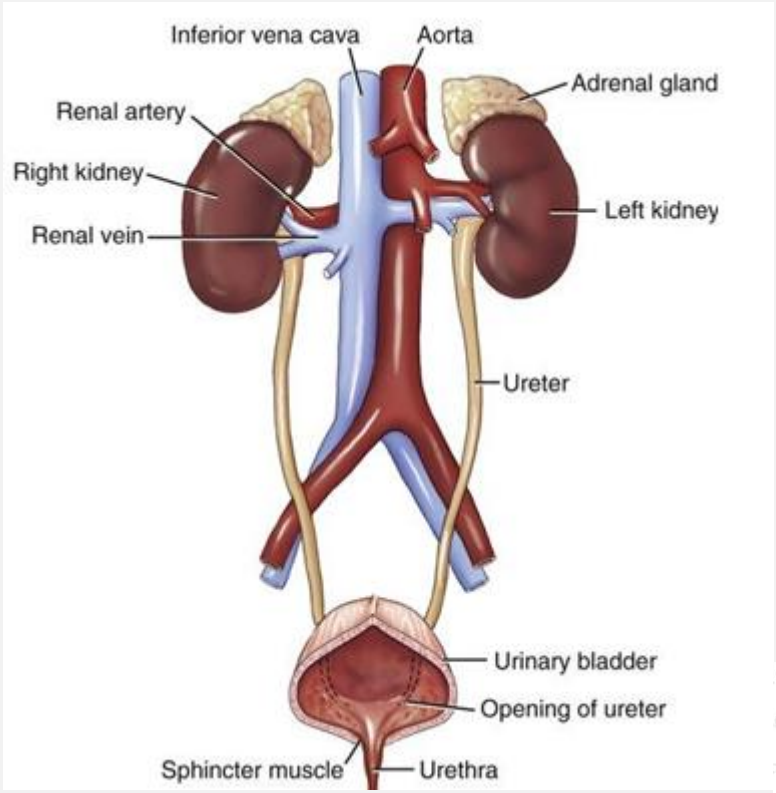
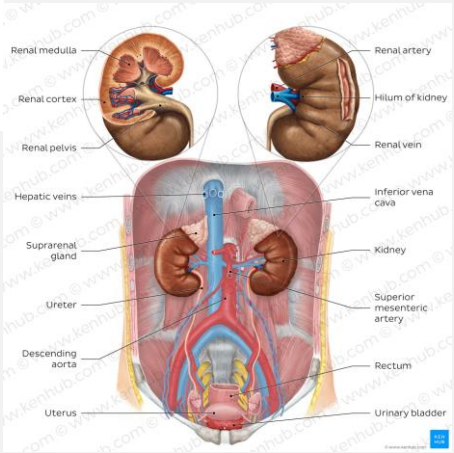
URINARY SYSTEM

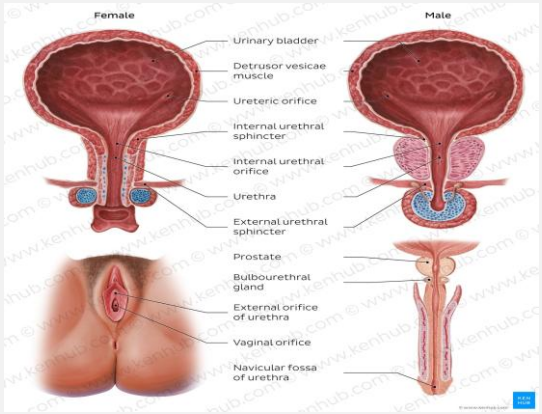


- **KIDNEYS**

- **RENAL PELVIS**
- **UTERETERS**
- **BLADDER**
- **URETHRA**

URINARY TRACT





Urine follows this pathway:

Kidneys → Renal pelvis → Ureters → Bladder → Urethra → Outside

FUNCTION OF URINARY SISTEM

- Elimination of metabolic waste products (bilirubin, urea), excretion of inorganic substances (traces of alkali and alkaline-earth metals), and excretion of exogenous substances (drugs)

- Maintenance of osmotic pressure and hydrogen ion (H^+) concentration in body fluids, through selective reabsorption and excretion of H^+ ions and H_2O

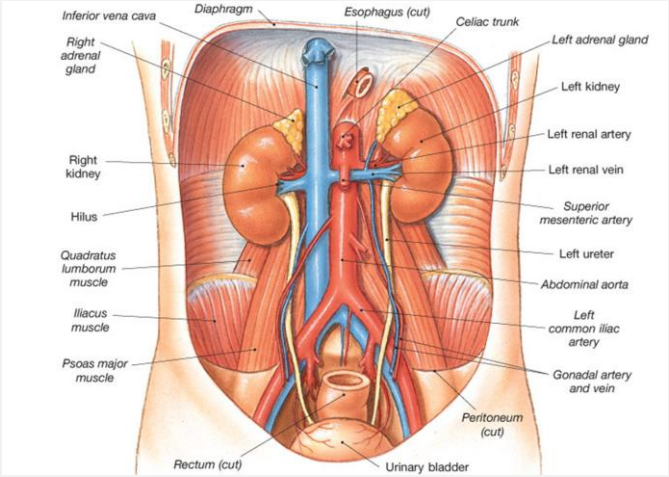
- Regulation of acid–base balance

- Synthesis of hormones involved in:
  -regulation of blood pressure (renin–angiotensin system)
  -regulation of erythropoiesis (erythropoietin)

- Formation of 1,25-dihydroxycholecalciferol (calcitriol) for the control of blood calcium levels

KIDNEYS

The Kidneys are Located Retroperitoneally



Large bean-shaped glands, red in color (varying depending on the amount of blood)

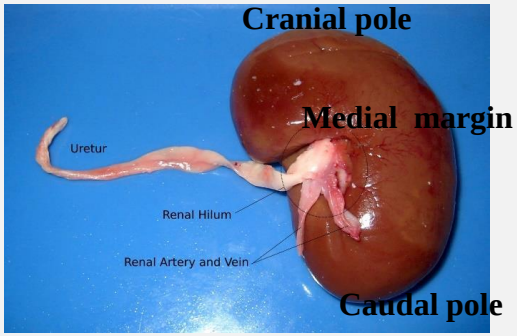
Due to the presence of the liver, the **right kidney is positioned 1–2 cm more cranially** than the left

•They are **paired organs**, **retroperitoneal**, located outside the parietal peritoneum, **surrounded by an adipose capsule** (functionally related to renal structure and serving as a fat reserve)

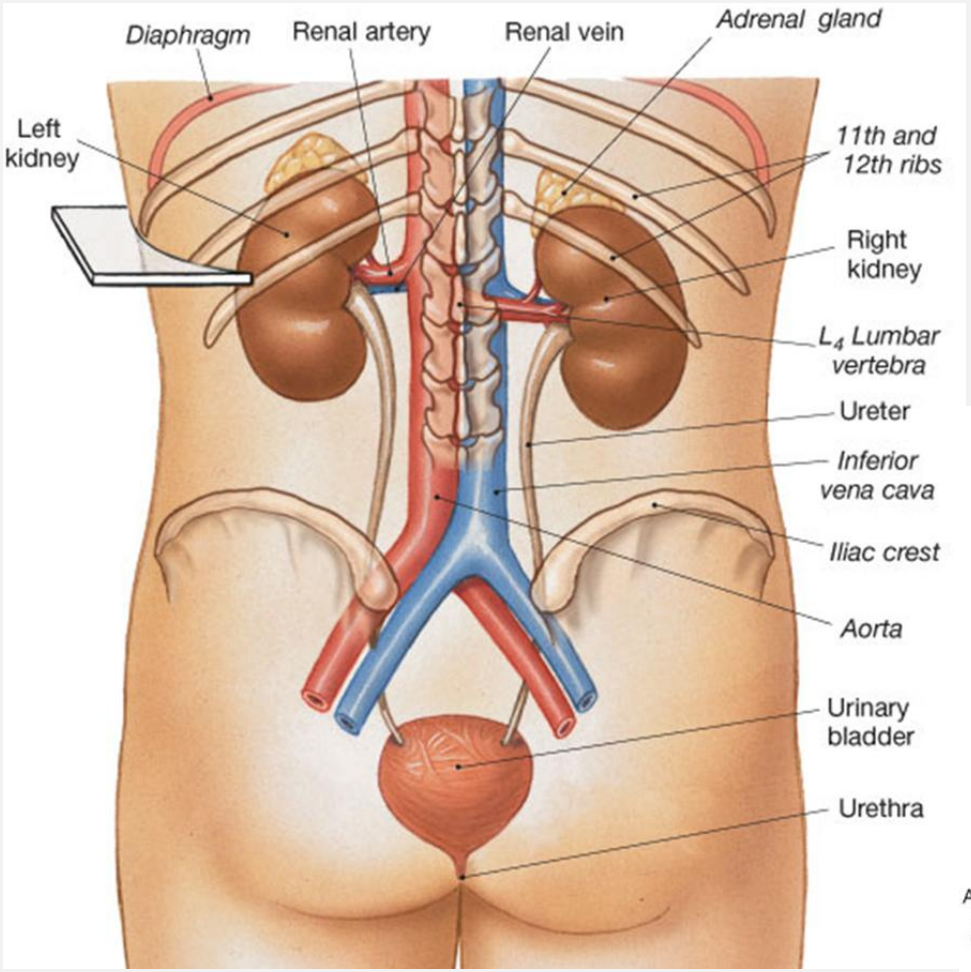
•They are **located in a renal lodge (renal fossa)** formed:

•dorsally by the lumbar wall muscles

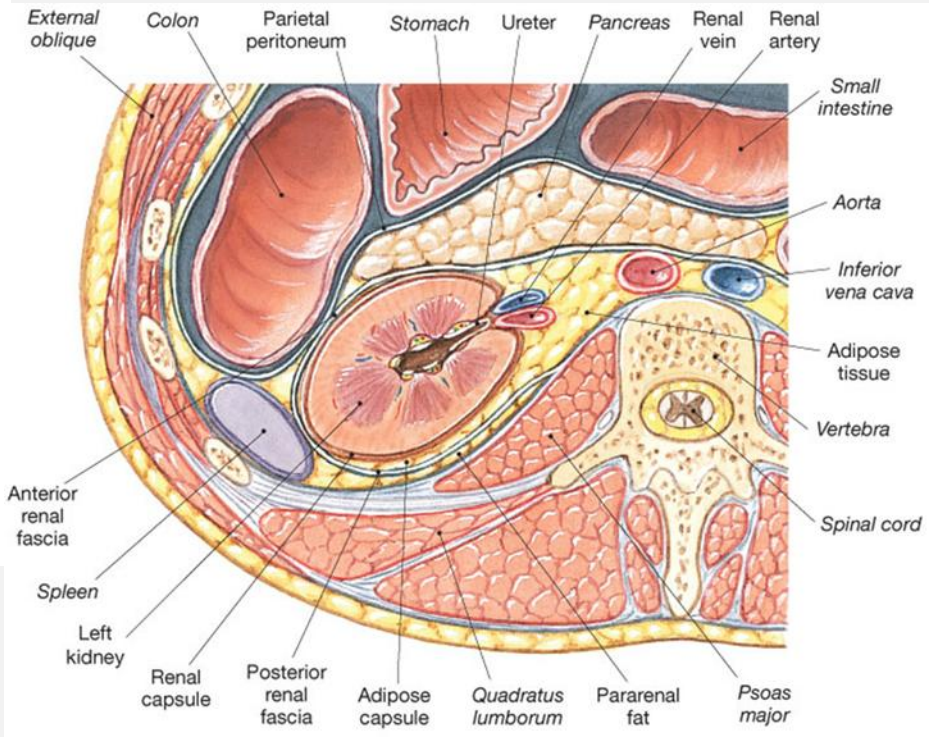
•ventrally by the parietal peritoneum *(except in cattle, where the left kidney has a mesentery)*



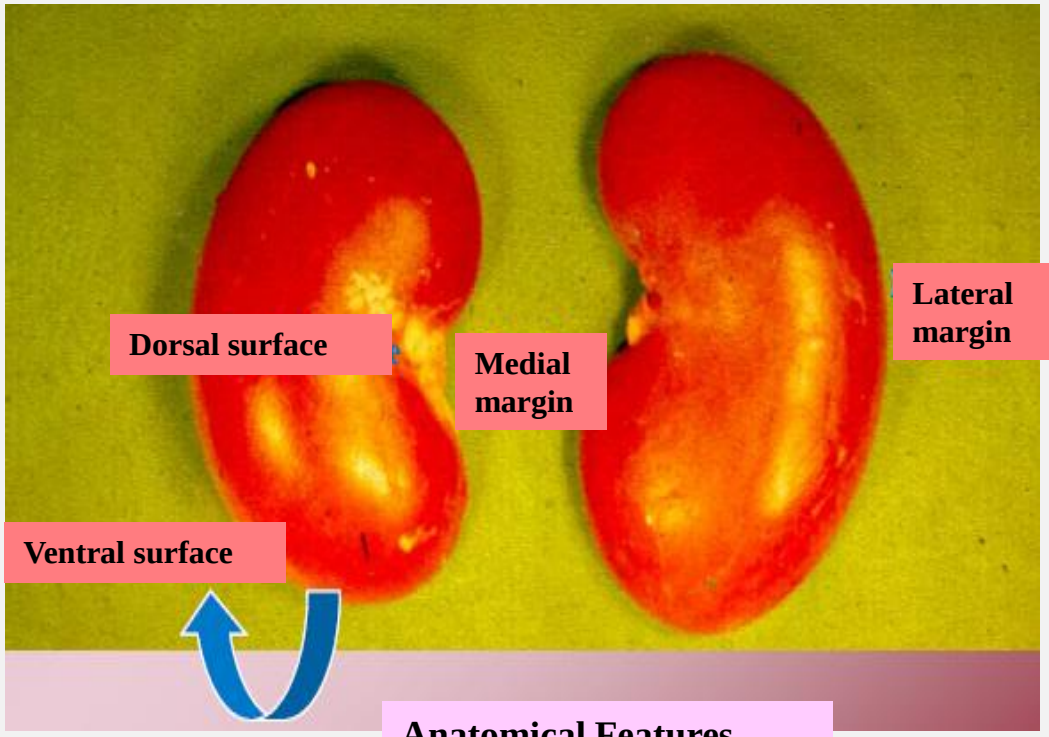
Posterior view of Kidneys



Transverse Section of Abdomen showing Kidneys



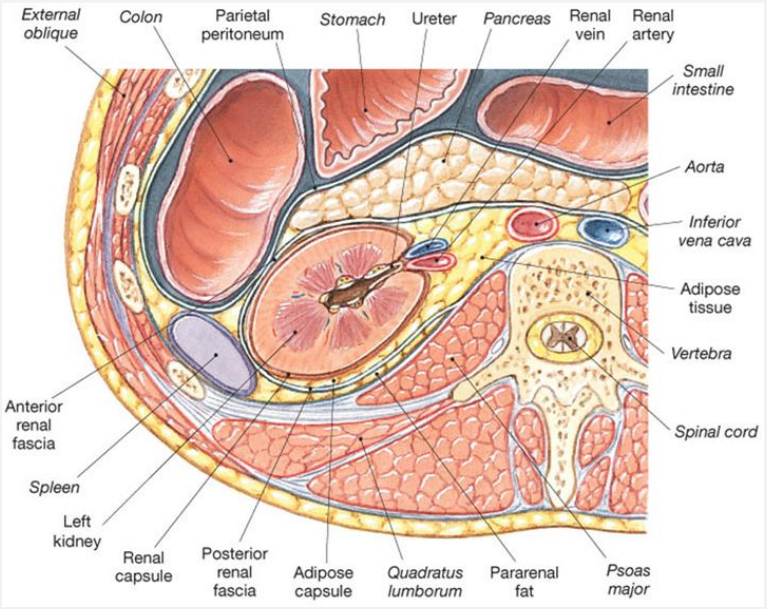
KIDNEYS



Anatomical Features

- **Dorsale surface**
- **Ventral surface**
- **Lateral margin**
- **Medial margin**
- **Cranial pole**
- **Caudal pole**

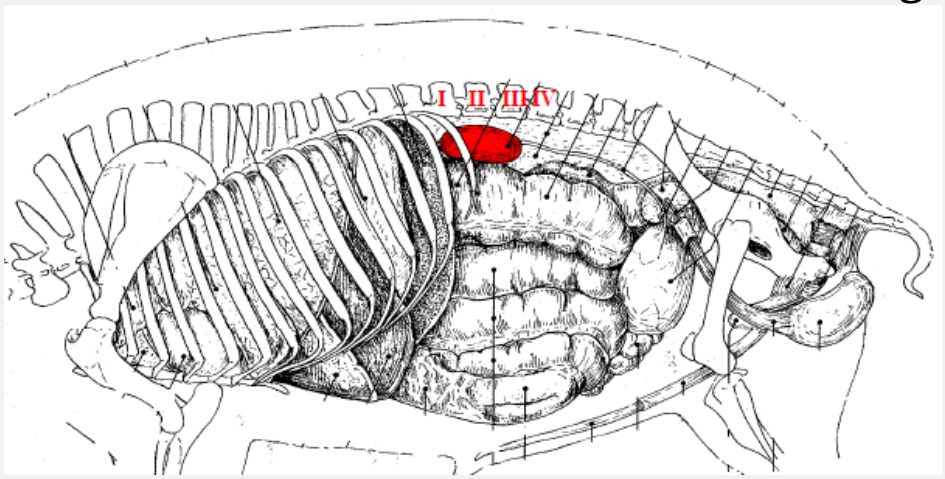
Transverse Section of Abdomen showing Kidneys



The medial margin present the **hilum**, through which blood vessels and nerves pass and from which the **ureter** originates

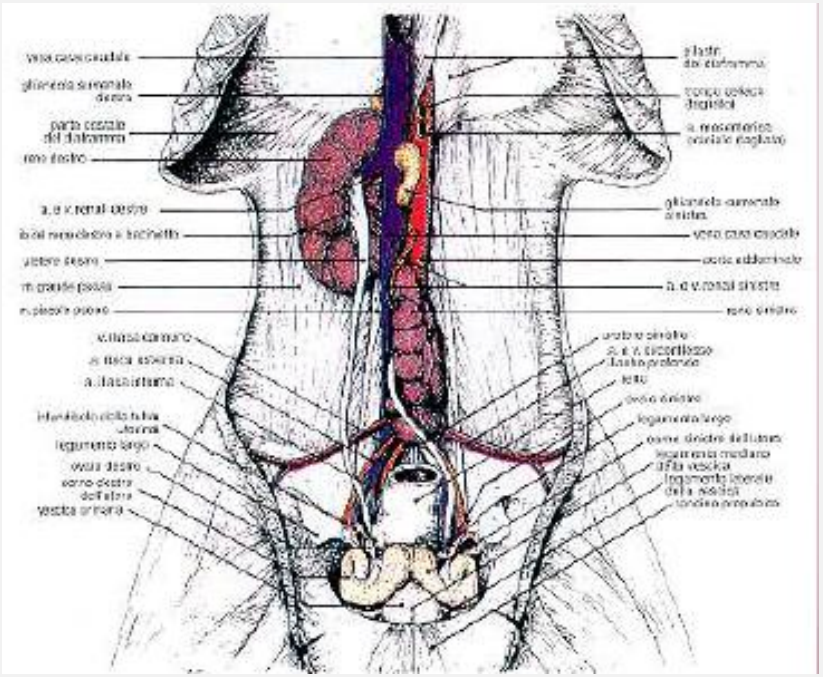
TOPOGRAPHY in Domestic Animal

Pig



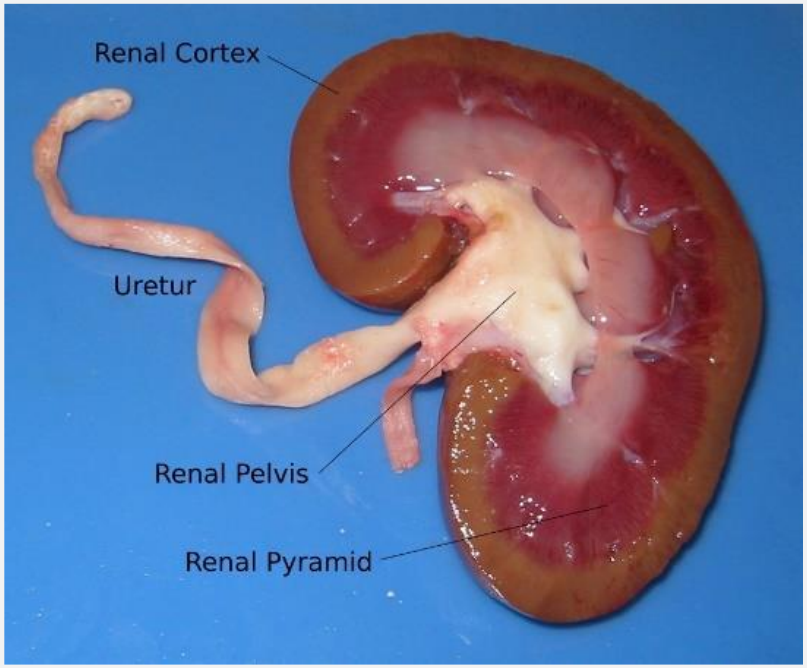
They are located in the sublumbar region, on the sides of the vertebral column and the crura of the diaphragm

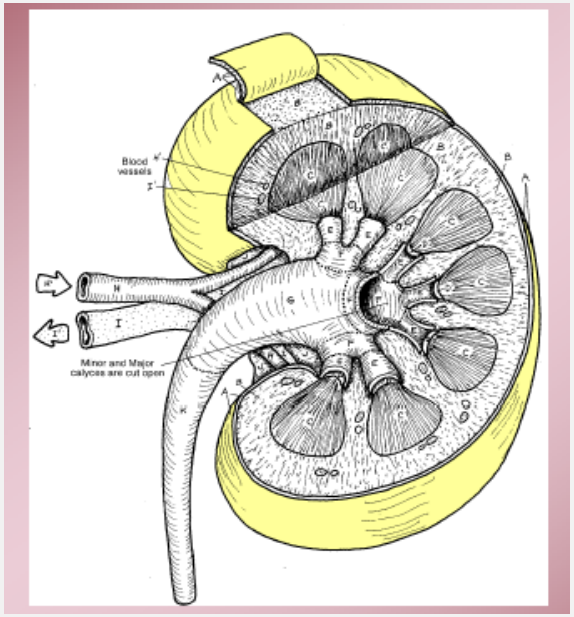
Cattle



Due to the large development of the rumen, the left kidney is displaced caudoventrally relative to the right. It is suspended from the roof of the abdominal cavity by a peritoneal mesentery rich in adipose tissue

KIDNEYS





The **hilum** leads to the **renal sinus**, which contains the **renal pelvis** and **the renal calyces**. At the hilum, the ureter leaves the kidney, whilst blood vessels enter and exit

Each kidney is surrounded by **3 distinct capsules** or layers which act to bind, support, protect and hold the kidneys in place:

- **The Renal Capsule**
- **The Adipose Capsule**
- **Renal Fascia -**

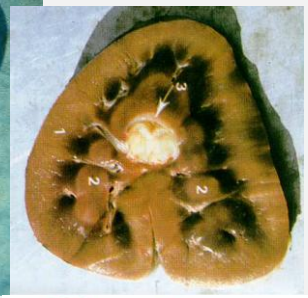
SPECIES-SPECIFIC FEATURES

During development, the renal lobes may fuse differently depending on the species, both in the cortical and medullary zones. Fusion at the cortical level leads to a **smooth kidney surface**. If fusion is incomplete, the kidney is described as **lobulated**.

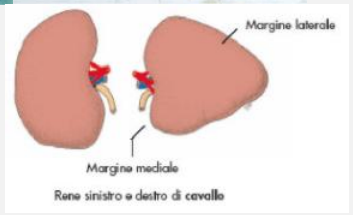
CATTLE

Lobulated, multipapillate kidney. The surface is marked by grooves that divide it into lobes.

HORSE – RIGHT KIDNEY

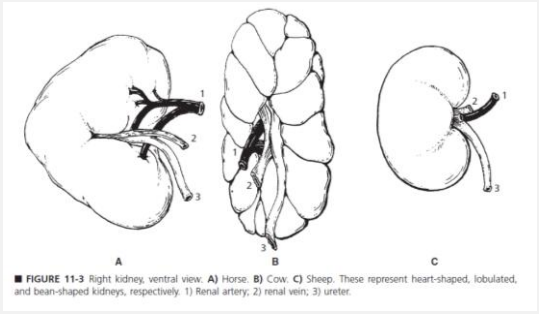


Smooth, unipapillate kidney.
The right kidney in the horse has a triangular shape



CARNIVORES

Smooth, multipapillate kidney.
The kidney, embedded in perirenal fat, has:a convex lateral border a concave medial border



■ FIGURE 11-3 Right kidney, ventral view. A) Horse. B) Cow. C) Sheep. These represent heart-shaped, lobulated, and bean-shaped kidneys, respectively. 1) Renal artery; 2) renal vein; 3) ureter.

KIDNEYS

Internal anatomy

The **parenchyma** of the kidney consists of the outer **renal cortex**, and inner **renal medulla**.

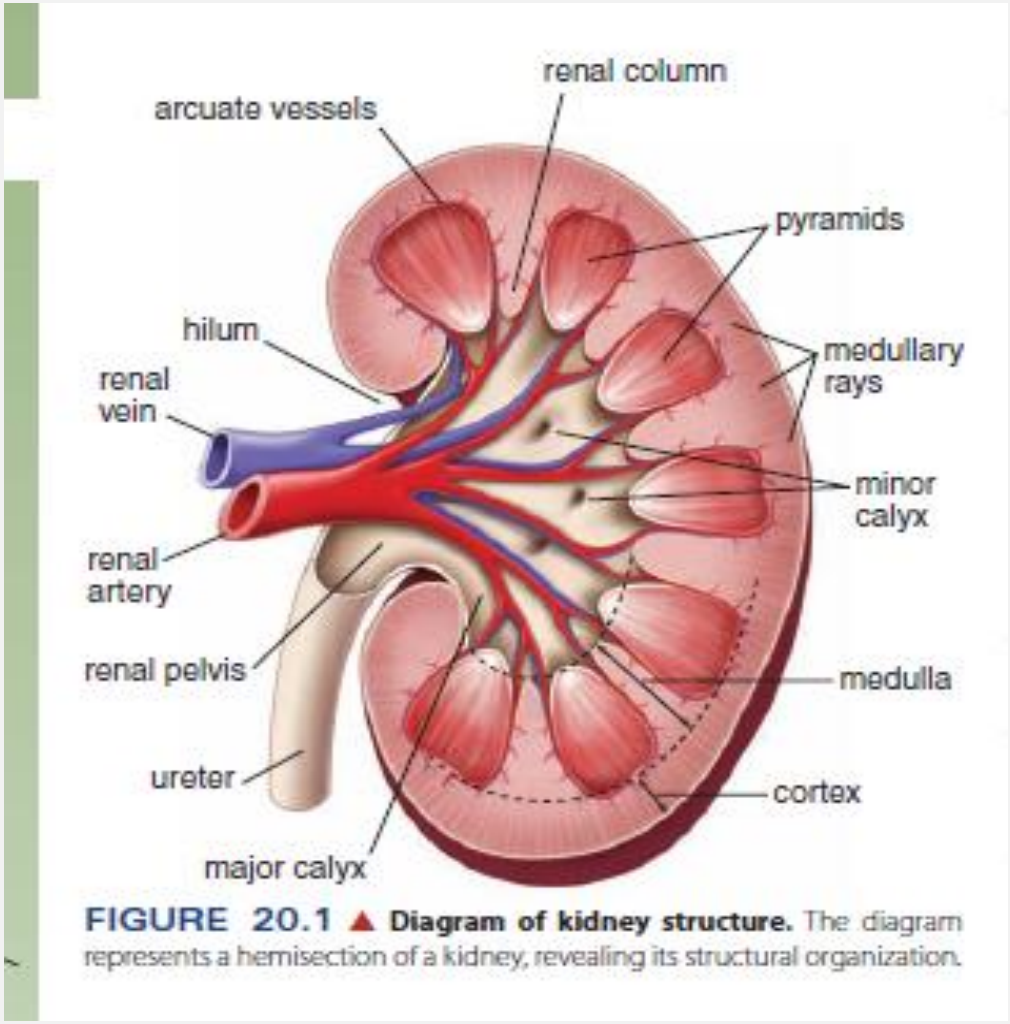


FIGURE 20.1 ▲ Diagram of kidney structure. The diagram represents a hemisection of a kidney, revealing its structural organization.

The **main unit of the medulla is the renal pyramid** that on the coronal section look like triangles lined next to each other with their bases directed toward the cortex and apex to the hilum**.**

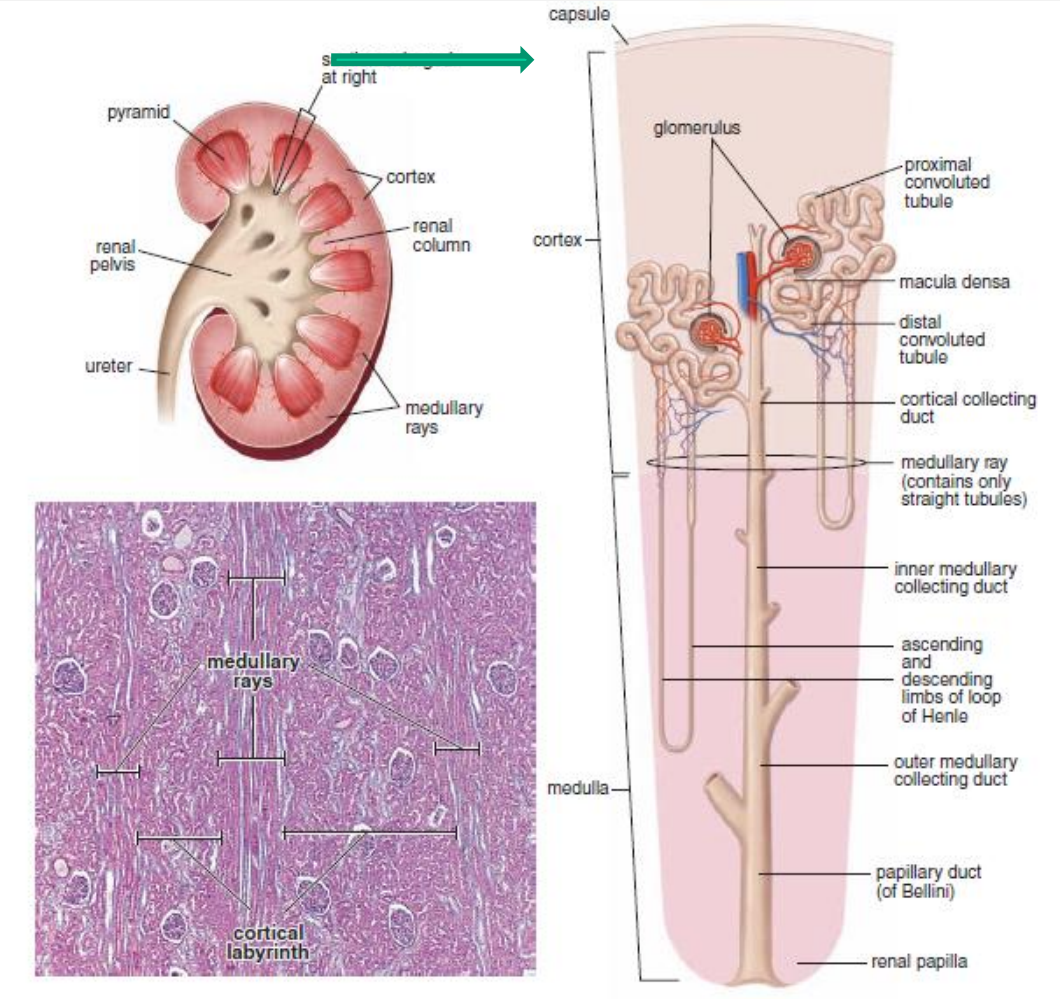
This apical projection is called the **renal papilla** and it opens to a minor calix. Several minor calices unite to form a major calix

The pyramids are separated by extensions of the cortex called the **renal columns**

The **pyramids** contain the functional units of the kidney, the **nephrons**

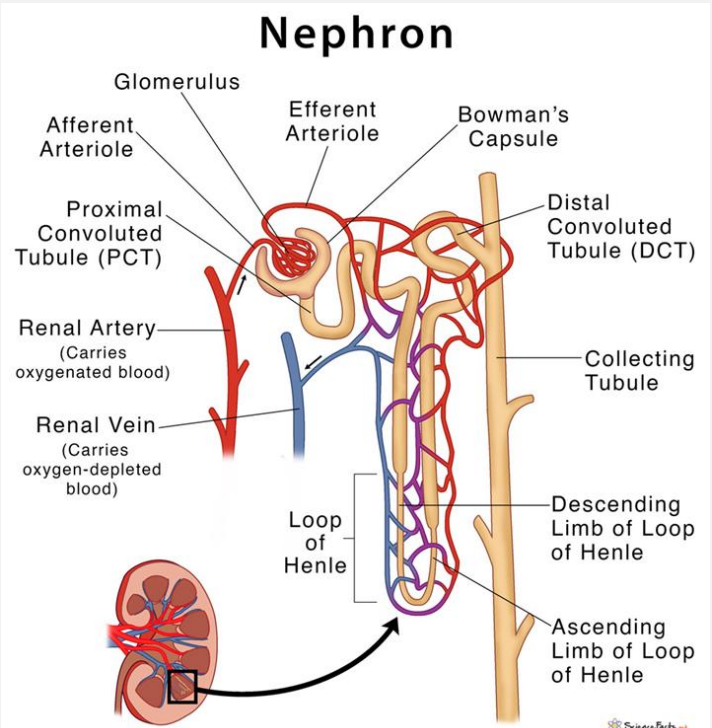
NEPHRON

The nephron **consists** of the **renal corpuscle** and a **tubule system**.



Each nephron is composed of:

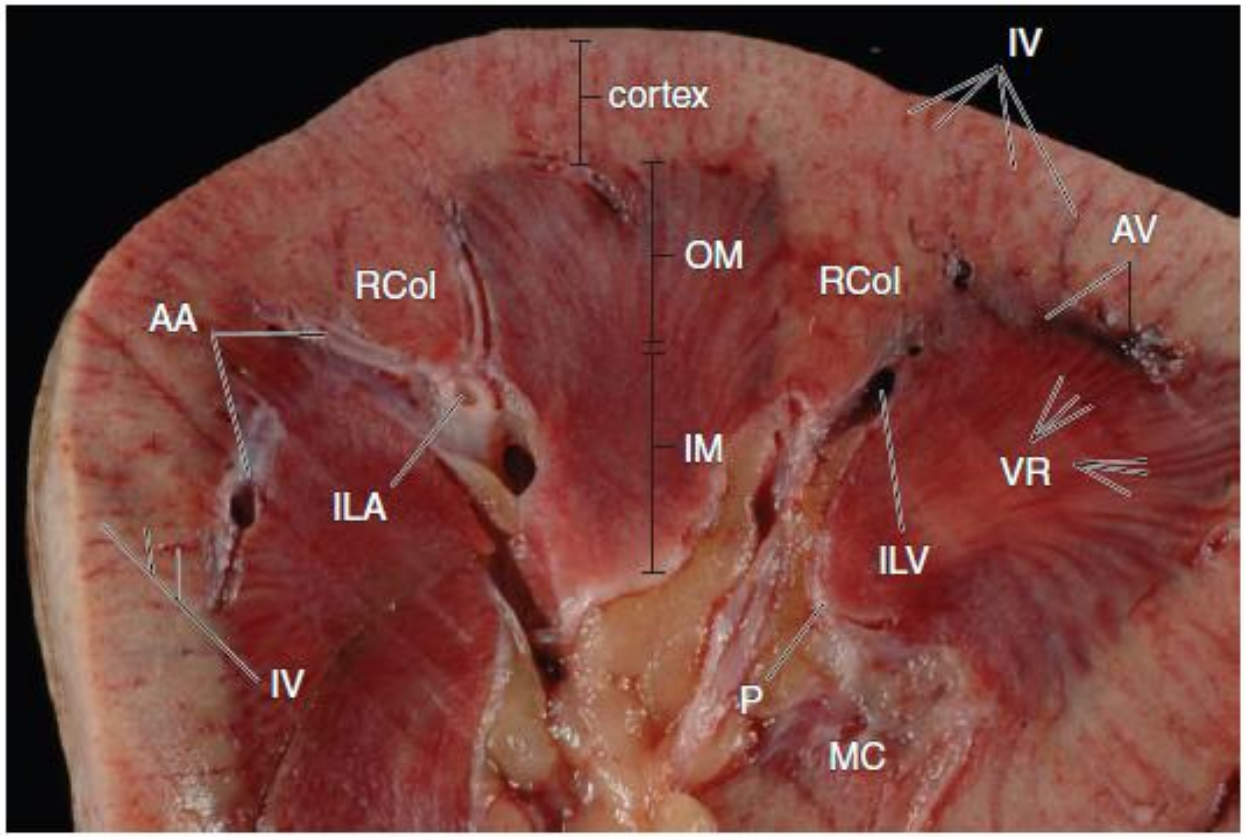
- **Renal corpuscle**
- **Proximal convoluted tubule**
- **Loop of Henle (nephron loop)**
- **Distal convoluted tubule**
- **Connecting tubule** *(or collecting segment)*



KIDNEY

A frontal section through the cortex and medulla of an un-embalmed kidney obtained from autopsy is shown here.

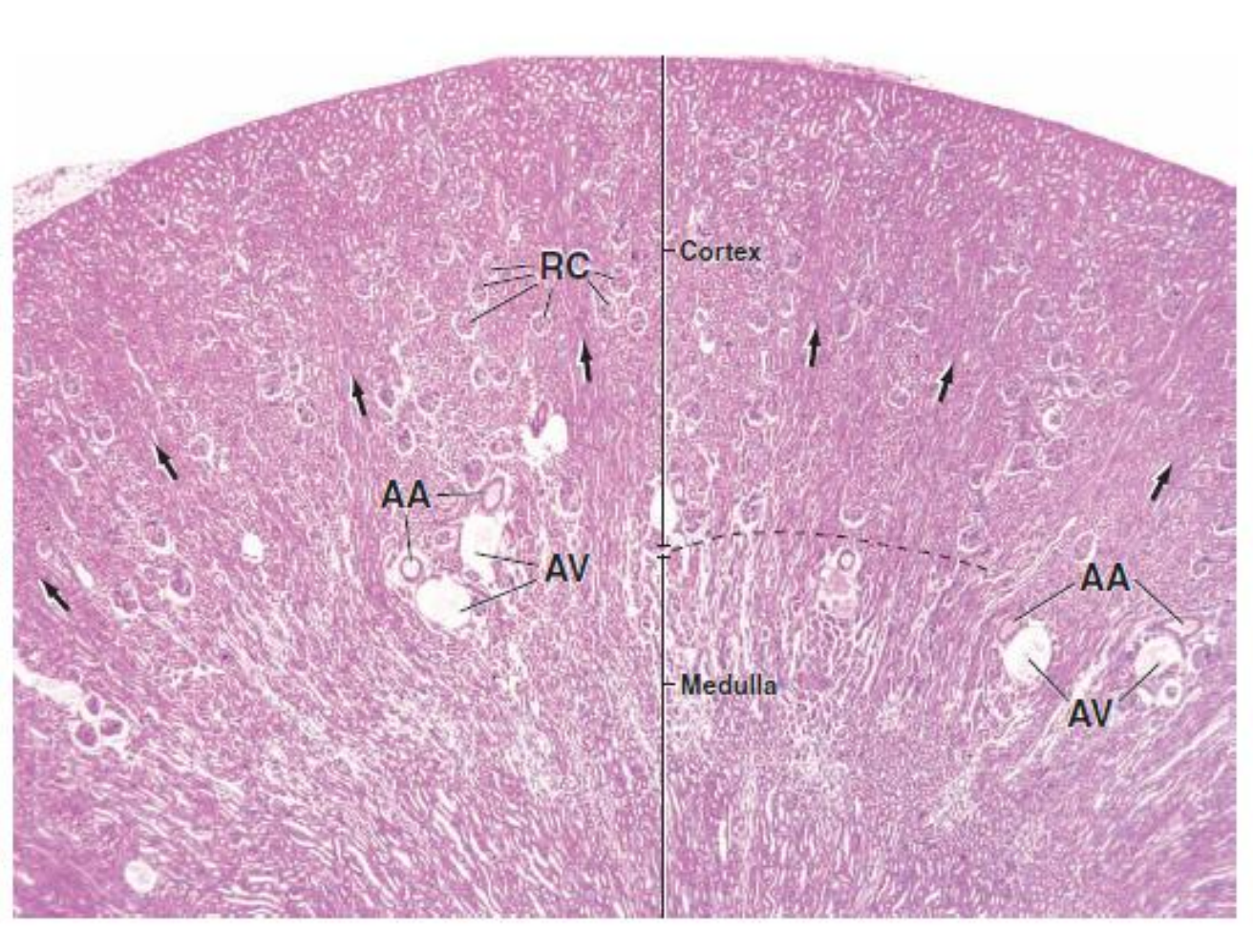
Kidney, human, fresh specimen
3X



AA, arcuate arteries
AV, arcuate veins
ILA, interlobar artery
ILV, interlobar vein
IM, inner medulla
IV, interlobular vessels
MC, minor calyx
OM, outer medulla
P, papilla
RCol, renal column
RC, renal corpuscles
VR, vasa recta
arrows, medullary rays
dashed line, boundary between cortex and medulla

KIDNEY

Cortex and medulla, kidney, human, H&E 20X.



AA, arcuate arteries
AV, arcuate veins
ILA, interlobar artery
RC, renal corpuscles

KIDNEYS

Internal anatomy

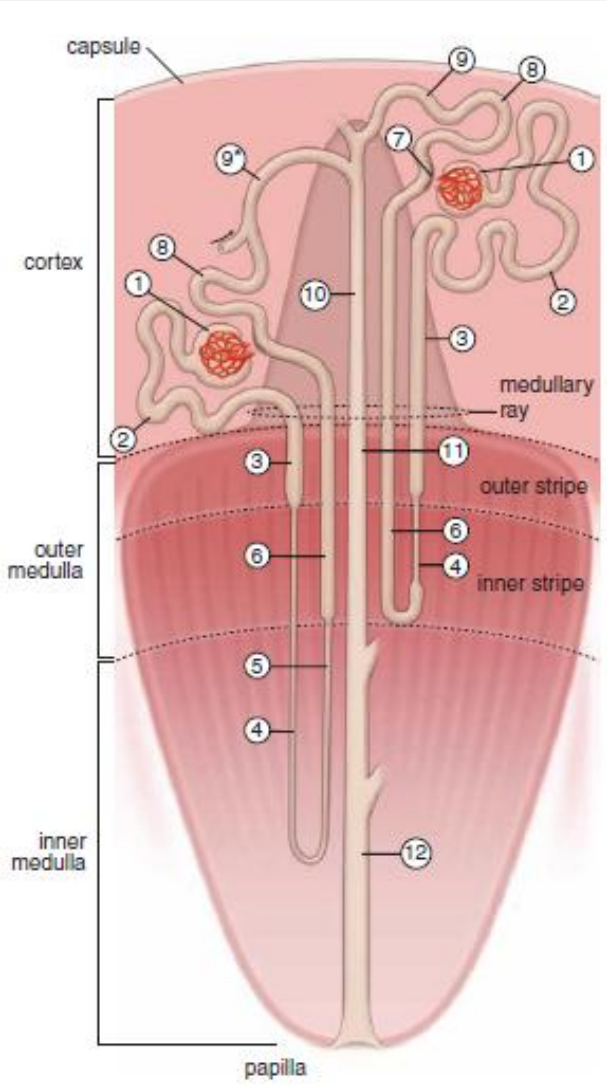


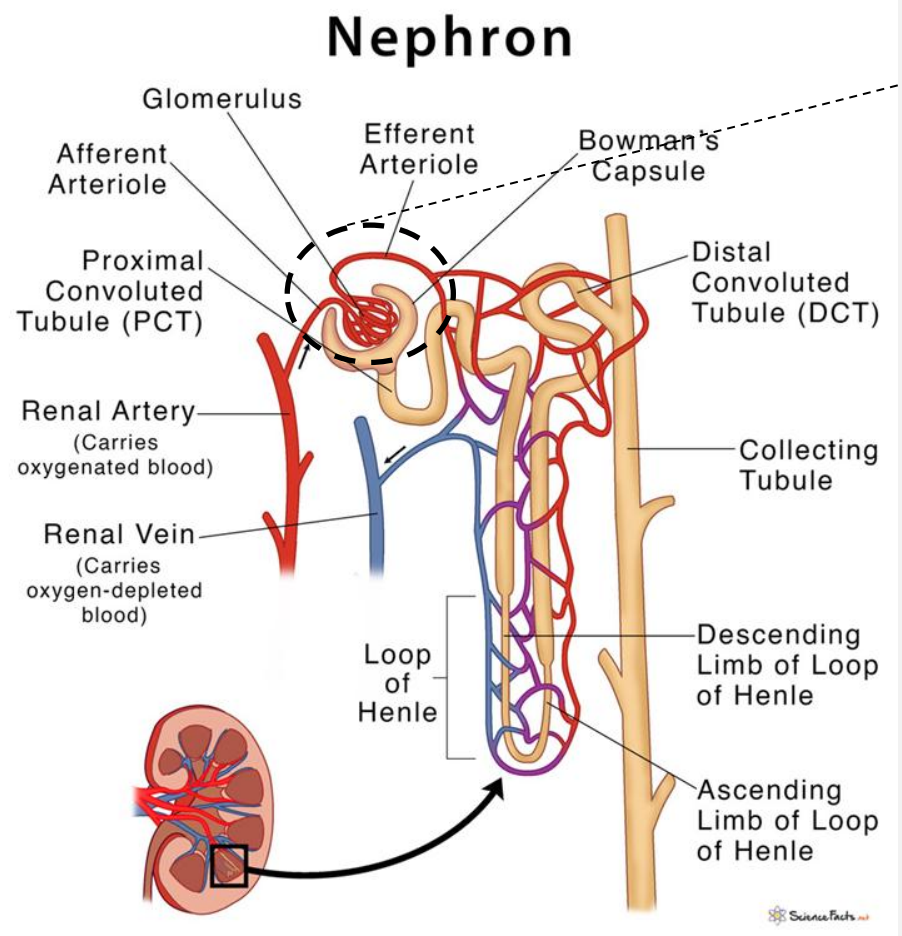
FIGURE 20.3 ▲ **Diagram showing standard nomenclature for structures in the kidney**.
The two types of nephrons in the kidney are shown with their associated duct systems. A long-looped nephron is shown on the left, and a short-looped nephron is shown on the right. The relative position of the cortex, medulla, papilla, and capsule are indicated (not drawn to scale).

The inverted cone-shaped area in the cortex represents a medullary ray. The parts of the nephron are indicated by number: 1, renal corpuscle including the glomerulus and Bowman's capsule; 2, proximal convoluted tubule; 3, proximal straight tubule; 4, descending thin limb; 5, ascending thin limb; 6, thick ascending limb (distal straight tubule); 7, macula densa located in the fi nal portion of the thick ascending limb; 8, distal convoluted tubule; 9, connecting tubule; 9*, connecting tubule of the juxtamedullary nephron that forms an arch (arched connecting tubule); 10, cortical collecting duct; 11, outer medullary collecting duct; and 12, inner medullary collecting duct.

(Modified from Kriz W, Bankir L. A standard nomenclature for structures of the kidney. The Renal Commission of the International Union of Physiological Sciences (IUPS). Kidney Int 1988;33:1–7.)

Structure of the renal corpuscle

Ball-shaped structure composed of a glomerulus (a tuft of capillaries) surrounded by Bowman's capsule (an expansion of the tubule). It is always located in the cortical region of the kidney.



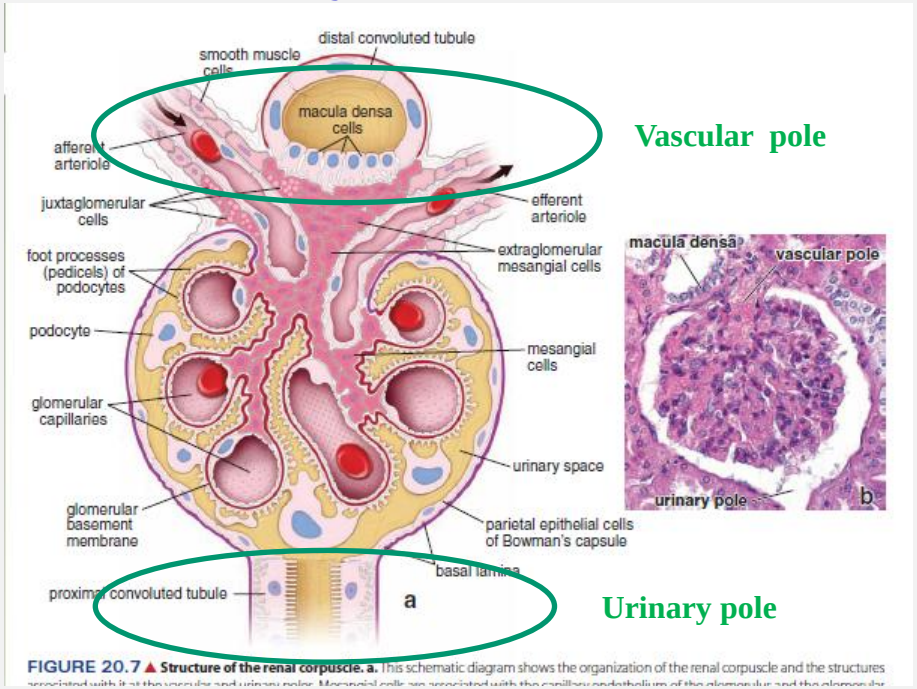


FIGURE 20.7 ▲ **Structure of the renal corpuscle. a.** This schematic diagram shows the organization of the renal corpuscle and the structures associated with it at the vascular and urinary poles. Mesangial cells are associated with the capillary endothelium of the glomerulus and the glomerular

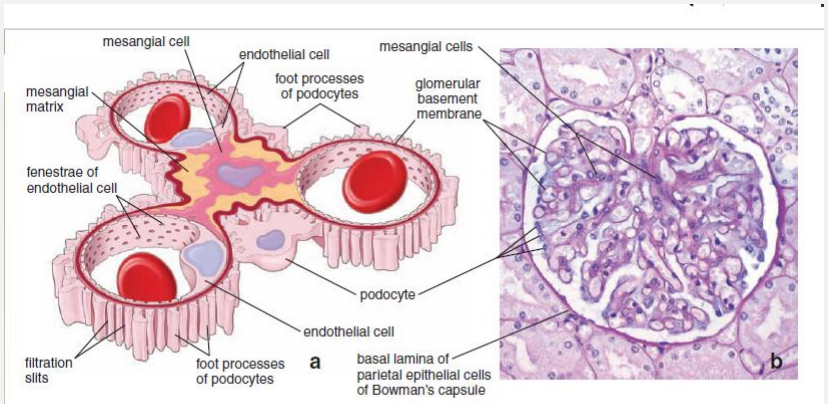
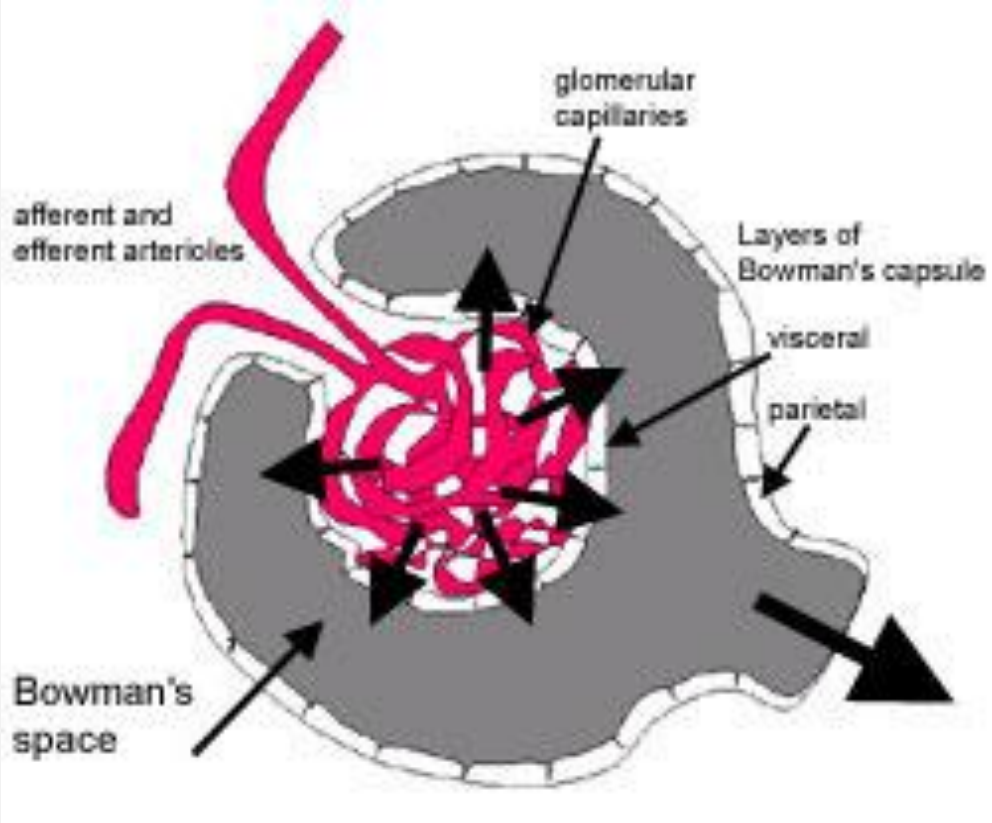


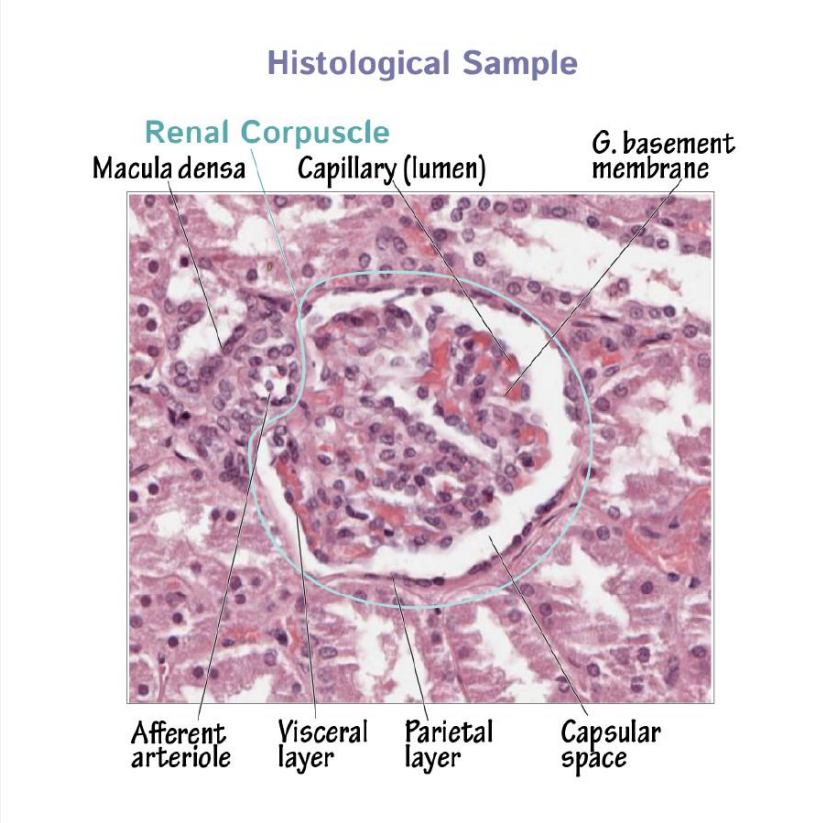
FIGURE 20.16 ▲ **Diagram and photomicrograph showing the relationship between the intraglomerular mesangial cells and the glomerular capillaries. a.** The mesangial cell and its surrounding matrix are enclosed by the glomerular basement membrane (GBM) of the glomerular capillaries. The mesangial cells are in the same compartment as the endothelial cells and can be intimately associated with the GBM as well

The portion of the glomerulus traversed by arterial structures is called the **vascular pole**, while the portion located between the renal corpuscle and the renal tubule is called the **urinary pole**.

Structure of the renal corpuscle: layers

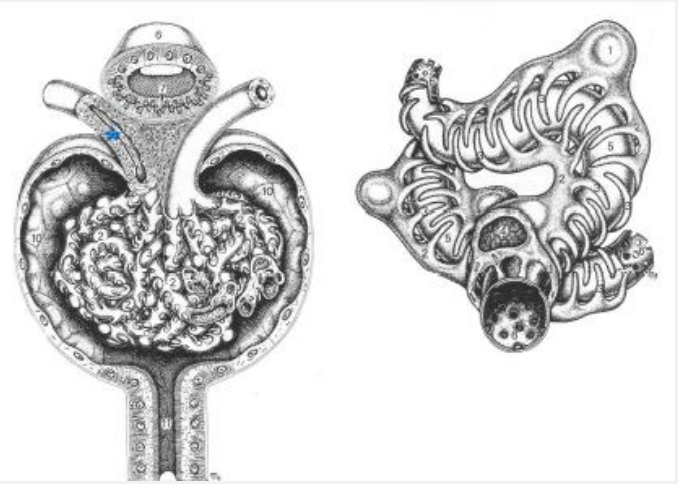
Bowman's capsule surrounds the arterial glomerulus, forming a double-walled cup.
The epithelium of the outer layer (parietal layer), at the level of the vascular pole, folds inward and continues as the inner layer (visceral layer).

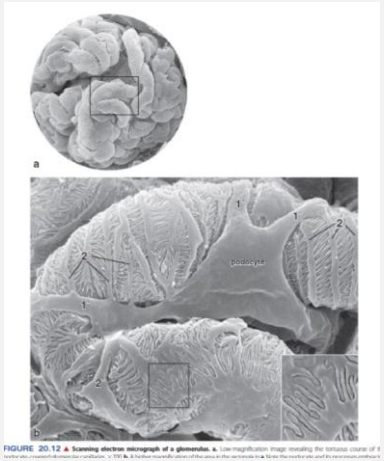


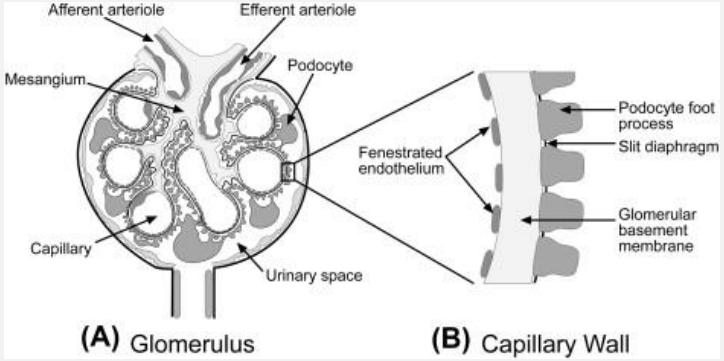


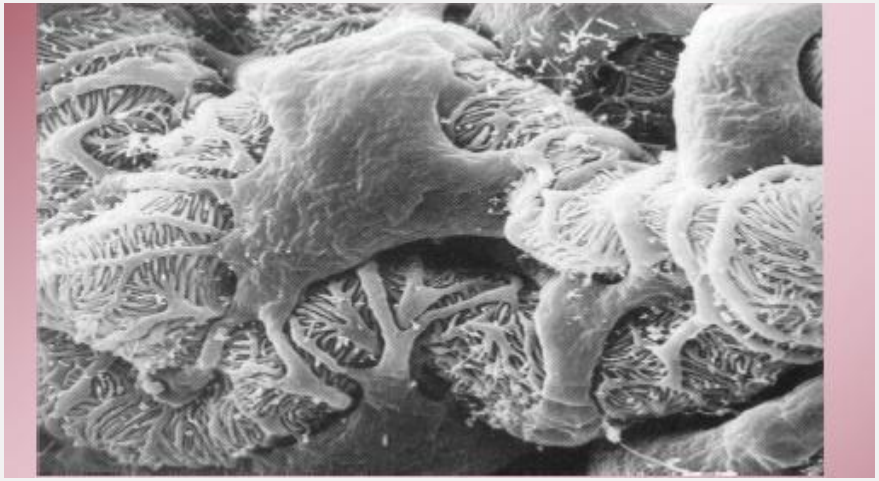
ARTERIAL GLOMERULUS: FILTRATION BARRIER

The muscular layer of the afferent arteriole, at the vascular pole, is replaced by epithelioid cells, known as juxtaglomerular cells.





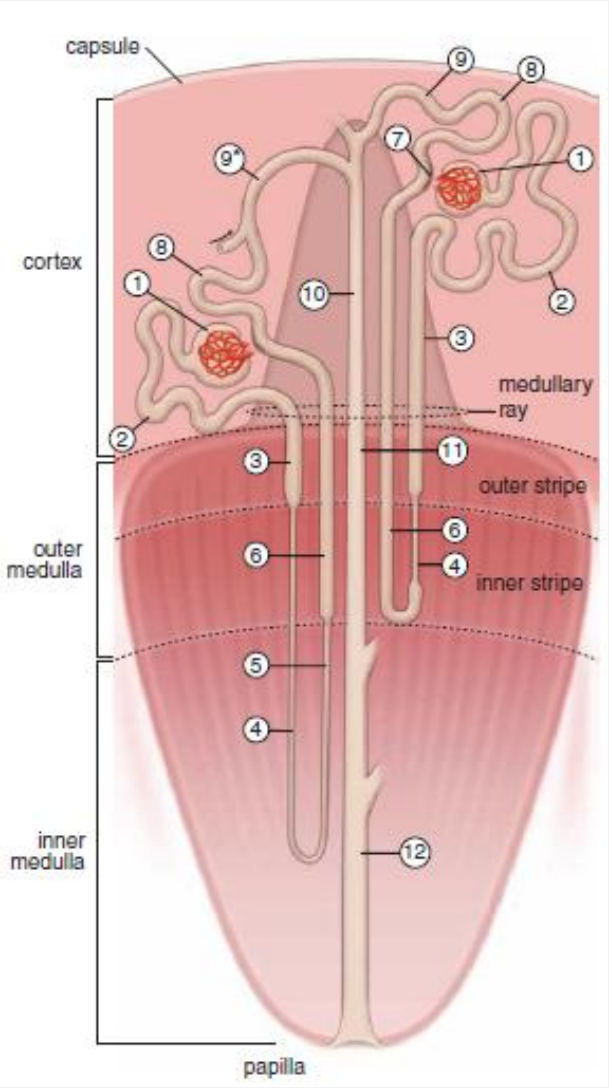




The afferent arteriole presents resistance to blood flow, causing an increase in pressure within the glomerular capillaries.

The filtered fluid passes through a filtration barrier, composed of
-Endothelial cells of the capillaries
-Basement membrane
-Visceral layer of Bowman’s capsule

Types of Nephrons



Several types of nephrons are identified based on the location of their renal corpuscles in the cortex (see Fig.

- **Subcapsular nephrons** or **cortical nephrons** have their renal corpuscles located in the outer part of the cortex.

- **Juxtamedullary nephrons** make up about one-eighth of the total nephron count. Their renal corpuscles occur in proximity to the base of a medullary pyramid. They have long loops of Henle and long ascending thin segments that extend well into the inner region of the pyramid.

- **Intermediate nephrons** or **midcortical nephrons** have their renal corpuscles in the midregion of the cortex

FUNCTIONAL ROLE OF THE NEPHRON

In the nephron, three processes occur that lead to urine formation:

- **Glomerular filtration** → occurs in the renal corpuscle and represents the initial step of urine formation
- **Tubular reabsorption** → allows recovery of useful substances along the tubules
- **Tubular secretion** → contributes to fine regulation of ions and waste elimination

👉 From an **anatomical perspective**, these processes are associated with specific nephron segments.
👉 Their **mechanisms and regulation** (hormonal control, transport systems, pressures) belong to the **Physiology module**.

FUNCTIONAL ROLE OF THE NEPHRON

In the nephron, three processes occur that lead to urine formation:

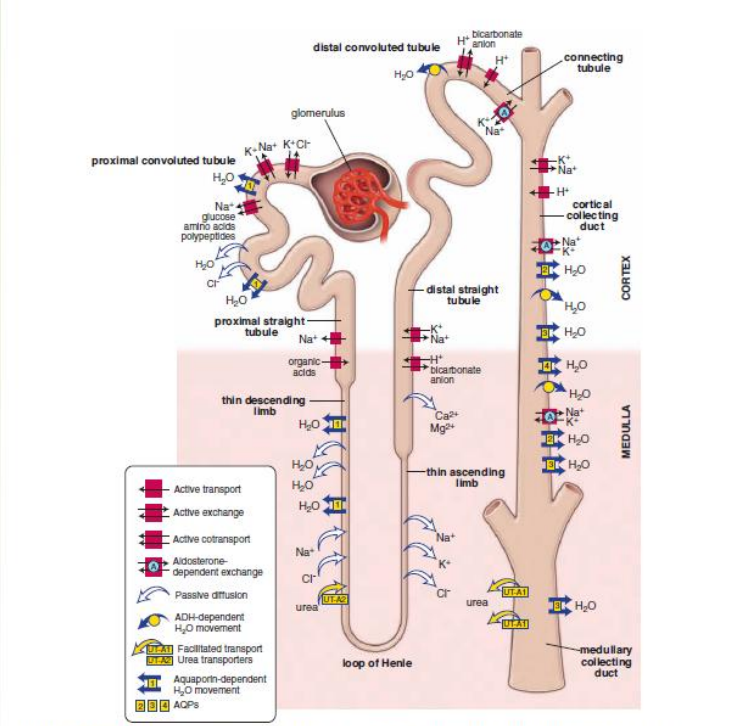
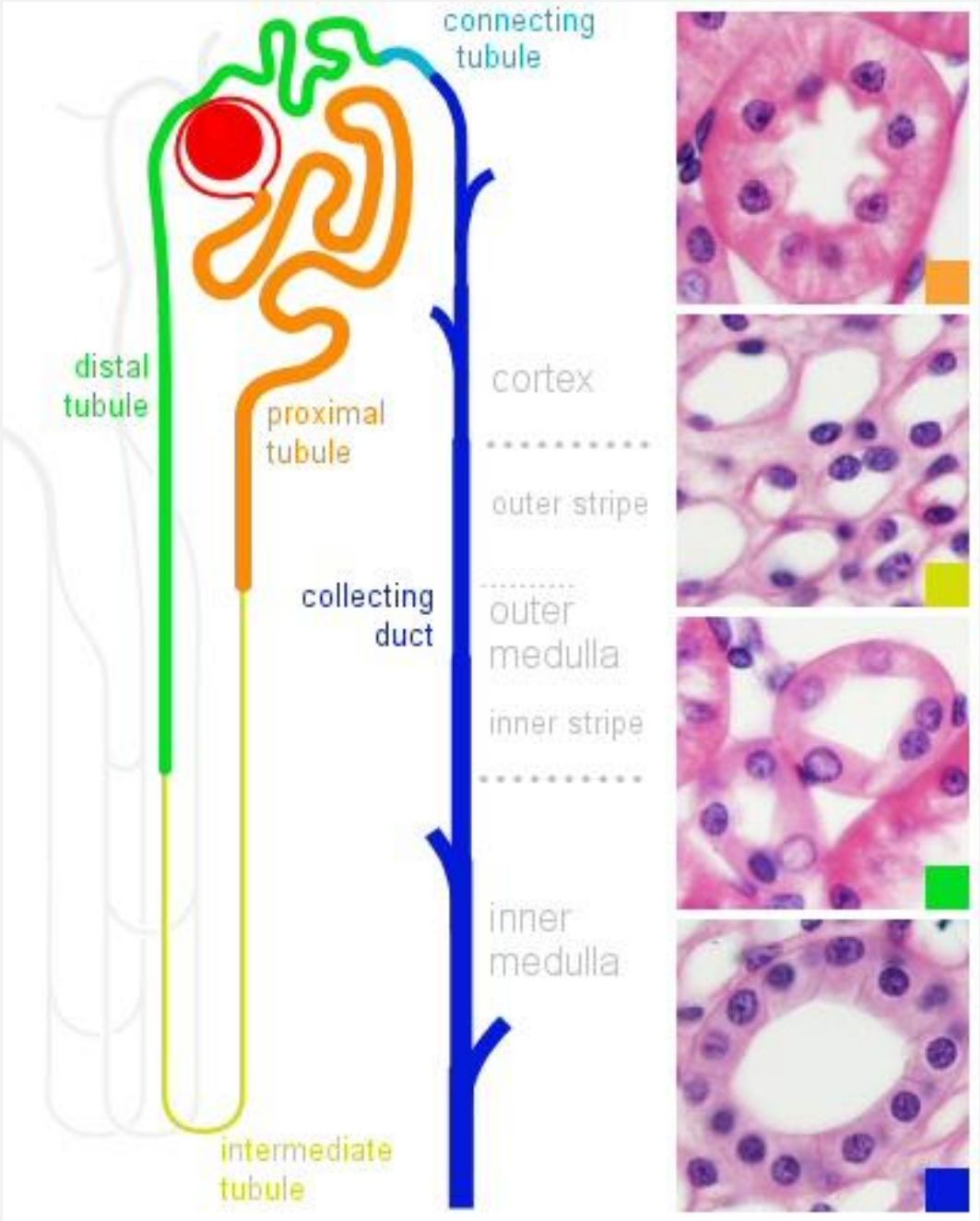
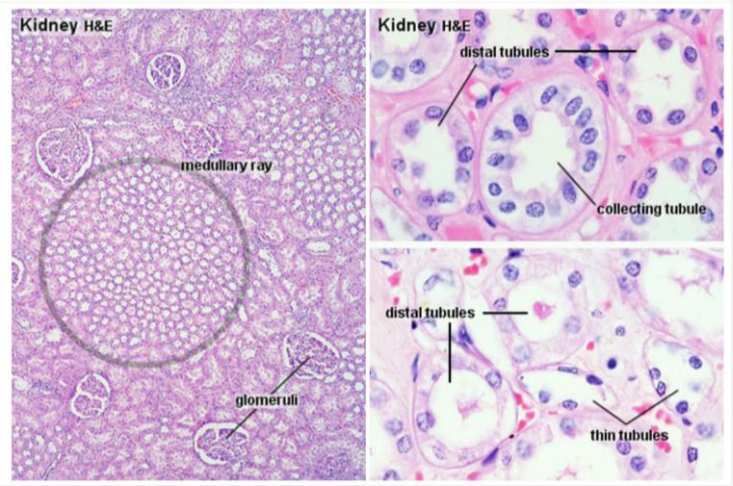


FIGURE 20.23 ▲ **Diagram showing movement of substances into and out of the nephron and collecting system.** The *symbols* indicate the mode of transport as well as specific molecule-dependent transporters that act on the nephron and collecting ducts (as noted in the key).

👉 Their **mechanisms and regulation** (hormonal control, transport systems, pressures) belong to the **Physiology module**.

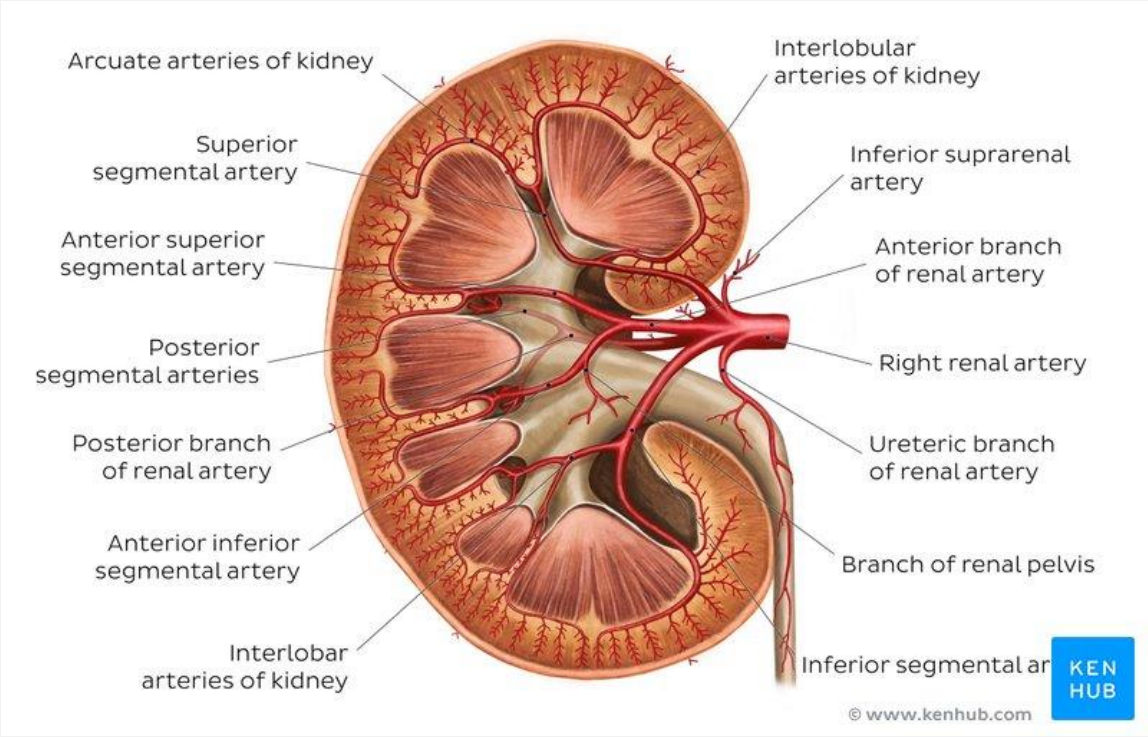


Each segment of the nephron has a **specific structure (morphology)** that reflects its **specific function**.



- **Proximal tubule**
- Rich in microvilli → **high reabsorption capacity**
- **Loop of Henle**
- Thin and thick segments → **osmotic gradient formation**
- **Distal tubule**
- Fewer microvilli → **fine regulation of ions**

Kidneys: Vasculature and lymphatic drainage



Arteries

Each kidney is supplied by a single renal artery, which is a direct lateral branch of the abdominal aorta. Both renal arteries, left and right, arise just below the superior mesenteric artery, with the left renal artery positioned slightly superiorly to the right one.

Veins and lymphatics

Each kidney has a single renal vein which conducts the blood out of the kidney and is positioned anterior to the artery. The renal veins empty to the inferior vena cava, so the right vein is shorter because the inferior vena cava runs closer to the right kidney. The left renal vein passes anteriorly to the aorta just below the trunk of the superior mesenteric artery, which is risky because it can be compressed by one of those two. This is called the nutcracker phenomenon

Concerning lymphatic drainage, each kidney drains into the lateral aortic (lumbar) lymph nodes, which are placed around the origin of the renal artery.

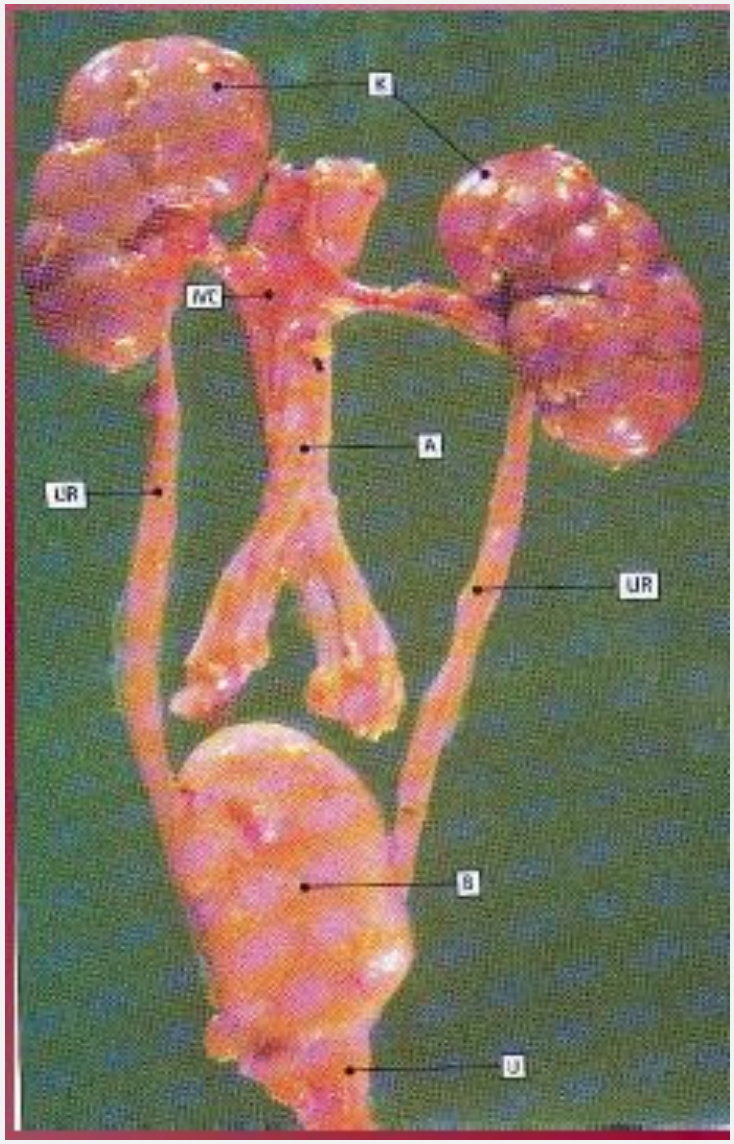
Kidneys: Innervation

The kidneys are innervated by the renal plexus. This plexus provides input from:

- the sympathetic nervous system from the lower thoracic splanchnic nerves for the regulation of the vascular tone, and from
- the parasympathetic nervous system as well, through the vagus nerve.

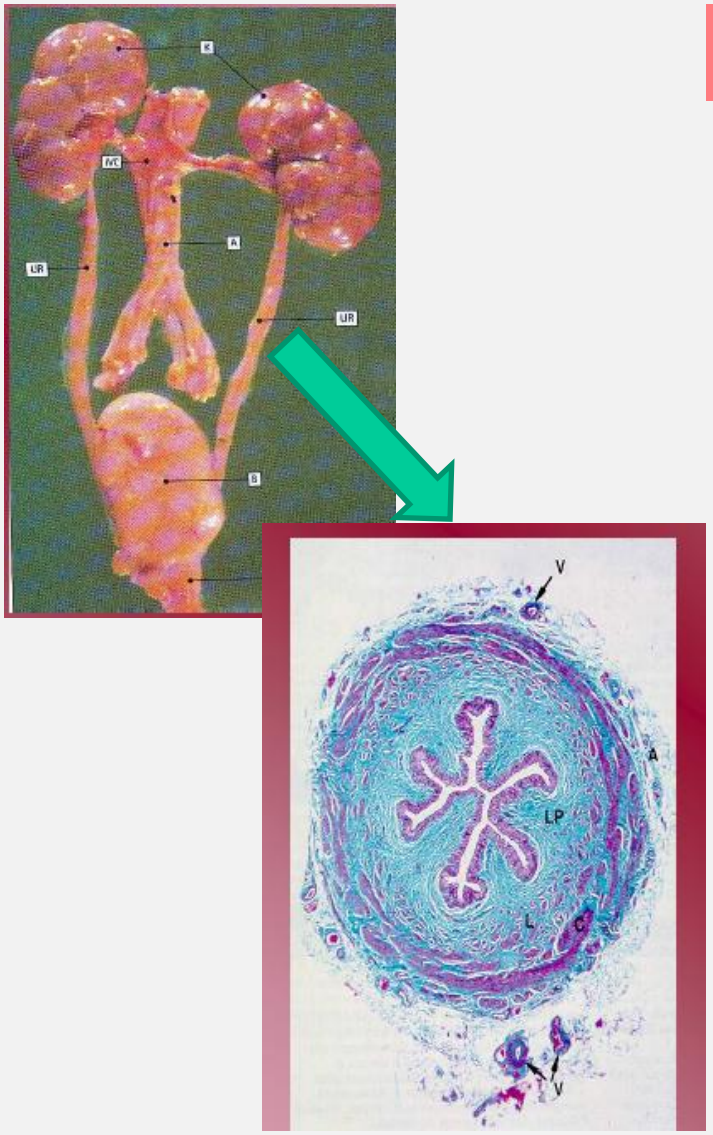
The sensory nerves from the kidney travel to the spinal cord at the levels T10-T11, which is why the pain in the flank region always rises suspicions that something is wrong with the corresponding kidney.

URINARY SYSTEM



- **RENAL PELVIS**
- **UTERETERS**
- **BLADDER**
- **URETHRA**

URINARY TRACT



UTERETER

•The adult ureter is a thick-walled muscular tube, 25 - 30 cm in length, running from the kidney to the urinary bladder.

•Anatomically can be described in two parts the abdominal part (*pars abdominalis*) and pelvic part (*pars pelvina*).

•The ureter is composed of three layers: outer fibrous layer (*tunica adventitia*), muscular layer (*tunica muscularis*) and mucous layer (*tunica mucosa*).

•The muscular layer has also been described as being subdivided into 3 fibre layers:

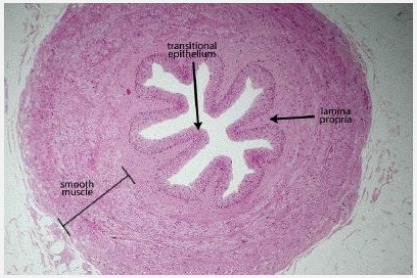
1.an external longitudinal

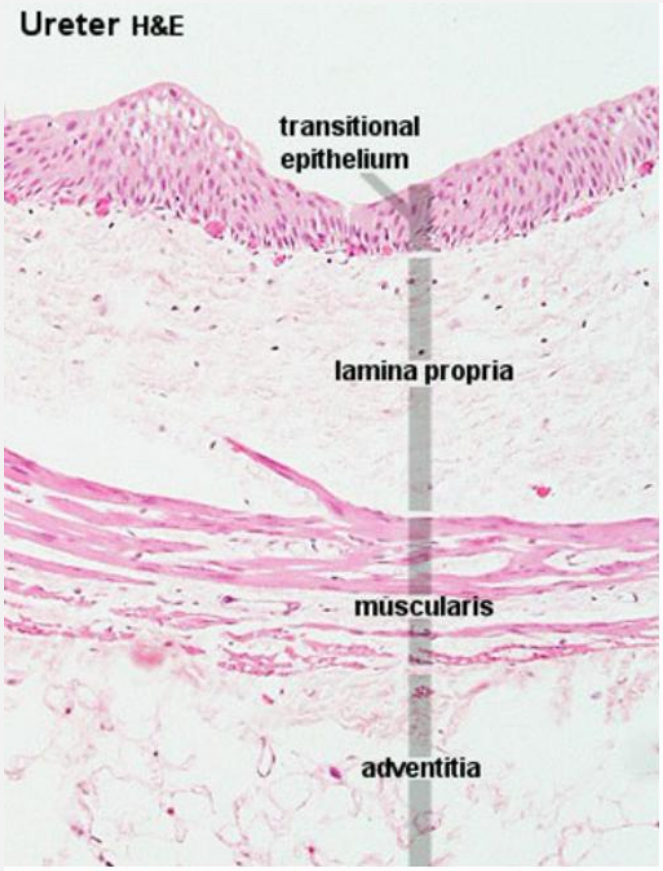
2.a middle circular

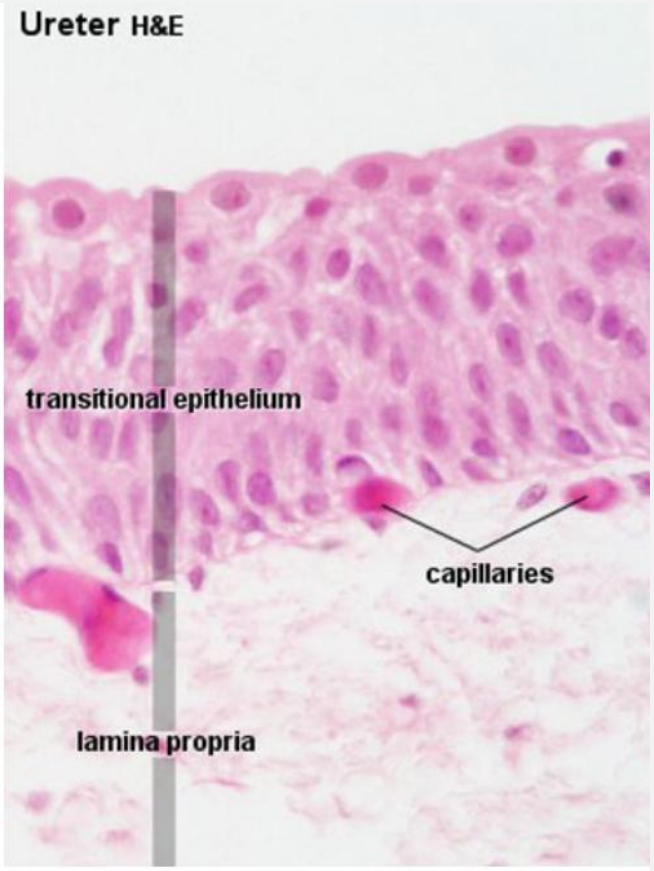
3.an internal longitudinal

The thick muscular wall of the ureters pushes urine into the bladder through peristaltic contractions and causes the mucosa to form large folds when the lumen is empty

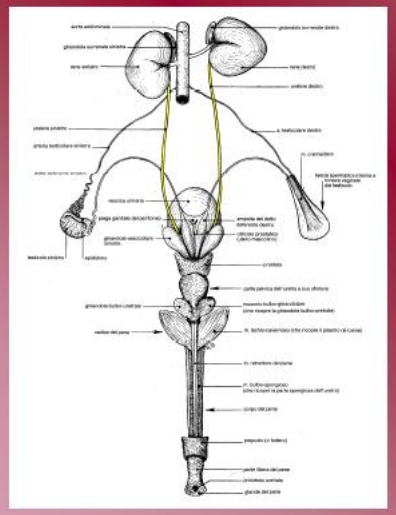
UTERETER


transitional epithelium
lamina propria
smooth muscle


Ureter H&E
transitional epithelium
lamina propria
muscularis
adventitia

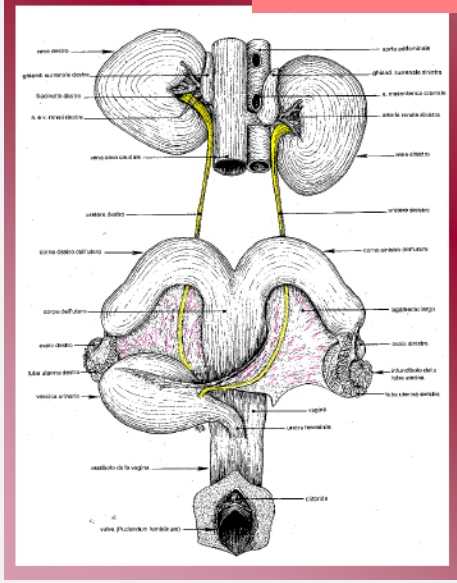

Ureter H&E
transitional epithelium
capillaries
lamina propria

URETERS MALES



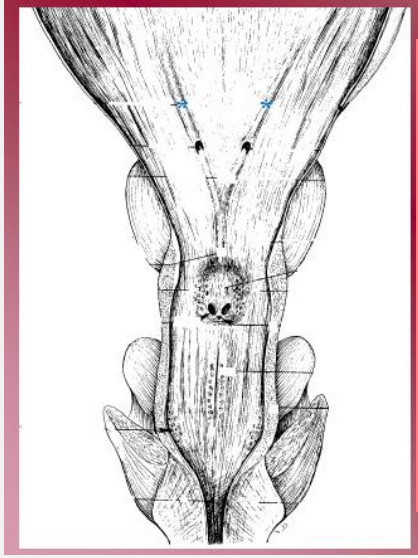
Along its course, it **crosses the ductus deferens (vas deferens)**

URETERS FEMALES



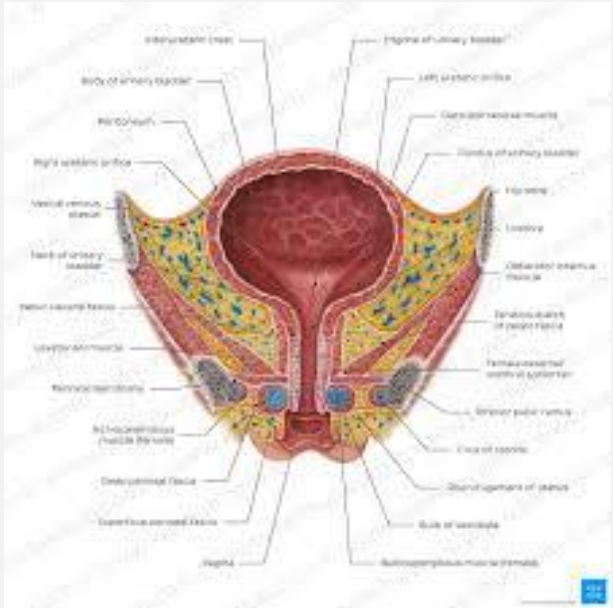
- It runs **in the thickness of the broad ligament of the uterus**
- It can be **dorsal or ventral to the vagina**
- It enters the bladder similarly to the male

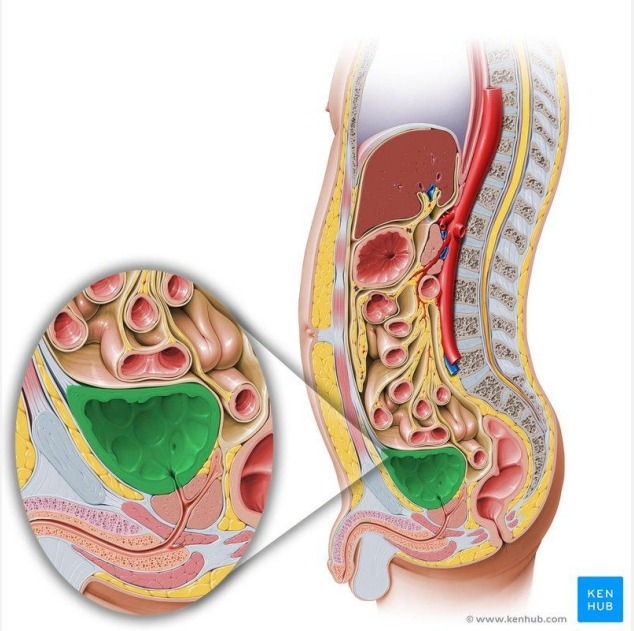
URETERIC COLUMNS (COLUMNAE URETERICAE)



- The ureter enters the bladder at an **acute angle**, preventing urine reflux when the bladder is full
- It first penetrates the **smooth muscle layer**, then runs in the **submucosa (forming the ureteric columns)**, and finally crosses the mucosa

URINARY BLADDER





The **urinary bladder is a hollow, muscular**, and distensible organ that sits on the pelvic floor and below the peritoneum.

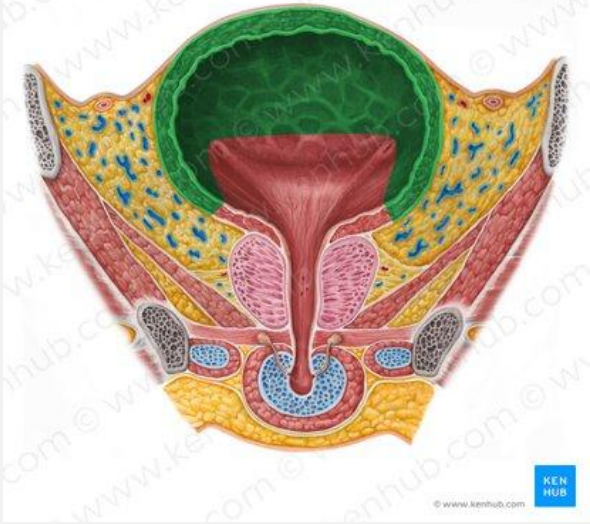
Generally, when empty it is pear-shaped with an **apex, a base (fundus**), **neck**, superior surface and two inferolateral surfaces.

However, the size, shape, position, and relationships to adjacent structures of the bladder can change considerably depending on the amount of urine it holds.

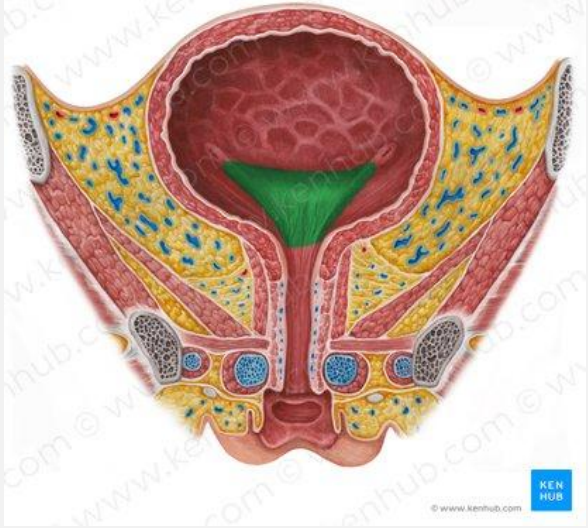
URINARY BLADDER

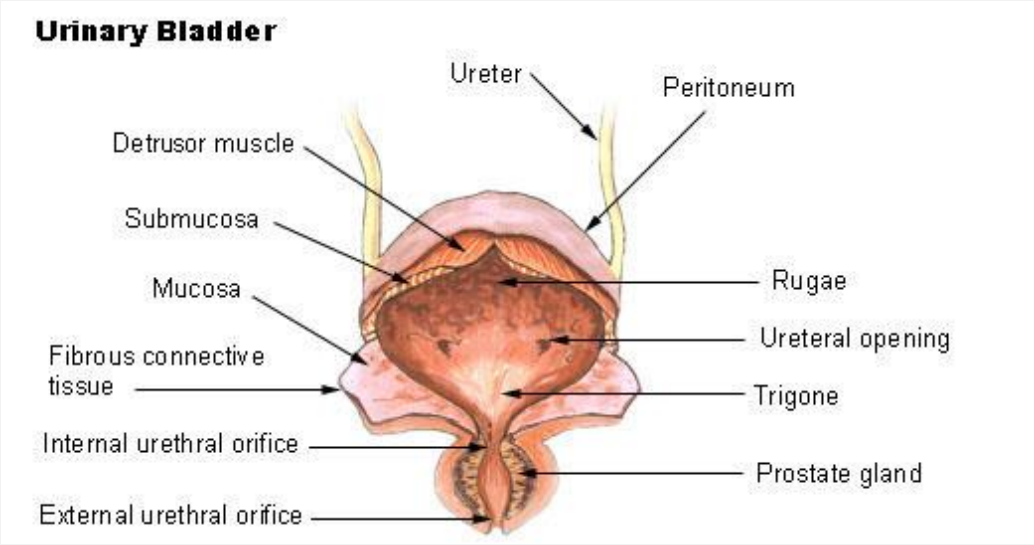
Fundus of urinary bladder (In green)

Body of urinary bladder

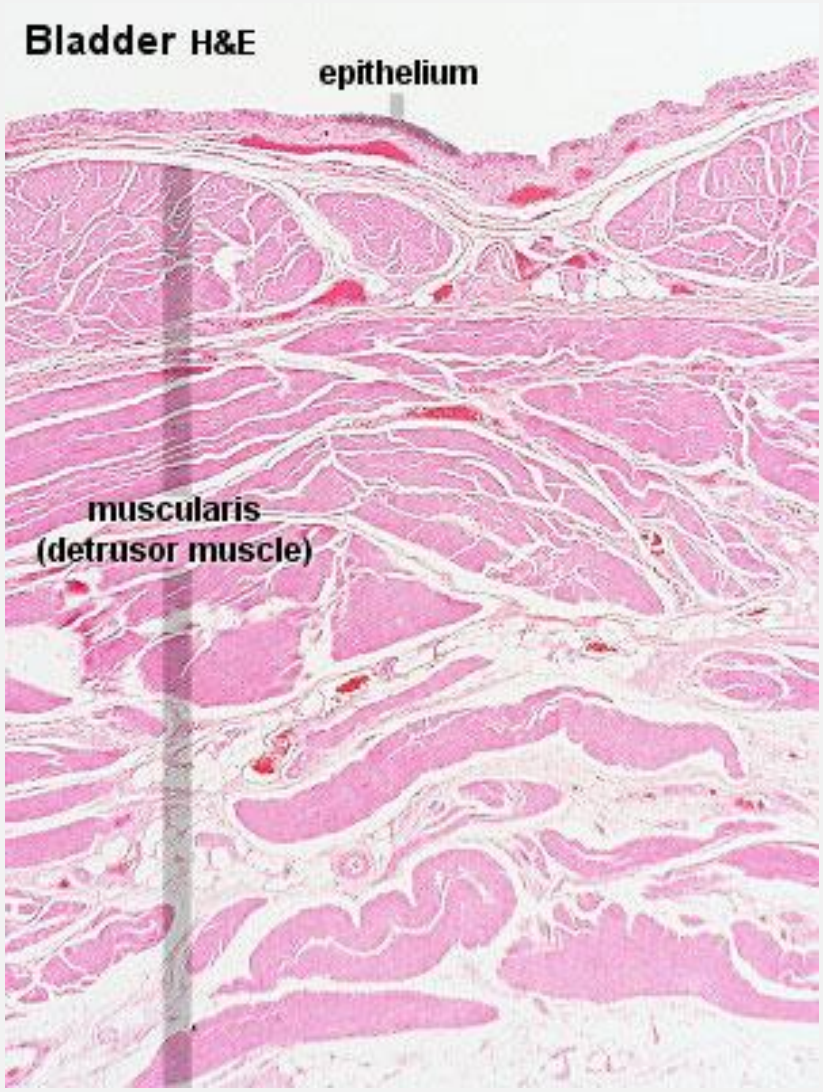


Trigone of urinary bladder





Bladder Histology



Can be described anatomically by its 4 layers from inside outward:

- **Mucosa** - (mucus layer) a transitional epithelium layer formed into folds (rugae).
- **Submucosa** - connects the muscular layer with the mucous layer.
- **Muscular** - the detrusor muscle is the muscle of the urinary bladder wall.
- **Serous** - the superior or abdominal surfaces and the lateral" surfaces of the bladder are covered by visceral peritoneum, the serous membrane (serosa) of the abdominal cavity, consisting of mesthelium and elastic fibrous connective tissue.

- The adult **detrusor muscle** consists of three layers of smooth (involuntary) muscle fibres.
  - internal layer - fibres arranged longitudinally
  - middle layer - fibres arranged circularly
  - external layer - fibres arranged longitudinally

Bladder: Blood supply

Arteries.

The urinary bladder receives arterial supply from branches of the anterior trunk of the internal iliac arteries.

Its anterosuperior aspects are supplied by the superior vesical arteries.

In males, the fundus and neck of the bladder are supplied by the inferior vesical arteries.

In females, however, this role is taken over mainly by the vaginal arteries, which provide small branches to the posterior and lower parts of the bladder

Veins

The veins that drain blood from the urinary bladder form a plexus around its inferolateral surfaces which ultimately drains into the internal iliac veins.

In males, the vesical venous plexus merges with the prostatic venous plexus forming a combined network that surrounds the base of the bladder and prostate, along with the seminal glands, the ductus deferentes, and the lower portions of the ureters.

In females, the vesical venous plexus surrounds the pelvic segment of the urethra and the neck of the bladder. This plexus typically empties into the internal iliac veins via the inferior vesical veins but could potentially empty into the vertebral venous plexuses through the sacral veins.

Bladder: Innervation

The urinary bladder receives autonomic innervation from the vesical plexuses composed of sympathetic and parasympathetic nerve fibres.

- Sympathetic fibers reach the vesical plexus via hypogastric nerves from the inferior mesenteric ganglion, which is supplied by the lumbar splanchnic nerves from the sympathetic lumbar outflow T10-T11. These fibers prevent urination by promoting detrusor relaxation and internal sphincter contraction.

- Parasympathetic nerve fibers, reach the vesical plexus via pelvic splanchnic nerves which are from the parasympathetic sacral outflow. In contrast to the sympathetic, the parasympathetic innervation facilitates urination by causing contraction of the detrusor muscle and relaxation of the internal sphincter.

Somatic innervation of the urinary bladder comes via the **pudendal nerves** (S2-S4), which also innervate the striated muscle of the pelvic floor and the external urethral sphincter. The hypogastric, pelvic splanchnic and pudendal nerves all have afferent components mainly involved in the sensation of pain and the perception of stretching.

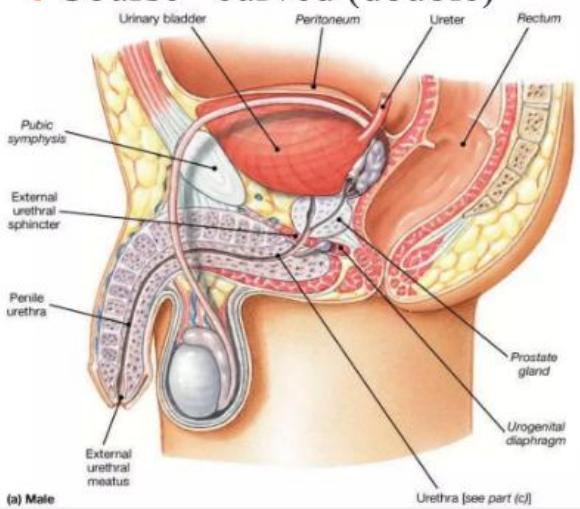
URETHRA

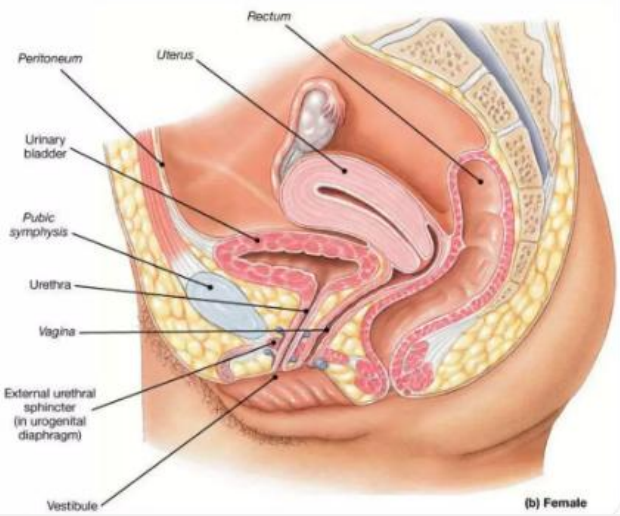
The urethra is a muscular tube that serves as the excretory canal for the urinary bladder, responsible for conveying urine from the bladder to the exterior of the body.

the anatomical path of the urethra differs between males and females

difference

Male urethra	Female urethra
1 Long	1 Short,,
2 Length= 18- 20 cm	2 Length= 4 cm
3 Function—	3 Function—only urination
i) urination	4 Course– nearly straight
ii) ejaculation of semen	5 Foley cathetarisation is easy
4 Course– curved (double)	





Urethra: Blood supply

Arteries

The urinary bladder is supplied by branches of the internal iliac artery: the superior and inferior vesical arteries (in males). Note that the latter are replaced by vaginal arteries in females. Venous blood is conveyed by similarly named veins that accompany the arteries. Together these veins form the vesical venous plexus, which ultimately drain into the internal iliac vein.

The urethra is also supplied by branches of the internal iliac artery. In males, supply is provided by the inferior vesical and middle rectal arteries.

Veins

Venous blood is drained into the prostatic venous plexus and then the internal iliac vein. The female urethra is supplied by the internal pudendal and vaginal arteries and drained by similarly named veins

Urethra: Innervation

Innervation comes from the inferior hypogastric plexus.

Both male and female urethrae are innervated by the vesical plexus which originates from the inferior hypogastric plexus.

Additional innervation is provided by the pudendal nerve for the female urethra and the prostatic plexus for the proximal male urethra.