

كلية المستقبل الجامعة قسم الفيزياء الطبية
المرحلة الثالثة

ANATOMY

(L7)

The Urinary System

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The urinary system

The urinary system consists of the kidneys, ureters, urinary bladder, and urethra, which filter blood and subsequently produce, transport, store, and intermittently excrete urine (liquid waste).

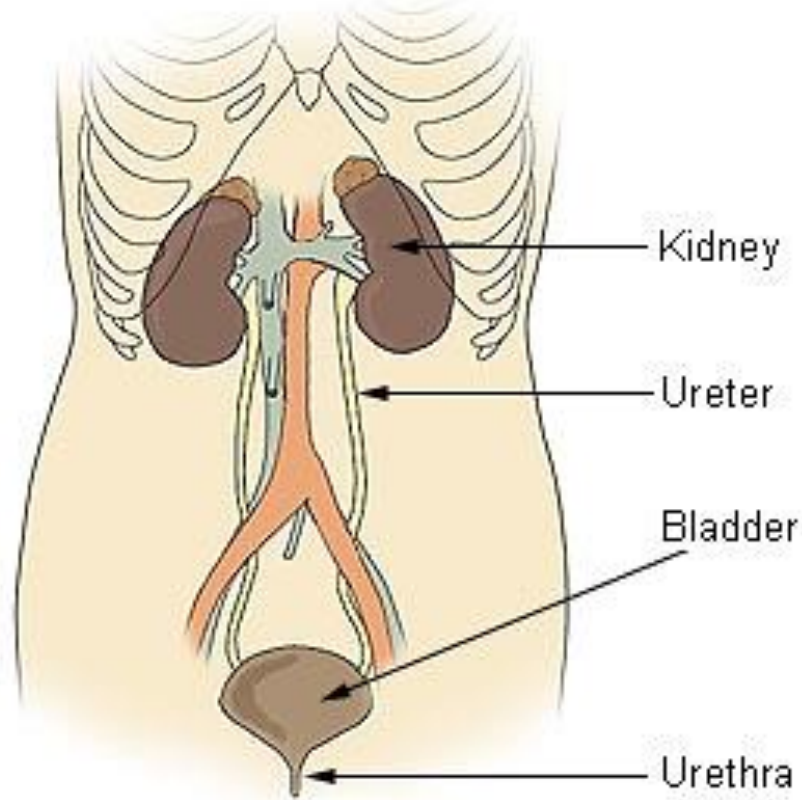
Function	Elimination of the waste from the body, regulation of blood volume, blood pressure, blood pH, electrolytes balance via producing and excreting of urine.
Upper (abdominal) part	Kidneys - paired organs that filter the blood and produce urine; reabsorb useful substances (electrolytes, amino acids), eliminates waste into urine (from food, medications, toxins) Ureters - tubes that transport urine from the kidneys to the urinary bladder
Lower (pelvic part)	Urinary bladder - muscular sac that stores the urine which allows urination to be controlled Urethra - tube that transports urine from the urinary bladder to outside of the body (in males additional function is to transport semen)

Divisions

The system is divisible into upper and lower parts. The upper part located within the abdomen and consists of the kidneys and a large portion of the ureters. The lower part constitutes the pelvic urinary organs, and includes the short portion of the ureters, the urinary bladder and the urethra. The superior urinary organs (kidneys and ureters) and their vessels are primary retroperitoneal structures on the posterior abdominal wall, that is, they were originally formed as, and remain, retroperitoneal viscera. The superomedial aspect of each kidney normally contacts a suprarenal gland, which is enclosed in a fibrous capsule and a cushion of pararenal fat. This gland is referred to as the adrenal gland, and a weak fascial septum separates it from the kidneys so that they are not actually attached

to each other. The suprarenal glands function as part of the endocrine system, secreting hormones like aldosterone. They completely separate in function from the kidneys and/or the urinary system.

Components of the Urinary System



Kidneys: external structures

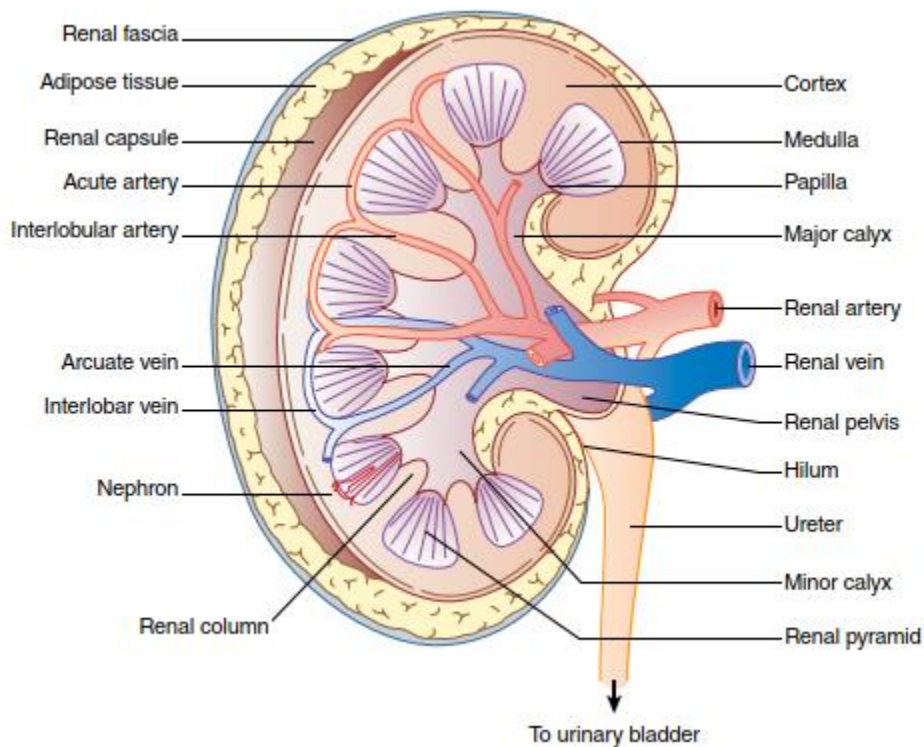
There are two kidneys, one on each side of the spinal column. They are approximately 11 cm long, 5–6 cm wide and 3–4 cm thick. They are said to be bean-shaped organs where the outer border is convex; the inner border is known as the hilum (also known as hilus), and it is here that the renal arteries, renal veins, nerves and the ureters enter and leave the kidneys. The renal artery carries blood to the kidneys and once the blood is filtered the renal vein takes the blood away from the kidney. The right kidney is in contact with the liver's large right lobe and hence the right kidney is approximately 2–4 cm lower than the left kidney.

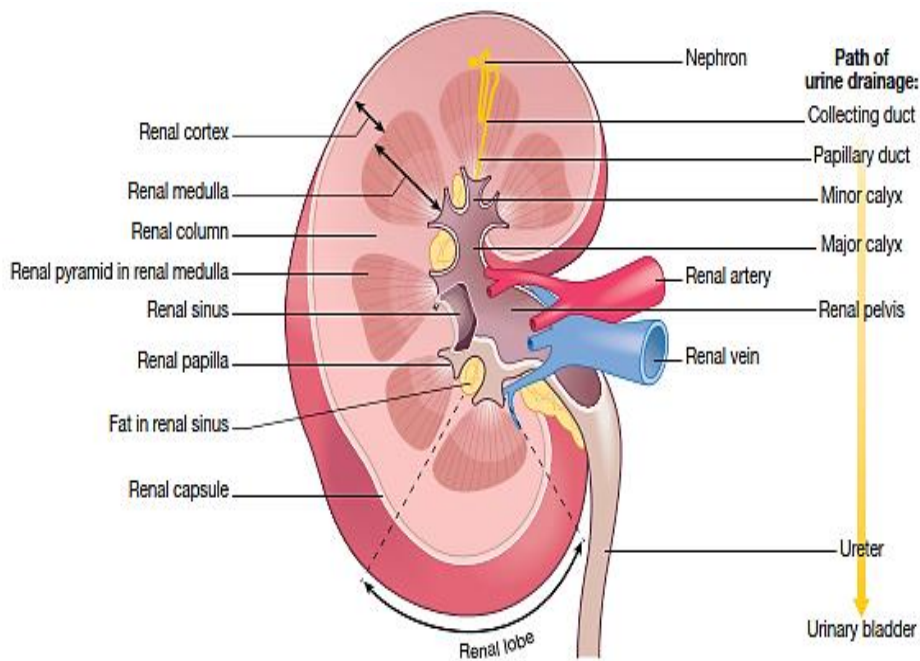
Each kidney is covered by three layers; the renal fascia, adipose tissue and renal capsule. The renal fascia is the outer layer and it consists of a thin layer of connective tissue that anchors the kidneys to the abdominal wall and the surrounding tissues. The middle layer is called the adipose tissue which surrounds the capsule. It cushions the kidneys from trauma. The inner layer is called the renal capsule. The renal capsule protects the kidneys from trauma and maintains the shape of the kidneys.

Kidneys: internal structures

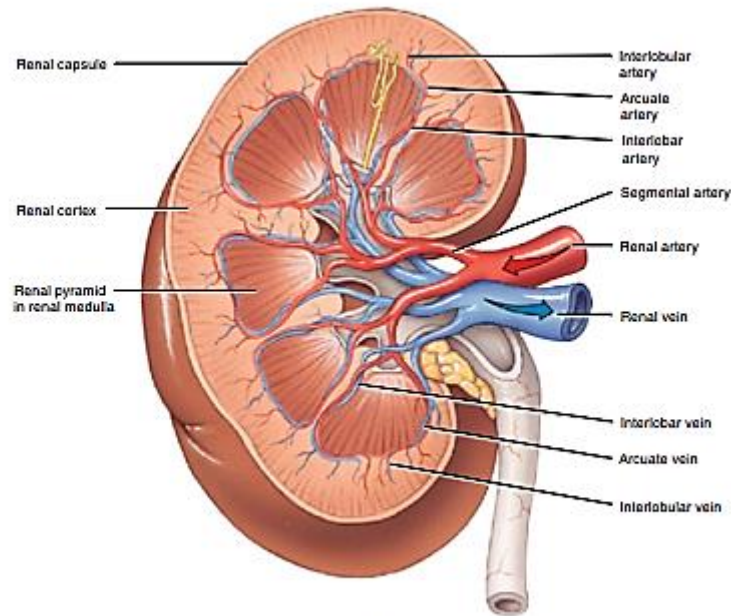
There are three distinct regions inside the kidney:

- renal cortex
- renal medulla
- renal pelvis.





The renal cortex is the outermost part of the kidney. In adults, it forms a continuous, smooth outer portion of the kidney with a number of projections (renal column) that extend down between the pyramids. The renal column is the medullary extension of the renal cortex. The renal cortex is reddish in colour and has a granular appearance, which is due to the capillaries and the structures of the nephron. **The medulla** is lighter in colour and has an abundance of blood vessels and tubules of the nephrons (see Figure). The medulla consists of approximately 8–12 renal pyramids. The renal pyramids, also called malpighian pyramids, are cone-shaped sections of the kidneys. The wider portion of the cone faces the renal cortex, while the narrow end points internally, and this section is called the renal papilla. Urine formed by the nephrons flows into cup-like structures, called calyces, via papillary ducts. Each kidney contains approximately 8–18 minor calyces and two or three major calyces. The minor calyces receive urine from the renal papilla, which conveys the urine to the major calyces. The major calyces unite to form the renal pelvis, which then conveys urine to the bladder. The renal pelvis forms the expanded upper portion of the ureter, which is funnel-shaped and it is the region where two or three calyces converge.



(a) Frontal section of right kidney

Nephrons

These are small structures and they form the functional units of the kidney. The nephron consists of a glomerulus and a renal tubule (see Figure). There are approximately over 1 million nephrons per kidney, and it is in these structures where urine is formed. The nephrons:

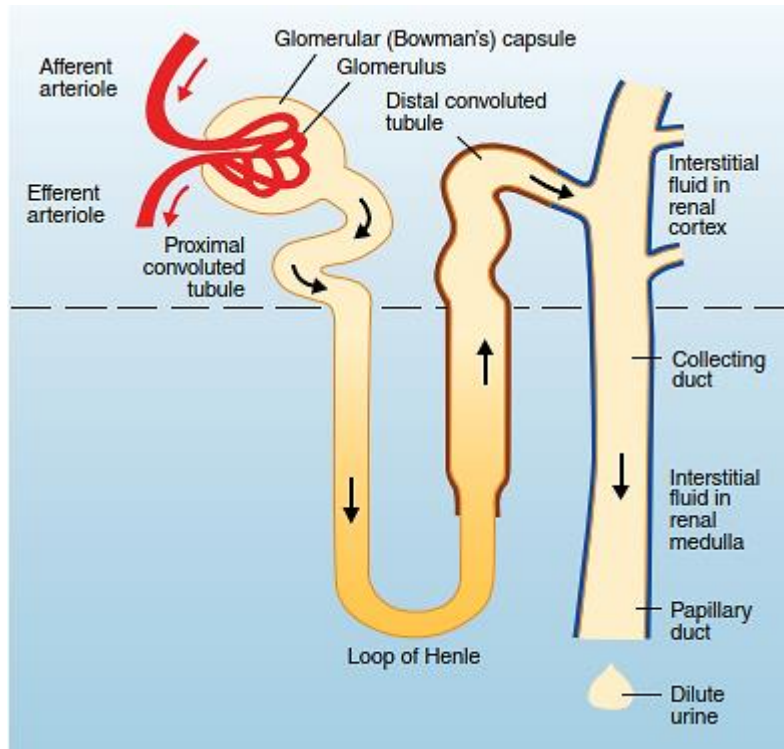
- filter blood;
- perform selective reabsorption;
- excrete unwanted waste products from the filtered blood.

The nephron is part of the homeostatic mechanism of the body. This system helps regulate the amount of water, salts, glucose, urea and other minerals in the body. The nephron is a filtration system located in the kidney and is responsible for the reabsorption of water and salts. The nephron is divided into several sections:

- Bowman's capsule
- proximal convoluted tubule
- loop of Henle
- distal convoluted tubule (DCT)

- the collecting ducts.

Each section performs a different function.



Blood supply of the kidney

The role of the kidney is to filter at least 20–25% of blood during the resting cardiac output. Approximately 1200 mL of blood flows through the kidney each minute. Each kidney receives its blood supply directly from the aorta via the renal artery, which is divided into anterior and posterior renal arteries. There are several arteries that deliver blood to the kidneys:

- renal artery – arises from the abdominal aorta at the level of first lumbar vertebra;
- segmental artery – branch of the renal artery;
- interlobar artery – branch of the segmental artery;
- arcuate artery – renal columns leading to the corticomedullary junction;
- interlobular arteries – divisions of the arcuate arteries.

The branches of the interlobular artery enter the nephrons as afferent arterioles. Each nephron receives one afferent arteriole, which further subdivides into a tuft of capillaries called the glomerulus. The glomerular capillaries reunite and leave Bowman's capsule as efferent arterioles. Efferent arterioles unite to form peritubular capillaries and then interlobular veins that unite to form the arcuate veins and finally into interlobar veins. Blood leaves the kidneys through the renal vein, which then flows into the inferior vena cava. The diameter of the afferent arteriole is larger than the diameter of the efferent arteriole.

Urine formation

Three processes are involved in the formation of urine:

- filtration
- selective reabsorption
- secretion.

Ureters

The ureters are tubular organs that run from the renal pelvis to the urinary bladder. The ureters are approximately 25–30 cm in length and 5 mm in diameter. The ureters have three layers:

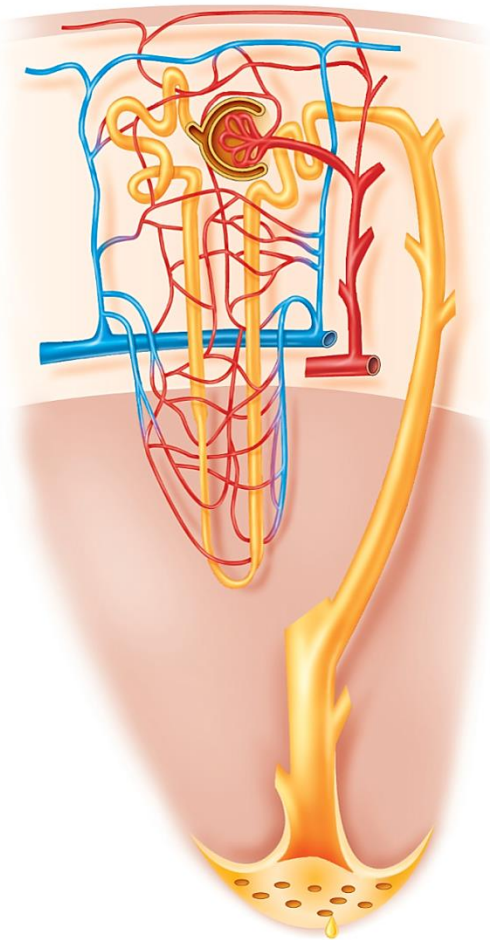
- transitional epithelial mucosa (inner layer);
- smooth muscle layer (middle layer);
- fibrous connective tissue (outer layer).

Urine is transported through the ureters via muscular movements of the urinary tract's peristaltic muscular waves.

Urinary bladder

The urinary bladder is a hollow muscular organ and is located in the pelvic cavity posterior to the symphysis pubis. In the male the bladder lies anterior to the rectum, and in the female it lies anterior to the vagina

and inferior to the uterus; it is a smooth muscular sac that stores urine. The bladder normally distends and holds approximately 350–750 mL.



Nephron with capillaries.

The inner lining of the urinary bladder is a mucous membrane of transitional epithelium that is continuous with that in the ureters. When the bladder is empty, the mucosa has numerous folds called rugae. The rugae and transitional epithelium allow the bladder to expand as it fills. The second layer in the walls is the submucosa, which supports the mucous membrane. It is composed of connective tissue with elastic fibres. The inner floor of the bladder includes a triangular section called the trigone. The trigone is formed by three openings in the floor of the urinary bladder. Two of the openings are from the ureters and form the base of the trigone. Small flaps of mucosa cover these openings and act as valves that allow urine to enter the bladder but prevent it from backing up from the bladder into the ureters. The third opening, at the apex of the trigone, is the opening into the urethra. A band of the detrusor muscle

encircles this opening to form the internal urethral sphincter. The walls of the bladder consist of :

- transitional epithelial mucosa;
- a thick muscular layer;
- a fibrous outer layer.

Urethra

The urethra is a muscular tube that drains urine from the bladder and conveys it out of the body. The urethra is longer in males than in females.

Micturition

The urinary bladder is a storage organ for urine and is located in the pelvic cavity. It contains three layers: the muscular, erectile and mucous layers. Urine is stored in the bladder until the person gets the urge to empty their bladder. The process of micturition is under the control of the sympathetic and parasympathetic system. During micturition, strong muscles in the bladder walls (the detrusor muscles) compress the bladder, pushing its contents into the urethra, thus voiding urine.

