

Anatomy of the Urinary System

The urinary system is primarily concerned with the removal of nitrogenous wastes from the body. In addition to this excretory function, the kidneys maintain the electrolyte, acid-base, and fluid balances of the blood and are the major homeostatic organs of the body. Malfunction of the urinary system leads to a failure in homeostasis, which is fatal if left uncorrected.

Gross Anatomy of the Human Urinary System

The urinary system consists of the paired kidneys and ureters and the single bladder and urethra. The kidneys filter the blood and manufacture urine in the process. The system's remaining organs provide temporary storage reservoirs or transportation channels for urine.

- The **ureters** drain urine from the kidneys and conduct it by peristalsis to the bladder.
- The **urinary bladder** provides temporary storage for urine.
- The single **urethra** drains the bladder.
- The triangular region of the bladder, which is delineated by three openings (two ureteral and one urethral orifice), is called the **trigone**.

→ Know Figures 40.1a, 40.1b, and 40.2.

- In males, the urethra is approximately 20 cm long. It has three regions: the **prostatic**, **membranous**, and **spongy (penile) urethrae**. It, also, has a dual function in males: it serves as a urine conduit to the body exterior, and it provides a passageway for semen ejaculation. So, in males, the urethra is part of both the urinary and reproductive systems.
- In females, the urethra is only about 4 cm long. The female urethra serves only to transport urine to the body exterior. The **external urethral orifice**, its external opening, lies anterior to the vaginal opening.

Important Terminology

- **Renal Capsule** – a smooth transparent membrane that tightly adheres to the external part of the kidney
- **Kidney Cortex** – the superficial kidney region, which is lighter in color

- **Medullary Region** – the region deep to the cortex and it is a darker reddish-brown color; the medulla is segregated into triangular regions that have a striped, or striated, appearance – the **medullary (renal) pyramids**.
- **Renal Columns** – areas of tissue, similar to the cortex is appearance, which segregate and dip inward between the pyramids
- **Renal Pelvis** – medial to the hilus; a fairly flat, basinlike cavity that is continuous with the ureter, which exits from the hilus region; the large or primary extensions are called the **major calyces** and subdivisions of the major calyces are called the **minor calyces**

About one-fourth of the total blood flow of the body is delivered to the kidneys each minute by the large renal arteries.

→ You need to know the blood supply of the kidneys.

Functional Microscopic Anatomy of the Kidney and Bladder

Kidney

Nephrons are the anatomical units responsible for forming urine. Each kidney contains over a million nephrons.

Each nephron consists of two major structures: a **glomerulus** (a capillary knot) and a **renal tubule**.

In embryonic development, each renal tubule starts as a blind-ended tubule that slowly encloses an adjacent glomerulus, or capillary cluster. The enlarged end of the tubule encasing the glomerulus is the **Bowman's capsule**, and its inner wall consists of highly specialized cells called **podocytes**.

The glomerulus-capsule complex is also known as the renal corpuscle. The rest of the tubule is about 3 cm long. When it emerges from the glomerular capsule, it becomes highly coiled before it enters a collecting duct. The anatomical areas of the renal tubule are (in order from the glomerular capsule): **the proximal convoluted tubule, loop of Henle, and the distal convoluted tubule**.

Most nephrons, called **cortical nephrons**, are found inside the cortex. Parts of the loops of Henle of **the juxtamedullary nephrons** penetrate into the medulla. The collecting ducts run downward through the medullary pyramids. Approaching the renal pelvis, the **collecting ducts** fuse to form

larger **papillary ducts**. These ducts empty the final urinary product into the calyces and pelvis of the kidney.

→ Know Figure 40.4.

The nephron function depends of several features of renal circulation. The capillary vascular supply consists of two distinct capillary beds, **the glomerulus and the peritubular capillary beds**. The vessels leading to and from the glomerulus, the first capillary bed, are both arterioles: the **afferent arteriole** feeds the bed and the **efferent arteriole** drains it.

The peritubular capillary bed arises from the efferent arteriole draining the glomerulus. The peritubular capillaries are low pressure porous capillaries that are adapted for absorption rather than filtration and take up the solutes and water reabsorbed from the filtrate by the tubule cells.

- These two capillary beds of the nephron have different, but complimentary, roles: the glomerulus produces the filtrate and the peritubular capillaries absorb most of that filtrate.

Each nephron, also, has a region called a **juxtaglomerular apparatus (JGA)**, which is important in forming concentrated urine.

Urine formation results from three processes: filtration, reabsorption, and secretion.

Filtration is a largely passive process where a portion of the blood passes from the glomerular bed into the glomerular capsule. The filtrate then enters the proximal convoluted tubule where tubular reabsorption and secretion begin.

Tubular reabsorption occurs when the filtrate components move through the tubule cells and return to the blood in the peritubular capillaries. Some of the reabsorption is passive, but the reabsorption of most substances depends on active transport processes. The current composition of the blood and the needs of the body at the time determine which substances are reabsorbed at the time.

Tubular secretion is the reverse process of tubular reabsorption. This process is important for the disposal of substances not already in the filtrate (drug metabolites, etc) and as a way for controlling blood pH.

Bladder

Urine production is a continuous process, but removal of urine from the body is performed when convenient. The urinary bladder receives urine from the ureters and discharges it through the urethra when not temporarily storing it.

Micturition, or voiding, is the process in which urine empties from the bladder. The **internal urethral sphincter** and the **external urethral sphincter** control the outflow of urine from the bladder. The internal sphincter is a smooth muscle involuntary sphincter. The external sphincter is skeletal muscle and is voluntarily controlled.

- **Incontinence** is the lack of voluntary control over the external sphincter. It is normal in children two years old or younger because they haven't learned control over the voluntary sphincter yet. In older children and adults, it is usually caused by spinal cord injury, bladder irritability, pathogenesis of the urinary tract, or trauma to the region.