The Urinary System

Collecting Ducts

The last part of each nephron, the **connecting tubule**, carries the filtrate into a collecting system that transports it to a minor calyx and in which more water is reabsorbed if needed by the body. As shown in **figures13 a and b**, a connecting tubule extends from each nephron and several join together in the cortical medullary rays to form **collecting ducts** of simple cuboidal epithelium and an average diameter of 40 µm. In the outer medulla these merge further as larger, straight collecting ducts (of Bellini), which run to the tips of the medullary pyramids with increasingly columnar cells and overall diameters reaching 200µm (**Figure 14**). In the apex of the pyramid, several collecting ducts merge further as a **papillary duct** which delivers urine to the minor calyx (see Figure 13).

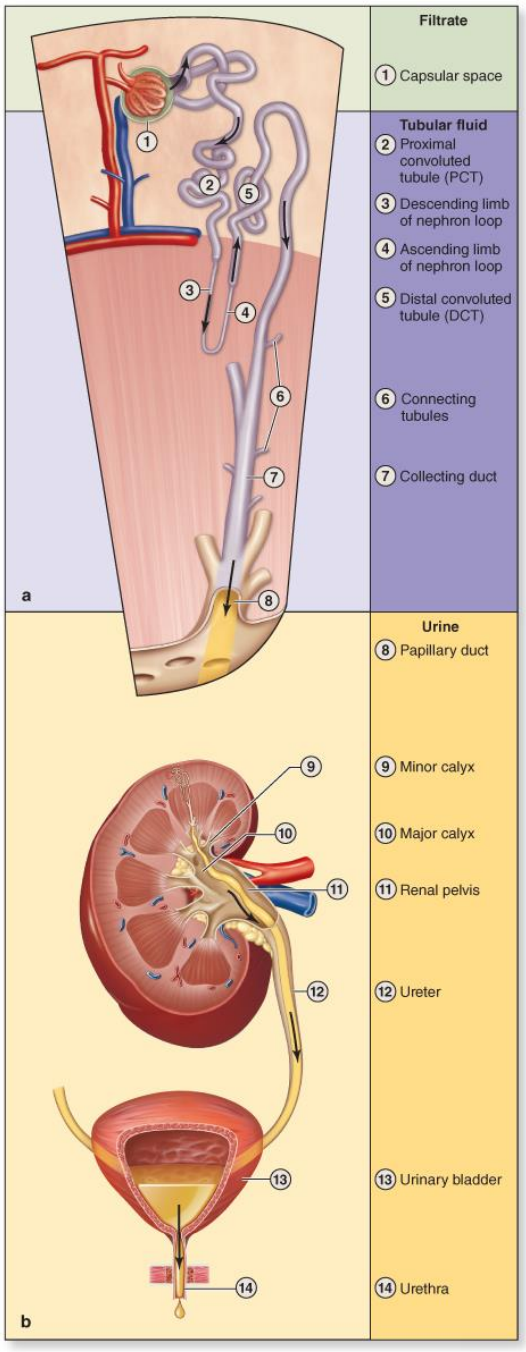

Figure 13.Fluid transport in the urinary system.

(a) diagram of a nephron and collecting system shows the flow of filtrate. (b) upon delivery at a minor calyx, filtrate is no longer modified by reabsorption or secretion and is called urine. It flows passively into the renal pelvis but moves by peristalsis along the ureters for temporary storage in the urinary bladder, which is emptied through the urethra.

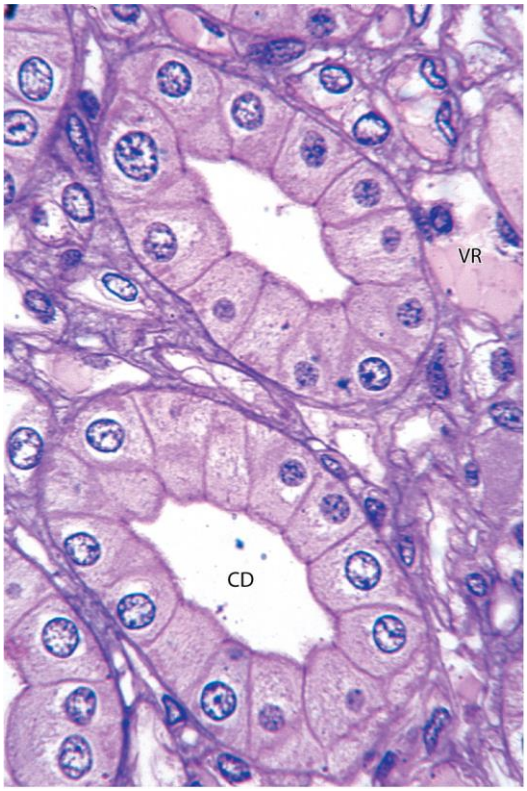

Figure 14. Transversely sectioned collecting ducts (CD) consisting of pale-staining columnar principal cells.

Collecting ducts are composed mainly of pale-staining **principal cells** (most abundant, cuboidal to columnar) with few organelles, sparse microvilli, and unusually distinct cell boundaries (see Figure 14). Ultrastructurally the principal cells can be seen to have basal membrane infoldings, consistent with their role in ion transport, and a primary cilium among the microvilli. The medullary collecting ducts are the final site of water reabsorption from the filtrate. Antidiuretic hormone (ADH), released from the pituitary gland as the body becomes dehydrated (water intake is limited) and the epithelium of the collecting ducts becomes permeable to water, which is absorbed from the glomerular filtrate, transferred to blood capillaries, and thus retained in the body.

Few scattered among the principal cells are slightly darker staining **intercalated cells**, with more abundant mitochondria and projecting apical folds. Intercalated cells help maintain acid-base balance by secreting hydrogen ions.

Ureters, Bladder, & Urethra

Urine is transported by the **ureters** from the renal pelvis to the **urinary bladder** where it is stored until emptying by micturition via the **urethra**. The calyces, renal pelvis, ureter, and bladder have somewhat similar histologic structure, with the walls becoming gradually thicker closer to the bladder. The mucosa of these organs is lined by the unique stratified **transitional epithelium** or urothelium.

Ureter

The ureter is a muscular tube that conveys urine from the kidneys to the urinary bladder by the contractions of the thick, smooth muscle layers found in its wall (Figure 15). The mucosa of the ureter is highly folded and lined with a thick **transitional epithelium**. Below the transitional epithelium is the connective tissue **lamina propria**. The muscularis of the ureter contains two smooth muscle layers: an **inner longitudinal layer** and a **middle circular muscle layer**. A third outer longitudinal layer (not shown) is added to the wall in the lower third of the ureter, near the bladder. A connective tissue **adventitia**, with **blood vessels**, **adipose tissue**, and **small nerves** surrounds the ureter.

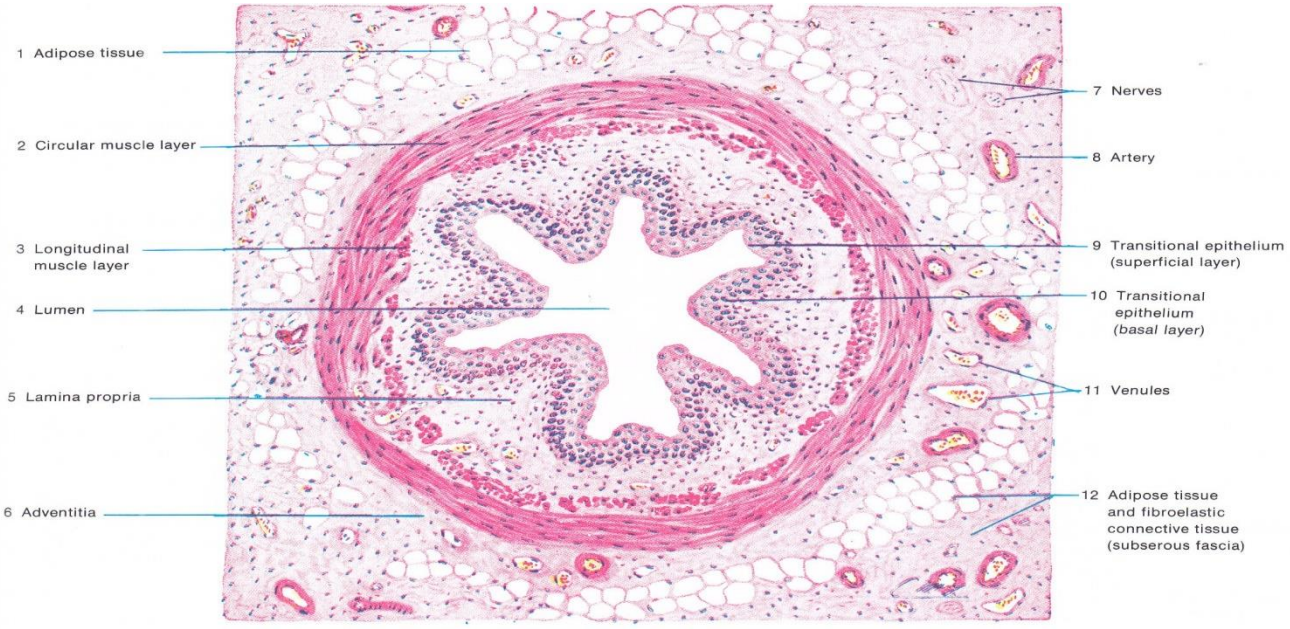

Figure 15. Ureter (transverse section).

Urinary Bladder

The urinary bladder stores urine until it is ready to be voided. The layers of the wall of the bladder are similar to those of the ureter but the thick muscular coat of the bladder is distinctive (**Figure 16**). The wall consists of: the **transitional epithelium** and **lamina propria** are as in the ureter but the epithelium has more cell layers, the lamina propria is wider and the loose connective tissue in its deeper zone contains many elastic fibrers. A **muscularis** is a thick coat. It is more or less in three layers of smooth muscle fibers, the middle layer is the widest. Actually, the muscle fibers are arranged in anastomosing bundles between which is loose connective tissue.

In a section, the groups of muscle fibers are seen in various planes and three layers are difficult to distinguish. A **serous layer (serosa)** on the superior surface is composed of superficial connective tissue and peritoneal mesothelium.

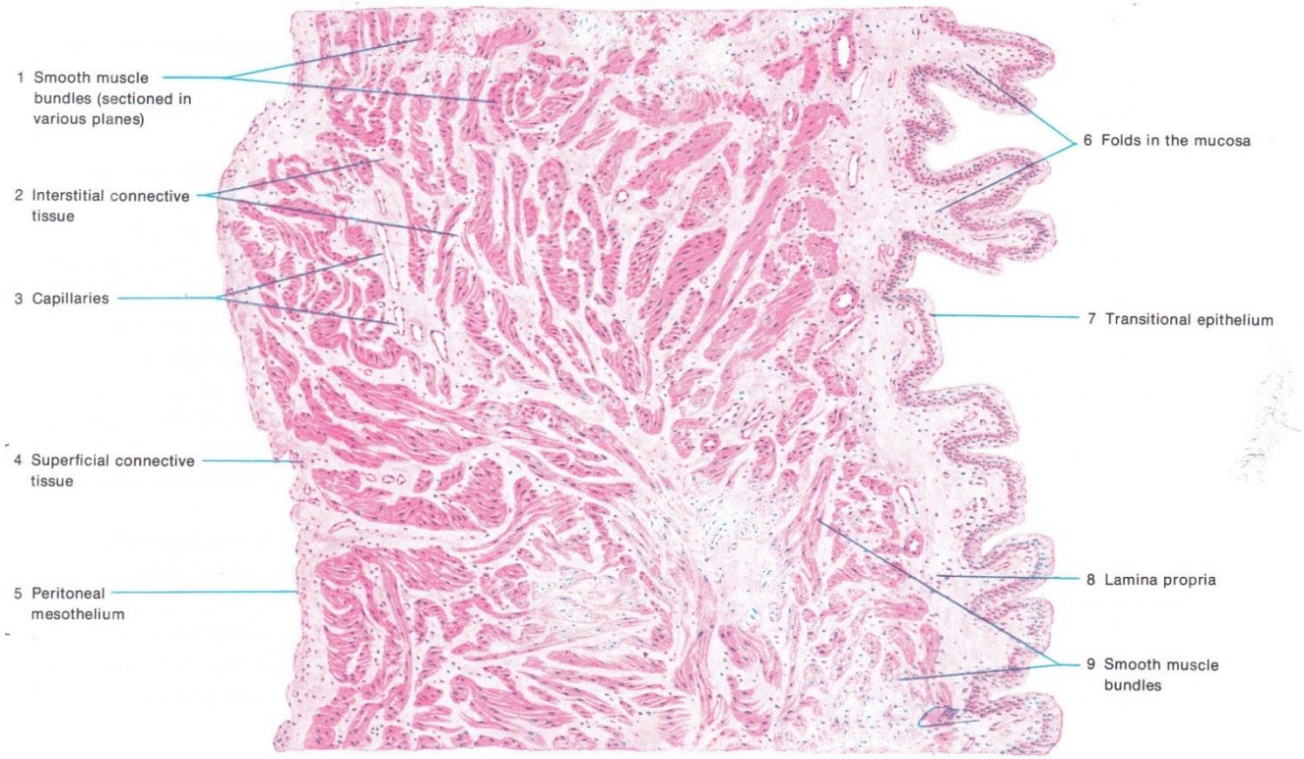

Figure 16. Urinary Bladder (superior part).

The lower part of the bladder has an adventitia (fibrosa) which merges with connective tissue of adjacent structures.

Urethra

The urethra is a tube that carries the urine from the bladder to the exterior. The urethral mucosa has prominent longitudinal folds, giving it a distinctive appearance in cross section. In men, the two ducts for sperm transport during ejaculation join the urethra at the prostate gland. In women, the urethra is exclusively a urinary organ.

Male Urethra

The male urethra is longer (15 to 20cm long), and consists of three segments:

1. The **prostatic urethra**, 3 to 4cm long, extends through the prostate gland and is lined by urothelium (**transitional epithelium**).
2. The **membranous urethra,** a short segment, passes through an **external sphincter** of striated muscle and is lined by **stratified columnar** and **pseudostratified columnar epithelium.**
3. **The spongy urethra,** about 15 cm in length, is enclosed within erectile tissue of the penis and is lined by **stratified columnar** and **pseudostatified columnar epithelium**, with **stratified squamous nonkeratinized epithelium** distally.

The **lamina propria** of all three regions is composed of a loose fibroelastic connective tissue with a rich vascular supply. It houses numerous **glands of Littre**, whose mucous secretion lubricates the epithelial lining of the urethra.

Female Urethra

The female urethra is a 4-5 cm long tube. It is lined initially with **transitional epithelium** near the bladder, then by a **stratified squamous nonkeratinized epithelium** along the remainder of its length, and some areas of **pseudostratified columnar epithelium**. The mucosa is arranged in elongated folds because of the organization of the fibroelastic **lamina propria**. Along the entire length of the urethra are numerous clear, mucous-secreting **glands of Littre**.

The middle part of the female urethra is surrounded by the external striated muscle (voluntary) sphincter.