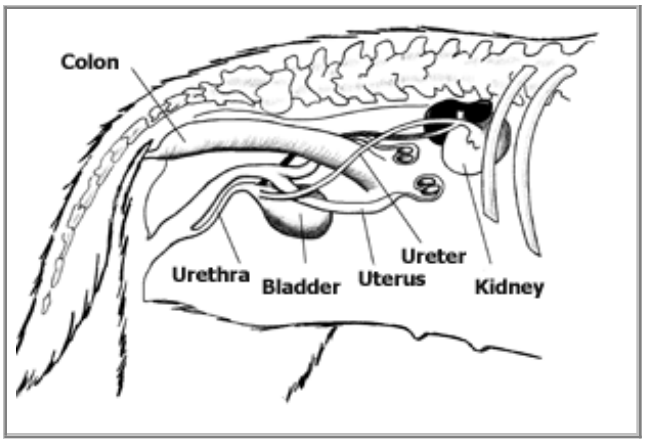
# Urinary System in Mammals: Anatomy and Function

*Drs. Foster & Smith Educational Staff*

The urinary system is responsible for filtering wastes from the blood and both forming and secreting urine. These functions help to maintain the composition and volume of body fluids. Although it has far-reaching effects, the urinary system is relatively simple anatomically and consists of:

- Kidneys
- Ureters
- Bladder
- Urethra

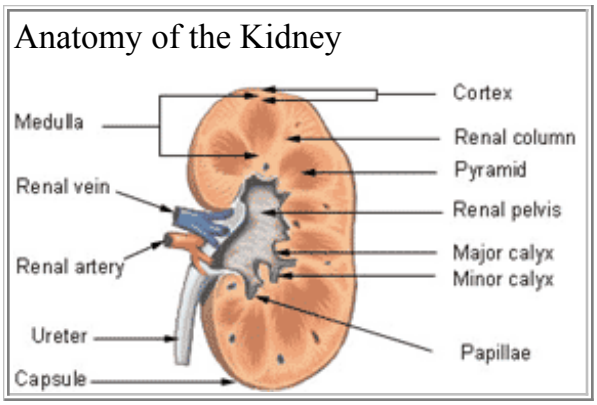



The main organs are the kidneys, which filter blood and produce urine. The other parts are simply accessory structures for the transport and storage of urine.

During the normal breakdown of protein and nucleic acids, nitrogen is released into the bloodstream. Some of this nitrogen is recycled to make new cellular products, but most of it is disposed of. The body has to have a way to rid itself of this unused nitrogen, as high levels in the blood can be toxic. Most of the nitrogen is bound with hydrogen as $NH_3$ (ammonia), which is readily dissolved in water. For this reason, fish are able to excrete much of their nitrogen by simple diffusion into the surrounding water. The build-up of nitrogen in the water is one of the reasons that tank water needs to be changed regularly. Terrestrial animals have a different way of ridding their bodies of excess nitrogen. It is either excreted as uric acid or urea. Animals that are concerned about water loss, such as birds and reptiles, excrete the more concentrated uric acid as a pasty white material. Mammals, on the other hand, can excrete urea, along with more water. The mixture of urea, water, and other wastes is called 'urine.' Urine is still very concentrated in comparison to the blood, and the system that facilitates this concentration is the 'urinary system.'

Kidneys

The kidneys of mammals are round or bean-shaped organs. They are located outside of the peritoneum – the membrane that encloses the organs of the abdominal cavity. Because of this position, they are referred to as 'retroperitoneal.' They are surrounded by fat tissue known as 'perirenal fat.' A fibrous capsule covers the kidney. The indentation of the bean shape is called the 'hilum.' The hilum is the site where the renal artery enters the kidney and both the renal vein and ureter exit.

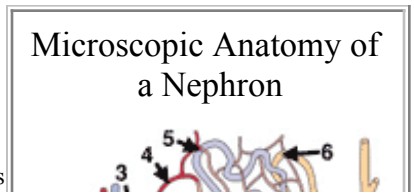



The kidney can be divided into two distinct regions – the outer cortex and the inner medulla. The cortex is where blood is actually filtered through small structures called 'glomeruli'. The medulla is where the urine is concentrated through a complex system of tubules. They accomplish this by absorbing the water and electrolytes while preventing waste products from being reabsorbed. One glomerulus and its corresponding set of tubules are called a 'nephron' – the microscopic functional unit of the kidney. The anatomy and function of the nephron will be discussed in detail below.

The tubules of multiple nephrons are grouped into larger visible portions of the kidney called 'pyramids'. The renal columns are spaces between the renal pyramids that provide a route for blood vessels traveling to the cortex. The tips of the pyramids are called 'papillae,' and they drain urine from nephron tubules into larger vessels called 'minor calyxes.' The minor calyxes converge into still larger vessels called the 'major calyxes'. These lead to the enlarged opening of the ureter. This collecting chamber is called the 'renal pelvis.'

Nephrons

The nephrons are the actual filtration elements of the kidneys. Blood enters the kidneys through the renal artery and travels through branching arteries. These arteries coming into the nephron become smaller and smaller, and are finally called 'afferent arterioles.' The blood in these vessels is under high pressure. The afferent arteriole branches into the glomerulus – a cluster of capillaries within a shell called 'Bowman's capsule.' The pressure of the blood causes water, glucose, amino acids, and salts to leave the blood vessels and enter the Bowman's capsule. The blood cells



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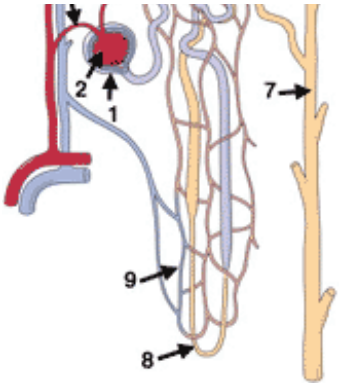
and most proteins are too big to be filtered out, and remain inside the blood vessel to be carried out of the glomerulus via the efferent arteriole.

Bowman's capsule leads to the network of tubules that concentrate the filtrate into urine. The tubules are surrounded by small blood vessel called a 'capillary'. This capillary is where materials are reabsorbed back into the blood. The first part of the tubule is aptly named the 'proximal convoluted tubule' for its twisted shape. Here 99% of the water is reabsorbed along with all of the glucose and amino acids. The presence of glucose or amino acids in the urine is a sign of disease. For example, diabetics that have too much glucose in their blood cannot reabsorb it all, so it is excreted in the urine.

The proximal convoluted tubule leads to the 'loop of henle,' a long looping structure that extends down into the medulla of the kidney. More water and electrolytes (salts) are absorbed here. Next, the filtrate is passed through the 'distal convoluted tubule,' where excess potassium ions, hydrogen ions, and some drugs or toxins are passed from the blood into the filtrate. The final product is then dumped into a large collecting duct, into which several nephrons empty. This collecting duct leads to the papillae of the pyramids, through the calyxes, and into the renal pelvis to be excreted through the ureter.




1. Bowman's capsule
2. Glomerulus
3. Afferent arteriole
4. Efferent arteriole
5. Proximal convoluted tubule
6. Distal convoluted tubule
7. Collecting duct
8. Loop of Henle
9. Peritubular capillary

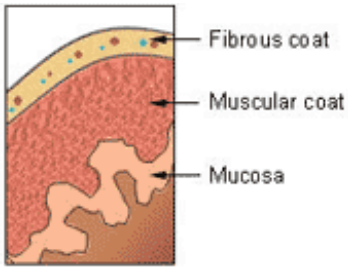
Ureters

The ureters are muscular tubes that transport urine from the kidneys to the urinary bladder. Ureters have three layers of tissue:

1. Fibrous outer coat
2. Muscular layer
3. Inner mucosal layer

The muscle layer is the functional layer, using peristalsis to move the urine along. Peristalsis is a waving contraction of the muscles to propel the contents of a tube in one direction. In this case, the urine is propelled to an opening at the base of the bladder.

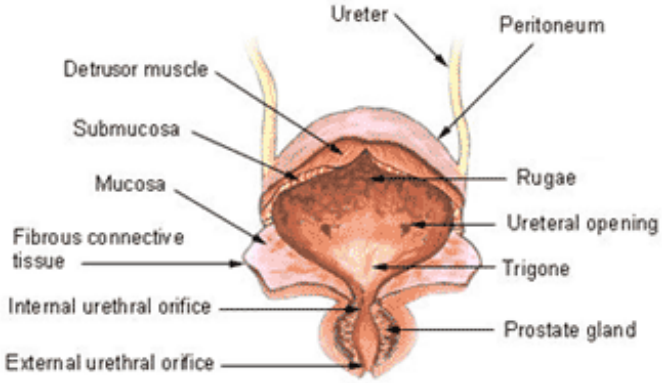
Microscopic Anatomy of the Ureter




Urinary Bladder

The urinary bladder is a sac for the temporary storage of urine. It is located in the pelvic cavity. The outer surface is covered with fibrous connective tissue. Inside the connective tissue is a muscular layer called the 'detrusor muscle.' This smooth muscle contracts to expel urine from the bladder. The next tissue layer is the 'submucosa,' an elastic fibrous membrane that supports the mucosa, which lines the inside of the bladder. The mucosa is composed of specialized cells called 'transitional epithelium.' When the bladder is empty, the mucosa has many folds termed 'rugae.' The rugae and transitional epithelium allow the bladder to stretch when filled with urine.
At the base of the bladder, a triangular structure called the 'trigone' is formed from the openings of the two ureters and the urethra. The opening of the urethra is surrounded by a band of detrusor muscle, forming an internal urethral sphincter. This sphincter is relaxed by involuntary muscle control, and is innervated such that when the bladder is approximately half full, the animal perceives the urge to urinate.

Anatomy of the Urinary Bladder




Urethra

The final passageway for urine out of the bladder is through the thin-walled urethra. This tube runs from the base of the urinary bladder to the outside of the body. In the female, it is relatively short, connecting the bladder to external urethral sphincter. In males, however, it is longer. It passes through the prostate gland (in those animals that have one) and travels the length of the penis before reaching the external sphincter. The external urethral sphincter is voluntarily controlled, and is relaxed by the animal when a suitable site and time for urination has been determined.



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Interesting facts

- Each kidney has over a million nephrons!
- The male urethra is also the pathway for products of the reproductive system.
- Even if 75% of the nephrons are lost, the kidney will still function. It is possible to live a healthy life with only one kidney.
- Urine was once used as a cleaning product!
- Normal urine is sterile (germ-free). It is composed of water, salts, and waste products.
- Reptiles have adapted a very long loop of henle to facilitate more water reabsorption and prevent dehydration.



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