The function of the digestive system is to break down large food particles into smaller ones that can be absorbed into the membranes of cells. Two main groups of organs comprise the digestive system. The first group is made up of the organs of the gastrointestinal (GI) tract, also known as the alimentary canal. This is a tube that extends from mouth to anus and is open at each end. The second group is made up of accessory structures such as the teeth, tongue, and glands that line the GI tract. These aid in the mechanical and chemical breakdown of foods.

This plate gives a view of the digestive system and focuses on the two groups mentioned above. Be prepared to use bold colors in this plate, since the structures and regions are easy to see and distinguish.

The process of digestion begins when food enters the digestive system at the oral cavity (A). Here the food is broken down mechanically and moistened with secretions. It is shaped into a foodball known as a bolus by the tongue, and then enters the next part of the GI tract, the pharynx (B), which starts at the rear of the mouth. A color that blends with the one used for the oral cavity should be used. The organ that transports food to the stomach is the muscular esophagus (C). This tube passes through the thoracic cavity and pierces the diaphragm before entering the pouch-like stomach (D). Here food mixes with acid and protein-digesting enzymes. Passing from the stomach, food enters the twenty-foot long small intestine (E). A great portion of the abdominal cavity is taken up by the numerous folds and twists of this organ, and the main processes of digestion and absorption occur here. At the lower left portion of the plate (the anatomical right), the small intestine leads into the large intestine (F). This tube can be seen ascending along the anatomical right side, passing along the midline, then turning and descending. Undigested material is dehydrated and compacted in this organ. Prior to defecation, indigestible waste is stored in the rectum (G). After a certain amount of feces has accumulated, it passes through the anus (H). A spot of color should be used to designate this opening.

The digestive process is aided by several organs that lie along the GI tract and contribute secretions. Three of these organs are mentioned briefly in this section, and we recommend the use of dark colors to indicate their location.

Three sets of salivary glands (I) supply enzymes that digest carbohydrate in the oral cavity. In the abdominal cavity, the liver (J) secretes bile that participates in fat digestion, and the liver processes some of the products of digestion before sending them to the tissue cells. Beneath the liver is the gallbladder (K). Bile from the liver is stored here before it is delivered to the intestine.

An important contributor of enzymes to the digestive process is the pancreas (L). Exocrine cells of this gland deliver their secretions into the first part of the small intestine.

In the final portion of this plate, we will mention the important digestive enzymes, in the order in which they are encountered by food passing through the digestive system.

Present in salivary secretions is the enzyme salivary amylase. This enzyme breaks down starch through the process of hydrolysis, producing the disaccharide maltose. The next digestive enzymes encountered by the food are present in the stomach. The stomach contains gastric juice, which has a pH of about 2, and this gastric juice contains the enzyme pepsin, which breaks down proteins. Chemical breakdown of food continues in the small intestine, where a pancreatic amylase continues to hydrolyze starch; and trypsin, chymotrypsin, carboxypeptidase, and aminopeptidase are all responsible for breaking down proteins.
Chapter 9-21: The Urinary System

Excretion refers to the elimination of the waste products of cellular metabolism and undigested food from the body. It also refers to the removal of surplus materials from tissues. Excretions help to regulate the water and salt content of the body. These regulatory functions are performed by the kidneys and their accessory structures in the urinary system. In this plate, we present an overview of the urinary system in two views. We point out the major organs of the system and describe their structure.

Looking over the plate, you will notice that it shows the organs of the urinary system in two views. In the front and back views, the organs are shown relative to each other and nearby structures. As you read the text, locate the structures and color them.

The main organs of waste filtration in the body are the kidneys \( A_1 \) and \( A_2 \). A medium color is recommended for both kidneys; red or purple would be suitable.

The kidneys are bean-shaped organs that are roughly the size of the fist. They are located on each side of the vertebral column, and as the posterior view shows, the twelfth rib partially protects them. It should be colored in a light color.

Leading from the kidneys are tubes called ureters \( B \). These tubes carry urine away from the kidney after it has been formed (this topic is discussed in depth in the next plate), and the ureters lead to the main storage organ, the urinary bladder \( C \). This hollow muscular sac is located at the floor of the pelvic cavity.

The tube that leads from the bladder to the exterior of the body is the urethra \( D \). This tube of smooth muscle is about one-and-a-half inches long in the female and about eight inches long in the male; in the male, the urethra passes through the penis.

The main circulatory vessel that transports blood to the kidney is the renal artery \( E \), seen in the posterior view. The renal vein \( F \) lies behind the renal artery in the posterior view and is difficult to see. A light color is recommended for this structure. The renal vein transports blood away from the kidney after it has been cleansed. The renal artery is supplied with blood by the abdominal aorta \( G \), while the renal vein empties its blood into the inferior vena cava \( H \).

We close the plate with a transverse section through the body. We are looking down from above at a level of the stomach, transverse colon, pancreas, and other organs of the abdominal cavity.

The view in the plate on the bottom shows structures of several systems. For example, we see an outline of the lumbar vertebra \( I \), and the spinal cord is visible. Sections are also shown through the kidneys (\( A_1 \) and \( A_2 \)). Note the renal arteries (\( E \)) which arise from the abdominal aorta \( G \). Also note the renal veins \( F \), which lead on both sides to the inferior vena cava \( H \). The kidney is surrounded by three layers of supportive tissue. Immediately adhering to the kidney surface is the renal capsule \( J \), which provides an impenetrable barrier to infection of the kidney surface; a dark color may be used to highlight this layer. Outside the renal capsule is a layer of fat called the adipose capsule \( K \). The fat tissue helps cushion the kidney against blows. Outside the adipose capsule is the renal fascia \( L \), which is composed of fibrous connective tissue. It helps anchor the kidneys to nearby tissues.

We will now discuss the blood supply to the kidney. The passageways for blood were mentioned previously in the discussion of the circulatory system, and we will review them here. As you encounter the structures in the reading, color them in the anterior and posterior views.
Chapter 9-22: The Nephron

As you learned in the preceding plate, the two major organs involved in the process of excretion are the kidneys. In this plate, we will discuss the nephron, the independent unit inside the kidney that produces urine. There are approximately one million nephrons in each human kidney. Nephrons perform the functions of filtration, reabsorption, and secretion.

Looking over the plate, you will notice that it is composed of three diagrams: the entire kidney, nephrons in their environment, and a close-up of a single nephron, the microscopic unit of the kidney. Color the structures as you encounter them.

In the first diagram, we see the kidney (A), as it was shown in the previous plate. One section of the kidney is enlarged and shown in detail, and this area contains a nephron (B). A pale shade is recommended to highlight it. The renal artery (C) delivers blood to the kidney, the renal vein (D) removes blood from it, and the ureter (E) is responsible for carrying urine away.

We now focus on the expanded view of a section of the kidney, in which we see eight nephrons. We will briefly study this perspective before going on to the detailed view of a single nephron.

The second diagram of the plate shows the cortex (F), which is indicated by a bracket and should be colored in a bold color; its general area can be colored in a pale hue. This diagram also shows the medulla (G).

Within the cortex and medulla we present the simplified views of eight nephrons. Each of the eight nephrons has a renal corpuscle (H), and we have circled one of these. Nephrons are oriented so that they're perpendicular to the kidney's surface. There are cortical nephrons (H1) and juxtamedullary nephrons (H2), both of which have capsules, proximal tubules, and distal tubules that are in the cortex, and long loops of Henle (R) that extend into the medulla. In this diagram, we recommend that you color in the cup-like renal corpuscles then the tubules that lead from the corpuscle as they extend toward a collecting duct. The collecting duct (I) receives urine from many nephrons.

Now we come to a single nephron and study its vascular and tubular components. We recommend variations of one color for all parts of the vascular system, and variations of a different color for parts of the tubular component. Continue reading below as you study the nephron, and color the structures as you come upon them.

Blood travels from the heart through a series of arteries and finally reaches the interlobular artery (J); one branch of this artery is the afferent arteriole (K). Blood flows through this vessel into a small network of capillaries called the glomerulus (L). Filtration takes place here (as we describe below), and then the blood enters a vessel called the efferent arteriole (M). The efferent arteriole branches into a network of capillaries, called the peritubular capillary network (N). You should use variations of a single color for these vascular tubules.

Filtration occurs when blood passes through the glomerulus. As blood passes through the glomerulus, normal blood pressure forces fluid across the wall of the nephron tubule, which is also known as Bowman's Capsule (O). Together the glomerulus and Bowman's capsule are called the renal corpuscle. This fluid, or filtrate, contains water, salts, glucose, nitrogenous wastes, and other small molecules. The blood then continues to flow through the tubular component, first encountering the proximal convoluted tubule (P). At several points along the nephron tubule, fluid is filtered out and reabsorbed back into blood that is traveling through the peritubular capillary network.

Now the proximal tubule descends toward the renal medulla. The descending tubule is called the descending limb (Q). This tubule turns abruptly at the loop of Henle (R) and ascends as the ascending limb (S). Variations of the color used for the proximal tubule should be used to color here. The peritubular capillaries surround the tubules as they dip into the medulla and water and salts are reabsorbed back into the blood.

As the tubule ascends, it forms the distal convoluted tubule (T). Again, it intertwines with capillaries of the peritubular capillary network (N), and selective reabsorption takes place. This reabsorption is critical; without it the body would lose an excess of water, vitamins, and other important molecules and ions in the process of excretion. The capillary network then moves toward the renal corpuscle and forms the interlobular vein (U). This vein ultimately leads to the renal vein, which removes the cleansed blood from the kidney.

Following the tubule once again, you will notice that the distal convoluted tubule (T) comes to the collecting duct (I). The fluid in the collecting tubule is urine, which is sent to the ureter for discharge.
The Nephron

- Kidney
- Nephron
- Renal Artery
- Renal Vein
- Ureter
- Cortex
- Medulla
- Renal Corpuscle
- Cortical Nephron
- Juxtamedullary Nephron
- Collecting Duct
- Interlobular Artery
- Afferent Arteriole
- Glomerulus
- Efferent Arteriole
- Peritubular Capillary Network
- Bowman's Capsule
- Proximal Convoluted Tubule
- Descending Limb
- Loop of Henle
- Ascending Limb
- Distal Convoluted Tubule
- Interlobular Vein