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BIOL 244L HUMAN ANATOMY AND PHYSIOLOGY II LABORATORY
URINARY SYSTEM I. ANATOMY AND HISTOLOGY

The urinary system is important in eliminating the nitrogenous waste products of protein metabolism. While carbohydrates and fats contain mostly carbon, hydrogen and oxygen and can be metabolized to water and carbon dioxide, protein is composed of amino acids with nitrogen containing amino groups. The nitrogen breakdown product can be ammonia, urea, or uric acid, and in mammals, urea is the dominant compound eliminated. The kidney is the organ of urinary excretion. The kidney is also known by the latin, "ren", and the term, "renal", refers to kidney. In addition to eliminating urea, the kidneys have a broader role in water and solute balance controlling the elimination of aqueous sodium, chloride, sulfate, phosphate, bilirubin (metabolic product of hemoglobin breakdown), and hydrogen ions. The kidneys are therefore important in regulating blood volume, body fluid ionic composition and blood pressure and in regulating acid-base balance.

I. CAT URINARY SYSTEM

Learn the structures in boldface and refer to the text chapter 26 for diagrams and details.

Observe the locations of the paired **kidneys** and the **ureters** that drain them. The kidneys are positioned against the dorsal wall of the peritoneal cavity. Because only half of the kidney, the half you see in the abdominal cavity, is covered by peritoneal membrane and the other half is sitting in abdominal tissues outside of the peritoneal cavity, the kidneys are said to be in a **retroperitoneal** position. Each kidney is surrounded by masses of fat, which provide a protective cushion. The fat should be removed to expose the kidney but with care to avoid disturbing the vascular connections and the ureter (see the figure at the end of the handout). The kidney is shaped like a bean, and the indentation at the medial border is the **hilum**. Remove the connective tissue at the hilum and observe the connections of the **renal artery** and **renal vein**. The kidneys receive a substantial blood supply (about 20% of resting cardiac output) which shows their importance in filtering the blood for fluid and solute regulation. This large blood supply and along with it a large oxygen supply reflects the high metabolic rate of kidney tissue; this metabolic energy is needed to run active transport pumps to recover valuable solutes that are filtered from the blood and are not allowed to be lost to the urine. The kidneys amount to only a half a percent of total body mass, but account for 8% of resting metabolic energy use.

With a sharp scalpel (ask the instructor for a new blade is yours is dull) slice one of the kidneys in a plane parallel with the table top. With the cat on its back, this is a frontal section. You can then open the kidney and view the internal anatomy like the diagram in the text and in the figure in this handout. The hilum opens up within the kidney to form the **renal sinus**, and the ureter is expanded within the renal sinus forming the **renal pelvis**. The section of kidney tissue shows an outer and lighter colored **renal cortex** and an inner and darker colored **renal medulla**. In humans the medulla is organized into 8-18 cone shaped structures called **renal pyramids** the tips of which are called **renal papillae**. However in the cat (and in carnivores in general) there is only one renal pyramid and papilla. The sheep kidney (below) will show multiple papillae.

Trace the ureters toward the cat's pelvis and find where they enter the **urinary bladder**. Urine is conducted from the bladder via the **urethra** to leave the body. Note this fact, however, as far as the cat dissection is concerned, we will save the lower urinary tract for future dissection of the urogenital system.

I. SHEEP KIDNEY ANATOMY

Observe the exterior of the sheep kidney for any familiar structures such as the ureter (or where the ureter had been cut off). Section the kidney in half, in the same plane as for the cat above, and so it lies showing the section like the one in Chapter 26 in the textbook.

Find the **renal hilus** (the indentation where the **ureter** is attached), the **renal pelvis**, the **renal pyramids**, and the **papillae** at the tips of the pyramids. In animals with multiple pyramids and papillae, the pelvis divides into **calyces** (singular calyx) to connect and drain the papillae. As above for the cat, identify the **renal cortex** and **renal medulla**.

WHEN FINISHED WITH DISSECTIONS:

***Return the cats to their bags and plastic barrel.**

***Place the sheep kidneys in the plastic bag at the front of the lab.**

***Throw small scraps of tissue in the scraps bag at the back or the front of the lab.**

***Wash out your dissecting trays and stack by the sink at the back (<u>please do not let tissue scraps go down the drain</u>).**

***Clean your dissecting tools, blot them dry, and return them in their boxes to the front of the class room. Please leave the lids open to complete drying.**

III. MODEL OF HUMAN KIDNEY

Find and know the structures described above for the sheep kidney.

IV. DISSECTION ILLUSTRATIONS

Illustrations are from the Martini text and
Gilbert, Steven G. Pictorial Anatomy of the Cat. 1975 University of Washington Press.

V. MICROSCOPIC ANATOMY OF THE KIDNEY AND URETER

1. Use the slide labeled "Kidney, Monkey". Through the microscope (low power at first), the **cortex** will be in what appears through the scope as the upper area, while the **medulla** is the lower right area (lower only as viewed through the microscope which inverts the image as viewed by the naked eye). The text figures in Chapter 26 show diagrams of the kidney tissue structures like glomeruli and tubules, however on the slide, these objects will be closely packed together.

In the **cortex** find some round areas of solid material with lots of nuclei, surrounded by thin, "empty" circular areas. The material showing the nuclei is the **glomerulus**, while the surrounding clear space is the **glomerular (Bowman's) capsular space**. Even with low power, one can see the **simple squamous epithelium** which forms the outer layer of the **glomerular (Bowman's) capsule**. Taken together, the glomerulus with its surrounding glomerular capsule is called the **renal corpuscle**. Because these are very thin sections through the renal corpuscles, it is not likely that the cut would have been made right through the connection of a convoluted tubule with a glomerular capsule, or through the spot where the afferent or efferent arterioles are connected to the glomerulus. Refer to text diagrams in Chapter 26 on the section describing the **nephron** to get an idea of the cellular architecture and arrangement of these and the following structures. The **nephron** is the functional unit of the kidney consisting of the combination of **renal corpuscle** and **renal tubule**.

Still in the cortex, examine the areas other than the glomeruli. These other areas are mostly closely packed transverse and oblique sections of **renal tubules**. The thickest-walled of these, with only a few (3 to 6) irregularly spaced nuclei per cross section, are the **proximal convoluted tubules**. The lumens of the proximal convoluted tubules typically contain a fuzzy-looking material. This is a precipitate of the filtrate at an early stage of transport through the renal tubule that occurred following death and preparation of the specimen. Further along following the re-absorption process, this precipitate is not observed. Thinner-walled tubes with more (6 to 8) regularly spaced nuclei are the **distal convoluted tubules**. The distal tubules also have a more clear looking lumen. What do you think the precipitate in the proximal tubules is?

In the lower middle to right part of the tissue on the slide (lower only as seen through the microscope), the kidney **medulla** appears. In it, parts of the **loops of Henle** and the **collecting ducts** have been cut either near transversely, obliquely, or near longitudinally, so these tubes appear as ovals or as parallel rows of cells. Find an area of parallel rows. The largest diameter tubes, with the thickest walls, are the **collecting ducts**. The other, thinner-walled tubules are the ascending and descending "limbs" of the **loops of Henle** (not seen as "loops" here). Farthest from the cortex on the slide there is **transitional epithelium** that lines a calyx branching off the renal pelvis.

2. To see the blood vessels in the kidney, use the slide labeled "Kidney, injected". Even without the microscope, you can identify the cortex by its darker, more grainy appearance due to the dark red-purple dye in the glomeruli and blood vessels.

With the microscope on LOW power, find the cortex and look for **glomeruli** (round, red-purple areas). See that the glomerular capillaries are dark purple as they received the injected material along with the other blood vessels. If you check all the glomeruli on the slide, you should find one or more that have the **afferent or efferent arteriole** attached and maybe one with both attached.

Among the proximal and distal tubules there are many thin vessels, seen as little patches of capillary "network"; and these are the **peritubular capillaries**. Peritubular means "around the tubules." The peritubular capillaries pick up the water and solutes which have been reabsorbed through the tubule walls.

3. Use the slide labeled ureter to see a cross section of the **ureter**. The ureter is lined with **transitional epithelium**. The cells of this epithelium are not as horizontally flattened as they are in stratified squamous epithelium (see the text Chapter 3 for a description). You can see distinct cells with cell plasma membranes here whereas in a stratified squamous epithelium, the flattened plasma membranes in the outer layers make individual cells indistinct. The most dense part of the ureter wall is made of **smooth muscle**. The smooth muscle strands are not organized in well defined layers like the smooth muscle in the digestive tract. Here, strands of interconnecting smooth muscle are separated by connective tissue. Farther out is additional loosely arranged connective tissue.

4. For the **urinary bladder,** the slide shows just a portion of the wall of the bladder. The epithelium is along what appears as the top border as viewed through the microscope. This is **transitional epithelium** (again, see Chapter 3 for a description of urinary bladder transitional epithelium). As above for the ureter, the epithelium cells are not flattened horizontally as they are in stratified squamous epithelium. The **muscularis** layer of the bladder wall consists of loosely arranged layers of **smooth muscle**. These layers are not as well defined as the muscularis of the

digestive tract. Strands of interconnecting smooth muscle are separated by connective tissue. This loose arrangement allows them to adjust to stretching of the bladder as it fills with urine. Where the fibers were cut longitudinally, you should recognize the oblong nuclei that are characteristic of smooth muscle.