HISTOLOGY – URINARY SYSTEM

I. **Urinary system** - General information

A. **Kidneys** - semetrically paired organs that form the urine.

B. **Ureters** - carry urine to bladder, one from each kidney.

C. **Bladder** - site where urine is collected and stored until urination

D. **Urethra** - carries urine from bladder to external environment

Kidney:

A. General external characteristics

1. Bean shaped => concave on one side, convex on the other

2. Kidney is surrounded by a dense connective tissue capsule.

3. An indentation in the concave side is called **hilus** where nerves, blood vessels and lymph vessels enter and leave.

4. **Renal pelvis** - expanded end of the ureter that connects to the hilus. A region where urine from the kidney collects and drains into ureter.

B. The Kidney can be divided into a **cortex** and a **medulla**.

1. **Renal cortex** contains

a. Upper portions of **nephrons**

b. Upper portions of the **collecting ducts**

2. **Renal medulla** consists of

a. Parts of nephrons called **loops of Henle**

b. The major portions of the **collecting ducts** that tranport urine to the calyces.

c. The **major calyces** and **minor calyces** that carry the urine to the renal pelvis

3. Cortex and Medulla in humans

a. The medulla can be subdivided into structures called the **medullary** or **Malpighian pyramids** (also called **renal lobules**).

b. These pyramids of tissue have there vertice (pointed end) at a renal calyx and their base at the border of the cortex.

c. The pyramid tissues consist of

* **Collecting ducts** that transfer urine from the nephrons in the cortex to the minor calyces

* Portions of the nephron's **loops of Henle**.

* Each side of the pyramid that extends toward the cortex is bordered by an **interlobular artery**.

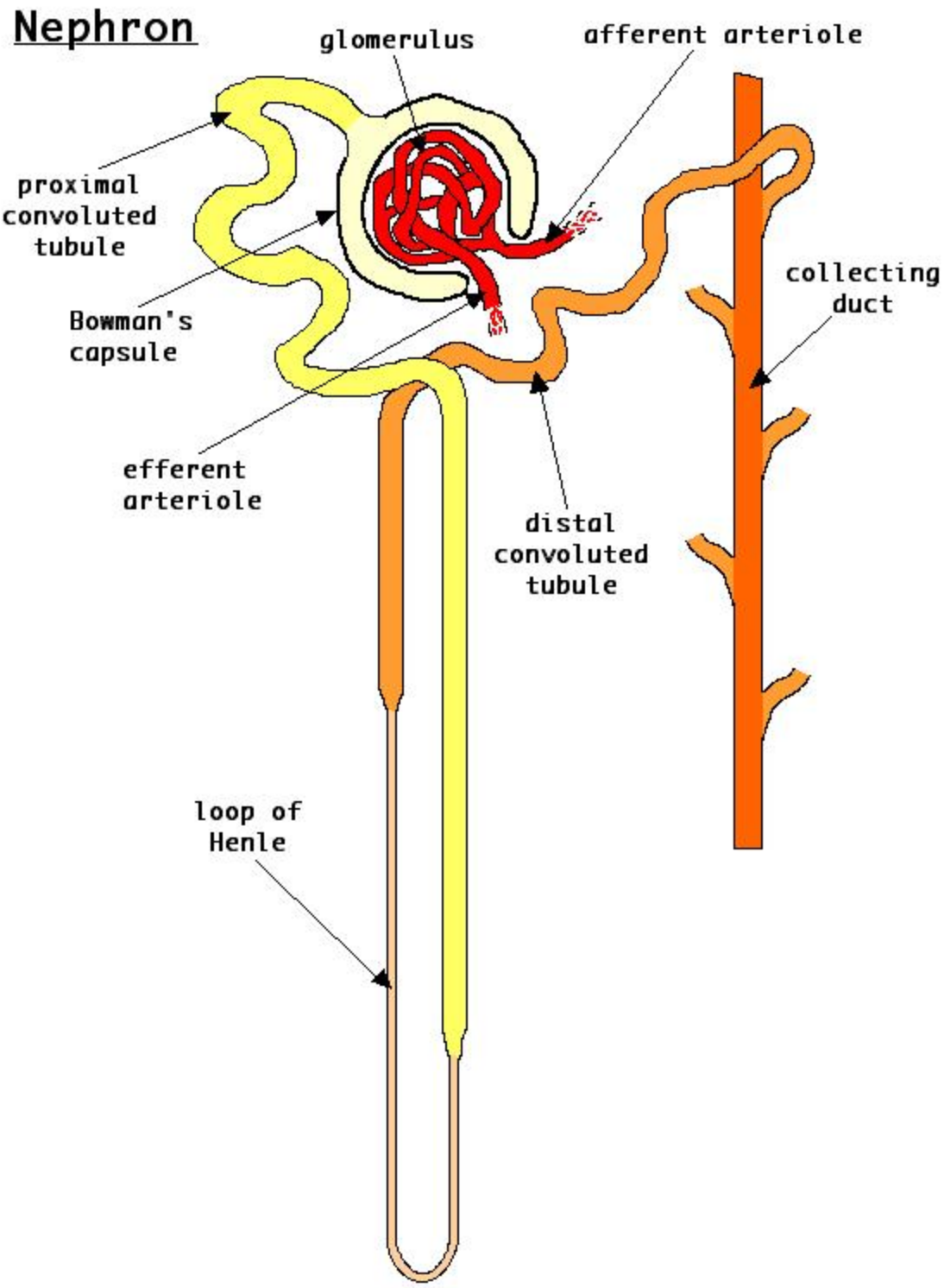
d. Where the medullary pyramid tissue meets the cortex their are large arched blood vessels called **arcuate vessels**.

e. Portions of the medullary tissues called **medullary rays** (=**pars radiata**) project into the cortical regions subdividing it into regions called **cortical labyrinths** (=**pars convoluta**).

f. The cortical labyrinths consist of many bowman's capsules, and proximal and distal convoluted tubules and have a "tortuous appearance.

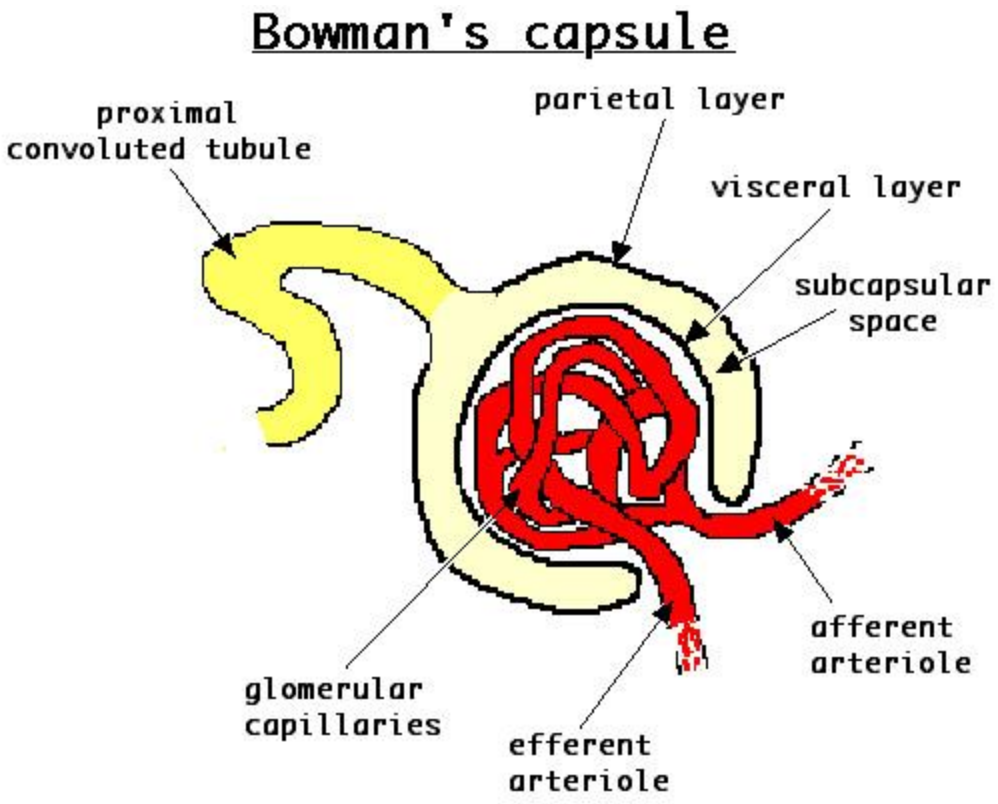
g. Note that in addition to the cortical areas between the capsule and the bases of the pyramids, cortical tissue also extends between the pyramids. These areas are called the **renal columns of Bertin**.

C. The **nephron** - the nephron is the functional unit of the kidney. There are approximately more than one million nephrons in each human kidney - consists of 2 components



1. **Renal corpuscle** - 4 parts

a. **Bowman's capsule**



* Can be considered to be the expanded and invaginated end of the proximal convoluted tubule.

* Outer surface - **parietal layer**

* Inner surface - **visceral layer**

** Composed of cells called **podocytes** that have many processes

** The smallest processes (**pedicels**) intimately surround the capillaries of the glomerulus.

** These pedicel interdigitate with each other and attach to the basal lamina of the capillary.

** Spaces betwen the interdigitating pedicels are called **slit diaphrgms or filtration slits**

** Filtrate that composes the urine enters Bowman's capsule through the filtration slits.

** The function of the podocytes is probably mechanical. They probably act to prevent the rupture of the glomerular capillaries due to blood pressure and at the same time allow filtration to proceed.

* space between the two layers called the **subcapsular space**

* parietal layer is composed of simple squamous epithelium

* Bowman's capsule intimately surrounds the glomerulus

b. **Glomerulus**

* Composed of a tuft of tortuous capillary loops that arise from the afferent arteriole and connect to the efferent arteriole.

* The capillary walls are highly fenestrated and completely encircled by a continuous basal lamina (formed from fusion of endothelial cell and podocyte basal lamina, see below).

* This arangement acts to form a selective filter that will allow certain components of the blood plasma (including excretory wastes) to pass into Bowman's capsule.

c. **Afferent arteriole**

* Typical arteriole except for the portion close to the glomerulus

** In this are it looses it's internal elastic lamina

** Smooth muscle cells of tunica medi become enlarged and glandular

** These are the juxtaglomerular cells that secrete the enzyme **renin** that is involved in the control of blood pressure.

* Function of renin

** Converts plasma protein **angiotensinogin** into **angiotensin I**.

** The angiotensin I is carried to the lungs by the circulatory system and it there is converted to **angiotensin II** by an enzyme in lung tissue.

** Angiotensin II is a powerful vasoconstrictor that causes contraction of smooth muscle in the tunica media of arteries and a resultant increase in systemic blood pressure.

** The angiotensin II also causes an increase in secretion of the hormone **aldosterone** by the adrenyl medulla.

** Aldosterone acts on cells of renal tubules causing increased reabsorption of sodium from the filtrate.

** This reabsorption of sodium and its increased concentration in the blood along with additional retension of fluid causes further increase in the systemic blood pressure.

d. **Efferent arteriole**

* Not called a venule because structure is like an arteriole

* Similar to afferent arteriole, but fewer juxtaglomerular cells

* Almost immediately breaks up into a capillary bed tht surrounds the convoluted tubules.

* Since it extends between capillary beds, this may be considered a portal system

2. **Renal tubule** - extends from Bowman's capsule, through cortex, into medulla, back into cortex where it connects with a papillary collecting duct - 3 parts

a. **Proximal convoluted tubule**

* Filtrate exits Bowman's capsule through proximal convoluted tubule.

* The tubule wall is composed of a simple cuboidal epithelium with a microvillar brush border along the lumen of the tubule.

* Cells have many mitochondria located basally, a central, spherical nucleus, and a well developed basement membrane.

* Lateral walls of these cells interdigitate with each other.

* The apical plasmelemma shows very active pinocytosis between microvilli. This is because these cells are responsible for reabsorption of proteineceous molecules from the filtrate.

* These cells also reabsorb 75 - 80% of the water and sodium ions in the filtrate, as well as certain sugars and amino acids.

b. **Loop of Henle**

* Composed of the decending and ascending components.

* Each of these has a thick and thin segment.

** Each thick segment is a transition zone: decending thick segment goes from a simple cuboidal to simple squamous epithelium, ascending thick segment goes from a simple squamous to a simple cuboidal epithelium.

** Thin segment resembles a blood capillary with somewhat thicker walls than normal.

* The loop of Henle further concentrates the urine by the removal of aditional water by a osmotic diffusion.

c. **Distal convoluted tubule**

* Lined by simple cuboidal epithelium in most regions (but see below).

* On your lab slides these cells will look similar to those that line the proximal tubule, however they lack a microvillar brush boarder.

* At the point where the distal tubule is adjacent to the afferent and efferent arterioles of it`s own renal corpuscle, the structure of its epithelium changes (called the **juxtaglomerular region**).

* Cells become more columnar and take on a darker stain.

* This region is called the **macula densa**.

* Function of the macula densa is not certain, but it's close association with the juxtglomerular cells suggests that it may provide "information" to these cells that regulates the secretion of renin.

D. **Collecting tubules and ducts**

1. The distal convoluted tubules of the nephrons empty into the **collecting tubules**.

2. The collecting tubules extend into the renal medulla and merge to form the large **papillary ducts of Bellini** that empty into the calyces.

3. The smaller tubules are lined with simple cuboidal epithelium. As they penetrate deeper into the medulla and approach the papillary ducts, the lining becomes columnar.

4. The collecting tubules and papillary ducts are not areas of reabsorption, but simply act to transfer the urine to the calyces.

E. **Cardiovascular circulation to the kidney**

1. The kidneys receive blood from **renal arteries**.

2. These enter the kidney through the connective tissue of the hilus.

3. Within the hilus these arteries branch to form the **interlobar arteries** which extend between the medullary pyramids.

4. As the interlobular arteries reach the medullary - cortical boundary, they branch to form the **arcuate arteries** that run parallel to the connective tissue capsule surrounding the kidney at the level of the cortical-medullary junction.

5. Branches from the arcuate arteries extend perpendicular into the cortex and give rise to the **afferent arterioles** of the glomeruli.

6. The capillaries of the glomerulus recoalesce to form the **efferent arteriole** that leaves the glomerulus and then rebranches to form two capillary networks,

a. one surrounding the proximal and distal convoluted tubules and

b. the other extending into the medullary tissue to form a capillary net around the loop of Henle.

7. In the case of the juxtamedullary (next to the medulla) nephrons, one arteriole branch of the efferent arteriole follows a path into the medulla were it breaks up into linear capillaries that run parallel to the linear portions of the loops Henle and the collecting ducts. These linear capillaries then loop back toward the cortex where they form venules that will join the arcuate vein. These linear capillaries are called the **vasa recta** and provide oxygen and nutrients to the tissues of the medulla.

8. The **interlobular veins** receive blood from the capillaries and carry it to the **arcuate veins** which connect to **interlobar veins** that extend parallel to their corresponding interlobar arteries.

9. The interlobar veins connect to the **renal vein** that carries blood out of the kidney.

10. There are also the stellate veins in the peripheral cortex of the kidney that result from the convergence of capillaries in this area.

E. The **calyces**, **pelvis**, **ureter**, **bladder** and **urethral** structure is relatively simple. Read about it on pp. 375 - 379 in text.

1. Note there are differences between male and female urethra.

2. Also note that the walls of the bladder and the urinary passages leaving the bladder are lined with transitional epithelium.

The histological structure of the calyces, renal pelvis, ureter and urinary bladder is broadly similar and each consists of a lumen surrounded by a wall of three coats (tunics): Mucosa, muscularis and adventitia/serosa. The mucosa is lined by transitional epithelium over a lamina propria of irregular connective tissue. The transitional epithelium is impermeable to water and salts. The muscularis is a bilaminar smooth muscle layer with inner longitudinal and outer circular bundles (but see urinary bladder, below). It produces peristalsis to move the urine. The adventitia is the outer connective tissue coat. If it is covered with peritoneum (mesothelium) it is referred to as serosa. The ureters are muscular tubes connecting the renal pelvis to the urinary bladder.

The urinary bladder It receives the bilateral ureters and empties via the midline urethra. The muscularis layer forms a detrussor muscle and is formed by smooth muscle bundles arranged in a complex meshwork characteristic of all expelling organs. At the distal end of the bladder, the muscularis is thickened to form the internal urethral sphincter

Urethra :

The urethra is a fibromuscular tube connecting the bladder to the external urethral orifice. It is sexually dimorphic. In the males it is the terminal duct for both the urinary and genital systems. In the 9 female it empties only the bladder. In both sexes the lining grades from a transitional epithelium adjacent to the bladder to a

stratified squamous epithelium at the orifice. Males often have a stratified columnar or pseudostratified columnar epithelium in the middle portion.