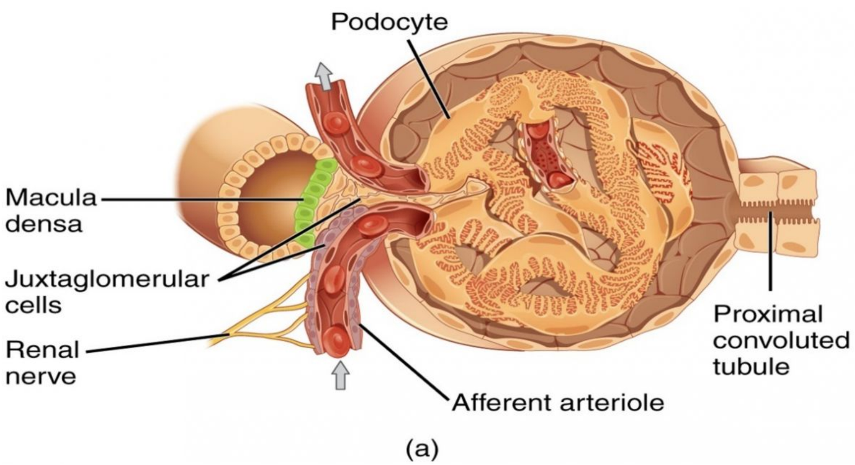
4.1.4

The Renal Corpuscle: Bowman's Capsule

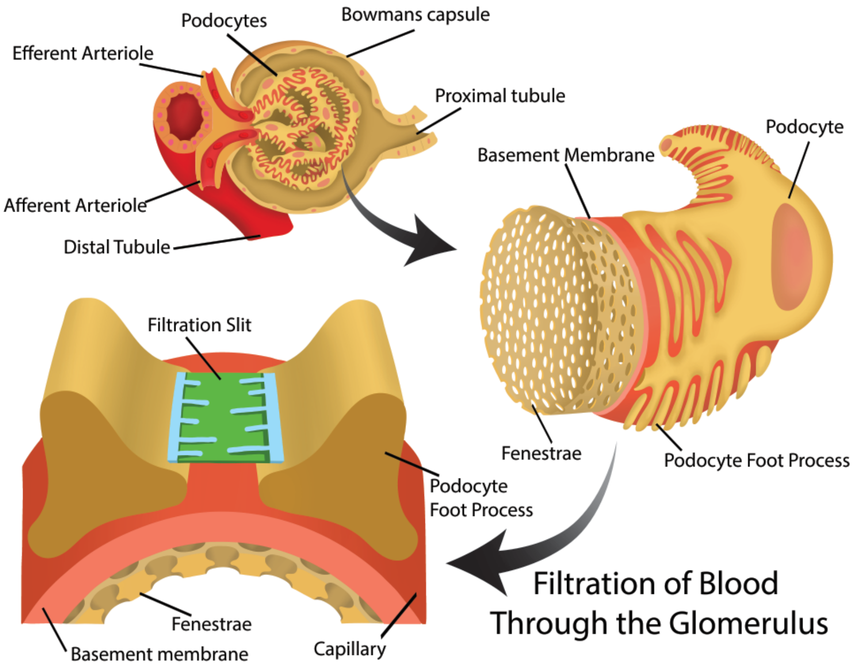


Juxtaglomerular Apparatus and Glomerulus

Urine formation begins with a process called **filtration**. Filtration takes place in the renal corpuscle. To describe the structure of the nephron, we will start at Bowman's capsule. Previously we drove the magic school backwards through the nephron, now we will start from where the blood is first filtered. Bowman's capsule is a cup-like sac that participates in the first step of urine formation. Intertwining within the cup is a capillary bed of blood vessels called the **glomerulus**. The glomerular capillaries contain blood that entered the kidney through the renal artery. Upon entering the kidneys, the renal artery branched into smaller and smaller arteries, eventually into an afferent arteriole and then the glomerular capillary. For its size (<0.5% of total body weight), the kidney receives an impressive amount of blood flow (~20% of cardiac output). For every Bowman's capsule there is an associated glomerular capillary bed (1.2 million/kidney). Together the two structures (Bowman's capsule and the glomerular capillaries) form the **renal corpuscle.**

As the blood travels to these capillaries, fluids and substances from the blood (plasma) spill out of the glomerulus and are collected in the cup-like portion of Bowman's capsule. Since Bowman's capsule is continuous with the rest of the nephron tubules, the solution that spills out, the **filtrate**, is the solution that will eventually become urine. The "spilling" out of the solution is a process referred to as **filtration** (the first of three processes resulting in the formation of urine). Whether a substance will be filtered or not, is determined by two criteria; **size** and **charge**. Substances that fit the criteria, and therefore will be filtered, include: water, glucose, NaCl, amino acids, small proteins, metabolites, and urea. Substances that do not fit the criteria, and thus will not be filtered, include medium to large proteins, red and white blood cells, and platelets. The normal rate of filtrate formation is 125ml of plasma per minute and is known as the **glomerular filtration rate** (GFR). The **GFR** is a very important diagnostic test of kidney function and will be used in subsequent discussions of kidney function.

In order for substances to pass from the glomerulus through to Bowman's capsule and the rest of the nephron they must be able to cross the filtration barrier. The barrier consists of four potential obstacles, the **fenestrated endothelium** of the glomerulus, the **basement membrane** of the endothelium, the visceral layer of Bowman's capsule (**podocytes**), and the **mesangial cells**.



Fenestrated Endothelium, Basement Membrane, and Podocytes forming a Visceral Layer.

Image by BYU-Idaho Becky T. F2018

Fenestrated Endothelium: Two features of the glomerular endothelium are responsible for the ability of these capillaries to effectively filter the plasma. First, the glomerulus is composed of a special type of capillary called fenestrated capillaries. The walls of these capillaries contain fenestra (Latin for window) which are pores in the capillary membranes and negatively charged glycoproteins. The fenestra are approximately 70nM in diameter. You are probably thinking, "why in the heck would anyone want to know that, and why DOES anyone know that?!" Well, red blood cells are 7000 nM in diameter so this should solidify the fact that finding blood in the urine is never a good a thing. The smallest of the plasma proteins have diameters about the same size as the fenestra and might be filtered, however, the negative charges on the endothelial cells impair filtration of these negatively charged proteins. Thus, the first filtration barrier is specific to prevent the filtration of blood cells and plasma proteins.

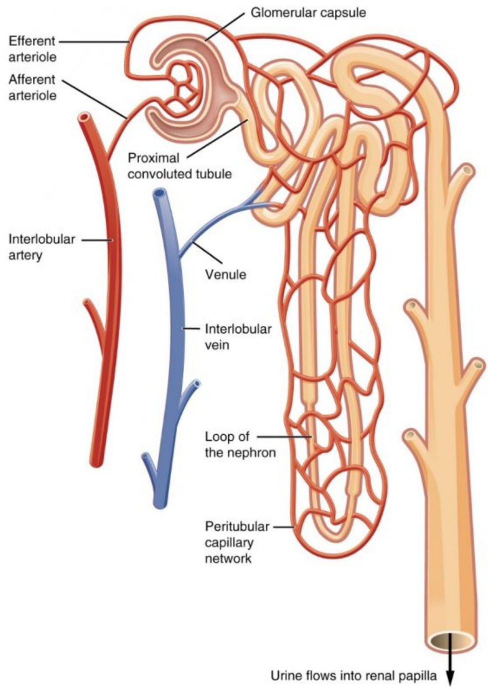
The basement membrane: A basement membrane is always found in association with epithelial cells and, in this case, serves as a porous matrix of anchored, negatively charged proteins that act as a barrier to circulating negatively charged proteins found in the blood. This barrier seems to function as a charge specific barrier that selects against negatively charged substances. However, this does not mean that all negatively charged substances are not filtered as some smaller substances (ions such as Cl-, HCO3-, etc.) are freely filtered. Still, **in terms of importance, the barrier seems to be the most important against negative charges**.

The podocytes: The podocytes are the specialized cells that form the visceral layer of Bowman's capsule. They contain long, finger-like processes that completely encircle the capillaries of the glomerulus. The finger-like processes interdigitate, forming gaps between them called filtration slits that serve as the third filter (see images below). Each filtration slit is bridged by proteins (nephrin, NEPH-1, podocin) that make up a thin diaphragm which functions as a size and charge selective filter.

Mesangial cells: Mesangial cells are similar to smooth muscle cells and are interspersed throughout the glomerular capillaries as well as between the afferent and efferent arterioles. Mesangial cells can contract which changes the surface area of the glomerular capillaries and thereby influencing filtration. In addition, they have been shown to have phagocytic activity and to secrete local regulatory hormones (paracrines).

Peritubular Capillaries

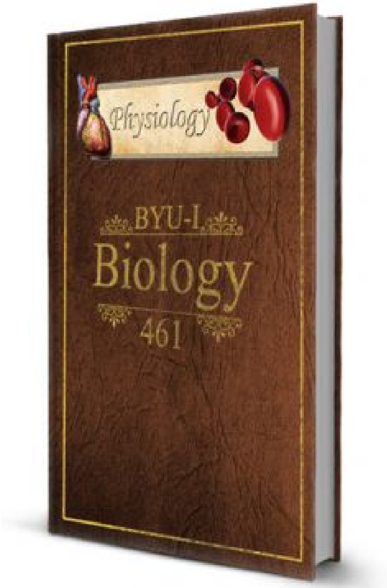
The kidney capillary bed (glomerulus) is unique in that it is not immediately drained by a venule, instead the glomerular capillaries rejoin to form the **efferent** arterioles which then divide into another capillary bed called the **peritubular capillaries**.



Peritubular Capillaries and Vasa Recta.

Author: OpenStax;
Site: http://cnx.org/contents/ee5f4420-7ba2-44d6-86f1-85ff5a0e4ada@3/Gross-Anatomy-of-the-Kidney; License: Creative Commons Attribution 4.0 License.

The peritubular capillary bed surrounds the proximal and distal tubules of the nephron in both cortical and juxtamedullary nephrons. In juxtamedullary nephrons, the peritubular capillaries branch again to form a third capillary bed that surrounds the loop of Henle, where they are known as the **vasa recta**. The **afferent** (before the glomerulus) and the **efferent** (after the glomerulus) arterioles play a very important role in determining the pressure in the glomerular capillaries.



Shaw, J. & Hunt, J. (n.d.). *BIO 461 Principles of Physiology*. EdTech Books. https://edtechbooks.org/bio_461_principles_o