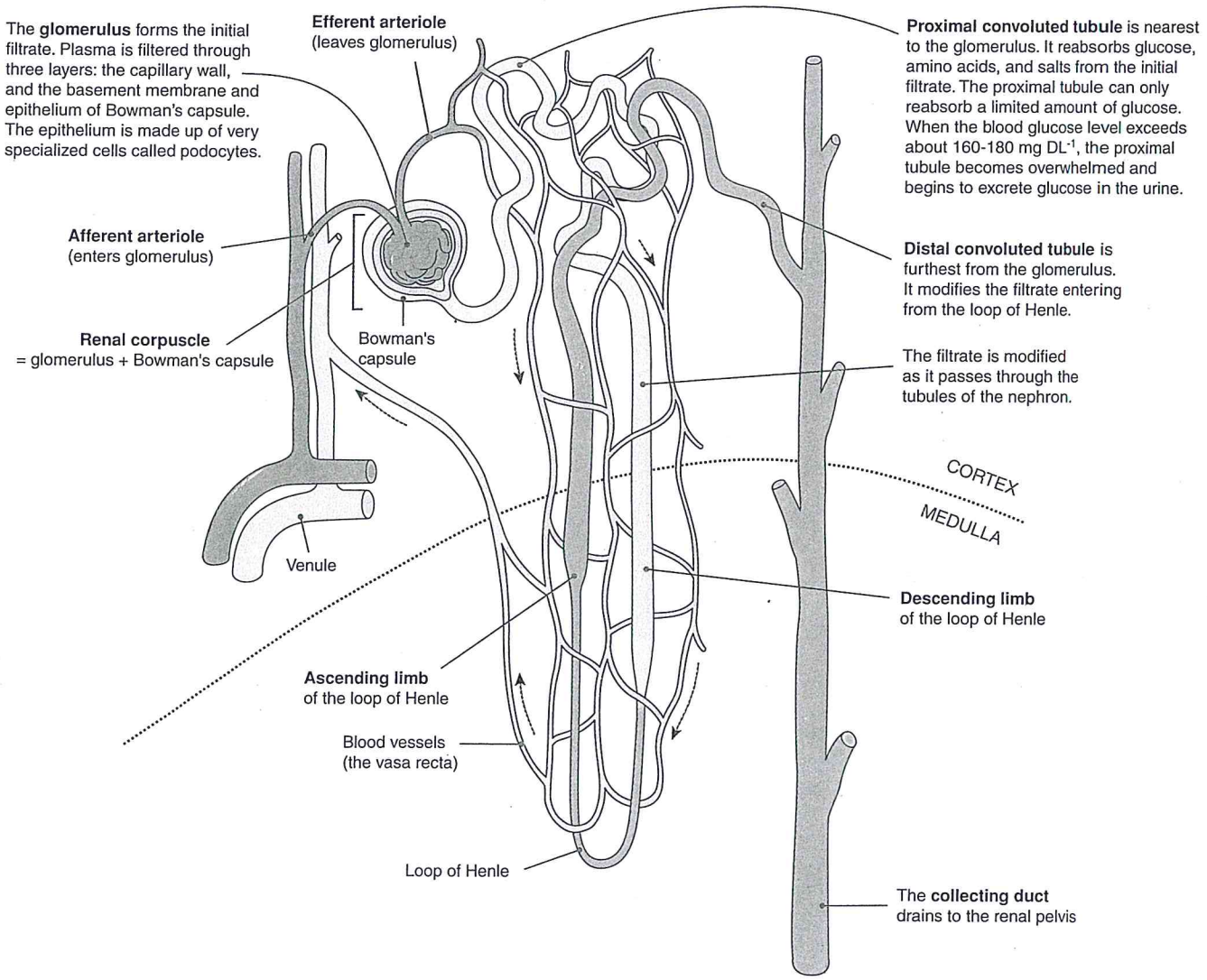
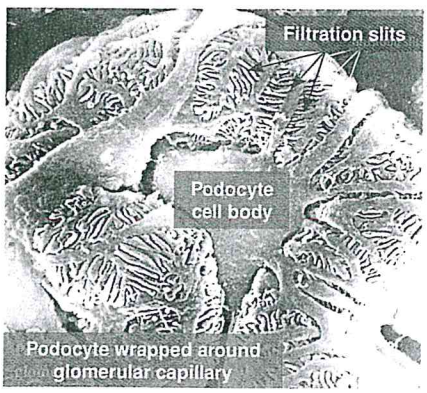
The Physiology of the Kidney

The kidney **nephron**, is a selective filter element, comprising a **renal corpuscle** and its associated tubules and ducts. **Ultrafiltration**, i.e. forcing fluid and dissolved substances through a membrane by pressure, occurs in the first part of the nephron, across the membranes of the capillaries and the glomerular capsule. The passage of water and solutes into the nephron and the formation of the glomerular filtrate depends on the pressure of the blood entering the afferent arteriole (below). If it increases, filtration rate increases. When it falls, glomerular filtration rate also falls. This process is so precisely regulated that, in spite of fluctuations in arteriolar pressure, glomerular filtration rate per day stays constant. After formation of the initial filtrate, the **urine** is modified through secretion and tubular reabsorption according to physiological needs at the time.

Nephron Structure





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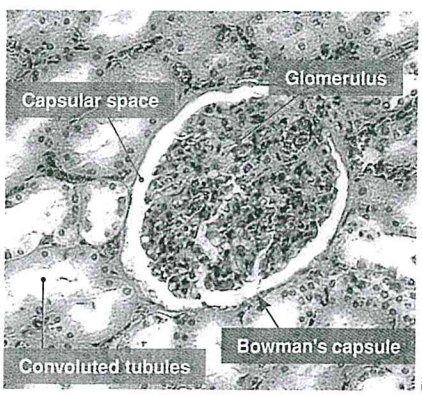
The epithelium of Bowman's capsule is made up of specialized cells called **podocytes**. The finger-like cellular processes of the podocytes wrap around the capillaries of the glomerulus, and the plasma filtrate passes through the filtration slits between them.

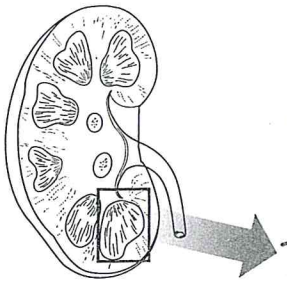


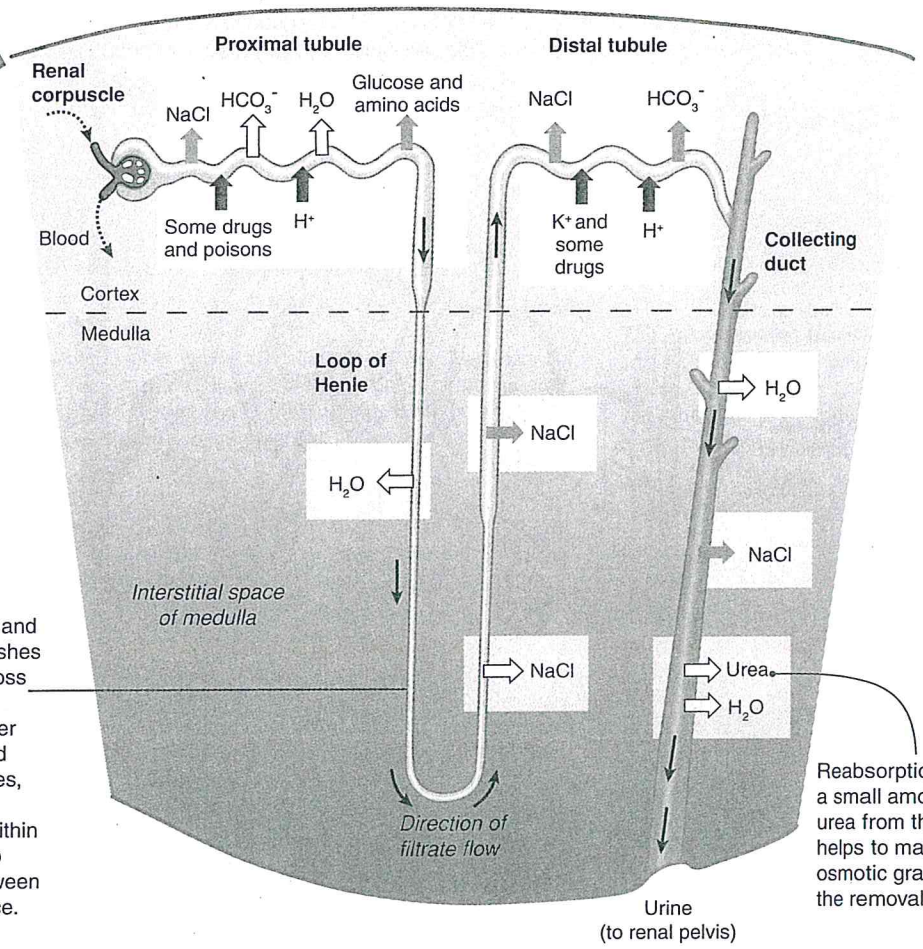
Bowman's capsule is a double walled cup, lying in the cortex of the kidney. It encloses a dense capillary network called the **glomerulus**. The capsule and its enclosed glomerulus form a **renal corpuscle**. In this section, the convoluted tubules can be seen surrounding the renal corpuscle.

Dipstick urinalysis is commonly used to detect metabolic errors. Less than 0.1% of glucose filtered by the glomerulus normally appears in urine. The presence of glucose in the urine is usually due to untreated diabetes mellitus, which is characterized by high blood glucose levels.

Summary of Activities in the Kidney Nephron

Urine formation begins by **ultrafiltration** of the blood, as fluid is forced through the capillaries of the glomerulus, forming a filtrate similar to blood but lacking cells and proteins. The filtrate is then modified by **secretion** and **reabsorption** to add or remove substances (e.g. ions). The processes involved in urine formation are summarized below. The loop of Henle acts as a **countercurrent multiplier**, establishing and increasing the salt gradient through the medullary region. This is possible because the descending loop is freely permeable to water but the ascending loop is not.





Filtrate

- H_2O
- Salts (e.g. NaCl)
- HCO_3^- (bicarbonate)
- H^+
- Urea
- Glucose, amino acids
- Some drugs

Reabsorption

- Active transport
- Passive transport
- Secretion (active transport)

The loop of Henle has varying permeability along its length to salt and water. The transport of salts establishes and maintains the salt gradient across the medulla needed to concentrate the urine in the collecting duct. Water follows the salt out of the filtrate and is transported away by the capillaries, maintaining the high interstitial salt gradient. The countercurrent flow within the descending and ascending limb multiplies the osmotic gradient between tubular fluid and the interstitial space.

Reabsorption of a small amount of urea from the urine helps to maintain the osmotic gradient for the removal of water.

1. Why does the kidney receive blood at a higher pressure than other organs? _____

_____

2. Explain the importance of the following in the production of urine in the kidney nephron:

   (a) Filtration of the blood at the glomerulus: _____

   _____

   (b) Active secretion: _____

   _____

   (c) Reabsorption: _____

   _____

   (d) Osmosis: _____

   _____

3. (a) What is the purpose of the salt gradient in the kidney? _____

   _____

   (b) How is this salt gradient produced? _____

   _____