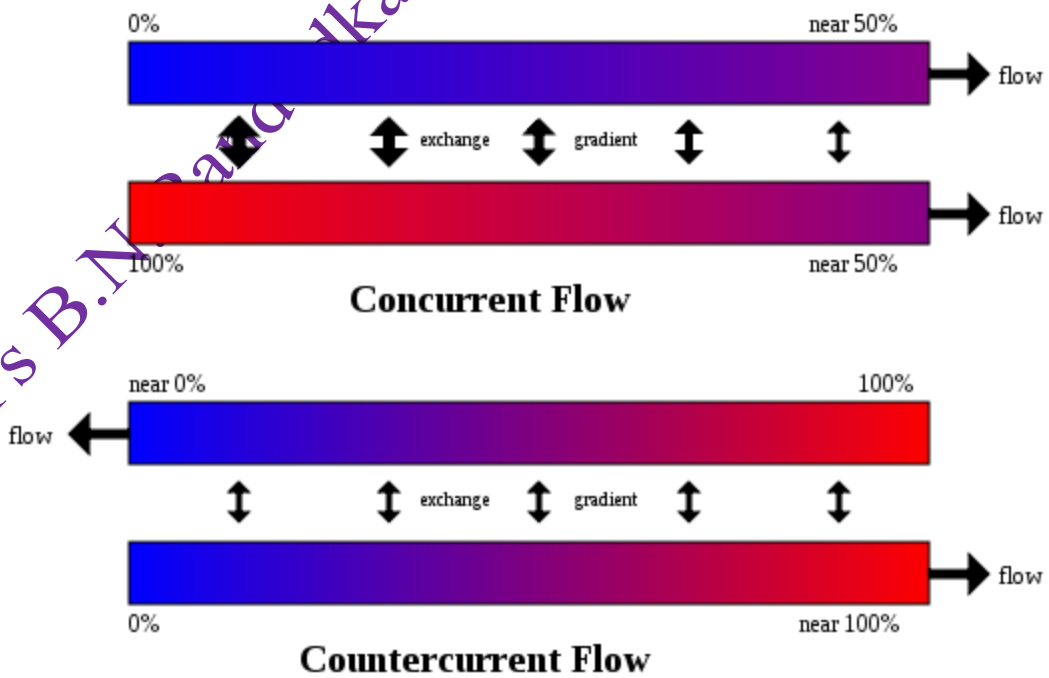
- # Countercurrent Mechanism: Concentrated Urine Formation

Unless one is drinking very large quantities of water, the urine has to be excreted in a concentrated form. Otherwise, the body will lose a lot of water and the person will suffer from the effects of dehydration and low blood pressure. The mechanism that the kidneys use to concentrate urine is called the countercurrent mechanism. In order to understand countercurrent mechanism, first, we have to understand how a countercurrent multiplier works.

Let us say there are 2 tubes, through which a solution of the same substance is flowing. There is a free exchange of the solution between the two tubes. There can be two kinds of flow through these tubes.

- **Concurrent flow:** Here, the solutions in the two tubes flow in the same direction. If at one end, one of them starts at 0% concentration and the other starts at 100% concentration. By the time they reach the other end of the tubes, the concentrations in each tube will be roughly 50%, as shown in the figure.

- **Countercurrent flow:** Here the solutions in the two tubes flow in opposite directions. In one tube 0% concentration of the solution starts to flow from one end, and in the other tube, 100% concentration of the solution starts to flow from the opposite end. Due to the free exchange of the substances between the two tubes, by the time the solutions reach the end of the tube, it will have acquired a concentration equal to the other tube at that end. This will become clear from the figure.



How is concentrated urine formed?

The countercurrent multiplier or the countercurrent mechanism is used to concentrate urine in the kidneys by the nephrons of the human excretory system.

The nephrons involved in the formation of concentrated urine extend all the way from the cortex of the kidney to the medulla. And they are accompanied by vasa recta. The flow of filtrate in the two limbs of the Henle's loop is in opposite directions, and so is the flow of blood cells in vasa recta. NaCl is transported from the ascending limb of the Henle's loop to the descending limb of the vasa recta. The ascending limb of the vasa recta, in turn, transports NaCl to the interstitium (the tissue between the loop of Henle and the vasa recta). Thus, a concentration gradient of 300mm in the cortex to 1200mm in the medulla is created (mOsm or milliosmoles is a unit of osmolarity i.e. the concentration of osmotically active substances). Urea contributes to this process by being transported by the descending limb of the loop of Henle to the interstitium.

As urine flows downwards in the collecting tubule, it encounters higher and higher concentrations of solutes in the interstitium. Hence it goes on losing water due to osmosis. This is how urine is concentrated.

- **What are the functions of the kidney?**

The primary function of the kidney is to make urine and purify the blood. Each kidney removes waste materials, and other chemicals which are not required by the body. Most important functions of the kidney are described below:

1. *Removal of waste products*

- Purification of blood by removal of waste products is the most important function of the kidney.
- The food that we consume contains protein. Protein is necessary for the growth and repair of the body. But as protein is utilized by the body it produces waste products. Accumulation and retention of these waste products is similar to retaining poison inside the body. Each kidney filters blood, and toxic waste products which are eventually excreted in the urine.
- Creatinine and urea are two important waste products that can easily be measured in the blood. Their "values" in blood tests reflects the function of the kidney. When both the kidneys fail, value of creatinine and urea will be high in blood test.

2. *Removal of excess fluid*

- The second most important function of the kidney is the regulation of fluid balance by excreting excess amount of water as urine while retaining the necessary amount of water in the body, that is essential for living .When the kidneys, fail they lose the ability of removing this excess amount of water. Excess water in the body leads to swelling.

3. *Balance minerals and chemicals*

- The kidneys play another important role of regulating minerals and chemicals like sodium, potassium, hydrogen, calcium, phosphorus, magnesium and bicarbonate and maintains normal composition of body fluid.

- Changes in the sodium level can affect person's mental state, while changes in the potassium level can have serious adverse effects on the rhythm of the heart as well as functioning of the muscles. Maintenance of normal level of the calcium and phosphorus is essential for healthy bones and teeth.

4. *Control of blood pressure*

- The kidneys produce different hormones (renin, angiotensin, aldosterone, prostaglandin etc) which help regulate water and salt in the body, which plays vital roles in the maintenance of good blood pressure control. Disturbances in hormone production and regulation of salt and water in a patient with kidney failure can lead to high blood pressure.

5. *Red blood cells production*

- Erythropoietin is another hormone produced in the kidneys, it plays an important role in the production of red blood cells (RBC). During kidney failure, production of erythropoietin is decreased, which in turn leads to decreased production of RBC resulting in low hemoglobin (anemia). This is the reason why in patients with kidney failure, the hemoglobin count does not improve despite supplementation with iron and vitamin preparations.

6. *To maintain healthy bones*

- The kidneys convert vitamin D into its active form which is essential for the absorption of calcium from food, growth of the bones and teeth, and keep the bones strong and healthy. During kidney failure, decreased active vitamin D leads to decreased, growth of bones and they also become weak. Growth retardation may be sign of kidney failure in children.

- **RENAL THRESHOLD**

In physiology, the **renal threshold** is the concentration of a substance dissolved in the blood above which the kidneys begin to remove it into theurine. When the renal threshold of a substance is exceeded, reabsorption of the substance by the proximal convoluted tubule is incomplete; consequently, part of the substance remains in the urine. Renal thresholds vary by substance – the low potency poison urea, for instance, is removed at much lower concentrations than glucose. Indeed, the most common reason for the glucose renal threshold ever being exceeded isdiabetes.

- **NEPHRITIS**

Nephritis is a condition in which the nephrons, the functional units of the kidneys, become inflamed. This inflammation, which is also known as glomerulonephritis, can adversely affect kidney function.

Types

There are several types of nephritis that can occur in the kidneys.

There are several different types of nephritis, including:

Acute glomerulonephritis: This form of nephritis can develop suddenly after a severe infection, such as strep throat, hepatitis, or HIV.

Lupus and rarer disorders, such as vasculitides and granulomatosis with polyangiitis (GPA), can also lead to acute inflammation of the kidneys. A person with these conditions will require prompt medical attention during a flare-up to reduce kidney damage.

Lupus nephritis: Lupus is an autoimmune disease, which means that the immune system mistakenly attacks healthy tissues in the body.

Over half of all individuals with a lupus diagnosis eventually develop lupus nephritis. This occurs when the immune system attacks the kidneys.

Causes

There are many different causes of nephritis. In some cases, the cause may not be clear.

Nephritis and kidney disease often seem to run in families, which suggests a possible genetic component. Some infections, such as HIV and hepatitis B or C, can also cause nephritis.

In some cases, kidney damage can occur as a result of medications, such as antibiotics. This damage can lead to nephritis. Taking too many pain relievers, nonsteroidal anti-inflammatory drugs (NSAIDs), or diuretic pills can also cause this condition.

The treatment for nephritis may vary according to the cause and type.

Acute nephritis sometimes resolves without treatment. However, it usually requires medication and special procedures that remove excess fluids and dangerous proteins.

Treating chronic nephritis typically involves regular kidney check-ups and blood pressure monitoring. Doctors may prescribe water pills to control blood pressure and reduce any swelling.