

Kidney and osmoregulation

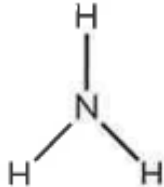
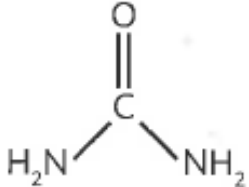
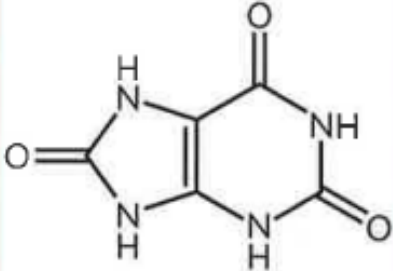
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Excretion of products of metabolism

The major product of metabolism is carbon dioxide, and that one is eliminated through the breath.

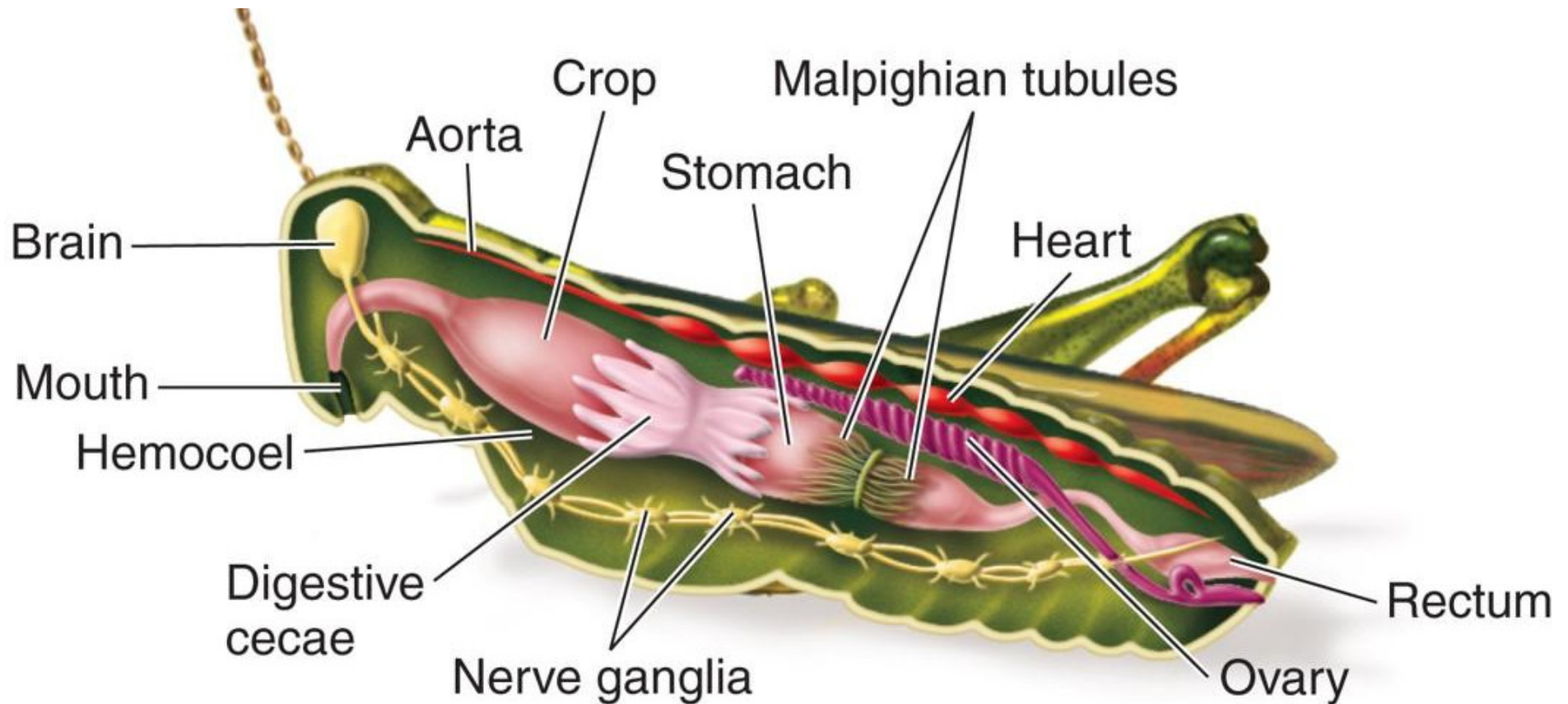
Aminoacids, however, contain nitrogen, which is not that easy to eliminate

Which way the excess of nitrogen is eliminated in a given species depends on the option evolved in ancestral stages.

Structure of nitrogenous waste	Example organism	Advantages	Disadvantages
Ammonia 	Fish	Requires very little energy to produce	Very toxic in blood and tissues; must be diluted and removed from the body quickly by using a great deal of water
Urea 	Mammals	Requires less energy to produce compared with uric acid; toxic in blood and tissues but only at physiologically abnormal levels	Requires more energy to produce compared with ammonia; requires some water for dilution and removal from the body
Uric acid 	Birds	Relatively insoluble in aqueous solutions such as blood and cytoplasm; can be stored within specialized structures within some animal's eggs; requires little to no water for dilution and removal from the body	Its complex structure requires a great deal of energy to produce

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Insects have an excretion system that resembles the mammalian lymphatic system.

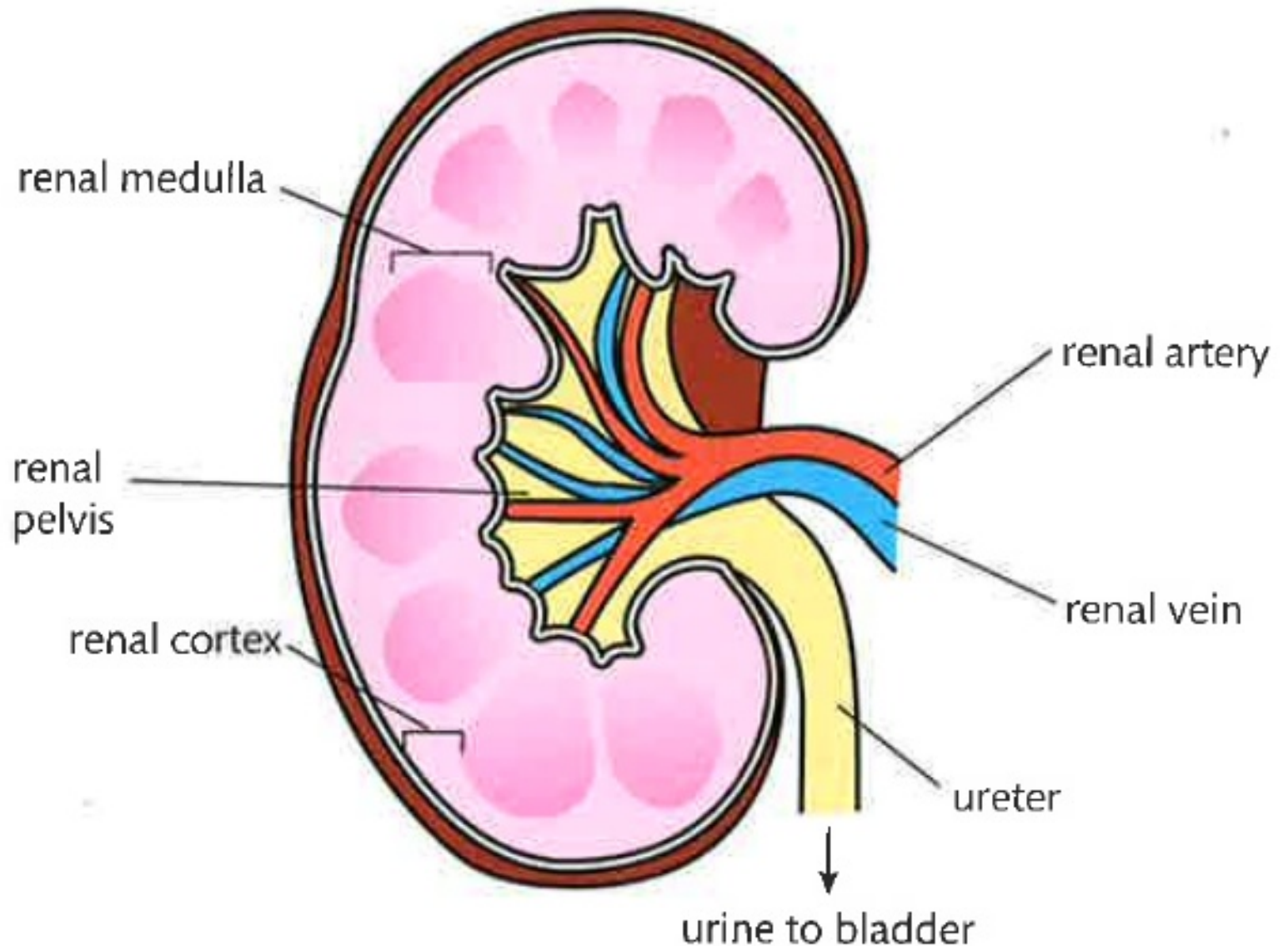


The Malpighian tubules drain fluids from the blood that bathes them and, during the flow, removes from them useful substances*. The content of the tubules is then poured into the gut.

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In mammals, the kidney is in charge of cleaning the blood of the products of metabolism.

Some of the parts of the kidney need to be known so as to make a labelled drawing



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Nephrons are the structures that carry out the actual filtration. They have several different parts.

Each nephron has five parts*

The Bowman capsule is at the beginning

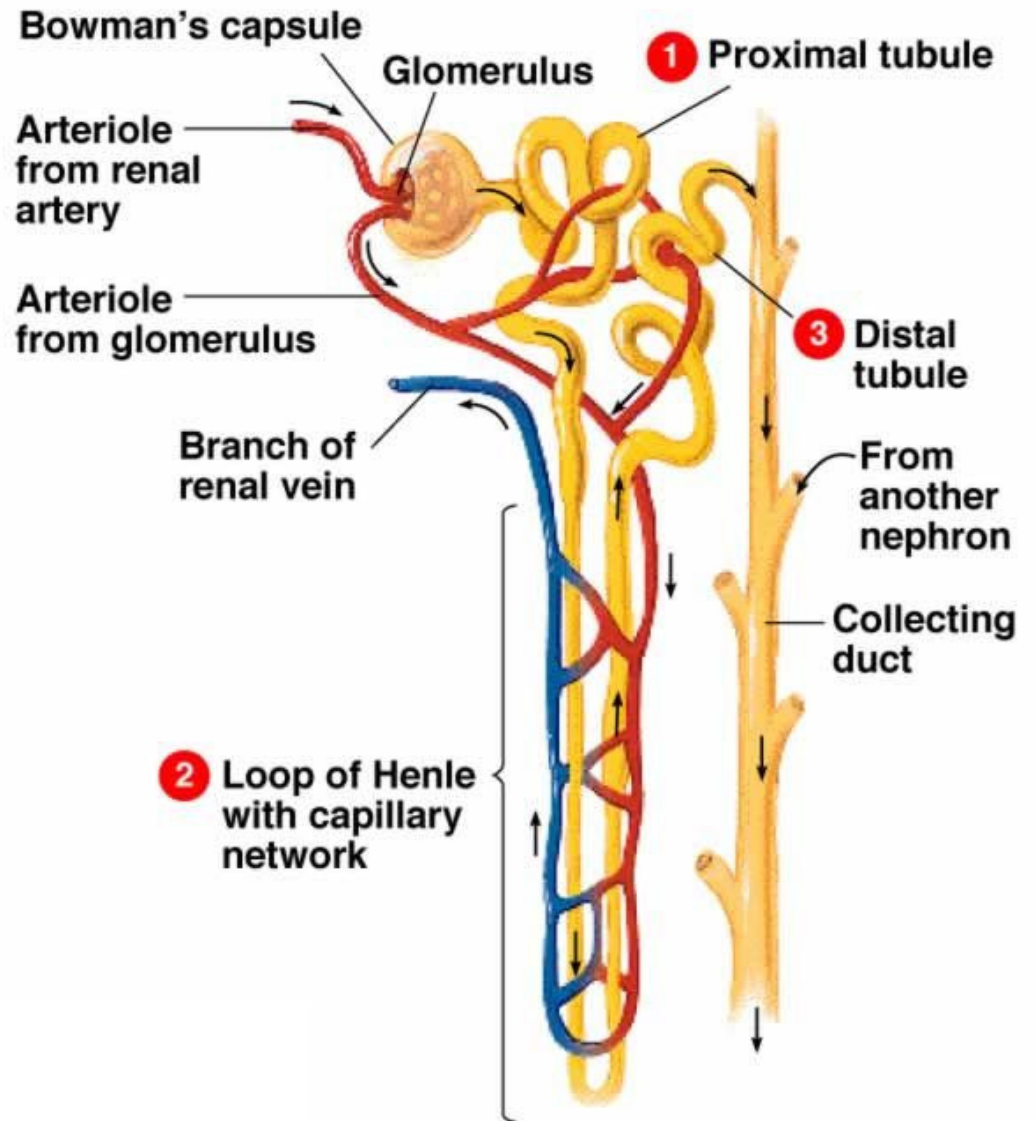
Proximal convoluted tube

Descending arm of Loop of Henle

Ascending arm of Loop of Henle

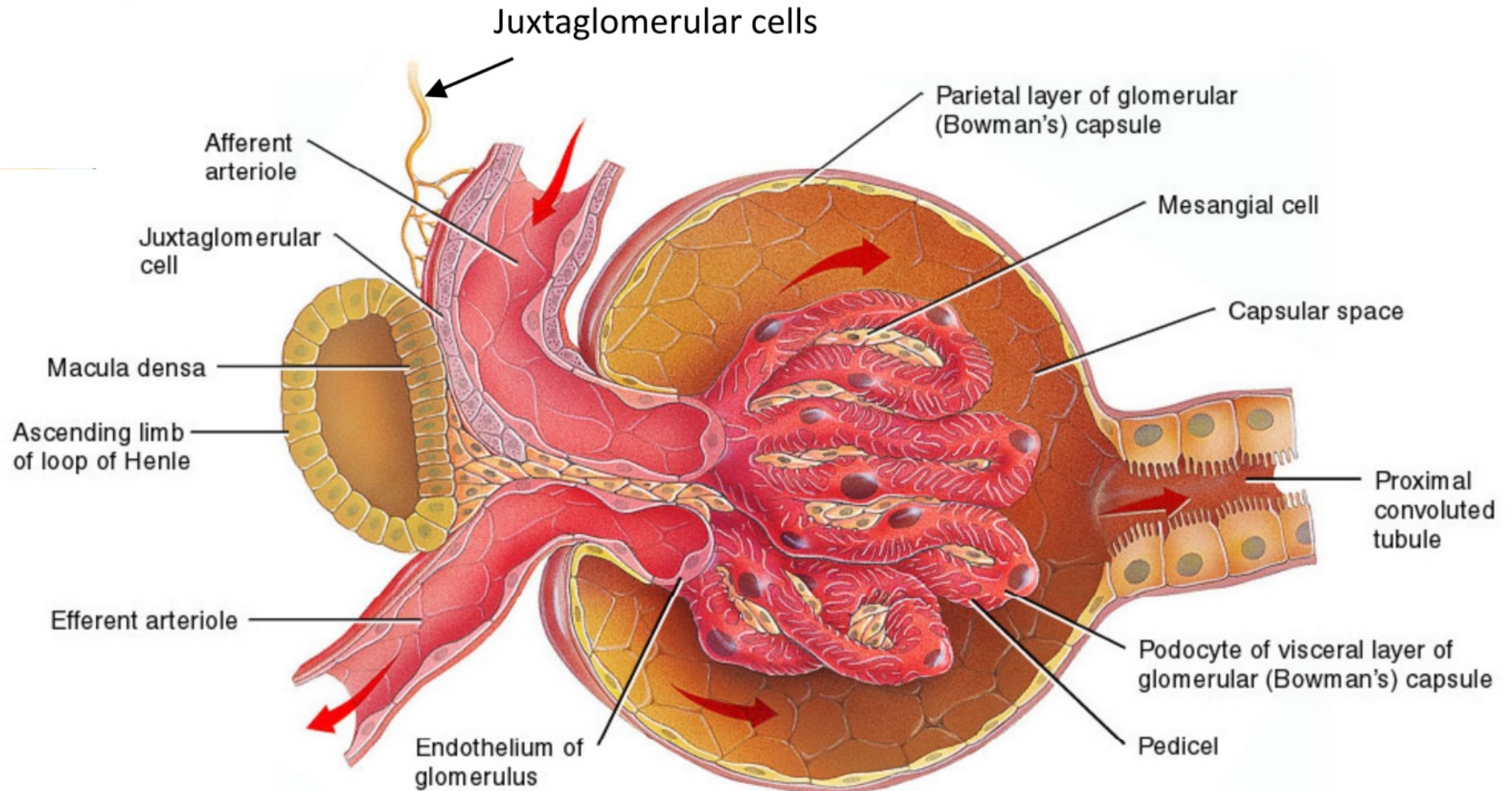
Distal convoluted tube

The collecting duct can be considered also part of other nephrons



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The blood enters the nephron through a small artery branched from the renal artery. The Bowman capsule allows for much of the plasma content to exit the bloodstream and enter the capsular space. We call this liquid “primary filtrate”.

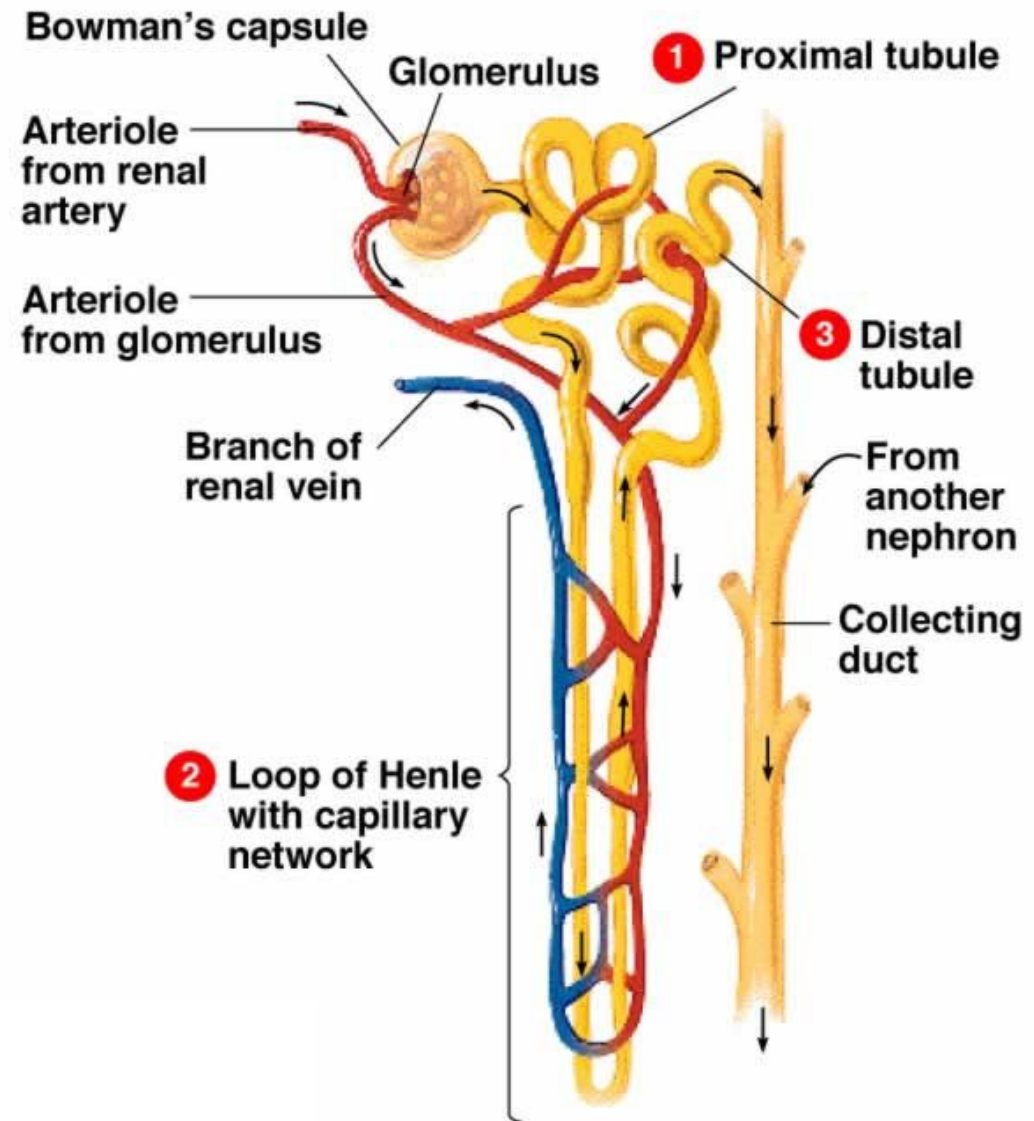


(a) Renal corpuscle (internal view)

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The proximal convoluted tubule is responsible for recovering all the glucose and amino acids as well as other organic compounds. It also recovers more than half of the sodium and the water.

It is irrigated by the same artery that comes out of the bowman's capsule, so the blood recovers these compounds rather quickly. We still consider it an artery because it still carries oxygen.

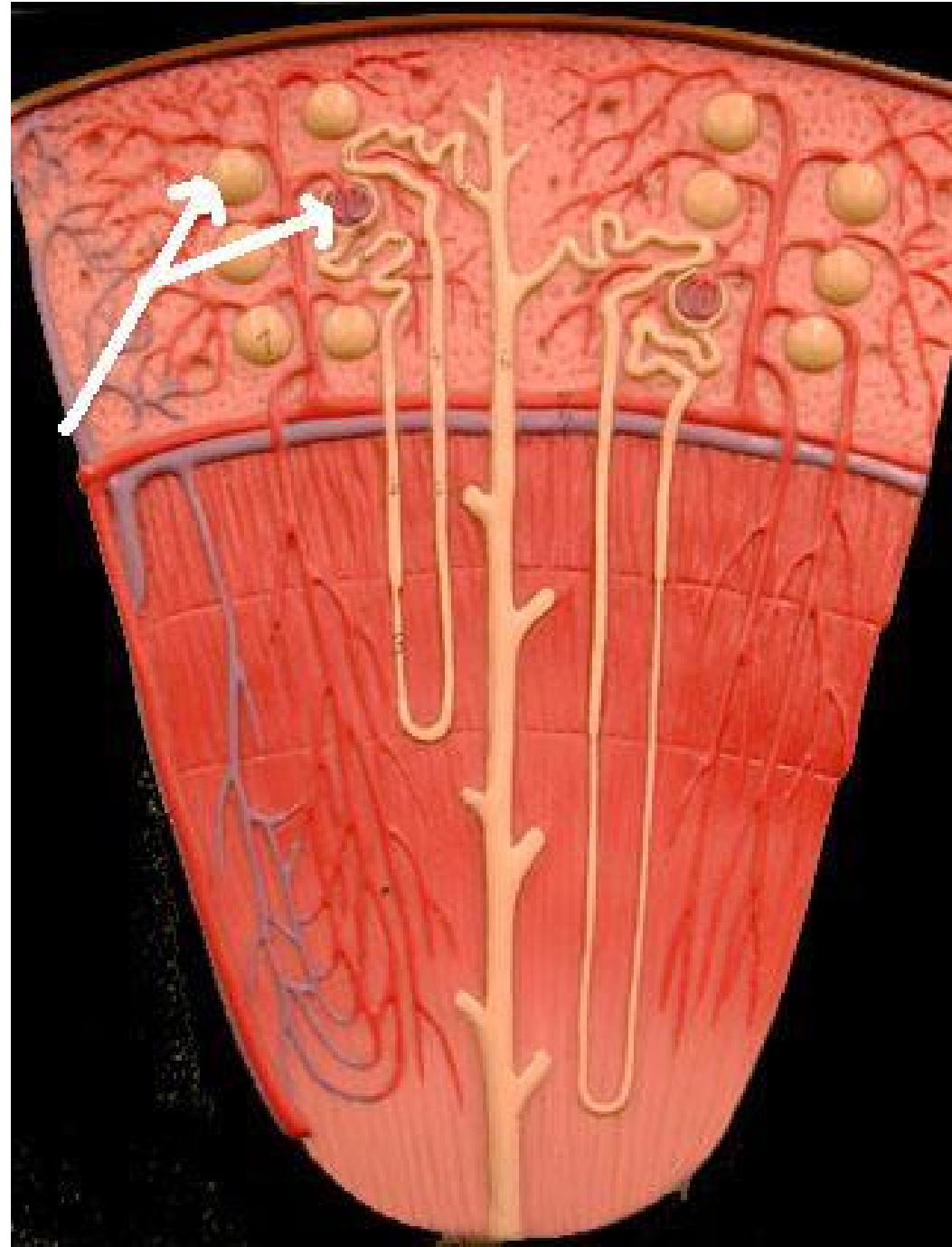


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The descending arm of the loop of Henle goes into a different section of the kidney that is called the medulla. We have to keep in mind that the medulla is hypertonic compared to the cortex, that is, the concentration of salt is higher.

The descending arm of the loop of Henle is permeable to water, so water exits the tubule through osmosis, that is, due to the higher concentration of salts in the medulla.

The ascending arm of the loop of Henle has zero permeability to water. Instead, there are active transporters (pumps) that force salt ions out of the tubule. This is the reason why the medulla is hypertonic.

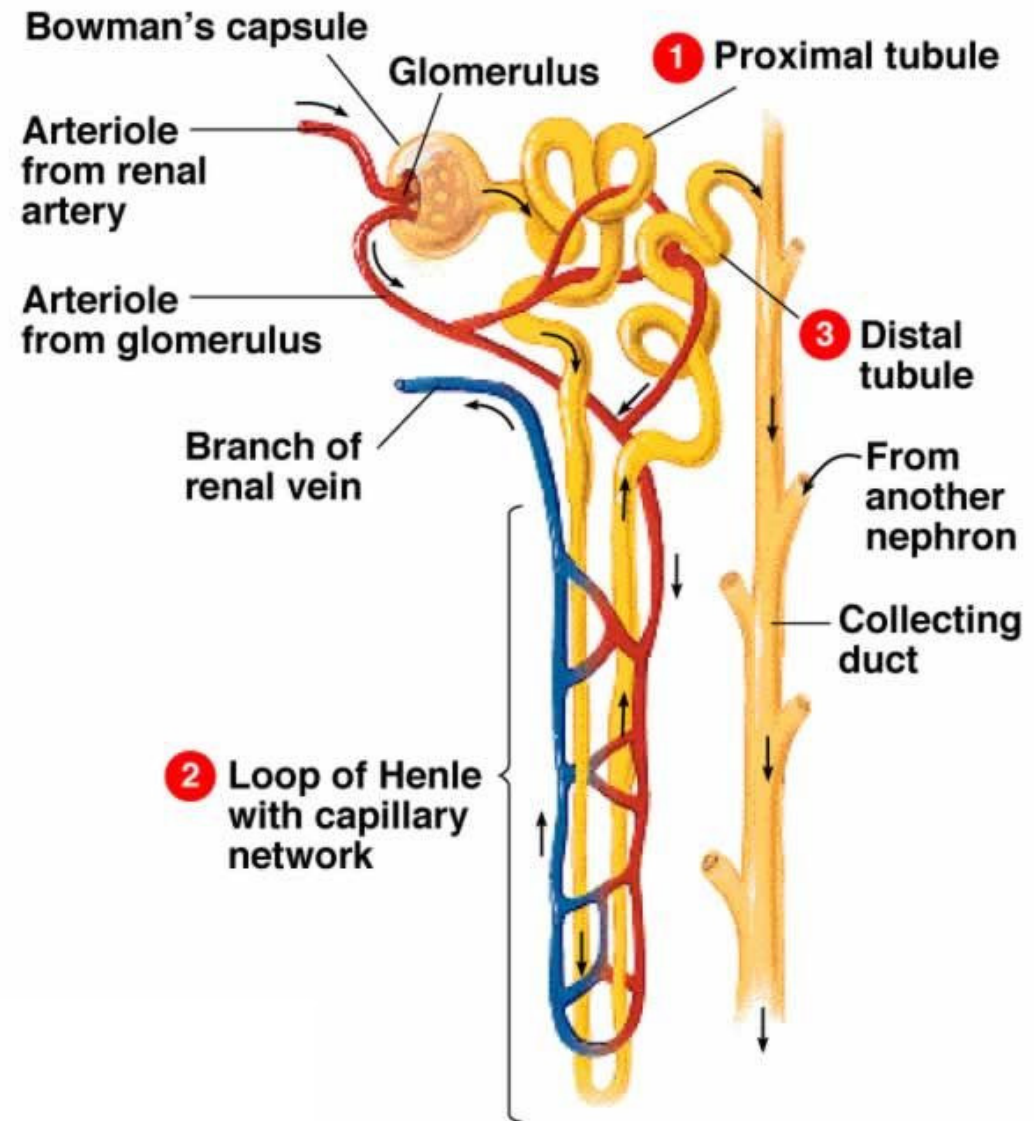


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The distal convoluted tubule is near the proximal one, but the composition of the lumen are very different. The distal tube contains a filtrate that is much less concentrated.

The distal convoluted tube does minor adjustments of the pH and can transport Ca^{2+} in or out.

The collecting duct gathers filtrate from several adjacent nephrons and goes through the medulla which, as you surely remember, is hypertonic.



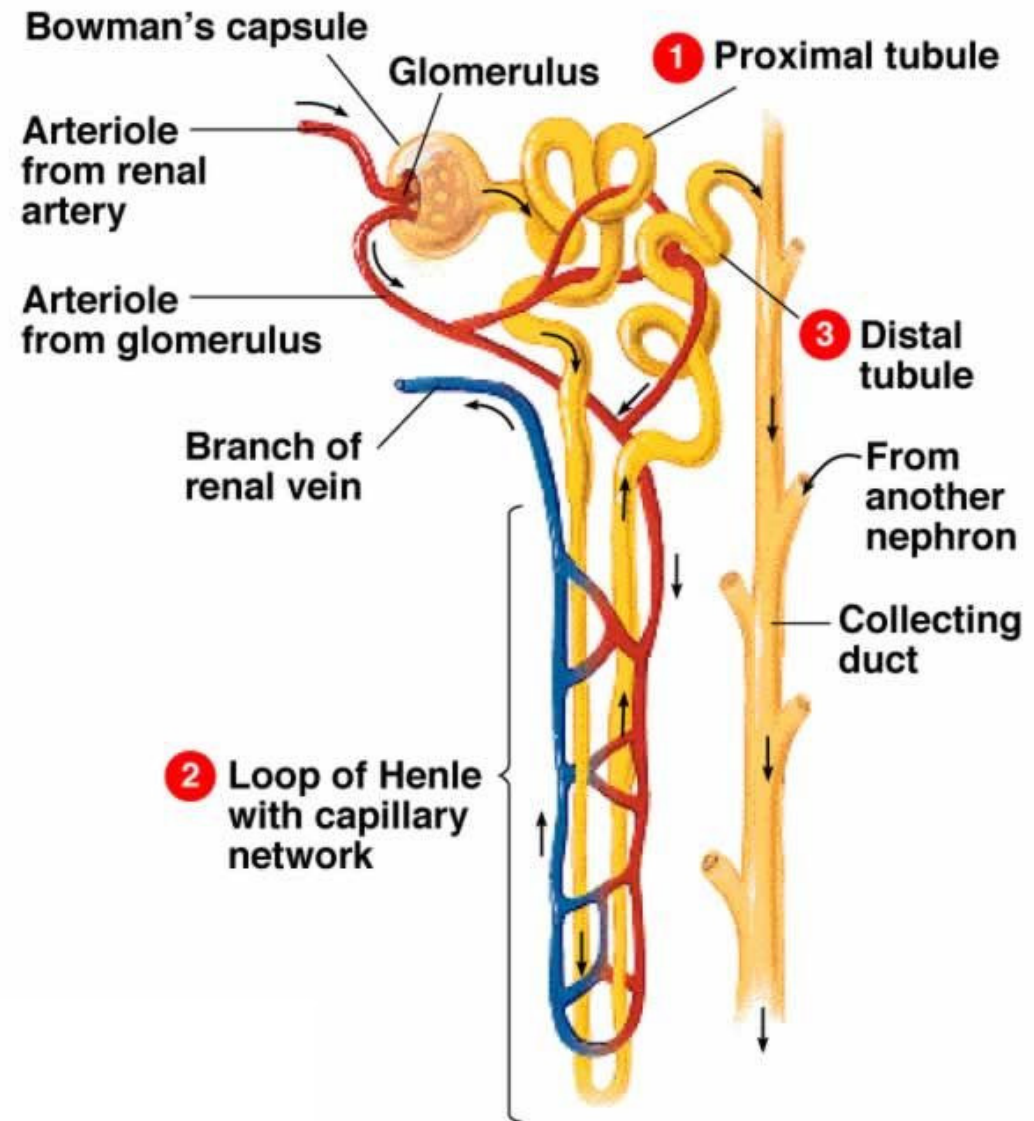
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The distal convoluted tubule and the collecting duct are under hormonal control.

ADH, the antidiuretic hormone (vasopressin) is a chemical signal for thirst. If it is present, the permeability to water of the collecting duct will increase, so as it goes through the medulla, the water will exit the duct, being recovered into the kidney.

Aldosterone stimulates the uptake of sodium and water by the distal convoluted tubule and the collecting duct.

Parathyroid hormone increases the recovery of calcium in the distal tubules and collecting duct. It also inhibits the recovery of phosphate and stimulates an intermediate step of the production of vitamin D, which stimulate the intestinal Ca^{2+} uptake.



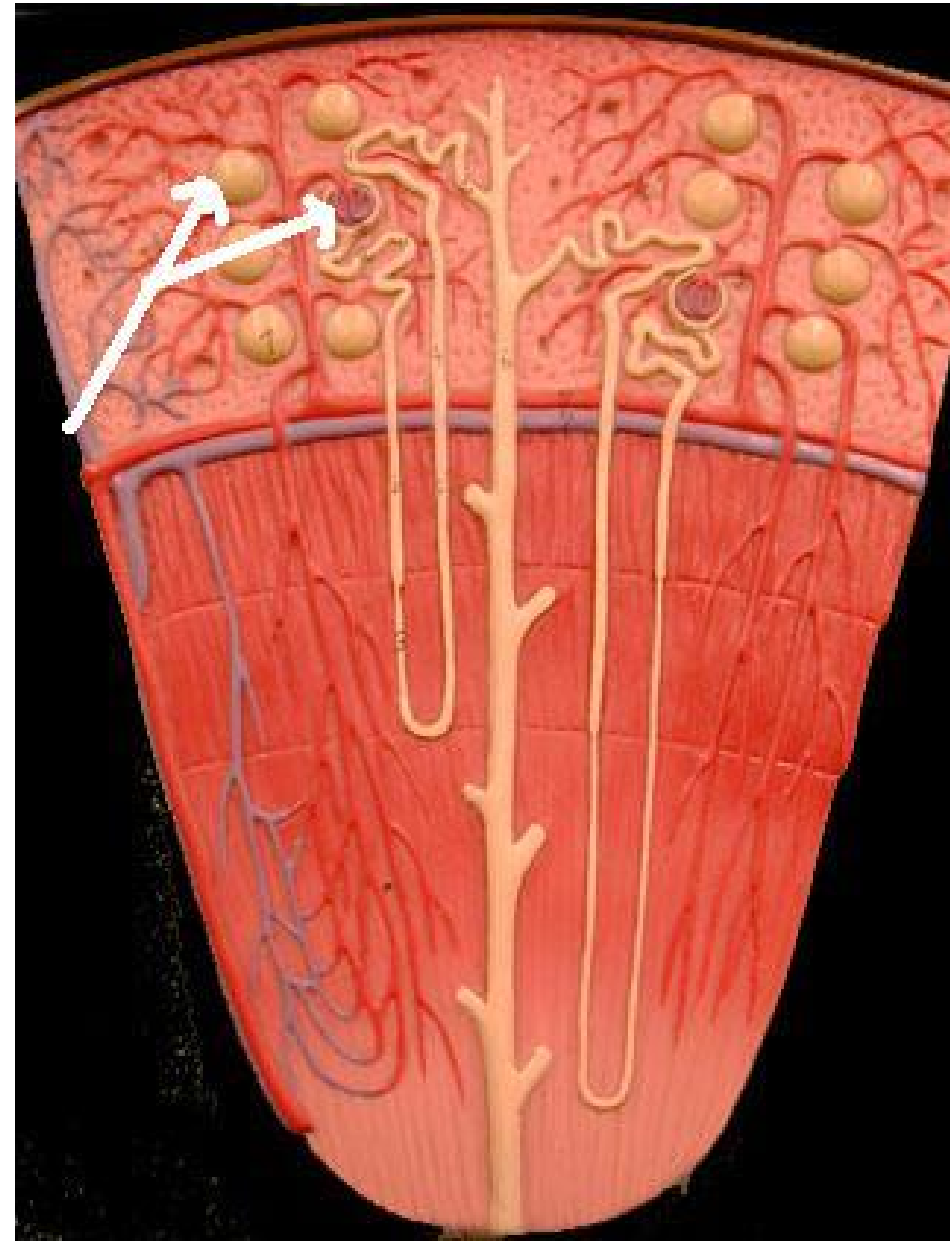
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The length of the loop of Henle determines how much water can be gathered from the filtrate.

The longer the loop of Henle is the higher the concentration that can be reached in the medulla

The collecting duct goes through the most hypertonic part of the medulla on its way to the renal pelvis, so if the membrane allows, water will filter out of it, leaving the urine more concentrated.

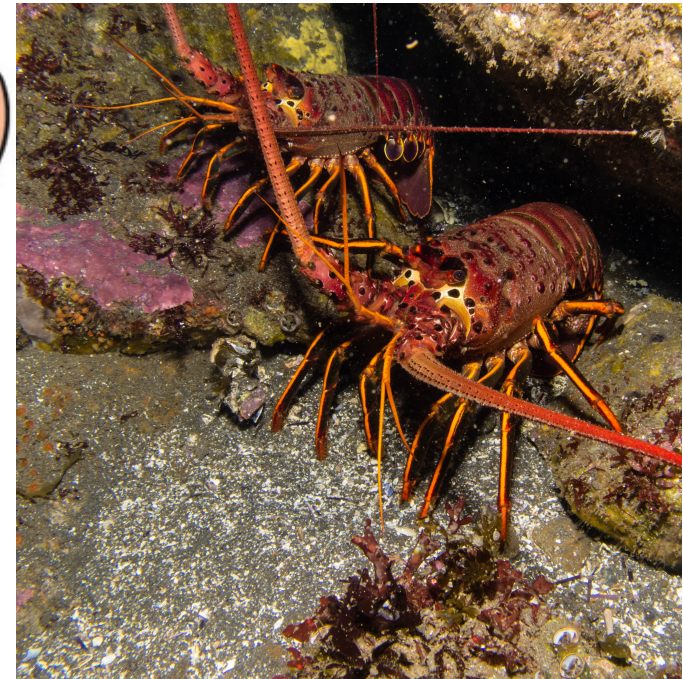
Therefore, the longer the loop of Henle, the more concentrated urine can be, which wastes less water in the elimination of metabolism products.



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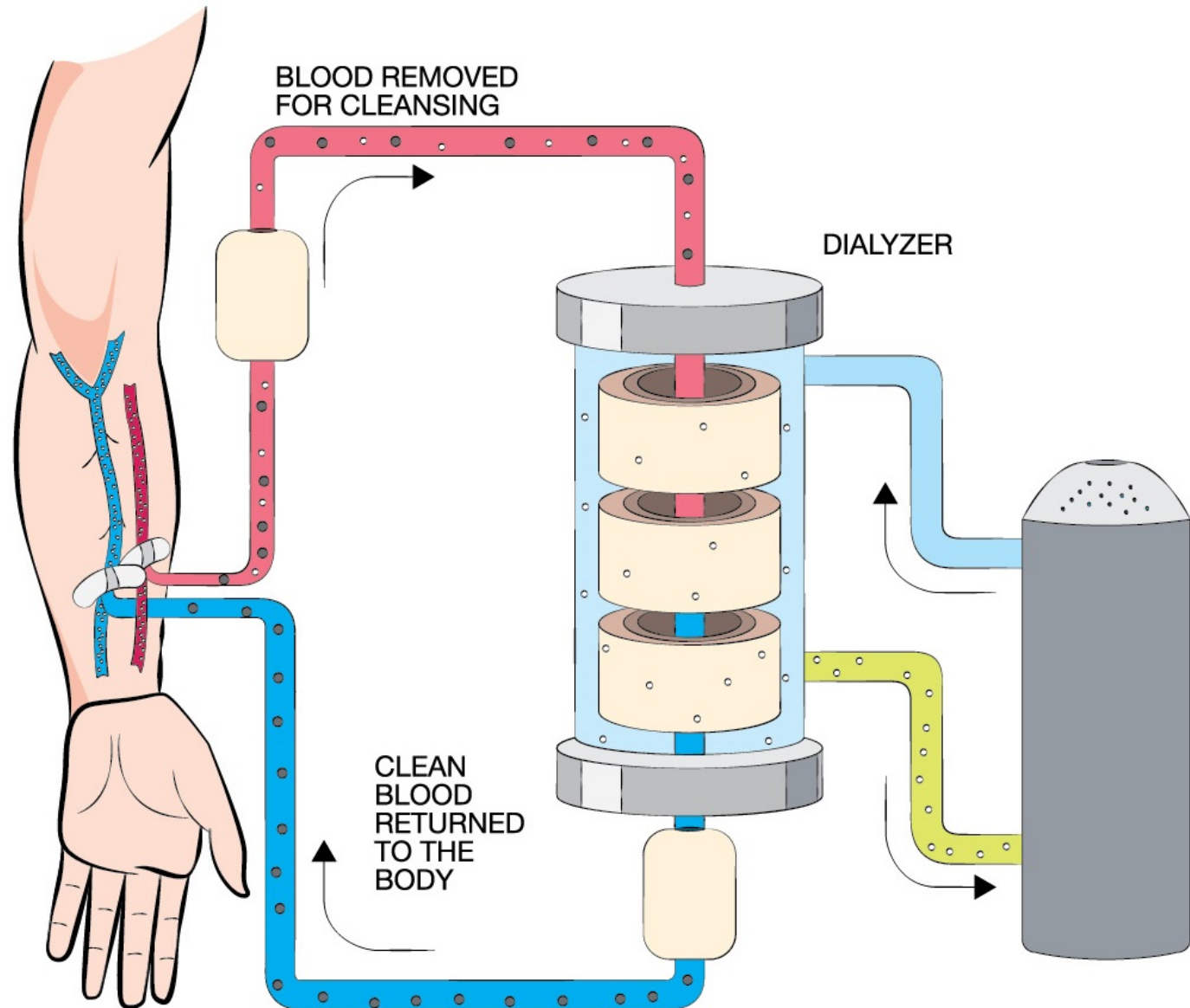
Not all animals are osmoregulators (have a different concentration than their surroundings). Some have essentially the same concentration, so they barely have to actively regulate how many solutes go in or out. They are called osmoconformers.

On the other hand, this means that they are very sensitive to changes in their environment.



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Dialysis is the process of a small solute being extracted from a solution while other bigger solutes stay there. This process can be used in case of kidney failure if a solution is prepared that has the same components as the patient's blood, but lacking those we want to get rid of, such as urea.



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Since urine contains many of the products of metabolism, it is possible to detect many conditions by looking at its composition.

Glucose

There should be no glucose in the urine. Its presence could be a symptom of diabetes.

Blood cells

Their presence in urine indicates the glomerular filtration is not working properly or there is damage in the vessels

Proteins

Proteins are not big enough to go through the glomerulus fenestrations. Their presence also indicates malfunction

Drugs

Many drugs or their metabolic products can be detected in urine

Any Questions?