

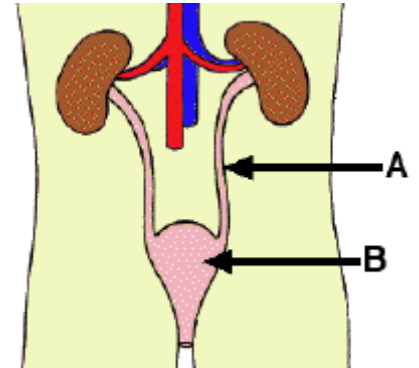
10. Excretion

#97 Structure of the kidney, the nephron

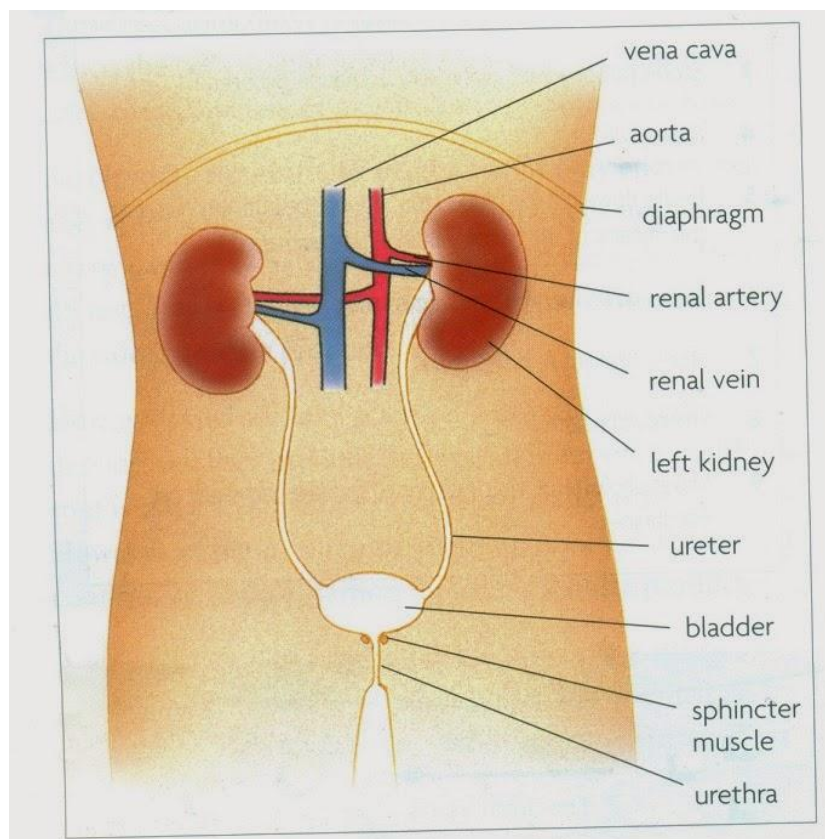
Excretion is the removal from organisms of **toxic materials**, the **waste products** of metabolism and **substances in excess** of requirements (**carbon dioxide, urea, salts...**).

Common misconceptions

Remember that faeces is **not** an example of excretion – it is mainly undigested material that has passed through the gut, but which has not been made in the body. The only excretory materials in it are bile pigments.



The relative position of the ureters, bladder and urethra in the body



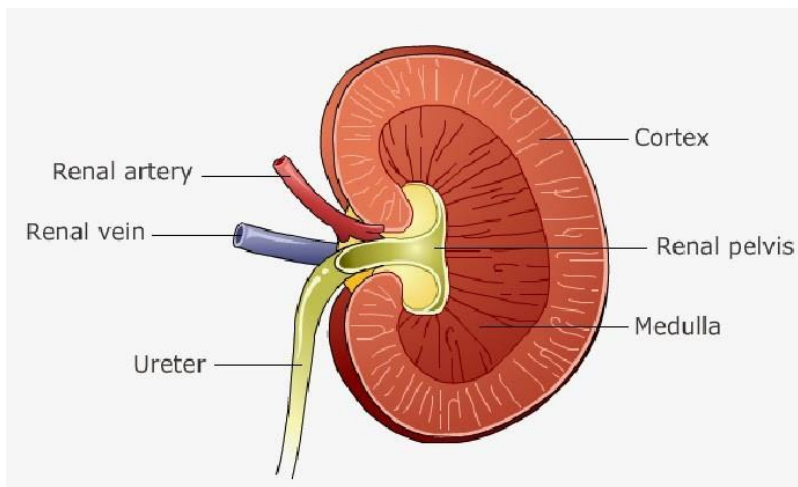
Examiner's tip

Make sure you can label the diagram showing the relative positions of the kidneys, ureters, bladder and urethra. The spellings of the **ureter** and **urethra** are really important.

Structure of a kidney

The kidney has 3 main parts: the **cortex**, **medulla**, and **pelvis**. Leading from the pelvis is a tube, called the **ureter**. The ureter carries urine that the kidney has made to the **bladder**.

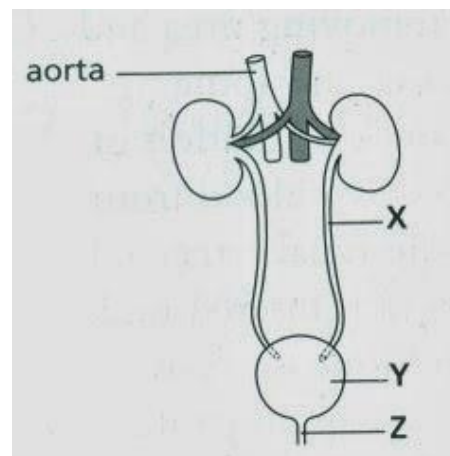
Kidneys are made up of thousands of tiny tubules, or **nephrons**. Each nephron begins in the cortex, loops down into the medulla, back into the cortex, and then goes down again through the medulla to the pelvis. In the pelvis, the nephrons join up with the ureter.



Sample question and answer

Figure on the right shows the human urinary system

- Name parts **X**, **Y** and **Z**. [3 marks]
- Name the blood vessel that carries blood from the aorta to the kidneys. [1 mark]
- Suggest two differences between the composition of the blood flowing to the kidneys and the blood flowing away from the kidneys. [2 marks]



Student's answer

- X** ureta ✗ **Y** Bladder ✓ **Z** vagina ✗
- renal artery
1. Blood going to the kidneys contains more urea.
2. Blood going to the kidney contains oxygen.

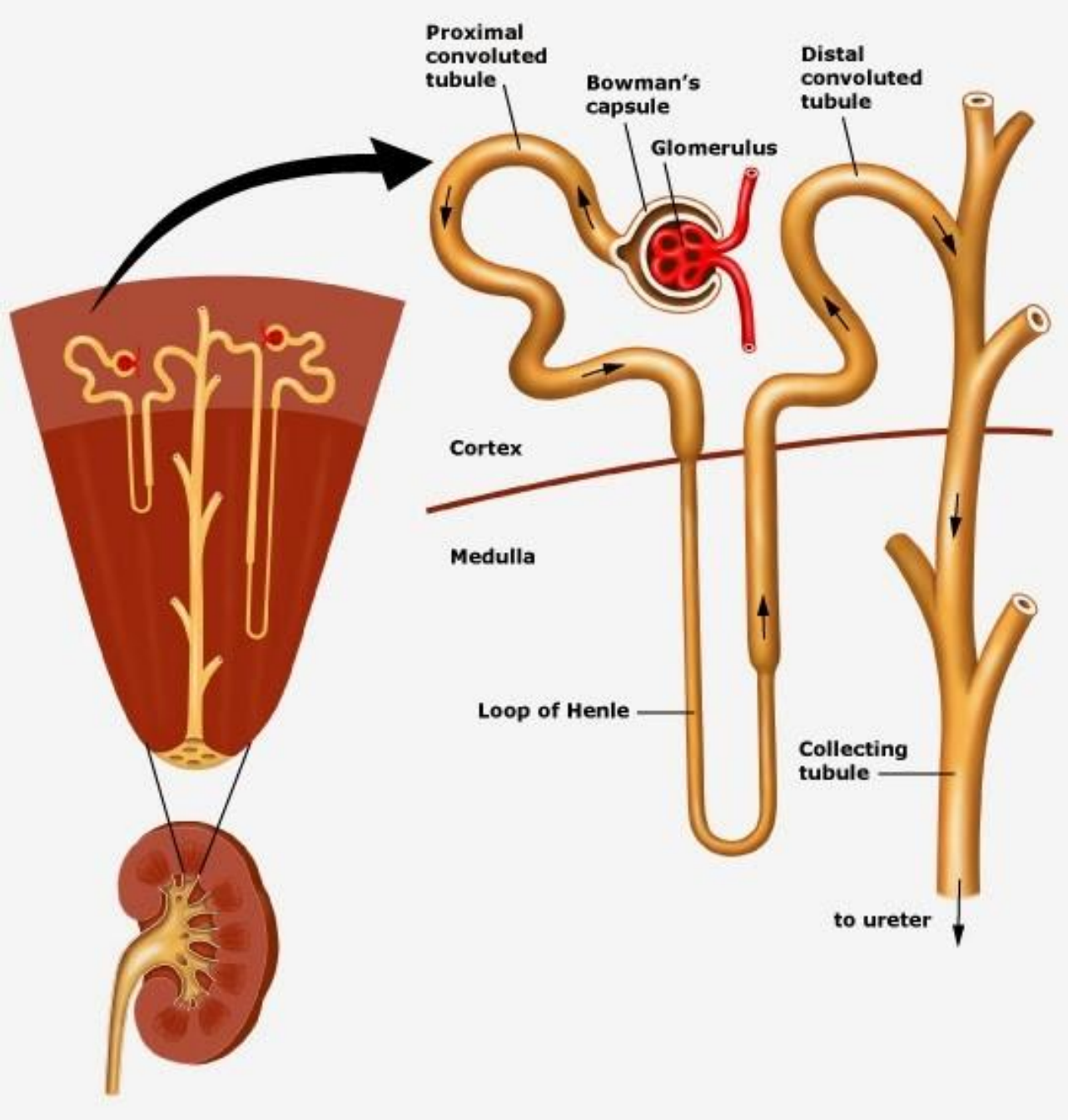
Examiner's comments

The spelling of **X** (ureter) must be accurate because this name is so similar to urethra.

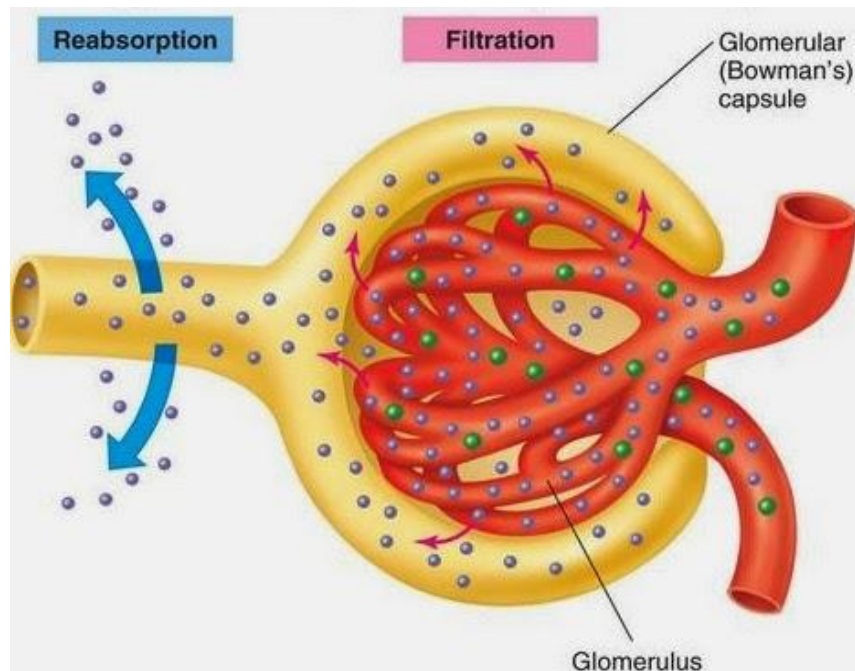
Part **Z** is the urethra, not the vagina (the vagina is attached to the uterus, not the bladder).

In part (c) the second answer given does not make a comparison. If the candidate had stated 'blood going to the kidney contains more oxygen', this would have gained the mark.

Video: Urinary system The nephron



#98 Function of the kidney - filtration and reabsorption



The function of the kidney is to filter blood, **removing** urea and excess H₂O, **reabsorbing** glucose, some H₂O and some mineral salts.

Urine is made by filtration and selective reabsorption

- As blood passes through the kidneys, it is filtered. This **removes** most of the **urea** from it, and also excess **H₂O** and **salts**.
- As this liquid moves through the kidneys, any **glucose** in it is **reabsorbed** back into the blood. Most of the **H₂O** is also reabsorbed along with some of the **salts**.

Remove from blood	Reabsorb into the blood
<ul style="list-style-type: none">• most urea• excess H₂O• excess salts	<ul style="list-style-type: none">• all glucose• most H₂O• some salts

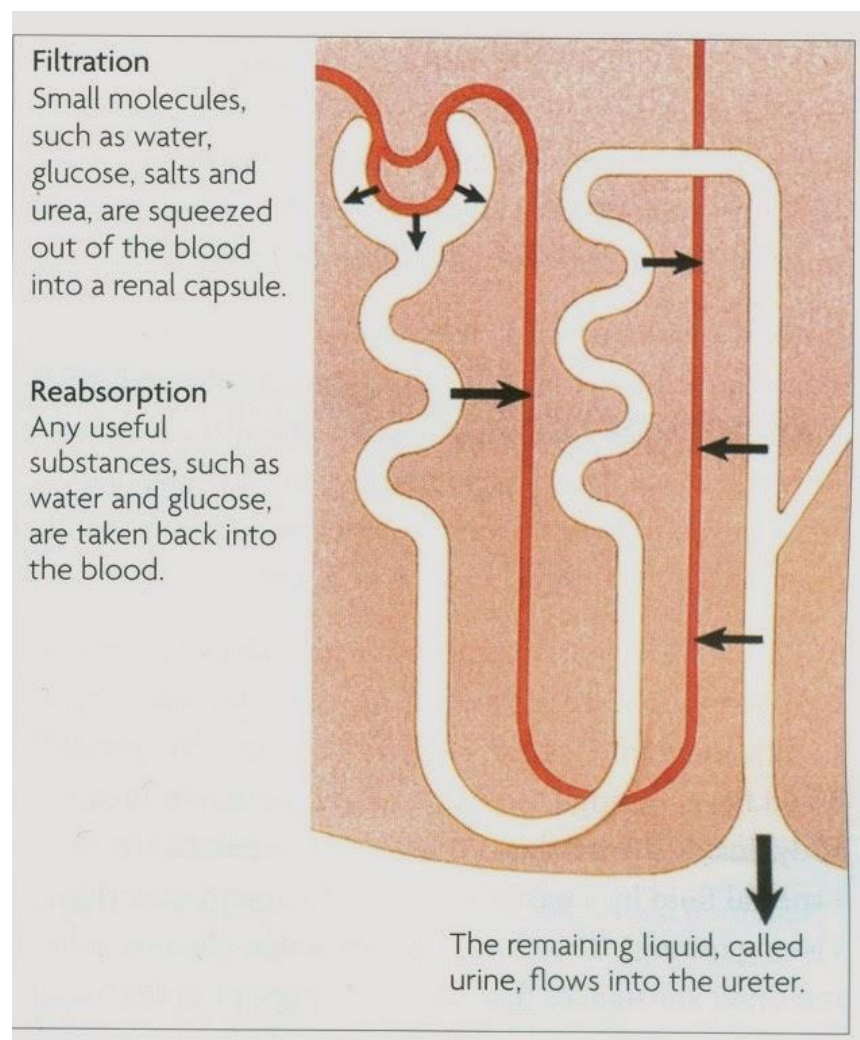
The final liquid produced by the kidneys is a solution of **urea** and **salts** in **water**. It is called **urine**, and it flows out of the kidneys, along the ureters and into the bladder. It is stored in the bladder for a while, before being released from the body through the **urethra**.

Filtration happens in renal capsules

Blood is brought to the **renal capsule** in a branch of the renal artery. Small molecules, including water and most of the things dissolved in its, are squeezed out of the blood into the renal capsule.

There are thousands of renal capsules in the cortex of each kidney. Each one is shaped like a cup. It has a tangle of blood capillaries, called a **glomerulus**, in the middle. The blood vessels bringing blood to each glomerulus is quite wide, but the one taking blood away is narrow. This means that the blood in the glomerulus cannot get away easily. Quite a high pressure builds up, squeezing the blood in the glomerulus against the capillary walls.

These walls have small holes in them. So do the walls of the renal capsules. Any molecules small enough to go through these holes will be squeezed through, into the space in the renal capsule. Only small molecules can go through. These include water, salt, glucose and urea. Most protein molecules are too big, so they stay in the blood, along with the blood cells.



Useful substances are reabsorbed

The fluid in the renal capsule is a solution of **glucose**, **salts** and **urea** dissolved in water. Some of the substances in this fluid are needed by the body. All of the **glucose**, some of the **water** and some of the **salts** need to be kept in the blood.

Wrapped around each kidney tubule are blood capillaries. Useful substances from the fluid in the kidney tubule are reabsorbed, and pass back into the blood in these capillaries.

The remaining fluid continues on its way along the tubule. By the time it gets to the collecting duct, it is mostly water, with urea and salts dissolved in it. It is called urine. The kidneys are extremely efficient at reabsorbing water. Over 99% of the water entering the tubules is reabsorbed.

The relative amount of water reabsorbed depends on the state of hydration of the body (how much water is in the blood), and is controlled by secretion of the hormone ADH.

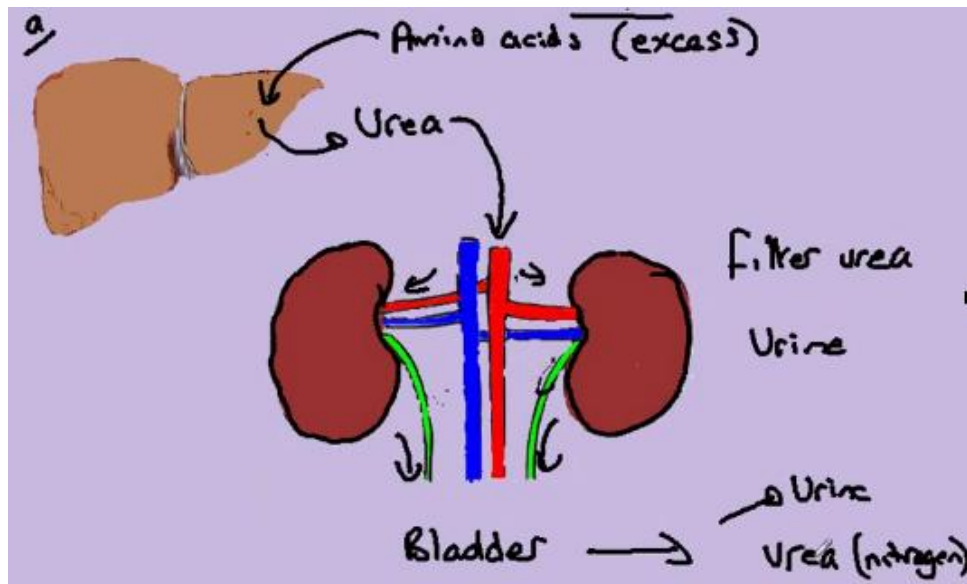
- On a hot day: we sweat more to cool down → the body needs to conserve water → produce a small amount of concentrated urine.
- On a cold day: little sweat is being produced → we tend to produce a larger volume of dilute urine.

Filtered blood returns to the vena cava (main vein) via a renal vein. The urine formed in the kidney passes down a ureter into the bladder, where it is stored. A sphincter muscle controls the release of urine through urethra.

Video: Nephron function

<https://www.youtube.com/watch?v=9rEhLRAzvKw>

99 Urea formation, breakdown of alcohol & drugs in liver



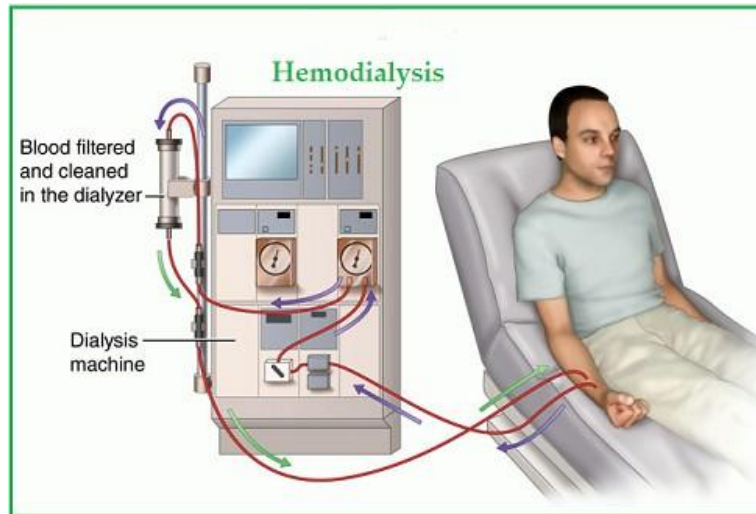
Surplus **amino acids** in the bloodstream cannot be stored. They are removed by the liver and broken down into the **urea** (which is the nitrogen-containing part of the amino acid) and a **sugar** residue, which can be respired to release energy. The breakdown of amino acids is called **deamination**.

Urea is returned to the bloodstream (into the hepatic vein) and filtered out when it reaches the kidneys.

The body treats alcohol as a poison. The liver removes poisons, such as **alcohol** and **drugs**, from the blood and breaks them down. Prolonged and excessive use of alcohol damages the liver and may cause it to fail. An overdose of **drugs**, such as **paracetamol**, can result in death due to liver failure, because the liver cannot cope with breaking down such a high concentration of the chemical.

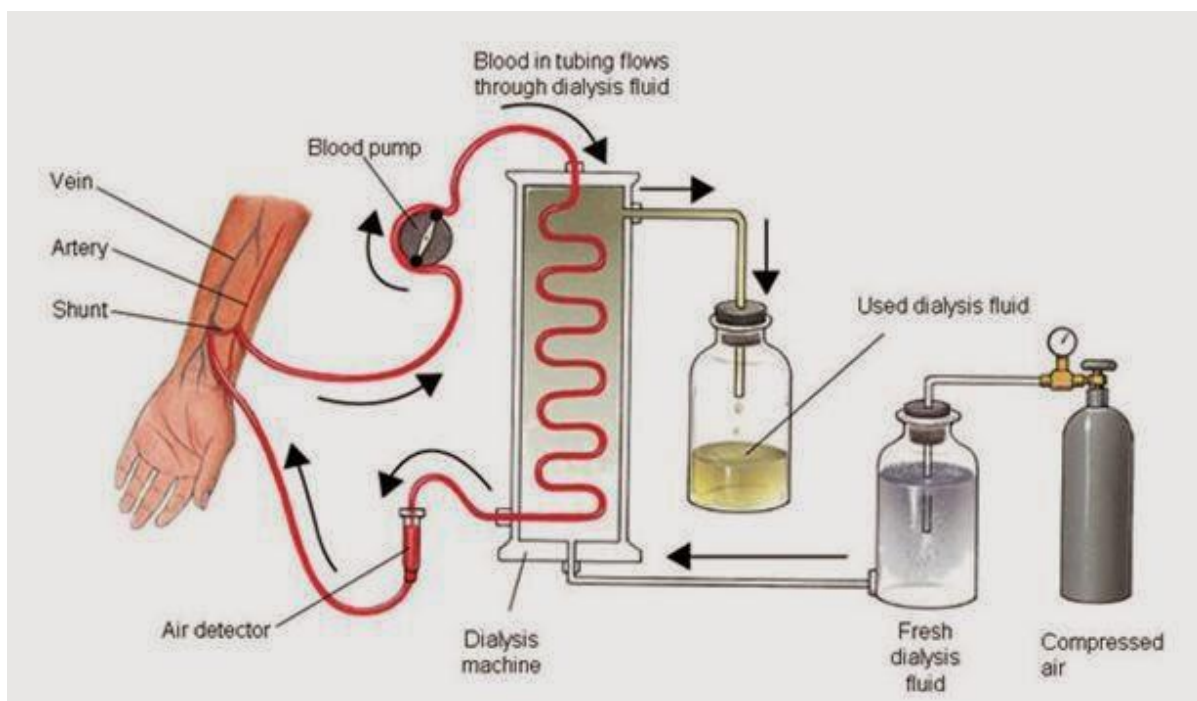
The liver also converts **hormones** into inactive compounds. These are filtered out of the blood by the kidneys.

100 Dialysis and its application in kidney machines



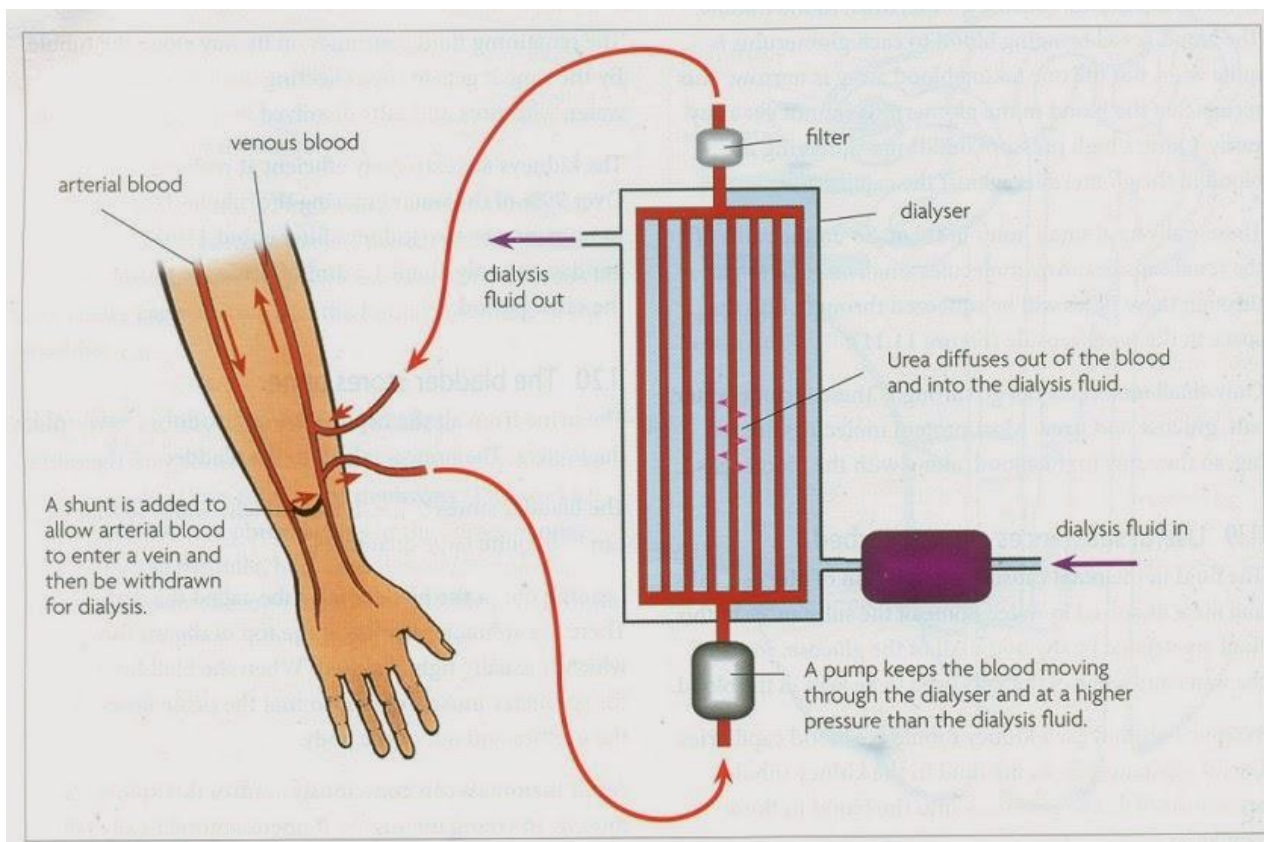
The usual treatment for a person with kidney failure is to have several sessions a week using a **dialysis unit** (a kidney machine), to maintain the glucose and protein concentration in blood diffusion of urea from blood to dialysis fluid.

Dialysis is a method of removing one or more components from a solution using the process of diffusion. The solution is separated from a bathing liquid contains none of the components that need to be removed from the solution, so these pass from the solution, through the membrane, into the bathing dilution by diffusion. The bathing solution needs to be changed regularly to maintain a concentration gradient.



Kidney dialysis.

A patient with kidney failure needs to have toxic chemicals removed from the blood to stay alive. Blood is removed from a vein in the arm, and is kept moving through dialysis tubing in the dialysis machine using a pump. The tubing is very long to provide a large surface area. The dialysis fluid has a composition similar to blood plasma, but with no urea or uric acid. **Urea** or **uric acid** and excess **mineral salts** are **removed** from the blood, by **diffusion**, into the dialysis fluid. The cleaned blood is then passed through a bubble trap to remove any air bubbles, before being returned to the patient's vein.



How kidney dialysis works.

Advantages and disadvantages of kidney transplants compared with dialysis.

Advantages

- The patients can return to a normal lifestyle – dialysis may require a lengthy session in hospital, 3 times a week, leaving the patient very tired after each session.
- A dialysis machine will be available for other patients to use.
- Dialysis machines are expensive to buy and maintain.

Disadvantages

- Transplants require a suitable donor – with a good tissue match. The donor may be a dead person, or a close living relative who is prepared to donate a healthy kidney (we can survive with one kidney_).
- The operation is very expensive.
- There is a risk of rejection of the donate kidney – immunosuppressive drugs have to be used.
- Transplantation is not accepted by some religions.

Video: Hemodialysis and how it works

<https://www.youtube.com/watch?v=shFSW8VE3Gs>