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Excretion

All of the many chemical processes that take place in an organism are collectively called the body metabolism. As a result of metabolism, waste products are formed in the cells. If these were not continually removed they would accumulate and poison the cells.

Excretion is the removal of metabolic waste products from the body of an organism.

In humans, waste products are formed by a number of processes. The main metabolic waste products are given in Table 1.1.

<table>
<thead>
<tr>
<th>Waste product</th>
<th>How it is formed</th>
<th>Where it is produced</th>
<th>How it is excreted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>During cellular respiration</td>
<td>In all living cells</td>
<td>Gaseous exchange in the lungs</td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td>Through the lungs and skin, and as urine and faeces</td>
</tr>
<tr>
<td>Urea</td>
<td>Deamination of unwanted amino acids</td>
<td>In the liver</td>
<td>As urea in urine and sweat</td>
</tr>
<tr>
<td>Bile pigments</td>
<td>Breakdown of old red blood cells</td>
<td></td>
<td>In the faeces</td>
</tr>
</tbody>
</table>

TABLE 1.1

The three organs mainly responsible for excretion in humans are the kidney, the lungs and the skin. The following flow chart summarises their roles.
Excretion is the removal of the waste products of metabolism from the body and not undigested food, which is removed by a different process called egestion. Egestion and excretion are different processes and should not be confused.

**FIG 1.2** Organs responsible for excretion

Exhaled air waste product
- lungs
- carbon dioxide
- water
- skin
- sweat
- urea
- kidneys
- urine

**FIG 1.3** Egestion and excretion

Food eating inside the body digestion nutrients
- undigested food
- waste products
- egestion
- excretion
Excretion by the kidneys

We are learning how to:

- identify location and parts of the kidneys
- understand how the kidneys filter our blood and remove substances.

Position of the kidneys

The kidneys remove waste products from the blood. These are stored in the bladder in solution as urine, ready to be excreted at regular intervals. The body has two kidneys situated in the lower abdomen. Each kidney is connected to the bladder by a tube called a ureter.

Structure of the kidneys

Each kidney consists of two main regions – the cortex and the medulla. Running between these regions are structures called nephrons where waste products are removed from the blood.

The nephrons are responsible for removing a mixture of useful substances and waste products from the blood by ultrafiltration and then reabsorbing useful substances by selective reabsorption.

Each nephron contains a knot of blood capillaries called a glomerulus. As blood is forced through these capillaries a solution called the filtrate is formed in Bowman’s capsule. This contains a mixture of both useful substances and waste products.

As the filtrate passes around the loop of Henle, useful substances like amino acids, glucose and some mineral salts are reabsorbed back into the blood capillaries. The remainder passes out of the nephron into a collecting duct from which it goes to the bladder.
Activity 1.1

Observing the structure of a kidney

Here is what you need:
- goat’s kidney
- scissors
- scalpel
- dissecting pins
- hand lens.

Here is what you should do:
1. Carefully examine the outside of the kidney. What shape is it? Observe where the kidney connects to the bladder via a ureter.
2. Cut the kidney in half longways and look at the inside. Can you see the cortex and the medulla regions? Can you see any other structures inside the kidney?

Check your understanding

1. The following table shows the concentration of substances in blood plasma, in the filtrate obtained in Bowman’s capsule and in urine.

<table>
<thead>
<tr>
<th>Substance</th>
<th>% in blood plasma</th>
<th>% in filtrate</th>
<th>% in urine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amino acids</td>
<td>0.05</td>
<td>0.05</td>
<td>0.0</td>
</tr>
<tr>
<td>Glucose</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Proteins</td>
<td>7.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Salts</td>
<td>0.45</td>
<td>0.45</td>
<td>0.80</td>
</tr>
<tr>
<td>Urea</td>
<td>0.03</td>
<td>0.04</td>
<td>2.0</td>
</tr>
</tbody>
</table>

a) Which substance is not removed from the blood plasma during ultrafiltration?

b) Which two substances are removed from blood plasma by ultrafiltration and are not reabsorbed by selective reabsorption? Explain how you can tell this from the figures in the table.

Key terms

ureter tube that connects a kidney to the bladder along which urine passes

ultrafiltration the removal of a mixture of useful substances and waste products as the filtrate in the glomerulus

selective reabsorption the reabsorption of useful substances as the filtrate passes through the loop of Henle

dialysis removal of metabolism waste products outside the body by machine

FIG 1.6 Structure of a nephron

FIG 1.7 Dialysis
The roles of the lungs and the skin in excretion

We are learning how to:
- understand how and what our lungs excrete
- measure which parts of our bodies sweat the most.

Excretion in the lungs

We think of the lungs as the organ that provides the body with oxygen but they also have an important role to play in excretion.

The oxygen absorbed by the lungs, and the glucose obtained by digestion, are carried around the body in the blood. They are required for the process of respiration which provides cells with energy:

\[
glucose + oxygen \rightarrow carbon dioxide + water + energy
\]

The waste products of respiration are carbon dioxide and water. If these were not continually removed from a cell the cell would soon cease to function. For example, carbon dioxide dissolves in water to give an acidic solution. If it was not removed from the cell it would lower the pH of the cytoplasm, which would interfere with other chemical reactions.

Carbon dioxide and water are carried away in the blood and excreted in the lungs. Exhaled air contains about 4% carbon dioxide and is always saturated with water vapour.

During deamination the –NH₂ group is removed from the amino acid forming NH₃ (ammonia). The remainder of the amino acid molecule is converted to carbohydrates to provide the body with energy:

\[
CO₂ + NH₃ \rightarrow CO(NH₂)₂ \text{ (urea)}
\]

Activity 1.2

Investigating which parts of the body sweat most

Here is what you will need:
- blue cobalt chloride paper – squares × 6
- access to a watch or clock.

Here is what you should do:
1. Mark each piece of blue cobalt chloride paper with a number from 1 to 6.

Formation of urea

Urea is formed in the liver as a result of the deamination of amino acids. The body cannot use all of the amino acids obtained from food to build new proteins.
2. Decide six places on your body which you are going to compare for the amount of sweat produced. List which number goes with which body part.

3. Go and stand somewhere warm so that you are sweating.

4. Place the first piece of blue cobalt chloride paper on a part of your body for example, your forehead. Leave it there for a few minutes until you can see it turning pink. The length of time will depend on how much you are sweating. Make a note of the time.

5. Repeat step 4 on the remaining five parts of your body using the same time period as you did for the first one.

6. Compare how much each cobalt chloride paper turned pink. Deduce which part of your body sweated more and which sweated least.

Ammonia is toxic so it is combined with carbon dioxide to form urea, which is less toxic and is removed from the body in urine and sweat.

**Excretion through the skin**

The skin is the largest organ of the body and has many functions, including the excretion of urea and water.

Within the skin there are many **sweat glands** leading to pores on the surface. It is through these pores that the body loses sweat. **Sweat** consists mostly of water but it also contains small amounts of dissolved substances such as urea and minerals.

Sweating serves two important purposes for the body:

- it allows the body to excrete water and urea
- when the water from sweat evaporates it cools the body.

After the water from sweat has evaporated small amounts of solids like urea are left behind, which is why people smell if they do not wash regularly.

**Check your understanding**

1. State from which organ(s) each of the following are excreted.
   
   a) carbon dioxide   b) urea   c) water.