Chapter 11 – Excretion in Humans

Subject content

Content ● Structure and function of kidneys ● Kidney dialysis **Learning outcomes** (a) define excretion and explain the importance of removing nitrogenous and other compounds from the body (b) outline the function of the nephron with reference to ultra-filtration and selective reabsorption in the production of urine (c) outline the role of antidiuretic hormone (ADH) in osmoregulation (d) outline the mechanism of dialysis in the case of kidney failure *Use the knowledge gained in this section in new situations or to solve related problems.*

Definition

Phrase	Definition
Metabolism	Sum of all chemical reactions within body of organism (catabolism + anabolism)
Catabolic reaction (catabolism)	Chemical reaction where complex substance → simple substances
Anabolic reaction (anabolism)	Chemical reaction where simple substances → complex substance
Excretion	Metabolic waste products and toxic substances removed from body
Osmoregulation	Control of water and solute concentrations in the blood to maintain constant water potential in body

11.1 The Need for Excretion

Chemical reactions in living cells produce waste products

Catabolic reactions (catabolism)	**Anabolic reactions (anabolism)**
● Oxidation of glucose into carbon dioxide + water during cellular respiration ● Deamination of proteins and amino acids to form urea in liver	● Synthesis of proteins from amino acids ● Synthesis of glycogen from glucose in liver & muscles ● Synthesis of glucose from carbon dioxide + water during photosynthesis

Differences between egestion and excretion:

Excretion	Egestion
Remove metabolic waste products and toxic substances	Remove undigested food matter from alimentary canal (uninvolved in metabolic activities of cells)

Faeces is not a product of metabolism

Effects of **accumulation** of metabolic waste materials and toxic substances

1. Alter water potential of cellular environment
2. Alter pH in cells
3. Slower down rate of enzymatic reactions in body

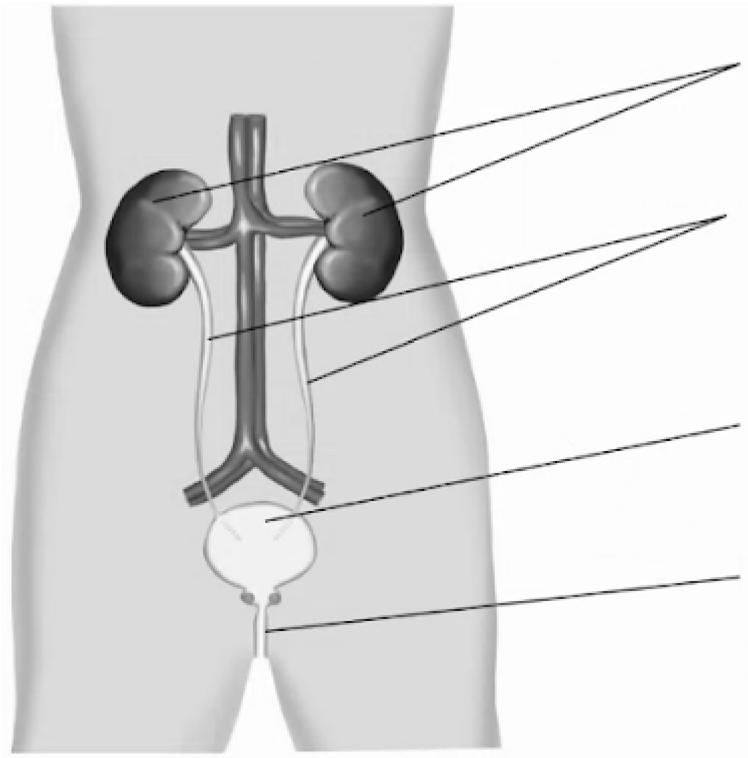
11.2 Excretion in Humans

Excretory organs

Excretory products: metabolic waste products + toxic substances

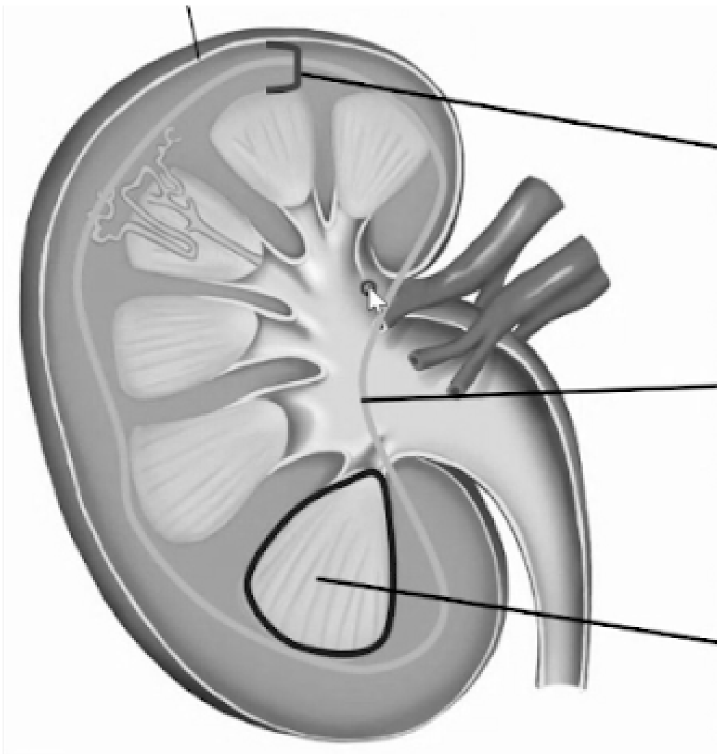
Excretory organ	Excretory product	Form of excretion
1. **Kidney**	• Excess water • Excess dissolved mineral salts • Nitrogenous waste products (urea, uric acid, creatinine)	Urine
2. **Skin**	• Excess water • Excess dissolved mineral salts	Sweat
3. **Lungs**	• Water vapour • Carbon dioxide	Exhaled air
4. **Liver**	• Bile pigments (breakdown of haemoglobin)	Faeces

Human urinary system



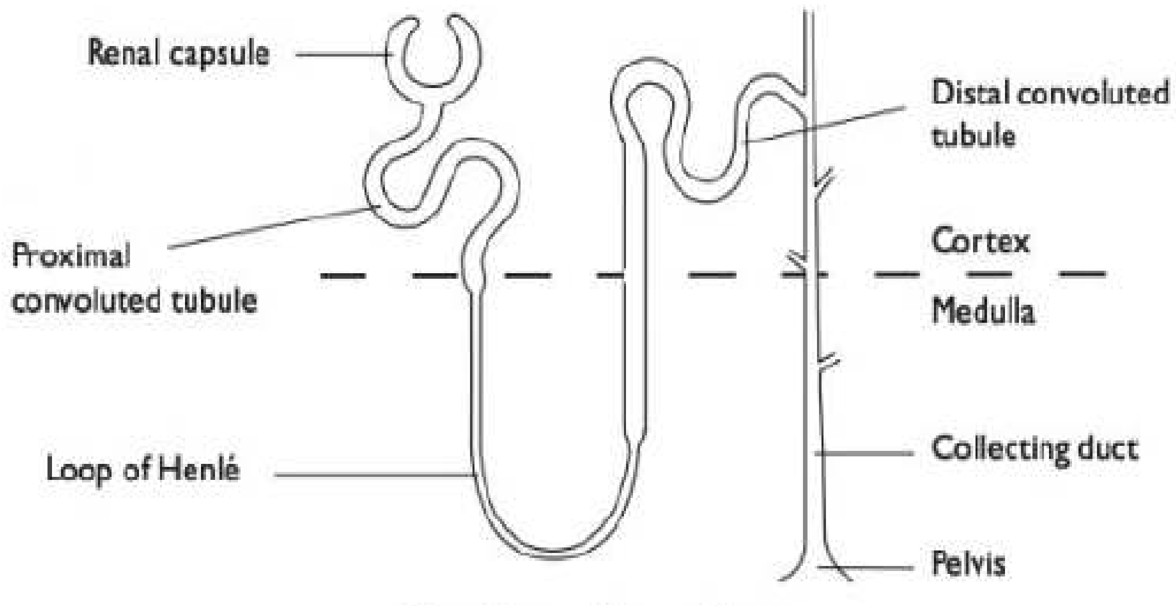
Part	Description	Function
1. **Kidneys**	Bean shaped	• **Excretory organ** • **Osmoregulator**
2. **Hilus**	Depression at the centre of concave surface of kidney	Region where renal artery, renal vein and nerves connected to kidney
3. **Ureter**	Narrow tube connecting kidney to urinary bladder	**Transport urine**: kidney → urinary bladder
4. **Urinary bladder**	Elastic muscular bag located in front of rectum	**Store urine** temporarily
5. **Urethra**	Narrow tube in middle of penis (male)	**Transport urine**: urinary bladder → exterior
6. **Sphincter muscle**	Located at bottom of urinary bladder, top of urethra	**Control discharge of urine** • Urinary bladder full: sensory neurons send nerve impulses → brain • Urinate: brain send nerve impulses → sphincter muscle → relax • Urine → urethra → exterior

Structure of kidney



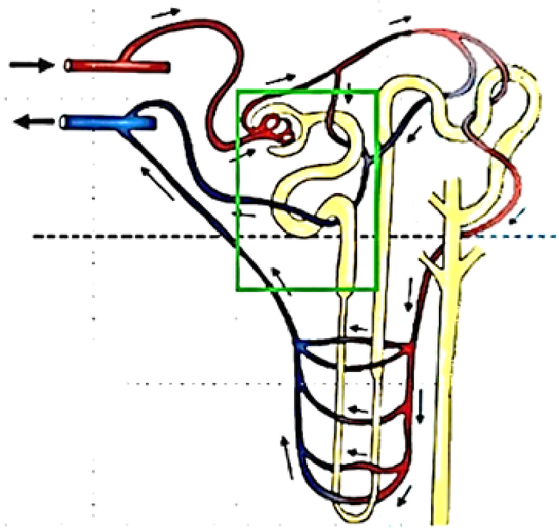
Part	Description	Function
1. **Cortex**	Outer dark red region	Covered, protected by **fibrous capsule**
2. **Medulla**	Inner pale red region	Contain 12 - 16 renal pyramids
3. **Renal pyramid**	Conical structures in medulla	**Radial stripes** → numerous nephrons
4. **Nephron** (kidney tubule)	Richly supplied with blood vessels	**Form urine**
5. **Renal pelvis**	Renal pyramids project into the funnel-like space	Enlarged portion of ureter inside kidney

Structure of nephron



Blood supply of nephron:

- Blood enter kidney by renal artery, branches out into arterioles
- **Glomerulus**: arteriole further branches into mass of blood capillaries in Bowman's capsule
- **Renal corpuscle**: Bowman's capsule + glomerulus
- Blood leaving glomerulus enters blood capillaries surrounding nephron
- Blood capillaries unite to form venules, which join to form branch of renal venule



renal artery → afferent arteriole → glomerulus → efferent arterioles → blood capillaries → venule → renal vein

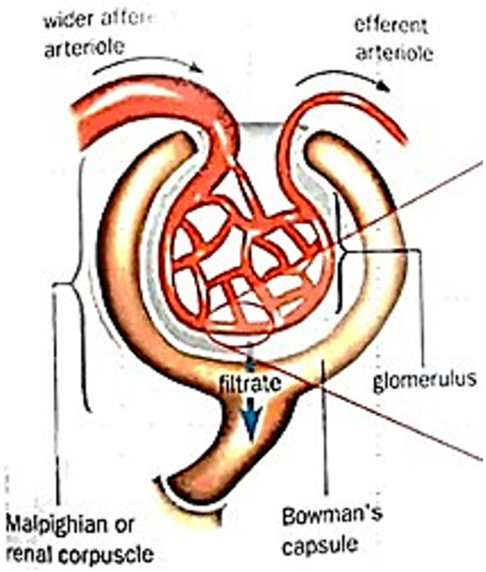
11.3 Urine Formation

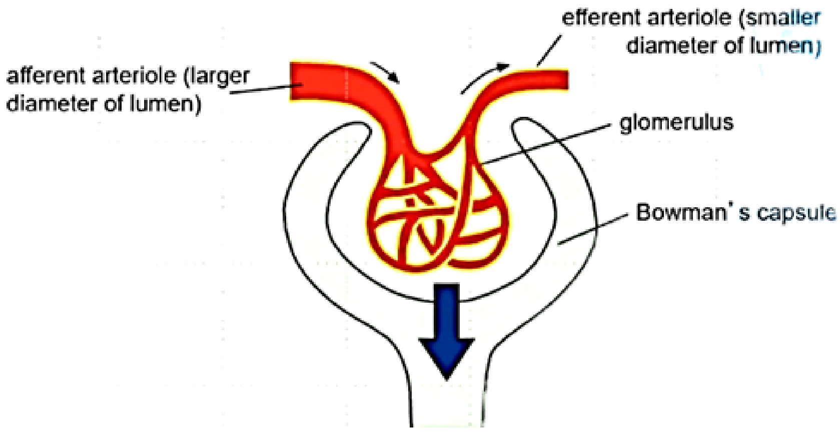
Excess mineral salts + nitrogenous waste products (urea, uric acid, creatinine)

- Harmful if accumulate in body
- Removed from body in form of **urine**

Component	Renal artery	Renal vein
Oxygen	high	low
Carbon dioxide	low	high
Dissolved mineral salts	high	low
Nitrogenous waste products	high	low

<u>Urine formed in kidneys</u>





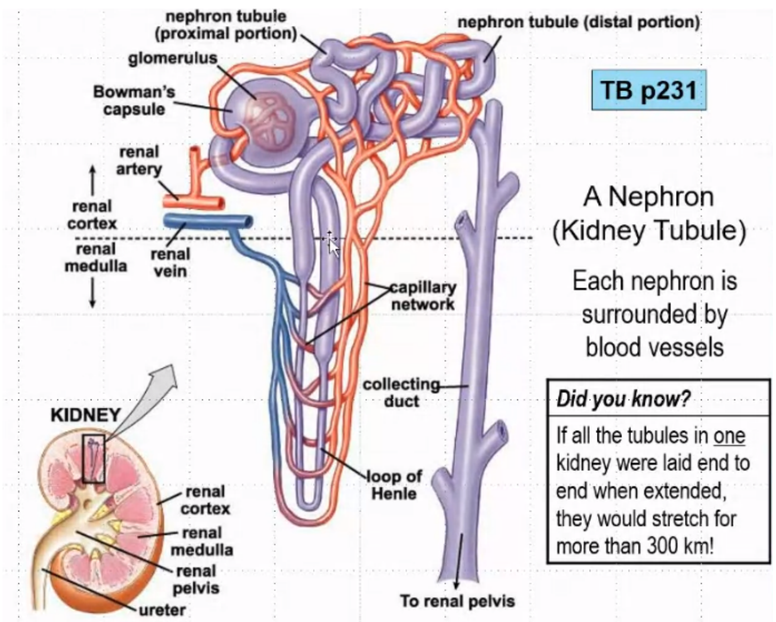
<table>
<tr><th>Formation</th><th>Explanation</th></tr>
<tr><td>1. Ultrafiltration
(renal corpuscle)</td><td>
1) High hydrostatic blood pressure
• <u>Afferent arteriole</u> wider than <u>efferent arteriole</u> → high blood pressure in glomerulus
• Substance in blood plasma <u>forced out</u> of glomerulus → Bowman's capsule
2) Partially permeable basement membrane
<table>
<tr><th>Small molecules</th><th>Large molecules</th></tr>
<tr><td>move into Bowman's capsule → filtrate</td><td>not filtered out & retain in blood</td></tr>
<tr><td>• water
• glucose
• amino acids
• dissolved mineral salts
• nitrogenous waste products</td><td>• blood cells
• platelets
• fats</td></tr>
</table>
</td></tr>
</table>

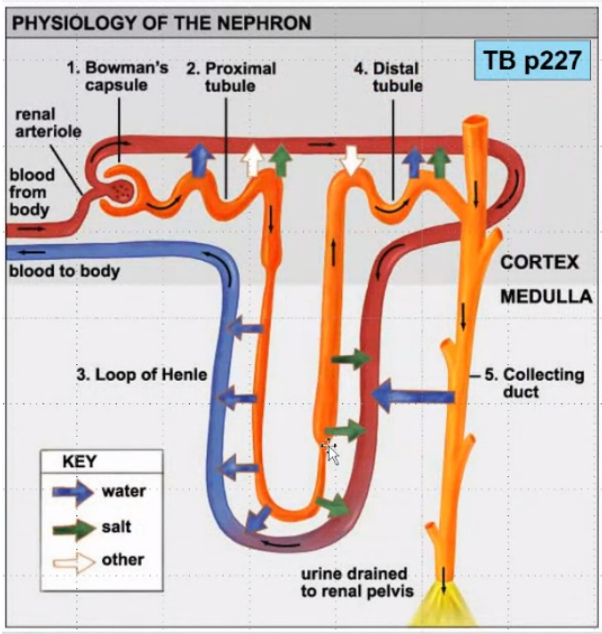
<table>
<tr>
<td>2. Selective reabsorption (renal tubule)</td>
<td>

Cannot afford to lose too much water, glucose and other useful substances → selectively reabsorbed into bloodstream
Process:
<table>
<tr><th>Part</th><th>Reabsorption into blood capillaries</th></tr>
<tr><td>proximal convoluted tubule</td><td>Most of filtrate
glucose molecules, amino acid molecules and dissolved mineral salts (diffusion & active transport)
water molecules (osmosis)</td></tr>
<tr><td>loop of Henle</td><td>some water molecules</td></tr>
<tr><td>distal convoluted tubule</td><td>some dissolved mineral salts</td></tr>
<tr><td>collecting duct</td><td>some water molecules</td></tr>
</table>

Remaining fluid in tubule: collecting duct → renal pelvis → urine

</td>
</tr>
</table>





Composition of urine

Mixture of various substances:

Composition	Percentage (g/100cm³)
1. **Water**	96
2. **Urea**	2
3. **Dissolved mineral salts**	1.8
4. **Nitrogenous substances**	0.2

<u>Urine samples</u>
Urine analysis → **indication of malfunctions of metabolism**
- e.g. glucose not normally present in urine (reabsorbed by the proximal convoluted tubule after ultrafiltration)
- Evidence of glucose in urine → diabetes mellitus

Diabetes mellitus
- High blood glucose concentration → large amount of glucose excreted in urine → unable to store up excess glucose as glycogen
- Glucose filtered out of glomerulus to form part of glomerular filtrate
  Nephrons unable to reabsorb all glucose fast enough
- <u>Production of insulin insufficient</u> to completely convert all excess glucose into glycogen

11.4 Osmoregulation
Water potential of blood kept relatively constant

Blood plasma	**too diluted**	**too concentrated**
Movement of water via osmosis	enter cells	move out of cells
Result	• Blood cells swell and burst • Tissue cells swell	• Blood cells and tissue cells become dehydrated and shrink • Unable to carry out metabolic functions properly

Water potential of blood depends on amount of water & dissolved mineral salts in blood plasma
Antidiuretic hormone (ADH): control amount of water in blood plasma
→ increase water reabsorption at nephrons
- produced by **hypothalamus**
- released by **pituitary gland**

Kidney regulate water potential of blood

Osmoregulator (kidney): regulate water & solute concentrations in blood

Osmoregulation:

Water	Loss of water	Large intake of water
Water potential in blood plasma	Decrease below normal	Increase above normal
Hypothalamus in brain	Stimulated	
Pituitary gland release ADH into bloodstream	More	Less
Cells in walls of collecting ducts permeable to water molecules	More	Less
Water molecules selectively reabsorbed from collecting duct → blood capillaries	More	Less
Water in collecting duct	Less	More
Volume of urine produced	Smaller	Larger
Concentration of urine produced	More	Less
Water potential of blood plasma	Return to normal	

Water potential of blood related to blood pressure

Kidneys: **osmoregulator** → regulate concentration of water & salts in blood

- Osmoregulation: maintain concentration of water and salts
- **Blood pressure** is indirectly regulated by osmoregulation (blood volume is controlled by removing excess salts and water)
- High blood pressure → blood vessels in brain burst → stroke
- **Diuretics**: drug to reduce production of ADH (large amount of dilute urine is produced → decrease volume of water in blood → lower blood pressure)

11.5 Kidney Failure

Functions of kidney

Functions of kidney:

<table>
<tr><th>Function</th><th>Explanation</th></tr>
<tr><td>1. Excretory organs</td><td>excrete metabolic waste products in the form of urine
(a) urea
(b) excess water
(c) excess dissolved mineral salts</td></tr>
<tr><td>2. Osmoregulators</td><td>● regulate solute and water concentration in blood
→ maintain constant water potential in blood
● maintain water in body at normal level:
<table>
<tr><th>Intake of liquid food</th><th>increase</th><th>decrease</th></tr>
<tr><td>Rate of cellular respiration</td><td>increase</td><td>decrease</td></tr>
<tr><td>Sweat secretion by skin</td><td>decrease</td><td>increase</td></tr>
<tr><td>Amount of water present in blood</td><td>increase</td><td>decrease</td></tr>
<tr><td><u>Amount of water reabsorbed at nephrons</u> into bloodstream</td><td>less</td><td>more</td></tr>
<tr><td>Amount of water removed in form of urine</td><td>more</td><td>less</td></tr>
</table>
</td></tr>
</table>

Kidney failure

Common causes of kidney failure:
1. High blood pressure
2. Diabetes
3. Alcohol abuse
4. Severe accidents that physically damage kidney
5. Complications from undergoing major surgery

Failed kidney	Outcome
1	lead normal life with the other kidney
2	die unless given prompt medical treatment

Medical treatment
- **Kidney transplant** → donate 1 kidney
- **Dialysis machine**: mimics function of kidney
  → clean blood from metabolic waste products and toxins

Dialysis machine

Functioning

1. Blood drawn from vein → pumped through tubing in dialysis machine
2. Tubing bathed in specially controlled dialysis fluid.
   Walls of tubing in dialysis machine are partially permeable
3. Small molecules (urea, other metabolic waste products) diffuse out of tubing into dialysis fluid
   Blood cells, platelets and large molecules remain in tubing
4. Filtered blood is returned to vein in patient's arm

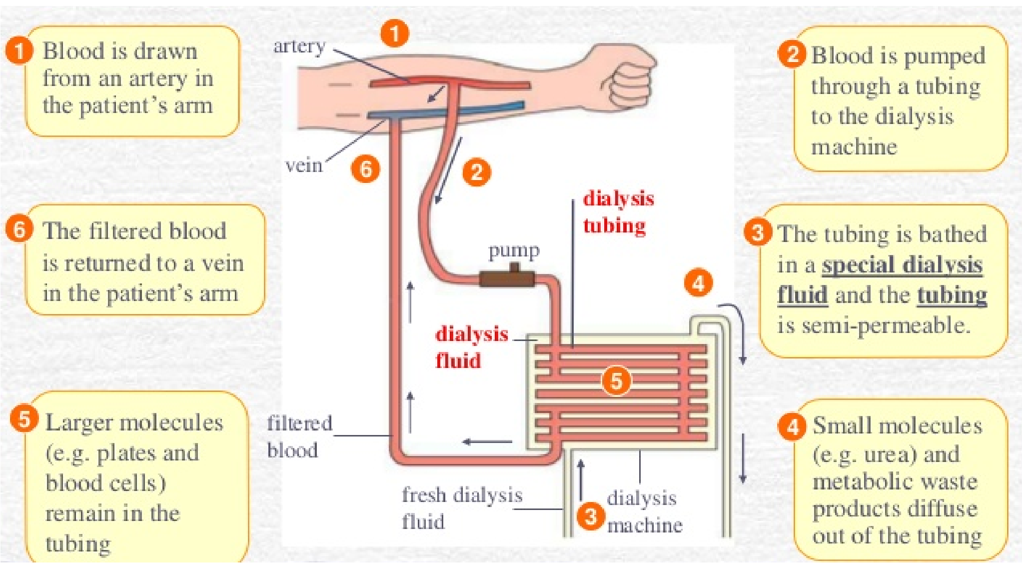
Features

Feature	Explanation

1. **Dialysis fluid contains same concentration of <u>essential substances</u> as healthy blood**	• <u>Essential substances do not diffuse out</u> of blood → dialysis fluid
	  ○ glucose
	  ○ amino acids
	  ○ dissolved mineral salts
	• Patient's blood lacks these essential substances → diffuse from dialysis fluid into blood

2. **Dialysis fluid does not contain <u>metabolic waste products</u>**	• Set up <u>concentration gradient</u> - diffuse out of tubing into dialysis fluid
	  ○ waste products (urea, uric acid, creatinine)
	  ○ excess water
	  ○ excess dissolved mineral salts
	• Waste products removed from blood
	• Maintain <u>correct solute composition and water potential</u> of blood

3. **Tubing in machine is <u>narrow, long and coiled</u>**	• Increases <u>SA:V</u> • Speed up rate of exchange of substances between patient's blood and dialysis fluid
4. **<u>Direction</u> of blood flow is opposite to flow of dialysis fluid**	• Maintain <u>concentration gradient</u> • for removal of waste products



Typical questions

Multiple choice questions

1. In which two body organs does the greatest amount of reabsorption of water take place? (N2011/P1/Q7)

   A colon and kidneys
   B duodenum and colon
   C kidneys and liver
   D liver and duodenum

2. What causes ultrafiltration in the kidney tubule? (N2011/P1/Q20 / N2015/P1/Q20)

   A antidiuretic hormone (ADH)
   B breakdown of urea
   C contraction of the left ventricle
   D mitochondria in the cells of Bowman's Capsule

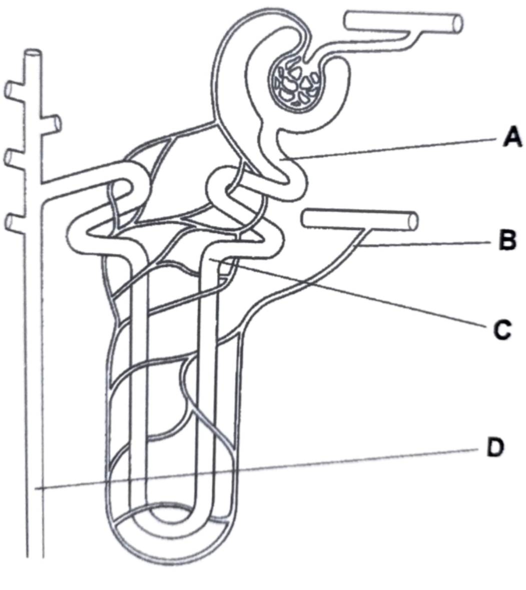
3. Which statement about excretory materials is correct? (N2013/P1/Q20)

   A All nitrogenous compounds must be excreted.
   B They always contain the element nitrogen.
   C They are always present in excess in the diet.
   D They are produced by the cells in the body.

4. Two samples of fluids were removed from different parts of a kidney tubule and analysed. The results, in arbitrary units, are shown in the table.

chemical	glomerular filtrate	second sample
urea	10	8
sodium ions	10	1
water	100	5
glucose	5	0

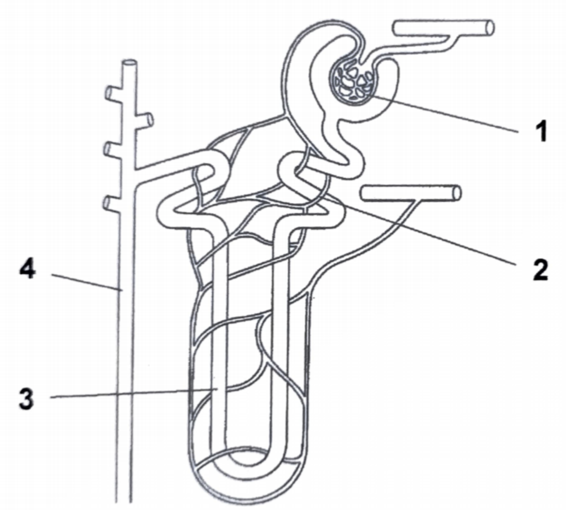
From which position was the second sample taken? (N2013/P1/Q21)



5. Where is the waste product of amino acid metabolism produced and which organ excretes it? (N2014/P1/Q20)

	produced by	excreted by
A	kidney	liver
B	kidney	skin
C	liver	kidney
D	liver	large intestine

6. The diagram represents a kidney tubule and associated blood vessels.



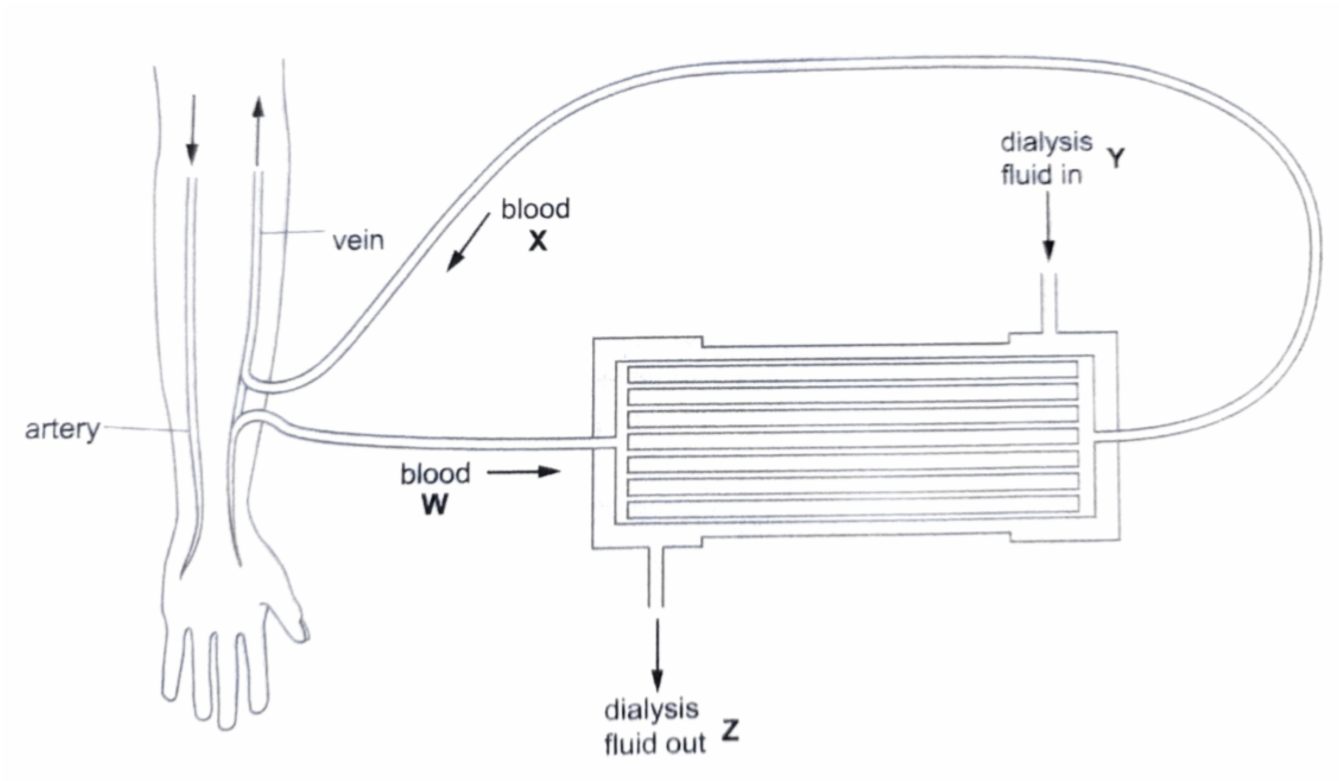
Where does antidiuretic hormone (ADH) have its effect and where does ultrafiltration occur? (N2014/P1/Q21)

	antidiuretic hormone	ultra-filtration
A	1	2
B	2	3
C	4	1
D	4	3

7. What are the percentages of urea, water and glucose in the urine of a healthy human? (N2016/P1/Q20)

	percentage in the urine		
	urea	water	glucose
A	0	95	0
B	2	65	3
C	2	95	0
D	10	80	5

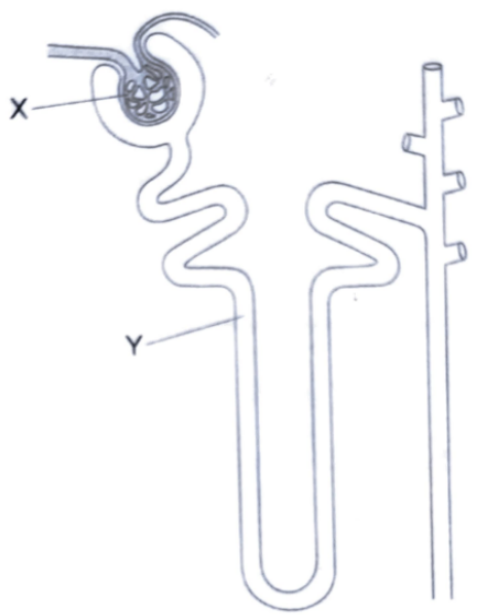
8. The diagram shows the flow of blood and dialysis fluid through a kidney machine.



Where would the concentration of urea be highest? (N2016/P1/Q21)

A W and X
B X and Y
C Y and Z
D W and Z

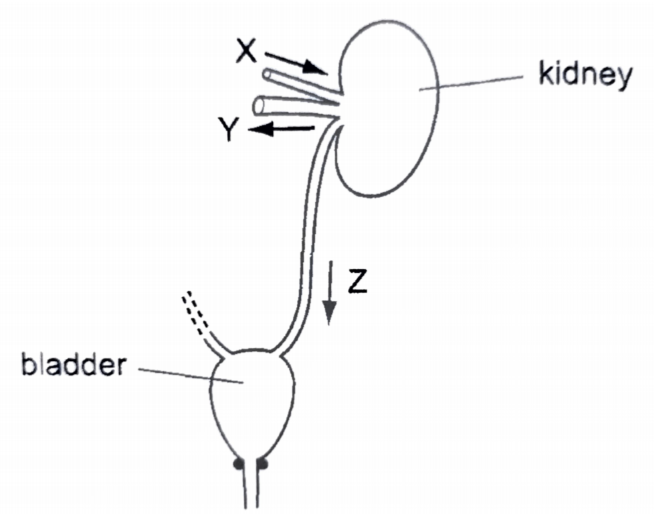
9. The diagram shows a nephron from a kidney and some associated blood vessels.



How do the concentrations of glucose and protein at Y compare with their concentrations at X in a healthy person? (N2017/P1/Q20)

	glucose concentration at Y	protein concentration at Y
A	lower	lower
B	lower	same
C	same	lower
D	same	same

10. The diagram shows part of the urinary system of a human. Liquids pass through tubes X, Y and Z in the directions shown by the arrows.



Which statement about the volume of liquid passing through Y in one day is correct? (N2017/P1/Q21)

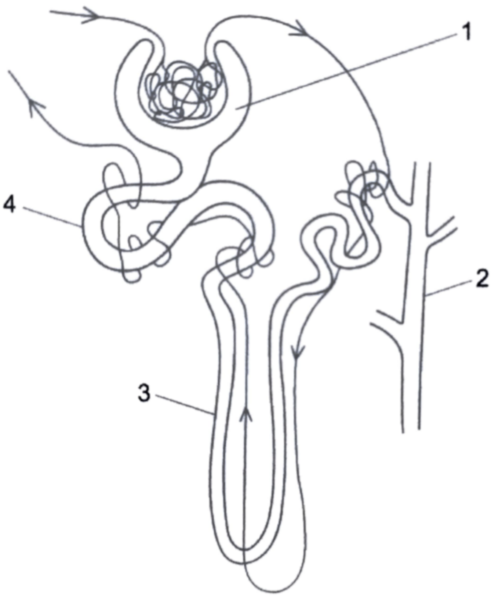
A It is greater than passing through X.
B It is less than passing through Z.
C It is much less than that passing through X but slightly greater than that passing through Z.
D It is slightly less than that passing through X but much greater than that passing through Z.

11. The four structures listed are part of the human excretory system.
1 bladder
2 kidney
3 ureter
4 urethra

Urea is a component of urine.
In which order does a molecule of urea pass through these structures?(N2018/P1/Q20)

A $1 \rightarrow 2 \rightarrow 3 \rightarrow 4$
B $1 \rightarrow 4 \rightarrow 3 \rightarrow 2$
C $2 \rightarrow 1 \rightarrow 3 \rightarrow 4$
D $2 \rightarrow 3 \rightarrow 1 \rightarrow 4$

12. The diagram represents a kidney tubule and its associated blood vessels.



If the concentration of ADH increases, which will increase? (N2018/P1/Q21)

A formation of filtrate at 1
B reabsorption of water at 2
C concentration of filtrate at 3
D reabsorption of ions at 4

13. Excess amino acids are metabolised to produce nitrogenous waste which is excreted. Which row shows the organs where these processes occur? (N2019/P1/Q7)

	site of metabolism	site of excretion
A	kidney	liver
B	liver	kidney
C	liver	lung
D	lung	kidney

Structured questions

1. The table below shows the composition of normal human urine.

Substance	Concentration in urine (g/100cm³)
Water	96.0
Urea	2.0
Glucose	0.0
Amino acids	0.0
Mineral salts	1.8
Proteins	0.0

(a) Which of the above substances are present in normal blood plasma at a higher concentration than in urine? Explain why. [4]

Normal blood plasma contains higher concentration of water, glucose, amino acids, dissolved mineral salts and proteins.
During ultrafiltration, large molecules such as proteins cannot pass through the partially permeable basement membrane into the Bowman's capsule. Therefore, proteins remain in the bloodstream and are not excreted out of the body in urine.
During selective reabsorption, glucose, amino acids, some excess water and some excess dissolved mineral salts are reabsorbed from the nephron into the bloodstream, with most of the substances reabsorbed at the proximal convoluted tubule.

(b) Explain how the composition of urine would change

(i) after a protein-rich diet; [2]

Concentration of urea in urine increases.
After a protein-rich diet, more urea molecules are formed from the deamination of protein molecules in the kidney. Therefore, a higher concentration of urea is excreted out of the body in urine.

(ii) in a person with diabetes mellitus. [2]

Concentration of glucose in urine increases.
The production of insulin by the islets of Langerhans in the pancreas is insufficient to completely convert all the excess glucose molecules into glycogen, and not all glucose molecules are selectively reabsorbed from the proximal convoluted tubule of nephrons into the bloodstream. Therefore, more glucose molecules are excreted out of the body in urine.

2. The kidneys also help in the regulation of blood pressure. Explain how this is so. [3]

The kidneys regulate blood pressure by regulating the solute level in the blood by excreting excess dissolved mineral salts. As a result, the kidneys also control blood volume and blood pressure. If blood volume increases, blood pressure rises.

3. A girl is suffering from anorexia nervosa, an eating disorder which involves voluntary starvation. There are signs of muscle wastage in the girl. What might be the **two** components that will be abnormally high in her urine? Give a reason for your answer. [4]

The levels of urea and creatinine will be abnormally high in her urine.
In severe malnutrition, her body does not have sufficient energy obtained from carbohydrates and fats, and that is when proteins are metabolised. During deamination, which happens in protein metabolism in the liver, amino acids formed increase the amount of ammonia in blood. Hence, the levels of urea in urine increases.
Creatinine is a by-product of the breakdown of muscle tissues. The evidence of creatinine in urine is a sign of serious physical degradation in the body.

4. Define the term excretion and state its importance in the functioning of the body. [3]
(N2011/P2/A4)

Excretion is the process by which waste products produced by the cells in the body of an organism and toxic materials are removed from the body of the organism.
Excretion is important because some waste products are toxic to the organism If they accumulate in the body of the organism. Nitrogenous waste products such as uric acid have to be removed for the body to function normally. For example, a high concentration of uric acid in blood can cause the organism to contract gout, a type of arthritis.

5. For one week, three groups of 10 people were fed a diet containing measured amounts of protein. On the last day of that week, the amount of urea in their urine was measured. The table below shows the results of the analysis. (N2012/P2/A2)

Amount of urea excreted / g per day		
Low protein diet	Normal protein diet	High protein diet
4.75	19.20	31.50

(a) State why groups of 10 people rather than individuals were used in this investigation. [1]

Groups of 10 people rather than individuals were used to ensure that a more accurate result can be obtained. Using more readings can offset any anomaly found in the readings.

(b) With reference to the table above, using appropriate figures, what effect increasing the amount of protein in the diet had on the amount of urea in the urine. [2]

As the amount of protein in the diet increased from low to high, the amount of urea excreted in the urine increased from 4.75 g per day to 1.50 g per day.

(c) The table below shows the relative composition of blood plasma and urine in humans.

substance	amount in plasma / g per 100 cm^3	amount of urine / g per 100 cm^3	concentration factor in urine
protein	8.500	0.000	-
urea	0.030	1.800	× 60.0
glucose	0.100	0.000	-
potassium	0.020	0.150	× 7.5
calcium	0.010	0.015	× 1.5
chloride	0.330	0.600	× 1.8

(i) Explain the absence of protein and glucose in the urine. [4]

Protein:

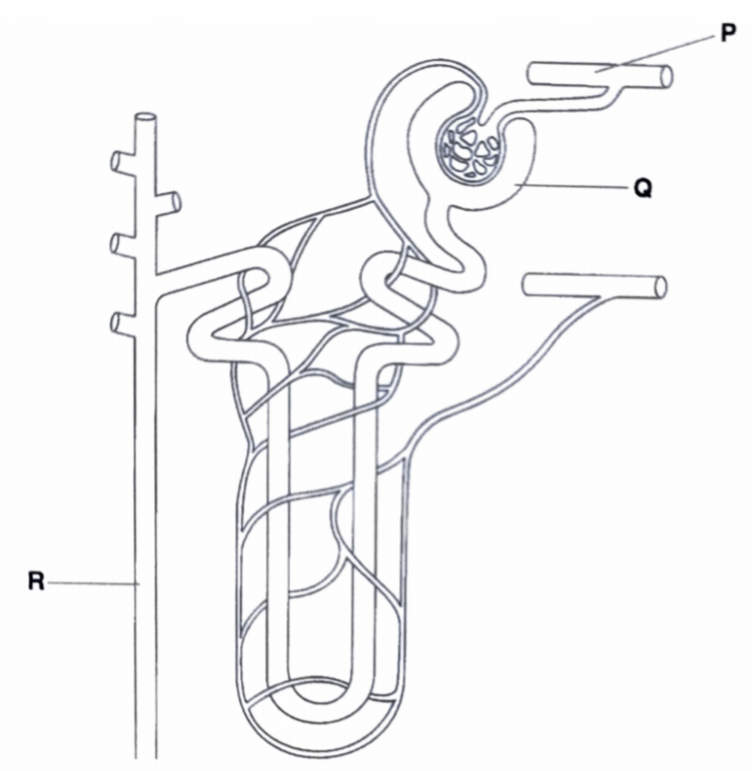
Protein is a large molecule and is unable to pass through the partially permeable basement membrane which wraps around the glomerular capillaries in the renal capsule. The protein is retained in the glomerular capillaries and transported to the blood capillaries surrounding the tubule. It passes into a venule and then into a branch of the renal vein and returns to the main blood circulation.

Glucose:

After glucose is forced out of the glomerulus by ultrafiltration into the renal capsule, it is selectively reabsorbed through the walls of the proximal convoluted tubule into surrounding blood capillaries by diffusion and active transport. It passes into a venule and then into a branch of the renal vein and returns to the main blood circulation.

(ii) Complete the table above for calcium. [1]

6. The figure below shows a kidney tubule. (N2013/P2/A3)



(a) Name the structure labelled P on the figure above. [1]

Branch of renal artery

(b) The table below shows some of the substances present at regions P, Q and R.

region	protein content g/100cm^3	glucose content g/100cm^3
P	8.0	0.1
Q	0.0	0.1
R	0.0	0.0

(i) Complete the table to show the protein content and the glucose content at region Q. [2]

(ii) Explain the differences in the protein content between regions P and R. [2]

Protein is present in region P but absent in region R because it is a large molecule and is unable to pass through the partially permeable membrane that wraps around the glomerular capillaries in the renal capsule. The protein is retained in the glomerular capillaries surrounding the tubule.

(iii) Explain the differences in the glucose content between regions Q and R. [1]

Glucose is present in region Q but absent in region R because after it is forced out of the glomerulus by ultrafiltration into the renal capsule, it is selectively reabsorbed through the walls of the proximal convoluted tubule into the surrounding blood capillaries by diffusion and active transport.

(c) Explain how antidiuretic hormone (ADH) affects the composition of the liquid passing through region R. [3]

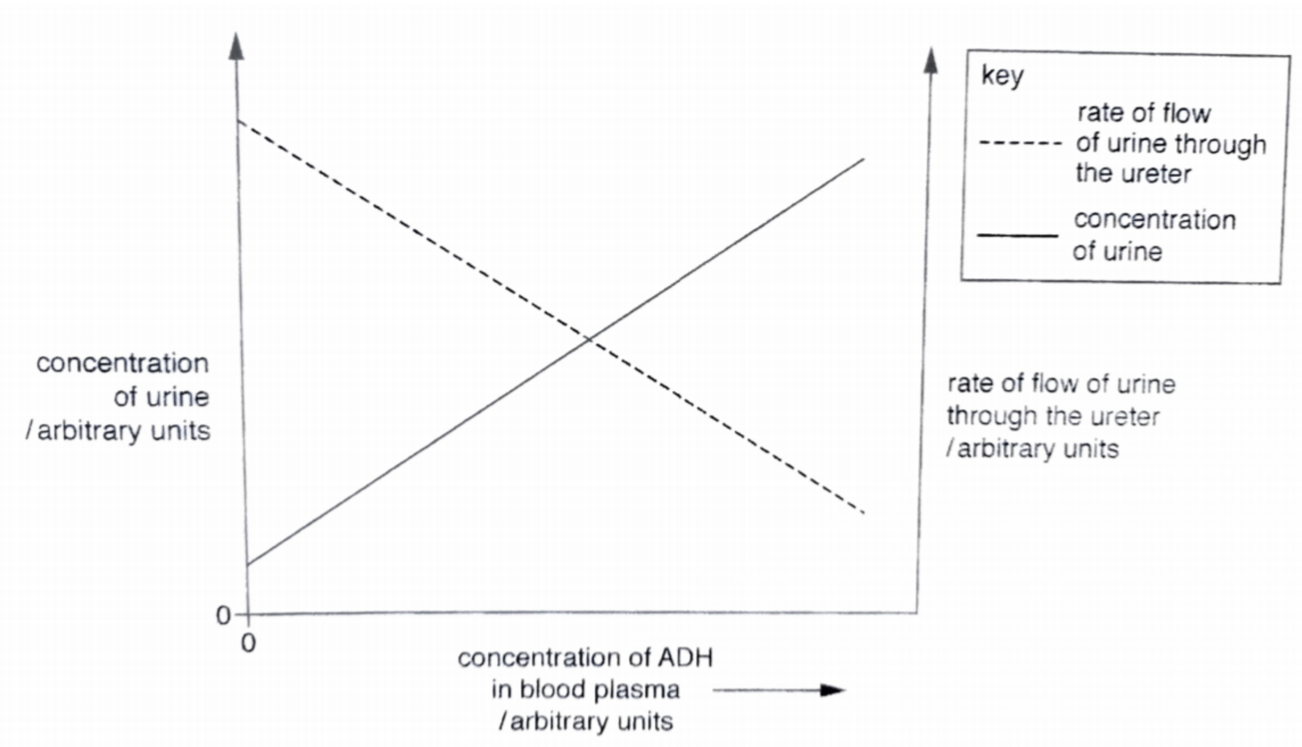
When the pituitary gland releases more ADH into the bloodstream, the cells in the wall of region R become more permeable to water. More water is reabsorbed from region R into the blood capillaries. Thus, a smaller volume of liquid that is more concentrated passes through region R.

When the pituitary gland releases less ADH into the bloodstream, the cells in the wall of region R become less permeable to water. Less water is reabsorbed from region R into the blood capillaries. Thus, a larger volume of liquid that is more concentrated passes through region R.

7. Describe and explain how reduced secretion of ADH would affect the composition of urine. [3]
(N2014/P2/A1)

When the pituitary gland secretes less ADH into the bloodstream, the cells in the wall of the collecting ducts become less permeable to water. Less water is reabsorbed from the collecting ducts back into the blood capillaries. Thus, a larger volume of urine that is less concentrated is produced.

8. The figure below shows the changes in the concentration of urine and the rate of flow of urine when the concentration of ADH in the blood plasma changes. (N2016/P2/A7)



(a) Describe the relationship between the concentration of ADH in the blood plasma and the concentration of the urine as shown in the figure above. [3]

As the concentration of ADH in the blood plasma increases, the concentration of urine increases. When more ADH is released into the bloodstream, the cells in the wall of the collecting ducts become more permeable to water. More water is reabsorbed from the collecting ducts back into the blood capillaries. Thus, a smaller volume of urine that is more concentrated is produced.

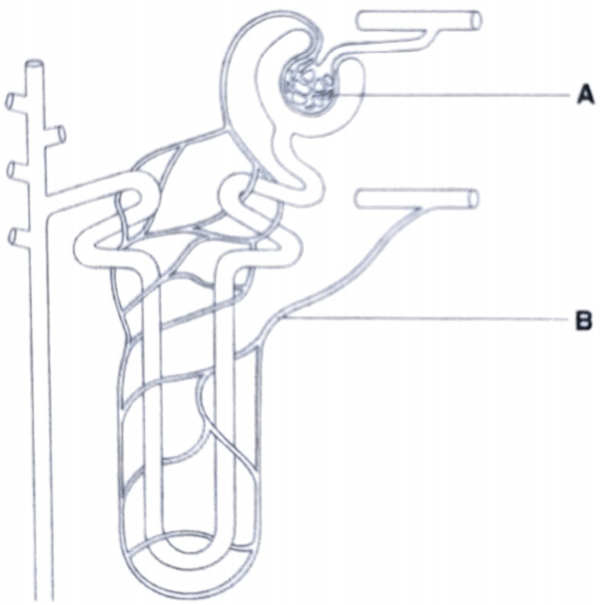
(b) Describe one other relationship shown in the figure above. [1]

As the concentration of ADH in the blood plasma increases, the rate of flow of urine through the ureter decreases.

(c) Suggest how vigorous exercise may affect the concentration of ADH in the blood. [2]

When a person carries out vigorous exercise, the person sweats a lot in order to remove excess heat from the body. The person loses a lot of water through perspiration when the water evaporates. As a result, the concentration of ADH in blood increases. More water is reabsorbed by the kidneys and a smaller volume of urine is produced to reduce water loss from the body.

9. The figure below shows a diagram of a kidney nephron. (N2018/P2/A5)

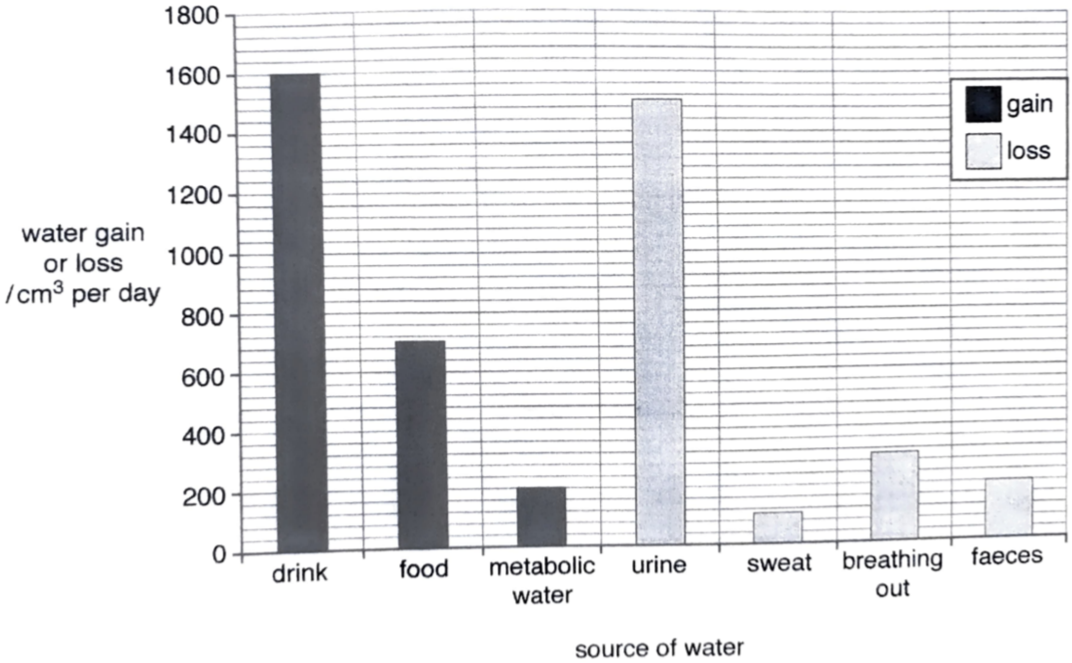


Describe the role of structure A and the role of structure B in the formation of urine. [3]

Ultrafiltration occurs at structure A to force small substances such as glucose, urea and water out of the glomerular capillaries into the renal capsule. Large substances such as proteins are unable to pass through the partially permeable basement membrane that wraps around the glomerular capillaries in structure A. These proteins are retained in glomerular capillaries and transported to the blood capillaries surrounding the tubule. Useful substances such as water and glucose are then selectively reabsorbed back into blood capillaries at the proximal convoluted tubule by diffusion and active transport.

The blood passes into structure B and returns to the main blood circulation. Substances such as excess water and mineral salts, and waste products such as urea and other nitrogenous wastes are excreted by the kidneys through urine.

10. The figure below shows the water balance of a person in an environment where the air temperature was 20°C. (N2017/P2/B9)



(a) Suggest what is meant by the term metabolic water. [2]

Metabolic water is water produced by metabolic reactions such as aerobic respiration carried out by cells in the body.

(b) Suggest how the water losses would change if the person was in an environment where the air temperature was 5°C. [4]

The amount of water lost through urine increases as the person urinates more often when it is colder. The amount of water lost through sweat decreases as the person sweats less to reduce heat loss to the environment. The amount of water lost through breathing out increases as the person respires more to produce more heat. The amount of water lost through faeces increases or decreases based on the person's intake of water.

(c) Antidiuretic hormone (ADH) is involved in the prevention of dehydration. Explain how ADH reduces water loss from the body. [3]

As the concentration of ADH in the blood plasma increases, the rate of flow of urine through the ureter decreases. When more ADH is released into the bloodstream, the cells in the wall of the collecting ducts become more permeable to water. More water is reabsorbed from the collecting ducts back into the blood capillaries. Thus, a smaller volume of urine is produced and ADH reduces water loss from the body.

11. (N2019/P2/B8)

(a) Describe the function of a nephron. [4]

Nephron is responsible for urine formation. A nephron consists of the Bowman's capsule, proximal and distal convoluted tubules, loop of Henle, collecting duct and a network of blood vessels including the glomerulus.
Ultrafiltration occurs at the glomerulus and Bowman's capsule as small substances found in blood plasma such as glucose, amino acids, mineral salts, urea and water leave the bloodstream into the nephron.
Selective reabsorption of useful substances such as glucose, amino acids and water are selectively reabsorbed by the proximal and distal convoluted tubules, lop of Henle and collecting duct.
The resulting mixture of excess water, mineral salts and nitrogenous wastes such as urea will then pass out of the collecting duct into the ureter as urine to be stored in the bladder.

(b) When a person suffers kidney failure, he is given dialysis. Describe the mechanism of kidney dialysis. [6]

The kidney dialysis machine helps remove urea and other waste products from the blood of the patient. Blood is taken from the vein of the patient's arm and pumped into the dialysis machine through a partially permeable dialysis tubing. The dialysis tubing is immersed in dialysis fluid in the machine at 37℃ to minimise heat loss from the patient.
The dialysis fluid consists of the same water potential and concentration of useful substances such as glucose and amino acids as compared to the blood, and does not contain waste products such as urea. The direction of flow of the dialysis fluid is opposite to the blood flow to maintain a steep concentration gradient of waste products to facilitate efficient diffusion of waste products from the blood into the dialysis fluid. The patient's blood is then returned to the patient via a vein in the patient's arm.