Surname	Date	Tutor
First name(s)		

BioWelsh

GCE A LEVEL

BW-A2-3.7-W1

TOPIC WORKSHEET 1 – 3.7 HOMEOSTASIS AND THE KIDNEY

BIOLOGY – A2 unit 3

Energy, Homeostasis and the Environment

Suggested time: 3 hours 15 minutes

For Tutor's use only

Question	Maximum Mark	Mark Awarded	Question	Maximum Mark	Mark Awarded
1.	10		9.	9	
2.	9		10.	10	
3.	9		11.	10	
4.	10		12.	10	
5.	9		13.	12	
6.	9		14.	11	
7.	10		15.	9	
8.	11		Total	148	

ADDITIONAL MATERIALS

In addition to this worksheet, you will require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.
You may use a pencil for graphs and diagrams only.
Write your name and the date in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this booklet. If you are working on screen, write your answers on paper and number each one clearly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question. The worksheet is out of **148** marks.
The assessment of the quality of extended response (QER) will take place in question **15**.
The quality of written communication will affect the awarding of marks.

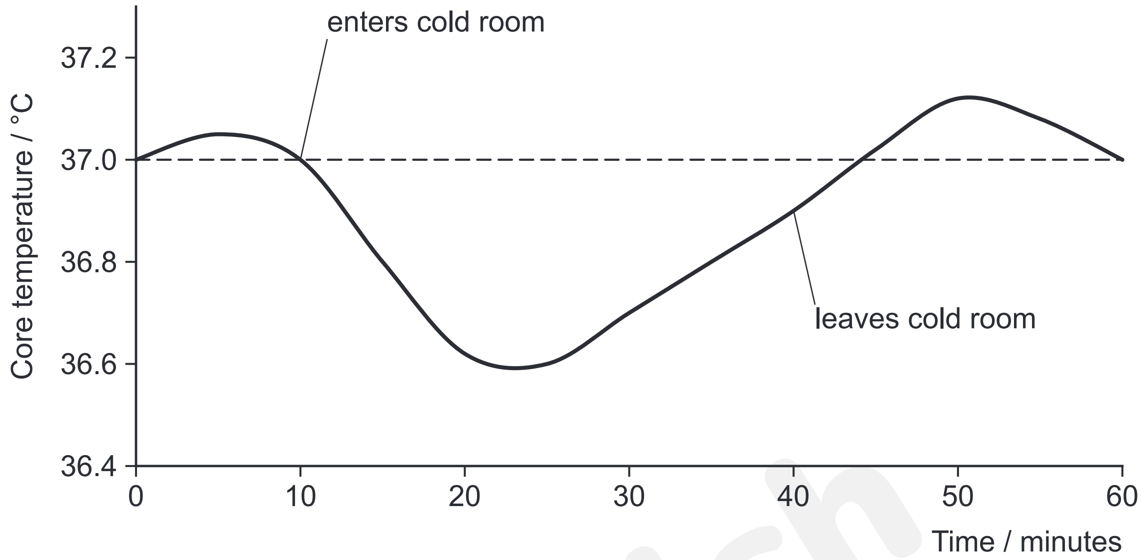
This worksheet is written by BioWelsh in the style of the WJEC A level Biology examination, following the WJEC specification (topic 3.7). It is not an official WJEC paper.

Turn over.

Tutor only

Answer **all** questions.

1. A volunteer sat in a room at 5 °C for 30 minutes. Their core body temperature was measured every 5 minutes before, during and after this time. **Graph 1.1** shows the results. The dashed line shows the set point.



Graph 1.1

(a) Explain what is meant by the term homeostasis. [2]

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(b) Use **Graph 1.1** to state the largest fall in core temperature below the set point. [1]

Fall = ... °C

Tutor only

Image 1.2 shows the negative feedback loop that controls core temperature.

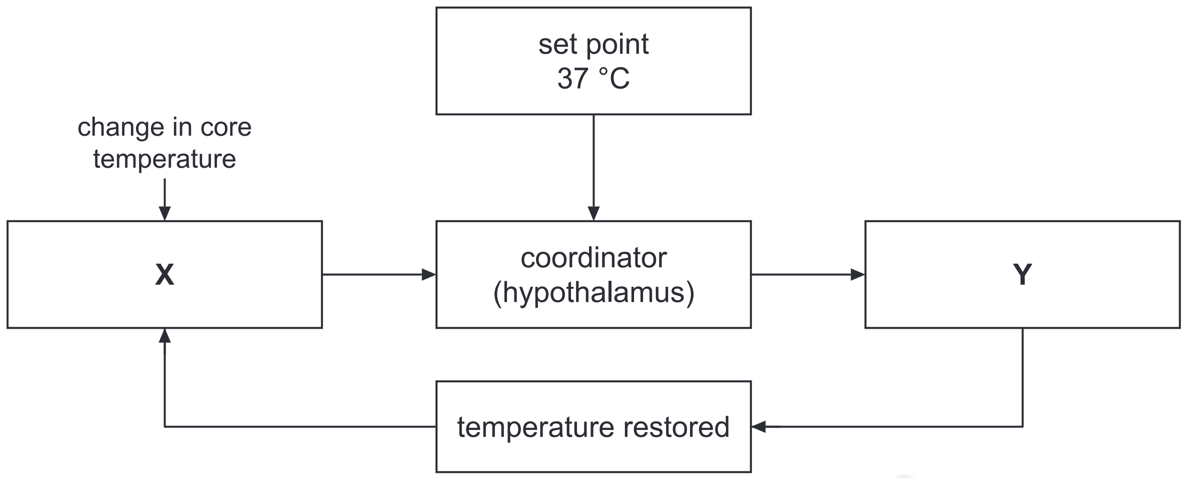

Image 1.2

(c) Identify the components labelled **X** and **Y** in **Image 1.2**. [2]

X ....

Y ....

(d) Use **Graph 1.1** and **Image 1.2** to explain how negative feedback returned the core temperature to the set point. [3]

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(e) Suggest why the core temperature rose above the set point between 45 and 55 minutes. [2]

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Turn over.

Tutor only

2. During labour, contractions of the muscle of the uterus push the baby towards the cervix. The hormone oxytocin increases the strength of these contractions. Oxytocin is made in the hypothalamus. **Image 2.1** shows how its release is controlled.

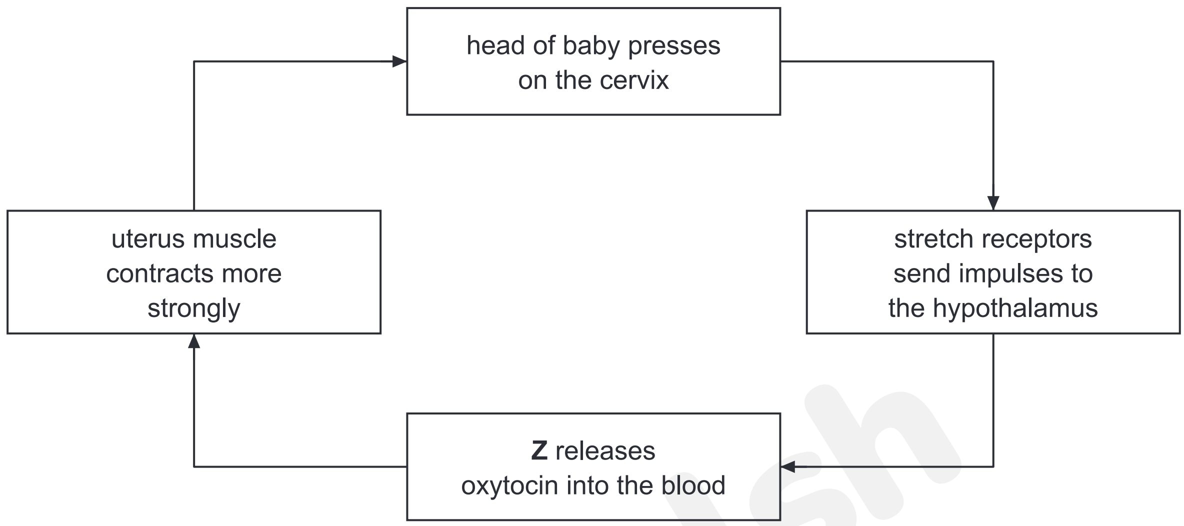

Image 2.1

(a) Name the endocrine gland **Z** which releases oxytocin into the blood. [1]

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(b) Using **Image 2.1**, explain why this is an example of positive feedback. [2]

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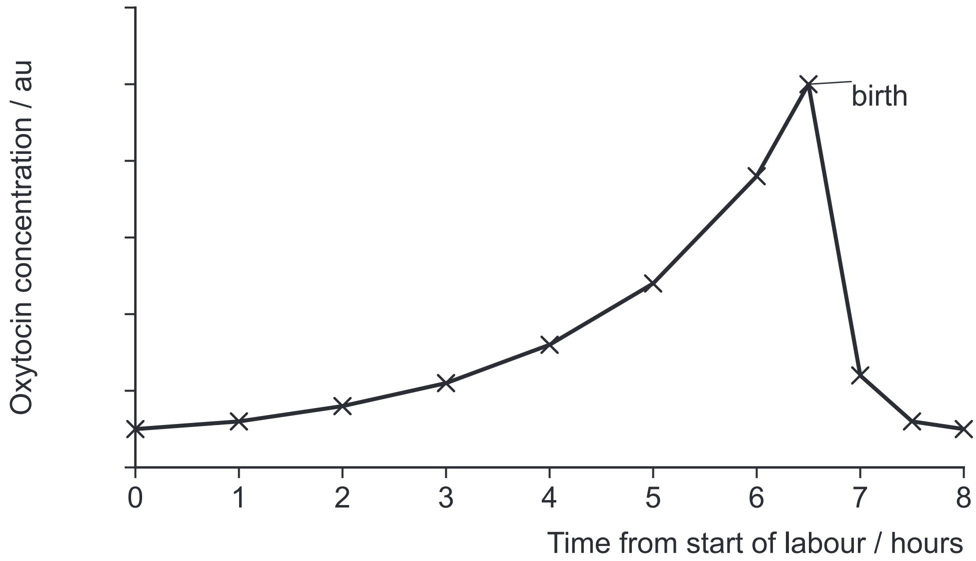
Tutor only

Graph 2.2 shows the concentration of oxytocin in the blood of a woman during labour.



Graph 2.2

(c) Describe the changes in the concentration of oxytocin shown in **Graph 2.2**. [2]

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(d) Suggest why the concentration of oxytocin falls rapidly after birth. [2]

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(e) Explain why most homeostatic mechanisms depend on negative feedback rather than positive feedback. [2]

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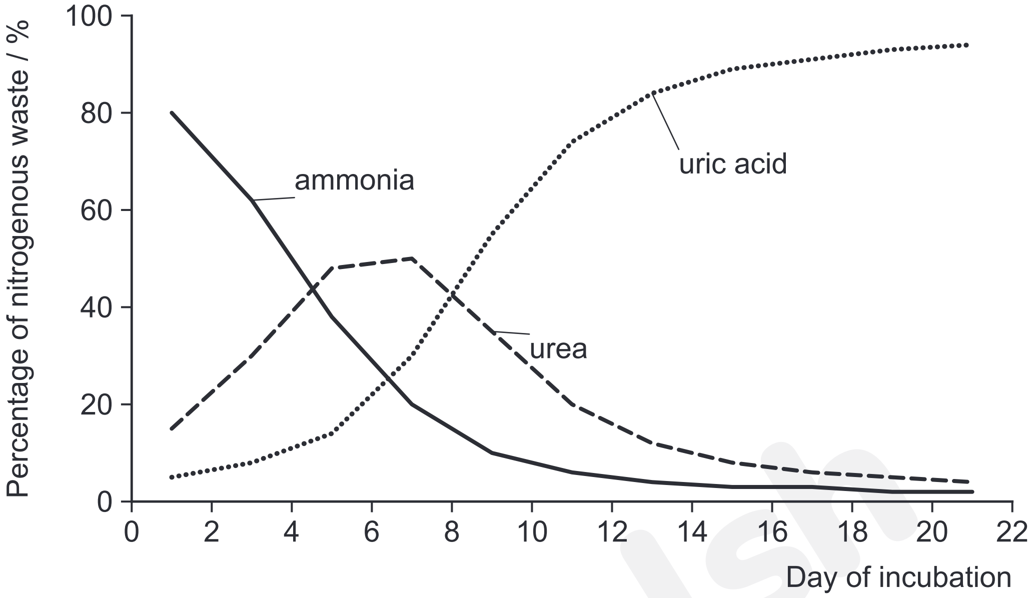
Turn over.

Tutor only

3. A chick develops inside a shelled egg for 21 days. Gases pass through the shell, but the embryo cannot obtain extra water. **Graph 3.1** shows the percentage of the nitrogenous waste produced by a chick embryo in the form of ammonia, urea and uric acid during incubation. The data are simplified from published studies.



Graph 3.1

(a) Nitrogenous waste is formed from excess amino acids. State where ammonia is formed from amino acids in a mammal and name the process involved. [2]

Where ....

Process ....

(b) Describe the changes in the form of nitrogenous waste during incubation shown in **Graph 3.1**. [2]

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(c) Explain why uric acid is the most suitable form of nitrogenous waste for most of the chick's development. [2]

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Tutor only

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(d) Suggest why the embryo can produce mostly ammonia in the first few days of incubation. [2]

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(e) Freshwater fish excrete most of their nitrogenous waste as ammonia. Suggest why this is possible for fish but not for birds. [1]

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Tutor only

4. A student dissected a lamb's kidney as part of a practical investigation. **Image 4.1** shows one half of the kidney after it was cut.

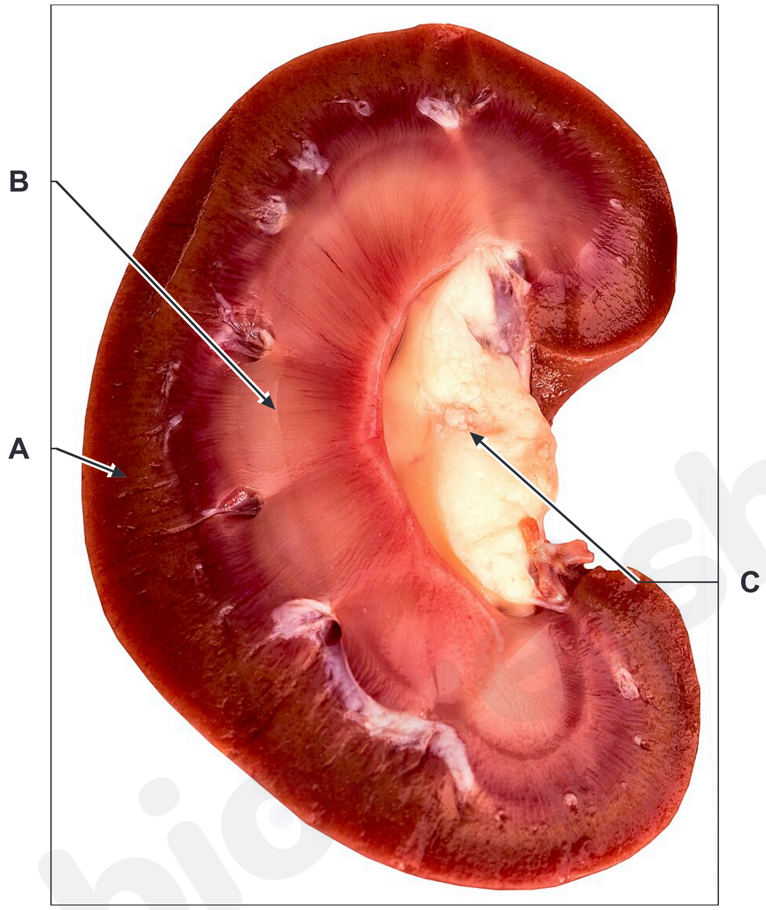

Image 4.1

(a) Identify the regions labelled **A**, **B** and **C**. [2]

A ....

B ....

C ....

(b) Describe how the student should have cut the kidney to produce the section shown in **Image 4.1**. Include **one** safety precaution in your answer. [3]

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Tutor only

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(c) Region **B** has a striped appearance. Explain what causes the stripes. [2]

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(d) Suggest why region **A** is a darker red colour than region **B**. [1]

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(e) The student made a drawing of the cut surface of the kidney. Give **two** features of a good scientific drawing. [2]

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Tutor only

5. **Image 5.1** is a light micrograph of a stained section of kidney from a prepared slide.

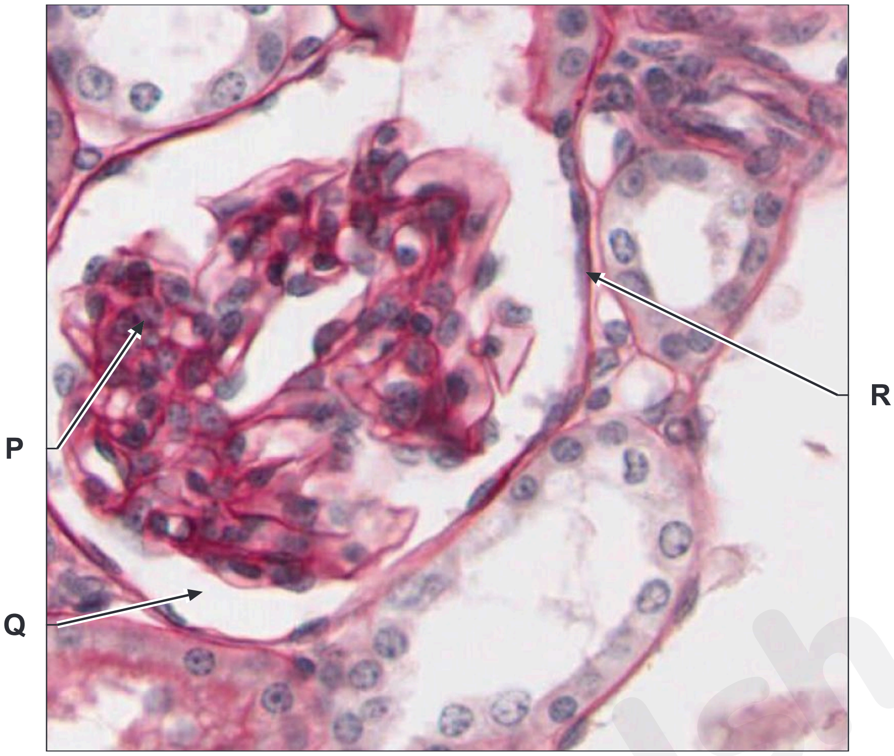

Image 5.1

(a) Identify the structures labelled **P**, **Q** and **R**. [2]

P ....

Q ....

R ....

(b) State whether this section was taken from the cortex or the medulla. Give a reason for your answer. [2]

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Tutor only

(c) The actual diameter of the glomerulus **P** is 150 µm. In a printed copy of this micrograph the glomerulus measured 60 mm across. Calculate the magnification of the printed copy. [2]

Magnification = × ....

(d) The tubules around the glomerulus appear as circles, ovals and irregular shapes. Explain why. [1]

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(e) Suggest how a student could tell a proximal convoluted tubule from a distal convoluted tubule on this slide at high power. [2]

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Tutor only

6. **Image 6.1** shows a nephron and part of its blood supply. It is not drawn to scale.

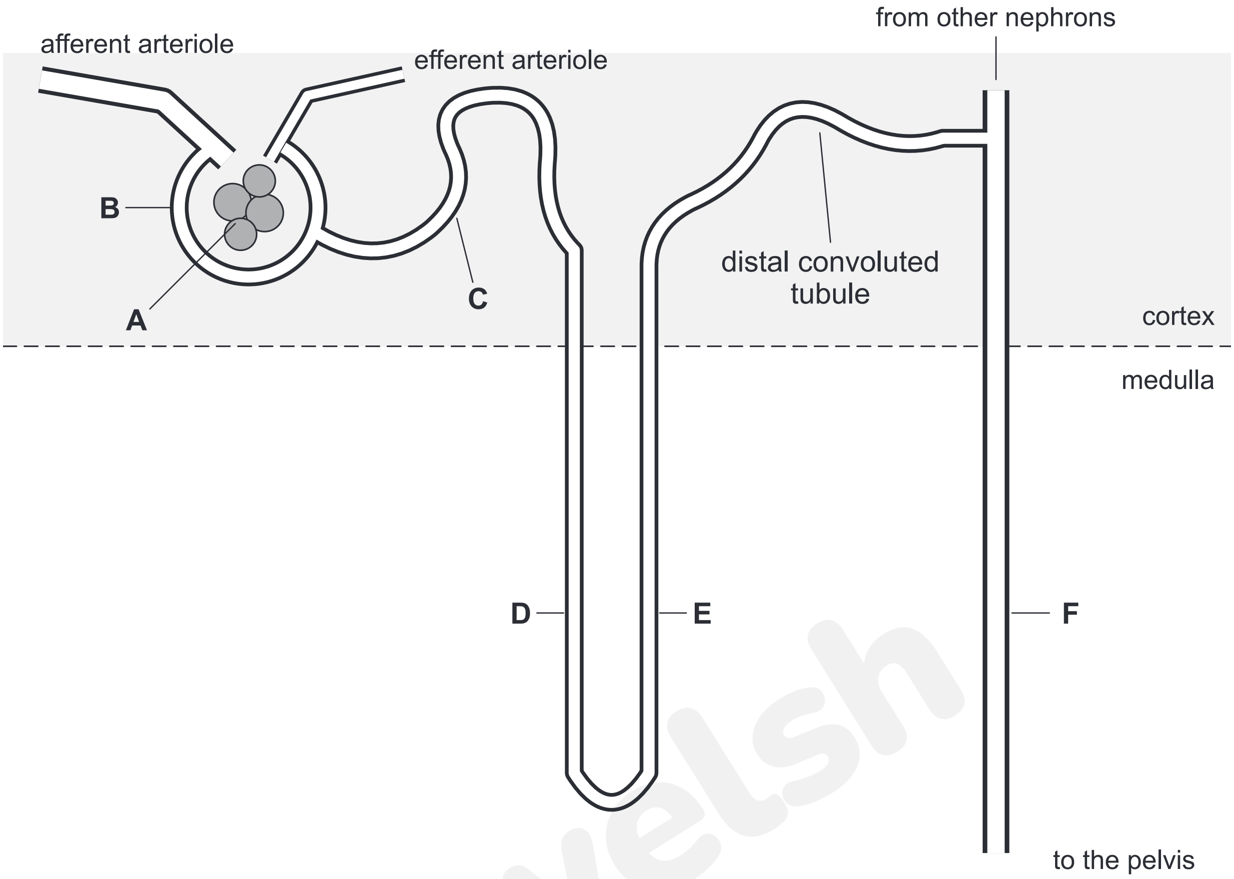

Image 6.1

(a) Name the parts labelled **A** to **F**. [3]

A ....

B ....

C ....

D ....

E ....

F ....

(b) On **Image 6.1**, label with an **X** the part of the nephron where ultrafiltration takes place. [1]

(c) Explain how the arterioles shown in **Image 6.1** help ultrafiltration to take place. [2]

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Tutor only

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(d) State which of the parts **A** to **F** are found in the medulla. [1]

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(e) The kidneys make up less than 1 % of the body mass but receive about 20 % of the blood pumped by the heart. Suggest **two** reasons why they need such a large blood supply. [2]

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Tutor only

7. **Image 7.1** shows the three layers that separate the blood in a glomerular capillary from the filtrate in the Bowman's space.

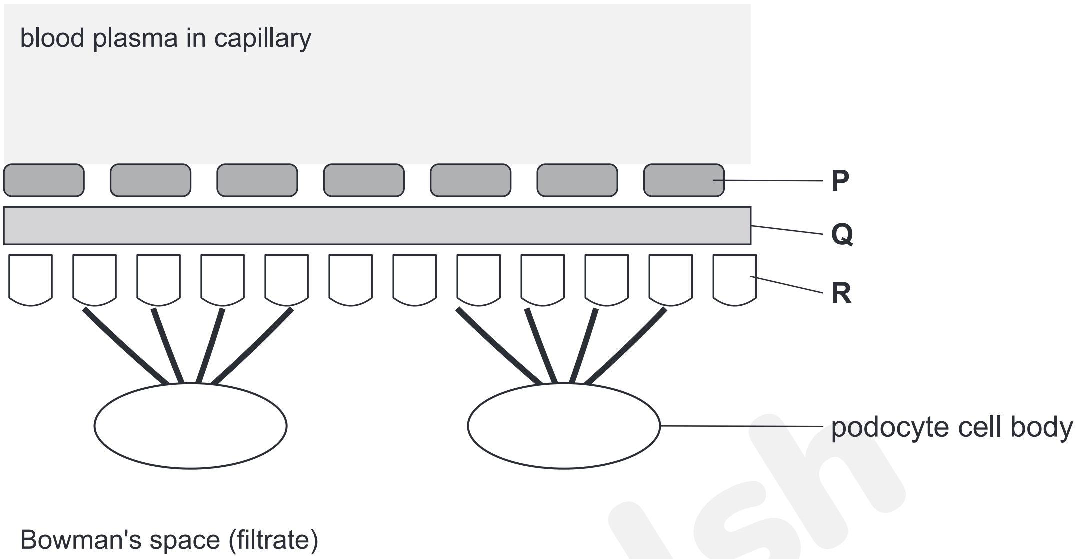

Image 7.1

(a) Name the layers labelled **P**, **Q** and **R**. [2]

P ....

Q ....

R ....

Table 7.2 shows the concentrations of some substances in the blood plasma and in the filtrate in the Bowman's space.

Table 7.2

Substance	Plasma concentration / g dm^{-3}	Filtrate concentration / g dm^{-3}
glucose	1.00	1.00
urea	0.30	0.30
amino acids	0.50	0.50
plasma proteins	75.00	0.05

(b) Use **Image 7.1** and **Table 7.2** to explain the difference between the results for glucose and for plasma proteins. [2]

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Tutor only

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The pressure that forms the filtrate can be calculated using this equation:

$$\text{net filtration pressure} = P_G - P_O - P_C$$

where P_G is the hydrostatic pressure of blood in the glomerulus, P_O is the osmotic pressure of the plasma proteins and P_C is the pressure in the Bowman's capsule. In a healthy person P_G is 7.2 kPa, P_O is 3.4 kPa and P_C is 2.1 kPa.

(c) (i) Calculate the net filtration pressure in this person. [1]

Net filtration pressure = ... kPa

(ii) After heavy bleeding, the hydrostatic pressure in the glomerulus fell by 25 %. The other pressures did not change. Calculate the new net filtration pressure. [2]

Net filtration pressure = ... kPa

(iii) Explain what your answer to (ii) suggests about urine production after heavy bleeding. [2]

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(d) In a healthy adult, filtrate is formed at a rate of 125 cm^3 per minute. Calculate the volume of filtrate formed in one day, in dm^3. [1]

Volume = ... dm^3

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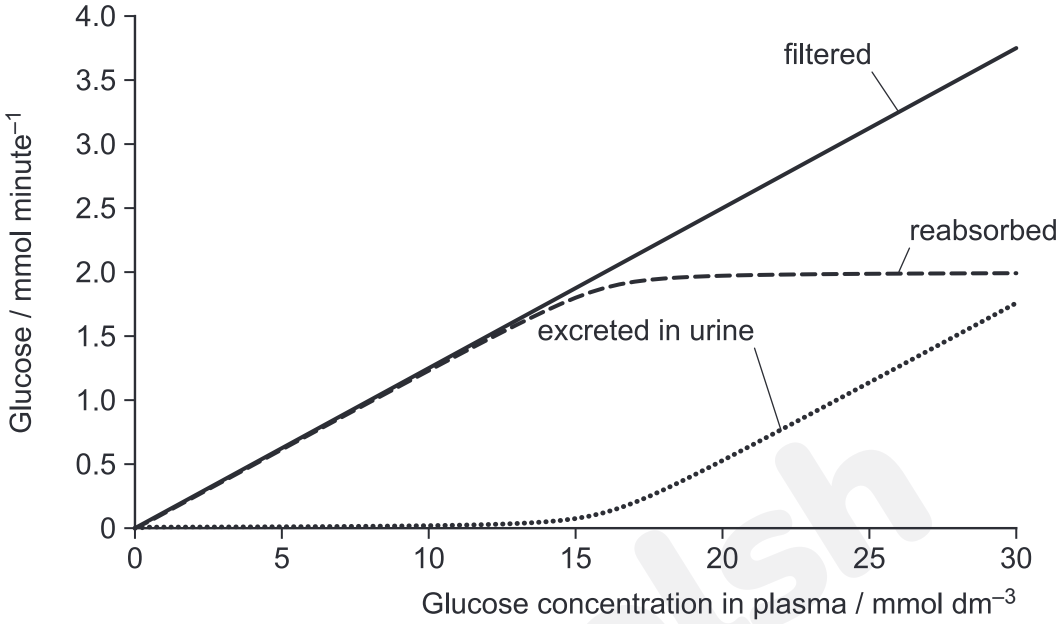
Tutor only

8. Glucose is filtered from the blood in the glomerulus and reabsorbed in the proximal convoluted tubule. **Graph 8.1** shows the rates at which glucose is filtered, reabsorbed and excreted in the urine at different plasma glucose concentrations. The normal plasma glucose concentration is about 5 mmol dm^{-3}.



Graph 8.1

(a) Describe how glucose is reabsorbed from the filtrate into the blood. [3]

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(b) Using **Graph 8.1**, explain why glucose appears in the urine when the plasma glucose concentration is above about 13 mmol dm^{-3}. [2]

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Tutor only

(c) Calculate the percentage of the filtered glucose that is reabsorbed when the plasma glucose concentration is 24 mmol dm^{-3}. Give your answer to **1 decimal place**. [2]

Percentage reabsorbed = ... %

(d) Drugs called SGLT2 inhibitors are used to treat some people with type 2 diabetes. They block the co-transporter protein that carries most of the glucose into the cells of the proximal convoluted tubule. Suggest how these drugs lower the concentration of glucose in the blood. [2]

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(e) People who take SGLT2 inhibitors produce a larger volume of urine. Suggest why. [2]

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Turn over.

Tutor only

9. **Image 9.1** shows a cell from the wall of the proximal convoluted tubule.

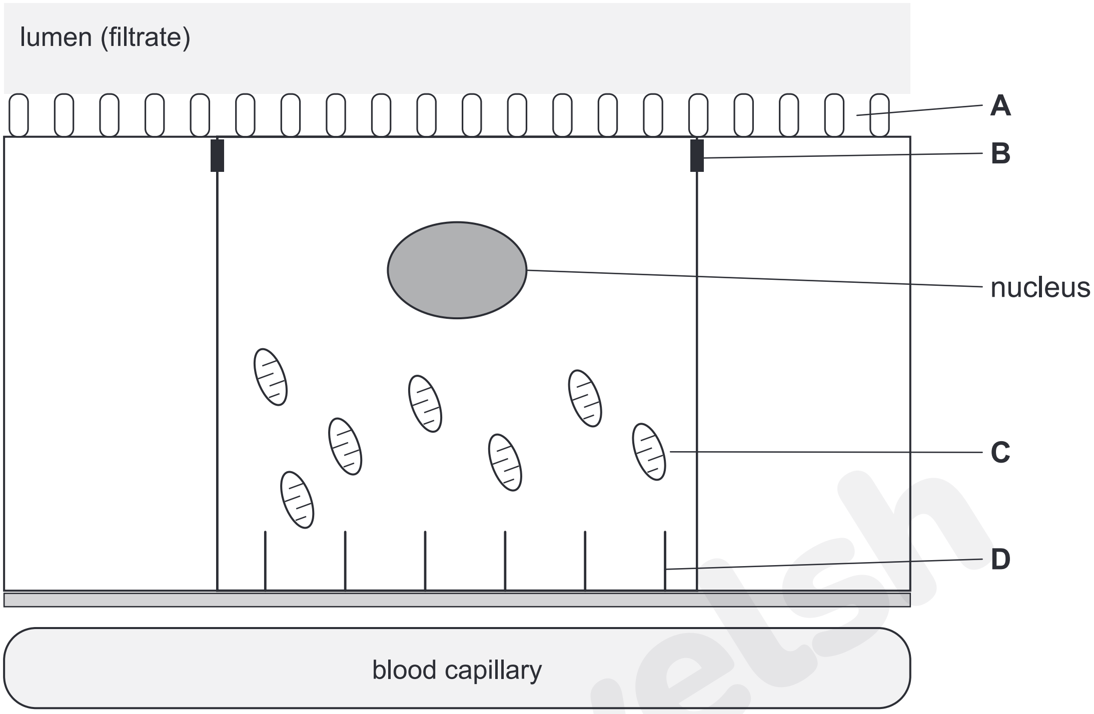

Image 9.1

(a) Identify the structures labelled **A**, **B**, **C** and **D**. [2]

A ....

B ....

C ....

D ....

(b) Explain how structures **A** and **C** adapt the cell for reabsorption. [3]

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Tutor only

Table 9.2 shows the percentage of each filtered substance that is reabsorbed in the proximal convoluted tubule.

Table 9.2

Substance	water	sodium ions	glucose	amino acids	urea
Percentage reabsorbed / %	65	65	100	100	50

(c) (i) About 180 dm^3 of filtrate is formed each day. Calculate the volume of water reabsorbed in the proximal convoluted tubules each day. [1]

Volume = ... dm^3

(ii) There are no carrier proteins for urea in the proximal convoluted tubule. Explain why about half of the urea is still reabsorbed. [2]

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(d) Suggest why the tight junctions labelled **B** are important in reabsorption. [1]

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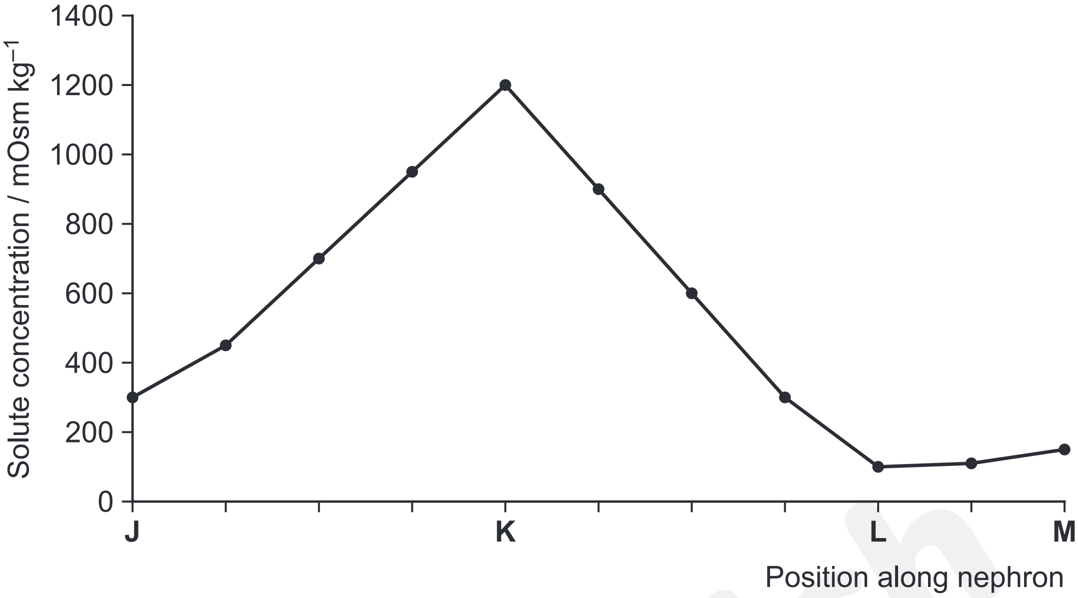
Tutor only

10. **Graph 10.1** shows the solute concentration of the filtrate at different points in a nephron of a person who is short of water. Solute concentration is measured in mOsm kg^{-1}. **J** is the start of the descending limb of the loop of Henle, **K** is the bend at the bottom of the loop, **L** is the top of the ascending limb and **M** is the end of the distal convoluted tubule.



Graph 10.1

(a) Describe and explain the change in the solute concentration of the filtrate between **J** and **K**. [3]

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(b) Explain why the solute concentration of the filtrate falls between **K** and **L**. [3]

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Tutor only

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(c) Explain how the loop of Henle makes it possible to produce concentrated urine in the collecting duct. [2]

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(d) Suggest how the solute concentration at **M** would be different in a person who had just drunk a large volume of water. Explain your answer. [2]

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Tutor only

11. A hiker walked for several hours on a hot day without drinking and lost a large volume of water in sweat. **Image 11.1** shows how the body responds to a fall in the water potential of the blood.

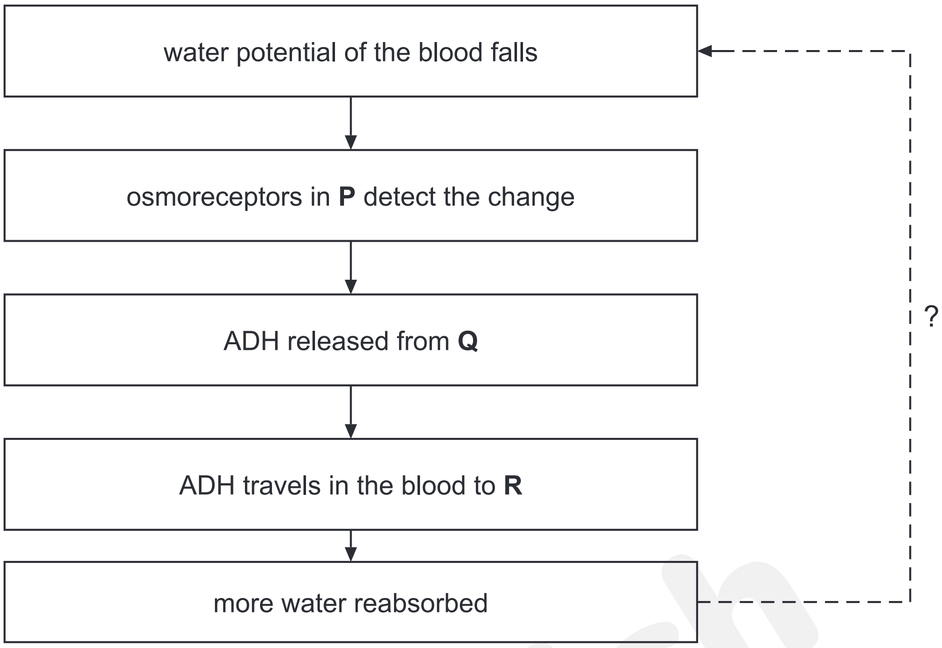


Image 11.1

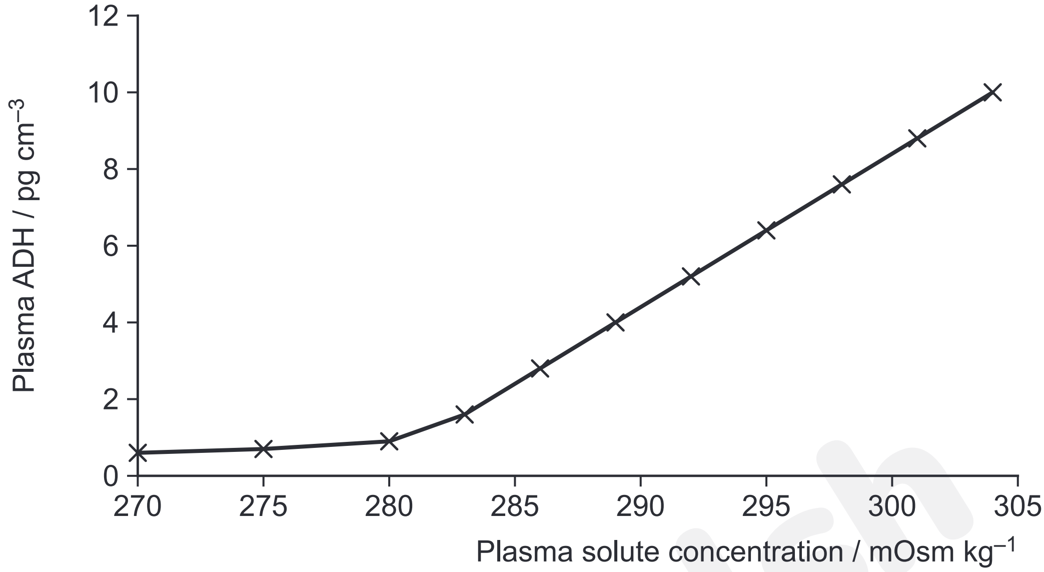
(a) Name the structures **P** and **Q**. [2]

P ....

Q ....

Tutor only

Graph 11.2 shows the concentration of ADH in the plasma at different plasma solute concentrations.



Graph 11.2

(b) Describe the relationship shown in **Graph 11.2**. [2]

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(c) Explain how ADH causes more water to be reabsorbed at **R**. [4]

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Turn over.

Tutor only

(d) The dashed arrow in **Image 11.1** completes a negative feedback loop. Explain how. [2]

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Tutor only

12. Volunteers each drank 500 cm^3 of water or 500 cm^3 of beer, or had no drink. The volume of urine they produced in the next two hours and its solute concentration were measured. **Table 12.1** shows the mean results.

Table 12.1

Drink	Mean volume of urine / cm^3	Mean solute concentration of urine / mOsm kg^{-1}
no drink	90	820
water	480	180
beer (4 % alcohol)	720	110

(a) Describe the effect of drinking beer compared with drinking water. [2]

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(b) Calculate the percentage increase in the volume of urine after drinking beer compared with water. [2]

Percentage increase = ... %

(c) Alcohol reduces the release of ADH. Explain how this could cause the results for beer. [2]

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(d) (i) Suggest why the investigation included a group who had no drink. [1]

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Turn over.

Tutor only

(ii) Give **one** variable, other than the volume of drink, that should have been controlled. [1]

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(e) Desmopressin is a synthetic form of ADH. It treats one type of diabetes insipidus, in which the posterior pituitary gland releases too little ADH. It does not work in another type, in which the gene for the ADH receptor on collecting duct cells is faulty. Explain why. [2]

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Tutor only

13. People with kidney failure may be treated by haemodialysis. **Image 13.1** shows a patient receiving haemodialysis. Blood flows from the arm to the machine and back again.

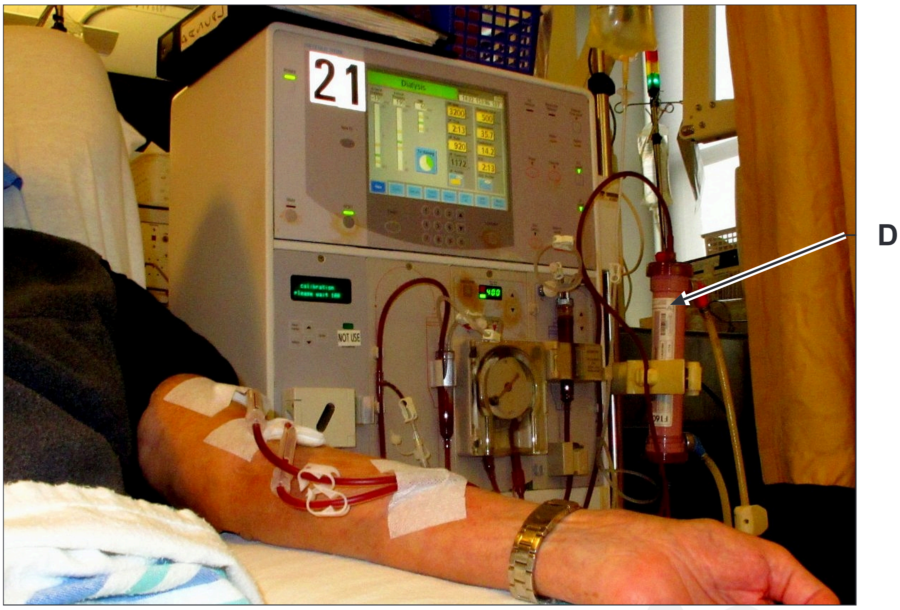

Image 13.1

(a) (i) Name the part labelled **D**, where substances are exchanged between the blood and the dialysis fluid. [1]

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(ii) Give **two** effects of kidney failure on the body. [2]

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Tutor only

Students made a model of dialysis, shown in **Image 13.2**. After 20 minutes at 37 °C they tested the water around the Visking tubing. **Table 13.3** shows their results.

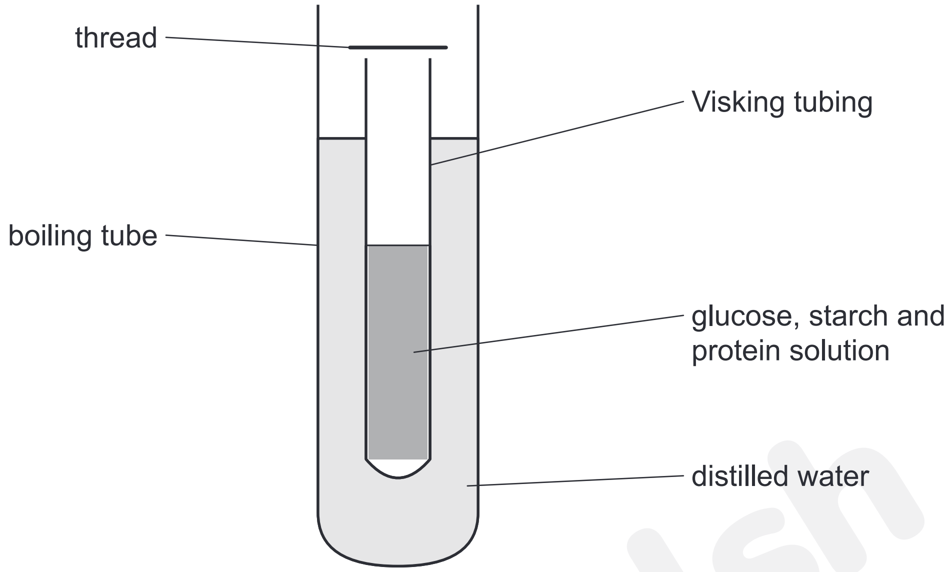

Image 13.2

Table 13.3

Test on the water	Result
Benedict's test (heated)	orange-red precipitate
iodine solution	stays yellow-brown
biuret test	stays blue

(b) Explain the results in **Table 13.3**. [2]

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(c) (i) In a second experiment the water around the tubing was replaced with fresh distilled water every 2 minutes. The mass of glucose that left the tubing in 20 minutes increased from 0.12 g to 0.33 g. Calculate how many times more glucose left the tubing when the water was replaced. [1]

Answer = ... times

Tutor only

(ii) Identify **two** variables that should have been kept the same in both experiments. [2]

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(iii) In a dialysis machine the blood and the dialysis fluid flow in opposite directions. Use the results of the second experiment to explain why this makes dialysis more efficient. [2]

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(d) Dialysis fluid contains glucose at the same concentration as normal blood plasma, but no urea. Explain why. [2]

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Tutor only

14. The relative medullary thickness is the thickness of the medulla compared with the overall size of the kidney. **Table 14.1** shows the relative medullary thickness and the maximum solute concentration of the urine for six mammals. The values are approximate and based on published data.

Table 14.1

Mammal	Relative medullary thickness	Maximum solute concentration of urine / mOsm kg^{-1}
beaver	1.3	520
pig	1.6	1100
human	3.0	1400
rat	5.8	2900
camel	7.9	2800
kangaroo rat	8.5	5500

(a) Plot a graph of the data in **Table 14.1** on the grid below. Draw a line of best fit. [4]

(b) Describe the relationship shown by your graph. [2]

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Tutor only

(c) A thicker medulla contains longer loops of Henle. Explain why longer loops of Henle allow more concentrated urine to be produced. [3]

Image 14.2 shows a kangaroo rat. It lives in the deserts of North America and may never drink water.

Image 14.2

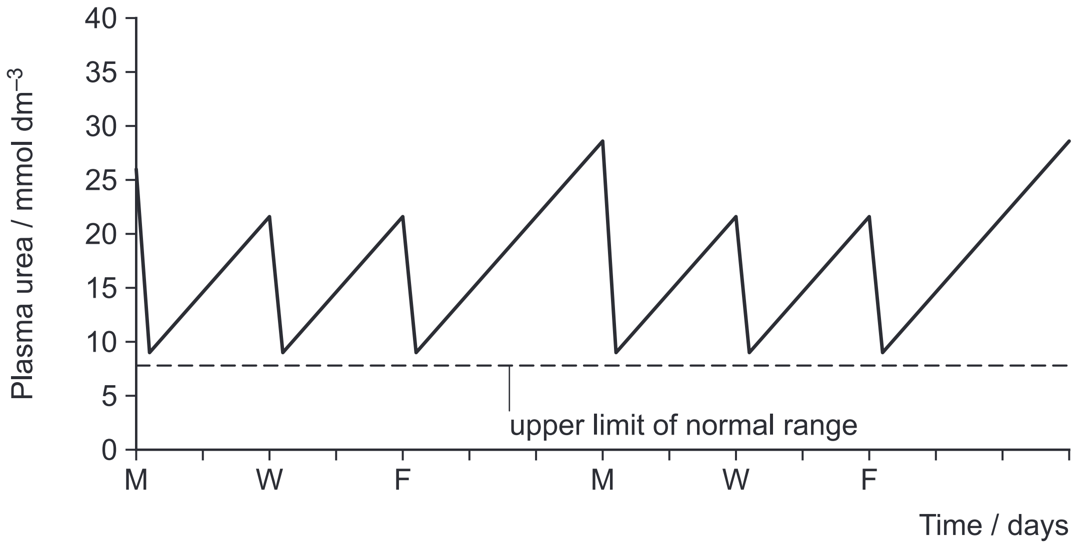
(d) Suggest **two** ways, other than having long loops of Henle, in which the kangaroo rat could reduce its water loss. [2]

11

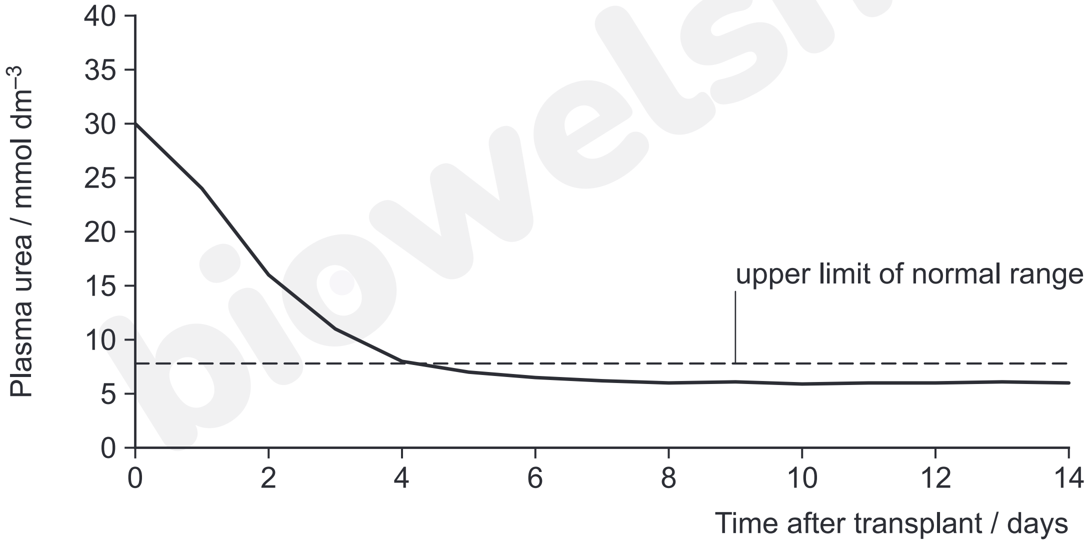
Turn over.

Tutor only

15. A patient has kidney failure. **Graph 15.1A** shows the concentration of urea in their plasma over two weeks of haemodialysis on Mondays (M), Wednesdays (W) and Fridays (F). **Graph 15.1B** shows the concentration of urea in their plasma after they received a kidney transplant.



Graph 15.1A



Graph 15.1B

Explain why kidney failure changes the composition of the blood and why these changes are harmful. Describe how haemodialysis removes urea and excess water from the blood. Use **Graphs 15.1A** and **15.1B** to compare the effectiveness of haemodialysis and a kidney transplant, and explain the problems of each treatment. [9 QER]

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Turn over.

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END OF WORKSHEET

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A Tutor Meets Tutee project

BioWelsh worksheets are written and checked by Tutor Meets Tutee tutors for WJEC A level Biology students.

Mark this worksheet with the BioWelsh mark scheme **BW-A2-3.7-W1** (MS).

Acknowledgements

Image 4.1: Photo: Jurfeld, CC BY 4.0 (Wikimedia Commons, 'Kidney of lamb 11'), https://creativecommons.org/licenses/by/4.0. Cropped to one half; letters and label lines added.

Image 5.1: Micrograph: OpenStax Anatomy and Physiology, CC BY 4.0 (Wikimedia Commons, '2616 Glomerulus'), https://creativecommons.org/licenses/by/4.0. Cropped to remove the original labels; letters and label lines added.

Image 13.1: Photo: Anna Frodesiak, CC0 (Wikimedia Commons, 'Dialysis - arm - 01'). Letter added.

Image 14.2: Photo: Merriam's kangaroo rat, United States Government, public domain (Wikimedia Commons).