HL Paper 2

a. Blood is a liquid tissue containing glucose, urea, plasma proteins and other components. List the other components of blood. [5]

b. Outline how the human body prevents blood glucose concentration from rising excessively. [5]

c. Blood plasma, glomerular filtrate and urine have different concentrations of solutes, such as glucose, protein and urea. Explain the processes occurring in the kidney that cause differences in the concentrations of these solutes between blood plasma, glomerular filtrate and urine. [8]

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a. Draw a labelled diagram of the heart showing the chambers, associated blood vessels and valves. [4]

b. Describe the processes involved in blood clotting. [6]

c. Discuss the benefits and risks associated with vaccination programmes. [8]

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a. Outline how antibiotic resistance in bacteria can arise in response to environmental change. [5]

b. Outline the principle of immunity. [6]

c. Discuss the benefits and dangers of vaccination. [7]

HIV was discovered in 1981 and is now one of the most serious causes of disease in the world. It causes the immune system to fail, leaving the patient vulnerable to other infections.

b. Outline how monoclonal antibodies are produced. [2]

c. Discuss how the HIV virus is transmitted. [2]

d. Explain why antibiotics are ineffective against viruses. [2]

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a. List the general functions of non-membrane proteins. [4]

b. Outline the digestion, absorption and assimilation of proteins in humans. [6]

c. Actin and myosin are two proteins found in muscles. Explain how skeletal muscle contracts, including the interaction of these proteins. [8]

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a. Outline what is meant by homeostasis. [4]

b. Describe how body temperature is maintained in humans. [6]

c. Explain the processes occurring in the kidney that contribute to osmoregulation. [8]

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a. Draw a labelled diagram of *Escherichia coli* as an example of a prokaryote. [4]

b. Explain the process of transcription in prokaryotes. [8]

c. Some prokaryotes cause infectious diseases which stimulate the body's immune system. Outline the principles that form the basis of immunity. [6]

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a. Describe the production of semen. [6]

b. Explain the structure and function of the placenta. [8]

c. Outline the hormonal control of birth. [4]

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a. Define the term *passive immunity*. [1]

b. State **one** use of monoclonal antibodies in diagnosis. [1]

c. Define the term *pathogen*. [1]

d. Outline why antibiotics are effective against bacteria but not against viruses. [2]

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b. Explain how skeletal muscle contracts. [8]

c. Active skeletal muscle requires a good supply of oxygen. Outline the mechanism of ventilation in the lungs. [6]

a. Outline the thermal, cohesive and solvent properties of water. [5]

c. Explain the role of the kidney in maintaining water balance in humans. [9]

Describe the role of ADH in human osmoregulation.

The human circulatory system is structured to serve the organs and tissues of the body efficiently.

a. Explain how circulation of the blood to the lungs and to other systems is separated in humans and what the advantages of this separation are. [8]

c. Distinguish between the composition of the blood of the renal artery and the blood of the renal vein. [3]

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a. Draw a labelled diagram of the adult female reproductive system. [4]

b. Outline the roles of progesterone and estrogen in the human menstrual cycle [6]

c. Explain the function and structure of the placenta. [8]

Defence occurs on the micro and macro levels.

a. Describe the functioning of immunoglobulins. [3]

b. Outline how antibiotics offer protection from certain forms of infectious disease. [4]

c. Coughing to clear the airways is accomplished by muscle contractions. Explain muscle contraction. [8]

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a. Outline how **three** properties of water enhance its use by living organisms. [6]

b. Describe the role of ADH in osmoregulation. [4]

c. Explain how water is moved from roots to leaves in terrestrial plants. [8]

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a. Draw a labelled diagram that shows the positions of proteins within the cell membrane. [3]

b. Outline the effects of putting plant tissue in a hypertonic solution. [4]

c. Explain how the structure of the nephron and its associated blood vessels enable the kidney to carry out its functions. [8]

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c. State the role of plasma cells in the immune system. [1]

d.i. Describe the production of hybridoma cells. [2]

d.ii. State **one** possible use of hybridoma cells. [1]

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a. Draw a labelled diagram of a mature sperm. [5]

b. Outline the formation of chiasmata during crossing over. [5]

c. Explain how an error in meiosis can lead to Down syndrome. [8]

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a. Outline the structure and functions of nucleosomes. [4]

b. Explain how DNA is used to pass on genetic information to offspring accurately but also produce variation in species. [8]

c. Accurate transmission of base sequences to offspring depends on successful gamete production. Describe how spermatogenesis occurs in humans. [6]

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a. Draw a labelled diagram to show the structure of a sarcomere. [5]

b. Explain how an impulse passes along the axon of a neuron. [8]

c. Describe the process of endocytosis. [5]

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a. Outline the role of the skin in temperature regulation. [5]

b. Outline the role of hormones in the process of birth in humans [4]

c. Explain the principles of vaccination. [9]

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a. Outline a possible cause of Down syndrome. [4]

b. Outline the processes involved in oogenesis within the human ovary. [8]

c. Discuss the ethical issues surrounding IVF. [6]

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a. Describe the process of fertilization in humans. [6]

b. Explain how the structure and function of the placenta helps to maintain pregnancy. [8]

c. Outline the hormonal control of the process of birth. [4]

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a. Draw a labelled diagram of the human heart showing the attached blood vessels. [6]

b. Describe the action of the heart in pumping blood. [5]

c. All parts of the body change the composition of the blood. Explain how the nephron changes the composition of blood. [7]

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a. Outline the process of glycolysis. [5]

b. Describe how pancreatic cells directly affect blood glucose levels. [5]

c. Explain why diabetes could be detected through the analysis of urine. [8]

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a. Draw a labelled diagram to show the structure of a sarcomere. [4]

b. Outline how skeletal muscle contracts. [5]

c. Explain how nerve impulses are transmitted along and between neurons. [9]

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a. Draw a labelled diagram of a mature human egg. [5]

b. Outline a technique used for gene transfer. [5]

c. Explain how evolution may happen in response to environmental change with evidence from examples. [8]

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a. Draw a labelled diagram of a mature sperm cell. [4]

b. Outline the role of hormones in the menstrual cycle. [6]

c. Discuss the cause, transmission and social implications of AIDS. [8]

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a. Water is essential to life on Earth. Outline **two** properties of water that are important for living organisms. [4]

c. Explain the roles of the structures in the kidney that maintain the water balance of the blood in humans. [8]

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a. Draw a labelled diagram of the digestive system. [4]

b. Many people cannot digest lactose and benefit from a diet containing no lactose. Outline the production of lactose-free milk. [6]

c. Explain how the kidney helps to retain useful substances in the blood and eliminate substances which the body does not need. [8]

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a. Describe **four** different types of transport of substances across a membrane. [4]

b. Hormones such as FSH (follicle stimulating hormone) and LH (luteinizing hormone) affect the development of certain cells by binding to receptors in the plasma membranes. Outline the role of FSH and LH in the menstrual cycle. [6]

c. In the placenta, many substances are transported across membranes. Explain the structure and role of the placenta. [8]

a. Outline how reproductive isolation can occur in an animal population. [3]

b. Describe the different cell types in the seminiferous tubules that are involved in the process of spermatogenesis. [4]

c. Explain the roles of specific hormones in the menstrual cycle, including positive and negative feedback mechanisms. [8]

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b. Outline the process of spermatogenesis in humans. [5]

c. Explain the structure and function of the placenta during pregnancy. [9]

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a. Draw a labelled diagram to show the structure of the heart. [5]

b. Outline how the human body responds to high blood glucose levels. [5]

c. Explain the role of the nephron in maintaining the water balance of the blood in the human body. [8]

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a. Draw a labelled diagram of a prokaryotic cell. [4]

b. Outline transcription in prokaryotes. [6]

c. Some prokaryotes cause infectious disease in humans. Explain the principles of vaccination. [8]

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a. Nitrogen is part of many important substances in living organisms. [3]

Draw labelled diagrams to show a condensation reaction between two amino acids.

b. Nitrogen is part of many important substances in living organisms. [4]

Distinguish between transcription and translation.

c. Nitrogen is part of many important substances in living organisms. [8]

Explain how insects excrete nitrogenous wastes.

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a. Outline pollination, fertilization and seed dispersal. [4]

b. Compare the processes of spermatogenesis and oogenesis. [8]

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a. Draw a labelled diagram of the human adult male reproductive system. [5]

b. Compare the processes of spermatogenesis and oogenesis [8]

c. Describe the consequences of the potential overproduction of offspring. [5]

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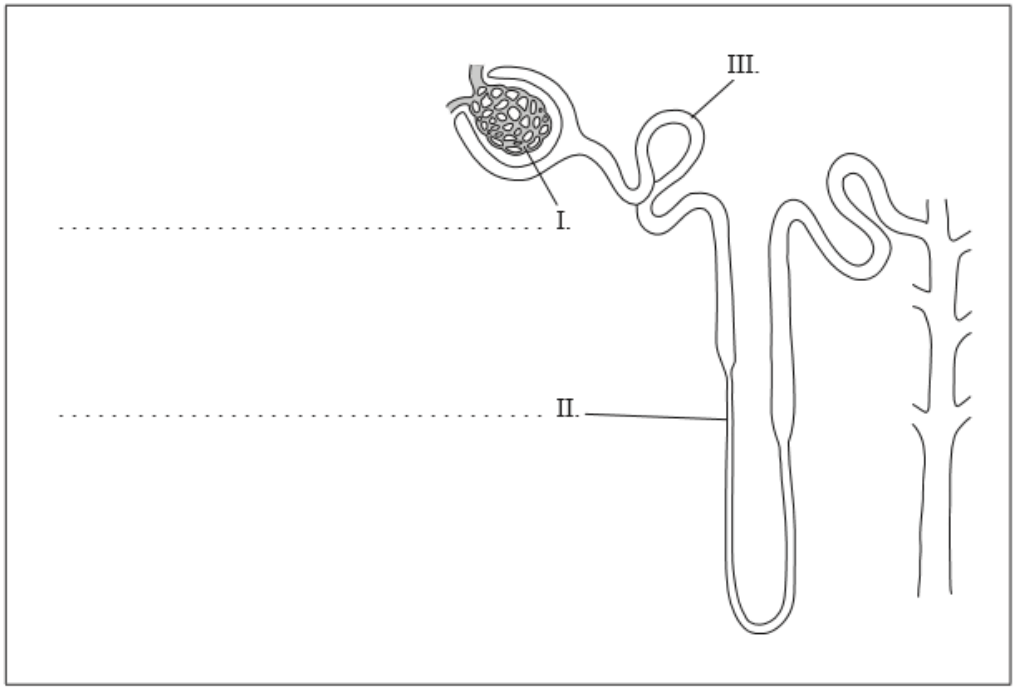
a. Draw molecular diagrams to show the condensation reaction between two amino acids to form a dipeptide. [4]

b. Outline the roles of the different binding sites for tRNA on ribosomes during translation. [4]

c. Explain the production of antibodies. [7]

The diagram shows the structure of a nephron.



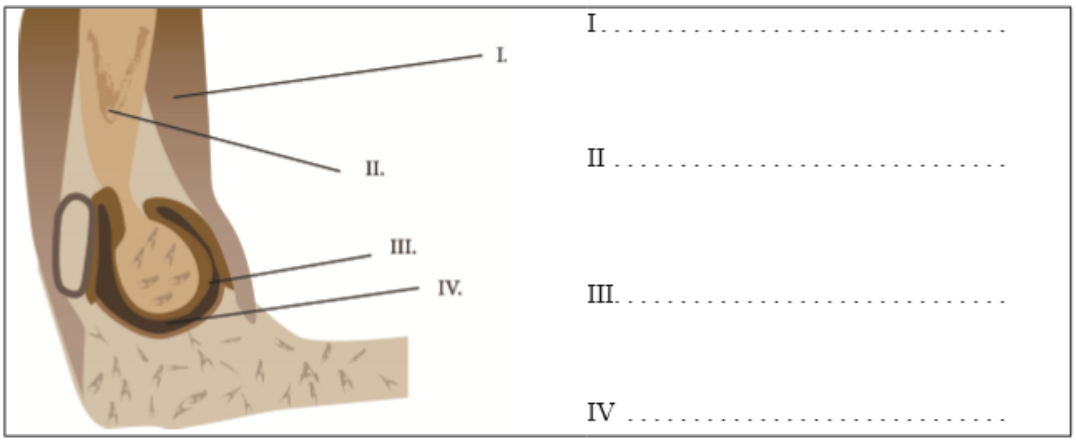
a (i) Label I and II. [1]

a (ii) Outline the function of III. [1]

b. Estimate the content of glomerular filtrate and urine of a healthy person by completing the following table. [2]

	Plasma proteins / mg 100 ml^{-1}	**Glucose / mg 100 ml^{-1}**	**Urea / mg 100 ml^{-1}**
Blood plasma in renal artery	740	90	30
Glomerular filtrate		90	
Urine			

c. Explain the role of the medulla and the collecting duct of the kidney in the maintenance of the water balance in blood. [3]



a. Label I, II, III and IV on the diagram of the human elbow. [2]

b. Outline the functions of I and III. [2]

I. .....
III. .....

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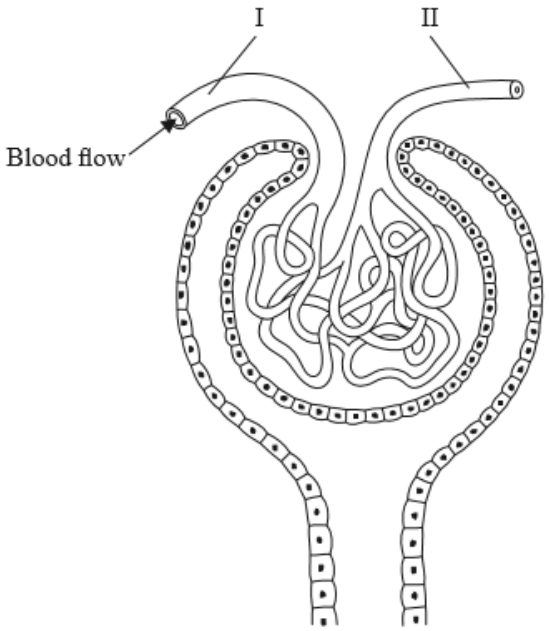
b. Explain the process of ultrafiltration. [2]

c. The diagram below shows part of the human kidney. The arrow shows the direction of blood flow. [2]



Compare the composition of the fluids found in the regions labelled I and II by giving **one** difference and **one** similarity.

Difference: .....
Similarity: .....

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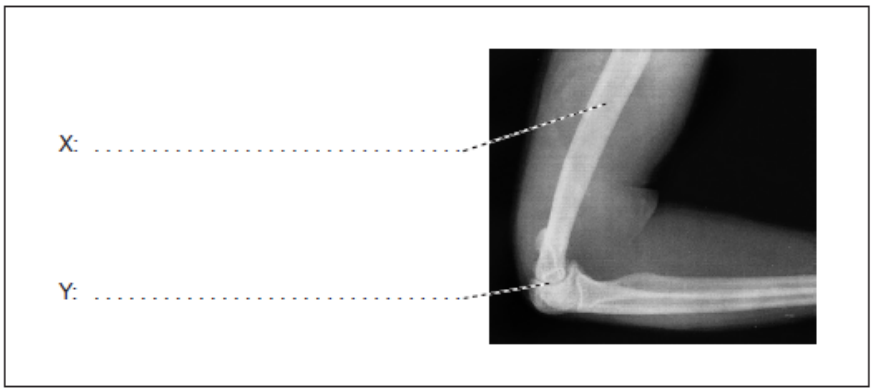
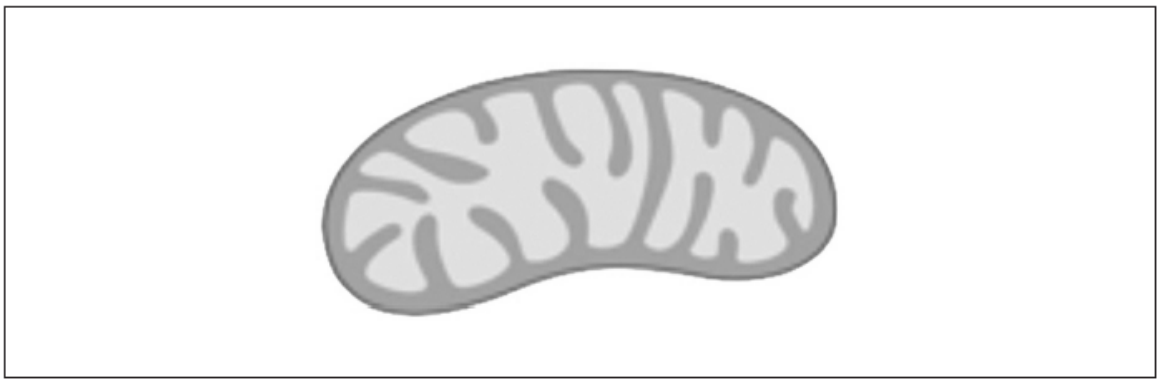
a(i). Label the structures indicated on the X-ray of a human elbow. [2]



b. Explain the role of calcium in muscle contraction. [3]

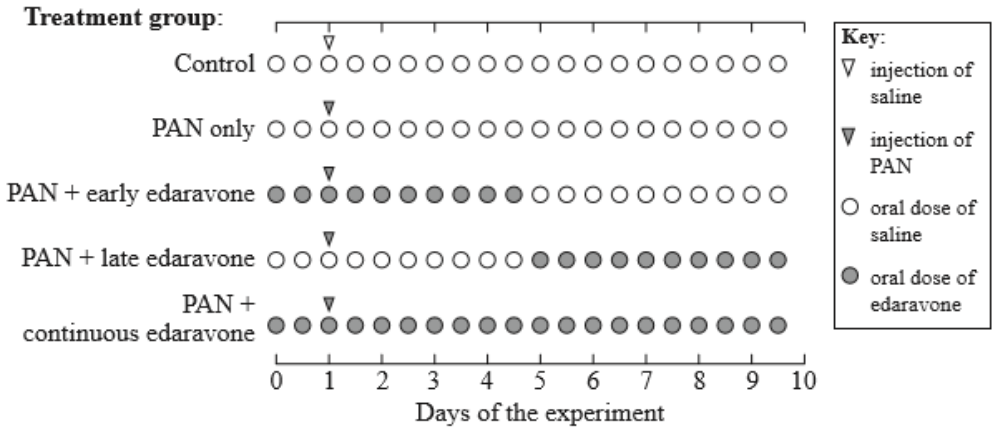
c(i). One of the stages of aerobic respiration is called the link reaction. [1]

Label the diagram to indicate where the link reaction occurs.



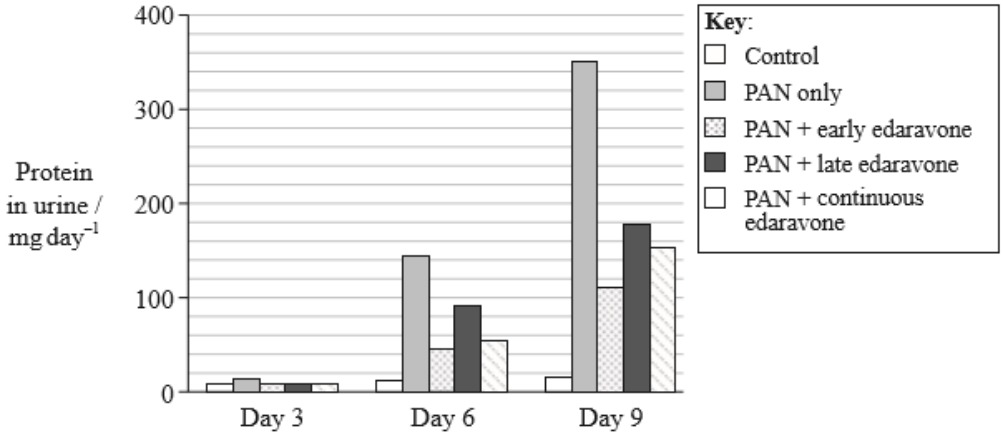
c(ii). Outline the role of coenzyme A in aerobic respiration. [2]

Medical scientists investigated the development of nephrotic syndrome, a kidney disease that results in the abnormal presence of protein in the urine. This symptom of the disease can also be caused by injecting puromycin aminonucleoside (PAN) into rats. The drug edaravone, a proposed treatment for the disease, was studied. The experimental timetable for the different treatment groups is summarized below. Edaravone was given by mouth (oral dose). Saline is a solution with the same concentration of solutes as blood plasma.



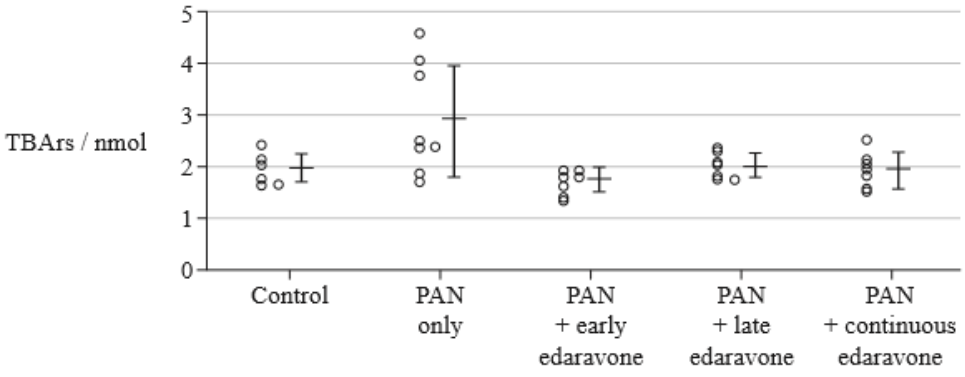
[Source: H Matsumura, *et al.*, (2006), *Clinical Nephrology*, **66** (6), pages 405–410]

The graph below shows the levels of protein found in the urine of the rats on day 3, day 6 and day 9 of the experiment.



[Source: H Matsumura, *et al.*, (2006), *Clinical Nephrology*, **66** (6), pages 405–410]

Oxidation reactions can cause damage to cells. Thiobarbituric acid reactive substances (TBArs) are produced when membrane lipids are damaged by oxidation. Experiments were carried out to investigate the effect of edaravone on the production of TBArs.



[Source: H Matsumura, *et al.*, (2006), *Clinical Nephrology*, **66** (6), pages 405–410]

a. State when PAN was injected into the rats. [1]

b. Outline the treatment given to the control group. [2]

c. Distinguish between the treatment received by the PAN only group and the PAN + early edaravone group. [1]

d. State the increase in protein in the urine of rats treated with PAN only between day 6 and day 9. [1]

e. Compare the levels of protein during the experiment in the urine of rats treated using PAN only with those treated using PAN + early edaravone. [3]

f. Evaluate whether the results support the hypothesis that a continuous dose of edaravone is better than the same drug administered over shorter periods. [3]

g. Analyse the results of this experiment. [3]

h. Suggest why oxidation of membrane lipids may lead to increased protein loss in the urine. [3]

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a. Cell biologists play an important role in research into disease, fertility, evolution and many other areas of science. [4]

Describe the origin of eukaryotic cells according to the endosymbiotic theory.

b. Cell biologists play an important role in research into disease, fertility, evolution and many other areas of science. [8]

Compare and contrast the processes of spermatogenesis and oogenesis.

c. Cell biologists play an important role in research into disease, fertility, evolution and many other areas of science. [3]

Outline the evidence for evolution provided by selective breeding.

The Chinese soft-shelled turtle, *Pelodiscus sinensis*, lives in salt water marshes. The turtle can live under water and out of water.

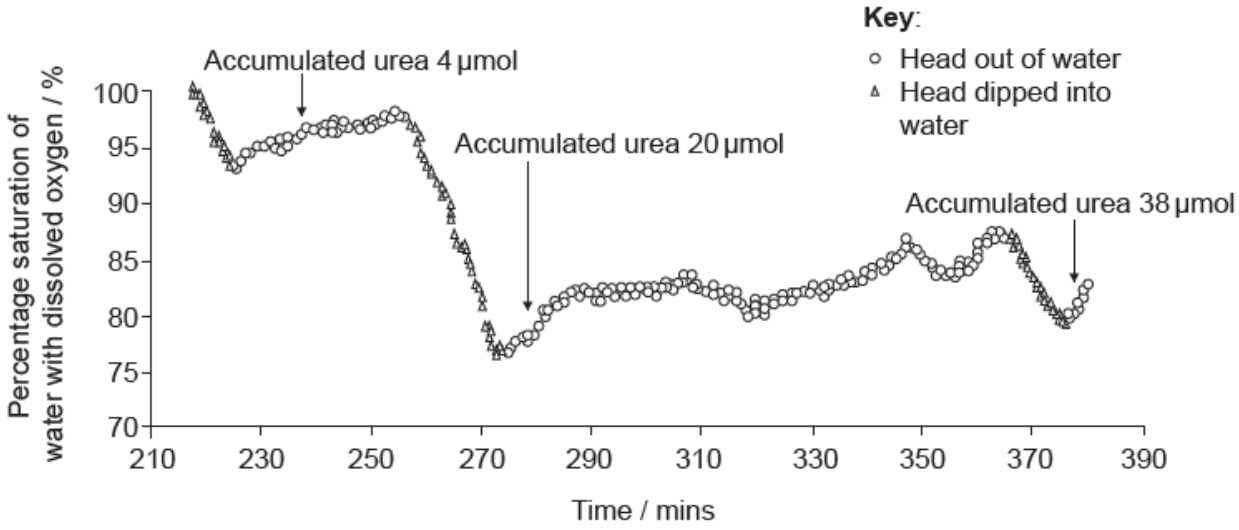
These turtles have fully developed lungs and kidneys, however, many microvilli have been discovered in the mouth of *P. sinensis*. A study was undertaken to test the hypothesis that oxygen uptake and urea excretion can simultaneously occur in the mouth.

Initial experiments involved collecting nitrogen excretion data from *P. sinensis*. The turtle urinates both in water and out of water. When in water it allows waste products to be washed out of its mouth. When out of water it regularly dips its head into shallow water to wash its mouth. The table shows the mean rates of ammonia and urea excretion from the mouth and kidney over six days.

	Excretion of nitrogen by the mouth / μmol day^{-1} g^{-1} turtle		Excretion of nitrogen by the kidney / μmol day^{-1} g^{-1} turtle	
	Turtle submerged in water	Turtle out of water	Turtle submerged in water	Turtle out of water
Ammonia	0.29	0.30	0.63	0.54
Urea	0.90	1.56	0.07	0.73

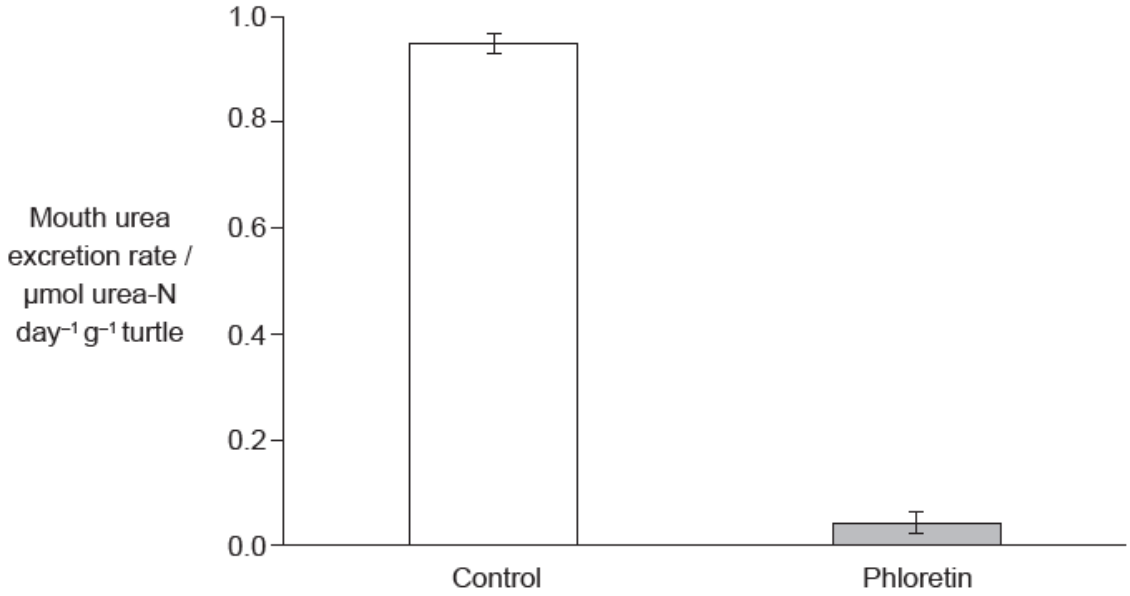
[Source: Reproduced with permission, Y. Ip *et al*. (2012) *The Journal of Experimental Biology*, 215, pages 3723—3733. jeb.biologists.org. doi: 10.1242/jeb.068916]

It was noted that during long periods out of water, turtles rhythmically moved their mouths to take in water from a shallow source and then discharge it. Changes in the dissolved oxygen and the quantity of accumulated urea in the rinse water discharged by the turtles were monitored over time as shown in this graph.



[Source: adapted with permission from Y. Ip *et al*. (2012) *The Journal of Experimental Biology*, 215, pages 3723–3733.]

In order to test whether a urea transporter was present in the mouth tissues of the turtles, phloretin (a known inhibitor of membrane proteins that transport urea) was added to the water in which a further set of turtles submerged their heads. The results of that treatment are shown.

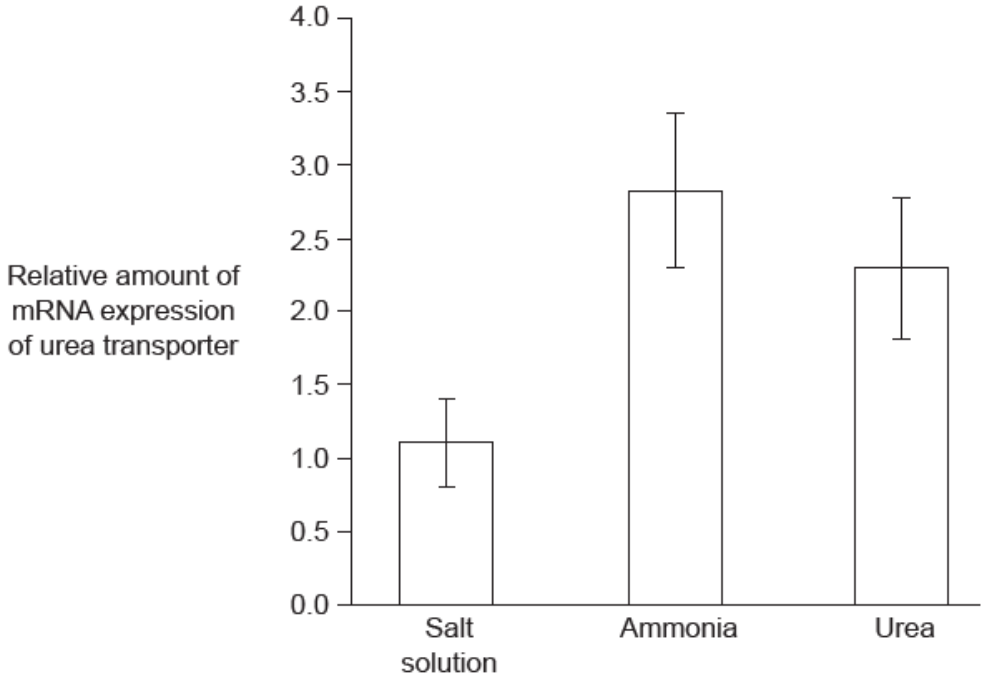


[Source: Reproduced with permission from Y. Ip *et al*. (2012) *The Journal of Experimental Biology*, 215, pages 3723–3733. jeb.biologists.org.]

Further research was conducted to determine where mRNA expression of a urea transporter gene might be occurring in *P. sinensis*. Gel electrophoresis was used to analyse different tissue samples for mRNA activity.

[Source: Reproduced with permission from Y. Ip *et al.* (2012) *The Journal of Experimental Biology*, 215, pages 3723–3733. jeb.biologists.org.]

Expression of the urea transporter gene by cells in the turtle's mouth was assessed by measuring mRNA activity. Turtles were kept out of water for 24 hours and then injected with either a salt solution that matched the salt concentration of the turtle, dissolved ammonia or urea, followed by another 24 hours out of water.



[Source: © International Baccalaureate Organization 2017]

a. Deduce whether the excretion of ammonia or urea changes more when a turtle emerges from water. [2]

b. Compare and contrast the changes in urea excretion in the mouth with the changes in urea excretion in the kidney when a turtle emerges from the water. [3]

c.i. Describe the trends shown by the graph for dissolved oxygen in water discharged from the mouth. [1]

c.ii. Suggest reasons for these trends in dissolved oxygen. [2]

d. Deduce with a reason whether a urea transporter is present in the mouth of *P. sinensis*. [2]

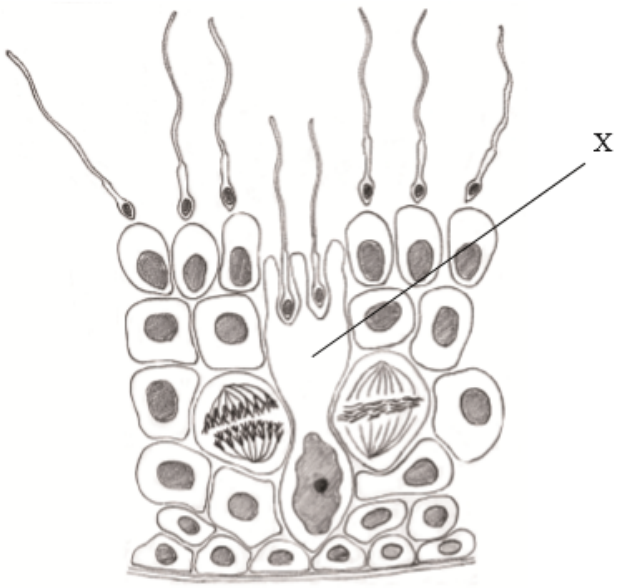
e. Outline the additional evidence provided by the gel electrophoresis results shown above. [2]

f.i. Identify which of these turtle groups represent the control, giving a reason for your answer. [1]

f.ii. Suggest a reason for the greater expression of the gene for the urea transporter after an injection with dissolved ammonia than an injection of urea. [2]

g. The salt marshes where these turtles live periodically dry up to small pools. Discuss the problems that this will cause for nitrogen excretion in the turtles and how their behaviour might overcome the problems. [3]

The diagram below shows a small portion of the tissue in a transverse section of a testis.



a. Outline the process of *in vitro* fertilization (IVF). [3]

b (i). Identify the cell labelled X. [1]

b (ii). Outline the function of this cell. [1]

c. Explain how meiosis results in genetic variation in gametes. [2]
