Surname	Centre Number	Candidate Number
Other Names		2

GCE A LEVEL

A400U30-1

S19-A400U30-1

BIOLOGY – A level component 3
Requirements for Life

MONDAY, 17 JUNE 2019 – MORNING

2 hours

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1.**	**12**	
	2.	**8**	
	3.	**9**	
	4.	**9**	
	5.	**18**	
	6.	**15**	
	7.	**9**	
Section B	**Option**	**20**	
	Total	**100**	

A400U301
01

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

This paper is in 2 sections, **A** and **B**.

Section A: 80 marks. Answer **all** questions. You are advised to spend about 1 hour 35 minutes on this section.

Section B: Options; 20 marks. Answer **one option only**. You are advised to spend about 25 minutes on this section.

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **7**.

The quality of written communication will affect the awarding of marks.

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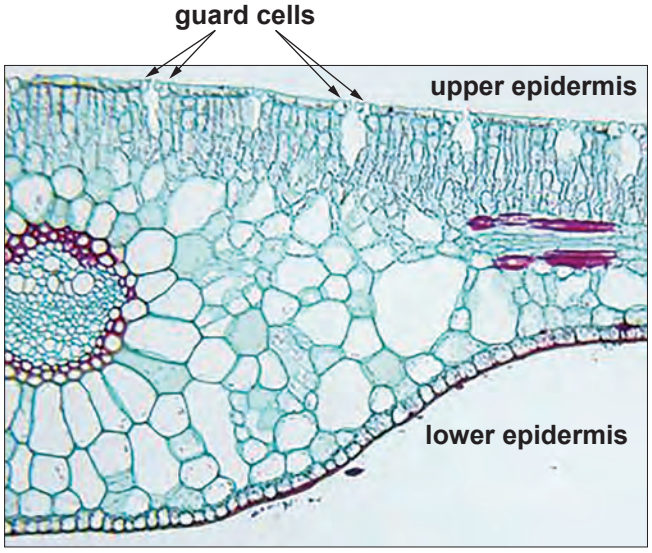
SECTION A

Answer **all** *questions.*

1. For plants to photosynthesise effectively they need to obtain certain resources. Leaves are the main sites of gas exchange and photosynthesis in plants. They are adapted to these main functions in several ways. Figure 1.1 is a photomicrograph showing a transverse section through a leaf.

Figure 1.1



(a) (i) **Label figure 1.1** using the letters **A** and **B** to show the position of the following:

A the main tissue responsible for photosynthesis [1]

B the tissue that transports water to the leaf tissues [1]

(ii) Conclude whether the leaf shown in figure 1.1 is from a hydrophyte or a xerophyte. Identify **two** adaptations that support your conclusion. [3]

Type of plant: .....

Adaptation 1: .....

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Adaptation 2: .....

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(iii) Explain why leaves and chloroplasts change their orientation during the day. [1]

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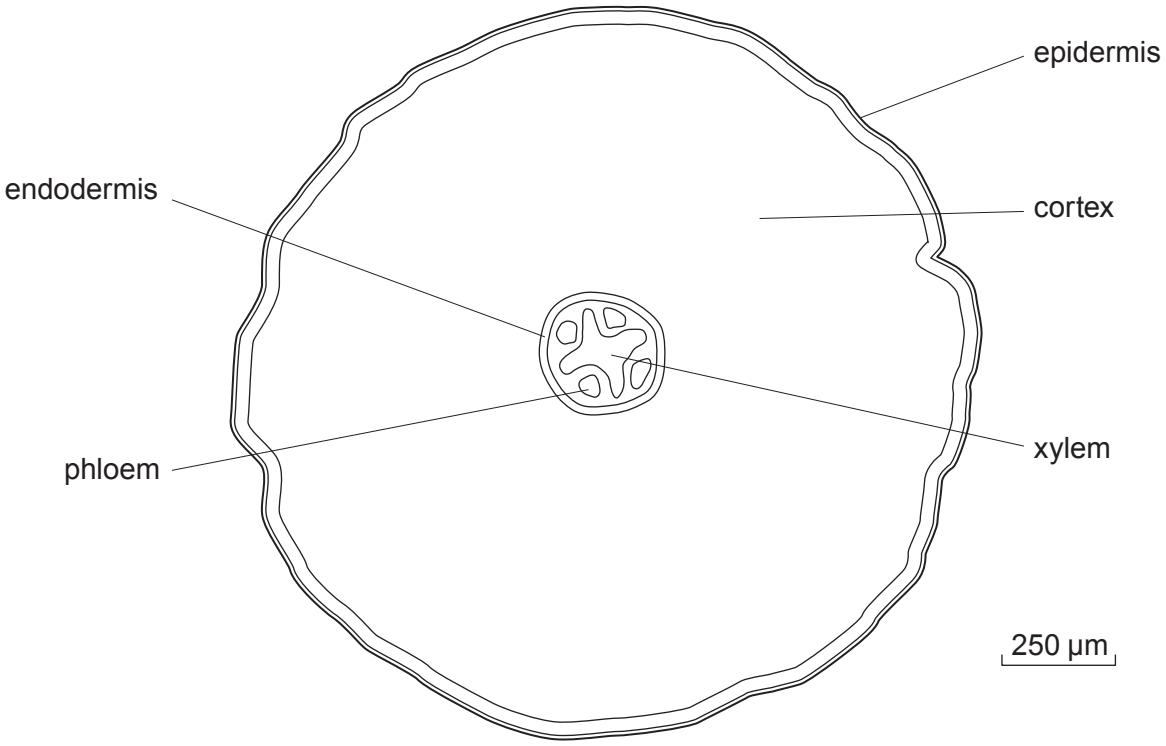
(b) Roots are the main site of water and mineral uptake. Figure 1.2 shows a low power plan of the structure of a root of a buttercup, *Ranunculus*, a dicotyledonous plant.

Figure 1.2



(i) **Using only the scale bar**, calculate the magnification of the image in figure 1.2. [2]

Magnification = × .....

(ii) Water and minerals can follow several paths from the soil to the xylem. These are the apoplast, symplast and vacuolar pathways. Both the symplast and vacuolar routes involve water crossing cell membranes. Explain why the vacuolar route is slower than the symplast pathway. [2]

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A400U301
03

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(c) In the stem of a buttercup, vascular tissues are organised into bundles.

(i) Describe how the arrangement of the vascular tissues in a stem of a buttercup is different from their arrangement in the root. [1]

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(ii) Xylem vessels and phloem sieve tubes are strengthened by different chemicals found in their cell walls. Name these chemicals. [1]

xylem .....

phloem .....

12

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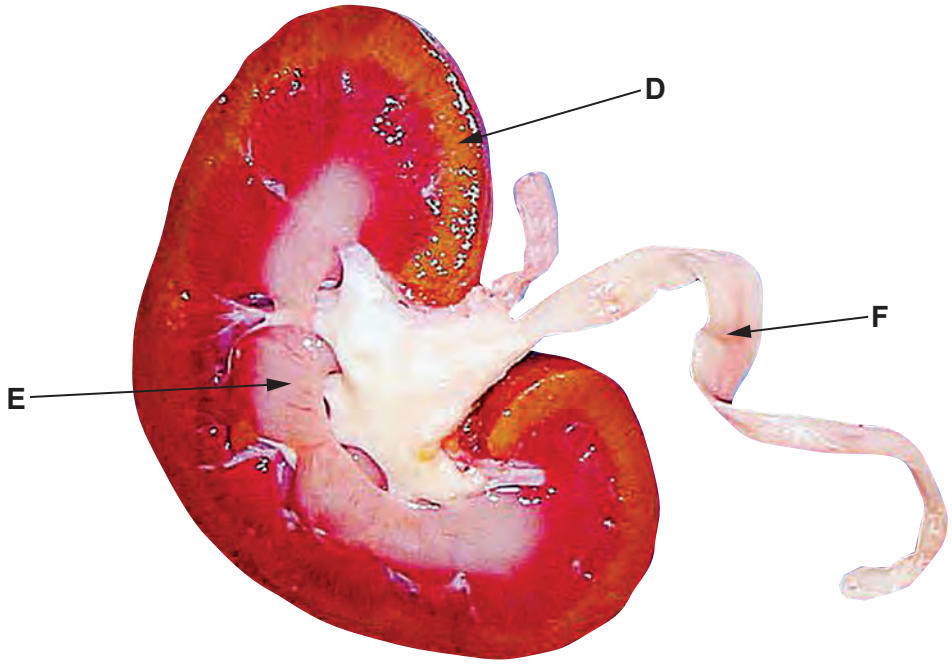
2. Osmoregulation and urine formation in mammals is carried out by the nephrons. During this process, many small soluble molecules and ions are initially forced out of the blood by **ultrafiltration** in the glomerulus followed by **selective reabsorption** in the proximal convoluted tubule. The remaining filtrate is concentrated in the loop of Henle and collecting duct to produce urine.

Figure 2.1 shows a section through a mammalian kidney.

Figure 2.1



(a) (i) Name the parts of the kidney labelled **D**, **E** and **F** on figure 2.1. [1]

D .....

E .....

F .....

(ii) Using letters **D**, **E** or **F** from figure 2.1, identify the part of the kidney in which each of the following processes takes place: [1]

ultrafiltration .....

selective reabsorption .....

A400U301
05

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(b) Figure 2.2 shows a section through a proximal convoluted tubule of a mammal.

Figure 2.2

(i) Identify the structures labelled **X** on figure 2.2 and explain how they are involved in selective reabsorption by the proximal convoluted tubules. [2]

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(ii) Explain how the capillaries increase the rate of selective reabsorption. [1]

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Examiner only

(c) Alport's Syndrome is an inherited condition which causes the thickening of the basement membrane of the glomerulus. This can lead to the retention of fluid in the blood, reduced urine volume and very high blood pressure.

There are two forms of the disease caused by different alleles:

Type 1 X-linked, dominant

Type 2 autosomal, recessive

A couple, both unaffected by Alport's Syndrome, had a child with Alport's Syndrome. Conclude which type of Alport's Syndrome the child inherited. Explain your answer. [3]

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A400U301
07

8

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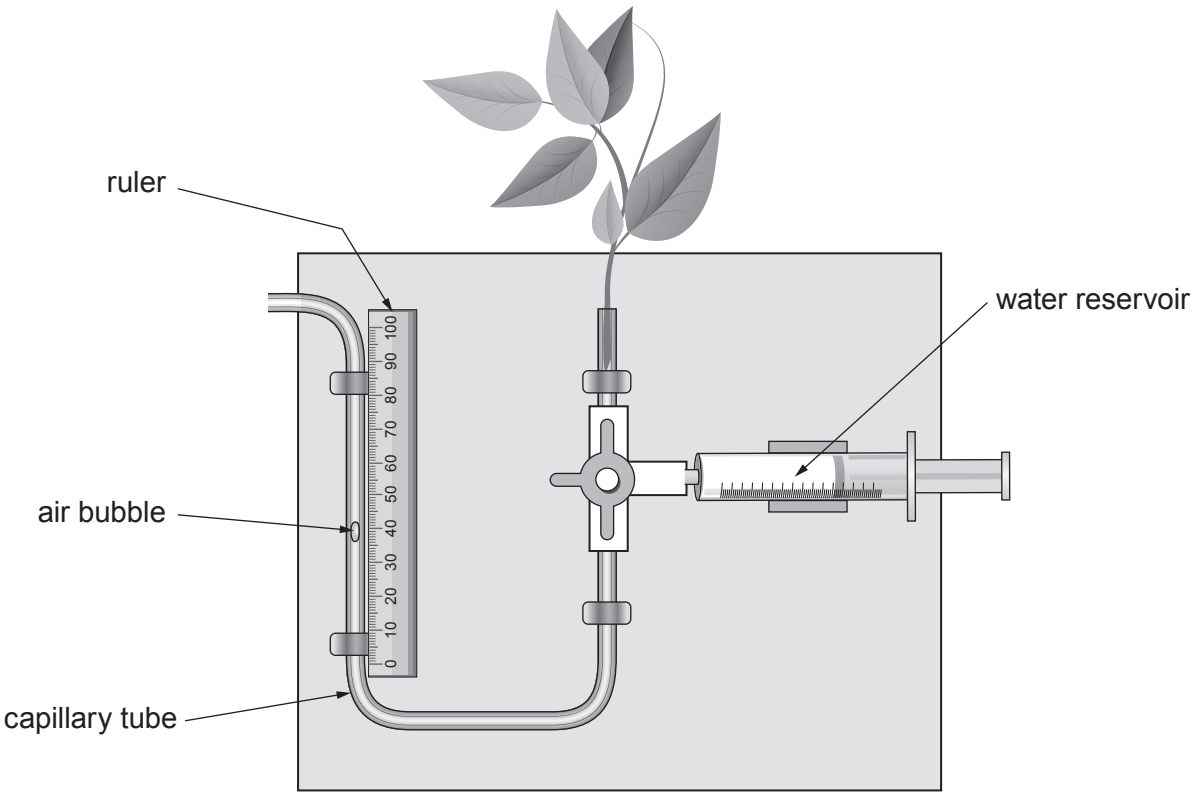
3. The rate of water uptake by a plant shoot can be measured in the laboratory using a potometer. Students set up a potometer as shown in figure 3.1.

Figure 3.1



The students investigated the effect of light intensity on the rate of water uptake by shining a light onto the shoot. They changed the light intensity by placing a lamp at different distances from the shoot.

(a) (i) The diameter of the capillary tube was measured as 1 mm. State **three** *other* measurements they would need to take in order to calculate the rate of water uptake in $mm^3\ cm^{-2}\ minute^{-1}$ at each light intensity. [2]

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(ii) Describe the purpose of the water reservoir in this apparatus. [1]

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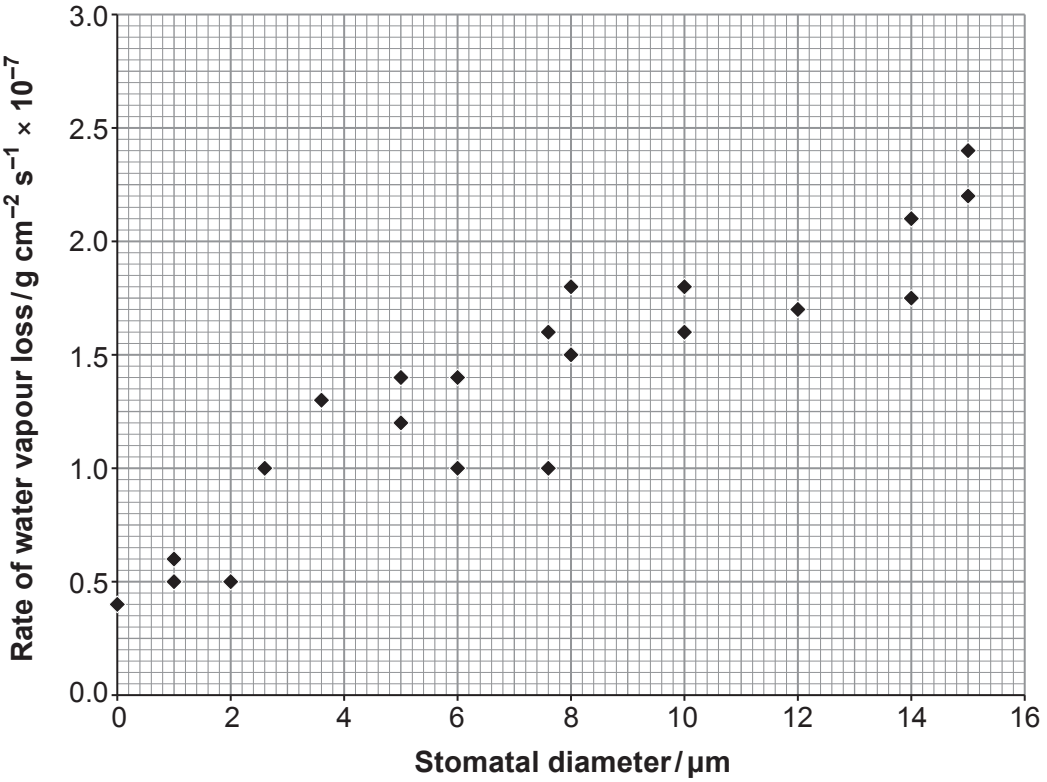
Examiner only

(b) A potometer measures water uptake but a **porometer** can measure actual water loss from the stomata of a leaf by measuring changes in humidity on the surface of a leaf.

An experiment was conducted to investigate how the diameter of stomata affected the rate of water loss from a leaf. Figure 3.2 shows the results of the experiment.

Figure 3.2



Analysis of the data showed that the line of best fit for these data followed the equation

$$y = mx + c$$

where m = gradient of the line

c = the intercept on the y axis

(i) Calculate the value of y when x = 10, m = 0.11 and c = 0.6. [1]

y = ... g cm^{-2} s^{-1} × 10^{-7}

(ii) Using the values provided and your calculated value of y **draw the line of best fit** for these data. [2]

(iii) Explain why there was still water loss when the stomatal diameter was zero. [1]

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A400U301
09

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(c) Stomata have been observed to close at high wind speeds.

(i) Predict what would happen to the rate of water loss from a plant when exposed to a high air speed. [1]

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(ii) Explain the advantage to the plant of closing stomata at high wind speeds. [1]

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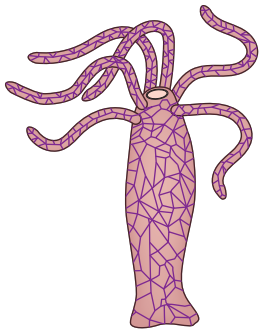
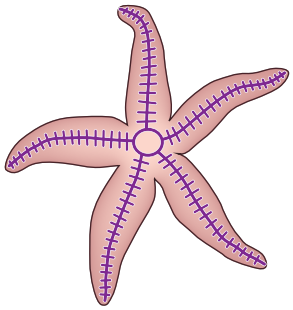
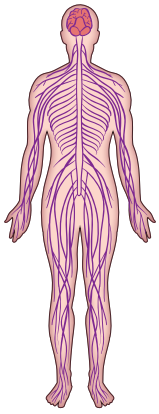
Examiner only

4. All animals have a degree of nervous coordination. During evolution, the nervous systems of animals have become organised in different ways as shown in figure 4.1 below.

Figure 4.1







Cnidaria – e.g. *Hydra*
- neurones arranged in a simple nerve net
- all neurones carry impulses in both directions

Starfish
- nerve ring around the mouth which acts as a co-ordinator
- neurones branch from the nerve ring and carry impulses in one direction only
- some carry impulses from mouth to arm, others carry from arm to mouth
- the neurones connect to a nerve net in each arm which carry impulses in both directions

Vertebrate
- neurones organised into a central nervous system with paired nerves
- all neurones carry impulses in one direction only

A400U301
11

(a) (i) Name the part of the vertebrate nervous system that carries impulses to and from the central nervous system. [1]

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Sensory receptors in *Hydra* are located across the whole body surface and the organism responds relatively slowly to stimuli.

In vertebrates, several sense organs are located in the head and they can respond quickly to many different stimuli with highly co-ordinated movements.

Starfish have many sensory receptors on the underside of their arms and around the mouth.

(ii) Using the information given, suggest why starfish have more co-ordinated movements than *Hydra* but they only move slowly. [3]

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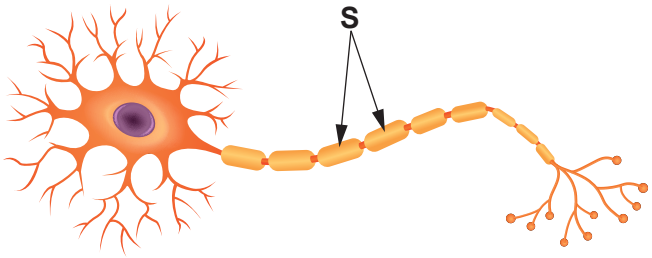
Examiner only

(b) Figure 4.2 shows the structure of a typical vertebrate motor neurone.

Figure 4.2



(i) Structures have evolved to ensure that action potentials are only transmitted in one direction.

Label Figure 4.2 using label lines with letters **P**, **Q** and **R** to show where you would expect to find the following: [2]

P Ca^{2+} ion channels

Q receptors for neurotransmitters

R synaptic vesicles

(ii) Explain how the structures labelled **S** increase the rate of transmission of an action potential. [3]

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Examiner only

5. Large organisms have evolved mechanisms to ventilate their gas exchange surfaces. Different mechanisms have evolved in bony fish and mammals.

(a) (i) Explain how each of the stages stated below enables a bony fish to ventilate its gills. [3]

I. mouth opens and floor of buccal cavity lowered

.....

II. mouth closes and floor of buccal cavity raised

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III. operculum opens

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(ii) Explain how in a mammal, the ribcage, diaphragm and pleural membranes are involved in lowering the pressure in the alveoli to below atmospheric pressure during inhalation. [3]

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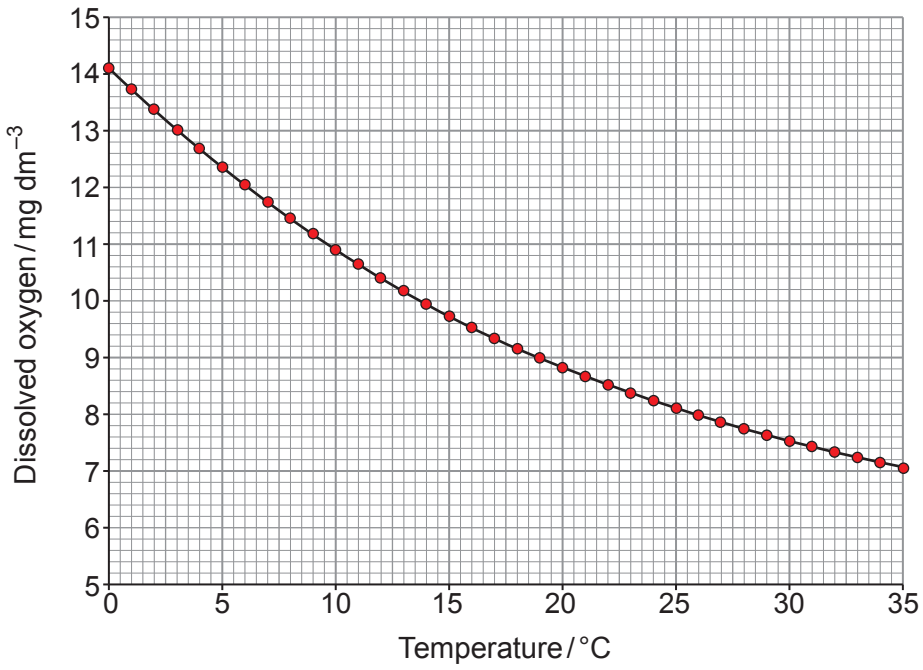
The Brown bullhead catfish *(Ameiurus nebulosus)* is a bony fish which lives in ponds in North America. Water temperatures can vary from about 2 °C to 30 °C. They are relatively slow moving fish that feed mostly at the bottom of the ponds. During the summer, the catfish come to the surface and gulp air. During the winter, ice forms over the surface and the fish become almost inactive.

Figure 5.1 below shows how the oxygen concentration of fresh water changes with temperature.

Figure 5.1



The rate of ventilation in bony fish can be measured by counting the opening and closing of the operculum during a certain period of time. An investigation was carried out to test the following hypothesis:

'the higher the temperature, the higher the ventilation rate'

In this investigation, catfish were used that had been living in tanks for two years.

- The temperature was changed using warm water or crushed ice made from water taken from the tanks.
- The number of times the operculum opened was counted per minute for four male catfish of the same age and approximate length.
- In each experiment the catfish were kept at the experimental temperature for 5 minutes before counting the opening of the operculum.
- During the experiment the catfish were prevented from going to the surface.

Examiner only

(b) (i) Identify the following variables for this experiment: [2]

independent variable: .....

dependent variable: .....

(ii) Explain why:

I. the warm water and crushed ice were made using water from the tanks; [1]

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II. the catfish were kept at the experimental temperature for five minutes before counting the number of times the operculum opened. [1]

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Examiner only

(c) The results of the experiment are shown in figure 5.2.

Figure 5.2

Mean water temperature / °C	Number of times the operculum opened per minute				
	Fish 1	Fish 2	Fish 3	Fish 4	Mean
28	46	44	40	42	43
24	36	40	34	36	37
19	28	30	33	27	30
16	26	20	22	19	22
14	**23**	14	19	17	17
9	14	8	8	9	10

(i) It was decided that the observation for Fish 1 at 14 °C (in **bold**) was anomalous and was not included in the calculation of the mean at this temperature.
With reference to the data, explain why this was **not** a valid decision. [2]

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(ii) Using all the information provided, explain why the ventilation rate increased as temperature increased and why these fish are known to gulp air during the summer. [4]

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Examiner only

(iii) The welfare of animals must be considered when using them in any experiment.

Suggest why the choice of temperatures used in the experiment was not a cause for concern but the decision to prevent the fish from going to the surface could have caused distress to the animals. [2]

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A400U301
17

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6. Current classification places nearly all nucleated, unicellular organisms, such as *Amoeba*, in the kingdom Protoctista. The size of these organisms is limited by their surface area to volume ratio. *Paramecium* is one of the largest protoctista – some species are visible to the naked eye. All species of *Paramecium* are active predators, hunting and ingesting other micro-organisms such as yeast, bacteria and other protoctista.

(a) Apart from the presence of a nucleus, state **two** *other* similarities between *Paramecium* and yeast that place them in the same domain as animal cells. [1]

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(b) Figure 6.1 is a photomicrograph showing an individual *Paramecium*.

Figure 6.1

The organism shown in the image is approximately cylindrical and has the following dimensions:

length	300 µm
average diameter	40 µm
approximate surface area	40 200 μm^2
approximate volume	377 000 μm^3

(i) Calculate the surface area to volume ratio for this organism. **Give your answer to one decimal place.** [2]

Surface area to volume ratio = ... : 1

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(ii) A spherical organism of the same volume would have a surface area of approximately 25 230 μm^2 and a diameter of approximately 90 μm.
Explain why it would be difficult for *Paramecium* to be highly active if it was spherical rather than cylindrical in shape. [2]

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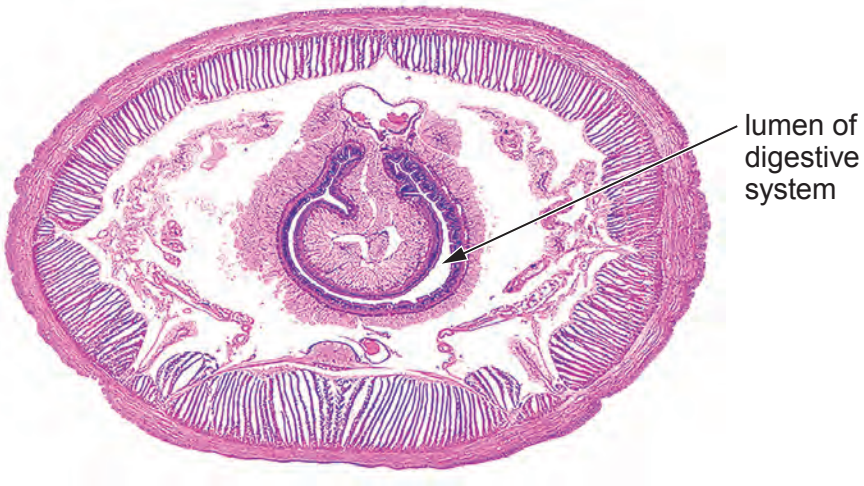
(c) Earthworms are multicellular organisms that rely on their external body surface for gas exchange.

Figure 6.2 shows a cross-section of an earthworm at a magnification of ×40.

Figure 6.2



(i) Earthworms rely on glucose as their main respiratory substrate and can respire glucose both aerobically and anaerobically.

State the maximum yield of ATP from one molecule of glucose under the following conditions. [2]

aerobic .....

anaerobic .....

(ii) To increase the efficiency of glucose transport to their tissues, earthworms have evolved a closed circulatory system. Explain why this is more efficient than the open circulatory system found in insects. [2]

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A400U301
19

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(d) Lugworms are related to earthworms but live in muddy sand on the seashore where oxygen levels are very low. Like earthworms, they use haemoglobin to transport oxygen from their gas exchange surfaces to their tissues. However, their haemoglobin has an oxygen affinity far higher than that of earthworms.

Explain why a very high oxygen affinity can be both an advantage and a disadvantage to lugworms. [2]

Advantage .....

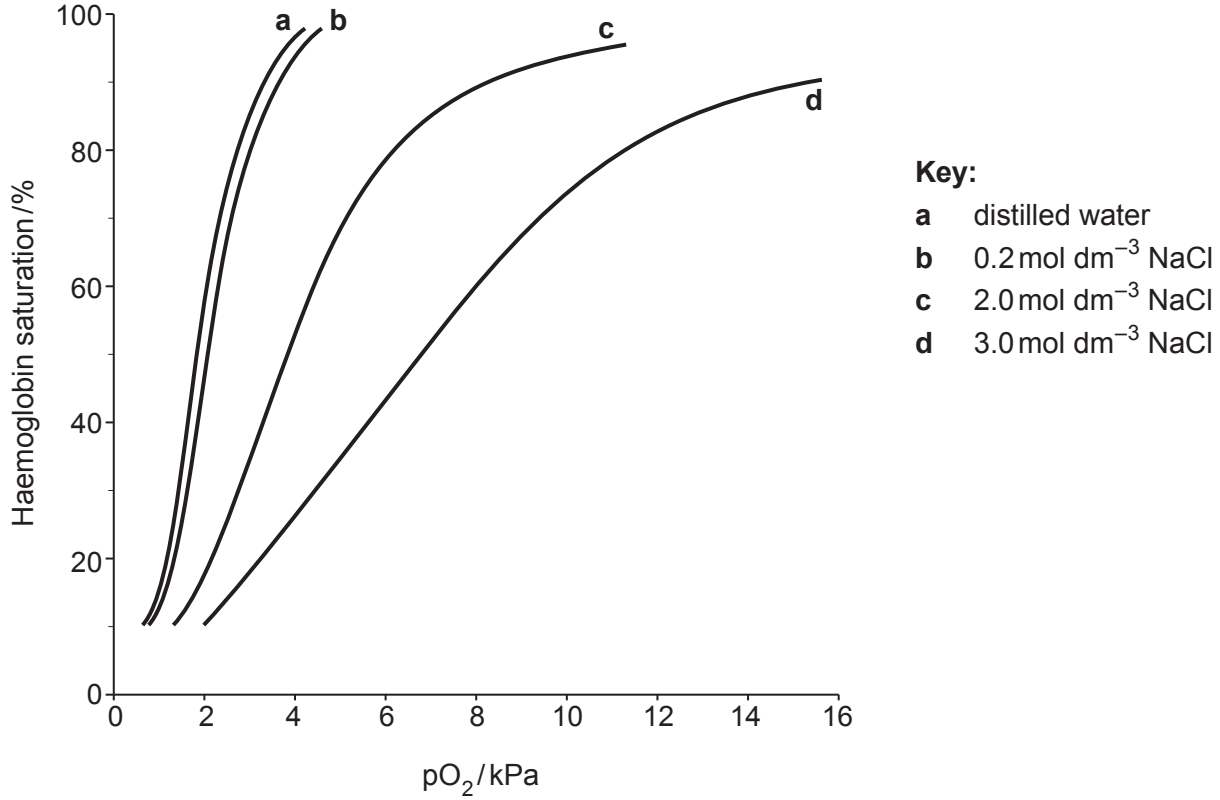
.....

Disadvantage .....

.....

(e) When the tide is out water temperature increases, oxygen concentration decreases and water evaporates from the muddy sand in which lugworms live. Experiments investigated the effect of increasing sodium chloride (NaCl) concentration on the oxygen affinity of lugworm haemoglobin. The results are shown in figure 6.3.

Figure 6.3



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The effect of increasing NaCl concentration was found to be the same as that of increasing carbon dioxide concentration on human haemoglobin.

Name this effect and explain the advantage to the lugworms. [4]

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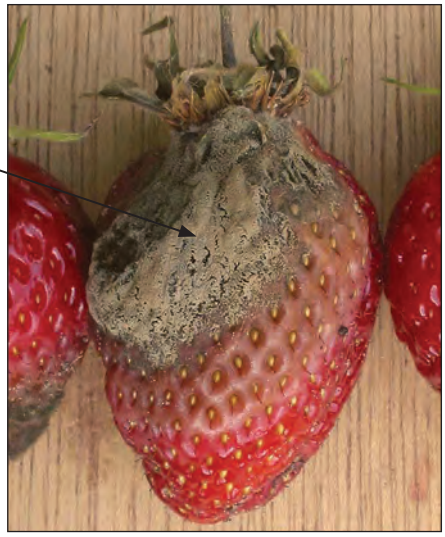
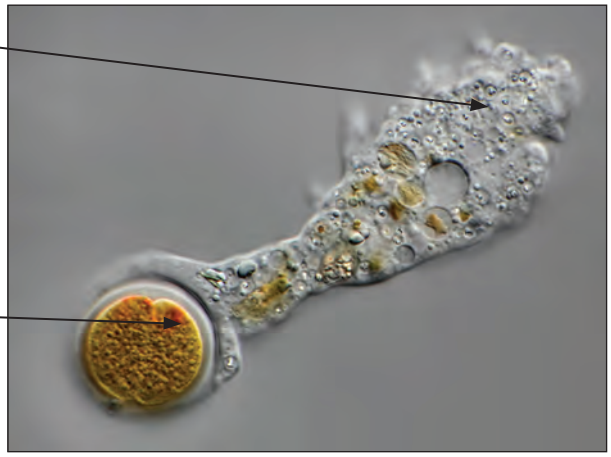
Turn over.

7. All living organisms need to obtain energy and raw materials for growth and survival but do this in different ways. The images below show **four** organisms that have different modes of nutrition.

Botrytis cinerea is a fungus that grows on a wide range of fruit causing decay.



Amoeba sp. ingesting a cell of *Chroococcus sp*, an unicellular alga.



Echinococcus granulosus is a small tapeworm (2 – 4 mm long) found in large numbers in intestines of infected dogs.

Examiner only

Using your knowledge of nutrition in different organisms and the information provided, identify the different modes of nutrition in each of the **four labelled** organisms shown in the images.
Describe what is meant by each mode of nutrition you identify.
Explain the adaptations of each of these organisms to their mode of nutrition. [9 QER]

Examiner only

Examiner only

9

SECTION B: OPTIONAL TOPICS

Option A: **Immunology and Disease** ☐

Option B: **Human Musculoskeletal Anatomy** ☐

Option C: **Neurobiology and Behaviour** ☐

Answer the question on **one topic only**.

Place a tick (✓) in **one** of the boxes above, to show which topic you are answering.

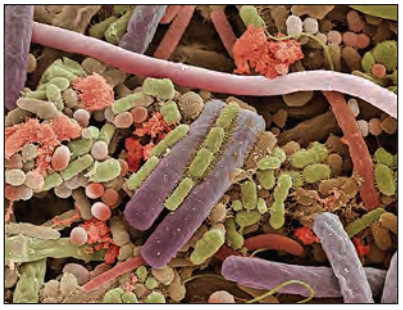
You are advised to spend about 25 minutes on this section.

Examiner only

Option A: Immunology and Disease

8. *(a)* Although micro-organisms can cause disease in humans, scientists believe that up to 10^{16} symbiotic microbial cells live in or on the human body. Up to 90% of all diseases can be traced back in some way to the composition of this microbiome. Figure 8.1 shows bacteria on the surface of a human tongue.

Figure 8.1



An average adult has 10^{13} cells in the body. Suggest why it is often said that we are more microbe than human in terms of our genomes and describe how the micro-organisms living inside our bodies and on the skin surface help protect us from infectious disease.
[3]

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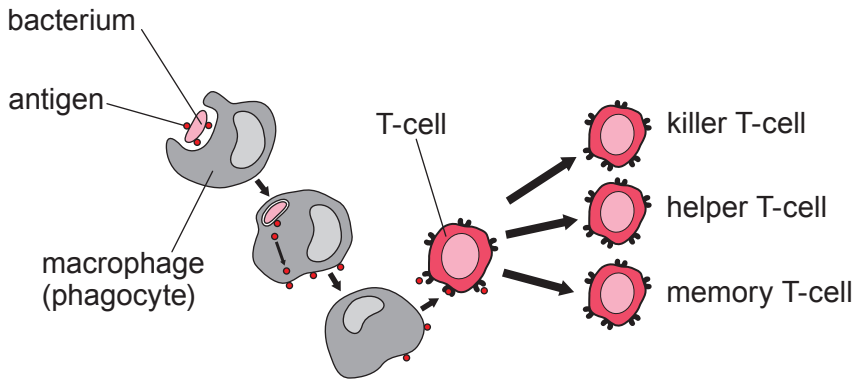
Examiner only

(b) Figure 8.2 shows part of the T-cell immune response when the body is infected with a pathogenic bacterium, such as *Vibrio cholerae*.

Figure 8.2



(i) Explain the role of the macrophage in the T-cell response. [3]

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(ii) Describe the roles of each of the T-cell types shown in figure 8.2 as part of the immune response. [3]

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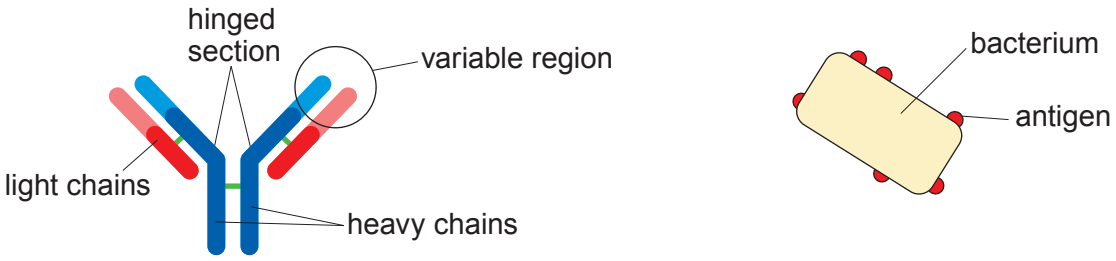
Examiner only

(c) B-cells are activated in a similar way but synthesise antibodies that are specific protein molecules that can bind to foreign antigens. These antibodies can be of different types, as shown in figure 8.3.

Figure 8.3

IgM is made up of five antibody molecules bonded together. A more detailed diagram of IgG is shown in figure 8.4 along with a bacterial cell, showing antigens on the surface.

Figure 8.4



(i) The hinged sections of the IgG molecule give it some structural flexibility. Suggest an advantage of this. [2]

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(ii) Suggest an advantage of the IgM molecule over IgG [1]

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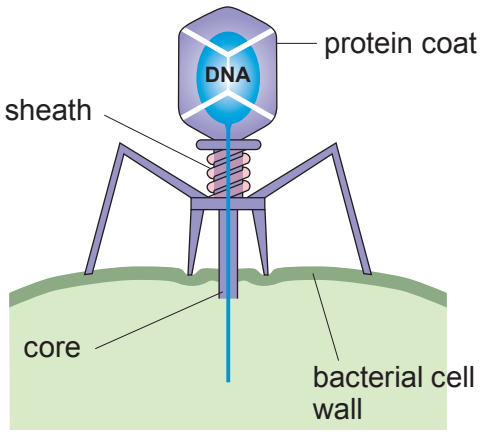
Examiner only

(d) Bacteriophages are viruses which infect bacteria specifically. When they infect bacteria, they result in cell lysis. Bacteriophages are harmless to humans. A typical bacteriophage is shown in figure 8.5.

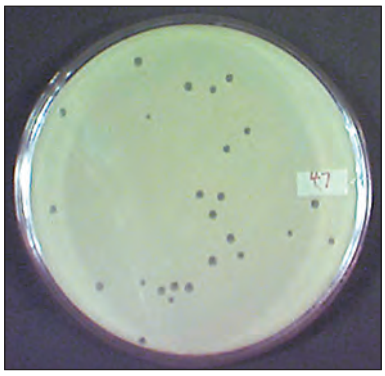
Figure 8.5



Bacteriophage therapy has been successful in trials against a range of bacterial infections, including chronic skin infections caused by bacteria such as MRSA. Their use in medicine to treat infectious disease in humans is called phage therapy.

Bacteriophages can be isolated from bacterial cultures and they can be grown on nutrient agar plates in a lawn of bacteria. Clear zones (plaques) appear on the plates as bacteria are lysed by the bacteriophages as shown in figure 8.6.
Each plaque is assumed to originate from a single bacteriophage.

Figure 8.6



The plate in figure 8.6 was prepared by mixing 0.02 cm^3 of a 10^{-5} dilution of bacteriophages with a bacterial culture and spreading it on an agar plate. This plate was incubated for 24 hours at 37 °C.

(i) On the plate shown in figure 8.6 there are 25 plaques. Calculate the number of bacteriophages per cm^3 in the original sample. [2]

Number of bacteriophages = ...

Examiner only

(ii) Describe **two** techniques that could have been used to maintain sterile conditions when inoculating the plates. [2]

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(iii) Explain why 37 °C was used as the incubation temperature. [1]

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(iv) Using the information provided and your own knowledge, suggest **two** disadvantages of antibiotic use that could be overcome by phage therapy. [2]

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(v) Suggest an ethical issue that should be considered before widespread use of phage therapy in humans. [1]

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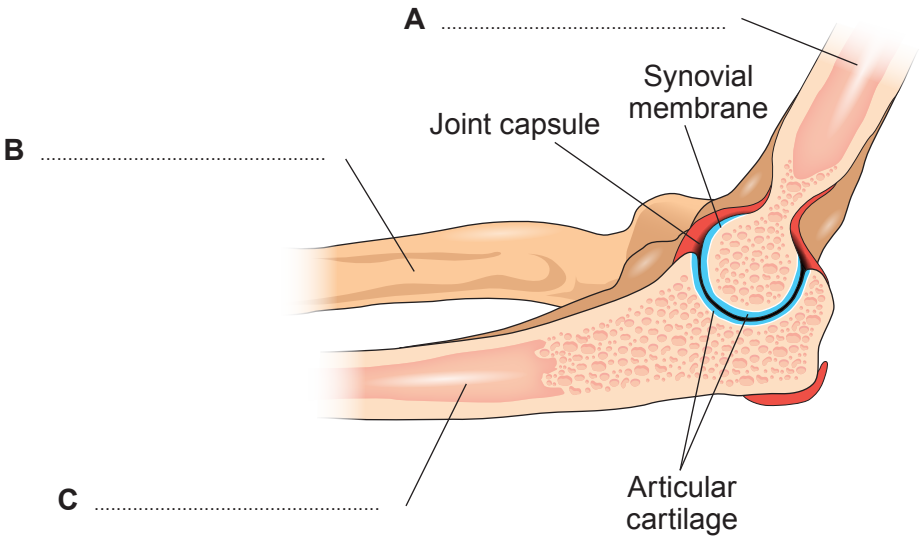
Examiner only

Option B: Human Musculoskeletal Anatomy

9. *(a)* Figure 9.1 shows the elbow joint, which is part of the appendicular skeleton. Muscles are attached to the bones and move the bones at the joint.

Figure 9.1



(i) Label the bones **A-C** of the arm as indicated in figure 9.1. [1]

(ii) The cartilage in the elbow joint is made of hyaline cartilage. Describe the role of the hyaline cartilage in the elbow joint and how the structure of the joint allows it to perform its function. [2]

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(iii) The external ear in mammals contains yellow elastic cartilage. Compare the structure of hyaline cartilage to yellow elastic cartilage. Explain the benefits of each type of cartilage. [3]

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Examiner only

(iv) When cartilage is damaged, it does not heal quickly, unlike bone and muscle. Use your knowledge of the structures of these tissues to explain why. [1]

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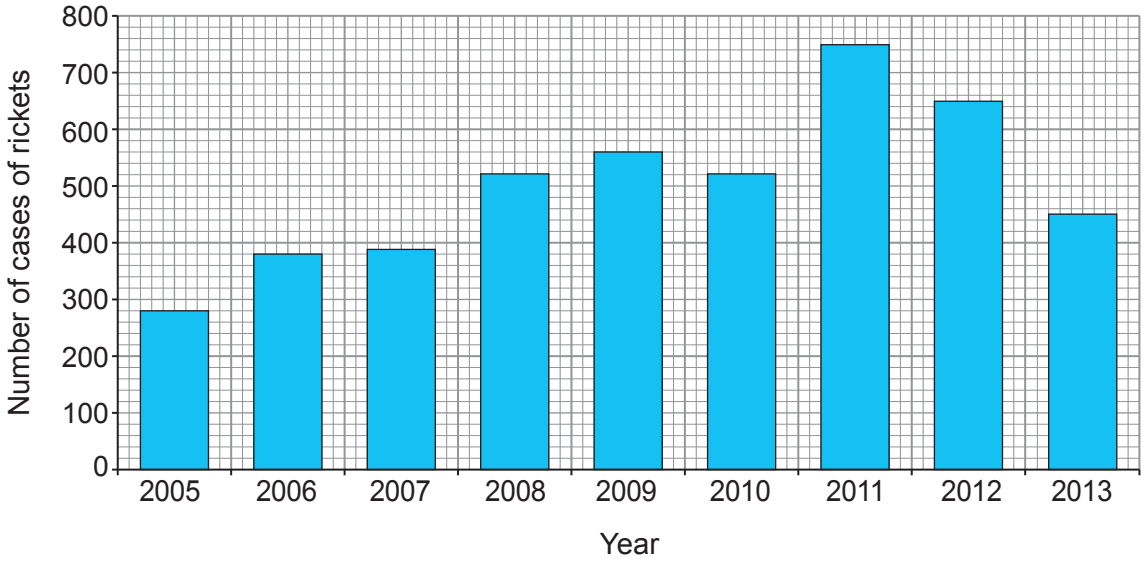
(b) Rickets is a deficiency disease associated with malnutrition resulting from lack of vitamin D or calcium in the diet. The bones in growing children become weak and bend as shown in figure 9.2.

Figure 9.2

From 2012, vitamin D supplements were offered to children under the age of five. Figure 9.3 shows the number of cases of rickets reported in the UK from 2005-2013.

Figure 9.3



(i) I. Calculate the percentage increase in cases from 2005 to 2011. [2]

Percentage increase = ... %

Examiner only

II. Explain the reason for this increase. [1]

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(ii) Suggest why the data collected may be inaccurate in representing the total number of cases in the UK. [1]

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(iii) Some scientists wanted to examine the effects of vitamin D supplements on prevention of rickets in children. They gave 500 children the supplement and compared them to another group of 500 children not taking the supplement. Suggest how the test should be managed to generate valid data and explain **one** ethical issue involved in this study. [3]

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(iv) State the name that is given to the similar, milder condition seen in adults. Explain why it is a less serious condition in adults. [1]

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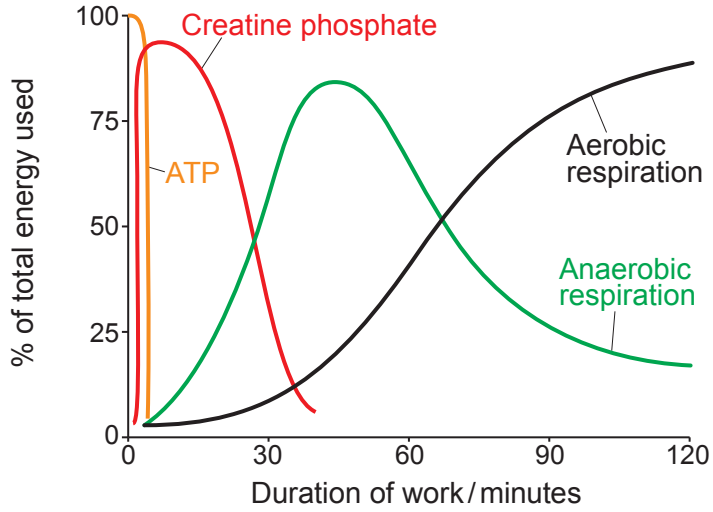
Examiner only

(c) The percentages of energy used from different energy sources in the muscle of a runner during exercise are shown in figure 9.4:

Figure 9.4



(i) Using figure 9.4 and your own knowledge, explain the shape of the graph for ATP and creatine phosphate and explain why aerobic respiration takes over from anaerobic respiration during sustained exercise. [3]

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(ii) The runner is interested in finding out which distance is suited to her muscle type and undertakes a muscle biopsy. The biopsy showed that her muscles contained 60% fast twitch fibres and 40% slow twitch fibres. State the conclusion that could be made based on this result. [1]

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Examiner only

(iii) The runner is concerned over the shape of her feet. Her footprint on the ground is not entirely normal and is shown next to a normal footprint in figure 9.5:

Figure 9.5

Normal footprint Runner footprint

Suggest which condition the runner maybe suffering from and suggest a treatment that would help. [1]

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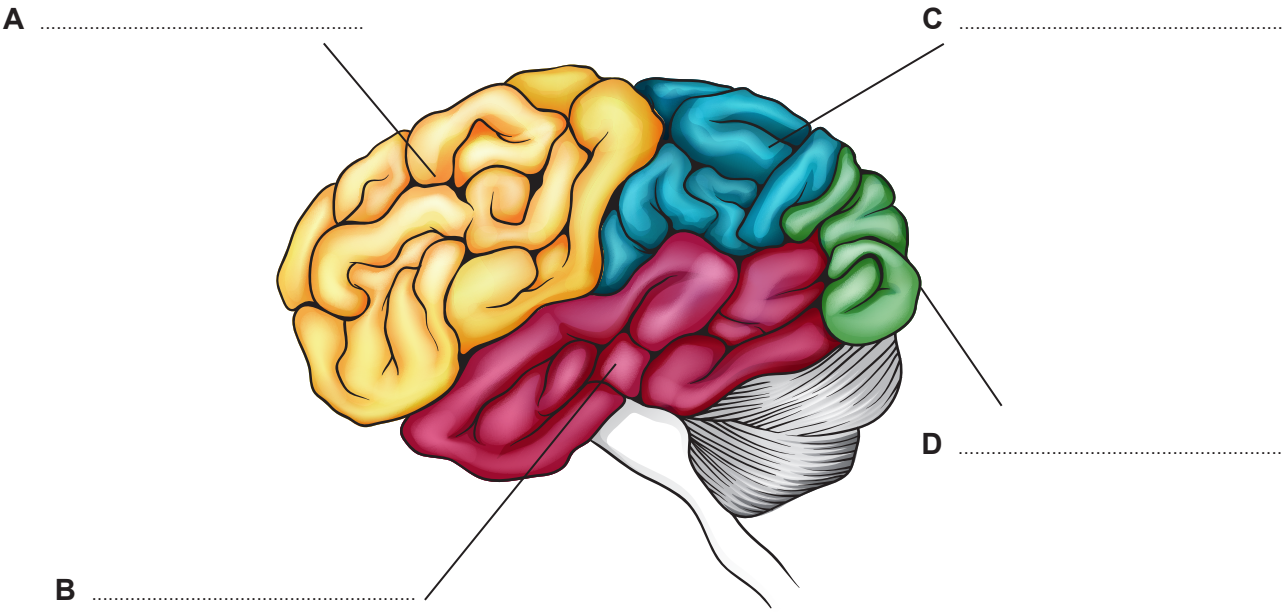
Option C: Neurobiology and Behaviour

10. *(a)* Figure 10.1 shows the lobes of the cerebral hemispheres of the human brain.

Figure 10.1



(i) **Label the lobes A-D of the cerebral cortex** shown in figure 10.1. [2]

(ii) In humans the cortex is greatly folded and contains around 1.6×10^{10} neurones. Figure 10.2 shows the values for some other mammals.

Figure 10.2

Mammal	Number of cortical neurones
mouse	4×10^{6}
dog	1.6×10^{9}
long-finned pilot whale	3.72×10^{10}

The human has ten times more cortical neurones than the dog. Calculate how many times more cortical neurones are present in the human compared to the mouse. [1]

Answer = ...

Examiner only

(iii) State the conclusion you could make about the cognitive function of a long-finned pilot whale when compared to the other mammals. [2]

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(iv) Damage to the cerebral cortex, through either injury or disease, produces different symptoms according to which lobe of the cerebral cortex is affected. Consider the case studies below and complete figure 10.3: [2]

Figure 10.3

Description of damage	Symptoms	Lobe of cerebral cortex affected
A steel bar went through the head of the patient in an accident in the 19th century.	Personality affected so he was rude to friends and lost all inhibitions, exhibiting very aggressive behaviour.	.....
Road traffic accident, the patient suffered head trauma.	Inability to distinguish colours and reported hallucinations.	.....
Injury sustained falling from mountain bike and banging his head against a tree.	The patient could not remember his children's names and forgot how to read a map.	.....

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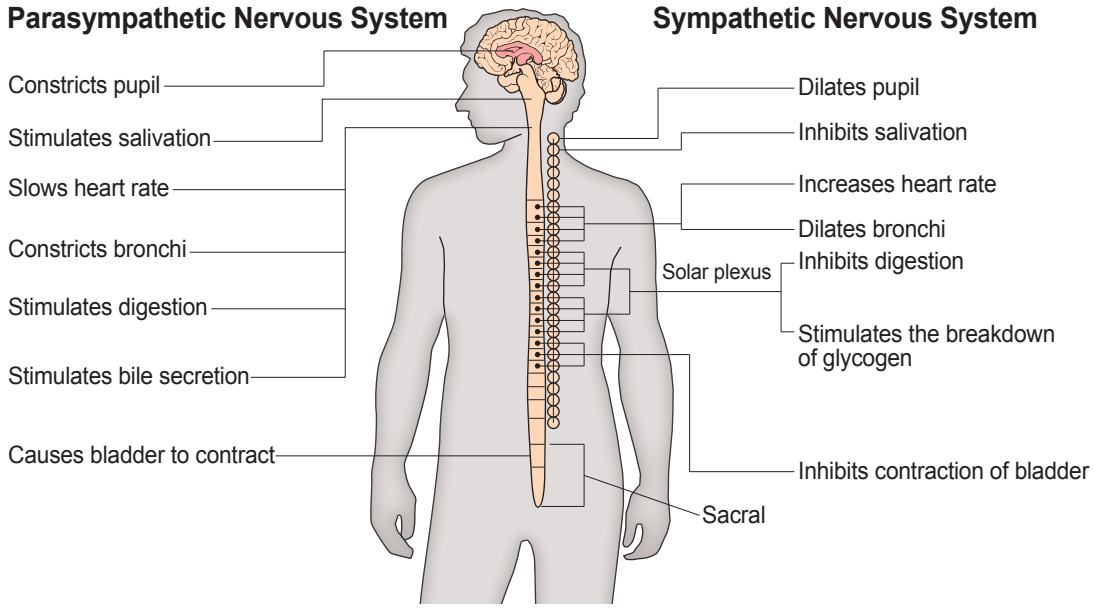
(b) Figure 10.4 shows the autonomic nervous system.

Figure 10.4



(i) Identify the neurotransmitters involved in the following divisions of the autonomic nervous system. [1]

parasympathetic .....

sympathetic .....

(ii) Using figure 10.4, describe and explain how the sympathetic nervous system helps an individual during a fight or flight response. [2]

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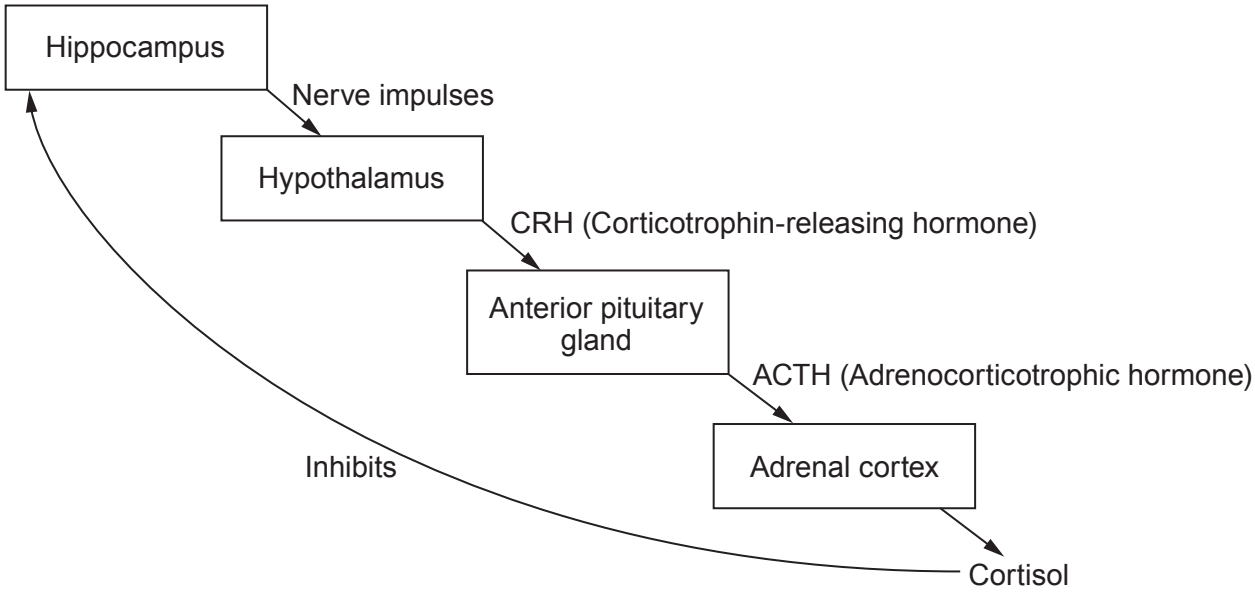
Examiner only

(c) The hypothalamus releases a hormone, which leads to the production of cortisol as shown in figure 10.5:

Figure 10.5



(i) Using the diagram and your own knowledge, explain the role of the brain in preventing the individual becoming overstressed. [2]

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(ii) The blood cortisol levels of an individual who had suffered a traumatic childhood would be expected to be higher than normal. Explain why such individuals may be pre-disposed to mental illnesses throughout their lives. [1]

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Examiner only

(d) Bees show a variety of behaviour patterns which are innate and instinctive. On returning to their colonies, worker honeybees perform a dance to communicate to other bees the direction and distance of a food source.

(i) Explain why this social behaviour benefits the colony. [1]

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Karl von Frisch discovered much of what we know today about honeybee communication. He studied thousands of bees and collected data from more than one hive.

(ii) Identify the main risk associated with the study and how the risk could be minimised. [1]

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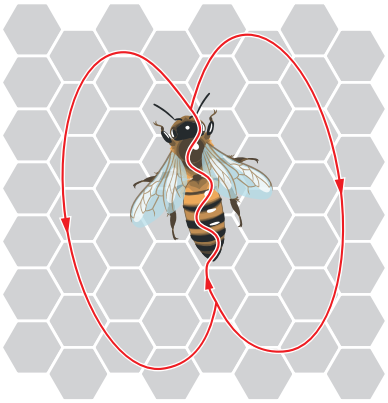
He observed that when food is more than 70 m away from the hive they perform a "waggle dance" in the hive. As shown in figure 10.6.

Figure 10.6

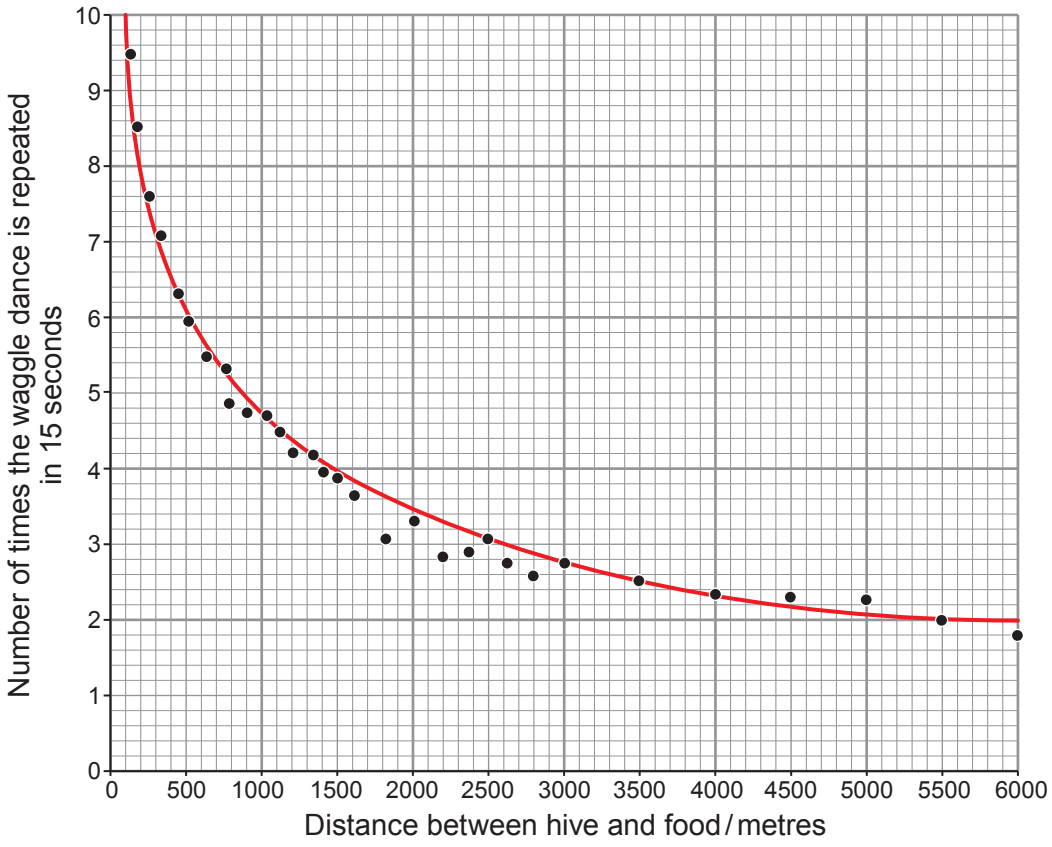


waggle dance
(food more than 70 m away)

Examiner only

The number of times the waggle dance is repeated in a unit of time depends on the distance between the hive and the food. This is shown in figure 10.7.

Figure 10.7



(iii) I. Using the graph, complete the table below by calculating the difference in the number of times the waggle dance is repeated in 15 seconds between 100 and 500 m. [1]

Distance between hive and food / m	Difference in number of times the waggle dance is repeated in 15 seconds
100-500	.....
3000-3500	0.2

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II. Use the values from the table to conclude what happens to the accuracy of the waggle dance for finding food as the distance of the food from the hive increases. [1]

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(iv) There were two factors which were important in terms of making a valid conclusion.

1. Karl von Frisch studied thousands of bees and collected data from more than one hive.
2. His study has also been repeated by other scientists many times.

Explain why these **two** factors were important in terms of making a valid conclusion. [2]

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(e) Different groups of chimpanzees obtain food in a variety of ways. One group of chimpanzees was observed trapping colobus monkeys in order to eat them. Other groups use tools to get food; the way they do this varies from group to group. This is an example of social learning.
Explain the advantages of social learning to the different groups of chimpanzees. [1]

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END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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