Surname	StemUp Model Solution	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**	

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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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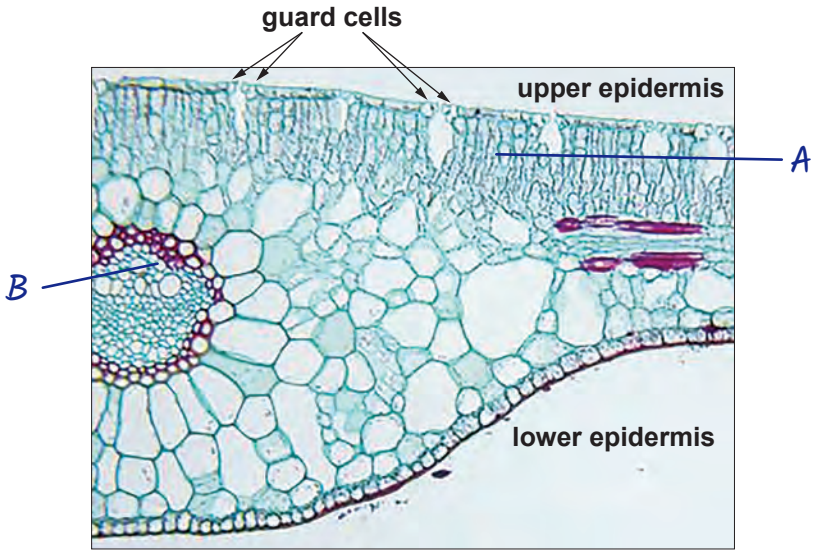
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SECTION A

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: hydrophyte

Adaptation 1: stomata (guard cells) are in the upper epidermis (on the upper surface of the leaf) and not in the lower epidermis.

Adaptation 2: large, numerous air spaces in the spongy mesophyll (for buoyancy and gas exchange); also a thin cuticle on the upper surface.

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

To maximise light absorption: the greatest leaf surface area faces the sun and the long axis of chloroplasts lines up with the light.

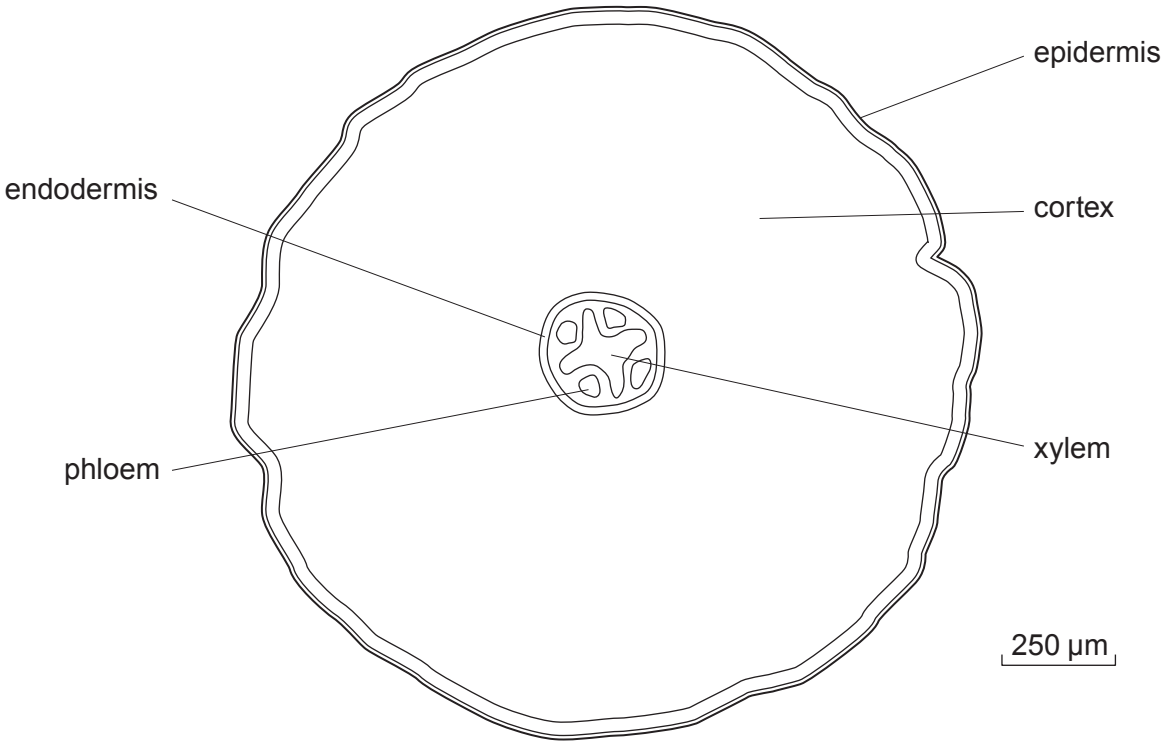
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(b) Roots are the main site of water and mineral uptake. Figure 1.2 shows a low power plan of the structure of a root of a buttercup, *Ranunculus*, a dicotyledonous plant.

Figure 1.2



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

scale bar = 1.5 cm = 15 000 µm

magnification = 15 000 ÷ 250 = 60

Magnification = × 60

(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]

Vacuolar: water crosses more membranes, passing into and out of the vacuole through the tonoplast and through the cytoplasm.

Symplast: water moves through cytoplasm and plasmodesmata, crossing only one membrane.

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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]

In the stem the vascular bundles are arranged around the periphery (edge) of the stem, not in the centre as in the root.

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

xylem lignin

phloem cellulose

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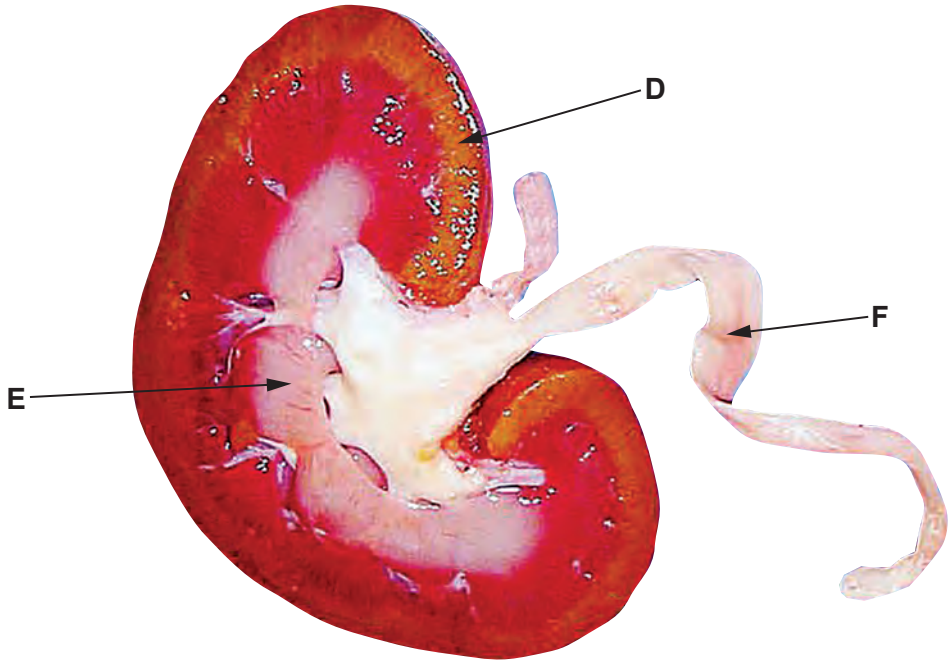
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2. Osmoregulation and urine formation in mammals is carried out by the nephrons. During this process, many small soluble molecules and ions are initially forced out of the blood by **ultrafiltration** in the glomerulus followed by **selective reabsorption** 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 cortex

E medulla (renal pyramid)

F ureter

(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 D

selective reabsorption D

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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]

X are microvilli. They increase the surface area of the cell membrane for reabsorption (e.g. of glucose by co-transport).

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

Blood flow carries away the reabsorbed substances, maintaining a steep concentration gradient between the tubule cells and the blood.

The capillary walls are thin (one cell thick), reducing the diffusion distance.

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(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]

The child inherited Type 2, the autosomal recessive form.

For Type 2 both parents must be carriers (heterozygous): they are unaffected but each passes on a recessive allele, so the child is homozygous recessive.

It cannot be Type 1 as it is caused by a dominant allele: both parents are unaffected so neither has the dominant allele. If the child had Type 1, one of the parents would also have Alport's Syndrome; males cannot be carriers.

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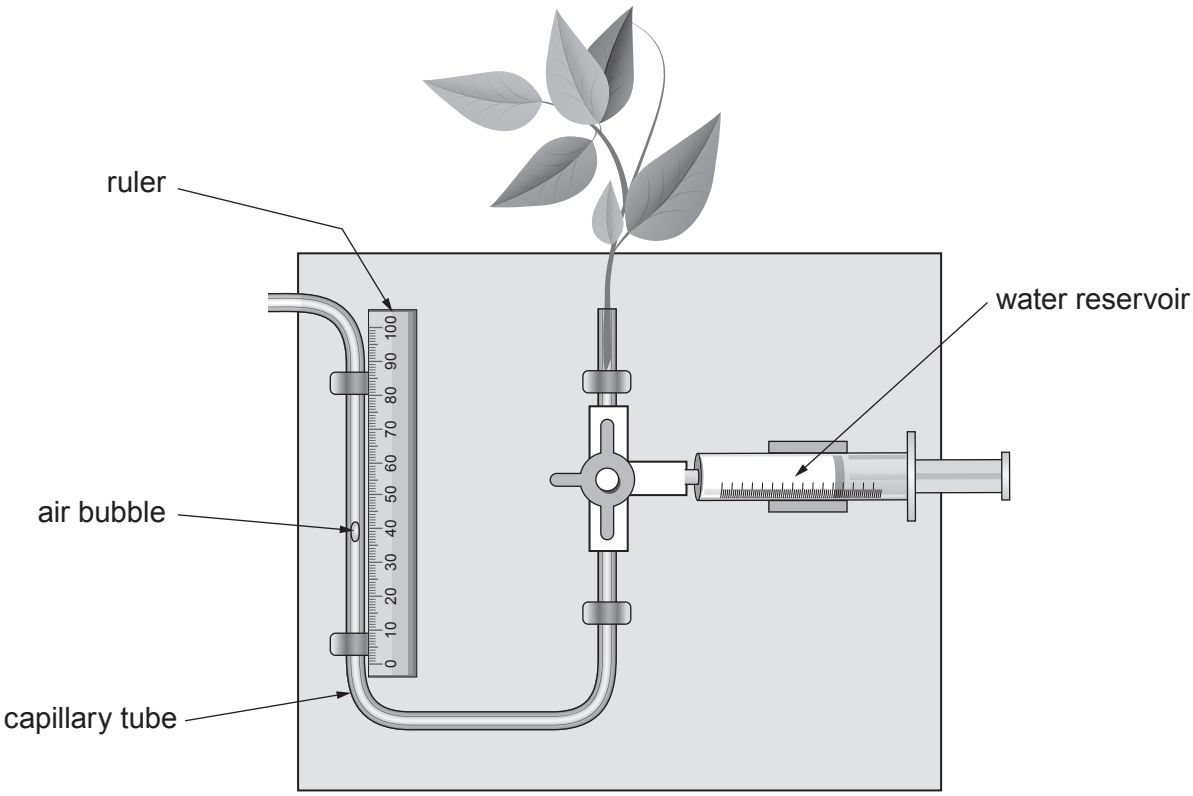
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3. The rate of water uptake by a plant shoot can be measured in the laboratory using a potometer. Students set up a potometer as shown in figure 3.1.

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]

distance moved by the air bubble (mm)

surface area of the leaves (cm^2)

time taken for the bubble to move (minutes)

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

To move the air bubble back to the start of the capillary tube (reset its position) between readings.

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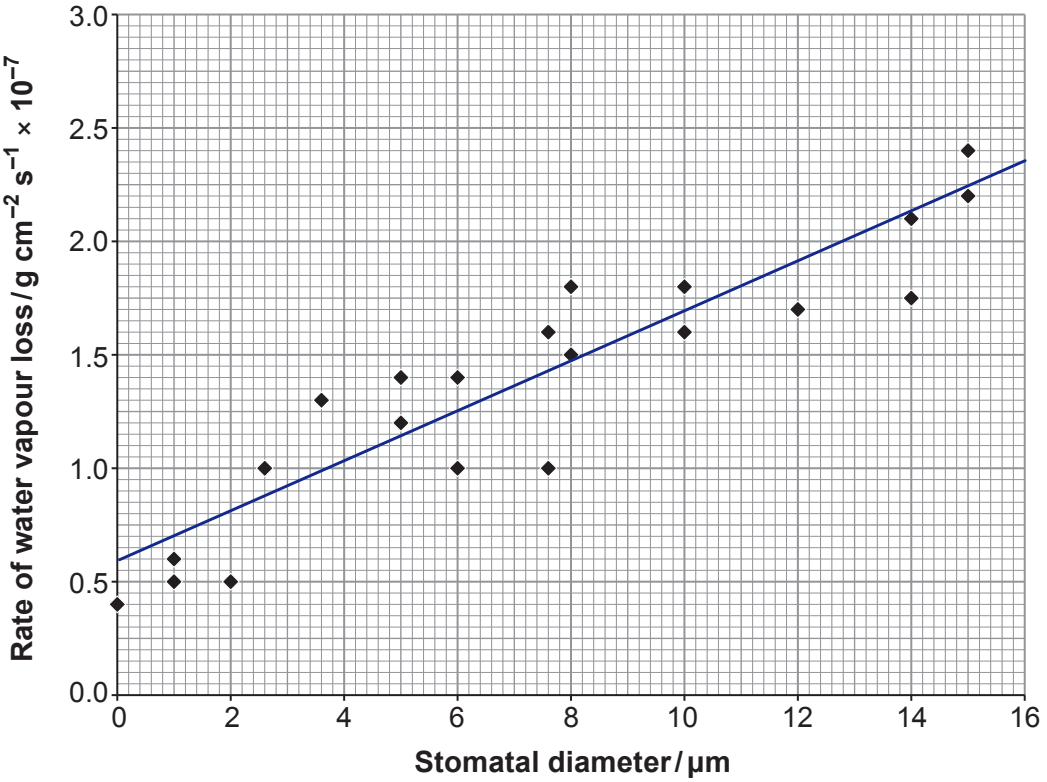
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(b) A potometer measures water uptake but a **porometer** can measure actual water loss from the stomata of a leaf by measuring changes in humidity on the surface of a leaf.

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]

$y = (0.11 \times 10) + 0.6 = 1.1 + 0.6$

y = 1.7 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]

Water evaporates from the surface of the leaf (epidermis), through the cuticle.

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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]

The rate of water loss would decrease and then plateau (constant rate).

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

Less water is lost from the leaves, so the plant is less likely to wilt.

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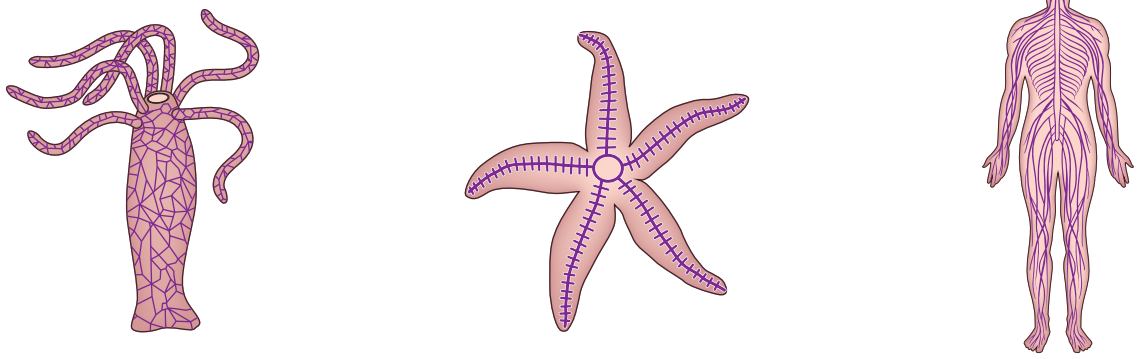
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4. All animals have a degree of nervous coordination. During evolution, the nervous systems of animals have become organised in different ways as shown in figure 4.1 below.

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

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

Peripheral nervous system

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]

More co-ordinated: starfish have a nerve ring acting as a co-ordinator (Hydra does not), and its neurones carry impulses in one direction only. Receptors are in specific places; neurones have specialised (sensory, motor) roles.

Slow: each arm has a nerve net with impulses in both directions, slowing transmission.

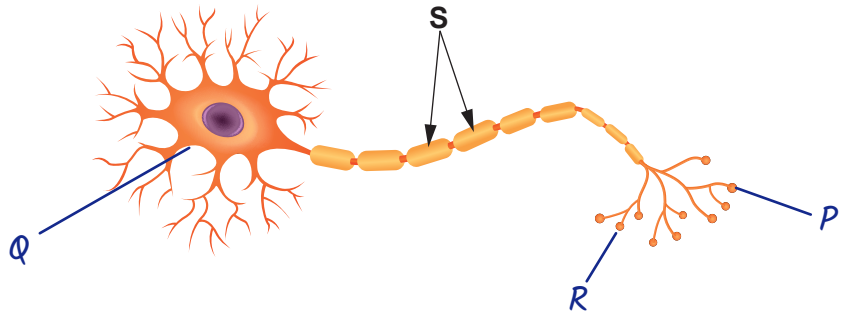
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(b) Figure 4.2 shows the structure of a typical vertebrate motor neurone.

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]

S is the myelin sheath, an electrical insulator that prevents ion movement across the membrane.

Depolarisation only occurs at the nodes of Ranvier (no insulation).

So the impulse jumps node to node (saltatory conduction), which is faster.

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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

Volume increases, lowering pressure so water enters.

II. mouth closes and floor of buccal cavity raised

Increases pressure, so water is forced over the gills.

III. operculum opens

So water leaves through the opercular opening.

(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]

The external intercostal muscles contract, so the ribcage moves up and out.

The diaphragm contracts and flattens (moves down).

The pleural membranes attach the lungs to the thoracic wall, so these movements pull the pleural membranes out, which expands the volume of the lungs and alveoli.

As the volume increases, the pressure in the alveoli falls below atmospheric pressure.

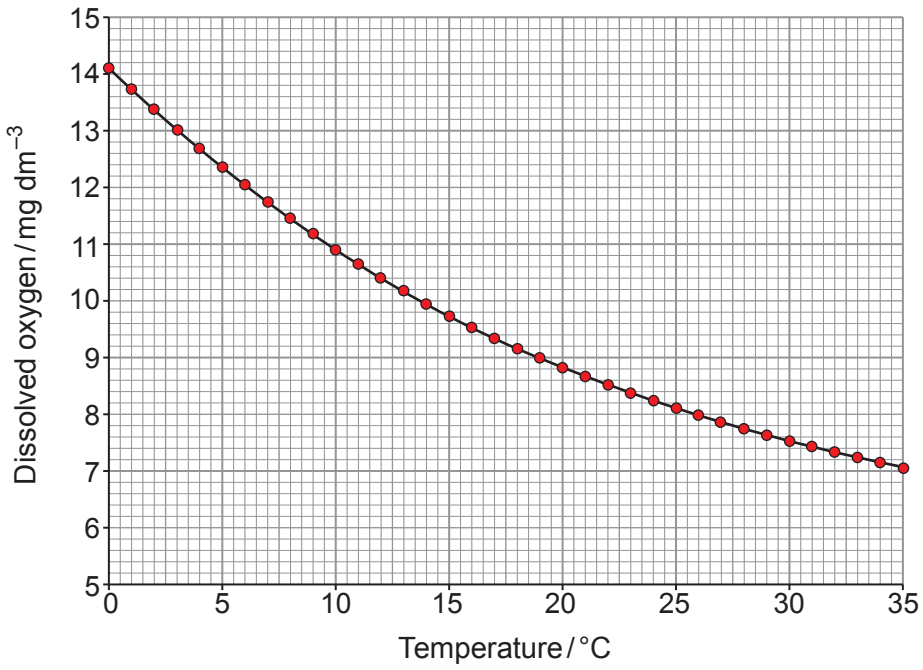
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The Brown bullhead catfish *(Ameiurus nebulosus)* is a bony fish which lives in ponds in North America. Water temperatures can vary from about 2 °C to 30 °C. They are relatively slow moving fish that feed mostly at the bottom of the ponds. During the 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.

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

independent variable: *temperature of the water (°C)*

dependent variable: *number of times the operculum opens per minute*

(ii) Explain why:

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

So there is no change to the ion (solute) concentration of the water; the water potential and pH stay the same.

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

To allow the fish to acclimatise (adjust) to the new temperature and return to resting conditions.

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(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]

It follows the same trend: Fish 1 is consistently higher than the other fish, and with only 4 fish the normal range is unknown.

Fish 1 falls from 26 to 23, the same as Fish 3 (22 to 19).

(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]

Figure 5.1 shows the O_2 content of water decreases as temperature increases (14 to about 7 mg dm^{-3}).

So the ventilation rate increases (operculum opens more often), passing more water over the gills so enough O_2 can be absorbed.

In summer, even at maximum ventilation rate, they cannot absorb enough O_2 from the warm water.

So they gulp air, which has a higher O_2 content, absorbing O_2 from it.

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(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]

The temperatures used (9 to 28 °C) are within the normal range of the fish's habitat (2 to 30 °C).

At higher temperatures the fish may not be able to absorb enough O_2 from the water and, if prevented from gulping air at the surface, could suffocate; this stops normal behaviour and causes distress.

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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]

Both have membrane-bound organelles (e.g. mitochondria) and large 80S ribosomes; also chromosomes containing histones.

(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]

40 200 ÷ 377 000 = 0.1066...

Surface area to volume ratio = 0.1 : 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]

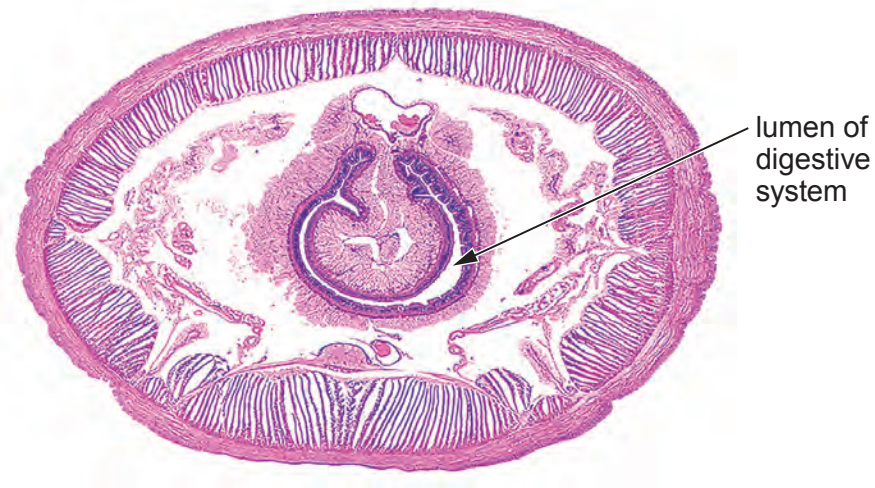
SA:vol ratio too small (0.07:1) to absorb enough O_2 for respiration;

diffusion distance to the centre too long (45 μm, not 20 μm) for O_2.

(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 38

anaerobic 2

(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]

Blood is pumped at a higher pressure, so it circulates faster and can be transported over longer distances.

This maintains a higher concentration gradient of glucose between the blood and the tissues.

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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.

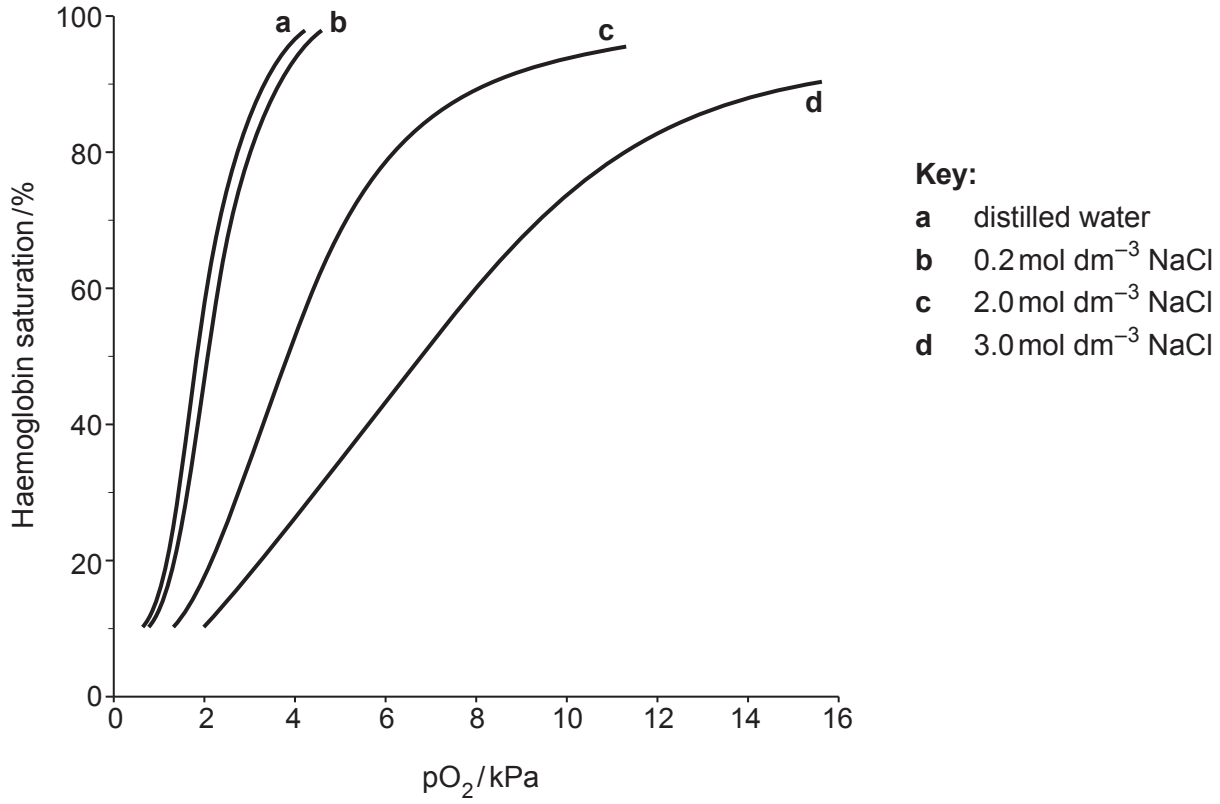
Explain why a very high oxygen affinity can be both an advantage and a disadvantage to lugworms. [2]

Advantage *it can reach a high O_2 saturation at low pO_2 in the mud, where oxygen levels are very low.*

Disadvantage *O_2 is not released readily to the tissues, as oxyhaemoglobin does not dissociate easily.*

(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]

Bohr effect (Bohr shift).

When the tide is out, water evaporates so the NaCl concentration increases.

Figure 6.3 shows that a higher NaCl concentration decreases the O_2 affinity of haemoglobin: the curve shifts to the right, e.g. at 4 kPa saturation is over 90% in distilled water but only about 30% in 3.0 mol dm^{-3} NaCl.

So O_2 is released (unloaded) more readily to the respiring tissues.

This is an advantage because the O_2 content of the water decreases as the water temperature increases when the tide is out.

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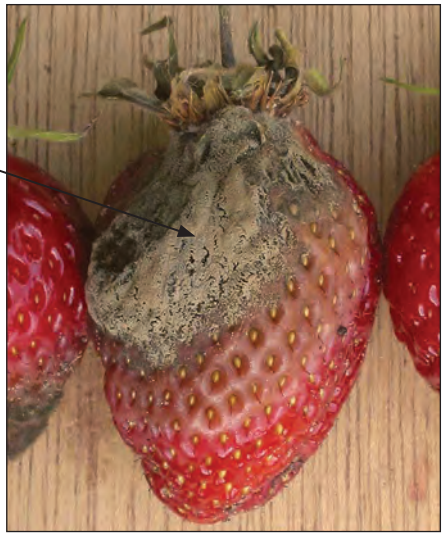
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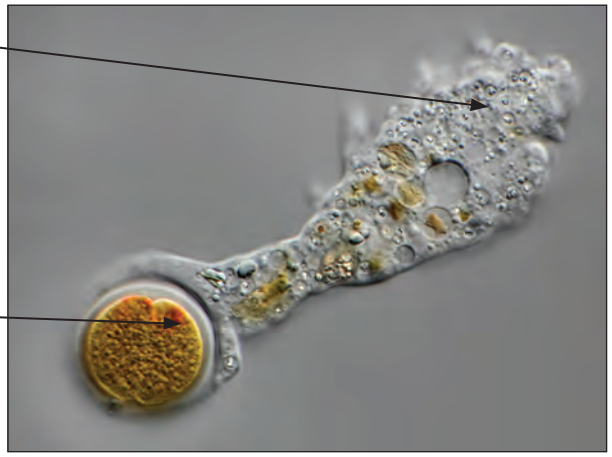
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7. All living organisms need to obtain energy and raw materials for growth and survival but do this in different ways. The images below show **four** organisms that have different modes of nutrition.

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.



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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]

Chroococcus is autotrophic. Autotrophic nutrition uses energy from the Sun (light) to combine simple inorganic compounds (carbon dioxide and water) to produce its own organic compounds by photosynthesis. Chroococcus is adapted by containing chlorophyll (photosynthetic pigments) to absorb light energy.

Botrytis, Amoeba and Echinococcus are all heterotrophic: they use organic compounds made by other organisms as a source of energy and raw materials to produce their own organic compounds.

Botrytis is saprotrophic. It feeds on dead or decaying organic matter (the fruit) by extracellular digestion: it digests food outside its body and then absorbs the soluble products of digestion. It is adapted by having a network of hyphae (a mycelium) that grows over and through the fruit, giving a large surface area. The hyphae secrete digestive enzymes (e.g. cellulases, proteases and amylases) onto the food, and the products, such as glucose and amino acids, are absorbed across the hyphal walls.

Amoeba is holozoic. Holozoic nutrition involves ingestion, digestion and egestion, with the food digested internally (intracellularly). Amoeba is adapted by engulfing its prey (here a Chroococcus cell) by endocytosis (phagocytosis), extending pseudopodia around it to form a food vacuole. Lysosomes fuse with the vacuole and release digestive (hydrolytic) enzymes; the soluble products are absorbed into the cytoplasm, and undigested waste is egested by exocytosis.

Echinococcus is parasitic. A parasite obtains its nutrients from a living host organism, here the intestine of a dog, and harms the host. It is adapted by having no digestive system and not secreting digestive enzymes, because its food has already been digested by its host; it absorbs soluble nutrients directly across

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its body surface. Its body is thin and flattened (proglottids), increasing the surface area and reducing the diffusion distance for absorption. It also has hooks and suckers to attach to the intestine wall and a thick cuticle that resists the host's digestive enzymes.

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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.

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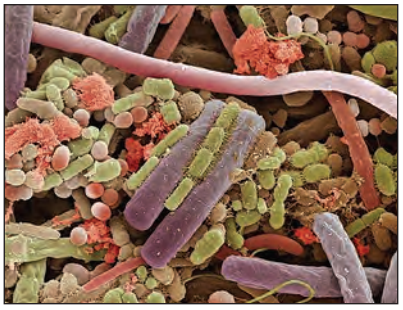
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Option A: Immunology and Disease

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]

There are many more microbial cells (10^{16}) than human cells (10^{13}), about 1000 times more, and they belong to many different bacterial species, so there are far more microbial genomes than human.

The microbes protect us by outcompeting pathogenic bacteria, preventing harmful microbes from colonising the body and causing disease.

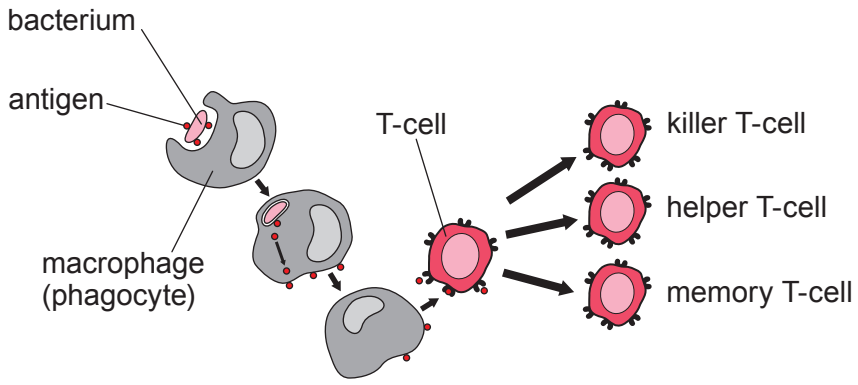
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(b) Figure 8.2 shows part of the T-cell immune response when the body is infected with a pathogenic bacterium, such as *Vibrio cholerae*.

Figure 8.2



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

The macrophage engulfs the bacterium by phagocytosis and digests it. It then displays the bacterium's antigens on its cell surface membrane (antigen presentation). A T-cell with a complementary receptor recognises the foreign antigen and is activated, undergoing clonal expansion (dividing by mitosis).

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

Killer T-cells: bind to and cause lysis of (destroy) infected target cells. Helper T-cells: secrete cytokines which activate B-cells to initiate the antibody response. Memory T-cells: remain in circulation until the host is exposed to the antigen again, then initiate a faster secondary immune response.

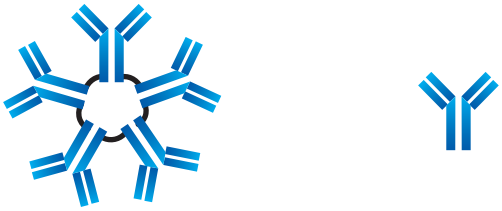
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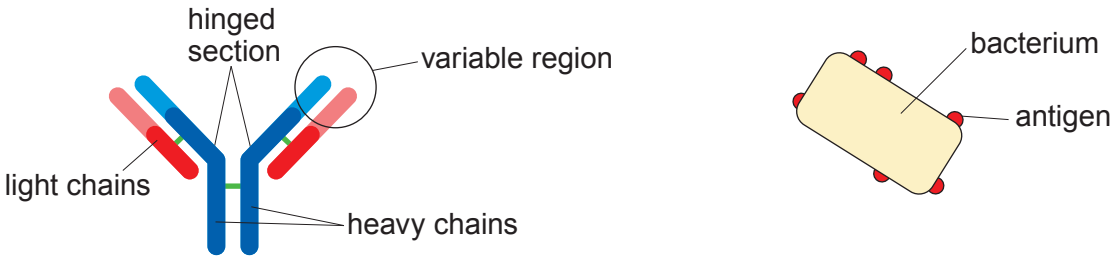
(c) B-cells are activated in a similar way but synthesise antibodies that are specific protein molecules that can bind to foreign antigens. These antibodies can be of different types, as shown in figure 8.3.

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]

Both arms can bend to bind antigens that are different distances apart, or on different cells, causing agglutination.

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

IgM can bind more antigen, so it forms larger clumps.

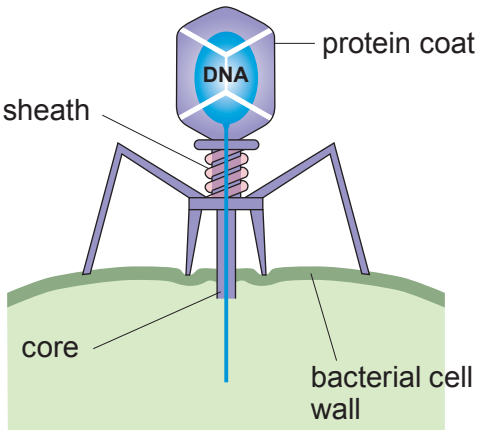
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(d) Bacteriophages are viruses which infect bacteria specifically. When they infect bacteria, they result in cell lysis. Bacteriophages are harmless to humans. A typical bacteriophage is shown in figure 8.5.

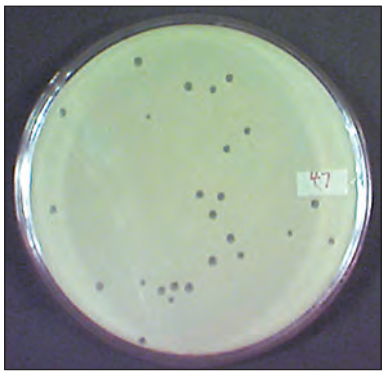
Figure 8.5



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]

$25 \div 0.02 = 1250$ bacteriophages per cm^3 of the 10^{-5} dilution

$1250 \times 100\,000 = 125\,000\,000$

Number of bacteriophages = 1.25×10^8

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

Flame the inoculating loop or spreader (or use a sterile pipette) before use.

Work near the updraft of a Bunsen burner and only tilt (partly lift) the lid of the Petri dish.

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

It is human body temperature, so it is used to culture human pathogens.

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

Antibiotics are not specific; phages only infect specific bacteria.

Bacteria often become resistant to antibiotics; resistance to phages is unlikely as phages mutate as fast as bacteria.

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

The bacteriophage could mutate and infect human cells, or have unknown side effects.

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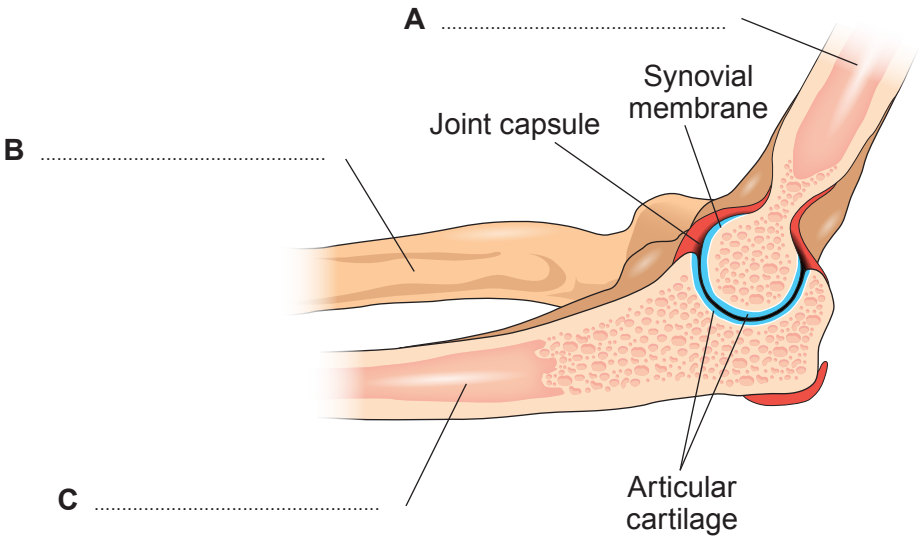
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Option B: Human Musculoskeletal Anatomy

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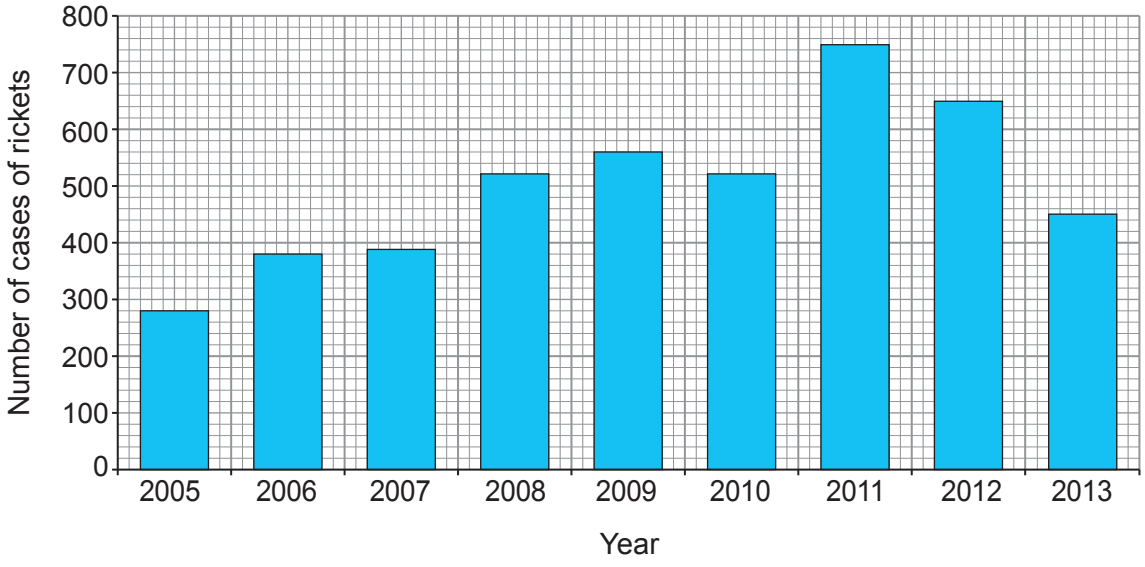
(b) Rickets is a deficiency disease associated with malnutrition resulting from lack of vitamin D or calcium in the diet. The bones in growing children become weak and bend as shown in figure 9.2.

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 = ... %

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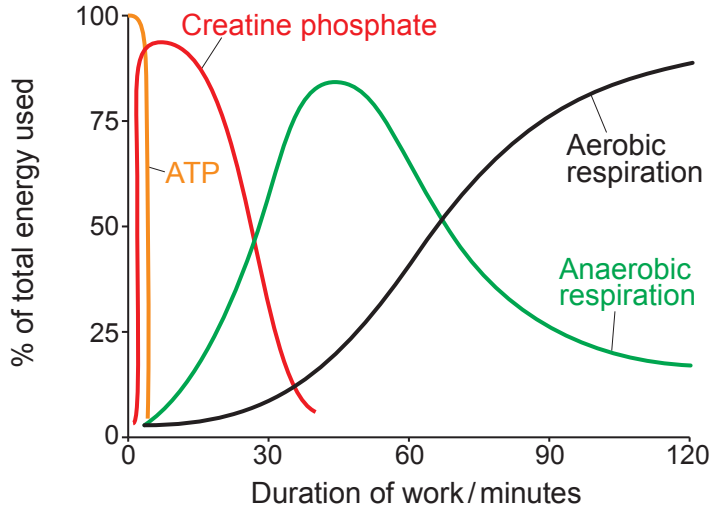
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(c) The percentages of energy used from different energy sources in the muscle of a runner during exercise are shown in figure 9.4:

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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(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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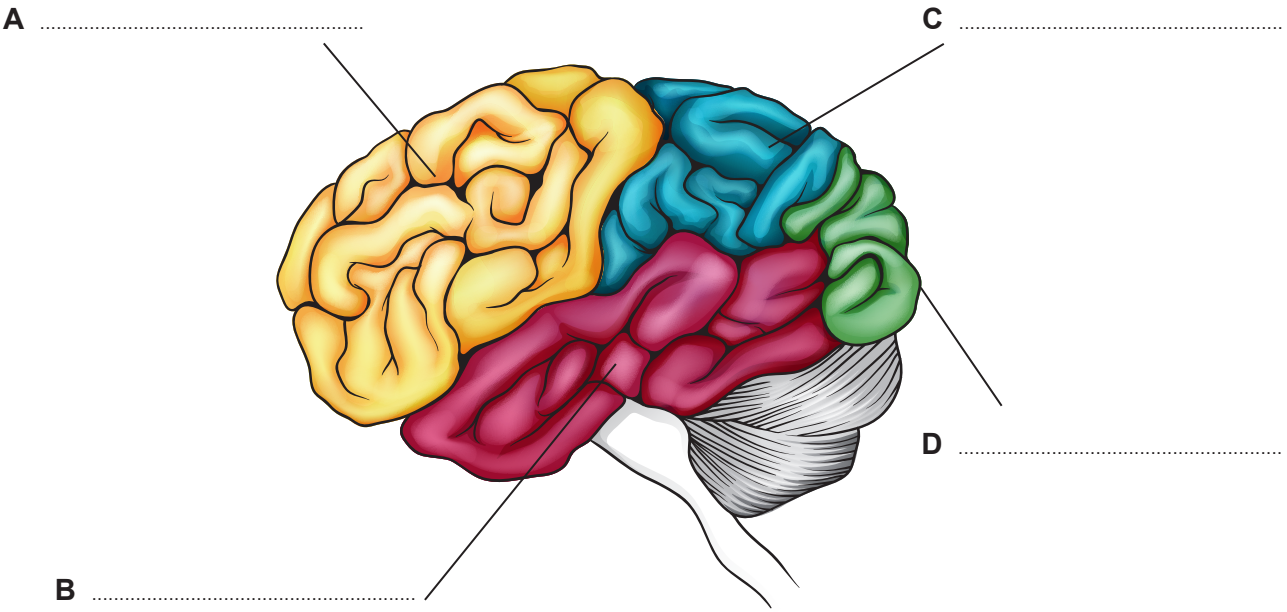
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Option C: Neurobiology and Behaviour

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 = ...

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(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.	.....

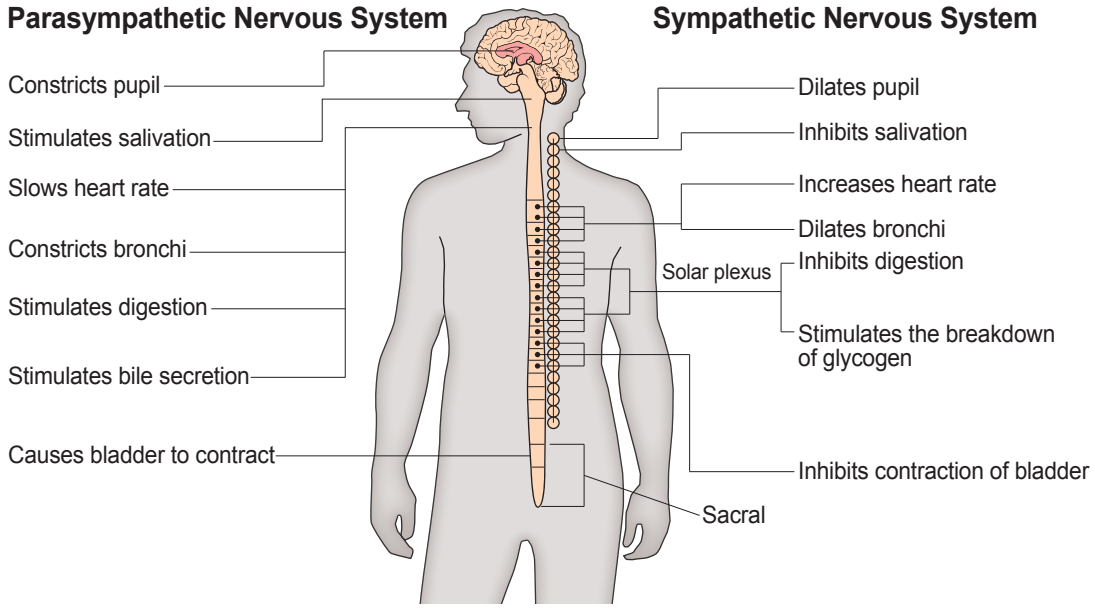
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(b) Figure 10.4 shows the autonomic nervous system.

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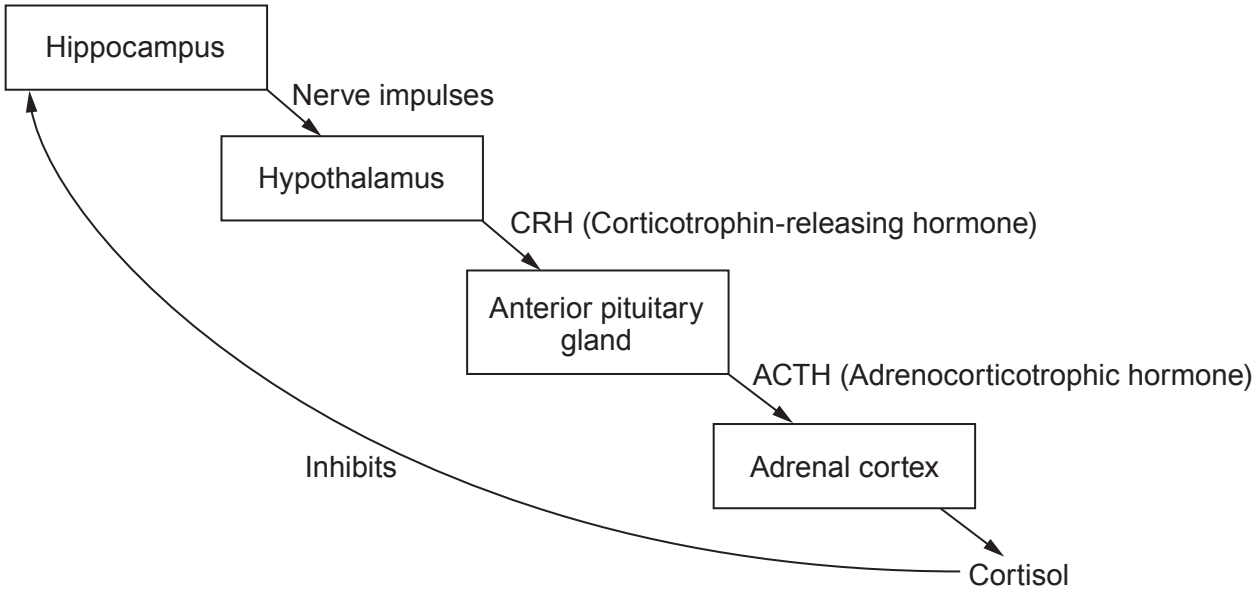
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(c) The hypothalamus releases a hormone, which leads to the production of cortisol as shown in figure 10.5:

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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(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.

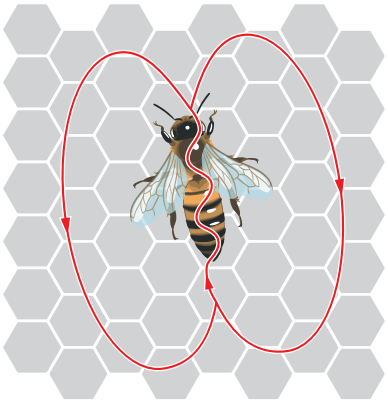
(ii) Identify the main risk associated with the study and how the risk could be minimised. [1]

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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)

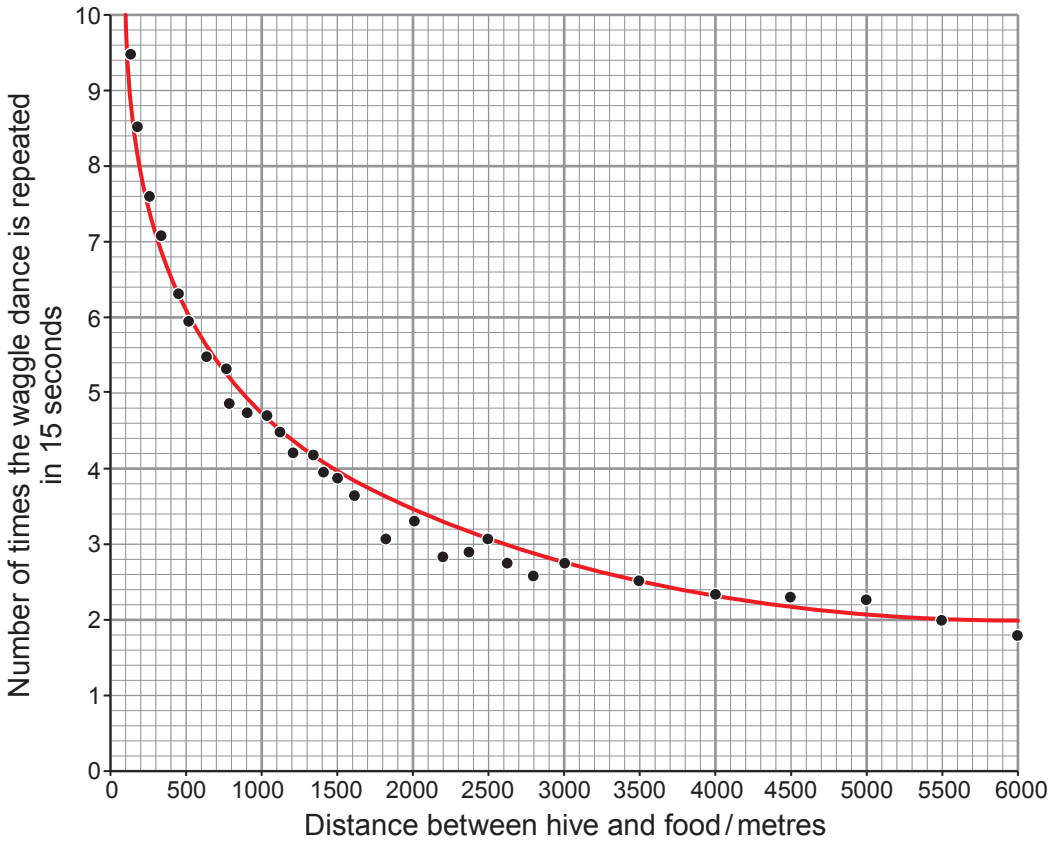
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The number of times the waggle dance is repeated in a unit of time depends on the distance between the hive and the food. This is shown in figure 10.7.

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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