GCE Biology

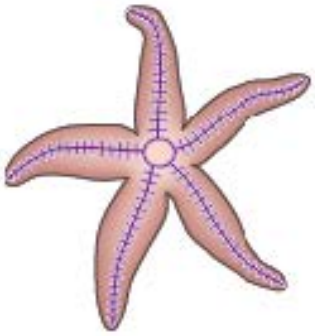
S21-A400U30-1

Assessment Resource 23

Requirements for Life E

1. 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 1.1 below.

Figure 1.1



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

(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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(b) Figure 1.2 shows the structure of a typical vertebrate motor neurone.

Figure 1.2

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

Label Figure 1.2 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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2. 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

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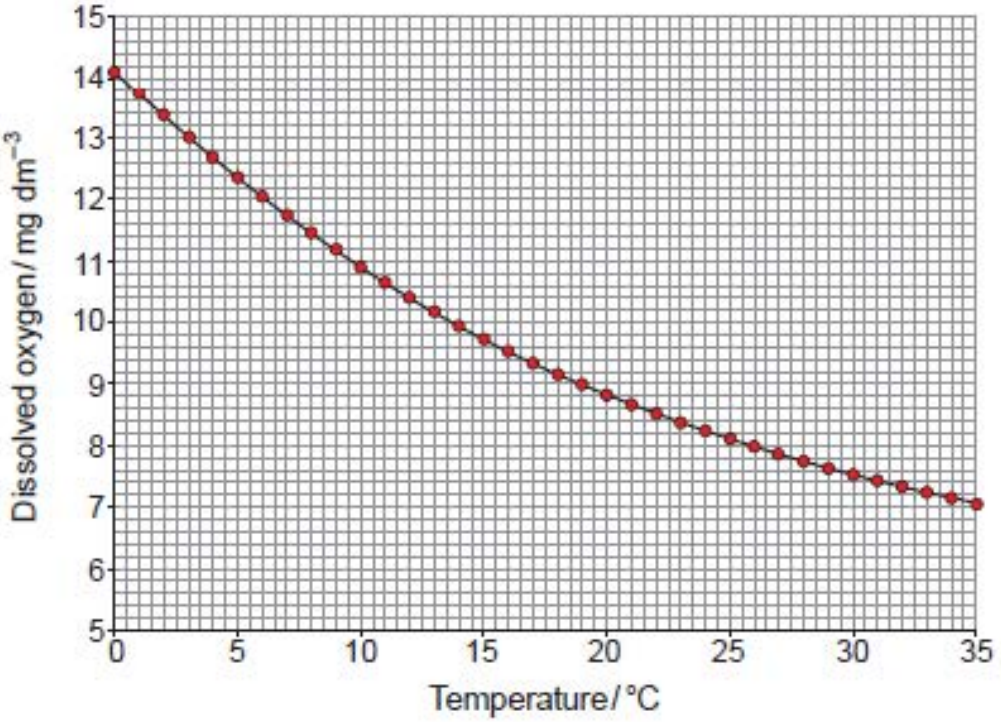
The Brown bullhead catfish *(Ameiurus nebulosus)* is a bony fish which lives in ponds in North America. Water temperatures can vary from about 2 °C to 30 °C. They are relatively slow moving fish that feed mostly at the bottom of the ponds. During the summer, the catfish come to the surface and gulp air.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

Figure 2.1 below shows how the oxygen concentration of fresh water changes with temperature.

Figure 2.1



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.

(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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(c) The results of the experiment are shown in figure 2.2.

Figure 2.2

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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(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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3. 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 3.1 is a photomicrograph showing an individual *Paramecium*.

Figure 3.1

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

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

(ii) A spherical organism of the same volume would have a surface area of approximately 25230 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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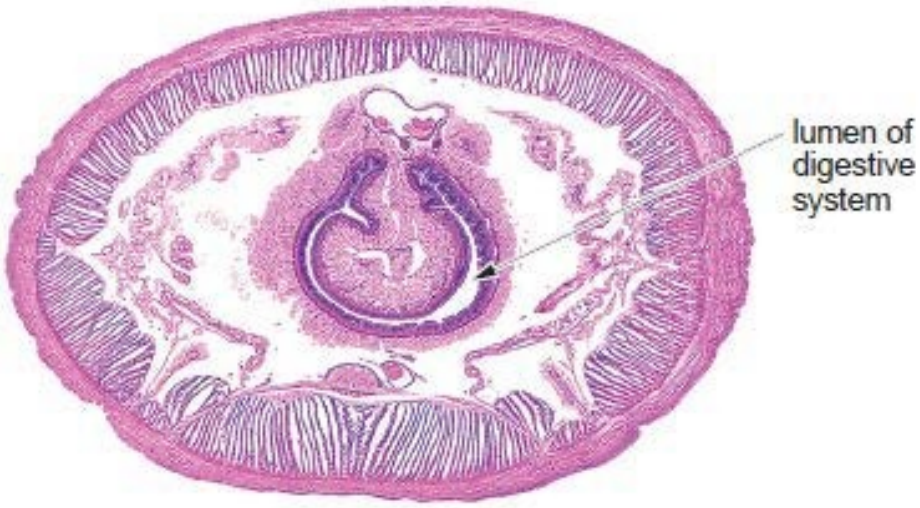
(c) Earthworms are multicellular organisms that rely on their external body surface for gas exchange.

Figure 3.2 shows a cross-section of an earthworm at a magnification of ×40.

Figure 3.2



(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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(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 .....

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Disadvantage .....

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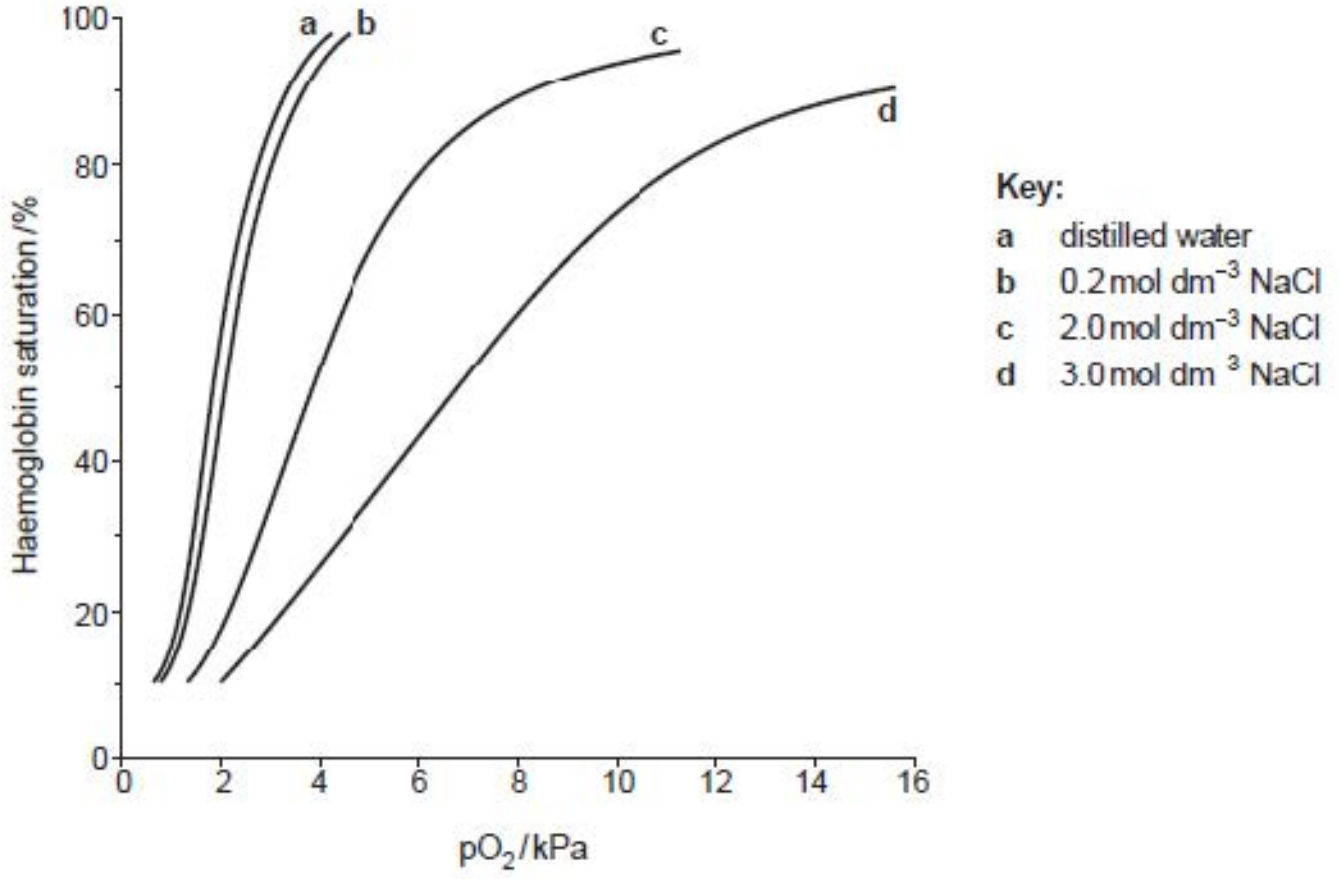
(e) When the tide is out water temperature increases, oxygen concentration decreases and water evaporates from the muddy sand in which lugworms live. Experiments investigated the effect of increasing sodium chloride (NaCl) concentration on the oxygen affinity of lugworm haemoglobin. The results are shown in figure 3.3.

Figure 3.3



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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