Candidate Name	Centre Number					Candidate Number				
StemUp Model Solution										

AS BIOLOGY

COMPONENT 2

Biodiversity and Physiology Of Body Systems

SPECIMEN PAPER

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**8**	
2.	**20**	
3.	**15**	
4.	**12**	
5.	**11**	
6.	**9**	
Total	**75**	

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.

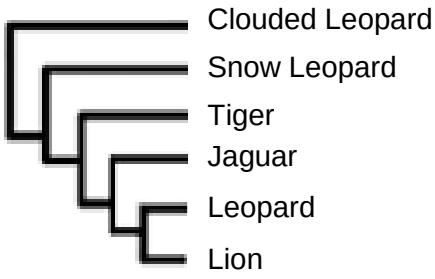
INFORMATION FOR CANDIDATES

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 6.

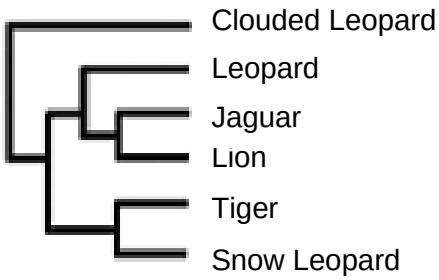
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1. Different scientists interpret available scientific evidence in different ways. The models below show possible evolutionary relationships between different species of 'big cat'. Model A is based solely on morphological evidence and model B is based on biochemical analyses.

A



B



(a) (i) What name is given to this type of diagram? [1]

Phylogenetic tree

(ii) Big cats are classified into the kingdom Animalia. Name the other kingdoms used in the classification of organisms. [2]

Plantae

Fungi

Protoctista

Prokaryotae

(b) The big cats shown in the diagrams above have been given the following scientific names according to the binomial system:

Clouded Leopard	*Neofelis nebulosa*
Leopard	*Panthera pardus*
Lion	*Panthera leo*
Jaguar	*Panthera onca*
Snow Leopard	*Uncia uncia*
Tiger	*Panthera tigris*

Based on their scientific names which of the big cats are the **least** closely related to the tiger? Give a reason to support your answer. [2]

Clouded leopard (Neofelis nebulosa) and snow leopard (Uncia uncia), because they have different genus names to the tiger (Panthera).

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(c) Samples of mitochondrial DNA from a lion, a tiger and a snow leopard were analysed. The base sequences for the same section of their mitochondrial DNA are shown below.

	10	20	30	40
Lion	ATACGTGTAT	ACGTGTACGT	GTGTACGTGT	GTACGTGTGT
Tiger	ACGTGTACGT	GTGTATACGT	GTACGTGTGT	ACGTGTGTAT
Snow Leopard	ATACGTGTAC	GTGTATACGT	GTACGTGTGT	ACGTGTGTAC

Species 1	Species 2	Number of bases in common
Lion	Tiger	20
Tiger	Snow Leopard	31
Lion	Snow Leopard	25

Based on this information which of the two proposed models is supported by these results? Explain your answer. [1]

Model B, because the tiger and snow leopard have the most bases in common (31), so they are the most closely related.

(d) Human mitochondrial DNA codes for proteins essential for some of the reactions which take place within the mitochondrion. Name **two** forms of RNA which are essential for the synthesis of these proteins within the mitochondrial matrix. [2]

Ribosomal RNA (rRNA) and transfer RNA (tRNA).

8

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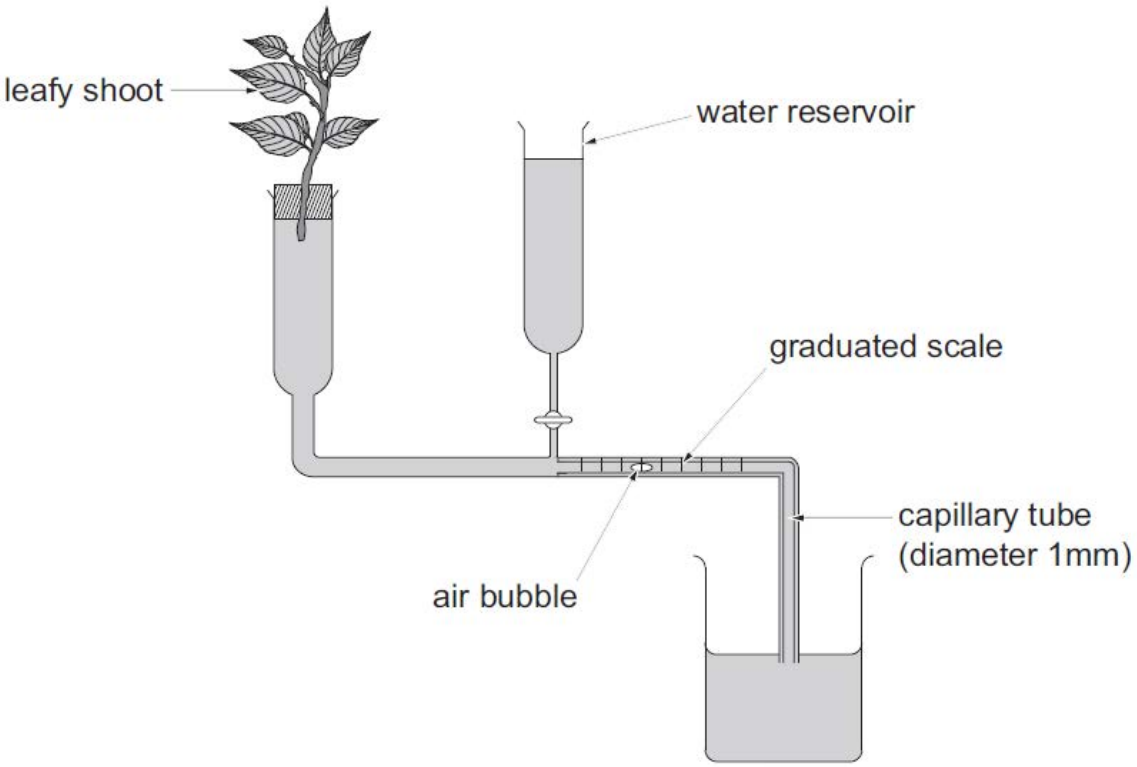
2. Plants need water for transport, support and photosynthesis among other biochemical processes. Water uptake from the soil is largely passive and the flow of water from the roots to the leaves is driven in part by the loss of water through the stomata.

(a) State the name of the process by which plants lose water from their leaves. [1]

..Transpiration……..

The apparatus shown in the diagram was used to study how wind speed affects the rate at which a leafy shoot takes up water.

The same shoot was exposed to air moving at different speeds. At each speed the distance moved by the air bubble in 5 minutes was recorded. The results were then used to calculate the rate of water uptake by the leafy shoot in $mm^3\ min^{-1}$.



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(b) The table below shows the results of the investigation.

Wind speed (m s^{-1})	0	5.0	10.0	15	20	25.0
Distance travelled by air bubble in 5 minutes (mm)	64	98	129	163	175	151
Rate of water uptake (mm^3 min^{-1})	10.0	15.3	20.2	25.5	27.4	23.7

(i) Using the formula below, calculate the rate of water uptake by the plant in mm^3 min^{-1} at a wind speed of 25 m s^{-1}. [3]

Volume of water = **distance travelled by bubble** x **π** x **radius²** (**π** = 3.14)

radius = 1 ÷ 2 = 0.5 mm

volume in 5 min = 151 × 3.14 × 0.5^2 = 118.5 mm^3

rate = 118.5 ÷ 5

Answer = ... 23.7 ..... mm^3 min^{-1}

(ii) Explain why the rate of water uptake increased as the wind speed increased from 0 to 20 m s^{-1}. [3]

Wind removes water vapour from the leaf surface (removes diffusion shells), increasing the diffusion (water potential) gradient between the inside and outside of the leaf, so more water is lost by transpiration and more is taken up to replace it.

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(c) The results show, that at a wind speed above 20 m s^{-1}, the rate of water uptake by the leafy shoot decreased. One explanation for this decrease could be due to the closure of the stomata by guard cells.

Describe the role of **each** of the following in the operation of guard cells in **closing** stomata.

(i) K^+ (potassium ions). [1]

K^+ ions are actively pumped into guard cells, lowering their water potential to draw water in (opening); for closing, K^+ ions leave, so water leaves by osmosis.

(ii) Water potential of the cells. [1]

Water potential is decreased to draw water in from adjacent cells by osmosis (opening); when it rises, water leaves and the guard cells become flaccid, closing the pore.

(iii) Unevenly thickened cell walls. [1]

The inner wall is thicker (less elastic), so the guard cells bend (curve) differently with changes in turgor; when flaccid they straighten and the pore closes.

(d) Suggest how you could adapt the experimental technique given to determine the location of the highest density of stomata. Predict the results you would expect. [3]

Cover the upper surface of the leaves with Vaseline (grease) on one shoot, and the lower surface of the leaves on another shoot.
Calculate the rate of water uptake for both, using the same wind speed.
Prediction: the rate of water uptake would be lower when the lower surface is covered, as this is where most stomata are.

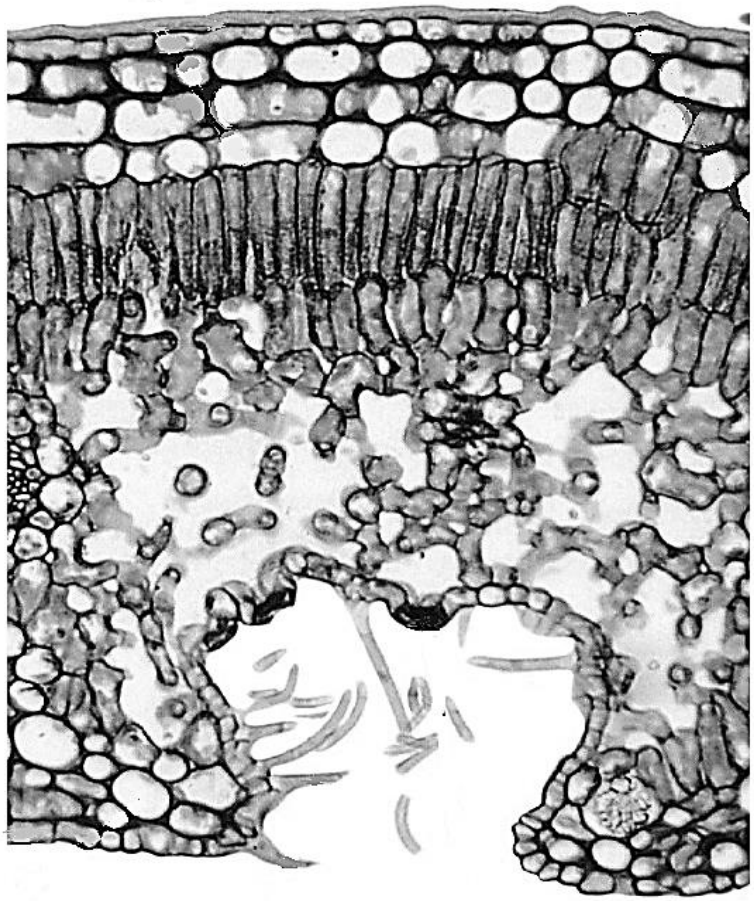
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(e) Many plants are adapted to living in regions of low water availability.

(i) What term is used to describe this type of plant? [1]

Xerophytes

(ii) The photomicrograph below shows a section through a leaf showing a number of adaptations to living in an arid environment.



Identify three features that can be seen in the photomicrograph and explain how each helps the plant to reduce water loss. [6]

Feature 1:

Thick (waxy) cuticle on the upper surface;

reduces evaporation of water from the leaf surface.

Feature 2:

Sunken stomata (in pits);

humid air is trapped outside the stomata, reducing the water vapour diffusion gradient.

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Feature 3:

Hairs surrounding the stomata (on the lower surface):

trap moisture, increasing humidity in the stomatal pit and reducing

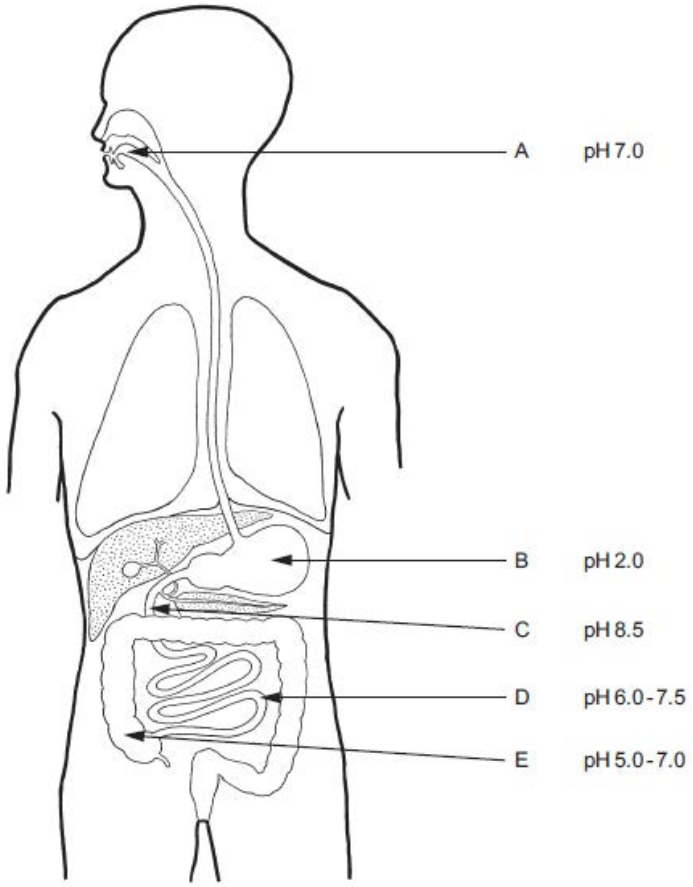
the water potential gradient.

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3. The mammalian gut is divided into several regions, each adapted to carry out different functions. The conditions in each region are different and parasites that inhabit the gut must be able to adapt to these conditions.

The diagram below shows how the pH of the alimentary canal changes in different regions.



(a) Explain the cause of the following:

(i) the increase in pH in region C; [1]

Alkaline secretions (bile from the gall bladder, and mucus from Brunner's glands) neutralise the acid from the stomach.

(ii) the decrease in pH in region D. [2]

Nutrients are digested (and absorbed) into acidic products such as amino acids and fatty acids.

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(b) (i) Using letters from the diagram, identify the regions of the human alimentary canal where you would expect to find the tapeworm *Taenia solium* in an infected person. [1]

C and D

(ii) How is the tapeworm adapted to survive in these regions? [2]

Thick cuticle resists acid pH and host immunity; scolex hooks and suckers attach to the gut wall so it is not removed by peristalsis.

(c) Adult *Taenia solium* usually have about 1 000 proglottids (segments), each of which contains both male and female reproductive systems. A mature proglottid can contain about 50 000 eggs and a mature tapeworm releases an average of six mature proglottids each day. Each tapeworm can survive for about 25 years.

(i) Suggest why *Taenia solium* needs to produce so many eggs. [1]

To increase the chance of infecting a secondary host (pig), as most eggs will die.

(ii) Estimate the number of eggs that could be produced by a single *Taenia solium* during its lifetime. Show your workings and give your answer in standard form to two significant figures. [3]

eggs per day = 50 000 × 6 = 300 000

lifetime = 50 000 × 6 × 365 × 25

= 2 737 500 000

Answer ..... 2.7×10^9 ..... eggs

(d) Explain why both humans and the tapeworm *Taenia solium* are described as being **heterotrophic** but only the human has **holozoic** nutrition. [3]

Both are heterotrophic because they obtain their energy and raw materials (organic molecules) from other organisms.

Holozoic nutrition involves ingesting food and then digesting it internally, as humans do.

Taenia has no gut; it only absorbs pre-digested nutrients from the host's intestine over its body surface.

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(e) The body of an animal, previously unknown to science, was discovered in Papua New Guinea. The passage below describes some of the initial observations made.

"The animal is a mammal approximately 1.2 m long and 0.6 m high. It has sharp upper and lower incisors with well-developed canines; the first pre-molars are sharp with serrated edges while the rear premolars are similar to the molars and have strong ridges. Total gut length is approximately 15.0m (compared to 30.8 m in a sheep and 5.1 m in a dog of similar size). The ratio of body length to intestine length is 1:13 (compared to 1:25 in a sheep and 1:6 in a dog of similar size)."

What conclusion could be reached about the animal's mode of nutrition? Give reasons for your answer. [2]

Most likely an omnivore: sharp incisors, canines and sharp premolars for biting and cutting food indicate animal material in the diet, while the grinding ridges of the rear premolars and molars indicate plant material. Its gut length and ratio of body length to gut length (1:13) are intermediate between the sheep (herbivore) and the dog (carnivore), but closer to the carnivore.

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4. Insects and mammals have both evolved to live in terrestrial environments. One of the main problems they have had to overcome is the absorption of oxygen from the air. To do this both types of organism have evolved internal gas exchange systems.

(a) (i) Name the sites of gas exchange in insects and mammals. [1]

Insects ..(ends of) tracheales.....

Mammals ..alveoli.....

(ii) Explain why insects and mammals have internal gas exchange systems. [2]

To protect the delicate gas exchange surface (from damage).

To reduce water loss (and heat loss) from the moist gas exchange surface.

The table below compares some facts about gas exchange and oxygen transport in insects and mammals.

		Insects	Mammals
% oxygen in air	before gas exchange	21%	21%
	after gas exchange	17 – 18%	13.5 - 16%
Surface Area of gas exchange surface : Volume of body tissue		Very high	High
Association with transport system		None	Close
Haemoglobin required		No	Yes
Maximum thickness of body tissue (approximate value)		20 mm	no limit

(b) Use the information above to evaluate the following statement:
'*The size and shape of insects is limited but that of mammals is not.*' [4]

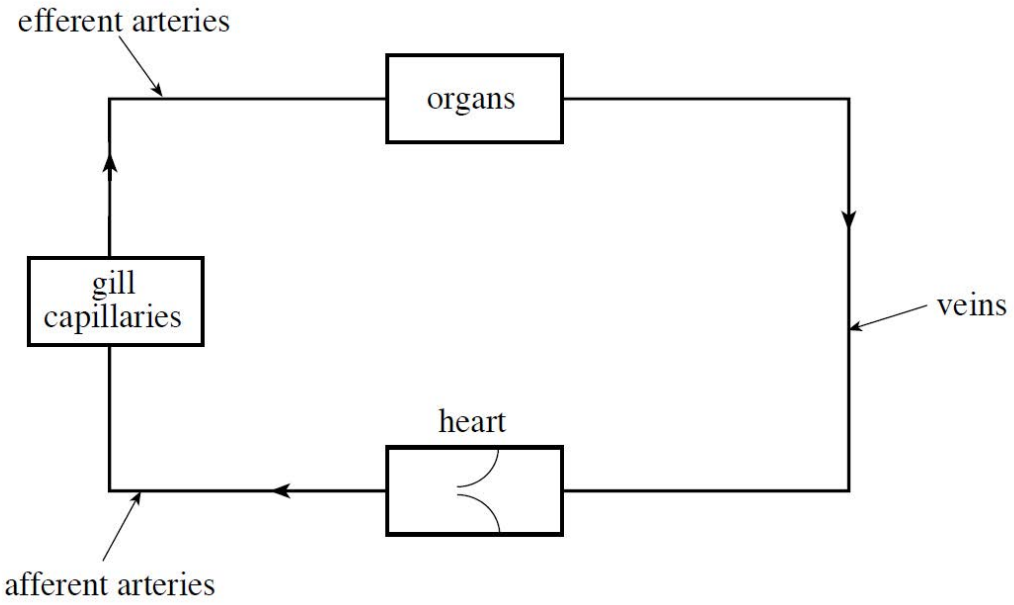
Mammals absorb more O_2 from air than insects (to 13.5 to 16% vs 17 to 18%), so need a smaller SA:volume ratio to absorb enough O_2.

Mammals have a circulatory system to transport O_2 to all tissues; insects rely on diffusion alone, limiting tissue thickness to 20 mm.

Mammalian haemoglobin increases the volume of O_2 absorbed and transported, so the statement is valid.

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The diagram below represents the circulatory system of a fish.



(c) Name the type of circulatory system. [1]

Single (circulation)

(d) Fish have evolved gills that allow gas exchange. Water contains approximately 1% dissolved oxygen but fish are able to absorb about 80% of the available oxygen and remain highly active.

Describe how the structure of their gills enables bony fish to be so efficient at gas exchange. [4]

Gills have a large surface area provided by the many gill filaments and gill lamellae.

Each lamella has an extensive network of blood capillaries (and thin walls, a short diffusion distance).

Blood flows in the opposite direction to the water (countercurrent flow), so a concentration (oxygen) gradient is maintained along the whole length of the capillaries/filament, so oxygen diffuses into the blood all the way along.

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5. In recent years scientists have become increasingly concerned about the global decrease in **biodiversity**. A higher than normal rate of **extinction** caused by humans has been proposed as the main reason for this decrease. In the UK, hedges have been identified as being habitats that have a high biodiversity.

(a) State what is meant by the terms: [2]

biodiversity

The number of species and the number of individuals within each species found in a specified geographical area.

extinction

When all individuals of a species have died, so the species has no living members.

(b) To assess the change in biodiversity the presence of some types of plant growing in a 100 m length of hedge was surveyed in 2000 and again in 2010. Each of these species provide a source of food for a wide variety of animals.

A diversity index was calculated based on the results. These are shown in the table below.

Species (description)	Number of plants present per species	
	2000	2010
Hawthorn dense structure; fairly slow growing; grows to 5 – 14m tall	**37**	**8**
Hazel open structure; grows to 4 – 8 m tall; grows many shoots directly from the roots	**21**	**10**
Ivy a climbing plant that covers the ground and grows up other plants to get light	**36**	**41**
Elder fast growing shrub usually between 3 and 8 m tall	**12**	**50**
Bramble produces long stems but usually does not exceed 2 m in height	**61**	**12**
DIVERSITY INDEX		**0.60**

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(i) Using the formula and the table given below, calculate the Diversity Index for the year 2000 data. [3]

$$\textbf{Diversity Index} = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Where: N = total number of individual plants
n = number of individuals per species
Σ = sum of

Species	*n*	*(n-1)*	*n(n-1)*
Hawthorn	37	36	1332
Hazel	21	20	420
Ivy	36	35	1260
Elder	12	11	132
Bramble	61	60	3660
	N = 167		$\sum n(n-1)$ = 6804
	N-1 = 166		

$N(N-1)$ = 167 × 166 = 27 722

Diversity Index = 1 – (6804 ÷ 27 722) = 0.75

(ii) Many hedges are being removed each year and many are not being maintained as hedges, but are turning into lines of trees with a corresponding change in the biodiversity of the habitat.
Using the information given and the values for the Diversity Index, what conclusions can be made about the change in biodiversity in this hedge? Suggest an explanation for this change. [3]

Biodiversity has decreased, as the diversity index fell from 0.75 in 2000 to 0.60 in 2010.

Elder (fast growing) has increased greatly in number and ivy covers more plants, while hawthorn (dense structure), hazel and bramble have decreased.

The taller elder and ivy cause increased shade, so the other plants cannot get enough light for photosynthesis.

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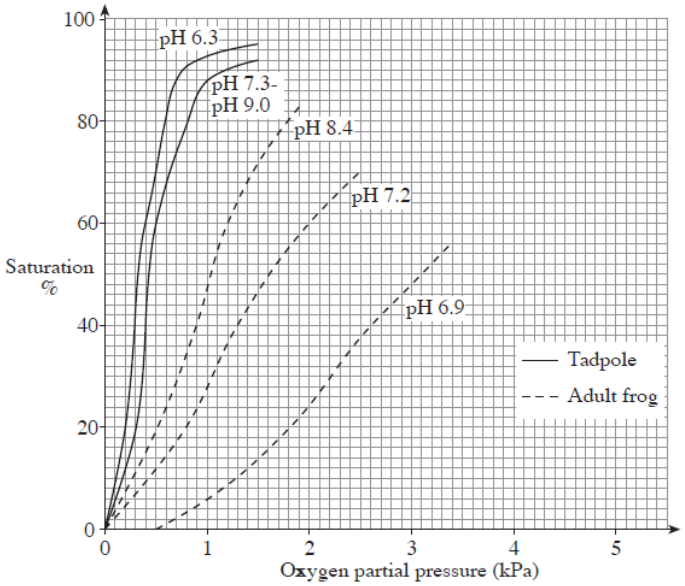
(c) Describe how a sweep net could be used to estimate the Diversity index of insects at the base of a hedge. [3]

Take sweeps at random distances along the base of the hedge, using the same technique at each position (same number of sweeps and net). Classify and count the insects of each species caught and calculate the diversity index.

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6. Frogs have a larval form called tadpoles. As tadpoles, they obtain oxygen from water which has a relatively low oxygen content, but as adults, oxygen is absorbed from the air in simple lungs. This change is accompanied by changes in the properties of the haemoglobin of the larval and adult frogs, which are similar to that observed in foetal and adult humans. Both larval and adult frog haemoglobin can adjust to changing oxygen demands and availability. The graph below shows the effect of pH on haemoglobin from tadpole and adult frogs.



With reference to the information provided, explain how the properties of haemoglobin enable tadpoles and frogs to gain the oxygen required for survival. (The quality of extended response will be assessed in this question.)

[9QER]

Tadpole haemoglobin has a higher affinity for oxygen than adult frog haemoglobin, so at a given partial pressure of oxygen it reaches a higher percentage saturation. This is shown on the graph because, at any pH, the dissociation curves for tadpole haemoglobin lie to the left of those for adult frog haemoglobin and reach a higher % saturation (over 90%).

Tadpoles live in water, which has a low pO_2. A high oxygen affinity enables the tadpole to load its haemoglobin with oxygen and absorb oxygen more efficiently than an adult frog could at the same low pO_2.

Adult frogs breathe air with simple lungs. Air has a much higher pO_2 than water, so adult frog haemoglobin does not need such a high affinity for oxygen and can still become well saturated in the lungs.

However, because of its higher oxygen affinity, tadpole haemoglobin does not dissociate and release oxygen as easily. The graph shows that the % saturation of

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tadpole haemoglobin does not fall (dissociation does not occur) until pO_2 is very low, whereas the % saturation of adult frog haemoglobin falls at a much higher pO_2. So adult haemoglobin dissociates more easily, due to its lower affinity, releasing oxygen readily to the respiring tissues of an active adult.

To meet changing oxygen needs, adult frog haemoglobin dissociates more easily as pH decreases: the curves shift to the right from pH 8.4 to pH 7.2 to pH 6.9.

The fall in pH is caused by an increase in pCO_2 released during respiration (carbon dioxide forms carbonic acid). This is the Bohr effect (Bohr shift), and it enables the adult frog to increase the oxygen supplied to its muscles and tissues when oxygen demand increases, e.g. during activity.

Tadpole haemoglobin shows the opposite effect: as pH decreases from the pH 7.3 to 9.0 range to pH 6.3, its oxygen affinity increases and the curve moves to the left. This enables the tadpole to absorb more oxygen if the pO_2 of the water falls, i.e. if the water it lives in becomes more anaerobic (stagnant water also has a lower pH due to more CO_2).

As a result, even when oxygen levels in the water become low, the tadpole is still able to absorb enough oxygen for aerobic respiration, while the adult frog, with plentiful oxygen in air, benefits from haemoglobin that unloads oxygen readily where it is needed. Therefore the different properties of the two haemoglobins are adaptations to the different oxygen availability and demands of the larval and adult habitats.

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