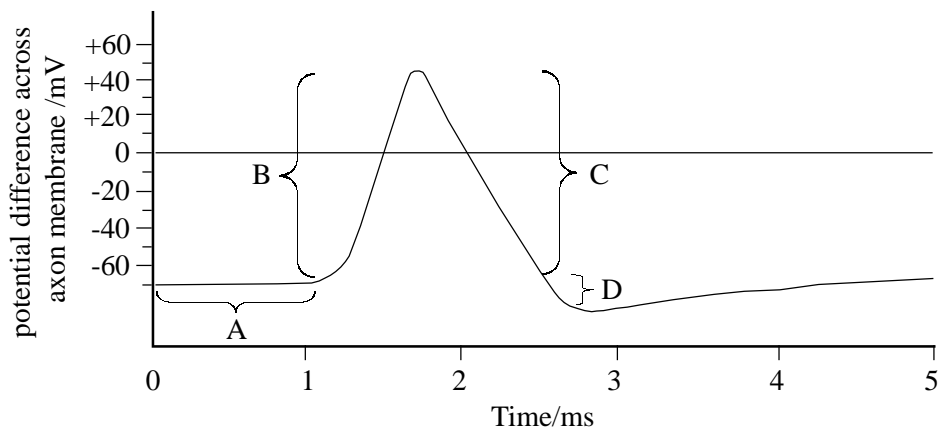


The diagram below represents an action potential in a nerve cell axon as seen on an oscilloscope.



(a) Give the membrane potential state for the regions labelled A, B, C and D

- A: .....
- B: .....
- C: .....
- D: ..... [4]

(b) Describe the potential difference across the membrane in the region A.

- .....
- ..... [2]

(c) Describe the processes which bring about this potential difference.

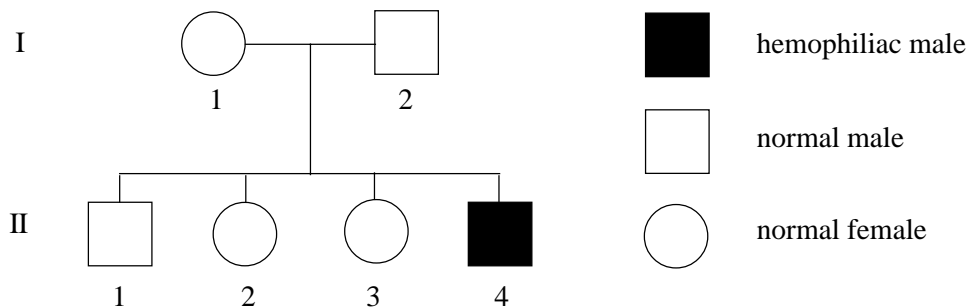
- .....
- .....
- .....
- ..... [4]

(d) Explain why aerobic respiration is important in the transmission of nerve impulses.

- .....
- .....
- .....

[3]

A recessive sex-linked allele, h, causes haemophilia. The pedigree below shows two generations in a family with the haemophilia allele in its gene pool.



(a) (i) If individual II 2 marries a normal man, give a full explanation for the probability of her first child being a haemophiliac boy.

.....

.....

.....

.....

.....

[6]

(ii) If the mother of I 1 was normal (not a carrier), what is the genotype of her father?

.....

[1]

(b) Colour blindness is another sex-linked trait determined by the recessive allele, c. A woman whose mother was not a carrier for either colour blindness or haemophilia produced a son who was both colour blind and haemophiliac.

(i) State the phenotype and genotype of her husband.

phenotype: .....

genotype: .....

[2]

(ii) This woman's daughter married a normal husband and produced a son who was colour blind but not haemophiliac. Suggest an explanation for this.

.....

.....

.....

[3]

In rabbits, coat colour is controlled by a multiple allelic system. The allele C allows full colour (dark grey) to develop. The allele c<sup>ch</sup> when homozygous produces chinchilla (silver grey) fur but when heterozygous with alleles lower in the dominance hierarchy produces light grey fur. The allele c<sup>h</sup> produces a white rabbit with black extremities called Himalayan when homozygous or when heterozygous with the allele c. The allele c when homozygous produces an albino rabbit.

The dominance hierarchy is C > c<sup>ch</sup> > c<sup>h</sup> > c

(a) State the genotypes that will produces full colour.

genotypes: ..... [1]

(b)(i) Explain why c<sup>ch</sup> c<sup>ch</sup> is the only genotype to produce chinchilla fur.

..... [2]

(ii) Explain why light grey rabbits never breed true.

..... [2]

(c) Determine the phenotypic ratios expected from mating full coloured males of genotype Cc<sup>ch</sup> to light grey females of genotype c<sup>ch</sup>c. Show your working.

[4]

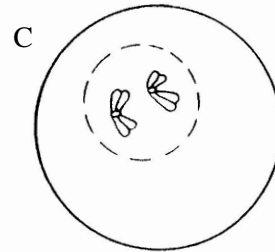
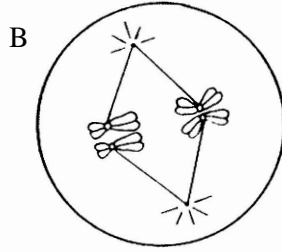
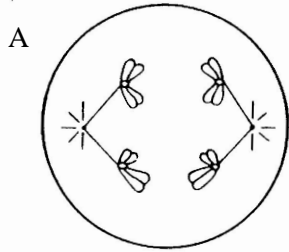
(d) All rabbits are born naked. When Himalayan rabbits develop their first coat in the nest, they are completely white. Adults kept in cool conditions develop more extensive black fur. Suggest why the black extremities only develop in older rabbits.

..... [3]

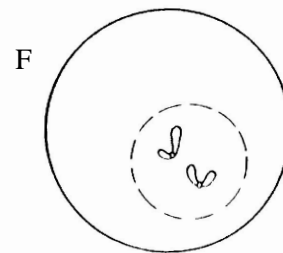
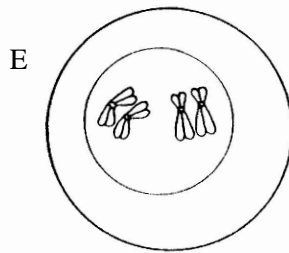
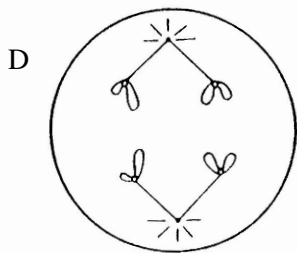
(a) Meiosis is also known as reduction division. What is the meaning of reduction division?

..... [1]

(b) The diagrams, A to F, below represent different stages in meiosis taking place in an individual with two pairs of chromosomes. Identify the meiotic stage represented by each diagram.



A: ..... B: ..... C: .....



D: ..... E: ..... F: .....

[6]

(c) Suggest three ways in which meiosis may give rise to variation in the offspring of a cross.

.....  
 .....  
 ..... [3]

(d) In an individual with three pairs of homologous chromosomes lettered A and a, B and b, C and c, how many different haploid cells will be produced by meiosis. Explain your answer.

.....  
 .....  
 ..... [3]

(e) A horse has a diploid complement of 60 chromosomes. A donkey has a diploid complement of 66 chromosomes. A mule is produced by mating a male donkey to a female horse.

(i) What would be the chromosome number in the mule produced by this mating?

..... [1]

(ii) Suggest two reasons why a mule is infertile.

.....  
 ..... [2]

The term variation describes the difference in characteristics shown by organisms of the same species. It occurs in two forms, continuous and discontinuous.

(a) Distinguish between continuous and discontinuous variation.

.....

.....

.....

.....

.....

.....

[6]

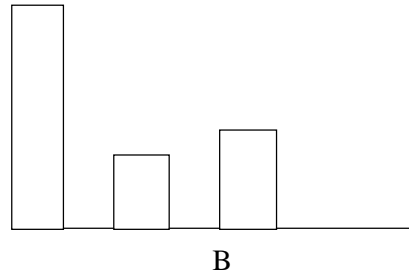
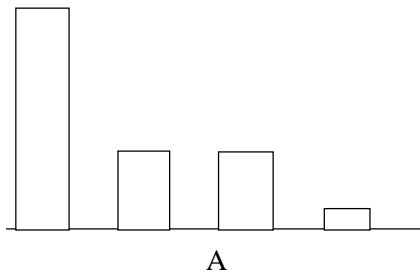
(b)(i) Explain what is meant by epistasis.

.....

.....

[2]

(ii) The histograms, A and B, below show two examples of discontinuous variation in the offspring produced by parents each heterozygous for two pairs of unlinked alleles.



Which histogram represents an example of epistasis?

.....

[1]

(c) Height in human beings shows continuous variation. Draw a histogram which would represent height frequencies in a human population.

[3]

(d) The average height of the population in Britain at the end of the twentieth century is greater than it was at the end of the nineteenth century.

(i) Suggest why this effect is more likely to be environmental than genetic.

.....  
.....

[1]

(ii) Suggest possible environmental reasons for this change.

.....  
.....

[2]

(a) The dominant allele, B, of the gene for coat colour in guinea pigs produces a black coat. The recessive allele, b, produces a white coat. A test cross between a black female guinea pig with a white male gave 3 black offspring and 2 white.

(i) What is meant by the term 'test cross'?

.....  
.....

[2]

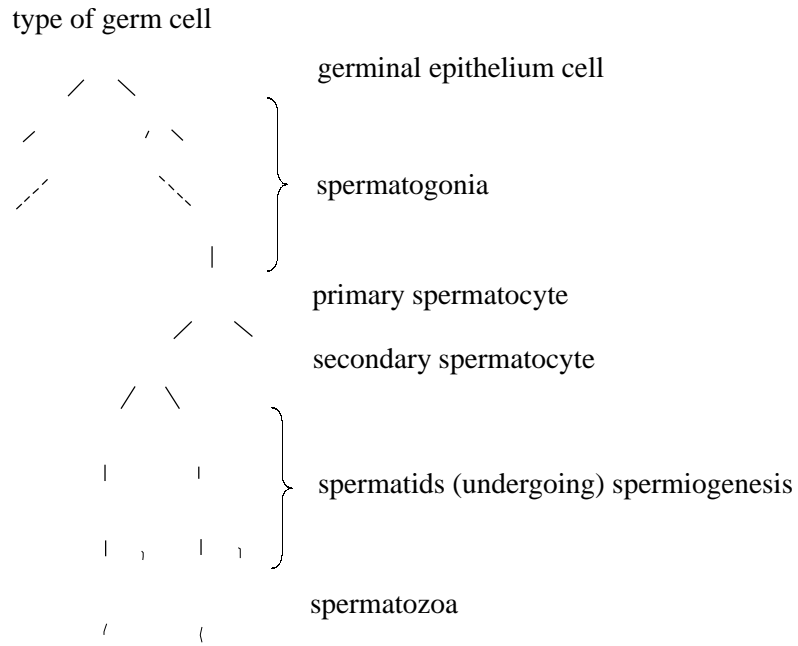
(ii) One of the black females from this cross was mated with a white male. What would be the expected genotypic ratio of the offspring from this cross with respect to coat colour? Show your working.

[5]

(b) A pair of heterozygous black guinea pigs are crossed and produce three offspring. What is the probability of the offspring being 2 black and 1 white? Show your working.

[5]

The diagram below shows the process of spermatogenesis.



(a) By means of labelled arrows, show where meiosis I and meiosis II occur. [2]

(b) State why both mitosis and meiosis are involved in the process.

.....  
..... [2]

(c) Explain the importance of meiosis in sexual reproduction.

.....  
.....  
.....  
..... [4]

(d) Give three differences between spermatogenesis and oogenesis.

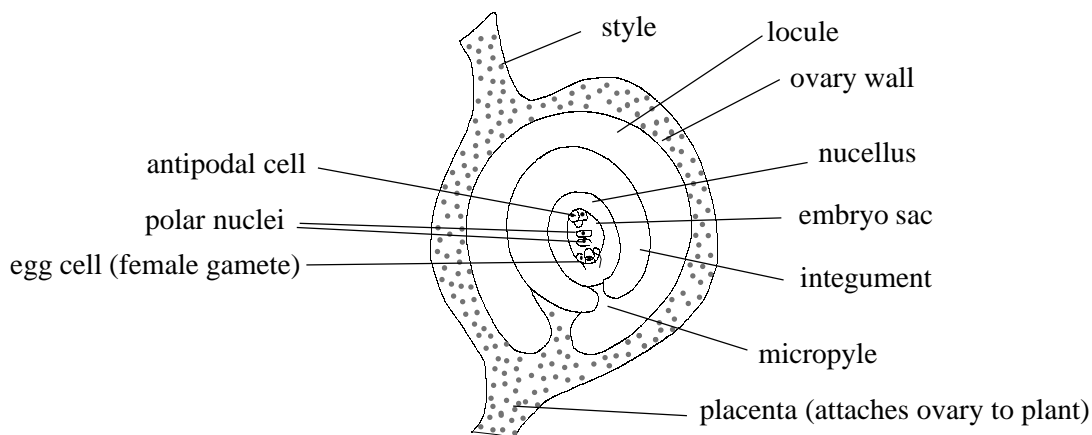
.....  
.....  
..... [3]

(e) Suggest why Sertoli cells contain large amounts of smooth endoplasmic reticulum, Golgi body and mitochondria.

.....  
.....  
.....  
..... [4]



The diagram below shows the structure of a mature carpel of a flowering plant.



(a) How many of the eight nuclei in the embryo sac will degenerate?

..... [1]

(b) Describe the fate of each of the other nuclei.

.....  
 ..... [2]

(c) Describe the sequence of changes involving a pollen grain nucleus after the formation of a tetrad of pollen grains.

.....  
 .....  
 ..... [3]

(d) Seeds need to contain large food reserves for the developing embryo. Suggest three disadvantages caused by this necessity.

.....  
 .....  
 ..... [3]

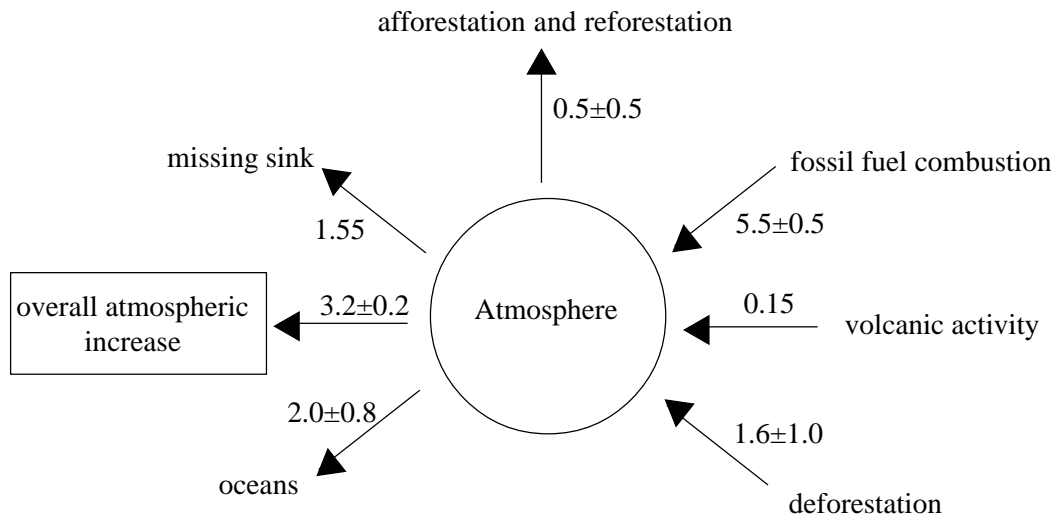
(e) Give three similarities between sexual reproduction in flowering plants and mammals.

- 1: ..... [1]
- 2: ..... [1]
- 3: ..... [1]

(f) Give three differences between sexual reproduction in flowering plants and mammals.

- 1: ..... [1]
- 2: ..... [1]
- 3: ..... [1]

The diagram below shows the fluxes of carbon into and out of the atmosphere.



(a) Explain why afforestation and reforestation help reduce atmospheric carbon dioxide levels.

..... [1]

(b) Many scientists believe that the temperature of the lower atmosphere is increasing because of the ‘enhanced green house effect’.

(i) Explain what is meant by the term ‘enhanced green house effect’.

.....  
 .....  
 ..... [3]

(ii) Suggest why the enhanced greenhouse effect may result in further temperature increases through positive feedback.

.....  
 .....  
 .....  
 ..... [4]

(c) Suggest two ways, other than afforestation and reforestation, by which CO<sub>2</sub> addition to the atmosphere may be reduced.

1. ....
2. ....

[2]

(a) (i) Define the term 'biodiversity'.

.....  
 ..... [2]

(ii) Why is it considered important to maintain diversity?

.....  
 ..... [2]

(iii) Global warming may accelerate the loss of biodiversity. Suggest two reasons why biodiversity loss may be accelerated by global warming.

1. ....  
 .....  
 2. ....  
 ..... [2]

(b) A student carried out an investigation to compare the number and types of invertebrates, found in leaf litter, in a deciduous oakwood and a coniferous pine forest. The results are shown below.

Species	Number of organisms recorded (n)	
	Deciduous litter	Coniferous litter
A	3	7
B	0	14
C	21	8
D	17	3
E	8	1
F	7	1
G	18	0
H	10	0
I	11	2
J	4	12
K	15	0
L	9	5
Total(N)	123	
Species diversity index (d)	9.40	

The species diversity index (d) can be calculated using the formula:

$$d = \frac{N(N - 1)}{\sum n(n - 1)}$$

N = total number of organisms of all species.

n = total number of organisms of each species.

The values for the deciduous oakwood have been calculated and shown in the table.

(i) Calculate the values of N and d for the coniferous forest. Write your answers in the table. [2]

(ii) Comment on the differences shown in the biodiversity of invertebrates in the two habitats.

.....  
.....  
.....  
..... [3]

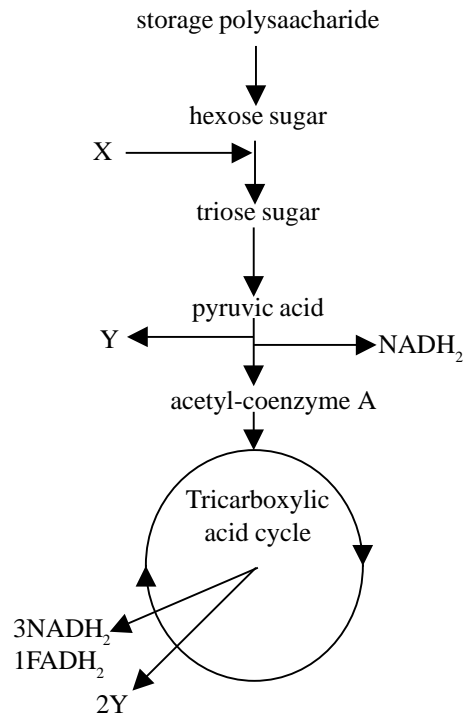
(iii) Suggest reasons for the differences shown in invertebrate diversity in the two habitats.

.....  
.....  
.....  
..... [3]

(c) With reference to biodiversity, explain why is it important to maintain the purity of the water in river systems?

.....  
.....  
.....  
..... [3]

The diagram below shows a summary of cellular respiration.



(a) Name the main polysaccharide stored in:

1. plants: ..... 2. animals: ..... [2]

(b) (i) Name the process by which the hexose sugar is converted to pyruvic acid.

..... [1]

(ii) Where in the cell does this process occur?

..... [1]

(iii) Name substance X and say why it is used in the process.

Name: ..... [1]

Why used: .....

..... [2]

(iv) Name substance Y.

..... [1]

(c) Name the compounds formed from pyruvic acid, in:

(i) fermentation by yeast cells.

..... [1]

(ii) skeletal muscle cells in oxygen debt.

..... [1]

(d) (i) Name the class or type of enzyme responsible for producing the reduced molecules of NAD and FAD.

..... [1]

(ii) Explain what happens to the  $\text{NADH}_2$  and  $\text{FADH}_2$  produced by these reactions.

.....  
.....  
.....  
.....  
..... [4]

(e) The energy change for the complete oxidation of glucose is  $2800\text{kJoule mole}^{-1}$ . The conversion of ADP to ATP requires approximately  $30\text{kJ mole}^{-1}$ . The efficiency of coupling respiration and ATP synthesis is 41%. Calculate the number of ATP molecules which can be synthesised from ADP and phosphate by the complete oxidation of one mole of glucose. Show your working.

Answer: ..... [3]

Skeletal muscle fibres were homogenised and separated into fractions by differential ultracentrifugation. Samples of the fractions were incubated with either (i) glucose or (ii) pyruvic acid. The samples tested were mitochondria, mitochondria with added cyanide and cytoplasmic residue. Tests were made for the production of carbon dioxide and lactate in each sample. The results are shown in the table below.

Cell fraction	Incubated with glucose		Incubated with pyruvate	
	CO <sub>2</sub>	Lactate	CO <sub>2</sub>	Lactate
Mitochondria	absent	absent	produced	absent
Mitochondria and cyanide	absent	absent	absent	absent
Cytoplasmic residue	absent	produced	absent	absent

(a) What do you understand by the terms:

(i) homogenisation.

..... [1]

(ii) differential centrifugation.

..... [2]

(iii) Suggest a precaution that should be taken when preparing the fractions from the muscle.

..... [1]

(b) Explain the results obtained with:

(i) The mitochondria (without cyanide).

..... [3]

(ii) The cytoplasmic residue.

..... [3]

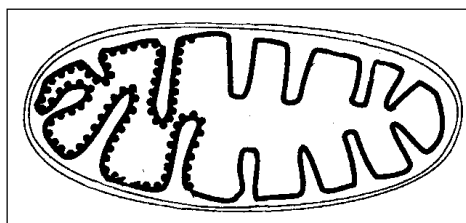
(iii) The mitochondria with cyanide.

..... [3]

(c) The diagram below shows a mitochondrion in sectional view. Insert the arrows to the correct structures from the surrounding labels.

site of oxidative phosphorylation

position of cytochrome oxidase



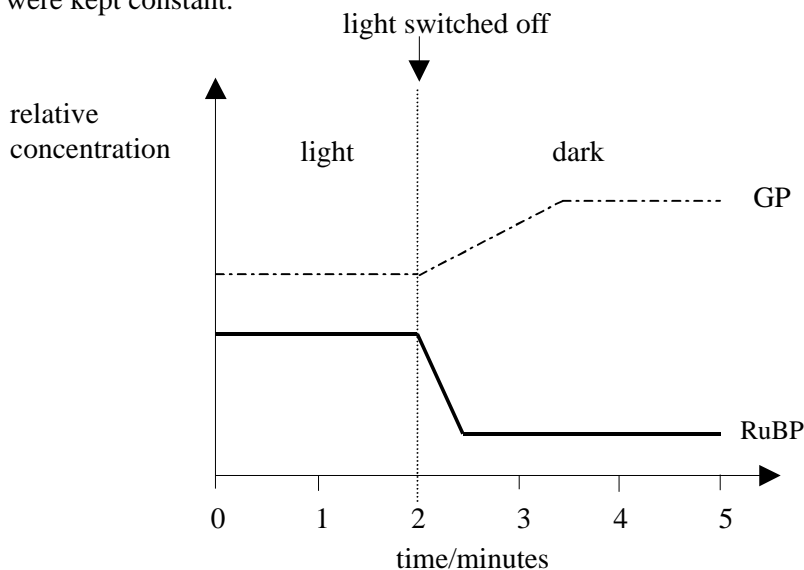
site of TCA cycle

site where H<sup>+</sup> accumulates

site of glycolysis

[5]

The graph shows changes in the relative concentrations of ribulose biphosphate (RuBP) and glycerate-3-phosphate (GP) produced in the light independent stage of photosynthesis before and after the light is switched off. All other conditions were kept constant.



(a) (i) What part of the chloroplast is responsible for carrying out the light independent reaction (Calvin cycle)?

..... [1]

(ii) What products of the light dependent reaction are used in the light independent cycle?

..... [2]

(iii) Name the enzyme in the chloroplast which is responsible for CO<sub>2</sub> fixation.

..... [1]

(b) Outline the main steps of the light independent reaction.

.....  
 .....  
 .....  
 ..... [4]

(c) Explain the changes in the relative concentrations of GP and RuBP after the light is switched off.

.....  
 .....  
 .....  
 ..... [4]

(d) What effect would raising the CO<sub>2</sub> concentration at 4 minutes have on the concentrations of RuBP and GP? Explain your answer.

.....  
 ..... [2]



The equation below represents Ficks' first law of diffusion.

$$J = DA \frac{\Delta C}{\Delta x}$$

- where J = net rate of diffusion
- D = diffusion coefficient of the dissolving solute in the membrane (constant)
- A = area of the membrane
- $\Delta C$  = concentration difference across the membrane
- $\Delta x$  = thickness of the membrane

(a) Use Fick's law to explain why:

(i) columnar epithelium cells on the villi of the small intestine possess a brush border of microvilli.

.....

.....

..... [3]

(ii) the walls of lung alveoli are made of pavement epithelium cells.

.....

.....

..... [3]

(b) Absorption across some membranes enables molecules to be taken up against the concentration gradient.

(i) With reference to a specific example, explain how this can be achieved.

.....

.....

.....

..... [4]

(c) Suggest reasons for:

(i) The impairment of salt uptake by roots from the soil, after the roots have been immersed in a dilute solution of cyanide.

.....

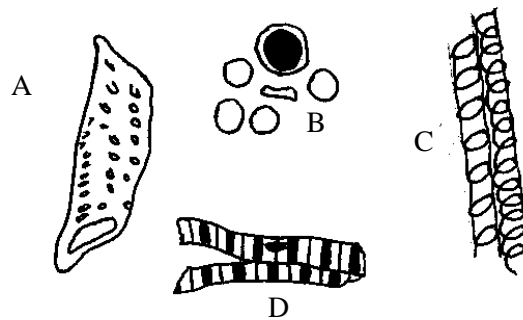
..... [2]

(ii) The absence of proteins in normal urine.

.....

..... [2]

Some students investigated the feeding habits of magpies. They collected samples of the magpies' droppings which they broke up into small pieces and then placed in water, on a microscope slide, so that small fragments in the droppings would float out and become visible when viewed under the light microscope. The drawing below shows some of the tissue and cell fragments which were seen.



(a) (i) Identify fragments A to D.

A: ..... B: .....

C: ..... D: ..... [4]

(ii) Classify the magpie as a carnivore, herbivore or omnivore. Explain your answer.

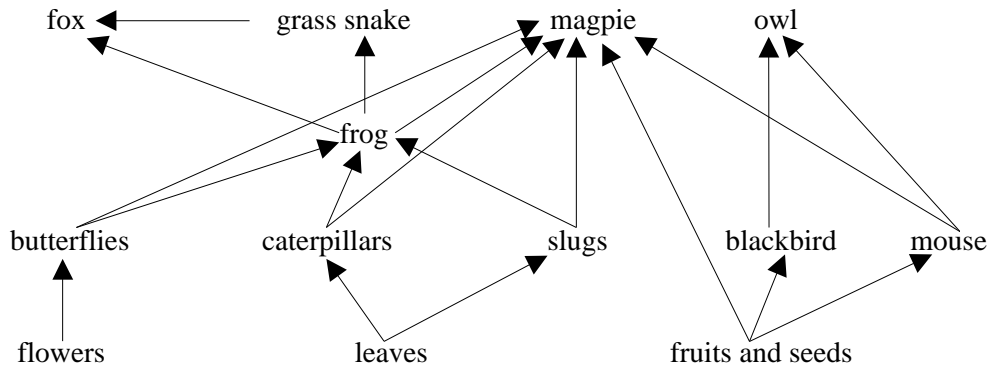
.....  
 ..... [2]

(iii) Suggest two reasons why the tissue fragments were not digested by the magpies' digestive systems.

1. ....

2. .... [2]

(b) The diagram shows part of a food web from a woodland environment.



(i) Give an example of a food chain in this web that has:

- two trophic levels. .... [1]
- three trophic levels. .... [1]
- four trophic levels. .... [1]
- five trophic levels. .... [1]

(ii) Name the trophic levels into which the magpie fits.

..... [1]

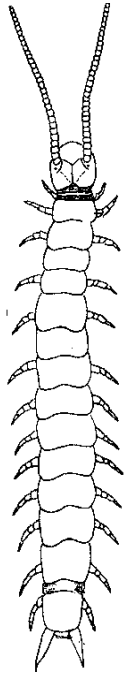
(iii) Explain why it is unusual for a food chain to have more than five trophic levels.

.....

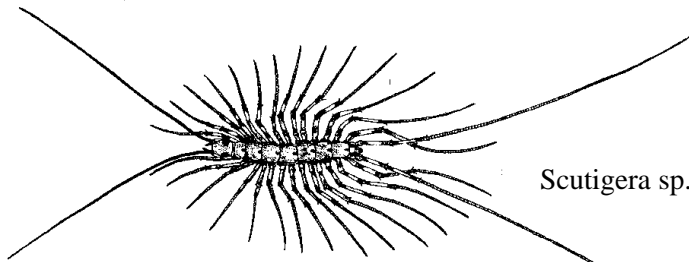
.....

..... [3]

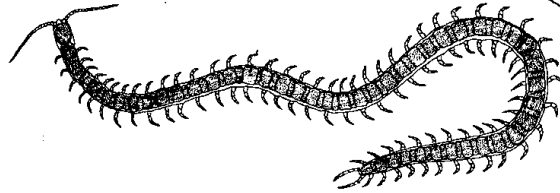
The drawings show five different genera of Myriapoda (centipedes and millipedes). Devise a dichotomous key which would enable the five organisms to be identified. Only use features that can be seen in the drawings.



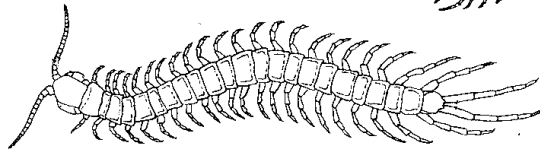
Scutigera sp.



Scutigera sp.



Scolopendra sp.



Otocryptops sp.



Iulus sp.

A student carried out an investigation into whether alcohol consumption was a factor in determining whether people who were trying to give up smoking relapsed back into the smoking habit. Altogether the student surveyed a total of 200 smokers (who had smoked more than 10 cigarettes per day) who had tried to give up smoking. The results are shown in the table.

Alcohol consumption	Relapsed and restarted smoking	Did not restart smoking	Total
No	54	88	
Yes	40	18	
Total			200

The student proposed the null hypothesis that ‘the drinking of alcohol did not increase the proportion of ex-smokers who relapsed into the smoking habit’. A Chi<sup>2</sup> ( $\chi^2$ ) test was performed to decide whether the null hypothesis was true. The formula for calculating  $\chi^2$  is:

$$\chi^2 = \sum \frac{(O - E)^2}{E} \quad \text{where} \quad \begin{array}{l} O = \text{observed results and} \\ E = \text{expected results} \end{array}$$

(a) (i) Complete the table of observed results above by writing the totals in the empty boxes. [1]

(ii) The expected numbers may be calculated by the formula:

$$E = \frac{\text{Row total}}{\text{Total}} \times \frac{\text{Column total}}{\text{Total}} \times \text{Total}$$

Complete the following contingency table of expected results.

Alcohol consumption	Relapsed and restarted smoking	Did not restart smoking
No		
Yes		

[4]

(iii) Calculate the value of  $\chi^2$ . Show your working.

Answer  $\chi^2 = \dots\dots\dots$  [2]

(iv) The number of degrees of freedom (n) is given by the equation:

$$n = (\text{no of rows} - 1)(\text{no of columns} - 1)$$

How many degrees of freedom are there?

..... [1]

(v) The critical value for  $\chi^2$  with these degrees of freedom is 3.84 at the 0.05 probability level. Does the calculated value enable the null hypothesis to be accepted or rejected? Explain your answer.

..... [2]

(b) (i) As a result of these findings what advice should be offered to people who are trying to give up smoking?

.....  
..... [1]

(ii) Smoking and drinking alcohol to excess can lead to the development of disease. Name:

Two diseases associated with smoking.

1. ....  
2. .... [2]

One disease associated with high alcohol intake.

..... [1]

The table below shows the results of an experiment on the effects of temperature on the production and use of sugars in the leaves of a plant kept in high light intensity.

Temperature/°C	Rate of sugar production or use/arbitrary units		Net gain or loss of sugar/arbitrary units
	Photosynthetic gain	Respiratory loss	
0	0	2	
10	36	4	
15	42	5	
20	72	6	
25	80	8	
30	48	16	
40	12	30	
50	0	10	
60	0	0	

(a) (i) Work out the net gain or loss of sugar at each temperature and write the figures in the appropriate box on the table. [2]

(ii) Plot the data in the table in a suitable graphical form. [5]

(b) (i) State the approximate optimum temperatures for,  
 photosynthesis: .....

respiration: ..... [2]

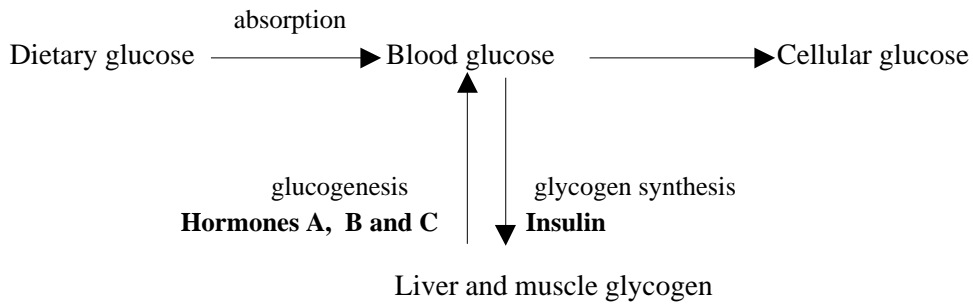
(ii) Use the graph to determine the temperature at which the rates of respiration and photosynthesis are the same.  
 ..... [1]

(iii) With reference to the data provided, explain why it is important for the plant to be able to photosynthesise more efficiently than respiration, at normal daily temperatures?  
 .....  
 .....  
 ..... [3]

(c) (i) Define the term 'compensation point'.  
 .....  
 ..... [2]

(ii) Why is it important to woodland herbaceous plants to have low compensation points?  
 .....  
 ..... [2]

The diagram shows the interchange of glucose and glycogen in the body.



(a) (i) How is dietary glucose absorbed through the intestinal villi to the blood?

.....  
 ..... [2]

(ii) Briefly describe the chemical nature of glycogen and properties that make it an ideal storage compound.

.....  
 .....  
 .....  
 ..... [4]

(iii) Suggest why the concentration of blood glucose is constantly maintained in the range 3.5 to 5.4 millimoles  $\text{dm}^{-3}$ ?

.....  
 ..... [2]

(iv) The interchange of glucose and glycogen is regulated by hormones. Name hormones A, B and C.

A: ..... B: ..... C: ..... [3]



(b) Non-insulin-dependent diabetes mellitus is caused by a failure of cells to respond adequately to insulin even though the body produces it. Injections of insulin have little or no effect. Clinical symptoms are not usually as severe as in insulin-dependent (juvenile) diabetes, but do include hyperglycaemia (raised blood glucose concentration) and glycosuria (glucose in the urine).

(i) Name the cells which release insulin.

..... [1]

(ii) Suggest and explain a possible cause for non-insulin-dependent diabetes.

.....  
..... [2]

(iii) The proximal tubule cells in the nephrons normally prevent glucose loss in the urine. State two ways in which they are adapted for this function.

- 1. ....
- 2. .... [2]

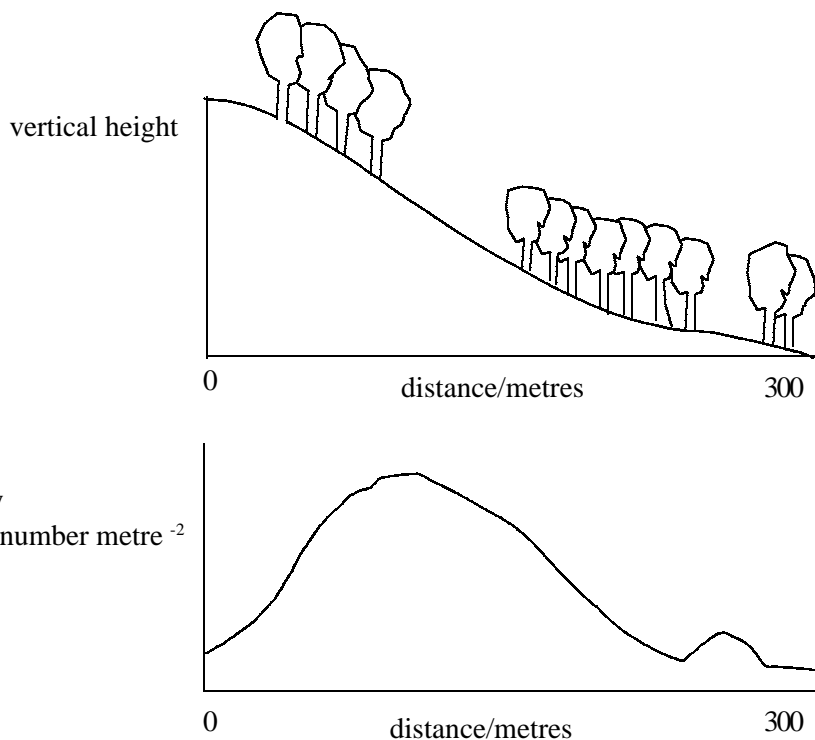
(iv) Explain why glycosuria may occur in diabetes.

.....  
..... [2]

(c) In order for blood glucose concentration to be regulated it must be sensed by the body. Briefly explain how the body senses and responds to changes in blood glucose concentration.

.....  
.....  
.....  
..... [4]

The diagram and graph below shows the distribution of seedlings of the Capulin Cherry tree (*Prunus capuli*) on a wooded hillside in Mexico. Part of the hillside had been deforested.



(a) (i) Describe how the distribution of the *P. capulin* seedlings could have been measured.

.....

.....

.....

.....

.....

.....

.....

..... [5]

(ii) Describe the distribution pattern of the *P. capulin* seedlings.

.....

.....

.....

.....

..... [3]

(iii) Suggest and explain three reasons to account for the distribution of the *P. capulin* seedlings.

- 1. ....  
.....
- 2. ....  
.....
- 3. ....  
..... [6]

(b) *Prunus capuli* is also known as the Tropical Cherry. The tree has white blossom and the fruit's skin has a deep maroon colour. The fruit flesh is green and is good to eat fresh or in preserves. It can also be propagated by grafting. It is being developed as a crop plant in Israel and New Zealand.

Suggest three features, other than features stated above, that it would be ideal for *P. capuli* to possess to enhance its value as a crop plant.

- 1. ....
- 2. ....
- 3. .... [3]