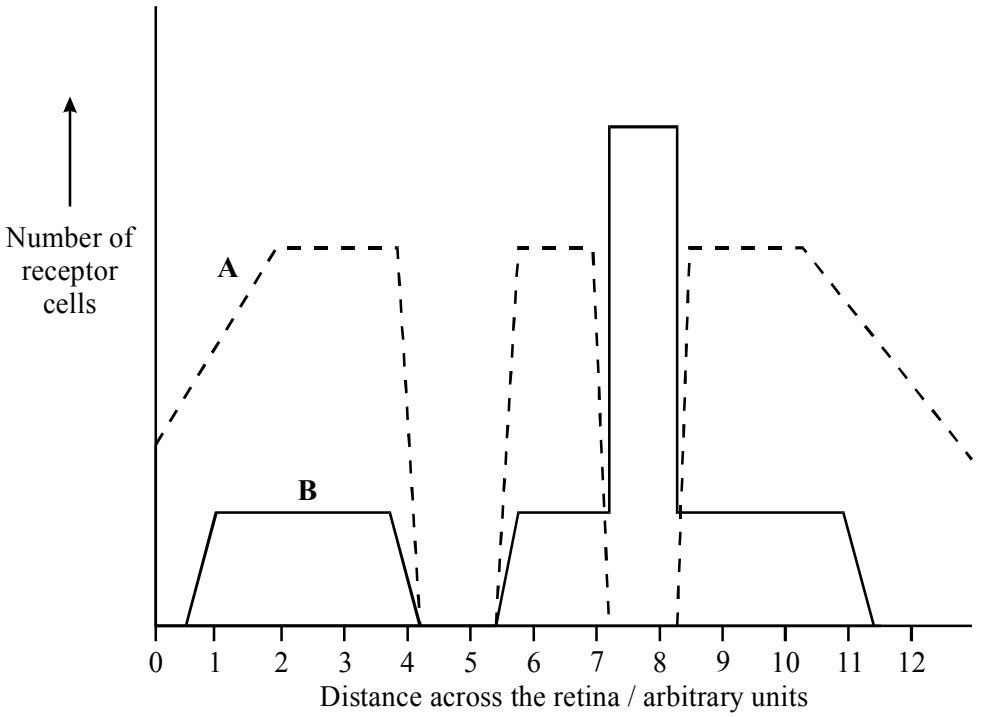
1. The graph represents the number of receptor cells (types **A** and **B**) found along a horizontal line across the human retina.



(a) Name the two different types of receptor cell.

A .....

B .....

(1)

(b) Name the region of the retina at position 8.

.....

(1)

(c) Explain why an object may be seen in greater detail if the image is focused at position 8, rather than at position 12.

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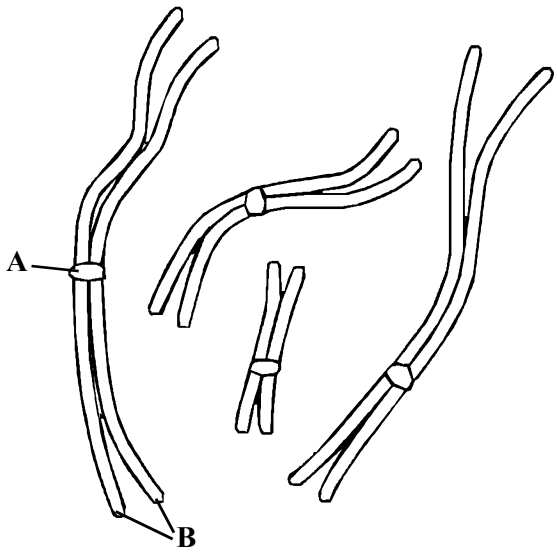
(2)

(Total 4 marks)

2. The diagram shows the chromosomes in the nucleus of a plant cell at a certain stage of meiosis.



(a) (i) Name the structure labelled **A**. .....

(1)

(ii) Describe the function of structure **A** during the separation of chromosomes.

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(1)

(b) Name the structures labelled **B**.

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(1)

(c) Is the nucleus shown haploid or diploid? Explain your answer.

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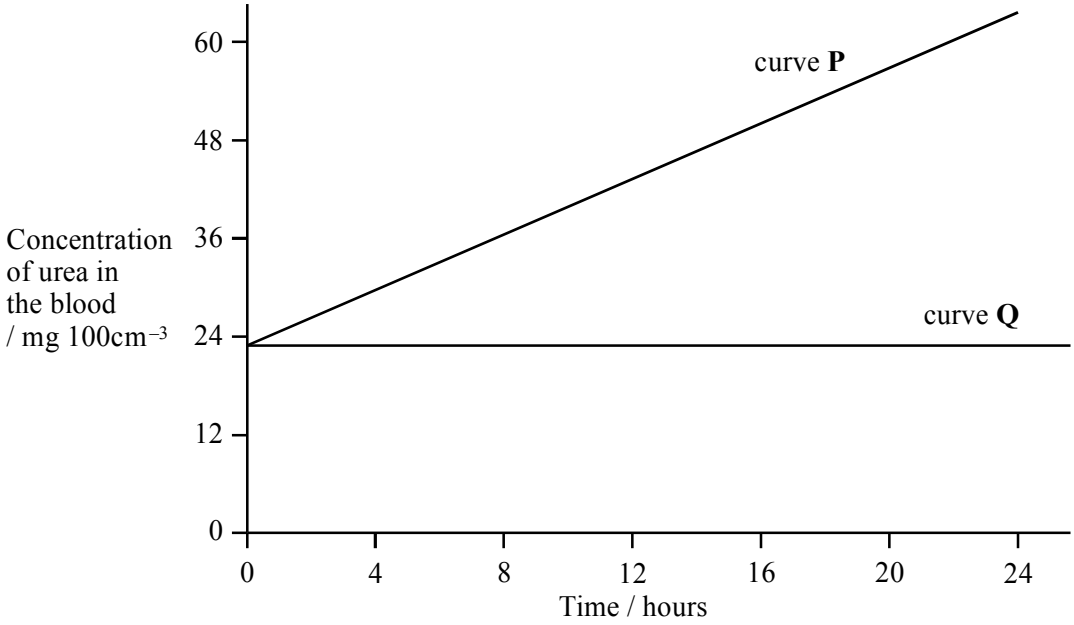
(1)

(Total 4 marks)

3. The graph shows the concentration of urea in the blood of a mammal after the kidneys stopped working (**P**) and after both the kidneys and the liver stopped working (**Q**).



(a) Explain how the evidence from the graph shows **one** function of

(i) the kidneys;

Function .....

Evidence from graph .....

.....

(1)

(ii) the liver.

Function .....

Evidence from graph .....

.....

(1)

(b) On the graph, draw the curve you would expect if the liver stopped working at time 0, and the kidneys stopped working 12 hours later.

(2)

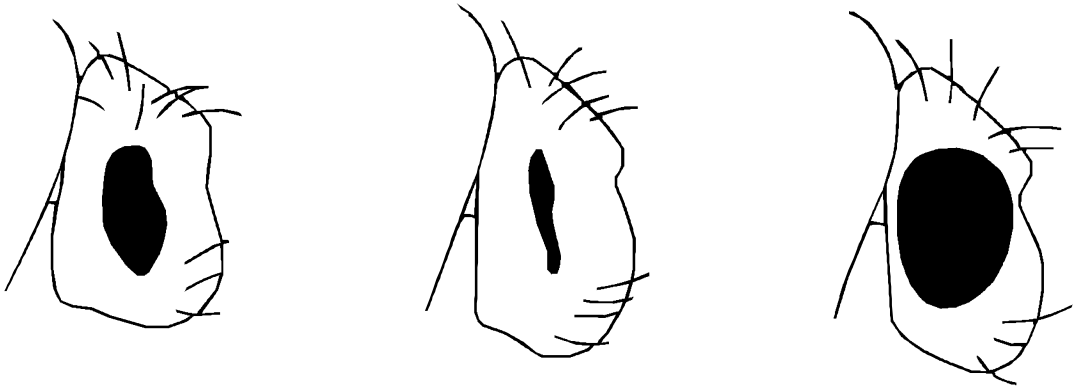
(Total 4 marks)

4. In a species of fruitfly, females have two X chromosomes, and males have an X and a Y chromosome.

A gene controlling eye shape in fruitflies is sex-linked, and found only on the X chromosome. This gene has two alleles, **R** for round eyes and **B** for bar eyes.

A homozygous, round-eyed female ($X^R X^R$) was crossed with a bar-eyed male. In the offspring (Offspring 1), all the female offspring had wide bar eyes (intermediate in size) and all the males had round eyes.

The figure shows the head of three fruitflies



Wide bar eye

Bar eye

Round eye

(a) Name the relationship between the two alleles that control eye shape.

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(1)

(b) Give the genotype of the male parent.

.....

(1)

(c) Offspring 1 were allowed to interbreed. Complete the genetic diagram to show the phenotypic ratio you would expect in the resulting Offspring 2.

Parental phenotypes	Round-eyed female	Bar-eyed male
Parental genotypes	$X^R X^R$	

Offspring 1 phenotypes	Wide bar-eyed female	Round-eyed male
Offspring 1 genotypes		

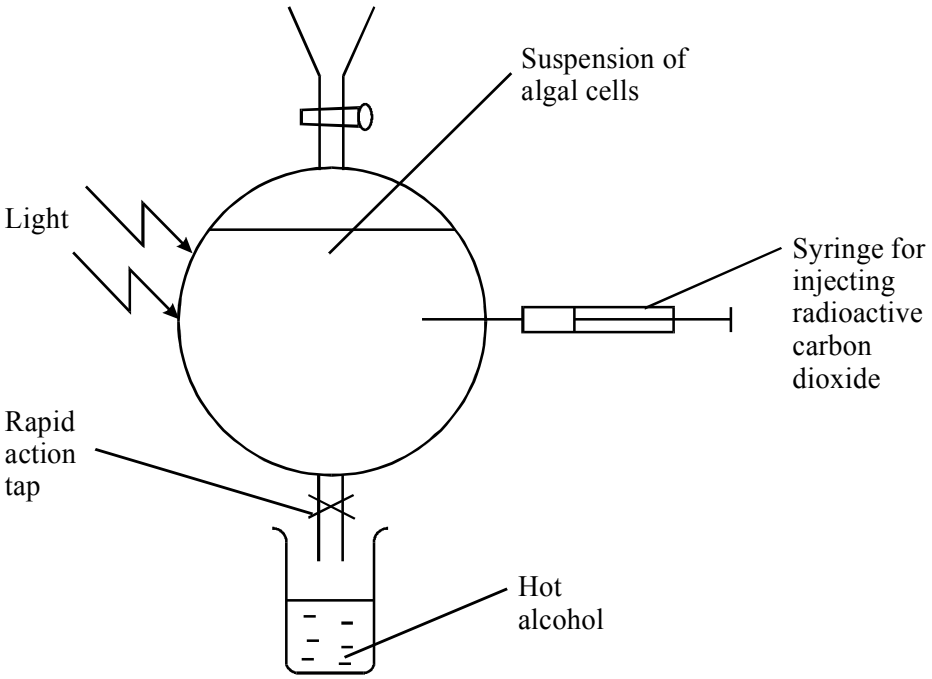
Gametes

Offspring 2 genotypes

Offspring 2 phenotypes and ratio

(3)
(Total 5 marks)

5. An investigation was carried out to find out the sequence of biochemical changes that occur during photosynthesis. Radioactive carbon dioxide was added to a suspension of algal cells, and they were allowed to photosynthesise. At intervals, samples of the suspension were removed into hot alcohol. These samples were analysed for different radioactively labelled compounds.



(a) Explain how the use of radioactive carbon dioxide in this investigation allows the sequence of biochemical changes in photosynthesis to be followed.

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(2)

(b) Suggest a reason for the use in this investigation of

(i) hot alcohol;

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(1)

(ii) a rapid action tap.

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(1)

Samples were removed from the suspension at five different times, between 5 seconds and 600 seconds after the start of the experiment. In each sample, the radioactivity in four different organic compounds, **P**, **Q**, **R** and **S**, was measured. The table shows the results.

Organic compound	Amount of radioactivity present / arbitrary units				
	5 s	**15 s**	**60 s**	**180 s**	**600 s**
P	0.01	0.02	0.08	0.17	0.67
Q	1.00	2.00	3.10	3.15	3.15
R	0.10	1.50	2.20	2.30	2.40
S	0.05	0.11	0.16	1.00	1.00

(c) Use this information to place the compounds **P**, **Q**, **R** and **S**, in the order in which they were formed in photosynthesis.

_____ → _____ → _____ → _____

(1)

(d) Using your knowledge of the light-independent reaction, explain why the level of radioactivity in compound **Q** remained steady after 180 seconds.

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(2)
(Total 7 marks)

6. (a) **Table 1** shows the classification of *Fucus vesiculosus*. Enter the three missing groups in the table.

Kingdom	Protoctista
	Phaeophyta
Class	Phyophyceae
	Fucales
Family	Fucaceae
	Fucus
Species	*vesiculosus*

Table 1

(2)

(b) Samples of DNA were removed from three species of *Fucus*. The DNA in each sample was separated into its two strands. This single-stranded DNA was then mixed with single-stranded DNA from another sample, either from the same species or from a different species. This allowed sections of DNA with complementary base sequences to join together to form 'new' double-stranded sections. The percentage of doublestranded DNA resulting is shown in **Table 2**.

***Fucus* species from which DNA was taken, separated into strands, and mixed together**		**Percentage of double-stranded DNA**
F. vesiculosus	*F. vesiculosus*	99.8
F. vesiculosus	*F. serratus*	81.3
F. vesiculosus	*F. spiralis*	85.4
F. serratus	*F. spiralis*	94.6
F. spirlis	*F. spiralis*	99.9

Table 2

Which **two** of these species seem to be the most closely related? Explain your answer.

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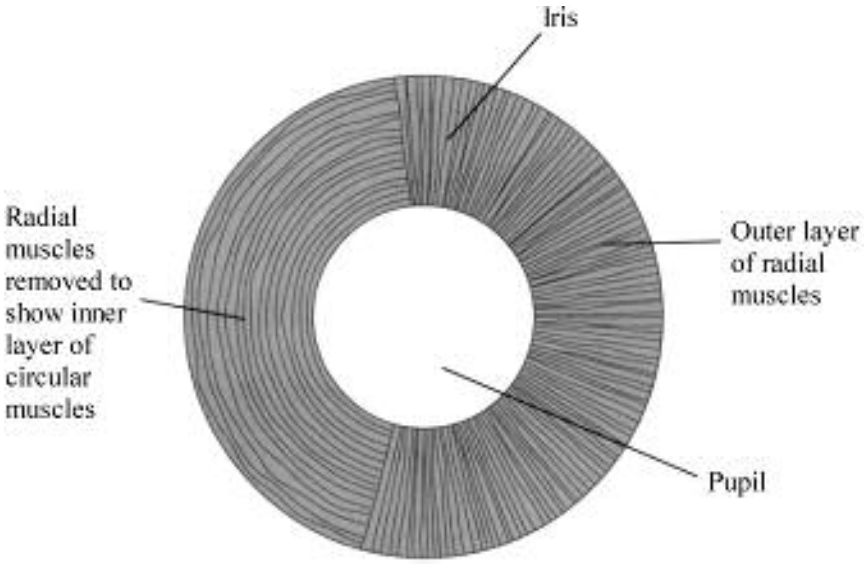
(3)
(Total 5 marks)

7. The size of the pupil is controlled by antagonistic muscles in the iris, which either dilate or constrict it. The two sets of muscles in the iris are innervated by the sympathetic nervous system, which uses the neurotransmitter noradrenaline, and by the parasympathetic nervous system, which uses acetylcholine.

The diagram shows the layout of muscles in the iris.



(a) Explain how a change in light intensity results in an increase in pupil diameter.

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(3)

(b) The table shows three different drugs, with some information about the way they act.

Drug	Nature of drug action
Atropine	occupies acetylcholine receptors in the postsynaptic membrane and blocks normal stimulation by the parasympathetic nervous system
Cocaine	inhibits the enzyme that breaks down noradrenaline
Eserine	inhibits the enzyme cholinesterase

(i) The drug atropine was once used by doctors when they needed to dilate a patient's pupils. Suggest an explanation for this effect.

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(1)

(ii) Which of cocaine or eserine is more likely to cause the pupils to constrict? Explain this in terms of this drug's effect on synaptic transmission.

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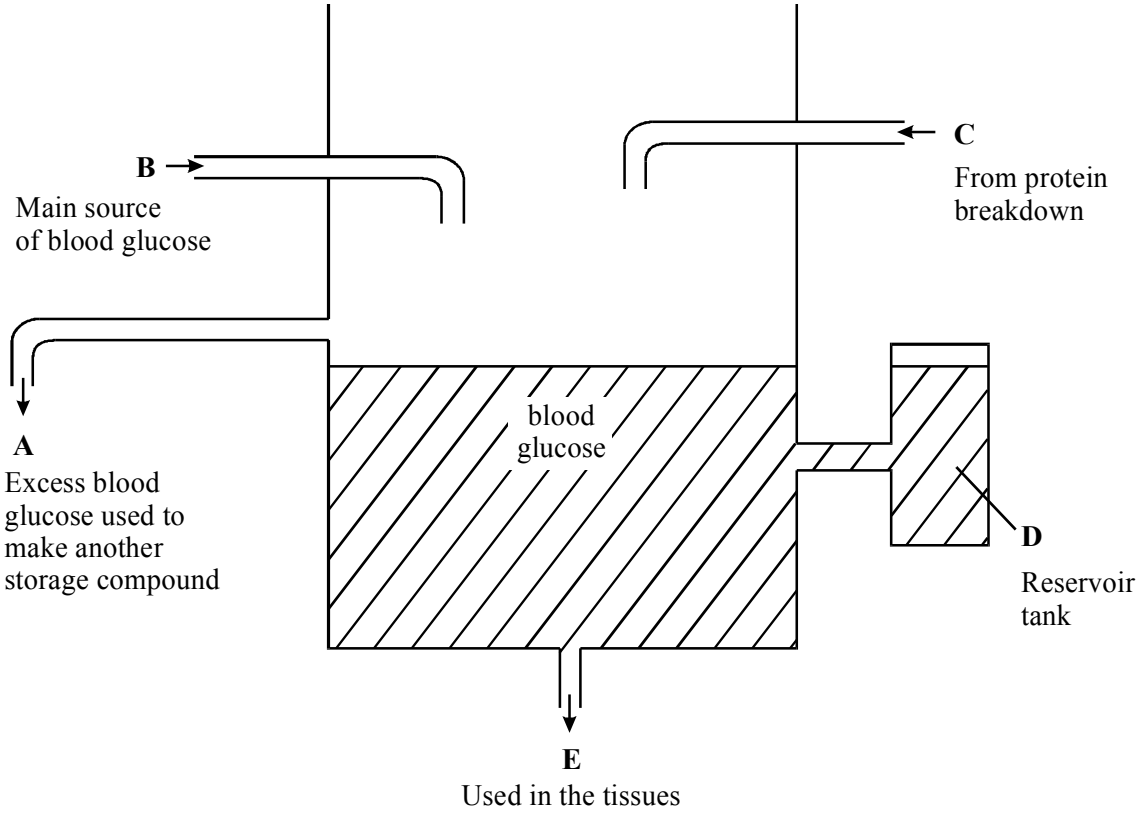
(2)
(Total 6 marks)

8. The diagram shows a model in which blood glucose is represented as a tank of fluid. In this model

- the pipes on the diagram represent 'routes' by which glucose may be added or removed;
- the main source of glucose to the tank is through **B**;
- a smaller amount of glucose enters through **C**, from protein breakdown;
- there is an outflow from the tank to the tissues through **E**;
- the reservoir tank, **D**, contains a carbohydrate that can be reconverted into blood glucose;
- through **A**, any excess glucose can be used to produce another type of storage compound which is different from the compound stored in **D**.



(a) What is the "main source of blood glucose" entering through **B**?

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(1)

(b) In the body, insulin and glucagon are both involved in regulating the concentration of blood glucose.

(i) Name the organ that produces both of these hormones.

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(1)

(ii) Tick the appropriate boxes in the table that match a description of one or more of the effects of the hormones.

Effect of hormone	Insulin	Glucagon
Reduces the amount of storage carbohydrate in reservoir **D**		
Promotes the loss of blood glucose through **A**		
Promotes protein breakdown so more glucose enters through **C**.		
Increases the rate of outflow at **E**		

(2)

(c) (i) Name the carbohydrate stored in reservoir **D**.

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(1)

(ii) Name the storage compound into which glucose is converted at **A**.

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(1)

(d) Adrenaline and thyroxine are two other hormones that can affect blood glucose levels.

Adrenaline acts rapidly, causing a sudden increase in the level of blood glucose. Thyroxine acts more slowly, and influences growth through its long-term effect in increasing the rate of respiration.

For each of these two hormones, give the letter on the diagram, **A-E**, that identifies where it is most likely to exert its main effect.

Adrenaline .....

Thyroxine .....

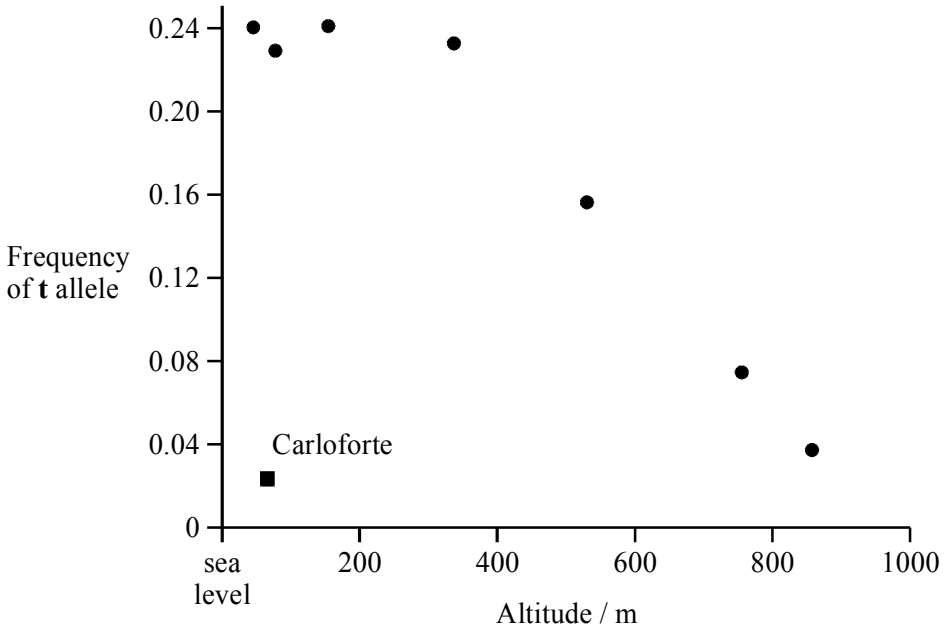
(2)
(Total 8 marks)

9. Thalassemia is a disease in which people homozygous for the recessive allele, t, show a severe anaemia. Before suitable medical treatment was available, they did not usually survive childhood. Heterozygotes are only mildly affected, but are more resistant to malaria than people who are homozygous dominant, **TT**.

The graph shows the relationship between altitude and the frequency of the thalassemia allele, **t**, for a group of villages on the Italian island of Sardinia. The information relates to the early 20th century.

The frequency of the allele t in a population can be calculated from the formula

$$\frac{(\text{Number of } \mathbf{tt} \text{ genotypes} + \frac{1}{2} \text{ number of } \mathbf{Tt} \text{ genotypes})}{\text{total number of people}}$$



(a) Ignoring the information for the village of Carloforte, describe the relationship between the frequency of the **t** allele and altitude.

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(2)

Until the late 19th century, malaria was commonly found among people living at low altitudes in Sardinia. It is a serious blood disease caused by a parasite which is carried in the salivary glands of certain species of mosquito. These mosquitoes, which thrive in warm conditions near to sources of still or slow-moving water, infect humans with malaria by biting them.

(b) Suggest an explanation for the higher frequency of the **t** allele found at certain altitudes.

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(3)

(c) Information for the village of Carloforte is shown on the graph as a square. This village

was founded more recently, by families from mainland Italy. Suggest two possible reasons for the unusually low frequency of the **t** allele found at Carloforte.

1. .....

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2. .....

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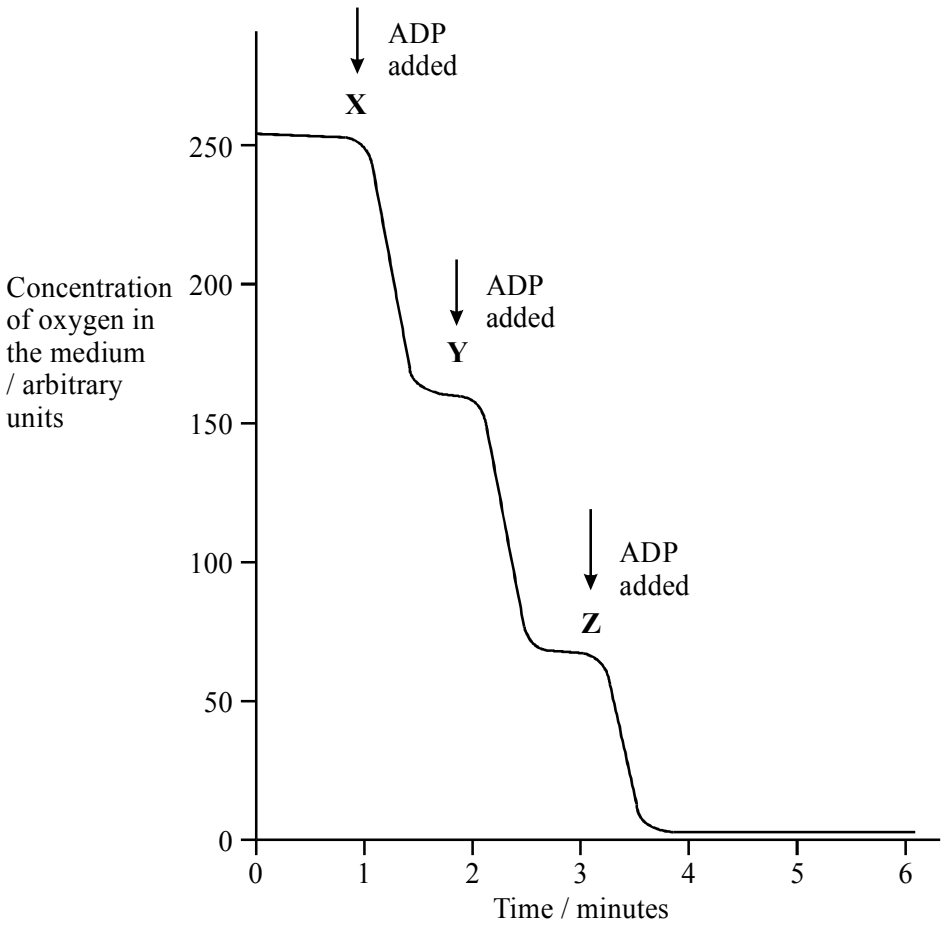
(2)
(Total 7 marks)

10. In an investigation of aerobic respiration, isolated mitochondria were added to a prepared medium containing succinate and inorganic phosphate. Succinate is a 4-carbon compound, which occurs in the Krebs cycle, and can be used as a respiratory substrate. The medium was saturated with oxygen. Equal amounts of ADP were added at one-minute intervals, and measurements were taken of the oxygen concentration in the medium. The graph shows the results.



(a) Why was inorganic phosphate added to the medium?

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(1)

(b) Explain why the oxygen concentration in the medium decreased after adding ADP at **X**.

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(3)

(c) Explain why the fall in oxygen concentration was the same following the addition of ADP at **X** and at **Y**.

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(1)

(d) Explain why the fall in oxygen concentration, following the addition of ADP, was less at **Z** than at **Y**.

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(1)

(e) Fresh mitochondria were isolated from cells and a similar experiment was carried out. This time the medium contained glucose instead of succinate. Again, the medium was saturated with oxygen, and excess ADP was added. However, there was almost no fall in oxygen concentration, even after 10 minutes.

(i) Suggest and explain a reason for this observation.

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(2)

(ii) Explain, in outline only, how you could test your suggestion.

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(1)

(f) When ATP is added to a muscle, it causes the muscle to contract.
Describe and explain how this contraction is brought about.

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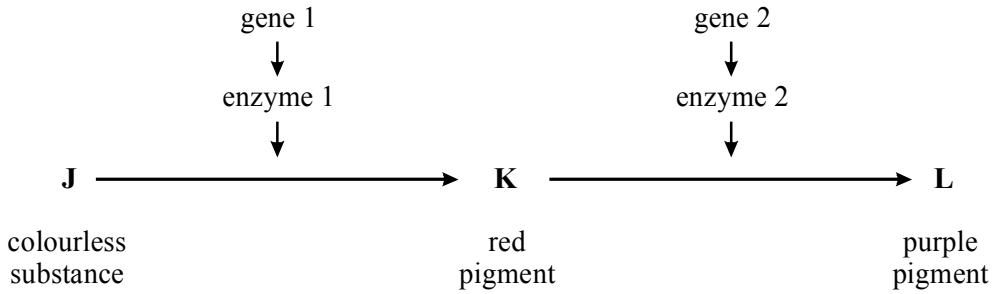
(6)
(Total 15 marks)

11. A species of flowering plant can have white, red or purple flowers. The colour of the flowers is controlled by two genes. Each gene is found on a different chromosome, and is responsible for one step in a biosynthetic pathway. The biosynthetic pathway is



Gene 1 has the dominant allele **A** and the recessive allele **a**. Gene 2 has the dominant allele **B** and the recessive allele **b**. In both cases, the dominant allele needs to be present for the production of the associated enzyme.

(a) Explain how the two genes are involved in producing white, red or purple flowers.

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(6)

(b) (i) A homozygous red-flowered plant was crossed with a homozygous white-flowered plant. All the flowers of the offspring were purple. What was the genotype of

the red-flowered parent;

.....

the white-flowered parent?

.....

(2)

(ii) The purple-flowered offspring were crossed. What phenotypic ratio would you

expect in the next generation? Use a genetic diagram to explain your answer.

(4)

(c) (i) Genetically, there are different types of white-flowered plants of this species. Give their different genotypes.

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(1)

(ii) You have samples of fresh petals from the two homozygous types of white flowers, and a pure sample of the red pigment, **K**. Explain, in outline, how you might distinguish the two types of petal from each other.

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(2)
(Total 15 marks)