Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

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7777700630

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **May/June 2019**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

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Write your centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **one** question.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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Section A

Answer **all** questions.

1 **(a)** Fig. 1.1 shows part of a cell in a growing region of a plant.

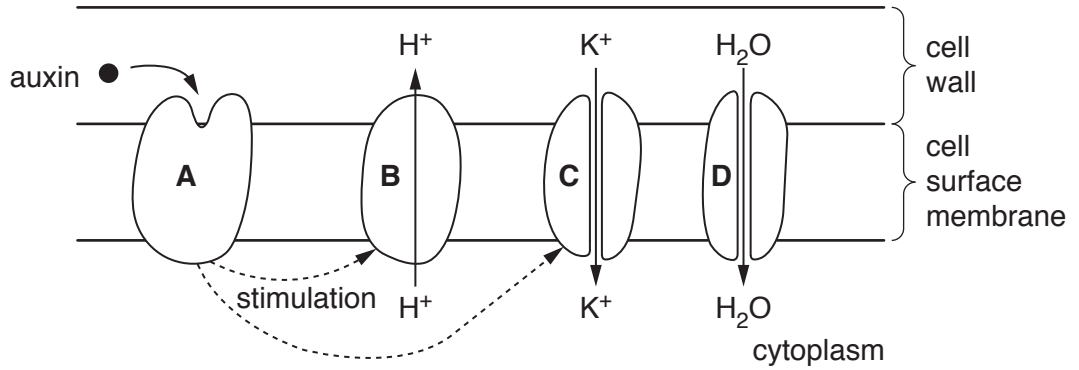


Fig. 1.1

(i) State the **type** of protein represented by **A**.

..... [1]

(ii) Proteins **B**, **C** and **D** are transport proteins.

Identify proteins **B**, **C** and **D**.

B .....

C .....

D .....

[3]

(b) Describe the effects on the cell wall of many hydrogen ions moving into the cell wall.

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..... [3]

(c) Explain the consequences of an influx of potassium ions into the cell.

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..... [2]

[Total: 9]

2 The interpupillary distance (IPD) is the distance in millimetres between the centres of the pupils of the eyes. Fig. 2.1 shows how IPD is measured.

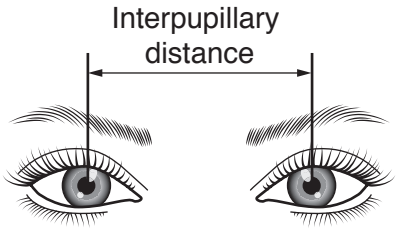


Fig. 2.1

IPD is one example of a characteristic of human facial structure that shows variation.

Fig. 2.2 shows the pattern of variation in IPD in a large sample of adults.

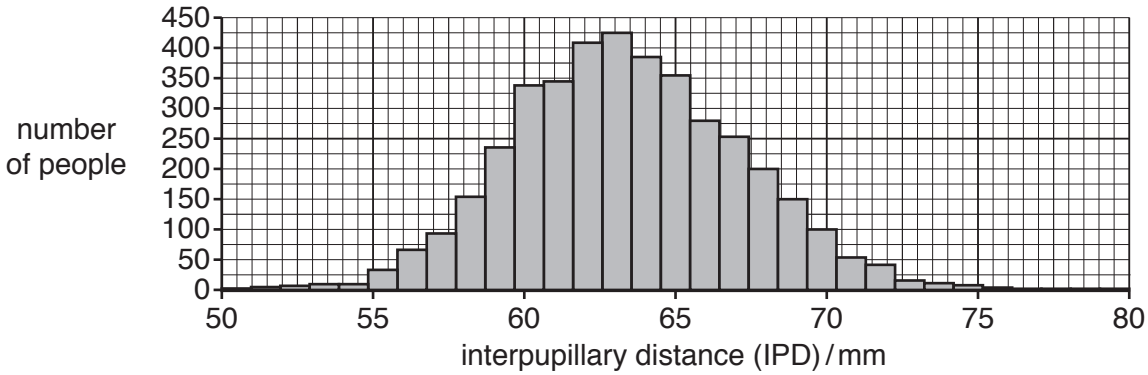


Fig. 2.2

(a) (i) Name the type of variation shown in Fig. 2.2.

..... [1]

(ii) Suggest **and** explain how genes and the environment contribute to variation in IPD in humans.

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..... [3]

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(b) Individuals with an IPD of 70 mm or more have a mutation in the *PAX3* gene that results in less PAX3 protein being made.

The normal role of the PAX3 protein is to increase the expression of many other genes involved in embryonic development. These genes affect a range of phenotypic features such as facial structure, hearing and eye colour.

(i) State the term that is used to describe a gene, such as *PAX3*, that controls the expression of other genes **and** suggest how the PAX3 protein controls the expression of other genes.

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..... [3]

(ii) Describe how microarray analysis could be used to identify the genes switched on by PAX3 in embryonic cells.

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..... [5]

(iii) The chimpanzee, *Pan troglodytes*, has DNA that is 98.5% similar to humans, including possession of the *PAX3* gene. Investigations show that chimpanzees express higher levels of the PAX3 protein during embryonic development than humans.

Fig. 2.3 shows a chimpanzee, *Pan troglodytes*.



Fig. 2.3

Suggest how knowledge of the *PAX3* gene helps scientists explain how humans and chimpanzees are very different in facial structure, even though they have very similar DNA.

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..... [3]

[Total: 15]

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3 Some neurones in the brain produce a neurotransmitter known as dopamine. Parkinson's disease occurs when the neurones that produce dopamine die. A person with the disease may experience difficulty in coordinating movement, often seen as tremors (shaking) in different parts of the body.

Parkinson's disease typically occurs in people older than 55 years. Younger people with these symptoms are said to have early onset Parkinson's disease (EOPD).

Recessive mutations in a gene known as *PINK1*, located on chromosome 1, an autosome, are believed to be one cause of EOPD. A person with this form of EOPD has a homozygous recessive genotype.

(a) Draw a genetic diagram of a cross between two individuals who are heterozygous at the *PINK1* gene locus.

key to symbols used for alleles

.....

.....

parental genotypes

gametes

offspring genotypes

ratio of offspring phenotypes

[4]

(b) *PINK1* codes for a protein kinase enzyme that is important in the functioning of mitochondria in neurones.

Most recessive *PINK1* mutations are base substitutions which lead to the production of a non-functioning protein kinase enzyme.

Explain how a base substitution mutation can lead to the production of a non-functioning protein kinase.

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..... [5]

(c) One rare, dominant mutation of the *PINK1* gene codes for a product that inhibits the normal protein kinase.

Explain how this mutation causes EOPD in a heterozygote.

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..... [2]

[Total: 11]

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Question 4 starts on page 10

4 (a) The link reaction and Krebs cycle take place in the mitochondrion.

The main stages of the link reaction and Krebs cycle are listed in Table 4.1.

They are **not** listed in the correct order.

Table 4.1

stage	description of stage
A	acetyl group combines with coenzyme A to form acetyl CoA
B	citrate is formed
C	hydrogen atoms are accepted by NAD and FAD
D	oxaloacetate is regenerated
E	pyruvate enters the mitochondrial matrix
F	acetyl group is formed
G	acetyl CoA enters Krebs cycle
H	ATP is made by substrate-linked phosphorylation
I	pyruvate is decarboxylated and dehydrogenated
J	acetyl CoA combines with oxaloacetate
K	citrate is decarboxylated and dehydrogenated

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Complete Table 4.2 to show the correct order of the stages.

Three of the stages have been done for you.

Table 4.2

correct order	letter of stage
1	**E**
2	.....
3	.....
4	.....
5	.....
6	**J**
7	.....
8	.....
9	.....
10	.....
11	**D**

[4]

(b) Outline the role of NAD in respiration in aerobic conditions.

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..... [4]

(c) Carbon dioxide is removed from compounds in the link reaction and Krebs cycle by decarboxylation.

(i) State the total number of molecules of carbon dioxide removed in the link reaction and Krebs cycle for each molecule of glucose respired.

..... [1]

(ii) In a mammal, carbon dioxide diffuses from cells into the blood to be transported to the lungs.

Suggest why carbon dioxide is transported in the blood mainly as hydrogen carbonate ions and not as carbonic acid.

..... [1]

[Total: 10]

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5 Researchers investigated the extent to which the founder effect and natural selection affected evolutionary change.

Fig. 5.1 shows the brown anole lizard, *Anolis sagrei*. These lizards live on a number of Caribbean islands and feed on a variety of invertebrates and other small animals.

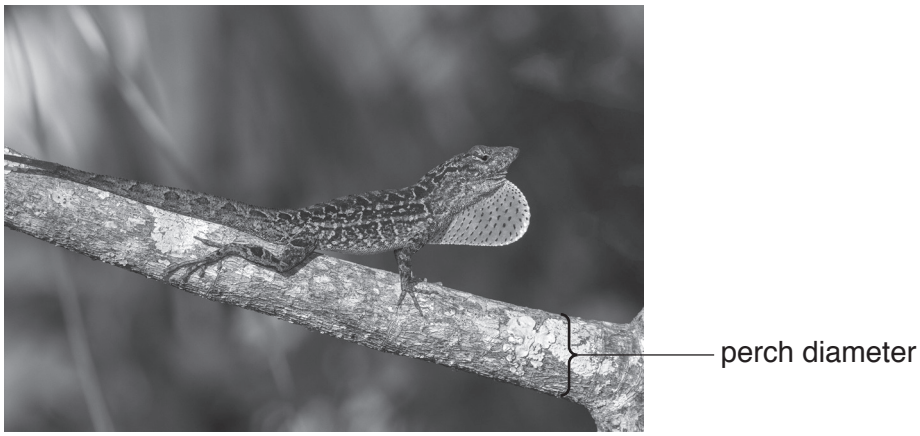


Fig. 5.1

A. sagrei spends a lot of time perching (resting) on, or moving along, branches of shrubs and trees. The width of the branch that *A. sagrei* perches on is known as the perch diameter, as labelled in Fig. 5.1.

There is a positive correlation between perch diameter and hind limb length of *A. sagrei*.
- Longer hind limbs allow *A. sagrei* to run faster on vegetation with a larger diameter.
- Shorter hind limbs are needed to provide stability on vegetation of a smaller diameter.

In 2004, a hurricane caused the death of all the *A. sagrei* lizards on seven islands.

In 2005, the researchers randomly collected seven male and seven female lizards from a source population on a nearby island. For each of the seven islands affected by the hurricane, a male and female lizard were mated and placed on each island. These islands formed the experimental founder islands where new populations of *A. sagrei* were successfully established from each founding pair.

Fig. 5.2 shows the difference in vegetation between the source island and the seven experimental founder islands.



Fig. 5.2

(a) (i) Predict the effect of natural selection on mean hind limb length of *A. sagrei* on the seven experimental founder islands.

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..... [1]

(ii) Predict how collecting individuals **at random** for the seven founding pairs affects the mean hind limb length of *A. sagrei* on the different islands.

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..... [1]

(b) Many generations of *A. sagrei* were produced over the four years after the introduction of the founding pairs.

Fig. 5.3 shows how the mean hind limb length of *A. sagrei* changed on the seven experimental islands and on the source island.

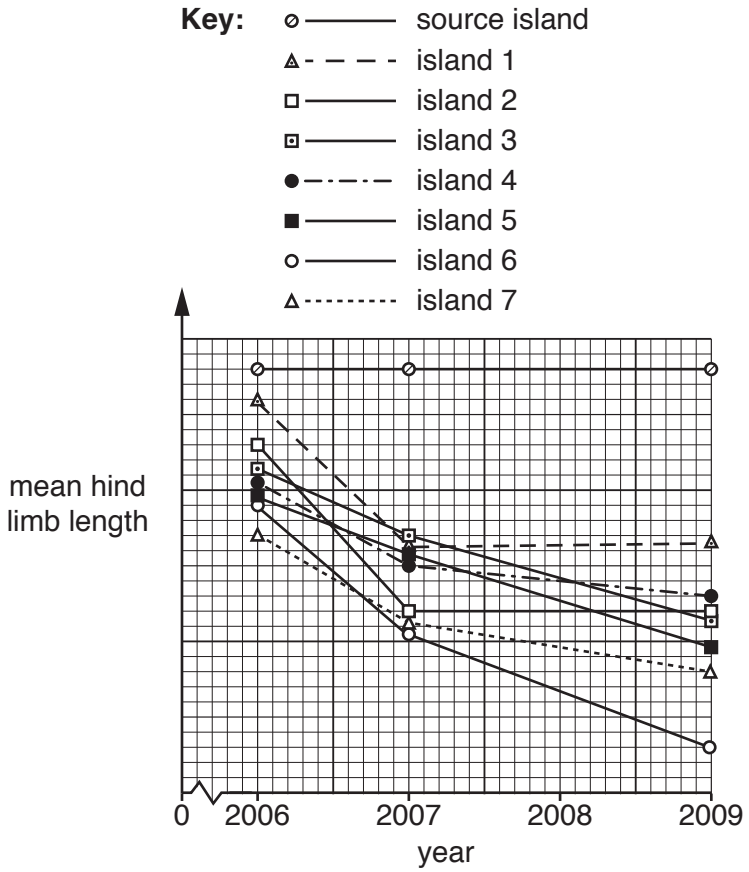


Fig. 5.3

With reference to Fig. 5.2 and Fig. 5.3, describe **and** suggest explanations for the results for the islands.

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..... [5]

(c) In the investigation, one population of *A. sagrei* was established on each experimental founder island.

Outline how speciation may occur on the seven experimental founder islands.

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..... [3]

(d) Speciation is one possible outcome for the experimental founder populations, but there is also a high risk that they may become extinct.

Explain why the experimental founder populations are at high risk of extinction.

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..... [3]

[Total: 13]

6 Maize, *Zea mays*, is an important food crop for human consumption and for feeding to animals.

Two varieties of maize are MON810 and Justina. Justina has been developed in the traditional way by selective breeding (artificial selection) and MON810 is an example of a genetically modified (GM) organism.

(a) MON810 produces a chemical that is toxic to insect pests. It is described as insect-resistant.

Outline how genetic engineering gave MON810 the trait of insect resistance.

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..... [4]

(b) Countries vary in the extent to which they grow GM varieties such as MON810, instead of traditional varieties such as Justina.

- In the USA, 88% of the total maize that is grown is GM.
- In most European countries, 0% of the maize that is grown is GM.

Scientists used computer models to predict the effect of two different changes in agricultural practice on maize crop yields:

- a global ban that reduces the cultivation of GM maize to 0% everywhere
- all countries increasing the cultivation of GM maize to the 88% level of the USA.

Table 6.1 shows the results of this modelling for four countries.

Table 6.1

country	percentage change in yield of maize	
	decrease GM maize cultivation to 0% of total	increase GM maize cultivation to 88% of total
Argentina	–8.86	+2.90
Honduras	–1.26	+16.75
Spain	–3.82	+5.39
USA	–7.63	0.00

Explain what the data in Table 6.1 suggests about the social and ethical implications of growing GM maize.

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..... [4]

[Total:8]

7 **(a)** Some people have a condition called diabetes. In type 1 diabetes the pancreas does not produce enough insulin.

Fig. 7.1 shows the blood glucose concentrations of a type 1 diabetic person and a non-diabetic person, at regular intervals after drinking a glucose drink.

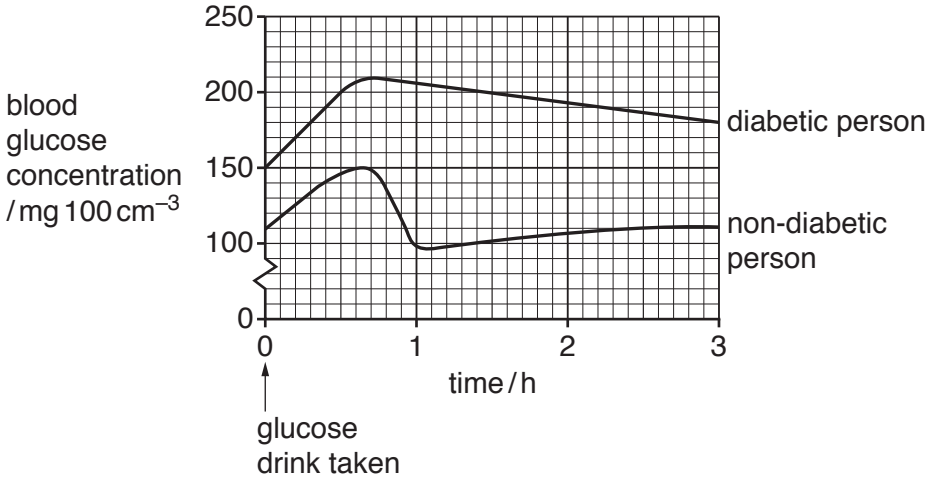


Fig. 7.1

(i) Describe the results shown in Fig. 7.1.

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..... [3]

(ii) Name the location of the receptors in a non-diabetic person that detect a change in blood glucose concentration.

..... [1]

(iii) Name the homeostatic mechanism by which blood glucose concentration is maintained.

..... [1]

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(b) The urine of a non-diabetic person does not contain glucose. A person with type 1 diabetes will excrete glucose in urine.

A reading of the concentration of glucose in the urine can be estimated using a dipstick.

Fig. 7.2 outlines how a dipstick works.

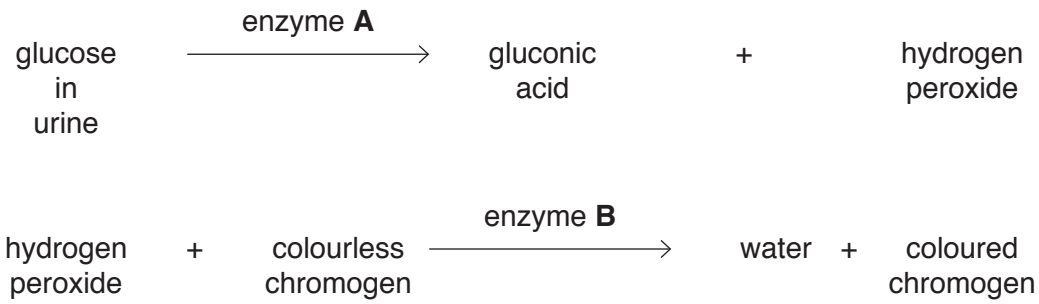


Fig. 7.2

The higher the concentration of glucose in the urine, the darker the colour on the dipstick.

(i) Name enzymes **A** and **B**.

A .....

B .....

[2]

(ii) An electronic biosensor can be used to measure the glucose concentration in a drop of blood.

Suggest **one** advantage of using a biosensor and **one** advantage of using a dipstick to measure glucose concentration.

biosensor .....

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dipstick .....

.....

[2]

(c) Describe the role played by insulin in the control of blood glucose concentration.

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..... [5]

[Total: 14]

8 Table 8.1 shows the total number of plant species, the total number of insect species and the number of habitats in three areas, **A**, **B** and **C**.

Table 8.1

area	total number of plant species	total number of insect species	number of habitats
A	6	5	1
B	15	23	4
C	362	70	12

(a) Identify the area with the highest biodiversity.

Give reasons for your choice of area.

area .....

reasons .....

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..... [3]

(b) Identify the area that is likely to be affected the most if the environment changes.

Give a reason for your choice of area.

area .....

reason .....

.....

[1]

(c) State **one** reason why it is important to conserve biodiversity in **all** three areas.

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..... [1]

[Total: 5]

Section B

Answer **one** question.

9 **(a)** Explain what is meant by the term limiting factor **and** explain how knowledge of limiting factors is used to increase crop yields in glasshouses. [7]

(b) Describe the behaviour of chromosomes during meiosis. [8]

[Total: 15]

10 **(a)** Explain how a cholinergic synapse functions. [7]

(b) Describe how you would carry out an investigation into the effect of wavelength of light on the rate of photosynthesis of a plant, using a redox indicator such as DCPIP. [8]

[Total: 15]

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BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **May/June 2019**

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Section A

Answer **all** questions.

1 **(a)** Fig. 1.1 is an electron micrograph showing a cross-section of a myelinated neurone.

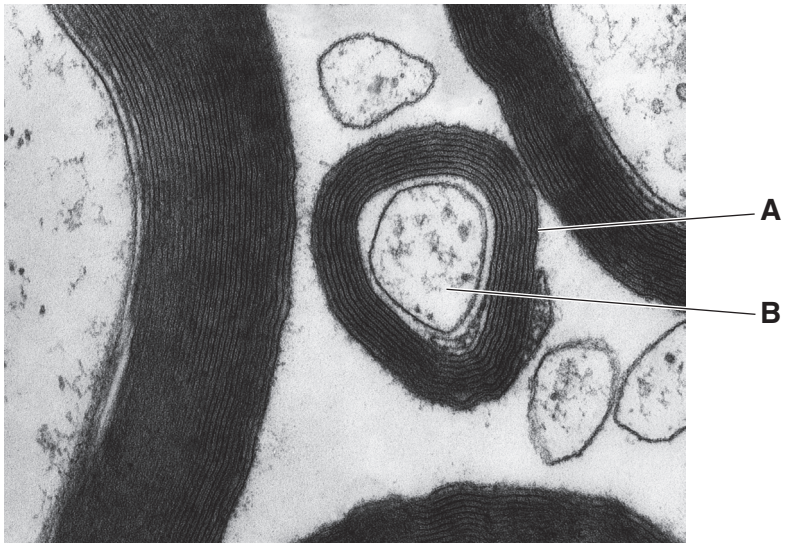


Fig. 1.1

Name **A** and **B**.

A .....

B .....
[2]

(b) Explain what is meant by saltatory conduction **and** describe its effect on the transmission of a nerve impulse.

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..... [3]

(c) A type of sea snail, *Conus purpurascens*, produces a toxin that blocks calcium ion channels in the presynaptic knob of a cholinergic synapse. The presence of this toxin results in no action potentials in the postsynaptic neurone.

Explain why the presence of this toxin results in **no** action potentials in the postsynaptic neurone.

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..... [5]

[Total: 10]

2 Steelhead trout, *Oncorhynchus mykiss*, are fish that live in streams in North America.

To increase the number of steelhead trout, captive breeding has occurred since 1992. Fish eggs and sperm are mixed and the young fish grow in large tanks of aerated water for the first year of their lives. Most are then released into the wild, however a few male and female fish are kept to become the parents of the next generation of captive-bred fish.

Each tank may hold up to 50 000 fish. The young captive fish are fed processed food. Some young fish are unable to survive these conditions and a proportion die. Death is usually the result of poor wound-healing after accidents due to overcrowding and due to the spread of diseases.

(a) (i) Name the expected pattern of variation in wound-healing ability in a population of fish.

..... [1]

(ii) Name the process that results in improved survival of captive fish in second, third and subsequent generations of captive-bred fish.

..... [1]

(b) Suggest **and** explain **three** ways in which the tank environment may make the phenotype of a captive fish different from a wild fish.

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..... [3]

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Two groups of fish were bred and grown in the **same** environment and were then compared to see if they showed differences in gene expression.

The two groups of fish came from:

- eggs and sperm from parent fish that had always lived in the wild
- eggs and sperm from parent fish that had been bred in captivity.

Results from microarray analysis showed that the offspring of the wild and captive-bred fish differed in the expression of over 700 genes.

(c) (i) Describe how microarray analysis can detect differences in the expression of many genes when comparing two samples, such as the offspring of wild and captive-bred fish.

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..... [5]

(ii) Explain how gene expression is controlled in eukaryotes such as fish.

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..... [4]

(d) Many of the differences in gene expression between the offspring of the wild and captive-bred fish were in genes coding for proteins involved in the immune response and in genes coding for proteins involved in wound healing. The fish from captive-bred parents expressed these genes to a greater degree.

The researchers concluded that the differences were inherited and adaptive.

Explain why the researchers concluded that the differences in gene expression between the two groups of fish were:

(i) inherited

.....

..... [1]

(ii) adaptive.

.....

..... [1]

[Total: 16]

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3 Soybean, *Glycine max*, is an important food crop for human consumption and for feeding to animals.

Two varieties of soybean are Vinton 81 and GTS 40-3-2.

Vinton 81 has been developed in the traditional way by selective breeding (artificial selection) and GTS 40-3-2 is an example of a genetically modified (GM) organism.

(a) GTS 40-3-2 is described as herbicide-resistant, as it can withstand the application of glyphosate herbicide. Glyphosate is sprayed on the crop to kill weeds.

Outline how genetic engineering gave GTS 40-3-2 the trait of herbicide resistance.

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..... [4]

(b) Countries vary in the extent to which they grow GM varieties, such as GTS 40-3-2, instead of traditional varieties such as Vinton 81.

- In the USA, 94% of soybeans grown are GM.
- In Europe, 0% of soybeans grown are GM.

Scientists used computer models to predict the effect of two different changes in agricultural practice on soybean crop yields:

- a global ban that reduces the cultivation of GM soybeans to 0% everywhere
- all countries increasing the cultivation of GM soybeans to the 94% level of the USA.

Table 3.1 shows the results of this modelling for four countries.

Table 3.1

country	percentage change in yield of soybeans	
	decrease GM soybean cultivation to 0% of total	increase GM soybean cultivation to 94% of total
Argentina	0.00	+6.23
Bolivia	–10.82	0.00
Brazil	0.00	+6.23
USA	–5.87	0.00

Explain what the data in Table 3.1 suggests about the social and ethical implications of growing GM soybeans.

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..... [5]

[Total: 9]

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4 Oculocutaneous albinism (OCA) is a type of albinism. There are many different forms of OCA.

OCA1A is one form of OCA, caused by a recessive mutation in the autosomal gene, *TYR*, coding for the enzyme tyrosinase. This enzyme is involved in the biosynthetic pathway that results in the production of melanin, the pigment responsible for the colour of hair, skin and eyes.

A person with OCA1A has white hair, very pale skin and pink eye colour.

(a) Draw a genetic diagram to show the probability of a child having OCA1A, if both parents are carriers.

Use the symbols **A** and **a** for the alleles.

parental genotypes

gametes

offspring genotypes

offspring phenotypes

probability

[4]

(b) Fig. 4.1 shows the biosynthetic pathway involving tyrosinase.

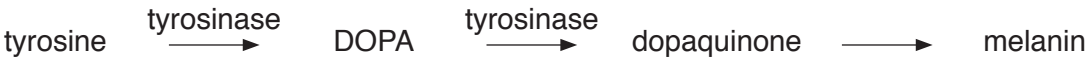


Fig. 4.1

There are a number of different mutations of the *TYR* gene that can result in an absence of melanin and cause OCA1A. These include:

- a missense mutation, caused by a base substitution, is most common
- a nonsense mutation, caused by a base substitution, is less common
- an insertion mutation, which is extremely rare.

(i) A missense mutation results in a complete polypeptide chain that does not fold properly to form the functioning enzyme.

A nonsense mutation results in a shortened polypeptide.

Explain why a missense mutation results in a different product from a nonsense mutation.

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..... [2]

(ii) Explain how an insertion mutation in *TYR* can lead to a lack of melanin in a person with OCA1A.

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..... [4]

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(c) Worldwide, 1 in 17 000 people are born with OCA. This compares with 1 in 165 people among the Guna people of Panama. The Guna people of Panama have a small population and mostly live on many small islands off the coast of Panama.

Suggest reasons why the Guna population of Panama has a relatively high number of cases of OCA.

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..... [2]

[Total: 12]

5 **(a)** Fig. 5.1 is a photomicrograph of part of the cortex of a kidney.

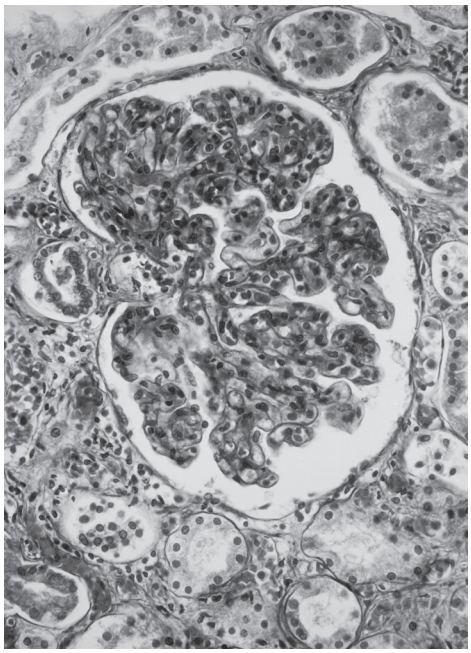


Fig. 5.1

(i) On Fig. 5.1, use label lines and letters to label:

G – the glomerulus

L – the lumen of the Bowman's (renal) capsule.

[2]

(ii) During ultrafiltration, components of blood in the glomerulus with a relative molecular mass greater than 68 000 are prevented from passing into the Bowman's capsule.

Name the structure that acts as this filtration barrier.

..... [1]

(b) The glomerular filtration rate (GFR) is the rate of flow of filtered fluid through the kidneys per unit time.

The afferent arterioles supply blood to the glomerulus of each nephron within the kidney and the efferent arterioles take blood away from each glomerulus. The lumen diameters of the afferent and efferent arterioles have a large effect on the GFR. Normally the lumen diameters of the afferent and efferent arterioles are different, but they can change to increase or decrease the normal GFR in response to changing conditions.

Complete Table 5.1 to indicate whether the GFR is normal, increased, or decreased for each combination of arteriole diameters shown.

The first row has been completed for you.

Table 5.1

afferent arteriole lumen diameter	efferent arteriole lumen diameter	GFR
normal	normal	normal
decreased	normal	.....
normal	increased	.....

[2]

(c) After leaving the Bowman's capsule, the glomerular filtrate passes through the proximal convoluted tubule, where selective reabsorption occurs.

Describe **and** explain how all of the glucose in the glomerular filtrate is reabsorbed back into the blood.

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..... [5]

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(d) State **and** explain **three** features of a proximal convoluted tubule cell that adapt it to its function.

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..... [3]

[Total: 13]

6 **(a)** State the general theory of evolution.

.....

.....

..... [1]

(b) Different types of organism have evolved different structures containing light receptors. Eyes are organs containing light receptors.

Fig. 6.1 describes the light receptors of several types of organism.

Euglena (a single-celled eukaryote) has a simple eyespot that can only detect the intensity and direction of light.
Turbellarian flatworms have cup-shaped eyes, each with a layer of light receptor cells. They can detect the intensity and direction of light better than *Euglena*. They also detect movement.
The mollusc *Nautilus* has eyes with deeper cups and narrower openings for light to enter. They can form a rough image, see shapes and detect the direction of light better than turbellarian flatworms.
The mollusc *Nucella* has eyes with lenses made of jelly. They can form a more detailed image than the eyes of *Nautilus* and can focus light to a small degree.
Mammals have eyes that are more complex than *Nucella*. They have a fixed lens (the cornea) that bends light and a lens that can change shape to focus on objects at different distances. The lenses focus light onto a deeply cup-shaped layer of light receptor cells. The eyes form a very detailed image.

Fig. 6.1

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Using the information in Fig. 6.1, suggest how a complex eye such as that of mammals could have evolved in successive stages.

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..... [4]

(c) Octopuses are molluscs that have eyes very similar to those of mammals.

Octopuses and mammals are not closely related.

Octopuses and mammals have lenses that can change shape to focus on objects at different distances.

Suggest reasons why octopuses and mammals have evolved similar eye structures.

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..... [2]

(d) Molecular evidence is used to investigate evolution. One study involved a marine worm, *Platynereis dumerilii*, that still has characteristics similar to its ancestors from 600 million years ago.

Researchers sequenced all the proteins in light receptor cells of *P. dumerilii* and humans. The results showed that there are many similarities between the protein sequences of *P. dumerilii* and humans, particularly in the light-detecting protein opsin.

(i) State what this molecular evidence indicates about the evolutionary origins of *P. dumerilii* and humans.

.....

..... [1]

(ii) Explain how amino acid sequences indicate how close the relationship is between two species.

.....

.....

.....

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..... [2]

[Total: 10]

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7 **(a)** Define the term *ecosystem*.

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.....

..... [3]

(b) State the term used to describe:

the functional role of a species within an ecosystem

.....

a reproductively isolated group of organisms that interbreed to produce fertile offspring

.....

physical factors in the environment such as temperature and soil pH.

.....
[3]

[Total: 6]

8 (a) Oxidative phosphorylation takes place in the mitochondrion.

Table 8.1 shows the different stages of oxidative phosphorylation.

The stages are **not** listed in the correct order.

Table 8.1

stage	description of stage
Q	protons diffuse through the membrane proteins into the matrix
R	a proton gradient is set up across the crista membrane
S	hydrogen atoms split into protons and electrons
T	protons combine with electrons and oxygen atoms to form water
U	electrons are passed from carrier to carrier
V	reduced NAD releases hydrogen atoms to cytochrome carriers
W	energy from electron transfer is used to pump protons into the intermembrane space
X	ATP synthase produces ATP

Complete Table 8.2 to show the correct order of the stages.

Two of the stages have been completed for you.

Table 8.2

correct order	letter of stage
1	**V**
2	.....
3	.....
4	.....
5	**R**
6	.....
7	.....
8	.....

[4]

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(b) State the precise location in a mitochondrion of each of the following.

ATP synthase .....

Krebs cycle .....

electron transport chain .....

coenzyme A .....

pyruvate .....

[5]

[Total: 9]

Section B

Answer **one** question.

9 **(a)** Describe how you would carry out an investigation into the effect of temperature on the rate of photosynthesis of an aquatic plant. [8]

(b) Outline how degraded habitats may be restored, with reference to named examples. [7]

[Total: 15]

10 **(a)** Outline the biological basis of contraceptive pills containing oestrogen and progesterone. [8]

(b) Explain how speciation may occur as a result of geographical separation. [7]

[Total: 15]

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BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **May/June 2019**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **one** question.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **24** printed pages.

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Cambridge Assessment International Education

[Turn over

Section A

Answer **all** questions.

1 **(a)** Fig. 1.1 shows a cholinergic synapse.

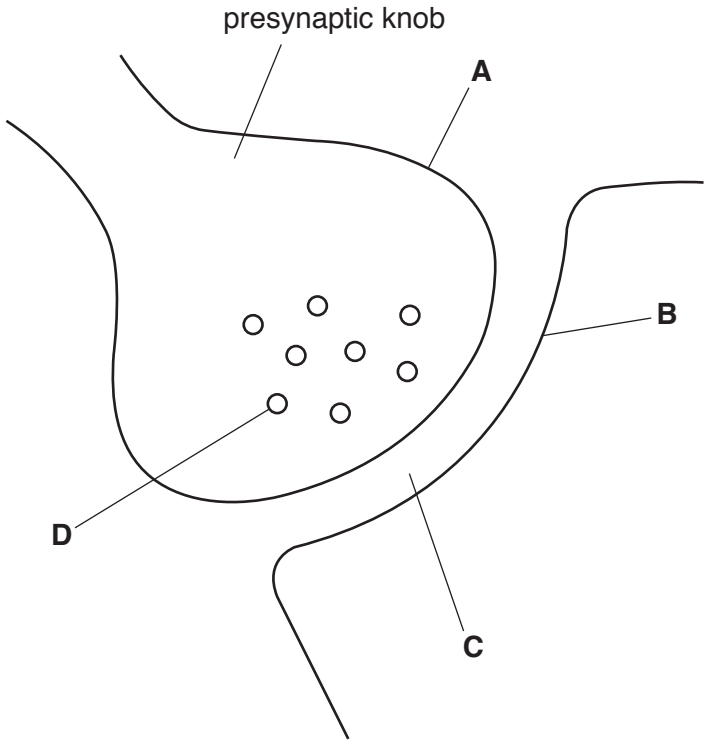


Fig. 1.1

Complete Table 1.1, using the letters **A**, **B**, **C** or **D** from Fig. 1.1, to show the location of compounds and structures associated with a cholinergic synapse.

You may use **A**, **B**, **C** and **D** once, more than once, or not at all.

Table 1.1

compound or structure	location
acetylcholine	.....
voltage-gated channel	.....
receptor protein	.....
acetylcholinesterase	.....

[4]

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(b) Explain what is meant by a voltage-gated channel.

.....

.....

.....

..... [2]

(c) Explain the role of acetylcholinesterase in a synapse.

.....

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..... [3]

(d) Outline the roles of synapses in the nervous system.

.....

.....

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..... [2]

[Total: 11]

2 Albinism is a condition that results from disruption of a biosynthetic pathway involving the enzyme tyrosinase. It is estimated that 1 in 17 000 people in the world has albinism.

(a) A recessive mutation in the *TYR* gene, which codes for the enzyme tyrosinase, is one cause of albinism. Individuals with this form of albinism are homozygous recessive.

Describe the phenotype of a person with albinism.

.....

.....

..... [2]

(b) A recessive mutation in a different gene causes a type of albinism that mainly affects the eyes (ocular albinism). A person with this condition has reduced clarity of vision and involuntary eye movements.

Fig. 2.1 shows the pattern of inheritance of ocular albinism in one family. The pattern indicates sex-linked inheritance.

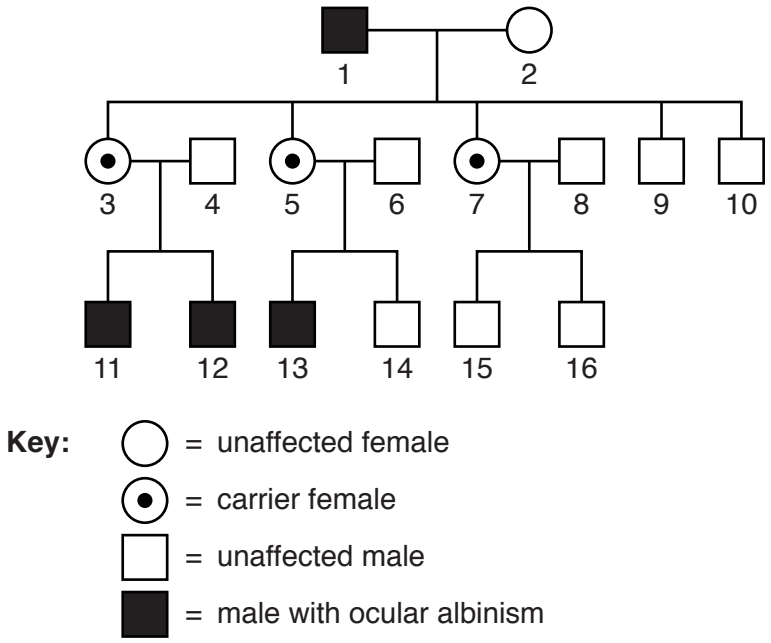


Fig. 2.1

(i) Explain why Fig. 2.1 supports sex-linked inheritance of ocular albinism.

.....

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..... [3]

(ii) Draw a genetic diagram to show how individuals 1 and 2 **cannot** have a child with ocular albinism.

key to symbols

.....

.....

parental genotypes

gametes

offspring genotypes

offspring phenotypes

[4]

(iii) Ocular albinism may be caused by a base deletion mutation. This mutation results in a non-functional protein.

Explain how a base deletion mutation can result in a non-functional protein.

.....

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..... [2]

(iv) Ocular albinism is a non-progressive disorder and clarity of vision remains stable throughout life.

A female has a family history of ocular albinism but she does not have any symptoms. A test to find out if she has the mutant allele is available.

Suggest **one** reason for taking this test and **one** reason against taking this test.

for .....

.....

against .....

.....

[2]

[Total: 13]

3 The cilia of ciliated epithelial cells show variation in length, within an individual and between different individuals.

Samples of ciliated epithelial tissue were removed from the airways of healthy people and the mean cilia length for each individual was calculated.

The people in the study formed two groups:

- people who were exposed to a harmful environmental factor
- people who were **not** exposed to a harmful environmental factor.

The results are shown in Fig. 3.1.

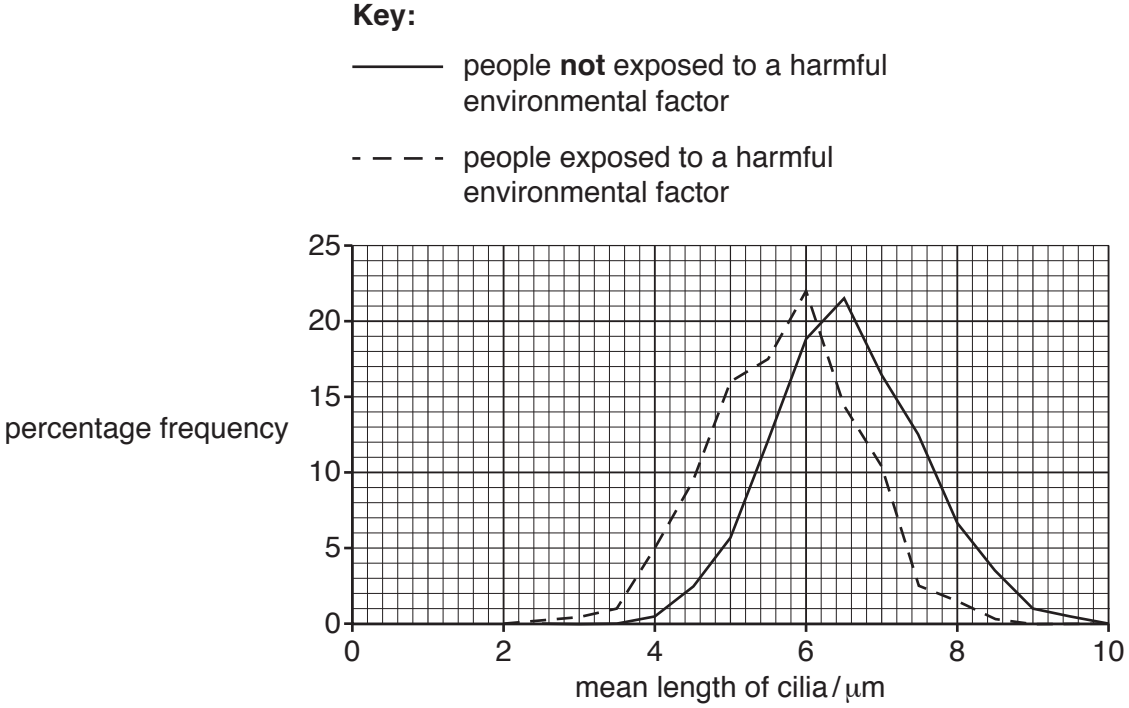


Fig. 3.1

(a) (i) Name the type of variation shown for mean cilia length in each group of people in Fig. 3.1.

..... [1]

(ii) Suggest **two** harmful environmental factors that people might have been exposed to that could explain the difference between the two curves in Fig. 3.1.

.....

.....

..... [2]

(b) The development and final length of cilia of epithelial cells is controlled by many genes.

Fig. 3.2 summarises the interactions of some of these genes. The arrows represent the genes being switched on.

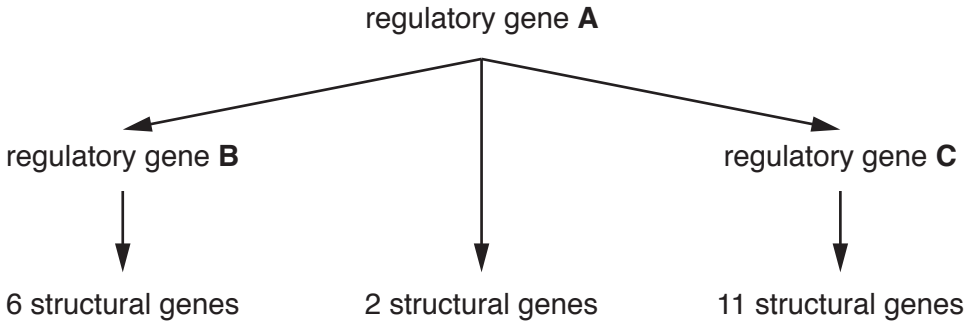


Fig. 3.2

(i) With reference to Fig. 3.2, explain how genes such as **A**, **B** and **C** are able to switch on other genes.

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..... [4]

(ii) Describe how microarray analysis can be used to identify the genes switched on by the product of gene **C**.

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..... [5]

(c) Microarray analysis has shown that ciliated epithelial cells and other epithelial cells in the airways express genes that code for receptor proteins on cell surface membranes. These receptor proteins detect specific chemicals.

When the receptor proteins bind to specific chemicals, this causes coughing, constriction of the airways and an increase in cilia activity. In people who have asthma, the response can be severe and life-threatening.

Suggest how knowledge of the genes for these receptor proteins could help in the treatment of asthma.

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..... [3]

[Total: 15]

4 Rice, *Oryza sativa*, is an important food crop for human consumption.

Two varieties of rice are T2A-1 and Shanyou 2.

Shanyou 2 has been developed in the traditional way by selective breeding (artificial selection) and T2A-1 is an example of a genetically modified (GM) organism.

(a) T2A-1 rice is described as insect-resistant as it produces a chemical that is toxic to insect pests.

Outline how genetic engineering gave T2A-1 rice the trait of insect resistance.

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..... [4]

(b) Countries vary in the extent to which they grow GM varieties instead of traditional crop varieties.

- The USA, Canada and countries in South America plant GM varieties on a large proportion of their crop-growing land, reaching 94% for soybeans in the USA.
- In most European countries, 0% of the crop-growing land is planted with GM varieties.

Scientists used computer models to predict the effects of a global ban that reduced the cultivation of GM crops to 0% everywhere.

Table 4.1 shows the results of this modelling on world crop yields and the purchase price of each crop.

Table 4.1

crop	percentage change in crop yield	percentage change in purchase price
rapeseed	–0.14	+1.96
rice	–0.12	+1.58
soybeans	–1.40	+4.05

(i) Explain what the data in Table 4.1 show about the **social** implications of growing GM crops.

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..... [2]

(ii) A worldwide ban on growing GM crop varieties would mean that more land would be needed to grow traditional crops, such as Shanyou 2. This would involve converting forest and grassland to crop-growing land.

Table 4.2 shows the predicted changes in carbon dioxide emissions associated with this change in use of land.

Table 4.2

change in use of land	change in carbon dioxide emissions / million kg CO_2
forest to crop-growing land	+ 608 726
grassland to crop-growing land	+ 276 042

Discuss what the data in Table 4.2 indicate about the environmental implications of growing GM crops.

.....

.....

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..... [2]

[Total: 8]

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5 **(a)** Fig. 5.1 is a photograph of a section through a kidney.



Fig. 5.1

On Fig 5.1, use label lines and letters to label the regions of the kidney where the following are located:

L – loop of Henlé

D – distal convoluted tubule

P – podocyte cells.

[3]

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[Turn over

(b) In a cold environment, people urinate more frequently. This condition is called cold diuresis.

In a cold environment, homeostatic mechanisms keep heat loss to a minimum. Blood is diverted away from the skin so that more blood circulates around the main body organs, including the kidney.

Suggest **and** explain why cold diuresis occurs.

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..... [4]

(c) The water potential of the blood is maintained at a constant level by a mechanism called negative feedback.

With reference to the maintenance of the water potential of the blood, explain what is meant by negative feedback.

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..... [5]

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(d) ADH affects the number of water channel proteins, aquaporins, in the cell surface membranes of the cells of the distal convoluted tubule.

State what happens to the water potential **and** volume of the urine if cells in the distal convoluted tubule have more aquaporins in their cell surface membranes.

water potential .....

volume of urine .....

[1]

[Total: 13]

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[Turn over

6 (a) Regressive evolution is a change in a population over time that involves the **loss** of certain phenotypic characteristics. It is thought to be caused by either genetic drift or natural selection.

An example of regressive evolution is the loss of eyes in one form of the Mexican cavefish, *Astyanax mexicanus*. These eyeless cavefish live in caves that are in total darkness.

There are three theories to explain how the loss of eyes in the cavefish has occurred.

Theory A
There is no advantage to having eyes in a cave that is in total darkness, where energy sources are scarce. Having eyes is a disadvantage as there may be an energy cost.

Theory B
A mutation has occurred in a single gene. This mutation has two effects:

- a lack of eye development
- an increase in the number of chemoreceptors on the skin.

Theory C
Various mutations occurred in the genes responsible for eye development over a period of time. By chance, these mutations increased in frequency in small isolated populations. Eventually this produced a population of eyeless cavefish.

(i) State **one** theory, **A**, **B** or **C**, which describes genetic drift as the cause of loss of eyes.

..... [1]

(ii) State **and** explain which theory or theories are based on natural selection as the cause of loss of eyes.

.....

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.....

.....

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..... [4]

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(b) There are several separate populations of eyeless *A. mexicanus* in different caves.

There are populations of *A. mexicanus* that spend time in areas with light and the fish in these populations have eyes.

The mitochondrial DNA (mtDNA) of eyeless *A. mexicanus* was compared to the mtDNA of *A. mexicanus* with eyes.

(i) Suggest how DNA evidence can help find out whether the eyeless *A. mexicanus* and the *A. mexicanus* with eyes are the same species or different species.

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..... [2]

(ii) Suggest why mtDNA is used instead of nuclear DNA when studying the closeness of the relationship between populations.

.....

.....

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..... [3]

[Total: 10]

7 The passage below outlines one method used by a student to estimate the population size of an animal species.

Complete the passage by using the most appropriate scientific term or terms.

A student estimated the population size of an animal species using the mark-release-..... technique. This can only be used for ..... animals such as mice.

The student caught a sample of mice using humane traps. The student then marked the mice in a way that did not ..... them. For example, the mark did not make them more visible to potential ..... . The student released the marked mice and left enough time for them to randomly ..... with the population.

The student then caught a second sample of mice and noted the numbers of marked and unmarked mice.

The student estimated the population size by multiplying the number of mice in the first sample by the number in the second sample, then dividing by the number of ..... mice in the second sample.

[6]

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8 **(a)** Table 8.1 shows some of the stages of glycolysis and respiration in anaerobic conditions in yeast.

The stages are **not** listed in the correct order.

Table 8.1

stage	description of stage
A	triose phosphate is dehydrogenated by NAD
B	pyruvate is decarboxylated
C	ethanal is formed
D	ethanol is formed
E	glucose is phosphorylated by ATP
F	pyruvate is formed
G	ethanal is reduced by alcohol dehydrogenase
H	fructose bisphosphate is formed
I	ATP is made by substrate-linked phosphorylation

Complete Table 8.2 to show the correct order of the stages.

One stage has been completed for you.

Table 8.2

correct order	letter of stage
1	.....
2	.....
3	.....
4	.....
5	**F**
6	.....
7	.....
8	.....
9	.....

[4]

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[Turn over

(b) Yeast respires glucose in aerobic and anaerobic conditions.

Explain why less ATP is produced when yeast respires in anaerobic conditions compared to when yeast respires in aerobic conditions.

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..... [5]

[Total: 9]

Section B

Answer **one** question.

9 **(a)** Describe how the structure of a chloroplast is related to its functions. [8]

(b) Describe how you would separate chloroplast pigments using chromatography. [7]

[Total: 15]

10 **(a)** Describe how ATP is synthesised by oxidative phosphorylation. [8]

(b) Describe how you would carry out an investigation, using a simple respirometer, to measure the effect of temperature on the respiration rate of insect larvae. [7]

[Total: 15]

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