Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9284596881

BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **May/June 2020**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Section A: answer **all** questions.
- Section B: answer **one** question.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 100.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **24** pages. Blank pages are indicated.

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Section A

Answer **all** questions.

1 The courgette plant, *Cucurbita pepo*, produces edible fruits that vary in colour and shape.

Fruit colour in courgettes is controlled by the gene **A/a**.
Fruit shape in courgettes is controlled by the gene **B/b**.

- A yellow fruit is produced when the dominant allele **A** is present.
- A round fruit is produced when the dominant allele **B** is present.

Genes **A/a** and **B/b** occur on different chromosomes.

Table 1.1 shows the genotypes and phenotypes of four different varieties of courgette with respect to their fruit colour and shape.

Table 1.1

name of variety	genotype	fruit colour	fruit shape
Defender	**aabb**	green	long
Floridor	**AABB**	yellow	round
Golden Dawn	**AAbb**	yellow	long
Tondo di Piacenza	**aaBB**	green	round

(a) (i) The varieties Golden Dawn and Tondo di Piacenza were grown in the same garden and cross-pollination occurred between them. The gardener grew these cross-pollinated F1 seeds into plants that formed fruits.

The gardener did not know the genotypes of the parent plants and did not know that cross-pollination had occurred.

State the phenotype of the fruits of the F1 plants **and** explain why it was unexpected for the gardener.

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..... [2]

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(ii) The gardener crossed two of these F1 plants.

Complete Fig. 1.1 with the F1 gametes, F2 genotypes and F2 phenotypes.

State the ratio of fruit phenotypes in the F2 offspring.

Fig. 1.1

ratio of fruit phenotypes ..... [4]

(b) Watermelons, *Citrullus lanatus*, are plants in the same family as courgettes. They produce large round edible fruits that usually contain many hard seeds. Seeds are the structures formed when the male and female gametes fuse at fertilisation.

In the 1990s a triploid (3n) watermelon plant was developed. To produce the triploid watermelon plant, a normal diploid parent plant (2n = 22) was crossed with an artificially created tetraploid plant (4n = 44).

Triploid watermelon plants develop edible fruits but these are sterile and do not contain seeds, making them more enjoyable to eat.

Explain why the fruits of the triploid plants are sterile and do not contain seeds.

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(c) (i) Watermelons are attacked by watermelon mosaic virus (WMV).
In 1965, a WMV-resistant plant in the same family, *Cucurbita ecuadorensis* (2n = 40), was found growing wild in South America.

State why a WMV-resistant variety of watermelon cannot be obtained by breeding *Cucurbita ecuadorensis* with a normal diploid watermelon.

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..... [1]

(ii) Outline how the WMV-resistant trait of *Cucurbita ecuadorensis* could be transferred to watermelon plants.

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..... [2]

[Total:12]

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2 **(a)** Diabetes insipidus (DI) is a condition in humans that causes a person to have an excessive thirst, which leads to increased drinking. One form of DI is caused by a tumour in the region of the hypothalamus concerned with osmoregulation.

(i) Explain how a tumour develops in the hypothalamus.

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..... [2]

(ii) Suggest how a tumour in the hypothalamus can lead to a person producing a large volume of dilute urine.

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..... [3]

(b) The nervous and endocrine systems of a mammal co-ordinate responses to changes in the internal and external environment. Table 2.1 compares some features of the nervous and endocrine systems.

Complete Table 2.1.

Table 2.1

feature	nervous system	endocrine system
signal	impulse	.....
method of transmission of signal	.....	in blood
type of communication	.....	chemical
duration of effect	.....	.....

[4]

[Total: 9]

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3 (a) The collared flycatcher, *Ficedula albicollis*, and the pied flycatcher, *F. hypoleuca* are two closely related species of bird. DNA analysis has shown that speciation from a common ancestor occurred approximately 1 million years ago.

A study was carried out on the island of Öland, Sweden. In Öland, the breeding areas of the two bird species overlap and small numbers of hybrid flycatchers are produced.

- Birds were captured and their DNA was analysed to identify whether each bird was *F. albicollis, F. hypoleuca* or a hybrid.
- Sperm samples were taken from the male birds.

Table 3.1 shows the percentage of males of each bird type with normal sperm.

Table 3.1

bird type	percentage of males with normal sperm
F. albicollis	68
F. hypoleuca	78
male hybrid	0

- The researchers observed that female birds mostly choose mates of their own species based on plumage (feathers) and song.
- Hybrid flycatchers are produced when female *F. albicollis* mate with male *F. hypoleuca* that have a song that is similar to *F. albicollis*.
- Analysis showed that all female hybrids were sterile.

The group of eggs a female bird lays at a single time in its nest is called a clutch. The offspring in the nest are looked after by a male-female pair. Sometimes the male in the male-female pair does not provide the sperm that fertilise the eggs of the female.

Table 3.2 shows:

- the percentage of clutches with eggs that hatched
- the percentage of extra-pair nestlings (offspring in the nest fathered by a male that was different from the male of the male-female pair).

Table 3.2

parents of nest		percentage of clutches with eggs that hatched	percentage of extra-pair nestlings
male	female		
F. albicollis	*F. albicollis*	94.5	17.2
F. hypoleuca	*F. hypoleuca*	89.3	22.4
hybrid	*F. albicollis* or *F. hypoleuca*	38.0	100.0

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(i) Discuss the pre-zygotic and post-zygotic isolating mechanisms that maintain *F. albicollis* and *F. hypoleuca* as separate species.

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(ii) Explain how the two species *F. albicollis* and *F. hypoleuca* could have evolved from one original ancestral population.

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(b) A single-nucleotide polymorphism (SNP) is caused by a base pair substitution mutation in a specific region of DNA.

One method of identifying whether two individuals have the same SNP is to:

- use a specific primer and polymerase chain reaction (PCR)
- add a restriction enzyme
- carry out gel electrophoresis
- stain with a dye to compare banding patterns.

(i) Explain why:

a specific primer is used

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a restriction enzyme is added

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gel electrophoresis is carried out.

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[3]

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(ii) The method of identifying whether two individuals have the same SNP method was carried out to compare species **A** and species **B**.

Fig. 3.1 shows the banding patterns that were observed.

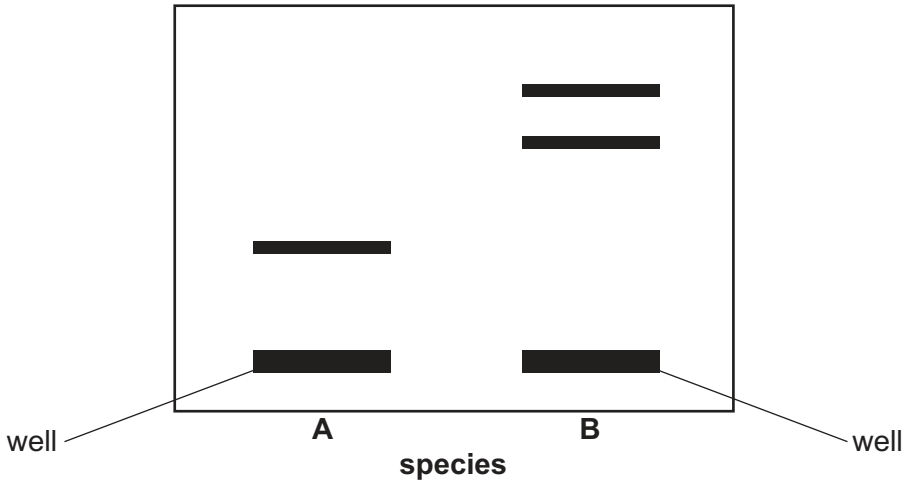

Fig. 3.1

Describe **and** suggest an explanation for the results obtained in Fig. 3.1.

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..... [2]

[Total: 14]

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4 Lung epithelial cells have a thin layer of watery mucus on their surface.

The normal allele of the *CFTR* gene codes for a transport protein that transports chloride ions out of epithelial cells.

Fig. 4.1 is a diagram of part of the cell surface membrane and the mucus layer of an epithelial cell with normal CFTR proteins.

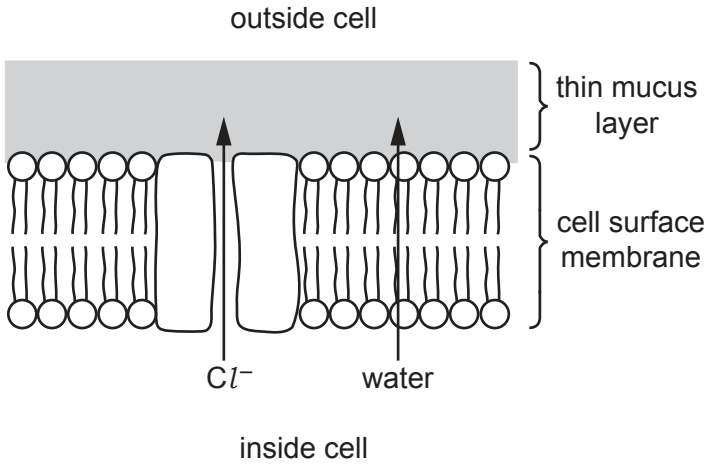

Fig. 4.1

Cystic fibrosis (CF) is a genetic disorder caused by having two recessive alleles of *CFTR*. In severe cases of CF, the transport proteins are not added to the cell surface membrane. This causes the mucus layer to be thick and sticky.

(a) Explain why the absence of CFTR proteins will cause the mucus layer to be thick and sticky.

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..... [2]

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(b) The probability of a baby having CF when both parents are heterozygous carriers for CF is 25%.

It is possible to carry out prenatal screening to check for CF by using one of these tests:

- amniocentesis, using cells from the amniotic fluid
- chorionic villus sampling, using cells from the placenta.

Both tests slightly increase the probability of the pregnancy failing (miscarriage).

Outline the advantages of carrying out prenatal screening for CF.

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..... [3]

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(c) Embryos produced by IVF may be screened for genetic abnormalities:
- to test for a specific genetic disease, such as cystic fibrosis
- to check whether there is an abnormal number of chromosomes present.

To improve the success of implantation and pregnancy, only embryos without any form of genetic abnormality are transferred to the woman's uterus.

A new double screening method was trialled where a single embryo biopsy was taken and used to test for a specific genetic disease **and** to check the number of chromosomes.
In the trial, 1122 embryos were tested using this double screening method.

In the trial, of the 1122 embryos tested:
- 50.6% did not have a genetic disease
- 27.5% did not have a genetic disease **and** did not have an abnormal number of chromosomes (normal embryos).

Only normal embryos were transferred into the women. The percentage of embryo transfers that resulted in pregnancy was calculated.

The results of the trial using double screening of a single biopsy were compared to the results of IVF procedures that used standard screening methods, as shown in Table 4.1.

Table 4.1

IVF method	percentage of embryo transfers that resulted in pregnancy
IVF with standard screening	32
IVF with double screening	49

Using the data in Table 4.1, discuss the social **and** ethical considerations of double screening for cystic fibrosis and chromosomal abnormalities in a single biopsy.

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..... [3]

[Total: 8]

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5 Yeast cells are unicellular eukaryotes that respond to the presence and absence of different sugars by switching genes on or off. One example of this is summarised in Fig. 5.1.

If glucose is **present**, a sequence of events occurs.
- Yeast cells metabolise glucose using constitutively expressed enzymes.
- Mig1 transcription factor (**A**) binds to promoter **B**.
- This stops transcription of gene **C**.
- Production of enzyme **D** stops.

If galactose is present and glucose is **absent**, a different sequence of events occurs.
- The Msn2 transcription factor (**E**) binds to promoter **B**.
- This activates transcription of gene **C**.
- Enzyme **D** is produced and helps convert galactose to glucose.

Gene **F** codes for the Mig1 transcription factor, **A**.
Gene **G** codes for the Msn2 transcription factor, **E**.

Fig. 5.1

(a) (i) With reference to Fig. 5.1, identify **one** letter corresponding to:

a structural gene .....

a control (regulatory) sequence .....

a repressor molecule .....

[3]

(ii) Explain why enzyme **D** is described as inducible.

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..... [2]

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(b) Scientists have produced genetically engineered yeast cells. The gene coding for Mig1 transcription factor and the marker gene coding for green fluorescent protein (GFP) are transcribed together to produce a single mRNA molecule.

The resulting Mig1 transcription factor proteins contain a GFP region as part of their structure and are called tagged Mig1 molecules. These tagged Mig1 molecules show up as green fluorescent spots when viewed using a microscope with a very high resolution.

An investigation was carried out to compare the distribution of tagged Mig1 molecules in yeast cells, when glucose is absent and when glucose is present.

The results are shown in Table 5.1.

Table 5.1

glucose availability	mean number of tagged Mig1 molecules present		
	cytoplasm	nucleus	total
glucose absent	1156	176	1332
glucose present	580	226	806

(i) Calculate the percentage of Mig1 molecules in the nucleus when glucose is **present**.

Show your working and write your answer to **two** significant figures.

..... % [2]

(ii) When glucose is **absent**, 13% of the available Mig1 molecules are present inside the nucleus.

Explain why this figure is different from your answer to **(i)**.

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..... [2]

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(c) Yeast cells are unable to take in and metabolise the disaccharide sugar lactose.

Some strains of yeast have been genetically engineered to overcome this, by inserting two genes from the bacterium *Escherichia coli* into yeast cells.

Name the **two** bacterial genes that have been inserted into the yeast cells.

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..... [2]

[Total: 11]

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6 **(a)** Structures and compounds involved in the light dependent stage of photosynthesis are listed, **A** to **J**.

A – thylakoid membrane

B – starch grain

C – chlorophyll a

D – chlorophyll b

E – water

F – NADP

G – electron

H – proton

I – ATP

J – chloroplast envelope

Complete Table 6.1 by matching each description with **one** letter chosen from **A** to **J** to show the correct structure or compound.

You may use each letter once, more than once or not at all.

Table 6.1

description	letter
accessory pigment	
location of ATP synthase	
acts as reaction centre	
transports hydrogen atoms	
diffuses through ATP synthase	
broken down in photolysis	

[6]

(b) GP (PGA) and TP (triose phosphate) are intermediates of the Calvin cycle of the light independent stage. Some GP and TP are used for the synthesis of organic compounds.

(i) Name a polysaccharide synthesised as a result of TP production.

..... [1]

(ii) Name the additional element that is required for the production of amino acids from Calvin cycle intermediates.

..... [1]

[Total: 8]

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7 **(a)** Fig. 7.1 shows part of the process of respiration in a mitochondrion.

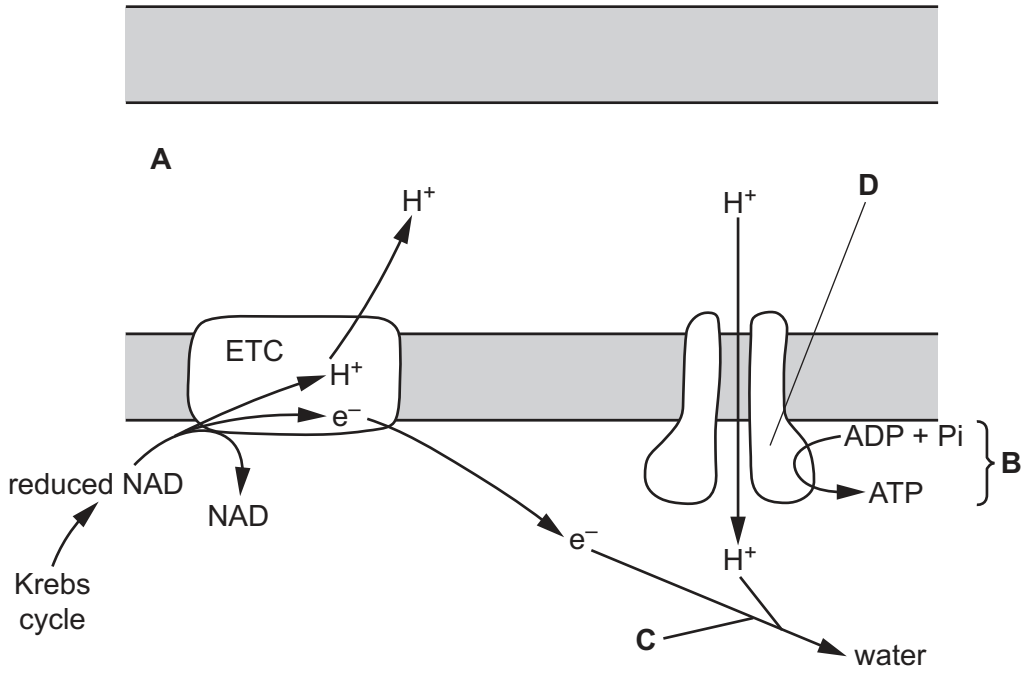

Fig. 7.1

(i) With reference to Fig. 7.1, name:

area **A** .....

process **B** .....

substance **C** .....

[3]

(ii) State the type of chemical compound that is represented by **D**.

..... [1]

(iii) State the process by which ATP can be synthesised directly during glycolysis or the Krebs cycle.

..... [1]

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The elephant seal, *Mirounga angustirostris*, spends most of its life in the ocean.

Fig. 7.2 is an elephant seal.

Fig. 7.2

(b) Elephant seals can stay underwater for up to two hours. During this time, respiration continues.

Fig. 7.3 shows the mass of blood in the body, as a percentage of total body mass, for the elephant seal and for three other mammals.

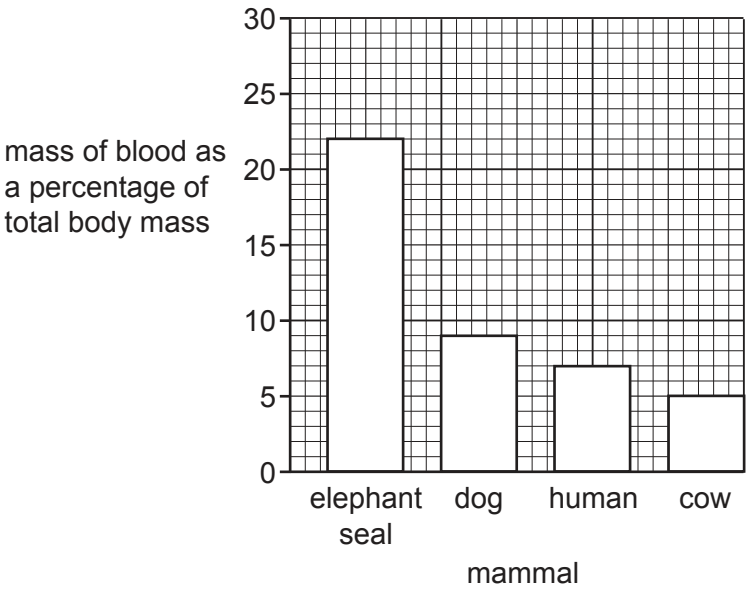

Fig. 7.3

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(i) Fig. 7.3 shows that elephant seals have a higher mass of blood as a percentage of total body mass than humans.

Calculate how many times greater this figure is for elephant seals compared to humans.

Show your working and write your answer to **two** decimal places.

answer ..... [2]

(ii) Suggest why an elephant seal needs such a large mass of blood as a percentage of total body mass.

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..... [2]

(c) Elephant seals have a very thick layer of adipose tissue under their skin. Adipose cells are rich in fat molecules.

Suggest why 1 g of fat will produce more ATP than 1 g of carbohydrate as a respiratory substrate in aerobic respiration.

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..... [2]

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(d) (i) Adipose tissue plays an important role in thermoregulation in elephant seals.

State the role of adipose tissue in thermoregulation.

..... [1]

(ii) The hypothalamus in the brain is the control centre for thermoregulation.

Outline how a change in temperature of the external environment results in an impulse arriving at the hypothalamus.

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..... [2]

(iii) When the blood temperature of a mammal decreases, one response is that its body secretes more adrenaline.

Suggest how an increase in adrenaline results in an increase in blood temperature.

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..... [2]

[Total: 16]

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8 **(a)** Sampling can be used to find the distribution and abundance of species in an area.

Students sampled a rocky shore from a high tide area to a low tide area. They decided to use a belt transect.

Describe how you would carry out a belt transect to assess the distribution and abundance of organisms in an area.

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..... [5]

(b) The results of an ecological investigation may suggest that there is a relationship between two variables, for example the abundance of a plant species and light intensity.

Scattergraphs can be drawn between the two variables.

(i) Fig. 8.1 shows three scattergraphs, **A**, **B** and **C**.

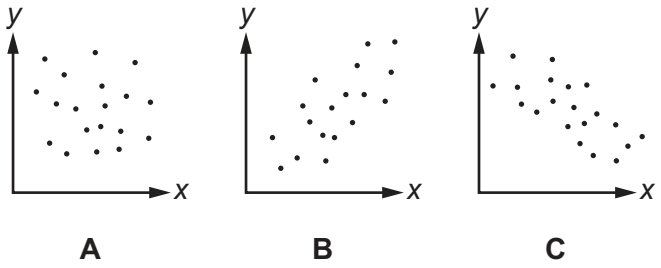

Fig. 8.1

State which scattergraphs show a relationship between the two variables, *x* and *y*.

..... [1]

(ii) Name a statistical test you would carry out to assess the strength of any relationship between two variables.

..... [1]

[Total: 7]

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Section B

Answer **one** question.

9 **(a)** Using named examples, describe **and** explain the differences between continuous variation and discontinuous variation. [8]

(b) Outline how selective breeding (artificial selection) has improved the yield of crops, such as wheat and maize.

[7]

[Total: 15]

10 **(a)** Describe **and** explain how the stimulation of sensory hair cells of a Venus fly trap plant leads to an insect being trapped. [8]

(b) Explain what is meant by the term *homeostasis* **and** describe the principles of homeostasis in mammals. [7]

[Total: 15]

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