

CANDIDATE
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BIOLOGY (PRINCIPAL)

Paper 1 Structured

9790/01

May/June 2019

2 hours 30 minutes

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.

Write your answers in the spaces provided on the Question Paper.

Section B

Answer **all** questions.

Write your answers in the spaces provided on the Question Paper.

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.

For Examiner's Use	
Section A	
21	
22	
23	
24	
25	
26	
Total	

This syllabus is regulated for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

This document consists of **31** printed pages and **1** blank page.

Section A

Answer **all** the questions.

You are advised to spend no more than 30 minutes on this section.

- 1 In which time period during the mitotic cell cycle does DNA replication occur?
- A between the end of cytokinesis and the G1 checkpoint
 - B between the G1 checkpoint and the G2 checkpoint
 - C between the end of chromosome condensation and the attachment of the chromosomes to the spindle
 - D between late prophase and the orientation of the chromosomes at the spindle equator

answer [1]

- 2 Which statement about cancer cells is correct?
- A They can develop from a stem cell when an oncogene mutates to a proto-oncogene.
 - B They can develop from a stem cell when a proto-oncogene mutates to an oncogene.
 - C They form tumour suppressor genes during uncontrolled cell division.
 - D They switch on tumour suppressor genes during uncontrolled cell division.

answer [1]

- 3 High density lipoproteins (HDLs) and low density lipoproteins (LDLs) are two types of lipoprotein found in humans.

Which is a correct statement about HDLs or LDLs?

- A HDLs transport cholesterol from the liver to other body tissues.
- B High plasma HDL concentrations increase the risk of developing atherosclerosis.
- C LDLs remove cholesterol that has accumulated in the lining of blood vessels.
- D LDLs transport cholesterol from the liver to other body tissues.

answer [1]

- 4 Table 4.1 shows the diameter and speed of nerve impulse of the axons of myelinated and unmyelinated motor neurones in a variety of animals. Two of these animals, cat and rabbit, are mammals.

Table 4.1

animal	diameter of neurone / μm	myelinated (\checkmark) or unmyelinated (\times)	speed of nerve impulse / ms^{-1}
cat	0.3	\times	0.7
rabbit	0.8	\times	0.8
garden snail	2	\times	0.3
cat	7	\checkmark	94
rabbit	10	\checkmark	50
frog	10	\checkmark	25
crab	30	\times	5
earthworm	70	\checkmark	23
squid	500	\times	25

Which statements correctly describe these data?

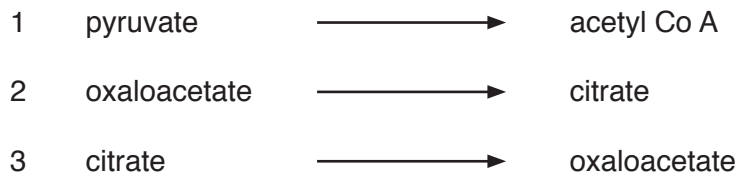
- 1 As the diameter of neurones increases, the speed of nerve impulse increases.
 - 2 In mammals, the speed of nerve impulse is greater in myelinated neurones than in unmyelinated neurones.
 - 3 In unmyelinated neurones, the speed of nerve impulse increases as neurone diameter increases.
 - 4 Myelinated neurones in mammals have a greater speed of nerve impulse than unmyelinated neurones in non-mammals.
- A** 1 and 2 only
- B** 1 and 3 only
- C** 2 and 4 only
- D** 3 and 4 only

answer [1]

- 5 Which feature shows that a substance is transported by facilitated diffusion rather than active transport?
- A Respiratory inhibitors affect the rate of transport.
 - B The substance is transported against the concentration gradient.
 - C The transport protein involved has a specific binding site for the substance.
 - D Transport across the membrane uses a membrane channel protein.

answer [1]

- 6 Which stages of respiration in aerobic conditions involve **both** decarboxylation and dehydrogenation?



- A 1 and 2 only
- B 1 and 3 only
- C 2 and 3 only
- D 1, 2 and 3

answer [1]

- 7 In 1972, Singer and Nicolson proposed the fluid mosaic model to describe cell membrane structure.

Which features of cell membrane structure are described by the term *fluid mosaic*?

- 1 the ability of a cell to engulf bacteria and to carry out phagocytosis
- 2 the lateral movement of phospholipids within the membrane
- 3 the different types of phospholipids that are present in the membrane
- 4 the proteins scattered within the phospholipid bilayer of the membrane

- A** 2 and 3 only
B 2 and 4 only
C 1, 2 and 3 only
D 1, 3 and 4 only

answer [1]

- 8 In the human menstrual cycle, what is the main cause of the surge in LH that occurs just before ovulation?

- A** negative feedback as a result of decreasing concentrations of FSH
B negative feedback as a result of decreasing concentrations of LH
C positive feedback as a result of increasing concentrations of oestrogen
D positive feedback as a result of increasing concentrations of progesterone

answer [1]

9 Each cycle of the polymerase chain reaction (PCR) has three steps.

- DNA denatures to produce separate strands.
- Single-stranded DNA anneals with primers.
- *Taq* polymerase elongates the primer strands.

Which statements about *Taq* polymerase are correct?

- 1 *Taq* polymerase is not denatured by the temperature of the DNA denaturation step.
- 2 *Taq* polymerase is needed for binding primers to the separated DNA strands.
- 3 *Taq* polymerase has a high optimum temperature therefore the temperature can be raised after annealing for efficient elongation.
- 4 *Taq* polymerase does not have to be replaced during each cycle.

- A** 1 only
- B** 1 and 2 only
- C** 3 and 4 only
- D** 1, 3 and 4 only

answer [1]

10 Lengths of DNA can be digested using restriction endonucleases to obtain smaller fragments.

Which is the correct term to describe a short section of single-stranded DNA that is used to identify a desired fragment of DNA from a mixture?

- A** DNA primer
- B** *GFP* gene
- C** gene probe
- D** promoter sequence

answer [1]

11 Which is an event that leads to the opening of a closed stoma?

- A** Hydrogen ions are pumped into the guard cells from the apoplast.
- B** Hydrogen ions cotransport sucrose into the guard cells.
- C** Potassium ions enter the guard cells by facilitated diffusion.
- D** The sodium-potassium pump moves potassium ions into the guard cells.

answer [1]

12 Phenylketonuria (PKU) is an example of an inherited metabolic disease.

Which statements about PKU are correct?

- 1 In PKU there is a deficiency of tyrosine hydroxylase.
- 2 PKU is caused by a build-up of phenylalanine.
- 3 PKU is caused by a build-up of tyrosine.
- 4 Treatment for PKU is a diet low in phenylalanine.
- 5 Treatment for PKU is a diet low in tyrosine.

- A** 2 and 4 only
- B** 3 and 5 only
- C** 1, 2 and 4 only
- D** 1, 3 and 5 only

answer [1]

13 A tumour that develops in the medulla oblongata can affect its functioning and may cause physiological changes elsewhere in the body.

Which changes could be associated with the presence of a tumour in the medulla oblongata?

- 1 decreased ability to control heart rate during exercise
- 2 decreased ADH production affecting osmoregulation in the kidneys
- 3 decreased coordination of voluntary movements
- 4 decreased control of core body temperature

- A** 1 only
- B** 2 only
- C** 1 and 3 only
- D** 2 and 4 only

answer [1]

Questions 14, 15 and 16

A genetic cross involving two genes for flower characteristics was carried out using the sweet pea plant, *Lathyrus odoratus*.

- The gene involved in petal colour has two alleles, a dominant purple allele and a recessive maroon allele.
- The gene involved in fertility of anthers has two alleles, a dominant fertile allele and a recessive sterile allele.

A double homozygous dominant parent was crossed with a double homozygous recessive parent to obtain F1 offspring. The F1 offspring were then crossed with a double homozygous recessive plant (a test cross).

The phenotypes of 200 test cross offspring were recorded.

A student carried out a chi-squared (χ^2) test and used the following hypothesis to work out the expected numbers.

“The inheritance of petal colour is independent of the inheritance of fertility of anthers.”

Table 14.1 shows:

- the observed numbers of the 200 test cross offspring for each phenotype
- the expected numbers calculated for each phenotype
- the first step in the calculation to obtain the χ^2 value.

Table 14.1

phenotype	maroon petals fertile anthers	maroon petals sterile anthers	purple petals fertile anthers	purple petals sterile anthers
observed numbers (O)	38	61	63	38
expected numbers (E)	50	50	50	50
$\frac{(O - E)^2}{E}$	2.88	2.42	3.38	2.88

The equation for determining the χ^2 value is $\chi^2 = \sum \frac{(O - E)^2}{E}$, where Σ = sum of .

Table 14.2 shows a table of critical χ^2 values.

Table 14.2

degrees of freedom, ν	critical value			
	$p=0.05$	$p=0.02$	$p=0.01$	$p=0.001$
1	3.84	5.41	6.64	10.83
2	5.99	7.82	9.21	13.82
3	7.82	9.84	11.35	16.27
4	9.49	11.67	13.28	18.47

14 Which deductions can be made using the information provided?

- 1 A sweet pea plant that has maroon petals is more likely to have fertile anthers than a sweet pea plant with purple petals.
- 2 Four different genotypes were represented in the gametes produced by the F1 individual used in the test cross.
- 3 The genotype of the F1 offspring used in the test cross was known before the test cross was carried out.
- 4 The genotypes of the test cross offspring can be worked out.

- A 2 only
 B 1 and 3 only
 C 1 and 4 only
 D 2, 3 and 4 only

answer [1]

15 Which row, **A** to **D**, in Table 15.1, may be concluded from performing the χ^2 test on the results in Table 14.1?

Table 15.1

conclusion	difference between the observed and the expected results	original hypothesis
A	due to chance effects	accepted
B	not due to chance effects	accepted
C	due to chance effects	rejected
D	not due to chance effects	rejected

answer [1]

16 At what probability levels (p) are the observed and expected values significantly different?

- A 0.05 only
 B 0.05 and 0.02 only
 C 0.05, 0.02 and 0.01 only
 D 0.05, 0.02, 0.01 and 0.001

answer [1]

17 Which observations would indicate that an organism is a prokaryote?

- 1 80S ribosomes free in the cytoplasm
- 2 cell walls of chitin
- 3 reproduce asexually by mitosis
- 4 no Golgi apparatus

- A** 4 only
- B** 1 and 2 only
- C** 1 and 3 only
- D** 3 and 4 only

answer [1]

18 The stem length gene is involved in controlling the length between nodes of the garden pea, *Pisum sativum*. There are two alleles of the gene, *Le* and *le*. Depending on their genotypes, pea plants of different heights are obtained.

Which features about the stem length gene are correct?

- 1 A heterozygous genotype results in a garden pea plant of medium height.
- 2 One of the homozygous genotypes results in a garden pea plant that is tall in height.
- 3 The gene codes for an enzyme in the synthesis pathway of active gibberellin.
- 4 The gene codes for an enzyme in the synthesis pathway of active auxin.

- A** 1 and 3 only
- B** 2 and 3 only
- C** 1, 2 and 4 only
- D** 2, 3 and 4 only

answer [1]

19 Fig. 19.1 is a flow chart showing features of organisms **A** to **H**. The organisms spend all or part of their life cycle inside *Anopheles* mosquitoes.

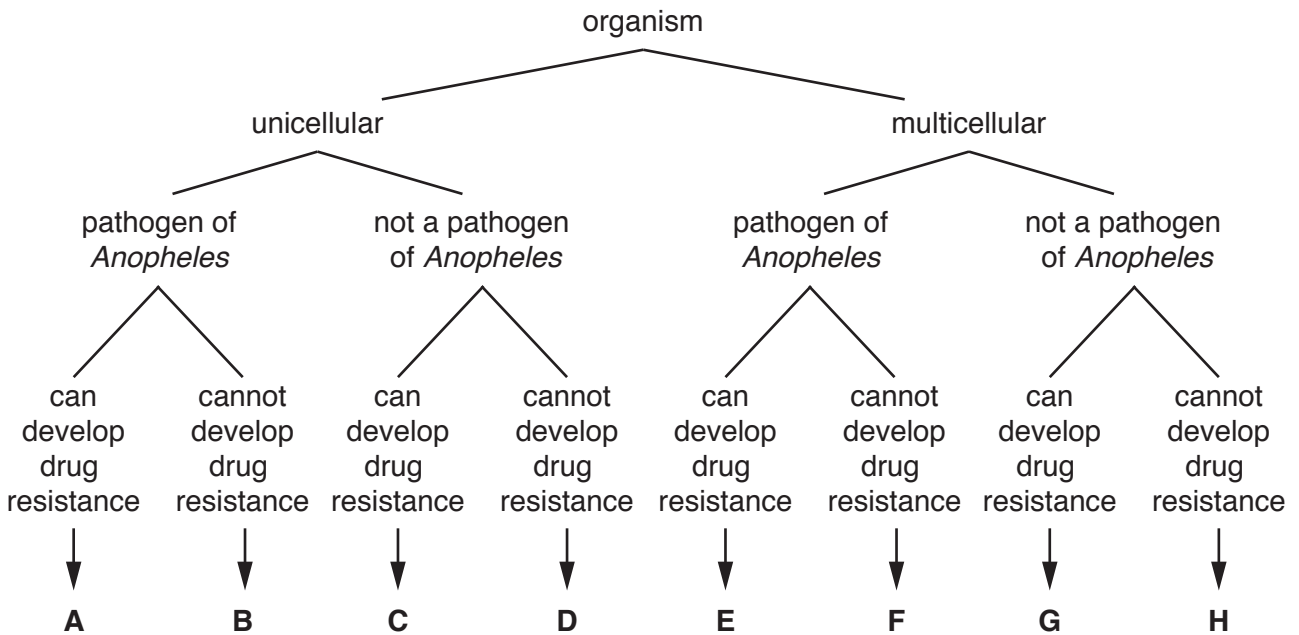


Fig. 19.1

Which letter, **A** to **H**, represents the organism that causes malaria?

answer [1]

20 Fig. 20.1 is a diagram of the human digestive system.

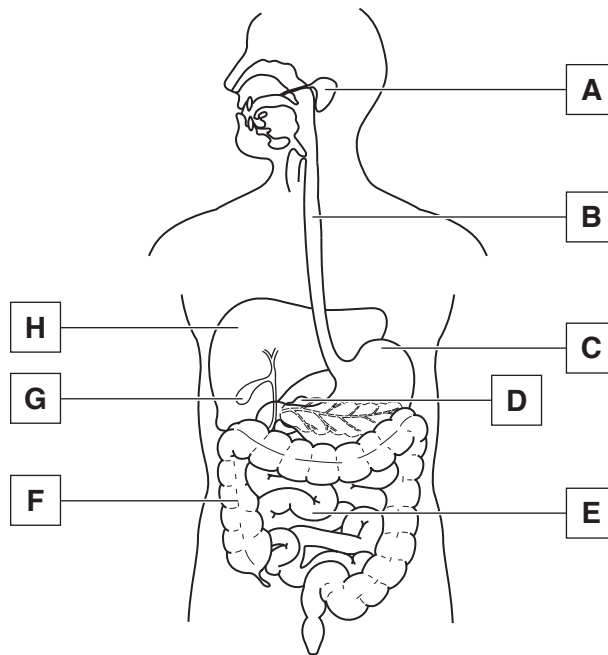


Fig. 20.1

State the letters of all of the structures that produce one or more carbohydrase enzymes.

answer [1]

- (c) Allergens are molecules that can cause allergic diseases. Allergens present on pollen produced by some species of *Bromus* can result in hayfever (allergic rhinitis) in some people.

Immunoglobulin E (IgE) is the class of antibody produced in response to allergens. IgE has a high affinity for receptors on a type of white blood cell known as a mast cell.

Fig. 21.2 is an outline summary of how hayfever develops after an initial 'sensitisation' process.

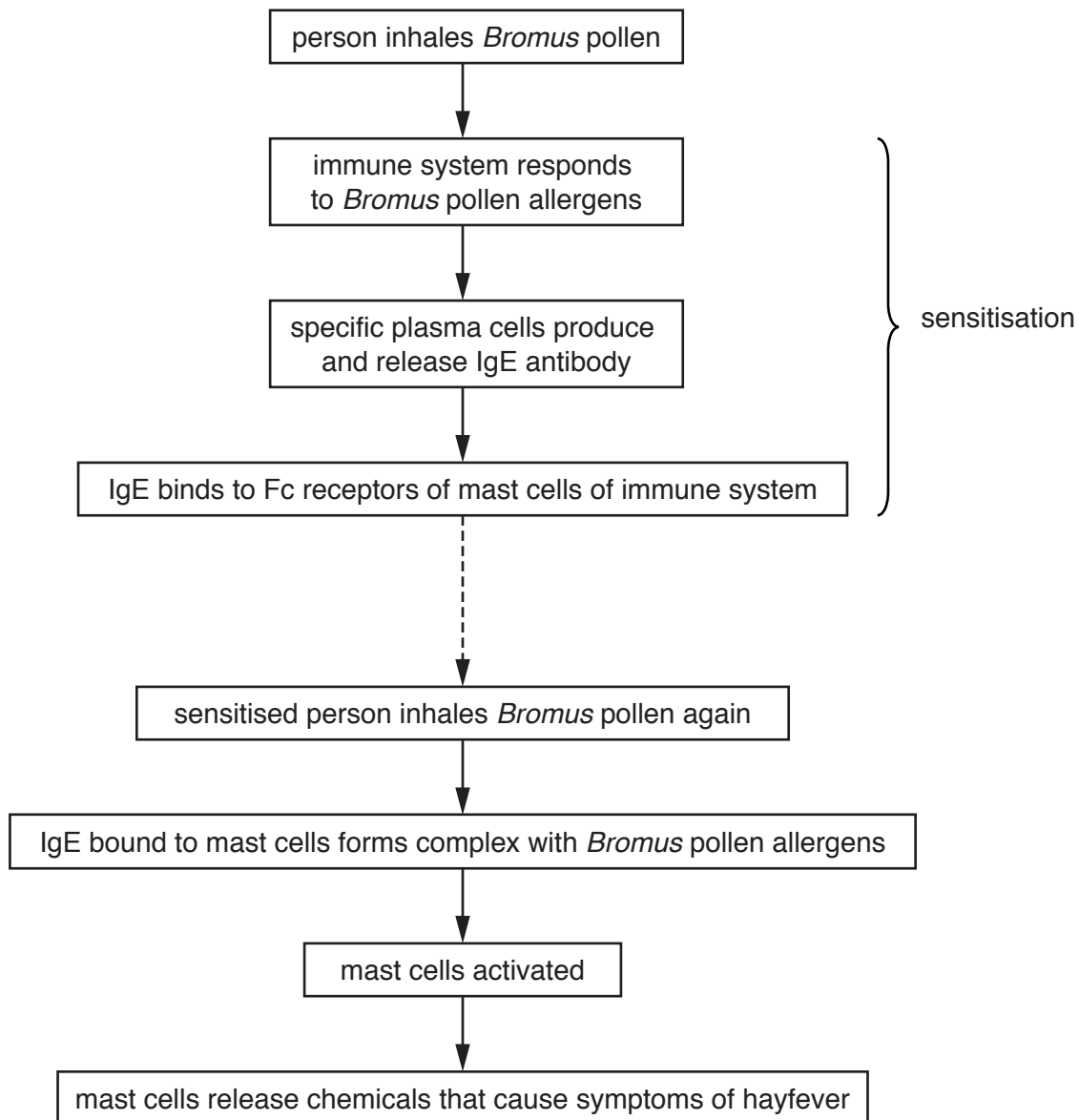


Fig. 21.2

- (i) The structure of an IgE molecule, which is very similar to the structure of an IgG molecule, is shown in Fig. 21.3.

With reference to Fig. 21.2, label and annotate Fig. 21.3 to show how the structure of an IgE molecule is suited to its mode of action.

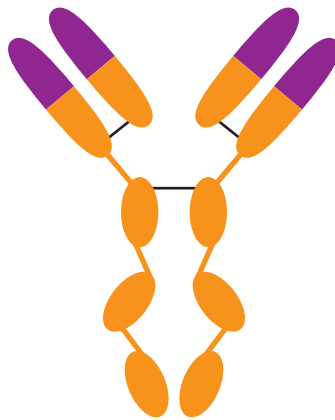


Fig. 21.3

[3]

- (ii) Omalizumab is a monoclonal anti-IgE antibody used in the treatment of hayfever.

Suggest how omalizumab may act to reduce the symptoms of hayfever.

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[Total: 14]

During maturation, an erythrocyte loses its nucleus and most other organelles, such as the ribosomes, rough and smooth endoplasmic reticulum, lysosomes and mitochondria. This gives more space for haemoglobin molecules.

A mature human erythrocyte can function for a mean lifespan of 115 days.

- (b) State the consequence to a mature erythrocyte of an absence of lysosomes and smooth endoplasmic reticulum.

lysosomes

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smooth endoplasmic reticulum

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[2]

- (c) Although there are no mitochondria, a mature erythrocyte can synthesise ATP.

- (i) Explain how ATP can be produced without mitochondria.

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- (ii) Suggest the benefit of a lack of mitochondria, other than to provide space for haemoglobin molecules.

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(d) Suggest why the quantity of RNA in the cell decreases during the development of a mature erythrocyte.

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(e) Homeostatic mechanisms regulate the concentration of blood glucose and the blood water potential. Blood glucose concentrations that deviate too far from the optimum range can affect the structure and functioning of erythrocytes.

(i) Erythrocytes were removed from a healthy person and placed in a glucose solution.

Fig. 22.2 is a coloured scanning electron micrograph of these erythrocytes.

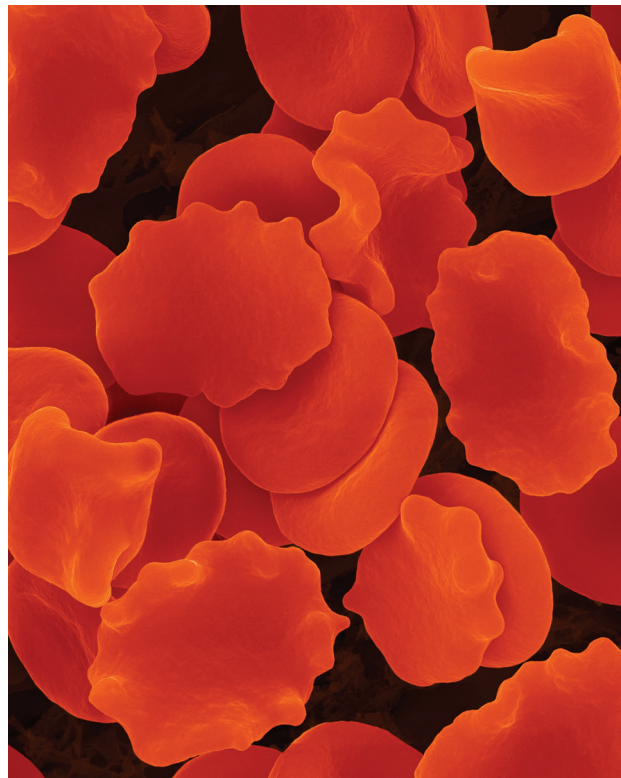


Fig. 22.2

23 A number of different proteins are involved in the control of the cell cycle.

To begin mitosis, cyclin B and cdk1 (a protein kinase) come together to form a complex termed the mitosis-promoting factor, MPF.

MPF phosphorylates proteins important in prophase. Examples of these proteins are:

- condensins, which cause chromosome condensation
- lamins, which are fibrous proteins that support the inner nuclear membrane.

(a) Suggest how MPF phosphorylation of lamins will affect the nuclear envelope.

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The condensed chromosomes visible in prophase each consist of sister chromatids. These are held together at the centromere. The sister chromatids are also held together along their length by a protein complex known as cohesin.

Cohesin can be broken down by the enzyme separase.

(b) Separase is an endopeptidase.

Outline how separase catalyses the breakdown of cohesin.

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(c) Separase is synthesised in an inactive form.

Fig. 23.1 shows the separase enzyme complexed to a protein called securin.

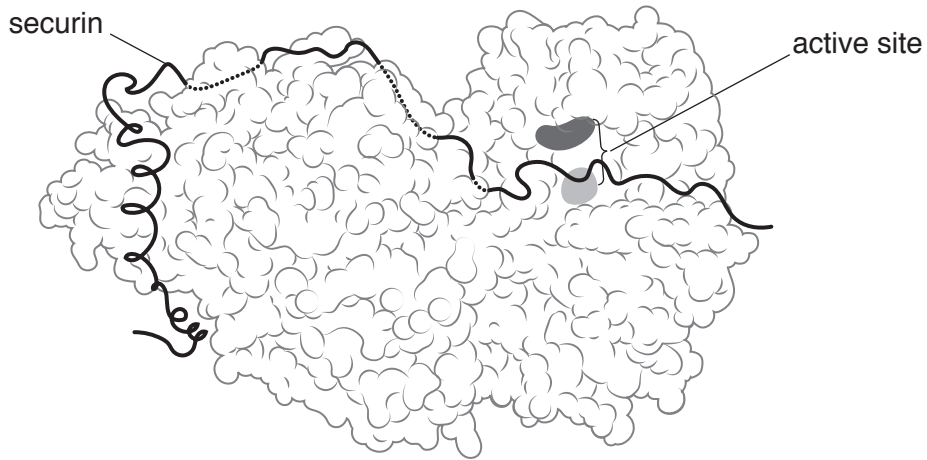


Fig. 23.1

(i) Securin promotes folding of separase.

Suggest why folding by securin is essential for separase activity.

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(ii) While securin remains bound to separase, the enzyme cannot catalyse cohesin breakdown.

With reference to Fig. 23.1, suggest how securin prevents separase activity.

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(d) Later in mitosis, MPF activates a protein complex, the anaphase-promoting complex (APC).

One role of activated APC is to catalyse the transfer of ubiquitin molecules to securin and to cyclin B. This leads to their degradation.

Suggest and explain how the ubiquitination of:

- securin triggers the transition from metaphase to anaphase
- cyclin B triggers the exit of the cell from mitosis, leading to cytokinesis.

securin

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cyclin B

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[5]

(e) State why chemical inhibitors of proteasome activity will disrupt control of the cell cycle.

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[Total: 12]

- 24** The coho salmon, *Oncorhynchus kisutch*, is a species of North American salmon with a three-year life cycle. It spends approximately equal time in fresh water, where the young fish mature in stages, and in the salt water of the Pacific Ocean, where adults spend the majority of their time.

Adults build up lipid reserves before migrating back to the stream in which they hatched from eggs (natal stream) in order to spawn (release sperm or eggs). They do not feed during their migration.

- (a)** The classification of the coho salmon is shown in Table 24.1.

Complete Table 24.1 to show how the classification of humans compares with coho salmon.

Table 24.1

taxon	coho salmon	human
Kingdom	Animalia	Animalia
Phylum	Chordata	
Class	Actinopterygii	
Order	Salmoniformes	
Family	Salmonidae	
Genus	<i>Oncorhynchus</i>	
Species	<i>kisutch</i>	

[2]

- (b)** The lipid reserves of the coho salmon are a good food source for humans as the stored triglyceride oils have a high concentration of polyunsaturated omega-3 fatty acids. Fish farms have been set up along the Pacific coast to meet the demand for salmon.

Describe the structure of a triglyceride that has polyunsaturated fatty acids.

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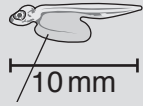

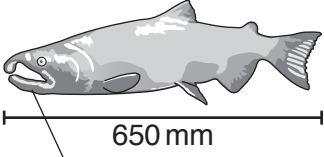
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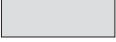

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Stages in the life cycle of the coho salmon are outlined in Table 24.2, together with some examples of the different behavioural responses shown.

The behavioural response to the water current is known as rheotaxis. A fish that turns and faces the current is showing positive rheotaxis.

Table 24.2

stage	examples of behavioural response	
young alevin  <ul style="list-style-type: none"> yolk sac used for growth and development 	<ul style="list-style-type: none"> after hatching out from egg in gravel nest, moves further down into the gravel away from light 	learns site specific odours, mainly in smolt stage
older alevin	<ul style="list-style-type: none"> moves up to water surface towards light takes in air to fill swim bladder for neutral buoyancy 	
fry	<ul style="list-style-type: none"> moves to areas nearby with slow currents to feed remains in feeding area 	
parr	<ul style="list-style-type: none"> remains in feeding area 	
smolt <ul style="list-style-type: none"> changes occur to prepare for transition to salt water 	<ul style="list-style-type: none"> turns to move with the current swims downstream towards the ocean 	
adult 	<ul style="list-style-type: none"> moves to feeding areas in ocean 	
breeding adult  <ul style="list-style-type: none"> develops hooked snout and large teeth 	<ul style="list-style-type: none"> returns from ocean to natal stream to spawn locates point of entry from ocean into the main river by various means, including sense of smell and taste (olfactory means). 	
breeding adult in fresh water	<ul style="list-style-type: none"> faces the current and swims up the main river locates natal stream, mainly by olfactory means 	

key  fresh water environment
 salt water environment

A number of mechanisms are believed to influence the migration back to the natal stream. One of these is the ability to detect the combination of odours that represent their natal stream, even in very low concentrations.

- (c) At each stage in its life cycle, the coho salmon shows innate and learned behavioural responses.

With reference to Table 24.2, describe and discuss the innate and learned behavioural responses shown by individuals in the different stages of the coho salmon life cycle.

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- (d) Unusually for a multicellular organism, the young alevin shown in Table 24.2 survives using only its skin surface to exchange respiratory gases. The other stages use gills.

State how it is possible for a multicellular organism, such as the young alevin, to survive by exchanging respiratory gases only through its skin surface.

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- (e) Adults die shortly after spawning.

Suggest how this contributes to the long-term survival of the local population of coho salmon.

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- (f) Some males, known as jacks, begin the migration to the natal stream much earlier in their adult lives than the normal breeding adult males.

Jacks are reproductively mature but are much smaller (300–400 mm in length) than the normal breeding adult males and do not develop the hooked snout and large teeth.

Some jacks compete successfully with normal breeding adult males to spawn as they sneak around the smaller boulders on the stream bed and avoid fighting for females. This means that both jacks and normal breeding adult males are able to spawn successfully.

Fig. 24.1 shows the variation in the body length of reproductively mature males in an original population of coho salmon, before evolution of the jack reproductive phenotype.

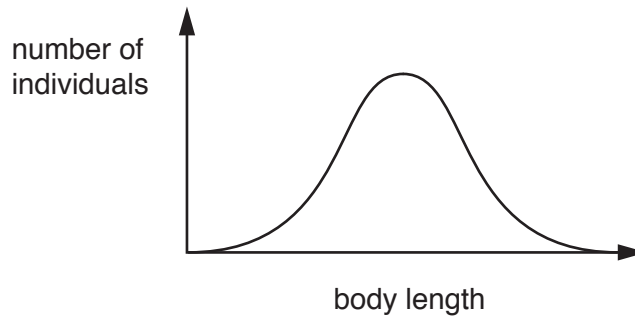


Fig. 24.1

Selection has since acted over time on this original population to change the distribution of body length in reproductively mature male salmon.

- (i) Sketch a curve on Fig. 24.1 to show the new distribution of body length in the present-day population of reproductively mature male salmon. [1]

- (ii) Name the type of selection that is occurring.
 [1]

(g) Conservation strategies have been put in place for several populations of coho salmon, which are listed as endangered. One population, the Interior Fraser population, is genetically distinct as all its closely related populations are extinct. Many of its sub-populations, originating from the small rivers flowing into the main river Fraser, have experienced a severe decrease in numbers in recent years.

(i) Explain why the loss of sub-populations of the Interior Fraser population represents a decrease in biodiversity.

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(ii) Discuss the importance **and** use of conservation strategies.

Include in your answer reference to the coho salmon.

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[Turn over

25 Plants may be termed C3 or C4 according to the type of photosynthesis that is carried out. In hot climates or in arid environments, C4 plants are adapted to photosynthesise more efficiently than C3 plants.

Both C3 and C4 plants rely on an initial light-dependent stage in order to proceed to synthesise organic molecules in the next stage.

Fig. 25.1 is a section through a leaf of maize, *Zea mays*, a C4 plant.

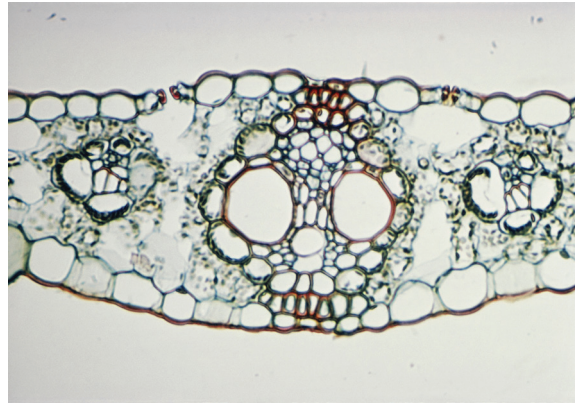


Fig. 25.1

(a) Describe how the leaf anatomy of a C4 plant differs from that of a C3 plant.

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- (b) Explain the relationship between the light-dependent and light-independent stages of photosynthesis within the chloroplast of a C3 plant.

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- (c) Xylem vessel elements and phloem sieve tube elements are visible in the photomicrograph of the section through the leaf of maize shown in Fig. 25.1.

State **one** way to distinguish between a xylem vessel element and a phloem sieve tube element when being viewed using a light microscope.

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- (d) Maize starch can be used to produce a sugar syrup known as corn syrup, which can be processed further to obtain a sweeter product, high fructose corn syrup.

Commercially, immobilised glucose isomerase, rather than the enzyme free in solution, is used to convert corn syrup into high fructose corn syrup.

Explain why the use of immobilised enzymes is of greater economic benefit than using enzymes free in solution.

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[Total: 8]

- 26 Individuals within a population of the dunnock, *Prunella modularis*, can show different adaptive behavioural strategies, particularly in mating and breeding behaviour. The type of mating strategy chosen is linked to the availability of territory. Both male and female birds hold territory, but these territories can be separate or overlapping and can vary in size and quality of food resources offered.

Table 26.1 summarises the different mating strategies observed in the dunnock.

Table 26.1

mating strategy	individuals involved
monogamous	<ul style="list-style-type: none"> • each bird has only one mate
polygynous	<ul style="list-style-type: none"> • one male mates with at least two females • each of these females mates only with this male
polyandrous	<ul style="list-style-type: none"> • one female mates with at least two males • each of these males mates only with this female
polygynandrous	<ul style="list-style-type: none"> • males and females have multiple mates

When the young hatch, they are fed in the nest by males and females. Fig. 26.1 shows a male dunnock feeding young nestlings.



Fig. 26.1

- (a) Availability of territory determines the benefits of adopting either monogamous or polygynous mating strategies.

Suggest how territory size and overlap will differ for birds showing monogamous and polygynous mating strategies.

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- (b) Suggest and explain which of the four mating strategies is most beneficial to a female dunnoek, if food is not readily available.

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- (c) Fig. 26.1 shows the response of young nestlings to the arrival of a bird with food. This begging behaviour is a simple reflex action.

Describe the nervous system pathway used to produce a simple reflex action.

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