Oxford Cambridge and RSA

Monday 12 October 2020 – Morning

A Level Biology B (Advancing Biology)

H422/01 Fundamentals of biology

Time allowed: 2 hours 15 minutes

You can use:
- a scientific or graphical calculator
- a ruler (cm/mm)

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **110**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*****).
- This document has **32** pages.

ADVICE
- Read each question carefully before you start your answer.

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SECTION A

You should spend a maximum of 40 minutes on this section.

Write your answer to each question in the box provided.

Answer **all** the questions.

1 Which of the options, **A** to **D**, is the potency of adult bone marrow stem cells?

A multipotent

B pluripotent

C totipotent

D unipotent

Your answer ☐

[1]

2 Which of the molecules, **A** to **D**, reduces the permeability of the plasma membrane to most substances?

A carbohydrate

B cholesterol

C glycoprotein

D protein

Your answer ☐

[1]

3 To which of the substances, **A** to **D**, is the plasma membrane of an axon **least** permeable?

A ATP

B glucose

C K^+

D Na^+

Your answer ☐

[1]

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4 Which of the following, **A** to **D**, describes the structure of haemoglobin?

A each of the four polypeptide chains is combined with an identical haem group

B each polypeptide chain has a quaternary structure

C the quaternary structure of each polypeptide chain contains ionic bonds

D two polypeptide chains contain an alpha haem group and two contain a beta haem group

Your answer ☐

[1]

5 Which of the following statements is/are true of anaerobic respiration in **both** animal **and** yeast cells?

1: Pyruvate is produced in glycolysis.

2: Reduced NAD is oxidised.

3: Two molecules of ATP are produced net, per glucose molecule.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

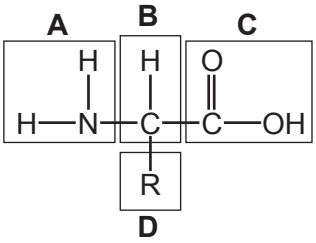
C Only 2 and 3 are correct

D Only 1 is correct

Your answer ☐

[1]

6 The diagram below shows the structure of an amino acid. Four regions are labelled **A** to **D**.



Which of the regions, **A** to **D**, is removed from the amino acid to produce urea?

Your answer ☐

[1]

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7 Which of the cell organelles, **A** to **D**, is most likely to increase the mass of a newly-translated protein?

A Golgi apparatus

B lysosome

C nucleus

D smooth endoplasmic reticulum

Your answer ☐

[1]

8 Which of the following statements is/are true of variable number tandem repeats (VNTRs) and single nucleotide polymorphisms (SNPs)?

1: Both VNTRs and SNPs are only found in intronic regions of DNA.

2: VNTRs are used in forensics to identify potential crime suspects.

3: VNTRs are generally more polymorphic than SNPs.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 1 is correct

Your answer ☐

[1]

9 Which of the protein types, **A** to **D**, could be coded for by a tumour suppressor gene?

A a protein activated by a growth factor

B a protein that helps prevent apoptosis

C a protein that promotes the cell cycle

D a protein that repairs DNA

Your answer ☐

[1]

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10 Which of the components, **A** to **D**, is **not** present in the human immunodeficiency virus?

A glycoprotein

B helicase

C reverse transcriptase

D RNA

Your answer ☐

[1]

11 Chromosome 1 in humans is composed of 2.5×10^9 base pairs.

DNA polymerase has an error rate of 1 base per 10^8 bases.

Which of the options, **A** to **D**, is the theoretical number of incorrect bases incorporated by DNA polymerase during replication of chromosome 1?

A 2.5

B 5

C 25

D 50

Your answer ☐

[1]

12 Which of the options, **A** to **D**, describes an indirect role of glucagon?

A condensation

B esterification

C hydrolysis

D oxidation

Your answer ☐

[1]

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13 Hypoalbuminaemia is a condition in which blood albumin levels are low. Albumin is a plasma protein.

Which of the options, **A** to **D**, is a correct explanation of why hypoalbuminaemia leads to accumulation of tissue fluid?

A decrease in blood pressure

B decrease in oncotic pressure

C increase in blood pressure

D increase in oncotic pressure

Your answer ☐

[1]

14 A body temperature measurement is 37.6 °C with an absolute uncertainty of 0.2 °C.

Which of the options, **A** to **D**, is the relative uncertainty for this temperature measurement?

A 0.20%

B 0.27%

C 0.53%

D 1.06%

Your answer ☐

[1]

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15 A patient was assessed for pulmonary function.

The volume of air breathed during a normal breath was $0.5\,dm^3$ in and $0.5\,dm^3$ out. The volumes of air breathed in and out during a maximum possible breath were seven times greater.

The estimated total lung volume was $4.5\,dm^3$.

Which of the options, **A** to **D**, is an estimate of residual volume in the patient?

A $1.0\,dm^3$

B $3.5\,dm^3$

C $4.0\,dm^3$

D $5.0\,dm^3$

Your answer ☐

[1]

16 Gas exchange in the lungs occurs as a function of partial pressure differences in oxygen and carbon dioxide between the alveoli, and blood in the pulmonary capillaries.

Which of the rows, **A** to **D**, shows the partial pressure values that would allow efficient gas exchange in a healthy lung?

	Alveoli		**Pulmonary capillaries**	
	pO_2 (mmHg)	**pCO_2 (mmHg)**	**pO_2 (mmHg)**	**pCO_2 (mmHg)**
A	104	40	40	45
B	40	40	104	45
C	40	104	45	40
D	104	45	40	40

Your answer ☐

[1]

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17 Benign prostatic hyperplasia (BPH) is an age-related condition in men.

Which of the options, **A** to **D**, is true of prostate cells in the development of BPH?

A cells become smaller

B cells increase in number

C cells increase in size

D cells merge together

Your answer ☐

[1]

18 A population of 1000 cancer cells was growing in culture. The doubling time of the cells was 36 hours.

Which of the options, **A** to **D**, is the theoretical number of cells present after 6 days?

A 3600

B 6000

C 16 000

D 36 000

Your answer ☐

[1]

19 Which of the following statements is/are true of herd immunity?

1: Herd immunity can protect against all diseases.

2: Herd immunity may eventually eradicate a disease from a population.

3: The more infectious the disease, the higher the proportion of individuals that must be vaccinated.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 1 is correct

Your answer ☐

[1]

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20 Which of the cell types, **A** to **D**, initiates the secondary immune response?

A helper T cell

B memory B cell

C plasma B cell

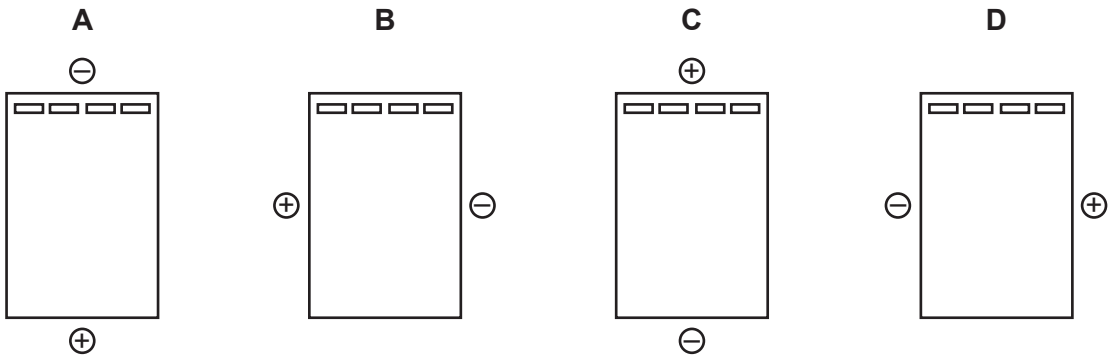
D regulatory T cell

Your answer ☐

[1]

21 The diagrams **A** to **D** represent different setups of an agarose gel electrophoresis experiment.

Each diagram shows an agarose gel and the positive and negative electrodes. DNA samples are loaded into the four wells at the top of each gel.



Which of the diagrams, **A** to **D**, shows the correct positioning of electrodes?

Your answer ☐

[1]

22 Which of the imaging techniques, **A** to **D**, uses X-rays to detect cancerous lung tissue?

A computed tomography imaging

B magnetic resonance imaging

C mammography

D ultrasound

Your answer ☐

[1]

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23 Which of the cancer treatments, **A** to **D**, can result in the need for a bone marrow stem cell transplant?

A chemotherapy

B hormone therapy

C immunotherapy

D surgery

Your answer ☐

[1]

24 Which of the methods, **A** to **D**, is considered the **least** accurate method of measuring core body temperature?

A axillary

B oral

C rectal

D tympanic

Your answer ☐

[1]

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25 An experiment collected data on the effect of ageing on reaction times.

Participants were placed into age groups, as shown in the table below.

Age group	Number of participants
18–29	43
30–39	39
40–49	45
50–59	40
60–69	44
70–79	39

Which of the statistical tests, **A** to **D**, is suitable to analyse the data produced in this experiment?

A chi-squared test

B paired Student's *t*-test

C standard deviation

D unpaired Student's *t*-test

Your answer ☐

[1]

26 Which of the following statements is/are true of haemodialysis?

1: Haemodialysis is often performed under medical supervision.

2: Molecules move from the patient's blood into the dialysis fluid by facilitated diffusion.

3: The water potential of the dialysis fluid is significantly greater than that of the patient's blood.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 1 is correct

Your answer ☐

[1]

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27 Which of the units, **A** to **D**, is suitable in calculating the energy content of areas of tidal mud?

A megajoules (MJ)

B $MJ\,m^{-1}$

C $MJ\,m^{-2}$

D $MJ\,m^{-2}\,yr^{-1}$

Your answer ☐

[1]

28 Which of the biological events, **A** to **D**, results from the activity of gibberellins during germination?

A synthesis of amylase in the aleurone

B synthesis of amylase in the endosperm

C synthesis of amylose in the aleurone

D synthesis of amylose in the endosperm

Your answer ☐

[1]

29 Water flows continuously through xylem vessels due to cohesion.

Which of the options, **A** to **D**, is responsible for the cohesive properties of water?

A covalent bonds

B hydrogen bonds

C hydrophobic interactions

D ionic bonds

Your answer ☐

[1]

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30 At high altitude, the lower atmospheric pressure decreases the water content of air.

Which of the options, **A** to **D**, describes the likely consequence of high altitude on transport pathways in plants?

A increases translocation rate

B increases transpiration rate

C no effect on transport pathways

D prevents transpiration

Your answer ☐

[1]

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SECTION B

Answer **all** the questions.

31 This question is about the female reproductive system and pregnancy.

(a) **(i)** Name the part of the reproductive system in which fertilisation occurs.

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

(ii) Fertilisation in humans involves a series of biological events that result in the formation of a zygote.

Some events in fertilisation are summarised in statements **A** to **F** below.

A	digestion of zona pellucida
B	completion of meiosis II
C	passage of sperm cell through follicular cells
D	nuclear fusion
E	digestion of plasma membrane of secondary oocyte
F	exocytosis of acrosome contents

Place the letters **A** to **F** representing the event statements into the correct order below. Statement **E** has been done for you.

			E		

[2]

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(b) **(i)** Pregnancy testing involves the use of antibodies. The antigen-binding site of an antibody recognises its antigen.

Describe the structure of the antigen-binding site.

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

(ii) The diagram in Fig. 31.1 shows a pregnancy test strip.

During the test, urine is deposited onto the sample pad and it migrates along the strip until it passes the control region.

Three regions of the strip that contain antibodies at the start of the test are labelled **A** to **C**.

The antibodies in region **A**, the antibody-antigen binding region, have a coloured dye attached that is visible by eye.

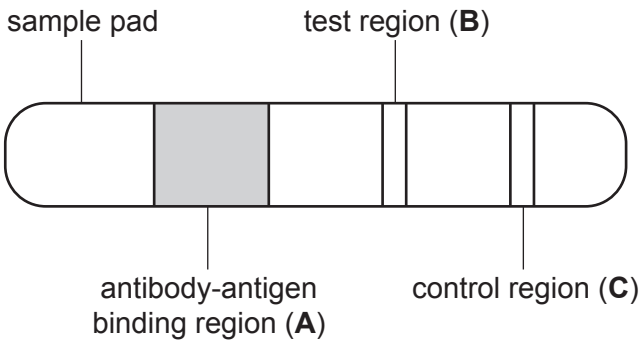

Fig. 31.1

Outline the role of the antibodies in each region of the test strip, **A** to **C**, in Fig. 31.1.

region **A** .....

.....

region **B** .....

.....

region **C** .....

.....

[3]

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(c)* During the menopause in women, menstruation becomes irregular and eventually ceases.

The menopause is associated with changes in the blood concentrations of some hormones.

Fig. 31.2 shows the mean blood concentrations of follicle-stimulating hormone (FSH) and oestrogen in a group of women from six years before the menopause to eight years after.

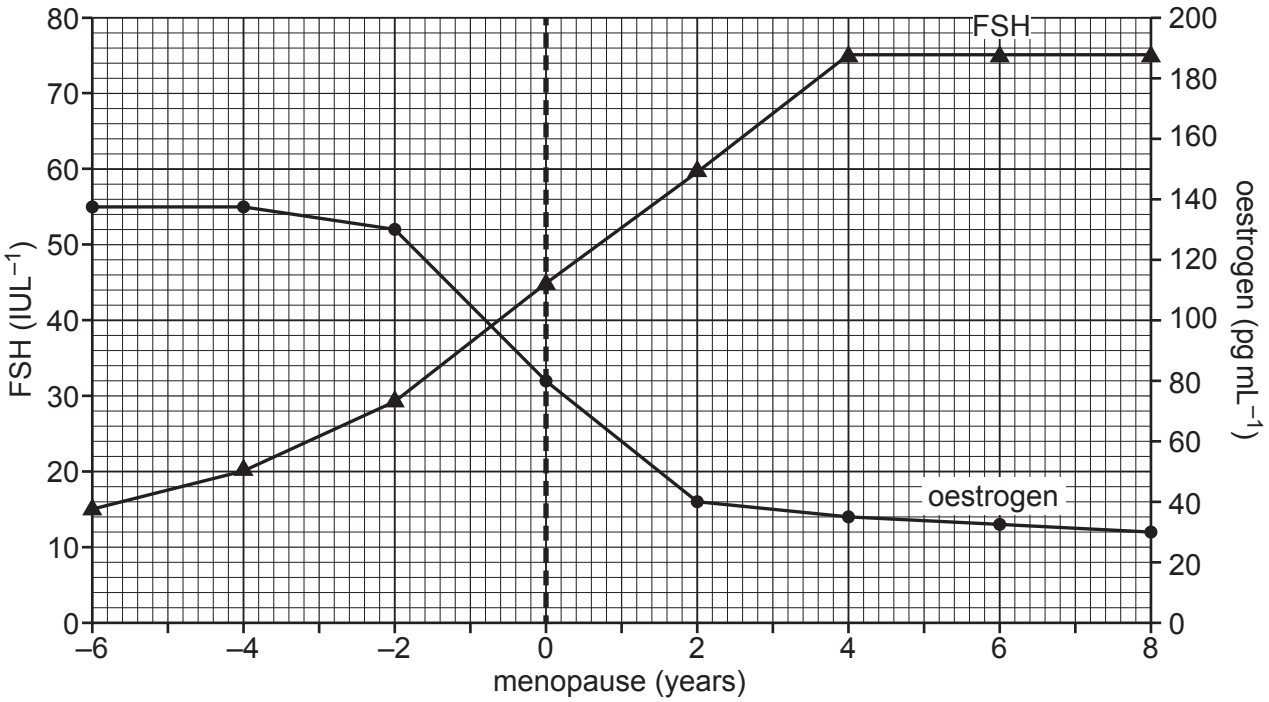

Fig. 31.2

Describe and explain the changes in blood FSH **and** oestrogen concentrations shown in Fig. 31.2. **[6]**

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Additional answer space if required.

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32 Model organisms such as *Drosophila melanogaster* (fruit fly) and *Pisum sativum* (common pea plant) are often used to study patterns of inheritance.

(a) Suggest **one** advantage and **one** disadvantage of using *D. melanogaster* over *P. sativum* as a model organism.

advantage .....

.....

disadvantage .....

.....
[2]

(b) An experiment was carried out to investigate the inheritance of plant height and flower colour in *P. sativum*.

The allele for tall stems is dominant to the allele for dwarf stems. The allele for purple flower colour is dominant to the allele for white flower colour.

(i) Two plants, both heterozygous for each trait, were crossed. State the genotype of the parental plants using the letters **R** for plant height and **Y** for flower colour.

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

(ii) Crossing of the parental plants produced 320 offspring. The numbers of offspring with each phenotype are shown in the table below.

Phenotype	**Observed (*O*)**	**Expected (*E*)**	***O* – *E***	**(*O* – *E*)^2**	**$\frac{(O-E)^2}{E}$**
tall stems, purple flowers	175				
dwarf stems, purple flowers	57				
tall stems, white flowers	63				
dwarf stems, white flowers	25				

Calculate chi-squared, χ^2.

Use the formula: $\chi^2 = \sum \frac{(O-E)^2}{E}$

You can complete the table to help.

χ^2 = ... **[4]**

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(iii) The table below is a χ^2 significance table.

p%	99	97.5	95	90	10	5.0	2.5	1.0	0.5
***v* = 1**	0.0001	0.0010	0.0039	0.0158	2.706	3.841	5.024	6.635	7.879
2	0.0201	0.0506	0.103	0.211	4.605	5.991	7.378	9.210	10.60
3	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.34	12.84
4	0.297	0.484	0.711	1.064	7.779	9.488	11.14	13.28	14.86

With reference to the χ^2 significance table, what **statistical** conclusion can be made from this experiment?

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

(c) Scientists often model human genetic diseases, such as Huntington's disease, in *D. melanogaster*.

Describe the genetic basis of Huntington's disease.

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

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33 Renal glucosuria is a rare condition in which glucose is excreted in the urine despite normal or low blood glucose levels.

(a) **(i)** Outline a test that could be used to detect glucose in a urine sample.

.....

.....

.....

.....

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

(ii) Draw the ring structure of a molecule of glucose in the space below.

[2]

(b) Familial renal glucosuria (FRG) is caused by mutations in the gene coding for the sodium-glucose cotransporter SGLT2. These mutations cause a reduction in SGLT2 protein or complete loss of SGLT2 protein function.

Fig. 33.1 shows SGLT2 in the plasma membrane of a cell in the kidney nephron.

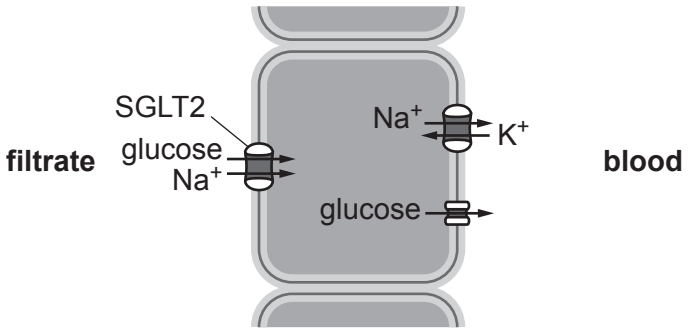

Fig. 33.1

Name the main area of the kidney, **and** the precise region of the nephron, in which the cell shown in Fig. 33.1 is located.

main area of the kidney .....

precise region of the nephron .....

.....

[2]

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(c) FRG is classified into type A, type B and type O.

Fig. 33.2 shows the relationship between blood glucose concentration and glucose reabsorption in healthy individuals and in patients with each type of FRG.

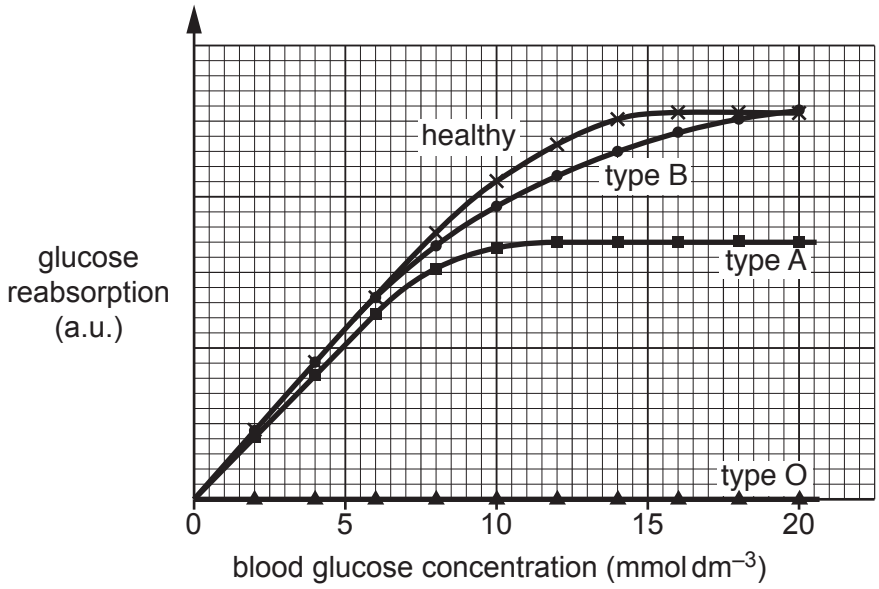

Fig. 33.2

Discuss the evidence in Fig. 33.2 to show that severity of renal dysfunction can vary among patients with FRG.

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

(d) **(i)** Patients with FRG often produce excessive quantities of urine. Suggest why.

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

(ii) Explain how concentration of urine is regulated in healthy individuals.

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

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34 Mitochondria are small eukaryotic organelles that generate ATP for cellular activity.

The image below is an electron micrograph of a mitochondrion. Two structures are labelled **X** and **Y**.

(a) Identify structures **X** and **Y** in the micrograph **and** explain how they adapt the mitochondrion to its function.

structure **X** .....

structure **Y** .....

explanation .....

.....

.....

[3]

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(b) The chemiosmotic theory was first proposed by Peter Mitchell in 1961. It has since been confirmed by experiments using isolated mitochondria.

One of the experiments was conducted as follows:

- Mitochondria were isolated from liver cells.
- The mitochondria were transferred to a buffer solution.
- The solution was poured into glass dishes, labelled A to D, to which ADP, Pi (inorganic phosphate) and other substances were added.
- Oxygen was excluded from dish B.
- After a period of time, the dishes were checked for the presence of ATP.

The results of the experiment are shown in the table below.

	Contents of dish	**ATP present?**
Dish A	mitochondria + ADP + Pi + acetyl CoA	yes
Dish B	mitochondria + ADP + Pi + acetyl CoA	no
Dish C	mitochondria + ADP + Pi + low concentration of acid (H^+)	no
Dish D	mitochondria + ADP + Pi + high concentration of acid (H^+)	yes

(i) Describe what is meant by the term chemiosmosis.

.....

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

(ii) Using your knowledge of mitochondrial respiration, explain the results for dishes B and C.

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

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(c) The volume of buffered mitochondria solution in each dish was controlled.

State **one** other variable in the experiment **and** explain why it should be controlled.

variable .....

.....

explanation .....

.....

[2]

(d) The experiment was extended by adding different metabolic intermediates to the dishes, such as succinate and oxaloacetate. Production of ATP was then measured quantitatively.

(i) Name a technique that can determine the concentration of a known molecule in a solution by measuring light absorbance.

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

(ii) Suggest an appropriate unit for quantitative ATP measurement.

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

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35 Translocation is the movement of organic substances made by a plant from one region to another along phloem tissue.

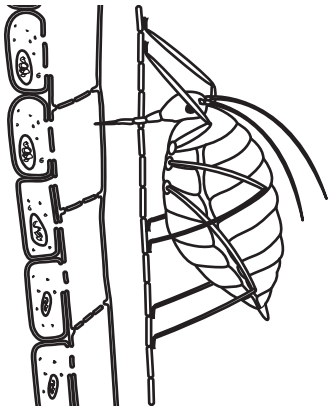
(a) Explain why plants require transport systems.

.....

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

(b) Aphids are small insects that feed on plants by inserting their tube-like mouthparts into phloem tissue, where they extract sap.

The diagram shows an aphid feeding from the stem of a plant.



(i) Name the sugar most commonly translocated.

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

(ii) After an aphid removes its mouthpart, sap continues to flow to the surface of the stem.

Explain why.

.....

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.....

.....

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

(iii) Some plant tissues are described as sources and sinks.

Explain why the stem tissue in the diagram could be described as neither a source nor a sink.

.....

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

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(iv)* Investigators could use the example of aphids in experiments to provide evidence of translocation. In these experiments, a fine glass tube is inserted into the phloem vessels and broken off at the stem surface. Droplets of sap forming at the stem surface drip from the plant.

Design an experiment using such tubes to investigate the effect of temperature on the rate of translocation.

In addition to basic laboratory apparatus, you are provided with the following:
- a room with temperature control
- plants with leafy tips and long, bare stems
- fine glass tubes.

Your answer should include details of appropriate methods to analyse data and measures to ensure validity of the results obtained.

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..... **[6]**

Additional answer space if required.

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36 Fig. 36.1 is a light micrograph showing a group of cells prepared from an onion root tip.

Five cells are labelled **P** to **T**.

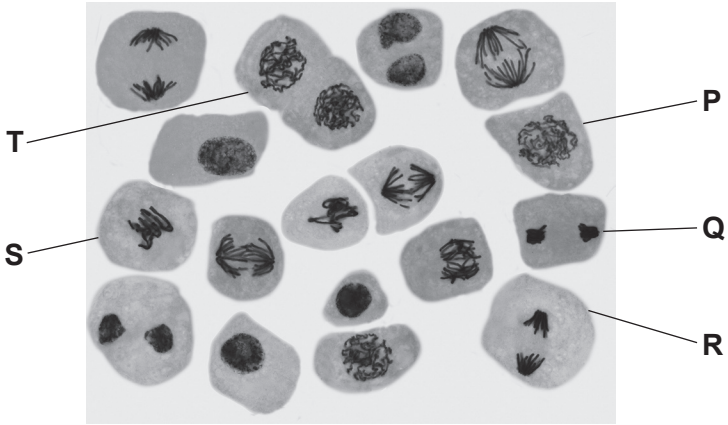

Fig. 36.1

(a) **(i)** Identify the stages of mitosis shown in cells labelled **P** to **S**. Write your answers in the table below.

Cell	Stage of mitosis
P	.....
Q	.....
R	.....
S	.....

[2]

(ii) Cytokinesis in plant cells includes a step absent from cytokinesis in animal cells.

State how that step allows two cells to be formed from cell **T**.

.....

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

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(b) A population of cells was isolated from an anther of a plant and viewed under a light microscope. The population comprised 254 cells, of which 118 were in interphase, 72 were in meiosis I and 64 were in meiosis II.

(i) Calculate the percentage of cells undergoing **reduction** division in the cell population.

percentage of cells = ... % **[2]**

(ii) Explain how specific events in meiosis give rise to genetic variation. State the **phase** of meiosis in which each event takes place.

.....

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

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(c) Apoptosis is a major mechanism of cell death that occurs as part of an organism's growth and development. Several features of apoptosis are shared between animals and plants.

Fig. 36.2 shows a plant cell in apoptosis.

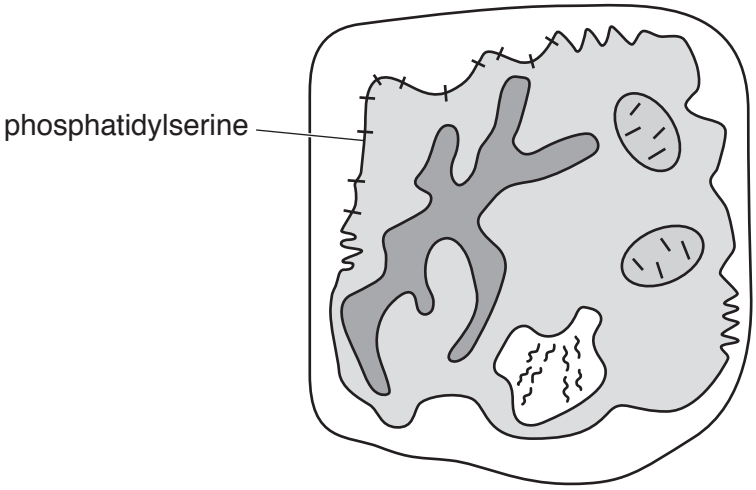

Fig. 36.2

Describe **three** features of apoptosis that can be observed in the plant cell in Fig. 36.2.

1. .....

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2. .....

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3. .....

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[3]

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37 The evolution of language in humans is one of the most challenging topics to research due to a lack of direct evidence. Instead, evidence must be drawn from indirect sources such as fossils, genetics and anatomical comparisons with other species.

(a) Scientists have proposed several theories to explain language evolution.

Suggest **one** way in which scientists formally communicate their ideas to other scientists.

.....

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

(b) The following text is a description of a theory of language evolution.

> **The Obligatory Reciprocal Altruism Theory (ORAT)**
>
> The obligatory reciprocal altruism theory states that honesty is required for language to evolve. In the context of language, reciprocal altruism means that if you speak truthfully to me, I'll speak truthfully to you. However, for language to be used across a whole community, trust and reciprocal communication must be enforced by all instead of being left to individual choice. Therefore, society as a whole must have been subjected to moral regulation.

Compare the obligatory reciprocal altruism theory with other **named** theories of language evolution.

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

(c) Bipedalism in hominids is an example of adaptation.

Suggest how bipedalism could have facilitated language evolution.

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

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(d) Complete the passage using the most appropriate word(s):

Genomes acquire mutations over time. This leads to ..... within a population. In the presence of a particular selection ....., some mutations provide organisms with a survival advantage. Sexual reproduction of surviving organisms results in a population of organisms that are adapted to their environment. This process is known as .... and is a mechanism of evolution.

[3]

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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