OCR
Oxford Cambridge and RSA

A Level Biology B (Advancing Biology)

H422/02 Scientific literacy in biology

Monday 11 June 2018 – Afternoon

Time allowed: 2 hours 15 minutes

6901207530

You must have:
- the Insert (inserted)

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

H422/02

First name									
Last name									
Centre number						Candidate number				

INSTRUCTIONS
- The Insert will be found inside this document.
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **24** pages.

Answer **all** the questions.

1 This question is based on the Advance Notice article **SPINAL CORD INJURIES: HOW COULD STEM CELLS HELP?**, which is an insert.

(a) The spinal cord contains both motor and sensory neurones.

(i) State one similarity and one difference between the structure of motor and sensory neurones.

similarity .....

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difference .....

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[2]

(ii) Explain why a spinal cord injury (SCI) causes both paralysis **and** loss of feeling below the site of the injury.

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

(iii) Describe the role of the myelin sheath in the propagation of nerve impulses.

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(iv) The Advance Notice discusses oligodendrocytes, which are cells found only in the central nervous system (CNS).

State the name of the cells that perform a function equivalent to oligodendrocytes in the peripheral nervous system.

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

(b) Treatment of injuries to the spinal cord, including with stem cell therapy, requires surgeons to determine the exact location and extent of the injury.

(i) State the name of an imaging technique that could be used for this purpose.

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

(ii) Describe how the technique you have given in **(i)** can be used to help surgeons to assess the location and extent of injury.

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(c) The Advance Notice article describes several types of stem cell.

Stem cells can be classified as totipotent, pluripotent, and multipotent.

Suggest which of these types of stem cell have been used in the clinical trials described in the Advance Notice. Give reasons for your choice.

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(d)* Using information from the Advance Notice, evaluate the risks, benefits and ethical issues related to the use of stem cells in the treatment of spinal cord injury (SCI).

In your answer, you should demonstrate an understanding of the current and future potential of stem cell therapy.

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

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2 In 1908, American plant breeder George F. Freeman published a paper called 'A method for the quantitative determination of transpiration in plants'. Freeman was working on breeding drought-resistant varieties of alfalfa. He reasoned that individual plants with the lowest rates of transpiration would show greatest drought resistance and should be used in selective breeding.

The rate of transpiration can be measured by using:

- a potometer with a shoot cut from the plant
- a whole plant growing in a pot, where water loss is calculated by measuring loss of mass.

Freeman investigated whether results obtained using a potometer were comparable with those obtained with whole plants. He measured the rate of transpiration in four types of plant by using either a potometer with cut shoots or whole plants growing in pots. The results are shown in Table 2.1.

Plant	**Average rate of transpiration / mg cm^{-2} leaf hr^{-1}**		**Rate of transpiration in potometer as percentage of transpiration in pots (%)**
	Pots	**Potometer**	
Daisy	7.21	1.44	20.0
Coleus	2.77	0.37	
Portulaca	1.72	0.47	
Geranium	0.65	0.65	100.0

Table 2.1

(a) Complete Table 2.1 by calculating the missing percentages for Coleus and Portulaca.

Show your working.

[1]

(b) **(i)** Temperature was controlled in this experiment. State **two** other variables that should be controlled to ensure valid results in this experiment.

1 .....

2 .....

[2]

(ii) Freeman made the following conclusions:

- There is a large difference between the rate of transpiration of a plant growing on its own roots ('normal' transpiration) and that of a cut shoot of the same plant placed in water.
- The difference is greatest in those plants having the highest rate of 'normal' transpiration.

Does the data in Table 2.1 support Freeman's conclusions? Give reasons for your answer.

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(c) Freeman then designed an experiment to allow him to measure the rate of transpiration in an alfalfa plant growing in soil in a greenhouse. Fig. 2 shows the apparatus he used.

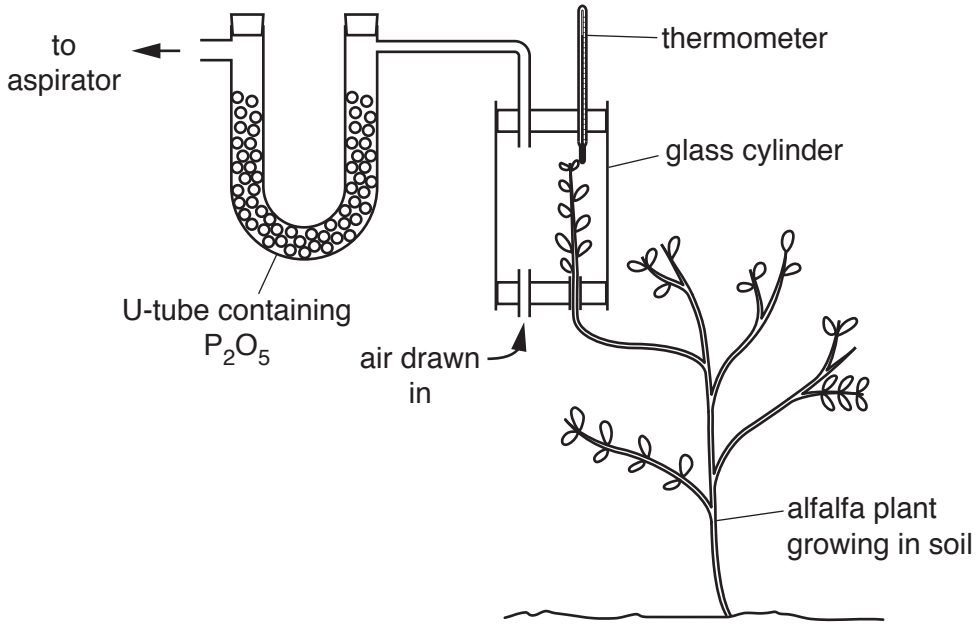


Fig. 2

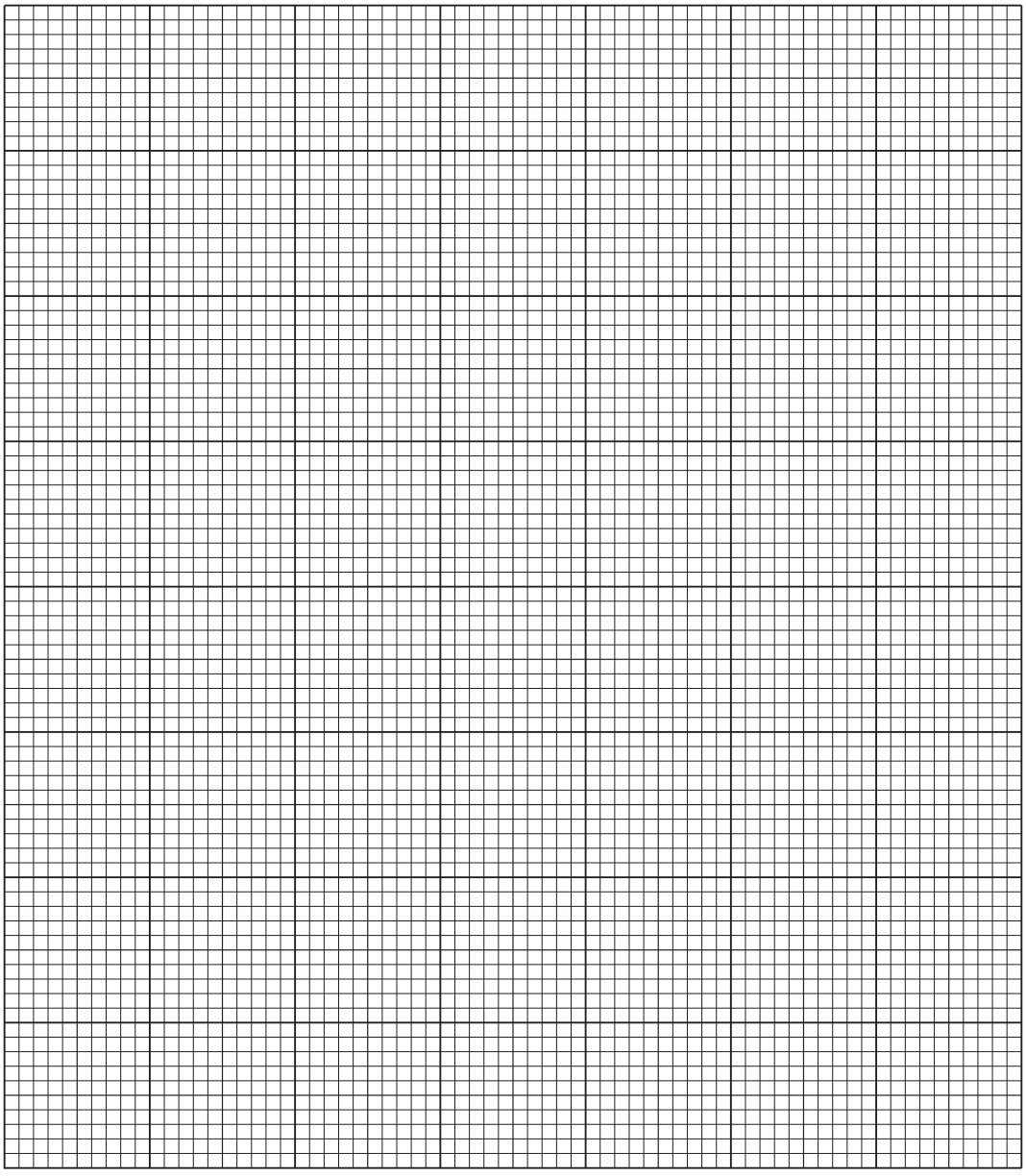
The aspirator created a steady flow of air into the cylinder past the stem of the alfalfa and through the U-tube. Phosphorous pentoxide (P_2O_5) absorbed any water in the air flowing through the U-tube. The mass of the U-tube was measured at ten minute intervals for one hour in order to calculate the rate of transpiration.

The results of one experiment are shown in Table 2.2.

Time (min)	Increase in mass of U-tube (mg)
0	0
10	65
20	120
30	184
40	255
50	309
60	379

Table 2.2

(i) Plot a graph of the results in Table 2.2 on the grid below.



[3]

(ii) The total area of leaves inside the cylinder was 22.28 cm^2. Use this value and your graph to calculate the rate of transpiration.

Give your answer in standard form to **two** decimal places.

answer = ... units = ... **[3]**

Question 2(d) begins on page 10

(d) Freeman was working on developing drought-resistant varieties of alfalfa using selective breeding, but this has proved difficult.

Drought resistance depends on the ability to withstand several abiotic factors, such as high temperatures and high light intensity.

(i) Use your knowledge of inheritance to suggest why it is difficult to study the genetic basis of drought resistance.

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

(ii) Alleles of the *miRNA 156* gene regulate a group of transcription factors in alfalfa. These transcription factors activate or inhibit promoters that control genes related to drought resistance.

Explain how the *miRNA 156* gene could be used to investigate the genetic basis of drought resistance.

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

(iii) Scientists have made a plasmid that produces more of the *miRNA 156* gene product than normal and want to use this to develop a drought-resistant alfalfa plant.

Explain how they could incorporate the plasmid into alfalfa cells.

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3 **(a)** The NHS has published the following advice about tuberculosis (TB) on its website:

> If you're diagnosed with active pulmonary TB (TB that affects your lungs and causes symptoms), you will be given a six-month course of a combination of antibiotics. The usual course of treatment is:
>
> - two antibiotics (isoniazid and rifampicin) for six months
> - two additional antibiotics (pyrazinamide and ethambutol) for the first two months
>
> It is important to take some basic precautions to stop TB spreading to your family and friends. You should:
>
> - always cover your mouth – preferably with a disposable tissue – when coughing, sneezing or laughing
> - open windows when possible to ensure a good supply of fresh air in the areas where you spend time
> - not sleep in the same room as other people.

(i) State the name of one organism that causes TB.

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

(ii) Explain why patients with pulmonary TB are advised to cover their mouths when coughing, to open windows when possible and not sleep in the same room as other people.

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

(iii) Most bacterial infections are treated with a single antibiotic for 7–10 days.

Explain why TB requires treatment with a combination of antibiotics for a much longer period.

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(b) Fig. 3 shows the structure of the human immunodeficiency virus (HIV).

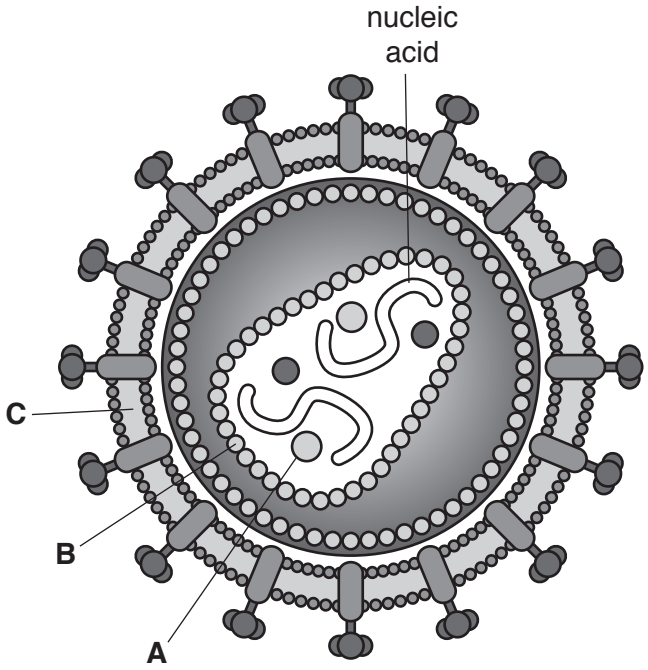

Fig. 3

(i) State the type of nucleic acid that forms the genetic material of HIV.

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

(ii) Identify the structures labelled **B** and **C** in Fig. 3.

B .....

C .....

[1]

(iii) State the name and describe the function of the enzyme labelled **A** in Fig. 3.

name .....

function .....

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[2]

(c) Acquired immunodeficiency syndrome (AIDS) refers to a series of symptoms and illnesses caused by HIV.

Describe how the life cycle and method of infection of HIV explains the following features of HIV/AIDS.

(i) There can be a long period (up to ten years) between infection and the onset of symptoms.

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(ii) A person infected with HIV becomes more susceptible to infections such as candidiasis, pneumonia and TB.

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(d) Studies have shown that HIV might increase the probability of clots forming inside blood vessels.

A student wrote the following notes about the process of blood clotting.

Complete the gaps in the student's notes using the most appropriate word or term.

Most clotting factors are ..... that convert an inactive clotting factor into an active clotting factor. For example, ... converts prothrombin to thrombin, which then hydrolyses ..... to form the protein fibrin. Because fibrin is a ..... protein the molecules become entangled with red blood cells and form a clot.

[4]

4 **(a)** Physiological ageing leads to changes in the male reproductive system. These changes can cause infertility and erectile dysfunction.

(i) Explain the difference between male infertility and erectile dysfunction.

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

(ii) State one factor, other than physiological ageing, that can cause erectile dysfunction.

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

(b) Hormone replacement therapy (HRT) is used to treat the symptoms of the menopause in some women. However, the molecules used in HRT can cause side effects.

Fig. 4 shows the results of a study, published in 2002, of the effect of HRT on the incidence of various conditions.

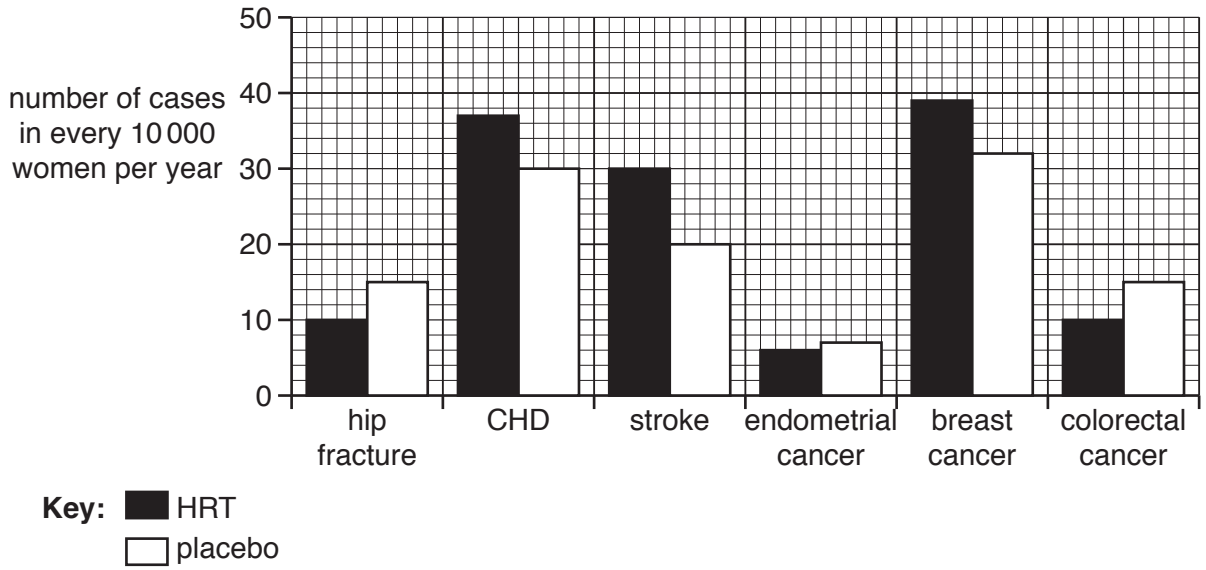

Fig. 4

(i) Use Fig. 4 to assess the effect of HRT on the incidence of disease and injury.

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(ii)* In November 2015 the National Institute for Health and Care Excellence (NICE) issued new guidelines for managing the menopause. These included:

- Women with cardiovascular risk factors should not automatically be excluded from taking HRT.
- Oestrogen-only HRT causes little or no increase in the incidence of breast cancer; HRT with oestrogen and progesterone can increase incidence of breast cancer, but any increased risk reduces after stopping HRT.

Use your own knowledge and these new guidelines to evaluate the risks of HRT.

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5 **(a)** Fig. 5.1 shows the changes in population, annual birth rate and annual death rate in Europe and Africa since 1950 and projected beyond 2080.

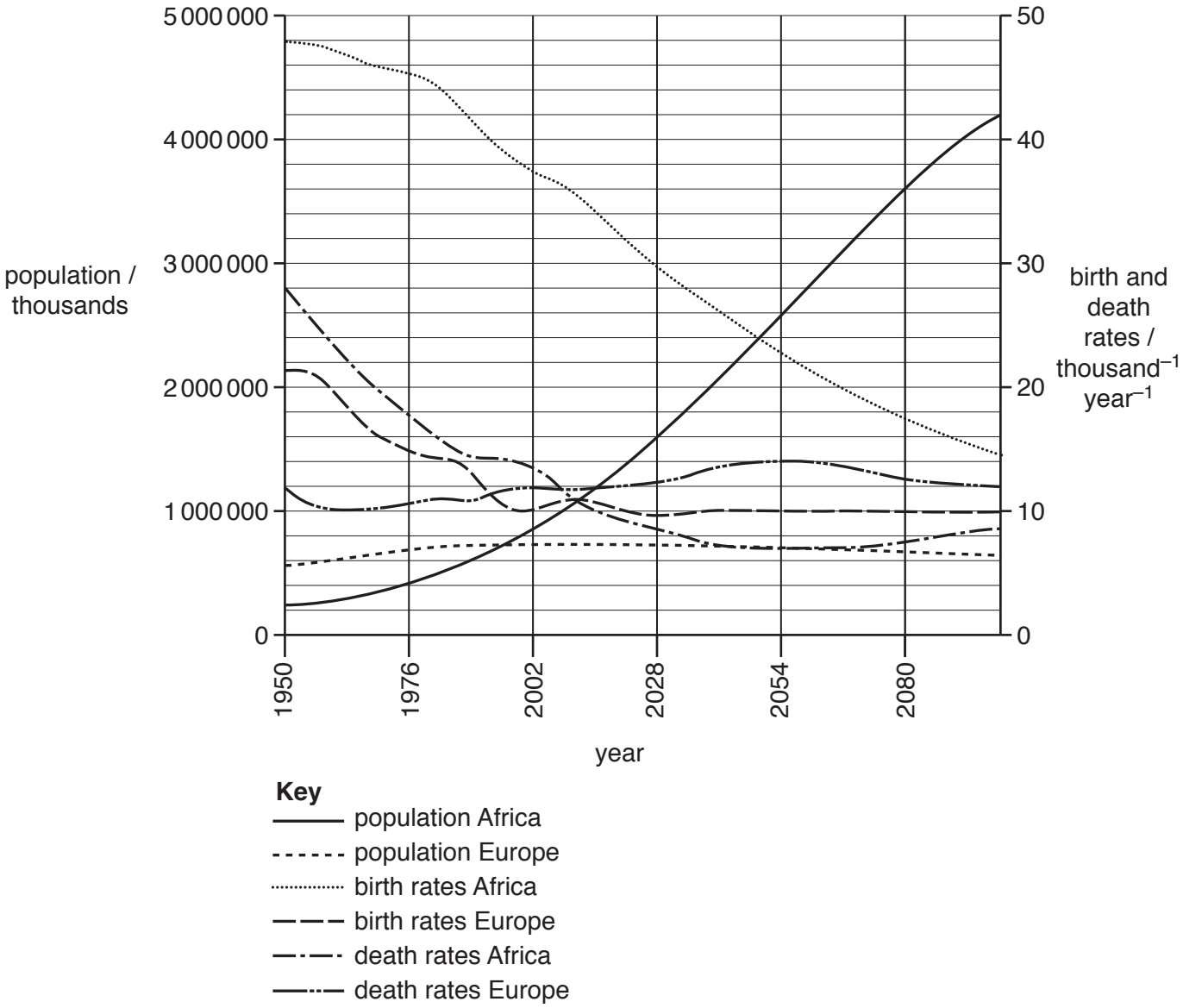

Fig. 5.1

(i) Explain why birth rates and death rates are shown in Fig. 5.1 as 'number per thousand per year'.

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

(ii) Use the data in Fig. 5.1 to calculate the projected rate of increase in the population of Africa between 2028 and 2080.

Show your working. Give your answer in standard form to **one** decimal place.

answer = ... thousands year^{-1} **[3]**

(iii) Use the birth rate and death rate data in Fig. 5.1 to explain the different trends in population for Africa and Europe.

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(b) Fig. 5.2 shows the total cereal production in Africa and cereal imports into Africa in the period 1960–2010.

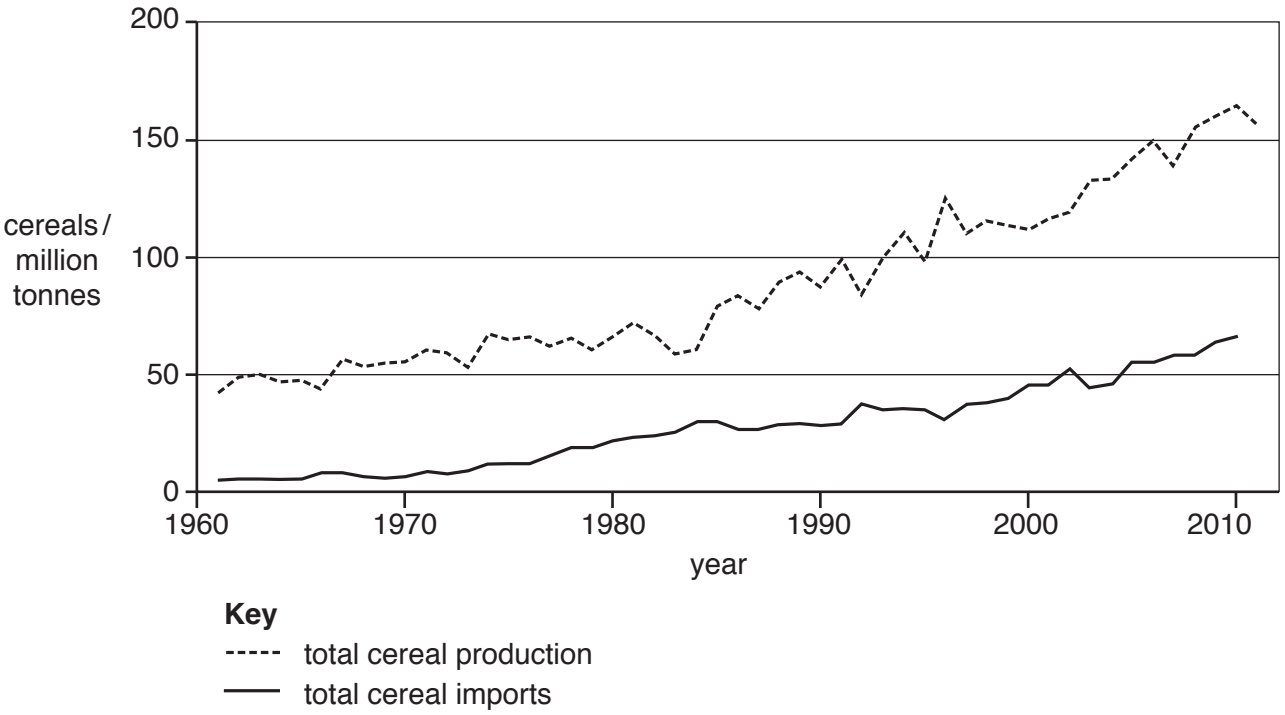

Fig. 5.2

(i) Explain why cereals are staple foods in many African countries.

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

(ii) Discuss to what extent the data in Fig. 5.2 explain the changes in death rates in Africa shown in Fig. 5.1.

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(c) Using Fig. 5.1 and Fig. 5.2, as well as your own knowledge, what can you conclude about the potential risks to food security and sustainability in Africa?

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6 The hormone erythropoietin (EPO) is produced by the kidneys.

(a) **(i)** Which cells in the body are targeted by EPO?

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

(ii) What change in conditions within the body would lead to an increase in the production of EPO?

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

(b) EPO can now be produced using recombinant DNA methods. The product is called rhEPO and has been used by athletes to enhance performance. This 'blood doping' has been banned since the early 1990s and anti-doping agencies have used a combination of blood and urine tests to detect the illicit use of rhEPO.

(i) Suggest how the use of rhEPO can be detected in a blood sample.

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(ii) Suggest why it has been difficult to determine the illicit use of rhEPO in the past.

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

(c) Patients who suffer from chronic kidney disease (CKD) often develop anaemia, the blood disorder that can occur when the body has fewer erythrocytes than normal.

(i) rhEPO can be used in the treatment of anaemia.

Explain why the normal action of EPO in the body makes it useful as a treatment for anaemia.

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

(ii) Suggest why CKD patients often develop anaemia.

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(iii) CKD can also trigger cardiovascular disease.

Explain how.

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

(iv) Darbepoetin alfa can also be used to treat CKD. It is a molecule with a similar structure to rhEPO.

Researchers injected a group of CKD patients with either darbepoetin alfa or rhEPO. They measured the concentration of each drug in patients' blood for up to 96 hours after injection.

Their results are shown in Fig. 6.

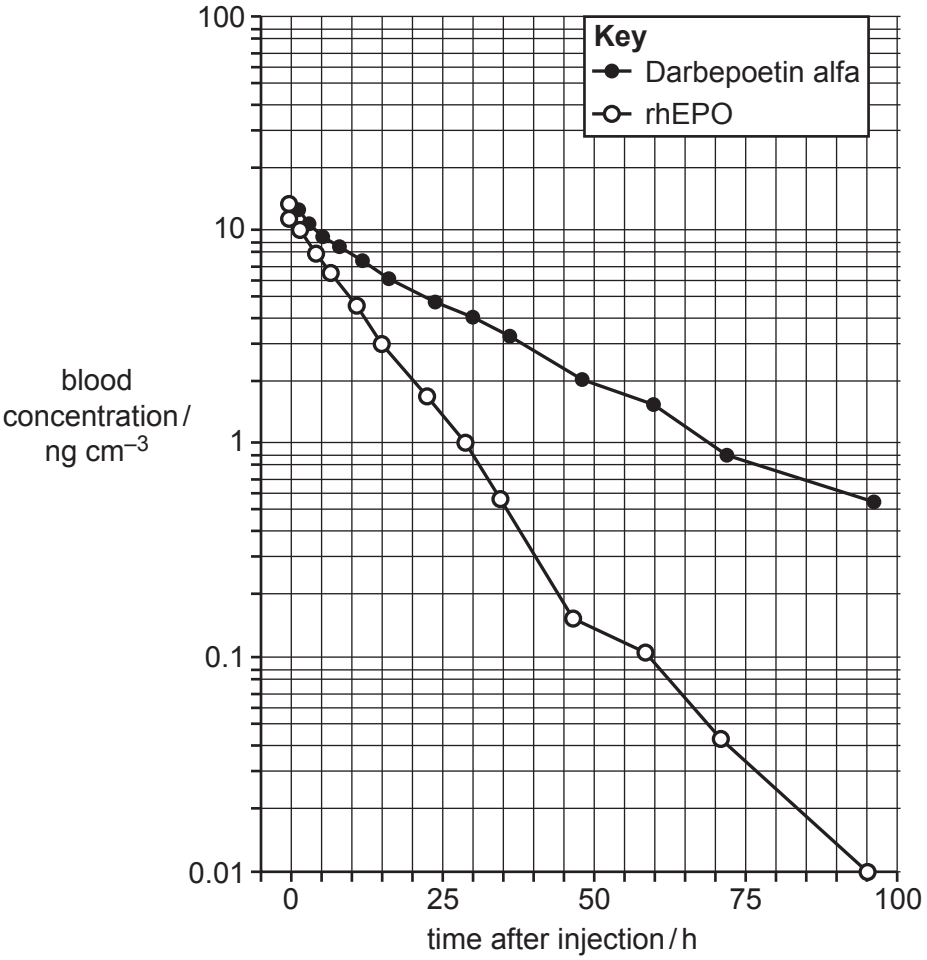

Fig. 6

A student looking at Fig. 6 stated:

After one day, there is five times more darbepoetin alfa than rhEPO remaining in the blood of patients.

Use Fig. 6 to calculate whether the student's statement is correct.

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

(d) CKD patients that develop kidney failure can be treated by dialysis, but this is not a cure. A kidney transplant can remove the need for dialysis. However, transplantation carries the risk of rejection of the transplanted kidney.

Describe how it might be possible to overcome rejection of a transplanted kidney in the future.

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END OF QUESTION PAPER

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).

Oxford Cambridge and RSA

A Level Biology B (Advancing Biology)

H422/02 Scientific literacy in biology

Insert

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Time allowed: 2 hours 15 minutes

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INSTRUCTIONS

- Do not send this Insert for marking; it should be retained in the centre or recycled.
- Please contact OCR Copyright should you wish to re-use this document.

INFORMATION

- This Insert contains the Advance Notice.
- This document consists of **4** pages.

SPINAL CORD INJURIES: HOW COULD STEM CELLS HELP?

The spinal cord transmits information between the brain and the rest of the body. Injury to the spinal cord, which currently affects 333,000 Europeans, can cause paralysis, and there is currently no effective treatment. Could stem cells help?

Introducing the spinal cord

The spinal cord is the delicate tissue encased in and protected by the hard vertebrae of the spinal column. Together, the brain and spinal cord form the body's central nervous system.

The spinal cord is made up of millions of nerve cells that carry signals to and from the brain and out into other parts of the body.

Neurones in the spinal cord also need the support of other cell types. Oligodendrocytes, for example, produce myelin.

What happens when the spinal cord is injured?

A spinal cord injury (SCI) affects both neurones and myelin sheath. At a cellular level, axons are crushed and torn, and oligodendrocytes begin to die.

The body cannot replace cells lost when the spinal cord is injured, and its function becomes impaired permanently. Patients may end up with severe movement and sensation disabilities. They will generally be paralysed and without sensation from the level of the injury downwards. Injuries high in the neck, such as those suffered by Superman actor Christopher Reeve, paralyse the whole body including the arms and shoulders. A common level of injury is just below the ribs, resulting in normal arm function but paralysed legs. Depending on the location and the extent of the injury, patients may suffer complete or incomplete paralysis, and loss of feeling, sexual function and bowel control.

How could stem cells contribute to spinal cord repair?

A spinal cord injury is complex, involving various forms of damage to different types of cell. The environment of the spinal cord changes drastically during the first few weeks after injury (immune cells flow in, toxic substances are released, and a scar is formed). A combination of therapies is needed, acting at the appropriate time-point and on the correct targets.

Studies in animals have shown that a transplantation of stem cells or stem-cell-derived cells may contribute to spinal cord repair by:

- replacing the nerve cells that have died as a result of the injury
- generating new supporting cells that will re-form myelin and act as a bridge across the injury to stimulate re-growth of damaged axons
- protecting the cells at the injury site from further damage by releasing protective substances such as growth factors, and soaking up toxins such as free radicals, when introduced into the spinal cord shortly after injury
- suppressing the damaging inflammation that can occur after injury.

Different cell types, including stem cells, have been tested in these studies. None of these cells has produced more than a partial recovery of function, but it is an active area of research, and several different types of stem cell are being tested and modified.

Stem cell treatments are beginning to be tested in clinical trials

Clinical trials using neural stem cells

In December 2010 a Phase I/II clinical trial on chronic spinal cord injury began at the Balgrist University Hospital in Zurich (Switzerland). The trial uses a type of stem cell derived from human brain tissue, which can make any of the three major kinds of neural cell found in the central nervous system. Analysis of clinical data to May 2014 has shown that the significant post-transplant gains in sensory function first reported in two patients have now been observed in two additional patients.

Neuralstem began a Phase I safety trial of its NSI-566 neural stem cells for chronic spinal cord injury (cSCI) at the University of California, San Diego School of Medicine. The four cSCI patients have no motor or sensory function in the relevant segments at or below the injury, and are considered to be completely paralysed.

All patients in the trial will receive six injections in, or around, the injury site. They will also receive immunosuppressive therapy for three months.

Clinical trials using mesenchymal stem cells (MSCs)

Mesenchymal/stromal stem cells are being investigated as possible treatments for spinal cord injuries. These include studies that investigate the safety and efficacy of MSCs derived from the patient's own bone marrow, adipose tissue (fat) or cord blood.

Clinical trials using embryonic stem cells

The company Asterias Biotherapeutics has developed a programme that focuses on the development of a kind of nerve cell, oligodendrocyte progenitor cells (OPCs), for spinal cord injury. These cells, known as AST-OPC1, are produced from human embryonic stem (hES) cells.

In a Phase 1 clinical trial, five patients with thoracic spinal cord injury were administered two million hES-derived OPCs at the spinal cord injury site. The subjects received low-level immunosuppression for the next 60 days. Delivery of OPCs was successful in all five subjects, with no serious adverse events associated with the administration of the cells or the immunosuppressive regimen. In four of the five subjects, scans suggested a reduction of the volume of injury in the spinal cord. The hope is that OPCs may re-myelinate and restore lost functions when transplanted into the injured spinal cord.

Can stem cells be used to treat spinal cord injuries now?

No. Although stem cells are already very useful in SCI research and are beginning to be tested in clinical trials, there are currently no proven and approved stem cell treatments available for spinal cord injuries. Several different approaches and types of stem cell are being investigated for their potential use in future treatments. The aims of the various strategies are to enable axons to regenerate, to replace lost myelin, and to protect the cord from spreading damage after the injury. It is likely that we will see further clinical trials based on these strategies.

Taken from: http://www.eurostemcell.org/factsheet/spinal-cord-injuries-how-could-stem-cells-help