Oxford Cambridge and RSA

Friday 16 October 2020 – Morning

AS Level Biology B (Advancing Biology)

H022/02 Biology in depth

Time allowed: 1 hour 30 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 StemUp Model Solution

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 you should 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 a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **70**.
- 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 **20** pages.

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

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Answer **all** the questions.

1 DNA normally contains four different nucleotides. Scientists have managed to create cells with six different nucleotides in their DNA.
The two new nucleotides are known as nucleotides X and Y.

Fig. 1.1 shows a section of a DNA molecule containing all six nucleotides, including X and Y.

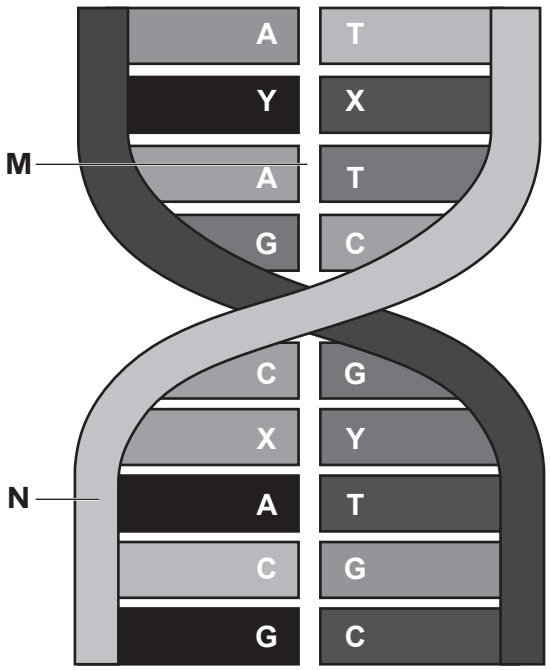

Fig. 1.1

(a) **(i)** Name the bonds found in the region labelled **M** on Fig. 1.1.

hydrogen bonds ..... **[1]**

(ii) Name the **two** components of DNA found in the region labelled **N** on Fig. 1.1.

phosphate (group) and deoxyribose (sugar) .....

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

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(b) Fig. 1.2 shows nucleotide X.

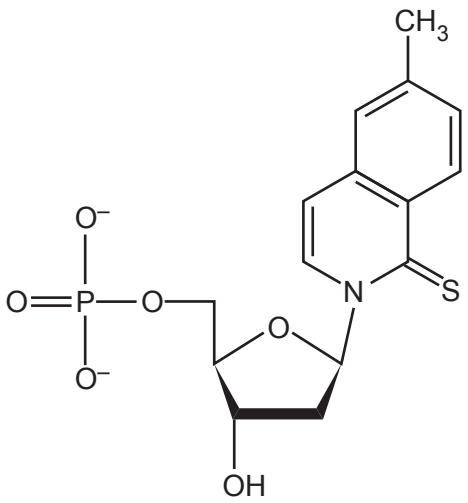

Fig. 1.2

Give **two** differences between the structures of nucleotide X and adenosine triphosphate (ATP).

1 X has deoxyribose sugar, whereas ATP has ribose

2 X has one phosphate group, not three; X has a sulfur atom

[2]

(c) The percentage of each nucleotide base in a DNA sequence can be estimated.

Complete the table using Chargaff's rule of DNA replication.

Nucleotide base	Percentage of each base in DNA strand 1 (%)	Percentage of each base in DNA strand 2 (%)
A	21	26
C	11	15
G	15	11
T	26	21
X	18	9
Y	9	18

[2]

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(d) Scientists have also been trialling cancer treatment drugs that form strong 'crosslinks' between the DNA strands. This is shown in Fig. 1.3.

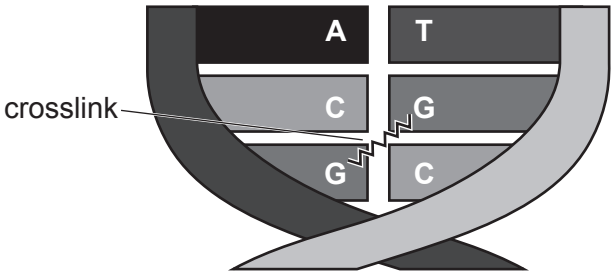

Fig. 1.3

Explain how the crosslinks would prevent DNA replication in the cancerous cell.

The crosslinks are strong bonds holding the two strands together, so DNA helicase cannot unzip the DNA: the hydrogen bonds between the complementary base pairs are not broken.
So the bases are not exposed, and free DNA nucleotides are unable to bind (pair) with the bases on the template strands, so DNA polymerase cannot join them together.
The whole strand cannot be copied, so the DNA cannot replicate and the cancerous cell cannot divide.

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

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(e) A student wanted to investigate the DNA content of two samples of plant tissue using the ethanol precipitation method in a school laboratory.

They used the following method:

1. Use an electric blender to blend 5 g of the plant tissue with table salt and cold water.
2. Filter this mixture and collect the filtrate in a beaker.
3. Add 30 cm^3 of washing-up liquid and swirl to mix.
4. Let the resulting mixture settle for 5–10 minutes and then pour into a test tube.
5. Add protease enzyme to the test tube.
6. Pour cold ethanol into the test tube.
7. Use a glass rod to collect the precipitated DNA.
8. Dry the precipitated DNA on a paper towel and measure the mass.
9. Repeat for the second plant tissue sample.

State **two** precautions that should be taken to produce valid results **and** explain why these two precautions are taken.

precaution 1 blend each sample for the same time at the same speed

explanation so that each sample has a similar surface area and similar cell wall breakage, releasing similar amounts of DNA

precaution 2 add the same volume and concentration of protease

explanation so that unwanted proteins (e.g. histones) are removed equally from each sample of DNA

[4]

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2 Human Papilloma Virus (HPV) has been linked to the development of cervical cancer.

A study was carried out involving 1000 women from five hospital trusts.

The table shows the number of cases of each strain of HPV found in women diagnosed with cervical cancer from the five hospital trusts between 2014 and 2015.

Hospital trust	Number of cases of cervical cancer for HPV strain					
	HPV 16	HPV 18	HPV 31	HPV 33	HPV 45	HPV 52
1	112	28	3	7	11	14
2	136	32	4	9	14	17
3	121	45	7	5	13	19
4	101	43	5	11	14	10
5	142	34	5	14	12	12
Total	612	182	24	46	64	72
Mean number of cases	122.4	36.4	4.8	9.2	12.8	14.4

(a) **(i)** Using only the data in the table, what conclusions can be made about the link between HPV and the development of cervical cancer?

Most cases of cervical cancer were linked to HPV 16 (mean 122.4) and HPV 18 (mean 36.4), and far fewer to HPV 31, 33, 45 and 52. But there is no control group (no comparison) to see if healthy women also have HPV, so the cancer could be caused by another factor, e.g. smoking. **[2]**

(ii) During the study the researchers wanted to use a statistical test to compare two of the strains of HPV and the associated risk of developing cervical cancer.

Name an appropriate statistical test that could be used **and** justify your choice.

An (unpaired) t-test, because the means of two groups are being compared. It is unpaired because the two strains of HPV are unrelated (independent of each other). **[2]**

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(b)* In 2008, the UK introduced the HPV vaccination into the national vaccination programme.

Outline the different types of vaccine available **and** the biological problems in developing these vaccines.

Vaccines contain antigenic material, which can be: a whole live organism; a live attenuated (weakened) organism that cannot cause disease; a dead (inactivated) pathogen; a preparation of antigens, such as purified surface proteins or virus-like particles (the HPV vaccine uses the L1 coat protein); or a toxoid, an inactivated toxin (for bacterial toxins).

There are biological problems in developing these vaccines. Viruses such as HPV have high mutation rates, so their antigens change (antigenic variability) and memory cells no longer recognise them. There are many strains of HPV with different antigens, so a vaccine must contain antigens from several strains (e.g. 16 and 18) and may not protect against all of them.

Live and attenuated vaccines carry a risk of causing the disease, especially in people with weakened immune systems, so the general health of the target group must be considered. Vaccines must be incubated and stored correctly, usually refrigerated, or the antigens are denatured; this makes **[6]**

Additional answer space if required.

distribution to remote areas difficult. Vaccines must also be given before infection, so girls and boys are vaccinated before they become sexually active.

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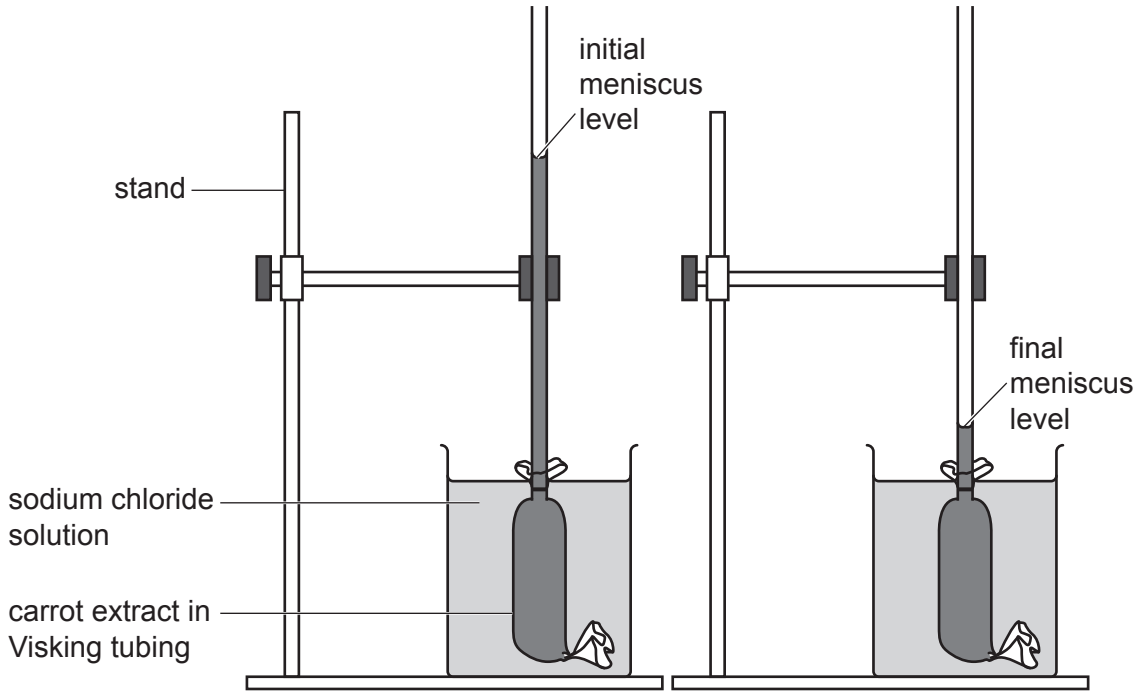
3 A student carried out an investigation into osmosis using the equipment shown. Carrot extract was placed into Visking tubing and the Visking tubing was then placed into a beaker filled with sodium chloride solution.

The initial level of the meniscus was recorded at the start and the final level of the meniscus was recorded after 24 hours.



The student repeated the investigation at a range of sodium chloride concentrations measuring the distance moved by the meniscus after 24 hours. The results are shown in the table.

Concentration of sodium chloride solution (mol dm^{-3})	Distance moved by meniscus (mm)
0.4	–17
0.6	–23
0.8	–29
1.0	–29

(a) **(i)** Calculate the percentage increase in the distance moved by the meniscus between 0.4 mol dm^{-3} and 0.6 mol dm^{-3} sodium chloride.

increase = 23 − 17 = 6 mm

(6 ÷ 17) × 100 = 35.3

percentage increase = ...35..... % **[2]**

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(ii) Explain why the Visking tubing containing carrot extract was left for 24 hours in the sodium chloride solution.

to allow enough time for a measurable (net) movement of water, as water loss is slow, and time to reach equilibrium **[1]**

(iii) What conclusions can be made about the movement of water from the results given in the table?

All the carrot extracts lost water, so the carrot extract has a higher water potential than all the NaCl solutions.

More water was lost into more concentrated NaCl solutions; at both 0.8 and 1.0 mol dm^{-3} the distance was −29 mm, so (net) loss of water had stopped. **[2]**

(iv) Explain how the investigation could be modified to find the concentration of sodium chloride solution that has the same water potential as the carrot extract.

Repeat with more concentrations between 0 and 0.4 mol dm^{-3} at smaller intervals, e.g. 0.0, 0.1, 0.2 and 0.3 mol dm^{-3} (more intervals).

Draw a graph of distance moved by the meniscus against concentration of NaCl, with a line of best fit, and read off the concentration where the line crosses the x-axis (distance moved = 0, no net movement of water). **[3]**

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(v) Explain how the student could have calculated the initial rate of osmosis in the different concentrations of sodium chloride.

Record the distance moved by the meniscus at regular time intervals, e.g. every 15 minutes, then plot a graph of distance against time and calculate the gradient of a tangent at the steepest (initial) part of the curve.

The volume of water could be found using $\pi r^2 d$. **[2]**

(b) (i) It is important to use carrots of a similar age when preparing extracts for this investigation.

Explain how using carrots of different ages could affect the results shown in the table.

Carrots of different ages could contain more or less sugar (or starch), so the extract could have a lower or higher water potential. So less or more water would leave by osmosis, and the meniscus would move down less or more.

[2]

(ii) Give **one** reason why using a Benedict's test to compare the sugar content of carrot extracts may **not** give valid results.

The sugar might be sucrose, a non-reducing sugar, which is not detected by the Benedict's test (and the orange-red colour is similar to the colour of carrot extract). **[1]**

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4 Pneumoconiosis is a respiratory disease often found in coal miners and is caused by the inhalation of coal dust.

Lung function tests can be used to help diagnose a patient with pneumoconiosis. The results from the tests can be used to show the volume of air remaining inside the patient's lungs as the patient forcefully exhales.

The table shows the results for a patient with pneumoconiosis.

Time (s)	Volume of air inside the lungs (dm^3)	
	Pneumoconiosis patient	**Mean for healthy individuals**
0	4.8	5.7
1	3.4	4.1
2	2.6	3.0
3	2.0	2.0
4	1.7	1.3
5	1.5	1.2
6	1.4	1.2
7	1.3	1.2
8	1.2	1.2
9	1.1	1.2
10	1.1	1.2

(a) **(i)** Calculate the rate at which air can be exhaled by the patient suffering from pneumoconiosis between 0 and 5 seconds.

$(4.8 - 1.5) \div 5$

$= 3.3 \div 5 = 0.66$

rate = ...0.66..... unit = .$dm^3 s^{-1}$..... **[2]**

(ii) Suggest why the mean lung volume for healthy individuals was included in the table.

..to allow a comparison with the patient's results, so the effect of.....

..pneumoconiosis can be seen..... **[1]**

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(b) What conclusions about the effect of pneumoconiosis can be made from the results in the table?

The patient has a reduced lung capacity: 4.8 dm^3 at 0 s compared with 5.7 dm^3.

There is less (elastic) recoil and force of exhalation: from 4 s the patient has more air left in the lungs (1.7 compared with 1.3 dm^3) and takes longer to exhale. **[2]**

(c) State **two** pieces of additional information that the doctor would need to consider when comparing the pneumoconiosis patient to a healthy person.

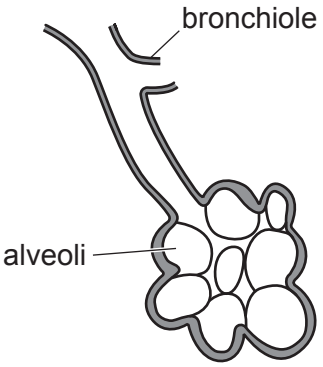
1 the patient's age and gender, as lung volume varies with these

2 whether the patient smokes, and their BMI (body mass and height)

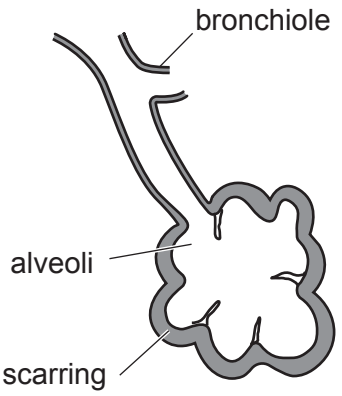
[2]

(d) The diagrams show the alveoli of a healthy person and a patient suffering from pneumoconiosis.

healthy person



pneumoconiosis patient



(i) Using the diagrams, explain why there would be a decrease in the oxygen concentration of the pneumoconiosis patient's blood.

The scarring makes the alveolar walls (squamous epithelium) thicker, which increases the diffusion distance for oxygen.

Alveolar walls are damaged or absent, so the alveoli have a lower surface area, so less oxygen diffuses into the blood. **[2]**

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(ii) Explain how the damage shown in the diagram could affect the physical activity of the patient.

Less oxygen is supplied to the muscle cells, so there is reduced aerobic respiration and less ATP production (energy release). The patient becomes tired (lethargic) and breathless, so physical activity decreases.

[2]

Turn over for the next question

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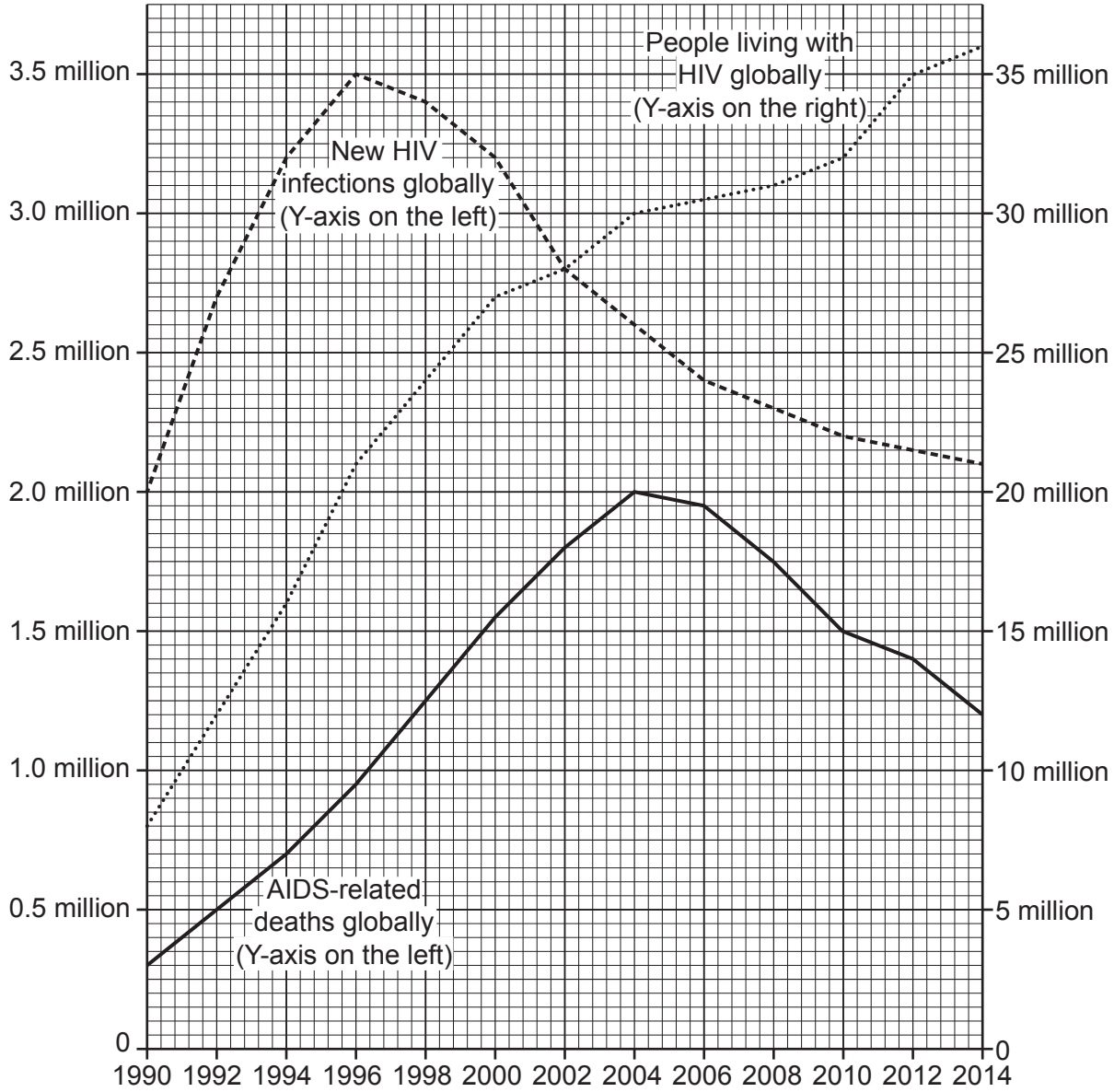
5 Acquired immune deficiency syndrome (AIDS) is caused by the Human Immunodeficiency Virus (HIV).

The graph shows the estimated global number of AIDS-related deaths, new HIV infections and the number of people living with HIV between 1990 and 2014.



(a) **(i)** Calculate the rate of increase in people living with HIV globally between 1990 and 1998.

1990: 8 million; 1998: 24 million

(24 – 8) million ÷ 8 years = 16 million ÷ 8

rate of increase = ...2 million.....yr^{-1} **[2]**

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(ii) Some scientists believe the rise in people living with HIV globally is proof that HIV has become a bigger problem since 1990.

Using only the information in the graph, explain why this may **not** be the case.

AIDS-related deaths have been falling since 2004, so more people with HIV are surviving for longer, e.g. due to treatment.

New HIV infections have been falling since 1996, so the rise is due to fewer deaths, not more spread of HIV.

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

(iii) Suggest why the data given in the graph is an estimate of the number of deaths and not the actual value.

not all countries have accurate records on the cause of death (many people are not tested or diagnosed) ..... **[1]**

(b) Discuss the effectiveness of antibiotics in the treatment of AIDS.

Antibiotics are not effective against HIV itself, as they cannot destroy a virus (viruses have no cell wall or bacterial ribosomes to target).

However, they can kill opportunistic bacterial pathogens, e.g. the bacterium that causes TB, which infect people with AIDS.

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

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(c)* Methods to control the spread of HIV in developing parts of the world have proved less successful than in developed countries.

Outline the biological, ethical and economic factors involved in the attempt to control the spread of HIV **and** how these factors may differ between developed and developing countries.

Biological factors: HIV has a high mutation rate, so its antigens change and no effective vaccine has been made. It hides in and destroys T helper cells, evading the immune system. There are symptomless carriers who do not know they are infected, and it is easily transmitted by unprotected sex, shared needles, blood and breast milk.

Ethical factors: encouraging the use of condoms (contraception) may meet religious objection; discouraging breast feeding by infected mothers; contact tracing and encouraging testing raise issues of confidentiality, and the stigma of HIV stops people being tested.

Economic factors: the cost of education programmes, contraception, tests, antiretroviral treatments, health facilities and medical staff.

Differences: developed countries can afford these, with good access to medical services, testing and education. In developing countries there is less access to medical services and education, treatments are too expensive, and cultural practices and beliefs (e.g. against condoms) are stronger, so control is less successful. **[6]**

Additional answer space if required.

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6 It is believed that the common ancestor of chimpanzees, gorillas and humans dates back around seven million years ago to a forest-dwelling ape.

Fig. 6.1 shows part of the phylogenetic tree for classifying these primates.

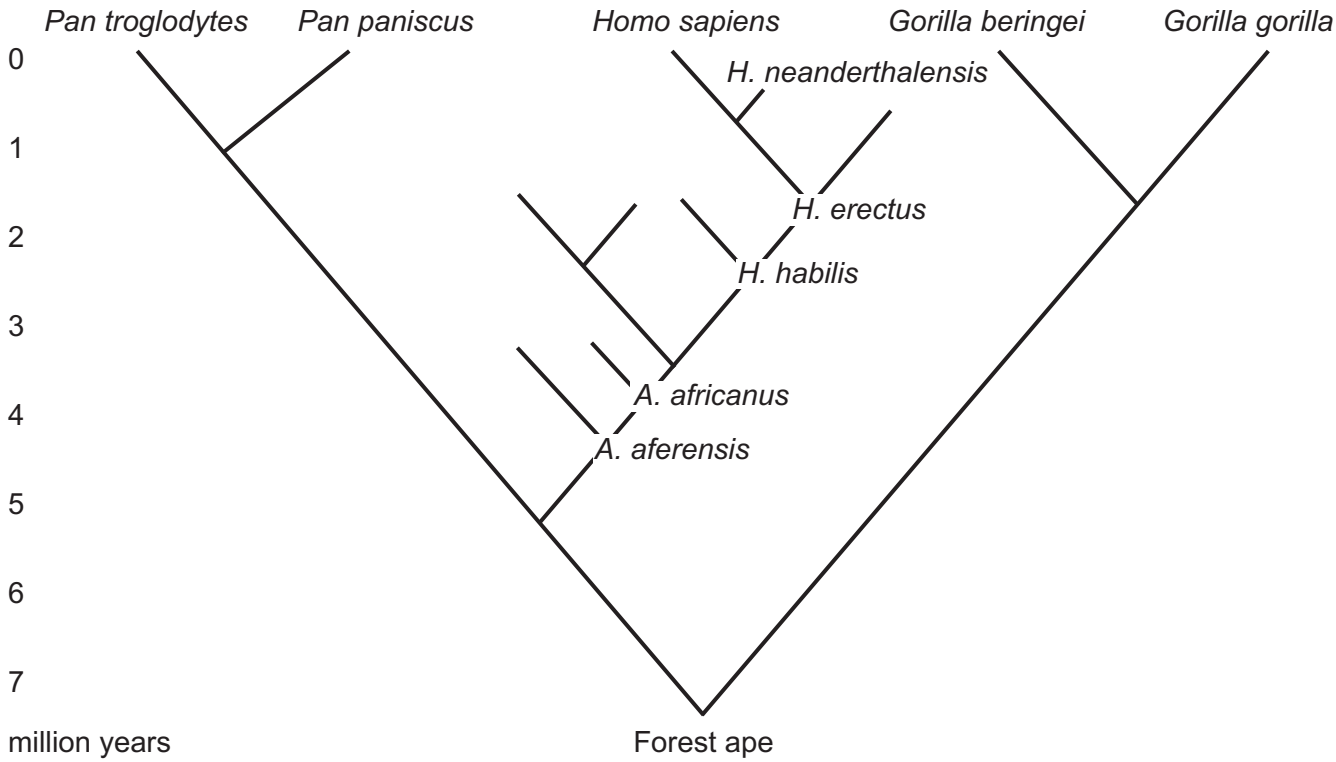

Fig. 6.1

(a) **(i)** Using Fig. 6.1, state how many species of primates that descended from forest apes are still alive today.

5 ..... **[1]**

(ii) Using Fig. 6.1, explain why *Homo sapiens* are more closely related to *Pan paniscus* than *Gorilla gorilla*.

they share a more recent common ancestor with Pan paniscus (5 million years ago) than with Gorilla gorilla (over 7 million) ..... **[1]**

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(b) Fig. 6.2 shows three primate skulls and the position of the foramen magnum.

The foramen magnum is the hole at the base of the skull that the spinal cord passes through.

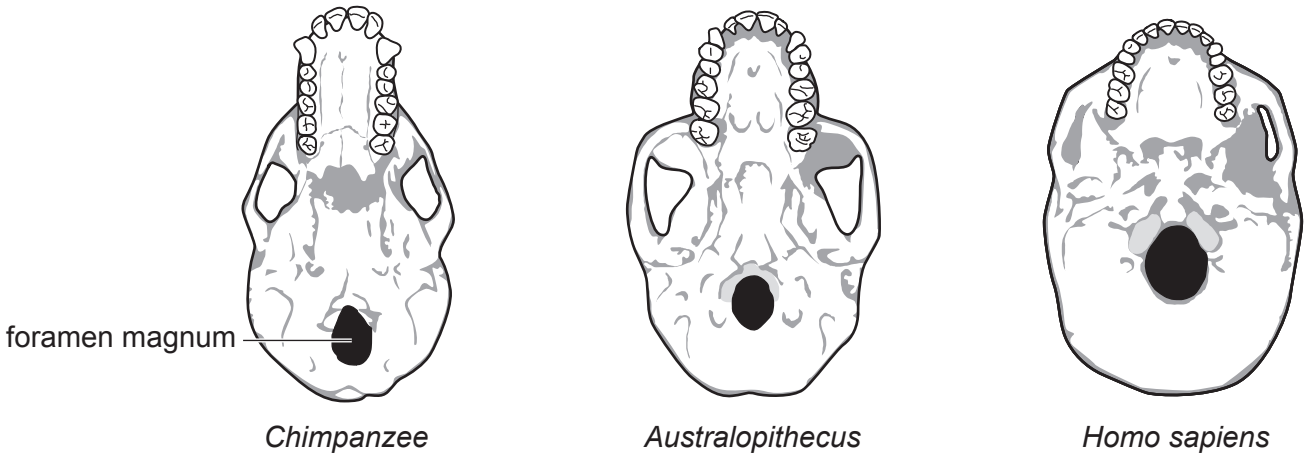

Fig. 6.2

(i) Describe the change in the position of the foramen magnum **and** explain how this could have affected the behaviour of the primates.

The foramen magnum moves further forward, to underneath the skull, from the chimpanzee to Australopithecus to Homo sapiens. This allows the spine to be vertical below the skull, so the species could walk upright (bipedal). **[2]**

(ii) Scientists claim that *Australopithecus* species may have been able to use smaller tools and understand a wider range of vocal sounds than a chimpanzee.

What evidence in Fig. 6.2 supports this claim?

Australopithecus has a larger skull, with a larger cranial capacity (cranial cavity), than the chimpanzee **[1]**

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(iii) A number of *Australopithecus* species have been discovered but it has been difficult for scientists to classify them as distinct species due to a lack of genetic material found.

One example is that specimens of *Australopithecus prometheus* have been grouped with the more well-known *Australopithecus africanus* species.

Suggest **one** reason, other than a lack of genetic material found, why it may be difficult to classify them as two distinct species.

only pieces of fossils are found, not complete fossils, and it is

unknown if they could produce viable offspring **[1]**

(c) State the name of **three** types of monomers or molecules that can be used in the genetic classification of a species.

1 deoxyribose nucleotides (DNA)

2 ribose nucleotides (RNA)

3 amino acids (proteins)

[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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