

Excel

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BIOLOGY

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2012
HIGHER SCHOOL CERTIFICATE
EXAMINATION

CHAPTER 15

Biology

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
Black pen is preferred
- Draw diagrams using pencil
- Board-approved calculators may be used
- Write your Centre Number and Student Number where required

Total marks – 100

Section I

75 marks

This section has two parts, Part A and Part B

Part A – 20 marks

- Attempt Questions 1–20
- Allow about 35 minutes for this part

Part B – 55 marks

- Attempt Questions 21–30
- Allow about 1 hour and 40 minutes for this part

Section II

25 marks

- Attempt ONE question from Questions 31–35
- Allow about 45 minutes for this section

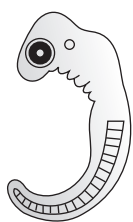
Section I**75 marks****Part A – 20 marks****Attempt Questions 1–20****Allow about 35 minutes for this part**

Use the multiple-choice answer sheet for Questions 1–20.

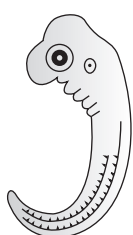
- 1 What is the name of the process that results in organisms containing DNA from different species?

- (A) Transcription
- (B) Transgenics
- (C) Translation
- (D) Translocation

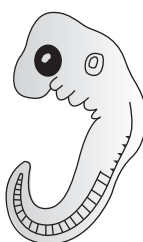
- 2 The diagram shows different vertebrate embryos at the same stage of development.



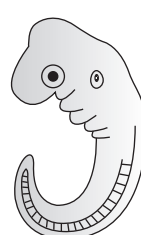
Fish



Amphibian



Bird

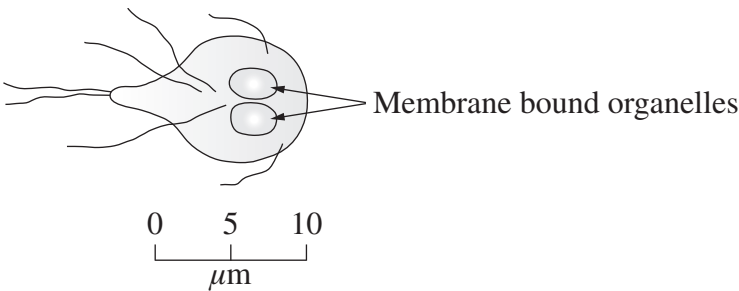


Human

How do the embryos provide evidence for evolution?

- (A) The embryos have different shaped eyes.
 - (B) Different adults evolve from the embryos.
 - (C) The embryos have structures that look similar.
 - (D) Divergent evolution results in common characteristics in the embryos.
- 3 Which of the following are all forms of defence that prevent the entry of pathogens into the body?
- (A) Cilia, sweat, saliva
 - (B) T cells, B cells, antibodies
 - (C) Inflammation, skin, phagocytosis
 - (D) Stomach acid, mucus, lymph system

4 The diagram shows a pathogen called Giardia.



What type of pathogen is Giardia?

- (A) Bacterium
- (B) Prion
- (C) Protozoan
- (D) Virus

5

Huntington's Disease is caused by an inherited gene that codes for a toxic protein.

Kwashiorkor is a disease caused by a deficiency of proteins in the body.

Mesothelioma is a disease caused by a gene mutation in the lungs after exposure to asbestos.

Which row in the table correctly classifies these diseases?

	<i>Huntington's Disease</i>	<i>Kwashiorkor</i>	<i>Mesothelioma</i>
(A)	Genetic	Nutritional	Environmental
(B)	Nutritional	Environmental	Environmental
(C)	Genetic	Nutritional	Genetic
(D)	Nutritional	Environmental	Genetic

6 How do vaccinations prevent disease?

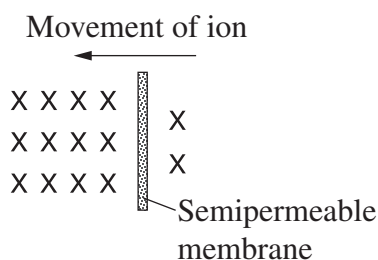
- (A) They increase the inflammation process.
- (B) They enable the infected cells to seal off the pathogen.
- (C) They increase the number of antibodies against the pathogen.
- (D) They decrease the number of antigens that trigger the immune response.

- 7 Why is it important to continue research into new antibiotics?
- (A) New prion diseases have been recently discovered.
 - (B) Resistant bacteria have evolved from the overuse of antibiotics.
 - (C) Viral infections require a broad range of antibiotics for eradication.
 - (D) New diseases are discovered regularly and all require new antibiotics.

- 8 Identical twins have the same genotype.

Why are there small differences between the phenotypes of identical twins?

- (A) Some genes are not co-dominant.
 - (B) Environment affects the expression of genes.
 - (C) Both parents are homozygous for those phenotypes.
 - (D) Chromosomes segregate independently during meiosis.
- 9 What feature can be used to distinguish mature xylem cells from mature phloem cells?
- (A) Phloem cells are located in vascular bundles.
 - (B) Phloem cells have a cytoplasm.
 - (C) Xylem cells are located in the leaves.
 - (D) Xylem cells have cell walls.
- 10 The diagram shows a model of the movement of ions (represented by X) across a semipermeable membrane.



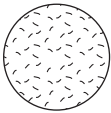
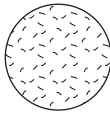
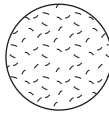
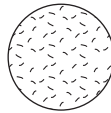
What type of process is modelled in the diagram?

- (A) Osmosis
- (B) Filtration
- (C) Diffusion
- (D) Active transport

- 11 Which of the following is an example of *hybridisation*?
- (A) The insertion of a bacterial gene for herbicide resistance into a cotton plant
 - (B) The culturing of a cell taken from the root of a carrot to form a small plant
 - (C) Artificial insemination of a domestic cat with wild cat semen to produce a Bengal cat
 - (D) A cutting taken from one variety of apple tree grafted onto the stem of a different variety of apple tree
- 12 Nitrogenous waste is at its highest concentration in
- (A) plasma in the renal vein.
 - (B) plasma in the renal artery.
 - (C) fluid in the collecting ducts of the kidney.
 - (D) interstitial fluid in the cortex of the kidney.
- 13 Why do organ transplants trigger an immune response in a recipient?
- (A) Antigens in the recipient's body recognise the organ as foreign.
 - (B) Cell surface markers on the organ attack the recipient's white blood cells.
 - (C) Antibodies in the recipient stimulate the production of antigens on the organ.
 - (D) The recipient's white blood cells recognise the antigens on the organ as foreign.
- 14 What is a role of the kidney in freshwater fish?
- (A) To remove water from the fish
 - (B) To absorb salt from the environment
 - (C) To excrete concentrated urine from the fish
 - (D) To decrease nitrogenous waste lost to the environment
- 15 Which of the following results in an increased absorption of water from the collecting tubule of the nephron?
- (A) An increase in the length of the collecting tubule
 - (B) A decrease in ADH released into the blood by the pituitary
 - (C) A decrease in glucose moving from the renal tubule into capillaries
 - (D) An increase in the concentration of dialysate solution in renal dialysis

16 A student carried out an investigation to identify the presence of microbes in water from different sources.

The student’s lab notes are shown.

	<i>Control</i>	<i>Bottled water</i>	<i>Tap water</i>	<i>Tank water</i>
Inoculation of an agar plate with water sample	X	✓	✓	✓
Incubation at 37°C	✓	✓	✓	✓
Appearance of agar plate				

What can be inferred from these results?

- (A) The inoculation loop was not sterilised properly.
 - (B) The water from each of these sources is unsafe to drink.
 - (C) These water sources are contaminated with the same microbe.
 - (D) The agar plates were contaminated prior to the beginning of the experiment.
- 17 Which of the following correctly identifies the relationship between alleles, chromosomes and genes?
- (A) Genes contain chromosomes and alleles.
 - (B) Chromosomes contain genes but not alleles.
 - (C) Alleles are found in chromosomes but not in genes.
 - (D) Genes are parts of chromosomes and have different alleles.
- 18 How does a plant respond in order to keep cool on an extremely hot day?
- (A) It grows smaller leaves.
 - (B) It opens stomata in the leaves.
 - (C) It grows more hairs on the surface of the leaves.
 - (D) It decreases the number of stomata on the top of the leaves.

- 19 Haemoglobin provides an adaptive advantage to an endotherm in a cold environment because it allows
- (A) more oxygen to be dissolved in plasma.
 - (B) the organism to decrease its metabolic rate.
 - (C) more energy to be available to the organism.
 - (D) less carbon dioxide to be transported in the blood.
- 20 A student performed a first-hand investigation in an attempt to model natural selection.

Each week, a jar was refilled with a fresh packet of cream biscuits containing five different types for people to eat. After a month, there were mostly lemon cream biscuits in the jar.

What is the limitation of this investigation as a model for natural selection?

- (A) There is no variation in the 'species'.
- (B) Characteristics are not transmitted to successive generations.
- (C) Variants of the 'species' do not have the same chance of 'survival'.
- (D) Unfavourable characteristics are selected out of the population over time.

2012 HIGHER SCHOOL CERTIFICATE EXAMINATION
Biology

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Centre Number

Section I (continued)

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Student Number

Part B – 55 marks
Attempt Questions 21–30
Allow about 1 hour and 40 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Question 21 (5 marks)

You performed a first-hand investigation to estimate the size of blood cells.

(a) How did you estimate the size of the cells? 2

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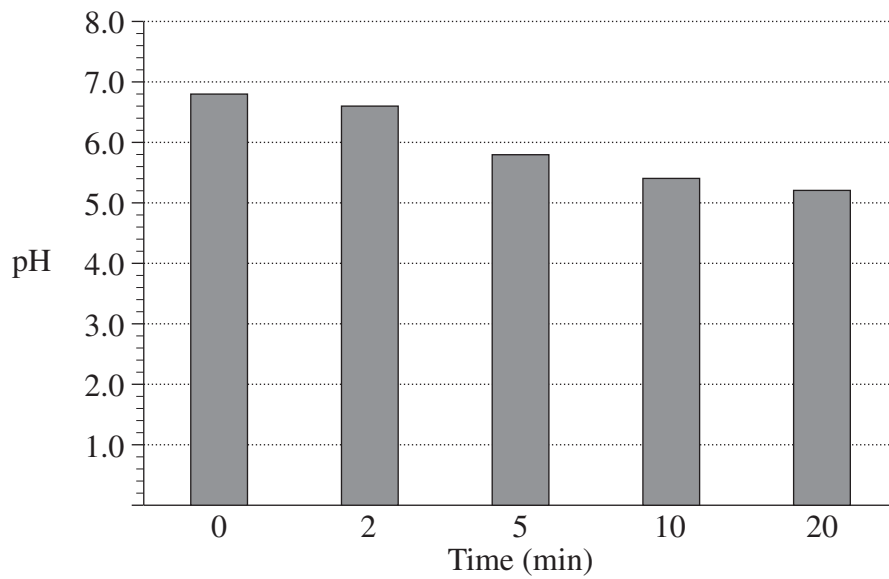
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(b) Draw a scaled diagram that shows the features of both a red blood cell and a white blood cell. 3

Question 22 (7 marks)

Students in a class conducted a first-hand investigation to test the hypothesis that if CO_2 were continually bubbled in water then the pH would decrease over time.

One student presented the data in the graph, as shown.



- (a) Present these data in a table.

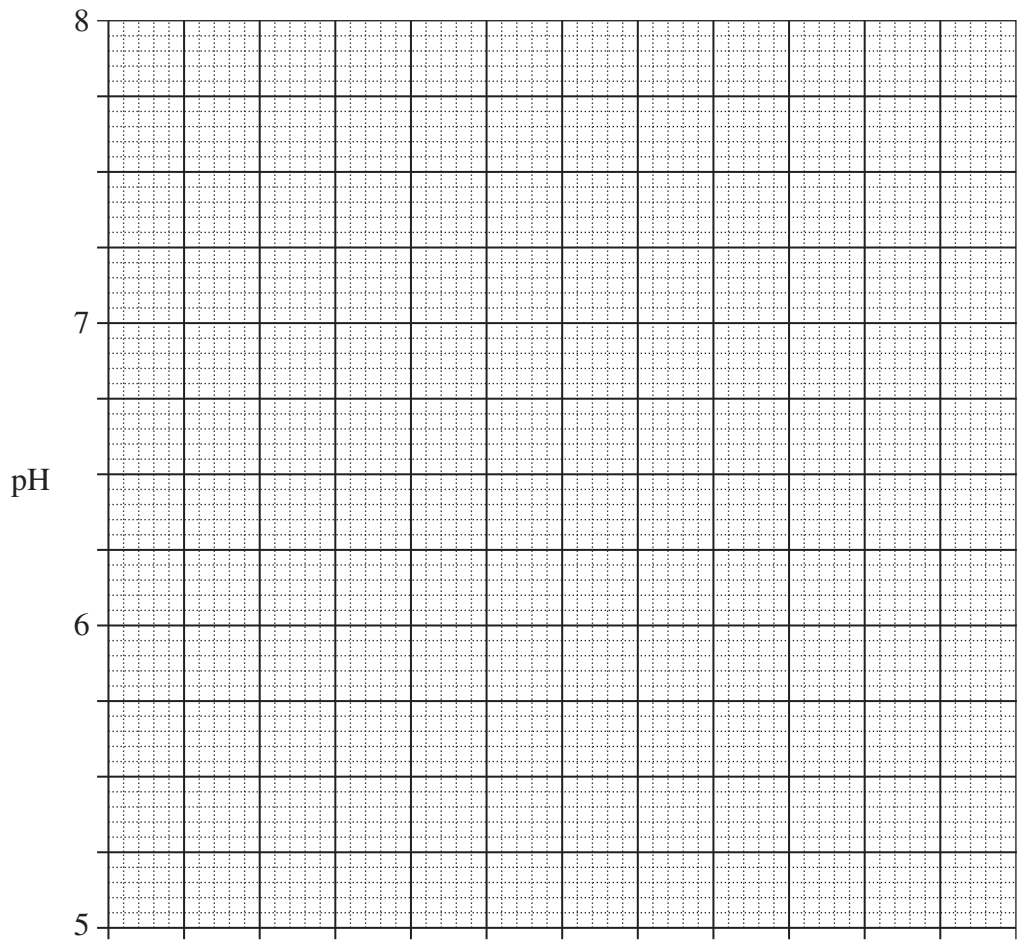
2

Time (min)	pH
0	6.8
2	6.6
5	5.8
10	5.4
20	5.2

Question 22 continues

Question 22 (continued)

- (b) On the grid below, plot the data from the table in part (a) and draw a curve of best fit.
- 3



- (c) Why is it better to represent these results as a curve of best fit rather than as a column graph?
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End of Question 22

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Centre Number

Section I – Part B (continued)

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Student Number

Question 23 (5 marks)

A non-infectious disease was observed in a mother and her four sons who live with her. She has no daughters. The father of these children does not have the disease and does not live with them. The woman's parents and her two sisters who live overseas do not have the disease.

- (a) Her doctor suspects that the disease is NOT inherited. Identify data that could be collected to investigate a non-inheritable cause of the disease. 1

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- (b) A geneticist suspects that the disease is inherited.

- (i) Draw the family pedigree for this disease. 2

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- (ii) From the evidence, what indicates that the disease could be the result of a recessive allele and not be sex linked? 2

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Question 24 (5 marks)

You conducted first-hand investigations to test the effects of temperature, pH and substrate concentration on enzyme activity.

- (a) Complete the following table by identifying the variables for ONE of your investigations.1

<i>Independent variable</i>	<i>Dependent variable</i>	<i>Kept constant</i>
.....		pH, substrate concentration, enzyme concentration

- (b) Outline how you measured the activity of an enzyme in your investigation. In your answer, name the enzyme.2

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- (c) Describe how a condition needed for optimal enzyme activity would be expected to vary between endotherms and ectotherms.2

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Centre Number

Section I – Part B (continued)

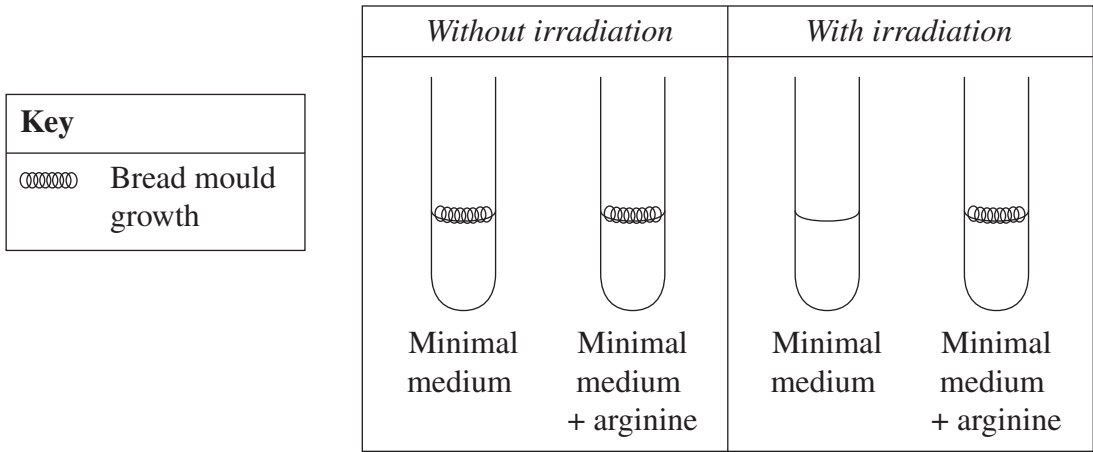
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Student Number

Question 25 (6 marks)

Beadle and Tatum’s experiment involved the analysis of bread mould growth. Bread mould uses an enzyme to make the amino acid arginine.

The diagram shows bread mould growth after culturing on two different media. In one part of the experiment, the bread mould had been irradiated before culturing.



(a) How do these results support the ‘one gene – one protein’ hypothesis? 4

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(b) Justify the types of secondary sources that would be acceptable to use to research Beadle and Tatum’s experiment. 2

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Question 26 (5 marks)

A scientist performed an epidemiological study to investigate the cause and effect relationship of smoking and lung cancer as follows:

5

- 1. Handed out a scientifically valid questionnaire to all colleagues (n = 144) at work
- 2. Checked that there were an equal number of male and female respondents
- 3. Discovered that there were more non-smoking respondents than smoking respondents. Removed some of the non-smokers until both groups had equal numbers
- 4. Checked that all the respondents had a medical check-up in the past year
- 5. Analysed data, wrote the paper and published it in a scientific blog.

From the information provided, analyse the methodology used by this scientist.

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Biology

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Centre Number

Section I – Part B (continued)

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Student Number

Question 27 (4 marks)

During a major international horse event in Australia, a group of horses, including some from overseas, is discovered to be infected by a deadly virus. This virus is only found in Australia.

4

Give reasons for strategies that could be carried out to control this disease outbreak.

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Question 28 (5 marks)

Explain the relationship between replication of DNA and evolution.

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Biology

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Centre Number

Section I – Part B (continued)

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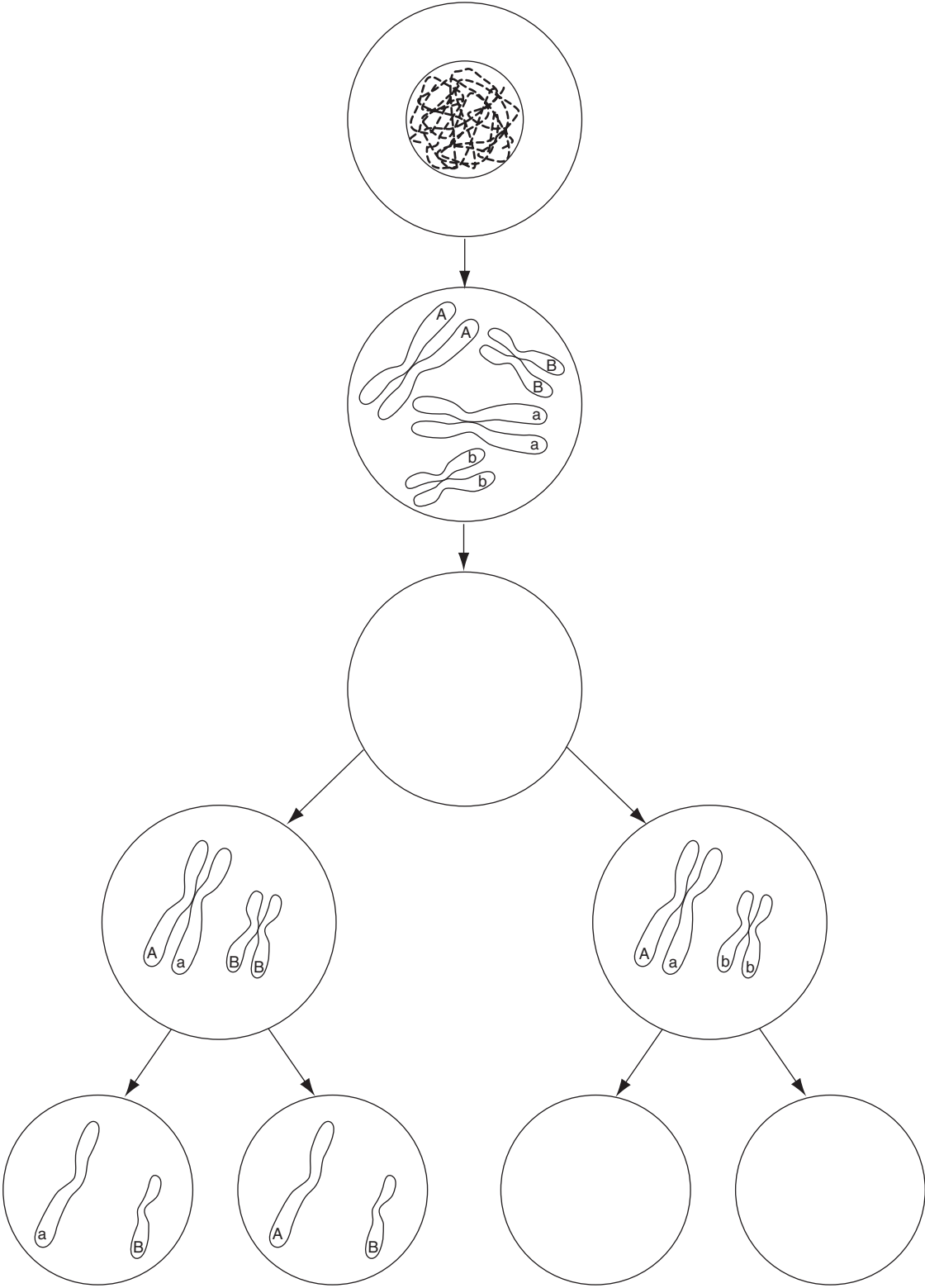
Student Number

Question 29 (5 marks)

Question 29 (5 marks)

- (a) Complete the following diagram to show the process by which gametes are formed.

3



Question 29 continues

Question 29 (continued)

- (b) How does the segregation of chromosomes during meiosis lead to a wide variety of gametes being produced?

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End of Question 29

Question 30 (8 marks)

Explain how the contributions of Louis Pasteur, Robert Koch and MacFarlane Burnet have increased our understanding of the nature and prevention of infectious disease.

[illegible]

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Biology

Section II

25 marks

Attempt ONE question from Questions 31–35

Allow about 45 minutes for this section

There are four Section II Answer Booklets labelled Part (a), Part (b), Part (c) and Part (d).

Answer each part of the question in the relevant Answer Booklet.

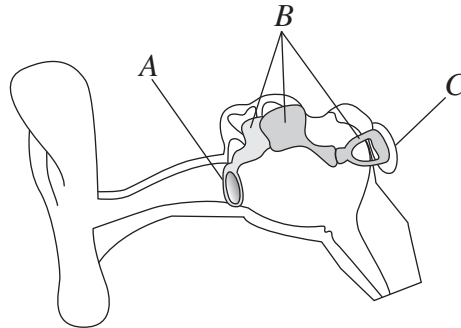
Extra writing booklets are available.

- | | |
|-------------|---|
| Question 31 | Communication |
| Question 32 | Biotechnology |
| Question 33 | Genetics: The Code Broken? |
| Question 34 | The Human Story |
| Question 35 | Biochemistry (<i>Not included in this reproduction</i>) |

Question 31 — Communication (25 marks)

Answer part (a) in Section II Answer Booklet – Part (a).

(a) Parts of the ear are shown below.



(i) Identify the parts *A*, *B* and *C*.

2

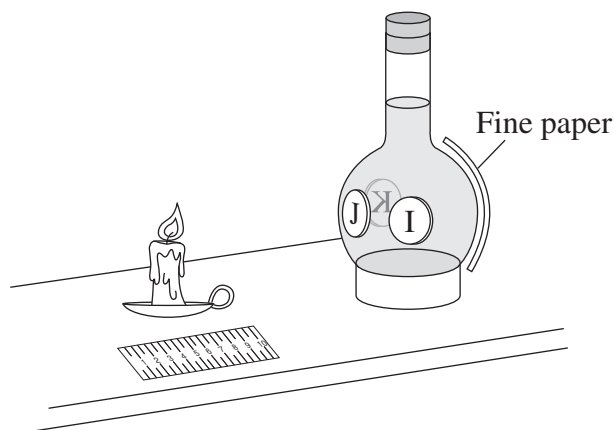
(ii) Outline the functions of part *B*.

2

Answer part (b) in Section II Answer Booklet – Part (b).

(b) An experiment was performed to model accommodation in the eye:

- a round bottom flask was filled with a solution
- the flask was placed on a stand on which it was able to rotate
- three lenses (I, J and K) of different thicknesses were attached to the surface of the flask
- a layer of fine paper was stuck around the opposite side of the flask
- a candle was placed near the flask
- different lenses could be brought into the light path by rotating the flask
- an image of the candle was observed on the layer of fine paper.



Question 32 continues

Question 31 (continued)

- (i) Match THREE pieces of apparatus used in this experiment with THREE identified parts of the eye. 2
- (ii) Describe the quantitative data that could be collected in the experiment. 2
- (iii) Compare this model to mechanisms of accommodation in the eye. 2

Answer part (c) in Section II Answer Booklet – Part (c).

- (c) (i) Relate specialised features of the eyes of TWO named animals to their environment. 2
- (ii) Describe the detection of vibrations by fish and insects, and the events which lead to a response. 5

Answer part (d) in Section II Answer Booklet – Part (d).

- (d) Demonstrate how technologies help correct specific biological problems associated with human communication. 8

End of Question 31

Question 32 — Biotechnology (25 marks)

Answer part (a) in Section II Answer Booklet – Part (a).

- (a) With reference to TWO biotechnological practices that use yeast, copy and complete the following table in your answer booklet. 4

<i>Biotechnological practice</i>	<i>Name of chemical produced by yeast</i>	<i>Purpose of chemical produced</i>

Answer part (b) in Section II Answer Booklet – Part (b).

- (b) (i) Explain the purpose of a named transgenic organism. 3
- (ii) Construct a diagram that demonstrates the sequence of events that results in the formation of recombinant DNA in a transgenic organism. 3

Answer part (c) in Section II Answer Booklet – Part (c).

- (c) (i) Why could aquaculture be considered a biotechnology? 2
- (ii) Compare aquaculture with early biotechnologies applied to agriculture. 5

Answer part (d) in Section II Answer Booklet – Part (d).

- (d) Explain how a detailed understanding of cell chemistry has resulted in society making more effective use of biotechnology. Support your answer with examples. 8

Question 33 — Genetics: The Code Broken? (25 marks)

Answer part (a) in Section II Answer Booklet – Part (a).

- (a) With reference to TWO types of cloning, copy and complete the following table in your answer booklet. 4

Type of cloning	Process used	Example

Answer part (b) in Section II Answer Booklet – Part (b).

- (b) (i) Construct a model of a section of a double stranded DNA molecule containing the sequence GAT using a selection of the symbols below. Include a key in your answer. 3

C P S A G T U

- (ii) Outline how genes are expressed. 3

Answer part (c) in Section II Answer Booklet – Part (c).

- (c) (i) What is the Human Genome Project? 2
- (ii) Explain how recombinant DNA technologies can be used to identify the position of a gene on a chromosome. 5

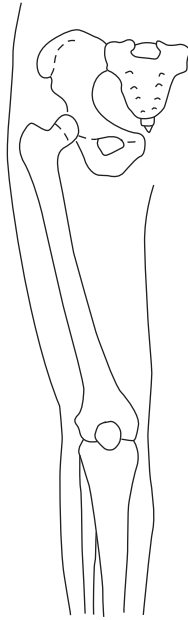
Answer part (d) in Section II Answer Booklet – Part (d).

- (d) Compare and contrast the effects of germ line mutation and transposable genetic elements on whole organisms. 8

Question 34 — The Human Story (25 marks)

Answer part (a) in Section II Answer Booklet – Part (a).

- (a) (i) Using the diagram, name TWO features of the *Homo sapiens* skeleton which make it unique among the primates. 2



- (ii) Outline how ONE named non-skeletal characteristic has assisted primates in their evolution. 2

Question 34 continues

Question 34 (continued)

Answer part (b) in Section II Answer Booklet – Part (b).

(b) Examine the data collected on *Homo neanderthalensis* fossils found in recent years.

Date	Data
2008	• Full sequence of mitochondrial DNA of a range of Neanderthal fossils from within and between different fossil sites • The sequence is nearly identical within one fossil site • The sequence is very different between fossil sites
2010	• Full sequence of Neanderthal nuclear DNA • 1%–4% of genes in European modern humans are specific Neanderthal genes • No identifiable specific Neanderthal genes in modern sub-Saharan African humans • No specific modern human genes in nuclear DNA of Neanderthal fossils

- (i) What inferences can be made about Neanderthal populations, based on the data collected in 2008?

3
- (ii) What inferences can be made about migration and breeding, based on the data collected in 2010?

3

Answer part (c) in Section II Answer Booklet – Part (c).

- (c) How have polymorphism and clinal gradation contributed to the diversity of human populations? In your answer, use at least one human phenotype as an example.

7

Answer part (d) in Section II Answer Booklet – Part (d).

- (d) (i) For TWO named hominids, describe fossil evidence that infers the use of technology which led to cultural development.

2
- (ii) Predict and justify future directions of human biological evolution in the context of TWO technologies already developed by modern humans.

6

End of Question 35

End of paper

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2012 HSC Examination Paper

Sample Answers

Section I Part A

(Total 20 marks)

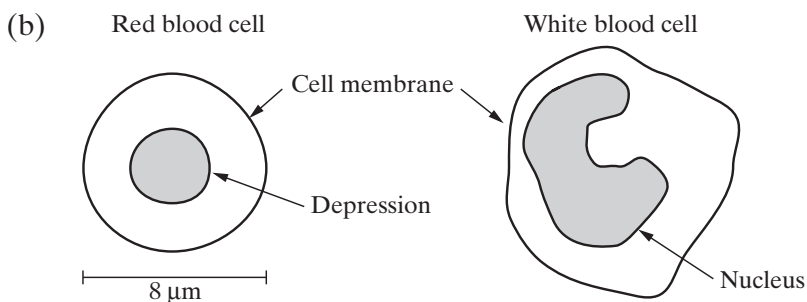
- 1 B Transgenic species are made by the insertion of another species' genetic information. This is passed onto the next generation.
- 2 C Similar structures on the embryos show that they have evolved from a common ancestor.
- 3 A These are all physical barriers and can prevent the entry of pathogens into the body.
- 4 C It is a protozoan as it is a single-celled organism with membrane-bound organelles.
- 5 A Inherited characteristics are genetic. Protein deficiency can be caused by poor diet, so it is nutritional. Mutations caused by exposure to asbestos are environmental.
- 6 C Vaccinations, through the introduction of harmless/dead strains of the disease, enable the body to build up antibodies so that it can fight the disease should it be exposed to it.
- 7 B Due to natural selection of bacteria, some antibiotics are ineffective and we have a problem with combating some severe bacterial infections.
- 8 B While identical twins may be identical genetically, they may express these genes differently (phenotype) due to the environment in which they grow up.
- 9 B Mature phloem cells are living tissue; mature xylem cells are not.
- 10 D The ions are moving across the semipermeable membrane against the diffusion gradient.
- 11 C The use of two varieties to produce unique characteristics of apple tree is an example of hybridisation. Under usual circumstances the act of mixing different species or varieties of animals or plants produces hybrids.

- 12 C The waste is taken from the collecting ducts to the bladder for removal from the body.
- 13 D The body produces T lymphocytes which would identify foreign tissue and destroy it.
- 14 A Freshwater fish release dilute urine.
- 15 A This is the only possible answer as the other options are incorrect.
- 16 D The control had the same growth as that of each sample of water.
- 17 D This is the correct definition for each term.
- 18 B This promotes transpiration, cooling the plant.
- 19 A More oxygen means that there can be greater rates of respiration to produce heat.
- 20 B The lemon cream biscuits are not able to reproduce, passing on their favourable characteristics.

Section I Part B

- 21 (a) The size of cells can be estimated by using a mini grid slide with known dimensions. The specimen is placed on this when under the microscope. (2 marks)

or The size of cells can be estimated by dividing the size of the field of view's diameter by the number of cells you can count across the field of view.



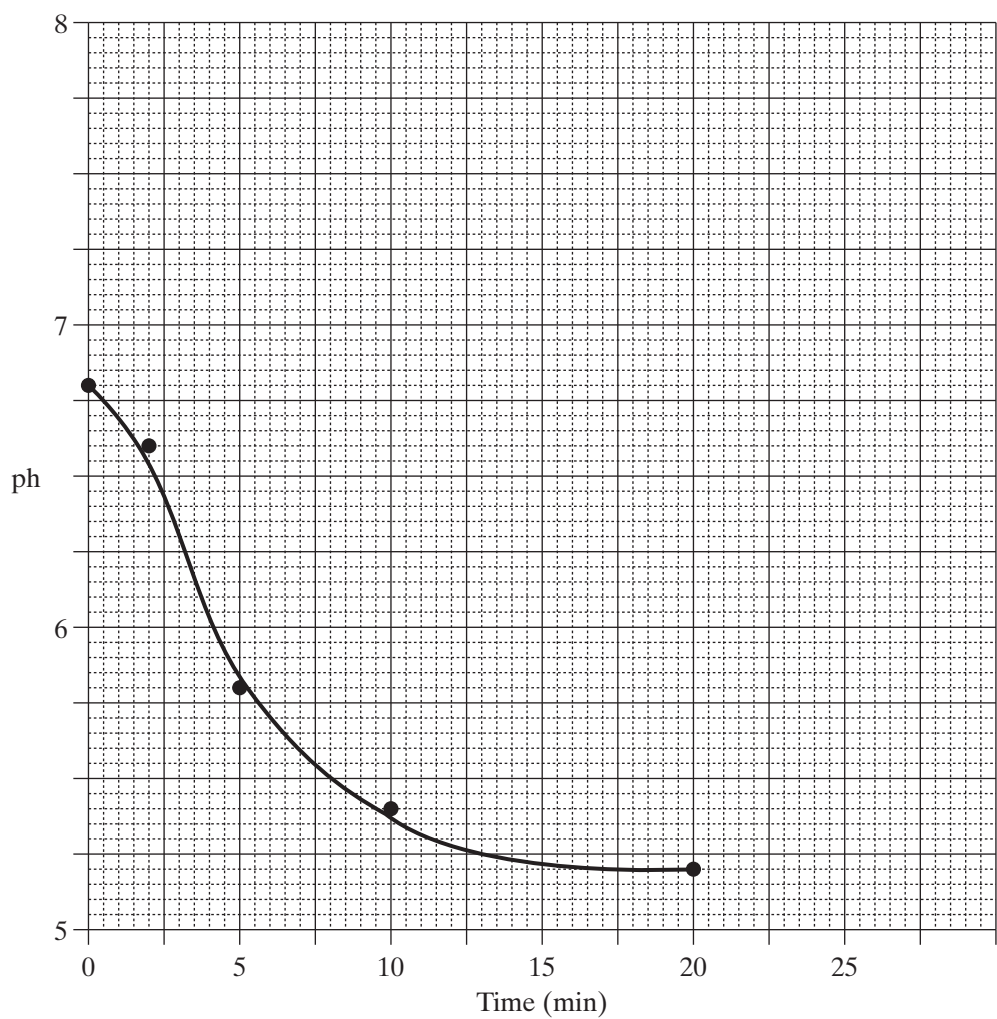
(3 marks)

22 (a)

<i>Time (min)</i>	<i>pH</i>
0	6.8
2	6.6
5	5.8
10	5.4
20	5.2

(2 marks)

(b)

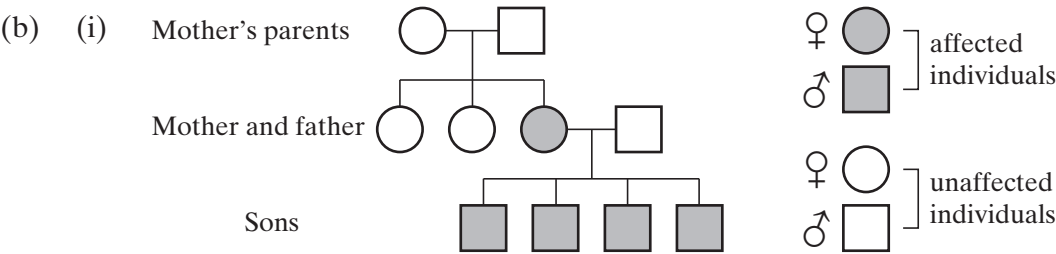


(3 marks)

(c) Presenting the result as a curve of best fit rather than a column graph makes it easier to see the relationships between the two variables, and the trend in the data becomes more obvious. (2 marks)

23 (a)

Data that would be useful in determining that the disease was not inherited could include checking the grandparents of the mother and the parents or siblings of the father. The disease could be recessive. (1 mark)



(2 marks)

(ii) The disease could be the result of a recessive allele rather than sex linked, because the father does not have it and each of the sons does. The father passes a Y to each of the sons and they inherit the affected X from their mother.

(2 marks)

24 (a) Answers will vary, but the following is one possibility.

<i>Independent variable</i>	<i>Dependent variable</i>	<i>Kept constant</i>
Temperature	Time for substrate to clot	pH, substrate concentration, enzyme concentration

(1 mark)

(b) Answers will vary. The following is one example.

Rennin was used to clot milk at different temperatures. A stopwatch was used to measure how long it takes for the rennin to clot the milk at different temperatures.

(2 marks)

(c) In endotherms, the temperature that the enzyme requires for optimum function will remain relatively constant. In an ectotherm, the temperature will vary with the ambient temperature and the activity will change relative to the temperature.

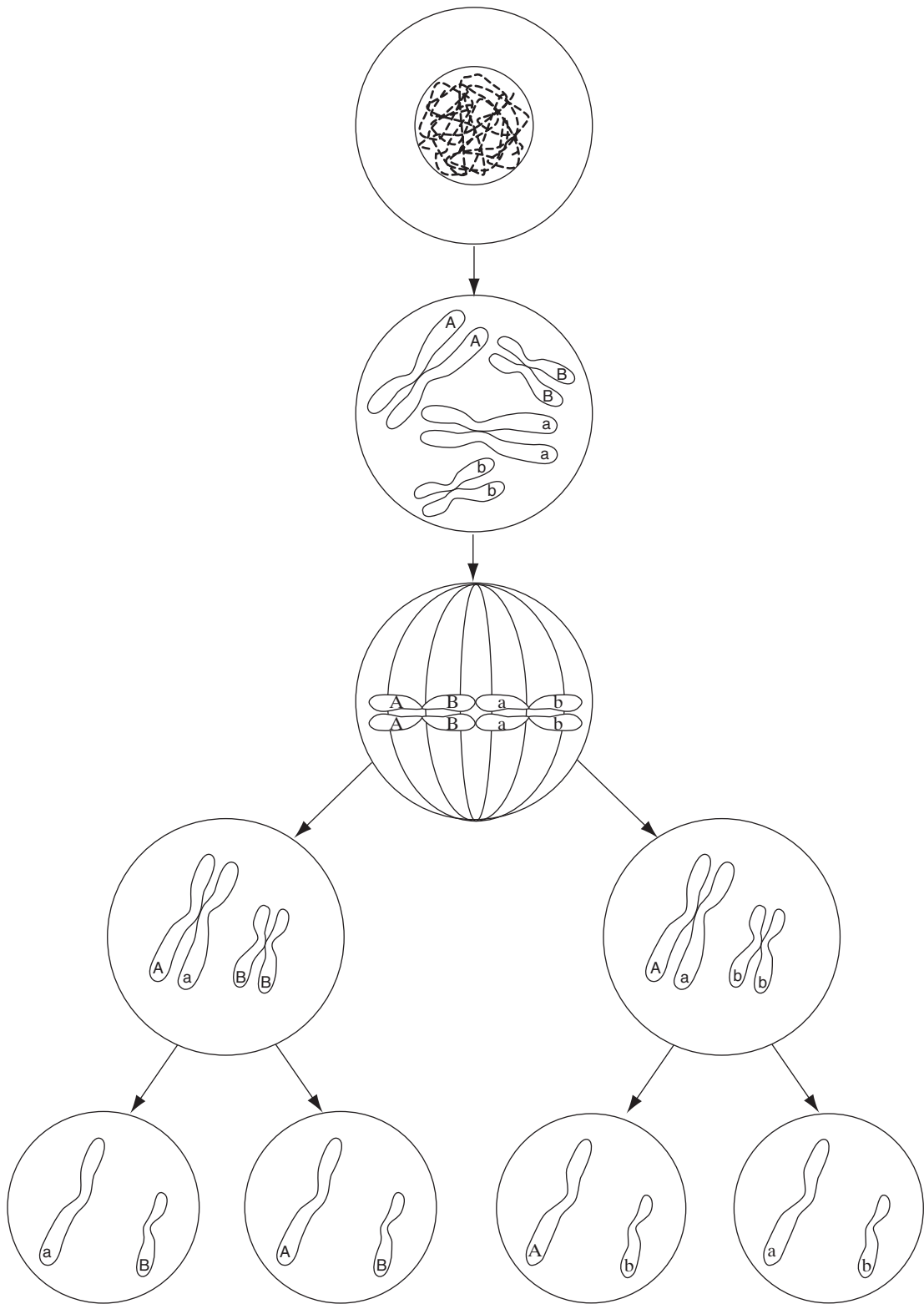
(2 marks)

25 (a) The results resemble the work of Beadle and Tatum because the bread mould did not grow in the sample that was irradiated. This represents a change that would have occurred to an enzyme that prevented growth when it was irradiated. Beadle and Tatum exposed strains of mould to X-rays, causing the creation of strains lacking enzymes that enabled the production of essential nutrients required for normal growth. Each change was on a particular location on the chromosome and hence the specific enzyme. This led to the 'one gene – one enzyme' hypothesis, which was later modified to 'one gene – one polypeptide' to account for the fact that not all proteins are enzymes.

(4 marks)

- (b) The secondary sources that would be acceptable to use to research Beadle and Tatum's experiment would be those that come from government/university institutions or from reputable scientific journals that have been peer reviewed. (2 marks)
- 26** The methodology described will provide general results only and would not be considered valid in terms of the number studied (144). What is more, the scientist removed non-smoking subjects to even out the numbers of smokers and non-smokers, thereby reducing the numbers even more. There was no indication of the basis on which the scientist selected the subjects that were eliminated from the study other than the fact that there were more non-smokers than smokers. In order for the study to be valid, the larger sample size without bias being introduced is essential. Removing some of the non-smokers can skew the results by removing links to other possible sources for the cancers. Checking whether the respondents had medical checks in the past year may only identify that the symptoms were not present and not accurately identify whether the subjects had any changes that were not exhibited yet. You would require specific tests on the lungs themselves to determine this accurately. Other useful information that needs to be included about smoking habits and history of the participants includes history about living/working/socialising with smokers. Without such information, the scientist's conclusions would not be very significant in terms of medical findings. (5 marks)
- 27** Strategies that could be implemented to prevent the spread of the disease would include immediate quarantine of the infected horses to isolate the infected host animals and thereby reduce the chance of contact with non-infected horses. Restriction of movement of all other horses in and out of the country is important to prevent further spread outside of the country via the international horses, possibly even restricting them to local areas to stop spread across the country. (4 marks)
- 28** Replication of DNA is a crucial part of evolution. It is through the replication of DNA that changes arise through mitosis. The mutations that occur to the genetic code result in some changes that can be harmful and others that can turn out to favour the survival of the individual. It is this survival of genetically different organisms that is central to natural selection, where those that are best suited to their surroundings survive to reproduce and manifest the genes, resulting in new species over extended periods of time. Without mutation, there can be no evolution. (5 marks)

29 (a) The completed diagram should look like the following.



(3 marks)

- (b) Segregation in meiosis leads to a wide variety of gametes being produced because there are a number of random ways in which the maternal and paternal chromosomes are combined in the daughter cells. The number of possible combinations in the haploid nuclei is very large. During the segregation, crossing over (where the tips of adjoining chromosomes are exchanged) can also take place, thereby increasing the variation. (2 marks)

- 30 MacFarlane Burnet was one of the key scientists associated with the understanding of immunology. He proposed the idea that the body recognises its own tissue and will not destroy it. This is crucial to the treatment of transplant patients that have new tissue needing to be kept and not destroyed as foreign material (clonal selection theory). This has resulted in the use of immunosuppression drugs in transplant patients to prevent tissue rejection. His work also dealt with the study of viruses and, in particular, influenza A, resulting in the development of a vaccine saving countless lives, preventing the spread of virulent strains of disease and dramatically reducing the incidence of some diseases.

Louis Pasteur has been attributed with demonstrating that spontaneous generation does not occur and most infectious diseases are caused by microscopic pathogens. This is now called the germ theory of disease. He demonstrated this by boiling broth in swan-necked flasks and then braking the top off one of the flasks, exposing the broth to air. The flask that was exposed to air then spoiled and the other remained uncontaminated, thereby showing that germs/pathogens are in the air and must be in contact with the host in order to cause disease. He went on to use methods of treating wine by heating it to 55°C for several minutes to destroy the microbes. This method (known as pasteurisation) is now widely used and has been adapted to treat products including beer and milk. Pasteurisation is commonly used to prevent microbes being consumed by people and causing illness, and has been adapted for sterilisation procedures to prevent the spread of disease.

Robert Koch was a German scientist who studied the cause of disease. In particular, he investigated the possible causes of anthrax, eventually isolating the bacterium that causes it. From his work he established a series of steps that need to be followed when identifying the cause of a particular disease. First, the pathogen must be present in every host with the disease. Second, the microorganism must be isolated from the host and grown in a pure culture. Third, when a new host is inoculated with the microorganism, the new host must develop the same symptoms as the original host. Finally, this microorganism must be able to be isolated and compared to, and be the same as, the original host.

Together these scientists have contributed significantly to the study of microorganisms, enabling the development of many practices that are vital to the nature and prevention of disease such as identification of pathogens, sterilisation and vaccination. (8 marks)

Section II—Options

Question 31—Communication

- (a) (i) *A* ear drum/tympanic membrane, *B* ossicles, *C* oval window (2 marks)

- (ii) The ossicles (made up of hammer, anvil and stirrup) are intended for the transmission of vibrations of air molecules under pressure through the middle ear to the oval window. This sets up pressure changes that vibrate the fluid in the inner ear. From here, the vibrations are received by the organ of corti within the cochlea in the inner ear and connected to the auditory nerve. (2 marks)

- (b) (i) Answers will vary. The following is one example.

The fine paper represents the retina. *I*, *J* and *K* represent the eye's lens adjusted to different thicknesses. The round bottom flask filled with solution represents the eyeball filled with vitreous humour. (2 marks)

- (ii) The quantitative data in the experiment would be collected by using the ruler to measure the distance (in cm) between the candle and the flask when the image is in focus on the fine paper at the back of the flask, as the different lenses (*I*, *J* and *K*) are placed in the path of the light. (2 marks)

- (iii) The model is used to demonstrate accommodation in the eye whereby the lens changes thickness in order to produce a focused/sharp image on the retina, depending on how far away from the eye the image is located. The changing lens thickness correlates to the degree of bending or refraction of the light entering the eye that is required to focus the image. (2 marks)

- (c) (i) Answers will vary. The following is an example.

Compound eyes in insects are made up of large numbers of individual light-detecting units called ommatidia, each with its own cornea and crystalline cone/lens that are connected to light-sensitive receptor cells that send messages to the brain. Having potentially thousands of these ommatidia in the compound eye enables the insect to have a large field of view.

Bees have three types of cones but these are sensitive to blue, green and ultraviolet rather than red wavelengths. This enables them to detect the coloured patterns in different species of plants more accurately. (2 marks)

- (ii) Fish possess a lateral line that runs down the length of each side of the fish. It is a sensory canal (connected to nerves) that detects the pressure changes/vibrations in the waves/currents that surround the fish. It is thought that this method of detection is a method of the fish perceiving sounds from its surroundings. Fish also possess otoliths found at the back of the head, in a chamber that is lined with hair cells. Auditory nerves detect the differences in vibration between the hairs and the otolith, recorded as a nerve impulse carried to the brain. Insects can detect vibrations in their surroundings using their cuticle and antennae. Crickets have a tympanum (a cavity containing air) on each leg below the knee. This is connected by a release valve on the inside, with nerves detecting the pressure changes directly. Cicadas have a pair of tympana connected to an auditory organ by tendons at the base of the abdomen.
- (5 marks)
- (d) There have been many technologies that have assisted in improvements to overcome biological problems encountered with communication between humans.

The verb *demonstrate* means to show by example. The following table summarises some possible examples that could be elaborated in producing an answer to this question.

<i>Problem</i>	<i>Cause</i>	<i>Technology</i>	<i>Method of improvement</i>	<i>Limitation</i>
Myopia/ hypermetropia	Ciliary muscles/ suspensory ligaments attaching to the lens do not work correctly	Spectacles/ contact lenses	Artificial lenses of different shapes and thicknesses can ensure that the image is focused onto the retina, worn as spectacles or directly on the eye as contact lenses. More recently, refractive laser surgery can be used to change the curvature of the cornea to alter its refractive power to focus the image on the retina.	These will only overcome visual difficulty if the retina and optic nerve are intact.
Cloudy vision	Cataract	Surgical removal or lens replacement	Protein deposits in the lens can be removed surgically using a laser. Another option is to substitute intraocular lenses for the original lens, which is removed.	These will only overcome visual difficulty if the retina and optic nerve are intact.

Continued

<i>Problem</i>	<i>Cause</i>	<i>Technology</i>	<i>Method of improvement</i>	<i>Limitation</i>
Impaired hearing	Damage to outer tympanic membrane or ossicles in the middle ear	Use of hearing aid	A hearing aid can be used. This is a battery-operated device that amplifies the vibrations entering the ear so that they can stimulate the nerve endings in the cochlea.	This requires battery replacement and will only work if the nerve endings in the inner ear are functional. Some frequencies will not be picked up and background noise causes interference.
Profound deafness	Damage to the hair cells in the cochlea within the inner ear	Cochlear implant	This is used when the normal auditory pathway does not function. Electrical stimulation of the nerve endings in the cochlea occurs after the attached implant array receiver detects sound waves from a microphone that has converted them to an electrical signal.	This requires battery replacement and will only work if the nerve endings in the cochlea are functional. It requires programming and surgical implantation.

(8 marks)

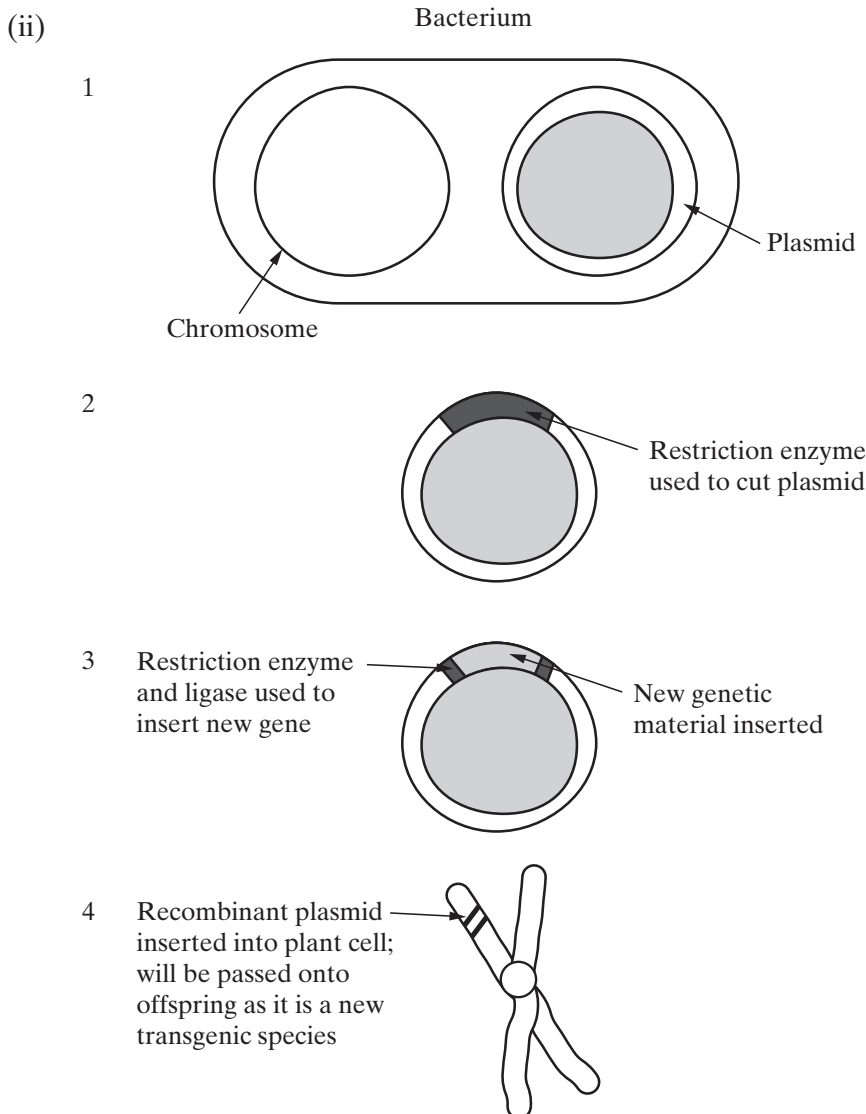
Question 32—Biotechnology

(a) Answers will vary. The following table shows two examples.

<i>Biotechnological practice</i>	<i>Name of chemical produced by yeast</i>	<i>Purpose of chemical product</i>
Beer/wine making	Ethanol	Preserves the beverage and prevents spoilage
Bread manufacture	Carbon dioxide	Assists in making the dough rise

(4 marks)

- (b) (i) Transgenic species have been used to create plants and animals for agricultural purposes. Specific genes from one species are inserted into different species to change and/or enhance their characteristics. For example, a gene for producing protein in beans has been introduced into sunflower plants, resulting in a higher quality of protein in these plants. Similarly, genes for the production of human proteins have been inserted into milk-producing animals, which in turn produce biopharmaceuticals in their milk that are later extracted and purified for use. (3 marks)



(3 marks)

- (c) (i) Aquaculture is the cultivation of aquatic organisms, such as various species of fish, crayfish and algae, shellfish such as oysters and abalone, crayfish and algae. This has been practiced by humans for thousands of years. The farming of these species for various purposes such as food, jewellery, building or industrial material, or pharmaceuticals requires an understanding of biological processes. Therefore, it is considered a form of biotechnology. More recently, genetically modified organisms have been used in aquaculture to prevent the release of these organisms into the wild. (2 marks)

- (ii) Early biotechnologies in agriculture involved the artificial selection of characteristics that were favourable such as higher yielding grains and better quality fruit, resulting in more reliable and better yielding crops to ensure quality food supply. Domesticating animals and permitting interbreeding proved to be a reliable source of food and once again specific characteristics could be encouraged rather than leaving breeding to chance. This was seen as the first attempt to manipulate other organisms for human advantage, making it a rudimentary form of biotechnology. In contrast, the aquaculture that is occurring today is far more specialised and advanced, in that artificially modified organisms with manipulated genetic material are being used to cultivate very specific products for consumption, materials production or use. Oysters are seeded to produce pearls or high quality or genetically enhanced growth rates. Genetically modified prawns are being farmed that are resistant to viral disease prevalent in local waters. *(5 marks)*

- (d) Greater understanding of cell chemistry has resulted in society making better use of biotechnology. This is evident in the many ways that organisms in the natural environment have been modified to produce more useful products for society's use.

Answers will vary and must outline multiple examples. These may include the following.

- Understanding of breeding mechanisms/patterns. This has enabled the understanding of inheritance patterns resulting in selective breeding and production of hybrids with desirable characteristics, including higher yield in wheat and higher butterfat content in cows.
- Knowledge of DNA structure/genome mapping and genetic screening. This relates to an understanding of the cause and effect of mutation or changes in the DNA sequence.
- Identification of stem cells and how they differentiate. Stem cells have the potential to be used for the creation of desired tissue or organs that can be used to potentially save lives and overcome rejection issues with transplant recipients.
- Understanding of DNA replication mechanism and development of technology such as cloning and recombinant DNA. This results in the ability to produce genetically modified organisms that can, for example, produce disease resistant crops (such as Bt cotton/corn), higher yields resulting from frost-free strawberries that contain a salmon gene, better quality wool, milk with higher protein, and biopharmaceuticals such as insulin.

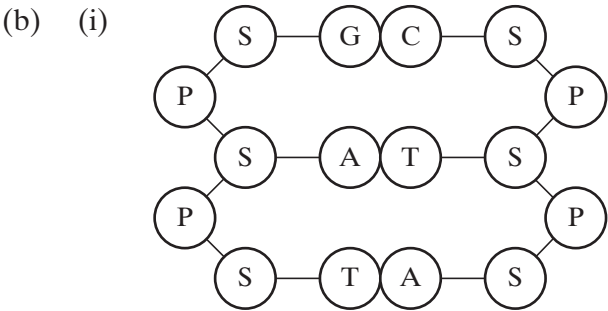
(8 marks)

Question 33—Genetics: The Code Broken?

(a) Answers will vary. The following table shows two types.

Type of cloning	Process used	Example
DNA cloning	Known genes are inserted into DNA of host	Used to produce unlimited amounts of identical copies of genes for study, production of useful protein, hormones, production of transgenic organisms (such as transferring the blue gene from a petunia into a carnation, creating the first light mauve carnation called Moondust) or insertion directly into plants such as tomatoes, cotton, corn of the <i>Bacillus thuringiensis</i> (Bt) gene which makes toxins that kill many pests
Whole organism cloning	A single cell is used to make an entire organism through recombinant DNA technology to create genetically identical offspring to the parent	Propagation of plants and production of animals for agriculture, such as fruit trees, sheep and pigs

(4 marks)



(3 marks)

(ii) Gene expression occurs when information from a gene is transcribed and translated into a polypeptide. Many factors manage the expression, which controls the process through splicing, translation and activation/inactivation of proteins. Gene expression is a regulated process in which information that is encoded on a gene is converted and used in the production of a specific protein or gene product. (3 marks)

- (c) (i) The Human Genome Project was completed in 2003. It identified the position of genes on chromosomes through sequencing the whole genome, increasing understanding of biological and in particular genetic processes in humans and other animals. It has enabled us to understand more fully the evolutionary relationships between humans and other organisms together with an insight into the treatment and prevention of disease. *(2 marks)*
- (ii) Restriction mapping has assisted in the physical mapping of chromosomes by using restriction enzymes to cut DNA into fragments. The fragments are labeled with radioactive phosphorous as a reference point, then cut by using restriction enzymes and the size of the fragment determined by gel electrophoresis. The position on the original fragment can then be deduced. The production of genetic probes has been used to identify genes; these are specific sequences of DNA that are complimentary to a gene or part of it. The probe can be cloned and tagged with fluorescent dye (FISH, fluorescent in situ hybridisation). These are then added to the separated chromosome strands that bond with the complimentary DNA, creating a hybrid. The tag will glow under a fluorescent light, showing its position. This can, for example, be used in genetic screening to identify abnormal chromosomes. *(5 marks)*
- (d) The gonads contain germ line cells that divide by meiosis to produce sex cells or gametes that are haploid. Mutation in germ line cells is passed on to offspring, resulting in sources of variation. If advantageous to the organism, these mutations or changes can manifest themselves and become the predominant characteristic through natural selection. Transposable genetic elements were identified about 50 years ago. Although not greatly understood at the time, it is now accepted that genes can change position on a chromosome. The transposable elements of genes are called transposons or 'jumping genes'. These represent segments of DNA coding for enzymes that can move from one part of a chromosome to another. This may sometimes occur after being stable for many generations, or cause an insertion into another gene resulting in a mutation. For example, the phenotype of wild corn can change by the movement of the colour genes resulting in red striping in the kernels, the transposons being the red stripes. It is also thought that these transposons are responsible for the transfer of resistance to antibiotics in bacteria, by transferring resistant genes into the DNA of plasmids, which can then be transferred even among different bacteria and back to the main DNA strand, carrying the resistance with it. Previously, it was thought that mutation alone was causing the build-up of resistance to antibiotics, but now it is believed to be the result of a combination of mutation and transposon movement. Scientists are looking for ways of suppressing jumping genes to limit the exchange of genetic information between pathogens. *(8 marks)*

Question 34—The Human Story

- (a) (i) Two features are the wide and bowl-shaped pelvis and the knee bent inwards to bring the foot under the centre of gravity. (2 marks)
- (ii) Forward-facing eyes that are close together have enabled primates to develop stereoscopic vision. This has enabled the development of depth perception which is advantageous for greater accuracy when hunting and when brachiating/climbing in trees. (2 marks)
- (b) (i) The identification of a full sequence of mitochondrial DNA being identical in one site only suggests that the individuals were descended from a single matriarchal female because the mitochondrial DNA can only ever be inherited from the female and not the male. The females did not tend to move between sites as the mitochondrial DNA is very different between the sites. (3 marks)
- (ii) The data collected in 2010 suggests that European modern humans are descended from Neanderthals because 1%–4% of genes are present in the population. As there are no specific Neanderthal genes in the modern sub-Saharan Africans, it is fair to say that the Neanderthals did not migrate outside of Europe. Without the presence of any specific modern human genes in the nuclear DNA of Neanderthal fossils, it could be said that ancestral species of the two did not interbreed but were separate lines. (3 marks)
- (c) Polymorphism has resulted from a wide geographical distribution across the world. Three major groups of races have formed, but subgroups of these have, in recent history, interbred. Three major races have been identified based on the continent of origin: Europe, Africa and Asia. Gradual changes or clinal gradation have been recognised in different geographical areas, resulting in more diversity and further renaming of groups that has continued to be accentuated by the migration and mixing of races over time. For example, blood groups have varied in native populations in various geographical areas. Three blood group alleles exist: A, B and O. These combine as a pair of genes and control the blood phenotype that prevails in particular races. This is an example of polymorphism in humans. The B allele is the rarest. It occurs most frequently in central Asia and in pockets within Africa, with the lowest frequency being in the New World and Australia. The blood group variations are an indicator of evolution in isolation due to the fact that A and B are dominant and O is recessive.

Skin colour evolved largely due to isolation. The earliest human populations were located in temperate regions further from the equator and were able to absorb more sunlight without burning for this reason. Lighter colour enabled the deeper penetration of sunlight into skin tissue and as such they were able to manufacture more vitamin D. Those located at the equator needed darker skin in order to protect themselves from sunburn, yet still manufacture enough vitamin D. This ability was decreased as darker-skinned people moved away from the equator. Natural selection would have played a significant role in the development of the specific gene pools that arose in different regions. (7 marks)

- (d) (i) Specific fossil evidence of hominids which infers the use of technology that led to cultural development could include the following.
- *Homo heidelbergensis*: fossil core tools, hunter-gatherer lifestyle, cave dweller, used animal skins for shelter and clothing.
 - *Homo ergaster*: fossil stone tools such as hand axes dated 1.8 to 1.6 million years old, evidence of a hunter-gatherer lifestyle with some permanent dwellings.
- (2 marks)
- (ii) Human population in 10000 years has increased to over 6 billion. The hunter-gatherer culture has been replaced by agricultural communities and subsequently the urbanisation of populations has occurred parallel to agriculture, with dense populations building up as people settled together and began to work together. Technology has improved dramatically and the reliance on complex machinery over the last 2000 years has resulted in an exponential increase in population. Populations have become very mobile, resulting in multiculturalism and the mixing of the gene pool across different races. Understanding of hygiene and advances in medical technology have increased, incorporating the use of drugs to treat and prevent disease. This has resulted in better health and extended the general life expectancy of people. Genetic technology and mapping of the human genome (identification of most genes in the human body and a location map of gene sequences) has enabled the identification of genes that cause disease and the ability to manipulate specific genes. The Human Genome Project has enabled us to compare the evolutionary relationships between us and other primates. Together with the ability to clone and advances in stem cell research, the potential to eliminate harmful genes from the gene pool is significant and may result in a great potential to eliminate or at least cure inherited diseases and live longer.
- (6 marks)