BIOLOGY

Written examination

Day Date

Reading time: *.* to *.* (15 minutes)
Writing time: *.* to *.* (2 hours 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

<table>
<thead>
<tr>
<th>Section</th>
<th>Number of questions</th>
<th>Number of questions to be answered</th>
<th>Number of marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>B</td>
<td>11</td>
<td>11</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total 120</td>
</tr>
</tbody>
</table>

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and rulers.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.
- No calculator is allowed in this examination.

Materials supplied
- Question and answer book of 39 pages
- Answer sheet for multiple-choice questions

Instructions
- Write your student number in the space provided above on this page.
- Check that your name and student number as printed on your answer sheet for multiple-choice questions are correct, and sign your name in the space provided to verify this.
- Unless otherwise indicated, the diagrams in this book are not drawn to scale.
- All written responses must be in English.

At the end of the examination
- Place the answer sheet for multiple-choice questions inside the front cover of this book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.
SECTION A – Multiple-choice questions

Instructions for Section A
Answer all questions in pencil on the answer sheet provided for multiple-choice questions. Choose the response that is correct or that best answers the question. A correct answer scores 1; an incorrect answer scores 0. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question. Unless otherwise indicated, the diagrams in this book are not drawn to scale.

Question 1
The genetic code specifies 20 different amino acids that can form proteins. Which one of the following explains the functional diversity of proteins?
A. Protein denaturation may be reversible or irreversible.
B. Proteins have structural, enzymatic and signalling functions.
C. Numerous combinations of amino acids can form a variety of polypeptide chains.
D. Codons correspond to a specific amino acid or stop signal during protein synthesis.

Question 2
Which of the following correctly describes a difference between DNA and rRNA?

<table>
<thead>
<tr>
<th>DNA contains</th>
<th>rRNA contains</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. deoxyribose sugar.</td>
<td>ribose sugar.</td>
</tr>
<tr>
<td>B. uracil.</td>
<td>thymine.</td>
</tr>
<tr>
<td>C. a single strand.</td>
<td>a double strand.</td>
</tr>
<tr>
<td>D. a different number of cytosine and guanine nitrogen bases.</td>
<td>the same number of cytosine and guanine nitrogen bases.</td>
</tr>
</tbody>
</table>

Question 3
Proteomics is the
A. theory that a single gene encodes for a single protein.
B. study of the proteins produced by a certain gene.
C. study of the proteins produced by an organism.
D. study of the genome of an organism.
**Question 4**
A small percentage of humans are born with malfunctioning protein channels in their plasma membranes.
Which one of the following molecules will be difficult to transport across plasma membranes with malfunctioning protein channels?
A. lipid-based hormones  
B. carbon dioxide  
C. glucose  
D. water

**Question 5**

The reaction shown in the diagram above is an example of a
A. hydrophilic reaction.  
B. hydrophobic reaction.  
C. denaturation reaction.  
D. condensation reaction.

**Question 6**
Consider the structure of a gene in a eukaryotic cell.
Which one of the following is a correct statement?
A. An exon is transcribed but not translated.  
B. A promoter region is found downstream of a gene.  
C. Introns contain nucleotides that code for the production of protein.  
D. Transcription factors may bind to nucleotides found in the promoter region of the gene.
Question 7
A regulatory gene
A. may code for the production of a molecule that inhibits the activity of another gene.
B. consists of a sequence of nucleotides, each containing a ribose sugar group.
C. requires the enzyme DNA polymerase to transcribe its code.
D. codes for the production of a structural protein.

Question 8
Which one of the following statements about coenzymes is correct?
A. NAD\(^+\) transfers energy from glycolysis to the electron transport chain in respiration.
B. ATP provides a supply of energy to the light-dependent reaction of photosynthesis.
C. NADPH transfers energy to the light-independent reaction in photosynthesis.
D. ADP provides energy for active transport across plasma membranes.
**Question 9**

The enzyme lactate dehydrogenase is found in a wide variety of organisms. It catalyses the conversion of both pyruvate to lactate and lactate to pyruvate. The bacterium *Thermoanaerobacter ethanolicus* lives in geothermal (hot) springs. The river buffalo (*Bubalus bubalis*) is a domestic animal common in Pakistan. Scientists studying the enzyme lactate dehydrogenase from these two organisms produced the following graphs.

<table>
<thead>
<tr>
<th>B. bubalis</th>
<th>T. ethanolicus</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Graph B. bubalis" /></td>
<td><img src="image2.png" alt="Graph T. ethanolicus" /></td>
</tr>
<tr>
<td><img src="image3.png" alt="Graph B. bubalis" /></td>
<td><img src="image4.png" alt="Graph T. ethanolicus" /></td>
</tr>
</tbody>
</table>


From the graphs, it is reasonable to conclude that the

A. optimum temperature at which the enzyme operates is higher in the bacteria than in the river buffalo
B. bacterial form of the enzyme would denature at temperatures below 60 °C
C. bacterial form of the enzyme has an optimum pH of 7.4
D. body temperature of a river buffalo is 40 °C

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C. bacterial form of the enzyme has an optimum pH of 7.4
D. body temperature of a river buffalo is 40 °C
Question 10
Consider an enzyme-facilitated reaction in which the concentration of the enzyme is constant. Which one of the following graphs shows the effect of increasing substrate concentration on the rate of product formation?

A. ![Graph A]

B. ![Graph B]

C. ![Graph C]

D. ![Graph D]

Question 11
The electronmicrograph below shows a portion of a cell.

![Electronmicrograph]

In organelle X
A. carbon dioxide is joined to an organic molecule.
B. the electron transport chain produces two ATP.
C. the cycling of NADH occurs.
D. pyruvate is synthesised.
**Question 12**
Which one of the following is an output of the Krebs cycle?
A. ADP  
B. NADPH  
C. pyruvate  
D. carbon dioxide

**Question 13**
Which one of the following is true of glycolysis?
A. It is the first stage of aerobic respiration, not anaerobic respiration.  
B. It results in the production of either lactic acid or ethanol.  
C. It produces more ATP than the Krebs cycle.  
D. It occurs in the cytosol of a cell.
Use the following information to answer Questions 14–16.

The graph below shows the net uptake of carbon dioxide by a leaf from its external environment as light intensity is altered. All other variables are kept constant throughout the experiment.

**Question 14**
Photosynthesis occurs
A. when light absorption is above 0.
B. only when light absorption is above 200.
C. only when the net uptake of carbon dioxide is above 0.
D. when light absorption is greater than or equal to point M.

**Question 15**
At point M, the rate of photosynthesis is
A. 0.
B. slow due to the temperature.
C. equal to the rate of cellular respiration.
D. limited by carbon dioxide available in the environment.

**Question 16**
Considering the experimental conditions outlined above, the graph begins to plateau as
A. the concentration of oxygen inhibits the rate of photosynthesis.
B. the rate of photosynthesis is at its maximum.
C. the level of carbon dioxide increases.
D. light is limited.
**Question 17**
Lipid-based hormones and protein-based hormones both stimulate their target cells. The two kinds of hormones have different mechanisms to initiate responses within their target cells.

Lipid-based hormones
A. form a hormone-receptor complex that binds to a site on a DNA molecule.
B. attach to protein receptors on the membranes of their target cells.
C. directly inhibit enzymes in the cytoplasm.
D. bind to proteins in the nuclear membrane.

**Question 18**
Some responses or reactions seen in individuals are caused by the release of chemicals into the environment by other individuals of the same species.

These chemicals are called
A. enzymes.
B. pheromones.
C. neurohormones.
D. neurotransmitters.

**Question 19**
Relenza was one of the first drugs developed through rational drug design.

Which one of the following statements is true of Relenza?
A. Relenza is an antibiotic drug.
B. Relenza increases the release of the virus from the host cell.
C. Relenza prevents the synthesis of specific viral proteins within the host cell.
D. Relenza binds to and blocks the active site of the viral enzyme neuraminidase.

**Question 20**
Four students carried out an experiment using a thermometer to record the temperature of a solution. The students repeated the experiment four times. Their teacher suggested that their results showed evidence of a systematic error.

A systematic error
A. may have been caused by using an incorrectly calibrated thermometer throughout the experiment.
B. will be shown by large variations in the individual temperature readings obtained by the students.
C. can be reduced if the students gathered more data by repeating the experiment many more times.
D. happens when the students take turns recording the temperature of the solution.

**Question 21**
In humans, a chemical barrier to help keep pathogens out of the internal environment includes
A. keratin deposited in skin cells.
B. the presence of acid in the stomach.
C. the release of histamine from neutrophils.
D. the production of interferon by virus-infected cells.
Question 22
An example of an innate response by the human immune system is
A. cytotoxic T cells releasing chemicals into infected cells.
B. the production of plasma cells that produce antibodies.
C. phagocytes engulfing non-self material.
D. the production of memory B cells.

Question 23
The human lymphatic system
A. contains all types of blood cells.
B. acts as a physical barrier against pathogens.
C. produces complement proteins by clonal selection.
D. acts as a transport system for antigen-presenting cells.

Question 24
Banana plants are polyploid.
This means that their cells have
A. multiple extra sets of chromosomes.
B. any number of extra chromosomes.
C. many copies of the same gene.
D. multiple nuclei.

Question 25
Over the past million years, Australia’s climate has become much drier, leading to reduced areas of forest and woodland. Studies of mitochondrial DNA in different spider species from various woodlands show they share a recent common ancestor dating back to just before the climate began to become drier.
The different species are likely to have evolved through the process known as
A. gene flow.
B. genetic drift.
C. allopatric speciation.
D. convergent evolution.
Question 26
Samples of DNA were taken from four individuals. The samples went through a series of steps and the resulting DNA is shown below.

Using information from the diagram, which conclusion could be drawn?

A. DNA samples 1 and 2 are from individuals belonging to the same species.
B. Treatment at Step X would have included cooling each of the original samples.
C. Treatment of mixed samples at Step Y would have included the addition of DNA helicase.
D. Individuals with DNA samples 1 and 2 are more closely related than individuals with DNA samples 3 and 4.
Use the following information to answer Questions 27 and 28.

Two proteins, BMP4 and CaM, act in the developing embryos of finches and are responsible for the variations in beak size and shape among the Galápagos finches.

Variations in beak size and shape, and the levels of the proteins in different types of Galápagos finches are shown in the diagram below.


**Question 27**
Consider the medium ground finch illustrated above.
Which of the following would be the most likely levels of proteins to produce the beak shape of this finch?

<table>
<thead>
<tr>
<th>Level of BMP4</th>
<th>Level of CaM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. low</td>
<td>high</td>
</tr>
<tr>
<td>B. moderate</td>
<td>low</td>
</tr>
<tr>
<td>C. low</td>
<td>low</td>
</tr>
<tr>
<td>D. moderate</td>
<td>high</td>
</tr>
</tbody>
</table>
Question 28
The differences in the levels of proteins in the different finches can be explained by
A. changes in gene expression.
B. natural selection.
C. adaptation.
D. evolution.

Question 29
Which one of the following statements correctly explains why 50,000 years is the limit of the radiocarbon dating method for determining the age of fossils?
A. Fossils older than 50,000 years have too much carbon contamination from atmospheric carbon dioxide for accurate measurements.
B. The half-life of carbon-14 is short and so, by 50,000 years, there is too little carbon left to measure.
C. The proportion of radioactive carbon in the atmosphere is not known beyond 50,000 years ago.
D. After 50,000 years, there is no carbon left in fossils.

Question 30
Some scientists argue that Australian marsupials are the descendants of marsupials that first evolved in what is now South America. These early marsupials moved to what became modern-day Australia. Other scientists argue that the evidence suggests that the marsupials originated in Australia, with some of the early marsupials moving to South America.
What evidence would support the view that marsupials originated in Australia rather than South America?
A. the discovery of identical marsupial fossils on both continents
B. the existence of very old placental mammal fossils in South America
C. finding, in Australia, a fossil of a common ancestor to all vertebrate species
D. finding, in Australia, a fossil of a marsupial ancestor that is older than any other marsupial ancestor fossil
Use the following information to answer Questions 31 and 32.

The fossils present in different rock strata in a particular location are shown in the diagram below.

![Diagram of rock strata with fossils]

**Question 31**
From the information above, it can be concluded that
A. Fossil B is extinct.
B. Fossil D is the youngest fossil present.
C. Fossil A is less than 5 million years old.
D. Fossil A and Fossil C are closely related.

**Question 32**
Scientists found that Fossil A and Fossil C both have limb-like appendages and so they decided that the limbs were analogous structures.
As Fossil A and Fossil C had analogous structures, they must have shared very similar
A. selection pressures.
B. DNA sequences.
C. RNA sequences.
D. environments.
Use the following information to answer Questions 33 and 34.

Chimpanzees are the closest living relatives of humans. Less than 1 per cent of our DNA has changed in the six million years or so since the human and chimpanzee lineages diverged.

**Question 33**
The measurement of the rate of accumulation of random genetic changes in the genomes of chimpanzees and humans is called

A. stratigraphy.
B. relative dating.
C. a molecular clock.
D. radiometric dating.

**Question 34**
Research has shown that, in a number of genes, the sequence of nucleotides is unique to humans and is not found in chimpanzees. Some of these genes are shown in the table below.

<table>
<thead>
<tr>
<th>Gene with sequence unique to humans</th>
<th>Functional role of gene with sequence unique to humans</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAR1</td>
<td>active in the brain&lt;br&gt;necessary for development of the cerebral cortex</td>
</tr>
<tr>
<td>FOXP2</td>
<td>facilitates formation of words by the mouth</td>
</tr>
<tr>
<td>AMY1</td>
<td>facilitates digestion of starch</td>
</tr>
<tr>
<td>ASPM</td>
<td>controls brain size</td>
</tr>
<tr>
<td>LCT</td>
<td>permits digestion of milk sugar in adulthood</td>
</tr>
<tr>
<td>HAR2</td>
<td>drives gene activity in the wrist and thumb during development</td>
</tr>
</tbody>
</table>

Using the information in the table, it is reasonable to conclude that humans

A. can digest milk sugar only in infancy.
B. have a weaker grasping grip than chimpanzees.
C. are able to walk on two feet in an upright position.
D. process and remember more complex information than chimpanzees.
Use the following information to answer Questions 35 and 36.

The human family tree below shows the relationship between different groups.

![Human family tree diagram]


**Question 35**
Based on the information above, Neanderthal DNA would not be found in the
A. Melanesian group.
B. Denisova group.
C. African group.
D. Han group.

**Question 36**
Based on the information above, the group most closely related to the Denisova group is the
A. Neanderthal group.
B. African group.
C. French group.
D. Han group.
Question 37
During a fight between a number of people, one was seriously injured. Blood samples were taken from the victim, the crime scene and four suspects. DNA was extracted from white blood cells in each of the blood samples and electrophoresis of the samples was carried out. The results are shown in the following diagram.

![DNA Electrophoresis Diagram]

The person most likely to have been at the crime scene is

A. Suspect 1.
B. Suspect 2.
C. Suspect 3.
D. Suspect 4.
Use the following information to answer Questions 38 and 39.

Genetic engineers use restriction enzymes to cut DNA into smaller lengths. The recognition sequences of several restriction enzymes are shown in the table below. The symbol * denotes the restriction site (position of the cut).

<table>
<thead>
<tr>
<th>Restriction enzyme</th>
<th>Recognition sequence (read in 5’ to 3’ direction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EcoRI</td>
<td>G* A A T T T C T T A A</td>
</tr>
<tr>
<td>HindIII</td>
<td>A* A G C T T C G A</td>
</tr>
<tr>
<td>AluI</td>
<td>A G* C T T C* G A</td>
</tr>
<tr>
<td>HaeIII</td>
<td>G G* C C C G G</td>
</tr>
</tbody>
</table>

**Question 38**
Consider a length of double-stranded DNA with the following sequence.

5’ T T A A G G A A T T C A A 3’
3’ A A T T C C T T A A G T T 5’

Adding EcoRI to a solution containing one copy of this double-stranded DNA produces
A. two fragments of double-stranded DNA, each with a sticky end.
B. four fragments of single-stranded DNA, each with a sticky end.
C. two fragments of double-stranded DNA, each with blunt ends.
D. four fragments of single-stranded DNA, each with blunt ends.

**Question 39**
Now consider a different length of double-stranded DNA with the following sequence.

5’ C T T A A G C T T C C A A A T T A C C G A 3’
3’ G A A T T C G A A G G T T T A A T G G C T 5’

Which enzyme(s) will cut this piece of DNA?
A. EcoRI only
B. HindIII only
C. AluI and HindIII only
D. AluI, HindIII and HaeIII only
Question 40
The following diagram summarises the steps involved in the production of a cloned sheep.

1. A cell is removed from the mammary gland of mature Sheep P.
2. The nucleus is removed from the cell.
3. The nucleus is implanted into a sheep's egg from which genetic material has been removed.
4. The resulting embryo is placed in Sheep Q.
5. A cloned sheep is born naturally.

The chromosomes in the cells of the cloned sheep will be identical to those in the cells of
A. Sheep M.
B. Sheep N.
C. Sheep P.
D. Sheep Q.
SECTION B

Instructions for Section B
Answer all questions in the spaces provided. Write using blue or black pen.
Unless otherwise indicated, the diagrams in this book are not drawn to scale.

Question 1 (6 marks)
Yeast is a single-celled microscopic fungus that uses sucrose as a food source. An experiment was carried out by four separate groups of students to investigate cellular respiration by a particular species of yeast. Yeast cells were placed in a container and a 0.1 M sucrose solution was added. The container was sealed in such a way as to prevent air from entering. The percentages of oxygen and ethanol in the container were recorded over a one-hour period. The experiment was carried out at a room temperature of 22 °C. The results for each group and the mean are shown in the following table.

<table>
<thead>
<tr>
<th>Group</th>
<th>Percentage of oxygen</th>
<th>Percentage of ethanol</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At the start of the experiment</td>
<td>At the end of the experiment</td>
</tr>
<tr>
<td>1</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>Mean for all groups</td>
<td>18</td>
<td>18</td>
</tr>
</tbody>
</table>

a. Why was it important that air could not enter the container? 1 mark

b. Examine the data above.
In order to draw valid conclusions from the data for the percentage of oxygen, would you use the raw student data or the mean provided? Explain your choice. 3 marks

SECTION B – Question 1 – continued
c. Consider the design of the experiment to investigate cellular respiration.

i. What factor, other than the levels of oxygen and ethanol, could be measured to monitor the progress of cellular respiration?  

ii. Identify a factor that could be changed in the original experiment to increase the rate of cellular respiration.
Question 2 (3 marks)
A genetic disease called phenylketonuria (PKU) may occur in babies. Affected individuals produce little or none of the enzyme phenylalanine hydroxylase (PAH). PKU is caused by the effects of too much of the amino acid phenylalanine building up in the body. Phenylalanine enters the body because it is abundant in a normal protein-rich human diet. Phenylalanine is metabolised in the biochemical pathway shown below.

a. Why would the absence of PAH result in too much phenylalanine building up in the body of an affected individual? 1 mark

[Diagram of metabolic pathway]

phenylalanine → PAH → tyrosine → p-hydroxyphenylpyruvate → homogentisate → 4-maleylacetoacetate → 4-fumarylacetoacetate → fumarate + acetoacetate

Enzyme T → Enzyme P → Enzyme H → Enzyme M → Enzyme F
b. The Guthrie test was developed to test a baby’s blood for high levels of phenylalanine a few days after birth. In this test, a drop of blood is taken from a baby, placed on special paper and dried. Small discs are cut from the paper and placed on an agar plate containing bacteria that grow well in the presence of phenylalanine.

One of the agar plates is shown in the following diagram.

Row 1 contains control discs, each with a different known level of phenylalanine. The concentration of phenylalanine increases in the discs from left to right. Row 2 contains sample discs from different babies.

i. Why are the control discs in Row 1 included on the agar plate? 1 mark

ii. Baby 1 was diagnosed with PKU, whereas Baby 2 was diagnosed as not having PKU.

Why was this decision made, given that there is some bacterial growth around the sample disc from Baby 2? 1 mark
Question 3 (4 marks)
The diagram below shows a chloroplast.

a. Name the stage of photosynthesis that occurs in the position labelled X within the chloroplast.  

b. What role does chlorophyll play in this reaction?  

c. Briefly outline the theory of the bacterial origin of chloroplasts. What evidence is provided by the chloroplasts to support this theory?
Question 4 (6 marks)
Apoptosis is the process of programmed cell death.

a. Explain the role of caspases in apoptosis and the consequence of apoptosis.  

b. Phagocytes are found in high concentrations around the cells undergoing apoptosis.

   Draw a series of labelled diagrams to show the role of phagocytosis in the destruction of cells undergoing apoptosis.
**Question 5** (10 marks)
Measles is an infectious disease caused by a virus. The measles virus is highly contagious.
In Australia, there is a recommended two-dose vaccination program for a person to achieve immunity to the measles virus. The first dose is given at 12 months of age and the second dose is given at 18 months of age.

a. Describe and explain the humoral response that occurs within a person after each vaccination dose. 5 marks

b. In order to protect communities from outbreaks of measles, the Australian Government is aiming to achieve a vaccination rate of 95 per cent in the Australian population.

   i. Name the type of immunity the government is trying to achieve in the population with this high vaccination rate. 1 mark

   ii. Explain how this type of immunity can protect the 5 per cent of the population who have not been vaccinated. 2 marks

c. Measles is rare in Australia, but in early 2016, twenty-five people living in Melbourne contracted the disease.

   Explain what may have happened to cause an outbreak of measles at this time. 2 marks
**Question 6** (12 marks)

The prostate is a gland found in the male reproductive system. Prostate cancer represents the second most frequent type of tumour in men worldwide. The BRCA1 and BRCA2 genes that have been linked to breast cancer have also been linked to an increased risk of prostate cancer.

A section of the normal BRCA2 gene and a section of a mutated BRCA2 gene are shown below.

![Diagram showing normal and mutated BRCA2 sequences](image)

Source: adapted from DA Caporale and EE Swenson, ‘Two different BRCA2 mutations found in a multigenerational family with a history of breast, prostate, and lung cancers’, in *Advances in Genomics and Genetics*, 2014:4, p. 92

**a.** Transcribe both DNA sequences into mRNA.  

mRNA BRCA2 normal

mRNA BRCA2 mutated
<table>
<thead>
<tr>
<th>First position</th>
<th>Second position</th>
<th>Third position</th>
</tr>
</thead>
<tbody>
<tr>
<td>code</td>
<td>amino acid</td>
<td>code</td>
</tr>
<tr>
<td>UUU</td>
<td>phe</td>
<td>UCU</td>
</tr>
<tr>
<td>UUC</td>
<td>phe</td>
<td>UCC</td>
</tr>
<tr>
<td>UUA</td>
<td>leu</td>
<td>UCA</td>
</tr>
<tr>
<td>UUG</td>
<td>leu</td>
<td>UCG</td>
</tr>
<tr>
<td>CUU</td>
<td>leu</td>
<td>CCU</td>
</tr>
<tr>
<td>CUC</td>
<td>leu</td>
<td>CCC</td>
</tr>
<tr>
<td>CUA</td>
<td>leu</td>
<td>CCA</td>
</tr>
<tr>
<td>CUG</td>
<td>leu</td>
<td>CCG</td>
</tr>
<tr>
<td>AUU</td>
<td>ile</td>
<td>ACU</td>
</tr>
<tr>
<td>AUC</td>
<td>ile</td>
<td>ACC</td>
</tr>
<tr>
<td>AUA</td>
<td>ile</td>
<td>ACA</td>
</tr>
<tr>
<td>AUG</td>
<td>met</td>
<td>ACG</td>
</tr>
<tr>
<td>GUU</td>
<td>val</td>
<td>GCU</td>
</tr>
<tr>
<td>GUC</td>
<td>val</td>
<td>GCC</td>
</tr>
<tr>
<td>GUA</td>
<td>val</td>
<td>GCA</td>
</tr>
<tr>
<td>GUG</td>
<td>val</td>
<td>GCG</td>
</tr>
</tbody>
</table>

Source: Plant and Soil Sciences eLibrary 2016

b. Using your answer to part a. and the codon table provided above, determine the amino acid sequence coded by the nucleotide sequence on each segment of the mRNA strands.  

2 marks

BRCA2 normal (amino acid chain)

BRCA2 mutated (amino acid chain)
c. Consider the mutation in the BRCA2 gene.
   Explain any changes that may affect the function of the transcribed protein. 2 marks

Scientists have investigated prostate cells and mapped the interaction between the proteins expressed by those cells in the hope of developing a quick and more accurate blood test to detect prostate cancer. The scientists investigated the expression pattern in both healthy and cancerous prostate cells from more than 100 individuals.

d. Explain the significance of using both healthy and cancerous prostate cells in the scientific study. 2 marks

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e. Why did the scientists collect healthy and cancerous prostate cells from more than 100 individuals? 2 marks

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f. The diagrams below show some of the interactions between the proteins found in healthy prostate cells compared to the interactions between the proteins found in cancerous prostate cells.

![Protein expression in a healthy prostate cell](image1)

![Protein expression in a cancerous prostate cell](image2)

Source: adapted from JR Heath, ME Davis and L Hood, ‘Nanomedicine targets cancer’, in *Scientific American*, 300(2), February 2009, pp. 44–51

The circles in the diagrams above represent the proteins. Each circle is a different protein. The larger the circle, the greater the expression of that protein. One of the proteins has been labelled SDC1.

The lines represent the interactions between the different proteins.

The SDC1 protein is found in the membrane of cells and is involved in cell proliferation.

Propose one conclusion that the scientists could have made about the amount of SDC1 in cancerous prostate cells.

1 mark

g. State two ethical considerations that the scientists must address when conducting this study.

2 marks
Question 7 (5 marks)
Fossils found in Australia include representatives from across the ages of life on Earth. The table below shows some of the groups of fossils found in Australia and their ages.

<table>
<thead>
<tr>
<th>Type of fossil</th>
<th>Location</th>
<th>Geological time</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>stromatolites</td>
<td>Arkaroola, South Australia</td>
<td>Precambrian era</td>
<td>770 mya</td>
</tr>
<tr>
<td>jellyfish</td>
<td>Flinders Ranges, South Australia</td>
<td>Ediacaran period</td>
<td>645–542 mya</td>
</tr>
<tr>
<td>dinosaurs</td>
<td>many places, including Queensland and Victoria</td>
<td>Jurassic and Cretaceous periods</td>
<td>200–65 mya</td>
</tr>
<tr>
<td>megafauna (large marsupials and flightless birds)</td>
<td>Naracoorte, South Australia</td>
<td>Cainozoic era</td>
<td>65–7000 ya</td>
</tr>
</tbody>
</table>

Note: mya – million years ago; ya – years ago

a. What type of organisms would have formed the stromatolite fossils of 770 mya? 1 mark

b. How are stromatolite fossils different from dinosaur fossils? 2 marks

c. The Ediacaran fossils found in the Flinders Ranges were dated using uranium–lead radiometric dating techniques.

Explain how these dating techniques allow scientists to establish the age of fossils. 2 marks
Question 8 (4 marks)
The skeletal structures of two extinct members of the hominin family tree, *Australopithecus africanus* and *Homo neanderthalensis*, are shown below.

Both of these species, along with *Homo sapiens*, are classified as follows.

order → Primate  
superfamily → Hominoidea  
tribe → Hominini

a. State a feature shared by all primates.  

b. From the skeletal structures above, choose one structural difference that has changed over time and explain the significance of the change.  

c. *H. neanderthalensis* shows evidence of cultural evolution.  
How is cultural evolution passed on to other members of a species?
Question 9 (14 marks)

Populations of a particular species can experience events that alter their genetic diversity.

a. Explain how the genetic diversity of a population is affected by a natural event such as a bottleneck. 2 marks

b. Rice is an important food source for humans. Over time, farmers have used selective breeding to increase the amount of rice that they produce.

i. Explain how farmers have used selective breeding to increase rice production. 2 marks

ii. How is the process of natural selection different from selective breeding? 1 mark

The genome of a new strain of rice (*Oryza sativa*) has two additional genes compared to other strains of rice of the same species. One of the genes was originally found in the daffodil (*Narcissus pseudonarcissus*). The second gene was originally found in a soil bacterium (*Pantoea ananatis*).

c. Explain why an individual plant of the new strain of rice could be described as both a genetically modified organism and a transgenic organism. 2 marks
d. One method of transferring the two genes into the cells of the new strain of rice involves the use of plasmids.

i. Explain how plasmids can be used to transfer the two genes into the cells of the new strain of rice.  

ii. A promoter for each gene, as well as the gene, must also be transferred into the cells of the new strain of rice.

   Describe the role of a promoter.

---

e. The new strain of rice has golden-coloured seeds. The two additional genes have allowed the production of beta-carotene in the seeds. Beta-carotene is converted to vitamin A in the human body. Scientists are suggesting that the new strain of rice could be used to feed people who are suffering from vitamin A deficiency. Before governments allow the commercial production of the new strain of rice, extensive field trials must be carried out by scientists.

   Give two reasons why these extensive field trials are necessary.
Question 10 (7 marks)

In 1976, a sample of blood was taken from a nun who died from a disease caused by an unknown pathogen. The nun worked in a mission hospital in Yambuku, a small village in Zaire (now known as the Democratic Republic of the Congo), Africa. Testing of the sample revealed the presence of an unknown virus.

One of the scientists who went to Africa, Peter Piot, wrote about the steps taken to help identify the virus and stop the spread of the virus. Here is part of his story.

### Into Africa

I was excited that we had isolated something new, but even more eager to find out how it was transmitted. What does it cause? And how? I wanted to go to Zaire … to investigate the epidemic.

…

The big worry was that the epidemic could spread in Kinshasa, a chaotic city of about 3 million people …

Six of us went out to Yambuku … Our aim was to stop the epidemic. First we had to work out how it was transmitted … [we] examine[d] sick people, taking blood and gathering information about age and gender, date of symptoms onset and exposure to other infected people. When you don’t know the cause of an epidemic, you must define it in terms of three things: time, place and person. For time, where are you in the epidemic? Has it peaked? For place, where are the victims coming from? And person: who is coming down with the virus we would later call Ebola?

When we arrived, the epidemic seemed to be declining. So what had happened? We learned that the hospital where the nun had worked had been closed down … Then we found out that the closer people lived to that hospital, the higher their risk of dying from Ebola. And when we looked at age, we saw that it was mostly fairly young adults who were affected, and also some newborns …

Also, twice as many women were infected as men.

…

We learned one other thing, too. The people in the villages kept telling us that about a week after a funeral of someone who had been sick, several cases would develop among the family members or other funeral attendees. Later, it was documented that the traditional funeral rites – when the corpse is washed with bare hands …

Source: Peter Piot, as told to Tiffany O’Callaghan, ‘Ebola: The bloody beginning’, in New Scientist, 23 July 2016, pp. 38 and 39
a. The outbreak of the disease was referred to by the scientist as an epidemic rather than a pandemic.

Why is the term ‘epidemic’ correct in this context? 1 mark

b. When the scientists arrived in Yambuku, they found that the hospital where the nun had worked had closed.

What effect would this have had on the epidemic and how did closing the hospital bring about this effect? 2 marks

c. Scientists decided that the virus was not being carried by mosquitoes.

Identify two pieces of evidence that support the hypothesis that the virus was not being carried by mosquitoes. 2 marks

d. What reason could there be for the people who attended funerals contracting the disease? 1 mark

e. In the 1970s, tests available to identify an unknown pathogen were limited.

Describe a modern method that is used to quickly identify a pathogen. 1 mark
Laura wanted to investigate the effectiveness of an antibiotic against the bacterium *Escherichia coli*. She prepared five different concentrations of the antibiotic. She wrote the following method:

1. Collect five agar plates containing nutrient agar.
2. Label each agar plate with the five different concentrations of the antibiotic.
3. Collect a sample of *E. coli* in a broth culture.
4. Put on a pair of disposable gloves.
5. Measure 0.5 mL of broth in a pipette and place in the centre of the first agar plate.
6. Spread the bacteria evenly over the agar plate with the spreader provided.
7. Place a drop of the antibiotic in the centre of the agar plate.
8. Close the lid of the agar plate and tape the lid to the bottom of the agar plate with sticky tape.
9. Repeat steps 6 to 8 with the other four concentrations of the antibiotic.
10. Place the agar plates on the side bench and leave overnight.
11. Wash your hands and dispose of the gloves.

a. What hypothesis is Laura testing with this experiment? 1 mark

b. Name the independent variable in this experiment. Justify your answer. 2 marks

c. Identify two sources of experimental errors in this investigation and suggest how the experimental design could be changed to reduce the effect of these errors. 4 marks
d. Laura wanted to repeat the experiment to test the effectiveness of an antiviral drug against *E.coli*. She prepared five different concentrations of the antiviral drug and followed the same steps that she used for the antibiotic.

Explain the results that Laura would be expected to obtain.  

2 marks
# Answers to multiple-choice questions

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