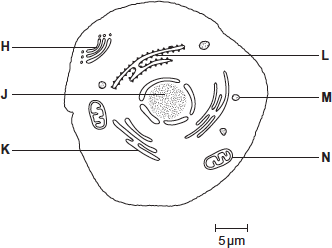
**Q1.**The diagram shows a eukaryotic cell.



(a)     Complete the table by giving the letter labelling the organelle that matches the function.

|  |  |  |
| --- | --- | --- |
|  | **Function of organelle** | **Letter** |
|  | Protein synthesis |  |
|  | Modifies protein (for example, adds carbohydrate to protein) |  |
|  | Aerobic respiration |  |

**(3)**

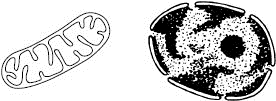
(b)     Use the scale bar in the diagram above to calculate the magnification of the drawing.  
Show your working.

Answer = ................................

**(2)**

**(Total 5 marks)**

**Q2.**          (a)     The diagram shows two organelles found in a eukaryotic cell.



**A**                                           **B**

(i)      Name the organelles.

**A** ..........................................................................................................

**B** ..........................................................................................................

**(1)**

(ii)     Explain how the inner membrane is adapted to its function in organelle **A**.

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**(2)**

(b)     Give **one** feature of a prokaryotic cell that is not found in a eukaryotic cell.

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**(1)**

(c)     Describe how a sample consisting only of chloroplasts could be obtained from homogenised plant tissue.

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**(3)**

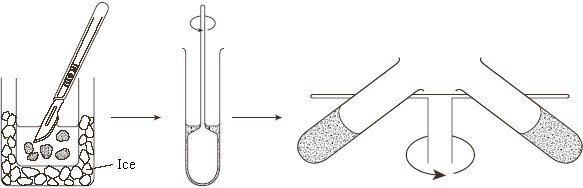
**(Total 7 marks)**

**Q3.**          Mitochondria were isolated from the liver tissue using differential centrifugation. The tissue was chopped in cold, isotonic buffer solution. A buffer solution maintains a constant pH. The first stages in the procedure are shown in the diagram.

Tissue chopped               Homogenised                                      Centrifuged

 in cold isotonic                                                                          at low speed

  buffer solution                                                                        for 10 minutes



**Stage 1                          Stage 2                                              Stage 3**

(i)      The tissue was chopped in cold, isotonic buffer solution. Explain the reason for using

a *cold* solution;

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an *isotonic* solution;

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a *buffer* solution.

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**(3)**

(ii)      Why is the liver tissue homogenised?

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**(1)**

(iii)     Describe what should be done after **Stage 3** to obtain a sample containing only mitochondria.

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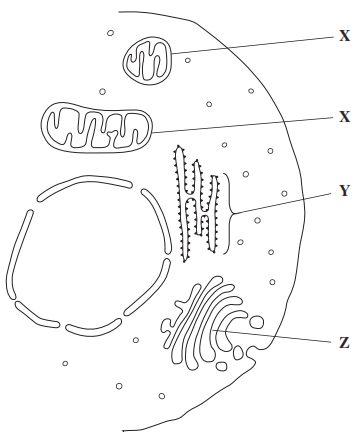
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**(2)**

**(Total 6 marks)**

**Q4.**          The drawing shows part of a human cell.



(a)     Name organelles

**X** ..................................................................................................................

**Y** ..................................................................................................................

**(2)**

(b)     (i)      The organelles labelled **X** all have very similar shapes in this cell.  
Explain why they appear to have different shapes in this drawing.

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*(Extra space)*  .....................................................................................

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**(1)**

(ii)     Large numbers of organelles **X** and **Z** are found in mucus-secreting cells.  
Explain why.

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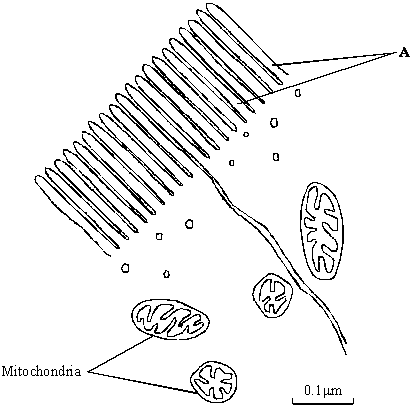
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**(2)**

**(Total 5 marks)**

**Q5.**          The drawing shows an electron micrograph of parts of epithelial cells from the small intestine.



(a)     (i)      Name the structures labelled **A**.

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**(1)**

(ii)     Explain how these structures help in the absorption of substances from the small intestine.

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**(1)**

(b)     (i)      The scale bar on this drawing represents a length of 0.1μm. Calculate the magnification of the drawing. Show your working.

Magnification .............................................

**(2)**

(ii)     Explain why an electron microscope shows more detail of cell structure than a light microscope.

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**(2)**

(c)     The length of mitochondria can vary from 1.5 μm to 10 μm but their width never exceeds 1μm. Explain the advantage of the width of mitochondria being no more than 1μm.

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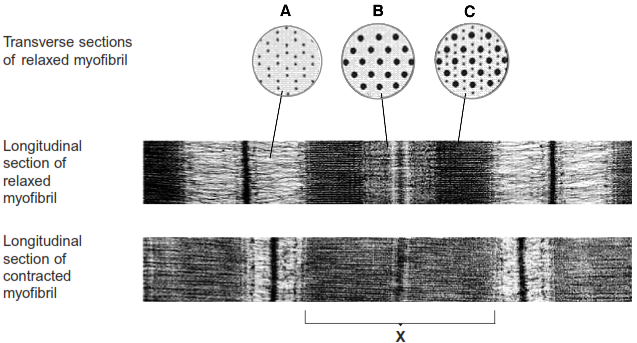
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**(1)**

**(Total 7 marks)**

**Q6.**          **Figure 1** shows sections through relaxed and contracted myofibrils of a skeletal muscle. The transverse sections are diagrams. The longitudinal sections are electron micrographs.

**Figure 1**

****

(a)     (i)      The electron micrographs are magnified 40 000 times.  
Calculate the length of  band **X** in micrometres.  
Show your working.

Length of band **X** =..................................... µm

**(2)**

(ii)     Explain the difference in appearance between transverse sections **A** and **C** in **Figure 1**.

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**(1)**

(b)     Explain what leads to the differences in appearance between the relaxed myofibril and the contracted myofibril.

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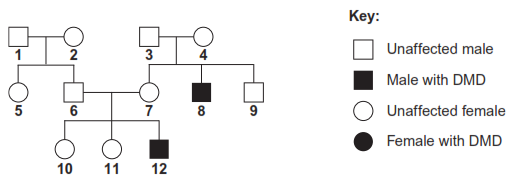
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**(4)**

(c)     Duchenne muscular dystrophy (DMD) is a condition caused by the recessive allele of a sex-linked gene. A couple have a son with DMD. They want to know the probability that they could produce another child with DMD. They consulted a genetic counsellor who produced a diagram showing the inheritance of DMD in this family.  
This is shown in **Figure 2**.

**Figure 2**

****

The couple who sought genetic counselling are persons **6** and **7**.

(i)      Give the evidence to show that DMD is caused by a recessive allele.

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**(1)**

(ii)     Give the numbers of **two** people in **Figure 2** who are definitely carriers of muscular dystrophy.

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**(1)**

(iii)     Complete the genetic diagram to find the probability that the next child of couple **6** and **7** will be a son with muscular dystrophy. Use the following symbols:

**X**D= normal X chromosome  
**X**d= X chromosome carrying the allele for muscular dystrophy  
**Y** = normal Y chromosome

|  |  |  |
| --- | --- | --- |
|  | **6** | **7** |
| *Parental phenotypes* | Unaffected | Unaffected |
| *Parental genotypes* | *..............* | *..............* |
| *Gametes* | *..............* | *..............* |

*Offspring genotypes          .....................................................................*

*Offspring phenotypes        .....................................................................*

*Probability of having a son with DMD ...................................................*

**(4)**

(d)     DMD is caused by a deletion mutation in the gene for a muscle protein called dystrophin. A deletion is where part of the DNA sequence of a gene is lost. People in different families may inherit mutations in different regions of this gene.

Scientists isolated the dystrophin gene from DNA samples taken from children **10**, **11** and **12**. They cut the gene into fragments using an enzyme. The scientists then used two DNA probes to identify the presence or absence of two of these fragments, called **F** and **G**. This allowed them to find the number of copies of each fragment in the DNA of a single cell from each child.

The table shows their results.

|  |  |  |
| --- | --- | --- |
| **Child** | **Number of copies of gene fragment per cell** | |
| **F** | **G** |
| **10** (unaffected girl) | 2 | 1 |
| **11** (unaffected girl) | 2 | 2 |
| **12** (boy with DMD) | 1 | 0 |

(i)      The number of copies of gene fragments **F** and **G** shows that person **12** has DMD.  
Explain how.

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**(1)**

(ii)     The number of copies of gene fragments **F** and **G** shows that person **12** is male.  
Explain how.

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**(2)**

(iii)     The genetic counsellor examined the scientists' results. He concluded that person **10** is a carrier of DMD but her sister, **11**, is not.

Describe and explain the evidence for this in the table.

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(*Extra space*) ......................................................................................

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**(3)**

(e)     Person **12** took part in a trial of a new technique to help people with DMD.

Doctors took muscle cells from person **12**’s father and grew them in tissue culture.

They suspended samples of the cultured cells in salt solution and injected them into a muscle in person **12**’s left leg. They injected an equal volume of salt solution into the corresponding muscle in his right leg. Person **12** was given drugs to suppress his immune system throughout the trial.

Four weeks later, the doctors removed a muscle sample from near the injection site in each leg. They treated these samples with fluorescent antibodies. These antibodies were specific for the polypeptide coded for by gene fragment **G** of the dystrophin gene.

The results are shown in the table.

|  |  |
| --- | --- |
| **Location and treatment** | **Percentage of muscle fibres labelled with antibody** |
| Left leg - injected with cultured cells suspended in salt solution | 6.8 |
| Right leg - injected with salt solution | 0.0 |

(i)      Why was it necessary to treat person **12** with drugs to suppress his immune system?

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**(1)**

(ii)     Explain why salt solution was injected into one leg and cultured cells suspended in salt solution into the other.

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**(1)**

(iii)     This technique is at an early stage in its development. The doctors suggested that further investigations need to be carried out to assess its usefulness for treating people with DMD.

Explain why they made this suggestion.

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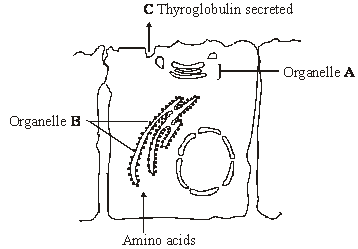
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**(4)**

**(Total 25 marks)**

**Q7.**          The thyroid gland is an organ in the neck. The diagram shows the process in which epithelial cells from the thyroid gland make and secrete a protein called thyroglobulin.



(a)     Name

(i)      organelle **A**;

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**(1)**

(ii)     the process by which thyroglobulin is secreted from the cell at **C**.

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**(1)**

(b)     (i)      Describe the part played by the organelles labelled **B**.

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**(1)**

(ii)     Organelle **B** is very small. It cannot be seen when thyroid cells are examined with an optical microscope but it can be seen with an electron microscope. Explain why this organelle can be seen with an electron microscope.

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**(2)**

**(Total 5 marks)**

**Q8.**          (a)     Small samples of plant tissue were placed in a cold, isotonic solution and then treated to break open the cells to release the organelles. The different organelles were then separated. Describe a technique that could be used to

(i)      break open the cells;

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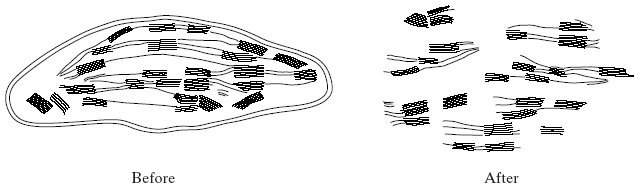
(ii)     separate the organelles.

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**(2)**

(b)     One group of organelles was placed in a hypotonic solution. The diagram shows one of these organelles seen under an electron microscope before and after it was placed in the hypotonic solution.



Name the organelle.

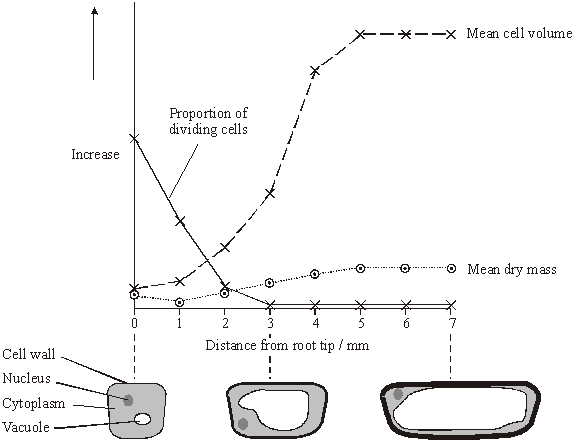
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**(1)**

**(Total 3 marks)**

**Q9.**          **S**       A large number of roots from many genetically identical bean plants were cut into short pieces. The pieces were sorted into groups, depending upon their distance from the root tip. Some pieces from each group were used to find the mean dry mass of their cells. Thin sections cut from other pieces were examined with a light microscope to find the proportion of dividing cells and the mean volume of the cells.

The graph shows the results. The diagrams below the graph show the appearance of cells in light microscope sections at different distances from the root tip.



(a)     Suggest **two** variables, other than genotype, which need to be controlled to ensure similar root growth in different plants. In each case give the reason for your answer.

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2 ...................................................................................................................

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**(2)**

(b)     Suggest how the proportion of dividing cells in a thin section could be determined.

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**(2)**

(c)     Explain the change in the proportion of dividing cells with increasing distance from the root tip.

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**(2)**

(d)     Using the graph and diagrams, suggest how a root tip gets longer.

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**(3)**

**(Total 9 marks)**

**Q10.**          The diagram shows how some organelles may be distinguished from each other.



Organelle found in prokaryotic           Organelle found only in

and eukaryotic cells                         eukaryotic cells

Organelle **A**

****

Organelle found in                    Organelle found in

animal cells and in                 plant cells. Contains

 plant cells. Does not                  inner membranes

  contain membranes                 arranged in stacks.

 arranged in stacks.                      Organelle **B**

****

Larger organelle surrounded             Smaller organelle surrounded

 by an envelope through which        by an outer membrane. Has an inner

 there are pores. usually one           membrane, folded to form cristae.

per cell.                                          Many in the cell.

Organelle **C** Organelle **D**

(a)     (i)      Name organelle **B**.

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**(1)**

(ii)     Describe the function of organelle **B**.

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.............................................................................................................

**(2)**

(b)     Which of organelles **A**, **B**, **C** or **D**

(i)      is a ribosome;

.............................................................................................................

**(1)**

(ii)     contains most of the DNA found in a plant cell?

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**(1)**

(c)     Some liver tissue was ground, filtered and centrifuged to make a suspension of organelle **D**.

(i)      Explain why the solution in which the liver tissue was ground should be ice-cold.

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**(1)**

(ii)     The ground liver was centrifuged at low speed. The pellet that formed at the bottom of the centrifuge tube was thrown away and the supernatant centrifuged again at higher speed. Explain why it was necessary to first centrifuge the ground liver at low speed in order to obtain a suspension of organelle **D**.

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**(2)**

**(Total 8 marks)**

**Q11.**          Read the following passage.

In a human, there are over 200 different types of cell clearly distinguishable from each other.  
What is more, many of these types include a number of different varieties. White blood cells,  
for example, include lymphocytes and granulocytes.

Although different animal cells have many features in common, each type has adaptations.

5       associated with its function in the organism. As an example, most cells contain the same  
organelles, but the number may differ from one type of cell to another. Muscle cells contain  
many mitochondria, while enzyme-secreting cells from salivary glands have particularly large  
amounts of rough endoplasmic reticulum.

The number of a particular kind of organelle may change during the life of the cell. An

10      example of this change is provided by cells in the tail of a tadpole. As a tadpole matures into  
a frog, its tail is gradually absorbed until it disappears completely. Absorption is associated  
with an increase in the number of lysosomes in the cells of the tail.

Use information from the passage and your own knowledge to answer the following questions.

(a)     Explain the link between.

(i)      mitochondria and muscle cells (lines 6 - 7);

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**(3)**

(ii)     rough endoplasmic reticulum and enzyme-secreting cells from salivary glands   
(lines 7 - 8).

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**(2)**

(b)     Use information in the passage to explain how a tadpole’s tail is absorbed as a tadpole changes into a frog.

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**(2)**

(c)     Starting with some lettuce leaves, describe how you would obtain a sample of undamaged chloroplasts. Use your knowledge of cell fractionation and ultracentrifugation to answer this question.

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**(6)**

**(Total 13 marks)**

**Q12.**          The flow chart outlines an investigation to determine from where the calcium ions involved in muscle contraction are released.

Calcium ion transport proteins were  
isolated from human tissue.

**↓**

These proteins were injected into a rabbit.

**↓**

The rabbit formed antibodies to the  
proteins. These antibodies were collected  
and labelled with gold particles.

**↓**

Muscle tissue was treated with the  
labelled antibodies and examined with an  
electron microscope. High concentrations  
of gold particles were observed attached  
to the sarcoplasmic reticulum.

**S**       (a)     Labelled antibodies and an electron microscope can be used to produce images locating proteins on the surface of organelles, but cannot be used to observe cross bridge cycling in muscle cells. Explain why.

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**(5)**

(b)     Describe the role of calcium ions and ATP in muscle contraction.

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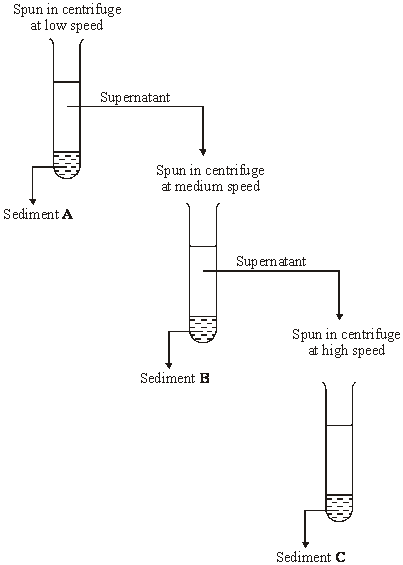
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**(5)**

**(Total 10 marks)**

**Q13.**          Liver was ground to produce a homogenate. The diagram shows how fractions containing different cell organelles were produced from the filtered homogenate.



(a)     Explain why the homogenate was filtered before spinning at low speed in the centrifuge.

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**(2)**

(b)     The main organelles present in sediment **B** were mitochondria. Suggest the main organelles present in

(i)      sediment **A**;

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**(1)**

(ii)     sediment **C**.

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**(1)**

(c)     What property of cell organelles allows them to be separated in this way?

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**(1)**

(d)     Explain why the organelles in sediment **C** could be seen with a transmission electron microscope but not with an optical microscope.

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**(2)**

**(Total 7 marks)**

**Q14.**          Read the following passage.

During the course of a day, we come into contact with many poisonous substances. These include industrial and household chemicals. The skin acts as a barrier and prevents many of these substances entering and harming the body.

The skin is one of the largest organs in the body. It is composed of several layers of

5        tissue. The outer layer consists of dead cells packed with keratins. Keratins are a group of proteins that differ from each other in their primary structure. Each keratin molecule consists of several polypeptide chains, each individual chain wound into a spiral or helix. The polypeptide chains include many sulphur-containing amino acids and these help to give the keratin molecules their characteristic strength.

Use information from the passage and your own knowledge to answer the questions.

(a)     What is the evidence from the passage that keratin molecules have a quaternary structure?

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**(1)**

(b)     Explain how sulphur-containing amino acids help to give keratin molecules their characteristic strength (lines 8–9).

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**(2)**

(c)     Explain why differences in primary structure result in keratins with different properties   
(line 6).

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**(2)**

(d)     The skin prevents poisonous substances entering and harming the body (line 3). Explain why these substances are unable to pass through the outer layer of skin cells by active transport.

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**(3)**

(e)     Skin cells may be studied with a transmission electron microscope or an optical microscope. Explain the advantages and limitations of using a transmission electron microscope to study cells.

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**(6)**

**(Total 14 marks)**

**Q15.**          A student found the number of stomata per cm2 on the lower surface of a daffodil leaf.  
He removed a small, thin piece of lower epidermis and mounted it on a microscope slide.

He examined the slide using an optical microscope.

(a)     Explain why it was important that the piece of the epidermis that the student removed was thin.

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**(2)**

(b)     Suggest how the student could have used his slide to find the number of stomata per cm2.

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**(3)**

(c)     The stomata on the leaves of pine trees are found in pits below the leaf surface. Explain how this helps to reduce water loss.

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**(2)**

**(Total 7 marks)**

**Q16.**          The flowchart shows how chloroplasts may be obtained from leaves.

|  |
| --- |
| Leaves homogenised by grinding in cold buffer solution |

**↓**

|  |
| --- |
| Homogenised leaves filtered. Filtrate centrifuged at low speed |

**↓                               ↓**

|  |  |  |
| --- | --- | --- |
| Pellet **A** |  | Supernatant centrifuged at high speed |

**↓              ↓**

|  |  |  |
| --- | --- | --- |
| Pellet **B** containing chloroplast |  | Supernatant C |

(a)     In the first step in this procedure, the leaves were homogenised by grinding in cold buffer solution. Explain why

(i)      the leaves were homogenised,

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**(1)**

(ii)     a buffer solution was used.

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**(2)**

(b)     The table shows some of the organelles present in the leaf cells.

|  |  |  |  |
| --- | --- | --- | --- |
| Organelle | **X** | **Y** | **Z** |
| Fraction containing organelle |  |  |  |

(i)      Complete the table to show in which of pellet **A**, pellet **B** or supernatant **C** you would expect to find each of these organelles.

**(2)**

(ii)     Organelle **X** is found in large numbers in cells which take up substances by active transport. Explain why.

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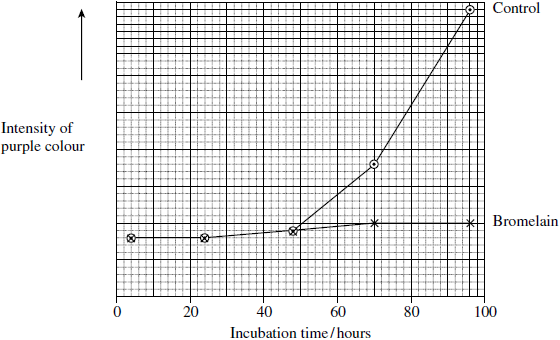
**(2)**

**(Total 7 marks)**

**Q17.**Scientists investigated the effect of bromelain on cancer cells. They took cells from skin cancers in mice and added them to a liquid growth medium in two dishes.

Four hours later they added a solution of bromelain to one of the dishes. They left the other dish as a control. They also added a substance to both dishes that is turned purple by respiring cells.

Both dishes were placed in an incubator. The scientists measured the intensity of the purple colour at intervals over a period of 100 hours.



(a)     The scientists put the same number of skin tumour cells in each dish at the start of this investigation. Explain why it was important to put the same number of cells in each dish.

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**(1)**

(b)     The scientists concluded that bromelain did not kill cancer cells but stopped them dividing. Does the graph support this conclusion? Explain your answer.

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**(2)**

(c)     An article in a newspaper claimed that these data show that bromelain can be used to treat cancer.

Give **three** reasons why we should be careful about accepting this claim.

1 .....................................................................................................................

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2 .....................................................................................................................

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3 .....................................................................................................................

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**(3)**

(d)     The rate of cell division is important in investigations into cancer. Suggest why.

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**(2)**

(e)     Scientists have investigated the effects of bromelain on cancer growth in humans. Suggest why they gave bromelain in addition to, rather than instead of, the usual treatment.

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**(2)**

**(Total 10 marks)**

**Q18.**          Scientists use optical microscopes and transmission electron microscopes (TEMs) to investigate cell structure. Explain the advantages and the limitations of using a TEM to investigate cell structure.

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**(Total 5 marks)**

**Q19.**          (a)     What is a tissue?

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**(1)**

(b)     A student cut a thin section of tissue from a potato and examined it with an optical microscope.

(i)      Starch was present in the cells of this tissue. Describe how the student could find out where in the cells the starch was present.

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**(2)**

(ii)     The student cut a thin section of the tissue. Explain why it was important that the section was thin.

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**(2)**

(c)     The cell walls of potato cells contain cellulose. Cellulose and starch are both carbohydrates. Describe **two** ways in which molecules of cellulose are similar to molecules of starch.

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**(2)**

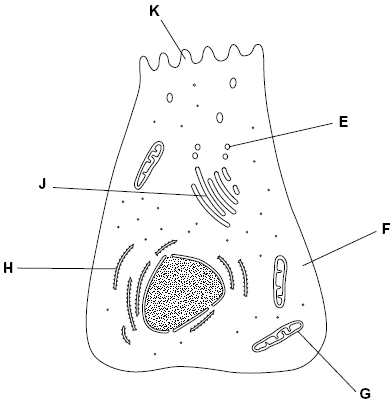
**(Total 7 marks)**

**Q20.**          (a)     Name the type of bond that joins amino acids together in a polypeptide.

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**(1)**

          The diagram shows a cell from the pancreas.



(b)     The cytoplasm at **F** contains amino acids. These amino acids are used to make proteins which are secreted from the cell.

Place the appropriate letters in the correct order to show the passage of an amino acid from the cytoplasm at **F** until it is secreted from the cell as a protein at **K**.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **F** |  |  |  | **K** |

**(2)**

(c)     There are lots of organelle **G** in this cell. Explain why.

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**(2)**

(d)     A group of scientists homogenised pancreatic tissue before carrying out cell fractionation to isolate organelle **G**.

Explain why the scientists

(i)      homogenised the tissue

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**(1)**

(ii)     filtered the resulting suspension

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**(1)**

(iii)     kept the suspension ice cold during the process

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**(1)**

(iv)    used isotonic solution during the process.

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**(2)**

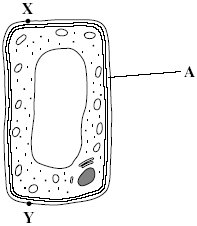
**(Total 10 marks)**

**Q21.**          (a)     Name the process in which cells become adapted for different functions.

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**(1)**

(b)     Palisade cells are found in leaves. The diagram shows a palisade cell.



(i)      Name structure **A**.

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**(1)**

(ii)     The real length of this cell between **X** and **Y** is 20 micrometres (µm). By how many times has it been magnified? Show your working.

Answer ............................................

**(2)**

(iii)     Explain **one** way in which this cell is adapted for photosynthesis.

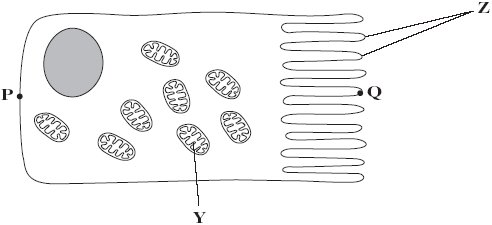
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**(1)**

**(Total 5 marks)**

**Q22.**          The diagram shows an epithelial cell from the small intestine.



(a)     (i)      Name organelle **Y**.

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**(1)**

(ii)     There are large numbers of organelle **Y** in this cell. Explain how these organelles help the cell to absorb the products of digestion.

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**(2)**

(b)     This diagram shows the cell magnified 1000 times. Calculate the actual length of the cell between points **P** and **Q**. Give your answer in µm. Show your working.

Answer ...................................... µm

**(2)**

(c)     Coeliac disease is a disease of the human digestive system. In coeliac disease, the structures labelled **Z** are damaged.

Although people with coeliac disease can digest proteins they have low concentrations of amino acids in their blood.

Explain why they have low concentrations of amino acids in their blood.

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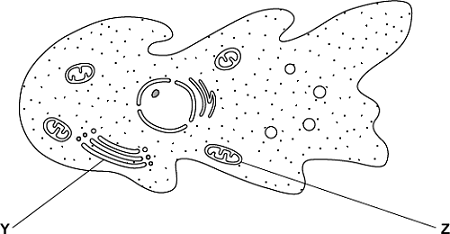
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**(2)**

**(Total 7 marks)**

**Q23.**          An amoeba is a single-celled, eukaryotic organism. Scientists used a transmission electron microscope to study an amoeba. The diagram shows its structure.



(a)     (i)      Name organelle **Y**.

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**(1)**

(ii)     Name **two** other structures in the diagram which show that the amoeba is a eukaryotic cell.

1 ............................................................................................................

2 ............................................................................................................

**(2)**

(b)     What is the function of organelle **Z**?

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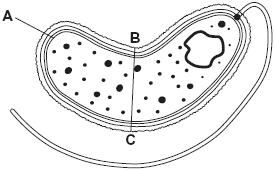
**(1)**

(c)     The scientists used a transmission electron microscope to study the structure of the amoeba. Explain why.

**(2)**

**(Total 6 marks)**

**Q24.**          The diagram shows a cholera bacterium. It has been magnified 50 000 times.



(a)     Name **A**.

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**(1)**

(b)     Name **two** structures present in an epithelial cell from the small intestine that are **not** present in a cholera bacterium.

1 ...................................................................................................................

2 ...................................................................................................................

**(2)**

(c)     Cholera bacteria can be viewed using a transmission electron microscope (TEM) or a scanning electron microscope (SEM).

(i)      Give **one** advantage of using a TEM rather than a SEM.

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**(1)**

(ii)     Give **one** advantage of using a SEM rather than a TEM.

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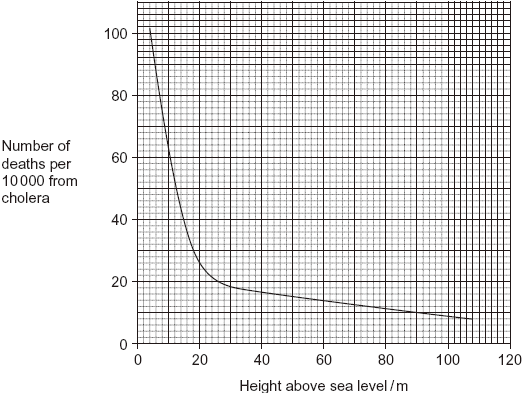
**(1)**

(d)     Calculate the actual width of the cholera bacterium between points **B** and **C**.  
Give your answer in micrometres and show your working.

.................................. µm

**(2)**

(e)     An outbreak of cholera occurred in London in 1849. The graph shows the relationship between the number of deaths from cholera and the height at which people lived above sea level.



Describe the relationship between the number of deaths from cholera and the height at which people lived above sea level.

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**(2)**

**(Total 9 marks)**

**Q25.**The figure below shows a test that has been developed to find out if a person has antibodies to the human immunodeficiency virus (HIV) antigen.

|  |  |  |
| --- | --- | --- |
|  | **Step 1** | HIV antigens are attached to a test well in a dish. |
|  |  |  |
|  | **Step 2** | A sample of blood plasma is added to the well. If HIV antibodies are present, they bind to the HIV antigen. |
|  |  |  |
|  | **Step 3** | The well is washed. A second antibody with an enzyme attached is then added. This binds specifically to the HIV antibody. |
|  |  |  |
|  | **Step 4** | The well is washed again. A yellow solution is added, which changes to blue if the enzyme is present. A blue colour shows that the person has HIV antibodies. |

(a)     This test only detects the presence of HIV antibodies. Give **two** reasons why it cannot be used to find out if a person has AIDS.

1 .....................................................................................................................

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2 .....................................................................................................................

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**(2)**

(b)     The solution will remain yellow if a person is **not** infected with HIV. Explain why.

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**(2)**

(c)     A mother who was infected with HIV gave birth to a baby. The baby tested positive using this test. This does not prove the baby is infected with HIV.  
Explain why.

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**(2)**

(d)     A control well is set up every time this test is used. This is treated in exactly the same way as the test wells, except that blood plasma is replaced by a salt solution.

Use information from the figure above to suggest **two** purposes of the control well.

1 .....................................................................................................................

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2 .....................................................................................................................

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**(2)**

**(Total 8 marks)**

**Q26.**(a)    The table shows some statements about three carbohydrates. Complete the table with a tick in each box if the statement is true.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Statement** | **Starch** | **Cellulose** | **Glycogen** |
|  | Found in plant cells |  |  |  |
|  | Contains glycosidic bonds |  |  |  |
|  | Contains β-glucose |  |  |  |

**(3)**

(b)     Name the type of reaction that would break down these carbohydrates into their monomers.

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**(1)**

(c)     Give **one** feature of starch and explain how this feature enables it to act as a storage substance.

Feature...........................................................................................................

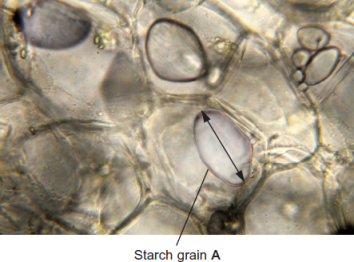
Explanation.....................................................................................................

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**(2)**

(d)     The picture shows starch grains as seen with an optical microscope. The actual length of starch grain **A** is 48 μm. Use this information and the arrow line to calculate the magnification of the picture. Show your working.

  
                                                                               © iStock/Thinkstock

Magnification ...................................... times

**(2)**

**(Total 8 marks)**

**Q27.**(a)     Describe how you could make a temporary mount of a piece of plant tissue to observe the position of starch grains in the cells when using an optical (light) microscope.

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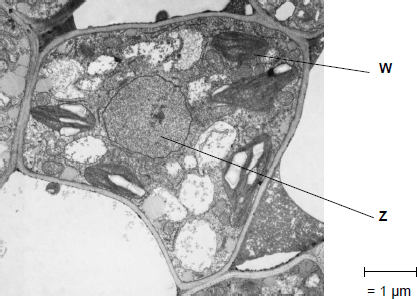
**(Extra space)** ................................................................................................

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**(4)**

The figure below shows a microscopic image of a plant cell.



© Science Photo Library

(b)     Give the name and function of the structures labelled **W** and **Z**.

Name of **W** .......................................................................................................

Function of **W** ...................................................................................................

Name of **Z** ........................................................................................................

Function of **Z** ....................................................................................................

**(2)**

(c)     A transmission electron microscope was used to produce the image in the figure above.   
Explain why.

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**(2)**

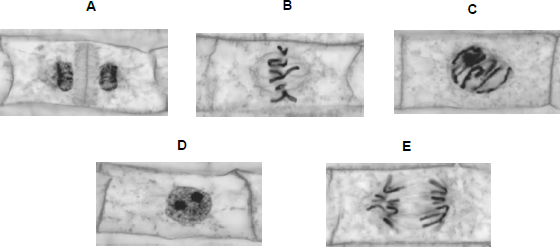
(d)     Calculate the magnification of the image shown in the figure in part (a).

Answer = ...................................

**(1)**

**(Total 9 marks)**

**Q28.**The figure below shows some cells from an onion root tip at different stages of the cell cycle.



© Ed Reschke/Oxford Scientific/Getty Images

(a)     Place stages **A** to **E** in the correct order. Start with stage **D**.

**D**.............................................................................................................

**(1)**

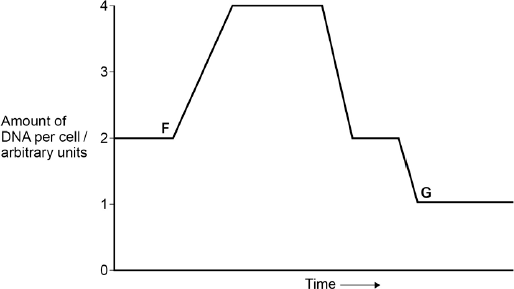
To obtain these images, the onion root tip was cut off, stained and put on a microscope slide. A cover slip was placed on top. The root tip was then firmly squashed and viewed under an optical microscope.

(b)     Complete the table below to give **one** reason why each of these steps was necessary.

|  |  |  |
| --- | --- | --- |
|  | **Step** | **Reason** |
|  | Taking cells from the root tip |  |
|  | Firmly squashing the root tip |  |

**(2)**

The figure below shows how the amount of DNA per cell changed during interphase and meiosis in an animal.



(c)     Explain how the behaviour of chromosomes causes these changes in the amount of DNA per cell between **F** and **G**.

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**(Extra space)** ................................................................................................

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**(3)**

(d)     What would happen to the amount of DNA per cell at fertilisation of cell **G?**

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**(1)**

**(Total 7 marks)**

**Q29.**A student investigated mitosis in the tissue from an onion root tip.

(a)     The student prepared a temporary mount of the onion tissue on a glass slide. She covered the tissue with a cover slip. She was then given the following instruction.

“Push down hard on the cover slip, but do not push the cover slip sideways.”

Explain why she was given this instruction.

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**(2)**

The image below shows one cell the student saw in the onion tissue.



© Ed Reschke/Oxford Scientific/Getty Images

(b)     The student concluded that the cell in the image above was in the anaphase stage of mitosis.  
Was she correct? Give **two** reasons for your answer.

1 .....................................................................................................................

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2 .....................................................................................................................

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**(2)**

(c)     The student counted the number of cells she observed in each stage of mitosis.  
Of the 200 cells she counted, only six were in anaphase.

One cell cycle of onion root tissue takes 16 hours. Calculate how many minutes these cells spend in anaphase.

Show your working.

Answer = ................................... minutes

**(2)**

**(Total 6 marks)**

**Q30.**(a)     Describe and explain how cell fractionation and ultracentrifugation can be used to isolate mitochondria from a suspension of animal cells.

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**(5)**

(b)     Describe the principles and the limitations of using a transmission electron microscope to investigate cell structure.

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**(5)**

**(Total 10 marks)**

**Q31.**(a)     The events that take place during interphase and mitosis lead to the production of two genetically identical cells. Explain how.

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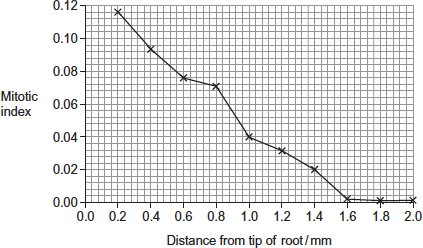
**(4)**

(b)     A student cut thin sections of tissue at different distances from the tip of a root. She stained the sections and viewed them with an optical microscope.

For each section, the student counted the number of cells in mitosis and the total number of cells in each field of view. She then calculated a **mitotic index** for each section using the equation:

mitotic index = 

The student’s results arer shown in the graph.



(i)      The student cut thin sections of tissue to view with an optical microscope.   
Explain why it was important that the sections were thin.

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**(2)**

(ii)     What does the graph show about the growth of roots?  
Use the data to explain your answer.

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**(2)**

**(Total 8 marks)**

**Q32.**(a)     Describe how you could use cell fractionation to isolate chloroplasts from leaf tissue.

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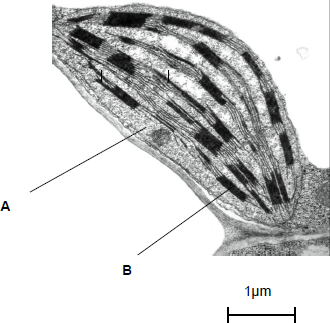
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**(Extra space)** .................................................................................................

........................................................................................................................

**(3)**

The figure below shows a photograph of a chloroplast taken with an electron microscope.



© Science Photo Library

(b)     Name the parts of the chloroplast labelled **A** and **B**.

Name of **A** .....................................................................................................

Name of **B** .....................................................................................................

**(2)**

(c)     Calculate the length of the chloroplast shown in the figure above.

Answer ................................................

**(1)**

(d)     Name **two** structures in a eukaryotic cell that **cannot** be identified using an optical microscope.

1 .....................................................................................................................

2 .....................................................................................................................

**(1)**

**(Total 7 marks)**

**Q33.**Researchers investigated whether the blood supply to slow and fast muscle fibres in a muscle changes with age. They used diaphragms taken from hamsters (*Mesocricetus auratus*). The diaphragm is in constant use for breathing. They took diaphragms from groups of young, adult and old hamsters.

They removed the diaphragm from each animal and took a sample of muscle tissue.They examined it under an optical (light) microscope. For each sample they selected several fields of view at random. In each field of view, they then counted the number of capillaries associated with each type of muscle fibre.

This allowed the researchers to calculate the mean number of capillaries for each type of muscle fibre, for each age group.

The table below shows the researchers’ results which include standard deviation (SD).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Hamster age group** | **Number of hamsters in group** | **Mean number of capillaries associated with each type of muscle fibre** | |
|  | **Slow fibres (± SD)** | **Fast fibres (± SD)** |
|  | **Young** | 9 | 3.4 (±0.8) | 4.0 (±0.8) |
|  | **Adult** | 10 | 4.7 (±0.2) | 6.3 (±0.4) |
|  | **Old** | 8 | 4.6 (±0.9) | 6.8 (±0.6) |

(a)     Give **four** precautions that the researchers took to make their calculations of mean number of capillaries per fibre reliable.

1 .....................................................................................................................

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2 .....................................................................................................................

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3 .....................................................................................................................

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4 .....................................................................................................................

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**(4)**

(b)     The researchers examined the muscle of an animal in the **old** age group. They found one field of view containing only slow muscle fibres. They counted 69 capillaries in this field of view.

(i)      Use a calculation to estimate how many slow muscle fibres were visible in this field of view. Show your working.

Number of slow muscle fibres = ..........................................................

**(2)**

(ii)     The actual number of slow muscle fibres in the field of view was **not** the same as the number you calculated in question (i).

Give **one** reason why.

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**(1)**

(c)     A student read the report of the researchers’ investigation. She thought that the investigation was unethical but that a conclusion could still be made.

(i)      Suggest why she thought the investigation was unethical.

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**(1)**

(ii)     She concluded that age had a significant effect on the mean number of capillaries per fibre.

Evaluate this conclusion.

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**(4)**

**(Total 12 marks)**

**Q34.**A stomach ulcer is caused by damage to the cells of the stomach lining. People with stomach ulcers often have the bacterium *Helicobacter pylori* in their stomachs.

A group of scientists was interested in trying to determine how infection by *H. pylori* results in the formation of stomach ulcers.

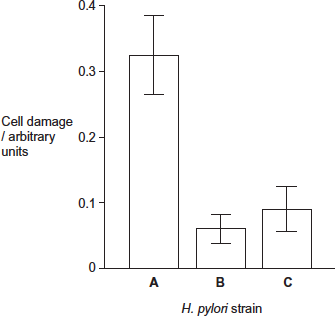
The scientists grew different strains of *H. pylori* in liquid culture.

The table below shows the substances released by each of these strains.

|  |  |  |  |
| --- | --- | --- | --- |
|  | ***H. pylori* strain** | **Substances released by the *H. pylori* cells** | |
|  | **Toxin** | **Enzyme that neutralises acid** |
|  | **A** |  |  |
|  | **B** |  |  |
|  | **C** |  |  |

The scientists centrifuged the cultures of each strain to obtain cell-free liquids. They added each liquid to a culture of human cells. They then recorded the amount of damage to the human cells.

Their results are shown below. The error bars show ± 1 standard deviation.



(a)     Describe and explain how centrifuging the culture allowed the scientists to obtain a cell-free liquid.

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**[Extra space]** ................................................................................................

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**(3)**

(b)     The scientists measured cell damage by measuring the activity of lysosomes.  
Give **one** function of lysosomes.

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**(1)**

(c)     *H. pylori* cells produce an enzyme that neutralises acid.  
Suggest **one** advantage to the *H. pylori* of producing this enzyme.

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**(2)**

(d)     What do these data suggest about the damage caused to human cells by the toxin and by the enzyme that neutralises acid?  
Explain your answer.

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**[Extra space]** ................................................................................................

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**(3)**

(e)     The scientists carried out a further investigation. They treated the liquid from **strain A** with a protein-digesting enzyme before adding it to a culture of human cells. No cell damage was recorded.  
Suggest why there was no damage to the cells.

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**[Extra space]** ................................................................................................

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**(3)**

**(Total 12 marks)**

**M1.**

(a)

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Protein synthesis | **L;** |
|  | Modifies protein | **H;** |
|  | Aerobic respiration | **N;** |

**3**

(b)     1800−2200;

*1.8, 2.0 or 2.2 in working or answer = 1 mark.*

*Ignore units in answer.*

1 mark for an incorrect answer in which student clearly divides measured length by actual length (of scale).

*Accept I / A or I / O for 1 mark but ignore triangle.*

*Accept approx 60mm divided by 30μm for 1 mark*

**2**

**[5]**

**M2.**          (a)     (i)      A mitochondrion and B nucleus;  
*(need both for one mark)*

**1**

(ii)     increased surface area;  
for respiration / enzymes;

**2**

(b)     *any suitable feature*e.g. plasmid / capsule / 70S ribosomes / smaller  
ribosomes / complex cell wall / mesosome / no nucleus;

**1**

(c)     use of differential centrifugation / or description;  
first / low-spin pellet discarded / spin at low speed to remove cell   
wall material / cell debris;  
supernatant re-spun at higher speed / until pellet with chloroplasts is found;  
method of identifying chloroplasts e.g. microscopy;

**3 max**

**[7]**

**M3.**          (i)      cold - no / reduced enzyme action / e.g. stops autolysis;

*(reject “cell activity reduced”)*

isotonic - stops osmotic effects / description of effect on  
cells or organelles;

buffer - prevents damage to enzymes / proteins;

**3**

(ii)      break open the cells / release the cell contents;

**1**

(iii)     supernatant / liquid above the pellet;  
spun at a high(er) speed;

*(mark as independent points)*

**2**

**[6]**

**M4.**         (a)     X = mitochondria;Y = (rough) endoplasmic reticulum;

*Accept ribosomes/ER/RER for Y*

*Reject smooth endoplasmic reticulum for Y*

**2**

(b)     (i)      (Sections cut at) different angles/in different planes;

*Ignore name given to organelle*

**1**

(ii)     Z modifies/packages/transports/secretes mucus/ Z adds sugars to proteins;X provides ATP/energy (for this);

*Accept makes in relation to Z but not X*

*Ignore names of organelles if function correct*

**2**

**[5]**

**M5.**          (a)     (i)      microvilli; (*reject brush border*)

**1**

(ii)     increased surface area (for diffusion);

**1**

(b)     (i)       principle of ;

*(15 –17 tolerance)*

160000;

*(correct answer award 2 marks)*

**2**

(ii)     electron microscope has a greater resolving  
power / objects closer   
together can be distinguished;   
electron (beams) have a shorter wavelength;

**2**

(c)     short diffusion pathway / short pathway to the centre / large SA:V ratio  
for faster, more diffusion;

**1**

**[7]**

**M6.**          (a)     Correct answer: 1.25;

*Ignore working*

***OR*** (if wrong answer)

 / = 1 mark

*125 but wrong order of magnitude = 1 mark*

**2**

(ii)     **C** has myosin / thick (and actin / thin) filaments;

***OR***

**A** has only actin / thin (/ no myosin / no thick) filaments;

**1 max**

(b)     When contracted:

Thick & thin filaments/myosin & actin overlap more;

Interaction between myosin heads & actin / cross-links form;

Movement of myosin head;

Thin filaments / actin moved along thick filaments / myosin;

Movement of thin filaments / actin pulls Z-lines closer together;

Displacement of tropomyosin to allow interaction;

Role of Ca2+;

Role of ATP;

*Allow ref. to ‘sliding filament mechanism’ /  
described if no other marks awarded*

**4 max**

(c)     (i)      8 has DMD but 3 and 4 do not / 12 has DMD but 6 and 7  
do not / neither parent has the condition but their child has;

*Allow parents 3 and 4 give 8, parents 6 and 7 give 12*

**1**

(ii)     4 ***AND*** 7;

**1**

(iii)     Parental genotypes:  6 = **XDY** AND 7 = **XDXd**

***AND***

Gametes correct for candidate’s P genotypes ‒ e.g.

**X**Dand **Y** + **X**Dand  **X**d**;**

Offspring genotypes correctly derived from gametes e.g.

**X**D**X**D+ **X**D**X**d+ **X**D**Y** + **X**d**Y**;

Male offspring with MD correctly identified: **X**d**Y**;

Probability = 0.25 / correct for candidates offsprings genotypes;

*Accept ¼ / 1 in 4 / 1:3 / 25%*

*NOT ‘3:1’ / ‘1:4’*

**4**

(d)     (i)      No gene fragment **G**;

**1**

(ii)     Only one copy of gene fragment **F**;

Male has only one X-chromosome / is XY  
(c.f. female has two / is XX);

**2**

(iii)     10 has only one copy of gene fragment **G**;

10 has only one normal X-chromosome / has one abnormal /  
has only one normal allele / has one Xd / is XDXd / is heterozygous;

11 has two normal X-chromosomes / has 2 normal alleles /  
is XDXD / has not got Xd / has 2 copies of (F and) G;

**3**

(e)     (i)      To prevent rejection / prevent antibody production vs. injected cells /  
injected cells have (foreign) antigen (on surface);

**1**

(ii)     Shows effect of cells / not just effect of injection / not just effect of  
salt solution;

**1**

(iii)     Only one person tested so far ‒ need more to see if similar results /  
need more to see if reliable;

Need to assess if new (dystrophin positive) muscle fibres are  
functional / if muscle becomes functional;

Can’t tell how widespread effect is in the muscle / sample taken  
near injection site;

Need to test for harmful side effects;

Need to test if successful for other mutations of dystrophin gene;

Need to assess permanence / longevity of result/insufficient time  
allowed in investigation;

(In this patient) only small response / %;

Further sensible suggestion;

**4 max**

**[25]**

**M7.**          (a)     (i)      Golgi;

**1**

(ii)     Exocytosis;

**1**

(b)     (i)      Joining together of amino acids / synthesis / production of  
thyroglobulin / makes protein;

*Do not credit synthesis of amino acids*

**1**

(ii)     Electron microscope has high / greater resolution;  
Because it uses electrons which have smaller wave(length);

**2**

**[5]**

**M8.**          (a)     (i)      homogeniser / blender / pestle and mortar / description  
e.g. grind with sand;

**1**

(ii)     centrifuge / description e.g. spin at high speeds;

**1**

(b)     (i)      chloroplast;

**1**

**[3]**

**M9.**          (a)     *two environmental or developmental variables and explanation;*

*examples*,

all plants of the same age, so same time for cell divisions / differentiation;  
all plants given the same watering, so same amount of water for  
cell expansion;  
*(reject reference to photosynthesis)*all plants given same light, so same rate of photosynthetic;  
same temperature, so enzymes / named metabolic process at  
optimum temperature;  
same named ion / minerals in soil(e.g. nitrate),  
so same available for a named function,  
(e.g. amino acid / protein synthesis);

**2 max**

(b)     count cells using microscope;  
count number of cells in cell division / where chromosomes visible;  
and then the total number of cells in field of view;

**2 max**

(c)     only cells at tip have ability to divide / cells further back don’t divide;  
cells further back differentiating / named example of  
*(accept reference to loss of totipotent cells)*differentiated tissue / too old / reduction in plant hormone;  
cell wall too thick / vacuole too large to allow division;

**2 max**

(d)     new cells added at tip;  
cells increase in volume / larger;  
increase in length (of cells);  
as vacuole s get larger;  
due to uptake of water (by osmosis);

**3 max**

**[9]**

**M10.**          (a)     (i)      Chloroplast;

**1**

(ii)     Photosynthesis;

Uses light (energy);

To produce carbohydrates / starch / glucose / sugars / ATP /   
reduced NADP;

*Note that candidates cannot be expected to have a detailed knowledge of photosynthesis.*

**max 2**

(b)     (i)      **A**;

**1**

(ii)     **C**;

**1**

(c)     (i)      Slows enzymes / prevents enzymes being denatured /

prevents / stops self-digestion;

*Ignore references to bacteria. Reject enzymes not working*

**1**

(ii)     To remove organelle C / nuclei;

Which are larger / more dense;

**2**

**[8]**

**M11.**          (a)     (i)      Mitochondria site of respiration;  
Production of ATP / release of energy;  
For contraction;

*Do not award credit for making or producing energy.*

**3**

(ii)     Enzymes are proteins;  
Proteins synthesised / made on ribosomes;

**2**

(b)     Lysosomes produce / contain enzymes;  
Which break down / hydrolyse proteins / substances / cells of tail;

**2**

(c)     1. Chop up (accept any reference to crude breaking up);  
2. Cold;  
3. Buffer solution;  
4. Isotonic / same water potential;  
5. Filter and centrifuge filtrate;  
6. Centrifuge supernatant;  
7. At higher speed;  
8. Chloroplasts in (second) pellet;

**max 6**

**[13]**

**M12.**          (a)     1. e.m. gives high resolution due to short wavelength of electrons;  
2. antibodies attach specifically to target proteins;  
3. gold particles are electron dense;  
4. electrons must pass through a vacuum so material must be dead / fixed for e.m.;  
5. cross-bridge cycling requires living cells / metabolism / named aspect-e.g. ATP synthesis;

**5**

(b)     1. Ca2+ removes blocking molecules / uncovers binding site on actin;  
2. correct references to Ca2+ binding to troponin / moving tropomyosin;  
3. allows myosin heads to attach to actin filaments;  
4. allows sliding of the actin and myosin filaments;  
5. binding of ATP causes myosin (head) to detach (from actin);  
6. (hydrolysis of) ATP releases energy;  
7. which changes the configuration / cocking of the myosin head;

**5 max**

**[10]**

**M13.**          (a)     removes debris / intact cells / sand;  
which would contaminate sediment A / interfere with the results;

**2**

(b)     (i)      nuclei;

**1**

(ii)     ribosomes / endoplasmic reticulum / membrane / Golgi;

**1**

(c)     density / size / mass / weight;

**1**

(d)     an electron microscope has a higher resolution;  
electrons with shorter wavelength;

**2**

**[7]**

**M14.**          (a)     Several / more than one polypeptide chain in molecule;

*Evidence must only relate to 4ºstructure*

**1**

(b)     Chemical bonds formed between sulphur-containing groups /   
R-groups / form stronger disulphide bonds;  
Bind chain(s) to each other;

**2**

(c)     Different number / sequences of amino acids;  
Bonds in different places which gives different shape;

**2**

(d)     Outer layer of skin cells are dead / do not respire  
Do not contain mitochondria / do not produce ATP / release energy;  
Cells do not have required proteins / carriers;

**3**

(e)     Advantages:

1       Small objects can be seen;

2       TEM has high resolution as wavelength of electrons shorter;

*Accept better*

Limitations:

3       Cannot look at living cells as cells must be in a vacuum;

4       must cut section / thin specimen;

5       Preparation may create artefact

6       Does not produce colour image;

**6**

**[14]**

**M15.**          (a)     Single layer of cells / few layers of cells;

So that light that can pass through / cells absorb light;

**2**

(b)     Method of determining area of field of view / area seen using microscope;

Count number of stomata in field of view;

Repeats and calculation of mean;

**3**

(c)     Water vapour accumulates / increased humidity / reduced air movement (around stomata);

Water potential / diffusion gradient reduced;

**2**

**[7]**

**M16.**          (a)     (i)      break open cells / release cell contents;

**1**

(ii)     keep pH the same / controls pH;  
prevent change to / denaturing of proteins / enzymes;

**2**

(b)     (i)

|  |  |  |
| --- | --- | --- |
| (supernatant) **C** | (pellet) **B**; | (pellet) **A**; |

**2**

(ii)     site of respiration which releases energy / ATP;  
required for movement against concentration gradient;  
*ignore first point for thermodynamically incorrect statements   
such as “making energy”.*

**2**

**[7]**

**M17.**(a)     To ensure the colour is the same at the start;

**1**

(b)     Yes – curve on graph with bromelain present remains approximately constant / rises very slightly;  
Would decrease if killing of cells occurred / would increase if cells still dividing;

**2**

(c)     Use of mouse cells (rather than human);  
(Carried out) *in vitro* / not in living organisms;  
Only tested on one type of cancer;  
Not possible to predict effect on humans (as no data collected);

**3 max**

(d)     The faster the rate of division the faster the cancer would grow;  
By measuring rate of cell division you could see how effective the treatment was;

**2**

(c)     Not ethical to replace conventional treatment;  
As life of patient is at risk (if bromelain not effective);

**2**

**[10]**

**M18.**          Advantages:

1       Small objects can be seen;

2       TEM has high resolution as wavelength of electrons shorter;

*Accept better*

Limitations:

3       Cannot look at living cells as cells must be in a vacuum / must cut section / thin specimen;

4       Preparation may create artefact

5       Does not produce colour image;

**[5]**

**M19.**          (a)     (Group of) similar / identical cells / cells with a common origin;

***Q*** *Ignore references to function*

**1**

(b)     (i)      Add iodine / stain specific for starch to the slide / cells / tissue / add iodine / stain specific for starch and examine under microscope;

Blue-black / blue / black / purple;

*Reject sample*

**2**

(ii)     Need a single layer of cells / only a few cells thick / not too many layers / detail obscured by cells underneath;

Light must be able to pass through;

**2**

(c)     Both are polymers / made of monomers;

Joined by condensation / molecules can be broken down by hydrolysis;

Both have 1-4 links;

Contain C(arbon), H(ydrogen) and O(xygen) / both made up of glucose;

Both insoluble;

Both contain glycosidic bonds;

*Accept other valid answers.  
Ignore ref to unbranched.*

**2 max**

**[7]**

**M20.**          (a)     Peptide;

***Q*** *Do not accept polypeptide  
Neutral: covalent*

**1**

(b)          (F) H J E (K);

*All three boxes correct = 2 marks  
Two boxes correct = 1 mark*

**2**

(c)     (Site of aerobic) respiration;

Release ATP / energy for active transport / transport against the concentration gradient / protein synthesis / exocytosis;

***Q*** *Reject: anaerobic respiration*

***Q*** *Reject: produces / makes energy*

*Accept: produces ATP for energy*

*Reject: produces ATP for respiration*

*Neutral: protein secretion*

**2**

(d)     (i)      Breaks open cells / disrupts cell membrane / releases cell contents / releases organelles / break up cells;

*Reject: breaks down cell wall*

*Neutral: separates the cells*

*Reject: breaks up cells so they can be separated*

*Reject: breaks up / separates organelles*

**1**

(ii)     Removes (cell) debris / complete cells / tissue;

*Neutral: to isolate organelle* ***G*** */ mitochondria*

*Neutral: removes unwanted substances / impurities*

*Reject: removes organelles / cell walls*

**1**

(iii)    Reduces / prevents enzyme activity;

*Reject: ref. to denaturation*

**1**

(iv)    Prevents osmosis / no (net) movement of water / water does not enter organelle / water does not leave organelle;

So organelle / named organelle is not damaged / does not burst / does not shrivel;

*Neutral: ref. to water potential*

***Q*** *Ref. to cells rather than organelles negates the second mark only*

*Reject: ref. to turgid / flaccid for second mark*

*Reject: organelle ‘explodes’ for second mark*

**2**

**[10]**

**M21.**          (a)     Differentiation / specialisation

**1**

(b)     (i)      (cellulose) Cell wall;

**1**

(ii)     Two marks for correct answer 2350–2500;;

*Accept measured and real lengths in different units for one mark.*

         One mark for a measured length divided by real length;

**2**

(iii)    Chloroplasts absorb light;

***Q*** *Do not accept chlorophyll as alternative to chloroplasts*

Or

         Large vacuole pushes chloroplasts to edge (of cell);

Or

         Thin / permeable (cell) wall to absorb carbon dioxide;

**1 max**

**[5]**

**M22.**          (a)     (i)      Mitochondrion;

*Neutral: cristae*

**1**

(ii)     (Site of aerobic) respiration / ATP production / energy release;

***Q*** *Reject: anaerobic respiration*

***Q*** *Reject: energy produced*

         Active transport / transport against the concentration gradient;

*Accept: energy produced in the form of ATP*

**2**

(b)     89 – 91 gains 2 marks;

*Correct answer gains 2 marks outright*

Principle of:

 gains 1 mark;

*89-91 (mm) / 1000 or 8.9-9.1 (cm) / 1000 gains 1 mark*

**2**

(c)     Suitable explanation given e.g.

*Accept: converse arguments*

          Reduced surface area; (So) less absorption;

*Neutral: structure* ***Z*** *incorrectly named*

(Membrane-bound) enzymes less effective;  
(So) proteins / polypeptides not digested;

*Reduced surface area for absorption gains 2 marks*

Cell membranes damaged;  
(So) Fewer / less effective carrier / channel proteins;

*Accept: references to diffusion and active transport for ‘absorption’*

Carrier / channel proteins damaged;  
(So) less absorption;

*Reject: active transport if linked to channel proteins*

**2**

**[7]**

**M23.**         (a)     (i)     Golgi (apparatus / body);

**1**

(ii)     1.      Nucleus;

*Accept: nucleolus / nuclear envelope / nuclear membranes*

2.      Mitochondrion;

*Accept cristae / mitochondrial membranes*

3.      Endoplasmic reticulum / ER;

*Ignore reference to rough / smooth*

4.      Lysosome;

*Reject lysozyme*

**2 max**

(b)     (Aerobic) respiration / ATP production / provide energy;

*Accept Krebs cycle / electron transport.*

*Ignore 'produces energy'*

*Reject anaerobic respiration*

*Ignore what energy is used for*

**1**

(c)     1.      High / better resolution;

2.      Shorter wavelength;

3.      To see internal structures / organelles / named organelles;

*Accept ultrastructure*

**2 max**

**[6]**

**M24.**          (a)     (Plasma / cell) membrane;

*Reject: nuclear membrane*

**1**

(b)     Nucleus / nuclear envelope / nuclear membrane / nucleolus;

*Accept: membrane-bound organelles only if an example has not been given*

Mitochondrion;

(Smooth / rough) ER;

Lysosome;

Microvillus / brush border;

*Neutral: villi*

Golgi;

Linear / non-circular DNA / chromosome;

*Neutral: DNA strands*

80S / denser / heavier / larger ribosomes;

*Neutral: ribosomes*

**2 max**

(c)     (i)      Higher resolution / higher (maximum) magnification / higher detail (of image);

***OR***

Allows internal details / structures within (cells) to be seen / cross section to be taken;

*Accept: ‘better’ instead of ‘higher’*

*Neutral: shorter wavelength*

*Reject: longer wavelength*

*Reject: can be used on living specimens*

***Q*** *Do not accept ‘clearer’ image*

**1**

(ii)     Thin sections do not need to be prepared / shows surface of specimen / can have 3-D images;

*Accept: can be used on thick(er) specimens*

*Reject: can be used on living specimens*

*Neutral: refs. to staining / preparation / artefacts / colour*

**1**

(d)     Two marks for correct answer of 0.42 – 0.46;;

One mark for incorrect answers in which candidate clearly divides measured width by magnification;

*Correct answer = 2 marks outright*

*Accept: 0.4 or 0.5 only if working is correct for 2 marks*

*Do not award a mark for 0.4 or 0.5 if there is no working out*

*Ignore rounding up*

**2**

(e)     As height increases, the number of deaths decrease / inversely proportional / negative correlation;

Correct reference to increase / decrease at 14-30m;

*Accept: converse statement*

*Must give a trend and not simply give individual points*

*Do not penalise for ‘more likely to get cholera’*

**2**

**[9]**

**M25.**(a)     (To diagnose AIDS, need to look for / at)

1.      (AIDS-related) symptoms;

2.      Number of helper T cells.

*Neutral: ‘only detects HIV antibodies’ as given in the question stem*

**2**

(b)     1.      HIV antibody is not present;

*Accept HIV antibodies will not bind (to antigen)*

2.      (So) second antibody / enzyme will not bind / is not present.

**2**

(c)     1.      Children receive (HIV) antibodies from their mothers / maternal antibodies;

2.      (So) solution will always turn blue / will always test positive (before 18 months).

*Allow 1 mark for the suggestion that the child does not produce antibodies yet so test may be negative*

**2**

(d)     (Shows that)

1.      Only the enzyme / nothing else is causing a colour change;

2.      Washing is effective / all unbound antibody is washed away.

**2**

**[8]**

**M26.**(a)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Statement | Starch | Cellulose | Glycogen |
|  | Found in  plant cells |  |  |  |
|  | Contains glycosidic bonds |  |  |  |
|  | Contains β-glucose |  |  |  |

*One mark for each correct row*

**3**

(b)     Hydrolysis;

*Accept: if phonetically correct*

*Do not accept: ‘hydration’*

**1**

(c)     1.      Coiled / helical / spiral;

*Feature = one mark*

*Explanation = one mark*

*Note: these are independent marking points*

*These must be related for both marks but can be in reverse order*

2.      (So) compact / tightly packed / can fit (lots) into a small space;

3.      Insoluble;

4.      (So) no osmotic effect / does not leave cell / does not affect water potential;

*Accept: prevents osmosis*

5.      Large molecule / long chain;

6.      (So) does not leave cell / contains large number of glucose units;

*4. and 6. Accept: can’ t cross membranes*

7.     Branched chains;

8.     (So) easy to remove glucose;

**2 max**

(d)     Two marks for correct answer of 479 - 521;

*Accept: measured and actual lengths in different but correct units for 1 mark*

One mark for incorrect answers in which candidate clearly divides measured length by actual length;

*The actual range is 23 - 25mm, If they just divide this by 48 they gain 1 mark*

*Just writing the formula is insufficient, numbers must be used*

**2**

**[8]**

**M27.**(a)     1.      Add drop of water to (glass) slide;

2.      Obtain thin section (of plant tissue) and place on slide / float on drop of water;

3.      Stain with / add iodine in potassium iodide.

*3.    Allow any appropriate method that avoids trapping air bubbles*

4.      Lower cover slip using mounted needle.

**4**

(b)     1.      **W** – chloroplast, photosynthesis;

2.      **Z** – nucleus, contains DNA / chromosomes / holds genetic information of cell.

**2**

(c)     1.      High resolution;

2.      Can see internal structure of organelles.

**2**

(d)     Length of bar in mm × 1000.

**1**

**[9]**

**M28.**(a)      (D)CBEA.

**1**

(b)

|  |  |  |
| --- | --- | --- |
|  | **Step** | **Reason** |
|  | (Taking cells from the root tip) | Region where mitosis / cell division occurs; |
|  | (Firmly squashing the root tip) | To allow light through /  make tissue layer thin; |

**2**

(c)     (Increase)

1.      Chromosomes / DNA replicates;  
(First decrease)

2.      Homologous chromosomes separate;  
(Second decrease)

3.      Sister chromatids separate.

**3**

(d)     1.      (DNA would) double / go to 2 (arbitrary units).

**1**

**[7]**

**M29.**(a)     1.      Push hard – spread / squash tissue;

2.      Not push sideways – avoid rolling cells together / breaking chromosomes.

*Neutral – to see cells clearly*

**2**

(b)     No (no mark)

Yes (no mark)

1.      Chromosomes / chromatids are (in two groups) at poles of spindle / at ends of spindle;

*Do not accept ‘ends of cell’*

2.      V-shape shows that (sister) chromatids have been pulled apart at their centromeres / that centromeres of (sister) chromatids have been pulled apart.

**2**

(c)     28.8 / 29.

*If incorrect, allow:*

* = 1 mark*

**2**

**[6]**

**M30.**(a)     Any **five** from:

1.      Cell homogenisation to break open cells;

*1. Accept suitable method of breaking open cells.*

2.      Filter to remove (large) debris / whole cells;

*2. Reject removes cell walls.*

3.      Use isotonic solution to prevent damage to mitochondria / organelles;

*3. Ignore to prevent damage to cells.*

4.      Keep cold to prevent / reduce damage by enzymes / use buffer to prevent protein / enzyme denaturation;

5.      Centrifuge (at lower speed / 1000 g) to separate nuclei / cell fragments / heavy organelles;

*5. Ignore incorrect numerical values.*

6.      Re-spin (supernatant / after nuclei / pellet removed) at higher speed to get mitochondria in pellet / at bottom.

*6. Must have location*

*Reject ref to plant cell organelles only once*

**5 max**

(b)     Principles:

1.      Electrons pass through / enter (thin) specimen;

2.      Denser parts absorb more electrons;

3.      (So) denser parts appear darker;

4.      Electrons have short wavelength so give high resolution;

*Principles:*

*Allow maximum of 3 marks*

Limitations:

5.      Cannot look at living material / Must be in a vacuum;

6.      Specimen must be (very) thin;

7.      Artefacts present;

8.      Complex staining method / complex / long preparation time;

9.      Image not in 3D / only 2D images produced.

*Limitations:*

*Context of limitation must be clear, not simply explaining how TEM works*

*E.g “allows you to see organelles as a thin section is used” is not a limitation*

*Allow maximum of 3 marks*

*Ignore ref to colour*

**5 max**

**[10]**

**M31.**(a)     1.      DNA replicated;

*Reject: DNA replication in the wrong stage*

2.      (Involving) specific / accurate / complementary base-pairing;

*Accept: semi conservative replication*

3.      (Ref to) two identical / sister chromatids;

4.      Each chromatid / moves / is separated to (opposite) poles / ends of cell.

*Reject: meiosis / homologous chromosomes / crossing over*

*Note: sister chromatids move to opposite poles / ends = 2 marks for mp 3 and mp 4*

*Reject: events in wrong phase / stage*

**4**

(b)     (i)      1.      To allow (more) light through;

*Accept: transparent*

2.      A single / few layer(s) of cells to be viewed.

*Accept: (thin) for better / easier stain penetration*

**2**

(ii)     1.      More / faster mitosis / division near tip / at 0.2 mm;

*Neutral: references to largest mitotic index*

2.      (Almost) no mitosis / division at / after 1.6 mm from tip;

*Accept: cell division for mitosis*

*Penalise once for references to meiosis*

3.      (So) roots grow by mitosis / adding new cells to the tip.

*Accept: growth occurs at / near / just behind the tip (of the root)*

*Accept: converse arguments*

**2 max**

**[8]**

**M32.**(a)     1.      How to break open cells and remove debris;

2.      Solution is cold / isotonic / buffered;

3.      Second pellet is chloroplast.

**3**

(b)     1.      **A** stroma;

2.      **B** granum.

*Accept thylakoid*

**2**

(c)      μm

**1**

(d)     **Two** of the following for **one** mark:

Mitochondrion / ribosome / endoplasmic reticulum / lysosome / cell-surface membrane.

**1 max**

**[7]**

**M33.**(a)     1.      Fields of view randomly chosen;

2.      Several fields of view;

3.      All same species (of animal / hamster);

*Reject general statements related to sample size. All mark points relate directly to information provided in Resource A.*

*Accept ‘all (Mesocricetus) auratus’.*

4.      Same muscle / organ used / only diaphragm used;

5.      Used at least 8 (animals) in each (age) group.

**4 max**

(b)     (i)      15

*Correct answer = 2 marks.*

*Allow 1 mark for showing*

*69 ÷ 4.6*

*OR*

*answer of 10 / 10.1 (correct calculation using fast in error.)*

**2**

(ii)     1.      (Calculation) used mean (number of capillaries);

2.      Variation in number of capillaries per fibre.

*Note: maximum of* ***1*** *mark for this question.*

*Ignore reference to an anomaly or calculation errors.*

**1 max**

(c)     (i)      (Removing diaphragm means) animals / hamsters are killed.

**1**

(ii)     1.      (Suggests) significant (difference) between young and adult;

*MP1, MP2, MP4 and MP5 can include use of figures but check figures are used correctly.*

2.      (Suggests) not significant (difference) between adult and old;

*Statements related to ‘results being significant / not significant’ do not meet the marking points. It is the difference that is significant or not. However, only penalise this error once.*

3.      For slow **and** fast fibres;

*This MP can be given in the context of either MP1 or MP2 but only allow once. As well as this context there must be a reference to ‘both’ types of fibre.*

4.      (Suggests) significant (difference) between young and old for fast (fibres)  
OR  
(Suggests) not significant (difference) between young and old for slow (fibres);

*All aspects of either approach required to gain credit.*

5.      (Suggests) significant (difference) where means ± SD do not overlap  
OR  
(Suggests) not significant (difference) where means ± SD overlap;

*All aspects of either approach required to gain credit.*

6.      Stats test is required (to establish whether significant or not).

**4 max**

**[12]**

**M34.**(a)     1.      Large / dense / heavy cells;

2.      Form pellet / move to bottom of tube (when centrifuged);

3.      Liquid / supernatant can be removed.

*Must refer to whole cells.*

**3**

(b)     Break down cells / cell parts / toxins.

*Idea of ‘break down / digestion’ needed, not just damage*

**1**

(c)     1.      To stop / reduce them being damaged / destroyed / killed;

*Reject (to stop) bacteria being denatured.*

2.      By stomach acid.

*Must be in context of stomach.*

**2**

(d)     1.      More cell damage when both present / A;

2.      Some cell damage when either there on their own / some cell damage in B and C;

*MP1 and MP2 − figures given from the graph are insufficient.*

3.      Standard deviation does not overlap for A with B and C so  
         difference is real;

*MP3 and MP4* ***both*** *aspects needed to gain mark.*

4.     Standard deviations do overlap between B and C so no real  
        difference.

*MP3 and MP4 accept reference to significance / chance for ‘real difference’*

**3 max**

(e)     1.      Enzyme (a protein) is broken down (so no enzyme activity);

*Accept hydrolyse / digested for ‘broken down’.*

2.      No toxin (as a result of protein-digesting enzyme activity);

*Must be in the correct context.*

3.      (So) toxin is protein.

*This must be stated, not inferred from use of ‘protein−digesting enzyme’.*

**3**

**[12]**

**E1.**(a)     It was pleasing to see that most students had a good understanding of the function of organelles with the majority scoring at least two marks. The most common error was in identifying the Golgi apparatus, organelle H.

(b)     Although most students knew the simple triangle for relating magnification to image and actual size, only about 40% knew how to apply it correctly to the scale line calculation. Many students found it difficult to work with the scale line, and one of the commonest mistakes was to use the figures to work out the actual size of the cell, rather than the magnification. Sometimes students confused two methods, using the cell proportions along with the scale line proportions. Other common errors occurred when converting units, with many answers being an order of magnitude or so out, in either direction.

**E2.**          The question was accessible to the majority of candidates and many obtained full marks.

          (a)     (i)      This was generally answered well, although some candidates thought that **B** was a nucleolus.

(ii)     Most candidates gained a mark for saying ‘increased surface area’ and many also knew the link to respiration.

(b)     This was answered well by the majority of candidates, although some misinterpretted the question and gave a feature of a eukaryotic cell instead. Some candidates gave flagellum, but did not qualify this with ‘bacterial’.

(c)     Generally, candidates achieved 3 marks in most cases. However, a significant number wasted time by describing how a homogenate is produced. Weak terminology let down other candidates.

**E3.**          Many candidates knew why the tissue was chopped in a cold tissue, although some gave general statements that it slowed cell activity, without qualification. Many candidates also knew that an isotonic solution was needed to reduce the osmotic effects, although this was sometimes worded in a rather vague way. Fewer candidates gained the mark for explaining the use of a buffer, with some answers just referring to ‘maintaining pH’, which was given in the question.

Many candidates correctly referred to centrifuging at a higher speed, but did not mention that it was the supernatant that was centrifuged.

**E4.**          (a)     There were many good responses here. Most candidates could identify these organelles, although a surprising number of candidates left the answer blank.

(b)     In (i), many candidates explained the differences in shape by suggesting that the drawing had been done badly, or that the person doing the drawing had not observed the cell section clearly enough. However, a significant minority correctly understood that the section could have cut the organelles in different planes. In (ii), most candidates who recognised the organelles could give an acceptable answer. A few failed to obtain marks due to careless expression; such as suggesting that **X** ‘produces energy’, or by a simplistic answer such as ‘they produce mucus’. A few thought that **Z** (the Golgi body) was involved in protein synthesis.

**E5.**          (a)     Only the weakest candidates failed to score here. Some candidates gave villi or failed to gain the mark by giving the examiner the choice of microvilli /villi.

(b)     Many candidates failed to measure the scale bar and most did not know that there are 1000µm in a mm. Answers were often out by a factor of 10. Most candidates gained the resolution mark but then failed to relate this to the shorter wavelength of the electrons’ beam. Some answers linked detail only to increased magnification.

(c)     This part was not well answered, only the better candidates recognising the link between width and short diffusion pathway. Many referred to SA:V ratio but then failed to relate this to diffusion. A common error was to assume the mitochondria would be able to move around the cell more easily, and weaker candidates often opted for the simple idea that more would fit into a cell.

**E6.**          (a)     Most candidates measured band X (the A-band in an electron micrograph of a myofibril) correctly. Many did not then understand that they had to divide this by the stated magnification. Among those who did, many had problems interconverting millimetres and micrometres and were often several orders of magnitude out. Only one quarter of candidates were entirely successful.

In part (ii), most candidates knew the correct distribution of actin and myosin filaments in the two distinct bands of the myofibril. One unusual, and erroneous, concept expressed by a number of candidates was that one part of the myofibril was contracted at the same time as the other part was relaxed.

(b)     Many candidates gave a full and clear account of the process of muscle contraction, including the roles of ATP, calcium ions, tropomyosin, the attachment of the myosin head to actin and its movement causing the actin filament to slide along the myosin. Weaker candidates just described how the appearance of the various bands changed when the myofibril contracted rather than offering the required explanation. Almost one-third of candidates scored full marks.

(c)     Using information from the pedigree diagram showing the inheritance of Duchenne muscular dystrophy (DMD) over three generations, almost two-thirds of candidates cited the production of a child with muscular dystrophy by unaffected parents as evidence for the condition being caused by a recessive allele. However, less than half the candidates were able to identify two carriers from the diagram.

In completion of the genetic diagram, common errors included switching the genders of the two parents, giving the male parent a genotype that would have resulted in him having muscular dystrophy, incomplete assignment of phenotypes to the offspring genotypes (both gender and having / not having DMD were important) and, having shown that 25% of the offspring would be expected to be male with DMD, to then halve this figure to 12.5 %. Additional, incorrect, answers on the probability line, e.g., ‘25% or 1 : 4’, failed to gain the mark. Despite this, almost one-third of candidates scored full marks in this section.

(d)     Just over half the candidates answered part (i) correctly, realising that the complete absence of one of the gene fragments indicated that the person would suffer from DMD. In part (ii), these candidates realised it was the single copy of the other gene fragment (compared with two copies in each of his sisters) that indicated the person concerned was male as he had just one X-chromosome while his sisters had two. Only about one-fifth of candidates were able to tell the complete story, although some two-thirds got half-way.

Part (iii) differentiated very well between candidates who gave varying degrees of appropriate detail in their answers. The most able noticed that one of the girls had two copies of one of the gene fragments while her sister, having but a single copy of this fragment, must have been the carrier as she would have had one normal X chromosome (hence being healthy herself) and one carrying the mutation responsible for DMD. Approximately one quarter scored full marks, although nearly two-thirds were able to make at least two of the three points required.

(e)     Far too many candidates failed to use appropriate terminology in part (i). There were no marks available for stating that the ‘immune system’ (given in the question) ‘fought against’ / ‘attacked’ the implanted cells. Terms such as *rejection*, *antibody* and *antigen* were required. Less than half the candidates used such terms.

Similarly, in part (ii), there was no mark available for merely stating that the injection with salt solution served as a ‘control’. The purpose of the control was required, e.g., so that the effect of the cells injected into the other leg became apparent, or to show it was not just the salt solution that had caused the effect in the other leg. Approximately half the candidates gave the appropriate detail.

In part (iii), there was plenty of scope for candidates to explain the limitations of the given investigation and to suggest appropriate further work that could be done. Candidates made general points about the limited sample size (i.e., just *one* individual), the short time period allowed to assess the effect of the treatment, or they made specific points relating to the given size of the response, the fact that success had so far been achieved only for this particular mutation, that only a measure of the *presence* of the appropriate type of muscle cells had been performed with no information about their ability to function, etc. The question differentiated very well amongst candidates who took varying amounts of care in selecting information, in assessing the reliability of the data and in applying their knowledge and understanding of how an investigation should be carried out in order to obtain reliable results and to draw valid conclusions. Although almost 90% of candidates were able to make at least one valid point, only 3% scored all 4 marks.

**E7.**          (a)     A well answered question with the majority of candidates gaining full credit. Diffusion and endocytosis occasionally appeared in the answers to part (ii).

(b)     In part (i), candidates who adopted the approach of identifying the organelle and then relating this to the context of the question generally described the role of the ribosomes in the synthesis of thyroglobulin. Others started from the end point of thyroglobulin secretion and met with rather less success by emphasising vesicle formation, and protein packaging and modification. Some candidates were clearly uncertain as to the meaning of the word synthesise and there were frequent references to amino acids being “synthesised” and RNA being “synthesised into” proteins. The answers to part (ii) revealed that many candidates understand the concept of resolution and could account for the higher resolving power of an electron microscope.

**E8.**          (a)     This was generally well answered. Most candidates understood the techniques and many gained both marks, although the spelling of ‘centrifugation’ was frequently poor. Incorrect answers included references to use of different solvents or enzymes to break open the cells.

(b)     Most candidates correctly identified the organelle as a chloroplast. Mitochondrion was the most frequent incorrect answer, with Golgi apparatus, endoplasmic reticulum or nucleus occasionally being given.

**E9.**          This proved to be the most difficult question for most candidates. It appeared that many were uncertain about how to find dry mass. Many also appeared to be unfamiliar with looking at thin sections under a microscope and interpreting what is seen.

(a)     The best answers seen related to light, temperature, or carbon dioxide concentration and rates of photosynthesis. Some good answers were also seen that related to nitrates in the soil and amino acid or protein synthesis. Some candidates identified variables that should be controlled but gave no reason for their answers, or inaccurate reasons. Many weaker candidates resorted to very general answers in terms of, for example, ‘The same light, so that the plants grow the same.’

(b)     The candidates who scored two marks were those who appreciated that the thin sections referred to in the question would be looked at with a microscope and that counts of cells would be made. Some who suggested using a microscope failed to gain one or both marks, because they wrote about observing cells dividing rather than counting them. Some candidates wrongly suggested using haemocytometers or dilution plating; apparently trying to use techniques from BYB7/A used to determine growth in populations of cells.

(c)     Many candidates were awarded one mark for demonstrating that they understood the decrease in the proportion of dividing cells further away from the root tip to mean that fewer cells were dividing. Very few candidates suggested a suitable explanation for this reduction. Correct suggestions included an increase in the number of differentiated cells (or a named example) and a decrease in hormones or 'chemicals' that promote cell division.

(d)     This was well answered by many candidates who used the graphs and diagrams. They obtained marks for ideas of new cells being added at the tip, cells getting longer, cell vacuoles increasing in size and the uptake of water by osmosis. Weak answers made no reference to the information provided.

**E10.**          (a)     Although most candidates were able to identify organelle **B** as a chloroplast, some were undoubtedly influenced by the reference to the inner membranes being arranged in stacks and identified it as Golgi. There were also occasional references to cell walls. Those who named the organelle correctly usually offered appropriate descriptions of photosynthesis, although there was evidence of some confusion with respiration.

(b)     It was likely that the considerable number of candidates who selected **D** for part (b)(i) were again unduly influenced by a single phrase in the description and selected this organelle because it was described as being smaller. However, part (b)(ii) was correctly answered by almost all.

(c)     It was apparent from part (c)(i) that although many candidates were familiar with the requirement for a cold, buffered, isotonic solution in preparing tissue for centrifugation, rather fewer understood the reasons for the procedure. Although there were many who wrote convincingly of minimising enzyme activity or preventing autolysis, there were numerous references to ice regulating pH or preventing osmosis. Even among those who realised that enzymes were involved, many failed to gain marks by ignoring the context of the question and describing the role of enzymes in “protecting’ cells from damage. Part (c)(ii) was generally answered well but many answers underlined the importance of reading the question carefully. This question related to liver. The initial centrifugation in this case removed the nuclei; it could not remove chloroplasts and cell walls.

**E11.**          (a)     Superficial answers along the lines that ‘muscles have many mitochondria because we use our muscles in everyday life’ failed to gain credit but, even where candidates had some understanding of the function of these organelles, errors crept into the accounts they gave. There were still many thermodynamically incorrect statements about ‘making’ energy and a significant number were reluctant to associate mitochondria with respiration, or having done so, expressed their ideas incorrectly in terms of the ATP produced by mitochondria being used for respiration or to ‘allow the muscle to respire’. Many candidates were clearly of the opinion that rough endoplasmic reticulum synthesises protein so did not refer to ribosomes in their answers to part (ii).  Others were somewhat equivocal about the status of enzymes and proteins.

(b)     There was considerable confusion between lymphocytes and phagocytes with many candidates describing reabsorption of the tail in terms of it being engulfed by lysosomes. Most, however, realised that lysosomes contained enzymes, although there were some who were of the opinion that they were enzymes. There was less clarity about the function of these enzymes. Their digestive role was seldom recognised and most responses concluded with a vague statement about ‘destroying’ the tail.

(c)     Responses to this part of the question were frequently marred by misuse of terminology. Homogenate and supernatant, fractionation and centrifugation were often confused. Where possible, examiners ignored such incorrect usage, but where this obscured the underlying meaning, marks were withheld. Most candidates clearly appreciated the significance of adding a cold, isotonic buffer although this was generally added at a rather late stage in the procedure. From this point on, many accounts became less convincing. Homogenisation as a process which breaks open cells was perhaps not understood, with many answers giving the impression that whole leaves, or small pieces of leaf were centrifuged; few referred to filtering before centrifugation, while others appeared to lose track of precisely what they were centrifuging, supernatant or pellet.

**E12.**          (a)     A full answer to this section required reference to several different aspects – the resolving power of the electron microscope, the need for tissue to be alive to demonstrate a physiological process but to be dead to be viewed in the electron microscope, and the specificity of antibodies (with gold particles attached) to label only certain structures. It was rare to find such an holistic view.

Some candidates appeared to have forgotten about the existence of the transmission electron microscope, explaining that only the outer surfaces of muscle fibres could be observed rather than any cross-bridge cycling that occurred within them. Others erroneously felt that, although the resolving power of the electron microscope was good, it was not good enough to observe crossbridges between muscle protein filaments.

(b)     The roles of calcium ions and of ATP in muscle contraction were generally well known by most candidates. Some over-emphasised the part played by calcium ions in transmission of the impulse to the muscle rather than in the contraction process itself. However, details of the removal of the blocking molecules from sites on the actin and the combination of the myosin head with these sites, followed by movement and release of the myosin head, were generally included.

A common omission was that ATP would need to be split into ADP and phosphate if its energy were to be made available.

**E13.**          (a)     Maximum credit was rarely awarded to answers. Although candidates appeared familiar with the need for initial filtration, few had a clear idea as to what was being removed, with many being of the opinion that it was either “broken organelles”, plasma membranes or individual molecules.

(b)     Most candidates answered correctly but some negated their answers by subsequently referring to chloroplasts and cell walls.

(c)     Apart from the few candidates who were of the opinion that centrifugation can only be used to separate membrane-bound organelles, answers were good.

(d)     Most candidates correctly involved the concept of resolution in their responses, but frequently linked this to the wavelength of the electron microscope rather than of the beam of electrons used.

**E14.**          (a)     Difficulties were experienced with this question where answers were frequently unselective, relating not only to quaternary structure but to aspects of secondary and tertiary structure as well. To gain credit here, candidates needed to confine their answers to the fact that keratin molecules consisted of several polypeptide chains.

(b)     Most candidates clearly appreciated that the bonds formed between sulphur- containing amino acids were strong and helped to bind the individual polypeptide chains. Less able candidates often confused these bonds with peptide bonds or did little more than paraphrase the wording of the question.

(c)     As was not infrequently the case with the answers to many of the questions in this paper, less able candidates gave the impression of relying on the recall of mark schemes from broadly similar past questions. In this case they either simply described the primary structure of a protein, which gained little credit, or described how the primary structure of a protein affected its tertiary structure which was potentially, at least, a better option. Those who read the question carefully were usually able to comment on differences in the amino acid sequence leading to differences in bonding and in molecular shape. There was some confusion, presumably among candidates who had also completed Module 2 or 3, between amino acids, proteins and bases.

(d)     As in part (c), the principal requirement here was to answer the question as written. Unfortunately, the response offered by many was no more than a description of active transport. In this question candidates were expected to use this knowledge along with information available in the passage to explain why substances were unable to pass through the outer layer of skin cells. Those who approached the question in the right way generally pointed out that the cells were dead and progressed to make an appropriate comment about respiration and the release of energy or generation of ATP. A not infrequent misconception was that since movement against a concentration gradient involves active transport, active transport cannot be involved in movement down a gradient.

(e)     The many good answers to this part of the question suggested that most candidates had a clear understanding of the principles of electron microscopy and were able to offer a lucid account of its advantages and limitations. Less able candidates were usually able to explain the advantages associated with high resolution but the limitations they suggested concerning expense, size, the production of black and white images and the need for technical support were of a more anecdotal nature and seldom gained significant credit.

**E15.**          (a)     Most candidates appreciated that having a thin piece of epidermis would allow light to pass through the specimen. However, far fewer candidates could explain this in terms of a single or few layers of cells being present. A common misconception was that being thin enabled organelles to be identified.

(b)     This proved to be the most demanding question on the paper with over 75% of candidates scoring zero. It was very evident that most candidates had little experience or recall of this type of practical work. Most candidates simply stated that the number of stomata on a leaf would be counted and divided by the area without any reference to using the slide. Almost invariably when candidates did gain a mark, this was for carrying out repeats and calculating a mean.

(c)     Although many candidates gained one mark, a significant minority did not mainly due to poor or imprecise terminology. References to ‘trapped water droplets’ rather than water vapour or to ‘concentration gradient’ rather than water potential gradient were frequently penalised. Consequently, few candidates obtained both marks.

**E16.**          (a)     Most candidates recognised that homogenising the leaves would release the organelles. However, there was some confusion over the nature of buffer solutions and explanations to part (ii) were often incorrectly linked to temperature and osmosis. Those who selected the appropriate property generally progressed to explain its importance in terms of denaturing proteins or enzymes. A significant number, however, linked pH with lower kinetic energy and less frequent molecular collisions.

(b)     Although most candidates followed the instruction in part (i) and inserted the letter representing the relevant fraction, there were a number of inappropriate responses relating either to the name of the organelles concerned or to X, Y and Z. Many candidates were able to gain maximum credit for part (ii), correctly relating the presence of mitochondria to the release of energy or the synthesis of ATP in respiration, and the movement of molecules against a concentration gradient. Some candidates, who were presumably repeating this module after completing their AS course, produced somewhat confused accounts based on the production of greater amounts of ATP for use in respiration.

**E18.**          The examiners were at something of a loss to explain why so many candidates chose to write about the advantages and limitations of using a transmission electron microscope rather than a scanning electron microscope. Those who selected the right instruments usually commented about the greater resolution of an electron microscope but occasionally attributed this to the **lower** wavelength of the instrument itself. Limitations, however, were somewhat less convincingly discussed and there were many vague references to size, cost and portability and an obsession among the least able with the fact that electron microscopes were unsuitable for school use.

**E19.**          (a)     In defining a tissue, care needs to be taken to produce a definition that excludes organs and other levels of organisation. Thus, it is essential to refer to the cells involved being similar or with a common origin. To say that a tissue consists of cells that carry out a particular function lacks the necessary precision.

(b)     In part (a)(i), most candidates appeared to appreciate that iodine solution could be used to locate starch but often failed to note the specific requirement of the question. There was a tendency to describe the test concerned without heeding the need to find out where in the cells the starch was present. On occasions, candidates failed to note that this question was directed towards what a student should do, and there were a number of inappropriate answers involving electron microscopes and ultracentrifugation. Most of the answers to part (b) (ii) identified the need to produce a section through which light could pass but seldom developed the arguments further to embrace the points made in the mark scheme. Some of the less able candidates confused optical and electron microscopes.

(c)     Although most candidates produced sound answers to part (c), some occasionally went far beyond the two differences required in the question. They should be aware that this approach is not without its drawbacks. Examiners cannot be expected to select correct answers from a mixture of correct and incorrect responses. In order to be fair to all, once the required number of responses has been exceeded, correct answers are disqualified by those that are clearly wrong. ***Guidance for Teachers Marking ISAs*** on the AQA Website has useful information about the application and interpretation of mark schemes.

**E20.**          (a)     Approximately 70% of candidates gained the mark for ‘peptide bond’. The most common incorrect responses seen were ‘hydrogen bond’ and ‘glycosidic bond’.

(b)     Fewer than half of the candidates gave the correct sequence HJE.

(c)     Most candidates gained one mark for describing the role of organelle G in respiration or in producing ATP. Unfortunately, some disqualified this mark through poor expression such as by stating that respiration ‘produces energy’ or ‘produces ATP for respiration’. However, it was encouraging to see that this seemed to be less frequent than in the January paper. Better candidates usually went on to link this role to active transport or protein synthesis. However, some candidates incorrectly referred to organelle G as a ribosome.

(d)     (i)      Fewer than half of the candidates were aware that the tissue was homogenised to break open cells or to release their contents. A common misconception was that this process alone separates the organelles. Weaker candidates usually gave vague answers or answers that were out of context such as ‘to break up the tissue’ or ‘to separate the cells’. Similarly, a minority seemed to focus on the homo- aspect of homogenised and suggested that this process was used ‘to keep the pH the same’.

(ii)     Only 35% of candidates were aware that the suspension was filtered to allow cell debris or complete cells to be removed. The most common misconception seen was that filtration separates the organelles. A number of weaker candidates failed to score though repeating information from the question stem in that ‘it allows organelle G to be isolated’.

(iii)     Just over 60% of candidates were aware that the suspension was kept ice cold to reduce enzyme activity. Candidates who failed to score often had the idea of ‘reduced activity’ or ‘less kinetic energy’ but they did not mention enzymes. A minority of weaker candidates incorrectly related the low temperature to preventing denaturation.

(iv)    Many candidates gained one mark for the idea that an isotonic solution prevents osmosis. However, it was usually only the better candidates who explained the advantage of this in terms of organelles not bursting or shrinking. Unfortunately, many candidates did have the general idea but referred to cells instead of organelles. Consequently, there were many references to ‘preventing cells from bursting’ and to ‘preventing cells from becoming turgid’.

**E21.**          (a)     The vast majority of candidates correctly named the process as differentiation or specialisation. The most common incorrect response was ‘mutation’.

(b)     (i)      Even more candidates correctly named structure **A** as the (cellulose) cell wall. A common incorrect response was ‘cell membrane’.

(ii)     It was disappointing that over a third of candidates scored zero on this question. Most candidates did gain one mark for the principle of dividing the measured length by the magnification. However, only one in every four candidates was able to complete the calculation to provide the correct answer in micrometres.

(iii)     Almost two thirds of candidates failed to obtain the mark for this question. Most candidates mentioned chloroplasts, but only better candidates outlined their role in absorbing light. A significant number of candidates confused chloroplasts with chlorophyll. Very few candidates provided answers relating to the thin cell wall or to chloroplasts being at the periphery of the cell.

**E22.**          (a)     (i)      Over 90% of candidates correctly identified organelle **Y** as a mitochondrion.

(ii)     This question proved to be a good discriminator. Most candidates gained at least one mark for the function of mitochondria in terms of respiration, energy release or ATP production. Better candidates usually went on to link this to active transport. Unfortunately, some candidates disqualified the first mark through poor expression e.g. ‘energy produced’ and ‘produces ATP for respiration’. Similarly, some answers referred to facilitated diffusion and linked this to a requirement for ATP. A minority of candidates incorrectly referred to structure **Y** as either ‘microvilli’ or ‘ribosome’. This resulted in incorrect answers relating to surface area and protein synthesis respectively.

(b)     Most candidates gained one mark for the principle of dividing the measured length by the magnification. However, only the best candidates were able to convert the measured length to micrometres. Candidates who failed to score often divided the magnification by the measured length.

(c)     Most candidates scored one mark for mentioning a reduced surface area. The more able usually went on to link this to reduced absorption for full marks. However, some candidates disqualified this mark by referring to less protein being absorbed. Relatively few candidates referred to the cell membrane or membrane proteins.

**E23.**         (a)      (i)     The vast majority of students correctly named organelle Y.

(ii)     Most students were able to identify two structures showing the cell was eukaryotic. Those who did not often failed to use the diagram as instructed or confused prokaryotic and eukaryotic cells.

(b)     Whilst most students correctly linked the mitochondrion with respiration or ATP production, there was still a sizeable minority with incorrect ideas about energy creation in the mitochondria.

(c)     Students generally had a good understanding of why a transmission electron microscope would be needed to see the organelles of the cell. Inevitably there were those who confused transmission with scanning electron microscopy or light microscopy with electron microscopy.

**E24.**          (a)     Just over 75% of candidates correctly named A as the membrane. The most common responses seen that did not gain credit were ‘cell wall’ and ‘capsule’.

(b)     Many candidates gained two marks for ‘nucleus’, ‘mitochondrion’, ‘Golgi’, ‘smooth/rough ER’ or ‘heavier ribosomes’. Unfortunately, some candidates failed to gain a mark due to a lack of detail. This was usually for failing to qualify ‘ribosomes’ or stating ‘villi’ instead of microvilli. A minority of weaker candidates failed to score through failing to read the question stem with sufficient care. They named structures that were present in a cholera bacterium but absent from an epithelial cell.

(c)     A common misconception seen by weaker candidates in both question parts was that a TEM or SEM can be used to view living specimens. Vague references to cost and preparation were not uncommon. A few candidates confused the two types of electron microscope.

(i)      Two thirds of candidates were aware that a TEM provides a higher resolution or that it can be used to view the internal structures within cells.

(ii)     Just over half of candidates were aware that an SEM allows a 3-D image, thicker sections to be prepared or the surface of a specimen to be viewed. Some candidates stated that an SEM provides colour images. This was not credited. Both types of electron microscope produce black and white images, which can then be enhanced with colour, using computer software.

(d)     Just over 40% of candidates scored full marks. Many candidates were aware of the equation used to calculate the actual width of the cholera bacterium. However, the ability to convert millimeters to micrometres proved to be a good discriminator. Where candidates had expressed their answer in standard form, this was usually done poorly. A common error seen by weaker candidates was to multiply the measured length and magnification.

(e)     Almost all candidates gained one mark for correctly describing the relationship between height above sea level and the number of deaths from cholera. However, a few then went on to disqualify this mark by referring to this as a ‘positive correlation’.

Some weaker candidates referred to the ‘sea level increasing’ rather than the height above sea level increasing.

**E26.**Given that this question was targeted at grade **E**, it is surprising that all parts proved to be good discriminators.

(a)     Nearly half of students gained full marks. Students who did not showed a vast range of incorrect answers.

(b)     Most students correctly named the type of reaction as ‘hydrolysis’. The most common incorrect response was ‘condensation’.

(c)     Just over 60% of students gained full marks. This was usually for relating the insolubility of starch to no osmotic effect, or the coiled shape of starch to being compact. However, some students were prevented from scoring full marks due to giving a definition of ‘compact’. The response ‘compact so can fit a lot into a small space’ was frequently seen.

(d)     Nearly half of students scored full marks. A common error seen in weaker responses was to divide the actual length by the measured length. Similarly, the ability to convert between millimetres and micrometres proved to be a good discriminator.

**E30.**(a)     Many students showed a good understanding of this part of the specification and some excellent answers were seen.

However, weaker students confused fractionation with homogenisation and it was not unusual to read 'the suspension is fractionated to break open the cells'.

There was a clear understanding of the need to filter the suspension, to remove whole cells or cell debris. A small minority failed to gain this marking point as they filtered to remove cell walls. Almost everyone understood that it was necessary to use a cold, isotonic buffer solution when carrying out the procedure. However, many students did not explain why this is necessary. Only a relatively small number realised that an isotonic solution was needed to prevent damage to organelles; most students incorrectly discussed this in the context of cell damage. Relatively few students explained that a cold solution was needed to prevent / reduce damage (to the mitochondria) by the enzymes. Many students who attempted to explain why a buffer was needed could not develop their argument beyond 'maintaining a constant pH’ with few explaining that a change in pH could denature or damage the enzymes or proteins. A greater degree of success was apparent with centrifugation. Large numbers of students were familiar with ‘supernatant’ and ‘pellet’ and used these terms in their responses. Most students understood that the densest / heaviest organelles / nuclei would be separated first. A small minority believed that these organelles would be floating in the supernatant / liquid. However, most appreciated that the nuclei would be in the pellet. Equally, there was good understanding of the need to re-spin the supernatant or liquid minus the pellet / nuclei at a faster speed. These same students also indicated that the mitochondria would be in the pellet at the bottom of the tube. Inevitably, a small number of students missed gaining a mark because they involved an organelle or part of a plant cell somewhere in the process.

(b)     Students tended to score well on this question with 62% of students gaining three or more marks. They were more able to describe the limitations of the transmission electron microscope than the principles. Very few students scored more than two marks for the principles, most commonly gaining a mark for stating that electrons would pass through the specimen. Very few students were able to describe the relationship between the density of the region of the cell and its darkness. Poor expression often prevented students obtaining the fourth marking point − frequently they wrote about the microscope having good resolving power as it (i.e. the microscope) has a short wavelength. There was evidence of confusion between the scanning and the transmission electron microscopes with references to electrons being reflected off the specimen, or the specimen being coated with gold. The vast majority were able to give some limitations, many giving more than the maximum of three allowed on the mark scheme.

**E31.**(a)     The examiners noted that many students approached this part as ‘describe mitosis’ and proceeded to do so in various degrees of correct detail. The question asked for an explanation of how events in mitosis lead to the production of genetically identical cells. Some students focused on DNA replication but ignored chromatid movements and others only discussed chromatids. Many obtained 1 or 2 marks for references to DNA replication and / or chromatids moving to the poles (of the spindle).

Some students clearly got confused between sister chromatids and homologous pairs of chromosomes.

The examiners were looking for replication of DNA, involving complementary base-pairing, in order to produce exact copies of genetic information. Then, how this is linked to sister chromatids and how their separation during mitosis leads to genetically identical cells.

(b)     (i)      About 60% of students correctly suggested that the sections had to be thin to allow light to pass through but few went beyond that. The examiners were looking for the idea that thin sections would allow individual cells, or layers of cells, to be seen (and the chromosomes within them, if present). Only about 20% obtained a second mark.

(ii)     Many students wrote about the size of the mitotic index in this part, simply describing the graph and not explaining growth. The examiners were looking for answers relating the rate of mitosis at the tip of the root to growth. A third of students did this and obtained both marks.

**E33.**(a)     It was vital that students used the information that was provided in the resource accurately rather than giving generalised methods of making data reliable. Mark points 1 and 2 could be awarded when given in a single statement such as, ‘several fields of view were selected at random’. In mark point 3 ‘species’ was essential, ‘same breed’ is not equivalent. Mark point 5 needed to be specific to the resource, i.e. that at least 8 animals were used in each group. General statements about each group having lots / large number of hamsters were insufficient.

(b)     (i)      Most students successfully carried out this calculation.

(ii)     Mark point 1 was most commonly seen. In this instance, ‘The calculation used an average’ was acceptable as equivalent to mean, as it demonstrates the correct understanding.

(c)     (i)      The occasional student suggested that this investigation was unethical as the hamsters would be in pain or stressed but the vast majority realised hamsters would be killed.

(ii)     Students encountered many problems with this question. Many only discussed changes ‘as the hamsters got older / younger’, rather than using the specific age groups. Some only discussed whether there was a change, or what the change was, rather than discussing the significance of this difference. Many students seemed unaware that it is not the ‘results’ that are deemed significant or not but the ‘differences between the results’. It was surprising at A2 that not more students achieved mark points 5 and 6. It was expected that students who had calculated standard error and 95% confidence limits in Stage 2 of this ISA would realise that standard deviation is insufficient to determine significance.

**E34.**(a)     Most students tried to answer this question by writing all they knew about the use of the centrifuge in cell fractionation, rather than applying their knowledge of the use of the centrifuge to this example of obtaining a cell free liquid. Mark points 2 and 3 were still available if the cells were homogenised first. Mark point 3 was rarely awarded, as many students simply referred to removing the pellet (rather than the supernatant), or they suggested filtering which would break up the pellet and mix the contents once again.

(b)     The vast majority of students could recall the function of lysosomes. Some only stated that lysosomes stored enzymes rather than identifying their active role.

(c)     This question was generally well answered, with just a few students showing confusion by suggesting that ‘bacteria would be denatured’ or that ‘neutralising acid would lower the pH’.

(d)     Mark points 1 and 2 were commonly awarded but few students could correctly describe the relevance of the standard deviation and the overlap with other strains. Some students tried to explain why the damage was caused to human cells, rather than explain how the data support the conclusion drawn.

(e)     Students who fully understood Resource B and the principle of the cell-free liquid answered this question very well. Many students gave answers suggesting the *H. pylori* cells were still present. They were often unable to score mark point 2, as they were suggesting there was no toxin as a result of the cells being unable to produce it; the incorrect context for awarding this mark.