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

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

**(1)**

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



(i)      Name structure **A**.

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

**(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.

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

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

**(1)**

**(Total 5 marks)**

**Q3.**          **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**.

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

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

**(1)**

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

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

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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.

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

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

**(1)**

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

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

**(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.

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

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

**(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 andtreatment** | **Percentage of musclefibres labelled withantibody** |
| Left leg - injectedwith cultured cellssuspended in saltsolution   | 6.8 |
| Right leg - injectedwith salt solution     | 0.0 |

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

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

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

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

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**(4)**

**(Total 25 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)     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]**

**M3.**          (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]**

**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.**          (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.

**E3.**          (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.