

# Markscheme

**May 2025**

**Biology**

**Higher level**

**Paper 2**

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### Subject Details: Biology HL Paper 2 Markscheme

Candidates are required to answer **all** questions in Section A and **two** out of **three** questions in Section B. Maximum total = **80 marks**.

1. A markscheme often has more marking points than the total allows. This is intentional.
2. Each marking point has a separate line and the end is shown by means of a semicolon (;).
3. An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.
4. An alternative answer is indicated by “**OR**”. Either answer can be accepted.
5. An alternative markscheme is indicated under heading **ALTERNATIVE 1** etc. Either alternative can be accepted.
6. Words in brackets ( ) in the markscheme are not necessary to gain the mark.
7. Words that are underlined are essential for the mark.
8. The order of marking points does not have to be as in the markscheme, unless stated otherwise.
9. If the candidate’s answer has the same “meaning” or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect).
10. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
11. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking indicate this by adding **ECF** (error carried forward) on the script.
12. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.

## Section B

### Extended response questions - quality of construction

- Extended response questions for HLP2 each carry a mark total of **[16]**. Of these marks, **[15]** are awarded for content and **[1]** for the quality of the answer.
- **[1]** for quality is to be awarded when:
  - the candidate's answers are clear enough to be understood without re-reading.
  - the candidate has answered the question succinctly with little or no repetition or irrelevant material.
- It is important to judge this on the overall answer, taking into account the answers to all parts of the question. Although, the part with the largest number of marks is likely to provide the most evidence.
- Candidates that score very highly on the content marks need not necessarily automatically gain **[1]** for quality (and *vice versa*).

**Section A**

| Question |   | Answers   | Notes  | Total |
|----------|---|---|--|-------|
| 1.       | a | 6;  |  | 1     |
| 1.       | b | <p>(Similarity/compare:)</p> <p>a. learners increase in both with time/days;</p> <p>(Difference/contrast:)</p> <p>b. B increase more in the first days</p> <p><b>OR</b></p> <p>B has learners from day 1 while R from day 3</p> <p><b>OR</b></p> <p>more total B throughout/on each day than R / B always higher (in numbers) than R;</p> | <p><i>Similarities and differences related to R and B only. Ignore statements related to C.</i></p>  | 2     |
| 1.       | c | 500;  |  | 1     |
| 1.       | d | 5;  | <p><i>Accept any value from 5 to 8. Do not accept decimals.</i></p>  | 1     |
| 1.       | e | <p>(R because) R has fewer/less learners and/but (R) managed to open/opened more (puzzle) boxes;</p>  | <p><i>Both aspects to the response are needed (the reference to there being fewer/less R learners and the idea that R managed to open more boxes).</i></p> | 1     |
| 1.       | f | 50 (%);   | <p><i>Allow any values ranging from 47% to 53% (accept decimals)</i></p>   | 1     |

| Question |   |    | Answers   | Notes   | Total    |
|----------|---|----|---|---|----------|
| 1.       | g | i  | 24;   | <i>Allow a range <math>\pm 1</math></i>   | 1        |
| 1.       | g | ii | 9;  | <i>Allow any values from 8 to 9 (including decimals).</i><br><br><i>Allow ECF (days to become a learner = <math>\frac{216}{24}</math>) from Q1gi if calculation is correctly shown and consistent answer is provided.</i> | 1        |
| 1.       | h |    | <p><i>(from figure 1)</i></p> <p>a. one learner in control (arose spontaneously) (in the first 6 days/by day 6)<br/> <b>OR</b><br/>                     one learner in control (in the first 6 days/by day 6) supports the idea of possible spontaneous learning;</p> <p>b. there are more learners in experimental/B/R (groups) than in control/C;</p> <p><i>(from figure 2)</i></p> <p>c. R/B/experimental opened (significantly) more boxes than C/control<br/> <b>OR</b><br/>                     more learners could mean more box opening (although not directly proportional);</p> <p><i>(from figure 3)</i></p> <p>d. LPI was (significantly) higher in experimental/B+R (group) than control/C;<br/>                     e. bumblebees took less time to learn in experimental/B+R (group) than control/C;<br/>                     f. bumblebee y12 supports the idea of box opening arising spontaneously;</p> | <p><i>Comparative terms expected (do not award marking points for just stating values).</i></p> <p><i>Accept the converse where appropriate.</i></p>  | 3<br>max |

| Question |   | Answers  | Notes   | Total    |
|----------|---|--|---|----------|
| 2.       | a | a. water has greater viscosity than air;<br>b. thermal conductivity is higher in water than in air;<br>c. specific heat capacity is higher in water than in air;<br>d. water is denser/has more buoyancy than air;   | <i>The physical property must be named. Comparative terms are expected, making reference to both eg: accept higher in water, but not high in water.</i><br><br><i>Accept the converse of any of the marking points.</i> | 2<br>max |
| 2.       | b | a. front limbs/flippers/legs are used for steering/to paddle/propel through the water <b>OR</b><br>tail forms a fluke with up-and-down movement / tail adapted to propel in water;<br>b. (covered in) blubber/thick layer of fat to insulate from cold / increase buoyancy<br><b>OR</b><br>water-proof fur for insulation;<br>c. can hold their breath (for many/45 minutes/long periods) to dive under water<br><b>OR</b><br>airways changed to allow periodic breathing between dives<br><b>OR</b><br>no connection between mouth and lungs / closing of nostrils to avoid water entering the lungs<br><b>OR</b><br>uses claws on their (fore/front) flippers/limbs/legs to make a breathing hole in ice;<br>d. more/increased blood (volume)/red blood cells/haemoglobin/myoglobin concentration for more oxygen storage;<br>e. streamlined (body) to minimize resistance/friction (when swimming); |   | 2<br>max |
| 2.       | c | primary consumer;  |   | 1<br>max |

| Question |   | Answers  | Notes                                       | Total    |
|----------|---|--|---|----------|
| 3.       | a | <p>a. (voltage-gated) potassium channels are closed when there is a negative membrane potential / when there are (relatively) more negative charges inside / (relatively) more positive charges outside;</p> <p>b. (voltage-gated) potassium channels open after depolarization of the axon / after closing of sodium channels / when a positive membrane potential develops / at +30mV / at +40mV;</p> <p>c. K<sup>+</sup> ions diffuse out of the cell / efflux of K<sup>+</sup>;</p> <p>d. (efflux of K<sup>+</sup>) causes/results in/happens during repolarization / membrane potential returns to -70mV/ to the resting potential;</p> <p>e. (voltage-gated) potassium channels close again (to terminate the action potential)</p> <p><b>OR</b></p> <p>globular protein ball (attached by a flexible chain of amino acids) blocks/closes the channel;</p> <p>f. (following an action potential) hyperpolarization can occur (due to slow closing of potassium channels / continued efflux of K<sup>+</sup> before potassium channels close / nature of potassium channels);</p> |   | 3<br>max |
| 3.       | b | neurotransmitter (gated ion channel) / ligand (gated ion channel) / mechanically (gated ion channel);  | <i>Do not accept examples.</i>              | 1        |
| 3.       | c | <p>a. <u>hydrophobic</u> regions at the phospholipid tail <b>and</b> <u>hydrophilic</u> regions at the heads;</p> <p>b. (long) carbon chains are <u>hydrophobic</u> (water insoluble) <b>and</b> phosphate head is <u>hydrophilic</u> (water soluble);</p>   | <i>Both parts of the answer are needed.</i> | 1<br>max |
| 3.       | d | <p>a. modulates/adjusts/controls/regulates membrane fluidity;</p> <p>b. cholesterol stabilizes membranes/prevents membranes becoming too fluid/too porous at <u>higher temperatures</u>;</p> <p>c. cholesterol prevents membranes becoming viscous/inflexible/stiff/stiffening / cholesterol prevents solidification of saturated fatty acids at <u>lower temperature</u>;</p>   |   | 1<br>max |
| 3.       | e | <p>a. more unsaturated fatty acids more flexible/fluid;</p> <p>b. more saturated fatty acids less flexible/fluid;</p>  | <i>Accept vice versa</i>                    | 1<br>max |

| Question |   | Answers  | Notes   | Total            |
|----------|---|--|---|------------------|
| 4.       | a | a. lack of cell contents making it hollow/empty with minimal resistance to the flow of sap / easier flow of sap/water;<br>b. incomplete/absent end walls (creating a long continuous tube) for flow;<br>c. lignocellulose/lignified walls to withstand tensions /prevent collapsing;<br>d. pits/gaps/pores for entry/exit/ horizontal movement of water;   | <i>The adaptation must be accompanied by a brief account.</i> | <b>2<br/>max</b> |
| 4.       | b | a. active transport of mineral ions into root/ xylem vessel (by endodermis cells);<br>b. (active transport causes) high minerals/mineral concentration in root / xylem (becomes hypertonic);<br>c. water moves to roots/xylem vessels by <u>osmosis</u> ;<br>d. increased root pressure in xylem vessels;<br>e. positive/increased pressure (potential/hydrostatic) causes water movement in roots/stems (upwards against gravity);<br>f. cohesion ensures a continuous column of water<br><b>OR</b><br>adhesion of water to xylem walls allows movement through capillary action; |   | <b>3<br/>max</b> |

| Question   |   | Answers   | Notes   | Total             |   |   |  |   |              |           |  |       |
|--|---|---|---|-------------------|---|---|--|---|--------------|-----------|--|-------|
| 5.   | a   | <table border="1"> <thead> <tr> <th>Innate Immunity</th> <th>Adaptive immunity</th> </tr> </thead> <tbody> <tr> <td>a. responds to a broad category/range of pathogens / non-specific</td> <td>responds in a specific way to particular pathogens/targets individual pathogens / specific;</td> </tr> <tr> <td>b. no immunological memory<br/><b>OR</b><br/>responses do not change during an organism's life<br/><b>OR</b><br/>different pathogens are all responded in the same way</td> <td>builds up immunological memory<br/><b>OR</b><br/>immune responses develop during an organism's life<br/><b>OR</b><br/>each pathogen elicits a new and different response;</td> </tr> <tr> <td>c. born with</td> <td>acquired;</td> </tr> </tbody> </table> | Innate Immunity                                     | Adaptive immunity | a. responds to a broad category/range of pathogens / non-specific | responds in a specific way to particular pathogens/targets individual pathogens / specific; | b. no immunological memory<br><b>OR</b><br>responses do not change during an organism's life<br><b>OR</b><br>different pathogens are all responded in the same way | builds up immunological memory<br><b>OR</b><br>immune responses develop during an organism's life<br><b>OR</b><br>each pathogen elicits a new and different response; | c. born with | acquired; | <p><i>Award [1] per row.</i></p> <p><i>A table format is not required.</i></p> <p><i>Note: The command term is "distinguish" so a clear difference between the 2 concepts is required.</i></p> | 1 max |
| Innate Immunity  | Adaptive immunity   |   |   |                   |   |   |  |   |              |           |  |       |
| a. responds to a broad category/range of pathogens / non-specific  | responds in a specific way to particular pathogens/targets individual pathogens / specific;   |   |   |                   |   |   |  |   |              |           |  |       |
| b. no immunological memory<br><b>OR</b><br>responses do not change during an organism's life<br><b>OR</b><br>different pathogens are all responded in the same way | builds up immunological memory<br><b>OR</b><br>immune responses develop during an organism's life<br><b>OR</b><br>each pathogen elicits a new and different response; |   |   |                   |   |   |  |   |              |           |  |       |
| c. born with   | acquired;   |   |   |                   |   |   |  |   |              |           |  |       |
| 5.   | b   | <p>a. T lymphocytes/cells (and antigen) activate B lymphocytes/cells;</p> <p>b. B lymphocytes/cells produce antibodies after activation (so peak is later)<br/><b>OR</b><br/>time needed to form a clone/plasma B-cells<br/><b>OR</b><br/>time needed to produce (significant number of) antibodies;</p> <p>c. (B lymphocytes/cells already differentiated into) plasma/memory cells which make antibodies quickly after secondary infection/vaccination (so peaks coincide);</p>   | <p><i>Accept the terms T-cells and B-cells.</i></p> | 2 max             |   |   |  |   |              |           |  |       |

| Question |   | Answers   | Notes  | Total                   |
|----------|---|---|--|-------------------------|
| 5.       | c | <p>a. DNA/RNA vaccines can be used because viruses have genetic material/RNA/DNA;</p> <p>b. viruses have a capsid made of protein / protein capsule so antigen/parts of protein can be used as vaccine;</p> <p>c. inactivated /attenuated virus can be used as immune system reacts against capsid / protein capsule;</p> | <p><i>Type of vaccines must be related to viral structure.</i></p> | <p><b>2<br/>max</b></p> |

| Question |   |   | Answers   | Notes   | Total            |
|----------|---|---|---|---|------------------|
| 6.       | a |   | a. loss of plant/animal species;<br>b. loss of (natural) habitat/nests/shelter/niche;<br>c. loss of food sources / disruption of food chains;<br>d. earth erosion/floods (as trees do not hold soil) affecting organisms in soil;   |   | <b>2<br/>max</b> |
| 6.       | b |   | a. human population growth/overpopulation/urbanization;<br>b. hunting / overfishing/ overharvesting;<br>c. loss of natural habitat by natural disasters<br><b>OR</b><br>climate change/global warming;<br>d. pollution by burning of fossil fuels;<br>e. pollution of land/water by use of fertilizers/pesticides/chemicals / acidification of oceans;<br>f. spread of pests/diseases/invasive alien species;                   | <i>b: Accept other forms of over-exploitation.<br/>                     c: Accept an example of natural disaster or loss of habitat.<br/>                     d and e: Do not accept "pollution" without any further details.</i> | <b>1<br/>max</b> |
| 6.       | c | i | a. estimates the expected loss of evolutionary history (per unit time) / helps maintain the evolutionary history<br><b>OR</b><br>focuses on species that belong to small clades (few or no close relatives);<br>b. focuses on species with populations in danger of <u>extinction</u> ;<br>c. conservation actions can be taken for EDGE species<br><b>OR</b><br>EDGE lists inform/inspire/suggest priorities for conservation; | <i>Do not award marking points for just repeating what ED and GE stand for.</i>   | <b>2<br/>max</b> |

| Question |   |    | Answers   | Notes   | Total        |
|----------|---|----|---|---|--------------|
| 6.       | c | ii | <p>a. reintroduction of top/apex predators/native species/original forms<br/> <b>OR</b><br/> retrobreeding/ artificial breeding/selection to restore wildtype<br/> <b>OR</b><br/> remove invasive species;</p> <p>b. restore habitats/rehabilitate degraded habitats /re-establishment of connectivity of habitats over large areas (where natural ecosystems have become fragmented)/land protection / reforestation;</p> <p>c. minimize human impact / regulate/limit/reduce/eliminate human activity in the ecosystem / creation of national parks/game/natural reserve;</p> <p>d. allow natural processes of regeneration and recovery;</p> | <p><i>a. Accept "reintroduction of keystone species".</i></p> <p><i>b. Do not accept "afforestation".</i></p> | <b>1 max</b> |

| Question             |                               | Answers  | Notes   | Total                |          |                      |                               |                  |                      |                               |                  |  |              |
|----------------------|-------------------------------|--|---|----------------------|----------|----------------------|-------------------------------|------------------|----------------------|-------------------------------|------------------|--|--------------|
| 7.                   | a                             | <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td></td> <td><b>X<sup>D</sup></b></td> <td><b>Y</b></td> </tr> <tr> <td><b>X<sup>D</sup></b></td> <td>X<sup>D</sup> X<sup>D</sup></td> <td>X<sup>D</sup>Y</td> </tr> <tr> <td><b>X<sup>d</sup></b></td> <td>X<sup>D</sup> X<sup>d</sup></td> <td>X<sup>d</sup> Y</td> </tr> </table> <p>a. parental gametes<br/><b>OR</b><br/>parental genotypes X<sup>D</sup>X<sup>d</sup> and X<sup>D</sup>Y;<br/>b. genotypes of offspring (X<sup>D</sup>X<sup>D</sup>; X<sup>D</sup> X<sup>d</sup>; X<sup>D</sup> Y; X<sup>d</sup>Y);<br/>c. probability of disease 25% / 1 out of 4 (offspring)<br/><b>OR</b><br/>is half /50 % /1 out of 2 <u>males</u>;</p> |   | <b>X<sup>D</sup></b> | <b>Y</b> | <b>X<sup>D</sup></b> | X <sup>D</sup> X <sup>D</sup> | X <sup>D</sup> Y | <b>X<sup>d</sup></b> | X <sup>D</sup> X <sup>d</sup> | X <sup>d</sup> Y | <p><i>Max 2 if Punnett grid NOT used.</i></p> <p><i>a and b: Accept any type of notation that differentiates between affected and non-affected X chromosome, but must use X and Y. Superscript not compulsory.</i></p> <p><i>b. allow ECF from a. as long as X and Y are used.</i></p> | <b>3 max</b> |
|                      | <b>X<sup>D</sup></b>          | <b>Y</b>   |   |                      |          |                      |                               |                  |                      |                               |                  |  |              |
| <b>X<sup>D</sup></b> | X <sup>D</sup> X <sup>D</sup> | X <sup>D</sup> Y   |   |                      |          |                      |                               |                  |                      |                               |                  |  |              |
| <b>X<sup>d</sup></b> | X <sup>D</sup> X <sup>d</sup> | X <sup>d</sup> Y   |   |                      |          |                      |                               |                  |                      |                               |                  |  |              |
| 7.                   | b                             | <p><u>deletion</u> is loss/removal of bases/nucleotides/part of DNA/gene while <u>insertion</u> is addition of bases/nucleotides/one/more copies of any piece of DNA/gene/chromosome;</p>  | <p><i>Both deletion and insertion needed.</i></p> <p><i>Do not award marking point for repeating the definition e.g. "deletion" is bases "deleted" / "insertion" is bases "inserted".</i></p> | <b>1</b>             |          |                      |                               |                  |                      |                               |                  |  |              |

| Question |   | Answers  | Notes  | Total               |
|----------|---|--|--|---------------------|
| 7.       | c | <p>a. gene editing requires a method for finding a target sequence in the genome/DNA/gene <b>and</b> replacing it with the desired sequence;</p> <p>b. (gene editing could) change codon/point mutation/substitution that encodes/codes for a different amino acid (causing change in protein/dystrophin);</p> <p>c. change codon that introduced a stop codon (making shorter peptide/dystrophin);</p> <p>d. introduce DNA section/bases if mutation is a deletion;</p> <p>e. delete DNA section/bases if mutation is an insertion;</p> | <p><i>a. both parts needed.</i></p>                | <p><b>3 max</b></p> |
| 7.       | d | <p>a. pluripotent stem cells can form/differentiate into a wider range of cell types;</p> <p>b. a multipotent stem cell can only form a (more limited) selection of (related) cell types<br/><b>OR</b><br/>multipotent stem cells are more committed (than pluripotent stem cells);</p> <p>c. multipotent are not found in skeletal muscle cells (DMD affects cardiac and skeletal muscle)<br/><b>OR</b><br/>multipotent cannot become cardiac/muscle cells;</p>   | <p><i>a. Do not allow any/every cell type.</i></p> | <p><b>1 max</b></p> |

**Section B**

**Clarity of communication: [1]**

The candidate’s answers are clear enough to be understood without re-reading. The candidate has answered the question succinctly with little or no repetition or irrelevant material.

| Question |   | Answers   | Notes  | Total |
|----------|---|---|--|-------|
| 8.       | a | a. cell walls are found in plant cells but not in animal cells;<br>b. vacuoles are large in plant and small in animal cells;<br>c. chloroplasts/plastids present in plants but not in animals cells;<br>d. centrioles present in animal cells but not in plant cells;<br>e. cilia/flagella present in (some) animal cells but not in plant cells;<br>f. lysosomes present in animal cells but not in plant cells;   | Accept answers in a table format.<br>Note: There must be a clear difference between the 2 types of cells.<br>Accept clearly annotated diagrams if the differences are evident and help to distinguish between the 2 cells. | 3 max |
| 8.       | b | a. (some) herbivores have piercing/chewing/jaw-like/modified mouthparts/teeth/tough mandibles to eat/chew leaves<br><b>OR</b><br>(some) herbivores have proboscis to suck nectar;<br>b. (some) herbivores/ruminants have different stomachs/cellulase to digest plant/cellulose;<br>c. (some) herbivores detoxify plant toxins;<br>d. (some) plants resist herbivory using/by the presence of (sharp) thorns/spines/spikes/other physical structures;<br>e. (some) plants have stings to cause pain/burning sensations / bad/unpleasant taste;<br>f. (some) plants produce toxins/toxic chemicals/(secondary) compounds/metabolites (in seeds and leaves) to avoid predation by herbivores; | Max 2 for herbivores and Max 2 for plants.   | 4 max |

| Question    | Answers  | Notes   | Total               |
|-------------|--|---|---------------------|
| <p>8. c</p> | <p><i>Similarities: [6 max]</i></p> <p>a. (in both plants and animals) produces two <u>genetically</u> identical daughter cells;</p> <p>b. maintains the chromosome number/genome of cell / produces diploid/2n cells;</p> <p>c. used for generation of new cells/cell replacement/tissue repair/growth;</p> <p>d. in prophase the chromatin/chromosome condenses/formation of chromatids/supercoiling of chromosomes;</p> <p>e. supercoiling of DNA around histones (to form nucleosomes);</p> <p>f. microtubules/microtubule motors to move chromosomes/chromatids;</p> <p>g. in metaphase chromosomes align in equator of cell;</p> <p>h. in anaphase separation of chromatids;</p> <p>i. in telophase two nuclei/cells form / nuclear membrane/envelope reforms</p> <p><b>OR</b></p> <p>cytokinesis is the division into two cells;</p> <p><i>Differences:</i></p> <p>j. in animal cell centrosomes/centrioles facilitates the organization of the mitotic spindle/ spindle poles/microtubules;</p> <p><b>Marking points for 8c continued on next page....</b></p> | <p><b>Max 6 for similarities.</b></p> <p><i>Allow clearly annotated diagrams.</i></p> | <p><b>8 max</b></p> |

**8c continued ....**

|    |   |   |  |  |
|----|---|---|--|--|
| 8. | c | <p>k. in plant cells spindle fibres attach to walls;</p> <p>l. in animal cells, the plasma membrane is pulled inwards around the equator to form a cleavage furrow in cytokinesis</p> <p><b>OR</b></p> <p>in animal cells actin and myosin pinch cell membrane to split cytoplasm/cytokinesis;</p> <p>m. in plant cells a cell plate forms (at the equator) to develop into the new cell wall to achieve cytokinesis</p> <p><b>OR</b></p> <p>in plant cell vesicles (containing pectin) assemble sections of membrane/cell wall (at/across the equator) to achieve splitting/cytokinesis;</p> |  |  |
|----|---|---|--|--|

| Question |   | Answers   | Notes  | Total        |
|----------|---|---|--|--------------|
| 9.       | a | <p>a. (homologous structures are) similar features/structures/anatomy that can have different functions;</p> <p>b. (homologies are) result of divergent evolution/adaptive radiation</p> <p><b>OR</b></p> <p>(homologies are) result of different selection pressures/natural selection;</p> <p>c. (organisms evolve) from a common ancestor / show evolutionary relationships;</p> <p>d. can be seen in ancient organism remains / fossils;</p> <p>e. can be seen in similarities among organism limbs/structures/vestigial organs/embryos/DNA alive today;</p> <p>f. an example of homologous structures are pentadactyl limbs;</p>   |  | <b>4 max</b> |
| 9.       | b | <p><i>conditions [2 max]:</i></p> <p>a. no mutation;</p> <p>b. random mating;</p> <p>c. no migration / gene flow;</p> <p>d. large population size / no genetic drift;</p> <p>e. no selection / (natural) selection does not favour one phenotype</p> <p><i>use [2 max]:</i></p> <p>f. p and q denote the two allele frequencies;</p> <p><b>OR</b></p> <p>p denotes frequency of dominant allele <u>and</u> q denotes frequency of recessive allele;</p> <p>g. p and q add up to 1 / <math>p + q = 1</math>;</p> <p>h. <math>p^2 + 2pq + q^2 = 1</math>;</p> <p>i. the frequency of the 2 homozygous genotypes are <math>p^2</math> and <math>q^2</math></p> <p><b>OR</b></p> <p>the frequency of the heterozygous genotype is <math>2pq</math>;</p> | <i>Max 2 for conditions and Max 2 for use.</i> | <b>3 max</b> |

| Question |   | Answers  | Notes   | Total        |
|----------|---|--|---|--------------|
| 9.       | c | <p>a. classification needed because of immense diversity of species/further study is facilitated/helps in identification of species;</p> <p>b. (ideal) classification follows/is based on evolutionary relationships (between species that have a common ancestor);</p> <p>c. (classification based on evolutionary relationships) allows characteristics of organisms within a group to be predicted because they are shared;</p> <p>d. relationships can be inferred using different kinds of evidence such as morphology/development/molecular markers/presence/absence of genes/DNA/RNA/protein/amino acid sequences;</p> <p>e. organisms that share similar structures/genetic sequences/DNA/RNA tend to be more closely related;</p> <p>f. differences in (DNA/amino acid) sequence are due to mutation;</p> <p>g. cladograms are branching diagrams/trees connected to a common ancestor<br/><b>OR</b><br/>the branches (in a cladogram) represent the evolutionary path of a group of organisms from a common ancestor;</p> <p>h. <u>cladograms</u> are based on phylogeny/evolutionary relationships<br/><b>OR</b><br/><u>cladograms</u> are built from multiple sequence alignments/ base sequences of genes / base sequences of amino acids in proteins;</p> <p style="text-align: center;"><b>Marking points for 9c continued on next page....</b></p> | <p><i>g. can be awarded through a labelled diagram.</i></p> | <b>8 max</b> |

**Question 9c continued....**

|           |          |   |   |  |
|-----------|----------|---|---|--|
| <b>9.</b> | <b>c</b> | <p>i. a clade is a group of organisms that have evolved from a common ancestor<br/><b>OR</b><br/>a clade includes a single common ancestor and all of its descendants/all species evolved from it;</p> <p>j. the <u>root</u> is the base of the cladogram / the hypothetical common ancestor <u>of all the clades</u>;</p> <p>k. the <u>node</u> of the branch shows the most recent common ancestor between two species of a clade<br/><b>OR</b><br/>the <u>node</u> represents a (hypothetical) common ancestor<br/><b>OR</b><br/>the <u>node</u> is a branching point indicating that a group of organisms are related;</p> <p>l. the <u>terminal branches</u> are ends that represent individual clades / species / group of closely related species;</p> | <p><i>j, k. and l. can be awarded in a clearly annotated diagram.</i></p> |  |
|-----------|----------|---|---|--|

| Question |   | Answers  | Notes   | Total                   |
|----------|---|--|---|-------------------------|
| 10.      | a | <p>a. a codon is a triplet of bases of <u>mRNA</u>;</p> <p>b. (a codon) codes for/ is translated into one amino acid;</p> <p>c. one codon (AUG) initiates the translation<br/> <b>OR</b><br/>                     AUG codes for Methionine/Met;</p> <p>d. 3 codons (UAA, UAG and UGA) are stop codons;</p> <p>e. one codon in <u>mRNA</u> matches/pairs with anticodon in <u>tRNA</u><br/> <b>OR</b><br/>                     complementary base pairing between <u>tRNA</u> and <u>mRNA</u> (in translation);</p> <p>f. genetic code is degenerate<br/> <b>OR</b><br/>                     more than one codon/multiple codons can code for one amino acid;</p> <p>g. order of codons determines order of amino acids/primary structure of polypeptide/protein;</p> | <p><i>b. Allow codons code for/are translated into amino acids.</i></p> | <p><b>4<br/>max</b></p> |
| 10.      | b | <p>a. photosystems embedded/located in chloroplast/thylakoid membranes;</p> <p>b. two types of photosystems, (Photosystem I and Photosystem II/PSI and PSII);</p> <p>c. structure allows light energy to be captured;</p> <p>d. (energy used) to emit excited electron;</p> <p>e. molecular <u>arrays</u> of chlorophyll (and accessory pigments)<br/> <b>OR</b><br/>                     photosystem combines different types of pigments in one <u>array</u>;</p> <p>f. a greater proportion of wavelengths can be absorbed / greater proportion of sunlight can be used<br/> <b>OR</b><br/>                     a single molecule of chlorophyll would not be able to perform photosynthesis;</p>   |   | <p><b>3<br/>max</b></p> |

| Question     | Answers  | Notes | Total            |
|--------------|--|-------|------------------|
| <p>10. c</p> | <p>a. increased (cellular) respiration can increase CO<sub>2</sub> levels in blood<br/> <b>OR</b><br/>                     anaerobic (cellular) respiration produces lactic acid;</p> <p>b. due to exercise/lack of oxygen;</p> <p>c. (aqueous) carbon dioxide reacts to form carbonic acid/H<sup>+</sup> ions (and HCO<sub>3</sub><sup>-</sup> ions)<br/> <b>OR</b><br/>                     increased CO<sub>2</sub> levels in blood cause a decrease in pH/acidosis<br/> <b>OR</b><br/>                     lactic acid in blood can release H<sup>+</sup> ions / can cause a decrease in pH/acidosis;</p> <p>d. in the presence of carbonic anhydrase (enzyme);</p> <p>e. <u>chemoreceptors</u> detect levels of carbon dioxide (in the blood)<br/> <b>OR</b><br/> <u>chemoreceptors</u> monitor (blood) pH / H<sup>+</sup> (in blood);</p> <p>f. (chemoreceptors) found in aorta/carotid arteries;</p> <p>g. (chemosensors/chemoreceptors) send information to respiratory centre in brain<br/> <b>OR</b><br/>                     to the medulla/brainstem;</p> <p>h. (medulla) sends nervous impulses to the <u>external</u> intercostal muscles;</p> <p>i. (medulla) sends nervous impulses to the diaphragm;</p> <p>j. through intercostal/phrenic nerve;</p> <p>k. increasing breathing/ventilation rate;</p> <p>l. increasing volume of the lungs (during inhalation)/ increasing depth of breathing;</p> |       | <p>8<br/>max</p> |