| Question | | | Expected Answer | Mark | Additional Guidance |
|---|---|---|---|---|---|
| 1 | (a) | (i) | **1** *idea that* (produces) large **,** yield / volume / amount**,** of milk **;**<br>**2** *idea of* long lactation period **;**<br>**3** *idea of* high milk quality **;**<br>**4** large udders / correct udder shape (for milking machine) **;**<br>**5** resistance to **,** (named) disease / mastitis / pathogens **or** effective immune system **;**<br>**6** *idea of* calm temperament **;**<br>**7** AVP **;** | **3 max** | **Mark the first suggestion on each line**<br>***1*** **DO NOT CREDIT** milk yield unqualified<br>***2***<br>***3*** **DO NOT CREDIT** milk quality unqualified or ref. meat<br>***4***<br>***5*** **DO NOT CREDIT** disease free<br>***6*** **CREDIT** docile / placid<br>***7*** eg • walk / stand **,** comfortably without need for hoof-trimming • *idea that* converts food to milk efficiently |
| 1 | (a) | (ii) | normal shaped curve **;**<br>shifted to the right of original **;** | **2** | Position of curve must meet the following conditions:<br>• **curve must end** to right of original end<br>• **must not start** to left of original<br>• **may start** at same point as original or to right of original |

| Question | | | Expected Answer | Mark | Additional Guidance |
|---|---|---|---|---|---|
| 1 | (a) | (iii) | **1** artificial insemination / AI **;**<br>**2** in vitro fertilisation / IVF **;**<br>**3** *idea of* progeny testing **;**<br>**4** embryo transplantation / use of surrogate mother **;**<br>**5** cloning **;**<br>**6** genetic screening / use of gene probes **;**<br>**7** AVP **;**<br>**8** AVP **;** | **2 max** | **Mark the first suggestion on each line**<br>***1*** **IGNORE** performance testing<br>***2***<br>***3***<br>***4*** **CREDIT** embryo splitting<br>***5***<br>***6*** **ACCEPT** genetic engineering<br>***7*** eg ● sex selection technique / screening X and Y sperm<br>***8*** eg ● portmanteau animals |
| 1 | (b) | (i) | *idea of* change to **,** <u>DNA</u> / <u>base</u>(s) / <u>nucleotide</u>(s) **;** | **1** | |
| 1 | (b) | (ii) | natural / directional **,** selection **;** | **1** | **ACCEPT** evolution<br>**DO NOT CREDIT** genetic drift |
| 1 | (c) | (i) | *regulatory*<br>*idea that* makes **,** repressor protein / transcription factor<br>**or**<br>*idea that* product switches (structural / another) gene **,** on / off **;**<br>*structural*<br>*idea that* makes **,** enzyme / polypeptide / protein **;**<br>*relationship between the 2*<br>*idea that* regulatory <u>gene</u> **,** controls / affects **,** the expression of structural <u>gene</u> **;** | **2 max** | **ACCEPT** 'makes regulatory protein'<br>**ACCEPT** 'switching on / off' for idea of control<br>**IGNORE** explanation involving repetition of word "regulates" |

| Question | | | Expected Answer | Mark | Additional Guidance |
|---|---|---|---|---|---|
| 1 | (c) | (ii) | lactose has been , removed / digested / respired / broken down (by bacteria) ;<br><br>to , lactic acid / lactate / other sugars ;<br><br>yogurt still a good source of , calcium / vitamins ; | 2 max | **DO NOT CREDIT** if context wrong (eg heat)<br><br>eg • glucose (and galactose) |
| 1 | (d) | | **1** lactose binds to repressor protein ;<br>**2** changes , shape / structure (of protein) ;<br>**3** removes it from / stops it binding to , operator ;<br><br>**4** RNA polymerase binds to promoter ;<br><br>**5** *idea that* (so that Z and Y) are , transcribed / mRNA made ; | 3 max | ***1*** **DO NOT CREDIT** regulator substance<br>***2*** **IGNORE** ref. to active site<br>***3***<br><br>***4*** **DO NOT CREDIT** DNA polymerase<br><br>***5*** **CREDIT** lactose permease and β-galactosidase for Z and Y<br>**IGNORE** gene , switched on / expressed |
| | | | **Total** | **16** | |

| Question | | | Expected Answers | Marks | Additional Guidance |
|---|---|---|---|---|---|
| 2 | (a) | (i) | red ;<br>vermillion ;<br>cinnabar ; | 3 | |
| 2 | (a) | (ii) | (recessive) epistasis / epistatic ; | 1 | **ACCEPT** complementary epistasis<br>**DO NOT CREDIT** dominant epistasis |
| 2 | (a) | (iii)<br>1<br>2<br><br><br>3<br><br>4<br><br><br>5<br><br>6 | gene products are enzymes ;<br>multi-enzyme / multi-step, pathway ;<br><br><br>3, steps / enzymes, change tryptophan to red pigment ;<br><br>product of one reaction / intermediate compound,<br>is, substrate / starting point, for next ;<br><br>dominant allele gives,<br>functional / wild-type / AW, enzyme ;<br>recessive allele gives,<br>non-functional / different / AW, enzyme ; | max 3 | ***2*** needs to be a clear generalised statement<br>(and not implied - e.g. by awarding mp 3)<br>**IGNORE** 'metabolic' pathway (as given in question)<br>***3*** **ACCEPT** V, C and B are responsible for the change of<br>tryptophan to red |
| 2 | (b) | (i)<br>1<br><br>2<br><br><br><br>3 | *if (red-eyed parent) was heterozygous*<br>there would be no difference between,<br>sexes / males and females ;<br>red-eyed males **and** white-eyed females would occur ;<br><br><br>1:1:1:1 ratio<br>**or**<br>1:1 ratio in both sexes ; | max 2 | **IGNORE** ref to sex linkage<br><br><br>***2*** **ACCEPT** "because there are no red-eyed males<br>**and** white-eyed females (in results)"<br>"*all* 4 phenotypes would, occur / be represented"<br>**DO NOT** infer phenotype(s) from genotype(s)<br><br>***3*** If 4 phenotypes stated / listed *together with the ratio*,<br>then award mp 2 as well |

<table>
<tr><th colspan="3">Question</th><th>Expected Answers</th><th>Marks</th><th>Additional Guidance</th></tr>
<tr><td>2</td><td>(b)</td><td>(ii)</td><td>parental genotypes XrXr XRY- ;<br>gametes Xr XR and Y- ;<br>F1 genotypes XRXr XrY- ;</td><td>3</td><td>ACCEPT alternative letters only if a KEY is given. Must have capital letter for dominant allele and small (same) letter for recessive allele.<br><br>CREDIT GAMETES either on the correct line or in correct place on Punnett square, whichever is correct. They do not need to be in circles.<br><br>ACCEPT ecf once only if Y wrongly shown as carrying ‘r’ allele<br>ACCEPT ecf once only if X and Y missing<br><br>DO NOT CREDIT F1 genotypes written in blank space if F1 phenotypes put on bottom lines instead</td></tr>
<tr><td>2</td><td>(b)</td><td>(iii)</td><td>
<table>
<tr><th>phenotype of fly</th><th>O</th><th>E</th><th>O - E</th><th>$(O-E)^2$</th><th>$\frac{(O-E)^2}{E}$</th></tr>
<tr><td>red-eyed female</td><td>27</td><td>2</td><td>2</td><td>4</td><td>0.16</td></tr>
<tr><td>white-eyed male</td><td>23</td><td>2</td><td>-</td><td>4</td><td>0.16</td></tr>
</table>
;<br>;<br>$\chi^2 = 0.32$ ;<br><br>no significant difference (at 95% confidence level) ;</td><td>4</td><td>One mark per row<br><br>ACCEPT fractions in last column (4/25)<br><br>ACCEPT not significant<br>IGNORE ref to happening by chance<br><br>ACCEPT ecf for last two points<br>IGNORE arguments referring to null hypothesis</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>16</td><td></td></tr>
</table>

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | (a) | | **1** geographical, isolation / separation / barrier **;**<br><br>**2** *idea of* reproductive isolation **;**<br><br>**3** different **,** selection pressures / adaptations (on different islands) **;**<br><br>**4** small **,** populations / gene pools **;**<br><br>**5** *idea of mp 4* resulting in founder effect **;**<br><br>**6** *idea of mp 4* resulting in greater genetic drift **;** | 2 | **1** **IGNORE** allopatric speciation<br><br>**2** e.g. no / less **,** interbreeding between different **,** populations (early) / species (late)<br><br>**3** **IGNOR** different to mainland<br>**ACCEPT** in different environments or conditions they evolve or adapt differently<br><br>**4** **DO NOT CREDIT** small species<br><br>**5** **ACC PT** *idea of mp 4* resulting in greater impact of **,** mutation / input of alleles (migration) / loss of alleles (accidents etc.) |
| 3 | (b) | (i) | 681 **; ;** | 2 | **Correct answer = 2 marks** even if no working shown<br><br>*Expected working*<br>*125 000 – 16 000 = 109 000*<br>*(109 000 ÷ 16 000) x 100 = 681 (%)*<br><br>If answer not rounded or rounded incorrectly<br>**ACCEPT** e.g. 682 **or** 681.3 **or** 681.25 for **1 mark**<br><br>If the final answer is incorrect **and** no mark was awarded for a figure close to correct value,<br>**ACCEPT** the figure 109 000 in the working **or** 125 000 – 16 000 for **1 mark**. |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | (b) | (ii) | **1** habitat / ecosystem , disturbance / destruction ;<br><br>**2** (land used for) (named) building / roads ;<br><br>**3** (land used for) agriculture / farming ;<br>**4** deforestation ;<br>**5** effect of (tourist) , boats / divers, described ;<br><br>**6** more / increased , pollution ;<br>**7** sewage / eutrophication , in sea / water ;<br>**8** oil / fuel , spill in sea ;<br><br>**9** (humans) hunting / collecting / (over-) fishing ;<br>**10** competition from introduced species ;<br>**11** predation / overgrazing , by introduced species ;<br>**12** (new / named) , diseases / pathogens, introduced ; | 6 | **2** e.g. houses, schools, factories **ACCEPT** urbanisation and development for tourism<br><br>**4** **ACCEPT** description e.g. cutting down trees / logging<br><br>**9** **CREDIT** poaching / green sea turtles caught in fish nets<br>**10** **CREDIT** nest / egg , trampling by introduced species<br><br>**12** **CREDIT** West Nile virus / avian malaria / bird flu |
| | | | **QWC** – linking **TWO** ecological pressures above to **TWO** examples of affected species ; | 1 | **Two** Galapagos animals or plants named in context.<br>e.g. • (marine / land) iguana, (lava) lizard, (ground) finch (**mp11** predation by cats)<br>• rock purslane (**mp11** overgrazing by goats)<br>• (giant) tortoise (**mp9** hunting, **mp10** competition from goats)<br>• whale / seal / named fish / sea cucumber (**mp9** hunting)<br>• *Scalesia* tree (**mp4** deforestation, **mp10** competition from red quinine tree)<br>• (blue-footed) boobies (**mp11** predation by rats) |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | (c) | | *economic*<br>fewer jobs / smaller profits / business closure / reduced tourism / less income / less revenue ;<br><br>*ethical*<br>question of , humane killing / animal suffering<br>**or**<br>people suffer through losing their , homes / friends / jobs ; | 2 | **IGNORE** economic loss<br><br>**IGNORE** right to life arguments |
| | | | **Total** | **13** | |

| Question | | | Answer | | Marks | Guidance |
|---|---|---|---|---|---|---|
| 4 | (a) | ( | 1 | artificial selection / selective breeding ; | 3 max | |
| | | | 2 | select (male and female) sheep that are, larger / woollier / meatier/ have desired characteristics ; | | 2 **ACCEPT** 'large / woolly / meaty, male and female that can produce healthy offspring' ;<br>**2** 'sheep' can be inferred from 'individuals' as it is in the stem of the question |
| | | | 3 | crossbreed / breed (together) / mate (together) / interbreed ; | | 3 **ACCEPT** 'reproduce' |
| | | | 4 | select , best / AW, offspring ; | | |
| | | | 5 | *idea of* breeding (and selecting) for , many / several , generations ; | | 5 **IGNORE** traits passed on through generations, answers must imply breeding and selection |
| | | (ii) | | (use of) (named) antibiotics ;<br>(use of) (named) pesticides / insecticides / fungicides ;<br><br>cloning / genetic modification / AW ;<br>artificial insemination / AI / IVF /<br>marker-assisted selection ;<br>hormones ;<br>vaccinations ; | 1 max | **Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**<br><br>**IGNORE** refs to 'fertiliser' etc., as 'sheep' is in question stem<br>**IGNORE** refs to diet<br><br>**ACCEPT** 'steroids' / 'growth supplements'<br>**IGNORE** 'better veterinary care' |

| Question | | | Answer | | Marks | Guidance |
|---|---|---|---|---|---|---|
| 4 | (b) | ( | 1 | broken down by, decomposers / bacteria / fungi ; | 3 max | |
| | | | 2 | add (named) mineral(s) to soil ; | | 2 **IGNORE** nutrients **ACCEPT** ions |
| | | | 3 | nitrate and phosphate and potassium / NPK ; | | 3 **ACCEPT** nitrogen , $NO_3^{(-)}$, $PO_4^{(3-)}$, $K^{(+)}$ $NH_3$, $NH_4^{(+)}$, ammonium, ammonia<br>3 **IGNORE** phosphorous, P , $N_2$ |
| | | | 4 | specific use of (any) named mineral ; | | 4 eg nitrate or nitrogen for protein, magnesium for chlorophyll, etc.<br>4 **DO NOT CREDIT** vague uses like 'nitrate for growth' |
| | | | 5 | lack of (named) , mineral(s) / nutrient(s) / ion(s), is limiting factor (for growth) ; | | |
| | | | 6 | *example of* way in which soil quality is improved ; | | 6 **ACCEPT** for example change in pH / crumb size / air content / moisture content / less leaching of minerals / increased humus / presence of (named) detritivores / less risk of soil erosion |

| Question | | | Answer | | Marks | Guidance |
|---|---|---|---|---|---|---|
| 4 | (b) | (i | 1 | (fertiliser) promotes growth of, one / few, (plant) species ; | 2 max | 1 **ACCEPT** 'once species might grow more than another'<br>1 **IGNORE** 'yield' |
| | | | 2 | other (plant) species , out-competed / AW (as a result of competition from crop species) ; | | 2 **IGNORE** fertilisers / eutrophication , killing other plants<br>2 **ACCEPT** 'other plants die' in the context of their being out-competed by the crop plant |
| | | | 3 | *idea of* disruption of food chains ; | | 3 **DO NOT CREDIT** in the context of biomagnification / eutrophication |
| | | | 4 | *idea of* reduction in , soil quality / humus , over time so plants cannot grow ; | | 4 **ACCEPT** 'might change soil pH so some plants can't grow' |
| | | (iii) | | | 3 max | **IGNORE** answers in the context of genetic variation **within the domestic population**. For example,' if one plant is susceptible to a disease then they might not all die'. |
| | | | 1 | loss of genetic , diversity / variation (in wild population) ; | | 1 **ACCEPT** small / reduced , gene pool |
| | | | 2 | environment / agricultural requirements, may change (in future) ; | | |
| | | | 3 | (lost) genes / alleles , may have been useful ; | | 3 **ACCEPT** 'potential genetic resource may have been lost' |
| | | | 4 | e.g. of gene useful to agriculture ; | | 4 *e.g., gene for* pest resistance / disease resistance / heat tolerance / drought tolerance ;<br>4 **DO NOT CREDIT** immunity to diseases |
| | | | 5 | fewer pollinators ; | | |
| | | | 6 | loss of (pest) predators ; | | |
| | | | | **Total** | 12 | |

| Question | | | Expected Answers | Marks | Additional Guidance |
|---|---|---|---|---|---|
| 5 | (a) | (i) | | | |
| | | 1 | similar / same, cells / metabolism ; | | *1* **ACCEPT** they are all eukaryotic cells |
| | | 2 | similar / same / share, genes<br>**or** have genes in common ; | | |
| | | 3 | similar / same, (embryonic) development ; | | |
| | | 4 | shared, ancestry / ancestor<br>**or** all related by evolution ; | | *4* **CREDIT** due to phylogeny<br>**ACCEPT** all same kingdom<br>**IGNORE** 'they are all animals' |
| | | | | max 2 | |
| 5 | (a) | (ii) | | | **Mark the FIRST answer on each numbered line** |
| | | 1 | small ; | | |
| | | 2 | short life cycle ; | | *2* **ACCEPT** fast development / mature quickly / fast reproductive rate / short generation time |
| | | 3 | easy to, keep / breed / AW ; | | *3* **ACCEPT** produce many offspring |
| | | 4 | cheap (to buy / keep ) ; | | |
| | | 5 | readily available / common / not rare ; | | |
| | | 6 | large cells ; | | |
| | | 7 | previously well-studied / many known mutants ; | | *7* **ACCEPT** genome has been, mapped / sequenced |
| | | | | max 2 | |
| 5 | (b) | (i) | scanning ;<br>electron (microscope) ; | 2 | **CREDIT** SEM = 2 marks<br>**ACCEPT** transmission electron / TEM = 1 mark<br>**IGNORE** micrograph |
| 5 | (b) | (ii) | description of legs in place of antennae in, mutant / 3.2 / AW ; | 1 | **ACCEPT** projections on head / antennae / feelers, longer (in Fig. 3.2)<br>**DO NOT CREDIT** antennae / projections vs. none<br>**DO NOT CREDIT** mandibles / fangs<br>**DO NOT CREDIT** incorrect statement e.g. legs on mouth |
| 5 | (b) | (iii) | homeotic / homeobox / hox ; | 1 | |

| Question | | | Expected Answers | Marks | Additional Guidance |
|---|---|---|---|---|---|
| 5 | (c) | 1 | *synthesis* | | **MAX 6** marks for synthesis<br>**MAX 6** marks for roles |
| | | 2 | DNA, copied into / →, mRNA **or** described ; | | |
| | | 3 | transcription / transcribed ; | | ***1*** **DO NOT CREDIT** descriptions that contain errors |
| | | | one strand copied ; | | |
| | | 4 | | | ***3*** **ACCEPT** coding / sense / non-sense / template, strand (implying one only) |
| | | 5 | complementary base-pairing ; | | ***4*** **CREDIT** description of base pairing as correct to context |
| | | 6 | triplet code / code read in threes / codon is 3 bases ; | | |
| | | 7 | base sequence determines amino acid sequence ; | | |
| | | 8 | translation ; | | |
| | | 9 | ribosomes ; | | |
| | | | role of tRNA described ; **(max 6)** | | ***9*** e.g. "tRNA brings amino acid" or "tRNA anticodon binds to mRNA codon" |
| | | 10 | *roles of polypeptides* | | |
| | | 11 | (named) structural protein ; | | |
| | | | enzymes / catalyse reactions / control metabolism ; | | ***10*** e.g. actin / myosin / collagen / keratin |
| | | 12 | | | |
| | | 13 | hormones / growth factors ; | | |
| | | 14 | receptor proteins ; | | ***12*** **CREDIT** growth hormone / GH / somatotrophin / FSH |
| | | | adenyl cyclase / cAMP ; | | |
| | | 15 | | | ***14*** most likely to be expressed in context of mp 12 |
| | | | idea of switching genes, on / off ; | | |
| | | 16 | | | ***15*** **CREDIT** transcription factors / regulatory proteins / repressor proteins |
| | | | homeotic / homeobox, genes | | |
| | | 17 | **or** homeodomain proteins ; | | |
| | | | *idea of* master switch gene / one gene turns on/off whole set of other genes / cascades of gene switching ; | | |
| | | 18 | | | |
| | | | apoptosis ; **(max 6)** | | |
| | | | | **7 max** | |
| | | | **QWC – balanced account ;** | **1** | At least 2 marks from points 1 - 9 **and** at least 2 marks from points 10 – 18 |
| | | | **Total** | **16** | |