Question			Answer/Indicative content	Marks	Guidance
1		i	25 (%);	1	IGNORE working Examiner's Comments The majority of candidates were able to calculate the theoretical percentage of a heterozygous individual being produced in a cross between two heterozygous individuals.

Question			Answer/Indicative content	Marks	Guidance
		ii	1. (island edges / cacti) subject to, sea/salt, spray; 2. qq (genotype) confers ability to obtain water from salt spray; 3. (gives) selective advantage; 4. (individuals with qq genotype) survive / reproduce; 5. allele / q, frequency increases; 6. directional selection; 7. geographic, isolation / barrier; 8. (means) no new alleles coming in;	4 max	ACCEPT ORA for mp 2 – 5 IGNORE mist / sea water for mp1 and 2 ACCEPT homozygous recessive / 'they' for qq genotype 2. ACCEPT qq gets water supply from salt spray 2. ACCEPT qq genotype confers tolerance to salt (spray) 3. ACCEPT description e.g. 'they are (at an advantage and are) selected for' 5. DO NOT CREDIT gene frequency increases 5. IGNORE 'qq frequency increases' 6. IGNORE natural selection Examiner's Comments Good responses were able to comprehensibly explain how individuals homozygous for the q allele would come to dominate the gene pool of the *Brachycereus* species of cactus in the Galapagos Islands. It was essential to refer to the local conditions where the cactus is subjected to salty sea spray. Candidates realising the prevailing conditions, correctly referred to the qq individuals being able to obtain water from the salty spray, giving them a selective advantage and allowing them to survive. A few acceptable alternative arguments were also seen for the other cacti with the Q allele being unable to thrive. A number of responses failed to go as far as explaining that this selective advantage would result in the frequency the q allele rapidly increasing. Rarely was it mentioned that this was directional selection or that the cactus was geographically isolated with no new alleles coming into the population.
			Total	5	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>2</td><td></td><td></td><td>
<table>
<tr><th>Explanation</th><th>Letter</th></tr>
<tr><td>One gene with two alleles.
The alleles show codominance.</td><td>A</td></tr>
<tr><td>One gene with two alleles, located on an autosome (gene not sex linked).
One allele is dominant and the other is recessive.</td><td>E</td></tr>
<tr><td>Two genes for two different characteristics on two different chromosomes.</td><td>D</td></tr>
<tr><td>A sex linked gene with a dominant and a recessive allele.</td><td>B</td></tr>
<tr><td>Epistasis, where two genes interact to affect one phenotypic character.</td><td>C</td></tr>
</table>
;
;
;
;
;
</td><td>5</td><td>Mark the first answer in each box. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks

Examiner's Comments

Most candidates showed a good understanding of the explanations of each of the examples of inheritance given, and gained full marks for this question. If mistakes were made it was with examples E and D.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>5</td><td></td></tr>
</table>

Question			Answer/Indicative content	Marks	Guidance
3	a	i	*Named treatment for short term:* Haemodialysis; peritoneal dialysis; *long term treatment* kidney transplant; *organ / donor detail* matched MHC antigens / blood groups between donor and recipient **OR** use of close relative to obtain tissue match **OR** ref to cadaver / xenotransplants; *recipient detail* use of immunosuppressant to prevent rejection; *idea of* control of diet / low salt; *operation detail* connection of renal artery and vein / connection to alternative artery (iliac) / old kidney left in place; *detail of alternative long term treatment peritoneal dialysis* dialysis fluid introduced into abdominal cavity **OR** peritoneum acts as the partially permeable membrane **OR** reference to CCPD / described	5	**DO NOT CREDIT** 'kidney or renal' dialysis **DO NOT CREDIT** haemodialysis as a **long term** treatment **ACCEPT** 'alternative treatment' as 'long term' **ACCEPT** alternative correct details **CREDIT** description of CCPD such as attached overnight to a dialysis exchanger **Examiner's Comments** In part **(i)** many candidates misread the question which was about treating kidney failure not treating an E.coli infection. The error was frequently compounded as description was only required for the long term treatment. Many candidates did score maximum marks but many failed to take into account the context of the question.

Question			Answer/Indicative content	Marks	Guidance
		ii	(injections of) erythropoeitin / EPO; *explanation:* (EPO) stimulates, RBC synthesis; as (damaged) kidneys not making EPO; OR (packed red blood cell, whole blood) transfusion; as {damaged) kidneys not making EPO; (so) RBC synthesis not stimulated (by EPO);	3	Examiner's Comments There were some good answers on EPO treatment and on blood transfusions in **(ii)** but many candidates again had lost the context of the question which was kidney damage and answered in terms of iron supplements.
	b		recessive; homozygous / double, recessive; sex; pedigree; fifty / 50;	5	Examiner's Comments Answers were good with the majority of candidates scoring at least 3 marks. The commonest mistakes were autosomal rather than sex linkage and mistake on the probability at the end suggesting this was a guess rather than using a Punnett square. Many scripts did show evidence that this is what good candidates did.
			Total	13	

Question			Answer/Indicative content	Marks	Guidance
4		i	*idea* of greater susceptibility to, infection / pathogens ✓ no / fewer, plasma cells / effector cells / antibodies ✓	2	e.g. immune deficiency/ slower immune response/weakened immune system / longer time to recover from infection IGNORE ref to illness / disease / immunological memory ALLOW 'fewer lymphocytes to produce antibodies' <u>Examiner's Comments</u> This question was generally well answered, with the majority of candidates achieving 1 or 2 marks. Some candidates were not credited a mark for using the term 'illness' or 'disease' rather than referring to an increased risk of infection or susceptibility to pathogens. Fewer candidates were credited the second mark point, but for those that were, the majority stated 'less plasma cells' or 'less antibodies'. Some candidates missed out on this mark by stating what they knew about B cells, but not answering the actual question. For example, only saying 'fewer B lymphocytes are present' or that 'B cells make antibodies', rather than there being fewer B cells making fewer antibodies. There was a misconception amongst a few candidates that B lymphocytes were involved in phagocytosis.

Question			Answer/Indicative content	Marks	Guidance
		ii	(allele is) recessive (because) ✓ healthy parents produce children with the disease ✓ 2 / 5 / 2 and 5 / mothers , heterozygous / carrier ✓ (likely to be) sex-linked / described ✓ (because) on the X chromosome / X linked ✓ only males have the disease/no females have the disease/AW ✓	4 max	ALLOW ‘3 has the disease, but 1and 2 / parents, do not ’ ALLOW ‘7, or / and, 8, has the disease, but, 5 and 6 /parents, do not’ ALLOW 'allele found on the sex chromosomes' <u>Examiner's Comments</u> Again, a well answered question with plenty of opportunities to pick up marks. The majority of candidates were credited 3 or 4 marks here. Most were able to identify that the allele was recessive, sex linked and located on the X chromosome. Marks were lost when candidates misunderstood the reasoning behind only males being affected, and linking this to the Y chromosome. Some candidates gave imprecise answers which did not gain credit e.g. '2 and 5 were carriers' or saying 'males are more likely to have the disease' rather than ‘only males have the disease’.
			Total	6	
5			C	1	
			Total	1	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6</td><td>a</td><td>i</td><td>parental genotypes
TtDd TtDd (1)

gametes
TD, Td, tD, td, (TD, Td, tD, td) (1)

offspring genotypes
TTDD TtDD TTDd TtDd TTdd Ttdd ttDD ttDd ttdd (1)

offspring phenotypes
curly / pink curly / black straight / pink straight / black (1)

phenotype ratio
9:3:3:1 (1)</td><td>5</td><td>ALLOW alternative letters only if clear key given.

Mark each line independently but offspring phenotypes must be correctly linked to genotype.

ALLOW phenotypes and genotypes in Punnett squares.</td></tr>
<tr><td></td><td></td><td>ii</td><td>higher proportion, heterozygous / like parents
OR
alleles not completely re-mixed / AW</td><td>1</td><td>DO NOT ALLOW genes.</td></tr>
<tr><td></td><td>b</td><td>i</td><td>
<table>
<tr><th>Phenotype</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>curly pink</td><td>20</td><td>26</td><td>6</td><td>36</td><td>1.38</td></tr>
<tr><td>curly black</td><td>30</td><td>26</td><td>4</td><td>16</td><td>0.62</td></tr>
<tr><td>straight pink</td><td>21</td><td>26</td><td>5</td><td>25</td><td>0.96</td></tr>
<tr><td>straight black</td><td>33</td><td>26</td><td>7</td><td>49</td><td>1.88</td></tr>
<tr><td></td><td></td><td></td><td></td><td>✓</td><td>✓</td></tr>
</table>
$\chi^2 = 4.84$ (1)
</td><td>1</td><td>Correct answer with no working shown = 3 marks.

ALLOW correct answer in the working if the answer line is left blank.

If O – E incorrect, allow ecf for $(O-E)^2$ line only

If $(O-E)^2$ incorrect, allow ecf for

$\frac{(O-E)^2}{E}$ line only</td></tr>
<tr><td></td><td></td><td>ii</td><td>(conclusion cannot be supported because results) not significantly different from expected (at 95% confidence) (1)</td><td>1</td><td>ALLOW not significant.
IGNORE ‘farmer wrong’, ‘due to chance’.
ALLOW ecf from incorrect chi-square result.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>10</td><td></td></tr>
<tr><td>7</td><td></td><td></td><td>A</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
</table>

Question			Answer/Indicative content	Marks	Guidance
8	a	i	e;	1	CREDIT X^e ACCEPT a single, lower case alternative letter IGNORE 'c' unless it is clearly 'lower case' IGNORE I^e
		ii	X^eY and X^eX^e	1	ecf for the allele symbol in (i)
		iii	X^EX^e	1	ecf for the allele symbol in (i) Examiner's Comments While many were aware that 'e' would be the allele symbol for the condition, some put a genotype (ee) in (i) and only the better candidates went on to give the correct genotypes for (ii) and (iii).
	b	i	1. nucleus / nucleolus; 2. ribosomes;	1	ANSWERS MUST BE IN THIS ORDER ACCEPT RER / rough endoplasmic reticulum
		ii	*idea that* mutation (in DNA) leads to a, stop / termination, codon OR *idea that* DNA sequence is deleted OR idea that mutation leads to more RNA being spliced out; *idea that* translation is terminated by stop codon; no (more) amino acids are added (after the stop codon) / fewer amino acids (in truncated protein);	2 max	IGNORE ref to a base deletion in context of shorter DNA Examiner's Comments Part (i) was synoptic and answered well but in (ii) too many answers were given in terms of changing the sequence of amino acids rather than producing a protein with fewer amino acids.
	c	i	reverse transcriptase;	1	
		ii	somatic (gene therapy);	1	CREDIT augmentation (gene therapy)

Question			Answer/Indicative content	Marks	Guidance
		iii	*Idea that* disease involves a defect in a single gene; no other cause; *idea that* disease is easily identified in sufferers; gene / gene product, is known; gene can be delivered reliably to affected cells;	3	Mp2 ACCEPT idea that disease will be cured / vision will be restored. Mp3 CREDIT reverse argument 'easy to see if it has worked' ACCEPT 'easy to insert the gene' Examiner's Comments This was intended to be accessible so it was disappointing how many candidates did not 'spot' reverse transcriptase or the fact that this would be somatic gene therapy. In part (iii) many candidates did not pick up on the question rubric and answered in terms of germ line therapy or ethics. It would be a worthwhile discussion for Centres to have with their candidates as to what makes some genetic diseases targets for treatment using gene therapy while others are not.
			Total	12	
9			C ☐	1	Examiner's Comments The first question requiring a calculation proved challenging. Only a quarter of candidates worked out that a haploid number of 8 would give 2^8 different gametic possibilities.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
10		i	YR, Yr, yR, yr ☐	1	ALLOW ry, Ry, RY, rY **Examiner's Comments** Almost two thirds of candidates got the mark.
		ii	*genotypes* YyRr, Yyrr, yyRr, yyrr ☐ *phenotypes* yellow round, yellow wrinkled, green round, green wrinkled ☐	2	ALLOW YRyr, Yryr, yRyr, yryr phenotypes must correspond to correct genotype **DO NOT CREDIT** if no or incorrect genotypes are given **Examiner's Comments** Just over half of candidates got full marks but many displayed the results of a dihybrid cross between two parents that were heterozygous for both characteristics – candidates are reminded of the need to read the question carefully. Without the correct genotypes, credit could not be given for any stated phenotypes. A surprising number of responses did not conform to convention, for example writing 'YRyr' instead of 'YyRr'. In the current series this approach did not result in lost marks but candidates are advised to follow convention in future.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
11		i	animal **and** plant **and** fungi;	1	any order **DO NOT CREDIT** other kingdoms **Examiner's Comments** The mark for (i) was rarely awarded. The most common mistake seen was to write animal and plant, but then miss out the fungi kingdom. Some answers incorrectly included protoctista and quite a few answers listed domains or classes instead of kingdoms.
		ii	head-tail orientation / anterior-posterior axis; position / development, of limbs; (traces of) segmentation; position / development, of eyes;	1 max	**IGNORE** dorso-ventral orientation / head, thorax, abdomen / polarity unqualified **ACCEPT** head at one end, tail at the other **ACCEPT** has limbs **DO NOT CREDIT** head segment / thorax segment / abdomen segment **Examiner's Comments** The majority of candidates got this correct, noting the head-tail orientation or position / development of limbs and segmentation. Very rarely was the development of an eye seen. A common error was to mention head at one end and legs at the other, instead of head and tail orientation. Some candidates just mentioned polarity but didn't qualify their answer and vague answers often included references to changes to the body plan, whilst a few misinterpreted the question and talked about genes switching on at different times (this cannot be seen so gained no mark).

Question			Answer/Indicative content	Marks	Guidance
		iii	(A to B) disappearance of tail / AW; (B to C) webbing / tissues /cells, removed between fingers / toes;	2	(B to C) ACCEPT fingers / toes / digits, become more defined / separate / form individual digits IGNORE fingers / toes / digits, forming / developing Examiner's Comments For stages A to B, few candidates indicated that the tail disappeared, instead mentioning other body structures. Candidates often incorrectly wrote about the head becoming detached from the body or about the eyes opening, which gained no credit. For stages B to C, most candidates got the idea of the webbing being removed from between fingers and toes but some did not phrase it accurately enough, instead talking about apoptosis and not what apoptosis meant, or only going so far as to mention the formation/development of digits, which actually occurs in stage B.
			Total	4	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>12</td><td></td><td>i</td><td>1401;;;</td><td>3</td><td>Correct answer = 3 marks

Award 2 max
if answer not given to the nearest whole number or is incorrect or missing,
then

CREDIT correct working in table columns as follows:
both figures in one column correct = 1 mark. (N.B. Minus sign required for column 1)

ALLOW ecf from any incorrect column to 2 max
<table><tr><th>Phenotype of fly</th><th>O - E</th><th>$(O - E)^2$</th><th>$\frac{(O - E)^2}{E}$</th></tr><tr><td>red eye, yellow body</td><td>- 354</td><td>125316</td><td>348 (348.100)</td></tr><tr><td>pink eye, yellow body</td><td>341</td><td>116281</td><td>323 (323.003)</td></tr><tr><td>red eye, ebony body</td><td>369</td><td>136161</td><td>378</td></tr><tr><td>pink eye, ebony body</td><td>- 356</td><td>126736</td><td>352</td></tr></table>
Examiner's Comments

It was pleasing to see that the vast majority of candidates had a thorough understanding of the chi-squared calculation, gaining full marks. Those who didn't tended to pick up 2 marks for getting the column numbers correct as they had made mistakes in their final calculation.</td></tr>
</table>

Question			Answer/Indicative content	Marks	Guidance
		ii	*reject hypothesis because* calculated χ^2 value / 1401, is (much) larger than, critical value / 11.35;	1	ALLOW **ecf** for a correct explanation that corresponds to the candidate's incorrect calculation for (i) CREDIT *idea that* probability that these results are due to chance is (much) less than 1% / 0.01 Examiner's Comments Many candidates gained this mark. Some candidates stated ´accept´ and lost the mark or didn´t give sufficient detail. For instance, several candidates just wrote 'reject hypothesis' without further explanation, and some did not mention critical value or chi squared value in their answers.

Question			Answer/Indicative content	Marks	Guidance
		iii	(autosomal) linkage **or** genes / alleles, are linked; on same chromosome; linked alleles inherited together; Ry and rY (on chromosomes in heterozygotes); crossing-over produced (rare) recombinants; tight linkage / two genes close together;	3 max	DO NOT CREDIT sex linkage IGNORE epistasis ACCEPT annotated drawing ACCEPT recombinant phenotypes described ACCEPT loci close together Note '*The alleles R & y and r & Y are inherited together*' = 2 marks (mps 3 & 4) '*The alleles for red eyes and ebony body, and pink eyes and a yellow body, are inherited together*' = 2 marks (mps 3 & 4) Examiner's Comments This question was very poorly answered. The majority of candidates gave ´epistasis´ as their answer and some also gave ´sex-linkage´ as an answer, which gained no credit. A significant number discussed environmental pressures as being the cause, even though the question asked for a genetic explanation. Those that correctly identified linkage were mostly able to give good descriptions and gain full marks. A few candidates who did mention linkage did not get mp 3 as they mentioned linked genes being inherited together rather than linked alleles being inherited together.
			Total	7	

Question			Answer/Indicative content	Marks	Guidance
13			hox gene does not produce transcription factor / transcription factor not activated (1) molecules signalling apoptosis not produced (1) apoptosis (to separate fingers) does not occur (1)	3	
			Total	3	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>14</td><td></td><td>i</td><td>8.73 or 8.8 ☐☐☐

<table><tr><td>O</td><td>E</td><td>$(O-E)^2 / E$</td><td></td></tr><tr><td>58</td><td>63</td><td>0.40</td><td>25/63</td></tr><tr><td>31</td><td>21</td><td>4.76</td><td>100/21</td></tr><tr><td>21</td><td>21</td><td>0</td><td>0</td></tr><tr><td>2</td><td>7</td><td>3.57</td><td>25/7</td></tr></table></td><td>3</td><td>ALLOW correct answers up to 4 s.f.
ALLOW 2 marks any answer between 8.73 and 8.8

If answer is incorrect
ALLOW 1 mark for correct expected numbers: 63, 21, 21, 7
ALLOW 1 mark for correctly calculated $(O-E)^2/E$
numbers: 0.40, 4.76, 0, 3.57

OR
ALLOW 2 marks for 636 to 638 (ECF from incorrect expected numbers – 9, 3, 3, 1)
Examiner's Comments
Around half of candidates got full marks, but it was hard to give credit for incorrect answers if no working was given. Many candidates made good use of the grid provided. A significant minority of candidates used 9, 3, 3, 1 as the expected numbers but were still able to access two of the three marks. Candidates should be aware answers given to an inappropriate number of significant figures are unlikely to attract full marks.</td></tr>
</table>

Question			Answer/Indicative content	Marks	Guidance
		ii	*supports because…* 1 (critical / table, value =) 7.82 ☐ 2 <u>differen</u>ce is <u>significant</u> as (X^2), higher than, 7.82 / critical value ☐ 3 (less than) 5% / 1 in 20, probability / chance, that difference is due to chance ☐☐ora 4 X^2 / calculated value is, smaller than, 9.35 / value at p=0.025 ☐ 5 greater than, 2.5% / 1 in 40, probability that difference is due to chance ☐☐ora	3 max	ALLOW correct interpretation of significance of incorrect X^2 value in part (i) If candidate has miscalculated degrees of freedom CREDIT only mps 2 and 3 IGNORE reject null hypothesis 1 ALLOW 7.82 highlighted in table 2 ALLOW difference is not significant as (selected number) less than (selected) critical value 3 ALLOW > 5% chance that difference is due to chance (if consistent with candidate's X^2 and critical value) 4 ACCEPT X^2 / calculated value is, close to critical value / 7.82 / value at p=0.05 4 ACCEPT X^2 / calculated value, <, 11.34 / value at p=0.01 5 ACCEPT > 1% probability that difference is due to chance Examiner's Comments This question differentiated well and candidates who had incorrectly calculated the chi squared value in part (i) were not penalised here. Many candidates gained one mark, invariably for identifying the correct critical value at 3 degrees of freedom. Those who chose the wrong critical value were still able to access two of the three available marks. A reasonable minority of candidates gained a mark for correctly stating the relationship between their calculated chi squared value and their chosen critical value in terms of significant difference. Candidates who simply stated 'the results are significant' were not awarded marking point 2. The command word 'discuss' ought to have encouraged candidates to address the implication of the chi squared test in terms of the numerical probability that any difference observed was due to chance but most did not attempt this and only a few were credited with a mark for it.

Question			Answer/Indicative content	Marks	Guidance
		iii	1 (autosomal) linkage ☐ 2 (both) genes / alleles, occur on same, chromosome / autosome / chromatid ☐ 3 no independent assortment ☐ 4 (so) alleles, inherited together / end up in same gamete ☐ 5 (unless) crossing over occurs / chiasma forms between gene loci ☐	3 max	1 IGNORE sex linkage / mutations 1 ALLOW *idea of* lethal genes 1 ALLOW genetic drift if number of individuals is small (in suggestion or explanation) 5 ALLOW if the genes are close together there is less chance of crossing over Examiner's Comments This question also differentiated well between candidates of differing ability. Around a third of candidates recognised linkage and most of these went on to achieve two or three marks. Many candidates cited mutations or random fertilization as a possible explanation, with no credit.
			Total	9	

Question			Answer/Indicative content	Marks	Guidance
15		i	geographic(al);	1	**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** **ACCEPT** ecological **IGNORE** physical / barrier **Examiner's Comments** This question was answered well, but sometimes candidates confused their answer with types of speciation. Allopatric was a common mistake, as was geological as opposed to geographical.
		ii	genetic drift;	1	**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** **Examiner's Comments** The majority of candidates answered this question correctly. The most common error was to name it as mutation.

Question			Answer/Indicative content	Marks	Guidance
		iii	*C because* has the greatest change in allele frequency / described; smaller population / fewer individuals; *idea that* more, subject to founder effect / unrepresentative at start; *(more subject to genetic change because)* each random mating more significant **or** each individual forms a greater proportion of gene pool **or** each individual has greater effects on gene pool (than in large population) **or** easier to lose allele from gene pool;	2 max	**If C not identified then no marks awarded** **Look for comparative points with other populations** **ACCEPT** p and q for allele eg 'frequency of allele in C changed by 0.20 whilst it changed by 0.02 in A and 0.14 in B' **ACCEPT** figs as % **ACCEPT** smallest /fewest **Examiner's Comments** A minority of candidates did not identify C correctly and gained no marks. Identifying C because it has the greatest change in allele frequency or the use of figures to demonstrate the same point was the most common correct answer. Some candidates failed to compare the allele frequency change to other populations so didn't gain the mark. Fewer candidates went onto gain a second mark for identifying C as the smallest population, many attempted it but again without making the answer comparative, gained no credit. Other mark points were very rarely awarded as candidates did not talk about individuals or the gene pool.
			Total	**4**	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>16</td><td>a</td><td></td><td>
<table>
<tr><td></td><td>Male</td><td>Female</td><td></td></tr>
<tr><td>Parental genotypes</td><td>$X^{Cr}X^{Cbl}$</td><td>$X^{Cbr}Y$</td><td>✓
✓</td></tr>
<tr><td>Gametes</td><td>X^{Cr} X^{Cbl}</td><td>X^{Cbr} Y</td><td>✓</td></tr>
<tr><td>F1 genotype</td><td colspan="2">$X^{Cr}X^{Cbr}$ $X^{Cr}Y$ $X^{Cbr}X^{Cbl}$ $X^{Cbl}Y$</td><td>✓</td></tr>
<tr><td>F1 Phenotype</td><td colspan="2">1red male : 1 red female : 1brown male : 1blue female</td><td></td></tr>
</table>
</td><td>4</td><td>One mark for each parental genotype

ALLOW ecf</td></tr>
<tr><td></td><td>b</td><td>i</td><td>1.6 ✓✓</td><td>2</td><td>Two marks for correct answer
If answer incorrect allow one mark for correct completion of table
<table>
<tr><td>$(O-E)^2$</td><td>4</td><td>0</td><td>4</td><td>0</td><td></td></tr>
<tr><td>$(O-E)^2 / E$</td><td>0.8</td><td>0</td><td>0.8</td><td>0</td><td></td></tr>
</table>
</td></tr>
<tr><td></td><td></td><td>ii</td><td>there is no significant difference between the expected and observed results ✓</td><td>1</td><td>ALLOW the observed results are similar to the expected

ALLOW ecf if value of chi-squared is calculated incorrectly</td></tr>
<tr><td></td><td></td><td>iii</td><td>random fertilisation ✓</td><td>1</td><td>DO NOT ALLOW random mating</td></tr>
<tr><td></td><td>c</td><td>i</td><td>value would rise to infinity ✓</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>ii</td><td>idea of:
they were not monogamous / another bird was involved✓</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>iii</td><td>in female offspring the allele for feather colour comes from male parent✓

original male bird did not hold allele for brown feathers✓

brown feather allele in female would not produce brown female offspring✓</td><td>Max 2</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>12</td><td></td></tr>
</table>

Question			Answer/Indicative content	Marks	Guidance
17		i	$q^2 = 15 \div 60$ or 0.25; $q = \sqrt{0.25}$ or 0.5; (p =) 0.5;	3	**Correct answer (0.5) = 3 marks** even if no working shown **No mark for incorrect q^2 value but apply ecf afterwards** **ALLOW** ecf from candidates q^2 value (likely to be 0.87 or 0.9 (if candidate's q^2 = 0.75)) **ALLOW** ecf for p from candidate's calculated q value, (if q value between 0 and 1) **IGNORE** % values given for p (e.g. 50 % for 0.5) **Examiner's Comments** Candidates still struggle with the application of the Hardy - Weinberg principle, and few candidates gained any marks. Often students used BB, Bb and bb instead of the p and q, and an obvious misunderstanding was not recognising the need to start with q^2. Many candidates calculated p instead of q and many also wrote a p answer above the value 1 which demonstrated a lack of understanding that p + q = 1. Those who got the 3 marks usually laid out their mathematics clearly, making it easy to award the three marks, and quite a few gained one or two ecf marks after not calculating q squared correctly, but calculating the q and p values from this.

Question			Answer/Indicative content	Marks	Guidance
		ii	*in the pet shop* 1 population is, small / not (sufficiently) large; 2 not all members of the population are breeding; 3 *idea that* mating is not random; 4 *idea that* migration / emigration / immigration, is occurring; 5 *idea that* the non-brown rabbits could be colours other than white;	2	IGNORE ref to (natural) selection / mutation (as these do not apply to the 'artificial' population in the pet shop) IGNORE 'albinos are infertile' Examiner's Comments It was good to see that the majority of candidates scored both marks on this question. The most common answers were a small population combined with non-random mating.
			Total	5	

Question			Answer/Indicative content	Marks	Guidance
18			*karyotypes* **K1** 2.1a has 46 chromosomes / DS karyotype has 47; **K2** 2.1a has 2 copies of chromosome 21 / DS karyotype has 3; **K3** 2.1a Chromosome 14 copies are different sizes / DS chromosome 14 same size; 1 (translocation) occurs during meiosis; 2 chromosomes / chromatids, break and rejoin; 3 *idea that* a piece of chromosome 21 attaches (to chromosome 14); 4 both copies of chromosome 14 and 21 segregating independently; 5 *idea that* one gamete has (both) chromosome 21 an additional piece of chromosome 21; 6 *idea that* (this) gamete, fertilised by / fertilises, a normal gamete;	6	**ACCEPT** a stage in meiosis e.g. prophase 1 **CREDIT** mps 2 to 6 if shown on annotated diagrams. **CREDIT** sperm or oocyte for gamete in mps 5 and 6 **CREDIT** description of a normal gamete e.g. one copy of 21 **ACCEPT** mp6 in context of Trisomy 21

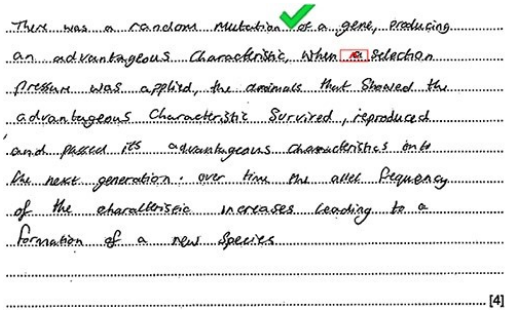
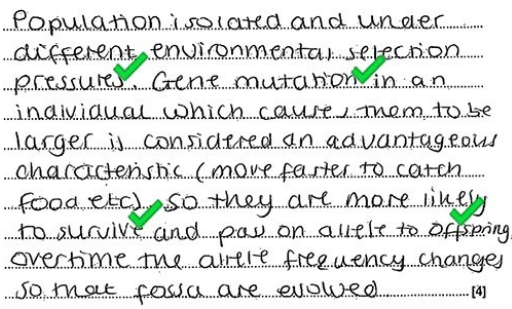
Question			Answer/Indicative content	Marks	Guidance
			QWC;	1	LOOK FOR ONE mark from K1 - K3: AND mps 5 and 6 Examiner's Comments This was split between AO1 and AO2 criteria. This question was split into two parts. The first part required candidates to 'spot' differences between the karyotype shown and that of DS due to Trisomy 21. For many candidates, this was the only mark they achieved. Some weaker candidates confused DS with Turner's or Klinefelter's syndrome. Many candidates could successfully describe what happens in a translocation although some were describing the process but calling it a non-disjunction. However, very few candidates realised that, following translocation, the 'extended' chromosome 14 could segregate with the 'normal' 21 and that it was the fertilisation of a gamete with this combination of chromosomes by a 'normal' gamete that would lead to this karyotype. Candidates are clearly familiar with this inherited form of DS but need far more guidance as to how it is actually inherited.
			Total	7	

Question			Answer/Indicative content	Marks	Guidance
19			2 ✓✓✓	3	Max 2 marks for calculation if answer not to one significant figure (q^2 = 1 in 10,000 = 0.0001) q = 0.01 ✓ (p = 1 – 0.01 = 0.99) 2pq = 0.0198 ✓ 0.02 = 2 marks 1.98 = 2 marks Examiner's Comments Most candidates failed to give the correct final result but managed to score at least one of the three marks available. A high proportion of candidates were able to correctly calculate the value of p and q but then got lost trying to substitute them into the equation. A few candidates calculated 2pq correctly but did not go on to calculate the percentage, while some others followed the calculation to the end but did not round up the result to one significant figure.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
20	a	i	4.7 ✓✓	2 (AO2.6)	*Max 1 if answer not given to 2 s.f.* IGNORE sign If answer incorrect ALLOW 1 mark for 4.8 or 4.9 Examiner's Comments Most candidates scored on this question, either getting the full 2 marks for 4.7 or getting one mark for 4.8 or 4.9 as a result of dividing by the female length rather than the male. The majority of candidates answered to 2 significant figures as instructed.
		ii	little / nothing (can be concluded) ✓ because no (named) statistical test done ✓	2 max (AO3.1)	IGNORE 'not significant' *If no other marks awarded*, ALLOW *1 mark only for…* (probably) not significant because , error bars / standard deviations , overlap Examiner's Comments Less than 1% of candidates gave the full correct answer, i.e. that, without performing a statistical test, nothing can be concluded. However, around a third of responses gained 1 mark by stating that the difference was probably not significant because the error bars overlapped. Although not strictly true, this approach is obviously being taught by centres. Many responses included phrases like 'low significance' or 'not very significant'. These largely meaningless terms gained no credit. Candidates are advised to stick with the absolute term: the difference is or is not significant. A number of candidates confused the percentage difference in height (4.7%) with the 5% probability used to determine significance and gained no marks.

Question			Answer/Indicative content	Marks	Guidance
		iii	*No, because…* *idea that* standard deviation is not the same as range ✓	1 (AO3.2)	ALLOW e.g. SD does not include all outliers / error bars don't show range Examiner's Comments Around half of responses stated, correctly, that the information did not support the candidate's answer and a majority of these gained a mark. A minority, however, believed that the reason the candidate's answer was not supported was that the mean length was that of the longest cheetah. The other half of responses incorrectly stated that the information did support the candidate's answer, usually because they interpreted the error bars as range bars.
		iv	environment ✓ genes / genetic / alleles , and environment ✓ many genes / polygenic ✓ age ✓	2 max (AO2.1)	ALLOW suitable example, e.g. diet Note 'genes and environment' = 2 marks IGNORE refs to mutation Examiner's Comments About half of responses achieved 2 marks. However, many wrote unnecessarily long explanations. The command word 'state' ought to have directed candidates to answer quickly with short, direct, statements. On this occasion a three-word answer 'genes and environment' easily achieved both marks. Many candidates missed the significance of the context of the question, i.e. that body length displays continuous variation and that any contribution from genes is likely to be minimal in the relatively genetically homogenous cheetah population; hence, answers that focussed on genetic variation alone achieved no credit. Responses that did not answer the question, such as lengthy discussions of the potential advantage of longer body length in males, received no credit.

Question			Answer/Indicative content	Marks	Guidance
	b	i	*Fossa has …* longer , legs ✓ different (shaped / size) , ears ✓ (proportionally) bigger eyes ✓	1 max (AO2.3)	*Mark the first response only* *Assume 'it' refers to mongoose* IGNORE references head / body / shape ALLOW ora for mongoose throughout ALLOW longer tail / larger jaw <u>Examiner's Comments</u> The vast majority of candidates achieved this mark. Some were even able to correctly refer to proportional sizes. Those few responses that did not gain a mark tended to refer to differences not visible in the figure or vague differences in body shape.
		ii	1 allopatric speciation ✓ 2 different , selection pressure / environmental conditions (from mainland) ✓ 3 (random) mutation ✓ 4 (fossa-like) individuals with , mutation / (new) feature , survive / reproduce ✓ ora 5 beneficial / AW , <u>alleles</u> passed on ✓ 6 <u>directional</u> selection	4 max (AO2.5)	3 ALLOW pre-existing genetic variation 4 IGNORE best adapted / fittest <u>Examiner's Comments</u> This question differentiated well between candidates of differing abilities and two marks were most commonly scored. The best responses outlined the natural selection of cat-like features using technical terms. Many responses were not credited marks because they did not use the term 'alleles' correctly. Some conflated 'alleles' with 'genes' while others merely referred to traits, characteristics or features. Answers that ignored the context completely struggled to gain full marks as generic references to selection pressures or survival of the best adapted were not credited without a link to the Madagascar/fossa-like context. A minority of responses did not address the question, which the evolution of the fossa, and devoted their entire answer to issues of speciation, gaining little credit. Use of the A

Question	Answer/Indicative content	Marks	Guidance
			Level key term, 'directional selection', was rare. Exemplar 9  There was a random mutation of a gene, producing an advantageous characteristic. When selection pressure was applied, the animals that showed the advantageous characteristic survived, reproduced and passed its advantageous characteristics onto the next generation. over time the allele frequency of the characteristic increases leading to a formation of a new species [4] This response ignores the context of the question and simply discusses natural selection in generic terms. One mark has been credited for discussing mutations but, although the response alludes to marking points 2 and 4, as these are context-dependent, the marks have not been given. Exemplar 10  Population isolated and under different environmental selection pressure. Gene mutation in an individual which cause them to be larger is considered an advantageous characteristic (move faster to catch food etc) so they are more likely to survive and pass on allele to offspring. overtime the allele frequency changes so that fossil are evolved [4] This response achieves full marks for the following marking points: 2 – recognising the context of an environment different from the African mainland, 3, 4 – recognising the context of a vacant large predator niche, and 5.

Question			Answer/Indicative content	Marks	Guidance
		iii	mutation / genetic diversity ✓ natural / directional , selection ✓ *idea that* environment / selection pressure , is <u>different</u> from the 'other' population ✓ time ✓	3 max (AO1.2)	IGNORE refs to isolation ALLOW genetically different / large gene pool ALLOW e.g. different food source ALLOW many generations <u>Examiner's Comments</u> This question was poorly answered with many candidates failing to appreciate the significance of 'other' in the question and, hence, listing methods of reproductive isolation. Mutation and different environmental conditions were the most commonly seen correct answers but references to natural selection and time were rare.
			Total	15	