



Section A – Multiple-choice

This table indicates the number of students who chose each option. The correct answer is indicated by shading.

Question	A %	B %	C %	D %	No Answer %	Comments
1	48	40	9	3	0	The genotypes of the parents are Tt and tt. The offspring will have genotypes of Tt or tt with the corresponding phenotypes 'mackerel tabby' and 'blotched tabby'. There is a 50% chance that any one offspring will be female. Therefore, in 100 kittens there would be approximately equal numbers of males and females, making both alternatives C and D incorrect. In 100 offspring there will be 50 mackerel tabby cats. Half of these will be females, which makes alternative A incorrect. There will only be 25 mackerel tabby females – so alternative B is the correct answer.
2	28	33	8	31	0	Consider the gene controlling the shapes of the tabby stripes. The genotypes of the parents are TT and tt, therefore all offspring will have a genotype Tt. Therefore, it is impossible to have a blotched tabby phenotype, which makes alternatives B, C and D incorrect as at least one of the offspring shown is a blotched tabby. Consider the gene controlling the expression of the tabby pattern in the cats. The parents were both heterozygous so their offspring could be AA, Aa or aa. The genotypes of the offspring with respect to both genes could be Tt AA, Tt Aa, or Tt aa. Offspring with the genotype Tt aa will be solid black in colour, making alternative A the correct answer.
3	11	57	27	4	0	
4	7	5	79	9	0	
5	22	55	18	5	0	A test cross involves a homozygous individual with respect to the recessive trait(s). The only possible genotype of the plant is given in alternative B.
6	7	7	80	5	0	
7	8	10	8	73	1	
8	8	24	57	11	0	
9	1	1	38	60	0	
10	9	30	56	4	0	There are eight nucleotides in the given template strand. A double-stranded DNA molecule consists of two nucleotide chains, therefore there must be 16 nucleotides in the double-stranded molecule formed from this template. Each nucleotide in a DNA molecule has one deoxyribose sugar group, therefore there must be 16 deoxyribose sugar groups in this molecule.
11	62	7	21	10	0	
12	2	2	16	79	0	
13	2	66	24	7	0	
14	9	44	30	16	1	The MN blood group has two alleles, so alternative D is incorrect. A person with the blood type M has a genotype $L^M L^M$ and therefore two copies of the same allele. Forty people with the blood group M will between them have 80 copies of $L^M$ allele (two copies each). Similarly, 40 people with the blood group N will have 80 copies of the $L^N$ allele. A person with the blood group MN will have one copy of the $L^M$ allele and one copy of the $L^N$ allele, so 20 people with the blood group MN will have 20 $L^M$ alleles and 20 $L^N$ alleles. In this group of 100 individuals there will be a total



						of 100 L <sup>M</sup> alleles and 100 L <sup>N</sup> alleles. This makes alternative C incorrect. The total number of copies of these two alleles in a group of 100 individuals is 200. Therefore, the frequency of both alleles in the group is 100/200 = 0.5. Alternative B is the correct answer.
15	4	17	63	17	0	
16	57	29	11	3	0	
17	2	16	79	2	0	
18	39	2	5	54	0	
19	16	7	5	72	0	
20	3	16	65	15	1	
21	94	2	1	3	0	
22	11	4	30	55	0	Homologous chromosomes are a pair of chromosomes that carry the same gene loci. As the form of the gene at a particular locus may vary, homologous chromosomes do not necessarily have the same alleles, so alternative C is incorrect. Different forms of a gene are made after events such as base substitutions or base additions, making alternatives A and B incorrect. Therefore, D is the correct answer.
23	21	17	52	10	0	
24	27	4	59	10	0	A selective agent acts differentially on the variety of phenotypes in a population. In this case the bird is selecting the moth to be eaten, so alternative A is incorrect. From the information given, the conclusions given in alternatives B and D cannot be drawn. The B allele was most likely present in the moth population before 1850, but the dark moths would have been eaten. Therefore, C is the correct answer.
25	3	6	5	86	1	

## Section B – Short answer

### Question 1a

Marks	0	1	Average
%	74	26	0.3

The diploid chromosome number is the number of chromosomes found as homologous pairs in a cell (organism) or the number of chromosomes in a cell (organism) that have two copies of each specific chromosome.

Responses that were not awarded marks included ‘number of chromosomes in a somatic cell’ and ‘ $2n = 16$ ’.

### 1b

Marks	0	1	Average
%	42	58	0.6

Each daughter cell would contain 15 chromosomes.

### 1c

Marks	0	1	2	Average
%	49	28	23	0.8

#### i.

Each gamete of a female will contain eight chromosomes.

#### ii.

Half of the male gametes will contain eight chromosomes and the other half will have seven chromosomes.

Students needed to have both answers to be awarded full marks. Some incorrect answers included seven and a half chromosomes and 15 chromosomes.

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1d

Marks	0	1	2	3	Average
%	31	11	23	35	1.7

Parents

$X^gX^g$  x  $X^G0$   
green female grey male

Offspring

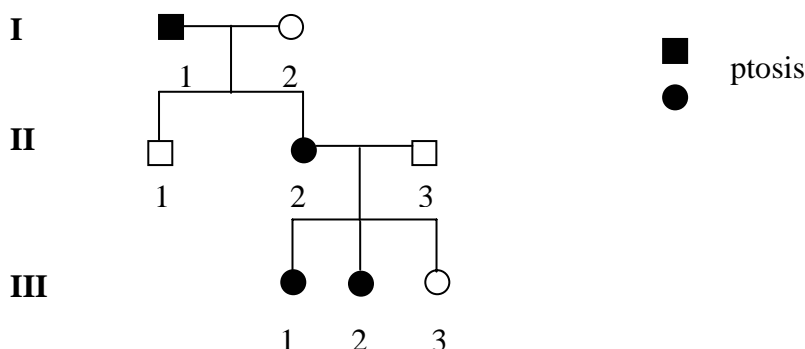
$X^g0$   $X^GX^g$   
green male grey female

One mark was given for correctly showing the parents' genotypes and phenotypes, and two marks for the genotypes and phenotypes of the offspring.

A common error made by students was to complete a punnet square to show the genotypes of the offspring but to make no connection to their phenotypes. These students also often failed to show the parental genotypes and phenotypes. Students whose answer stated the offspring would be green and grey without indicating the sex of the offspring were not awarded full marks. Students are reminded to read the question and formulate an answer that clearly covers all parts of the question.

Question 2a

Marks	0	1	2	Average
%	6	35	59	1.6



One mark was awarded for the pedigree and one mark for the key.

2b

Marks	0	1	2	3	Average
%	36	17	25	21	1.4

i.

The most likely mode of inheritance of ptosis is autosomal dominant.

ii.

- Two affecteds (I-1 and I-2) have unaffected children, so the trait must be dominant. If it was recessive I-1 and I-2 could not have unaffected children.
- There is an affected father (I-1) with unaffected daughters (II-2 and II-3), therefore the trait is not X-linked dominant.

To be awarded full marks the answer needed to have a piece of evidence for dominance and a piece of evidence for autosomal. Students are reminded that the question asked for evidence from the given pedigree and the easiest way to show that the pedigree is being used is to name individuals in the pedigree (for example, I-1).

A common error made by students was to refer to the pedigree that they had drawn in part a of this question.

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## Question 3a

Marks	0	1	Average
%	67	33	<b>0.3</b>

Phenylalanine is converted into tyrosine which is converted into pigment. With low phenylalanine there is reduced tyrosine and therefore reduced pigment in the hair and skin.

Students needed to explain that there is less pigment being made to be awarded the mark. Answers such as 'there is no tyrosine, so no pigment' could not be awarded the mark because tyrosine is still available through a person's diet and so some pigment will be made.

## 3b

Marks	0	1	2	Average
%	54	34	12	<b>0.6</b>

### i.

The control discs show the bacterial growth for different phenylalanine concentrations and are compared to the sample discs to estimate the level of phenylalanine in a baby.

Students were not awarded a mark if their response only stated 'the control is used as a comparison'. Students must relate their responses to the given situation and in this question they were asked why the control discs were included on the plate.

### ii.

All babies will have some phenylalanine in their blood, hence the growth around baby 2's disc. Baby 1's phenylalanine level is in the elevated range associated with PKU.

## 3c

Marks	0	1	2	3	Average
%	16	3	17	64	<b>2.4</b>

### i.

Profile 2

### ii.

There is an elevated phenylalanine level and low tyrosine level.

## 3d

Marks	0	1	Average
%	81	19	<b>0.2</b>

The diet changes the phenotype but not the genotype, so the person has the genotype pp. Therefore they will produce only gametes containing p or gametes containing the allele for the recessive trait.

Students need to be careful in the wording of their responses. A common incorrect statement made was 'the PKU gene was present in the gametes'. The PKU gene will be present in all gametes regardless of the phenotype of the parent. Gametes may have a different allele of the PKU gene.

Students should be able to use correct terminology when referencing genes or alleles of genes.

## 3e

Marks	0	1	Average
%	65	35	<b>0.4</b>

There was a range of acceptable responses for this question, including:

- fear of discrimination as a potential partner
- fear of stigmatisation or discrimination in work or health insurance
- compulsory testing is an invasion of privacy
- compulsory testing may expose non-paternity in a family
- if the condition is untreatable this may result in anxiety for those who can pass it on to offspring or anxiety about reproducing
- screening is pointless if there is no treatment.

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## Question 4a

Marks	0	1	Average
%	38	62	<b>0.6</b>

AUGAAAUUCUCGAAUAGC

Some students transcribed the non-template strand and could not be awarded the mark.

## 4b

Marks	0	1	2	Average
%	35	33	32	<b>1.0</b>

### i.

This mutation is a point mutation or base substitution.

### ii.

There will be a different amino acid in the amino acid sequence. Asn (asparagine) is replaced by Lys (lysine).

## 4c

Marks	0	1	Average
%	78	22	<b>0.2</b>

The amino acid sequence will be shortened as a stop codon has been introduced into the mRNA.

## Question 5a

Marks	0	1	Average
%	84	16	<b>0.2</b>

The genetic code is universal which means that the codons in mRNA code for the same amino acids irrespective of the species.

## 5b

Marks	0	1	2	Average
%	85	6	9	<b>0.3</b>

The DNA is transcribed into mRNA in the nucleus and then translated in the cytoplasm at the ribosome into a polypeptide/protein.

The most common error was that students did not relate expression of a gene to the production of the protein that was coded for by the sea coral gene.

## 5c

Marks	0	1	2	Average
%	32	20	48	<b>1.2</b>

The survival of the Glofish is likely to be poor in the natural environment. The fish would be more noticeable to predators because it is red or glows in ultraviolet light, so may be captured more often. Another reason for the decrease in the number of fish is that they are no longer recognised by the silver fish with black stripes and so have fewer opportunities to mate.

Students often recognised that the fish had less chance of survival but needed to say more than that the fish would be at a disadvantage to be awarded full marks.

## Question 6a

Marks	0	1	Average
%	62	38	<b>0.4</b>

Identical twins are genetically identical, non-identical have variations in their DNA or alleles.

Students needed to make a comparison between the two sets of twins to be awarded full marks. The most common incorrect response given by students was 'identical twins have the same genes while non-identical twins have different genes'. Identical twins will have the same alleles of a particular gene; non-identical twins may have different alleles of a gene.

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6b

Marks	0	1	Average
%	20	80	0.8

Type of twin pair	A. Number of twin pairs	B. Number of twin pairs that one develops asthma	B. Number of twin pairs that both develop asthma	C. Percentage of twin pairs that both develop asthma
Monozygotic (identical twins)	50	25	25	50
Dizygotic (non-identical twins)	100	75	25	25

6c

Marks	0	1	Average
%	23	77	0.8

Identical twins are more likely to share a tendency to develop asthma.

6d

Marks	0	1	2	Average
%	56	16	29	0.8

If asthma were completely genetic, both monozygous twins of a pair would have asthma because they are genetically identical. Therefore, as only 50% of identical twins both develop asthma, the environment must play a role in the development of asthma.

or

Fifty per cent of identical twins do not get asthma. Because they are genetically identical, the other cases must be due to the environment.

Question 7a

Marks	0	1	Average
%	24	76	0.8

Sticky ends are produced by *MstII*.

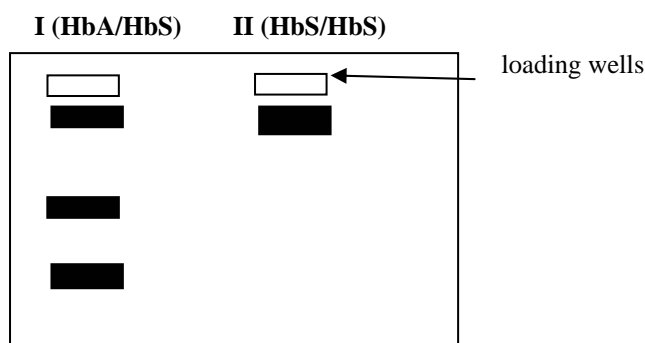
7b

Marks	0	1	Average
%	51	49	0.5

The enzyme does not cut the DNA, or the enzyme no longer recognises the sequence.

7c

Marks	0	1	2	Average
%	52	36	12	0.6



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A person with a copy of the HbA allele will still have the *MstII* recognition sequence and the DNA will be cut into two pieces, one piece of 52 base pairs the other 175 base pairs.

A person with a copy of the HbS allele will not have the *MstII* recognition sequence and the DNA will not be cut, leaving it as a piece 230 base pairs in length.

A person who has the genotype HbS/HbS will have all pieces of DNA 230 base pairs in length and thus present one band on the gel.

A person who has the genotype HbA/HbS will have pieces of DNA 230 base pairs in length as well as pieces of DNA 175 and 52 base pairs in length. There will be three separate bands on the gel, the first lining up with the band created by the person with the HbS/HbS genotype and the other two running further down the gel as they are smaller in size.

## Question 8a

<b>Marks</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>Average</b>
<b>%</b>	63	25	12	

A genetic bottleneck results in a severe reduction in population size and as a consequence allele frequencies may change by chance, which will decrease genetic diversity.

## 8b

<b>Marks</b>	<b>0</b>	<b>1</b>	<b>Average</b>
<b>%</b>	47	53	

There were many acceptable answers to this question. Some of these included:

- the wallabies are well adapted to the environment
- there have been no changes in the selection pressures acting on the wallabies
- the wallabies are protected from new predators as they are on an island.

## 8c

<b>Marks</b>	<b>0</b>	<b>1</b>	<b>Average</b>
<b>%</b>	87	13	

The scientists want to increase the genetic diversity of the wallabies, giving the population a better chance of survival if the environment changes.

## Question 9a

<b>Marks</b>	<b>0</b>	<b>1</b>	<b>Average</b>
<b>%</b>	7	93	

Layer one

## 9b

<b>Marks</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>Average</b>
<b>%</b>	78	18	5	

Any **two** of the following answers were acceptable:

- an index fossil must be distinctive and easily recognisable
- an index fossil should be abundant
- an index fossil lived a short range through time
- an index fossil lived in a wide geographic distribution.

Many students defined an index fossil rather than describing the features of a fossil that would make it useful as an index fossil.

## 9c

<b>Marks</b>	<b>0</b>	<b>1</b>	<b>Average</b>
<b>%</b>	73	27	

**One** of the following was an acceptable method:

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- radioactive isotopes (for example, potassium/argon, argon/argon, lead/lead, uranium/lead)
- stratigraphy, which involves a study of the relative ages of the surrounding rock layers.

Carbon dating was not acceptable, as it only dates to within 30 000 – 50 000 years.

**9d**

Marks	0	1	Average
%	61	39	<b>0.4</b>

The remains have been undisturbed from both scavenging animals and the weather.

Students were not awarded a mark if they stated the cave protected the fossil and gave no further information as to what it was offering protection from.

**9e**

Marks	0	1	Average
%	15	85	<b>0.9</b>

The teeth or jaw would be used to determine that the animal was carnivorous.

**9f**

Marks	0	1	2	Average
%	59	37	4	<b>0.5</b>

The scientists would compare the hard parts of the extinct animal to living species. They would look for points of muscle attachment to animals living today and for indications on the fossil bones where ligaments might have been attached to gain insight into musculature, or compare the sizes and types of bones of the fossil to animals living today to help establish the weight of the fossil.