Model Answers: Medium

1a

a) Mark allocation for the genetic cross would be as follows:

- *parental genotypes*: Tt **AND** Tt; [1 mark]
- *gametes*: T t **AND** T t; [1 mark]
- *offspring genotypes*: TT **AND** Tt **AND** tt; [1 mark]
- *offspring phenotypes*: triangular (fruit shape) **AND** top (fruit shape); [1 mark]

[Total: 4 marks]

The Punnett square for this cross:

		Parent 1 gametes	
		T	t
Parent 2 gametes	T	TT	Tt
	t	Tt	tt

This cross would lead to three possible genotypes:
TT , Tt , tt
Since allele T is dominant over allele t , it would lead to the following phenotypes:
TT and Tt = triangular shaped fruit
tt = top shaped fruit

1b

b) The parental phenotype was triangular shaped fruit because....

- Both parents carried a dominant allele for triangular shaped fruit; [1 mark]
- The dominant allele will always be expressed in the phenotype **OR** the dominant allele will mask the presence of a recessive allele **OR** the recessive allele will only be expressed in the phenotype in the absence of a dominant allele; [1 mark]

[Total: 2 marks]

1c

c) The results from this cross could be interpreted as follow:

- There cannot be a certainty that the genotype of the parent plant is **TT**; [1 mark]

Reason:

- Several test crosses should be done in order to determine whether the recessive allele is present in the parent plant **OR** the number of offspring is not high enough to say with certainty that the recessive allele is not present in the parent plant; [1 mark]

[Total: 2 marks]

For a test cross to be successful it must be repeated several times in order to produce enough offspring to represent all possible allele combinations in the parents. The fact that all the offspring of this test cross showed only triangular shaped fruit does not necessarily mean that the parent plant is homozygous for this fruit shape.

1d

d) The possible phenotype of heterozygous individuals if the alleles for fruit shape were codominant:

- Individuals would carry both triangular and top shaped fruit; [1 mark]

[Total: 1 mark]

In examples of codominance, both alleles are expressed in the phenotype. This means that if the alleles for fruit shape in *C. bursa* was codominant, then both types of fruit shape would be visible in the phenotype of heterozygous individuals.

2a

The phenotypes that is represented by the genotypes in Table 1 is....

- AaBB = purple (flowers); [1 mark]
- AAbb = pink (flowers); [1 mark]
- aaBb = white (flowers); [1 mark]

[Total: 3 marks]

2b

b) The interaction between gene loci responsible for the phenotypes identified in part a) is:

- The presence / absence of allele **A** affects the expression of allele **B**/**b OR** one gene locus masks / suppresses the expression of another; [1 mark]
- This is known as epistasis; [1 mark]

[Total: 2 marks]

When epistasis is involved, it is important to consider the whole combination of alleles from the different genes in order to determine the possible phenotype.

2c

c) Mark allocation for the genetic cross between the two *Salvia* plants would be as follows:

- Gametes of homozygous pink Salvia: Ab; [1 mark]
- Gametes of homozygous white Salvia: aB; [1 mark]
- Genotype of the offspring: AaBb; [1 mark]

[Total: 3 marks]

For the homozygous pink-flowered *Salvia*, the genotype would be AAbb. As there are purple-flowered offspring produced at least one of the homozygous parents had to be BB, meaning the homozygous white-flowered *Salvia* would have a genotype of aaBB.

The Punnett square would look as follows:

		Gametes of Pink flower
		Ab [1 mark]
Gametes of White flower	aB [1 mark]	AaBb [1 mark]

2d

d) The phenotypic ratios of the F_2 generation would be....

- 9 : 3 : 4; [1 mark]
- purple (flowers) : pink (flowers) : white (flowers); [1 mark]

Flower colour must match the correct part of the ratio to receive a mark.

[Total: 2 marks]

The genetic cross would be the following:

F_1 generation:

Genotype: AaBb × AaBb

Gametes: AB Ab aB ab × AB Ab aB ab

F_2:

		Parent 1			
		AB	Ab	aB	ab
Parent 2	AB	AABB	AABb	AaBB	AaBb
	Ab	AABb	AAbb	AaBb	Aabb
	aB	AaBB	AaBb	aaBB	aaBb
	ab	AaBb	Aabb	aaBb	aabb

Phenotype: Purple : Pink : White [1 mark]

Ratios: 9 : 3 : 4 [1 mark]

3a

a) The corresponding genotype and phenotype for the offspring are:

One mark for each correct column:

Phenotype of offspring	**Genotype of offspring**

Non-prickly stem, linear fruit	PPrr **OR** Pprr
Non-prickly stem, round fruit	PpRR
Prickly stem, round fruit	ppRr
Prickly stem, linear fruit	pprr
; [1 mark]	; [1 mark]

[Total: 2 marks]

3b

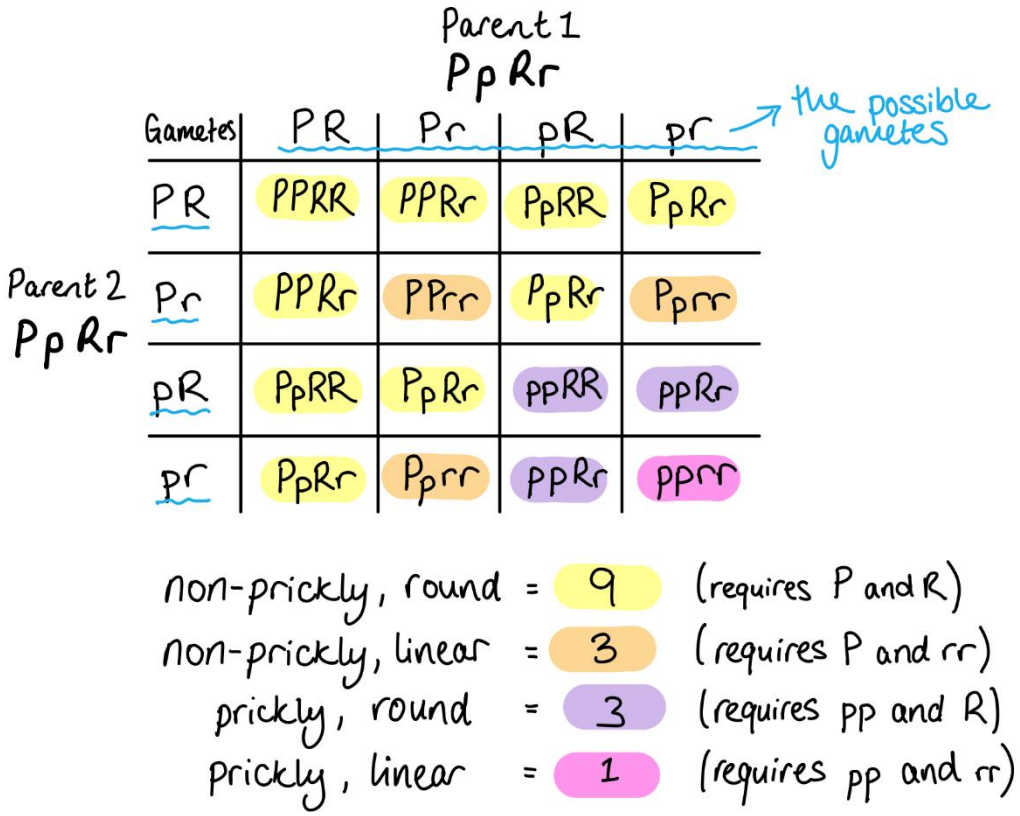
b) The expected ratio for each phenotype is:

One mark for each correct **row**:

Phenotype of offspring	**Ratio of offspring**	
Non-prickly stem, round fruit	9	; [1 mark]
Prickly stem, round fruit	3	; [1 mark]
Non-prickly stem, linear fruit	3	; [1 mark]
Prickly stem, linear fruit	1	; [1 mark]

[Total: 4 marks]

In a dihybrid cross between two heterozygous parents, where the genes are located on different chromosomes it is common to see a ratio of 9:3:3:1.



3c

c) The observed ratios did not reflect the expected ratio of 9:3:3:1 because:

Any **two** of the following:

- The genes are linked **OR** crossing over may have occurred **OR** due to sex linkage; [1 mark]

- Random fusion/fertilisation of gametes occurred; [1 mark]
- Epistasis may be involved; [1 mark]

[Total: 2 marks]

If genes are located on the same chromosome (they are linked in other words) then this limits the possible gametes that can form. Crossing over results in the exchange of genetic material between homologous chromosomes so this can alter ratios. The outcome of fertilisation is unpredictable due to the process of meiosis and the random fusion of gametes, resulting in a different genetic combination every time. When epistasis is involved, the expression of one gene may be influenced by the presence of another. All of these factors can lead to phenotypic ratios that do not correspond with expected values.

3d

d) The reason that allele ***le*** leads to short plants is:

- It produces an enzyme with a different primary structure at the active site; [1 mark]
- This enzyme will be non-functional (as a result); [1 mark]
- No active gibberellin is formed (to cause stem elongation); [1 mark]

[Total: 3 marks]

4a

a) A sex-linked gene:

- Is found on a region of a sex chromosome that is not present on the other sex chromosome; [1 mark]
- The inheritance of these genes is dependent on the sex of the individual **OR** the sex of the individual will affect which alleles are passed on to their offspring; [1 mark]

[Total: 2 marks]

Make sure that you familiarise yourself with the term sex linkage. If a gene is sex-linked, the inheritance of these alleles will be affected by whether an individual is male or female.

4b

b) The ***F8*** gene can affect the phenotype of a person in the following way:

- A copy of the gene/***F8*** (on the DNA) is transcribed to produce (m)RNA; [1 mark]
- This is translated into a polypeptide/protein/Factor VIII (by ribosomes); [1 mark]
- The protein/Factor VIII will affect the phenotype / blood clotting abilities of the person; [1 mark]

[Total: 3 marks]

The blood clotting abilities of the individual will be determined by the allele(s) that's inherited. Inheriting the abnormal allele{s) of the *F8* gene will lead to haemophilia, which results in the inability of blood to clot normally. Even minor injuries can be potentially life threatening due to the lack of clotting factor.

4c

c) The genetic cross would look as follows:

- *parental genotypes* = X^HX^h **AND** X^hY; [1 mark]
- *gametes* = X^H **AND** X^h **AND** X^h **AND** Y; [1 mark]
- *offspring genotypes* = X^HX^h **AND** X^hX^h **AND** X^HY **AND** X^hY; [1 mark]

[Total: 3 marks]

The fact that the female is a carrier of haemophilia, means that she is heterozygous and therefore has one normal allele and one allele for haemophilia. The male has only one

X-chromosome, which contains the allele for haemophilia.
The Punnett square for this cross would be as follows:

		Female gametes	
		X^H	X^h
Male gametes	X^h	$X^H X^h$	$X^h X^h$
	Y	$X^H Y$	$X^h Y$

4d
d) Male offspring cannot inherit haemophilia from their father because....

- They only inherit a Y-chromosome from their father **OR** they do not inherit an X-chromosome from their father; [1 mark]
- The allele for haemophilia is only located on the X-chromosome **OR** the allele for haemophilia is not located on the Y-chromosome; [1 mark]

[Total: 2 marks]

Other sex-linked conditions, such as colour blindness, will also be passed down to male offspring by their mothers. If the mother is a carrier of these alleles, there is a 50% chance that her sons will inherit the abnormal allele and show the condition in their phenotype.

5a
a) The starfish extract could affect the activity of tyrosinase as follows...
Any **three** of the following:

- The greater the concentration of extract the lower the tyrosinase activity / extract concentration is inversely proportional to tyrosinase activity; [1 mark]
- The extract acts as an inhibitor; [1 mark]
- (The extract) binds to the active/allosteric site (of tyrosinase); [1 mark]
- The extract could alter pH; [1 mark]
- The active site is changed (due to inhibition) / the enzymes denatures (due to change in pH); [1 mark]

[Total: 3 marks]

This is another **suggest** question. You need to use your knowledge of factors that affect enzyme action to come up with reasons why the addition of a particular substance might cause activity levels to decrease.

5b
b) i) The terms recessive and allele refer to...
Recessive:

- Only expressed when a dominant allele is not present / in a homozygote **OR** not

expressed in a heterozygote; [1 mark]

Allele:

- A form/version of a gene; [1 mark]

b) ii) A genetic diagram to show how a man and a woman, who both produce melanin, could have a child with albinism would be as follows…

- Use of symbols clearly explained, eg. A = allele for melanin production **AND** a = allele for no melanin/albinism; [1 mark]
- Parental genotypes **AND** gametes shown, e.g. genotypes = Aa and Aa **AND** gametes = A and a (for both parents); [1 mark]
- Offspring genotypes shown **AND** child with albinism clearly identified as homozygous recessive/aa, e.g. (AA **AND** Aa **AND** Aa) **AND** aa; [1 mark]

Allow letters other than Aa to be used as symbols (e.g. Pp for pigment), but upper and lower case must clearly represent dominant and recessive respectively.

Relevant marks for gametes, offspring genotypes, and the child with albinism can all be awarded for answers written within the Punnett square.

[Total: 5 marks]

ii) A Punnett square with clearly explained symbols could have the following appearance.

ii) Construct a genetic diagram to show how a man and a woman, who both produce melanin, could have a child with albinism.

Use appropriate symbols in your answer and state what they represent.

Both parents produce melanin, so must have a copy of the dominant allele.

In order to inherit albinism a child must have two copies of the recessive allele, so each parent must also have a copy of the recessive allele.

Allele for pigment is dominant = A
Allele for albinism is recessive = a
[1 mark]

Parent genotypes: Aa × Aa

gametes: (A) (a) (A) (a)

using circles can help to clearly show gametes rather than genotypes

[1 mark]

	A	a
A	AA	Aa
a	Aa	aa

offspring genotypes

child with albinism

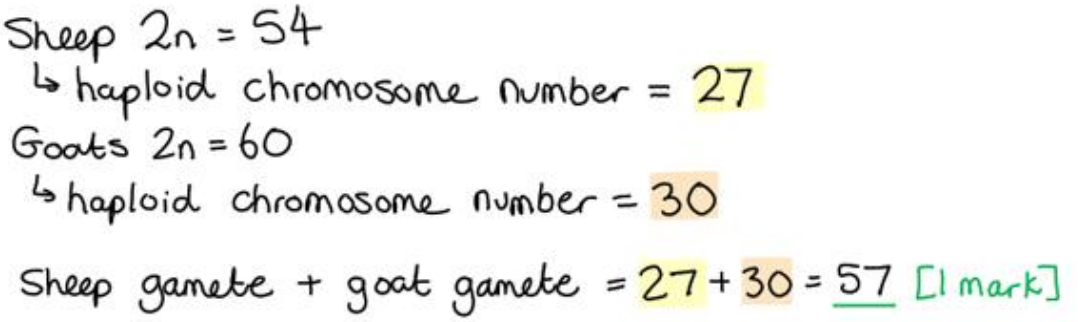
[1 mark]

6a

a) i) The diploid chromosome number of the hybrid offspring of a sheep and a goat is...

- 57; [1 mark]

You need to add together the haploid chromosome number of the two species, not the diploid chromosome number.



a) ii) The classification of sheep and goats suggests that hybridisation between them should **not** be likely to occur because...

- Parents are from a different species/genus; [1 mark]

[Total: 2 marks]

6b

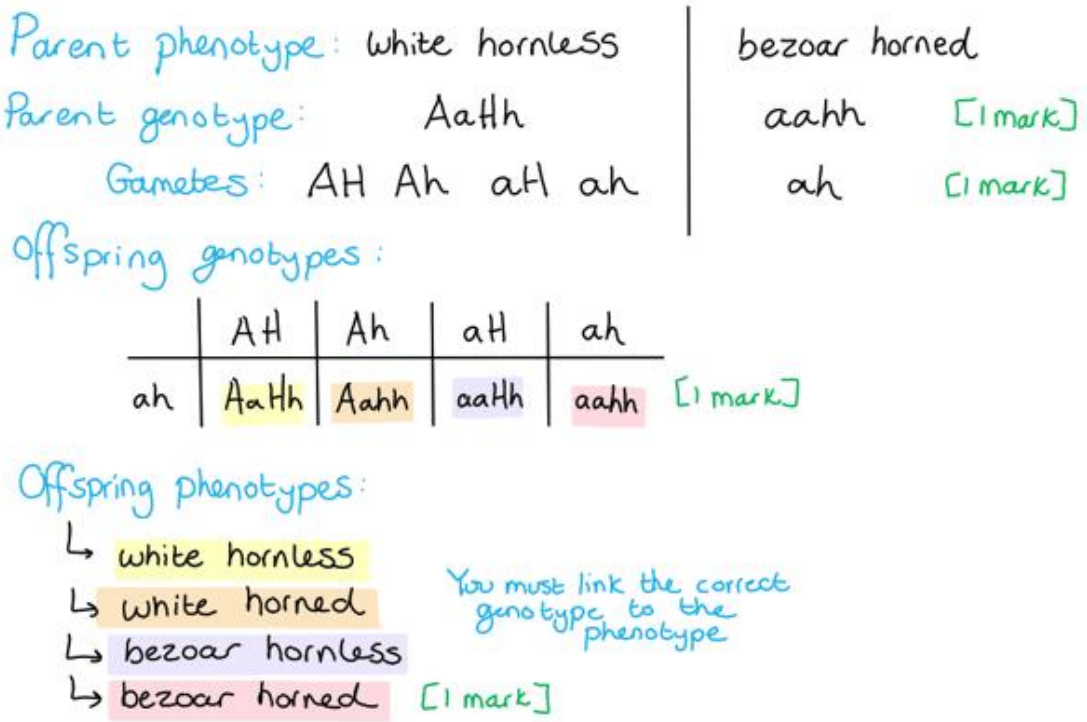
b) A genetic diagram to show the genotypes of the two parents, their gametes and the offspring, and the phenotypes of the offspring is as follows...

- *Parents:* AaHh x aahh; [1 mark]
- *Gametes:* AH Ah aH ah, ah; [1 mark]
- *Offspring genotype:* AaHh Aahh aaHh aahh; [1 mark]
- *Offspring phenotype linked to genotype:* white hornless, white horned, bezoar hornless, bezoar horned; [1 mark]

[Total: 4 marks]

It is really important that you remember to link the correct genotype to the phenotype.

If the white hornless goat was double homozygous recessive (AAHH) then that would not result in four different phenotypes in the offspring. Instead all the offspring would be white and hornless because they would always inherit the dominant alleles, which would be expressed.



6c

c) i) An ethical advantage of this example of genetic modification is…

- Less painful/stressful/harmful for animal; [1 mark]

c) ii) Genetic modification that causes a deletion in the horned allele, in established breeds of dairy cattle, is preferable to selective breeding for hornless animals because…

Any **one** of the following:

- Does not change other genes / only changes one gene; [1 mark]
- Less time consuming / higher success rate; [1 mark]

[Total: 2 marks]

7a

a) Gibberellin is involved in activating genes for stem elongation by…

Any **two** of the following:

- DELLA proteins prevent the activation of genes (for stem elongation); [1 mark]
- Gibberellin binds to receptors (on cell surface membrane); [1 mark]
- Causes breakdown of DELLA proteins; [1 mark]
- (So) transcription / gene expression / gene activation / mRNA synthesis can occur; [1 mark]

[Total: 2 marks]

Gibberellin does not directly influence DELLA proteins, instead the DELLA proteins are influenced by an enzyme, which is produced as a result of gibberellin binding to a receptor.

7b

b) The role played by gibberellin in the germination of wheat seeds is…

Any **four** of the following:

- Seed absorbs water; [1 mark]
- Embryo produces gibberellin; [1 mark]
- Gibberellin moves to/acts on aleurone layer; [1 mark]

- (Where) production of amylase occurs; [1 mark]
- Amylase hydrolyses/breaks down starch in endosperm; [1 mark]
- To maltose/glucose; [1 mark]
- Embryo uses sugars for respiration/growth; [1 mark]
- Gibberellins affect gene/synthesis of mRNA coding for amylase; [1 mark]

[Total: 4 marks]

There is not a direct involvement of starch breakdown products in the embryo in terms of respiration or growth.

7c

c) The growth of **P** and **Q** can be described as follows…

Any **four** of the following:

- Both **P** and **Q** same until day 2/paste applied; [1 mark]
- **P** greater height/taller than **Q** (after day 2/paste applied); [1 mark]
- **P** 35 cm and **Q** 15cm / **P** 20cm longer than **Q** at end (of investigation)/day 20; [1 mark]
- **P** greater rate than **Q**; [1 mark]
- Comparative calculated growth rates for **P** and **Q** e.g. 1.75 (cm day^{-1}) and 0.75 (cm day^{-1}) or 1.89 (cm day^{-1}) and 0.78 (cm day^{-1}); [1 mark]

[Total: 4 marks]

When quoting data in an answer you must always remember to include the units.

7d

d) The role of the gene controlling stem length in pea plants is…

Any **three** of the following:

- Tall pea plants have dominant allele/*Le*; [1 mark]
- (Which codes for) enzyme that produces active gibberellin; [1 mark]
- Dwarf pea plants (only) have recessive alleles/*le*; [1 mark]
- (So) no (active) gibberellin formed; [1 mark]
- GA_1 is the active form of gibberellin; [1 mark]

[Total: 3 marks]