1. The gene for the ABO blood group has three alleles, I^A, I^B and I^o.

(d) A person with blood group O has parents who have blood groups A and B. Complete the genetic diagram to show how this is possible.

Use the symbols, I^A, I^B and I^o, for the blood group alleles.

parental phenotypes	blood group A	×	blood group B
parental genotypes	.....	×	.....
gametes	....	+	....

offspring genotype	.....
offspring phenotype	blood group O

[3]

(e) Use your answer to **(d)** to give examples of the following. The first one has been completed for you.

term	example
a dominant allele	I^A
heterozygous genotype	.....
codominant alleles	.....
phenotype	.....

[3]

2. Fig. 11.1 shows a white sweet pea flower and a red sweet pea flower.

white red

Fig. 11.1

These colours in sweet pea are controlled by a single gene with two alleles.

(a) Define the term *allele*.

.....

.....[1]

(b) A homozygous sweet pea with white flowers was crossed with a homozygous sweet pea with red flowers. All of the offspring had red flowers.

State which allele of this gene is dominant.

.....[1]

(c) Two heterozygous sweet pea plants with red flowers were crossed as shown below.

parental phenotype	**red flowers**	**red flowers**
parental genotype	**Rr**	**Rr**
gametes	**R** **r**	**R** **r**

(i) Draw a Punnet square to show the genotypes that are produced in this cross.

[2]

(ii) State the phenotypic ratio produced in this cross.

..... [1]

[Total: 5]

3. **(a)** Describe the effect sickle cell anaemia has on red blood cells.

.....

.....

..... [2]

(b) **(i)** The allele for normal haemoglobin production is I^N. The allele for sickle cell haemoglobin production is I^S. Two parents who are heterozygous have a child. With the help of a genetic diagram, predict the probability that this child would be heterozygous.

[4]

(ii) Explain why, under some circumstances, people who are heterozygous for this condition have a greater chance of survival than homozygous people.

.....

.....

.....

..... [3]

[Total: 9]

4. **(a)** Four definitions of terms used in genetics are shown in Table 5.1.

Table 5.1

definitions	terms
the outward appearance of an organism	.....
a length of DNA that codes for a protein	.....
having one set of chromosomes	.....
type of nuclear division which gives daughter nuclei that are genetically identical	.....

For each of the definitions, select an appropriate term from the list and write it in the box provided.

chromosome	genotype	mitosis
diploid	haploid	mutation
dominant	heterozygous	phenotype
gene	homozygous	recessive

[4]

(b) A couple who have blood groups **A** and **B** have four children. Each child has a different blood group.

Use the space below to draw a genetic diagram to show how this is possible. Use the symbols, I^A, I^B and I^o, for the alleles.

parental blood groups		**A**	×	**B**
parental genotypes		.....	×	.....
gamete genotypes		.....		.....
children's genotypes	.....	.....	.....	.....
children's blood groups	.....	.....	.....	.....

[4]

(c) Explain what is meant by *codominance*. You may refer to the genetic diagram in **(b)** to help you with your answer.

.....

.....

.....

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.....

.....

..... [3]

(d) Insulin produced by genetically engineered bacteria first became available in 1982. Before 1982, insulin had been prepared from dead animal tissues.

Explain the **advantages** of using insulin produced by genetically engineered bacteria rather than insulin from dead animal tissues.

.....

.....

.....

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.....

..... [3]

5. **(a)** Define the term *self-pollination*.

.....

.....

.....

..... [2]

Snapdragon plants have flowers with three colours: red, pink and white.

Some students investigated the inheritance of flower colour in snapdragons.

In **cross 1** they cross-pollinated plants that were homozygous for red flowers with plants that were homozygous for white flowers. They collected and planted the seeds from cross 1. All of the resulting plants had pink flowers.

In **cross 2** they self-pollinated all the pink-flowered plants and found that in the next generation there were red-flowered plants, white-flowered plants and pink-flowered plants.

(b) Complete the genetic diagrams to show how flower colour is inherited in snapdragon plants.

Use the symbol I^R for the allele for red flowers and I^W for the allele for white flowers.

cross 1

parental phenotypes	red flowers	×	white flowers
parental genotypes	.....	×	.....
gametes	.....		.....
offspring genotypes	.....		
offspring phenotypes	pink flowers		

cross 2

parental phenotypes	pink flowers	×	pink flowers
parental genotypes	.....	×	.....
gametes	....		....

offspring genotypes .....

ratio of offspring phenotypes ..... [4]

(c) Another student cross-pollinated pink-flowered plants with white-flowered plants.

Complete the genetic diagram to show the results that the student would expect.

phenotypes	pink flowers	×	white flowers
genotypes	.....	×	.....
gametes	....		.....

offspring genotypes .....

ratio of offspring phenotypes ..... [3]

(d) Explain the advantages of sexual reproduction to a species of flowering plant, such as the snapdragon.

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 13]

6 Haemoglobin is a protein that is made inside developing red blood cells in the bone marrow.

(a) (i) State the function of haemoglobin.

.....

[1]

(ii) Name the small molecules that are combined to make haemoglobin.

.....

[1]

(iii) Name the mineral ion provided in the diet that is needed to make haemoglobin.

.....

[1]

There are many different varieties of haemoglobin. The gene for haemoglobin exists as two alleles, $\mathbf{Hb^A}$ and $\mathbf{Hb^S}$.

People with the genotype $\mathbf{Hb^SHb^S}$ have a condition called sickle cell anaemia.

(b) Describe the features of sickle cell anaemia.

.....

.....

.....

.....

.....

.....

[3]

(c) The allele for $\mathbf{Hb^S}$ is rare in many parts of the world, but it is more common in parts of tropical Africa.

Explain why $\mathbf{Hb^S}$ is more common in parts of tropical Africa.

.....

.....

.....

.....

.....

.....

[3]

(d) The parents of people with sickle cell anaemia rarely have this condition.

Explain, using a genetic diagram, how two parents who do not have sickle cell anaemia may have a child with the condition.

.....

.....

.....

parental genotypes ..... × .....

gametes .... + ...

genotype of child with sickle cell anaemia .....

[3]

(e) Sickle cell anaemia is an example of variation in humans. There are many causes of variation, including nuclear fall-out.

Suggest how nuclear fall-out could cause variation in humans.

.....

.....

.....

.....

.....

[2]

[Total: 14]

7. The gene for haemoglobin exists in two alternative forms:

H^A codes for the normal form of haemoglobin;
H^S codes for the abnormal form of haemoglobin.

(i) State the name for the alternative forms of a gene.

.....

[1]

(ii) A child has sickle cell anaemia. The parents do not have this disorder.

Complete the genetic diagram to show how the child inherited the disorder.

Use the symbols H^A and H^S in your answer.

parental phenotypes	normal	×	normal
parental genotypes	H^AH^S	×	H^AH^S
gametes	◯ ◯	+	◯ ◯
child's genotype	.....		
child's phenotype	sickle cell anaemia		

[2]

(iii) The parents are about to have another child.

What is the probability that this child will have sickle cell anaemia?

.....

[1]

(c) The maps in Fig. 4.2 show the distribution of sickle cell anaemia and malaria in some parts of the world.

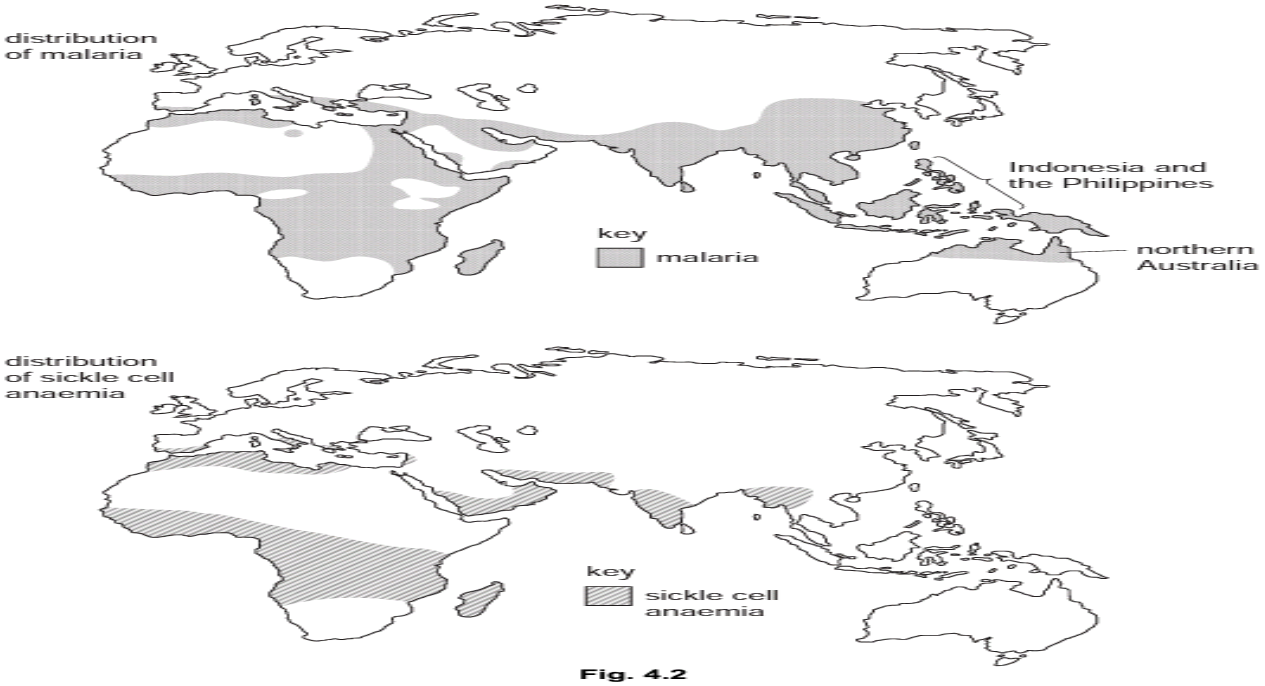

Fig. 4.2

(i) Explain why sickle cell anaemia is common in people who live in areas where malaria occurs.

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.....

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.....

[4]

(ii) Suggest why sickle cell anaemia is very rare among people who live in Indonesia and northern Australia.

.....

.....

.....

.....

.....

[2]

[Total: 14]

8. Haemoglobin is a large protein molecule. The structure of each haemoglobin molecule is controlled by a gene that has two alleles:

- Hb^A codes for the normal form of haemoglobin,
- Hb^S codes for an abnormal form of haemoglobin.

Red blood cells containing only the abnormal form of haemoglobin become a stiff, sickle shape in conditions of low oxygen concentration. This gives rise to sickle cell anaemia.

(a) Describe the harmful effects on the body of having red blood cells which become sickle-shaped.

.....

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..... [5]

People who are heterozygous for the gene for haemoglobin produce both the normal and abnormal forms of haemoglobin. These people show no symptoms or have very mild symptoms known as sickle cell trait.

(b) (i) Complete the genetic diagram to show how a couple who are both heterozygous may have a child with sickle cell anaemia.

parental phenotypes	sickle cell trait	×	sickle cell trait
parental genotypes	.....	×	.....
gametes	(.....) (.....)	+	(.....) (.....)

offspring genotypes	.....	.....	.....	.....
offspring phenotypes	.....	.....	.....	.....

[3]

(ii) What is the chance of a child born to this couple having sickle cell anaemia?

..... [1]

In some parts of the world, up to 25% of the population have sickle cell trait.

(c) State the advantage of having sickle cell trait.

.....

..... [1]

(d) Discuss whether sickle cell trait is an example of codominance.

.....

.....

.....

.....

..... [2]

[Total: 12]

9. One of the genes that controls the ability of blood to clot is found **only** on the X chromosome.

X^H represents an X chromosome with the dominant allele for normal blood clotting.

X^h represents an X chromosome with the recessive allele which causes the blood to clot slowly.

The Y chromosome is small and does not have the gene for blood clotting.

Here is a list of four genotypes.

X^HX^H, X^HX^h, X^HY, X^hY

Choose the genotype from the list that matches each of the following:

- gives a phenotype of long clotting time; .....
- is heterozygous; .....
- is homozygous. ..... [3]

(e) Haemophilia is a rare genetic condition in which the blood clots very slowly.

In the USA, haemophilia affects 1 in 5000 male births each year. In some cases these births occur in families where the condition has not occurred before.

Explain how boys can have haemophilia when the condition has not previously existed in their family.

.....

.....

.....

.....

..... [2]

[Total: 13]

10. In tulip plants, the petals can have markings called flecks.
There are two alleles for flecks in tulip plants: with flecks **F**; and without flecks **f**.

(a) Explain the meaning of the term *dominant* allele.

.....

..... [1]

(b) A tulip grower crosses two tulip plants.

He finds that 76 of the offspring have petals with flecks and 23 of the offspring have petals without flecks.

(i) Complete the genetic diagram to explain this result.

parental genotypes ..... X .....

parental phenotypes ..... X .....

gametes (....) (....) X (....) (....)

offspring genotypes ....

offspring phenotypes petals with flecks present petals without flecks

[5]

(ii) The tulip grower wants to produce a pure-breeding variety of tulips with petals without flecks.

State the genotypes of the parent plants he should use to produce tulip plants without flecks. Explain your answer.

parental genotypes ..... X .....

explanation .....

.....

..... [2]

[Total: 8]

11. The four o'clock plant, *Mirabilis jalapa*, can have flowers of three different colours as shown in Fig. 4.1.

Fig. 4.1

(a) A student crossed some crimson-flowered plants with some yellow-flowered plants (cross 1). She collected the seeds and grew them. All of the plants that grew from these seeds had orange-red flowers.

Complete the genetic diagram to explain the result of cross 1.

parental phenotypes	crimson flowers	×	yellow flowers
parental genotypes	A^CA^C	×	A^YA^Y
gametes	.....	+	.....
offspring genotype	.....		
offspring phenotype	.....		

[3]

(b) The student then carried out three further crosses as shown in Table 4.1.

Table 4.1

	cross	genotypes of offspring
2	offspring of cross 1 × offspring of cross	
3	offspring of cross 1 × crimson-flowered plant	
4	offspring of cross 1 × yellow-flowered plant	

Complete Table 4.1 by writing the genotypes of the offspring of crosses **2**, **3** and **4**, using the same symbols as in the genetic diagram in **(a)**.

Write the genotypes in Table 4.1.

You may use the space below for any working.

[3]

(c) Flower colour in *M. jalapa* is not an example of the inheritance of dominant and recessive alleles.

Explain how the results of the crosses show that these alleles for flower colour are **not** dominant or recessive.

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..... [3]

Flowers from *M. jalapa* were cross-pollinated.

(d) Explain the difference between self-pollination and cross-pollination.

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..... [2]

(e) Some species of plants are self-pollinated.

Discuss the long-term effects of self-pollination on the evolution of these plants.

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..... [4]

[Total: 15]