1. Acrylamide is a chemical that is formed when bread is toasted.

During toasting, acrylamide is made from a chemical called asparagine.

Asparagine is produced in plant cells by an enzyme called asparagine synthetase.

The gene coding for asparagine synthetase needs to be switched on by other proteins.

i. Complete these sentences about how genes are expressed.

Use words from the list.

coding DNA	**denaturing**	**non-coding DNA**
nucleus	**ribosomes**	**transcription**
translation	**tRNA**	

Gene expression can be switched on by the action of other proteins on ..... .

When a gene is expressed, ... occurs which makes mRNA.

The mRNA then moves to the ..... .

Proteins, such as asparagine synthetase are then made by the process of ..... .

[4]

ii. Scientists want to produce a variety of wheat that contains less asparagine.

This is done by preventing expression of the gene that codes for asparagine synthetase.

Describe the difference between this process and genetic engineering.

_____

_____

[1]

2(a). The table shows some details of three genetic diseases that can affect humans.

Disease	Cause	Number of UK cases	Effect
Huntington's	a dominant allele	12 in 100 000 people	The mutation produces a protein that stops the cerebrum communicating with the spinal cord.
Muscular dystrophy (MD)	a recessive allele	1 in 4 000 males	The mutation prevents a muscle protein being made.
Spinal muscular atrophy (SMA)	a recessive allele	1 in 10 000 people	The mutation prevents a protein being made that is needed for motor neurones to work.

All three diseases affect proteins in different parts of the body.

Explain why each of these diseases cause difficulty in moving the legs.

Huntington's _____

_____

MD _____

_____

SMA _____

[3]

(b). Suggest why the mutation that causes Huntington's is dominant but the mutation that causes MD and SMA is recessive.

Use the information in the **effect** column of the table.

_____

_____

_____

[2]

(c). Scientists are trying to develop treatments for Huntington's using stem cells to replace cells damaged by the protein.

Describe **two** risks of using stem cells to treat patients.

1 _____

_____

2 _____

[2]

3. In East Africa, elephants are hunted for their tusks.

Scientists have found that:

- occasionally female elephants are born without tusks,
- the absence of tusks is caused by a mutated dominant allele,
- the allele for an absence of tusks is lethal if inherited by a male embryo.

Explain why the number of tuskless elephants is rapidly increasing in East Africa.

Explain also why the spread of this allele may have negative effects on the elephant population.

[6]

4. A gene controlling a characteristic has two possible alleles, **A** and **a**. **A** is the dominant allele.

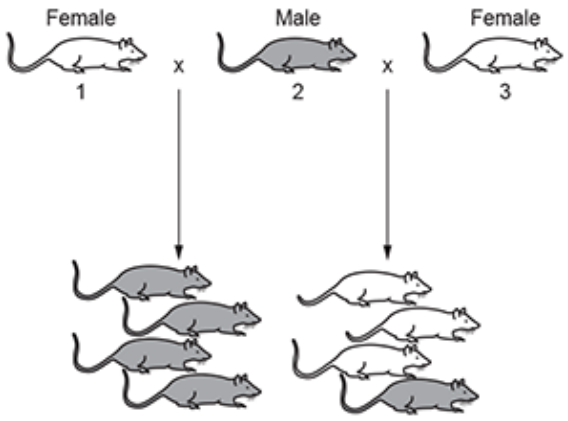
One person is **Aa** and another person is **AA** for this gene.

Which statement correctly describes both people?

A They have different genomes but the same genotype.
B They have different phenotypes but the same genotype for this characteristic.
C They have the same genome but different genotypes.
D They have the same phenotype but different genotypes for this characteristic.

Your answer ☐ **[1]**

5. The diagram shows the results of two different crosses of rats.

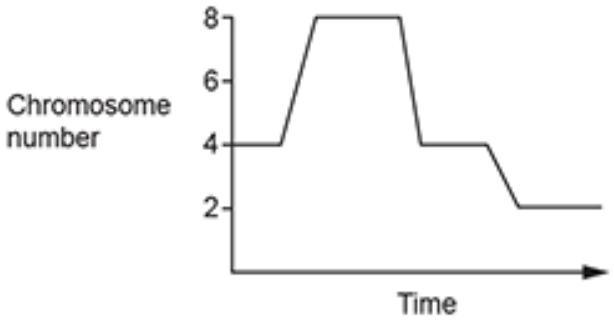


Which is a possible explanation of the results of these crosses?

A Grey is dominant. Rat 2 is heterozygous.
B Grey is dominant. Rat 2 is homozygous dominant.
C White is dominant. Rat 1 is homozygous dominant.
D White is dominant. Rat 2 is heterozygous.

Your answer ☐ **[1]**

6. The graph shows the changes in chromosome number in a cell during meiosis.



What is the diploid number of chromosomes for this cell?

A 2
B 4
C 6
D 8

Your answer ☐ **[1]**

7.

Buddleia, a butterfly's friend?

Buddleia flowers attract butterflies that feed on nectar.

Buddleia bushes produce large numbers of very small seeds. This means that buddleia bushes quickly colonise new habitats.

This has resulted in the populations of other plants decreasing. Scientists have noticed there are large communities of butterflies in these areas but the biodiversity of butterflies is low.

Scientists have suggested two possible methods of reducing the damage caused to habitats by too many buddleia bushes.

Explain how each of these methods would reduce the damage to habitats.

i. genetically engineering buddleia bushes that produce larger seeds

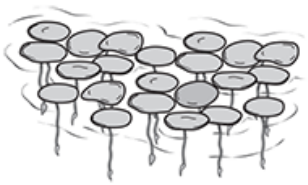
[2]

ii. producing hybrid buddleia bushes that have uneven numbers of chromosomes, which prevent meiosis occurring

[2]

8. Some students investigate the effect of run-off water from a farm on the growth of plants. The run-off water is washed off the fields in the farm when it rains.

They use a pond plant called duckweed, shown in the diagram. A duckweed plant has a single leaf that floats on the surface of the water.
They chose duckweed because it is easy to count the plants.



This is the method they follow:

- Put different volumes of clean pond water and run-off water into 4 beakers.
- Add 3 duckweed plants into each beaker.
- Leave the beakers for ten days at the same temperature.

The table shows the results.

Beaker number	Contents	Number of duckweed plants after ten days
1	250 cm^3 of pond water	6
2	230 cm^3 of pond water + 20 cm^3 of run-off	12
3	210 cm^3 of pond water + 40 cm^3 of run-off	24
4	190 cm^3 of pond water + 60 cm^3 of run-off	48

Duckweed plants reproduce by dividing into two.

i. What is the name given to this type of reproduction?

---------- **[1]**

ii. In beaker **4**, how many generations of duckweed plants are present after 10 days?

Number of generations = ... **[1]**

9. Human fetuses have a different form of haemoglobin to adults.
When a baby is born, a gene called BCL11A produces a protein that switches off the production of fetal haemoglobin.

Sickle cell disease affects adult haemoglobin but **not** fetal haemoglobin.
Scientists are trying to treat sickle cell disease by targeting the BCL11A gene.

How could this new treatment for sickle cell disease work?

A Disabling all the ribosomes in the cells to prevent protein synthesis
B Genetically engineering cells by inserting extra copies of the BCL11A gene
C Making sure that the translation of the BCL11A gene continues after birth
D Preventing the BCL11A gene from being expressed, so that transcription of the fetal haemoglobin gene continues

Your answer ☐ **[1]**

10. Which statement about genes and alleles is correct?

A Mutations can produce new genes but not new alleles.
B Only genes but not alleles can be dominant or recessive.
C The alleles of a gene are always found on the same pair of chromosomes.
D There can only be two different alleles of each gene in a population.

Your answer ☐ **[1]**

11. In 2022, there were 66 900 000 people living in the UK.

Estimate how many of these people have a Y chromosome in their cells.

Individuals of each sex in the UK (%)	
males	females
49.2	50.8

A 32 914 800
B 33 985 200
C 50 442 600
D 66 900 000

Your answer ☐ **[1]**

12. What is the definition of the **genome**?

A All the alleles that are expressed in the phenotype of an individual.
B All the coding DNA that is present in an individual.
C All the genetic material that is present in an individual.
D All the non-coding DNA that is present in an individual.

Your answer ☐ **[1]**

13. Which sentence describes Gregor Mendel's discovery that helped develop our understanding of genetics?

A Characteristics are controlled by DNA found in the nucleus of each cell.
B Characteristics are controlled by factors and these factors can be dominant or recessive.
C Chromosomes are found in pairs and one from each pair is found in the gamete.
D Genes are found on chromosomes and each chromosome is made of DNA.

Your answer ☐ **[1]**

14(a). Read the text below about two different genetic disorders or syndromes.

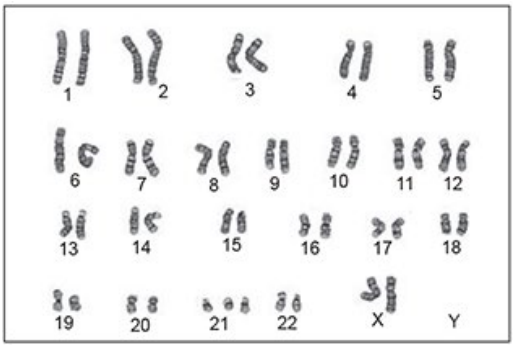
Human genes are found on chromosomes in the nuclei of cells.

In body cells, there is the diploid number of chromosomes, and in gametes there is the haploid number.

Sometimes a gamete is formed that has an extra chromosome.

- If this is chromosome number 18, a child with Edward's syndrome can be born.
- If it is chromosome 21, a child that has Down's syndrome can be born.

The diagram shows the chromosomes found in a cell of a child.

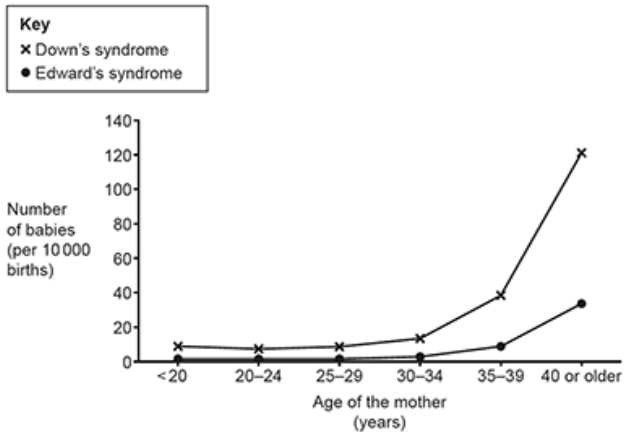


Write down **two** conclusions that can be made about this child from the diagram.

1 _____

2 _____ **[2]**

(b). The graph shows how the number of babies born with Down's syndrome or Edward's syndrome varies with the age of the mother.



i. Give **two** conclusions that can be made from this graph.

1 _____

_____

2 _____

_____ **[2]**

ii. In the ovary, meiosis starts before a woman is born and is not completed until just before ovulation.

How does this information explain the trends shown in the graph?

_____

_____

_____ **[1]**

(c).

i. Explain the difference between haploid and diploid cells.

_____

_____

[2]

ii. Explain how meiosis usually makes gametes that will produce children without these genetic disorders.

[2]

15(a). The diagram shows a tulip plant. Many gardeners like to grow tulip plants.

Tulips can be grown from seeds produced from sexual reproduction.

They can also be grown from bulbs that are produced by asexual reproduction.

Explain why most gardeners choose to grow bulbs produced by asexual reproduction rather than seeds.

[2]

(b). In 1637, tulip growers found that a small number of their tulip plants produced flowers with different coloured stripes.

Until recently, there were two possible theories that explained the colours of these tulips.

Theory **1** -	The stripes are caused by a mutation in the gene that produced the chemical that coloured the flower.
Theory **2** -	The stripes are caused by a pathogen that infects the plant and changes the production of the coloured chemical.

Put ticks (✓) or crosses (✗) in the table to show whether each theory would produce changes in the phenotype and in the genotype of the tulip plants.

	Theory 1	Theory 2
Changes the phenotype of the tulip plant		
Changes the genotype of the tulip plant		

[2]

(c). Scientists now know that the colour changes are caused by a virus which infects the tulip tissue.

- The virus is injected into the phloem of the tulip by feeding insects.
- Although the infected bulbs produce attractive flowers, the infected bulbs become weaker every year until they die.

i. 2.0×10^9 tulips are grown in the Netherlands every year. This uses 14 200 hectares of land.

1.5% of all the tulips grown are infected.

Calculate how many infected tulips there are in one hectare of land.

Number of infected tulips = ... **[2]**

ii. * Growers need to identify infected tulips as soon as possible.

This allows them to only spray a small area with insecticide.

Scientists have developed a machine that moves rapidly through the fields scanning for infected tulips.

The text box shows the results of a trial of the machine in a field containing 1000 tulips.

The results of a trial of the machine are:

Actual results:
- 15 tulips infected
- 985 tulips not infected

Machine results:
- All 15 infected tulips identified
- 14 not infected tulips identified as infected
- 971 not infected tulips identified as not infected

Discuss the advantage of early detection of infected tulips and how useful the machine may be in making this possible.

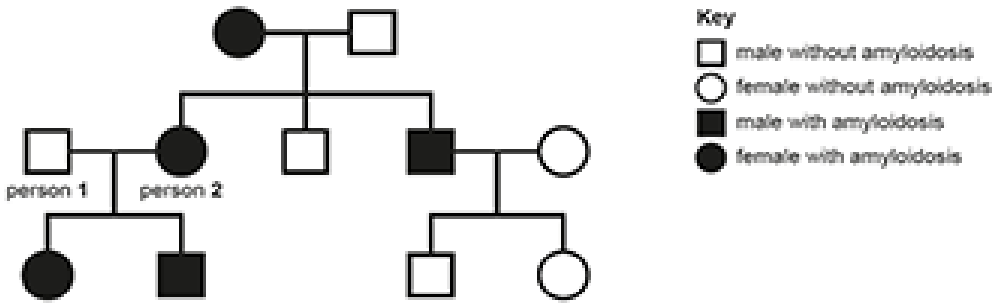
Use data from the text box in your answer.

[6]

16. Amyloidosis is a group of inherited conditions that affect people's health.

The most common type of amyloidosis is caused by a dominant allele (**A**) of a gene.

The diagram shows the inheritance of amyloidosis in a family.



i. Complete the table about the family tree.

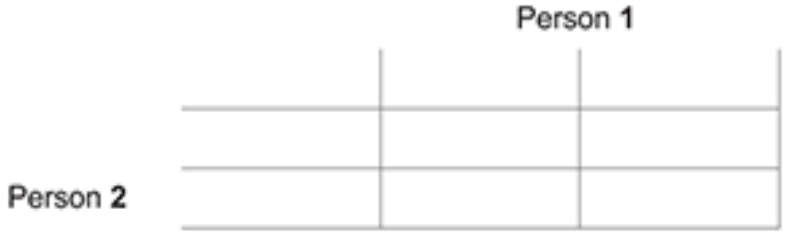
The first row has been done for you.

	Number of people in the family
males	6
people who are **homozygous recessive** for the gene	
people who are **homozygous dominant** for the gene	

[2]

ii. Person **1** and person **2** are expecting another baby.

Complete the genetic diagram to find the probability that the baby will have amyloidosis.



Probability = ... **[3]**

END OF QUESTION PAPER