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H

Wednesday 15 June 2022 – Morning

GCSE (9–1) Biology A (Gateway Science)

J247/04 Paper 4 (Higher Tier)

Time allowed: 1 hour 45 minutes

You must have:
- a ruler (cm/mm)

You can use:
- a scientific or graphical calculator
- an HB pencil

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if the answer is wrong.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **32** pages.

ADVICE
- Read each question carefully before you start your answer.

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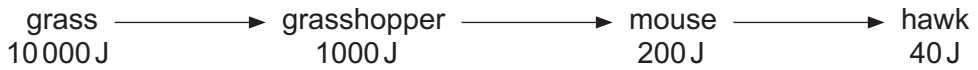
SECTION A

Answer **all** the questions.

You should spend a maximum of 30 minutes on this section.
Write your answer to each question in the box provided.

1 The diagram shows the energy trapped as biomass at each stage of a food chain.



What is the percentage efficiency in the transfer of energy between the grasshopper and the mouse?

A 0.2%

B 8%

C 10%

D 20%

Your answer ☐ **[1]**

2 What is the definition of a genome?

A All the genes present in a community of organisms.

B All the genes present in a gamete.

C The entire genetic material of an organism.

D The genes inherited by an offspring from their mother.

Your answer ☐ **[1]**

3 What is phylogenetics?

A Classification using behavioural characteristics

B Classification using evolutionary links

C Classification using physical characteristics

D Classification using species name

Your answer ☐ **[1]**

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4 Which of these is a use of monoclonal antibodies?

A Detecting antigens in pregnancy testing.

B Removing cholesterol from blocked arteries.

C Sterilising instruments used in operations.

D Vaccinating people against type 2 diabetes.

Your answer ☐ **[1]**

5 What is the definition of a parasite?

A An organism that kills another organism and then feeds from it.

B An organism that kills another organism by out-competing it.

C An organism that lives on or in another organism causing it harm.

D A microorganism that causes disease in another living organism.

Your answer ☐ **[1]**

6 Animal populations can be estimated using a method called capture-recapture.
The number of animals in the population is estimated using the formula:

$$\text{population estimate} = \frac{\text{number in first sample} \times \text{number in second sample}}{\text{number of marked animals in second sample}}$$

Sometimes marking the animals makes them less well-camouflaged.

What effect would this have on the population estimate?

A The estimate is always too high.

B The estimate is always too low.

C The estimate is either too high or too low.

D There is no effect on the estimate.

Your answer ☐ **[1]**

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7 The table shows the number of insects caught using a net in a week.

Day	**M**	**Tu**	**W**	**Th**	**F**	**S**	**Su**
Number of insects	6	8	5	4	8	9	2

Which of these types of average have the same value for this data?

A Mean and median

B Mean and mode

C Median and mode

D Median, mode and mean

Your answer ☐ **[1]**

8 Which is a description of an antigen?

A A chemical group on the surface of a pathogen.

B A chemical that kills bacteria or stops them dividing.

C A drug that is used to kill viruses.

D A protein molecule made by white blood cells.

Your answer ☐ **[1]**

9 Charles Darwin and Alfred Wallace were both involved in the development of the theory of evolution by natural selection.

How were they involved?

A Darwin first suggested the theory and Wallace developed it a hundred years later.

B They both travelled together on a ship called the Beagle.

C They worked together writing a book called ‘On the Origin of Species’.

D They wrote scientific papers separately but then presented them together.

Your answer ☐ **[1]**

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10 Which statement is correct about HIV/AIDS?

A AIDS is a virus that weakens the immune system.

B HIV and AIDS are alternative names for the same disease.

C HIV is a pathogen and AIDS is a set of infections.

D HIV is a virus that produces toxins which kill an infected person.

Your answer ☐ **[1]**

11 New medicines can be tested in different ways.

Which is the main reason for testing a new medicine using tissue culture?

A To predict the effects on body systems.

B To see if it affects other organs.

C To see if it harms cells.

D To see if it reduces symptoms.

Your answer ☐ **[1]**

12 Errors in experiments can be random or systematic.

- A student investigates the effect of fertilisers on the dry mass of seedlings.
- They use pots of seedlings, solutions of fertilisers and a mass balance.

Which of these would produce a systematic error in the student's results?

A Some of the seedlings receive more light than others.

B Some of the seedlings are infected by a fungus.

C The student's mass balance is not calibrated correctly.

D The temperature in the classroom changes during the experiment.

Your answer ☐ **[1]**

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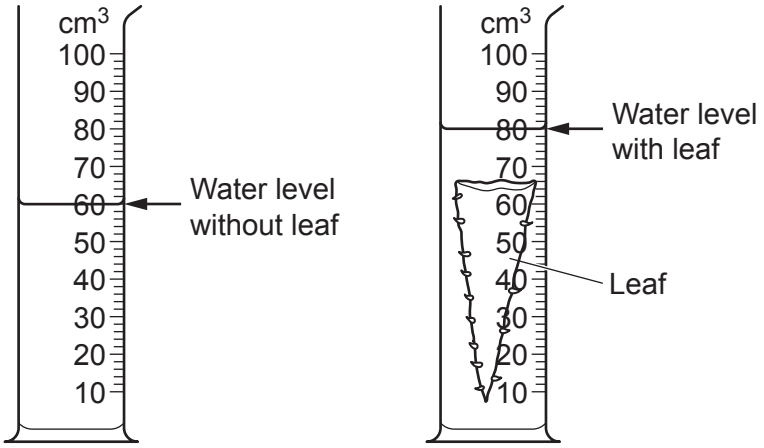
13 A teacher measures the volume of a leaf by placing it in a measuring cylinder of water.

They take the two measurements shown in the diagram.



The uncertainty of the scale is half of the smallest divisions shown on the scale.

What is the volume of the leaf, including the correct level of uncertainty?

A $20 \pm 0.1\,cm^3$

B $20 \pm 0.2\,cm^3$

C $20 \pm 1\,cm^3$

D $20 \pm 2\,cm^3$

Your answer ☐ **[1]**

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14 Genetic engineering involves the use of vectors.

Which is an example of a vector?

A A set of unpaired bases on the end of a DNA molecule.

B A small ring of DNA present in a bacterium.

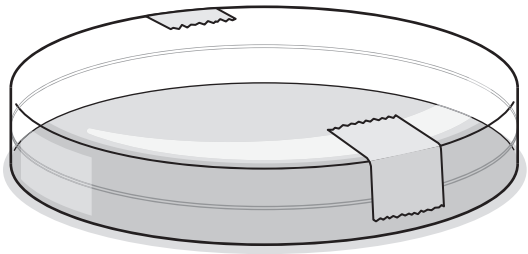
C An enzyme that joins together two pieces of DNA at specific sites.

D An organism that has undergone genetic modification.

Your answer ☐ **[1]**

15 A scientist inoculates an agar plate with bacteria.

The plate is now ready to be incubated.



Why do they seal the lid with two strips of tape, rather than sealing it all round the lid?

A If sealed all round the lid, no bacteria could grow.

B To make it easier to remove the lid after incubation.

C To prevent water condensing on the lid of the Petri dish.

D To reduce the chance of pathogenic anaerobic bacteria growing on the dish.

Your answer ☐ **[1]**

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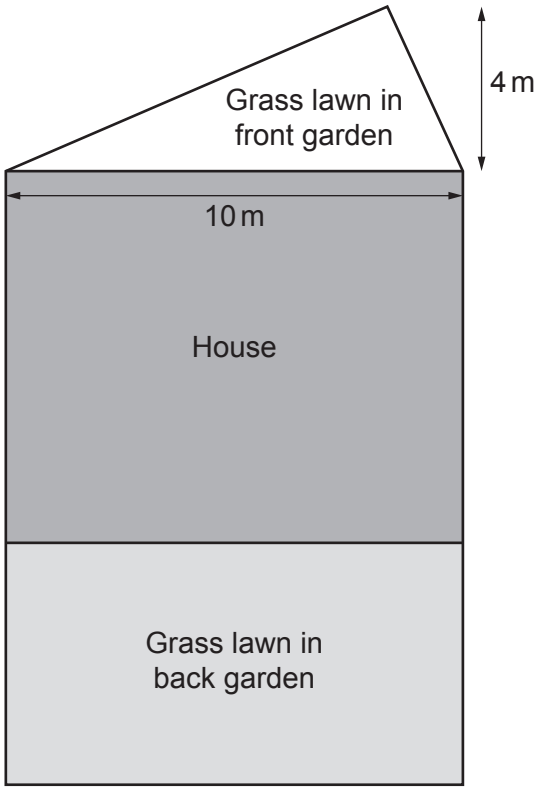
SECTION B

Answer **all** the questions.

16 A gardener grows thistle plants as weeds in his grass lawns.
He wants to see if thistle plants grow better in the front garden than in the back garden.

The diagram shows a plan of the grass lawns in each garden.



(a) The gardener estimates the number of thistle plants in each metre squared of the **back** garden. He gets an estimate of 2.5 thistle plants / m^2.

Describe an experimental method the gardener uses to get this estimate.

Include the name of the piece of apparatus he uses.

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..... **[3]**

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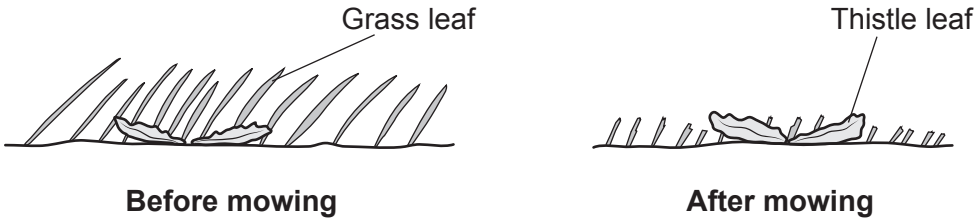
(b) The **front** garden is smaller so he counts all the thistle plants growing in the lawn.
He counts 36 plants.

Calculate the number of thistle plants per metre squared in the front garden.
Use the formula: area of a triangle = ½ × base × height

Number of thistles = ... / m^2 **[2]**

(c) The gardener cuts the grass more often in the back garden. He thinks thistles grow better when he mows the grass more often.

The diagram shows the grass lawns before and after he has mown them.



Explain how cutting the grass more often can affect how well the thistles grow.

Use ideas about competition and photosynthesis.

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..... **[3]**

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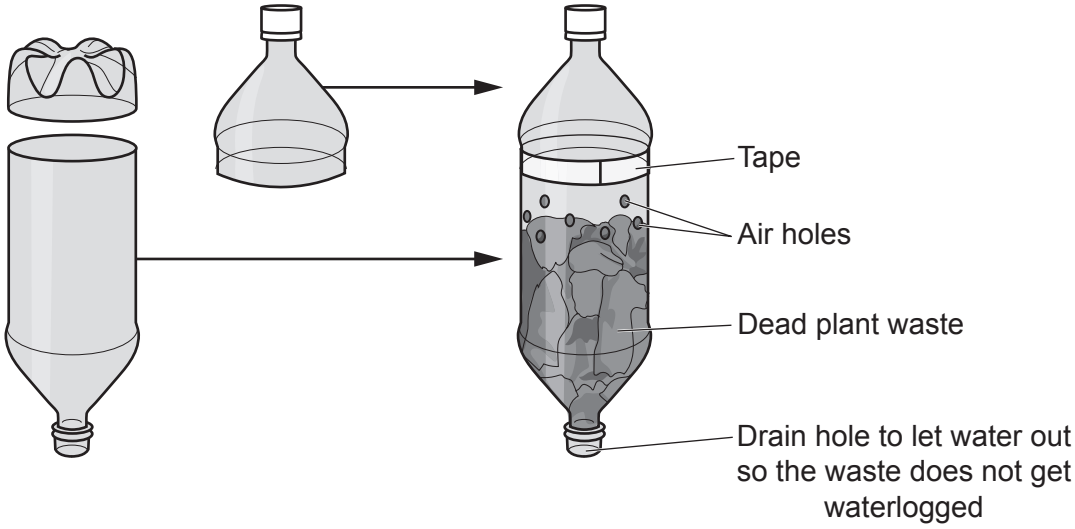
17 Some students investigate decomposition of dead plant waste.
They make a composter from two plastic bottles.



(a) Why do the students make air holes in the bottle?
Tick (✓) **one** box.

To allow heat into the bottle. ☐

To allow oxygen gas into the bottle. ☐

To prevent the build-up of nitrogen gas in the bottle. ☐

So that carbon dioxide gas can enter. ☐

[1]

(b) The students want to see if the number of air holes in the bottles affects the rate of decomposition.

- They set up bottles with different numbers of air holes.
- They then measure the mass of the bottle and compost at the start and after four weeks.

The table shows their results.

	Mass of bottles and plant waste (g)	
Number of air holes	**At the start**	**After 4 weeks**
2	300	270
4	300	250
8	300	240
16	300	235

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(i) Calculate the loss in mass **per week** of the bottle and plant waste with 16 air holes.

Give your answer to **3** significant figures.

Loss in mass = ... grams / week **[3]**

(ii) Describe the effect of the number of air holes on the rate of decomposition of the plant waste.

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..... **[2]**

(iii) The students checked that all the bottles and plant waste had a mass of 300 g at the start of the experiment.

Explain why this helps the students to analyse the results.

.....

..... **[1]**

(iv) What is the independent variable in the students' investigation?

..... **[1]**

(v) The students notice that during the experiment, water drips through the drain hole at the bottom of the apparatus on to the floor.

Explain why this can produce inaccurate results **and** how the students can change their method to correct this.

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..... **[2]**

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18 The diagram shows a tulip plant. Many gardeners like to grow tulip plants.

(a) 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.

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..... **[2]**

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(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]

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(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]**

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***(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.

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..... **[6]**

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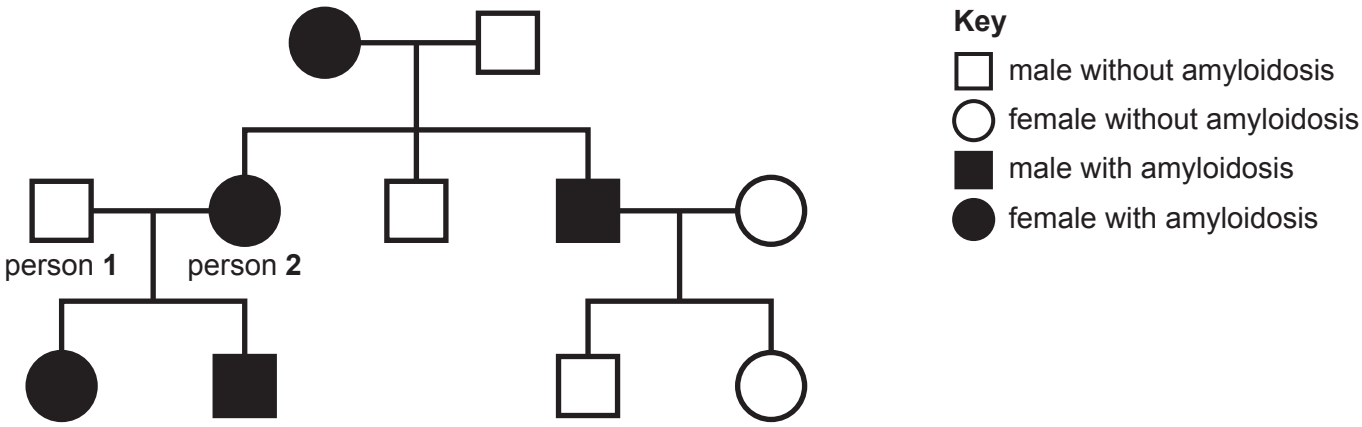
19 Amyloidosis is a group of inherited conditions that affect people's health.

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

(a) 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.

Person **1**

Person **2**			

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

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(b) Allele **(A)** codes for the production of a protein called amyloid.
Amyloid can block the blood vessels that leave the pancreas and the thyroid gland, preventing the release of hormones.

Complete the sentences to explain the symptoms that might be shown by person **2** in **(a)**.

Symptoms of person **2** can include:

- Being unable to control blood ..... due to a lack of the hormones ..... and ..... .
- Being unable to control ..... rate due to a lack of the hormone ..... .

[4]

(c) One treatment that doctors use for amyloidosis involves:

- Killing all the plasma cells in the body.
- Then giving the patient healthy stem cells.

Explain how this treatment could help people with amyloidosis.

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..... **[2]**

(d) Scientists are now developing a new treatment called gene silencing.
They have developed a drug that destroys the mRNA that codes for the amyloid protein.

Explain why this technique is called **gene silencing**.

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..... **[2]**

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20 Pine processionary moths lay eggs that develop into larvae and then into caterpillars, as shown in the diagram.

moth

caterpillar

The caterpillars are a major pest, eating and killing pine trees.

The caterpillars are fed on by birds such as cuckoos. The caterpillars are also parasitised by fungi.

(a) Draw a labelled pyramid of biomass for these feeding relationships showing the organisms at each level.

[2]

(b) The caterpillars have long hairs on their bodies that cause irritation to predators. Cuckoos have a special sticky membrane lining their guts that traps these hairs. This allows the cuckoos to eat the caterpillars.

Explain how natural selection may have resulted in all cuckoos having the sticky membrane.

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..... **[4]**

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(c) Scientists are controlling the pine processionary moth to conserve pine trees.

They spray the caterpillar's eggs or larvae with fungal spores.

This has been successful when spraying different concentrations of spores:

- 1×10^6 spores / ml on the eggs
- 1×10^8 spores / ml on the larvae.

(i) Name this type of control method.

..... **[1]**

(ii) The concentration of spores used on the larvae is higher than the concentration used on the eggs.

By how many orders of magnitude is it higher?

..... **[1]**

(d) Scientists have also tried to use natural plant defence methods on the larvae.

The table shows the effects of two plant-based oils on the larvae in laboratory conditions and on the pine trees.

Type of oil	**Deaths per 1000 larvae**	
	In the laboratory	**On the pine tree**
Ginger	712	874
Rosemary	300	761
Control treatment	13	22

(i) Calculate the percentage increase in the death of larvae on the pine trees compared to in the laboratory for the control treatment.

Percentage change = ... % **[2]**

(ii) More larvae die in the natural environment of the pine trees than in the laboratory for all treatments.

Suggest **one** reason why.

..... **[1]**

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(iii) Evaluate the use of the two plant oils in the control of the larvae.

Use data from the table.

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..... **[3]**

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21 Measles is an infectious disease caused by a virus.

A vaccine is available to protect people against measles.

(a) Explain how vaccinations can protect people against diseases such as measles.

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..... **[3]**

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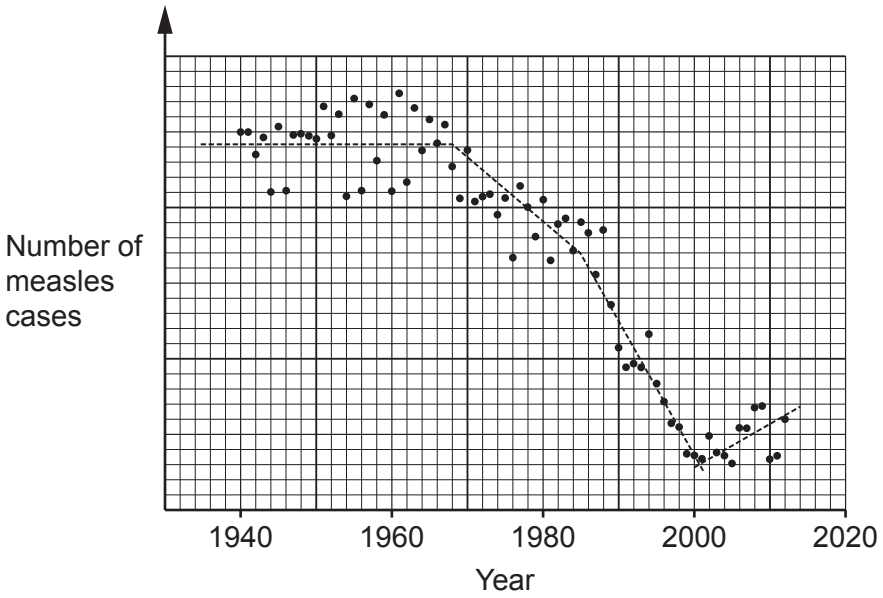
(b) The graph shows the number of cases of measles in the UK from 1940 to 2012.



In 1968, vaccinations against measles started for children.
Since then, there have been two other significant events that have affected the number of measles cases.

Use the graph to suggest a year when each event occurred.
Give **one** reason for your choice of year for each event.

(i) The measles vaccine was given as a triple vaccine called MMR. This was more convenient because MMR vaccinated children for three diseases at the same time.

Year .....

Reason .....

.....

..... **[2]**

(ii) A report claiming a link between the MMR vaccine and an increased risk of the disorder called autism.

Year .....

Reason .....

.....

.....

..... **[2]**

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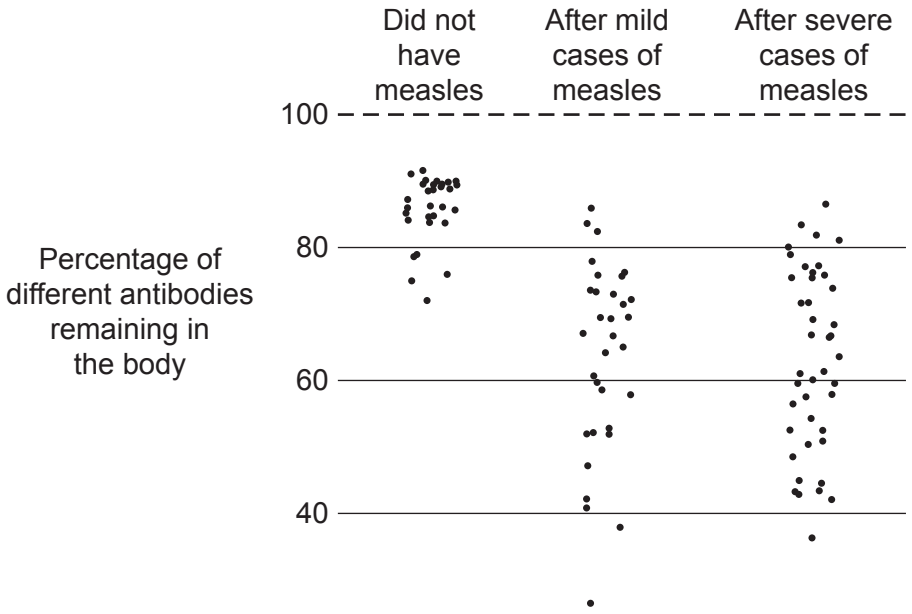
(c) A study looked at how measles infections can affect the number of antibodies for other pathogens in a person's body.

The study included three groups of children:

- children who did not have measles
- children with mild cases of measles
- children with severe cases of measles.

The study measured the percentage of different antibodies remaining in the children six weeks after infection.

The diagram shows the results. The result for each child is marked with a dot.



Most people recover from measles but may get ill again with different symptoms afterwards.

How do the findings shown in this diagram explain this after-effect of a measles infection?

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..... **[2]**

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22 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.

(a) **(i)** Explain the difference between haploid and diploid cells.

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..... **[2]**

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

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..... **[2]**

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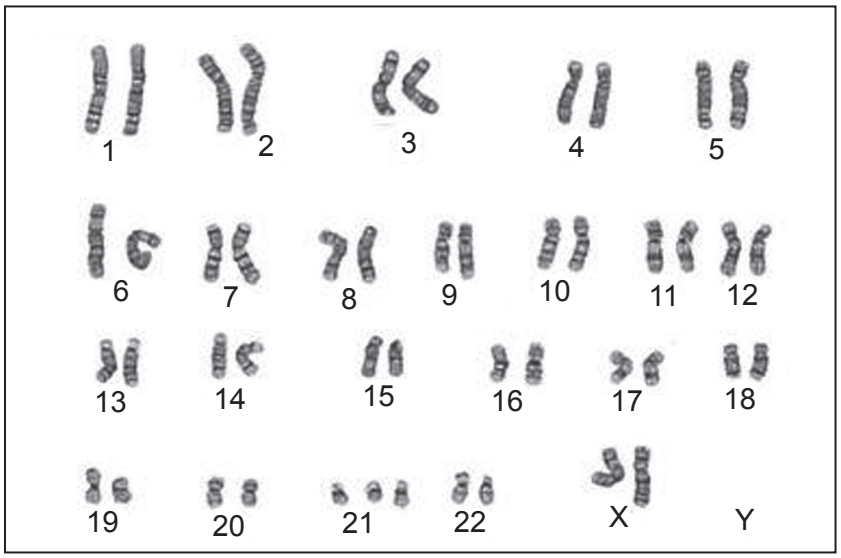
(b) The diagram shows the chromosomes found in a cell of a child.

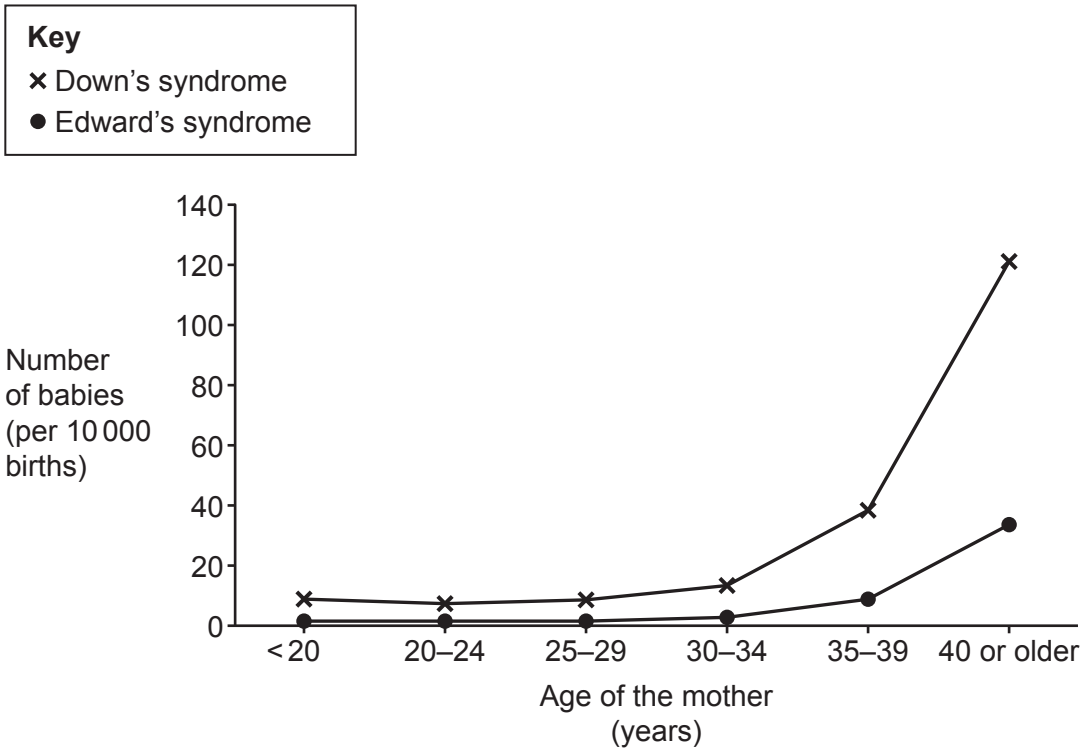


Write down **two** conclusions that can be made about this child from the diagram.

1.....

2..... **[2]**

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



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

1 .....

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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?

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..... **[1]**

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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