Materials
For this paper you must have:

• Ruler
• Pencil, Rubber, Protractor and Compass
• Scientific calculator, which you are expected to use when appropriate

Instructions
• Answer all questions
• Answer questions in the space provided
• All working must be shown
• Do all rough work in this book. Cross out any rough work you don’t want to be marked

Information
• The marks for the questions are shown in brackets
The genetic material in cells is made of DNA.

(a) Which **two** of the following describe the structure of DNA?

Tick **two** boxes.

- A double helix
- A monomer
- A polymer
- A protein
- A single strand

(b) Complete the sentences.

Choose answers from the box.

<table>
<thead>
<tr>
<th>clone</th>
<th>disorder</th>
<th>gene</th>
</tr>
</thead>
<tbody>
<tr>
<td>genome</td>
<td>mutation</td>
<td></td>
</tr>
</tbody>
</table>

A small section of DNA which codes for one protein is called a ________________.

All the genetic material of an organism is called its ________________.

(c) Gametes (sex cells) contain half the amount of DNA compared to body cells.

Give the names of the **two** types of gametes in humans.

____________________________________ and ____________________________________

(d) What is the process called when the gametes join?

_____________________________________
(e) The diagram below shows cell division by meiosis to form gametes.

Which two features in the diagram above show that this cell division is meiosis and not mitosis?
Tick two boxes.

- The cell divides twice
- The chromosomes pull apart into the new cells
- The cytoplasm divides into new cells
- The DNA is copied
- The new cells have half the number of chromosomes

(2)
(Total 8 marks)

Sperm cells and egg cells carry genetic information.

(a) What is the name of the chemical that carries genetic information?

___________________________________________________________________

(1)
(b) What are sperm cells and egg cells?

Tick one box.

Gametes
Genes
Homozygous
Phenotype

(c) Which process produces sperm cells?

Tick one box.

Fertilisation
Homeostasis
Meiosis
Respiration
(d) Mice have 40 chromosomes in each body cell.

How many chromosomes will be in each sperm cell?

Tick one box.

10  

20  

40  

80  

(1)

A mouse will always have black fur if one or two black fur alleles are inherited.

(e) What word describes the black fur allele?

Tick one box.

Dominant  

Recessive  

Heterozygous  

Homozygous  

(1)
Two black mice both have one black fur allele (B) and one brown fur allele (b).

(f) Complete the genetic diagram below to show the possible offspring of these mice.

```
Parent 1

B  b

Parent 2

B  BB  Bb
b  bb
```

(g) On the diagram above draw a ring around one offspring with brown fur.

(h) What is the chance of the offspring from the two black mice being brown?

___________________________________________________________________
___________________________________________________________________

(Total 8 marks)

Variation in individual organisms can be caused by:

- genes
- the environment
- a combination of both genes and the environment.

Figure 1 shows variations in a woman.
(a) What is the cause of each variation in the table below?

Tick only one box in each row.

<table>
<thead>
<tr>
<th>Variation</th>
<th>Cause of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Genes only</td>
</tr>
<tr>
<td>Brown eyes</td>
<td></td>
</tr>
<tr>
<td>Light brown skin colour</td>
<td></td>
</tr>
<tr>
<td>Short hair</td>
<td></td>
</tr>
</tbody>
</table>

(b) The allele for blue eyes is recessive (b).

The allele for brown eyes is dominant (B).

A woman has blue eyes.

What are the woman’s alleles?

Tick one box.

BB   Bb   bb

(c) The woman marries a man with the alleles Bb for eye colour.

What colour eyes does the man have?

___________________________________________________________________

(d) Complete the Punnett square diagram in Figure 2 for this man and woman.

Figure 2

Woman

Man

B

b
(e) What is the probability that a child of this man and woman will have brown eyes?

____________________________________________________________________

(1)

(f) What is the scientific term used for the child’s eye colour?

Tick one box.

- Chromosome
- Condition
- Genotype
- Phenotype

(1)

(g) What effect will a mutation have?

Tick one box.

- Almost certainly have no effect
- Definitely change appearance
- Definitely be passed on to all children
- Probably cause a disease

(1)

(Total 9 marks)
Cells divide in a series of stages called the cell cycle.

Stage 2 of the cycle is mitosis.

The diagram below shows a simplified cell cycle for a human body cell.

(a) Draw **one** line from each stage in the cell cycle to what happens during that stage.

<table>
<thead>
<tr>
<th>Stage in the cell cycle</th>
<th>What happens during that stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>Nucleus divides</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Cell divides into two</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Copies of the DNA are made</td>
</tr>
</tbody>
</table>
(b) The mass of DNA in a human body cell at the start of the cell cycle is 6 picograms.

What mass of DNA will be in each of the new cells produced by this cell division?

Tick one box.

3 picograms

6 picograms

9 picograms

12 picograms

(c) Stem cells are undifferentiated cells.

Which statement about stem cells is correct?

Tick one box.

Animal stem cells are found in meristems

Animal stem cells divide by meiosis

Meristem cells in plants can differentiate throughout the life of the plant

Meristem cells in plants can only differentiate into one type of cell

(1)
Stem cells from human embryos can differentiate into most types of human cell.

Research is being done into the use of embryonic stem cells in medical treatments.

The long-term effects of using embryonic stem cells in patients are not well understood.

In therapeutic cloning, human embryos are produced using a donated human egg cell and a cell from the patient.

- The embryo produced contains the same genetic information as the patient.
- Stem cells are taken from the embryo and stimulated to divide to form cells the patient needs.
- The embryo is then destroyed.

(d) Suggest two advantages of therapeutic cloning.

1. _________________________________________________________________
   ____________________________________________________________________

2. _________________________________________________________________
   ____________________________________________________________________

   (2)

(e) Suggest two disadvantages of therapeutic cloning.

1. _________________________________________________________________
   ____________________________________________________________________

2. _________________________________________________________________
   ____________________________________________________________________

   (2)

(Total 8 marks)
Pseudomonas bacteria cause infections in hospital patients.

A new strain of *Pseudomonas* bacteria has evolved. This new strain can only be killed by one antibiotic called fluroquinolone.

Scientists want to prevent the new strain of *Pseudomonas* from spreading in the human population.

Explain the advice doctors should be given to prevent the spread of the new strain.

_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

(Total 6 marks)

This question is about stem cells.

(a) Give one place in a plant where stem cells are found.

_______________________________________________________________________
_______________________________________________________________________

(1)
(b) What is one economic use of plant stem cells?

Tick one box.

- To create genetically modified crops
- To create new species of plants
- To increase variation in plants
- To produce large numbers of identical plants

Embryonic stem cells divide by mitosis.

**Figure 1** represents a cell cycle for a human embryonic stem cell.
(c) The mass of DNA in the cell at the start of the cycle is 6 picograms.

A picogram is $10^{-3}$ nanograms.

Convert 6 picograms to grams.

Give your answer in standard form.

Mass = _____________________ g

(1)

(d) The time taken for this complete cell cycle is 15 hours.

Calculate how many hours the cell spent in mitosis.

Give your answer to 3 significant figures.

Time spent in mitosis = _____________________ hours

(2)
(e) Describe what happens in each of the three stages of the cell cycle.

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___________________________________________________________________
___________________________________________________________________
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___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
(5)

(f) Figure 2 shows how embryonic stem cells are produced in therapeutic cloning for use in patients.

![Figure 2](image-url)
Give **two** advantages and **two** disadvantages of therapeutic cloning in medical treatments.

Use **Figure 2** to help you.

Advantage 1  
___________________________________________________________________

Advantage 2  
___________________________________________________________________

Disadvantage 1  
___________________________________________________________________

Disadvantage 2  
___________________________________________________________________

(4) (Total 14 marks)

Marfan syndrome is a rare genetic disorder that causes problems with many body systems.

(a) Which sentence best describes a gene?

Tick **one** box.

- A long chain of carbohydrate
- A short section of DNA
- All of the chromosomes in an organism
- Several amino acids joined together

(1)
(b) What does a gene code for?

Tick one box.

A carbohydrate polymer
A DNA double helix
One glycerol and three fatty acids
A sequence of amino acids

(c) What scientific term is used to describe all the genes of one organism?

(1)

(d) What term is used to describe the observed characteristics of an individual?

Tick one box.

Allele
Genotype
Homozygous
Phenotype

(1)
(e) Marfan syndrome is caused by a dominant allele, $R$.

The normal allele is recessive, $r$.

A man who is heterozygous for Marfan syndrome has a child with a woman who does not have the disorder.

Draw a genetic diagram to show the probability of their child inheriting Marfan syndrome.

Probability = ___________________

(f) Very rarely, a new case of Marfan syndrome can occur because of a mutation during meiosis.

Explain how a mutation during meiosis could affect every cell in one offspring.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(4)

(Total 12 marks)

Many people eat shellfish called oysters.

An oyster has 20 chromosomes in each body cell.
(a) Which arrangement of chromosomes will a male oyster have in each body cell?

Tick one box.

- One X and one Y chromosome and 8 pairs of other chromosomes
- Two X and two Y chromosomes and 8 pairs of other chromosomes
- One X and one Y chromosome and 9 pairs of other chromosomes
- Two X chromosomes and 9 pairs of other chromosomes

(b) Oyster gametes only contain half the amount of DNA compared to a normal oyster body cell.

Describe the type of cell division that produces gametes.

___________________________________________________________________
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___________________________________________________________________
Biologists have discovered a way to produce oysters that have three sets of chromosomes (triploid) instead of the usual two sets (diploid).

The triploid oysters cannot reproduce and so they grow more quickly.

Diploid oysters do not taste good in the reproductive season. Triploid oysters taste good all year.

The diagram below shows the chromosomes in a diploid cell and in a triploid cell.

Only two sets of chromosomes are shown.

(c) Suggest why the triploid oysters are not able to reproduce.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(1)

(d) Explain why the triploid oysters grow more quickly than the diploid oysters.

___________________________________________________________________
___________________________________________________________________
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___________________________________________________________________
___________________________________________________________________
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___________________________________________________________________

(2)
(e) The population of diploid oysters growing in the wild has reduced by over 80% in the last 20 years.

Suggest two environmental factors which may be causing this reduction.

Give a reason why each factor may be causing the reduction in the population.

1. ____________________________________________________________________________
   ____________________________________________________________________________

2. ____________________________________________________________________________
   ____________________________________________________________________________

(f) Oyster farmers grow the triploid oysters from young seed oysters.

The production of seed oysters involves the use of a chemical called cytochalasin B. Cytochalasin B has been shown to cause cancer in mice.

Evaluate the production of triploid oysters for supermarkets and restaurants.

______________________________________________________________________________
______________________________________________________________________________
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______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

(6) (Total 15 marks)
In the 1950s farmers in India could not grow enough rice to feed the rapidly increasing population.

At the International Rice Research Institute (IRRI) scientists began a selective breeding programme with 10,000 different varieties of rice plants.

In 1966 the IRRI produced a new variety called IR8 which gave a yield of up to ten times the traditional varieties. IR8 has short stems and large rice grains.

IR8 was grown by farmers all over India so people had enough to eat.

(a) The IR8 variety of rice was produced by selective breeding.

Describe the steps the scientists would have taken to produce IR8

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(4)
The IRRI has now developed several new varieties of genetically modified (GM) rice plants.

Some people in India agree and some people disagree with GM varieties of rice being grown.

Explain why.
Scientists have removed microorganisms from inside rocks in caves in Mexico. The microorganisms have been trapped there for between 10,000 and 50,000 years. The caves are dark, very hot, humid and acidic.

(a) Why are these microorganisms called extremophiles?

Tick two boxes.

- They are thousands of years old
- They survive in high humidity
- They survive in high temperatures
- They survive in the dark
- They survive inside rocks
- They survive where it is acidic

The microorganisms have been inactive for thousands of years but the scientists have reactivated them.

The diagram below shows the results of enzyme analysis on four enzymes, A, B, C and D. Three of the enzymes were from microorganisms found in the soil near the caves. One of the enzymes was from a reactivated microorganism from the caves.
(b) Which enzyme comes from the microorganism from the caves?

Tick one box.

A  B  C  D

(1)

(c) Give the reasons for your answer to part (b)

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(1)

(d) Carl Woese developed the ‘three-domain system’ of classification.

Describe the ‘three-domain system’ of classification.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(3)

(e) Most of the microorganisms from the caves were classified as belonging to the Archaea domain of the ‘three-domain system’.

Suggest why.

___________________________________________________________________

(1)

(Total 8 marks)