Helicate

HELICATE · AS AND A-LEVEL BIOLOGY · TOPIC BANK

3.4.3 Genetic diversity can arise as a result of mutation or during meiosis

Topic question bank

Version 1 · 9 October 2026

Name

Date

QUESTIONS	TOTAL MARKS	TIME	YOUR SCORE
13	66	No time limit	/ 66

Contents

Subtopic	Questions	Marks
Gene mutations Specification 3.4.3	01–03	18
Non-disjunction and chromosome mutations Specification 3.4.3	04–05	13
Meiosis: chromosome content of cells and life cycles Specification 3.4.3	06–09	18
Meiosis, random fertilisation and genetic variation Specification 3.4.3	10–13	17
Total		**66**

Instructions

- Answer the questions in the spaces provided. Show all your working.
- The marks for each question are shown in brackets. Use them to judge how much detail to give.
- Work through a subtopic at a time, then mark your answers with the matching mark scheme.

Original questions by Helicate for AQA AS and A-level Biology (7401/7402), specification section 3.4.3. Not affiliated with or endorsed by AQA.

Do not write outside the box

Gene mutations 3.4.3

0 1 Which statement about gene mutations is correct?
Tick (✓) one box.

[1 mark]

A gene mutation always changes the sequence of amino acids in the encoded polypeptide. ☐

Gene mutations can arise spontaneously when DNA is replicated. ☐

Gene mutations only happen in cells that are exposed to a mutagenic agent. ☐

A gene mutation is a change in the number of chromosomes in a cell. ☐

1

Gene *F* codes for an enzyme in a species of fungus. The enzyme is needed to make a pigment in the fungal cells.

0 2 . 1 What is meant by a gene mutation?

[1 mark]

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Question 2 continues on the next page

Do not write outside the box

Two alleles of gene *F* are found in the fungus. Table 1 shows part of the base sequence of the template strand of DNA for each allele.

Table 1

Allele	Base sequence of the template strand of DNA
Allele 1	GGA CTT AAC TGT
Allele 2	GGA CTC AAC TGT

0 2 . 2 Name the type of gene mutation that produced allele 2. Describe exactly how the base sequence of allele 2 differs from allele 1.

[2 marks]

Type of mutation .....

Difference .....

.....

Question 2 continues on the next page

Do not write outside the box

Table 2 shows some mRNA codons and the amino acids they code for.

Table 2

mRNA codon	Amino acid	mRNA codon	Amino acid
AAC	Asparagine	GAC	Aspartic acid
ACA	Threonine	GAG	Glutamic acid
CCU	Proline	UGU	Cysteine
GAA	Glutamic acid	UUG	Leucine

0 2 . 3 The enzyme produced from allele 2 has the same activity as the enzyme produced from allele 1.
Use Table 1 and Table 2 to explain why.

[3 marks]

6

Turn over for the next question

Do not write outside the box

A strain of yeast cannot make amino acid X because it has a gene mutation in the gene coding for an enzyme needed to make X. Cells of this strain can only grow if X is added to their growth medium.

Occasionally, a second gene mutation in the same gene restores the enzyme. A cell with this second mutation can divide on a medium without X and forms a colony.

Scientists investigated the effect of ultraviolet (UV) light on gene mutation in this yeast. For each exposure time, they:

- exposed a sample of yeast cells to UV light
- estimated the number of cells in the sample that survived
- spread the whole sample onto a medium without amino acid X
- counted the colonies that grew after 3 days.

Table 3 shows their results.

Table 3

Time exposed to UV light / s	Number of cells that survived	Number of colonies on medium without amino acid X
0	5.0×10^7	6
10	4.2×10^7	38
20	2.9×10^7	87
30	1.6×10^7	104
40	6.0×10^6	66

0 3 . 1 UV light is a mutagenic agent.
What is meant by a mutagenic agent?

[1 mark]

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Question 3 continues on the next page

Do not write outside the box

0 3 . 2 Colonies grew from 6 of the cells that were not exposed to UV light.
Suggest why these colonies grew, and explain why the scientists included a sample that was not exposed to UV light.

[2 marks]

0 3 . 3 The scientists calculated the mutation frequency for each exposure time. The mutation frequency is the number of colonies on medium without amino acid X per million (1×10^6) cells that survived.
Use Table 3 to calculate the mutation frequency for cells exposed to UV light for 40 s.

[2 marks]

Answer _____ **per million cells**

Question 3 continues on the next page

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0 3 . 4 A student concluded that exposure to UV light for 30 s caused more gene mutations than exposure for 40 s.
Use Table 3 and your answer to 03.3 to evaluate the student's conclusion.

[4 marks]

0 3 . 5 Give **two** variables, other than the type of yeast, that the scientists should have kept the same for each sample.

[2 marks]

1

2

11

Turn over for the next question

Do not write outside the box

Non-disjunction and chromosome mutations 3.4.3

0 4 . 1 The body cells of a species of insect each contain 8 chromosomes. During meiosis in one cell, one pair of homologous chromosomes does not separate in the first meiotic division. The second meiotic division is normal.
Which shows the number of chromosomes in each of the four cells produced?
Tick (✓) one box.

[1 mark]

- 4, 4, 4 and 4 ☐
- 5, 5, 3 and 3 ☐
- 5, 5, 4 and 4 ☐
- 9, 9, 7 and 7 ☐

0 4 . 2 In another cell from the same insect, the first meiotic division is normal. In the second meiotic division, the chromatids of one chromosome do not separate in one of the two cells. The other cell divides normally.
Give the number of chromosomes in each of the four cells produced.

[1 mark]

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Question 4 continues on the next page

Do not write outside the box

0 4 . 3 Non-disjunction in the first meiotic division produces no cells with the normal number of chromosomes. Non-disjunction in the second meiotic division produces two cells with the normal number of chromosomes.
Explain why.

[3 marks]

5

Turn over for the next question

Do not write outside the box

In flowering plants, cells in the anthers divide by meiosis to produce haploid cells that develop into pollen grains.

Scientists investigated the effect of temperature on non-disjunction during meiosis in the anthers of a species of plant. The diploid number of this species is 24.

They grew plants at four temperatures. From the plants at each temperature, they collected cells that had just completed meiosis. They stained the chromosomes and used an optical microscope to count the chromosomes in each cell.

Table 4 shows their results.

Table 4

Temperature / °C	Number of cells examined	Number of cells with 13 chromosomes	Number of cells with 11 chromosomes
20	1200	7	6
25	1150	10	11
30	1240	31	29
35	1180	88	91

0 5 . 1 The scientists examined more than 1000 cells at each temperature.
Suggest why they examined so many cells.

[1 mark]

Question 5 continues on the next page

Do not write outside the box

0 5 . 2 Calculate the percentage of cells at 35 °C that had an abnormal number of chromosomes.
Give your answer to 1 decimal place.

[2 marks]

Answer ..... **%**

0 5 . 3 At every temperature, the number of cells with 13 chromosomes was similar to the number of cells with 11 chromosomes.
Use your knowledge of non-disjunction to suggest why.

[2 marks]

0 5 . 4 The scientists concluded that temperatures above 25 °C increase the frequency of non-disjunction in this species.
Evaluate this conclusion.

[3 marks]

8

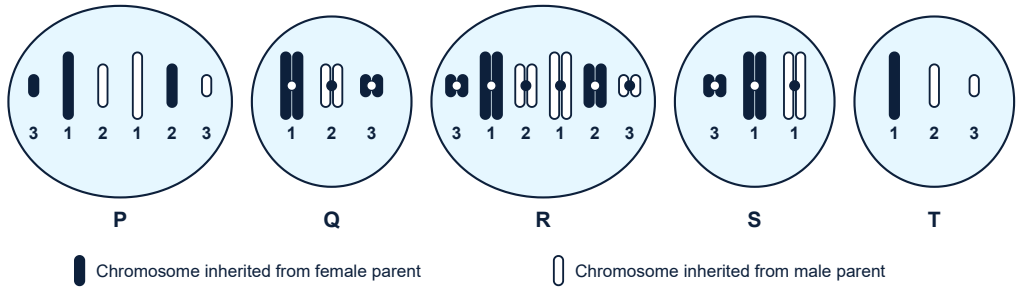
Turn over for the next question

Do not write outside the box

Meiosis: chromosome content of cells and life cycles 3.4.3

The diploid number of a species of plant is 6. Figure 1 shows the chromosomes in five cells, **P** to **T**, from this species. The number under each chromosome shows the homologous pair it belongs to. Two bars side by side show a chromosome made of two chromatids; a single bar shows a chromosome made of one chromatid. Crossing over is not shown.

Figure 1



0 6 . 1 Which cell has just completed the first meiotic division?
Tick (✓) one box.

[1 mark]

P ☐

Q ☐

R ☐

S ☐

T ☐

Question 6 continues on the next page

Do not write outside the box

0 6 . 2 Cell **S** could **not** be produced by normal meiosis.
Explain why.

[2 marks]

3

Turn over for the next question

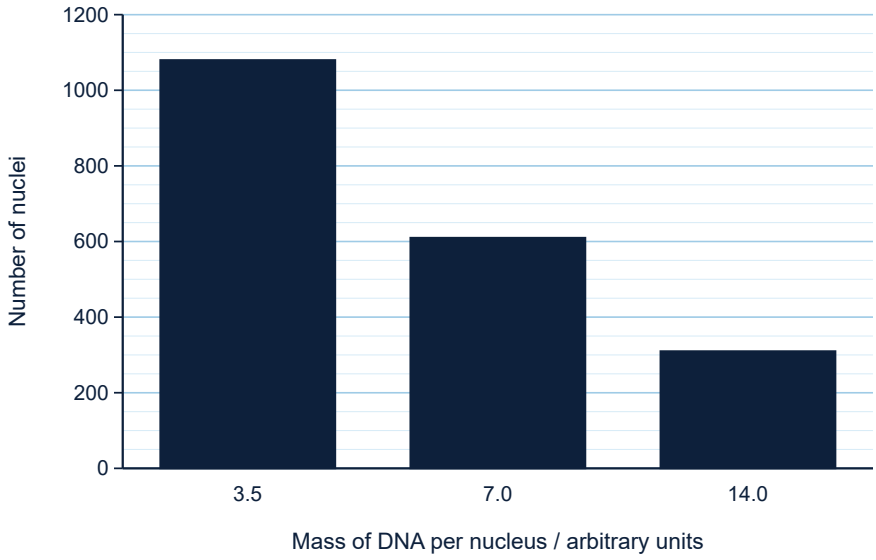
Do not write outside the box

In the testes of a mammal, some cells divide by mitosis. Other cells divide by meiosis to produce sperm cells.

Scientists used a stain that binds to DNA to measure the mass of DNA in nuclei from the testes of a mammal. The amount of stain in a nucleus is proportional to the mass of DNA it contains. Nuclei with intermediate masses, from cells that were replicating their DNA, were not included. Each of the remaining 2000 nuclei had one of three masses of DNA.

Figure 2 shows the number of nuclei with each of these masses.

Figure 2



0 7 . 1 Which mass of DNA, 3.5, 7.0 or 14.0 arbitrary units, is found in the nucleus of a sperm cell?
Explain your answer.

[2 marks]

Question 7 continues on the next page

Do not write outside the box

0 7 . 2 A student said that all of the nuclei containing 7.0 arbitrary units of DNA were in diploid cells.
Evaluate this statement.

[3 marks]

0 7 . 3 The scientists said that their data could not be used to find the number of cells about to divide by meiosis.
Suggest why.

[1 mark]

6

Turn over for the next question

Do not write outside the box

0 8 A diploid cell in an animal divides by mitosis. Another diploid cell from the same animal divides by meiosis.
Explain how the cells produced by mitosis differ from the cells produced by meiosis.

[5 marks]

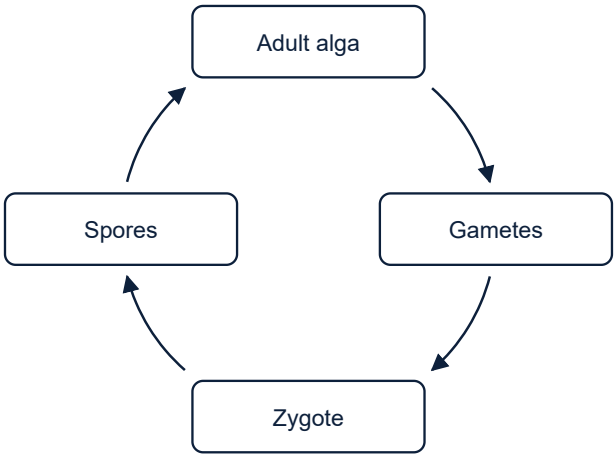
5

Turn over for the next question

Do not write outside the box

The life cycle of one species of alga is summarised in Figure 3.

Figure 3



- The cells of an adult alga each contain 17 chromosomes.
- An adult alga produces gametes that also contain 17 chromosomes.
- Two gametes from different adult algae fuse to form a zygote.
- The zygote divides to produce spores. Each spore contains 17 chromosomes and grows into a new adult alga.

0 9 . 1 Identify the stage of this life cycle at which meiosis takes place. Explain your answer.

[2 marks]

Question 9 continues on the next page

Do not write outside the box

0 9 . 2 Explain why the gametes produced by one adult alga are genetically identical to each other, but the spores produced by one zygote are genetically different from each other.

[2 marks]

4

Turn over for the next question

Do not write outside the box

Meiosis, random fertilisation and genetic variation 3.4.3

1 0 Which process happens during meiosis but **not** during mitosis?
Tick (✓) one box.

[1 mark]

Replication of DNA before the cell divides ☐

Separation of sister chromatids ☐

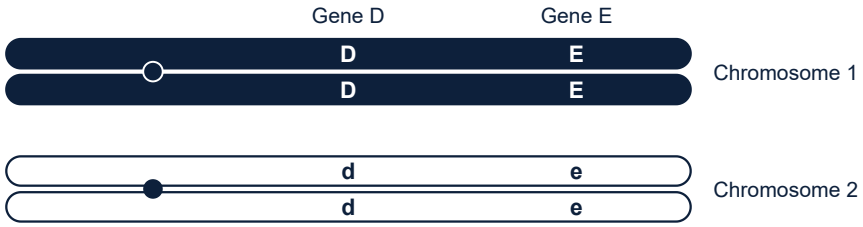
Crossing over between homologous chromosomes ☐

Attachment of chromosomes to spindle fibres ☐

1

Figure 4 shows one pair of homologous chromosomes in a cell at the start of meiosis. Each chromosome is made of two chromatids. The letters show the alleles of two genes, gene D and gene E.

Figure 4



1 1 . 1 Describe what happens during crossing over and how it increases genetic variation.

[2 marks]

Question 11 continues on the next page

Do not write outside the box

1 1 . 2 In this cell, crossing over happens once, between one chromatid of chromosome 1 and one chromatid of chromosome 2, at a point between gene D and gene E.
Give the combination of alleles of genes D and E in each of the four haploid cells produced from this cell.

[2 marks]

Cell 1 .....

Cell 2 .....

Cell 3 .....

Cell 4 .....

1 1 . 3 In males of one species of fruit fly, crossing over does not happen during meiosis.
Explain why the sperm cells produced by one male fly of this species are still genetically different from each other.

[2 marks]

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6

Turn over for the next question

Do not write outside the box

1 2 . 1 The diploid number of a species of plant is 18. Two plants of this species reproduce sexually. Assume that meiosis takes place without crossing over. Calculate the number of different combinations of chromosomes that are possible in a zygote produced by random fertilisation of gametes from these two plants.
Give your answer in standard form.

[2 marks]

Answer .....

1 2 . 2 Without crossing over, the gametes of a species of insect can contain 4096 different combinations of chromosomes.
Calculate the diploid number of this species.

[2 marks]

Answer .....

4

Turn over for the next question

Do not write outside the box

1 3 Genetic variation within a species can result from gene mutation, from meiosis and from the random fertilisation of haploid gametes.
Explain how each of these produces genetic variation.

[6 marks]

6

END OF QUESTIONS

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