

16.1 Passage of information from parents to offspring

Name: _____ Class: _____ Date: _____

Total: 25 marks

KEY WORDS gamete • meiosis • haploid • diploid
• crossing over

Objective

Build the skills to answer exam questions on the **passage of information from parents to offspring** – **meiosis**, and how **crossing over**, **independent assortment** and fertilisation create variation.

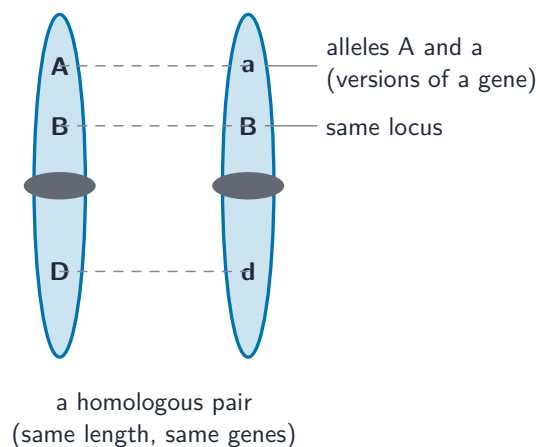
You must be able to:

- explain haploid and diploid, homologous pairs, and the need for a reduction division
- describe the behaviour of chromosomes during meiosis and identify its stages
- explain how meiosis and fertilisation produce genetically different individuals

1 Key knowledge and worked examples

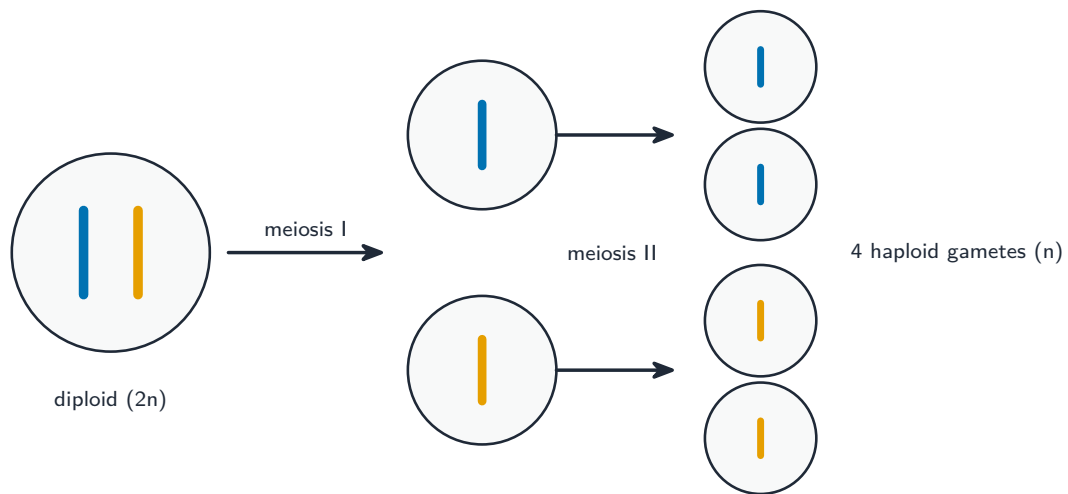
■ Haploid, diploid and homologous pairs

A **diploid** cell ($2n$) has two sets of chromosomes; a **haploid** cell (n) has one. **Homologous chromosomes** are a pair of the same length carrying the same genes (alleles may differ).



A homologous pair carries the same genes at the same loci; the alleles may differ

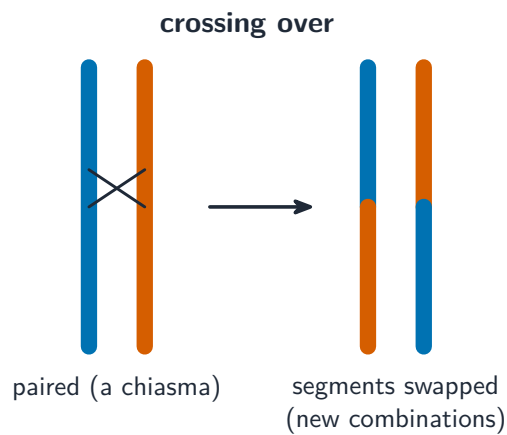
■ Meiosis halves the chromosome number



Meiosis I separates the homologous pair; meiosis II separates the chromatids → four haploid gametes

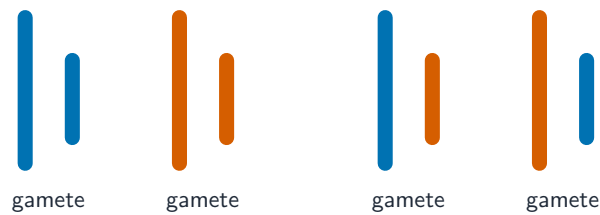
Gametes must be haploid, or the chromosome number would double each generation. Meiosis has two divisions (meiosis I and II).

■ How meiosis makes variation



Crossing over swaps matching segments, making new allele combinations

independent assortment



the pairs line up in a random order, so each gamete gets a random mix

Independent assortment: pairs line up randomly, so gametes get many different mixes

Then **random fertilisation** lets any gamete fuse with any other, so every new individual is genetically different.

2 Practice

2.1 State the difference between a haploid and a diploid cell.

[2]

2.2 Name the two processes during meiosis that make gametes genetically different.

[2]

3 Exam-style questions

3.1 Why must gametes be produced by a reduction division?

[1]

- ☐ A to make the gametes larger
☐ B to keep the chromosome number constant from generation to generation
☐ C to copy the DNA
☐ D to produce identical cells

3.2 During which division of meiosis are homologous chromosomes separated?

[1]

- ☐ A meiosis I
☐ B meiosis II
☐ C mitosis
☐ D fertilisation

3.3 Explain how crossing over and independent assortment each increase genetic variation. [4]

3.4 An organism has a haploid number of $n = 4$.

(a) Calculate the number of different chromosome combinations possible in its gametes from independent assortment alone (2^n). [2]

(b) Explain why the actual number of genetically different gametes is even larger than this. [1]

3.5 A diploid animal has $2n = 6$.

(a) Describe **three** events in meiosis that produce genetic variation, naming the stage at which each occurs. [6]

(b) Calculate the number of genetically different gametes this animal could produce by independent assortment alone, showing your working. [2]

(c) Explain why the number of possible offspring is far larger than your answer to (b). [2]

(d) State **two** differences between the products of meiosis and the products of mitosis. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- haploid has one set of chromosomes (n); diploid has two sets ($2n$)

2.2

- crossing over; independent assortment (random orientation)

3.1 B

- Halving the number means fertilisation restores the diploid number, keeping it constant

3.2 A

- Homologous chromosomes are separated in meiosis I

3.3

- crossing over: homologous chromosomes swap matching segments at chiasmata, making new combinations of alleles; independent assortment: the homologous pairs line up in a random order at the equator, so gametes receive different mixes of maternal and paternal chromosomes

3.4

(a)

- $2^4 = 16$

(b)

- crossing over also creates new allele combinations, adding to the variety

3.5

(a)

- **Crossing over** in prophase I – non-sister chromatids of a bivalent exchange lengths of DNA at a chiasma, producing new combinations of alleles on one chromosome. **Independent assortment** in metaphase I – each bivalent lines up on the equator independently of the others, so either homologue may go to either pole. **Random assortment of chromatids** in metaphase II – the sister chromatids, no longer identical after crossing over, separate independently

(b)

- 2^n where n is the haploid number, here 3; $2^3 = 8$ different gametes

(c)

- Crossing over creates chromatids that are not simply one homologue or the other, so the real number of gamete types is far greater than 8; and fertilisation is random –

any one of the male gametes may fuse with any one of the female gametes, multiplying the possibilities

(d)

- Meiosis gives four haploid cells, mitosis two diploid cells; meiotic products are all genetically different from each other and from the parent, mitotic products are genetically identical to it