A-LEVEL BIOLOGY • EXERCISE SHEET

16.1 Passage of information from parents to offspring

Name: _____ Class: _____ Date: _____ **Total: 25 marks**

KEY WORDS gamete 配子 • meiosis 减数分裂 • haploid 单倍体 • diploid 二倍体 • crossing over 交叉互换

Objective

Build the skills to answer exam questions on the **passage of information from parents to offspring** — **meiosis** 减数分裂, and how **crossing over** 交叉互换, **independent assortment** 自由组合 and fertilisation create variation.

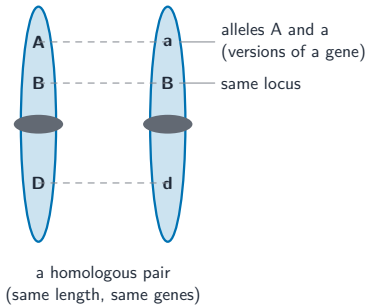
You must be able to:

- 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 Worked examples

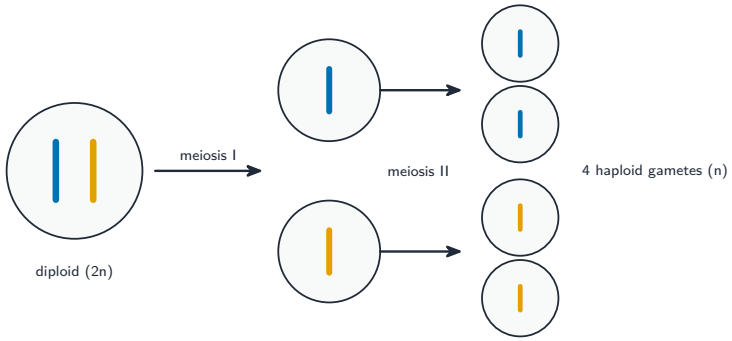
Haploid, diploid and homologous pairs

A **diploid** 二倍体 cell (2n) has two sets of chromosomes; a **haploid** 单倍体 cell (n) has one. **Homologous chromosomes** 同源染色体 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

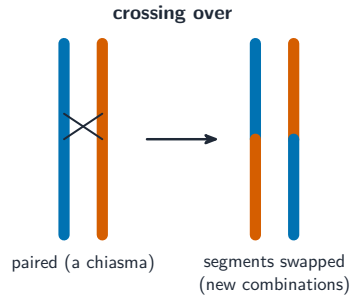
Meiosis halves the chromosome number



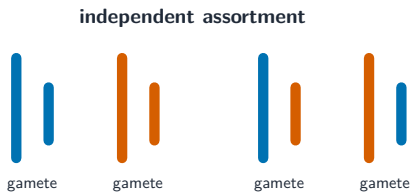
Meiosis I separates the homologous pair; meiosis II separates the chromatids → four haploid gametes

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: 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

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.