Meiosis

Essential Question

How does meiosis make gametes with half the chromosomes and new gene combinations?

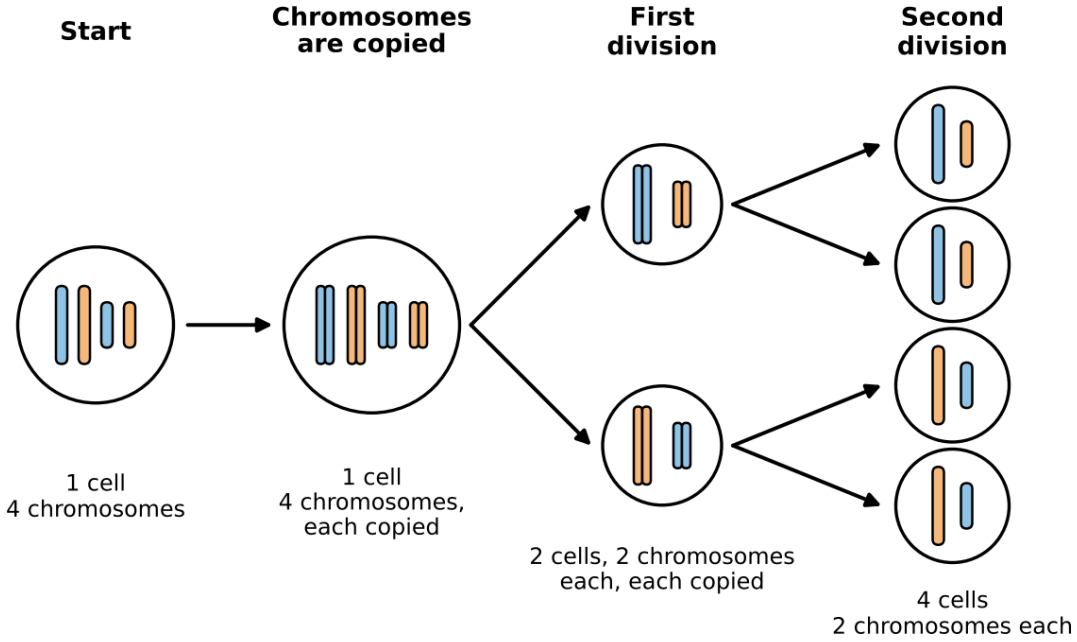
Diploid and Haploid Cells

- Body cells are diploid (2n): they have two sets of chromosomes
- Gametes are haploid (n): they have one set
- Homologous chromosomes are a matching pair, one from each parent
- Human body cells: 2n = 46. Human gametes: n = 23

Cell type	Symbol	Human chromosomes	Example
Body cell (diploid)	2n	46	Skin cell
Gamete (haploid)	n	23	Egg or sperm
Zygote (diploid)	2n	46	Fertilized egg

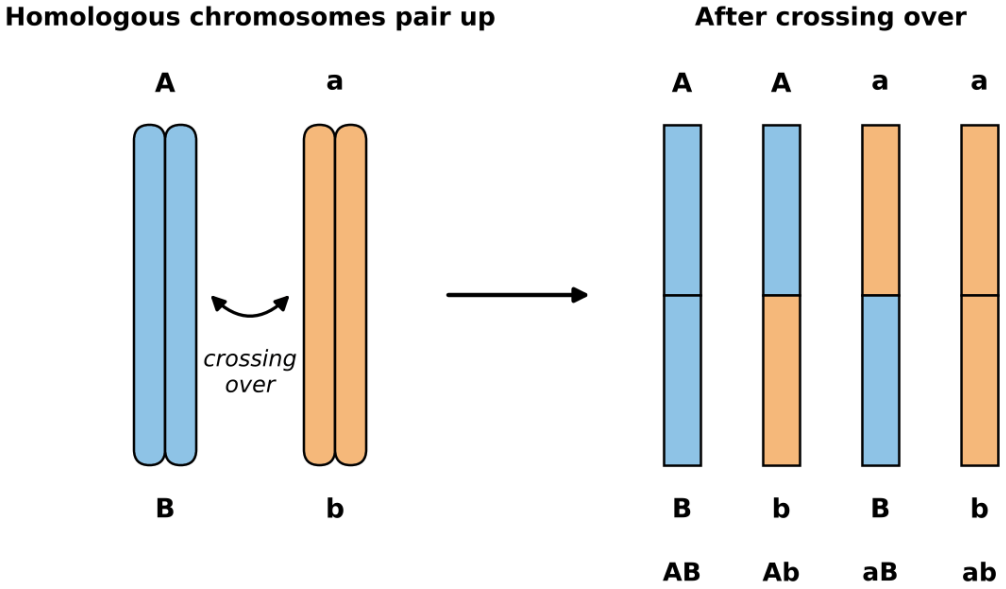
How Meiosis Works

- A cell copies its chromosomes once
- It then divides twice
- The first division separates the homologous chromosomes
- The second division separates the copies of each chromosome
- One diploid cell makes four haploid cells



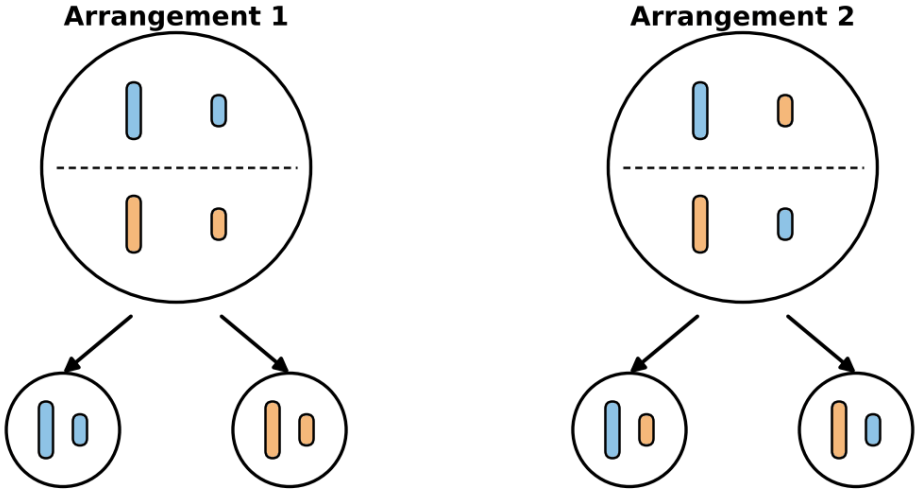
Crossing Over

- Homologous chromosomes pair up and swap matching pieces
- This is called crossing over
- It makes chromosomes with new combinations of alleles
- Two of the four combinations in the diagram are new



Independent Assortment and Random Fertilization

- Each pair of homologous chromosomes separates independently of the others
- With n pairs, a gamete can have 2^n different chromosome combinations
- In humans, 2^{23} = 8,388,608 combinations, before crossing over
- Any sperm can fertilize any egg, which multiplies the possibilities



2 arrangements x 2 gametes = 4 different gametes (2 x 2 = 2^2)

Example 1: Counting Chromosomes

A dog has 78 chromosomes in each body cell. A fruit fly has 4 pairs of chromosomes in each body cell. (a) How many chromosomes are in a dog gamete? (b) How many different chromosome combinations can one fruit fly make in its gametes, ignoring crossing over? (c) Two dog gametes fuse in fertilization. How many chromosomes does the zygote have?

Organism	Chromosomes in a body cell
Dog	78
Fruit fly	4 pairs

Solution: Counting Chromosomes

(a) Haploid number: A gamete has half the chromosomes of a body cell. n = 78 / 2 = 39.

(b) Combinations: With 4 pairs, each pair sorts independently into one of 2 ways, so there are $2^4 = 16$ combinations.

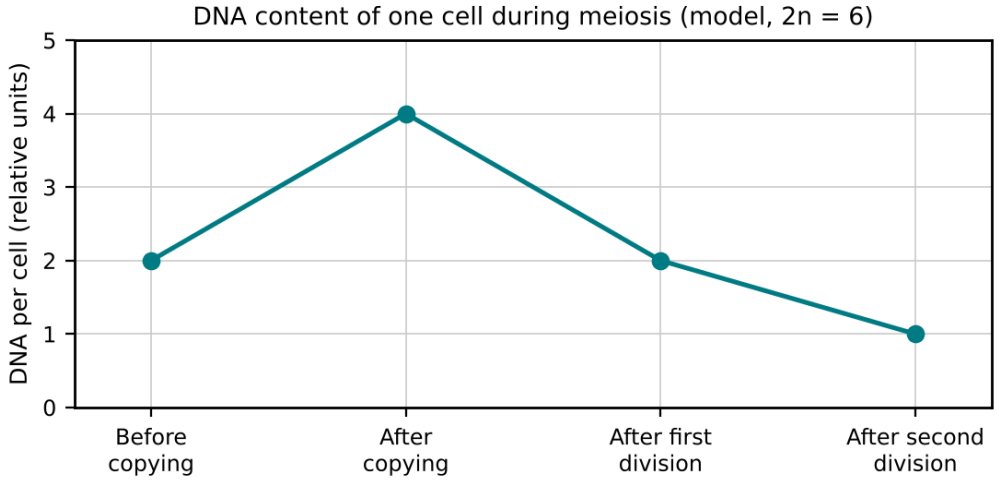
(c) Zygote: Two gametes with 39 chromosomes each make a zygote with 39 + 39 = 78 chromosomes, the diploid number.

Answer: (a) 39 chromosomes. (b) 16 combinations. (c) 78 chromosomes.

Example 2: DNA and Chromosomes in Meiosis

The graph and table show one cell with 2n = 6 during meiosis. (a) By how much does the DNA per cell change during copying? (b) At which stage is the chromosome number cut in half? (c) Write a claim, evidence, reasoning statement for this claim: meiosis makes haploid cells.

Stage	Chromosomes per cell
Before copying	6
After copying	6
After first division	3
After second division	3



Solution: DNA and Chromosomes in Meiosis

(a) Copying: DNA rises from 2 to 4 relative units, so it doubles (an increase of 2 units).

(b) Halving: The chromosome number falls from 6 to 3 after the first division.

(c) Claim: Meiosis makes haploid cells.

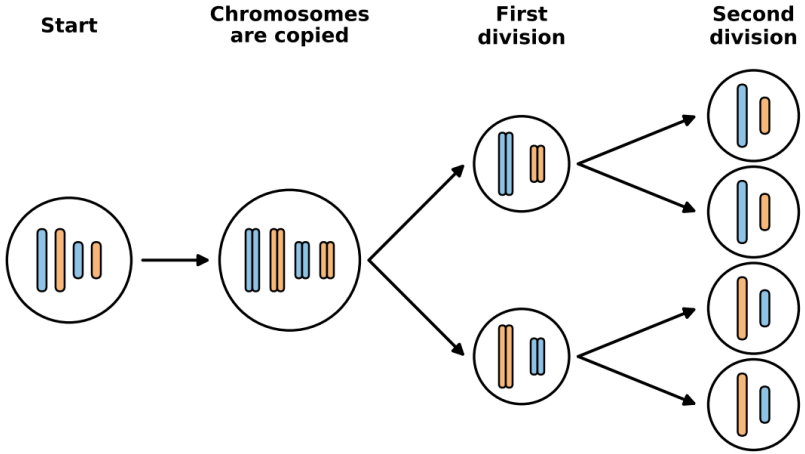
Evidence: The chromosome number falls from 6 to 3 and stays at 3 after the second division. The DNA per cell ends at 1 unit, half of the 2 units before copying.

Reasoning: DNA is copied once but the cell divides twice, so the four resulting cells each have half the DNA and one set of chromosomes. That is what haploid means.

Answer: (a) It doubles, from 2 to 4 units. (b) After the first division. (c) Chromosome number halves from 6 to 3 and DNA ends at half the starting amount.

Example 3: Use the Meiosis Model

The diagram shows meiosis in a cell with 4 chromosomes. Blue chromosomes came from the mother and orange ones from the father. (a) How many chromosomes are in each final cell? (b) Is each final cell diploid or haploid? (c) Are all four final cells the same? Describe the chromosomes in each.



Solution: Use the Meiosis Model

(a) Count: Each final cell has 2 chromosomes, one long and one short.

(b) Ploidy: The starting cell has 4 chromosomes (2 pairs), so it is diploid. Each final cell has 2 chromosomes, one of each pair, so it is haploid.

(c) Compare: Not all four are the same. The top two cells each have a long blue and a short orange chromosome. The bottom two each have a long orange and a short blue chromosome. Crossing over, which is not shown, would make the cells even more different.

Answer: (a) 2 chromosomes. (b) Haploid. (c) Two types of cell, so the four cells are not all the same.

Meiosis

Big Ideas

- Gametes are haploid (n) and body cells are diploid (2n)
- Meiosis copies chromosomes once and divides twice
- One diploid cell makes four haploid cells
- Crossing over and independent assortment make every gamete different
- Fertilization restores the diploid number and adds more variation