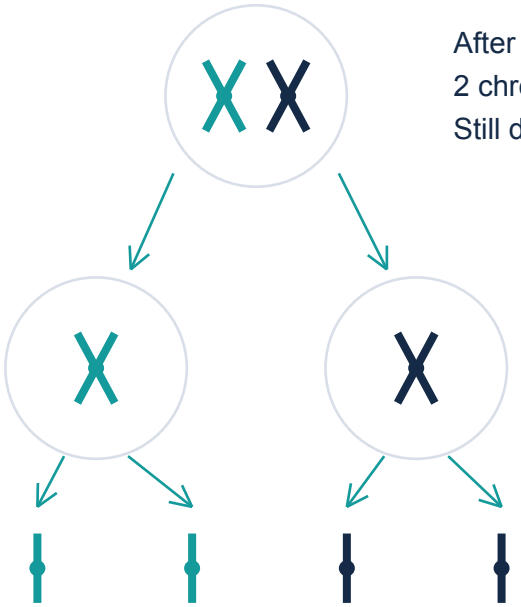
One replication, two divisions

Diploid (2n) means two chromosome sets; haploid (n) means one. Meiosis reduces the number of sets so fertilisation can restore diploidy without doubling it each generation.

1. FOLLOW ONE HOMOLOGOUS PAIR: 2n = 2



After DNA replication:
2 chromosomes, 4 chromatids.
Still diploid.

Meiosis I separates homologues.
Each cell: 1 chromosome with
2 chromatids; now haploid.

Meiosis II separates sisters.
Four haploid nuclei, each with
1 single-chromatid chromosome.

2. HOMOLOGUES ARE NOT SISTER CHROMATIDS

Homologues carry the same genes at corresponding loci, but may have different alleles. One is inherited from each parent. Sister chromatids are replicated copies of one chromosome; crossing over can later make them genetically different.

3. COUNT SETS, NOT X-SHAPED ARMS

One replicated X represents one chromosome with two chromatids, not two chromosomes. No DNA replication occurs between meiosis I and II. The simplified diagram omits crossing over and shows the four final nuclei without cell boundaries.

Chromosome reduction and gametes: NHGRI, Meiosis.
Replication and chromosome behaviour: OpenStax, Biology 2e 11.1.

Scope: Cambridge Biology 9700, section 16.1, outcomes 1-7, p. 41.

Recognise the meiotic stages

Use chromosome arrangement and what is separating to identify a stage. Homologous pairs separate in division I; sister chromatids separate in division II.

1. STAGE-BY-STAGE LANDMARKS

Prophase I	Chromosomes condense; homologues pair into bivalents. Crossing over occurs. Spindle forms; nuclear envelope breaks down.
Metaphase I	Bivalents align at the equator with random orientation. Homologues attach to opposite spindle poles.
Anaphase I	Homologues move apart; sister chromatids remain joined at their centromeres.
Telophase I	Chromosomes reach poles. Nuclei may reform; cytokinesis often follows. Each set is haploid.
Prophase II	A new spindle forms. Any reformed nuclear envelopes break down.
Metaphase II	Individual replicated chromosomes align at each equator; sister kinetochores face opposite poles.
Anaphase II	Centromeric cohesion is lost; sisters separate and are now individual chromosomes.
Telophase II	Nuclear envelopes reform, chromosomes decondense and spindles disappear; cytokinesis completes division.

2. DIVIDING THE CYTOPLASM

Animal cells typically form a cleavage furrow as the surface membrane pinches inward. Plant cells form a cell plate and new separating walls. Meiosis yields four haploid nuclei, but unequal divisions in animal egg production mean not all products become functional gametes.

Stage names and plant/animal cell behaviour: Cambridge 9700, 16.1.4-5.
Division stages and cytokinesis: OpenStax, Biology 2e 11.1.

Scope: Cambridge Biology 9700, section 16.1, outcomes 1-7, p. 41.

Meiosis reshuffles existing alleles

Crossing over and independent assortment generate new allele combinations. Random fertilisation combines them again; mutation is the source of new alleles.

1. CROSSING OVER: NON-SISTER CHROMATIDS

In prophase I, homologues pair. Corresponding DNA segments are exchanged between non-sister chromatids; chiasmata mark crossover connections.



AB	Ab	aB	ab
Parental	Recombinant	Recombinant	Parental

Example: AB / ab before exchange. One crossover between the loci produces AB, Ab, aB and ab chromatids. These rods show products, not a metaphase cell.

2. INDEPENDENT ASSORTMENT

Each bivalent orients independently at metaphase I. Maternal and paternal homologues therefore enter different combinations of daughter nuclei. At meiosis II, orientation also distributes potentially non-identical sister chromatids. Excluding crossing over, n pairs allow 2^n whole-chromosome combinations across many meioses.

3. RANDOM FERTILISATION

Which genetically distinct gametes fuse adds further variation. Their haploid nuclei combine to restore 2n. In animals, meiosis is part of gamete production; in plants, it produces spores, and the haploid generation later forms gametes by mitosis.

Keep distinct: homologues = a pair; chromatids = replicated copies; bivalent = paired replicated homologues (four chromatids).

Recombination: NHGRI, Crossing Over.
Life cycles and fertilisation: OpenStax, Biology 2e 11.2.

Scope: Cambridge Biology 9700, section 16.1, outcomes 1-7, p. 41.