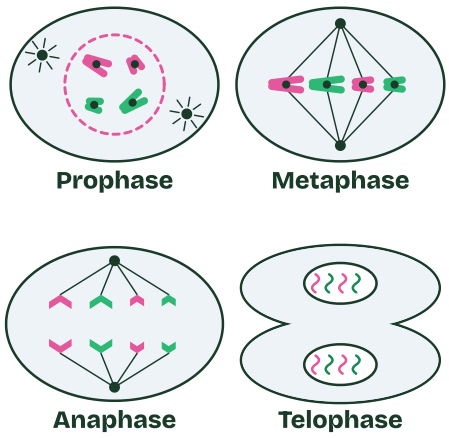
One cell becomes *two*

What to know, what to draw and what to say. Nothing else.

THE ONE IDEA

Copy the DNA, then share it out. Mitosis gives two identical nuclei; meiosis gives four haploid, varied ones.



Draw it like this. Each chromosome two chromatids until anaphase; pink and green for the two of each pair.

D2.1.7 START HERE

Mitosis makes two *identical* nuclei

- **Prophase:** chromosomes **condense**, the nuclear membrane breaks down and the spindle forms.
- **Metaphase:** microtubules from both poles attach at each centromere; chromosomes **line up on the equator**.
- **Anaphase:** centromeres separate and **sister chromatids** are pulled to opposite poles.
- **Telophase:** a nuclear membrane forms round each group and the chromosomes uncoil. Then cytokinesis.

Sister chromatids are copies, and each nucleus gets one of every chromosome: so the nuclei are **genetically identical** to each other and the parent.

THE FOUR PHASES, IN ORDER

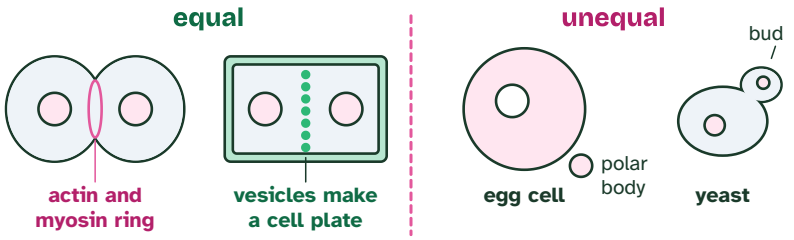
Make your own: four words, P M A T

P Prophase condense, membrane goes	**M** Metaphase line up in the middle	**A** Anaphase chromatids pulled apart	**T** Telophase two nuclei form

D2.1.1 to 3

Splitting the *cytoplasm*

- A parent (mother) cell divides into **two daughter cells**: the nucleus first, then the cytoplasm (**cytokinesis**).
- **Animal:** a **ring of actin and myosin** contracts and pinches the membrane in. **Plant:** vesicles fuse into a **cell plate**, the new membranes and wall.
- Usually equal, but **unequal** in human **oogenesis** and yeast **budding**. Each daughter needs at least **one mitochondrion** (and plastid): these arise only by division.



D2.1.4 to 6

Copy, coil, *move*

- Nuclear division comes first, so no daughter cell is left **anucleate**.
- **Replication first:** each chromosome becomes **two sister chromatids** (two DNA molecules) held at the centromere until anaphase.
- **Condense:** DNA winds round **histones** and supercoils. **Move:** spindle **microtubules** and motor proteins.

Mitosis growth, repair	Keeps the chromosome number and genome.
Meiosis gametes	Halves the chromosome number; makes genetic diversity.

D2.1.8 SKILLS

Name the *phase*

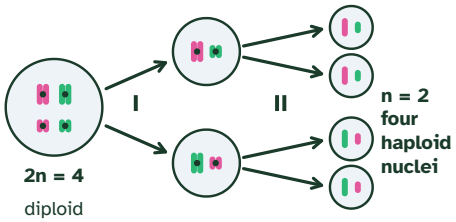
- Name phases in diagrams and in root tip cells seen down a microscope or in a micrograph, **one clue each**.

NOT DIVIDING	1	2	3	4
Interphase	**Prophase**	**Metaphase**	**Anaphase**	**Telophase**
Round nucleus, dark nucleolus, no separate chromosomes.	Thick threads; the nuclear edge fading.	A band across the middle (end on, a ring).	Two groups moving apart, often V shapes.	Two groups at the ends, new nuclei, often a cell plate.

D2.1.9

Meiosis *halves* the number

- **Diploid (2n):** two sets of chromosomes, one from each parent. **Haploid (n):** one set. Humans: 2n = 46, n = 23.
- **Meiosis I** separates **homologous chromosomes**; **meiosis II** separates **sister chromatids**: two rounds of segregation.
- One replication, two divisions: one diploid nucleus gives **four haploid nuclei**.
- Fertilisation restores 2n, so a **sexual life cycle** needs meiosis.



D2.1.10

Down syndrome

- **Non-disjunction**: a pair (meiosis I) or two chromatids (meiosis II) **fail to separate**; both go to one pole.
- A gamete with two chromosome 21s plus a normal one gives **trisomy 21**: 47 chromosomes. The chance rises with the mother's age.

D2.1.11

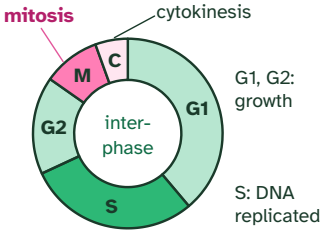
Every gamete *different*

- **Shuffle (random orientation):** each **bivalent** lines up either way in metaphase I: 2^n combinations, over 8 million (2^{23}) in humans.
- **Swap (crossing over)** in prophase I: non-sister chromatids swap ends, giving **new combinations of alleles**.

D2.1.12 to 14 HIGHER LEVEL

Growth and the *cell cycle*

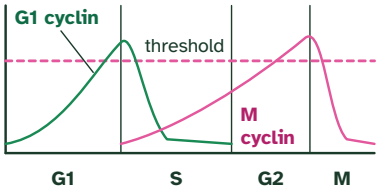
- **Proliferation:** growth in **plant meristems** and **early embryos**; replacement and wound healing in **skin**.
- **Interphase is busy:** proteins and DNA made; mitochondria and chloroplasts **grow and divide**.



D2.1.15 HIGHER LEVEL

Cyclins open the gates

- Different cyclins **rise and fall** through the cycle.
- A **threshold** of a specific cyclin is needed to pass each **checkpoint**; then it is broken down.
- A cyclin is a go signal: it activates the enzymes that start the next stage.



D2.1.16 and 17 HIGHER LEVEL

When control *fails*

- **Proto-oncogene** mutated to an **oncogene**: division stimulated. **Tumour suppressor** lost: division not stopped.
- **Primary tumour:** where it starts. **Secondary:** where spread cells grow.

Benign not cancer
Slow division; stays in place, often in a capsule.

Malignant cancer
Fast division; **invades** neighbouring tissue and spreads (metastasis).

Mitotic index = cells in mitosis ÷ total cells

WATCH OUT

Six mistakes that *cost marks*

- ✕ **Cytokinesis is not a phase of mitosis.** Mitosis divides the nucleus; cytokinesis, the cytoplasm.
- ✕ **Interphase is not a resting phase.** The cell grows and copies its DNA.
- ✕ **A replicated chromosome still counts as one.** A human cell entering mitosis has 46 chromosomes, 92 chromatids.
- ✕ **The halving happens in meiosis I.** Meiosis II separates chromatids, as mitosis does.
- ✕ **Crossing over is between non-sister chromatids** of a pair; sister chromatids are identical anyway.
- ✕ **A tumour is not always a cancer.** Only a malignant tumour invades and spreads.

COVER THE SHEET

Can you *answer these?*

1. Outline how cytokinesis differs in animal and plant cells.
2. Distinguish the roles of mitosis and meiosis.
3. Explain why mitosis gives genetically identical nuclei.
4. Identify the phase with chromosomes on the equator.
5. Outline the two rounds of segregation in meiosis.
6. Explain how non-disjunction can cause Down syndrome.
7. Explain two ways meiosis makes gametes vary.
8. Outline what happens in G1, S and G2. HL
9. Describe how cyclins control the cell cycle. HL
10. Distinguish a benign from a malignant tumour. HL

IN THE EXAM

Name the structure that moves: chromosomes in meiosis I, chromatids in mitosis and meiosis II. A mitotic index divides by **all** the cells counted.

GO FURTHER

Animated figures, a dry lab and a marked Check are in the full guide online.