

Cambridge IGCSE · Biology 0610 · Notes

Mitosis and meiosis

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Read first: [Chromosomes, genes and proteins](#)

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What you need to know

This topic is about the two ways a nucleus divides: **mitosis**, which makes identical copies of a cell, and **meiosis**, which makes gametes with half the chromosomes. In the current syllabus the whole topic is **Extended only**, so it is tested on Papers 2 and 4: mostly one-mark multiple-choice questions on Paper 2, and parts of longer questions (often with a life-cycle diagram or a graph of DNA mass) on Paper 4. By the end of this topic you should be able to:

1. **Extended only:** describe **mitosis** as nuclear division that gives rise to **genetically identical** cells. You don't need the names or details of its stages.
2. **Extended only:** state what mitosis is used for: **growth, repair of damaged tissues, replacement of cells** and **asexual reproduction**.
3. **Extended only:** state that the chromosomes are **copied exactly** (replicated) **before** mitosis.
4. **Extended only:** state that **during** mitosis the **copies of the chromosomes separate**, so each daughter cell keeps the **same chromosome number** as the parent cell.
5. **Extended only:** describe **stem cells** as **unspecialised cells that divide by mitosis** to produce daughter cells that can become **specialised** for specific functions.
6. **Extended only:** state that **meiosis** is involved in **producing gametes**.
7. **Extended only:** describe meiosis as a **reduction division** in which the chromosome number is **halved from diploid to haploid**, giving **genetically different** cells. You don't need the names or details of its stages.

The words **haploid** (one set of chromosomes) and **diploid** (two sets, a pair of each type) come from the Chromosomes, genes and proteins note; this topic uses them all the time.

Understand it

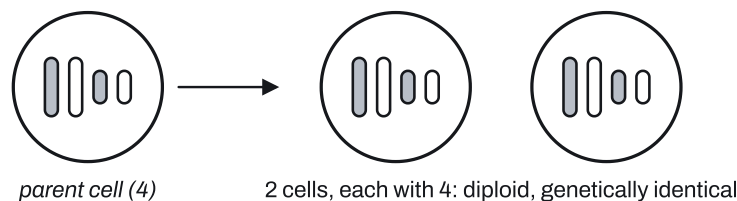
Everything in this section is **Extended only**.

Why cells divide in two different ways

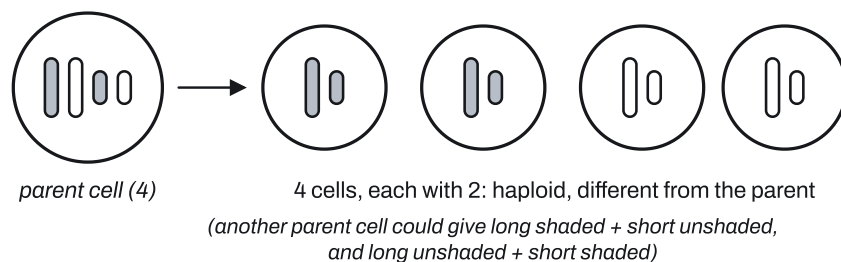
Your body started as one cell, the **zygote**, and now has trillions. Each new cell was made when one cell divided into two. Before a cell divides, its **nucleus** divides, so that each new cell gets a nucleus with a full set of instructions. That is **nuclear division**, and there are two kinds:

- **Mitosis** makes cells for the body itself: new cells that are **exact copies** of the parent cell.
- **Meiosis** makes **gametes** (sperm and egg cells in animals; pollen nuclei and egg cells in flowering plants), which must have **half** the usual number of chromosomes.

mitosis



meiosis



Mitosis: identical copies

Mitosis happens in two steps you need to know:

1. **Before mitosis**, every chromosome is **copied exactly** (the DNA is **replicated**). The cell now has two identical copies of each chromosome, joined together, so it has **twice** its usual mass of DNA.
2. **During mitosis**, the two **copies of each chromosome separate** and move apart. A new nucleus forms around each group, and the cell splits into two.

Each daughter cell gets **one copy of every chromosome**, so it has **the same number of chromosomes** as the parent cell and **exactly the same genes**. The daughter cells are **genetically identical** to each other and to the parent. A diploid human cell with 46 chromosomes makes two cells with 46 chromosomes each.

Mitosis is used whenever an organism needs more cells that are the same as the ones it has:

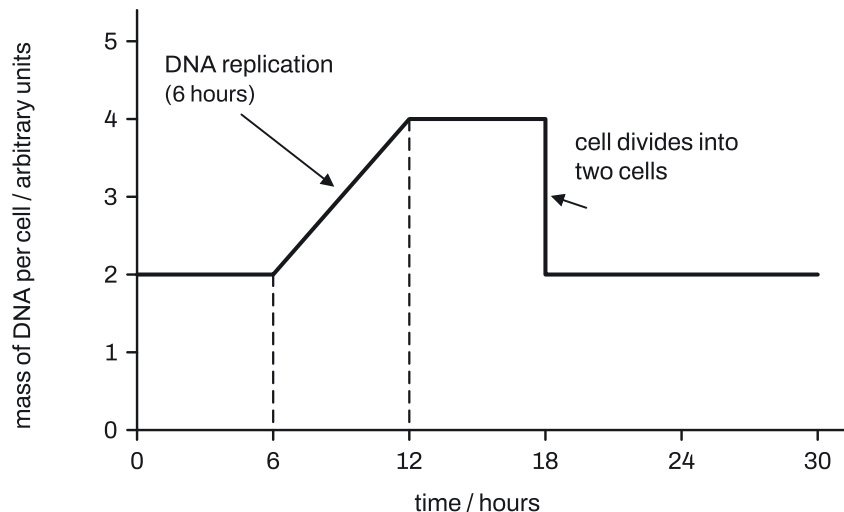
- **Growth**: a zygote becomes an embryo and then an adult; a root tip grows longer.
- **Repair of damaged tissues**: a cut in the skin heals; a broken bone mends; a lizard regrows a lost tail.
- **Replacement of cells**: worn-out cells, such as red blood cells and cells lining the gut, are replaced.

- **Asexual reproduction:** one parent makes offspring that are genetically identical to it (a clone), for example a strawberry plant's runners or a potato's tubers.

Mitosis produces **no variation**, because every daughter cell is identical.

Mitosis on a graph of DNA mass

Questions often show a graph of the **mass of DNA per cell** against time. It always has the same shape:



- **Level line:** the cell is growing, but its DNA is not changing.
- **Sloping rise to double:** **DNA replication**, the exact copying of the chromosomes **before** mitosis. On this graph it takes $12 - 6 = 6$ hours.
- **Level at double:** the chromosomes have been copied but have not yet separated.
- **Sudden drop to half:** the copies of the chromosomes have separated and the cell has **divided into two**. This is where the **two daughter cells** form. Each has the same DNA mass as the parent had at the start, $4 \div 2 = 2$ units.

After mitosis each daughter cell ends with the **same** DNA mass as the parent started with. (After meiosis, which divides twice, each cell ends with **half** the starting mass.)

Stem cells

Most cells in your body are **specialised**: a neurone, a red blood cell and a muscle cell each have a shape and contents that suit one job, and most of them no longer divide. **Stem cells** are different: they are **unspecialised** cells that **divide by mitosis**. Their daughter cells **can become specialised** for specific functions.

The cells of an embryo just after fertilisation are stem cells: they divide by mitosis to make more cells, which later become all the different tissues of the body. Adults keep some stem cells too, for example in the bone marrow, where they make new blood cells.

All the cells made from a zygote by mitosis have the **same genes**. A cell becomes specialised because it **expresses** (uses) only some of its genes, so it makes only the **proteins** it needs (see Chromosomes, genes and proteins).

Meiosis: halving the chromosome number

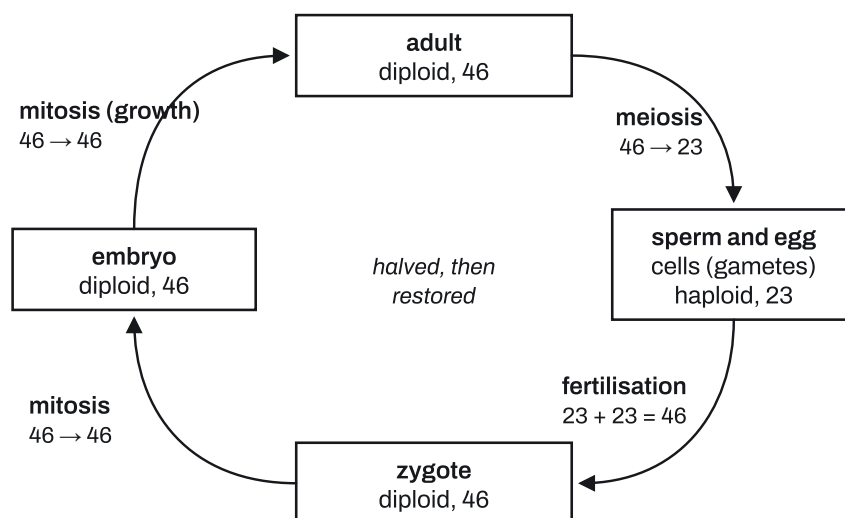
Every human body cell has 46 chromosomes. If sperm and eggs also had 46, a zygote would have $46 + 46 = 92$, and the number would double in every generation. Meiosis prevents this.

Meiosis is a **reduction division**: a **diploid** cell divides to make cells that are **haploid**, with **half** the chromosome number. Each new cell gets **one chromosome from each pair**. In humans, meiosis in the **testes** and the **ovaries** turns diploid cells with **46** chromosomes into sperm or egg cells with **23**. In a flowering plant, meiosis in the **anthers** makes the pollen nuclei, and meiosis in the **ovules** makes the egg cells.

The cells made by meiosis are **genetically different** from each other and from the parent cell, because each gets a different mixture of chromosomes (one from each pair, chosen at random), so they carry different combinations of alleles. This makes meiosis a **source of genetic variation**, and it is why children of the same parents are not identical. You don't need the stages of meiosis or how the mixing happens.

At **fertilisation** a haploid sperm nucleus fuses with a haploid egg nucleus: $23 + 23 = 46$, so the **zygote is diploid** again. Meiosis halves the number and fertilisation restores it, so the **chromosome number stays the same from one generation to the next**.

Where each division happens in a life cycle



Every life cycle with sexual reproduction has the same three events, and the chromosome number tells you which is which:

What happens to the chromosome number	Process
diploid ($2n$) $\rightarrow$ haploid (n): halved	meiosis
diploid $\rightarrow$ diploid, or haploid $\rightarrow$ haploid: unchanged	mitosis

What happens to the chromosome number

Process

haploid + haploid → diploid: **doubled** by fusing two nuclei

fertilisation

Some organisms, such as mosses and ferns, have a stage that is haploid for its whole life. That haploid stage makes its gametes by **mitosis**, not meiosis: the number stays at n . Meiosis can only happen in a diploid cell.

In **asexual reproduction** there is only one parent and only mitosis: no meiosis, no gametes, no fertilisation and no zygote.

Mitosis and meiosis side by side

	Mitosis	Meiosis
What it is	nuclear division	nuclear division (a reduction division)
Chromosome number in the new cells	the same as the parent	halved: diploid → haploid
New cells are genetically	identical	different
Causes variation?	no	yes
Used for	growth, repair of damaged tissues, replacement of cells, asexual reproduction	producing gametes
Where (examples)	all over the body; root and shoot tips; embryos; stem cells	testes, ovaries, anthers, ovules

Key facts and formulas

There is no formula list in the IGCSE Biology exam. Everything below must be learnt (all **Extended only**), except the mitotic index, which a question defines when it needs it.

Formula	Status
Mitosis: nuclear division giving rise to genetically identical cells	Learn it
Mitosis is for growth, repair of damaged tissues, replacement of cells and asexual reproduction	Learn it
Exact replication of chromosomes happens before mitosis; DNA mass per cell doubles	Learn it
During mitosis the copies of chromosomes separate, so each daughter cell keeps the same chromosome number	Learn it
Stem cells: unspecialised cells that divide by mitosis to produce daughter cells that can become specialised for specific functions	Learn it

Formula	Status
Meiosis is involved in the production of gametes	Learn it
Meiosis: a reduction division; chromosome number halved from diploid to haploid; genetically different cells	Learn it
Haploid: one set of chromosomes (n); diploid: two sets ($2n$). Human: $2n = 46$, $n = 23$	Learn it
Gamete number = $\frac{\text{diploid number}}{2}$; zygote number = gamete + gamete	Learn it
$2n \rightarrow n$: meiosis; $2n \rightarrow 2n$ or $n \rightarrow n$: mitosis; $n + n \rightarrow 2n$: fertilisation	Learn it
Mitotic index = $\frac{\text{cells dividing}}{\text{total cells}} \times 100\%$	Given (the question defines it)

How to do it

We tagged 51 questions for this topic (2021–2025, Papers 1–4). 6 of them mix types, so the counts add up to 57.

Question type	Questions
What mitosis and meiosis are, what they do and where	22
Haploid, diploid and chromosome numbers	17
Stem cells	8
Graphs and data on dividing cells	7
Life cycles: which division happens where	3

1. What mitosis and meiosis are, what they do and where (22 questions)

1. **Decide which division** the question is about: identical cells, growth, repair, replacement, asexual reproduction or an embryo → **mitosis**; gametes, pollen, sperm, eggs, halving, "reduction division" or variation → **meiosis**.
2. **Test each statement on its own** against the side-by-side table above before choosing a letter.
3. **In written answers**, use the syllabus words: "nuclear division", "genetically identical", "reduction division", "diploid to haploid", "genetically different".

Variations you will meet:

- **"Which statements describe meiosis?"** Yes: produces haploid cells; reduction division; gives variation; involved in producing gametes. No: genetically identical cells; diploid cells; repair of damaged tissues; producing body cells.

- **"Which row shows correct information about mitosis?"** Genetically identical; the same number of chromosomes as the parent cell; the chromosomes are copied **before** mitosis, not during it.
- **"Which are functions of mitosis?"** Growth, repair of damaged tissue, replacement of cells and asexual reproduction, but **not** producing gametes.
- **A named example:** a lizard regrowing its tail, a healing wound, a growing root or shoot, a seedling growing, an embryo forming from a zygote, plantlets or runners → all **mitosis**. Sunflower pollen nuclei or human sperm → **meiosis**.
- **"Complete the sentences"** (Paper 4): fill each gap with a syllabus word: mitosis is for growth, **repair** of tissues, replacement of cells and **asexual** reproduction; the copies of chromosomes **separate**; meiosis halves the number from **diploid** to haploid; two gametes' nuclei fuse to form a **zygote**, in **fertilisation**.
- **"Describe mitosis and its roles"** (4 marks): nuclear division; makes genetically identical cells; the copies of the chromosomes separate; the chromosome number is kept the same; then name two roles, such as growth and repair of damaged tissues. Examiners say most answers give the roles but forget the process, so write both.
- **Tick table of statements** for mitosis and meiosis: "a type of nuclear division" is ticked for **both**; "genetically different cells" and "produces gametes" for meiosis only; "repair", "growth" and "asexual reproduction" for mitosis only.
- **"Describe how an embryo is formed from a zygote"**: the zygote divides by **mitosis**; the chromosomes are copied, then the copies separate; it makes 2 cells, then 4, then a ball of cells; the cells are genetically identical. Never meiosis.
- **"State the name of the process that produces haploid gametes"**: meiosis (accept "reduction division").

2. Haploid, diploid and chromosome numbers (17 questions)

1. **Find the diploid number ($2n$)**: the number in a body cell, a zygote or an embryo cell.
2. **Gametes** (sperm, egg, pollen nucleus) have **half**: $n = 2n \div 2$.
3. **Mitosis** keeps the number; **meiosis** halves it; **fertilisation** adds two gametes' numbers.

For example, a pangolin has 40 chromosomes per body cell, so its sperm cells have $40 \div 2 = 20$.

Variations you will meet:

- **Human cells**: body cell, zygote, embryo: diploid, **two sets, 46**; gamete: haploid, **one set, 23** (one set of unpaired chromosomes).
- **"Before meiosis a cell has 24 chromosomes"**: each cell made has $24 \div 2 = 12$. Not 48.
- **Given the zygote or a pollen nucleus**: a zygote with 10 chromosomes means body and embryo cells have 10 and sperm have 5; a pollen nucleus with 17 means the zygote has $17 + 17 = 34$.
- **A hybrid of two species**: the zygote gets one gamete from each. If species 1 has a diploid number of 70, its gamete has 35. A hybrid zygote with 64 means the other gamete had $64 - 35 = 29$, so species 2 has a diploid number of $29 \times 2 = 58$.

- **Chromosome diagrams:** count the chromosomes and look for pairs (two of the same length and shape). Pairs present → diploid; one of each type, no pairs → haploid. For "which diagram shows a daughter cell after mitosis", pick the cell with **the same chromosomes** as the parent, each one a single copy (not the joined copies from before division, and not half of them).
- **"Why must gametes be haploid?":** so that when two nuclei fuse at fertilisation, the zygote is diploid; the chromosome number is kept the same from generation to generation instead of doubling each time.
- **"Explain how the chromosome number is maintained from one generation to the next":** meiosis halves the number from diploid to haploid in the gametes; at fertilisation two haploid nuclei fuse; the zygote is diploid again; it then grows by mitosis, which keeps the number the same.

3. Stem cells (8 questions)

1. **Learn the three parts:** **unspecialised** cells; that **divide by mitosis**; to produce daughter cells that **can become specialised** for specific functions. Each part is usually worth a mark.
2. **In multiple choice**, reject "specialised" and "meiosis".

Variations you will meet:

- **"Which word describes stem cells?"** Unspecialised. Not gametes, haploid or homozygous.
- **Diagram of the cells of an embryo soon after fertilisation:** they are **stem cells undergoing mitosis**. Not gametes, not a zygote (a zygote is one cell), and not meiosis.
- **"State the name of the unspecialised cells that divide by mitosis":** stem cells.
- **Stem cells and gene expression** (a completion question): body cells contain the same genes, but many genes in a particular cell are not **expressed**, because the cell makes only the specific **proteins** it needs.

4. Graphs and data on dividing cells (7 questions)

1. **Label the graph** of DNA mass per cell in your head: level → **rise** (DNA replication, before mitosis) → level at double → **sudden drop** (the cell divides into two).
2. **Answer from the label:** "where are two cells formed?" → at the drop; "what is happening on the rise?" → DNA replication; "what happens to the DNA mass before mitosis?" → it doubles.
3. **Read times from the axis:** the time for DNA to double is from the start of the rise to the top of the rise. Two complete cell cycles on one graph show two rises and two drops.

Variations you will meet:

- **"Which graph shows DNA mass before, during and after mitosis?"** The one that doubles, stays level, then halves back to the **starting** value.
- **"Which type of division, and what chromosome number do the daughter cells have?"** A graph that halves once, back to the start, from a diploid cell → mitosis, diploid daughter cells.
- **Wrong options to reject** at the rise: "the cell is dividing", "reduction division", "changing from haploid to diploid". The rise is only copying.

- **Mitotic index:** the question gives the definition, the percentage of cells in a tissue that are dividing by mitosis. Divide the number of dividing cells by the **total** number of cells (not by the number not dividing), times 100. The tissue with the **higher** index is **growing faster**. For example, 25 dividing cells out of 80 gives $25 \div 80 \times 100 = 31.25$, so 31.3%.

5. Life cycles: which division happens where (3 questions)

1. **Write n or $2n$** next to every stage of the diagram (the question usually gives some).
2. **Look at each arrow:** $2n \rightarrow n$ is **meiosis**; $2n \rightarrow 2n$ or $n \rightarrow n$ is **mitosis**; two gametes joining to make a zygote is **fertilisation**.
3. **Name the process**, not a description: "meiosis", "mitosis", "fertilisation". Examiners saw spores or eggs being made named as "dispersal", "pollination" or "ovulation"; if the number halves, it is meiosis.

Variations you will meet:

- **Numbers from the diagram:** a diploid stage with 1200 chromosomes means haploid stages (spores, a gametophyte, gametes) have $1200 \div 2 = 600$.
- **"Identify and describe process A"** where a diploid adult makes haploid spores: meiosis; a reduction division; halves the chromosome number from diploid to haploid; makes genetically different spores.
- **"Which events would not be in a life cycle for asexual reproduction?"** Meiosis (the haploid stage), making gametes, and fertilisation (the zygote).
- **A flow diagram of human reproduction:** diploid cells in the organs (testes, ovaries) $\rightarrow$ meiosis $\rightarrow$ haploid sperm and egg $\rightarrow$ fertilisation $\rightarrow$ diploid zygote $\rightarrow$ mitosis $\rightarrow$ embryo.

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **B1** mark for a correct result on its own, with no method needed.

Example 1

A species of fish has 48 chromosomes in each of its body cells.

(a) State the number of chromosomes in (i) a sperm cell, (ii) a zygote and (iii) each cell produced when a skin cell divides by mitosis. **[3]**

(b) State the name of the type of nuclear division that produces the sperm cells, and describe this division. **[3]**

(c) State **two** roles of mitosis in the fish, other than growth. **[2]**

(a) (i) $48 \div 2 = 24$ **B1**. (ii) $24 + 24 = 48$ **B1**. (iii) 48 **B1**.

(b) Meiosis **B1**. It is a reduction division: the chromosome number is halved from diploid to haploid **B1**, and the cells produced are genetically different **B1**.

(c) Any two: repair of damaged tissues **B1**; replacement of cells **B1**; asexual reproduction.

Example 2

The second diagram in "Understand it" shows the mass of DNA in one cell of a root tip.

(a) State what is happening to the DNA between 6 hours and 12 hours. **[1]**

(b) Use the graph to find how long it takes for the DNA to double in mass. **[1]**

(c) Describe what happens to the chromosomes and the cell at 18 hours. **[2]**

(d) The root tip cells are diploid. State the type of nuclear division shown, and explain how the graph shows that the chromosome number of the daughter cells is the same as that of the parent cell. **[3]**

(a) DNA replication: the chromosomes are being copied exactly **B1**.

(b) $12 - 6 = 6$ hours **B1**.

(c) The copies of the chromosomes separate **B1**, and the cell divides into two cells **B1**.

(d) Mitosis **B1**. The DNA mass doubles and then halves once **B1**, so each daughter cell has the same mass of DNA as the parent had at the start, 2 units, and so the same number of chromosomes **B1**.

Example 3

A moss plant is haploid (n) for most of its life. Its cells have 10 chromosomes. The moss plant makes gametes (process **J**). A male and a female gamete fuse (process **K**) to form a zygote. The zygote divides many times (process **L**) to form a stalk that stays attached to the moss plant. Cells in the stalk divide (process **M**) to make haploid spores, which grow into new moss plants (process **N**).

(a) State the number of chromosomes in (i) a moss gamete and (ii) a cell of the stalk. **[2]**

(b) State whether each of processes **J**, **L**, **M** and **N** is mitosis or meiosis. **[3]**

(c) State the name of process **K**. **[1]**

(d) The early cells of the stalk are stem cells. Describe what is meant by the term *stem cell*. **[3]**

(a) (i) 10: the gametes are made by a haploid plant and stay haploid **B1**. (ii) $10 + 10 = 20$: the zygote is diploid and the stalk is made from it by mitosis **B1**.

(b)

Process	Chromosome number	Division
J moss plant → gametes	$n \rightarrow n$ ($10 \rightarrow 10$)	mitosis

Process	Chromosome number	Division
L zygote → stalk	$2n \rightarrow 2n$ (20 → 20)	mitosis
M stalk → spores	$2n \rightarrow n$ (20 → 10)	meiosis
N spore → moss plant	$n \rightarrow n$ (10 → 10)	mitosis

All four correct **B3**; three correct **B2**; two correct **B1**.

(c) Fertilisation **B1**.

(d) Unspecialised cells **B1** that divide by mitosis **B1** to produce daughter cells that can become specialised for specific functions **B1**.

Common mistakes

- **Mixing up the names.** Examiners see the right facts ticked under the wrong heading. Learn one pair of facts and build from it: **meiosis makes gametes; mitosis makes identical body cells.**
- **Misspelling them.** "Meitosis" and "meosis" can lose the mark. Write **mitosis** and **meiosis**.
- **Saying growth, repair or an embryo uses meiosis.** A regrowing tail, a healing wound, a growing root and a dividing zygote all use mitosis. Only gamete production uses meiosis.
- **Thinking mitosis causes variation.** Mitosis makes identical cells; meiosis (with mutation and random fertilisation) is what makes offspring different.
- **Doubling instead of halving.** A cell with 24 chromosomes makes cells with 12 by meiosis, not 48.
- **Thinking meiosis makes identical cells,** or that a haploid cell can divide by meiosis. Meiosis takes a **diploid** cell to **haploid**, genetically **different** cells.
- **Putting DNA copying during mitosis, or saying the DNA mass stays the same.** Replication happens **before** mitosis, and the DNA mass doubles.
- **Reading the rise on a DNA graph as division.** The rise is replication; the cells form at the sudden drop.
- **Calling stem cells specialised,** or saying they divide by meiosis. They are **unspecialised** and divide by **mitosis**.
- **Naming a life-cycle process wrongly.** Making eggs is meiosis, not ovulation; diploid to haploid spores is meiosis, not dispersal or pollination.
- **Adding the stages of mitosis or meiosis.** They are not in the syllabus and earn nothing; use the time to give the process and its result.

How to get the marks

- **"Describe mitosis":** "nuclear division" + "genetically identical cells", then the chromosome detail: copied exactly before; copies separate; same chromosome number in each daughter cell.
- **"Describe meiosis":** "reduction division" + "chromosome number halved" + "diploid to haploid" + "genetically different cells". Each phrase can be a mark.

- **"State the role"**: one word or phrase per mark: growth, repair of damaged tissues, replacement of cells, asexual reproduction. "Making cells" is too vague.
- **Stem cells**: three separate ideas for three marks: unspecialised; divide by mitosis; daughter cells become specialised.
- **"State the name"**: give the name, not a description: "meiosis", "fertilisation", "stem cells".
- **Tick tables**: one tick per row unless the row is true for both; a row with a tick in the wrong box, or an extra tick, loses that row.
- **Graphs**: say what the line is doing and why ("the DNA mass doubles because the chromosomes are replicated"); read times off the axis carefully and give the unit (hours).
- **Numbers**: show the halving or adding, for example $70 \div 2 = 35$, and give a whole number of chromosomes.
- **Multiple choice with numbered statements**: test each statement on its own, then choose the letter.

Quick check

1. State whether mitosis or meiosis is used in each case: (a) healing a graze on the knee; (b) making pollen nuclei in an anther; (c) a strawberry plant producing new plants on runners; (d) a root tip growing longer.
2. A cat has 38 chromosomes in each body cell. How many are in (a) an egg cell and (b) each cell made when a liver cell divides by mitosis?
3. The mitotic index is the percentage of cells in a tissue that are dividing by mitosis. In tissue A, 18 of 120 cells are dividing; in tissue B, 30 of 250 cells are dividing. Calculate both mitotic indices and state which tissue is growing faster.
4. Species P has a diploid number of 38. A gamete of P fuses with a gamete of species Q to form a hybrid zygote with 33 chromosomes. Calculate the diploid number of species Q.
5. Describe what is meant by the term *stem cell*.

Answers

1. (a) Mitosis (repair). (b) Meiosis (gametes). (c) Mitosis (asexual reproduction). (d) Mitosis (growth).
2. (a) $38 \div 2 = 19$. (b) 38: mitosis keeps the chromosome number the same.
3. A: $18 \div 120 \times 100 = 15\%$. B: $30 \div 250 \times 100 = 12\%$. Tissue A has the higher mitotic index, so it is growing faster.
4. Gamete of P: $38 \div 2 = 19$. Gamete of Q: $33 - 19 = 14$. Diploid number of Q: $14 \times 2 = 28$.
5. Unspecialised cells that divide by mitosis to produce daughter cells that can become specialised for specific functions.

Past questions to try

- [0610/41/M/J/25 Q3](#): describing mitosis and its roles, and naming stem cells, in (d) and (e).
- [0610/41/O/N/23 Q4](#): completing sentences about mitosis and meiosis.
- [0610/42/F/M/23 Q3](#): a fern life cycle: chromosome numbers and naming meiosis, in (b).
- [0610/22/F/M/24 Q35](#): calculating and comparing mitotic indices.