# B1 L6 Revision notes 1 of 4

## Why cells divide, chromosomes, DNA and genes, and a real root tip

### 1. Why cells divide

A **multicellular organism**, such as a human or a tree, is made of many cells. You started as one cell. To grow, an organism needs more cells, so its cells divide to make new cells. New body cells are made by mitosis.

Cells divide for:

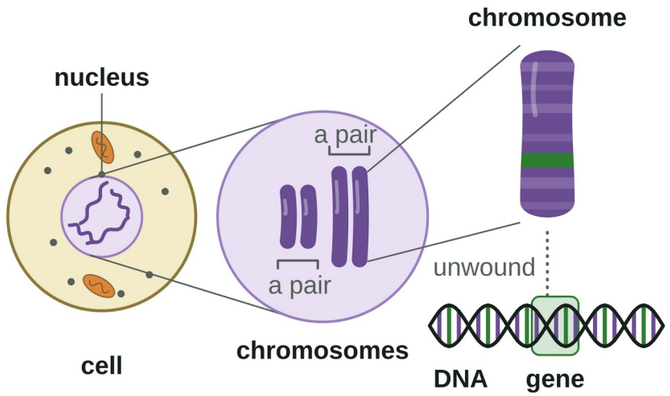
- **growth and development**: making a bigger organism, such as a root growing longer;
- **repair**: mending damage, such as a cut in the skin;
- **replacement**: replacing cells that wear out, such as skin cells that rub off.

Before a cell divides, it copies its genetic material, so that each new cell gets a full set (section 6).

### 2. Chromosomes, DNA and genes

The **nucleus** of a cell contains **chromosomes**. A chromosome is made of one very long, coiled molecule of **DNA**, the chemical that carries the genetic instructions for a cell. Each chromosome carries a large number of **genes**. A gene is a small section of DNA on a chromosome.

In body cells, chromosomes are normally found in **pairs**.




A diagram is simplified: this model cell has only 4 chromosomes. A human body cell has 46.

| Cell | Chromosomes | Pairs |
|---|---|---|
| **a human body cell** | 46 | 23 |
| **an onion cell** | 16 | 8 |
| **the model cell in diagrams** | 4 | 2 |

**Watch out:** a gene is not a whole chromosome. It is a small section of the DNA in a chromosome. From smallest to largest: gene, chromosome, nucleus, cell.

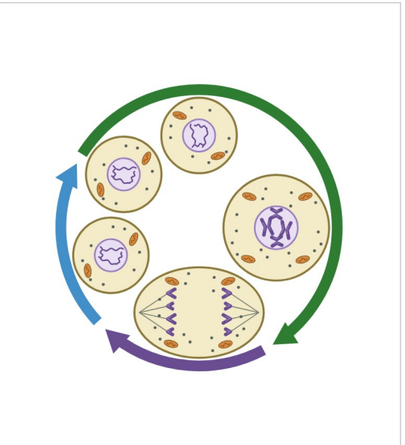
### 3. A real root tip and a diagram

A painting based on a light micrograph. Stains colour the chromosomes; most cells are not dividing.

Both show cells with one round nucleus, and dividing cells with one set of chromosomes pulled to each end.




**A real root tip (painting)**



**A diagram**

Roots grow at their tips, so this is where cells divide. To see them, a thin root tip is squashed on a slide and **stained**, then looked at with a light microscope (B1 L3 Using a microscope). A picture of what you see is a **light micrograph**.

Exam pictures of the cell cycle are usually **diagrams**. A diagram is simplified on purpose:

- Most real cells are not dividing: many are growing and copying their DNA, ready to divide. The diagram gives every stage its own picture.
- In real cells, chromosomes show as separate threads only when a cell divides. The diagram draws them in every cell.
- A real onion cell has 16 chromosomes. The diagram cell has only 4 (2 pairs), so they are easy to count.
- The purple is a stain: real chromosomes are colourless. The diagram colours them so you can see them.
- Real cells are packed together in rows, sharing their walls. The diagram draws one cell on its own.

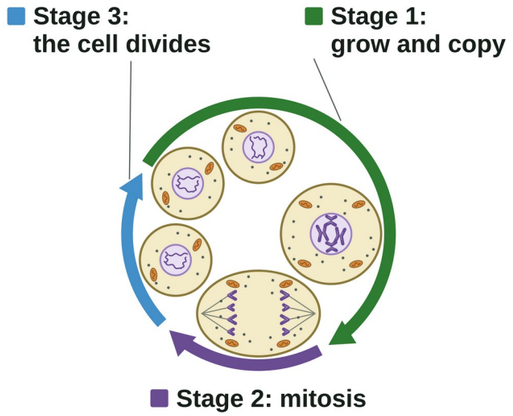
**Watch out:** chromosomes are in the nucleus all the time. Between divisions they are long, thin threads, so you cannot see them one by one. When a cell divides, they coil up, short and thick, and show up.

# B1 L6 Revision notes 2 of 4

## The cell cycle, mitosis and two identical cells

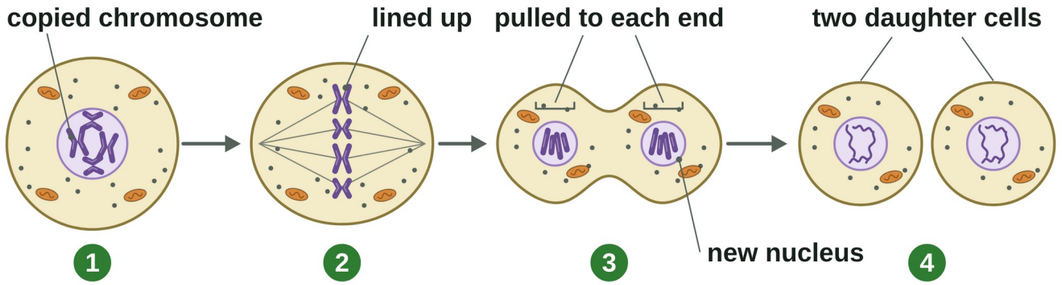
### 4. The cell cycle

| Stage | What happens |
|---|---|
| **Stage 1: grow and copy** | The cell grows and makes more sub-cellular structures, such as ribosomes and mitochondria. The DNA replicates to form two copies of each chromosome. |
| **Stage 2: mitosis** | One set of chromosomes is pulled to each end of the cell, and the nucleus divides. |
| **Stage 3: the cell divides** | The cytoplasm and cell membrane divide to form two identical cells. |




Cells divide in a series of stages called the **cell cycle**. A human cell cycle takes about 24 hours. Mitosis takes only about 1 hour of it: most of the time, a cell is growing and copying its DNA.

### 5. Mitosis step by step



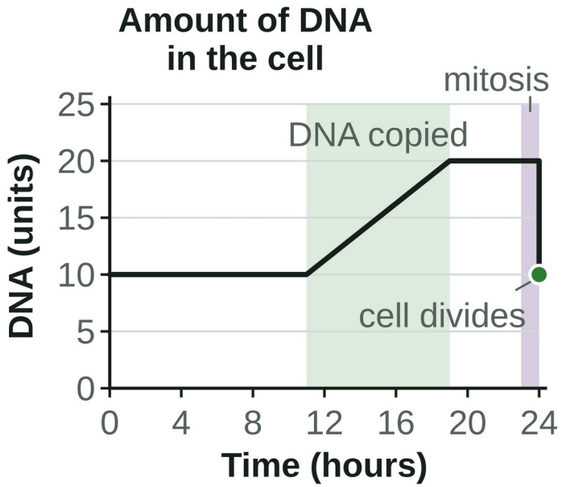

1. Each chromosome has been copied. The two copies are joined together.
2. The chromosomes line up across the middle of the cell.
3. The copies are pulled apart: one set of chromosomes goes to each end of the cell. A new nucleus forms round each set, so the nucleus has divided.
4. The cytoplasm and cell membrane divide. There are now two daughter cells.

You do not need the names of the phases of mitosis. Describe what the chromosomes do.

### 6. Two genetically identical cells

During the cell cycle the genetic material is **doubled** and then **divided** into two identical cells:

- In stage 1, the DNA is copied, so the amount of DNA in the cell doubles.
- In mitosis, one copy of every chromosome goes to each end of the cell.
- When the cell divides, each daughter cell has the starting amount of DNA again.




So the two **daughter cells** are **genetically identical**: they have exactly the same genetic material as each other and as the parent cell. They have the same number of chromosomes as the parent cell. A human body cell with 46 chromosomes makes two daughter cells with 46 each.

> **Watch out:** mitosis is only stage 2, when the nucleus divides. The DNA is copied before mitosis, in stage 1, while the cell grows.

> **Watch out:** mitosis makes two cells, not four. Each new cell has 46 chromosomes, not 23. Halving the number happens only when sex cells are made, by a different division, meiosis (B6 Inheritance, variation and evolution).

> **Watch out:** a pair is two matching chromosomes of the same size (why they come in pairs is B6). The two copies made when the DNA is copied are not a pair: they are exact copies, and mitosis shares them out, one to each new cell.

# B1 L6 Revision notes 3 of 4

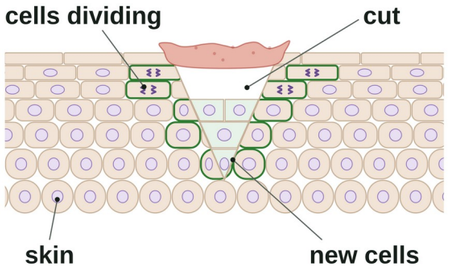
## Growth, repair and replacement, and the maths

### 7. Where does mitosis happen?

Cell division by mitosis is important in the **growth and development** of multicellular organisms. It is also used for **repair** and **replacement**.

In adult animals, most mitosis is for repair and replacement. Plants keep growing at their root and shoot tips all their lives.

Not mitosis: making sex cells (sperm and egg cells are made by meiosis, B6); a bacterium splitting into two (it has no nucleus, B1 L2 Bacterial cells).




| Job | Example | Which cells divide |
|---|---|---|
| **growth and development** | a root growing longer; a young tree growing taller; one cell growing into a ball of cells | cells at the root and shoot tips; every cell in the ball |
| **repair** | a cut in the skin healing; a lizard regrowing its tail | cells beside the cut; cells at the end of the tail |
| **replacement** | replacing skin cells that rub off | cells deep in the skin |

Some organisms reproduce using mitosis: asexual reproduction (B6). Cells that divide to make new cells for growth and repair: B1 L7 Stem cells. Changes in cells that lead to uncontrolled division can cause a tumour (B2 L11 Health, risk factors and cancer).

**Spot it:** in a question, look for an organism that is growing, repairing damage or replacing cells. That is where mitosis is happening.

### 8. Doubling

If every cell divides once in each round, the number of cells doubles: 1 → 2 → 4 → 8 → 16.

**after n rounds, number of cells = $2^n$**

| Rounds | 0 | 1 | 2 | 3 | 4 | 5 | 10 |
|---|---|---|---|---|---|---|---|
| **Cells** | 1 | 2 | 4 | 8 | 16 | 32 | 1024 |

**Worked example:** a cell divides by mitosis every 24 hours, and every new cell does the same. How many cells are there after 10 days, starting from one cell?

Step 1: 10 days = 10 rounds of division.

Step 2: $2^{10} = 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 = 1024$.

Answer: **1024 cells**, about $1 \times 10^3$ in standard form (B1 L4 Magnification and cell size).

### 9. Counting dividing cells

Scientists count the dividing cells in a stained root tip to find where the root grows fastest. Close to the tip, many cells are dividing; further back, cells stop dividing, get longer and become specialised.

**percentage of cells dividing = cells dividing ÷ total cells × 100**

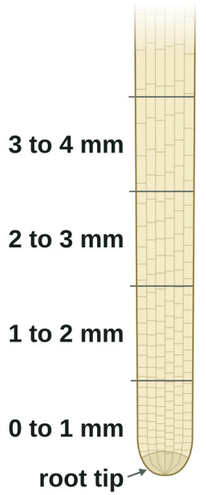
**Worked example:** 9 of 180 cells in a root tip are dividing. What percentage of the cells are dividing?

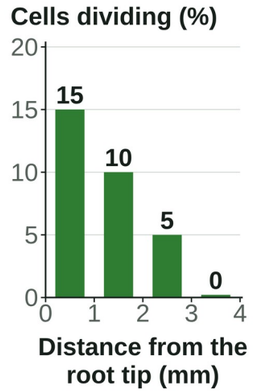
Step 1: 9 ÷ 180 = 0.05.

Step 2: 0.05 × 100 = 5 %.

Answer: **5 %**.

Check: 5 % of 180 = 180 ÷ 100 × 5 = 9. ✓




**Watch out:** divide the number of cells dividing by the total, not the other way round, and multiply by 100. A percentage of cells can never be more than 100 %.

**Time in a stage (stretch):** the more cells you see in a stage, the longer that stage lasts.

time in mitosis = (cells in mitosis ÷ total cells) × time for one cell cycle

For example, 10 of 240 cells are in mitosis, and the cycle takes 24 hours: 10 ÷ 240 × 24 = 1 hour.

### 10. Answering cell cycle questions

Give the stages in order, and use the key words: grows, sub-cellular structures, the DNA replicates (is copied), one set of chromosomes pulled to each end, the nucleus divides, the cytoplasm and cell membrane divide, two genetically identical cells.

- Question: "Explain why a cell must copy its DNA before it divides."
- Model answer: "So that each daughter cell gets a full set of chromosomes. The DNA replicates to form two copies of each chromosome. In mitosis, one copy of each chromosome goes to each end of the cell. If the DNA were not copied, each new cell would get only some of the chromosomes."
- "The chromosomes split" or "the cell splits into four" scores nothing: say one set of chromosomes is pulled to each end, and two cells are made.

# B1 L6 Revision notes 4 of 4



## Key words, exam tips and check yourself

### Key words

**Cell cycle**: the series of stages in which a cell grows, copies its DNA and divides into two identical cells.

**Chromosome**: a structure in the nucleus, made of DNA, that carries a large number of genes.

**Daughter cells**: the two new cells made when a cell divides.

**DNA**: the chemical that carries the genetic instructions for a cell.

**Gene**: a small section of DNA on a chromosome.

**Genetically identical**: having exactly the same genetic material.

**Light micrograph**: a picture of something seen through a light microscope.

**Mitosis**: the stage of the cell cycle in which one set of chromosomes is pulled to each end of the cell and the nucleus divides.

**Multicellular organism**: an organism made of many cells, such as a human or a tree.

**Nucleus**: the part of a cell that contains the genetic material, which controls the activities of the cell.

**Stain**: a dye that colours cells, or parts of cells, so they are easier to see.

**Sub-cellular structure**: a part inside a cell that has a particular job, such as the nucleus or a mitochondrion.

### Exam tips

- Learn the three stages in order: grow and copy the DNA; mitosis; the cytoplasm and cell membrane divide.
- Mitosis is the stage when one set of chromosomes is pulled to each end and the nucleus divides.
- Say "two genetically identical cells", and give the chromosome number: 46 → 46.
- Do not use the phase names: describe what the chromosomes do.
- In percentage questions, write the formula, show your working and check the answer is sensible.
- Energy is **released** by respiration in mitochondria. Never write that energy is "made".

### Check yourself

Cover the answers, then check.

1. What is a chromosome made of, and what does it carry?
2. How many chromosomes are in a human body cell, and how are they arranged?
3. Name the three stages of the cell cycle.
4. What happens to the number of sub-cellular structures in stage 1?
5. Describe what happens in mitosis.
6. Why are the two daughter cells genetically identical?
7. Give three reasons why cells divide by mitosis.
8. One cell divides by mitosis. In each round, every cell divides once. How many cells are there after 6 rounds?

### Answers

1. DNA. It carries a large number of genes.
2. 46, in 23 pairs.
3. Stage 1: the cell grows and copies its DNA. Stage 2: mitosis. Stage 3: the cytoplasm and cell membrane divide.
4. It increases: the cell makes more of them, such as ribosomes and mitochondria.
5. One set of chromosomes is pulled to each end of the cell, and the nucleus divides.
6. The DNA is copied, and each daughter cell gets one copy of every chromosome.
7. Growth (and development), repair and replacement.
8. $2^6 = 64$ cells.

### Common mistakes

- **Wrong:** "Mitosis makes four cells." **Right:** mitosis makes two cells.
- **Wrong:** "Each new cell has 23 chromosomes." **Right:** it has 46, the same as the parent cell.
- **Wrong:** "The DNA is copied during mitosis." **Right:** it is copied before, in stage 1.
- **Wrong:** "Chromosomes appear when a cell divides." **Right:** they are there all the time; they only show up then.