Cell Division

GCSE Additional Science
Cell Division

Introduction to cell division

Mitosis

Fertilization

Meiosis

DNA replication

Summary activities
Why do cells divide? What would happen if they didn’t?

- Organisms would only ever exist as single cells – fine for bacteria but not so good for plants and animals!

- Old and damaged cells would never be replaced.

- Organisms wouldn’t reproduce.
Genetic material

When cells divide, it is essential that genes are copied into the new cells.

Genes are the basic unit of inheritance, and are responsible for the characteristics of an organism.

Genes are located on chromosomes, each of which is made from a very long, tightly coiled molecule of DNA.
Different organisms have different numbers of chromosomes. Humans have **46 chromosomes**. This is the **haploid** number of humans.

Chromosomes can be grouped in pairs called **homologous chromosomes**. In each pair, one chromosome has been inherited from the mother and the other inherited from the father.

How many pairs of chromosomes do humans have? **23**
Homologous pairs of human chromosomes

Click on the nucleus to organize these human chromosomes into homologous pairs.

How many pairs will there be?
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How do cells divide?
Most animals and plants start off life as just a single cell, but grow to become adults containing billions and billions of cells.

How does one cell become billions and billions of cells?

The type of cell division that makes animals and plants grow is called **mitosis**.

In mitosis, a **parent** cell divides into two identical **daughter** cells. These daughter cells divide in two, and so on.

Mitosis is also the way in old and damaged cells are replaced.
One of a kind?

The two daughter cells produced by mitosis are genetically identical to the parent cell. What does this mean?

All the genes and chromosomes from the parent cell must be copied and passed on to the daughter cells.

Normally, a cell only contains one copy of each chromosome, but before dividing a cell must duplicate all its chromosomes. This means that all the genes will also be duplicated.
A cell’s chromosomes are usually long, thin strands. Just before the cell divides, however, the chromosomes become shorter, thicker and more visible. They are said to **condense**.

Each chromosome duplicates and becomes two strands, each one called a **chromatid**. The two chromatids are joined at the **centromere**.
What are the stages of mitosis?

Once the chromosomes have duplicated, mitosis takes place. This is a continuous process but can be divided into several parts:

- Each chromosome replicates so it contains two identical chromatids.
- The chromosomes align in the middle of the parent cell.
- The two chromatids in each chromosome are pulled apart into separate halves of the cell.
- The cell splits in two to produce two daughter cells, each containing the same chromosomes.

Mitosis involves copying a cell and its chromosomes exactly, so it is sometimes called **copying division**.
Mitosis is cell division that produces two identical body cells. It is used during growth, and to replace old and damaged cells.

Click the cell or "play" to find out what happens.
What is the order of stages in mitosis?

1. Chromatids move to opposite sides of the cell
2. Chromosomes become shorter and thicker
3. Spindle fibres attach to the chromosomes
4. Chromosomes align in the centre of the cell
5. The cell divides into two daughter cells
6. Spindle fibres shorten, separating the chromosomes
Chromosomes during mitosis

What happens to chromosomes during mitosis?

parent cell → cell division → daughter cells

chromosome bank

X  X  X  1
What are sex cells?

Sex cells in animals and plants are called **gametes**. In animals, the gametes are eggs (ova) and sperm.

In mammals, egg cells are produced in the ovaries, and sperm cells are produced in the testes. How are these cells specialized for their roles in reproduction?
Fertilization is the stage of sexual reproduction when gametes fuse. This is the first step in the creation of a new life.

When an egg cell is fertilized, it becomes a zygote.

This zygote divides by mitosis many times and becomes an embryo.

The embryo continues to grow and develop into a fetus.
What happens during fertilization?

Fertilization occurs when an egg cell and a sperm cell fuse together.

Click the uterus or "play" to find out what happens.
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How many chromosomes in gametes?

If gametes had the same number of chromosomes as body cells, what problem would this cause at fertilization?

The embryo would have double the number of chromosomes – 92 instead of 46 in humans.

Why does this not happen?

Only one chromosome from each homologous pair in the parent cell is copied to the gametes during cell division.

This means that human gametes only have **23 chromosomes**. Gametess are said to be **diploid** cells.
What is meiosis?

Gametes are produced by a type of cell division called **meiosis**.

The number of chromosomes is halved in meiosis so it is sometimes called **reduction division**.

Unlike mitosis, meiosis produces **four unique** daughter cells.

Why is it important to produce genetically unique gametes?

It ensures natural variation within a species.
Increasing genetic variation

Meiosis produces genetically-unique daughter cells, but how does this happen?

In the early stages of meiosis, homologous chromosomes exchange DNA, which creates genetic variation and new combinations of characteristics. This is called crossing-over.

![Diagram of homologous pair before and after crossing-over](image)
What happens during meiosis?

Before meiosis begins, all the chromosomes duplicate to form two chromatids. Cells then undergo two rounds of division.

In the first round of division:

● Homologous pairs of chromosomes align in the middle of the parent cell and are separated.

● The cell divides so each new daughter cell only contains one chromosome from each pair; 23 chromosomes in total.

In the second round of division:

● In each cell, the chromosomes align in the centre and its chromatids are pulled apart into separate halves of the cell.

● Each cell divides again, so each new cell only contains one chromatid from each chromosome.
What happens during meiosis?

Meiosis is cell division that produces four unique sex cells, or gametes.

Click the cell or "play" to find out what happens.
The stages of meiosis

What is the order of stages in meiosis?

1. each cell divides into two daughter cells
2. spindle fibres separate homologous chromosomes
3. chromosomes align in the centre of each cell
4. the cell divides into two daughter cells
5. chromosomes become shorter and thicker
6. homologous chromosomes pair up in the centre of the cell
7. spindle fibres separate chromosomes into chromatids
What happens to chromosomes during meiosis?

- Parent cell
- Crossing over
- 2 daughter cells
- Chromosome bank
- 4 daughter cells
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Before cell division takes place, the chromosomes duplicate. How does this affect DNA?

Each chromosome is made of a DNA molecule, so DNA also needs to replicate.

DNA is a very interesting molecule because it is able to copy itself. It is able to do this because it is double stranded.
What is the structure of DNA?

Click on the labels to find out about the structure of DNA.
How does DNA replicate?

The replication of DNA is a continuous process but can be broken down into several stages:

- The DNA helix unwinds.
- The two strands separate.
- New bases bond to each strand, creating two new molecules of DNA.
- Each molecule of DNA winds up again, creating two new helices.
How does DNA replicate?

What happens during DNA replication?

Before a cell divides, its chromosomes need to replicate. This means that DNA needs to replicate too.

Click the chromosome or "play" to find out how DNA replicates.
DNA is able to copy itself very accurately – for every 1 billion bases replicated, only 1 will be wrong!

Sometimes, however, mistakes do happen. When this happens, it is called a mutation.

Most mutations are harmful and many have no effect, but sometimes a mutation results in a new, beneficial characteristic for the individual.

How important are mutations in natural selection and evolution?
• **base** – The chemical in DNA that forms the basis of the genetic code.

• **centromere** – The point at which two chromatids are joined in a chromosome after it has replicated.

• **chromatid** – One of the two strands of a chromosome that form after DNA replication.

• **chromosome** – A long molecule of tightly coiled DNA found in the nucleus of most cells.

• **crossing-over** – The exchange of DNA between homologous chromosomes during meiosis.

• **DNA** – The molecule that contains the genetic code.

• **fertilization** – The fusion of an egg and sperm cell.
Glossary (2/2)

- **gamete** – A male or female reproductive cell – sperm or egg.
- **gene** – The unit of inheritance.
- **homologous** – Two chromosomes containing the same type of genes and which pair up during meiosis.
- **meiosis** – The type of cell division that produces four unique daughter cells (gametes).
- **mitosis** – The type of cell division that produces two identical daughter cells.
- **mutation** – A random change in the genetic code of a cell.
- **spindle** – A network of tiny fibres that attach to chromosomes during cell division and separate them.
- **zygote** – A fertilized egg cell.
How quickly can you unscramble anagrams of words about

**cell**

**division**?

start
Cell division terms

Match the term to its description

- **centromere**: where two chromatids join on a chromosome
- **chromatid**: one of two chromosomes in a pair
- **chromosome**: a long molecule of DNA on which genes are found
- **homologous**: one of two chromosome strands after DNA replication
- **spindle**: tiny fibres that separate chromosomes in cell division
What are the differences between mitosis and meiosis?

Mitosis and meiosis sound the same, but there are many differences between these two types of cell division.

Click "start" to see if you can tell the difference between them.
Multiple-choice quiz

It's time to replicate everything you know about cell division!

start