

Cell division, variation and evolution

Revision notes · Mitosis and meiosis, genetic and environmental variation, mutation, natural selection and antibiotic resistance.

For Pearson Edexcel International GCSE Biology 4BI1 and Science (Double Award) 4SD0. **Biology only** is not in the Double Award and is only examined on Paper 2.

Cell division, variation and evolution Spec 3.28-3.39

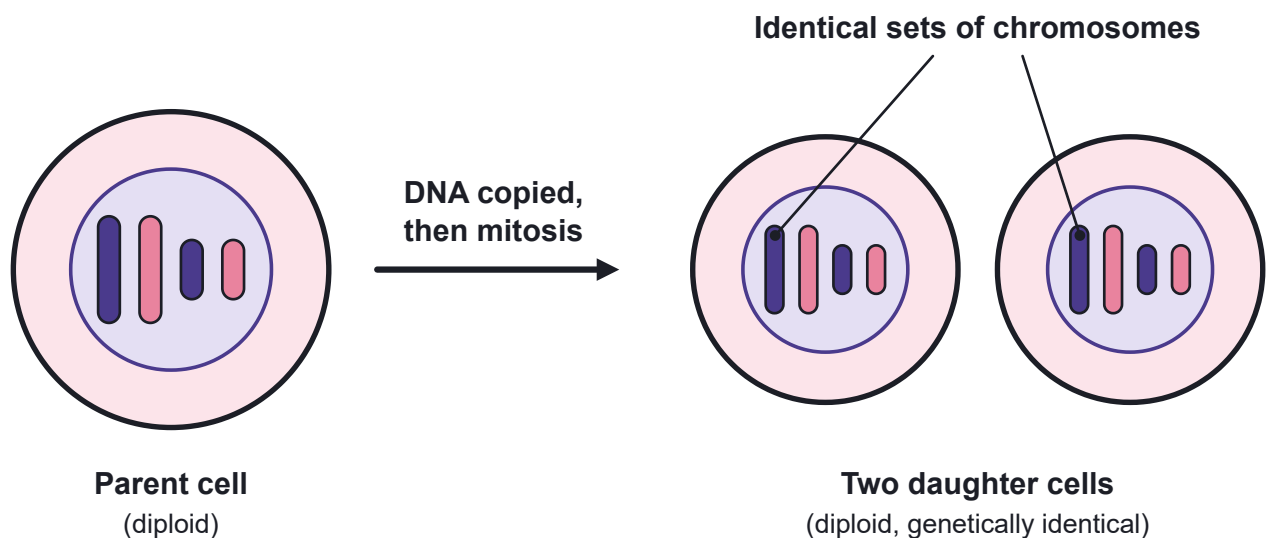
Mitosis Spec 3.28

Body cells are **diploid**. This means the nucleus contains two sets of chromosomes, which form pairs.

In **mitosis**, a diploid cell divides to produce **two cells** (daughter cells). Each daughter cell has an **identical set of chromosomes** to the parent cell, so the two cells are **genetically identical** to the parent and to each other.

The DNA is copied before the cell divides, and the copies are shared equally between the two daughter cells. So each daughter cell is also diploid. In humans each daughter cell has 46 chromosomes.

Mitosis	Division of a diploid cell to produce two cells that contain identical sets of chromosomes.
Diploid	A cell with two sets of chromosomes in its nucleus.
Genetically identical	Having exactly the same genetic information (the same DNA).



Mitosis gives **two genetically identical cells**, each with the same set of chromosomes as the parent.

Exam tip: To describe the result of mitosis, give the key points: two cells, identical sets of chromosomes to the parent cell, genetically identical. The stages of mitosis are not required.

Growth, repair, cloning and asexual reproduction Spec 3.29

Mitosis occurs during growth, repair, cloning and asexual reproduction.

- **Growth**: a multicellular organism grows by making more cells by mitosis. All the new cells are genetically identical, so they have the same instructions.
- **Repair**: damaged or worn-out cells are replaced with new cells made by mitosis, for example when skin is cut.
- **Cloning**: a clone is a group of genetically identical organisms or cells. Clones are made using mitosis, for example plants grown from cuttings.
- **Asexual reproduction**: one parent produces offspring that are genetically identical to it. The offspring are made by mitosis, so there is no mixing of genetic information.

Exam tip: Asexual reproduction needs only one parent and gives genetically identical offspring. Say both if the question asks you to describe it.

Meiosis, fertilisation and chromosome number Spec 3.30, 3.31, 3.32

Meiosis is the type of cell division that makes gametes (sex cells). In humans it happens in the reproductive organs: the ovaries and the testes.

- One diploid cell divides to produce four cells.
- Each cell has half the number of chromosomes of the parent cell.
- The cells are genetically different from each other and from the parent cell.
- The four cells are **haploid gametes**, with one set of chromosomes.

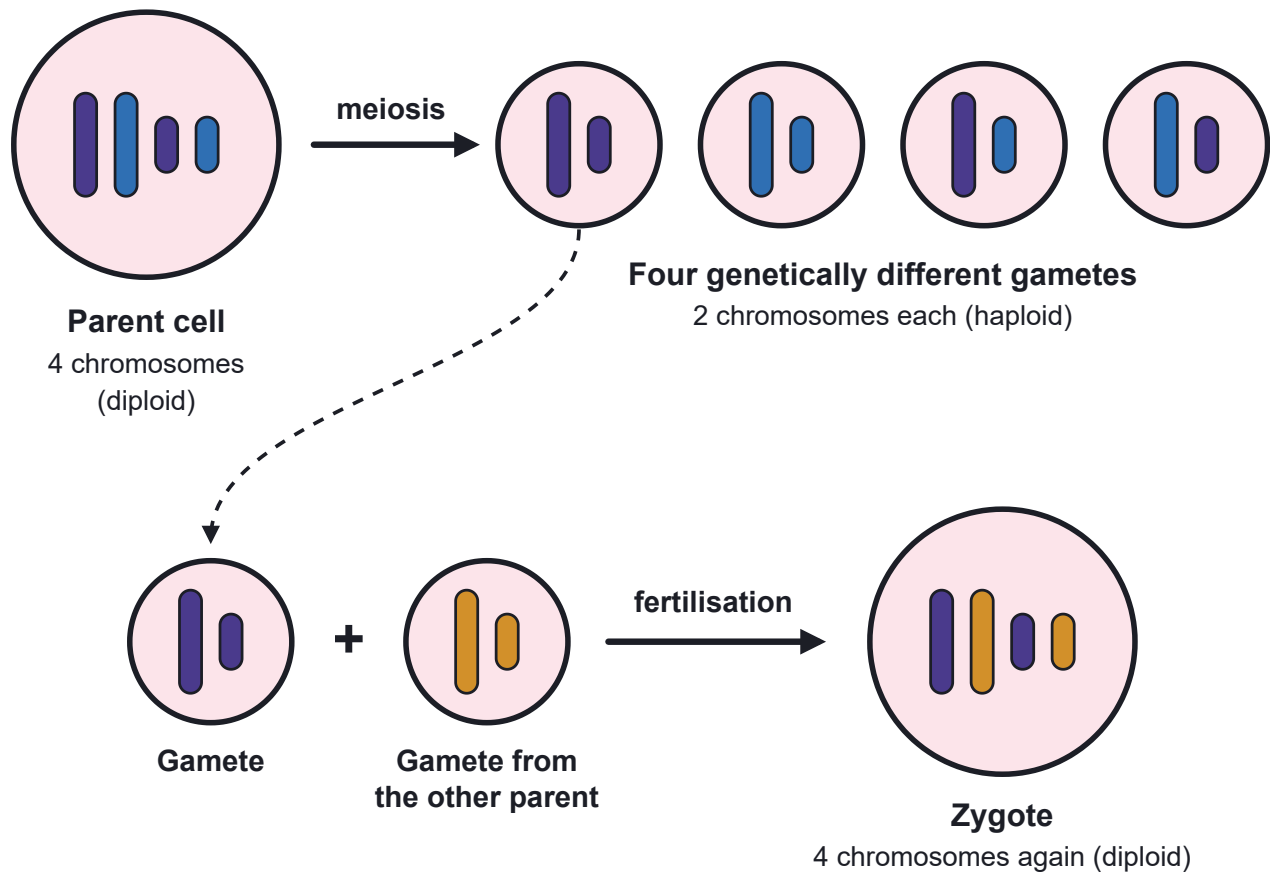
In human cells the **diploid number is 46** and the haploid number is 23. Meiosis makes sperm and egg cells with 23 chromosomes each.

Body cells and gametes		
	Body cell (diploid)	Gamete (haploid)
Chromosomes in a human cell	46	23
Genetically identical to the others?	Yes, if made by mitosis	No, each gamete is different
Made by	Mitosis	Meiosis

Fertilisation and variation

At fertilisation, a sperm and an egg fuse to make a zygote with 46 chromosomes again, half from each parent. Fertilisation is random: any sperm can fuse with any egg.

Each gamete is genetically different, and any gamete can fuse with any other. So random fertilisation produces **genetic variation** in the offspring. Brothers and sisters are not identical to each other, or to either parent.



Meiosis halves the chromosome number; **fertilisation** restores it in the zygote.

Exam tip: The stages of meiosis are not required. Learn the outcome: four genetically different haploid gametes, each with half the number of chromosomes.

Genetic and environmental variation Spec 3.33

Differences between individuals of the same species are called **variation**. Variation within a species can be **genetic**, **environmental**, or a combination of both.

Genetic and environmental variation		
	Genetic variation	Environmental variation
What it is	Differences caused by the alleles an organism inherits	Differences caused by an organism's surroundings and way of life
Examples	Blood group, eye colour, sex	A scar, body mass affected by diet, plant height affected by light

Many features are affected by both. For example, a person's height depends on the alleles they inherit and also on their diet when growing up. A plant's height depends on its alleles, and also on the light and minerals it receives.

Exam tip: Identical twins have the same alleles. Differences between them must be caused by the environment, which is a favourite way of testing this point.

Mutations and the phenotype Spec 3.34, 3.35B, 3.36B

A **mutation** is a rare, random change in genetic material that can be inherited. Usually it is a change in the base sequence of DNA.

Mutations are one source of genetic variation. A mutation in a gamete, or in a cell that makes gametes, can be passed on to offspring.

Biology only

How a mutation can change the phenotype

Biology only

1. A change in the DNA changes the **base sequence** of a gene.
2. This can change the **sequence of amino acids** in the protein that the gene codes for.
3. The protein may then fold into a different shape and no longer work in the same way. For example, an enzyme's active site may no longer fit its substrate.
4. The change in the protein can change the phenotype.

Biology only

- Most genetic mutations have **no effect** on the phenotype.
- Some mutations have a small effect on the phenotype.
- Rarely, a mutation has a **significant effect** on the phenotype.

Biology only

Common mistake: Do not write that all mutations are harmful. Most have no effect on the phenotype.

Causes of mutation Spec 3.37B Biology only

Mutations happen naturally and at random, but the **incidence** (how often they happen) can be increased by exposure to certain things called **mutagens**.

- **Ionising radiation**, for example gamma rays, X-rays and ultraviolet (UV) rays.
- Some **chemical mutagens**, for example chemicals in tobacco.

Exposure to a mutagen makes a mutation more likely. It does not mean that a mutation will definitely happen. This is one reason why people are protected from unnecessary exposure to radiation, and why tobacco smoke is harmful.

Exam tip: Learn one radiation example and one chemical example: for instance X-rays and chemicals in tobacco. Say they increase the rate of mutation.

Darwin's theory of evolution by natural selection Spec 3.38

Evolution is a change in the inherited characteristics of a population over many generations. Darwin's theory explains how it happens by **natural selection**.

1. Individuals in a population show **variation**. Some of this variation is genetic, and arises from mutation and sexual reproduction.
2. More offspring are born than can survive, so individuals compete for resources such as food, space and mates. Some are eaten or die of disease.
3. Individuals with characteristics that suit their environment are more likely to **survive and reproduce**.
4. They **pass on the alleles** for those characteristics to their offspring.
5. Over many generations, the proportion of the population with the advantageous alleles increases.

This is sometimes summed up as 'survival of the fittest'. 'Fittest' means best suited to the environment, not strongest.

Common mistake: Individuals do not change during their lives to cope with their environment. The advantageous allele has to be there already, and the proportion of individuals with it increases over generations.

Exam tip: Write the full chain in your answer: variation, competition, survival and reproduction of the better adapted, alleles passed on, proportion increases.

Antibiotic resistance Spec 3.39

The increase in antibiotic-resistant bacteria is an example of natural selection that can be seen happening within a human lifetime. Bacteria reproduce very quickly, so changes in a population happen fast.

1. In a population of bacteria, a **mutation** produces an allele that makes one bacterium **resistant** to an antibiotic. This is variation.
2. The antibiotic is used. It kills the non-resistant bacteria, but the resistant bacterium survives. The antibiotic is the **selection pressure**.
3. The resistant bacterium reproduces with less competition and passes the resistance allele on to its offspring.
4. Over time the population becomes mostly resistant bacteria, so the antibiotic no longer works against the infection.

As a result, infections caused by resistant bacteria are **difficult to control**. The antibiotic does not work, so the infection can spread to other people. Using antibiotics only when they are needed, and finishing the course, helps to slow the increase of resistance.

Percentage of resistant bacteria (practice data)

A sample of 300 bacteria had 12 resistant to an antibiotic. After several rounds of treatment, a sample of 300 bacteria had 192 resistant. Calculate the percentage resistant each time.

1. Before: $12 \div 300 \times 100 = 4\%$
2. After: $192 \div 300 \times 100 = 64\%$

Answer: 4% before and 64% after.

Common mistake: Antibiotics do not cause the mutation, and bacteria do not 'get used to' antibiotics. The resistant bacteria were there by chance and are selected by the antibiotic.

Quick check

1. How many cells does mitosis produce, and how do they compare with the parent cell?
2. What is the diploid number and the haploid number of chromosomes in human cells?
3. Name the type of cell division that produces gametes.
4. Give two causes of variation within a species.
5. **Biology only** Name one mutagen.

Quick check answers

Cell division, variation and evolution

1. Two cells, genetically identical to the parent cell.
2. Diploid 46 and haploid 23.
3. Meiosis.
4. Genetic (alleles inherited) and environmental.
5. Ionising radiation (such as X-rays) or chemicals in tobacco.