

Cells and control revision notes

This topic explains how cells divide, how an organism grows and how cells become specialised, and how stem cells might be used in medicine. It then looks at how the nervous system controls the body through receptors, neurones, synapses and reflex arcs.

For Edexcel GCSE Combined Science 1SC0. **Higher tier** is only on the Higher paper.

1 Mitosis and cancer Spec 2.1-2.4

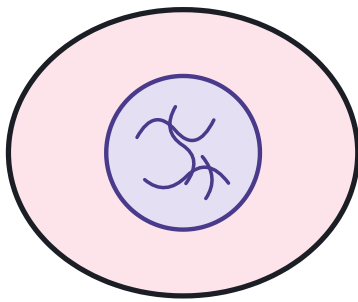
The cell cycle and mitosis Spec 2.1

Cells grow and divide in a repeating sequence called the **cell cycle**. Most of the cycle is **interphase**, when the cell is not dividing. **Mitosis** is the part of the cycle in which the nucleus divides. It is followed by **cytokinesis**, when the cytoplasm and cell membrane divide.

The stages of the cell cycle

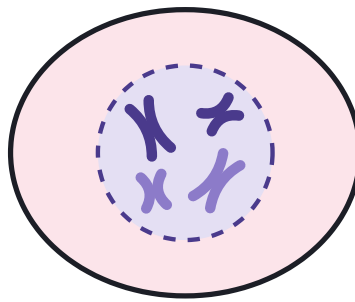
Stage	What happens
Interphase	The cell grows and makes more of its sub-cellular structures. The DNA is copied, so each chromosome is made of two identical copies (chromatids).
Prophase	The chromosomes become shorter and thicker, so they can be seen. The membrane around the nucleus breaks down.
Metaphase	The chromosomes line up along the middle (the equator) of the cell. They are attached to spindle fibres.
Anaphase	The spindle fibres pull the two copies of each chromosome apart, to opposite ends of the cell.
Telophase	A new nuclear membrane forms around each set of chromosomes, so there are two nuclei.
Cytokinesis	The cytoplasm and cell membrane divide to make two separate cells.

The order is interphase, prophase, metaphase, anaphase, telophase, then cytokinesis.



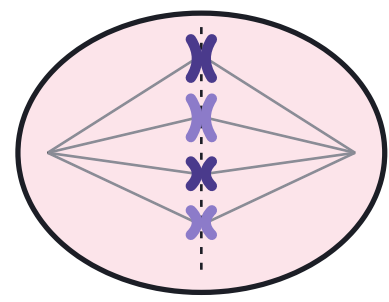
1 Interphase

cell grows; DNA is copied



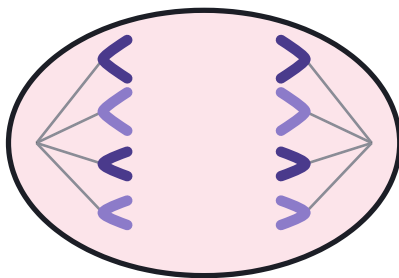
2 Prophase

chromosomes visible;
nuclear membrane breaks down



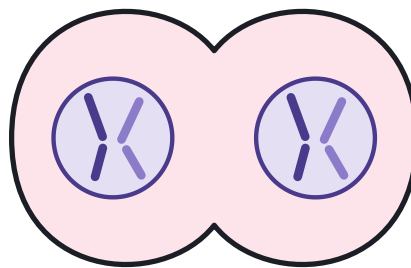
3 Metaphase

chromosomes line up on the
equator, on spindle fibres



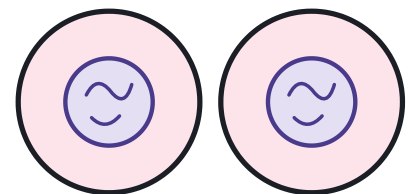
4 Anaphase

copies pulled to opposite
ends of the cell



5 Telophase

new nuclear membranes form:
two nuclei



6 Cytokinesis

cytoplasm and cell membrane
divide: two identical cells

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The stages in order: **interphase, prophase, metaphase, anaphase, telophase, cytokinesis**.

Common mistake: Interphase is not a resting stage. The cell is very busy: it grows and copies its DNA ready for mitosis.

What mitosis produces Spec 2.3

Mitosis produces **two daughter cells**. Each daughter cell has an **identical set of chromosomes** in its nucleus to the parent cell, so the two cells are **genetically identical** to the parent and to each other.

Body cells are **diploid**. This means the nucleus contains two sets of chromosomes, which form pairs. For example, human body cells have 46 chromosomes, arranged as 23 pairs. The DNA is copied in interphase and the copies are shared equally in mitosis, so each daughter cell also has 46 chromosomes.

Daughter cell	One of the two new cells produced when a parent cell divides.
Diploid	A cell with two sets of chromosomes in its nucleus.
Genetically identical	Having exactly the same genetic information (the same DNA).

Exam tip: To describe the result of mitosis, give the key points: two daughter cells, identical sets of chromosomes to the parent, genetically identical and diploid.

Why mitosis is important Spec 2.2

Mitosis is important in three ways.

- **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.
- **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.

Cancer Spec 2.4

Cell division is normally controlled, so a tissue makes only the cells it needs. **Cancer** is the result of changes in cells that lead to **uncontrolled cell division**.

The cells keep dividing by mitosis when they should not. This can form a mass of cells called a **tumour**.

Common mistake: Do not just say cancer is 'cells dividing'. Healthy cells divide too. The key idea is that the division is uncontrolled.

Quick check

1. Put the stages of the cell cycle in order, starting with interphase.
2. What happens to the chromosomes in metaphase?
3. Name three uses of mitosis.
4. What does diploid mean?
5. What causes cancer?

2 Growth, differentiation and stem cells Spec 2.5-2.9

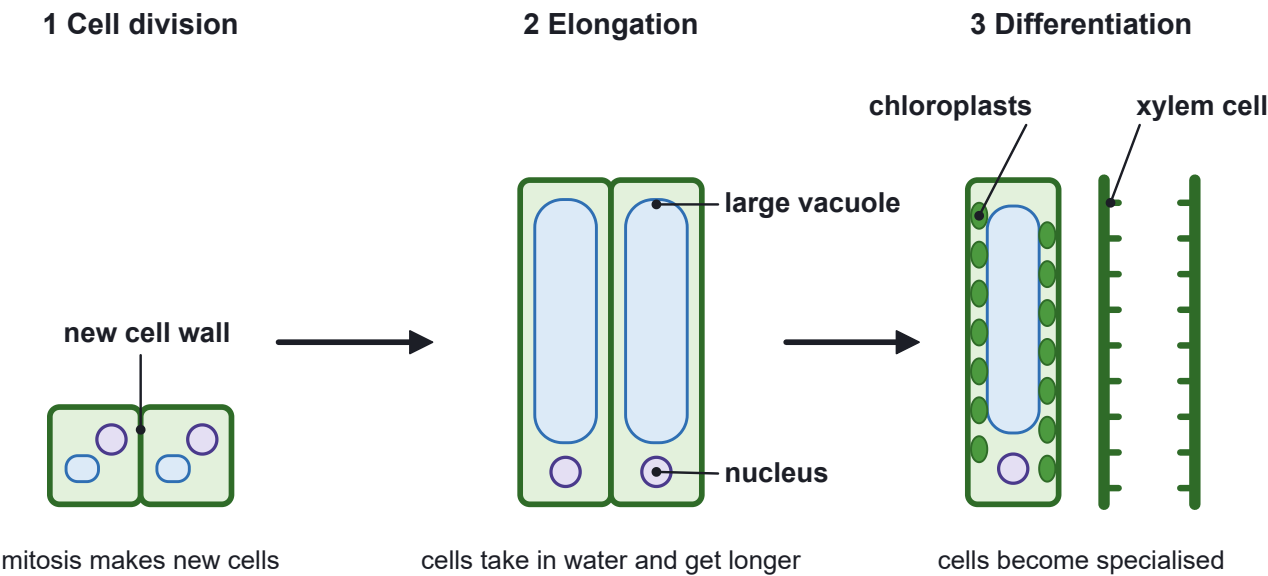
Growth in animals and plants Spec 2.5

Growth is an increase in the size or mass of an organism. It involves different processes in animals and plants.

Growth in animals and plants		
	Animals	Plants
Cell division	Yes, by mitosis	Yes, by mitosis
Differentiation	Yes	Yes
Elongation	No	Yes: cells get longer

In animals, growth happens by **cell division** and **differentiation**. New cells are made by mitosis and then become specialised for particular jobs.

In plants, growth happens by **cell division**, **elongation** and **differentiation**. Cells made by mitosis then get longer (elongate), mostly by taking in water so that the cell expands. After elongating, they differentiate. Elongation is what makes plants grow taller and roots grow longer.



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Plants grow by **cell division**, then **elongation**, then **differentiation**.

Exam tip: If a question asks how plants grow, name all three processes. Animals do not grow by elongation.

Cell differentiation Spec 2.6

Differentiation is the process by which a cell becomes specialised for a particular job. The cell gains the sub-cellular structures it needs to carry out its function. For example, a nerve cell has a long axon, and a root hair cell has a long projection that gives a large surface area.

Differentiation is important in the development of specialised cells because a multicellular organism needs many different cell types doing different jobs. Specialised cells form tissues, which make up organs. Each type of cell can carry out its job efficiently.

Exam tip: Link structure to function. 'The cell has become specialised' earns less than saying what structure it gained and what job that structure helps with.

Percentile charts Spec 2.7

A **percentile chart** is used to monitor the growth of a baby or child. It shows curves for the measurements of a large number of children of the same age and sex, such as mass. A child's measurement is plotted on the chart.

- The **50th percentile** line means 50% of children have a lower value and 50% have a higher value.
- A child on the **25th percentile** has a value higher than 25% of children and lower than 75% of children.
- Plotting a child's measurements over time shows whether they follow a curve or move across to a different one. A large change may need to be investigated.

The chart is a graph. Use it to turn a number into a percentile, or the reverse.

$$\text{percentage change} = (\text{change in mass} \div \text{original mass}) \times 100$$

Percentage gain in mass

A baby has a mass of 3.2 kg at birth and 4.0 kg at 8 weeks. Calculate the percentage gain in mass.

1. change in mass = $4.0 - 3.2 = 0.8$ kg
2. percentage gain = $0.8 \div 3.2 \times 100$

Answer: 25%

Maths skill: For percentage loss, use the same equation with the decrease in mass. Always divide by the original mass, not the final mass.

Maths skill: Use an estimate to check your answer is sensible. Round 3.2 to 3: $0.8 \div 3$ is about 0.27, so the answer should be a little under 27%.

Stem cells and meristems Spec 2.8

A **stem cell** is an undifferentiated cell. It can divide to make more cells and can differentiate to become specialised cells.

Types of stem cell	
Type	Function
Embryonic stem cells	Found in early embryos. They can differentiate into any type of cell, so they produce all the specialised cells as the embryo develops.
Stem cells in animals (adult stem cells)	Found in some tissues, such as bone marrow. They can differentiate into only a limited range of cell types. They replace cells that are damaged or worn out, for example bone marrow makes new blood cells.
Meristems in plants	Found at the tips of roots and shoots. The cells divide and can differentiate into any type of plant cell, so the plant can keep growing throughout its life.

Exam tip: Be precise: embryonic stem cells can become any type of cell, but adult stem cells can only become some types.

Stem cells in medicine Spec 2.9

Stem cells may be able to replace damaged or diseased cells. Some potential uses are treating conditions such as diabetes and paralysis, and replacing damaged tissue.

Benefits and risks of using stem cells	
Benefits	Risks
Could treat conditions that are currently hard to treat, such as diabetes or paralysis.	Stem cells can divide out of control and form a tumour.
Could replace damaged cells with new healthy cells.	Viruses in donated stem cells could be passed to the patient and cause disease.
Could be used to grow replacement tissues.	The patient's immune system may reject cells from another person.
	Some people object to using embryos for ethical or religious reasons.

Exam tip: In a 'discuss' question, include at least one benefit and one risk, and finish by weighing them up.

Quick check

1. Which process in plant growth does not happen in animals?
2. What does the 50th percentile mean?
3. What is a stem cell?
4. What is the function of a meristem?
5. Give one risk of using stem cells in medicine.

3 Neurones and reflexes Spec 2.13-2.14

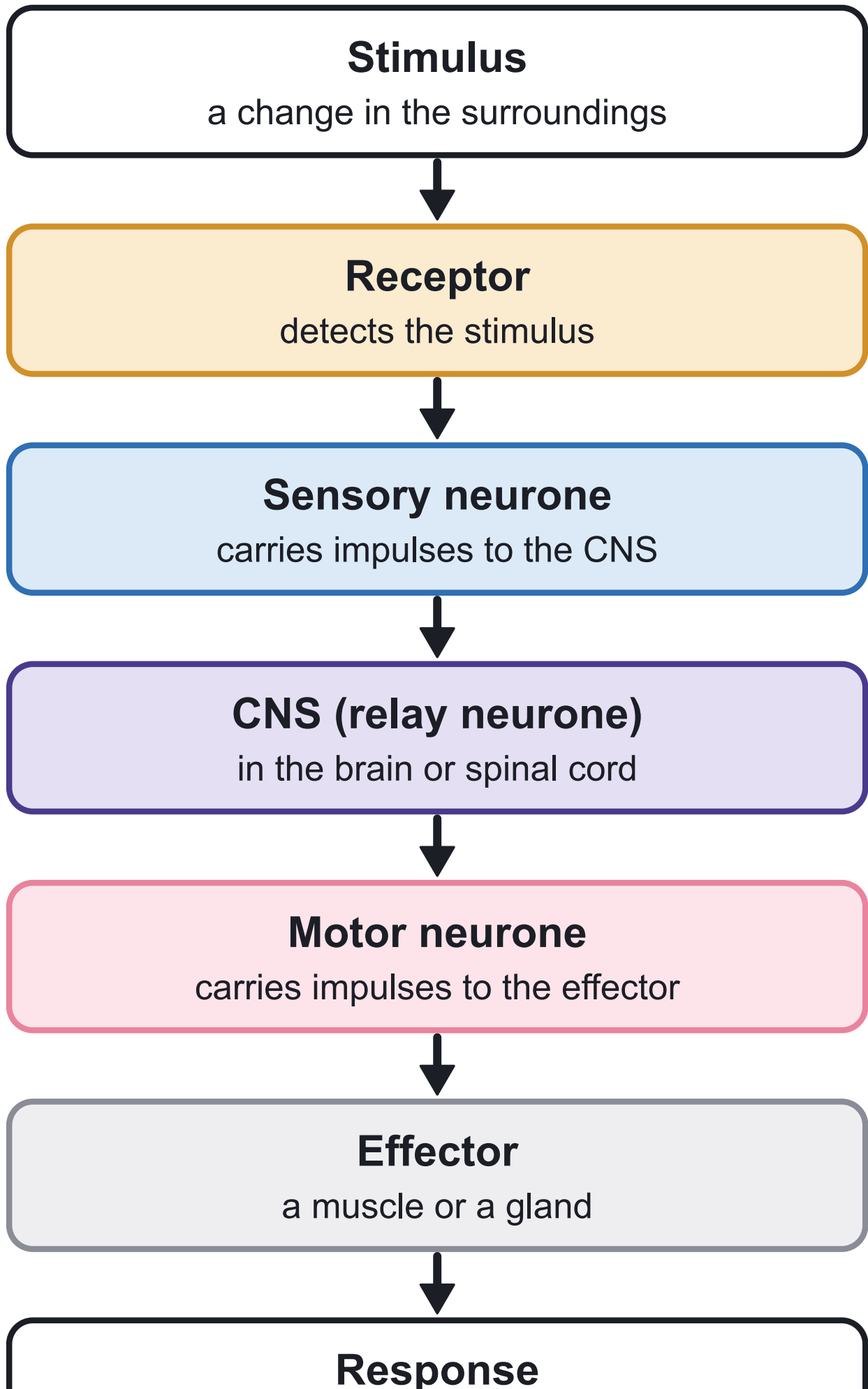
Receptors and the nervous pathway Spec 2.13

The nervous system lets an organism respond to changes in its surroundings. The brain and spinal cord make up the central nervous system (CNS). A **sensory receptor** is a cell that detects a stimulus (a change in the surroundings) and produces an electrical impulse.

1. A sensory receptor detects a stimulus.
2. A **sensory neurone** carries the electrical impulses to the CNS.
3. A **relay neurone** in the CNS passes the impulses on.
4. A **motor neurone** carries the impulses from the CNS to an effector (a muscle or a gland).
5. The effector produces a response.

The three types of neurone

Neurone	Function
Sensory neurone	Carries impulses from a receptor to the CNS
Relay neurone	Found in the CNS. Connects the sensory neurone to the motor neurone
Motor neurone	Carries impulses from the CNS to an effector



e.g. a muscle contracts

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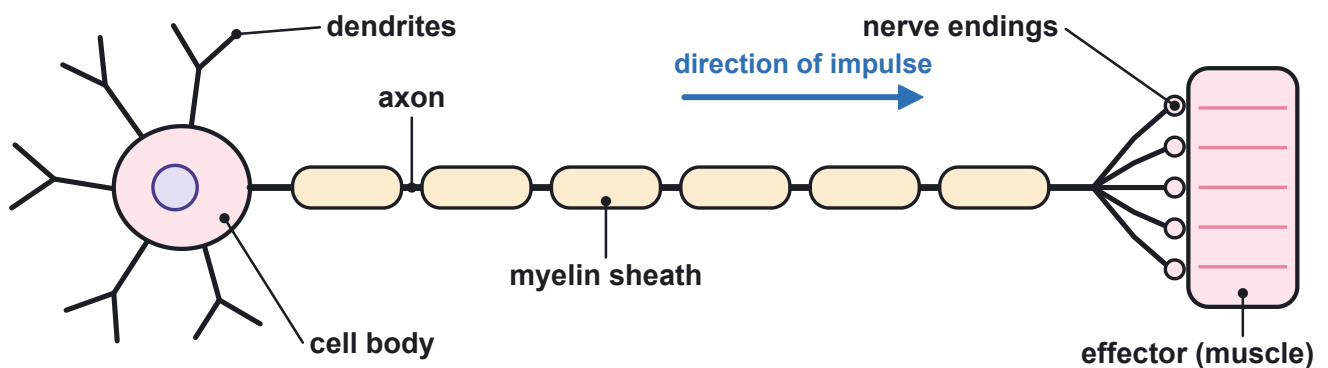
The pathway from **stimulus** to **response**.

Neurone structure Spec 2.13

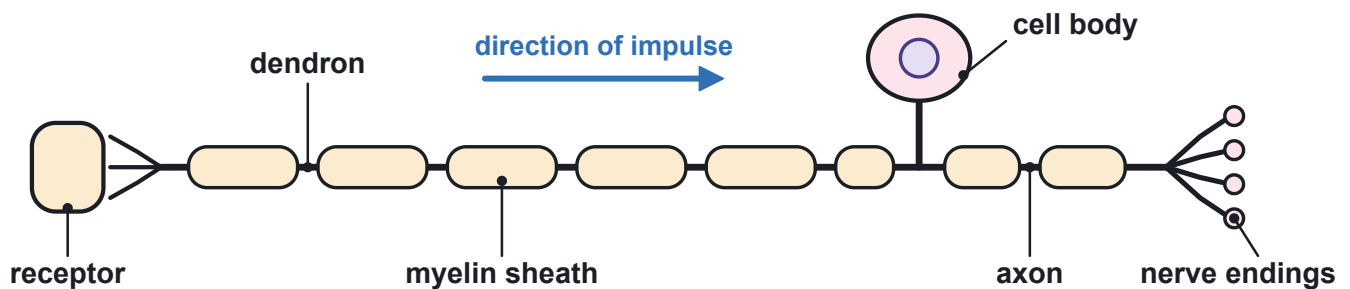
Neurones are specialised to carry electrical impulses quickly over long distances.

Axon	A long fibre that carries electrical impulses away from the cell body.
Dendron	A fibre that carries electrical impulses towards the cell body.
Myelin sheath	A fatty layer around the neurone that insulates it and speeds up the transmission of impulses.

Motor neurone



Sensory neurone



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A **motor neurone** and a **sensory neurone**. The **myelin sheath** insulates the fibre and speeds up impulses.

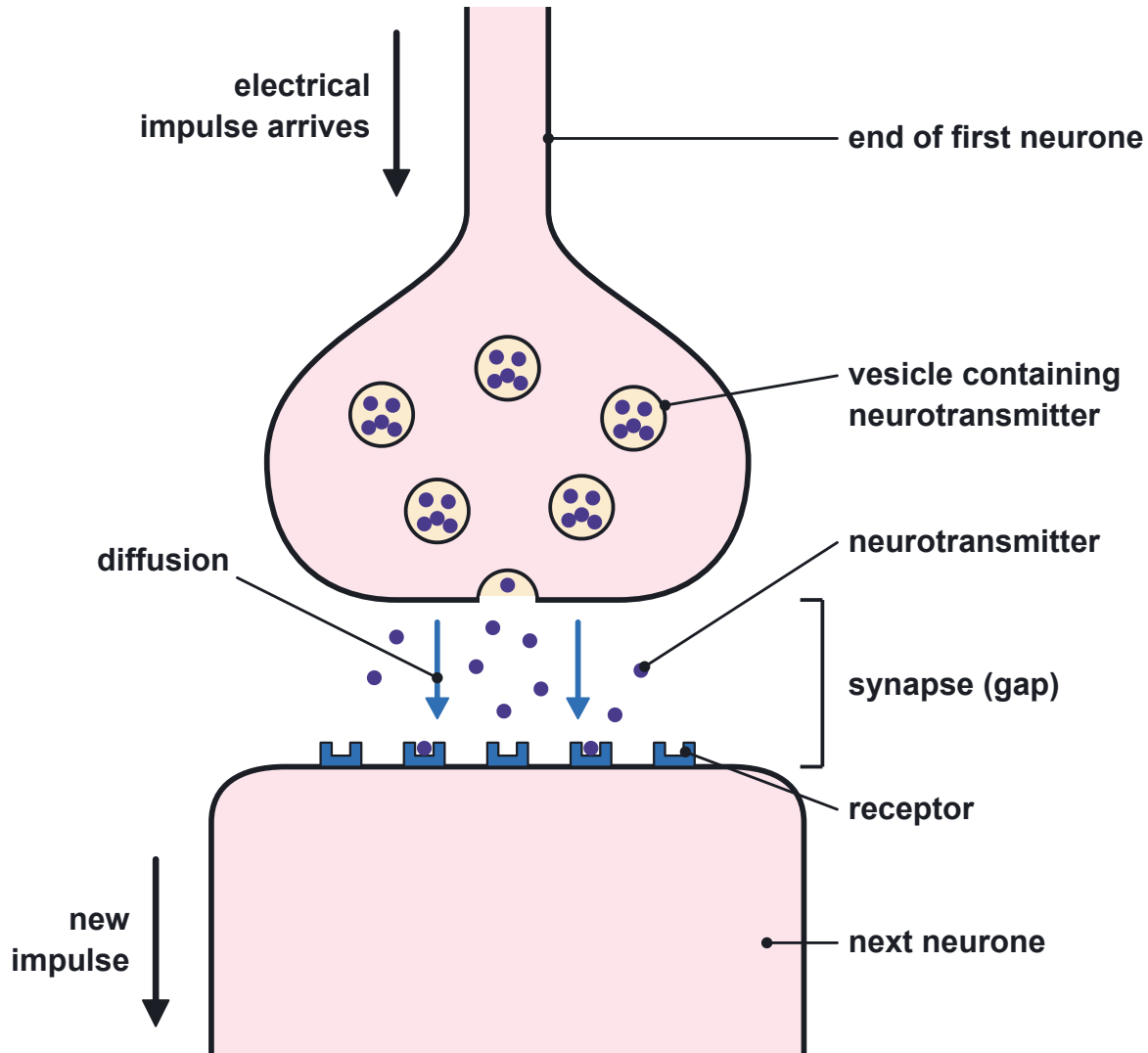
Exam tip: Link the structure to its function. The myelin sheath is an insulator, which makes the impulse travel faster.

Synapses Spec 2.13

A **synapse** is a gap between two neurones. The electrical impulse cannot cross the gap, so a chemical is used instead.

1. An electrical impulse arrives at the end of the first neurone.
2. The neurone releases a chemical called a **neurotransmitter** into the synapse.
3. The neurotransmitter **diffuses** across the gap.

4. It binds to receptors on the membrane of the next neurone.
5. This triggers a new electrical impulse in the next neurone.



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At a synapse the **neurotransmitter diffuses** across the gap and binds to **receptors** on the next neurone.

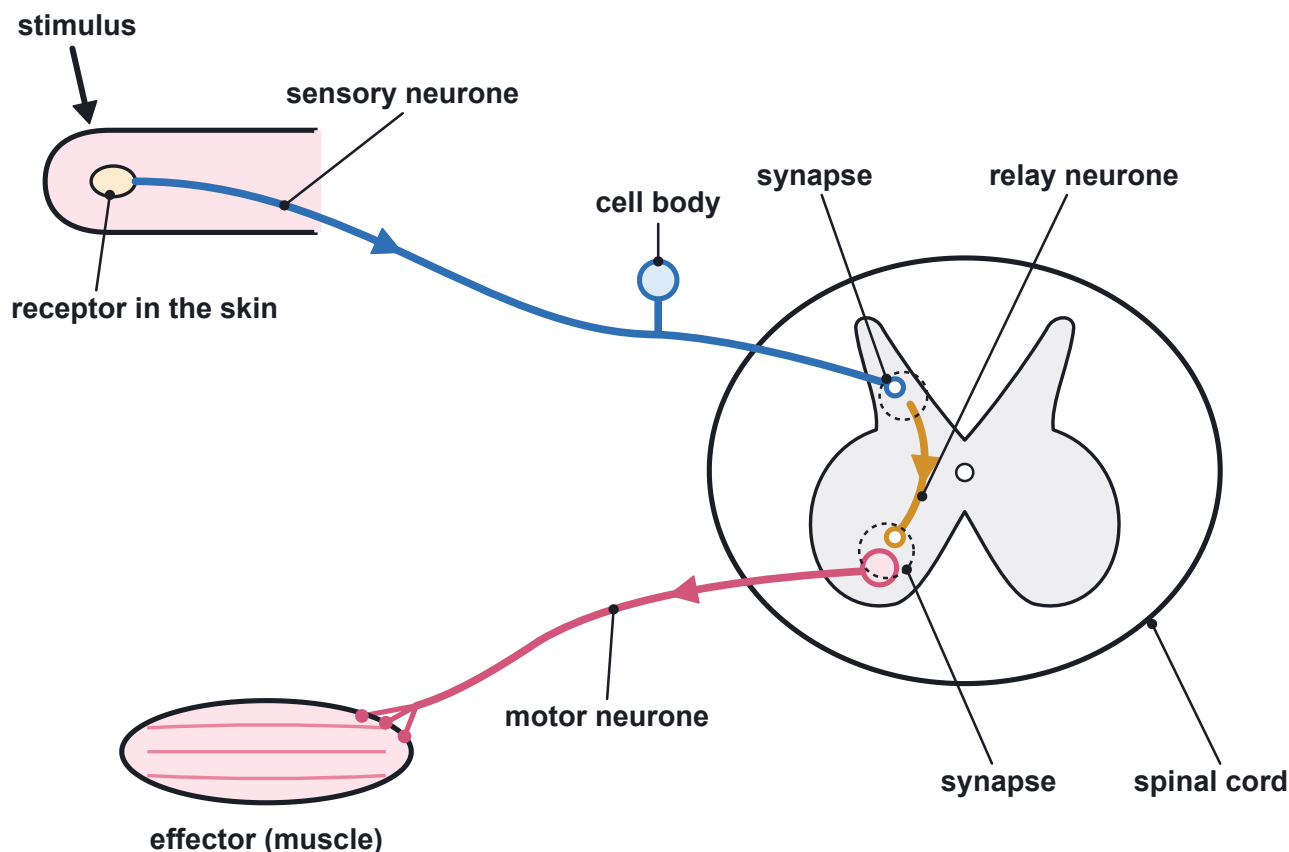
Common mistake: The impulse itself does not cross the synapse. A neurotransmitter diffuses across and starts a new impulse in the next neurone.

Reflex arcs Spec 2.14

A **reflex** is a fast, automatic response to a stimulus that does not involve conscious thought. The pathway it follows is called a **reflex arc**. Reflexes protect the body from harm.

1. The stimulus is detected by a receptor (for example, a pain receptor in the skin).
2. A sensory neurone carries impulses to the CNS.
3. At a synapse the impulses pass to a relay neurone in the CNS.
4. At another synapse the impulses pass to a motor neurone.
5. The motor neurone carries the impulses to an effector, such as a muscle.
6. The effector produces a response, such as the muscle contracting to pull the hand away.

The impulses do not have to travel to the conscious part of the brain before the response, so the reflex is very fast.



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A reflex arc: receptor, **sensory neurone**, **relay neurone**, **motor neurone**, effector. Impulses cross a **synapse** between each pair of neurones.

Investigating reaction times Spec 2.13, 2.14

The suggested practicals ask you to investigate human responses to external stimuli, reaction times and the speed of transmission of electrical impulses in the nervous system.

Exam tip: Ruler-drop test: one person holds a ruler vertically with the zero level with the top of the other person's open thumb and finger. They drop it without warning and the other person catches it. Record the distance it fell. A shorter distance means a faster reaction time.

- Independent variable: the factor you change, such as hand used, practice or a distraction.
- Control variables: the same person dropping the ruler, the same ruler, the same starting position and the same person catching.
- Repeat several times and calculate a **mean**. This reduces the effect of random errors and lets you spot anomalous results.
- A reaction time is the time between a stimulus and a response.

Typical results: practice usually makes the response quicker, and distractions usually make it slower.

Mean distance

A student catches a ruler five times. The distances it fell were 20, 17, 15, 14 and 12 cm. Calculate the mean.

1. add the results: $20 + 17 + 15 + 14 + 12 = 78$

2. divide by the number of results: $78 \div 5$

Answer: 15.6 cm

Maths skill: If you plot reaction time against a variable on a scatter diagram, look for a correlation. Points sloping down show a negative correlation: as one variable rises, the other falls.

Quick check

- 1 . Name the three types of neurone in a reflex arc, in order.
- 2 . What does the myelin sheath do?
- 3 . What is a synapse?
- 4 . How does an impulse cross a synapse?
- 5 . Why are reflexes important?

Quick check answers

Mitosis and cancer

1. Interphase, prophase, metaphase, anaphase, telophase, cytokinesis.
2. They line up along the equator of the cell.
3. Growth, repair and asexual reproduction.
4. The nucleus contains two sets of chromosomes, which form pairs.
5. Changes in cells that lead to uncontrolled cell division.

Growth, differentiation and stem cells

1. Elongation (cells getting longer).
2. 50% of children have a lower value and 50% have a higher value.
3. An undifferentiated cell that can divide and can differentiate into specialised cells.
4. Its cells divide and can differentiate into any type of plant cell, so the plant can keep growing throughout its life.
5. Any one of: tumour formation, viral infection from donor cells, immune rejection, ethical or religious objections.

Neurones and reflexes

1. Sensory neurone, relay neurone, motor neurone.
2. It insulates the neurone and speeds up the transmission of impulses.
3. A gap between two neurones.
4. A neurotransmitter is released, diffuses across the gap and triggers a new impulse in the next neurone.
5. They are fast and automatic, so they protect the body from harm.