PCFGSTUDY

Edexcel GCSE Combined Science — Biology

Topic 2

Cells and control

Specification 1SC0 · Pearson Edexcel

Free edition

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These are the summary notes only. The full edition of this booklet also carries the worked examples, the required practicals and the formula sheets, with every topic in one place.

Colour Codes

Definitions

Diagrams

Notes and warnings

Sub-topic headings

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Define Interphase

- the longest stage of the cell cycle: the cell grows and replicates its DNA.

Define Cytokinesis

- the division of the cytoplasm and cell membrane to form two separate daughter cells.

Define Differentiation

- the process by which a cell becomes specialised for a particular job.

Define Meristem

- a region at the tips of roots and shoots where plant cells keep dividing by mitosis.

Define Stimulus

- a change in the environment that is detected by a receptor.

Define Neurone

- a nerve cell, adapted to carry electrical impulses.

Define Reflex arc

- the pathway stimulus → receptor → sensory neurone → relay neurone → motor neurone → effector → response, not involving the conscious brain.

Define Cell cycle

- the repeating sequence of growth, DNA replication and division in a body cell.

Define Mitosis

- the stage in which the nucleus divides to give two nuclei with identical sets of chromosomes.

Define Cancer

- the result of changes in cells that lead to uncontrolled cell division.

Define Elongation

- growth of a plant cell by taking water into its vacuole so the cell gets longer.

Define Percentile chart

- a growth chart comparing a child's mass, length or head size with a large sample of children of the same age.

Define Stem cell

- an undifferentiated cell that can divide by mitosis and differentiate into other cell types.

Define Synapse

- the gap between two neurones, crossed by a **neurotransmitter**: a chemical that diffuses across and triggers an impulse in the next neurone.

Define CNS

- the central nervous system: the brain and spinal cord.

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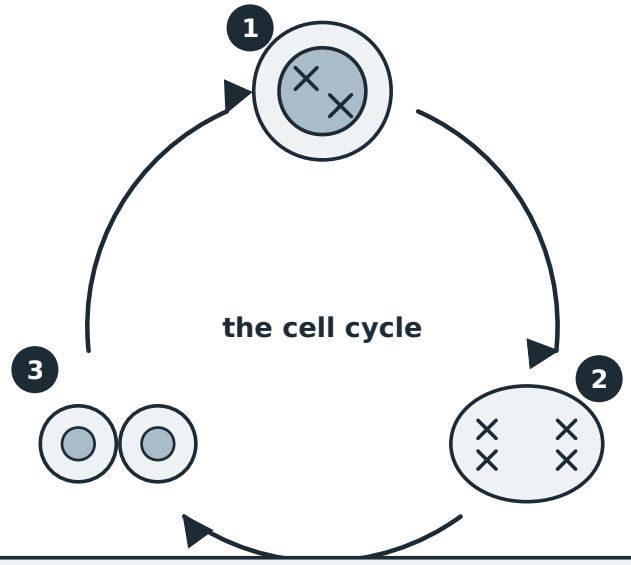
2.1 Mitosis and the cell cycle (2.1–2.3)

- **Interphase** — by far the longest stage. The cell grows, sub-cellular structures such as mitochondria and ribosomes increase, and the **DNA replicates**.
- **Mitosis** — the nucleus divides, in four named stages:
- **Prophase** — chromosomes condense and become visible; the nuclear membrane breaks down.
- **Metaphase** — chromosomes line up along the middle of the cell.
- **Anaphase** — the copies of each chromosome are pulled to opposite poles by spindle fibres.
- **Telophase** — a nuclear membrane forms around each set, giving two nuclei.
- **Cytokinesis** — the cytoplasm and cell membrane divide, giving **two separate daughter cells**.

Mitosis produces **two daughter cells, each with identical sets of chromosomes in the nucleus to the parent cell**, so they are **genetically identical diploid body cells** (2.3).

The cell cycle: interphase, mitosis and cytokinesis



1 Cell grows and DNA replicates

The cell grows and the number of sub-cellular structures such as ribosomes and mitochondria increases. The DNA replicates to form two copies of each chromosome.

2 Mitosis

One set of chromosomes is pulled to each end of the cell and the nucleus divides.

3 Cell divides in two

The cytoplasm and cell membranes divide to form two identical daughter cells.

The cell cycle produces two genetically identical cells. Cell division by mitosis is important in the growth and development of multicellular organisms.

ANALOGY

The cell cycle is a photocopier used on a book. Interphase is the long, dull part — copying every page (DNA replication). Mitosis sorts the pages into two identical piles, and cytokinesis staples each pile into its own book. Both books are word-for-word identical to the original.

Importance of mitosis (2.2)

- **Growth** — the organism gets bigger because cell number increases.
- **Repair** — damaged or worn-out cells are replaced with identical cells, e.g. skin healing.
- **Asexual reproduction** — one parent produces genetically identical offspring, e.g. strawberry runners.

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WATCH OUT

Mitosis is not the whole cell cycle — the **nucleus** divides in mitosis, and the cell itself only splits at cytokinesis.

2.2 Uncontrolled cell division and cancer (2.4)

- The cell cycle is normally tightly controlled, so cells divide only when new cells are needed.
- **Cancer** is the result of **changes in cells that lead to uncontrolled cell division**.
- These changes are mutations in the genes controlling the cell cycle. The cells divide over and over, forming a **tumour** — a mass of abnormal cells — which can spread elsewhere in the body.
- Risk is raised by carcinogens such as tobacco smoke, ionising radiation and UV light.

2.3 Growth and differentiation (2.5–2.6)

Animals (2.5a) grow by **cell division** followed by **differentiation**. Once adult size is reached, division is mostly limited to repair, and specialised animal cells cannot usually change back.

Plants (2.5b) grow by **cell division, elongation and differentiation**:

- **Cell division** happens only in the **meristems** at the tips of roots and shoots.
- **Elongation** — new cells just behind the meristem take in water, which fills the vacuole and makes the cell much longer. This is what makes the root or shoot longer.
- **Differentiation** — the elongated cells then specialise, e.g. into xylem, phloem or root hair cells.

Plants keep growing throughout life and their cells can re-differentiate.

Importance of differentiation (2.6)

- It produces **specialised cells** whose structure suits their function (red blood cell with no nucleus, neurone with a long axon, root hair cell with a large surface area).
- Specialised cells allow tissues, organs and organ systems to develop, making the organism far more efficient.

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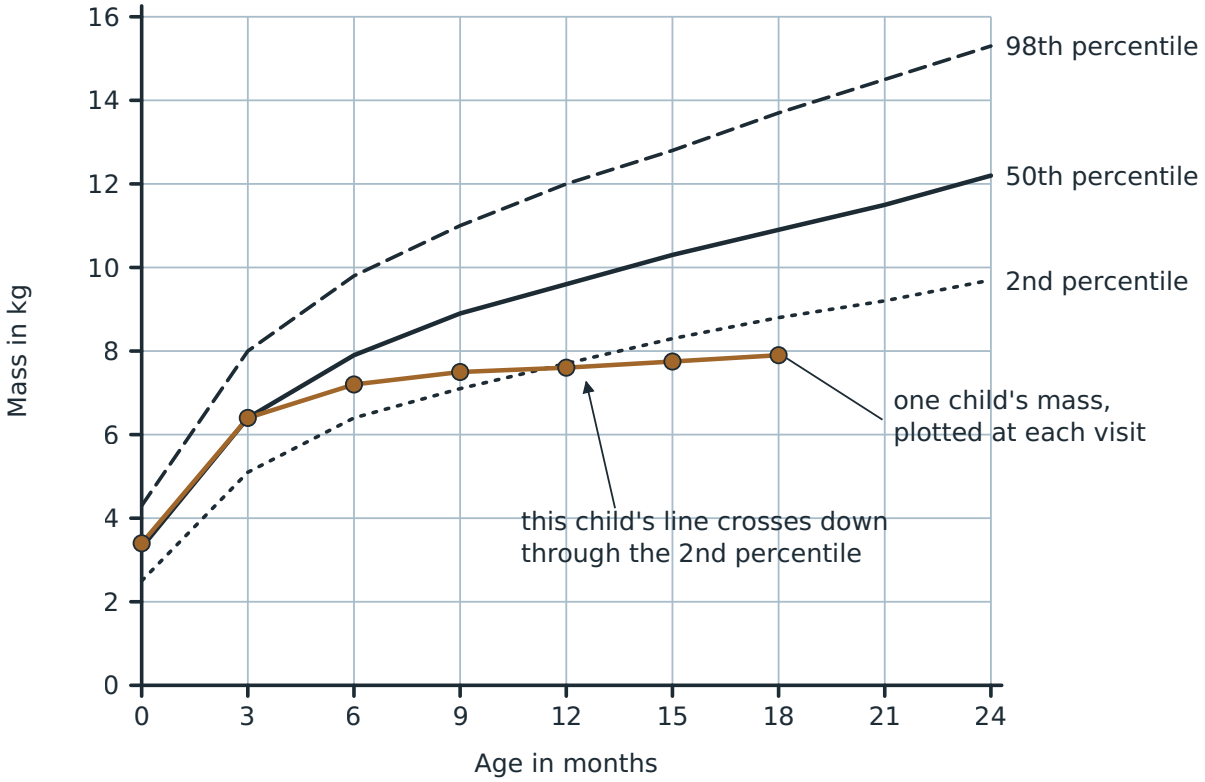
2.4 Percentile charts (2.7)

Percentile charts monitor the growth of babies and children: mass, length/height and head circumference are plotted against age.

- The curved lines are **percentiles**. A child on the **75th percentile** for mass is heavier than **75% of children of that age**.
- The **50th percentile** is the median. Data come from very large samples, so the chart is representative.
- What matters is whether a child **stays on roughly the same percentile** over time. Crossing several percentile lines downwards (or upwards) may signal a health or feeding problem.

Reading a percentile growth chart



How to read a percentile chart

Find the child's age along the bottom and their mass up the side, then plot the point. Repeat at every check-up.

50th percentile = half of children of this age are lighter and half are heavier. Most children lie between the 2nd and the 98th.

Only 2% of children of this age lie below the 2nd percentile, and only 2% lie above the 98th percentile.

Crossing percentile lines (here falling from the 50th to below the 2nd) can be a sign that growth is not normal and needs checking.

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2.5 Stem cells and meristems (2.8–2.9)

A **stem cell** is an undifferentiated cell that can keep dividing by mitosis and can differentiate into other cell types.

Type	Where found	Can become
Embryonic stem cell	Early human embryo	Any type of cell in the body
Adult stem cell	Certain adult tissues, e.g. bone marrow	Only a limited range of cell types, e.g. blood cells
Meristem	Tips of plant roots and shoots	Any type of plant cell, throughout the plant's life

Functions and uses (2.8)

- **Embryonic stem cells** could be grown and differentiated to replace faulty or damaged cells — nerve cells in paralysis, insulin-producing cells in type 1 diabetes, retinal cells to restore sight.
- **Adult stem cells** from bone marrow already treat leukaemia and other blood disorders.
- **Meristems** produce **clones of plants** quickly and cheaply — useful for rare species, for identical crop plants with desirable characteristics, and for disease-free stock.

ANALOGY

A stem cell is a school leaver who has not chosen a career: they could still train as a doctor, an electrician or a chef. A specialised cell is someone twenty years into one job — excellent at it, but unable to switch. Embryonic stem cells have every option open; adult stem cells have already picked a course and can only choose within it.

Benefits and risks (2.9)

- **Benefits** — could cure currently untreatable conditions; a patient's own adult stem cells are not rejected; meristems allow rapid, cheap plant cloning.
- **Rejection** — donor stem cells carry different antigens, so the immune system may attack them; immunosuppressant drugs then leave the patient vulnerable to infection.
- **Infection** — viruses could be transferred with the cells.
- **Uncontrolled division** — transplanted stem cells could form a tumour.
- **Ethical issues** — obtaining embryonic stem cells destroys an embryo. Some regard the embryo as a potential human life with a right to protection; others argue that relieving the suffering of existing patients matters more. Research is tightly regulated.

2.6 Neurones, synapses and the reflex arc (2.13–2.14)

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Sensory receptors detect a **stimulus** and convert it into an electrical impulse, which neurones then carry.

Neurone structure (2.13)

- **Axon** — a long fibre carrying the impulse **away** from the cell body.
- **Dendron / dendrites** — fibres carrying impulses **towards** the cell body; branching gives many connections.
- **Myelin sheath** — a fatty insulating layer around the axon that **speeds up transmission** and stops the impulse leaking to neighbouring neurones.
- The long, thin shape lets one cell carry an impulse a long way.

Neurone	Runs from → to	Key features
Sensory neurone	Receptor → CNS	Long dendron, short axon; cell body off to one side, part-way along
Relay neurone	Within the CNS only	Short dendrites and short axon; no myelin sheath; links sensory to motor
Motor neurone	CNS → effector (muscle or gland)	Many short dendrites, one very long axon; cell body at the CNS end

Synapses (2.13)

1. The impulse arrives at the end of the first neurone.
2. A chemical **neurotransmitter** is released into the **synapse**.
3. The neurotransmitter **diffuses** across the gap.
4. It binds to receptor molecules on the next neurone, triggering a new electrical impulse.

Diffusion is slower than an electrical impulse, so synapses slow the signal slightly and make it travel in one direction only.

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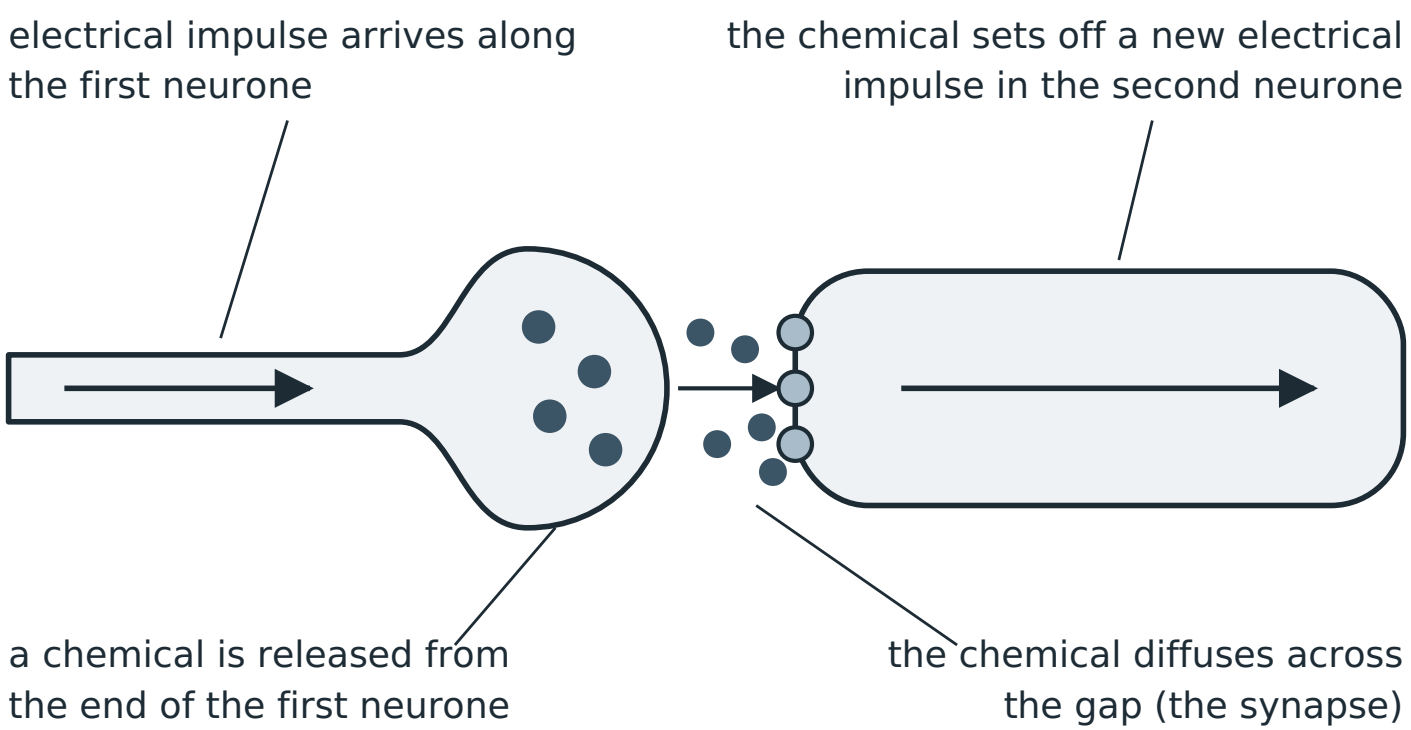
Transmission across a synapse



The reflex arc (2.14)

A reflex is a rapid, automatic, protective response that does **not** involve the conscious brain.

stimulus → receptor → sensory neurone → relay neurone → motor neurone → effector → response

Touching a hot object:

1. Heat (**stimulus**) is detected by a temperature **receptor** in the skin, which generates an impulse.
2. The **sensory neurone** carries it to the spinal cord (CNS).
3. At a **synapse** the impulse passes to a **relay neurone**, and at a second synapse to a **motor neurone**.
4. The motor neurone carries it to the **effector** — an arm muscle.
5. **Response**: the muscle contracts and the hand is pulled away.

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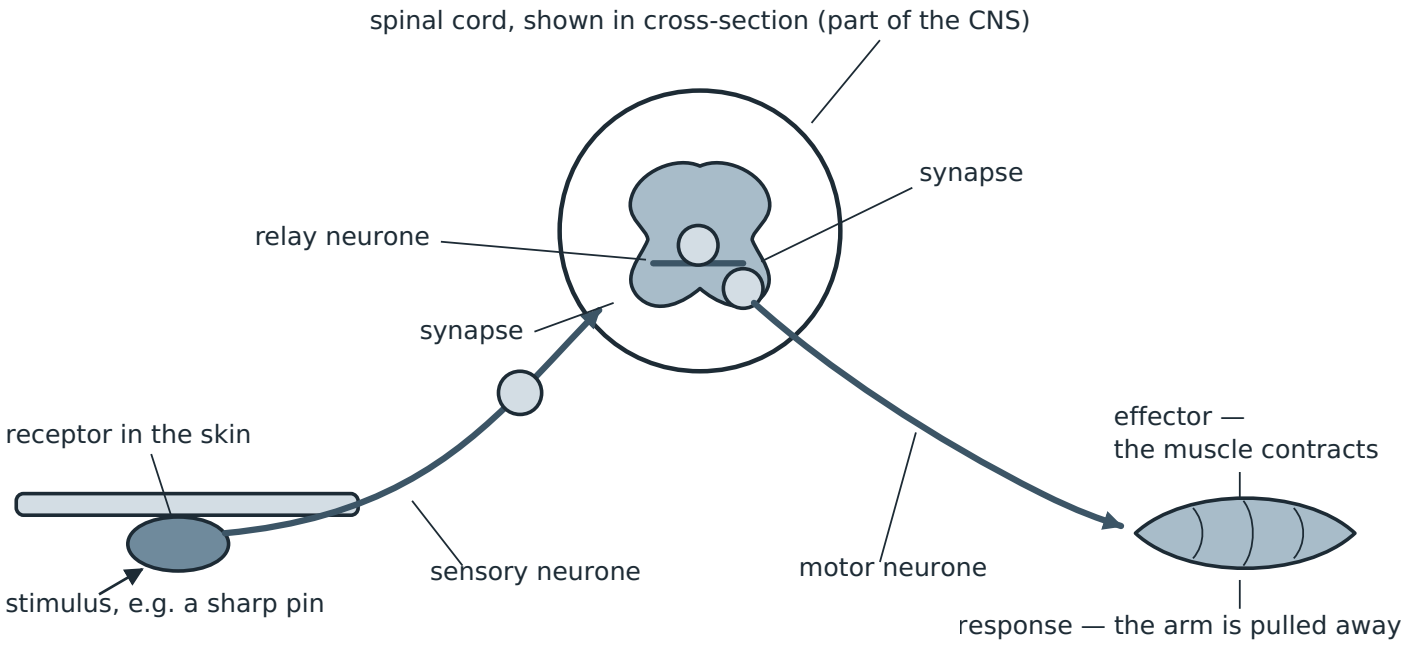
The reflex arc



stimulus → receptor → coordinator → effector → response

Reflex actions are automatic and rapid. They do not involve the conscious part of the brain, so the body is protected before you have time to think about it.

ANALOGY

The reflex arc is a fire alarm wired straight to the sprinklers. The smoke detector (receptor) sets off the sprinklers (effector) through a junction box in the corridor (the spinal cord), without waiting for the manager (the conscious brain) to decide. The manager finds out afterwards — which is why you feel the pain a moment *after* your hand has moved.

2.7 Use of mathematics in this topic

- Understand and use **percentiles**; calculate **percentage gain and loss of mass** (1c).
- Use **estimations**, and explain when they should be used.
- **Translate between numerical and graphical forms**; interpret graphs, charts and tables.
- Use a **scatter diagram** to identify a correlation, e.g. reaction time against age.

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