Neurons, synapses and brain systems

Supported GRE teaching and original transfer practice

Neurons, synapses and brain systems

- Explain the **action potential** and the **all-or-none principle** .
- Describe the steps of chemical transmission at a **synapse** , including **reuptake** .
- Classify drugs as **agonists** or **antagonists** .
- Link major brain structures and transmitters to functions.

The action potential

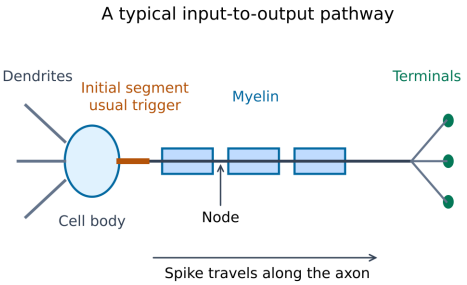
- At rest, the inside of a neuron is about -70 mV compared with the outside.
- Inputs from other cells cause small graded potentials that add up at the axon hillock. If the total reaches threshold (about -55 mV), sodium channels open and the neuron fires.
- All or none: every spike has the same size. A stronger stimulus raises the firing rate and the number of neurons that fire, not the spike height.

The action potential (2)

- After a spike, the absolute refractory period stops the neuron firing again for about a millisecond.
- Myelin speeds conduction: the signal jumps between gaps (nodes of Ranvier). Myelinated axons conduct at up to about 100 m/s, thin unmyelinated ones at about 1 m/s. Multiple sclerosis damages myelin.

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Figure: The action potential

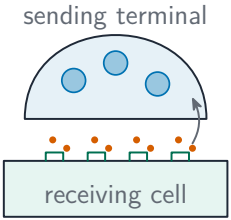


- A spike starts at the initial segment and travels along the axon to the terminals
- Match each part of the diagram to the text.

The synapse

- An agonist mimics or strengthens a transmitter's action; an antagonist blocks it.
- SSRIs (such as fluoxetine) block the **reuptake** of serotonin, so more stays in the gap.

Figure: The synapse



1 spike arrives; calcium channels open
2 vesicles release transmitter
3 transmitter binds receptors
4 receiving cell: new graded potential
5 reuptake or breakdown clears the cleft

antagonist: blocks step 3 SSRI: slows step 5 for serotonin

- Each drug action targets one step.
- Match each part of the diagram to the text.

Transmitters

- Acetylcholine: muscle movement and memory; it is lost early in Alzheimer's disease.
- Dopamine: movement and reward. Loss of dopamine neurons causes Parkinson's disease; too much dopamine activity is linked to the hallucinations and delusions of schizophrenia, and many antipsychotic drugs block D2 dopamine receptors.
- Serotonin: mood, sleep and appetite. GABA is the main inhibitory transmitter, glutamate the main excitatory one.
- One transmitter serves many systems, so a drug's effect depends on the pathway and receptor type.

Brain structures

- Amygdala: emotion and fear learning. Hippocampus: forming new episodic memories.
- Hypothalamus: hunger, thirst, temperature and hormones. Cerebellum: coordination and timing of movement.
- Broca's area (left frontal): producing speech. Wernicke's area (left temporal): understanding speech.
- Prefrontal cortex: planning and self-control. Most behaviour depends on networks, not one centre.

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Worked example: a stronger stimulus

- This supports the **all-or-none principle**: intensity is coded by rate, not size.
- More neurons also fire for the firm press: recruitment.
- A student who calls this evidence against all-or-none firing has confused spike rate with spike size.

Worked example: drug actions

- A drug binds dopamine receptors without activating them: an antagonist. It would be expected to reduce dopamine-driven symptoms.
- A drug slows serotonin **reuptake**: an agonist-like effect, keeping serotonin in the gap longer.
- Neither description predicts the whole behavioural effect. Receptor subtypes and feedback matter.

Common errors

- Saying a stronger stimulus makes a bigger spike.
- Placing the start of the spike in the dendrites.
- Mixing up Broca's area (production) and Wernicke's area (comprehension).

Common errors (2)

- Saying one transmitter has one function.
- Naming one structure as the whole basis of a complex behaviour.

Key terms

- **action potential**: A brief, all-or-none electrical impulse that travels along an axon.
- **all-or-none principle**: Once threshold is reached, a neuron fires a complete spike of fixed size.
- **synapse**: The junction where a neuron passes a signal to another cell.
- **reuptake**: The return of a released neurotransmitter into the sending neuron.

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Check yourself

- Which part of the neuron usually starts the action potential?
- A patient speaks fluently but makes little sense and understands poorly. Which area is damaged?
- How do SSRIs act?