PSYC1022: The Psychology of Addiction

Topic 6: Neuropharmacology (I)

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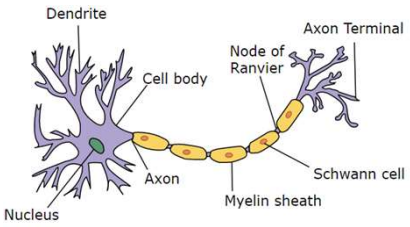
Outline:

- The neuron
  - Background
  - Structure
- Neuron potentials
  - Resting potential
  - Action potential
- Neurotransmission
  - Synapse
  - Excitatory & inhibitory synaptic potentials



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The neuron

Early philosophers knew that the ability of animals to change their behaviour in response to external events must be mediated by some form of communication along biological material.

Early "balloonist" theories

- René Descartes: expansion of fluids within the brain & spine were transduced into muscle movements.

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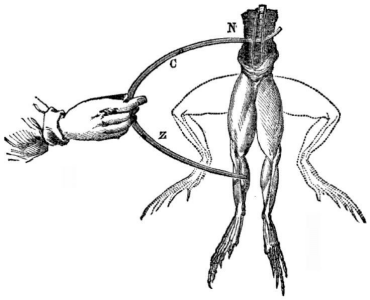
The neuron

Galvani: electrical induction of muscle movements in frogs' legs indicated that electrical energy mediated the transduction of sensory information into muscular activity (behaviour).

- Frog see's a fly (sensory information) so it jumps (muscular activity behaviour) to catch it
- Communication between sensory (visual) neurons & motor neurons occurs via electrical energy which runs along a "neural pathway"



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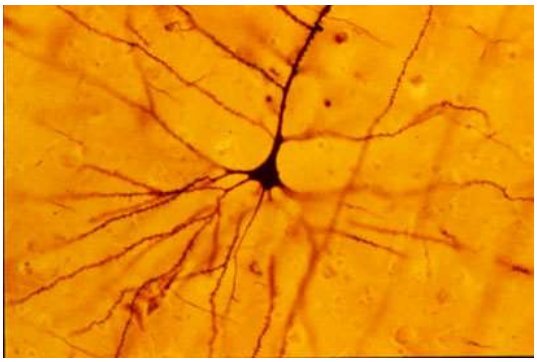
The neuron

Camillo Golgi: discovered a method for staining brain cells that involves fixing black silver chromate particles into the neuron membrane.

- This results in a stark black deposit which provides clear & well contrasted picture of the neuron.
- The ability to visualize separate neurons led to the eventual acceptance of the 'neuron theory'.



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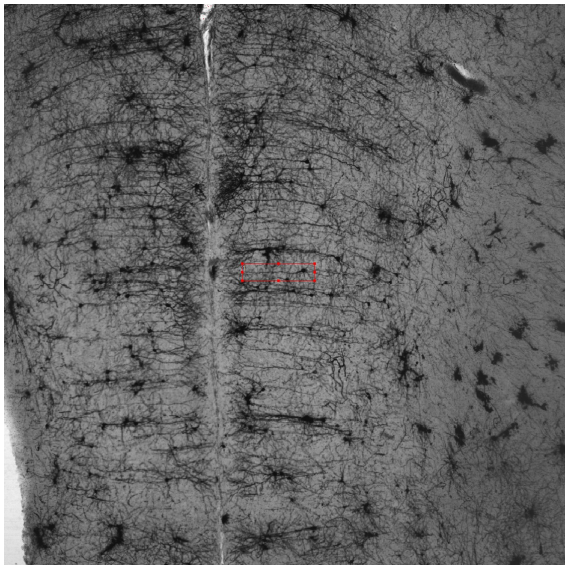
The neuron

4x magnification of pyramidal neuron in Prelimbic region of mPFC.

Pacitti, Balleine & Killcross (2018)



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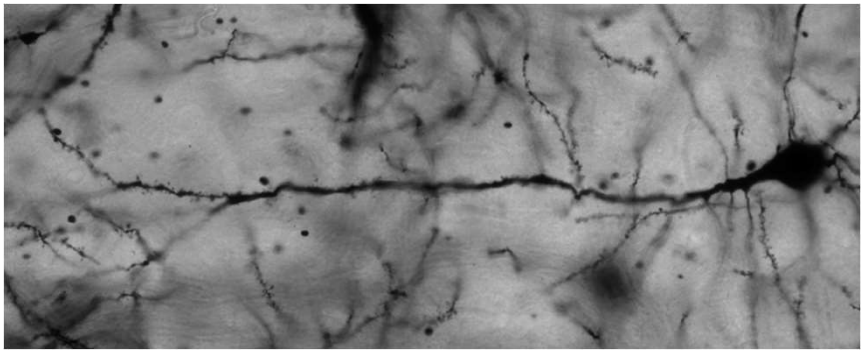
The neuron



60x magnification of pyramidal neuron in Prelimbic region of mPFC.

Pacitti, Balleine & Killcross (2018)

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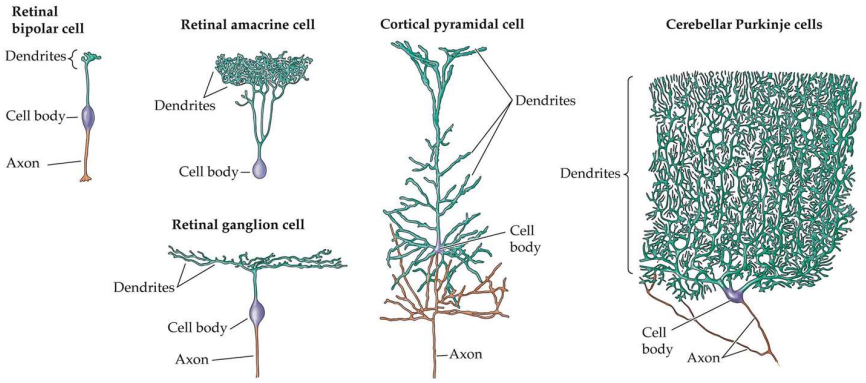
The neuron

(Meyer & Quenzer, 2004)

Staining methods have now been used to identify lots of different types of brain cells which do different things within the nervous system.



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The neuron Video: The neuron

Dendrites: branch-like structures that receive information/signals from other neurons.

Cell body (soma): control region which contains the machinery that keeps the neuron alive & functioning.

Axon hillock: where the excitatory & inhibitory input fror other cells are summated to determine whether the cell will "fire" (AKA action potential) or not.

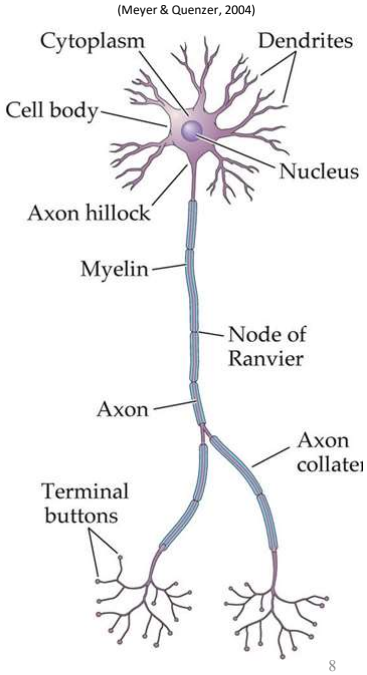
Axon: thin fibre extending from the soma which is involved in transmitting electrical signals to other neuron (via an action potential)

Myelin sheath: is a fatty layer that covers portions of the axon which speeds up electrical conduction down the axon.

Nodes of Ranvier: allows the electrical charge to jump to each node, speeding conduction.

Terminal buttons: passes the electrical signal to the dendrite of a neighbouring cell (via neurotransmitter release)

(Meyer & Quenzer, 2004)



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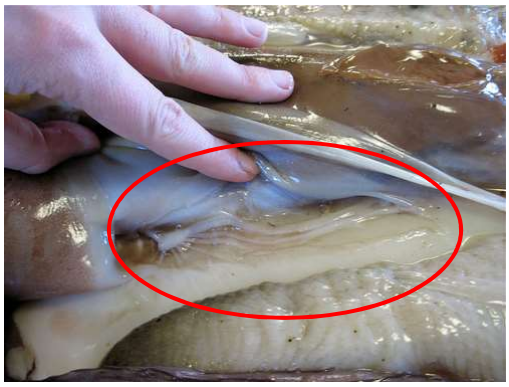
The action potential

Action potential: the process by which an electrical signal is transmitted along an axon

- Andrew Huxley: breakthrough in understanding the action potential using the giant squid axon (red circle) as his experimental model.



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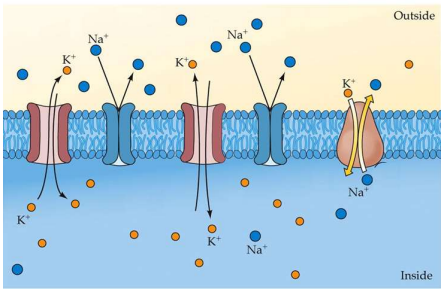
Resting membrane potential

Resting membrane potential: voltage of a neuron when it is not "firing"

- Maintained by pumping positively charged sodium ions (Na+) out of the cell & potassium ions (K+) into the cell
- More positive ions outside compared to inside the cell creates a negative electrical charge inside the cell (-70mV)

Video: membrane potential

	concentration	
	Na^+	K^+
Outside cell	440	20
Inside cell	50	400



(Meyer & Quenzer, 2004)

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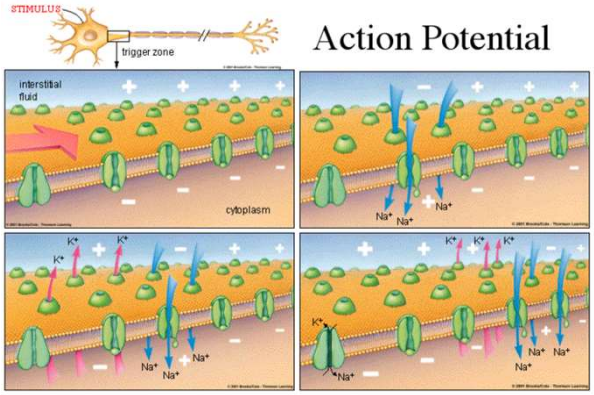
The action potential

Video: The action potential (Meyer & Quenzer, 2004)

Occurs when a neurotransmitter from another cell, or a drug, causes sodium channels to open which allows sodium ions to flood inside the cell

- creates a brief positive charge ("fires") inside the cell before the sodium ions are pumped out again.
- This brief positive electrical charge within the cell causes neighbouring voltage-gated sodium ions channels on the axon to open, allowing the positive electrical signal to move down the length of the neuron like a Mexican wave.



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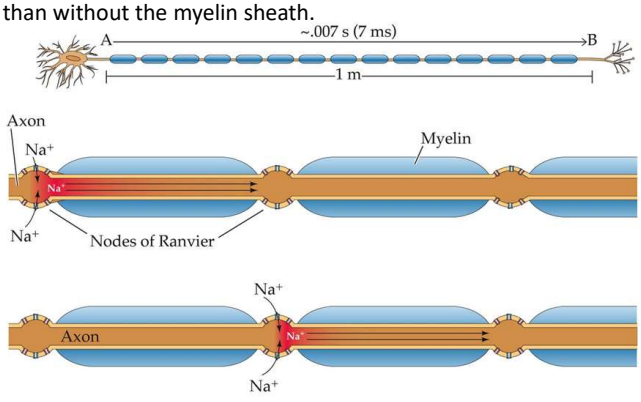
The action potential

(Meyer & Quenzer, 2004)

Myelin sheath acts as an electrical insulator. It blocks the transit of ions across the cell membrane except at the Nodes of Ranvier.

- This enables the electrical signal to pump down the neuron at a much faster speed than without the myelin sheath.



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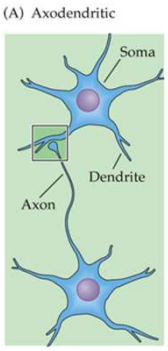
Neurotransmission

(Meyer & Quenzer, 2004)

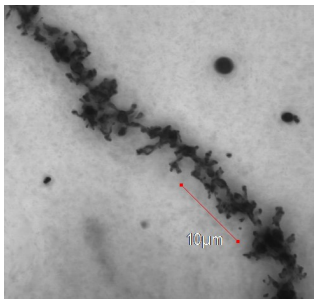


The action potential may continue into the next cell through a process known as neurotransmission or synaptic communication.

Synaptic cleft (gap): space between the terminal button & the dendrite (spine) of the target (neighbouring) cell.

- Changes in neurotransmission at the synaptic cleft are the basis for learning & behaviour, and it is here that drugs act to create addiction.

Dendritic spines of Medium Spiny Neurons in the Dorsolateral Striatum
Pacitti, Balleine & Killcross (2017)



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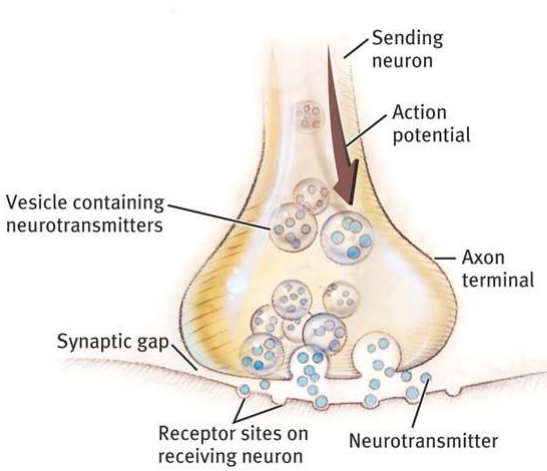
Neurotransmission

Video: Synaptic transmission (Meyer & Quenzer, 2004)



When an action potential reaches an axon terminal, it stimulates the release of neurotransmitter molecules from sacs called vesicles. These molecules cross the synaptic gap and bind to receptor sites on the receiving neuron. This allows electrically charged atoms (not pictured here) to enter the receiving neuron and excite or inhibit a new action potential.

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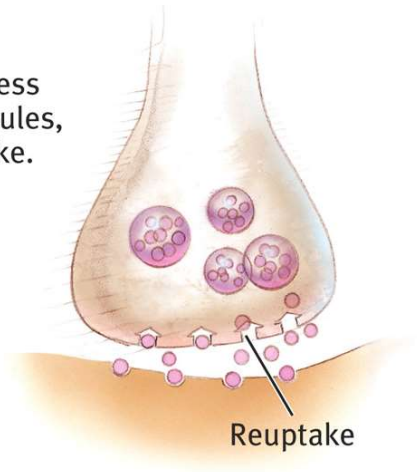
Neurotransmission

(Meyer & Quenzer, 2004)

The sending neuron normally reabsorbs excess neurotransmitter molecules, a process called reuptake.



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Synaptic Potentials

Video: Summation

Excitatory neurotransmitter: opens sodium (Na+) channels allowing sodium ions to enter the postsynaptic cell which creates a positive internal charge increasing the probability of an action potential.

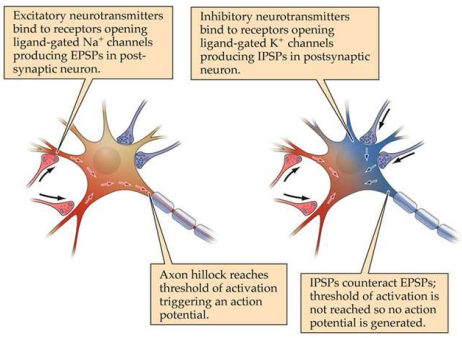
- Excitatory Postsynaptic Potential (EPSP)

Inhibitory neurotransmitter: opens potassium channels (K+) releasing potassium ions trapped within the postsynaptic cell which creates a negative internal charge decreasing the probability of an action potential.

- Inhibitory Postsynaptic Potential (IPSP)

Excitatory & inhibitory inputs compete (summate) to determine whether the cell "fires" or not.

- Drugs act by modifying these process to change cell firing rates.



(Meyer & Quenzer, 2004)

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