Lecture 1:Information Processing and Signal Detection

Lecture 01 Part 04

The Physiology of Perception

Learning Objectives

To develop an understanding of the physiological processes underlying perception, transduction, transmission, processing.

To develop an understanding of the neural transmission process whereby information generated in response to an external stimulus can be conveyed to different areas of the brain (depending on the sense organ stimulated.

Learning Outcomes

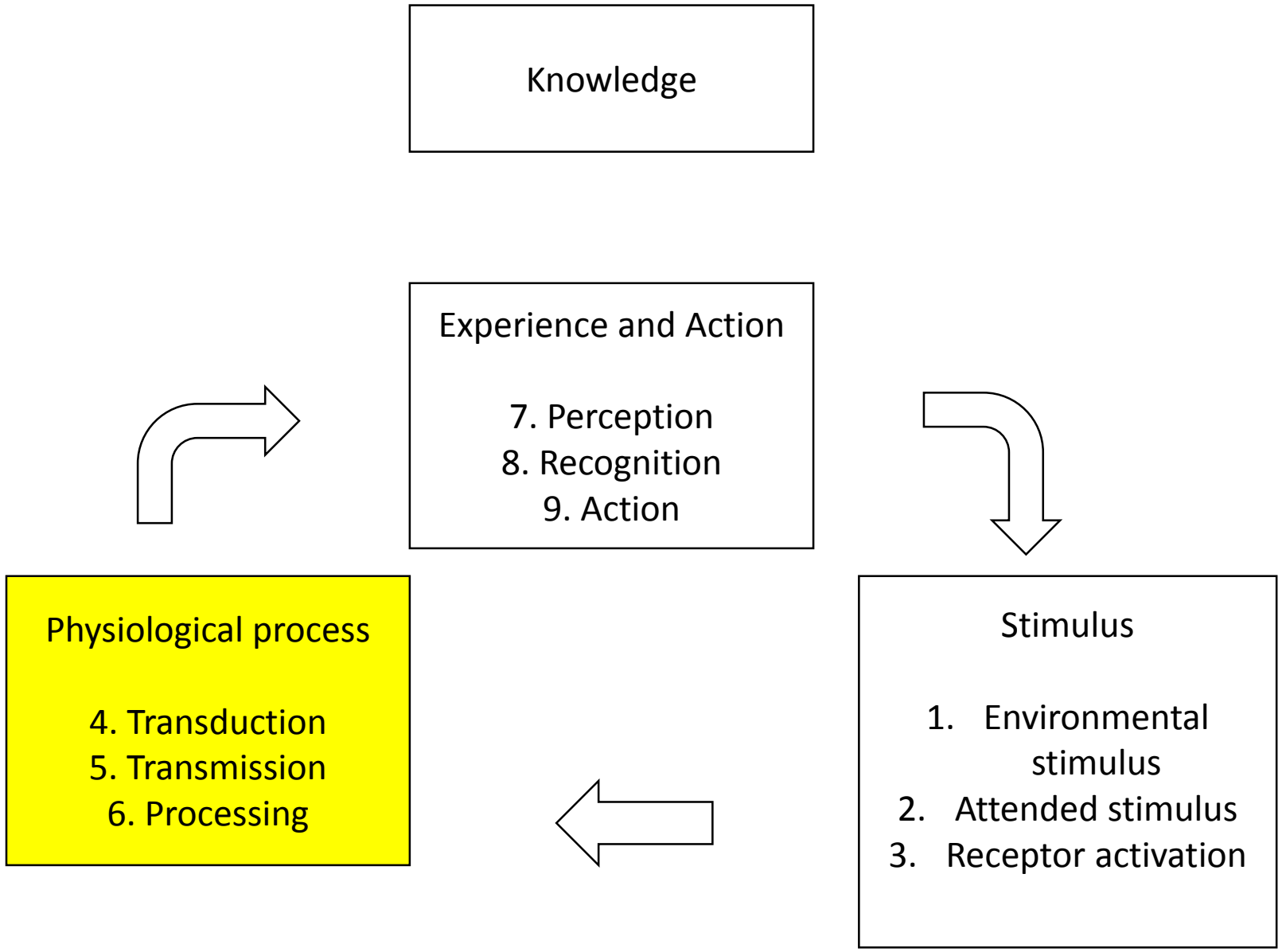
To be able to describe the basic brain areas for perceptual processing of information received from neurons for the different senses.

To be able to describe the basic components of a neuron and the transmission process.

To be able to describe what happens when a sense receptor is activated and an action potential is generated.

To be able to describe how electrical information is conveyed from neuron to neuron.

We Shall now Focus on the Physiological Basis of Perception



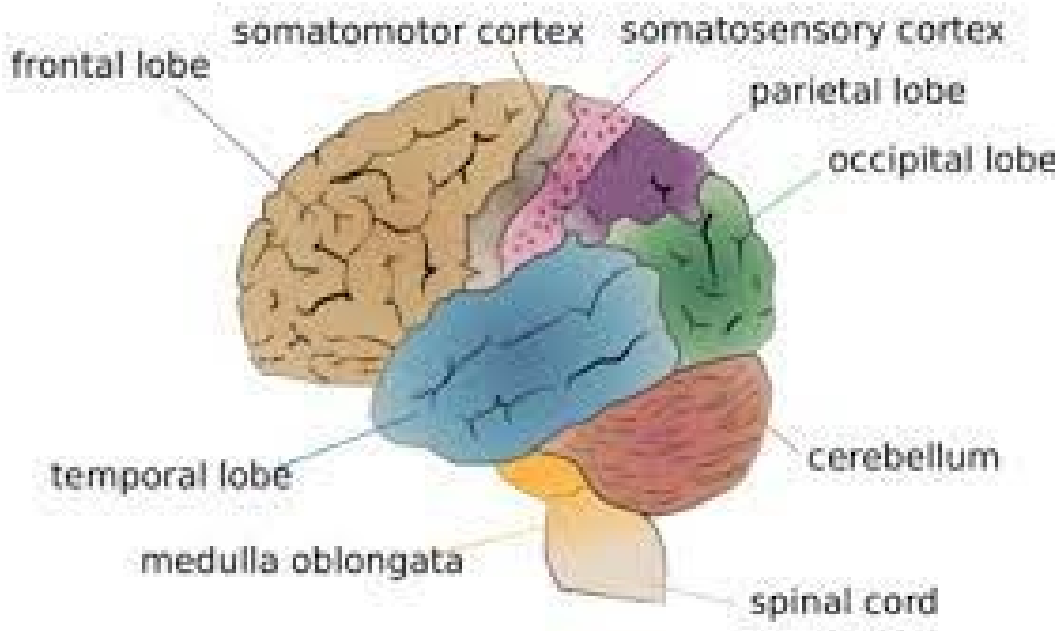
As we have already seen, the perceptual process can be broken down into 4 categories:

Knowledge
Experience & action
Stimulus
Neural Activity

<u>We will be looking at the physiological process highlighted in the diagram.</u>

How is a stimulus in the environment converted to the perception of colour, or loudness, softness, or smell.

Primary brain receiving areas for the senses

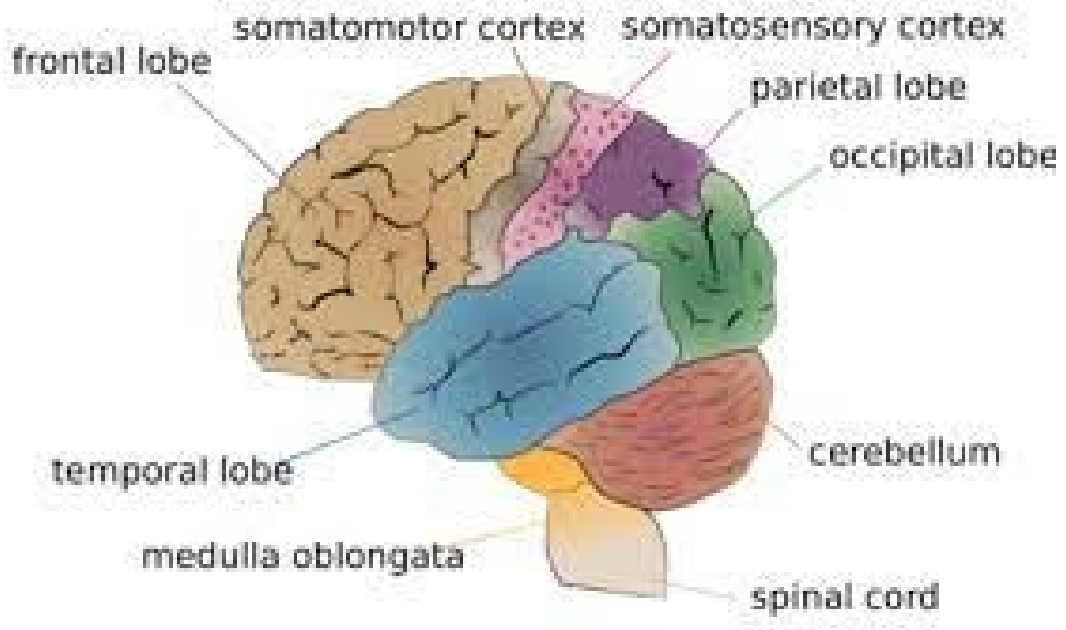


https://en.wikipedia.org/wiki/Perception

Locations of the primary receiving areas (lobes) for the senses in the human brain.

Shown are the:
Occipital lobe for receiving visual information
Temporal lobe for receiving auditory information
Parietal lobe for receiving tactile information
Frontal lobe for receiving information from all the senses and is involved In the coordination of information received through multiple senses.

Primary brain receiving areas for the senses



How is environmental information transferred to these brain areas?
Via neurons, which transduce the environmental information into electrical signals which can be transmitted to the relevant brain area(s).

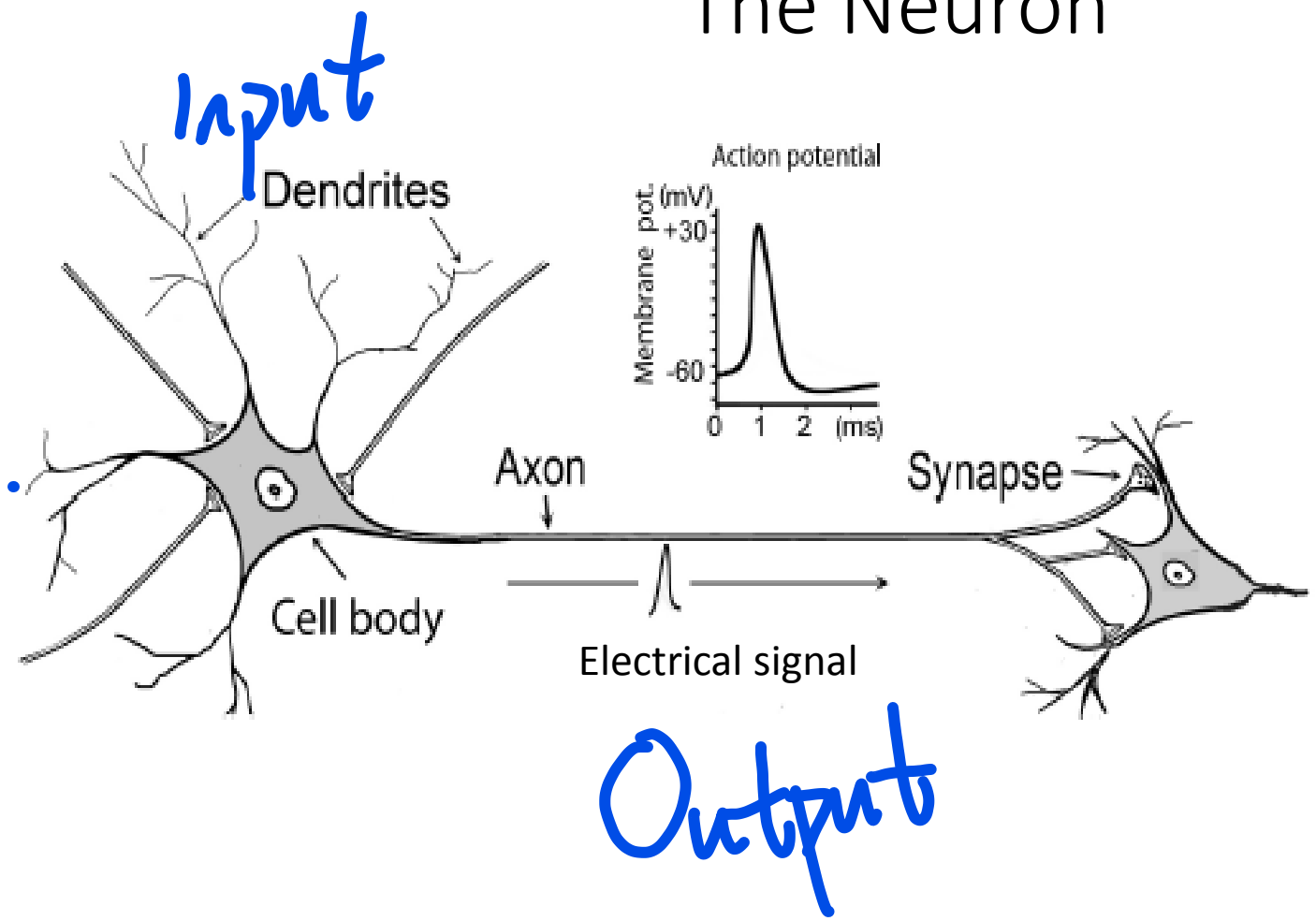
Neurons also communicate with one another (transduction) to assist in the information flow.

When the electrical information reaches the appropriate area of the brain it can be processed in order to be perceived appropriately.

Transduction

We shall focus on the transmission process which occurs after transduction, and involves the transfer of electrical information via neurons.

The Neuron



The concept and terminology of Neural Networks in computer science originated from physiology, especially terminology relating to neural function, stimulation and interconnections.

Neurons (nerve cell) have a cell body.

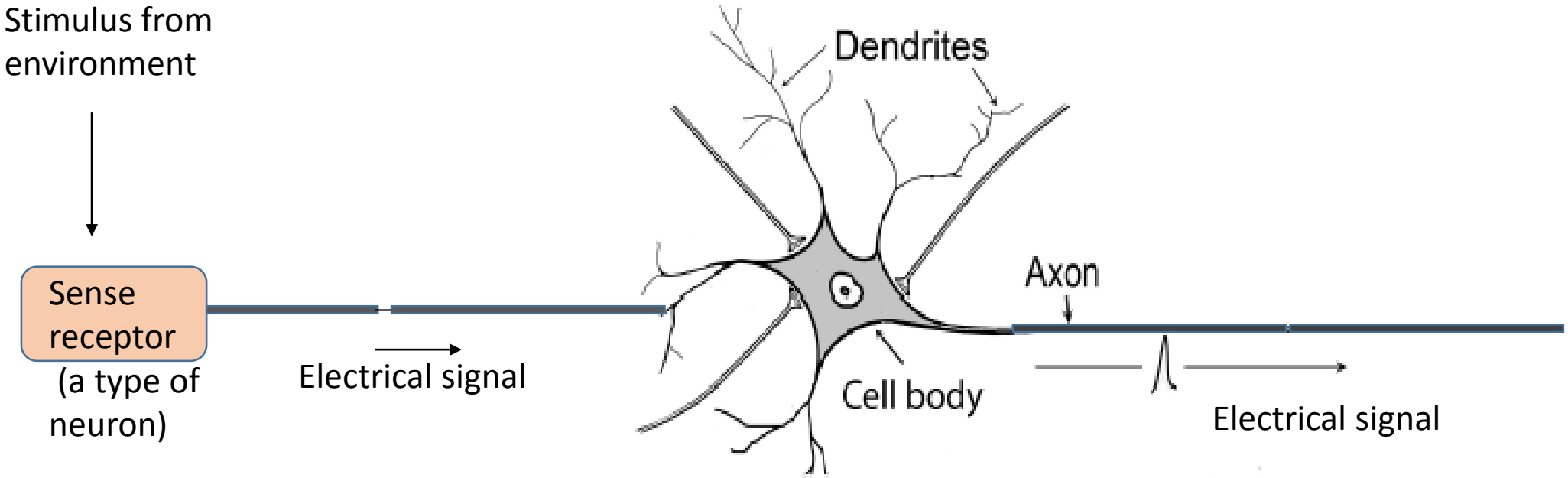
A cell body has 2 appendices- the dendrites and an axon.

Inputs: A neuron may have thousands of inputs at its dendrites or cell body.

Output: has 1 output, the axon, that may split to form multiple branches.

Neurons communicate with one another by sending electrical signals (the action potentials) along their axons.

The Neuron



A stimulus from the environment can be received by a specific sense receptor. The receptor transduces this information into electrical activity and this is transmitted to the dendrites of a neuron.

This electrical activity can then be transmitted neuron to neuron(s) until it reaches the brain for further processing.

Action Potential

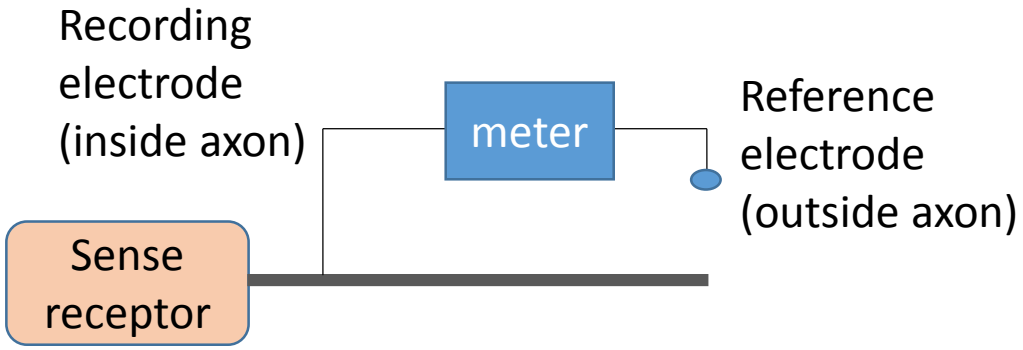
Sense receptors

Sense receptor

A sense receptor is a generic term.
A receptor for each sense is specialised to transduce a specific type of environmental information.

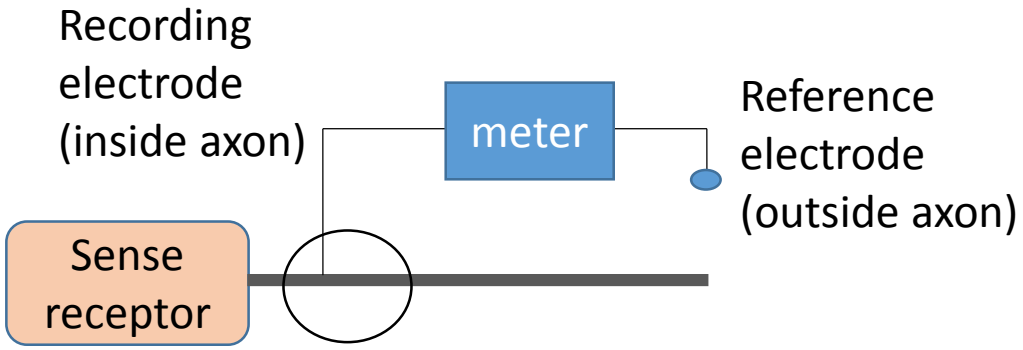
Receptors for responding to light (vision)
Receptors for responding to sound (audition)
Receptors for responding to pressure on the skin (touch)
Receptors for responding to chemicals in the air (smell)
Receptors for responding to chemicals in liquid form (taste)

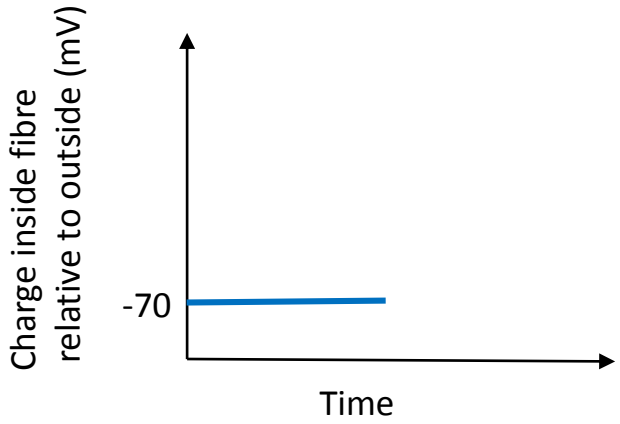
What happens when a sense receptor is activated



Can record electrical activity from a neuron by measuring the difference in electrical charge between 2 electrodes.
One is a recording electrode located where the electrical activity will occur, inside the axon. The other is the reference electrode, located away from the axon, so that it is not affected by the electrical signals generated in the axon.
The difference in charge between the recording and reference electrode is measured.

What happens when a sense receptor is activated

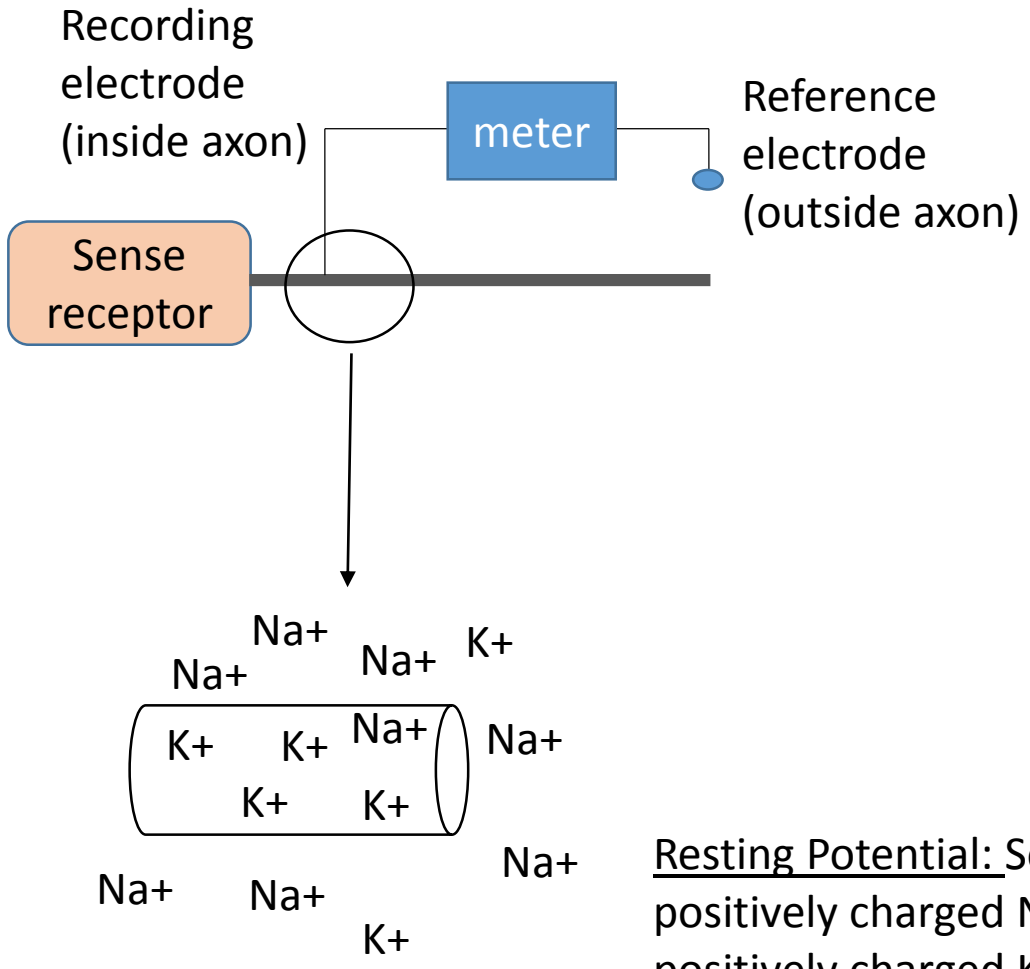




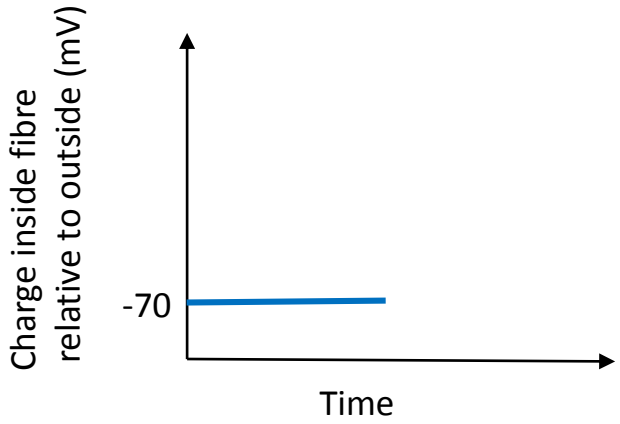
When nerve fibre is at rest, the difference potential is around -70 milli Volts (the difference in charge between the outside and inside of the fibre).

This is called the resting potential.

What happens when a sense receptor is activated



Na+ = Sodium ion
K+ = Potassium ion

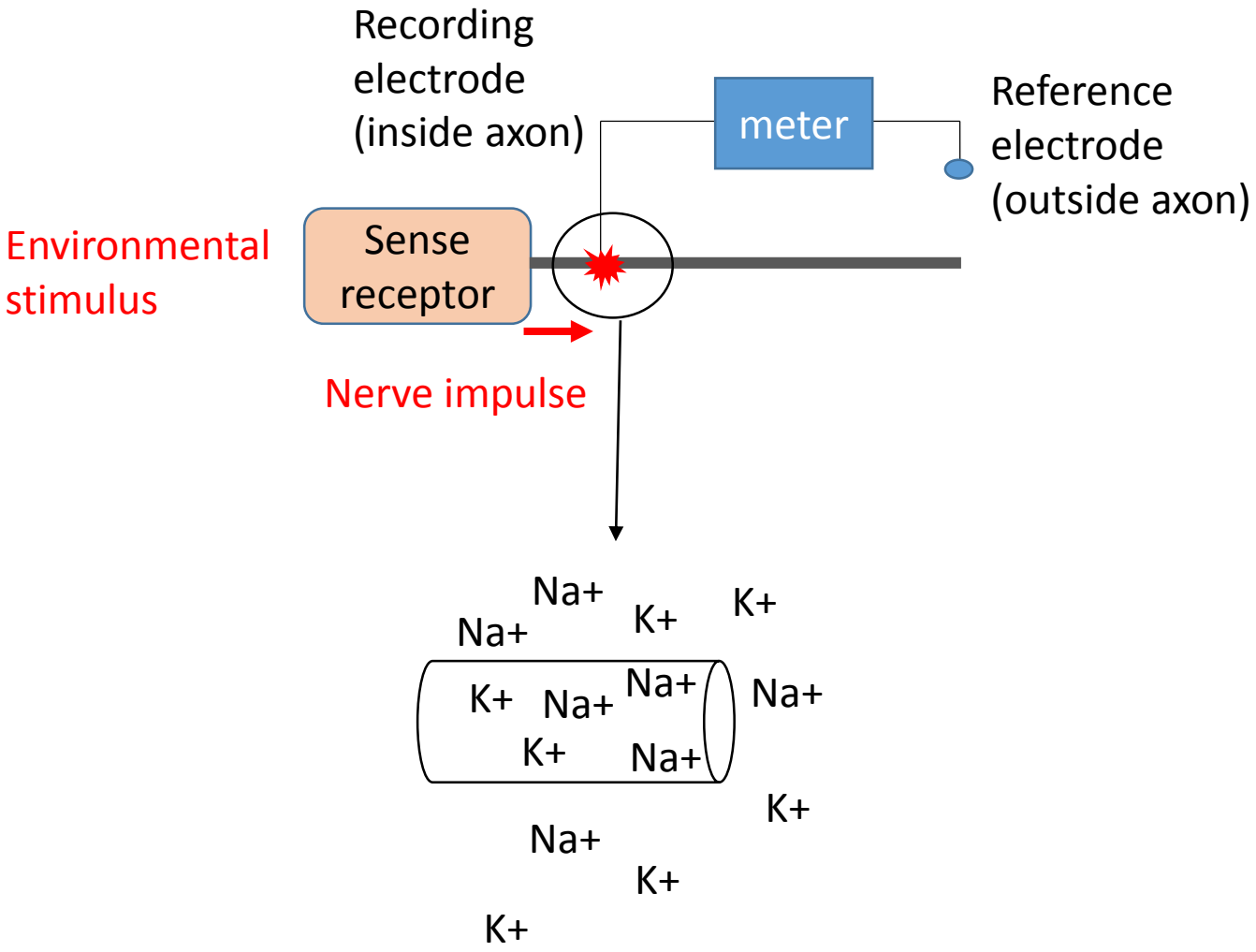


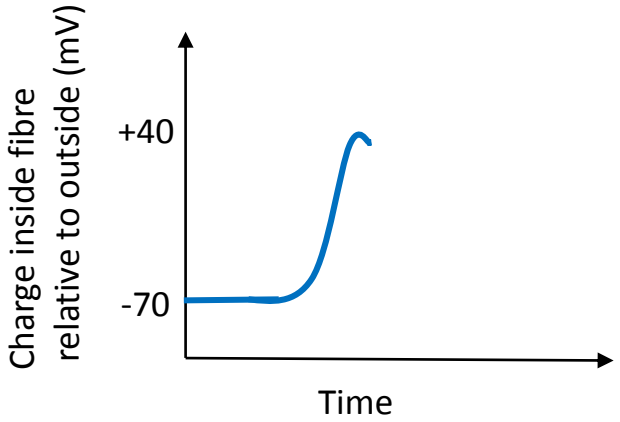
When nerve fibre is at rest, the difference potential is around -70 milli Volts (the difference in charge between the outside and inside of the fibre).

This is called the resting potential.

<u>Resting Potential:</u> Solution outside the axon of a neuron has a high concentration of positively charged Na+ ions. Solution inside the axon has a high concentration of positively charged K+ ions.
Ions can flow in and out of the axon as a consequence of the cell membrane's selective permeability. It is "selective" because properties of the membrane allow it to become more permeable to a specific ion and not another.

What happens when a sense receptor is activated

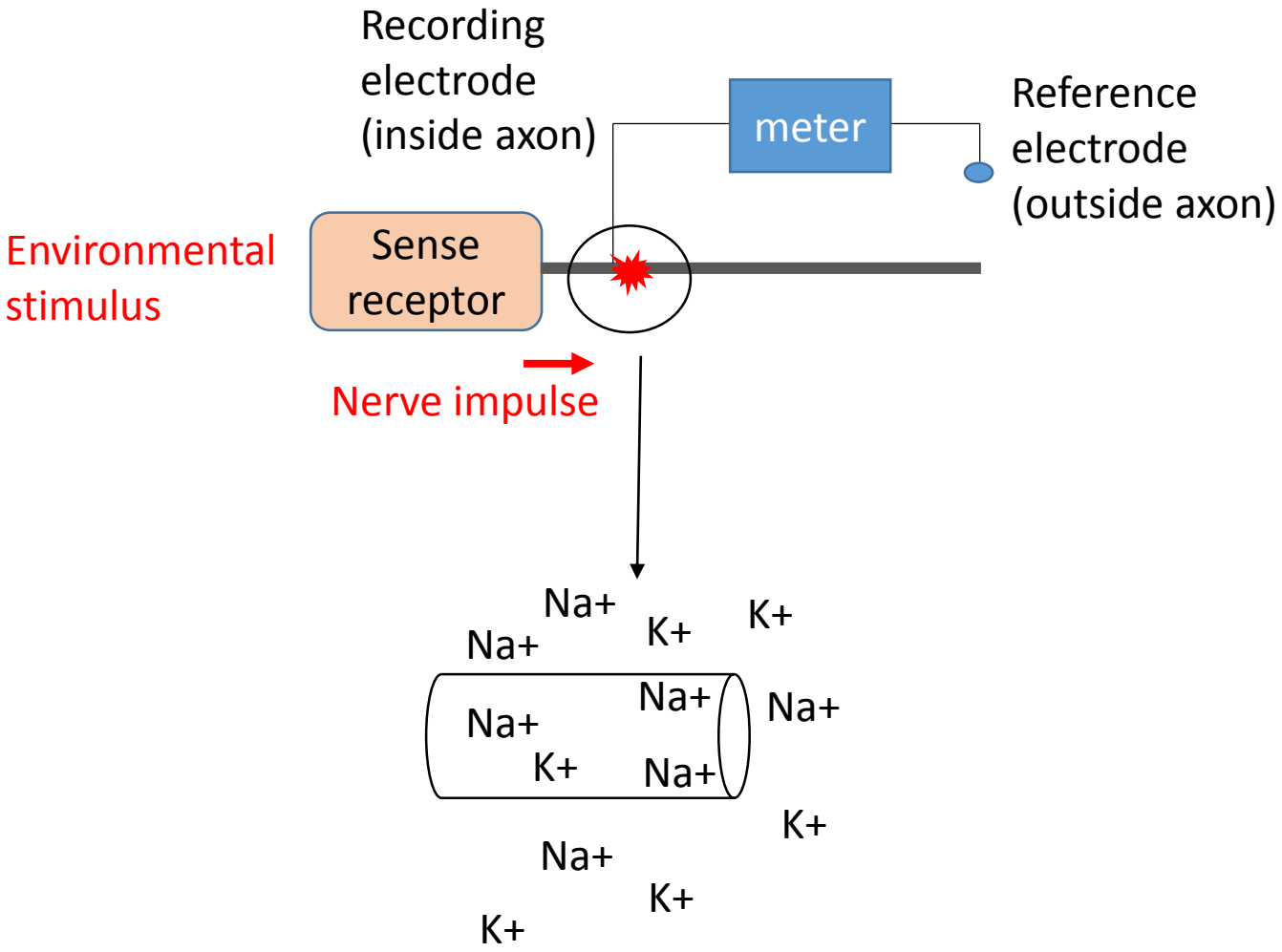


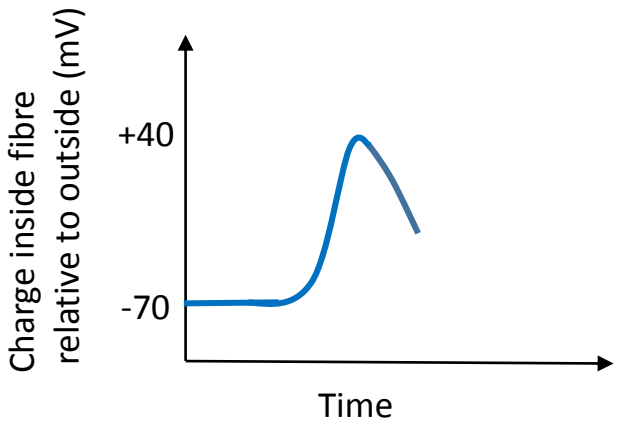


Sodium ions flow into the axon, and the inside of the neuron becomes more positive (action potential becomes more positive towards +40mV).

This creates the **Action Potential**

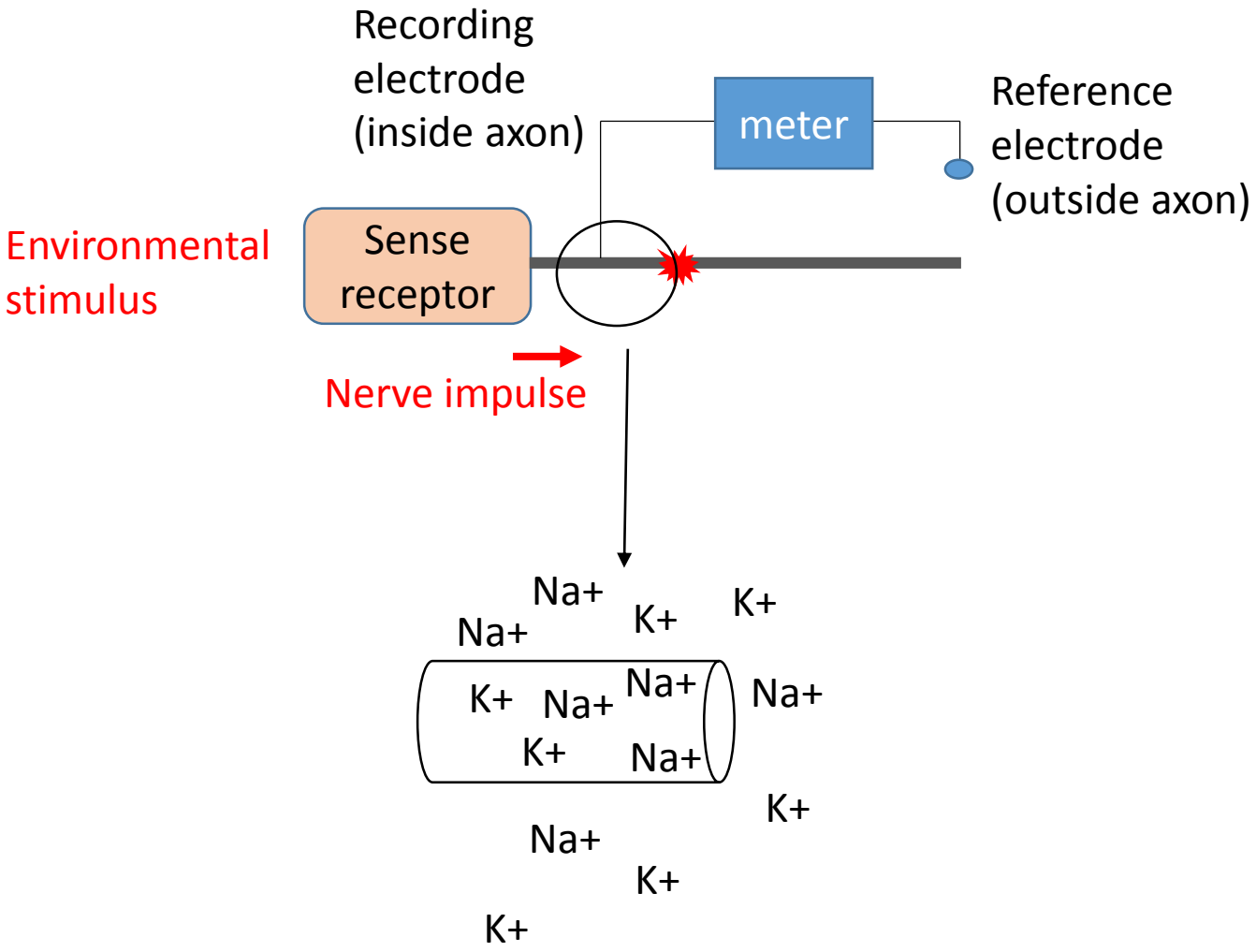
What happens when a sense receptor is activated

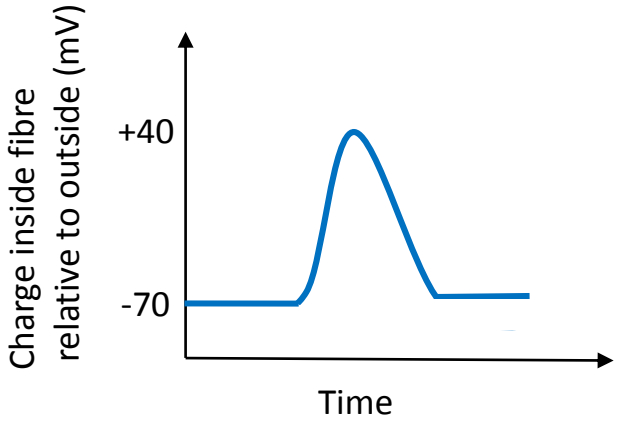




Potassium ions flow out of the axon, and the inside of the neuron becomes more negative (action potential falls back to negative.

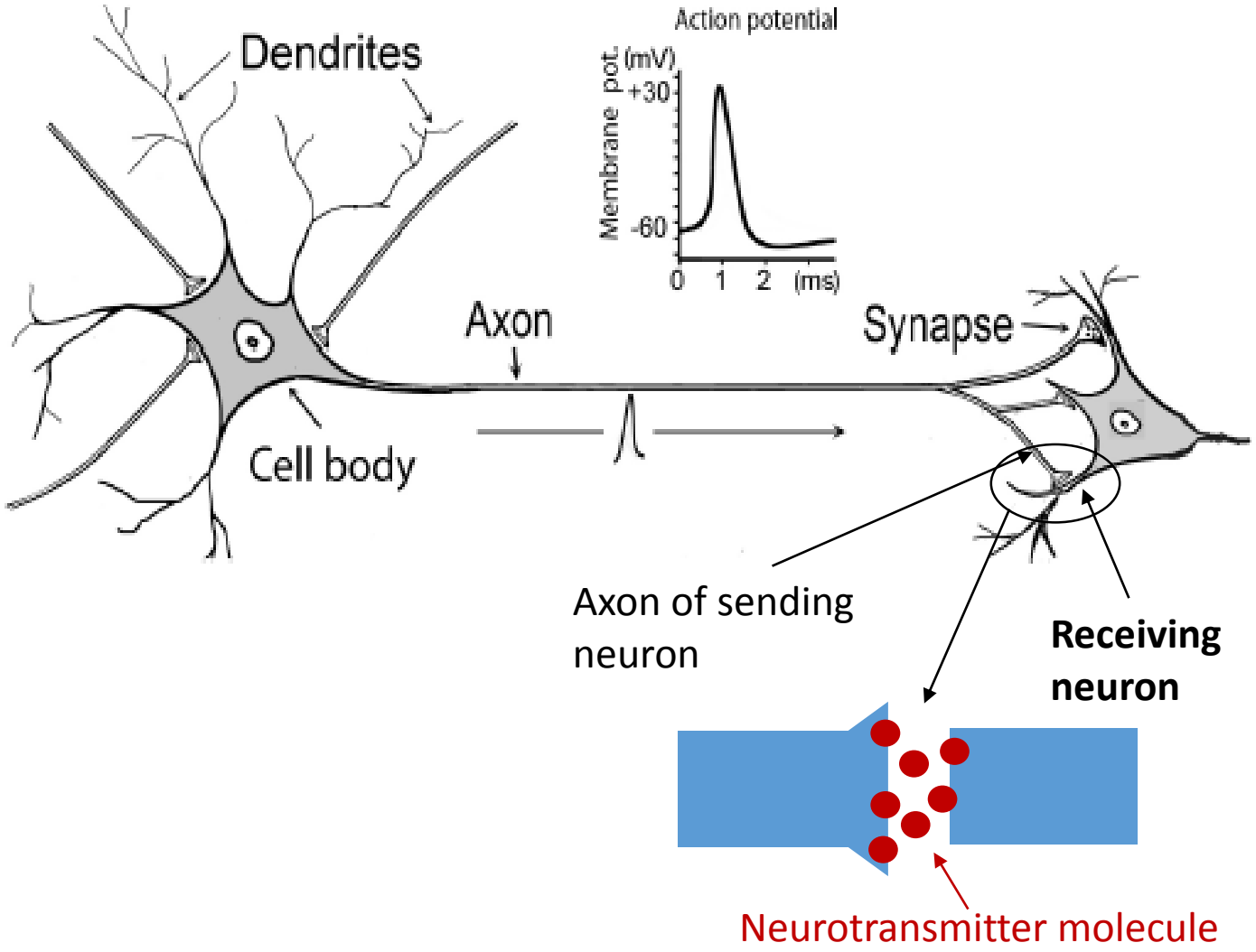
What happens when a sense receptor is activated





The fibre's charge returns to the resting level after the flow of sodium and potassium ions has returned back to its normal levels inside and outside of the axon.

Neuron to Neuron Communication



Information can be transmitted from one neuron to another by synaptic transmission.

Signal travelling down axon of a neuron reaches the synapse at the end of the axon.

Nerve impulse causes release of neurotransmitter molecules from the sending neuron. The neurotransmitter causes a voltage change in the receiving neuron.

This can happen multiple times as the original neural message is transmitted from one neuron to another.

Overall Summary

The physiological process of perception involves transduction, transmission and processing of information.

There are different primary areas of the brain involved in receiving and processing information from the different senses.

A stimulus from the environment can be received by a specific sense receptor. The receptor transduces this information into electrical activity and this is transmitted to the dendrites of a neuron.

This electrical activity can then be transmitted neuron to neuron(s) until it reaches the brain for further processing.

Resources

<u>Essential:</u>

Sensation and Perception 8th edition (book), pages 23-31.