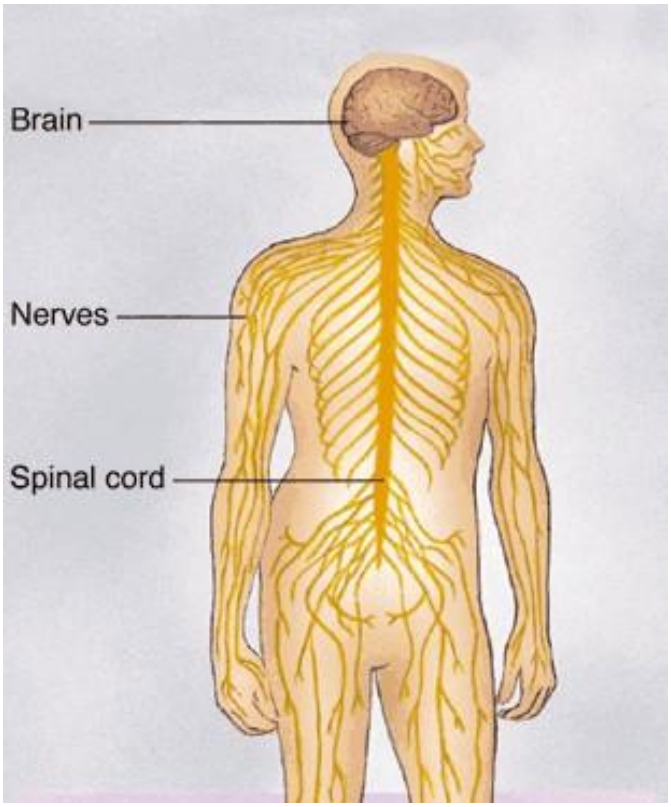
09 Coordination and response

#86 The human nervous system



The human nervous system is made up of two parts:

- ***Central*** *nervous system* (CNS) - **brain** and **spinal cord**: role of coordination
- ***Peripheral*** *nervous system* - **nerves**: connect all parts of the body to the CNS.

Together, they coordinate and regulate body functions.

Sense organs are linked to the peripheral nervous system. They are groups of receptor cells responding to specific stimuli: light, sound, touch, temperature and chemicals. When exposed to a stimulus they generate an electrical impulse which passes along peripheral nerves to the CNS, triggering a response.

Peripheral nerves contain **sensory** and **motor** neurones (nerve cells).

	transmit nerve impules
Motor neurone	sense organs à CNS
Sensory neurone	CNS à effectors (muscles or glands)

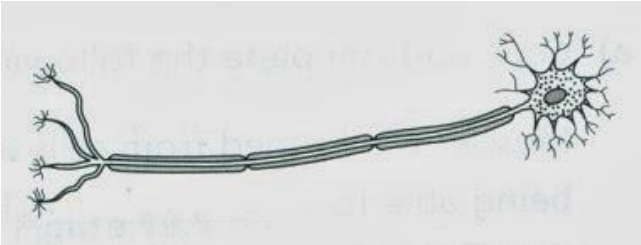
Motor and sensory neurones are covered with a **myelin sheath**, which insulates the neurone to make transmission of the impulse more efficient.

The cytoplasm (mainly **axon** and **dendron**) is elongated to transmit the impulse for long distances.

Structure	**Sensory neurone**	**Motor neurone**
Cell body	Near end of neurone, in a ganglion (swelling) just outside the spinal cord	At start of neurone, indise the grey matter of the spinal cord
Dendrites	Present at end of neurone	Attached to cell body
Axon	Very short	Very long
Dendron	Very long	None

Fun fact: The human nervous system runs on electrical impulses that travel close to the speed of light.

Sample question and answer

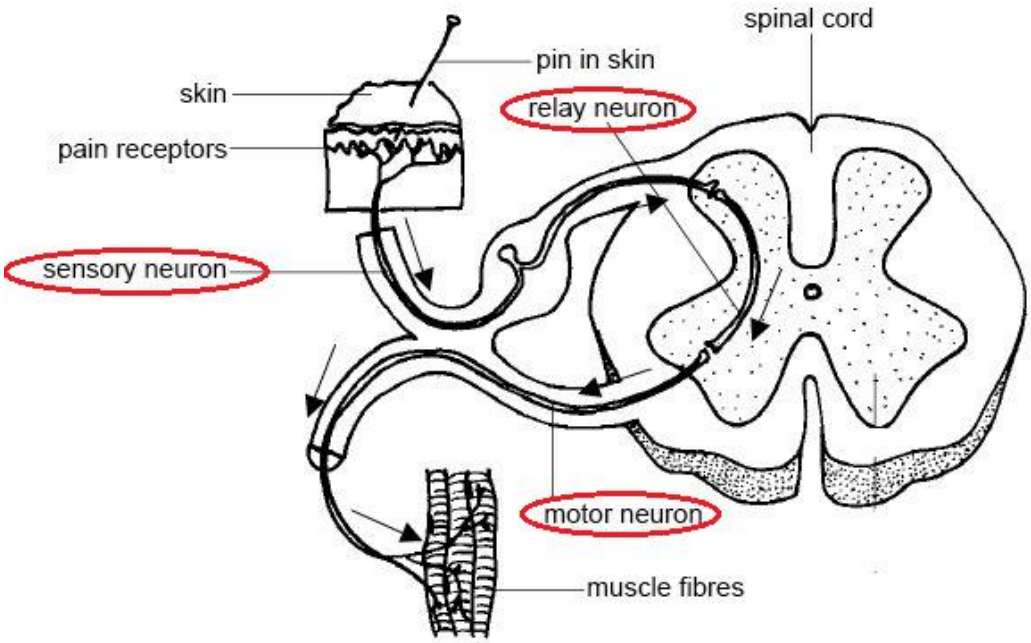


Question Figure above shows a type of neurone. Name this type of neurone and state a reason for your choice. [2 marks]

Answer Name: *motor neurone.*
Reason: *It has a cell body, the cell body is at the and of the cell.*

Video: The Human Nervous System
Video: The Spinal Cord
Video: Human Body Nervous System

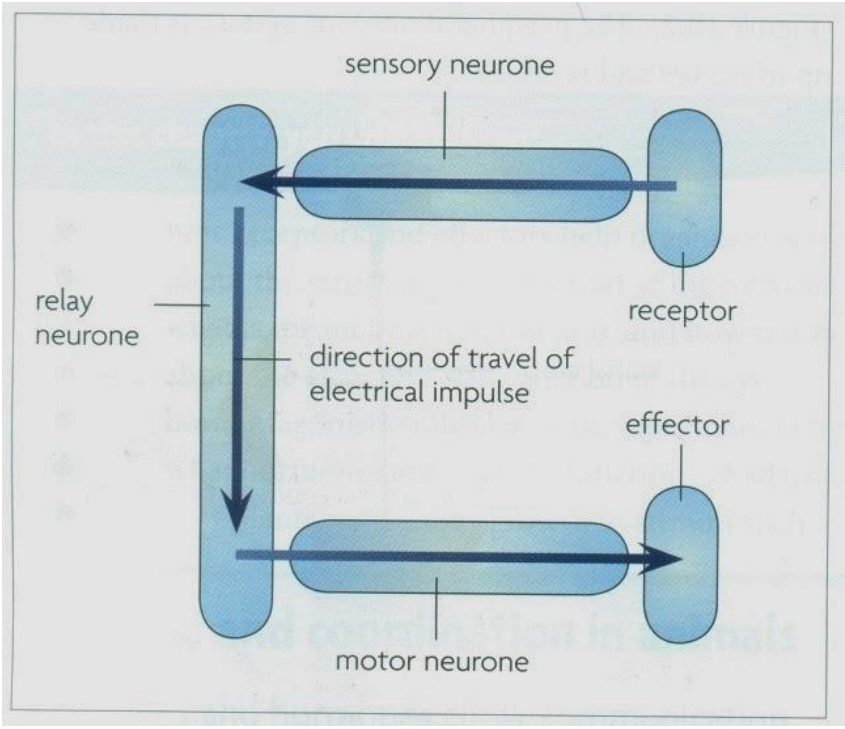
#87 Simple reflex arc



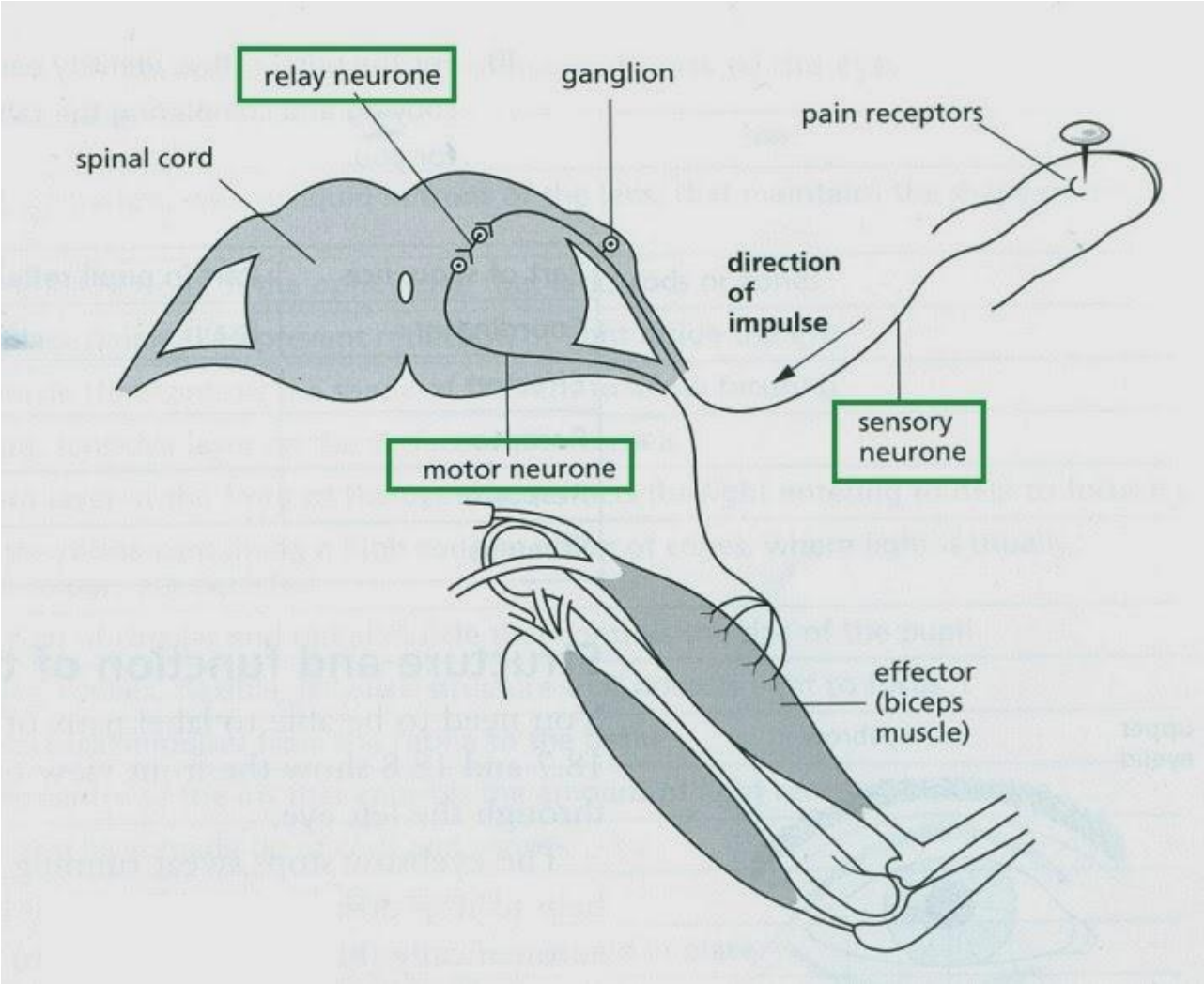
A **reflex** action is an **automatic response** to a stimulus.

A **reflex arc** describes the **pathway** of an **electrical impulse** in response to a stimulus.

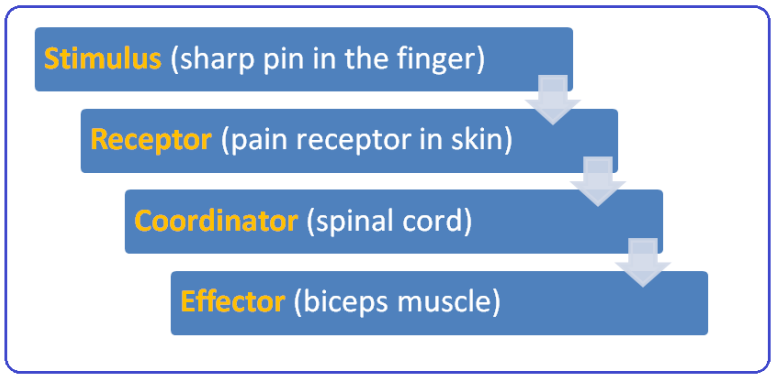
Relay neurones are found in the spinal cord, connecting **sensosy** neurones to **motor** neurones.



On the picture below, the stimulus is a drawing-pin sticking in the finger.
The response is the withdrawal of the arm due to contraction of the biceps.



The sequence of events is:

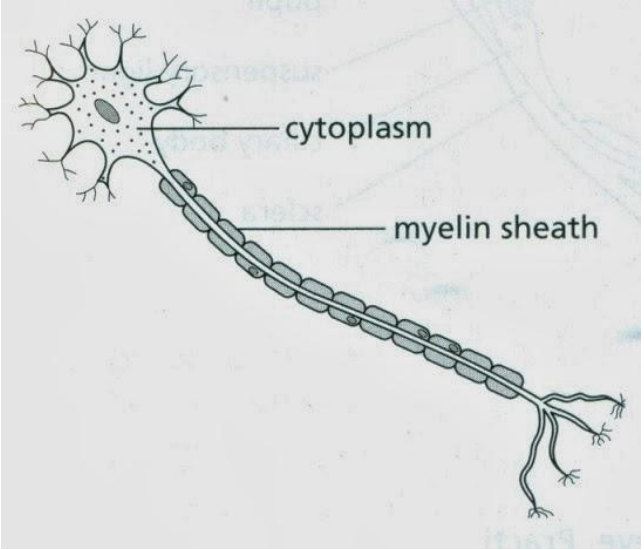


Reflex: automatically and rapidly integrating and coordinating stimuli with responses

Neurones do not connect directly with each other: there is a gap called a synapse. The impulse is 'transmitted' across the synapse by means of a chemical called acetylcholine.

Try this

Figure below shows a nerve cell.



a. i) Name the type of nerve cell shown in the figure [1 mark]

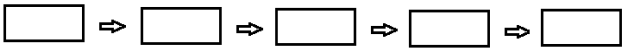
ii) State two features that distinguish it from other types of nerve cell [2 mark]

iii) Where, in the nervous system, is this cell located? [1 mark]

b. Nerve cells are specialised cells. Suggest how the following parts of the nerve cell, labelled in the figure, enable the nerve cell to function successfully:
cytoplasm; myelin sheath. [4 mark]

c. Reflex involve a response to a stimulus.

i) Copy and completes the flowchart by putting the following terms in the boxes to show the correct sequence in a reflex. [2 marks]



ii) For the pupil reflex , identify each of the parts of the sequence by copying and completing the table below. The first has been done for you. [4 marks]

Part of sequence	Part in pupil reflex
Coordinator	Brain
Effector	
Receptor	
Response	
Stimulus	

Answer

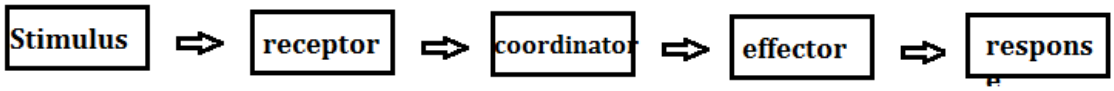
a. i) Motor neurone
ii) Two features from:
- presence of motor end plates
- the cell body is at the beginning of the cell
- the cell body has dendrites on
- there is no dendron (only on axon).

iii) Peripheral nervous system.

b. Cytoplasm: two suggestions from:
- is elongated
- passes electrical signals along
- connects different parts of the body
- is modified to form dendrites.

Myelin sheath: two suggestions from:
- acts as insulating material
- so prevents leakage of electrical signal from axon
- allows faster transmission of impulses.

c. i) flowchart

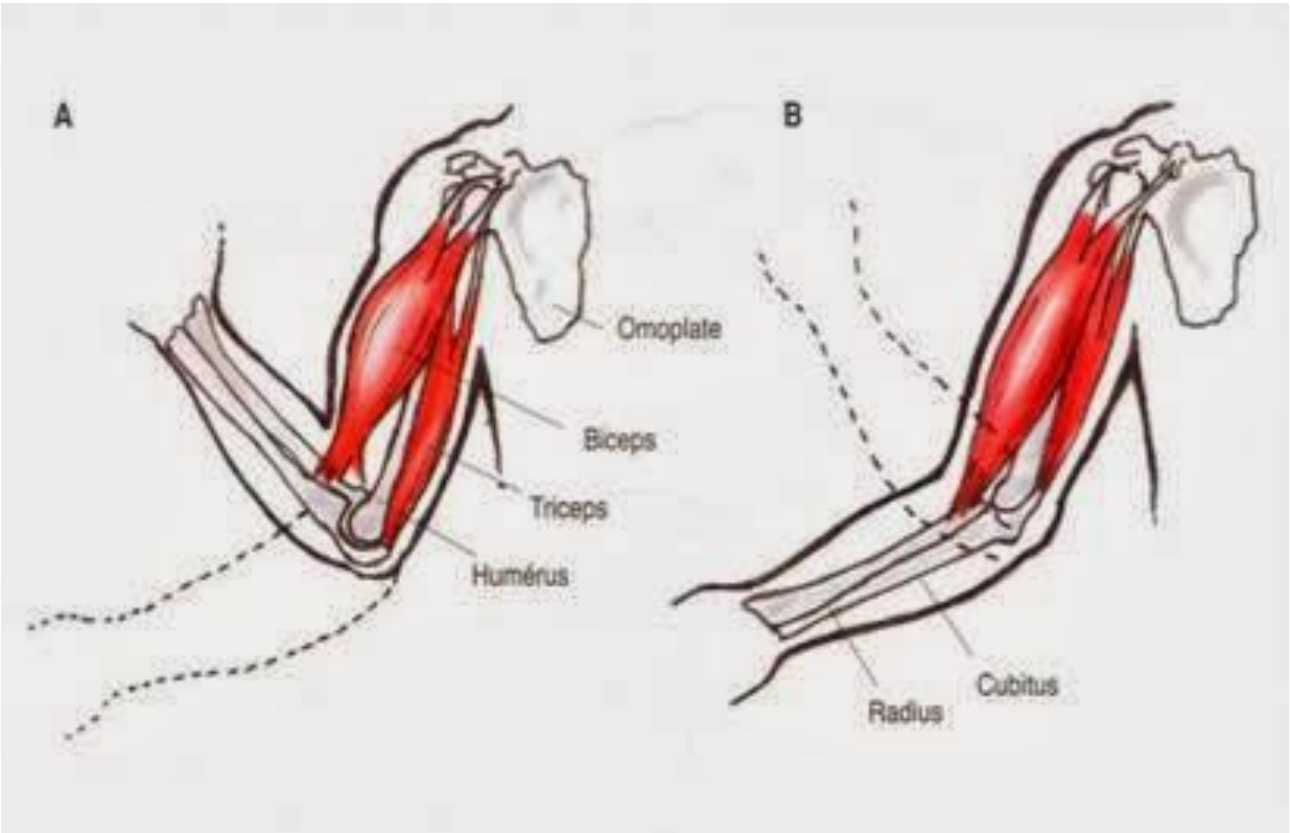


ii)

Part of sequence	Part in pupil reflex
Coordinator	Brain
Effector	Iris (muscle)
Receptor	Retina or rods or cones
Response	Pupil changes diameter or iris muscles contract
Stimulus	Bright light or change in light intensity

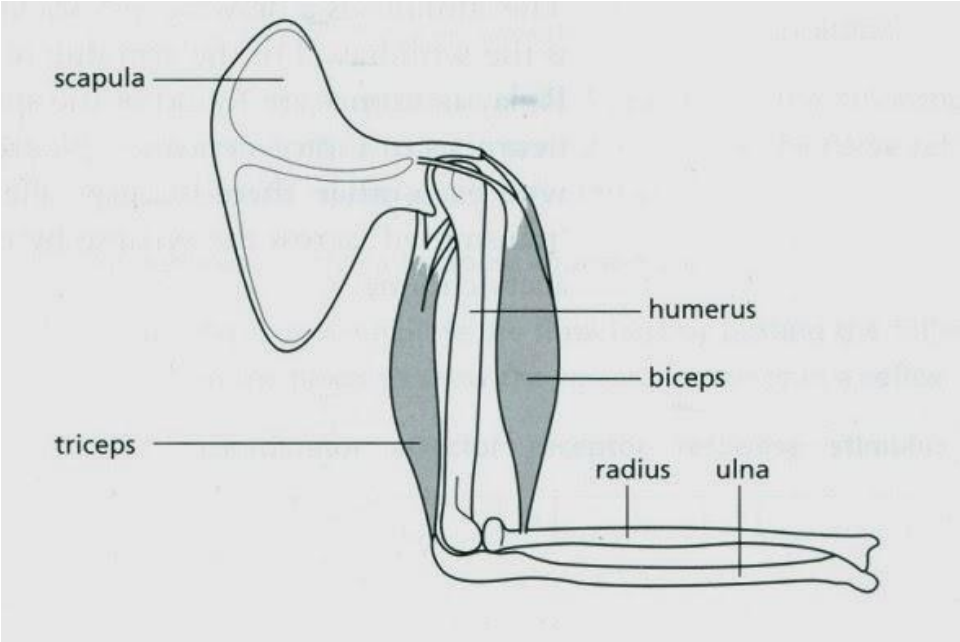
Video: Reflex Arc https://www.youtube.com/watch?v=Y5nj3ZfeYDQ

#88 Effectors, biceps and triceps



Effectors are muscles or glands which respond when they receive impulses from motor neurones. Examples of effectors are the biceps and triceps muscles in the arm.

Structure of the human arm



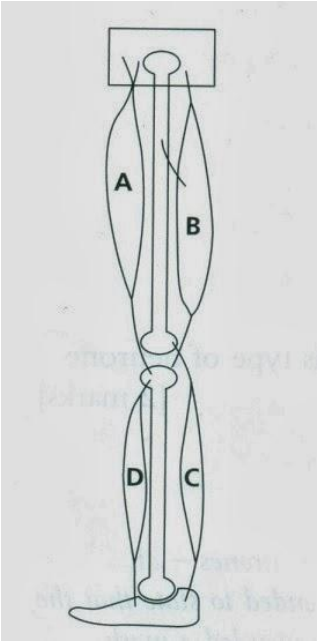
When stimulated, muscles contract get shorter). The biceps and triceps are antagonistic muscles - they have opposite effects when they contract.

The biceps is attached to the scapula (shoulder blade) and the radius. Contraction of the biceps pulls on the radius, moving the lower arm toward the scapula. This results in the arm bending (flexing) at the below - the arm is raised.

The triceps is attached to the scapula, humerus and ulna.
Contractions of the triceps pulls on the ulna, straightening (extending) the arm. In doing so, the triceps pulls the biceps back to its original lengths.

Try this

Figure below is a simplified diagram of the muscles and bones of the human leg.



a) Complete the following sentences.

Muscles are formed from cells which have special property of being able to _____ . Because of this, muscles can not push, they can only ___. [2 marks]

b) Muscles operate as antagonistic pairs. With reference to figure above, explain what is mean by this statement. [2 marks]

c) i) Which muscles **A, B, C** or **D**, must contraction in order to raise the heel to stand on tiptoe? [1 mark]

ii) Which muscles **A, B, C** or **D**, must contract to bend the leg at the knee? [1 mark]

d) When running very quickly, the muscles of the leg may not receive sufficient oxygen to supply all their energy requirements.

i) Name the type of respiration these muscle cells carry out to release additional energy. [1 mark]

ii) Name the waste product produced by this process. [1 mark]

Answer

a) Contract; pull

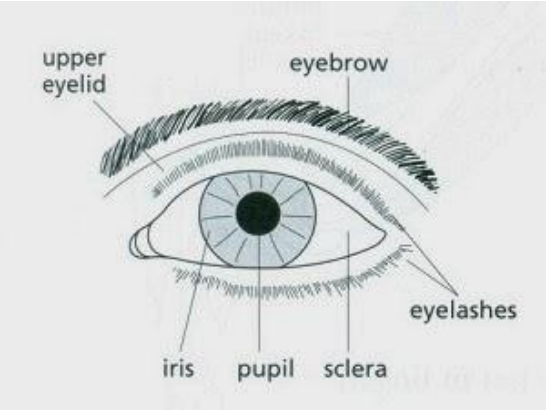
b) Muscles **A** and **B**; and **C** and **D** are antagonistic pairs. They have opposite effects when they contract.

c) i) **C**
ii) **B**

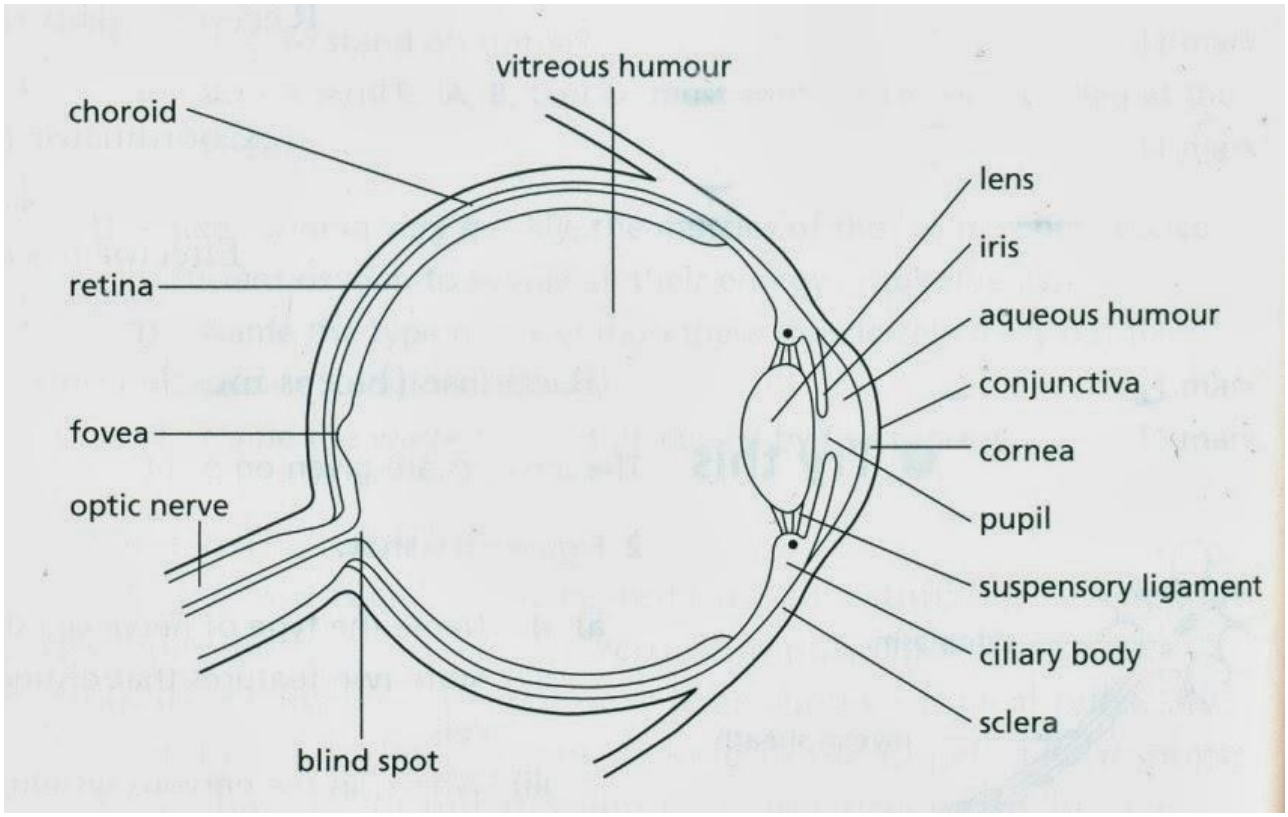
d) i) Anaerobic respiration.
ii) Lactic acid (or lactate).

#89 Structure and function of the eye, rods and cones

You need to be able to label parts of the eye on diagrams.



- The eyebrow stops sweat running down into the eye.
- Eyelashes help to stop dust blowing on to the eye.
- Eyelids can close automatically (blinking is a reflex) to prevent dust and other particles getting ton to the surface of the cornea.
- Blinking also helps to keep the surface moist by moving liquid secretions (tears) over the exposed surface. Tears also contain enzymes that have an antibacterial function.

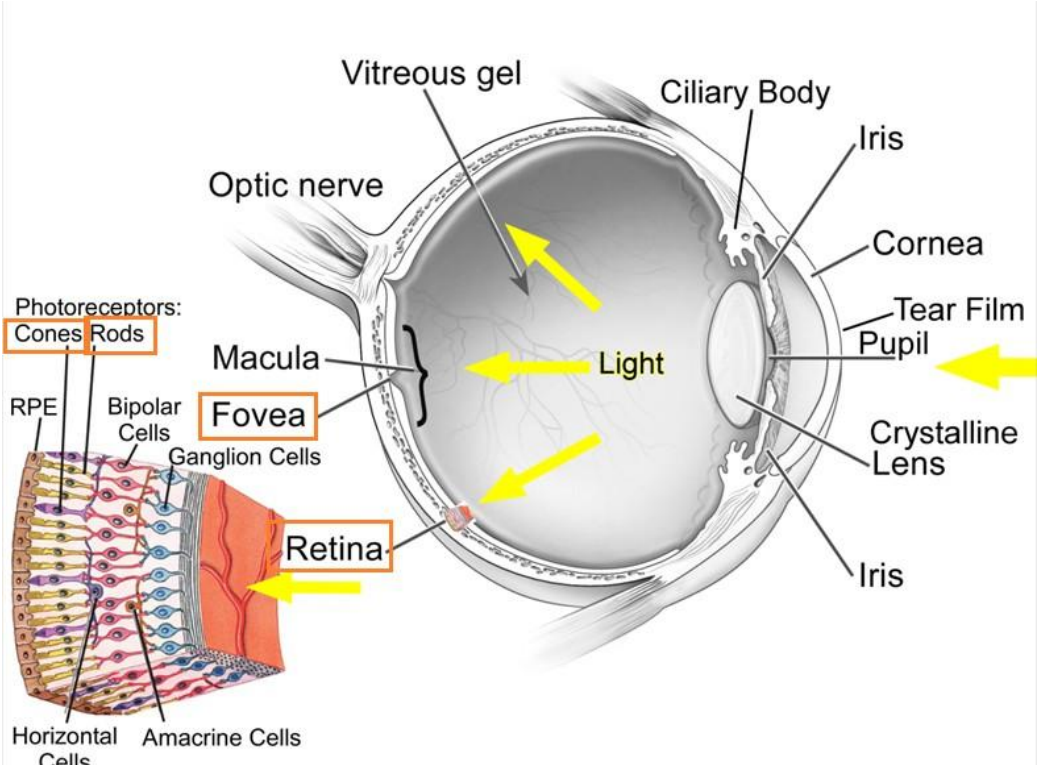


*** Try this**

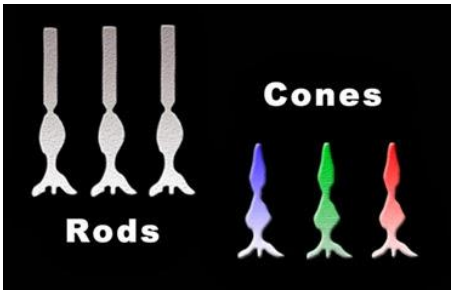
Trace or copy both diagrams of the eyes. Practice adding the labels. [8 marks]

Distinguishing between rods and cones

Rods and cones are light-sensitive cells in the retina. When stimulated they generate electrical impulses, which pass to the brain along the optic nerve.

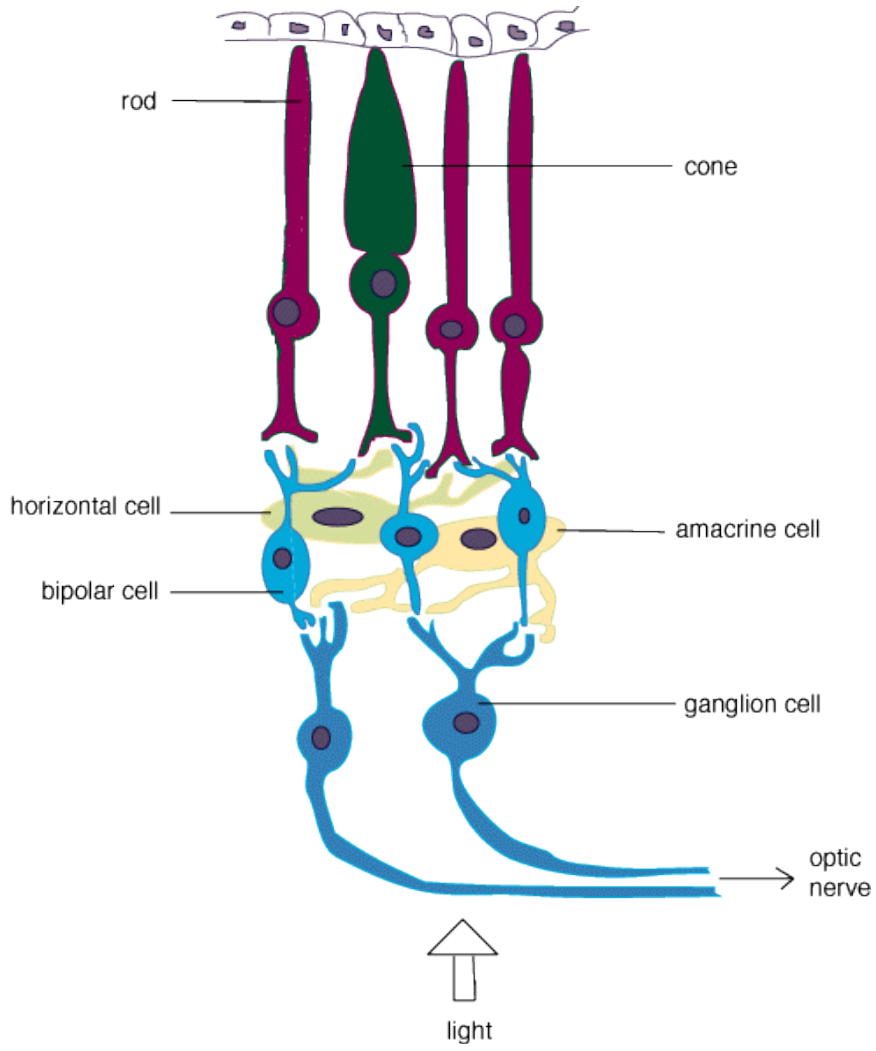


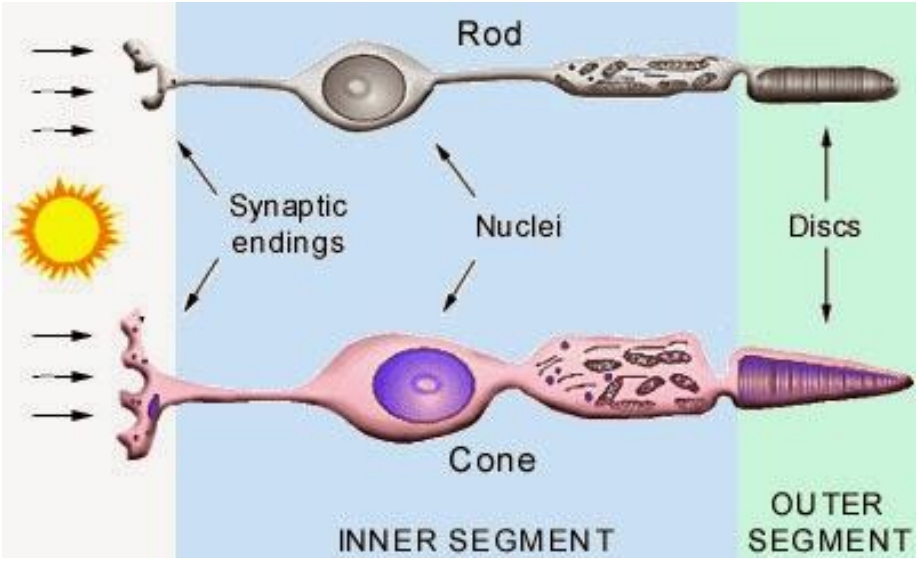
The normal retina has rods that see only black, white, and shades of grey and tones and three forms of color cones, red, green, and blue.



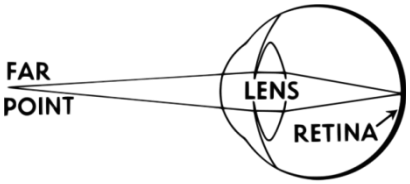
	Function	Distribution	Comments
Rods	Sensitive to low light intensity. Detect shades of grey	Found throught the retina, but none in the centrer of the fovea or in the blind spot	Provide us with night vision, when we can recognise shapes but not colours
Cones	Sensitive only to high light intensity. Detect colour (don't operate in poor light)	Concentrated in the fovea	There are three types, sensitive to red, green and blue light

Photos of rods and cones.

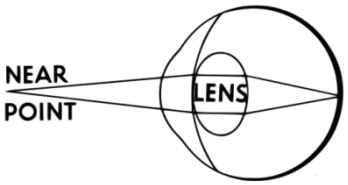




#90 Accommodation - focusing on objects far and near



The amount of focusing needed by the lens depends on the distance of the object being viewed – light from near objects requires a more convex lens than light from a distant objects.



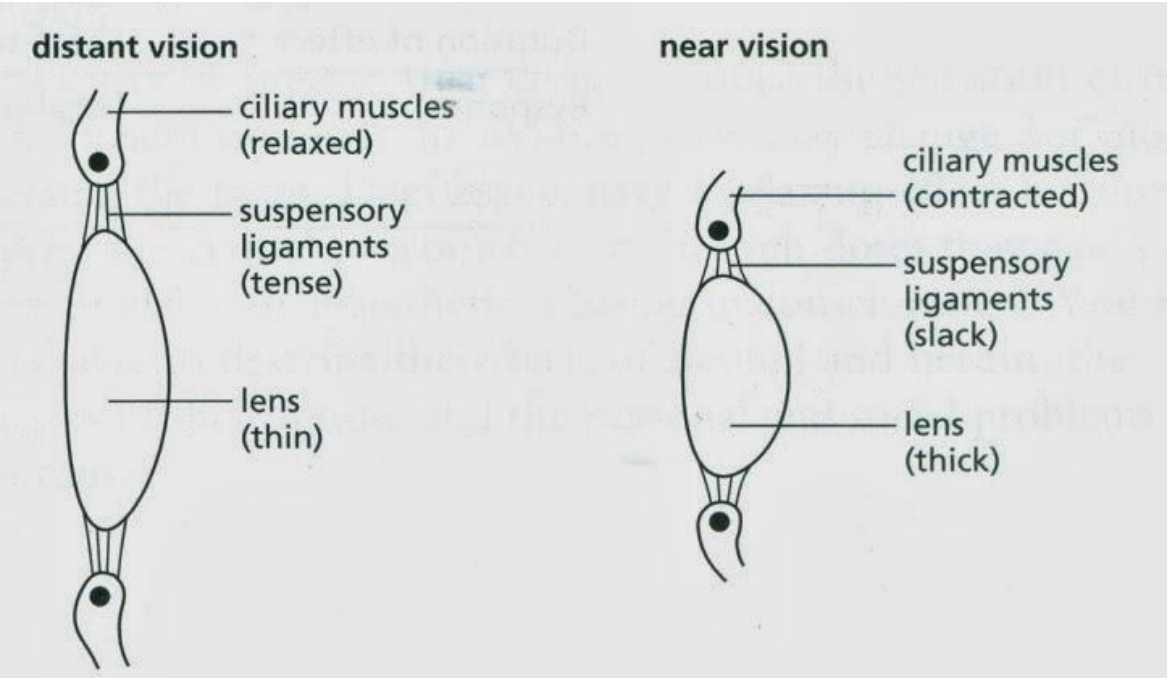
The shape of the lens needed to accommodate the image is controlled by the ciliary body - this contains a ring of muscle around the lens.

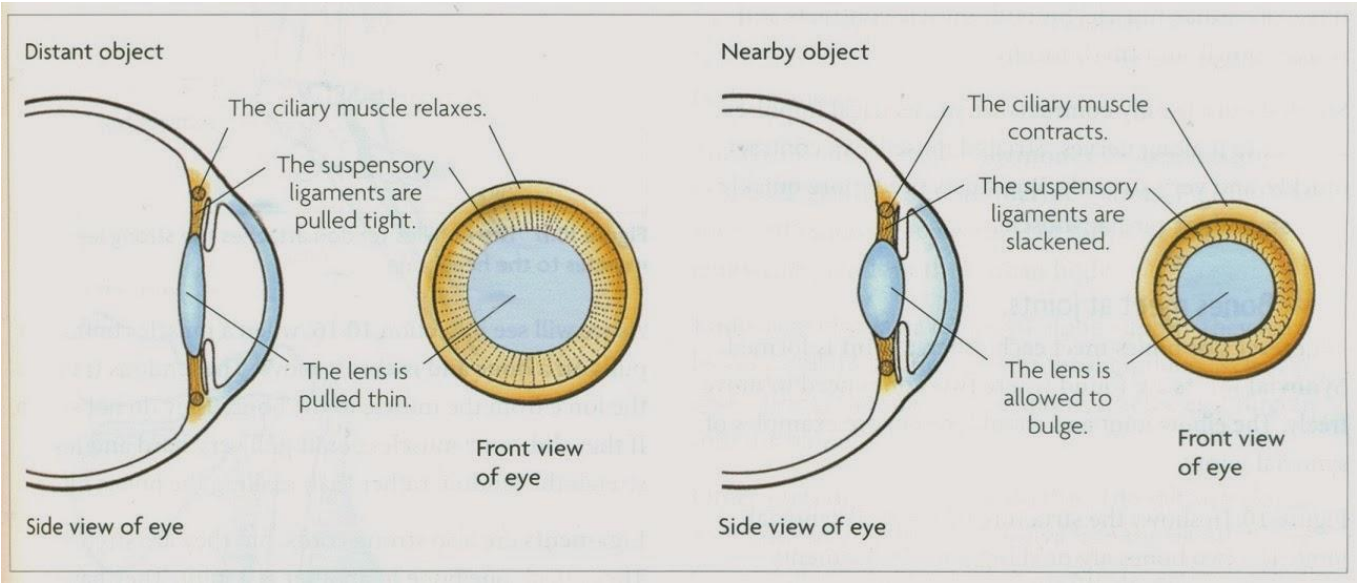
Distance objects

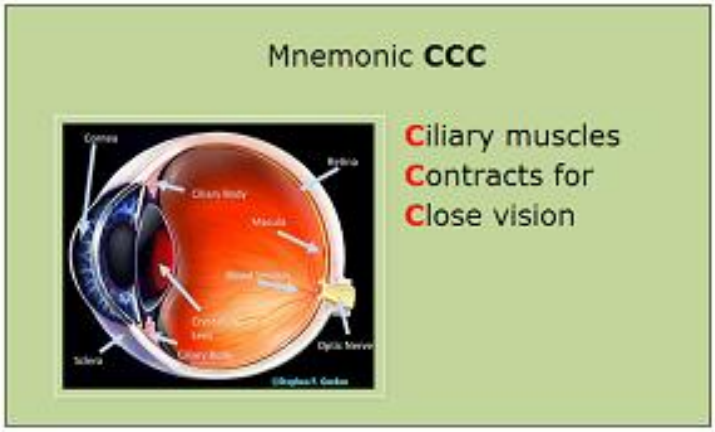
The ciliary muscles relax, giving them a larger diameter. This pulls on the suspensory ligaments which, in turn, pull on the lens. This makes the lens thinner (less convex). As the ciliary muscles are relaxed, there is no strain on the eye.

Near objects

The ciliary muscles contract, giving them a smaller diameter. This removes the tenssion on the suspensory ligaments which , in turn, stop pulling on the lens. The lens becomes thicker (more convex). As the ciliary muscles are contracted, there is strain on the eye, which can cause a headache if a near object (book, microscope, computer screen etc.) is viewed for too long.



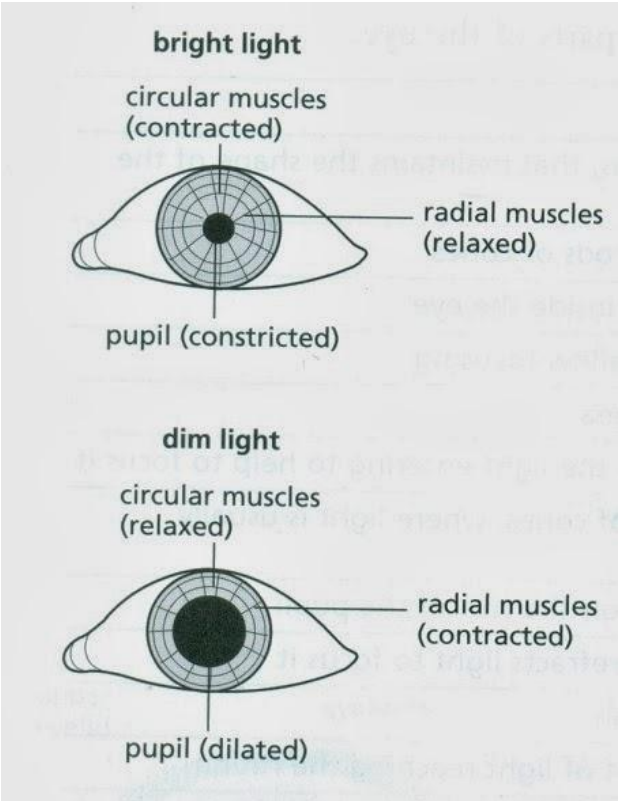




Pupil reflex

The reflex changes the size of the pupil to control the amount of light entering the eye. In bright light, pupil size is reduced as too much light falling on the retina could damage it. In dim light, pupil size is increased to allow as much light as possible to enter the eye.

The retina detects the brightness of light entering the eye. An impulse passes to the brain along sensory neurones and travels back to the muscles of the iris along motor neurones, triggering a response - the change in size of the pupil due to contraction of radial or circular muscles.



Video: BBC Eye pupil reflex

Common misconceptions

Students often confuse circular muscles and ciliary mucles. Remember that **circular** muscles affect the size of the **iris**, **ciliary** muscles affect the shape of the **lens**.

Try this

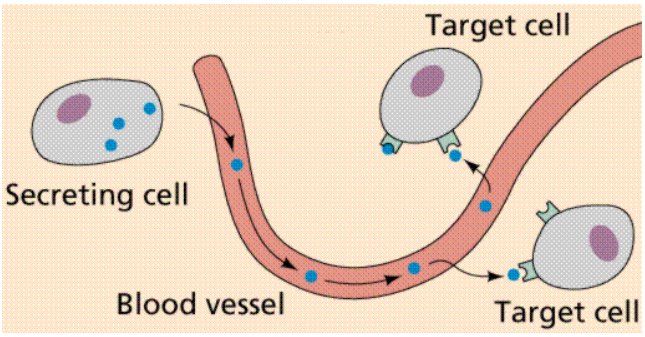
Describe and explain how the eye changes its focus from a distant object to a near object.

Answer

- ciliary muscle contract
- the suspensory ligaments become relaxed
- so tension is removed from the lens
- the lens becomes more convex
- so light is focused more strongly.

Video: Human eye structure, accomodation

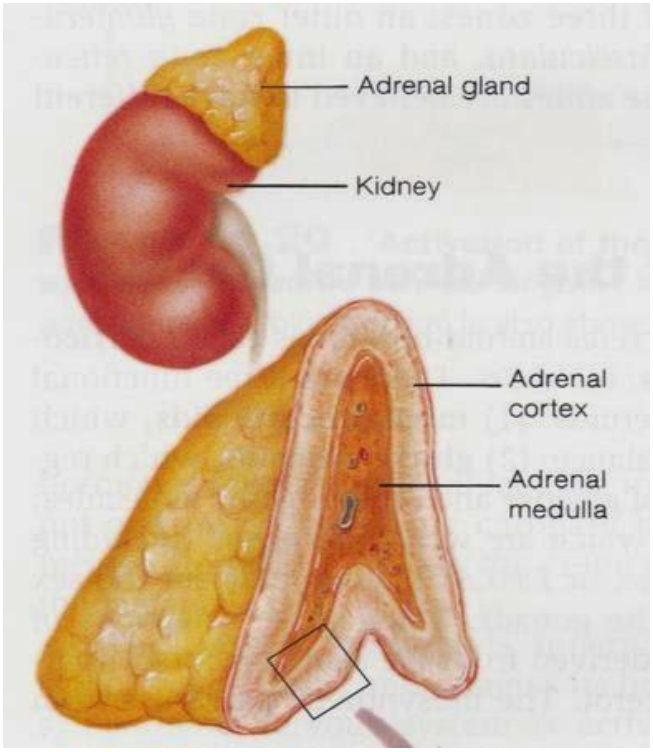
#91 Hormones, role of adrenaline



Hormone is a **chemical** substance, secreted by **endocrine gland,** carried by the **blood**, which alters the activity of one or more specific **target organs** and is then destroyed by the **liver**.

1. Chemical control of metabolic activity by adrenaline

Adrenaline is a hormone secreted by **adrenal glands**. When you are frightened, excited, your brain sends impulses along a verve to your adrenal glands. This makes them secrete adrenaline into the blood.



Adrenal gland is situated above each kidney.

Adrenaline helps you to cope with danger:

1. ↑ **heart rate** → supply O_2 to brain and muscle more **quickly** →↑ energy for action (fighting, running…).

Contract blood vessels in skin and digestive system → they carry very little blood → supplies blood back to vital organs (brain and muscles).

2. Stimulate **liver** to convert glycogen to glucose, ↑ **glucose** release into the blood by liver → extra glucose for muscle →help muscle to contract.

Examples of situations in which adrenaline secretion increases

Adrenaline is needed and secreted in a "fright, fight or flight" situation.

E.g.: When you are facing danger, for example, a masked man with a gun is approaching you.

- Your brain sends a signal to the adrenal glands, to start secreting and pumping adrenaline into the bloodstream.

- the actions of the adrenaline is listed above

- this gets you ready to either stand and fight or run away from the man.

2. Comparison of nervous and hormonal control systems

Comparison of nervous and hormonal control systems

Feature	Nervous	Hormonal (endocrine)
Made up of	Neurones	Secretory cells
Form of transmission	Electrical impulses	Chemical (hormones0
Transmission pathway	Nerves fibres (axons and dendrons)	Blood plasma
Speed of transmission	Fast	Slow
Duration of effect	Short term	Long term
Response	Localised	Widespread (although there may be a specific target organ)

#92 Use of hormones in food production

Farmer sometimes use **hormones** to make their animals **grow faster**, or to produce **more** of a particular **product**. One hormone used in this way is called **bovine somatotropin**, or **BST.**

BST is a hormone which is naturally produced by cattle. However, if cows are given extra BS, they make more milk. Some people think it would be a good idea to give cow BST, to get higher milk yields. You would need fewer cows to get the same amount of milk.

Here are arguments against it.

- Some people are worried about drinking milk form cows treated with BST. They think BST might damage their health. This is very unlikely, because the hormone does not get into the milk in any significant quantity.

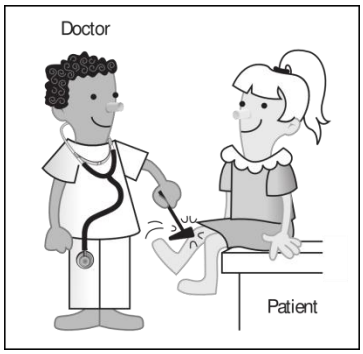
- It is difficult to see why we need BST. For example, the European Union already produces more milk than it needs, so milk quotas have to be imposed, to stop farmer from producing too much milk.

- There are concerns that the BST might harm the cows. Cows treated with BST make very large amounts of milk, far beyond the 'natural' levels which they produce. This make them more likely to get infections of their udders (breast), and may make them feel less comfortable.

Mammary infections in BST treated cows require treatment with antibiotics.

Read more on this topic:
Recombinant bovine somatotropin

#93 Voluntary and involuntary actions



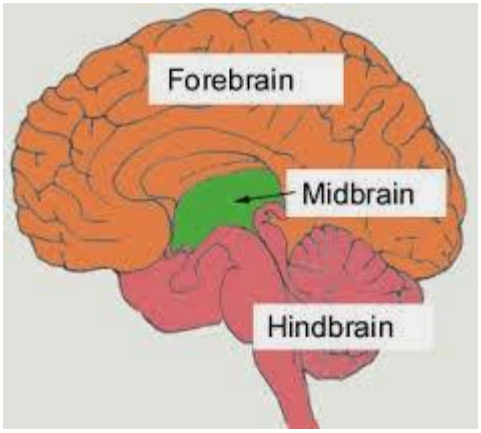
Knee jerk is an involuntary reflex

Two types of action controlled by the human nervous system are: **voluntary** and **involuntary** actions. The peripheral nerves transmit both of them.

Comparison of voluntary and involuntary ations

Feature	Voluntary action	Involuntary action
Nature	- Conscious thought (make decision about making action). - Free will - Consciously control skeletal muscles	- Does not involve thought - Not under the control of the will - Cannot control the activities.
Examples	If we want to ask question, we raise our hands	Involving - skeletal muscle (e.g. knee jerk) - smooth muscles (e.g. peristalsis) - cardiac muscles (e.g. pumping of the heart)
Role	Respond with the benefit of experience	Respond quickly to avoid danger
Controlled by	Forebrain (Cerebrum): - coordinates incoming information, initiates impulses sent to the effectors. - may spontaneously initiates actions without any sensory stimulation.	- Hind-brain (cranial reflex action) - Spinal cord (spinal reflex action), e.g. blinking of the eyes

Speed of action	Slow response, as the cerebrum needs time to "think" before an action is carried out.	Rapid response, as the cerebrum is not involved.
Response to the same stimulus	The same stimulus may produce various responses. E.g. when you are hungry, you may decide to eat or not to eat, or just need to drink water.	The same stimulus always results in the same response (stereotyped response), e.g. the knee jerk reflex.



Forebrain is responsible for voluntary actions, hindbrain is responsible for involuntary actions

Source: [Voluntary and Involuntary Actions]

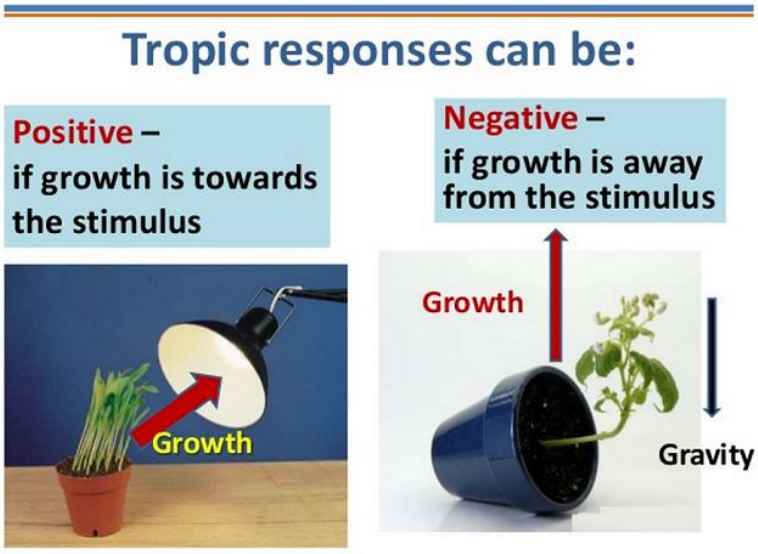
#94 Coordination in plants – tropism

Tropism are responses by part of a plant **toward** of **away** from a **stimulus** coming from one direction.

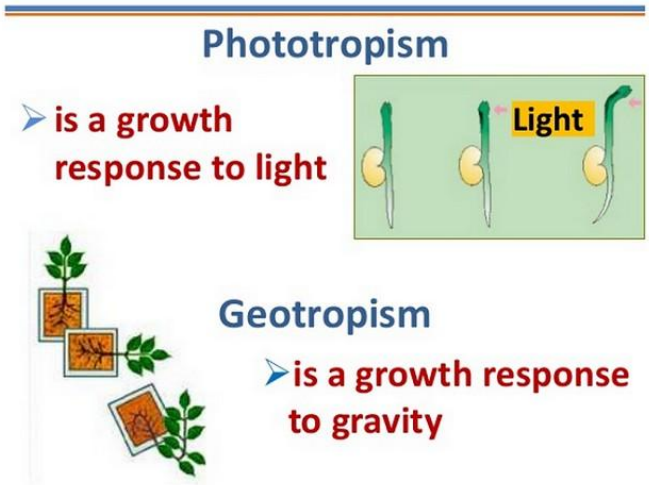
The movement is always a **growth movement**.

Like animals, plants are able to response to their environment, although usually with much **slower** responses than those of animals.

In general, plants respond to stimuli by changing their rate or direction of growth. They may grow either **towards** or **away** from a stimulus. These responses are called **tropisms**.



Two important stimuli for plants are **light** and **gravity**.



Shoots normally grow towards light. Roots do not usually respond to light, but a few grow away from it.

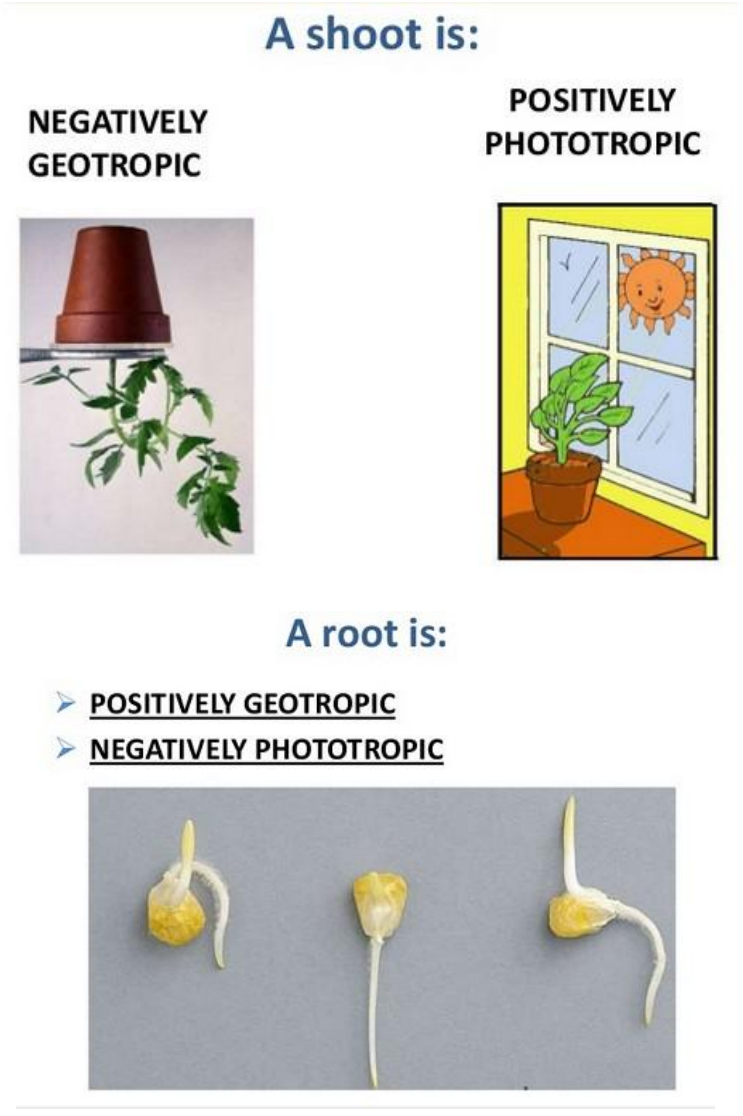
Shoots tend to grow away from the pull of gravity, while roots normally grow towards it.

Plant tropism

	Stimulus	
	Light	Gravity
Shoot	(+)	(-)
Root	(-)	(+)

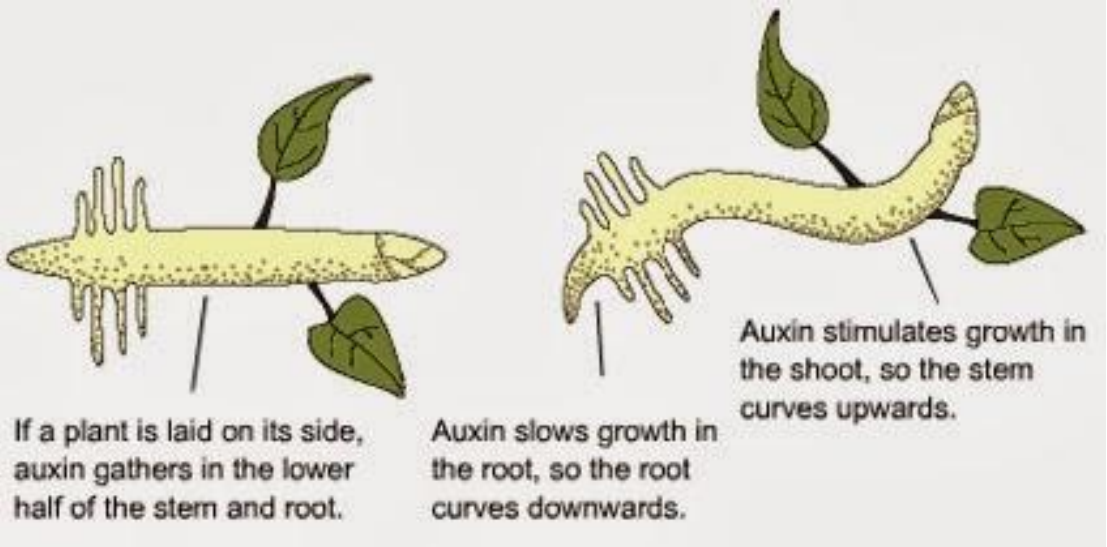
(+) Grow towards the stimulus

(-) Grow away from the stimulus



Pictures are taken from: **Tropism slideshow**

#95 Control of plant growth by auxins, weedkillers



Auxins are plant **growth substances**, produced by the shoot and root tips of growing plants.

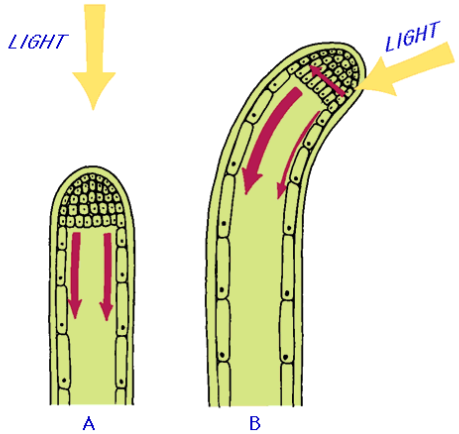
- Auxins in the **shoot** → **stimulate** cell growth, by the absorption of water.

- Auxins in the **root** → **slow down** the cell growth.

Auxin in phototropism

*1. If a **shoot** is exposed to light from one side*

- More auxins are moving in the **shaded** side (from the tip of the shoot)
- On this side, cells are stimulated to absorb **more** water, plant grows more
- Shoot bends **toward** the light.
- This is called **positive phototropism.**



*2. If a **root** is exposed to light in the absence of gravity*

- More auxins are moving in the **shaded** side (from the tip of the root) →
- On this side, cells are stimulated to absorb **less** water, plant grows less
- Root bends **away** from the light.
- This is called **negative phototropism.**

When exposed to light from one side

Fetures	Shoot	Root
More auxins are moving in the **shaded** side	**(+)**	**(+)**
Cell are stimulated to absorb (on the shaded side)	**more** water	**less** water
Stem bends	**toward** the light	**away** from the light
Process	Positive phototropism	Negative phototropism.

Auxin in geotropism

1. If a shoot is placed horizontally in the absence of light:

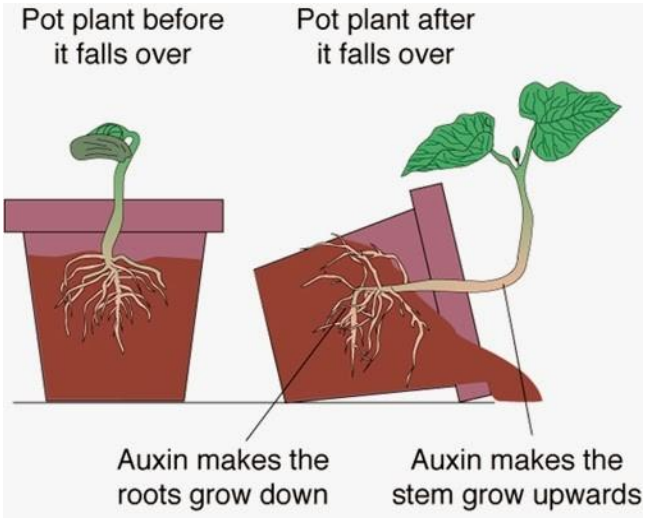
- Auxins accumulate on the lower side of the shoot, due to gravity.
- Cells on the lower side grow more **quickly**
- The shoot bends **upwards**.
- This is called **negative geotropism.**

2. If a root is placed horizontally in the absence of light:

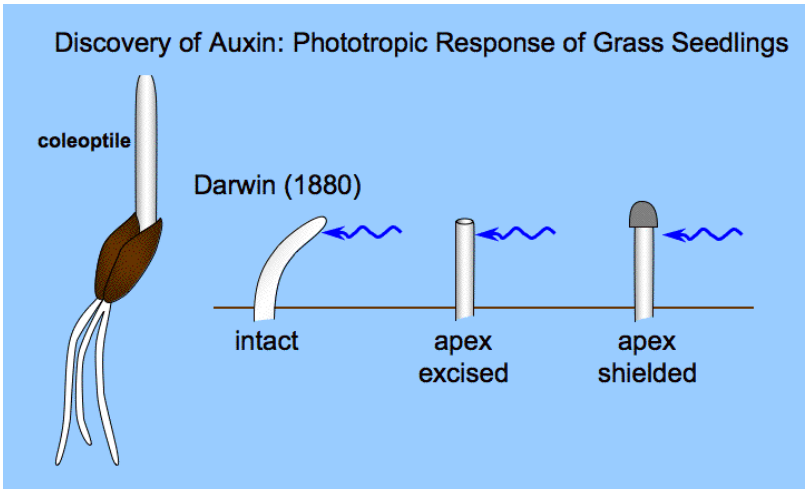
- Auxins accumulate on the lower side of the shoot, due to gravity.
- Cells on the lower side grow more **slowly**
- The shoot bends **downwards**.
- This is called **positive geotropism.**

When is placed horizontally in the absence of light

Fetures	Shoot	Root
More auxins are moving in the **lower side**	**(+)**	**(+)**
Cell growth (on the lower side)	more **quickly**	more **slowly**
Bending	**upwards**	**downwards**
Process	Negative geotropism	Positive phototropism.



Darwin did the first experiments to study the effects of Auxin



Credit: plantphys.info

- Shoots and roots that have their **tips removed** will not respond to light or gravity because the part that produces auxins has been cut off.
- Shoots that have their tips covered with **opaque material** grow **straight** upwards when exposed to one-sided light, because the auxin distribution is not influenced by the light.

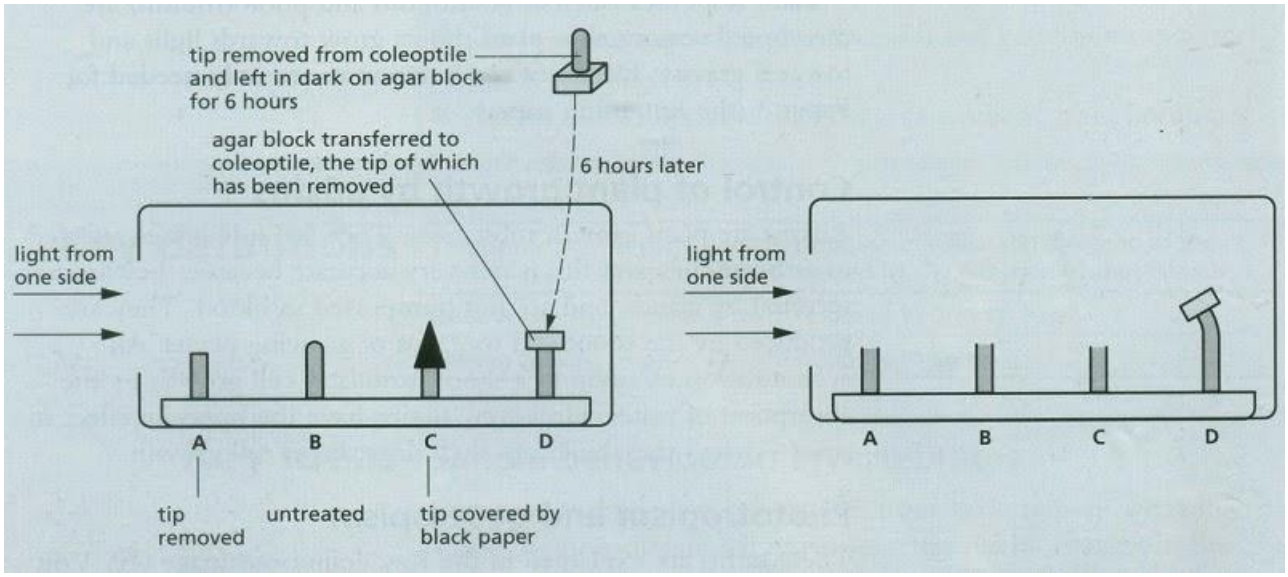
Effects of weedkillers

Weedkillers (herbicide) are synthetic plant hormones, similar to auxins. If these chemicals are sprayed on to plants they can cause rapid, uncontrolled growth and respiration, resulting in the death of the plant.

Some plant species are more sensitive than others to synthetic plant hormones, so weedkillers can be selective.

Many weedkillers kill only broad-leaved plants (dicotyledons), leaving grasses (moncotyledons) unharmed.

Try this



In figure above, the left-hand side shows an experiment in which the coleoptiles (shoots) of similar seedlings have been treated in different ways, and the right-hand side shows the result in shoot D 24 hours later.

a) i) Name the response shown by shoot D. [2 marks]
ii) Explain what has caused this response. [3 marks]
b) Copy and complete the right-hand side figure to show the likely results for shoots A, B and C. [3 marks]

Answer

a) i) Positive phototropism
ii) Three points from:
- the coleoptiles have been exposed to one-sided light
- auxins have been produced by the tip
- and have passed into the block
- auxins have passed from the block to the cut coleoptile
- more auxins accumulates on the shaded side of the coleoptile
- causing more growth on the shaded side.

b)**A,** taller and growing vertically upwards;
B, taller and bending towards the light;
C, taller and growing vertically upwards.

#96 Summary of coordination and response

- All organisms are able to sense changes in their environment, called **stimuli**, and respond to them. The part of the body that senses the stimulus is a **receptor**, and the part that responds is an **effector**.

- The **human nervous system** contains specialized cells called neurons. The brain and spinal cord make up the central nervous system (CNS), which coordinates responses to stimuli.

- **Reflex actions** are fast, automatic responses to a stimulus. They involve a series of neurons making up a reflex arc. A sensory neurone takes the impulse to the CNS and a motor neurone takes it from the CNS to an effector.

- Receptors are generally found within **sense organs**.

- The receptors in the eye are **rod** and **cone cells**, found in the retina. Rods respond to dim light and cones to bright light. Cones give colour vision.

- The cornea and lens focus light rays onto the **fovea**, the part of the eye where cone cells are most densely packed.

- The shape of the lens is changed by the contraction or relaxation of the **ciliary muscle**. When focusing on a distance subject , the muscle relaxes so that the suspensory ligament are pulled taut and the lens is pulled into a thin shape. When focusing on a near object, the muscle contracts and the lens falls into its natural, more rounded shape.

- Muscles can pull when they contracts, but they cannot push. A pair of muscles is therefore needed to pull in different directions, e.g. at the elbow joint. They are **antagonistic muscles**.

- **Hormones** are chemicals made in endocrine glands and carried in the blood plasma. **Adrenaline** is secreted by the adrenal glands, and bring about changes that supply the muscles with extra glucose. This gives the energy for contraction for 'fight or flight'.

- Plant response to some stimuli by growing towards or away from them. These responses are **tropism**.

- **Auxins** are mostly made in the tips of the shoots and roots, and can diffuse to other parts of the shoots or roots. It collects in the shady side of the shoot, making the side grow faster so the shoot bends towards the light. Auxins are used as selective weedkillers.