Rewarding Learning

eGUIDE//Biology

Physiology, Co-ordination and Control, and Ecosystems

Unit A2 1 4.3 Co-ordination and Control

This e-book is designed to complement other support materials and enhance the understanding of this unit for students at GCE level. The topics covered are in accordance with those topics present in the current specification.

Contents

Co-ordination and Control

4.3

4.3.1 Key Concepts

Students should be able to:

- demonstrate knowledge and understanding of the role of phytochromes in the control of flowering in long-day and short-day plants

(a) Plants

Phytochromes

Flowering plants produce a pigment phytochrome which is a protein with a light absorbing prosthetic group. Phytochromes are found in the cytosol.
A phytochrome can switch between two forms P_{660} (also known as Pr) and $_{P730}$ (also known as Pfr):

- P_{660} /Pr absorbs red light with peak absorption at about 660nm
- P_{730}/Pfr absorbs far red light where the visible spectrum meets the infra-red around 730nm.

When P_{660} absorbs red light it is rapidly converted to P_{730} and when P_{730} absorbs far red light it is rapidly converted to P_{660}. In the dark P_{730} is slowly converted into P_{660}.
In natural sunlight the dominant reaction is P_{660} is converted to P_{730} as sunlight contains more red than far-red light so P_{730} tends to accumulate during daylight hours and then at night is converted slowly back.
The term PHOTOPERIODISM is the influence of the length of day and night on the activities of an organism such as flowering in plants.
On the basis of different responses to light and dark flowering plants can be divided into three groups:

1. Long day plants – require long days and short nights. They flower only when the light period exceeds a critical length in each 24 hour cycle. The shorter night results in non-removal of the P_{730} form allowing the plant to flower. In these plants light treatment can induce early flowering while dark treatment will delay it. By adjusting the light period early and late varieties of these plants, such as chrysanthemums and rice, can be made to flower enabling cross breeding. Spinach, lettuce and wheat are examples of long day plants.
2. Short day plants –- require short days and long nights. They flower only when the light period is shorter than a critical length in each 24 hour cycle. The long night ensures removal of the P_{730} form which is required for flowering to occur. If these plants are exposed to a brief flash of light in the middle of the night flowering will be delayed, or they can be made to flower early by giving them extra darkness. This is made use of by horticulturalists in generating plants such as poinsettias (red flowering plant) at Christmas.
3. Day neutral plants – these are indifferent to day length and include plants such as tomatoes and cucumber.

The following video covers Long and Short Day Plants-Photoperiodism
https://youtu.be/0jm3OPnpZhw

Glossary

Photoperiod	duration of daylight.
Phytochrome	a plant pigment that is associated with the absorption of light in the photoperiodic response and that may regulate various types of growth and development.

4.3.2 Key Concepts

Students should be able to:

- demonstrate knowledge and understanding of the role of plant growth substances (hormones) in stem elongation

Plants contain growth promoters and inhibitors which control plant growth and development. These substances are generally called plant hormones and are divided into three main families;

1. **Auxins** are produced at the apex of the shoot (apical meristem). The main auxin is indoloaceteic acid (IAA) produced from the amino acid tryptophan. It is transported back down the shoot to the zones of elongation in roots and shoots where it regulates cell extension and elongation and the differentiation of vascular tissues. The auxin IAA inhibits lateral buds from growing into side shoots and this is called apical dominance. Leaf expansion and the growth of fruits and seeds are also controlled by the IAA auxin. The discovery of auxins resulted from investigations into why plants tended to grow towards a source of light. Light on a shoot causes more auxin to be released on the shaded side. The result is the shaded side elongates more and the shoot bends towards the light. It has been suggested that auxins enable the cell walls to be stretched more easily by the osmotic forces in the vacuoles.

2. **Cytokinins** are frequently found in xylem sap. They are thought to be synthesised in the roots and are carried to other parts of the plant in the transpiration stream. Their production is highest when a plant is growing rapidly as they promote cell division and then production falls off as ageing begins.

3. **Gibberellins** take their name from a fungal parasite *Gibberella fujikuroi* which causes disease in rice plants. Seedlings which are attacked by the fungus develop very long internodes so the shoots are much taller than healthy plants. The growth promoting substance was gibberellic acid. Many similar substances to gibberellic acid have been isolated from higher plants. They are made at the tips of roots and shoots. While the best known effect of gibberellic acid is internode elongation it also stimulates enzyme production during seed germination and plays a role in cell division and tissue differentiation. In spite of the many different specific gibberellins found in plants, most are inactive forms that serve as biosynthesis precursors or breakdown products of the active gibberellic acids.

Glossary

Apical meristem	region responsible for vertical growth of a plant at the root and shoot tips.
Differentiation	when cells become specialised for a particular function.
Internode	the portion of a plant's stem in between the insertion of two successive leaves or branches.
Transpiration stream	the flow of water from the soil through the tissues of the plant to the evaporating surfaces, all driven by transpiration.

The following animations cover the 5 types of plant hormones;
https://youtu.be/x2baAwvDaqM
https://youtu.be/Zu9h7Wf7iBI

Cabbage treated with gibberellic acid. This is a hormone found in plants which promotes growth and elongation of cells.

4.3.3 Key Concepts

Students should be able to:

- demonstrate knowledge and understanding of the structure of a neurone, recognising components in photomicrographs and electron micrographs (TEM) and diagrams

(b) Animals

Nerones

Neurones are the cells of the nervous system. They play a role in communicating between sense organs and the brain and between the brain and muscles.

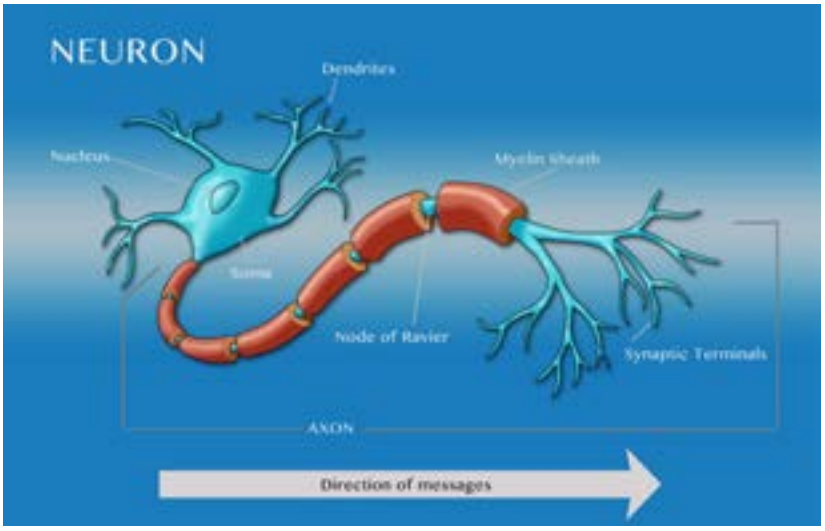
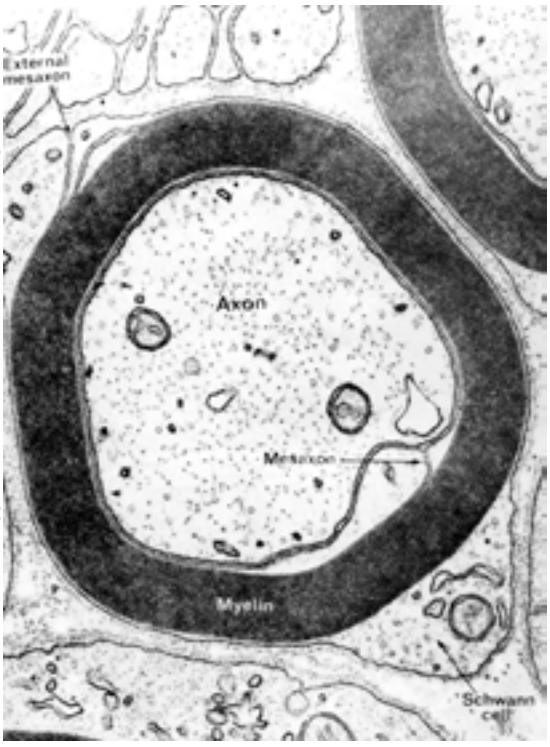
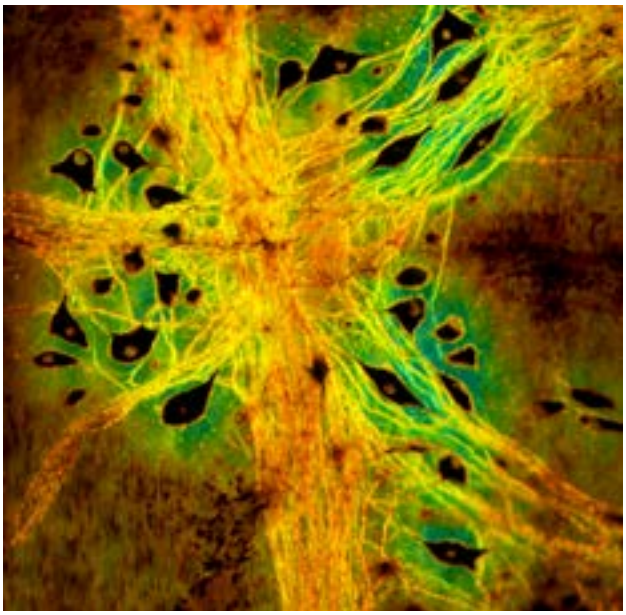


Illustration of a motor neuron showing dendrites, nucleus within the cell body (soma, blue end on left) and parts of the axon including node of Ranvier, myelin sheath around the orange Schwann cells and synaptic terminals. Direction of messages in this illustration is from left to right.

Neurones are specialised for carrying information quickly. Each nerve cell has a cell body containing a nucleus and a number of fine extensions called dendrites which receive information from other neurones. Most have one long membrane enclosed extension called an axon. The ends of the axons divide into many branches which almost touch the dendrites of the next adjacent neurones. Axons carry signals from one place to another, they can be very long as in the giraffe where they are several metres long. Dendrites and the axon ends make connections called synapses with other neurones. Information passes across the synapse from one neurone to another. Axons are coated in a fatty layer called the myelin sheath. This is formed by Schwann cells which grow like a Swiss-roll around the axon. Myelin allows faster conduction of the signal.



Transmission electron micrograph (TEM) of a cross-section through a nerve axon, with various structures labelled. Axons are extensions of nerve cells that join them to other nerve cells. The cross-section here is circular, showing the myelin sheath (dark) that insulates the axon.
The labels indicate an internal and external mesaxon, as well as a Schwann cell. The mesaxons are membrane junctions between the Schwann cells and the myelin sheath.
The Schwann cells are part of the support structure for the nervous system. Here, they produce the axon's myelin sheath.



Light micrograph of a section of intestinal muscle, showing nerve cell bodies (black) and their axons and dendrites (yellow and orange colour). This network of neurons controls local intestinal wall movement. When the wall is stretched or dilated by its contents, nerves cause the muscles above the dilation to contract and those below it to relax, resulting in a wave-like movement (peristalsis) of the gut contents towards the anus.
The nerves are arranged in groups (ganglia), connected by long projections (narrow orange/yellow lines), which deliver signals between the nerves.

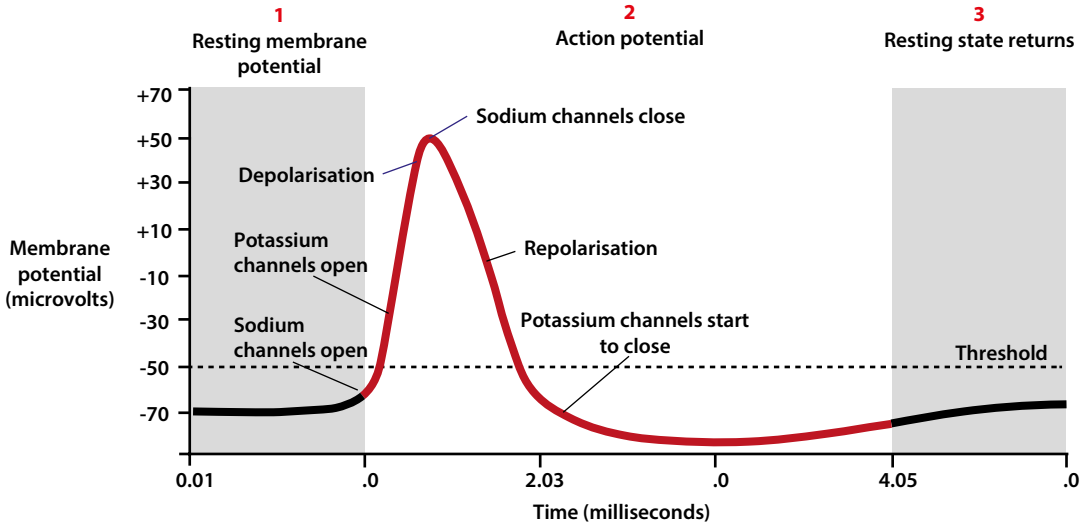
4.3.4 Key Concepts

Students should be able to:

- demonstrate knowledge and understanding of the generation and transmission of nerve impulses

The main function of neurones is to transmit nerve impulses over relatively long distances. The ability to transmit impulses is only found in neurones and in muscle cells. These cells are said to be excitable. When a nerve axon is not transmitting an impulse it is said to be in a resting state.

- In the resting state the inside of the axon is negatively charged and the outside is positively charged. As this is the state when the axon is at rest it is called the resting potential.
- When a stimulus occurs that is strong enough a change will occur and the inside of the axon will become positively charged relative to the outside and the membrane is said to be depolarised. This change occurs due to the movement of sodium and potassium ions.
- When a threshold level in this change in charge or depolarisation is reached, an action potential arises which results in an impulse.
- If the depolarisation is not great enough to reach threshold, an action potential and thus an impulse will not be generated; this is called the all or nothing law.
- This change in charge from positive to negative sets up a current of ions. The current at the leading end of the action potential causes the next section of the membrane to become depolarised so the impulse is propagated along the axon. This is said to be a self-propagating event.
- An impulse basically disturbs the resting potential of an excitable cell's membrane. Before another impulse can be generated the cell must recover its resting potential. The recovery period is called the refractory period. During this time the membrane repolarises restoring the original resting state of negative charge inside and positive charge outside.



Three things affect the rate at which an action potential moves along an axon;

1. Temperature – higher temperature gives higher speed of conduction,
2. Thickness of the axon – thicker the axon the faster the impulse travels,
3. Presence of a myelin sheath – this speeds up conduction.

Glossary

Action potential	a short term change in the electrical potential on the surface of a cell such as a nerve cell or muscle cell in response to a stimulus which leads to the transmission of a nerve impulse.
Depolarisation	an electrical state in an excitable cell whereby the inside of the cell is made less negative relative to the outside than at the resting membrane potential.
Refractory period	a short period after a nerve or muscle cell fires during which the cell cannot respond to additional stimulation.
Repolarisation	the return of cell membrane potential to resting potential after depolarization.
Resting potential	the electrical potential of a neuron (or other excitable cell) relative to its surroundings when not stimulated or involved in passage of an impulse.

4.3.5 Key Concepts

Students should be able to:

- demonstrate knowledge and understanding of synaptic transmission and recognise structures in photomicrographs, electron micrographs and diagrams

Nerve pathways consist of at least two neurones joined end to end. The junctions of nerves are called synapses. In vertebrates most synapses are in the brain and spinal cord. Information enters neurones through synapses. There are two different types; chemical and electrical. Electrical synapses are quick and uncommon. Chemical synapses pass information more slowly with information only crossing in one direction. The neurone carrying the information into the synapse is the pre-synaptic neurone and the one carrying it onward is the post-synaptic neurone.

The synapse consists of a synaptic knob or bulb which has many mitochondria and sac like vesicles. These vesicles are called the synaptic vesicles and they contain a transmitter substance called a neurotransmitter. At the end of the synaptic bulb is the pre-synaptic membrane, then follows a small but definite gap called the synaptic cleft followed by the membrane of the next nerve cell called the post-synaptic membrane.

The arrival of an impulse at a synaptic bulb at an axon terminal causes calcium ions to enter from the synaptic cleft. This then causes the synaptic vesicles to move towards the pre-synaptic membrane. These vesicles attach themselves to the membrane and release the neurotransmitter contents of the vesicle by exocytosis. The neurotransmitter diffuses across the cleft and attaches to specific receptor sites on the post-synaptic membrane. This then causes an influx of sodium ions (+) into the post-synaptic nerve cell which is now depolarised and a positive (+) charge now develops in this part of the cell. This charge is called the excitory post-synaptic potential (EPSP). If the EPSP (or positive + charge) builds up to a critical level an action potential is generated in the nerve cell.

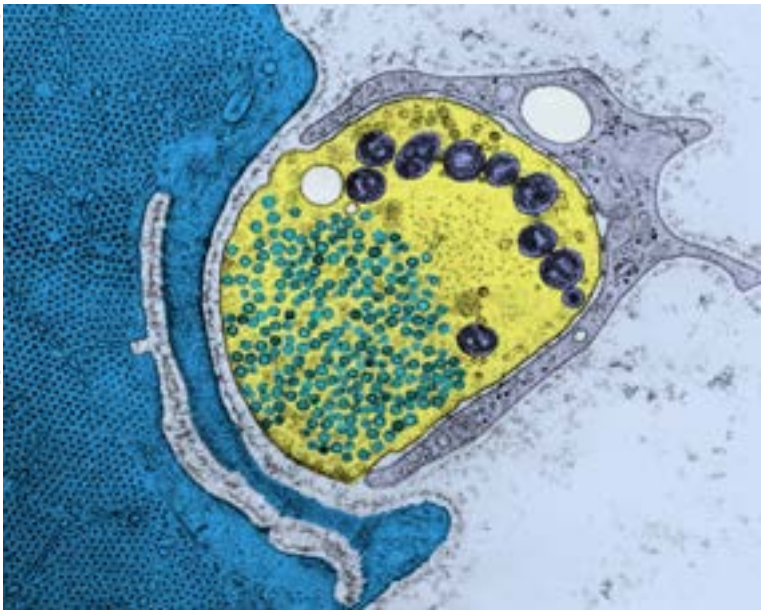
Synapses prevent impulses going in the wrong direction; an impulse can pass along an axon in both directions but can cross the synapse in only one direction. This is because the synaptic vesicles are only found on one side of the synaptic cleft.

This video introduces synaptic transmission taking place between the presynaptic neurone, synaptic cleft, and the postsynaptic neurone.
https://youtu.be/zx46xADMIBY

Many neurotransmitters have been isolated from nerve endings. The most widespread are acetylcholine, noradrenaline and GABA. Following their release into synaptic clefts they need to be removed, otherwise the post-synaptic membrane would keep on responding indefinitely. Some neurotransmitters are destroyed by enzymes in the synaptic cleft, for example acetylcholine is destroyed (hydrolysed) by acetylcholinesterase. The products

of this hydrolysis pass back into the synaptic bulb where they are resynthesized into acetylcholine and repackaged into new vesicles using energy from ATP. Noradrenaline is reabsorbed into the pre-synaptic terminal for reuse.

Some synapses in the central nervous system (CNS) are inhibitory. On arrival of an impulse inhibitory synapses release transmitter substances that prevent generation of impulses in the post-synaptic neurone. They do this by hyperpolarising rather than depolarising the post-synaptic membrane. This means the inside of the post synaptic nerve cell becomes more negative (-). This negative charge is called the inhibitory post-synaptic potential (IPSP). An IPSP makes it more difficult for EPSP's to build up and generate an impulse in the nerve cell.



Electron micrograph of a nerve ending at a neural junction, showing accumulation of mitochondria and numerous synaptic vesicles.

4.3.6 Key Concepts

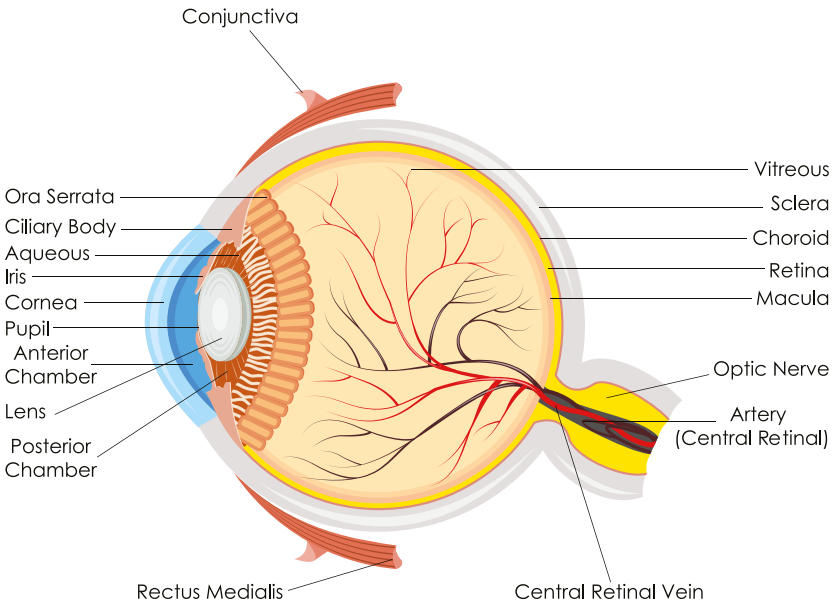
Students should be able to:

- demonstrate knowledge and understanding of the gross structure of the mammalian eye and the functioning of its component parts in normal vision

Receptor cells trigger nerve impulses when they receive a particular environmental stimulus. The body has a variety of receptor cells which feed impulses into the nervous system in response to for example heat, light, sound, touch, chemicals.

Some receptors are grouped into complex sense organs such as the eye. The retina of the mammalian eye contains light receptors called rod cells which respond to light intensity. The retina is sensitive to light. The energy that comes in the form of light rays is converted to nerve impulses that are carried in the optic nerve. Mammals with colour vision also have cone cells which respond to red, green and blue light. Each cone is linked to its own neurone while any one of a group of rods can fire a single neurone. This means cones are less effective for vision in dim light but provide better resolution.

The diagram below identifies the parts of the mammalian eye.



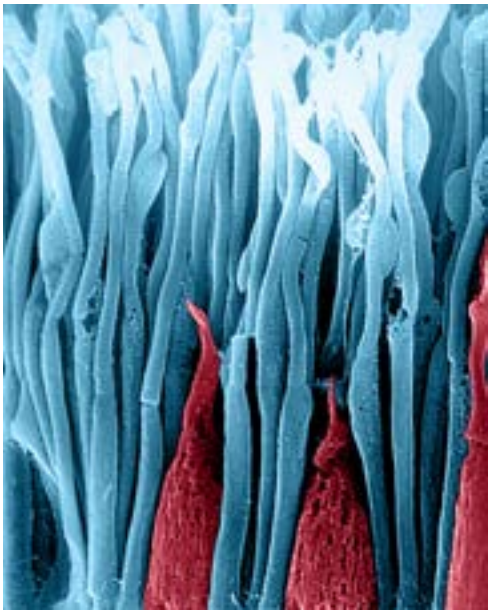
The table below describes the functioning of the component parts.

Conjunctiva	Is a thin protective covering of epithelial cells. It protects the cornea against damage by friction (tears from the tear glands help this process by lubricating the surface of the conjunctiva)
Cornea	Is the transparent, curved front of the eye which helps to converge the light rays which enter the eye
Sclera	Is an opaque, fibrous, protective outer structure. It is soft connective tissue, and the spherical shape of the eye is maintained by the pressure of the liquid inside. It provides attachment surfaces for eye muscles
Choroid	Has a network of blood vessels to supply nutrients to the cells and remove waste products. It is pigmented that makes the retina appear black, thus preventing reflection of light within the eyeball.
Ciliary body	Has suspensory ligaments that hold the lens in place. It secretes the aqueous humour, and contains ciliary muscles that enable the lens to change shape, during accommodation (focusing on near and distant objects)
Iris	Is a pigmented muscular structure consisting of an inner ring of circular muscle and an outer layer of radial muscle. Its function is to help control the amount of light entering the eye so that: - too much light does not enter the eye which would damage the retina - enough light enters to allow a person to see
Pupil	Is a hole in the middle of the iris where light is allowed to continue its passage. In bright light it is constricted and in dim light it is dilated
Lens	Is a transparent, flexible, curved structure. Its function is to focus incoming light rays onto the retina using its refractive properties
Retina	Is a layer of sensory neurones, the key structures being photoreceptors (rod and cone cells) which respond to light. Contains relay neurones and sensory neurones that pass impulses along the optic nerve to the part of the brain that controls vision
Fovea (yellow spot)	A part of the retina that is directly opposite the pupil and contains only cone cells. It is responsible for good visual acuity (good resolution)
Blind spot	Is where the bundle of sensory fibres form the optic nerve; it contains no light-sensitive receptors
Vitreous humour	Is a transparent, jelly-like mass located behind the lens. It acts as a 'suspension' for the lens so that the delicate lens is not damaged. It helps to maintain the shape of the posterior chamber of the eyeball
Aqueous humour	Helps to maintain the shape of the anterior chamber of the eyeball

The ciliary body contains a complex set of smooth muscles arranged mostly in a circular direction and controlled by the nervous system. When the muscles relax the lens is pulled outwards giving it a flattened shape and when they contract the tension on the lens is released so it returns to a more spherical shape. By altering its shape the lens is said to **accommodate** for near and far objects; flatter for distant objects and rounder for closer objects.

Rods are sensitive to different intensities of light while cones are sensitive to different wavelengths of light. Most mammals only possess rods in the retina so the assumption a bull will charge at a red object is incorrect as the retina of a bull's eye has no cones.
The rods lie outside the fovea in the peripheral parts of the retina and are responsible for night-vision. They contain the pigment rhodopsin which is easily bleached by a small amount of light and is quickly regenerated. Many rods will make contact with a single bi-polar neurone which connects with the cell body of a single optic nerve fibre. This is called **retinal convergence.** The importance of retinal convergence is that it increases the sensitivity of the eye.

Cones are packed together in the fovea where they are responsible for day-light vision. They contain photochemical pigments that are not readily bleached even by light of high intensity. The closer together the cones the higher the acuity of the eye. Cones have high visual acuity because approximately 7 million of them are densely packed in the centre of the fovea having direct connections with the optic nerve. To be able to distinguish two separate signals they must connect with different optic nerve fibres. They would lose their identity if they were to share the same afferent pathway. For this reason cones show little or no convergence.



Scanning Electron Micrograph (SEM) showing the rods and cones which act as photoreceptors in the human retina. Rods (blue) are long nerve cells which respond to dim light, allowing the detection of images. Cones (red) are shorter cells which detect colour. Together, rods and cones pass visual signals through the optic nerve to the brain.

The functioning of rods and cones depends on photosensitive pigments. The outer segments of rods contain rhodopsin which consists of a protein called opsin attached to retinal, a derivative of vitamin A. Cones contain a similar pigment called iodopsin. When exposed to light rhodopsin splits into its two component parts and the retinal produces an impulse which is transmitted from the rod to a receptor neurone. Rhodopsin split in this way must be resynthesized in order to maintain the rods ability to respond to light. This takes time and requires ATP from the many mitochondria in the rods.

When exposed to bright light rhodopsin is broken down rapidly and the rhodopsin reserve is low. The eyes are said to be light adapted. If the retina is then exposed to dim light rods show little response so vision is poor. The period required to get used to the dark is the time it takes for the rhodopsin to be resynthesized. When the retina is sensitive enough for us to see in the dim light the eyes are said to be dark adapted.

Because we have two eyes that sit side by side, each eye will capture a slightly different view. This is called binocular vision. When signals from the two eyes reach the brain, they are superimposed and processed into a single picture with depth. As a result, we get a 3D picture and are able to judge distances well.

The following video animation presents the structure and workings of the human eye.
https://youtu.be/yzyphSTkW2U

Glossary

Accommodation	focusing of the lens.
Acuity of the eye	ability of the eye to resolve 2 or more stimuli separated spatially (ability to distinguish or resolve 2 separate images).
Binocular vision	vision using two eyes with overlapping fields of view allowing good perception of depth.
Bipolar neurone	a neurone with 2 processes, an axon and a dendrite extending from opposite ends.
Peripheral	around the edge.
Retinal convergence	the exciting of a single sensory neurone by incoming impulses from multiple other neurones.

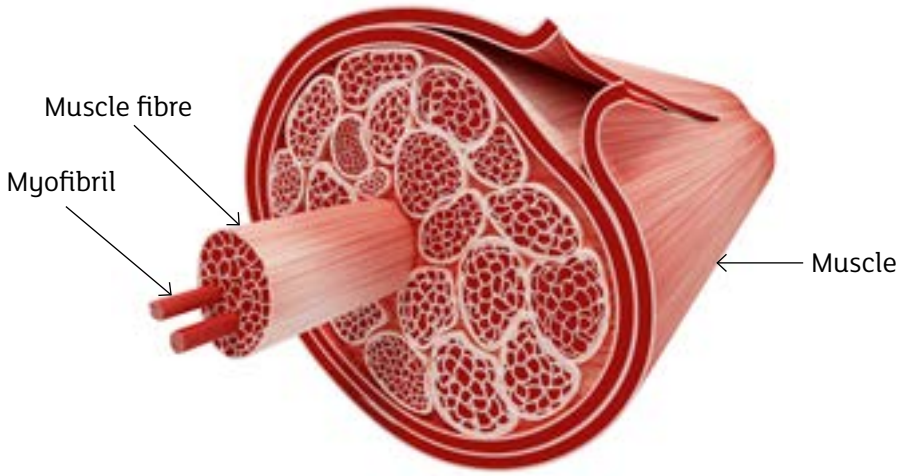
4.3.8 Key Concepts

Students should be able to:

- demonstrate knowledge and understanding of the structure and function of voluntary (skeletal) muscle as an effector

Skeletal muscle can be controlled consciously to move the bones of the skeleton; hence it is also called voluntary muscle. The arrangement of protein filaments that bring about contractions in skeletal muscle give it a banded or striped appearance when viewed under a microscope and it can also be called striated muscle.

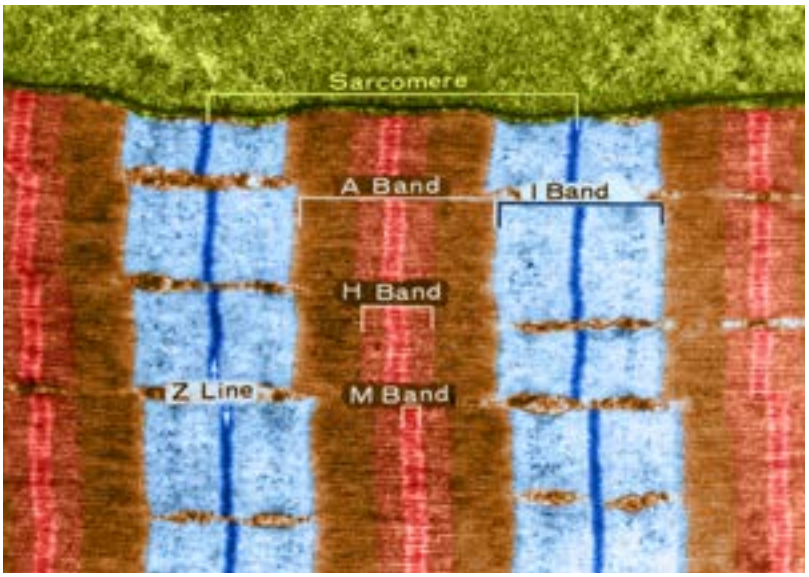
Skeletal muscle consists of many muscle fibres which are arranged in groups. Each fibre has an outer membrane called the sarcolemma which contains large numbers of myofibrils which are like thin threads running along the length of the fibre. Nuclei are scattered along the length of each fibre underneath the sarcolemma.



A diagram showing the structure of skeletal muscle

The myofibrils are divided into compartments called sarcomeres by internal membrane partitions called Z-lines. Each myofibril contains actin filaments and myosin filaments. The two types of filaments run lengthwise and overlap. There are several light and dark bands that are seen to run across the myofibrils and fibres. The light bands are called I-bands and are regions where only thin filaments of actin are found. Running across the middle of the light band is a dark line called the Z-line. Between the I-bands are the A-bands which are dark and contain thick and thin filaments of the protein myosin. In the middle of each A-band is a lighter band called the H-band containing only thick filaments. Running across the middle of the H-band is a dark line called the M-line. The sarcomere

is the basic unit of the myofibril containing all these bands and lines, with the whole myofibril consisting of a chain of these units placed end to end. Thick myosin filaments are found in the dark bands and thin actin filaments occur in the light bands. Under the light microscope little detail can be seen and the myofibrils appear as very thin lines. However under the electron microscope the internal structure and banding pattern is clearly seen.



Transmission Electron Micrograph (TEM) of relaxed skeletal muscle showing several myofibrils, labelled to identify the various bands in the pattern of cross-striations.

When the muscle fibres contract the thin filaments slide in between the thick filaments and meet in the middle of each sarcomere. When this happens the H-bands become narrower and may even disappear. The I-bands become narrower as the Z lines are drawn closer to each other. Since the filaments do not shorten on contraction the A-bands remain the same length. This is evidence to support the sliding filament theory of contraction. When the muscle is relaxed the light bands and H bands will be comparatively long with the dark ends of the dark band relatively short, so the sarcomeres are shorter in in contracted muscle and longer in relaxed muscle. In very contracted muscles the ends of the filaments actually meet. This will have the effect of creating new bands.

When an action potential passes along the sarcolemma an electrical signal is transmitted which results in the release of calcium ions from vesicles. Calcium ions are necessary for the hydrolysis of ATP which provides the necessary energy for the process of contraction. In the sliding filament mechanism calcium ions cause binding sites on actin filaments to become available allowing myosin and actin to bind.

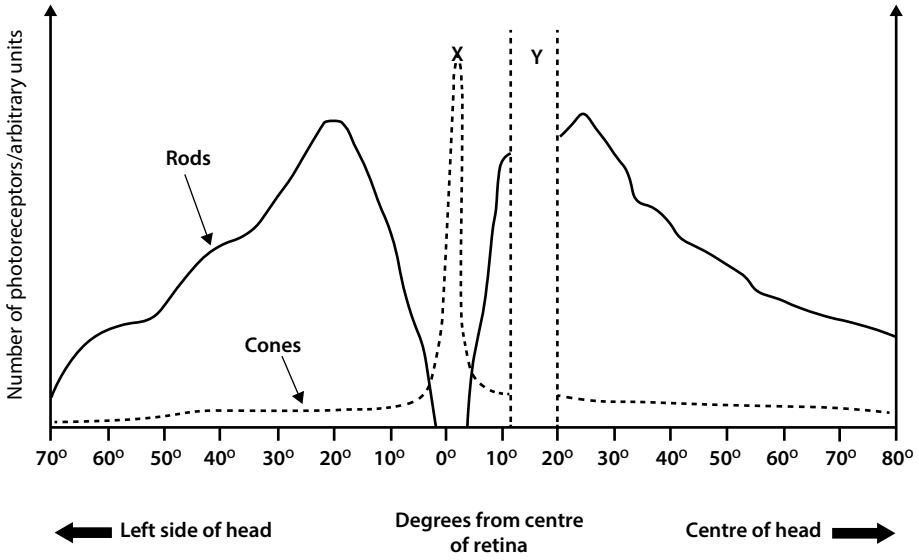
The myosin head rotates and pulls actin filaments over the myosin. ATP allows myosin to detach from actin and the myosin head returns to original position and re-attaches to actin further along. This process repeats in a ratchet mechanism resulting in the contraction of the muscle.

The following video animation demonstrates the changes in the sarcomere that occur when a muscle contracts.
https://youtu.be/U2TSaz8-yNQ

The following video animation presents the sliding filament theory and discusses the role of calcium ions in the muscle contraction process.
https://youtu.be/4HhgnG-C0BM

Activities/Revision Exercises

Q1 (a) Photoreceptor cells (rods and cones) are not distributed evenly across the retina. The diagram below shows the distribution of rods and cones across the retina of the human left eye. Name regions of the retina represented by **X** and **Y**.



(b) The diagram shows that there are more photoreceptor cells (rods and cones) at the edge of the retina closest to the centre of the head compared to the edge closest to the side of the head. Suggest a reason for this.

(c) Peripheral vision can be described as vision at the limits of our field of view. With reference to both rods and cones, explain why peripheral vision has reduced visual acuity.

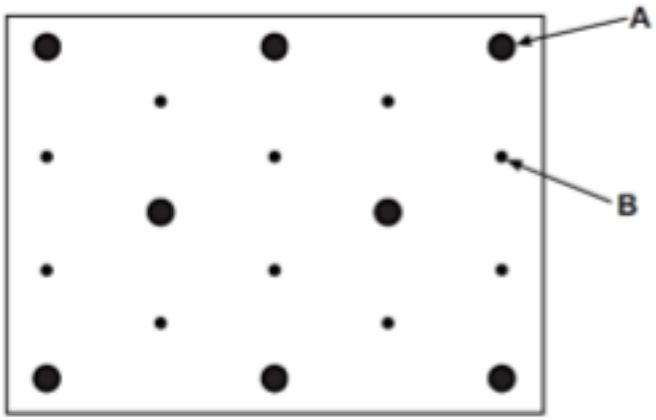
Q2 The ability of the eye to focus on near and distant objects is called accommodation. Describe and explain the events that occur in the eye when accommodating a distant object.

Q3 The diagram below shows a representation of part of a myofibril in cross-section.

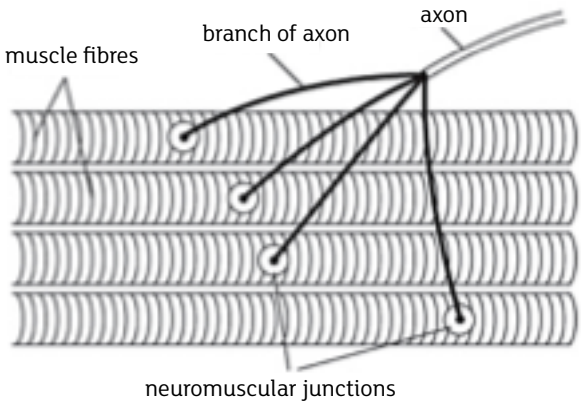
(a) Name the type of protein found in the structures represented by **A** and **B**.

(b) Name the region (band) of the myofibril the section represents.

(c) Describe the sliding filament mechanism of muscle contraction.



Q4 Neuromuscular junctions are specialised synapses that link neurones to muscle fibres. Each motor neurone subdivides into several branches, each with its own neuromuscular junction, as shown in the diagram below.

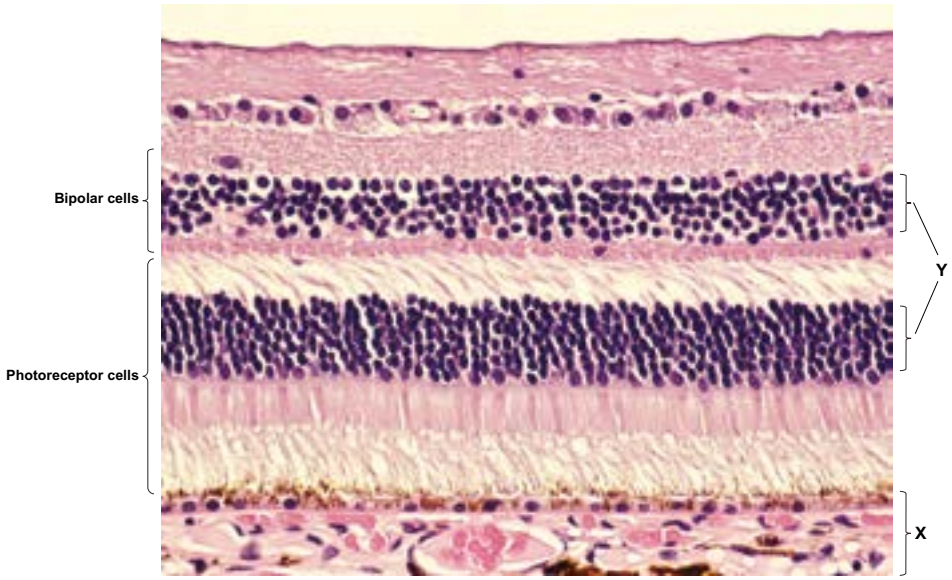


(a) In terms of outcome, identify the main difference between neuromuscular junctions and neurone to neurone synapses in the nervous system.

(b) The diagram shows that the axon of one motor neurone branches to supply a number of muscle fibres. Suggest a reason for this.

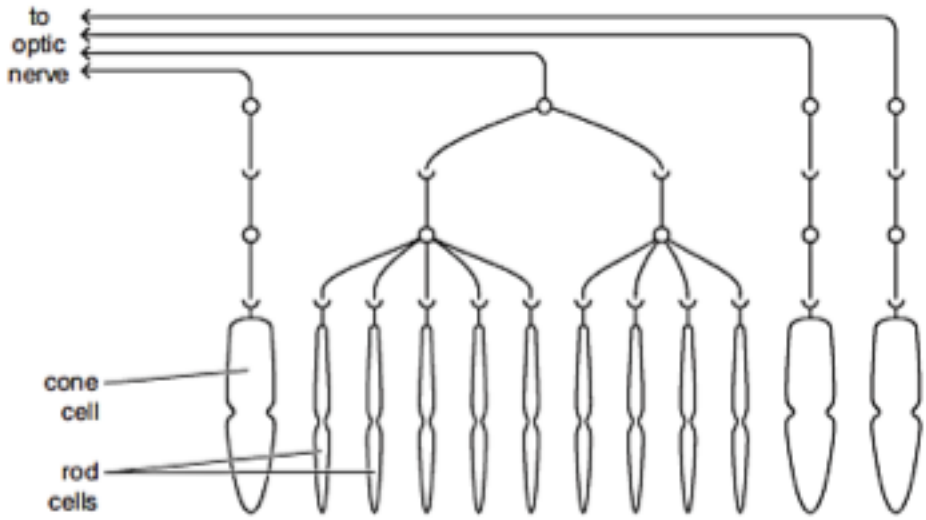
Q5 Read the following passage about the control of flowering in plants and write the most appropriate word(s) in the blank spaces to complete the account.
The pigment _____ is found in the leaves of flowering plants and occurs in two interchangeable forms. In daylight, the _____ form is rapidly changed to the _____ form. Short day plants will flower when the period of _____ reaches or exceeds a minimum length.

Q6 The photograph below shows a section through part of the wall of a mammalian eye.



(i) Identify layer X that lies immediately below the photoreceptor cells.
(ii) Identify the dark circular structures in the layers labelled Y.
(iii) The mammalian retina is described as being 'inverted'. Using the photograph below, suggest why the mammalian retina is described as being inverted and suggest a possible disadvantage of this.

Q7 Mammalian photoreceptor cells (rods and cones) and their associated neurones are represented in the diagram below. The diagram shows that the rods and cones differ in the structural arrangement with their associated neurones. Describe and explain the significance of this to human vision.



Q8 The following statements relate to the structure or function of the eye. Identify the term described by each statement.

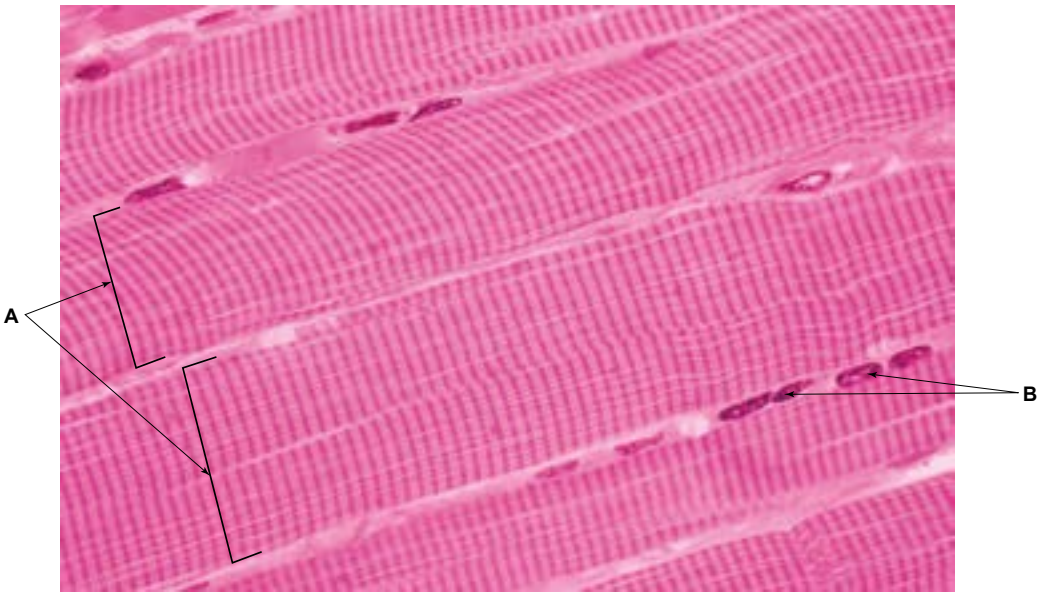
(i) The structures that link the ciliary body and the lens

(ii) The layer that prevents internal reflection of light in the eye

(iii) The neurone arrangement that provides high sensitivity in low light intensities

(iv) The type of vision that makes three dimensional images possible

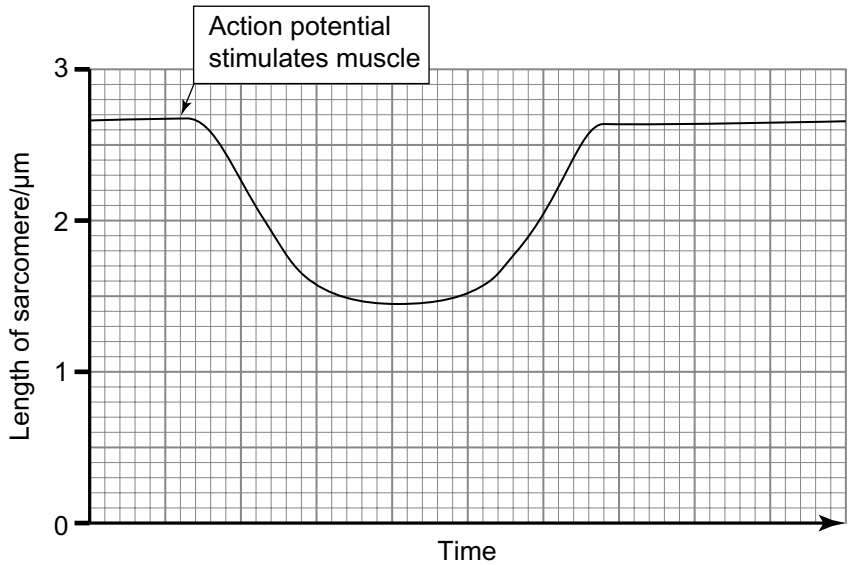
Q9 The photograph below is a photomicrograph of muscle tissue. Identify the features labelled **A** and **B**.



Q10 The graph below shows the length of a sarcomere during muscle contraction.

(a) Explain the role of calcium ions, myosin and actin in bringing about the changes in the length of the sarcomere, as shown in the graph below.

(b) A sarcomere will only shorten by a very small amount (approximately 1.2 µm) when it contracts. Explain how muscle tissue is able to contract many centimetres when stimulated.



Answers

A1 (a) X – fovea/yellow spot;
Y – blind spot;
(b) There are more photoreceptor cells (rods and cones) at the edge of the retina closest to the centre of the head compared to the edge closest to the side of the head as they are positioned more centrally to improve vision at periphery. There are fewer at the side since there is overlap with other eye.
(c) Peripheral vision has reduced visual acuity because of a lower density of cones (in the periphery of the retina); rods do not provide acuity since there is retinal convergence.

A2 When accommodating a distant object. The circular muscles in ciliary body relaxes, the tension in the wall of eye is transferred to suspensory ligaments. Suspensory ligaments are pulled taut and the lens is pulled into a flattened shape resulting in a thin lens.

A3 (a) A: myosin;
B: actin;
(b) A-band (dark/anisotropic)/region of overlapping filaments
(c) In the sliding filament mechanism calcium ions cause binding sites on actin filaments to become available allowing myosin and actin to bind.
The myosin head rotates and pulls actin filaments over the myosin. ATP allows myosin to detach from actin and the myosin head returns to original position and re-attaches to actin further along. This process repeats in a ratchet mechanism.

A4 (a) Synapse results in muscle contraction and not further nerve impulses or depolarisation of sarcolemma. T-tubules are not in the membrane of adjacent neurones.
(b) The axon of one motor neurone branches to supply a number of muscle fibres so a number of muscle fibres can contract simultaneously.

A5 Phytochrome
P660 to P730/Pr to Pfr *[must have P prefix];*
Darkness.

A6 (i) Choroid layer
(ii) Nuclei
(iii) To reach photoreceptor cells light has to pass through neurones, the photoreceptor cells are not at the front of retina where light enters and neurones lie over the photoreceptor cells. Detection of light is compromised (e.g. not fully reaching photoreceptors) and there is a blind spot where neurones leave the eye which is necessary in this arrangement.

A7 Each cone cell synapses with one bipolar neurone while several rods synapse with a bipolar neurone. A rod bipolar neurones synapse with one ganglion cell. Convergence of rods allows summation of light stimuli which results in increased visual sensitivity of rods. Decreased visual acuity of rods with visual acuity provided by cones. Cones only reach threshold levels in bright light which results in reduced sensitivity.

A8 (i) Suspensory ligaments;
(ii) choroid;

(iii) retinal convergence;
(iv) stereoscopic.

A9 A= Muscle fibre B= Nucleus

A10 (a) An action potential causes calcium ions to leave the sarcoplasmic reticulum and enter the sarcoplasm. This causes myosin binding sites on actin to be exposed allowing myosin heads to attach forming across bridge. Myosin heads rotate pulling actin over myosin, a reduction in calcium ions allows the sarcomere to relax and re-lengthen.

(b) Muscle fibre contains many sarcomeres arranged end to end. A muscle contraction involves all the sarcomeres in a row contracting simultaneously. This means the contraction is sum total of all sarcomeres.