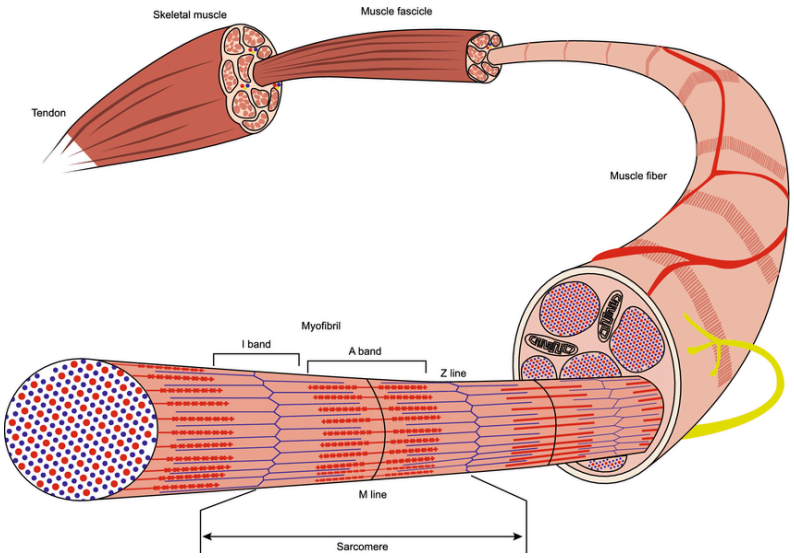
Year 13 AHL

IB BIOLOGY

11.2 Movement



Name:

Teacher:

11.2 Muscles and Movement

Understandings

11.2.1 Bones and exoskeletons provide anchorage for muscles and act as levers

11.2.2 Synovial joints allow certain movements but not others

11.2.3 Movement of the body requires muscles to work in antagonistic pairs
11.2.4 Skeletal muscle fibres are multinucleate and contain specialised endoplasmic reticulum
11.2.5 Muscle fibres contain many myofibrils
11.2.6 Each myofibril is made up of contractile sarcomeres
11.2.7 The contraction of the skeletal muscle is achieved by the sliding of actin and myosin filaments
11.2.8 ATP hydrolysis and cross bridge formation are necessary for the filaments to slide
11.2.9 Calcium ions and the proteins tropomyosin and troponin control muscle contractions

Applications:

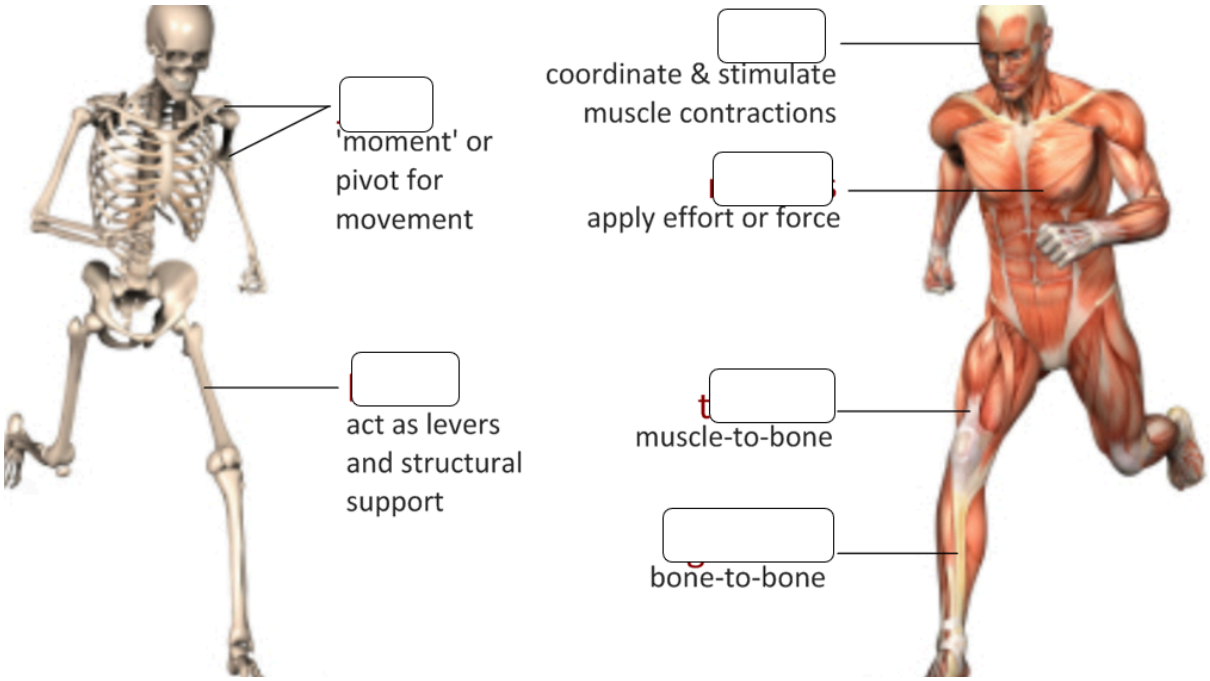
11.2.A1 Antagonistic pairs of muscles in an insect leg

Skills:

11.2.S1 Annotation of a diagram of the human elbow
11.2.S2 Drawing labelled diagrams of the structure of a sarcomere
11.2.S3 Analysis of electron micrographs to find the state of contraction of muscle fibres

11.2.1 Bones and exoskeletons provide anchorage for muscles and act as levers

Label the following features and state their function in movement.

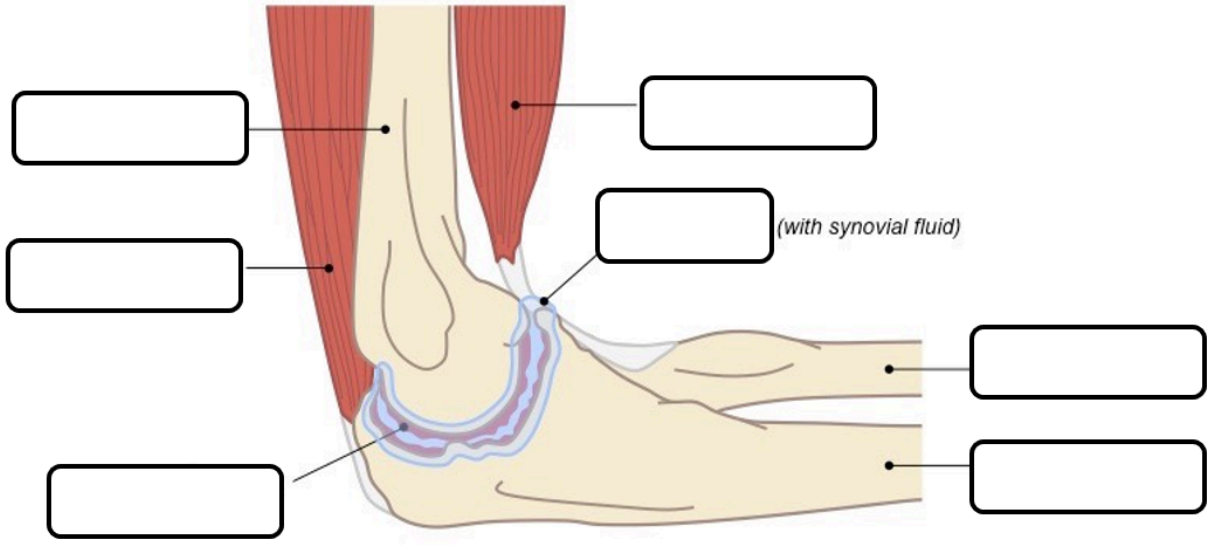


- _____system – consists of bones that act as levers and provide a structure for the muscles to pull
- _____ system – muscles deliver the force required to move one bone in relation to another
- _____) system – delivers signals to the muscles which cause them to contract and create movement

- B_____ and exoskeletons provide anchorage for muscles and act as levers.

11.2.S1 Annotation of a diagram of the human elbow

Label the diagram of the elbow joint:



11.2.2 Synovial joints allow certain movements but not others

Outline the functions of the parts of a synovial joint:

Structure	**Function**
Biceps	
Triceps	
Humerus	
Radius / Ulna	
Cartilage	

Synovial fluid	
Joint Capsule	
Tendons	
Ligaments	

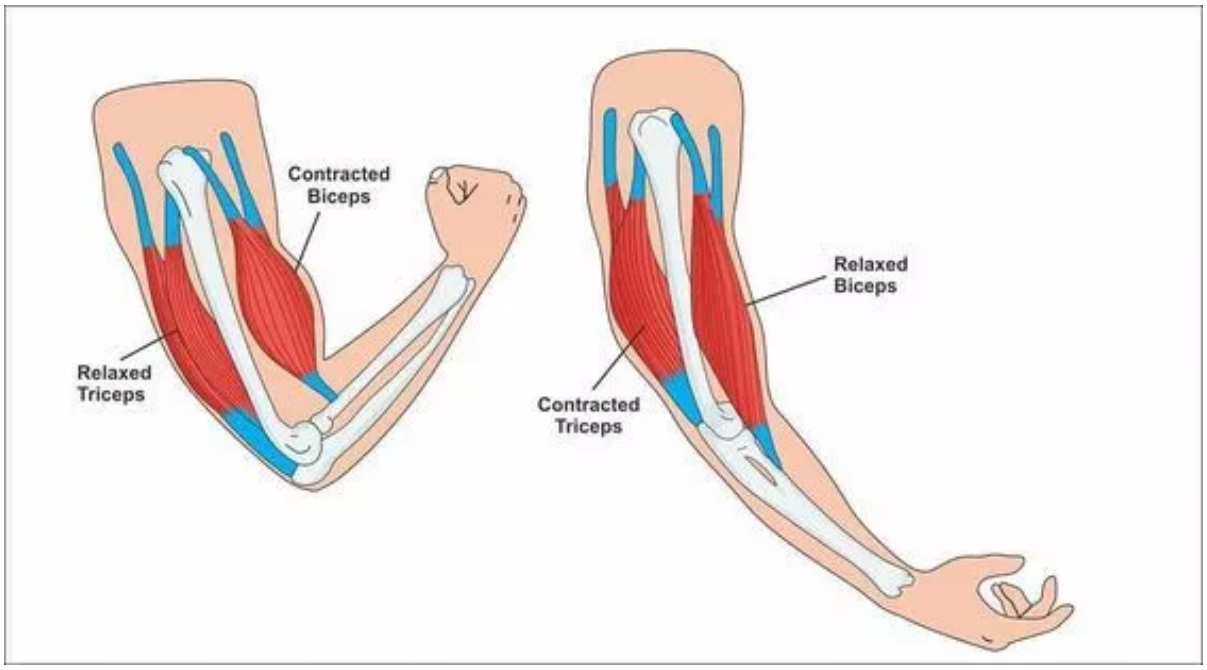
Structure		***Function***
Joint capsule		Seals the joint space and provides stability by restricting the range of possible movements
Cartilage		Lines the bone surface to facilitate smoother movement, as well as absorbing shock and distributing load

Synovial fluid		Provides oxygen and nutrition to the cartilage, as well as lubrication (reduces friction)

11.2.3 Movement of the body requires muscles to work in antagonistic pairs
11.2.A1 Antagonistic pairs of muscles in an insect leg

Outline the antagonistic nature of the action of muscles in the human body, using the elbow as an example.

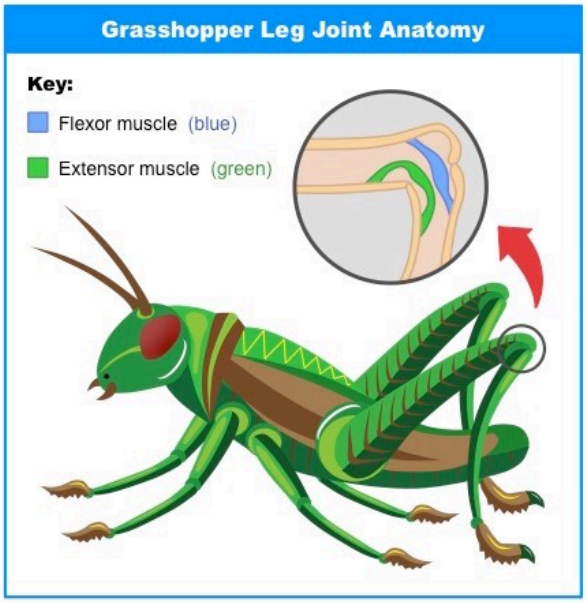
	Flexing (bending)	**Extending**
Biceps		
Triceps		

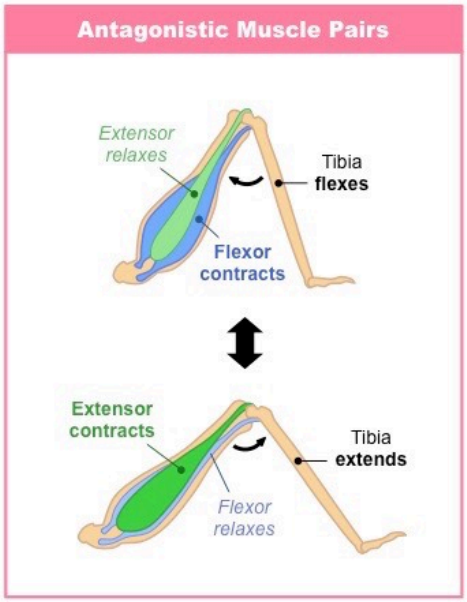


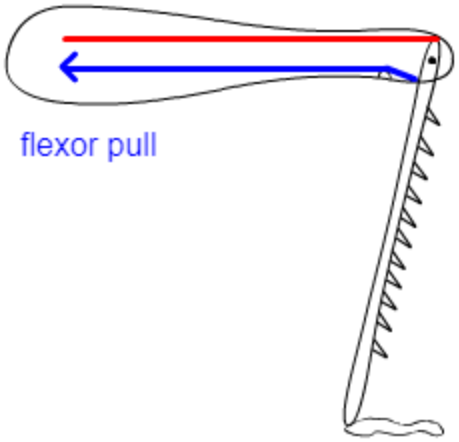
What are antagonistic pairs of muscles in an insect leg?

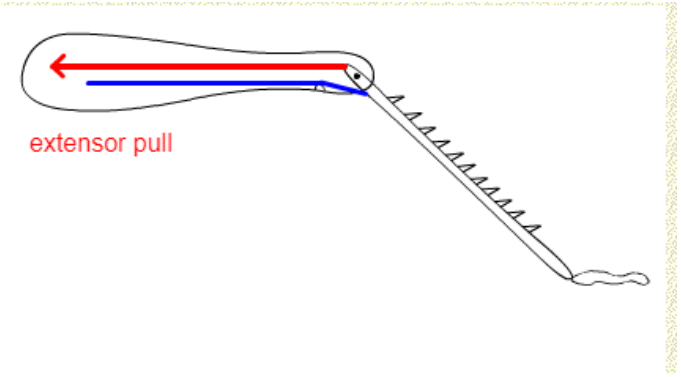
The two main muscles inside are the **extensor tibiae muscle** which contracts to _____ the

leg, and the **flexor tibiae muscle** which contracts to_____ the leg. These muscles pull on tendons which are attached to the tibia on either side of the joint pivot.

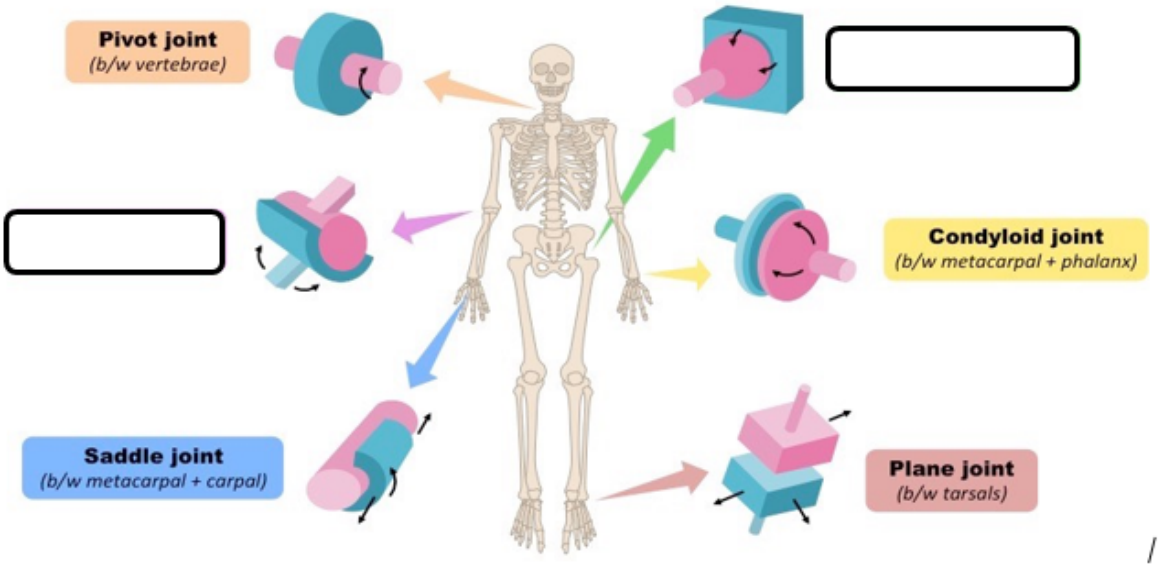








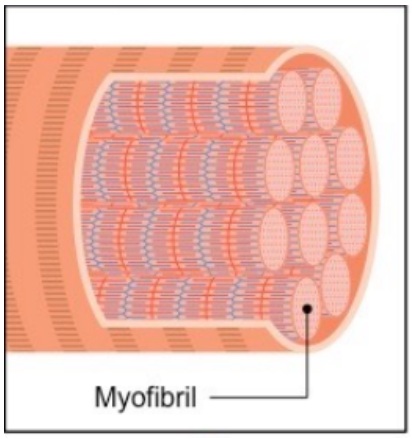
Fill in the missing joints and where they are found

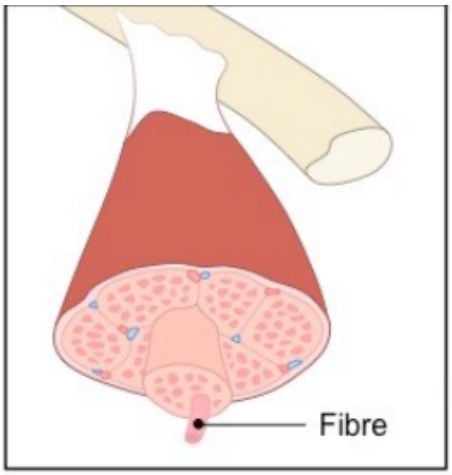


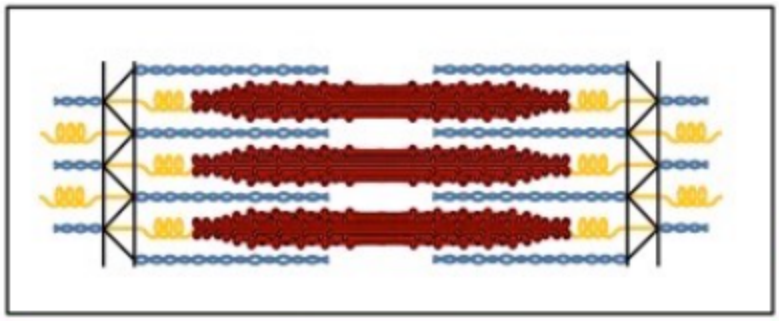
Explain why we need different types of joints in the human body:

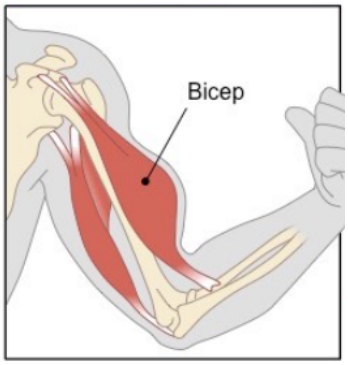
11.2.4 Skeletal muscle fibres are multinucleate and contain specialised endoplasmic reticulum
11.2.5 Muscle fibres contain many myofibrils
11.2.6 Each myofibril is made up of contractile sarcomeres

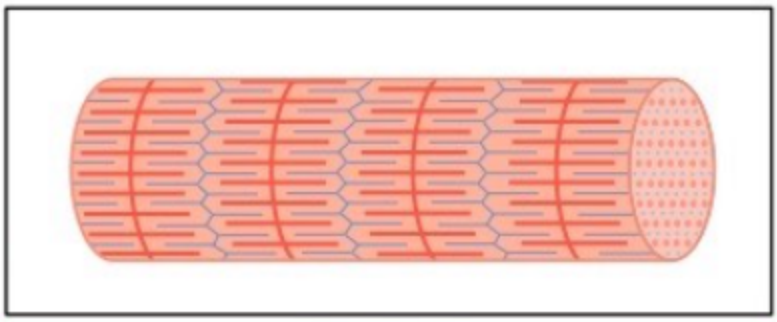
Name these images and put them in order of decreasing size


Myofibril

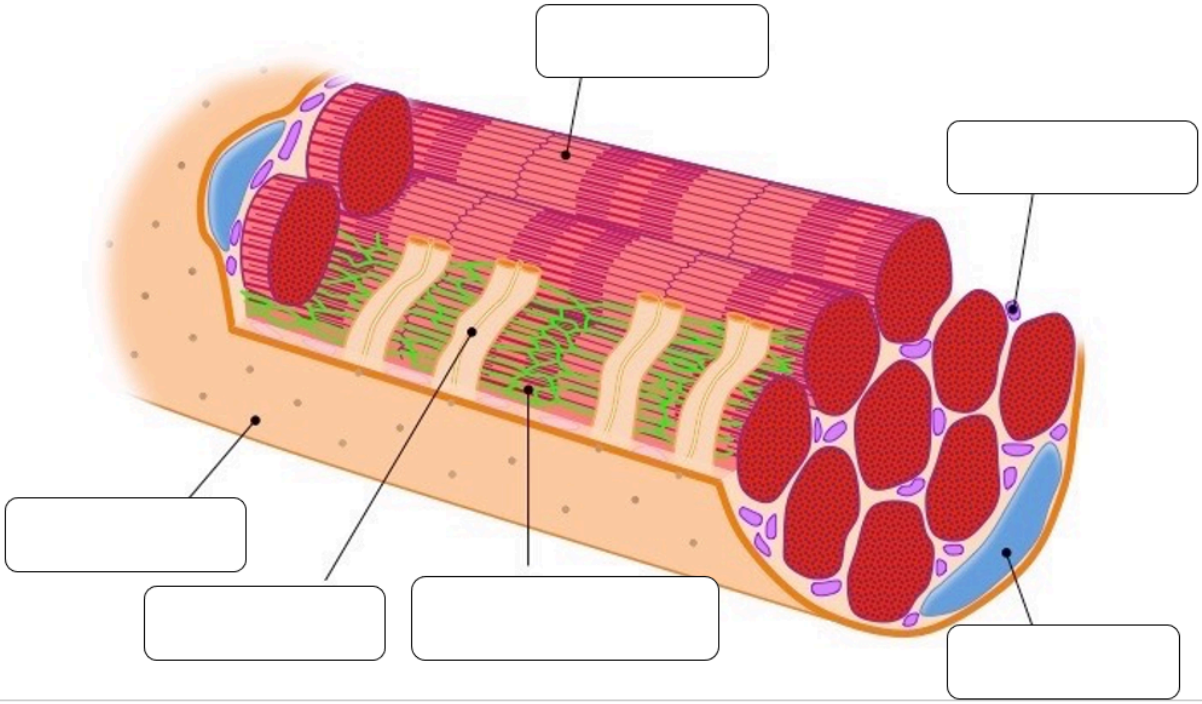

Fibre




Bicep



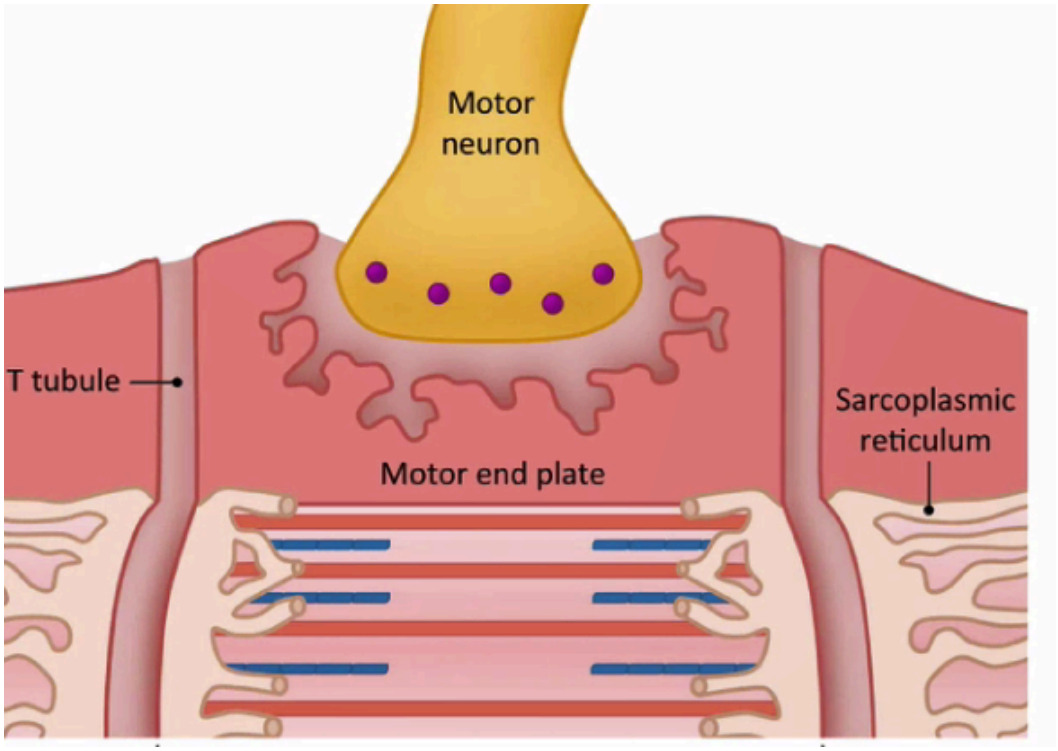
Label the muscle fibre

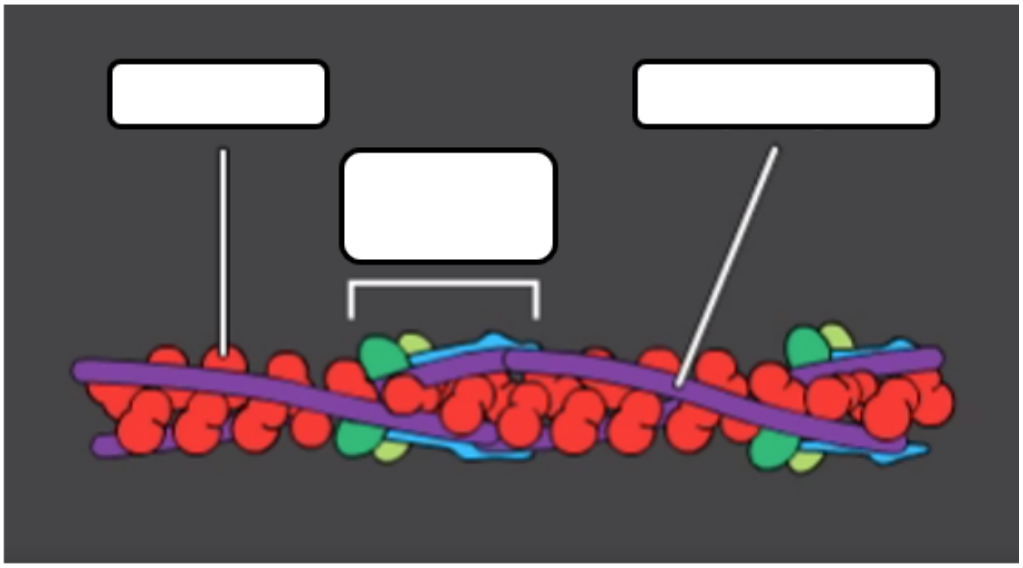


The sarcoplasm is c_____ of the muscle fibre.

Muscle cells contain _____reticulum, a specialised type of endoplasmic reticulum, that _____ calcium ions and pumps them out into the _____ when the muscle fibre is stimulated.

11.2.9 Calcium ions and the proteins tropomyosin and troponin control muscle contractions





Troponin **Tropomyosin** **Actin**

Label these structures of a muscle cell:

Outline the need for large numbers of mitochondria in muscle cells:

.

Muscle cells contract as a result of nerve impulses.

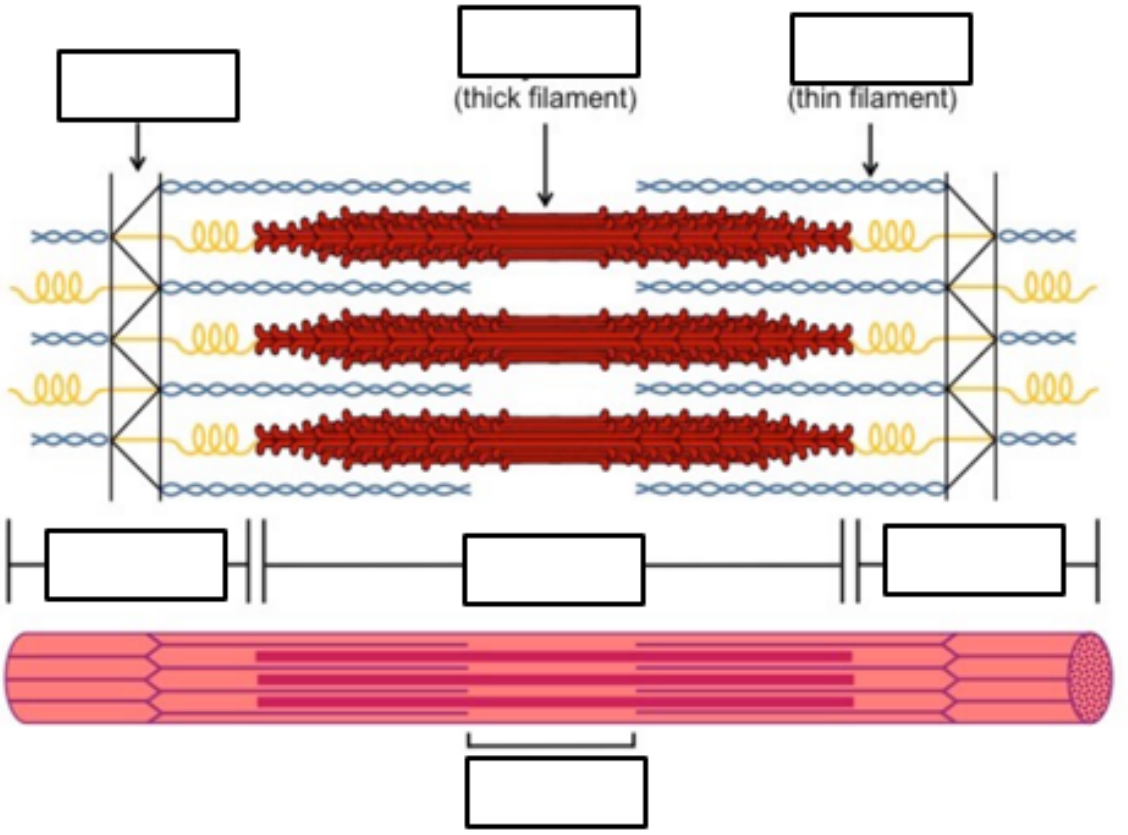
a. State the part of the motor neuron which connects to the muscle cells

.

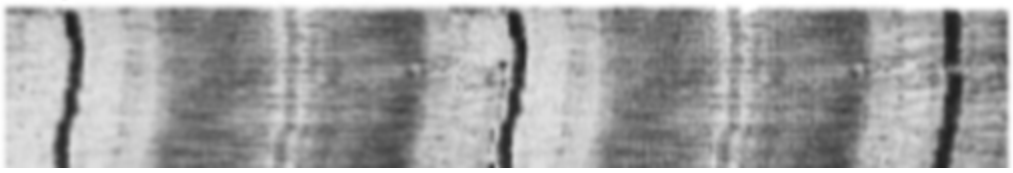
b. Identify the neurotransmitter used at the neuromuscular junction.

11.2.S2 Drawing labelled diagrams of the structure of a sarcomere

Label the structures of the sarcomere:

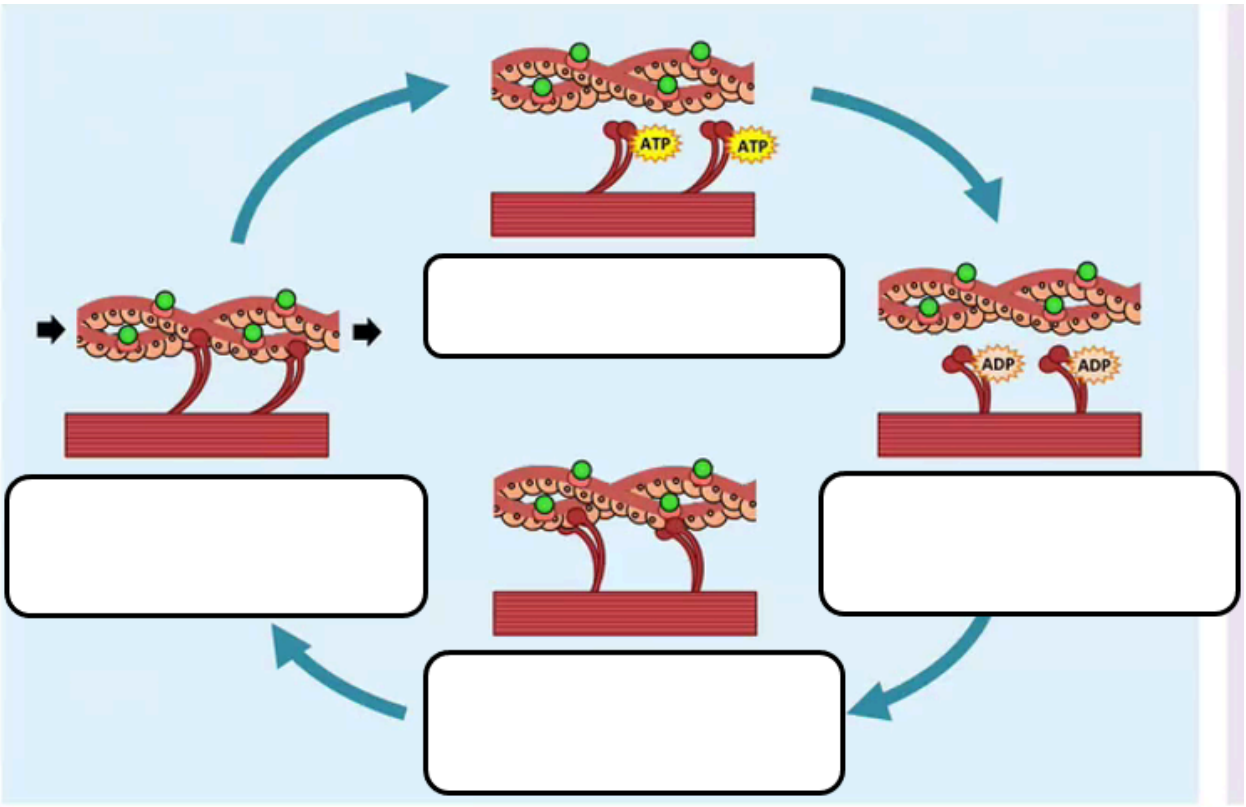


Identify the number of complete sarcomeres in this picture:



11.2.7 The contraction of the skeletal muscle is achieved by the sliding of actin and myosin filaments
11.2.8 ATP hydrolysis and cross bridge formation are necessary for the filaments to slide

Explain the contraction of skeletal muscle:


ATP
ATP
ADP
ADP

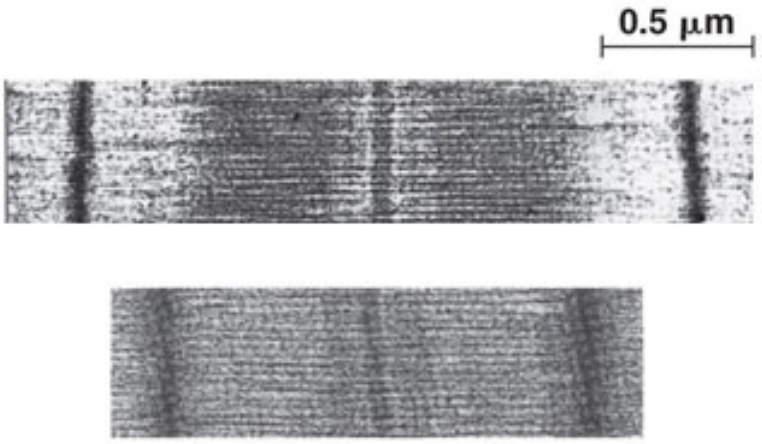
Paste the statements in the correct order below

- An action potential propagated along a motor neuron arrives at the neuromuscular junction.
- This causes the release of the neurotransmitter acetylcholine into the synapse between the terminal axon of the motor neuron and the sarcolemma of the skeletal muscle.
- The acetylcholine binds to receptors on the sarcolemma, causing voltage-gated channels to open and $Na^{\pm}$ ions to flow into the muscle cells.
- This creates an action potential in the striated muscle.
- The action potential is further propagated along the sarcolemma of the skeletal muscle.
- The action potential moves into the interior of the muscle cell through folds called *t tubules*.
- The depolarization of the *t tubules* causes voltage-gated $Ca^{\pm}$ channels on the sarcoplasmic reticulum to open, causing an influx of $Ca^{\pm}$ ions into the sarcoplasm.
- $Ca^{\pm}$ ions bind to troponin which causes tropomyosin to move exposing the myosin binding sites (troponin and tropomyosin are regulatory proteins blocking the myosin binding sites).
- ATP attaches to the myosin heads breaking the cross-bridges between the myosin heads and actin binding sites
- The ATP undergoes a hydrolysis reaction forming ADP + P_i. This causes a positional change in the myosin head (cocked back).
- The myosin heads bind to actin filaments forming cross-bridges at a site one position further from the centre of the sarcomere

- When the ADP + P_i are released the myosin heads change conformational position, sliding the actin filaments towards the center of the Sarcomere. This is called the "power stroke".
- After the power stroke ATP again binds to the myosin head, causing it to detach from the actin filament ready for another cycle.

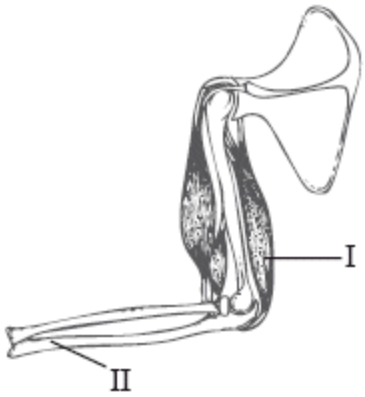
11.2.S3 Analysis of electron micrographs to find the state of contraction of muscle fibres

Compare these two micrographs of skeletal muscle sarcomere:



Contracted or relaxed?		
Sarcomere length		Shorter
Z-bands		Closer
H-bands	No change	
Light bands		
Dark bands	No change	

1. What are the names of the two structures labelled I and II in the arm joint diagram below?



	I	II
A.	biceps	radius
B.	biceps	humerus
C.	triceps	humerus
D.	triceps	ulna

(Total 1 mark)

2. Which is the sequence of events in muscle contraction?

I. Use of ATP

II. Formation of cross bridges

III. Release of calcium ions from the sarcoplasmic reticulum

IV. Actin filament moves towards the centre of the sarcomere

A. I → II → III → IV

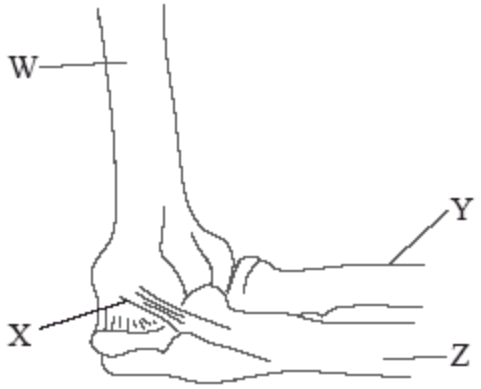
B. III → II → IV → I

C. IV → I → II → III

D. II → IV → I → III

(Total 1 mark)

3. The diagram below shows the side view of the arm joint.



Which letter is pointing to the ulna?

A. W

B. X

C. Y

D. Z

(Total 1 mark)

4. What happens when ATP binds to myosin heads during muscle contraction?

A. Calcium ions are released from the sarcoplasmic reticulum.

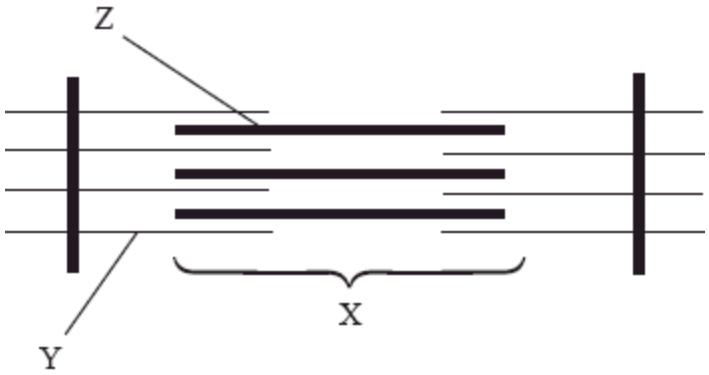
B. Calcium ions are taken up by the sarcoplasmic reticulum.

C. Cross-bridges between myosin heads and actin filaments are broken.

D. Myosin heads form cross-bridges with actin filaments.

(Total 1 mark)

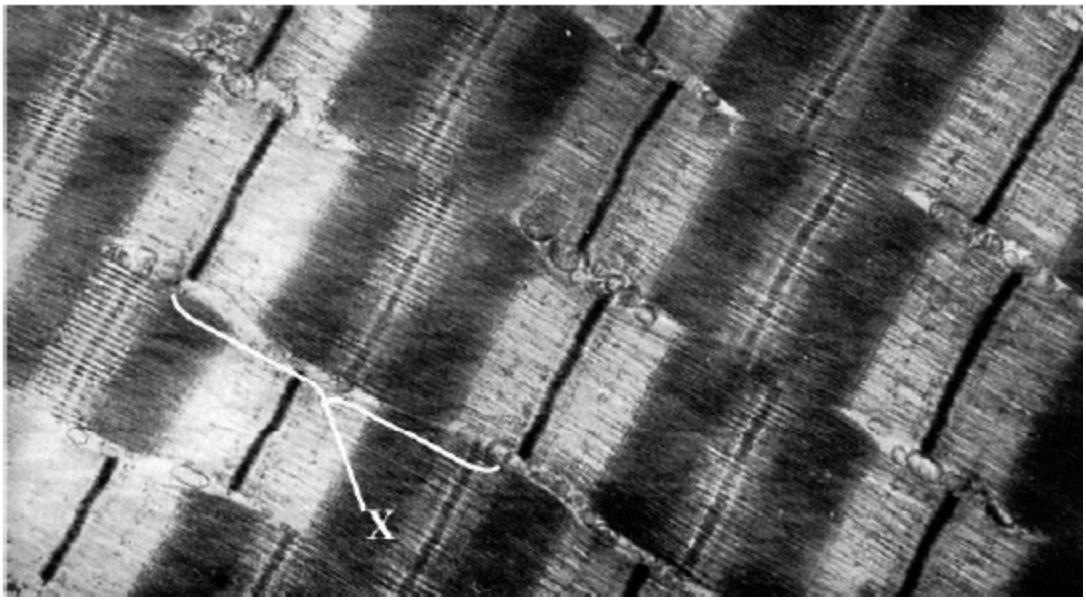
5. What is indicated by the letters X, Y and Z?



	X	Y	Z
A.	sarcomere	myosin filaments	actin filaments
B.	sarcomere	actin filaments	myosin filaments
C.	dark band	myosin filaments	actin filaments
D.	dark band	actin filaments	myosin filaments

(Total 1 mark)

6. What does label X indicate?



A. Sarcolemma

B. Sarcomere

C. Sarcoplasmic reticulum

D. Endoplasmic reticulum

(Total 1 mark)

7. *Up to two additional marks are available for the construction of your answers.*

(2)

(a) Draw a labelled diagram showing the structure of a motor neurone.

(4)

(b) Outline how heartbeat is controlled as the body goes from rest to hard exercise.

(6)

(c) Explain how skeletal muscle contracts.

(8)

(Total 20 marks)

8. *Up to two additional marks are available for the construction of your answers.*

(2)

(a) Draw a labelled diagram to show the structure of a sarcomere.

(4)

(b) Outline how skeletal muscle contracts.

(5)

(c) Explain how nerve impulses are transmitted along and between neurons.

(9)

(Total 20 marks)

1. D

2. B

3. D

4. C

5. D

6. B

7. (a) *Award **[1]** for each of the following clearly drawn and correctly labelled.*
cell body — complete with nucleus and dendrites;
axon—shown longer than the longest dendrite, with the membrane drawn as a
continuous line;
myelin sheath — surrounding the axon, showing nodes of Ranvier;
motor end plates — not covered by myelin sheath and ending in a button / dot; 4

(b) heart muscle is myogenic / pacemaker;
rise in CO_2 detected in medulla of brain;
nerve impulse sent to pacemaker;
sympathetic / parasympathetic control;
modifies heart beat;
SA node initiates contraction of atria;
impulses (from SA) cause AV node to contract ventricles;
transmitted through Purkinje fibres;
output rises;
CO_2 level falls; 6 max

Allow converse of above

c) (skeletal) muscle is composed of myofibrils;
operational unit is a sarcomere;
viewed as a series of light and dark bands;
thin actin fibres;
thick myosin fibres;
arrival of action potential;
release of Ca^{2+};
from sarcoplasmic reticulum;
exposes binding sites of myosin fibres;
ATP used to break cross bridges between myosin and actin fibres;

hydrolysis of ATP resets myosin head;
causing sliding of actin and myosin; 8 max

*(Plus up to **[2]** for quality)*

[20]

8. (a) *Award **[1]** for each structure clearly drawn and correctly labelled.*
Sarcomere — clearly indicated between Z lines;
Z lines;
actin filaments attached to Z line;
myosin filaments with heads;
(two) light bands;
dark band; 4 max

(b) calcium ions are released from the sarcoplasmic reticulum;
they expose the myosin binding sites (on actin) / cause movement of blocking molecules/troponin;
cross-bridges form between actin and myosin molecules;
ATP provides energy;
for actin filaments to slide over the myosin filaments / for myosin to push actin;
ATP provides energy to release myosin from binding site;
action can be repeated further along the molecule; 5 max

(c) the resting potential of cell is negative inside compared with outside;
stimulation causes depolarization/reversal of charge on each side;
due to Na^+ channels opening / Na^+ flowing into the cell;
which causes an action potential;
K^+ channels open / K^+ flows out of the cell;
sodium potassium pump restores resting potential;
transmitted between neurons across a synapse;
neurotransmitter released into synaptic cleft;
diffuse across cleft to postsynaptic membrane;
where they bind to receptors;
influx of Na^+ into cell;
which may initiate action potential; 9 max

*(Plus up to **[2]** for quality)*

[20]