FUNCTIONAL ANATOMY

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PHYSICAL EDUCATION STUDIES 3A-3B
A TEXTBOOK FOR TEACHERS AND STUDENTS

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Skeletal Muscle Structure

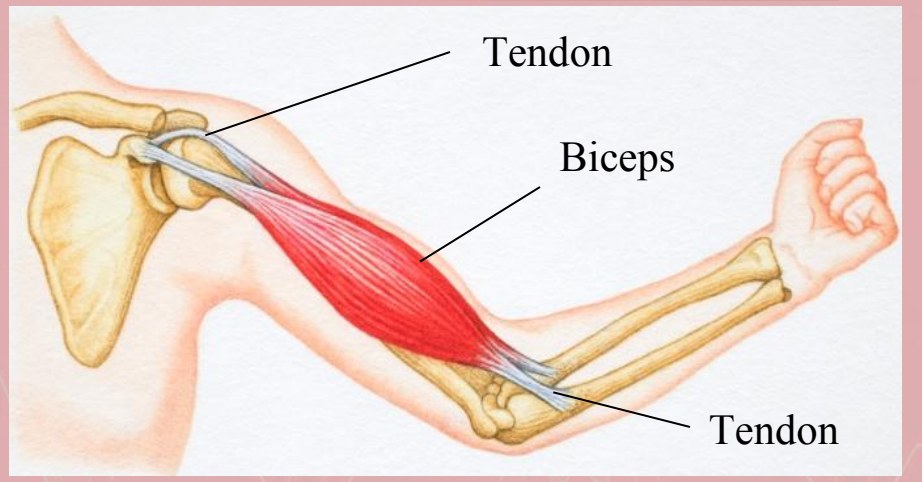
Skeletal muscles create movement or assists maintaining posture when they contract.

They are connected to bones via tendons.

Contraction is voluntary, that is you must think about the movement for it to happen.

Skeletal muscles only pull, they do not push.

During contraction the muscle shortens as tension develops and the muscle appears to get bigger.



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Skeletal Muscle Structure

Muscle Components

The smallest units in the muscle are the *actin* & *myosin*.

Actin is a thin protein whereas myosin is a thick protein.

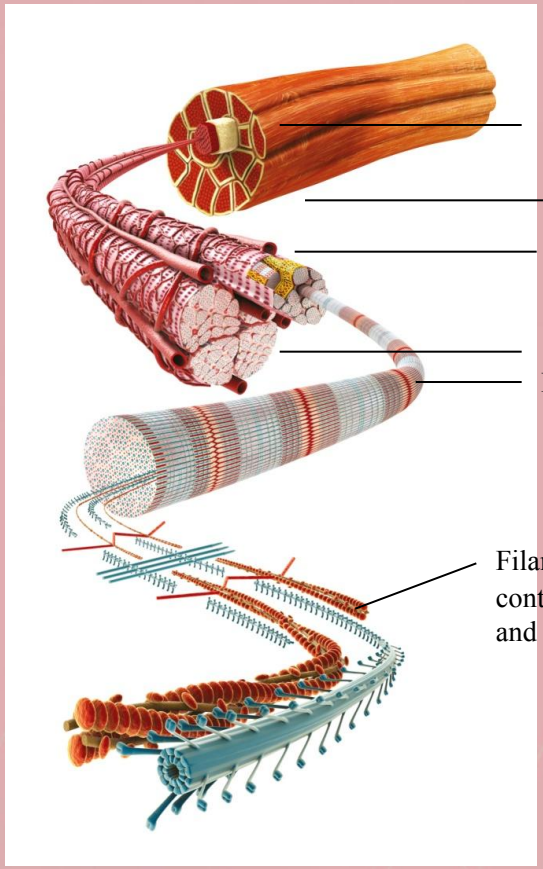
The *myofibrils* are a combination of the actin & myosin.

A group of myofibrils make up the *muscle fibres*.

Muscle fibres are surrounded by the *perimysium*.

Skeletal muscles are made up of long muscle fibres all bundled together forming the *muscle belly*.

The *epimysium* surrounds the muscle belly holding all the muscle fibres together.



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Skeletal Muscle Structure

Shopping Bags – an example

The structure of the muscles similar to filling shopping bags.

Each bag represents the outer layer – *epimysium* of a muscle and separates your shopping (muscles) and holds it all together.

Inside the shopping bag we have a number of groceries (*fascicle* – bundles of muscle fibres).

Each with their own external packaging – or *perimysium* which keeps each item (or bundle of muscle fibres) separated.

Each grocery item (fascicle) is comprised of number smaller components.

That is within the individual packaging (perimysium) we find the strands of spaghetti, slices of bread or a dozen eggs (*fibre*).

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Skeletal Muscle Structure

Exam style question

Place in order, from the largest to the smallest component, the following terms related to skeletal muscle structure:

Muscle fibre

Myofilament

Muscle belly

Myofibrils

Fascicle

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Skeletal Muscle Structure

Answer

Place in order, from the largest to the smallest component, the following terms related to skeletal muscle structure:

Muscle fibre, Myofilament, Muscle belly, Myofibrils, Fascicle.

Muscle belly

Fascicle

Muscle fibre

Myofibrils

Myofilament

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Skeletal Muscle Contraction

Contractile Unit

The contractile unit of the muscle is the *sarcomere*.

A sarcomere is made up of overlapping *actin* & *myosin* proteins.

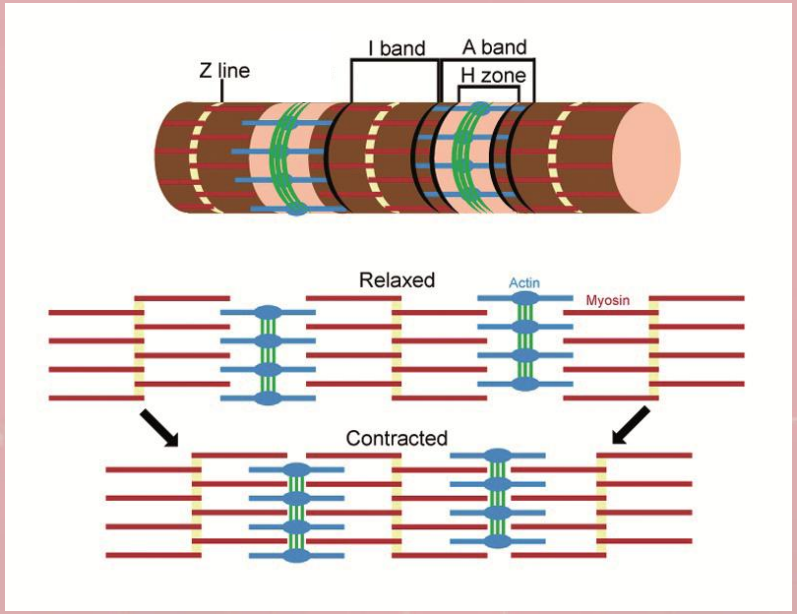
Z lines form the boundary of the sarcomere.

Actin is attached to the Z lines.

The myosin filaments run parallel to the actin and sit between each actin filament, in the middle of the sarcomere.

Myosin does not attach to the Z lines.

Myofibrils are made up of many sarcomeres.



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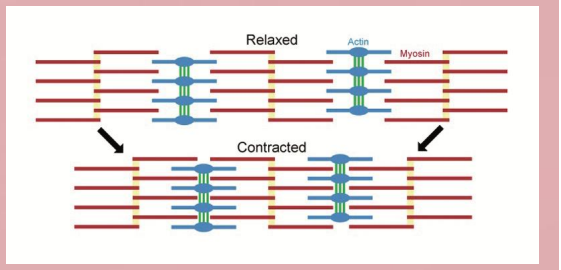
Skeletal Muscle Contraction



Sliding Filament Theory

The sliding filament theory explains the process of muscle contraction.

During contraction actin and myosin filaments slide past each other.

This brings the Z lines closer together, reducing the length of the sarcomere.

As more sarcomeres contract the length of the muscle belly is reduced.

Each sarcomere may shorten 20-50% of its resting length.

Millions of sarcomeres may contract at the same time creating a forceful contraction.

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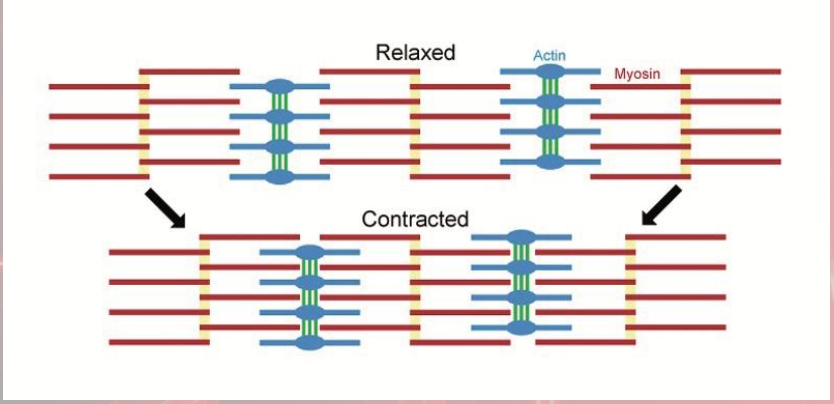
Skeletal Muscle Contraction

Exam style question

Using your understanding of the sliding filament theory, upon receiving a neural stimulus to contract a muscle, what happens first?



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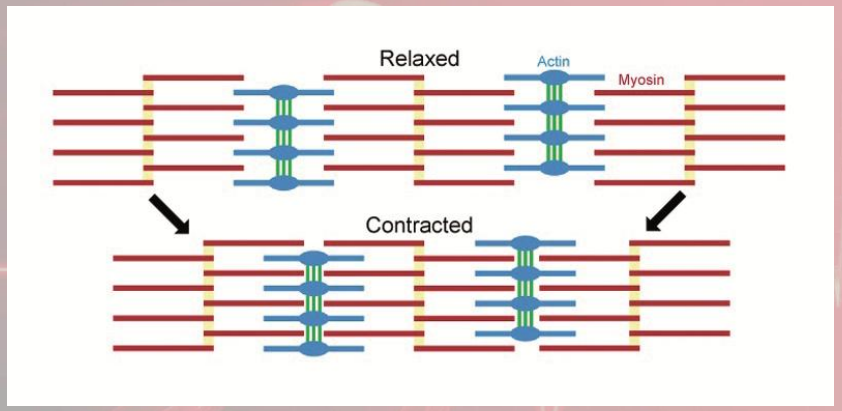
Skeletal Muscle Contraction

Answer

Using your understanding of the sliding filament theory, upon receiving a neural stimulus to contract a muscle, what happens first?

The myosin cross-bridges reach out and grab-on to the actin and begin to oscillate.



Developing Muscle Force

Force-Velocity Relationship

It takes time for sarcomeres to contract.

Rapid movements do not allow complete contraction of the sarcomere.

To develop greater force more time is required for all sarcomeres to contract fully thus movements may be slower e.g. pulling a truck.

The greatest amount of force can be developed during an isometric contraction, when there is no movement in the muscle.

When there is no resistance to the movement or no force exerted, the greatest velocity of that movement is achievable.

If you were to throw a table tennis ball you could move your arm much faster than if you were trying to throw a shot put.

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Developing Muscle Force

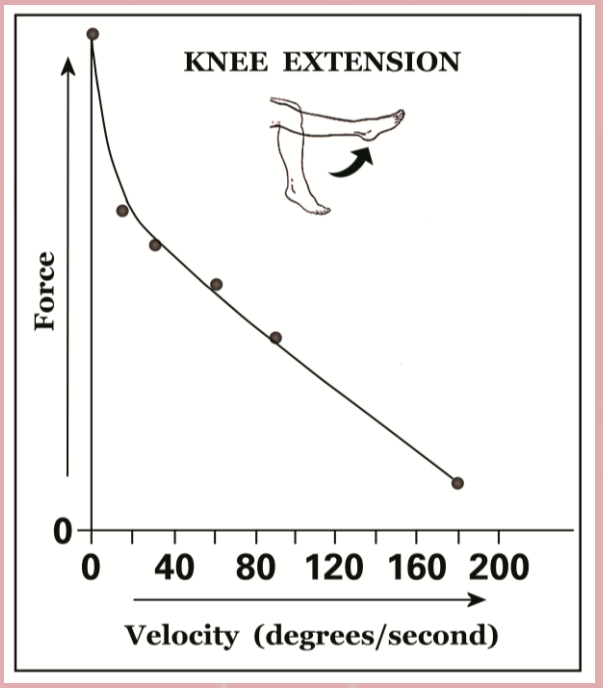
Force-Velocity Relationship

Maximum force is generated from an isometric contraction.

Power is a combination of strength and speed.

To achieve maximum power, the velocity and the resistance should be approximately one third of maximum values.

Most cyclists, choose a gear that maintains a cadence of between 75 and 90 rpm (30-40% of maximum).This offers the most efficient combination of resistance and velocity of leg turn over. Therefore, the greatest horizontal velocity can be produced.



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Developing Muscle Force

Force-Length Relationship

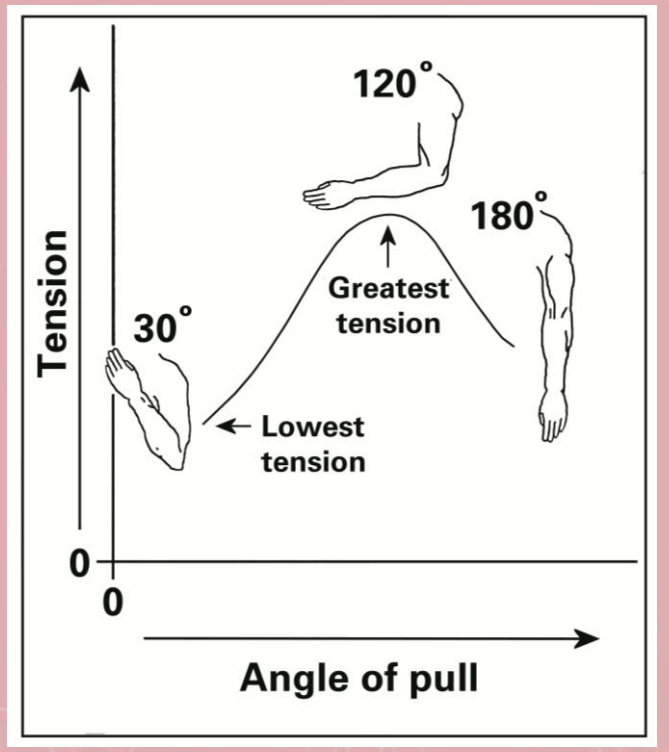
The length of a muscle and the angle at the joint has an impact on the force that can be generated.

The optimum muscle length and joint angle is different for each part of the body.

However, the optimal position is somewhere near the middle of a joints range, allowing maximum attachment of the myosin cross-bridges with the actin.

The longer muscles can create a greater range of motion at a joint.

A shorter wider muscle produces greater amounts of force.



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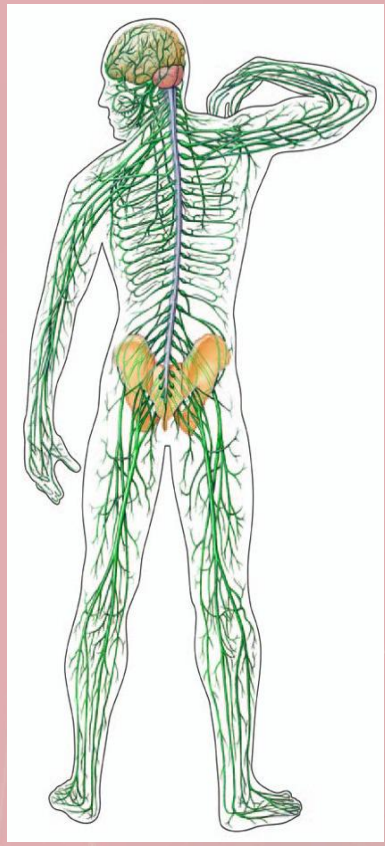
Neuromuscular Structure and Function

Nervous System



The *nervous system* comprises two main parts, the CNS & PNS.

The *CNS* is comprised of the brain and spinal cord.

The *PNS* includes all the nerve branches that our outside the spinal cord.

Information must be sent from the brain down the spinal cord then to the target muscle for muscle contraction, and thus movement to occur.

The information is sent via an electrical impulse with the nerves acting as a conductor. These nerves act in the same manner as an electrical cable such as the power cord for a toaster.

When neural messages travel to the muscle from the CNS, they do so along *motor neurons* and when they send impulses back from receptors to the brain, they do so along *sensory neurons*.

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Neuromuscular Structure and Function

Components of a Motor Neuron

A *motor neuron* is a nerve whose end point is a muscle.

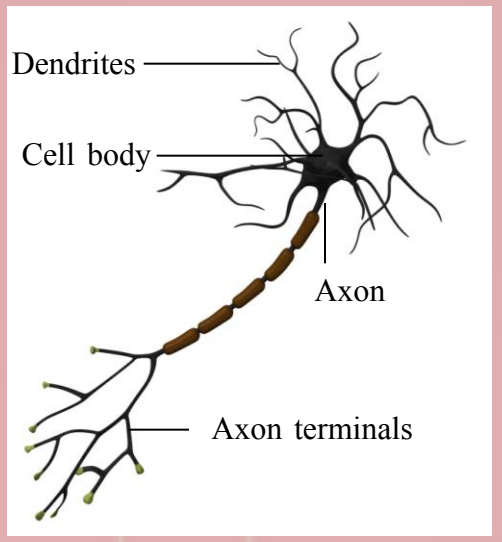
A motor neuron or nerve is made up of three main parts; the dendrite, cell body and axon.

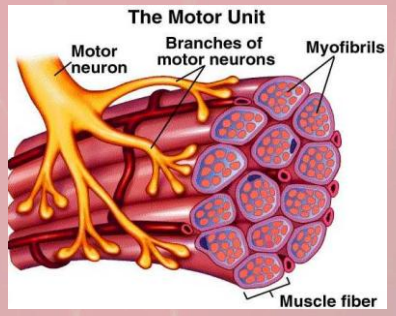
The *dendrite* is like a TV antennae, it receives the signal or information from the CNS. It feeds this information to the cell body.

A *cell body* directs the activities of the neuron, so when it receives the signal it then transmits the information along the length of the axon.

The *axon* is responsible for transmitting messages away from the cell body.

The motor neuron and the muscle fibres that it innervates are collectively called a *motor unit*.





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Neuromuscular Structure and Function

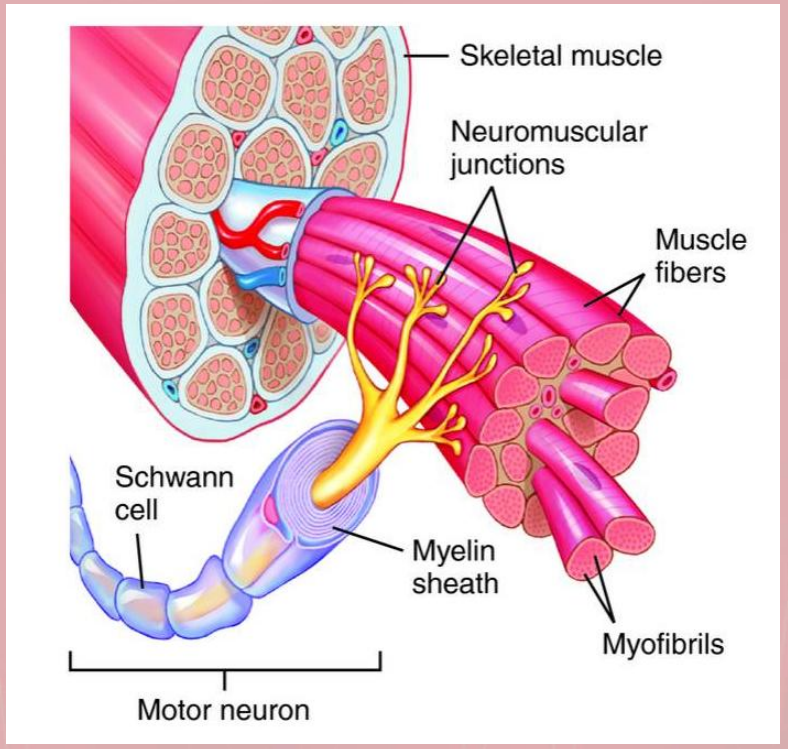
Motor Units

The *motor unit* refers to the muscle fibres which are influenced by each nerve.

The axons of the neurons can branch to one or many thousands of muscle fibres.

In large muscles, such as the quadriceps in the thigh, a motor unit may comprise 1000s of muscle fibres where big, powerful movements are required.

When precision is needed, such as movements of the eye, a motor unit may be 1–3 muscle fibres.



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Developing Muscle Tension

The All-or-None Principle of Motor Neuron Stimulation

The *all-or-none principle* of a motor unit states:

If an electric stimulus reaches a threshold level, then all of the muscle fibres associated with that unit will contract to their maximum level and all at the same time.

The relationship between muscle contraction and nerve function is similar to turning on a light in a darkened area.

Each time you 'flick the switch' a light will come on.

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Developing Muscle Tension

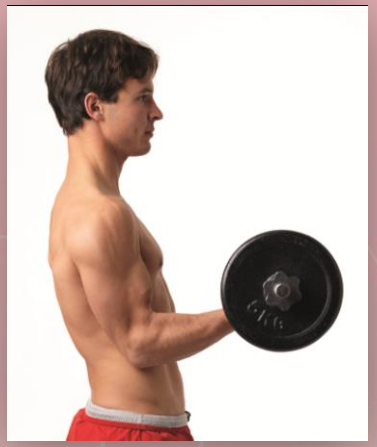
Neuromuscular Response to Strength Training

Improvements in muscular strength can occur in the first two to eight weeks of training without any changes in muscle size.

This is because the improvements first occur at the neuromuscular level, that is, the skill level of the movement improves.

There are four main responses to strength training without changes in muscle bulk:

1. improved technique
2. increased firing rate of motor units
3. more motor units are recruited, and
4. the firing pattern of the motor units are better coordinated.



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Muscle Fibre Types

Comparing Fast & Slow Twitch Muscle Fibres

	Type I fibres	Type IIa fibres	Type IIb fibres
Speed of contraction	Slow	Fast - intermediate	Fast - explosive
Endurance qualities	High	Low	Very low
Predominant energy system used	Aerobic	Anaerobic	Anaerobic
Size	Small	Large	Large
Colour	Red	White	White

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Muscles

Exam style question

Using your understanding of fibre types, explain how sprint athletes are born and not made.

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Muscles

Answer

Using your understanding of fibre types, explain how sprint athletes are born and not made.

Elite sprinters have relatively high percentages or predominance of Type II fibres (fast-twitch). You are born with and do not change your percentage of muscle fibre types. That is, they are determined by your genetic heritage (your parents) and do not change even with training. Therefore, the limits placed on your allocation of specific fibre types at birth, limits your ability to generate high levels of force in exceptionally short periods of time – as in sprinting.