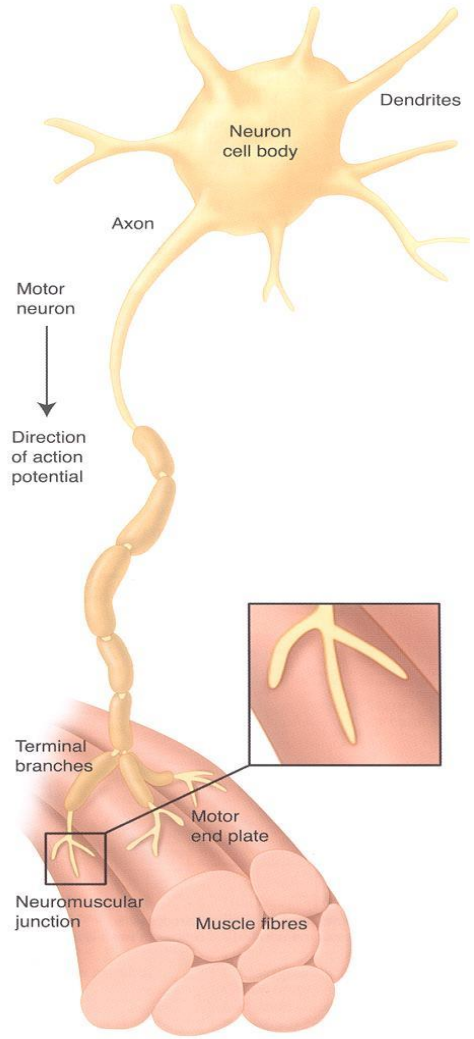
The Neuromuscular System

The neuromuscular system refers to the complex link between the nervous system and muscular system.

Muscle movement is controlled by the **motor nerve.** Motor nerves extend from the spinal cord to the muscle fibres.

Impulses are transmitted from the brain, through the central nervous system to the **motor unit.**



The Motor Unit

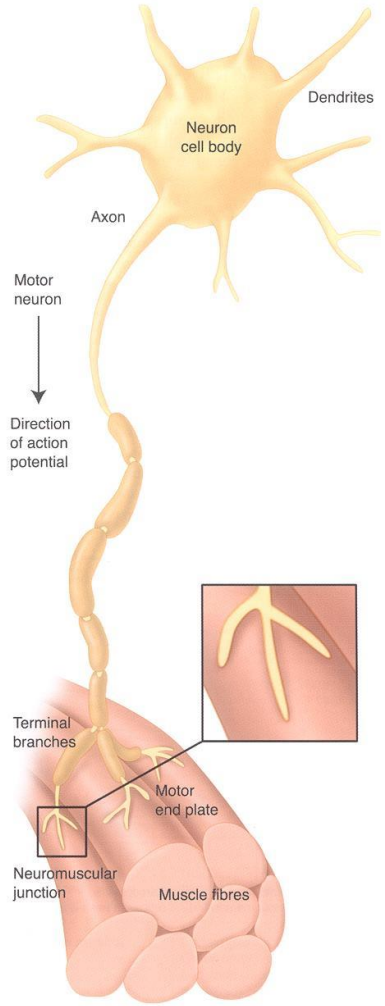
A motor unit is a group of muscle fibres activated by the same nerve.

Motor units can be categorized into small or large units

- Small motor units may have only a few muscle fibres that it stimulates. Necessary for fine motor control – eye

- Larger motor units may stimulate 300-800 muscle fibres to produce gross movement – arms and legs

All muscle fibres of a particular motor unit always of the same fibre type

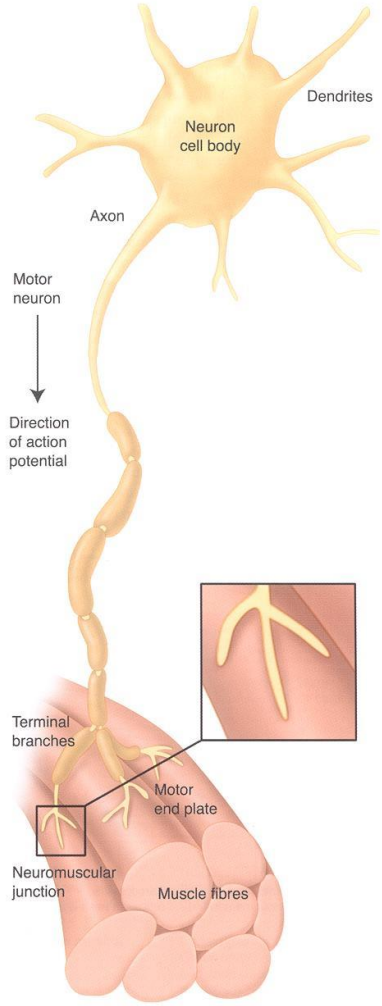


Each motor unit has a nerve cell (neuron) is made up of an **axon** and a **dendrite.**

The dendrite receives the motor impulse and it passes through the nerve cell to the axon.

At the muscle the fibre splits into numerous branches with each branch ending at the **motor end plate**.

Each muscle fibre is activated by impulses delivered through its motor end plate.

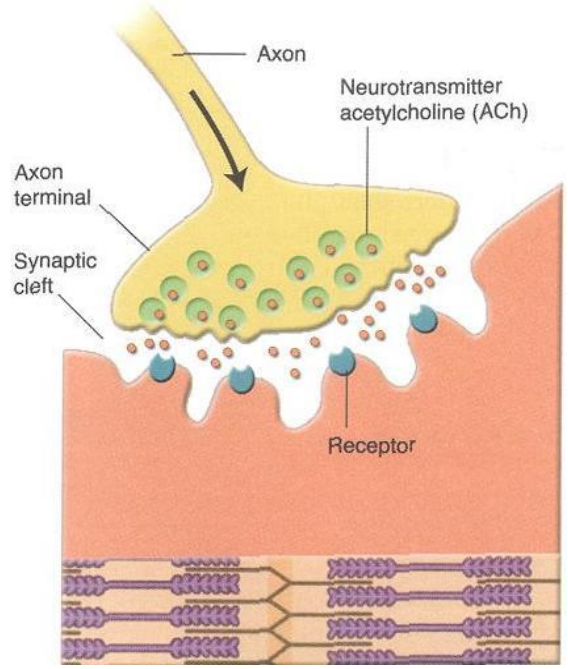


The Motor End Plate

At the motor end plate a chemical reaction takes place at the **neuromuscular junction** between the nervous system and the muscular system.

If a motor unit is activated it causes the muscle fibres to contract. This contraction is called a **muscle twitch**.

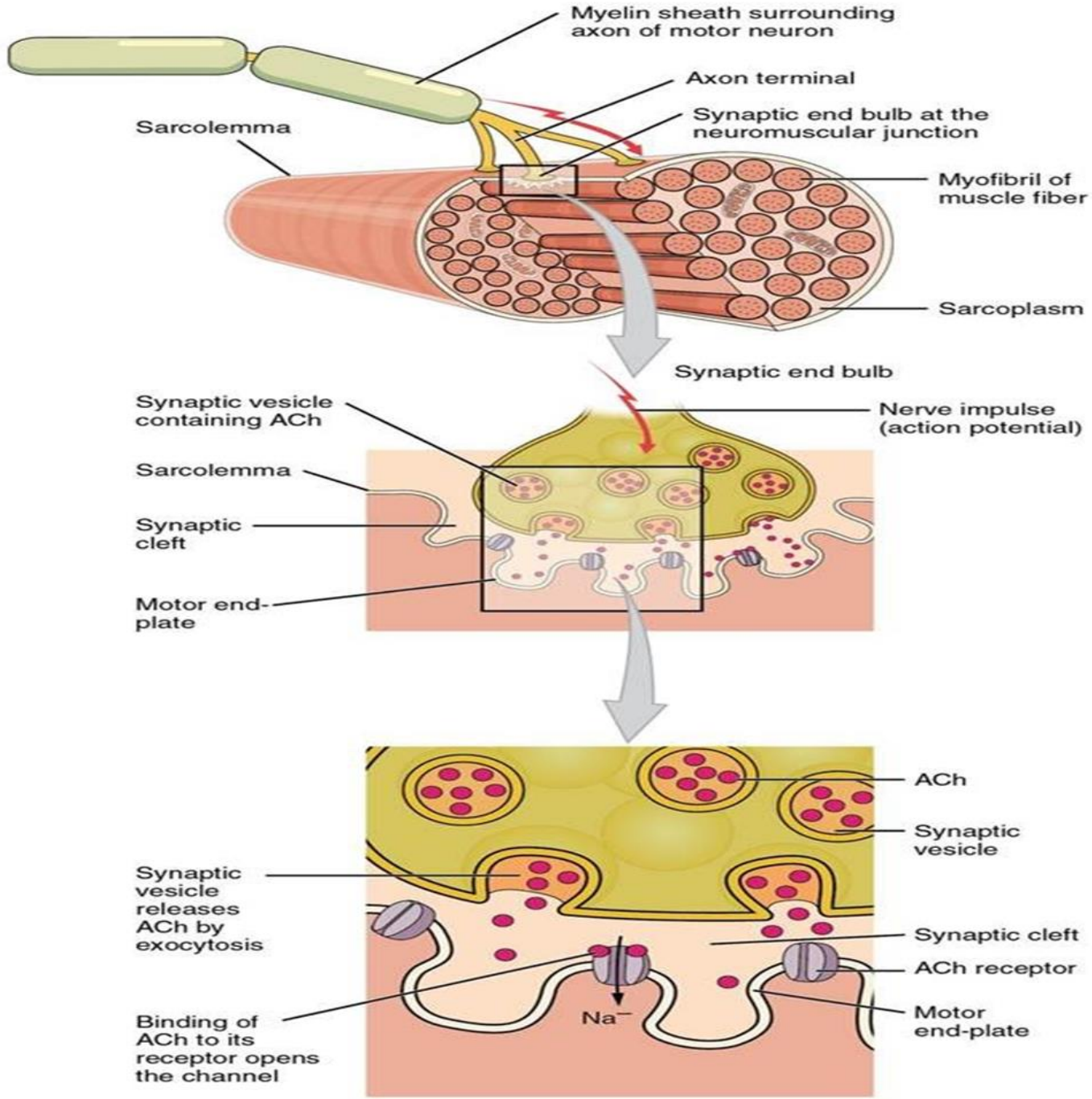
To ensure smooth movement the nerves send impulses in **waves.**



Neuromuscular Junction

Point at which the nerves transmit message directing the muscle to move and where the muscle come into CONTACT

1. Electrical impulse travels along nerve pathway to the “Junction” (between nerve and muscle)
2. Chemical “neurotransmitter” is released (ACh - acetylcholine)
3. Chemical is detected by receptors on the surface of the muscle fibre
4. Results in Muscle Contraction
5. Electrical energy is converted into chemical energy and then into mechanical work


Myelin sheath surrounding axon of motor neuron
Axon terminal
Synaptic end bulb at the neuromuscular junction
Sarcolemma
Myofibril of muscle fiber
Sarcoplasm
Synaptic end bulb
Synaptic vesicle containing ACh
Nerve impulse (action potential)
Sarcolemma
Synaptic cleft
Motor end-plate
ACh
Synaptic vesicle
Synaptic vesicle releases ACh by exocytosis
Synaptic cleft
ACh receptor
Na⁻
Motor end-plate
Binding of ACh to its receptor opens the channel

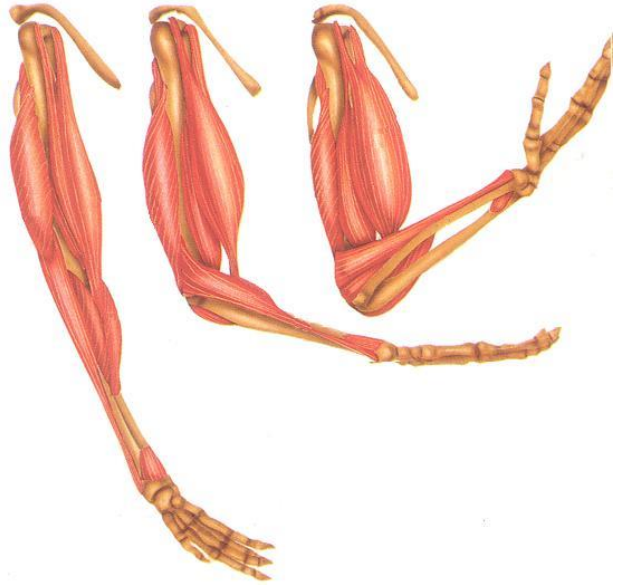
Muscle Contraction

Skeletal muscles are arranged in opposing pairs.

Since a muscle cannot expand, another muscle is required to move the bone in the opposite direction and stretch the first muscle. These muscles are **antagonist muscles.**

The muscle that contracts to initiate movement is called the ***agonist*** or ***prime mover***.

When the agonist contracts the ***antagonist*** must relax. The antagonist is a muscle that opposes movement.



Examples of Opposing Muscles

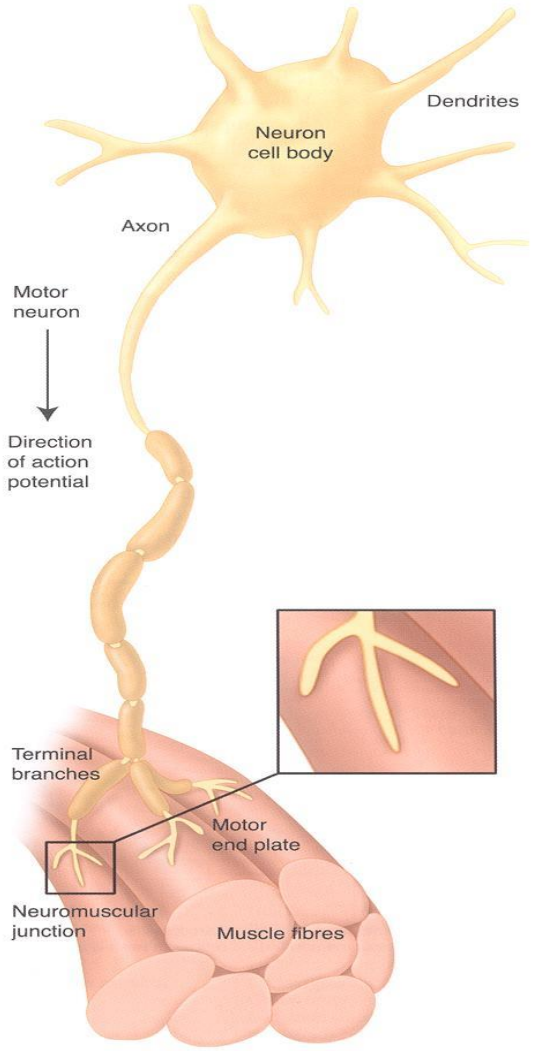
Action	Agonist (Prime Mover)	Antagonist
Elbow flexion	Biceps brachii	Triceps brachii
Shoulder abduction	Deltoid	Latissimus dorsi
Medial shoulder rotation	Pectoralis major	Infraspinatus
Knee extension	Quadriceps	Hamstrings
Wrist flexion	Flexor carpi radialis	Extensor carpi radialis
Dorsi flexion	Tibialis anterior	Gastrocnemius
Trunk flexion	Rectus abdominus	Erector spinae group
Hip flexion	Iliopsoas	Gluteus maximus

The All or None Principle

In order for maximum muscle force to be produced all of the motor units in a muscle or muscle group must be activated.

Every motor unit has a specific threshold that must be reached in order to be activated.

Each motor unit must be activated at the same time.



The All or None Principle Continued

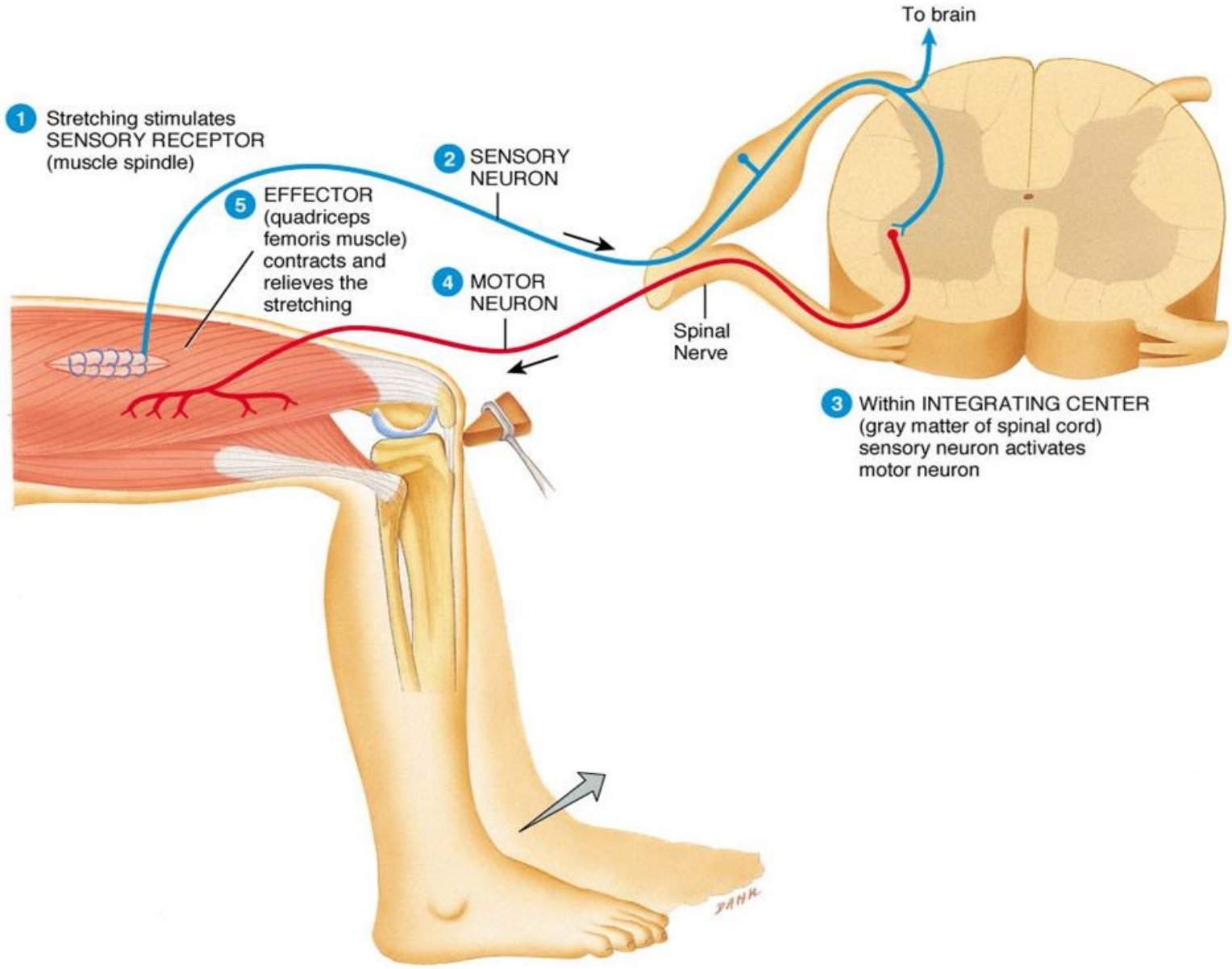
Once enough strength is transmitted the entire muscle fibre or group of fibres will contract according to the all or none principle.

When a motor unit contracts it will contract completely or not at all.

As the resistance increases, more motor units must be activated by stronger, more intense impulses.

- A weak nerve impulse will activate only those motor units that have a low threshold of activation.
- A stronger nerve impulse will activate additional motor units with higher thresholds.

The Reflex Arc



Intra-muscle Coordination

The ability to use motor units simultaneously is known as **intra-muscle coordination**

Trained athletes have not only a larger muscle mass than untrained individuals, but can also exploit a larger number of muscle fibres

Many highly trained power athletes, such as football linemen weightlifters and shot putters, are able to activate up to 85% of their available muscle fibres at the same time as compared to 60% for the untrained.

Inter-muscle Coordination

The interplay between muscles that generate movement through contraction (agonists) and muscles responsible for opposing movement (antagonists) is called **inter-muscle coordination**

The greater the participation of muscles and muscle groups, the higher the importance of inter-muscle coordination

High-level inter-muscle coordination greatly improves strength performance and also enhances the flow, rhythm, and precision of movement

Trained athlete is able to translate strength potential to enhance inter-muscle coordination

Reciprocal Innervation

Muscles seldom work alone. In almost all cases muscles work in pairs or groups to produce movement.

When you move your body, a coordinated action of several muscles must occur. Different muscles attached around the joint cooperate to produce a smooth efficient movement.

Reciprocal innervation is a process which produces the exact amount of relaxation in the antagonist to balance the amount of contraction generated in the agonist.

Reciprocal Innervation Continued

For example, in the human arm, the **triceps** acts to **extend** the lower arm outward while the **biceps** acts to the lower arm inward.

In order to reach optimum efficiency, **contraction of opposing muscles must be inhibited while muscles with the desired action are excited.** This reciprocal innervation occurs so that the contraction of a muscle results in the simultaneous relaxation of its corresponding antagonist.