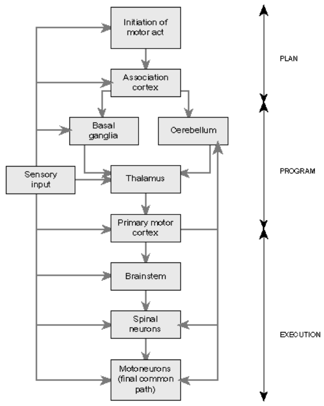
## MOTOR SYSTEM




- the group of muscle fibres that are innervated by the branches of a single nerve fibre (motor axon) is called a motor unit - the motor unit is the functional unit of the neuromuscular system.

- when the motor neuron produces an action potential all muscles fibres in the motor unit contract together.

- motor units vary in size from 2 or 3 muscle fibres to hundreds of muscle fibres

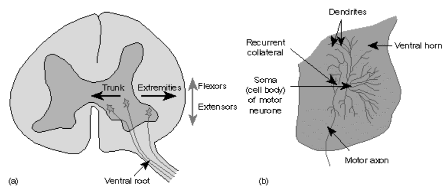
- the amount of force that a muscle generates during its contraction is controlled by the nervous system in two ways:

1) tension controlled in a single muscle fibre by frequency of the action potentials (frequency code).

2) more motor units can be activated to increase the force of contraction (population code).

- motor neurons that innervate a single muscle are functionally grouped in the spinal cord in motor neuron pools

- motor neurons within a single pool are located in several adjacent segments of the spinal cord



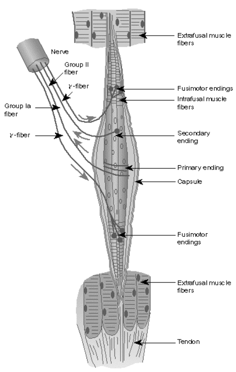

- motor units may be selectively activated or recruited.

- the first motor units to be activated are the smallest - size principle of motor unit recruitment.

- the recruitment of motor units in order of size leads to smooth increases in force.

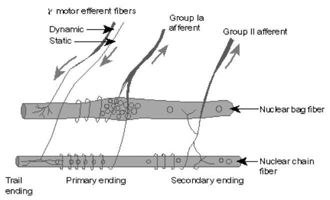
- muscles have two types of receptors associated with them: muscle spindles and golgi tendon organs

## Muscle Spindles



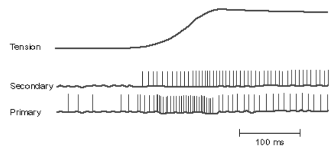
- muscle spindles made up of 2 types of intrafusal fibres: nuclear bag fibres and nuclear chain fibres

- afferent fibres of muscle spindles are Group 1 with the nuclear bag and chain fibres (Ia fibre) and Group II with the nuclear chain fibre.




-muscle spindle receptors provide information about muscle length.

- if a muscle is stretched 2 components can be seen in the response of muscle spindles: a phasic component in which the frequency of action potentials provides information on the rate of stretch and a tonic component in which the frequency of action potentials provides information on the muscle length.




- Ia fibres respond with both a phasic and tonic component and group II fibres with tonic component only.

- muscles that are involved in very fine delicate movements contain large numbers of muscle spindles while larger muscles have much lower density of muscle spindles.

- muscle spindles are also innervated by efferent fibres arising from neurons in the ventral horn of the spinal cord - γ-motor neurons

- the γ-motor neurons innervate the end of the intrafusal fibres → maintain the muscle spindle in its optimal sensitivity range

## Golgi tendon organs

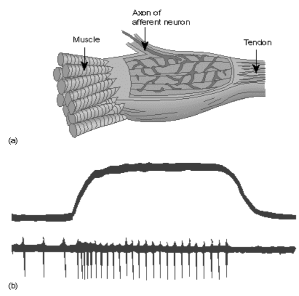
- golgi tendon organs are in series with the extrafusal muscle fibres.

- active when the muscle is stretched and provide information on the tension in a muscle.

- afferent Group Ib

- activity in the Ib afferent results in inhibition of the motor neurons that innervate the muscle under tension, and excitation of antagonist muscles.

- operates to prevent powerful active or passive muscle loading



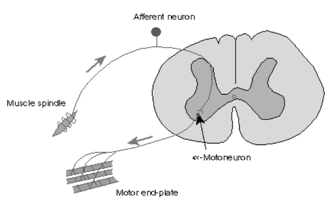

## REFLEXES

**Stretch reflex - (myotatic reflex)**

- example is the knee jerk reflex - tapping the patellor tendon results in stretching of muscle which also stretches the muscle spindle and activates the Ia nerve fibres.

- Ia activity proceeds to the spinal cord where the fibre synapses with a motor neuron that innervates the same muscle.

- this is an excitatory connection; the motor neuron activity causes contraction of the muscle, resulting in the leg kicking forward (extending).




- in order for the leg to extend need to inhibit the flexor muscles -> this is achieved by the muscle spindle afferent also activating an inhibitory interneuron in the spinal cord that inhibits the activity of a motor neuron that projects to the antagonist muscle.

- stretch reflex is a feedback loop that maintains muscle length and opposes passive increases in length.

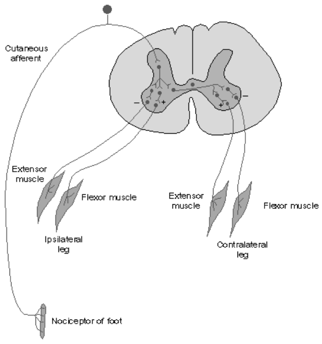
**Withdrawal reflex**

- involves cutaneous receptors, in particular nociceptors.

- information is sent to spinal cord where it influences both excitatory and inhibitory interneurons.

- reflexly activate flexors while the antagonist (extensors) are inhibited.

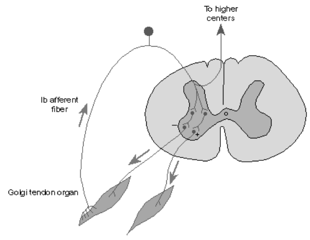
- with the injured leg flexed, in order to support the rest of the body the extensor muscles of the opposite leg must be activated -> termed <u>crossed-extensor reflex</u>.




**Golgi reflex - (inverse myotatic reflex)**

-if weight is too great for a muscle, Golgi tendon organ detects the potentially damaging tension and activates inhibitory interneurons to stop the muscle contraction.

- in addition, synergistic muscles are inhibited while antagonists are activated



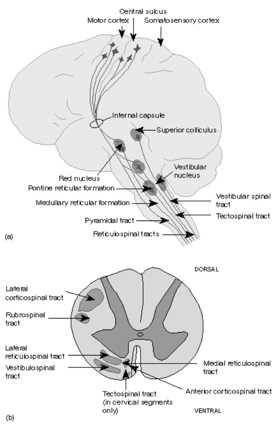

Central control of motor activity

-there are many areas of the brain and brainstem that are involved in the control of muscle and movement.

-maintenance and adjustment of posture is controlled to a large extent by groups of neurons in the brainstem.

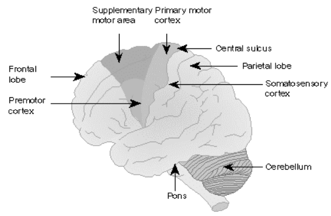
- these centres have their effect via nerve fibres that descend in the spinal cord and make connection with motor neurons

- these groups of neurons are not only involved in postural functions, but also in goal directed movements.




**Motor Cortex**

- the control of reaching and fine voluntary movements is due to instructions transmitted from the motor cortex to the spinal cord via descending nerve pathways.

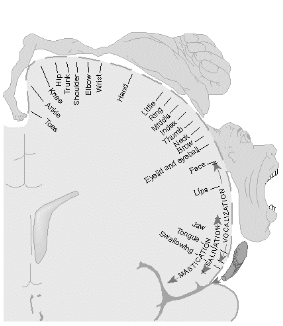



- the motor cortex is located anterior to the somatosensory cortex on the precentral gyrus (and further anterior into the frontal lobe).

-the organisation of the cells in the motor cortex is similar to that found in the somatosensory cortex in that they are topographically organised.

-certain body parts have a larger area of cortex, and therefore more cells, devoted to them e.g. fingers, lips, tongue the amount of cortical area devoted to the different parts is in proportion to its degree of fine motor control.

- there are 3 divisions of the motor cortex: primary motor cortex, premotor cortex, supplementary motor cortex.




**Primary Motor Cortex**

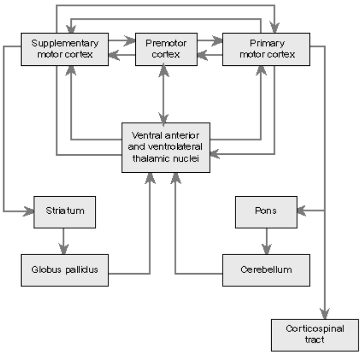
- neurons in this area give rise to nerve fibres that are involved primarily in controlling distal muscles and therefore fine movement control.

- they excite both alpha and gamma motor neurons.

- the nerve fibres from the primary motor cortex neurons descend in the corticospinal tract (sometimes referred to as the pyramidal tract).

**Premotor Cortex and Supplementary Motor Cortex**

- these two areas are primarily involved in determining the appropriate muscle groups required to achieve a desired movement (i.e. they are involved in developing the components of the motor program).




**Cerebellum**

- plays a crucial role in the nervous control of posture and movement

- its primary role is to supplement the activity of other motor centres and to correlate them (i.e. coordinate the activity of these centres).

- in particular it is responsible for:
    1) control of posture and muscle tone
    2) correction and coordination during slow goal-directed movement and coordination of these movements with posture.
    3) ensure smooth execution of rapid goal-directed movement.

-carries out these activities via corrections with other motor centres rather than by direct effects on motorneurons.

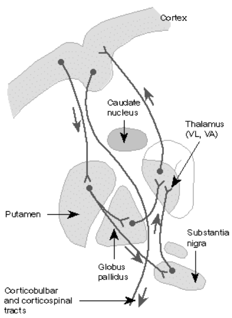
- lesions may result in dizziness and postural difficulties and/or in a generalized loss of motor control involving intention tremor, clumsiness and problems with speech

**Basal ganglia**

-consists of a number of groups of neurons located in the brain.

-these groups of neurons receive input from many other areas of the brain, both motor and non-motor and their output is mainly to the brainstem motor centres and to the motor area of the cerebral cortex.

-important in organising motor programs (i.e. sets of instructions concerned with the proper timing and sequence of activation of motor units).




-damage to the basal ganglia results in disorders referred to as dyskinesias (characterised by spontaneous movements such as flinging an arm) – chorea, ballismus, athetosis

- best known disorder associated with basal ganglia damage is Parkinson's disease – charactrised by tremor, muscle rigidity and slowness or absence of movement.