

Organization of the Nervous System and Motor Unit

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Classification of the Nervous System

- The nervous system can be divided (classified) in several ways into :
- A/ (1) Central and (2) Peripheral .
- B/ (1) Somatic and (2) Autonomic .
- C/ (1) Sensory and (2) Motor .

A/Central and Peripheral NS

- 1-Central Nervous System (CNS),
consisting of brain and spinal cord (with
its somatic and autonomic components) .
- 2-Peripheral Nervous System (PNS),
consisting of peripheral nerves (whether
somatic or autonomic peripheral nerves) .

Central Nervous System (CNS)

- The CNS (brain & spinal cord) constitute the majority of the nervous system.
- The CNS integrates the information that it receives from all parts of the body
- and also it initiates and coordinates the motor activity of all parts of the body
- Because they are delicate structures , the brain and spinal cord need to be protected from the external environment (including mechanical injury) .
- the brain is protected by the skull, while the spinal cord is protected by the vertebrae, and both are enclosed in the meninges .

Peripheral Nervous System (PNS)

- Comprises cranial nerves and spinal nerves .
- Cranial nerves :
 - arise from the brain skull (cranium) .
 - are 12 on either side (i.e., 12 pairs) .
 - The first two cranial nerves (Cr nerves I and II) arise from the cerebrum , while the rest of cranial nerves arise from the brainstem
- Spinal nerves :
 - Arise from the spinal cord.
 - They are 31 pairs : 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal.

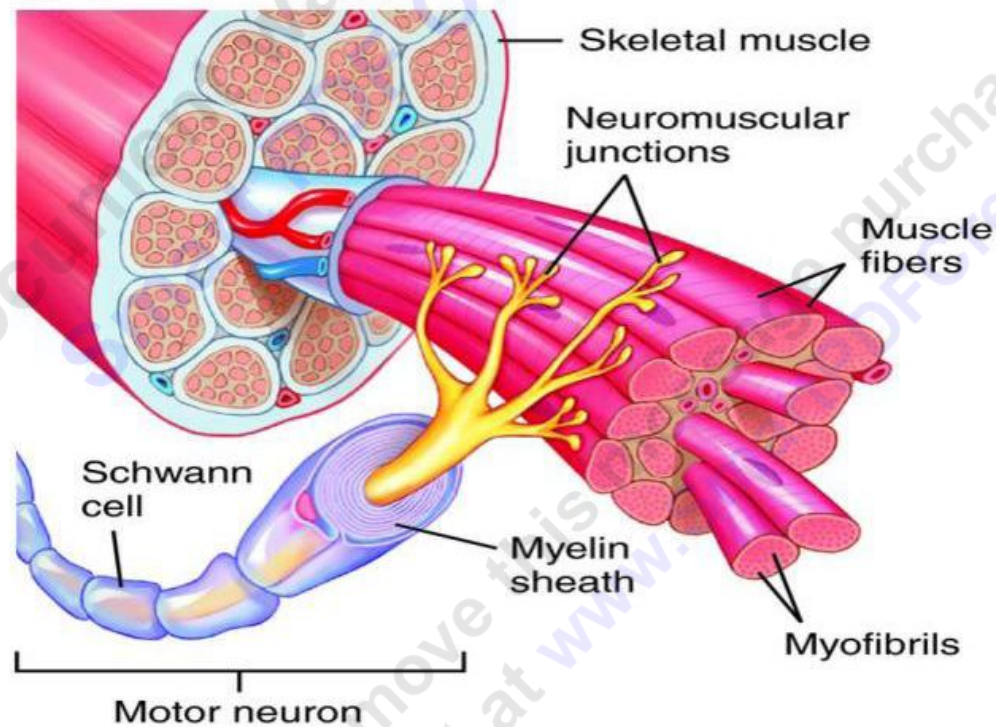
B/ Somatic & Autonomic NS

- (1) Somatic NS : concerned with
 - (i) somatic sensations → sensations from somatic structure , including body surface , &
 - (ii) voluntary movement
- (2) Autonomic NS : concerned with
 - (i) visceral sensations : sensations arising from internal structures (such as the heart , lungs , intestines , etc) ,
 - (ii) involuntary movements executed by smooth and cardiac muscles .
 - (iii) secretions by glands (endocrine & exocrine) , which are also involuntary

C/ Sensory & Motor NS

- Sensory neurons carry information from the stimulus receptor to the CNS .
- Motor neurons emerge from the CNS carrying motor orders to the effector organs (muscles and glands).

Motor unit



- Functionally speaking , muscles can be considered as being made of consist of a number of motor units
- A motor unit is the motor neuron and all muscle fibers within the muscle it innervates (supplied with it)
- All muscles consist of a number of motor units and the fibers belonging to a motor unit are dispersed and intermingle amongst fibers of other units.
- All of these fibers will be of the same type (either fast twitch or slow twitch) .
- When a motor unit is activated, all of its fibers contract.
- Groups of motor units often work together to coordinate the contractions of a single muscle
- All of the motor units that subserve a single muscle are considered a motor unit pool.

- The number of muscle fibers within each motor unit can vary →
- In general , the smaller the motor unit, the more precise the action of the muscle.
- Therefore , muscles that carry gross , unrefined movement have motor units containing large number of muscle fibers .
- Conversely , muscles that carry fine , refined movements (like muscles of the eye) have motor units containing small number of muscle fibers .
- In case of fine movement of eye muscles → A single motor neuron triggers fewer than 10 fibers in the muscles controlling eye movements (i.e., motor unit contains < 10 muscle fibers) .
- In case of gross movement of calf muscle → single motor unit can have a thousand fibers in each unit .
- For example , a single motor unit for a muscle like the Gastrocnemius (a calf muscle) may include 1000-2000 fibers .

- In electrodiagnostic testing (EMG) for a patient with weakness, careful analysis of the motor unit action potential (MUAP) size, shape, and recruitment pattern can help in distinguishing a myopathy from neuropathy.
 - Motor unit recruitment
- Recruitment of motor units is the progressive activation of a muscle by successive recruitment of contractile units (motor units) to accomplish increasing gradations of contractile strength.
- The muscle fibers belonging to one motor unit can be spread throughout part, or most of the entire muscle, depending on the number of fibers and size of the muscle.
- When a motor neuron is activated, all of the muscle fibers innervated by the motor neuron are stimulated and contract.

- The activation of one motor neuron will result in a weak but distributed muscle contraction.
- The activation of more motor neurons will result in more muscle fibers being activated, and therefore a stronger muscle contraction.
- Motor unit recruitment is a measure of how many motor neurons are activated in a particular muscle, and therefore is a measure of how many muscle fibers of that muscle are activated.
- The higher the motor unit recruitment , the stronger the muscle contraction .

Rate coding of muscle force

- The force produced by a single motor unit is determined in part by the number of muscle fibers in the unit.
- Another important determinant of force is the frequency with which the muscle fibers are stimulated by their innervating axon.
- The rate at which the nerve impulses arrive is known as the motor unit firing rate, and may vary from frequencies low enough to produce a series of single twitch contractions to frequencies high enough to produce a fused tetanic contraction.
- Generally, this allows a 2 to 4-fold change in force.
- In general, the motor unit firing rate of each individual motor unit increases with increasing muscular effort until a maximum rate is reached.

- Thanks