

Organization of the Nervous System and Motor unit BY

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Lecture2:- Organization of the Nervous System

Objectives:-

At the end of this lecture the student should be able to:-

- Diagnose what is the organization of the Nervous System**
- Appreciate differences between both central nervous system (CNS) & peripheral nervous system (PNS)**
- Identify motor unit**
- know function&recruitment of motor unit**
- Appreciate effect of motor units number on action performance**

Organization of the Nervous System

The nervous system is divided into the

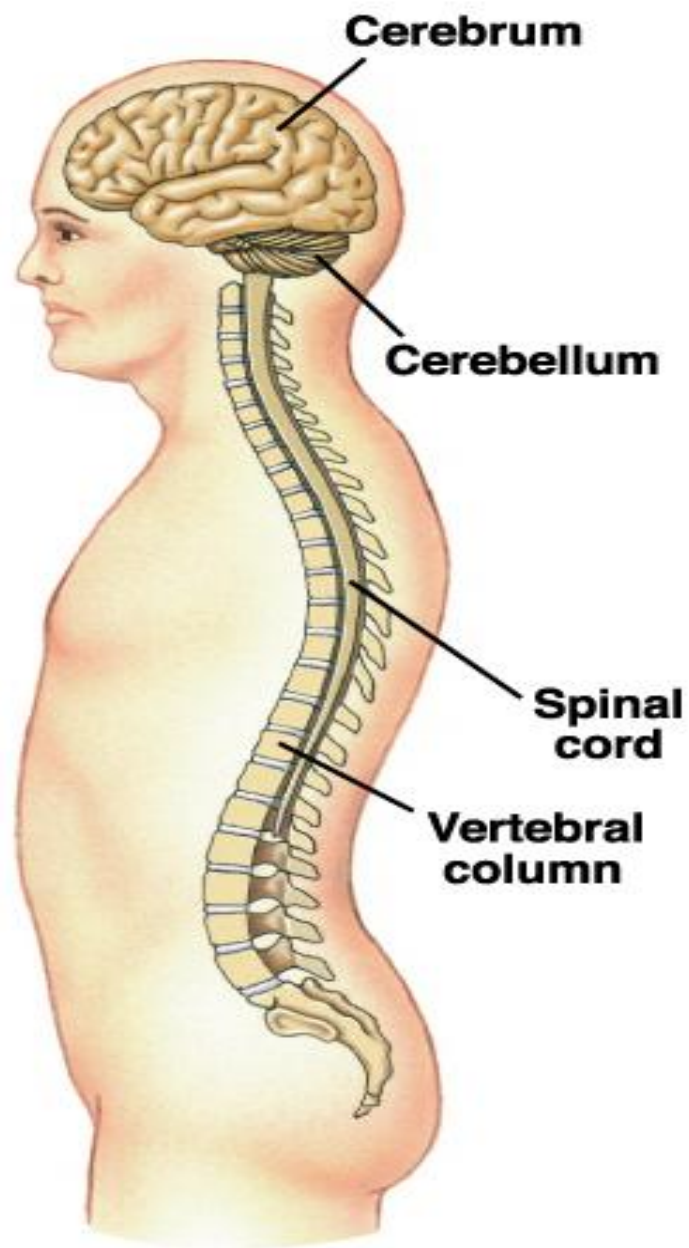
- 1- central nervous system (CNS)
- 2-peripheral nervous system (PNS)

1- Central nervous system (CNS)

- It is the part of the nervous system that integrates the information that it receives from, and coordinates the activity of all parts of the bodies
;It contains the majority of the nervous system and consists of

- 1- the brain
- 2-the spinal cord.

-the brain is protected by the skull, while the spinal cord is protected by the vertebrae, and both are enclosed in the meninges



- Brain: cerebral cortex & white matter has groups of nuclei & cerebellum
- - Two cerebral hemispheres connected together
- - Each hemisphere consists of frontal, parietal, temporal & occipital lobes
- - Cerebral cortex has sulci & gyri to increase brain surface area
- - Deep white matter has groups of nuclei as basal ganglia and others
- - Brain stem

- The peripheral nervous system is subdivided into the :-
- **1-sensory-somatic nervous system**
- **2- autonomic nervous system**

- **A-Sensory-somatic nervous system**

- - The actions of the Sensory-Somatic nervous system **are largely voluntary**
- operate through the sensory-somatic division of the PNS.
- The Sensory-Somatic Nervous System is concerned with all our conscious awareness of the external environment and all our motor activity to cope with it
- **The sensory-somatic system consists of**
 - 1-12 pairs of cranial nerves and
 - 2- 31 pairs of spinal nerves.
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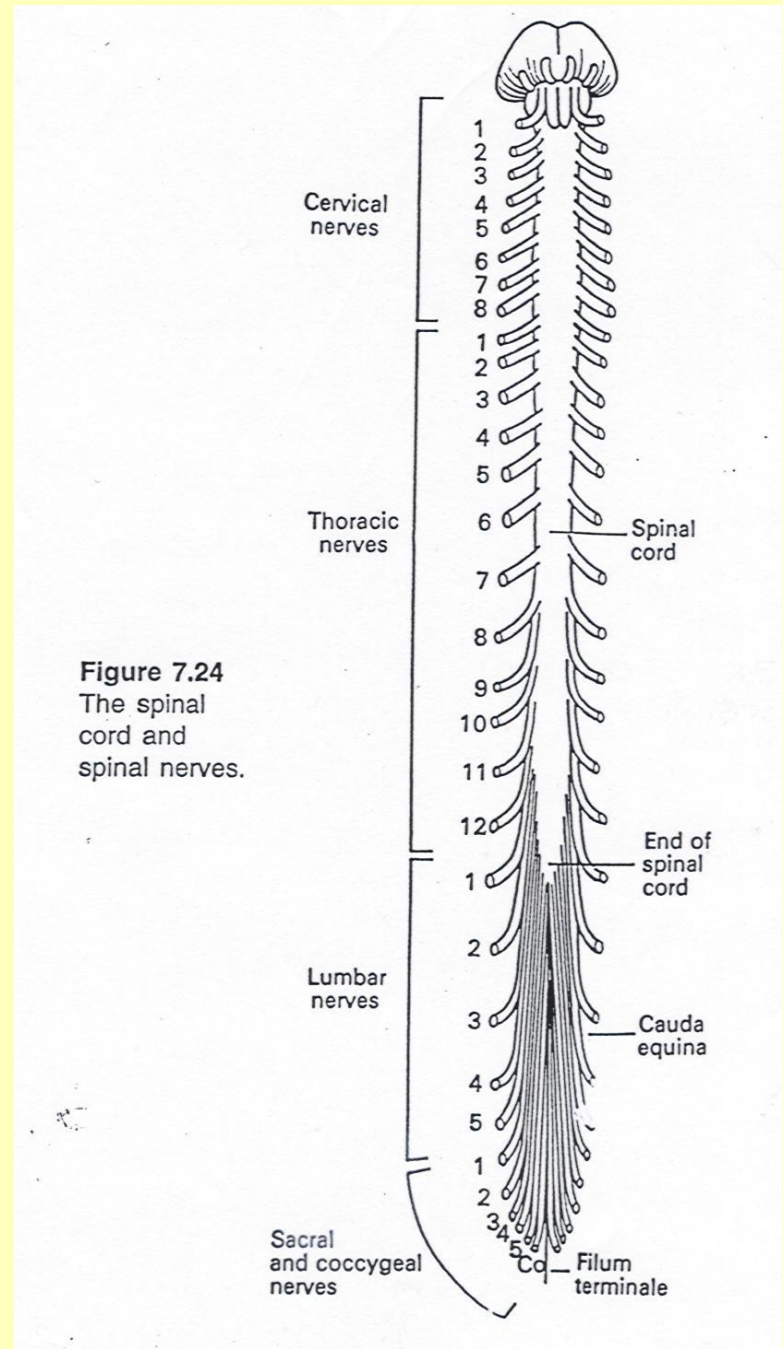
1-SPINAL NERVES:-

- Spinal nerves take their origins from the spinal cord.

-In humans, there are 31 pairs of spinal nerves: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal.

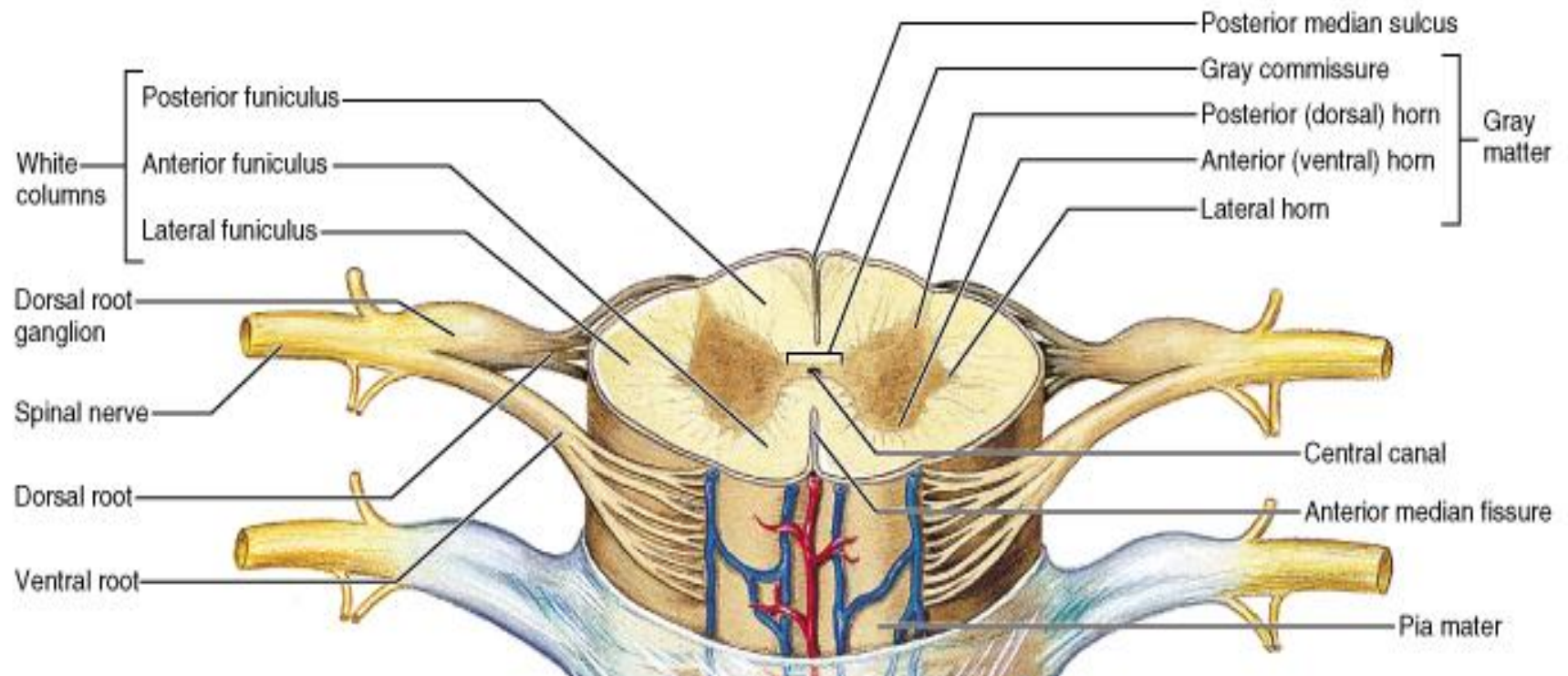
-They control the functions of the rest of the body.

- All of the spinal nerves are "mixed"; that is, they contain both sensory and motor neurons.(pass in dorsal & ventral root)



- **The sensory neurons are afferent neurons which relay nerve impulses toward the central nervous system.
- Sensory neurons running from stimulus receptors that inform the CNS about all types of sensations.
- (pass in the dorsal root)

- **The motor neurons are efferent neurons which relay nerve impulses away from the central nervous system to periphery (skeletal muscles , or gland) to take action.
- (pass in the ventral root)
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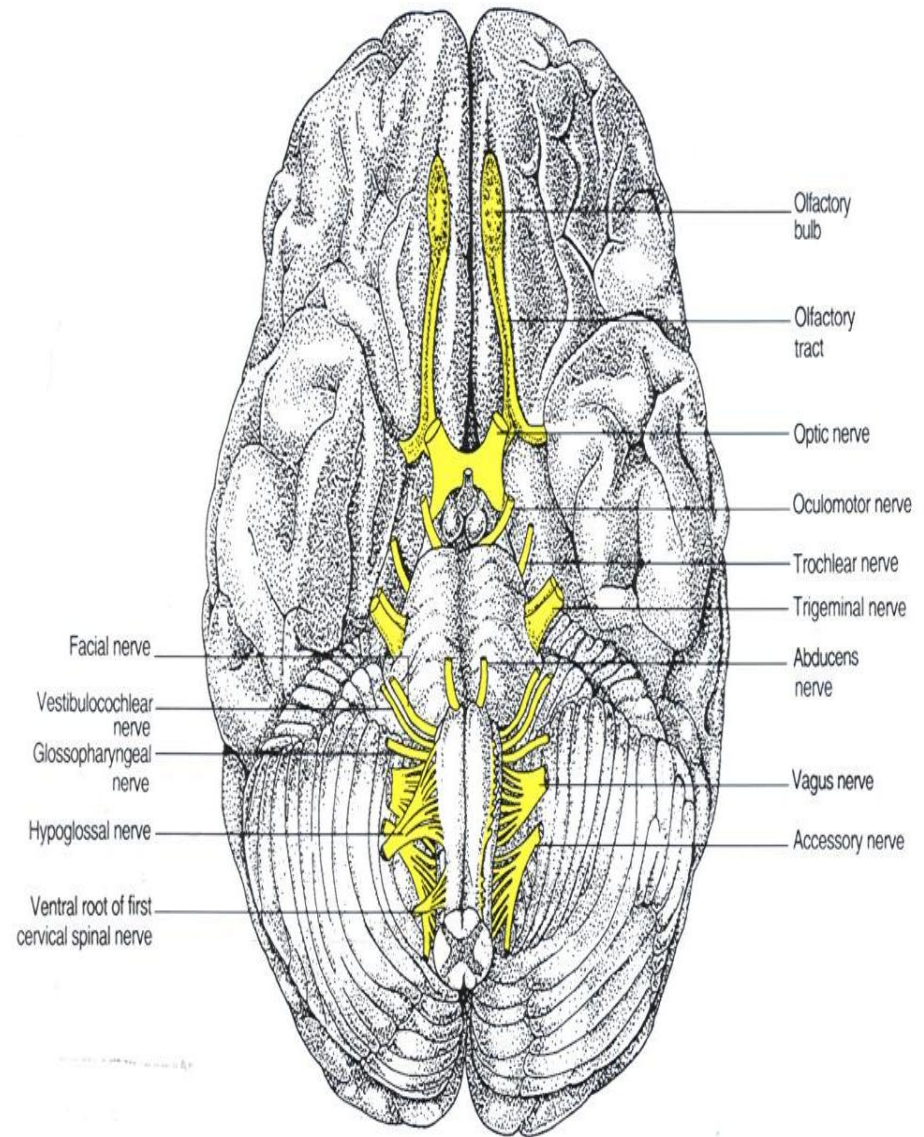
2-CRANIAL NERVES:-

- 12 PAIR

- Ten out of the twelve cranial nerves originate from the brainstem

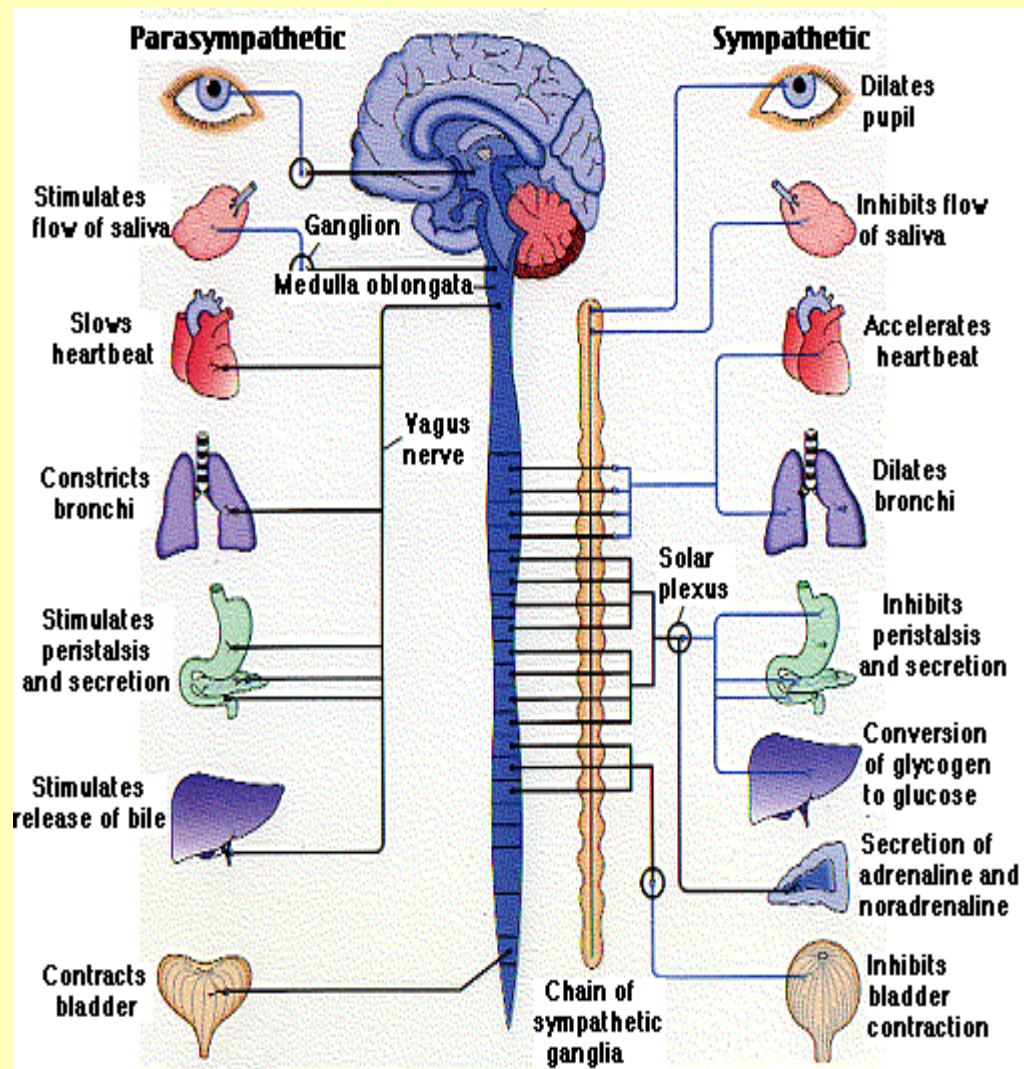
-mainly control the functions of all structures of the head with some exceptions.

-The nuclei of cranial nerves I and II lie in the forebrain and thalamus

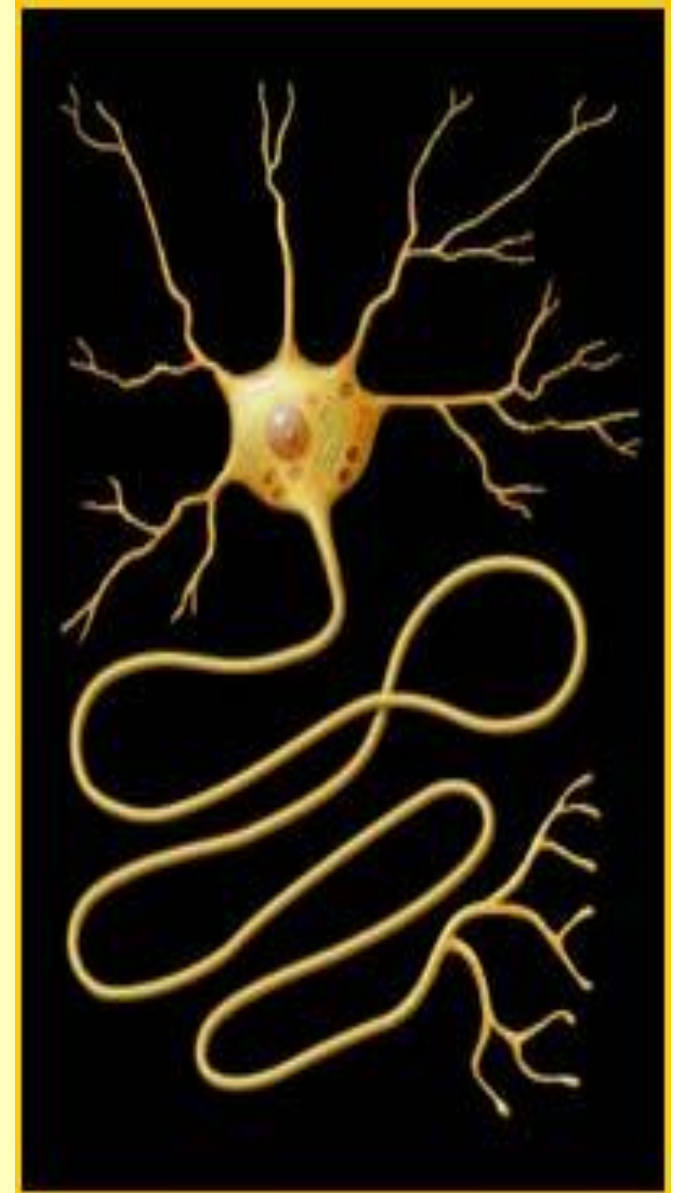


- **B-The Autonomic Nervous System**

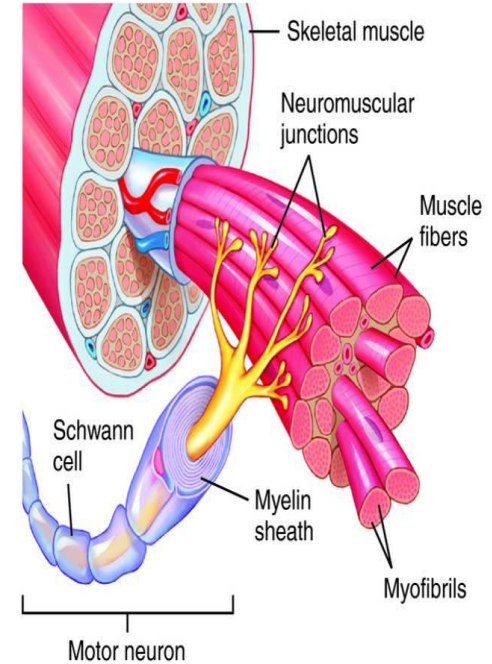
- The autonomic nervous system consists of neurons that run between the central nervous system (especially the hypothalamus and medulla oblongata) and various internal organs such as the:
 - heart
 - lungs
 - viscera
 - glands (both exocrine and endocrine)
- -It is responsible for monitoring conditions in the internal environment and bringing about appropriate changes in them.
- -The contraction of both smooth muscle and cardiac muscle is controlled by the autonomic system.
- -The actions of the autonomic nervous system are largely involuntary (in contrast to those of the sensory-somatic system).
- The first, the preganglionic neurons, arise in the CNS and run to a ganglion in the body.
- Here they synapse with postganglionic neurons, which run to the effector organ (cardiac muscle, smooth muscle, or a gland).
- -The autonomic nervous system has two subdivisions, the
 - 1-sympathetic nervous system and the
 - 2-parasympathetic nervous system.



- **Neuron:-**
- **-DIF;-**unit of function of the central nervous system, mostly anterior horn cell in the spinal cord supply skeletal muscle
- **Parts of motor neuron & function of each part:**
- **1- Soma (cell body)**
- **2-Dendrites** carry nerve impulses from surroundings to the soma
- **3 Axon hillock** at which nerve impulses begin & pass in one direction from soma to the axon(nerve fiber) then to axon terminal.
- **4-Axon and axon terminal end on skeletal muscle**
- Nerve cell **axons** are very thin, about 1 micrometer.
- However, they are extraordinarily long. For many motor neurons the axon is over a meter long, extending from the spinal column to a muscle cell



- Motor unit
- A motor unit is a single α -motor neuron and all of the corresponding muscle fibers it innervates (supplied with it)
- 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 unit can vary:
- - Fine movements/ need motor units have small number of muscle fibers
- - Gross movements/ need motor units have large number of muscle fibers
- -thigh muscles can have a thousand fibers in each unit& a single motor unit for a muscle like the gastrocnemius (calf) muscle may include 1000-2000 fibers
- - a single motor neuron triggers fewer than 10 fibers in the muscles controlling eye movements.
- -In general, the number of muscle fibers innervated by a motor unit is a function of a muscle's need for refined motion.
- - The smaller the motor unit, the more precise the action of the muscle.
- -Muscles requiring more refined motion are innervated by motor units that synapse with fewer muscle fibers.
- In medical electrodiagnostic testing 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 a neuropathy.

• Motor unit recruitment

- Motor unit recruitment is the progressive activation of a muscle by successive recruitment of contractile units (motor units) to accomplish increasing gradations of contractile strength.
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- All muscles consist of a number of motor units and the fibers belonging to a motor unit are dispersed amongst fibers of other units.
- -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 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 recruitment the stronger the muscle contraction will be

Rate coding of muscle force

The force produced by a single motor unit is determined in part by:-

- 1- the number of muscle fibers in the unit.
- 2- 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:-

- 1- frequencies low enough to produce a series of single twitch contractions
- 2- frequencies high enough to produce a fused tetanic contraction.

-- In general, the motor unit firing rate of each individual motor unit increases with increasing muscular effort until a maximum rate is reached.