

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 the 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 sensory information that it receives from diff parts of body , and coordinates the activity of all parts of the body .

It consists of :-

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

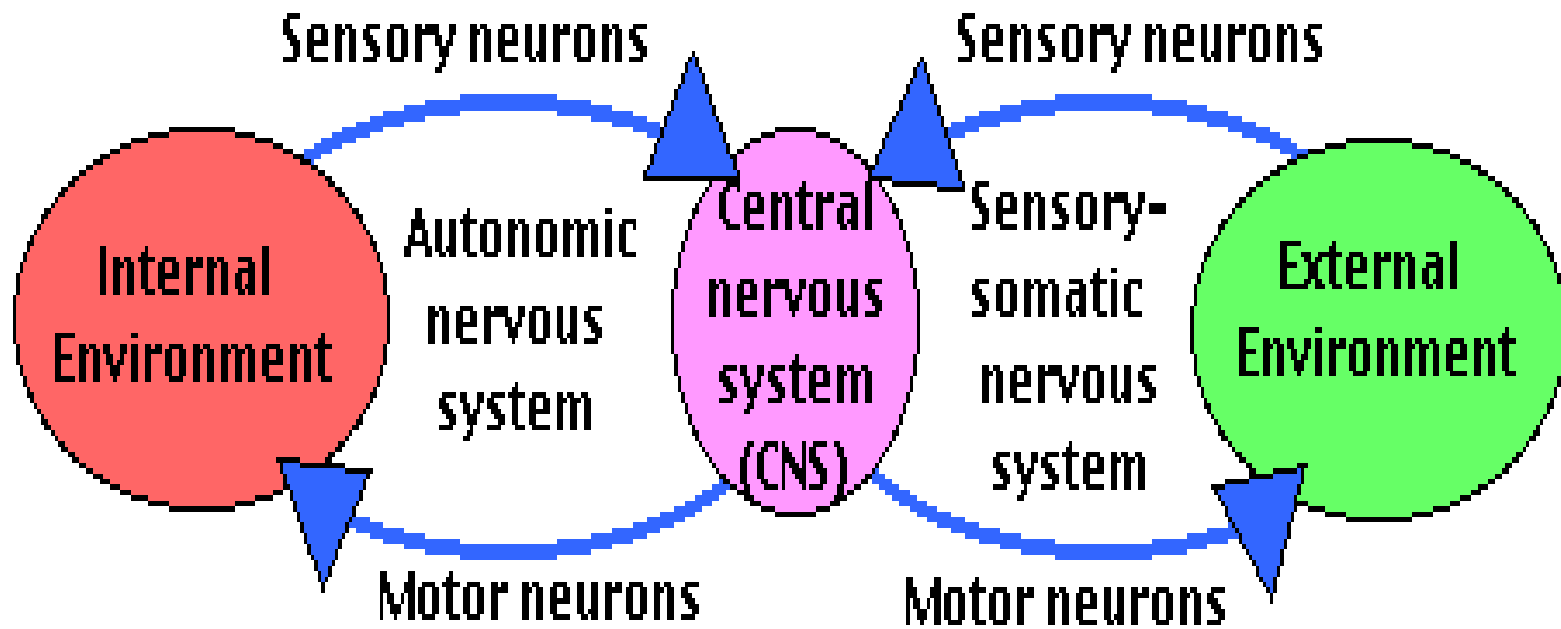
-the brain is protected by the skull, while the spinal cord is protected by the vertebrae, and both are enclosed in the meninges

- Brain:

- - 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
- - cerebellum

- Spinal cord:-
- - Consists of H- shape grey matter formed of neurons(nerve cells)
- -(dorsal horn has sensory neurons& ventral horn has motor neurons)
- - Surrounded by white matter of nerve fibers(tracts)

- **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** ارادية
- 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
- Operate through the sensory-somatic division of the PNS.
- **The sensory-somatic system consists of**
- 1-12 pairs of cranial nerves (control function of head & neck)
- 2- 31 pairs of spinal nerves.
- -All has sensory afferent & motor efferent
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1-SPINAL NERVES:-

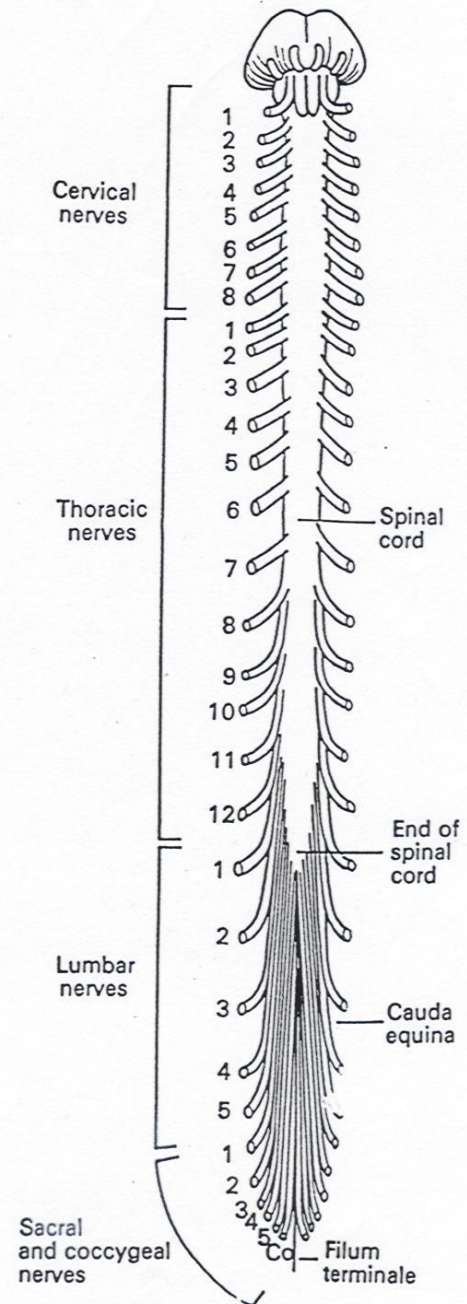
- Spinal nerves take their origins from the spinal cord.

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

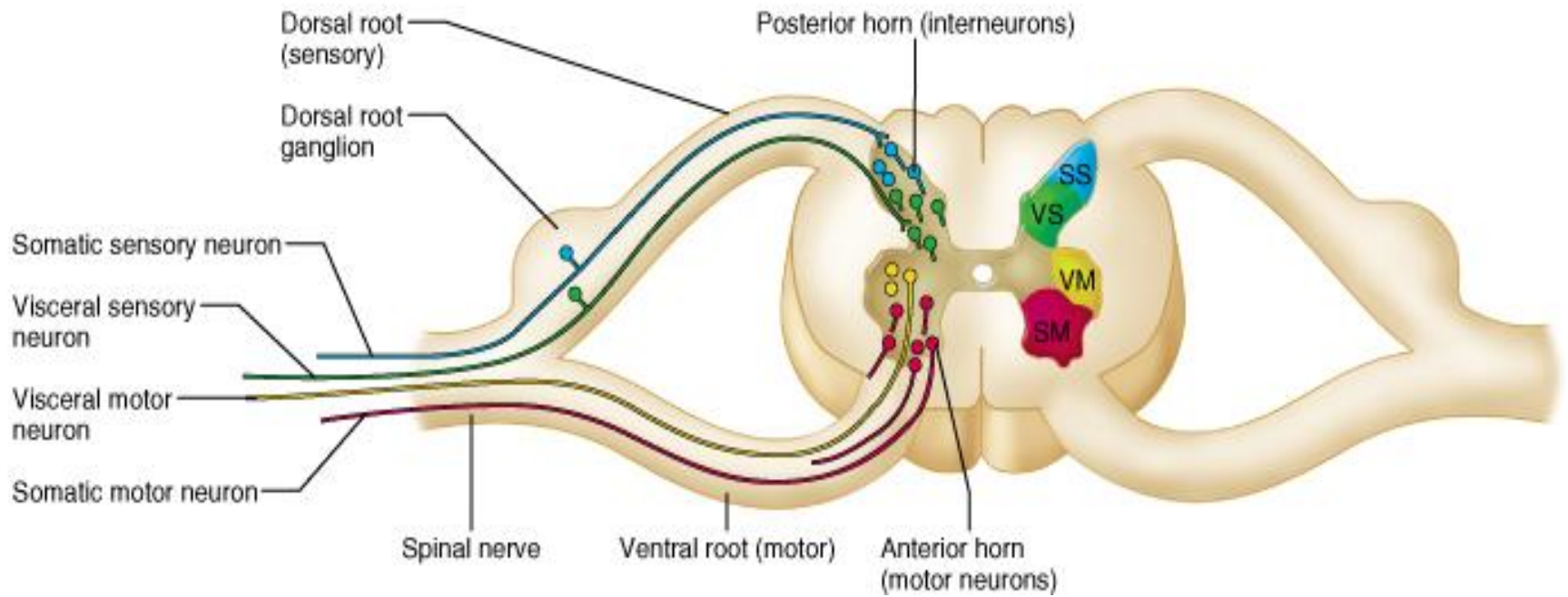
-They control the functions of all parts of body except head & neck.

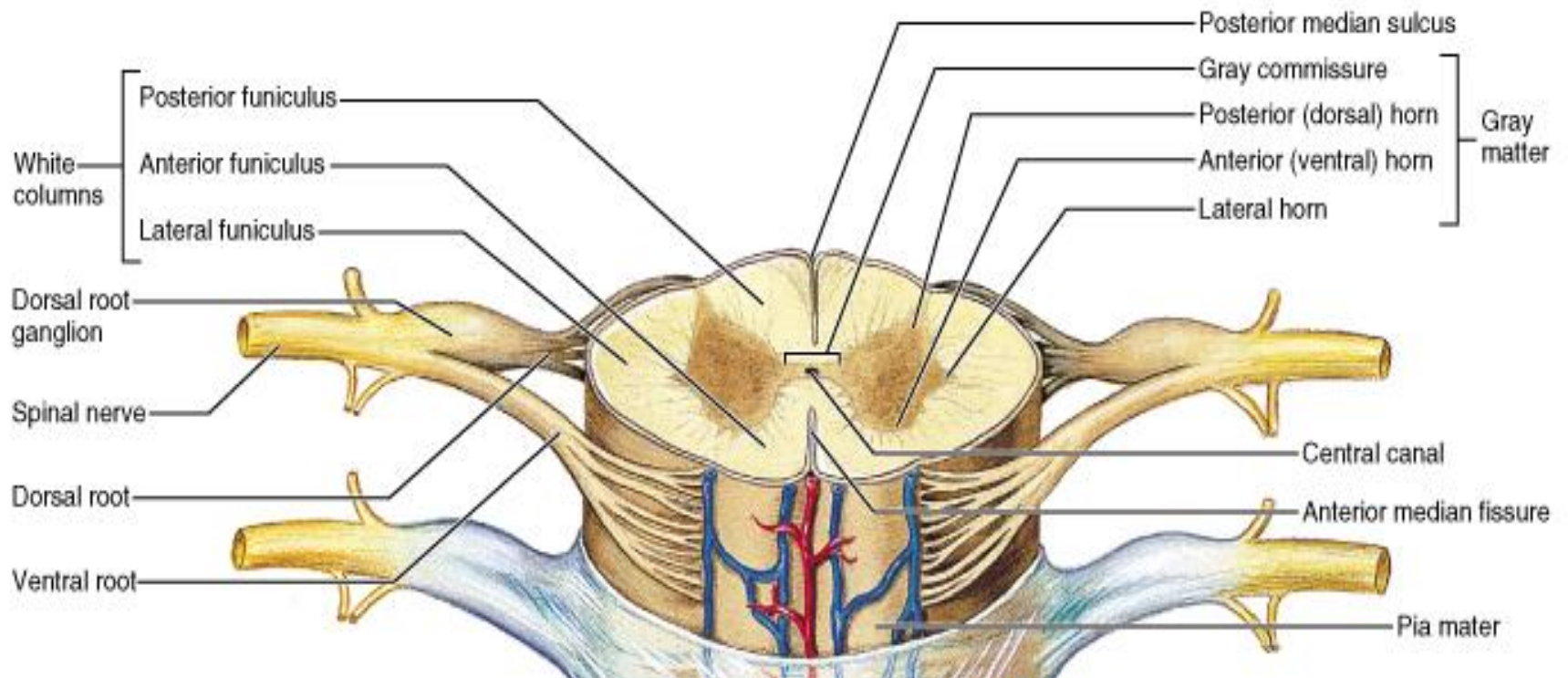
- All of the spinal nerves are "mixed"; that is, they contain both sensory and motor neurons.(pass in dorsal & ventral root)

Figure 7.24
The spinal cord and spinal nerves.



- **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.(pain,touch...etc)(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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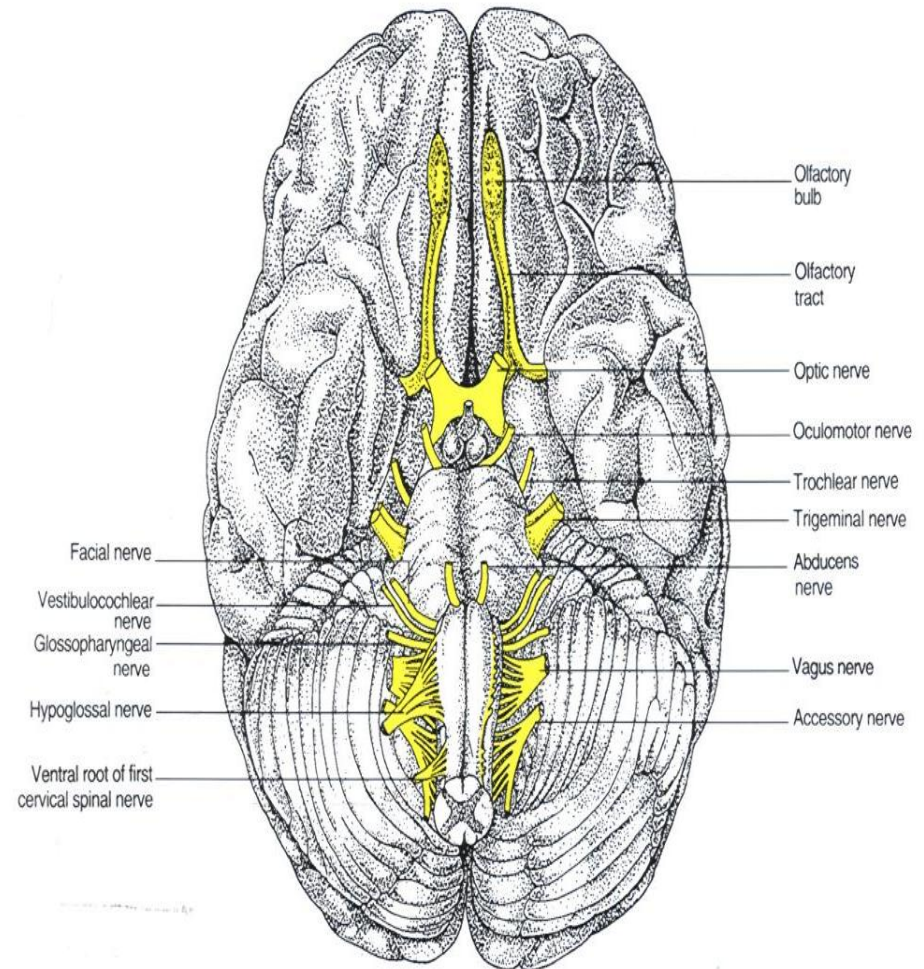
2-CRANIAL NERVES:-

- 12 PAIR

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

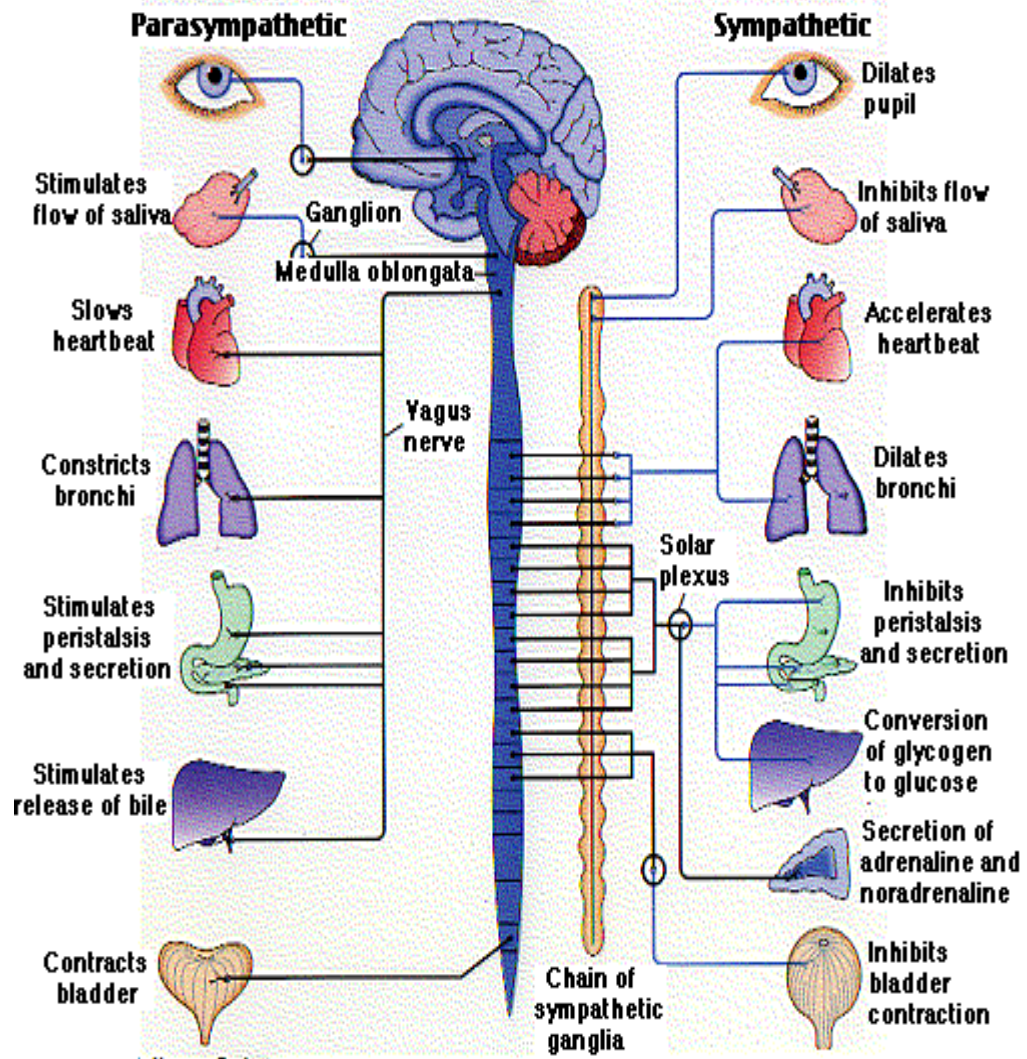
-The nuclei of cranial nerves I and II lie in the forebrain and thalamus

-_mainly control the functions of all structures of the head & neck with some exceptions.



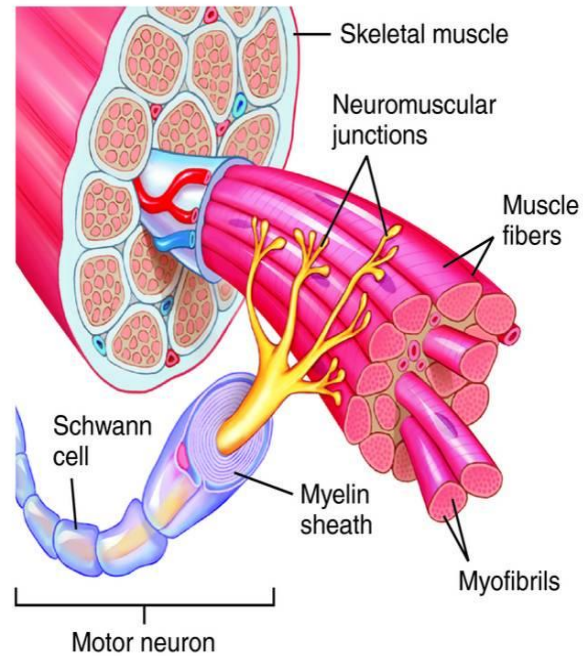
- **B-The Autonomic Nervous System**

- 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 **يشبك** with postganglionic neurons, which run to the effector organ (cardiac muscle, smooth muscle, or a gland).
- -The autonomic nervous system has two subdivisions :-
 - 1-sympathetic nervous system
 - 2-parasympathetic nervous system.



Motor unit

وحدة حركية



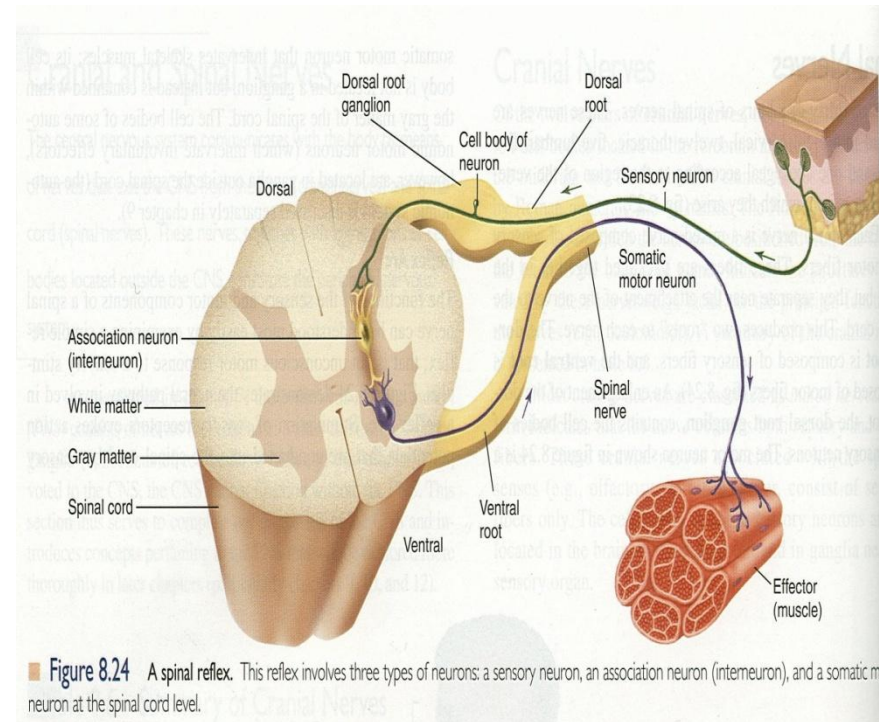
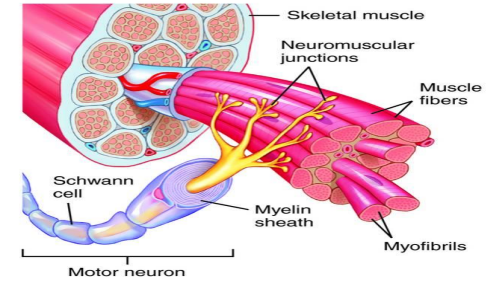
• Neuron:-

- -DIF;-unit of function of the central nervous system, Either sensory or motor
- Motor neuron is 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** التشعبات carry nerve impulses from surroundings to the soma
 - 3 **Axon hillock** بروز 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 via neuromuscular junction**
- 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 muscle fibers will be of the same type (either fast twitch fibers or slow twitch-انتفاض).
- -When a motor unit is activated, all of its muscle fibers contract.
- Groups of motor units often work together to coordinate the contractions of a single muscle
- -all of the motor units that subserve تنفيذ a single muscle are considered a motor unit pool.



- The number of muscle fibers within each motor unit can vary according to type of muscle movements:
- - Fine movements الحركات الدقيقة / need motor units have small number of muscle fibers
 - Gross movements الحركات الجسيمة / need motor units have large number of muscle fibers
- -Thigh muscles can have a thousand fibers in each motor unit
- - A single motor unit for a muscle like the gastrocnemius (calf) muscle (for gross movements) may include 1000-2000 muscle fibers
- - A single motor unit for eye muscle controlling eye movements (fine movements) may trigger fewer than 10 muscle fibers

- -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 number of muscle fibers in the motor unit, the more precise **دقيق** 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 muscle **weakness**, careful analysis of the motor unit action potential (MUAP) size, shape, and recruitment pattern can help in distinguishing a **myopathy** **مرض عضلى** from a **neuropathy** **مرض فى الاعصاب**

- **Motor unit recruitment**التوظيف
- 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 each one has its own muscle fibers belonging to it.
- -When a motor neuron is activated, all of the muscle fibers innervated by this motor neuron are stimulated and contract.
- The activation of **one motor neuron** (motor unit) will result **in a weak muscle contraction**.
- The activation **of more motor neurons (multiple motor units)** 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 of muscle contraction produced by a single motor unit is determined in part by:-

- 1- the number of muscle fibers in the unit.
- 2- the frequency of nerve impulses **نبضات عصبية** 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**. **انقباض تقلصي**
مدموج (contraction without relaxation)

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