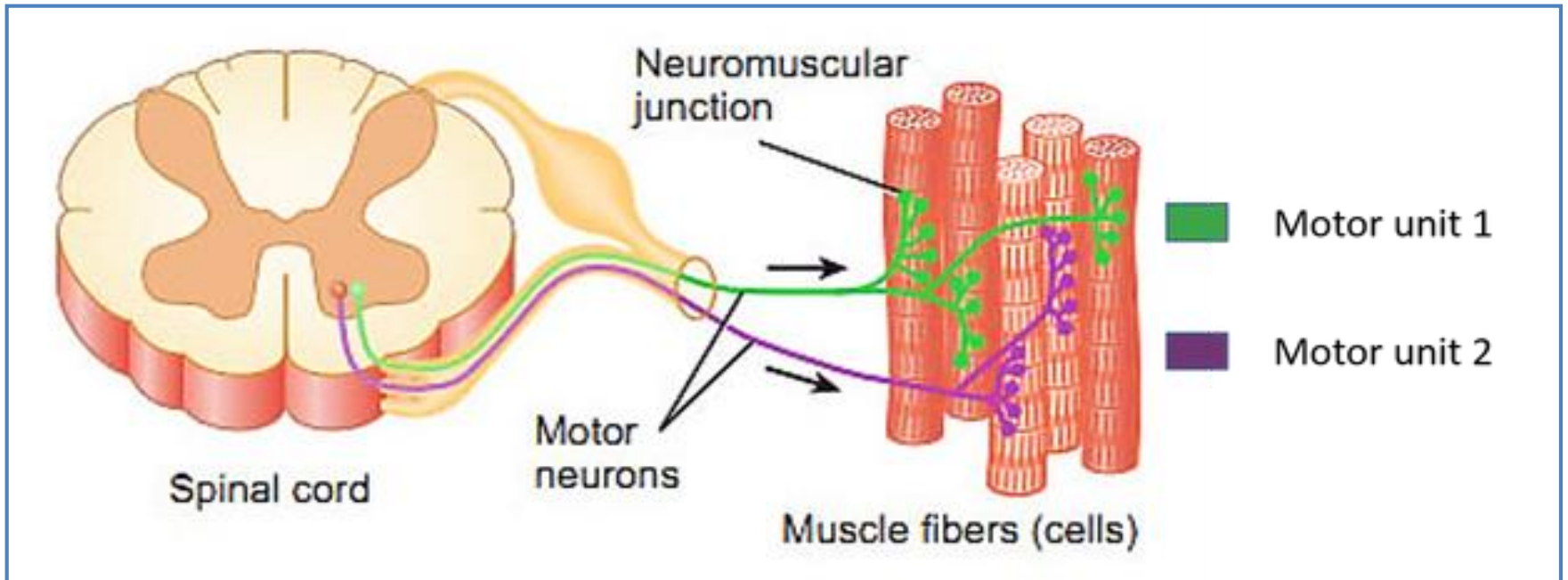


# Motor Unit



**Dr. Aida Korish**  
**Assoc. Prof. Physiology**  
**KSU**

# Objectives

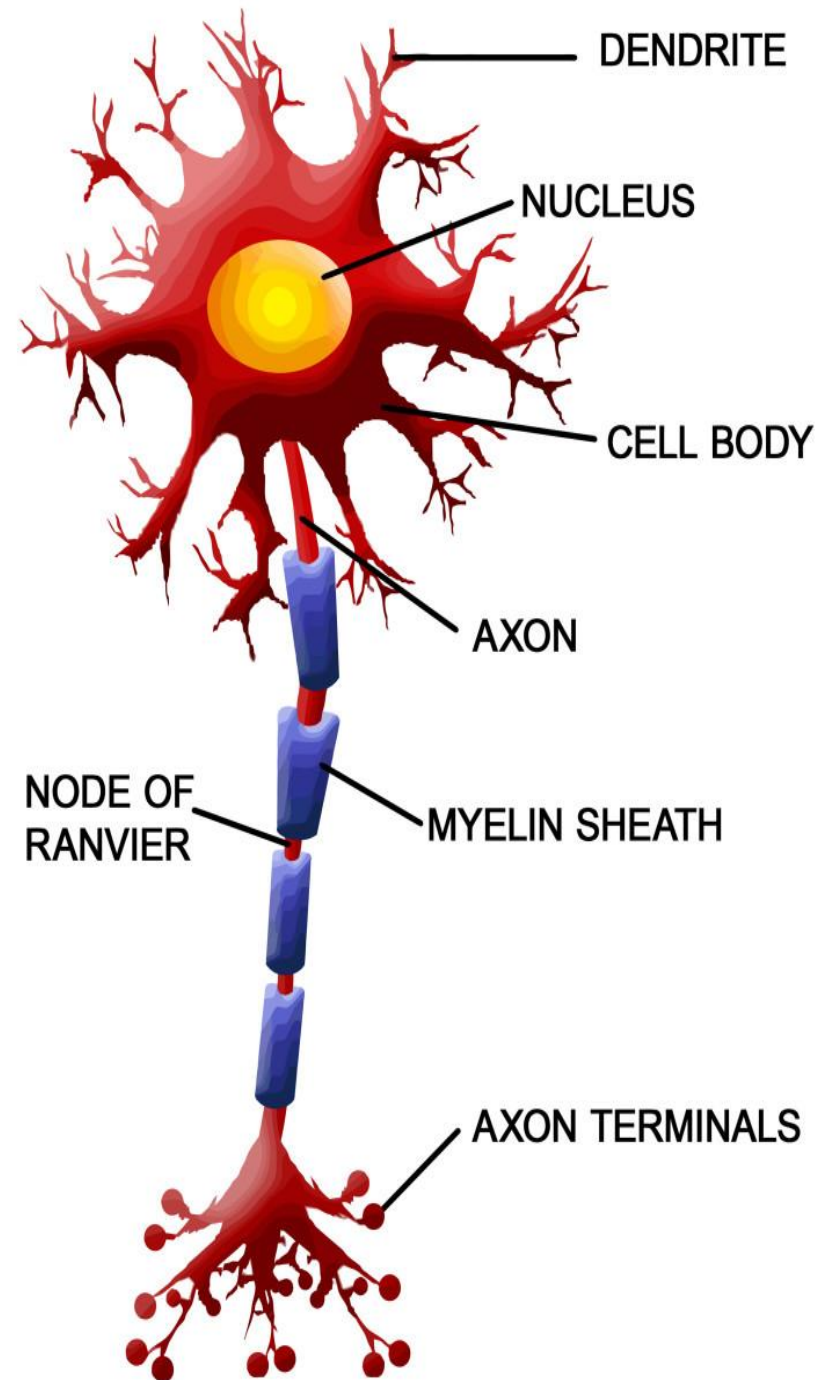
**At the end of this lecture you should be able to:**

- 1-Recognize the organization of the nervous system.
- 2-Detect the differences between central nervous system (CNS) and the peripheral nervous system (PNS).
- 3-Discuss the functions and recruitment of the motor unit.
- 4- Interpret the effect of motor units number on motor action performance.

# Neurons

**The building unit** of the nervous system is the neuron which has

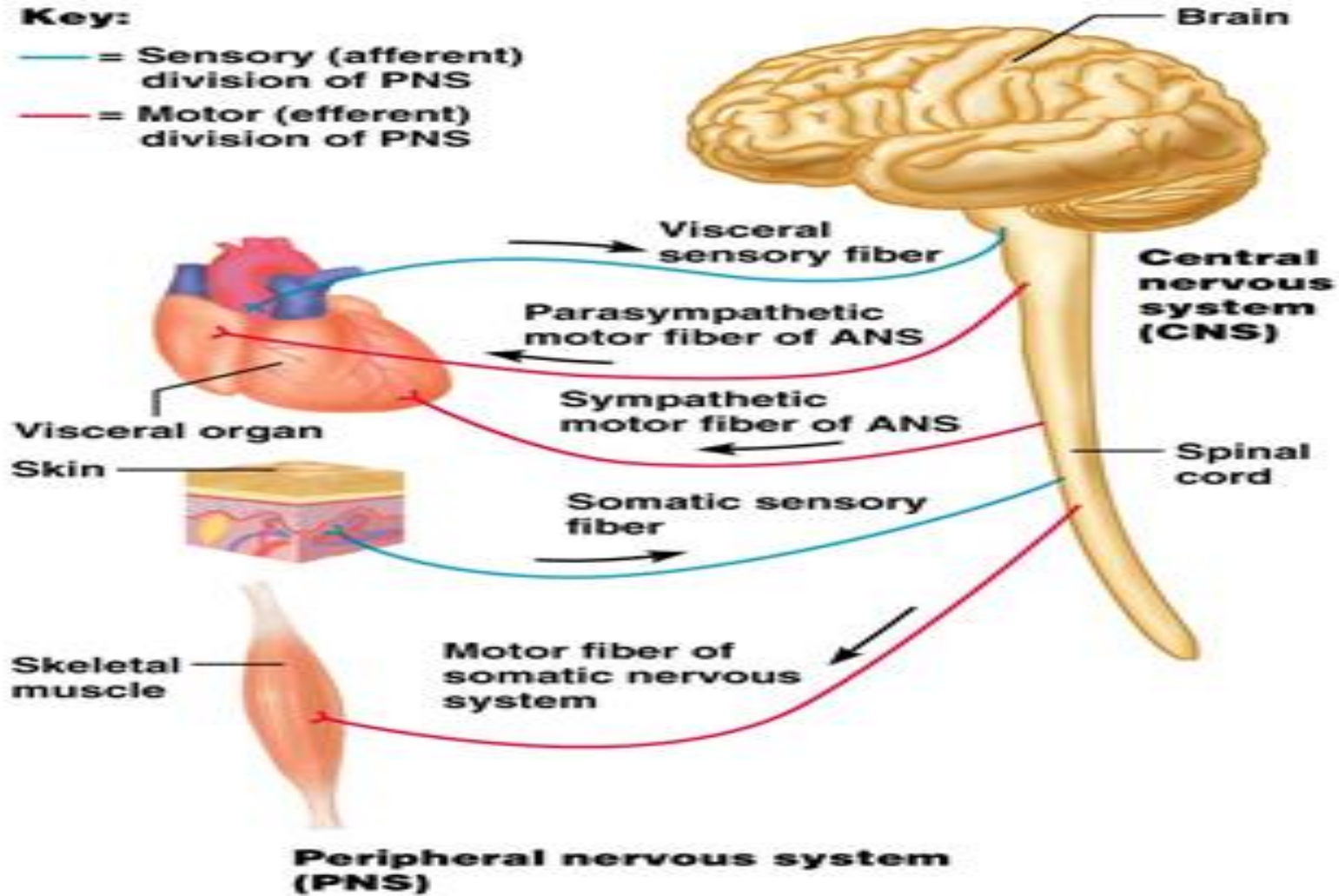
- Cell body
  - Nucleus
- Dendrites
- Axon
  - Myelination
  - Nodes of Ranvier
- Axon terminals
- Synaptic end bulbs
- Neurotransmitter
  - Acetylcholine (ACH)



# Organization of Nervous System

## Key:

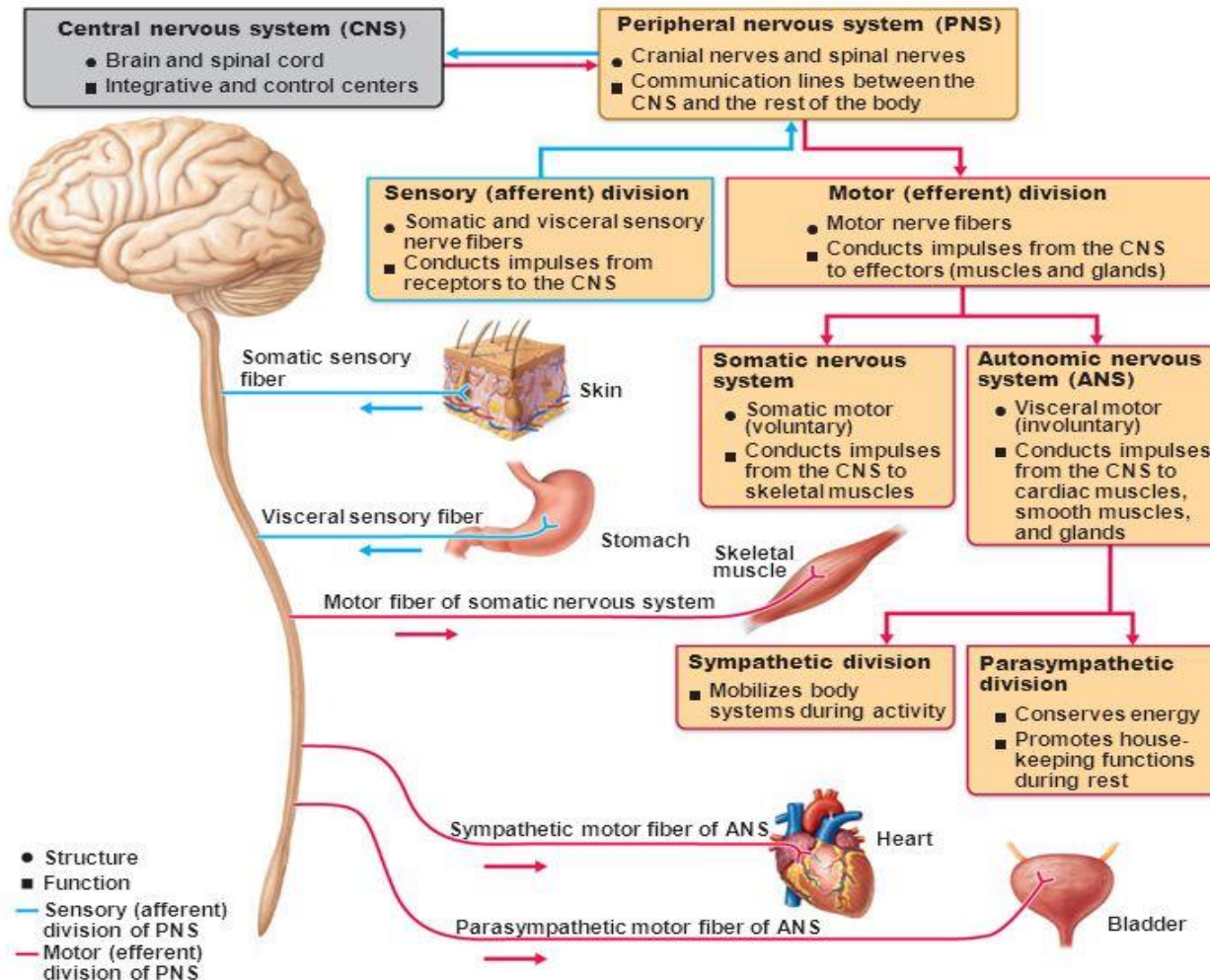
- = Sensory (afferent) division of PNS
- = Motor (efferent) division of PNS



(b)

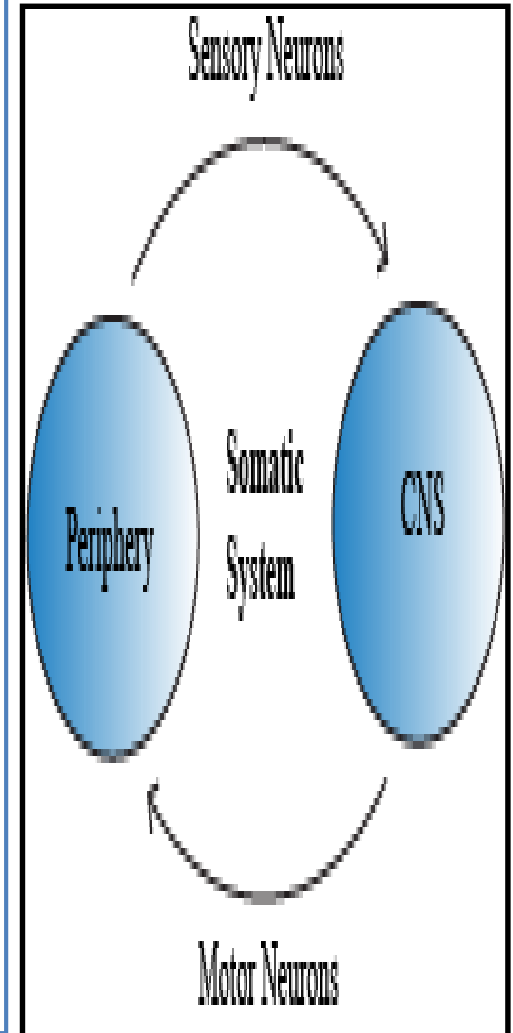
# Organization of The Nervous System

Figure 11.2 Schematic of levels of organization in the nervous system.

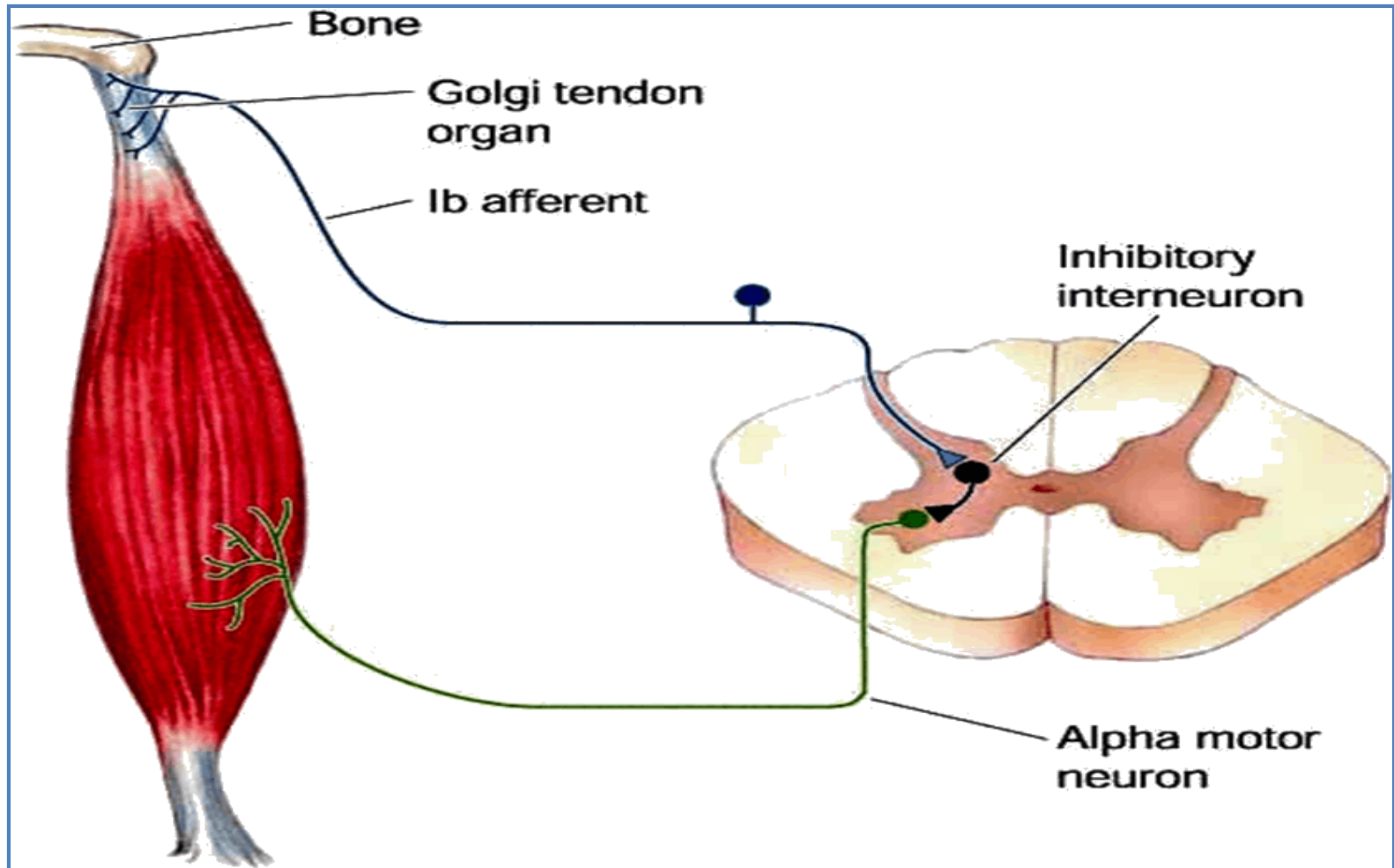


# Nerve-Muscle Interaction

- The nervous system can be divided into central (CNS) and peripheral (PNS).
- PNS can be divided in terms of function into motor and sensory activities.
- **Sensory Neurons:** collects information from the various receptors located throughout the body and transmits them to the brain.
- **Motor Neurons:** conducts signals to activate muscle contraction.
- Skeletal muscle activation is initiated through neural activation.
- **A nerve is made up of a group of axons of neurons.**

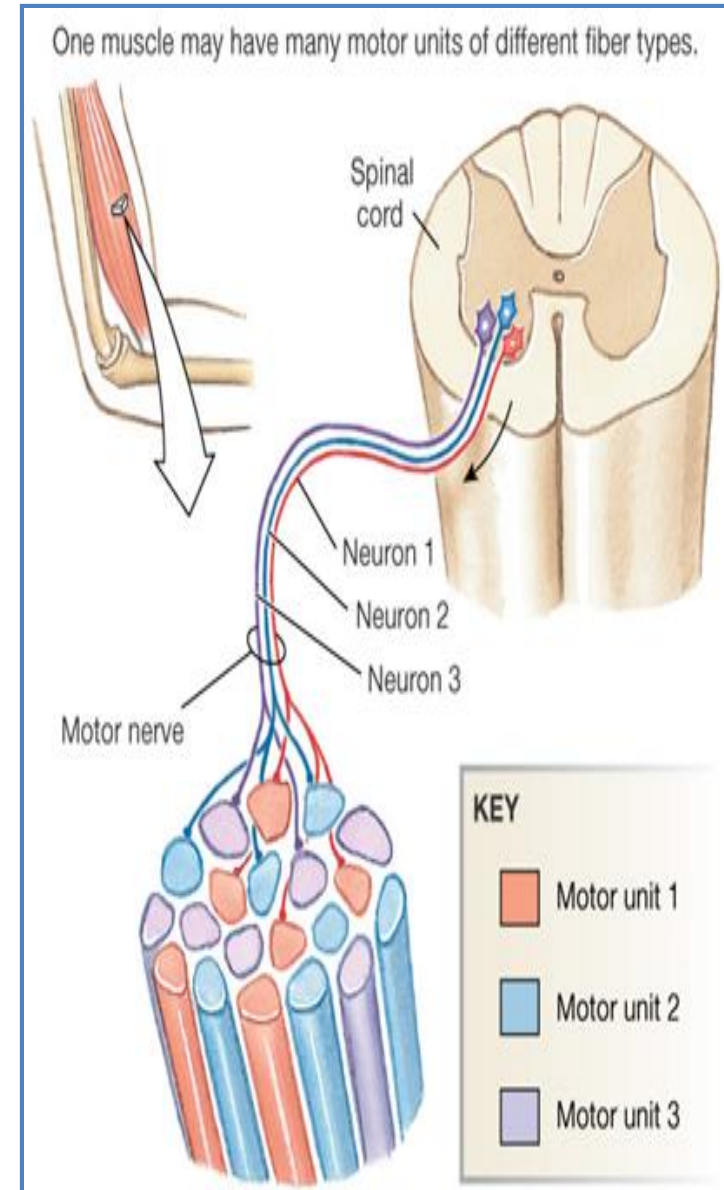


# $\alpha$ -motor neuron in the anterior horn cell



# What is a Motor Unit ?

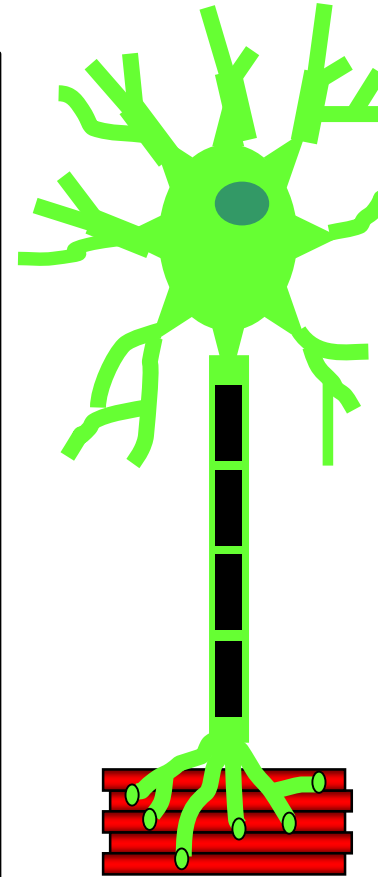
- It is the  $\alpha$ -motor neuron in the anterior horn cell (AHC) and all the muscle fibers it innervates (supplies).
- All of these muscle fibers will be of the same type (either fast twitch or slow twitch).
- Each muscle consist of a number of motor units.
- When a motor neuron is activated, all the muscle fibers it innervates are stimulated and will contract.



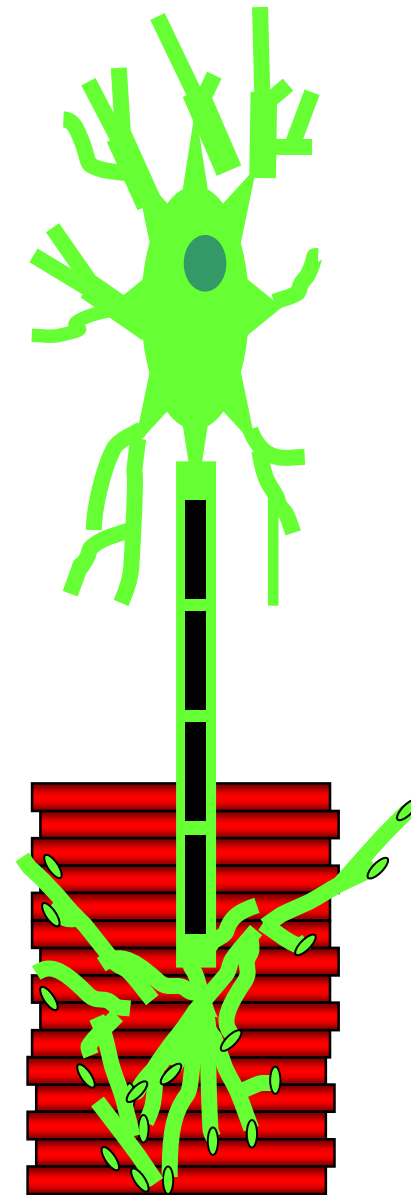


# Motor Unit

- The number of muscle fibers in a motor unit innervated by one motor neuron varies
  - Leg muscles
    - 600 muscle fibers per motor neuron
  - Extra ocular muscles
    - < 10 muscle fibers per motor neuron
    - Some laryngeal muscles (2-3 muscle fibers per MU).
    - The average all over the body is 80-100/MU
- Ratio of muscle fibers to motor neurons
  - Affects the precision of movement i.e small number is associated with more precise movements and vice versa.

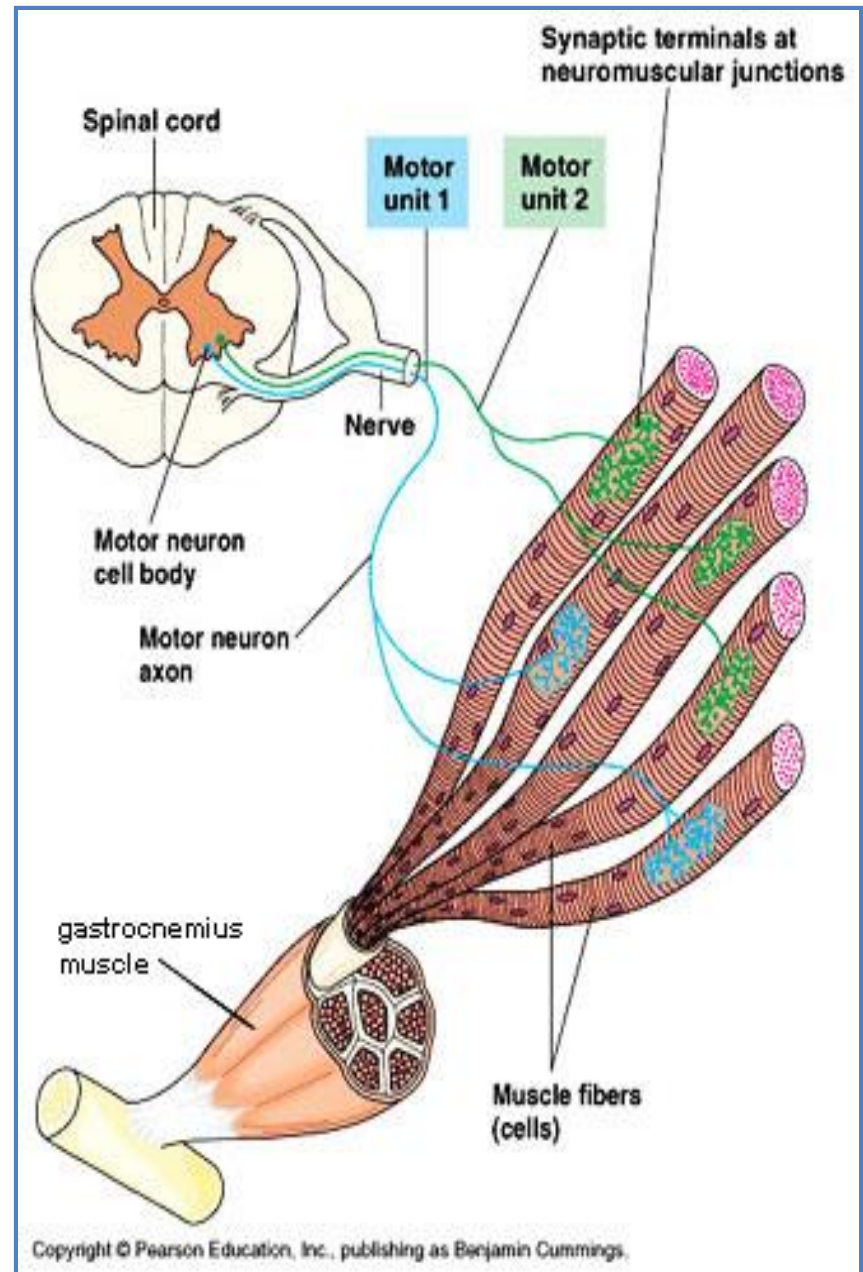


More precise



Less precise movements

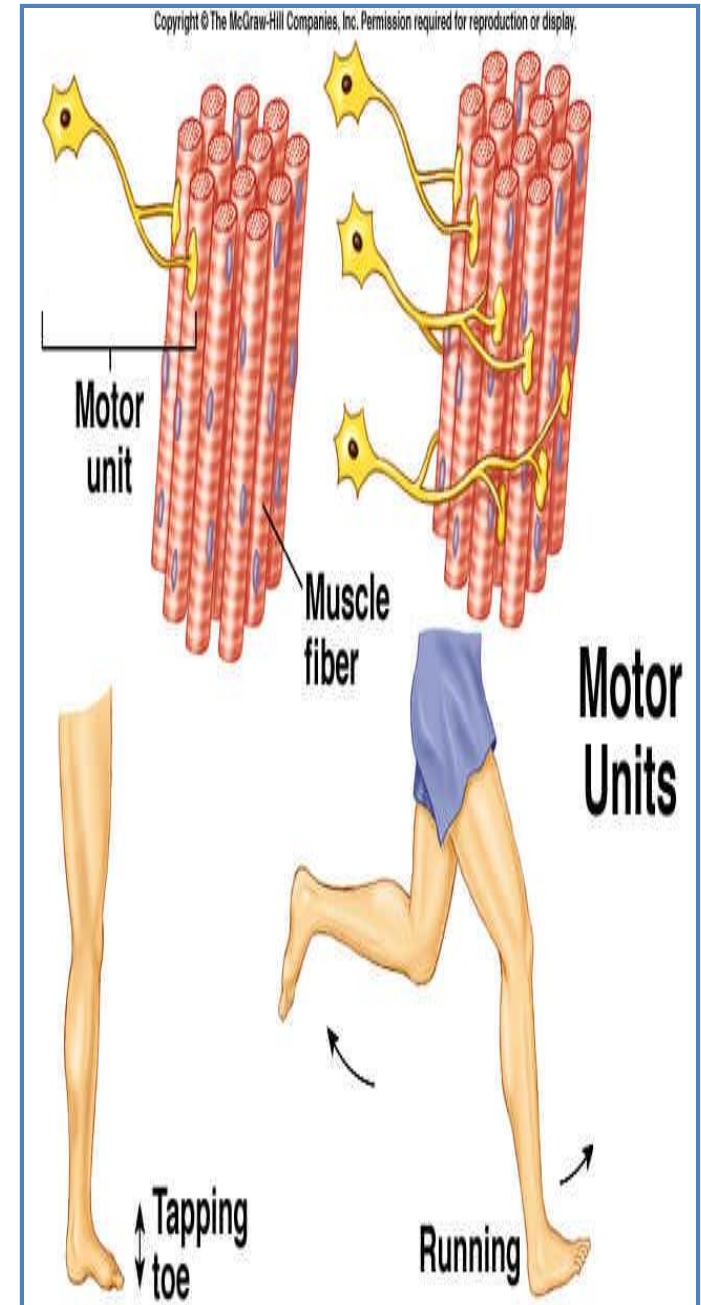
- Groups of motor units often work together to help the contractions of a single muscle.
- The number of muscle fibers within each motor unit can vary.
- Muscles needed to perform **precise movements** generally consist of a large number of motor units and few muscle fibers in each motor unit e.g Hands and eyes muscles
- **Less precise movements** are carried out by muscles composed of fewer motor units with many fibers per unit e.g Trunk muscles.



## Motor unit recruitment:

The group of motor units supplying a single muscle are called *Motor Unit Pool*.

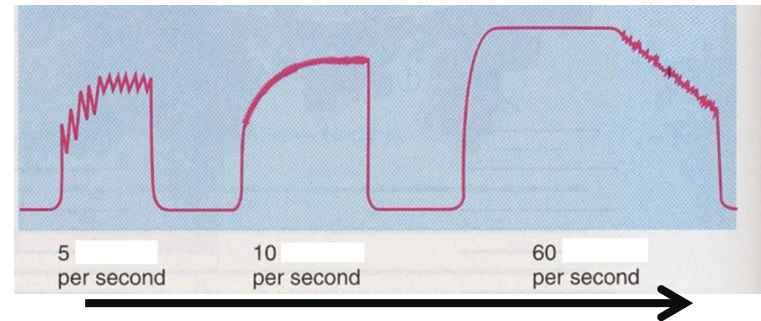
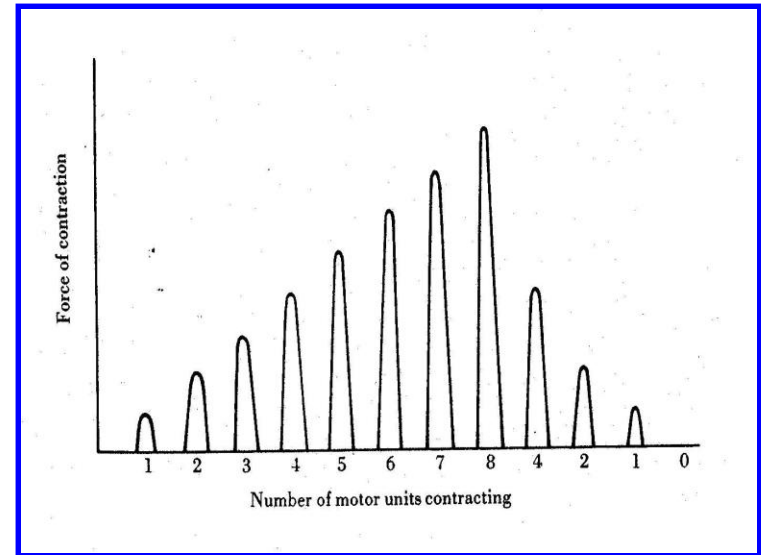
- The two ways the nervous system increases the force production is through
  - 1 - **Recruitment of new motor units** and
  - 2- **Increasing stimulation frequency** (rate coding).
- The activation of one motor neuron will result in a weak muscle contraction.
- The activation of more motor neurons will result in more muscle fibers being activated, and therefore a stronger muscle contraction.



# Motor unit recruitment

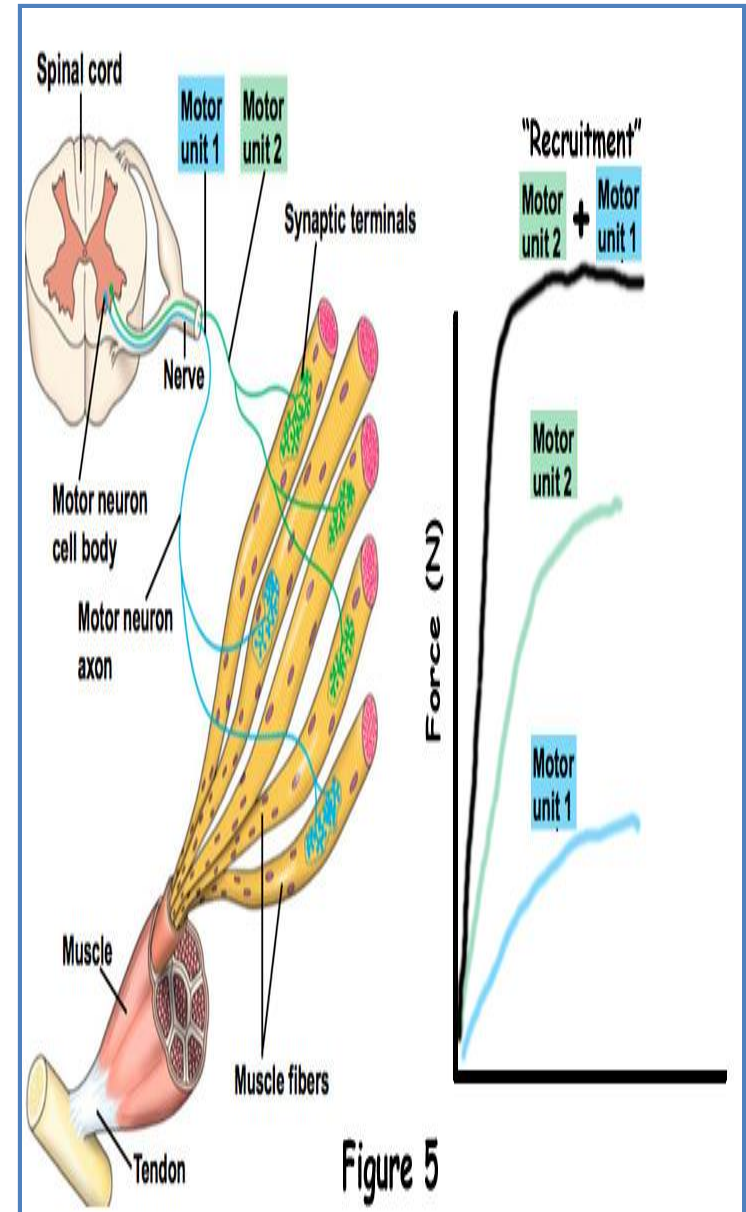
## توظيف الوحدات الحركية

- Recruitment of motor units is the progressive activation of a muscle by successive recruitment of contractile units (motor units) to accomplish increasing degrees of contractile strength (force).
- When the AHC fires at slow rates , motor unit potentials (MUPs) will be at slow rate & the force of muscle contraction is weak.
- If AHCs fire at very fast rates → fast MUPs → stronger contraction.



**Increasing frequency of  
action potentials  
resulting in stronger force of  
contraction**

- The higher the motor unit recruitment, the stronger the muscle contraction .
- The force produced by a single motor unit is determined by →
  - (1) the number of muscle fibers in the unit and
  - (2) the frequency with which the muscle fibers are stimulated by their innervating axon.
- Generally, this allows a 2 to 4-fold change in force.



# Motor Unit Recruitment

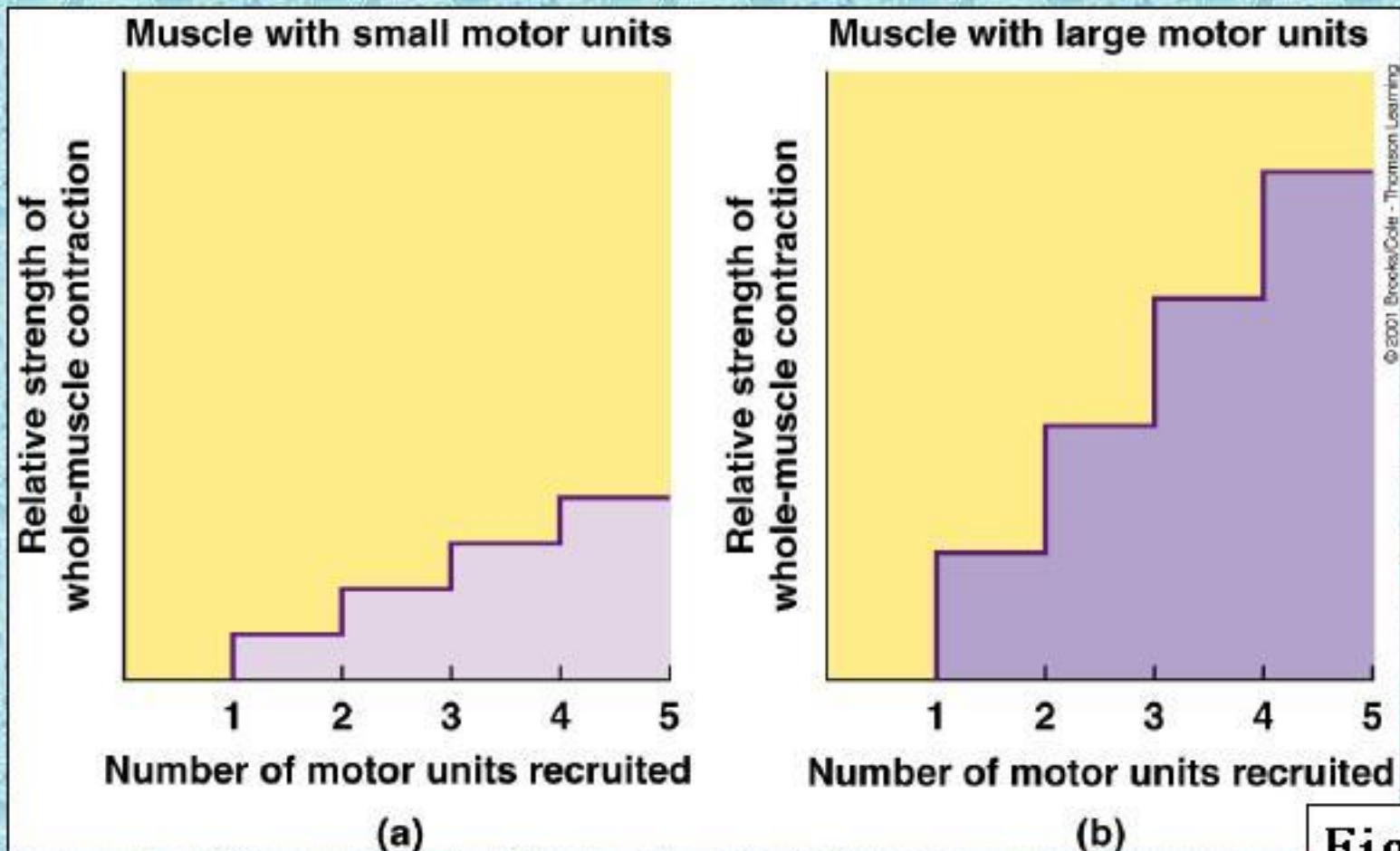
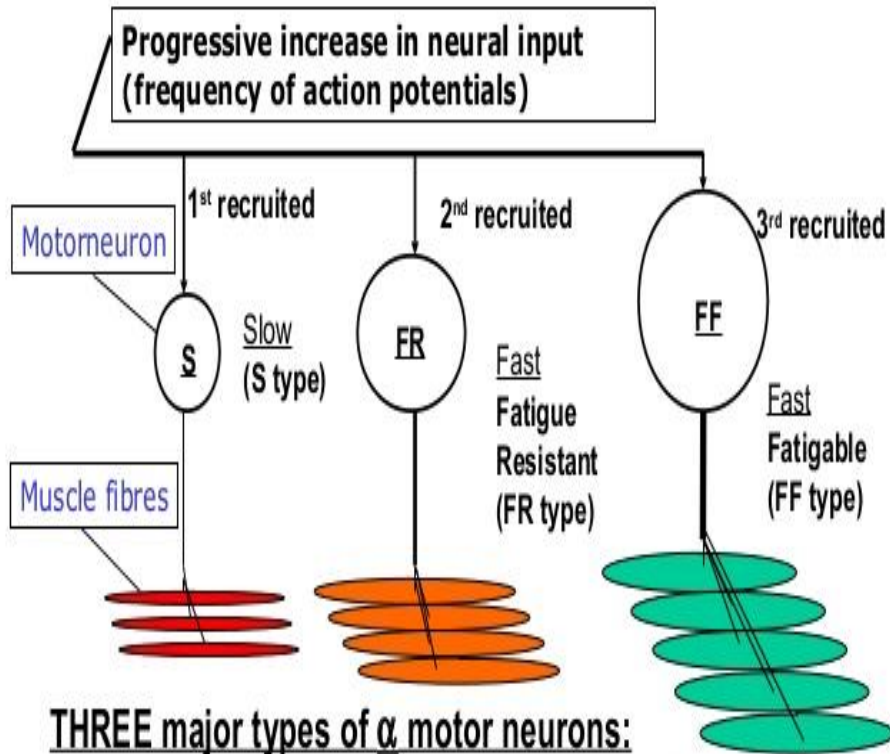


Fig 8-16

**Motor Unit Recruitment Increases the Strength of Muscle Contraction**

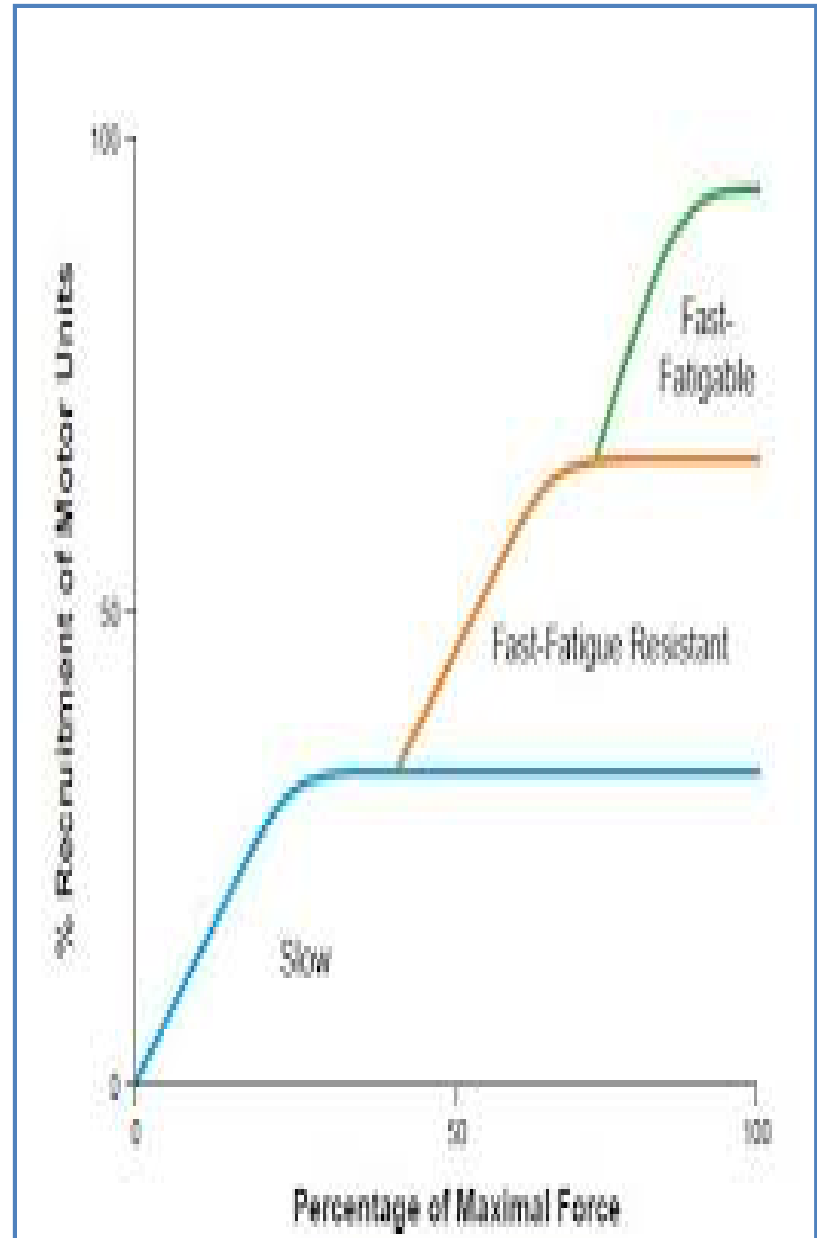
**Important rule:**

**MUs receive common neural input and are recruited according to their sizes !!! (Henneman's Size Principle)**



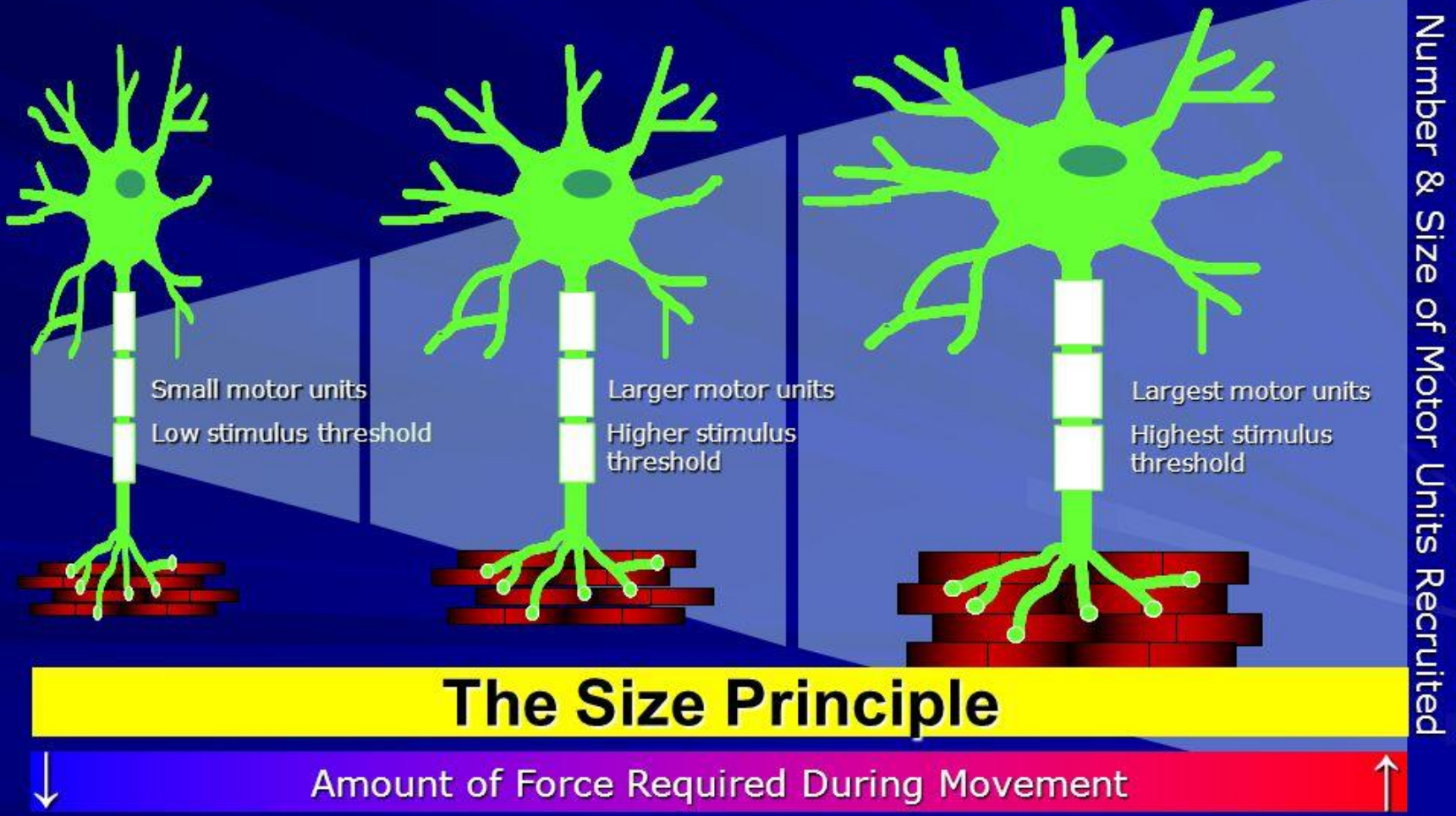
**THREE major types of  $\alpha$  motor neurons:**

S type	are	small	"high" excitability
FR type	are	big	"average" excitability
FF type	are	very big	"low" excitability



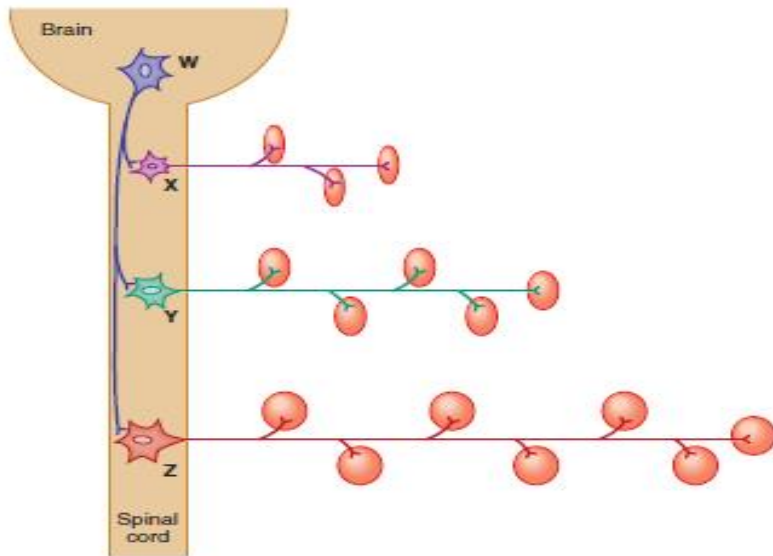
# Recruitment

- Varying the number of motor units activated.

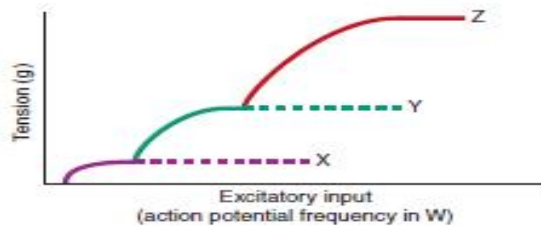




# Recruitment and Size Principle

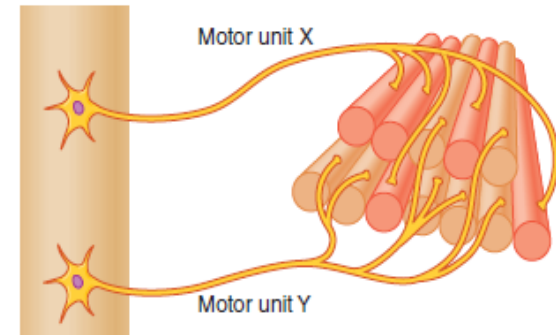


(a)

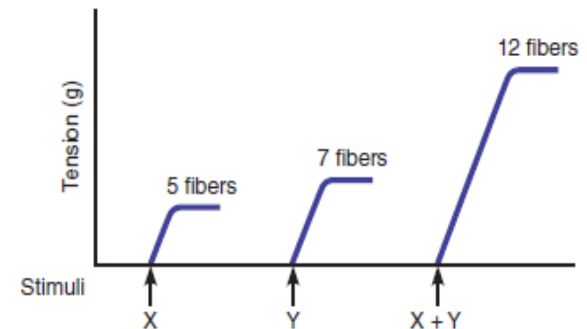


(b)

**Figure 12.19** The size principle. (a) The anatomical relationship of three motor units (X, Y, and Z) of increasing size to an excitatory neuron W within the CNS. (b) As the frequency of action potentials in neuron W increases, the order of motor units activated proceeds from smallest (X) to largest (Z).



(a)

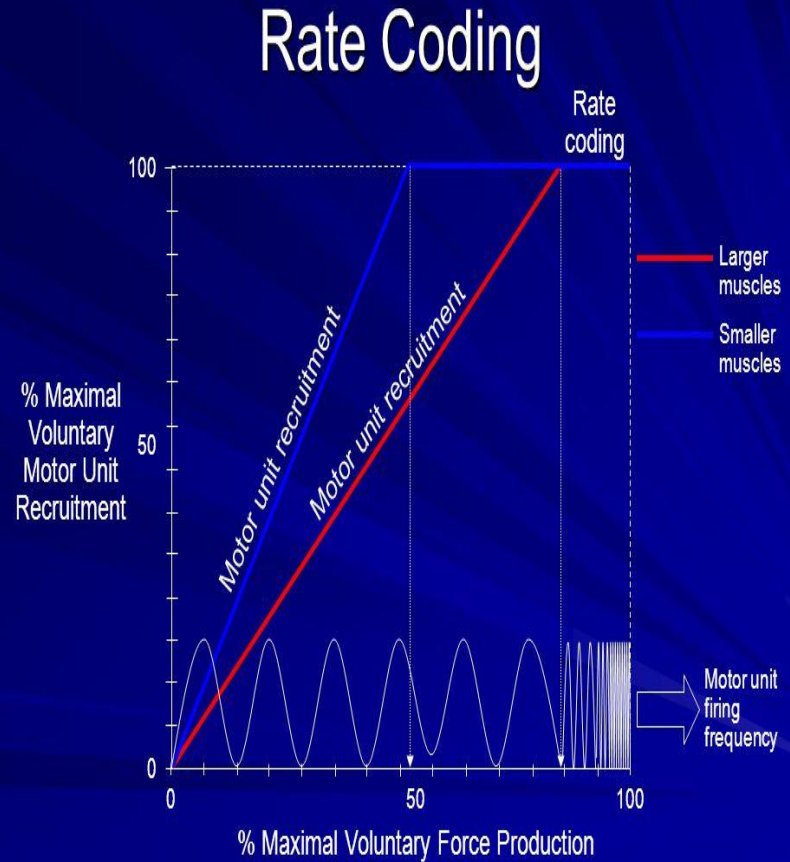


(b)

**Figure 12.18** Increases in force generation with recruitment of motor units. (a) Motor units X and Y, which possess five fibers and seven fibers, respectively. (b) Tension developed by motor unit X, by motor unit Y, and by motor units X and Y together.

# Rate Coding

- **Rate coding refers to the motor unit firing rate.** Active motor units can discharge at higher frequencies to generate greater tensions.
- **Recruitment versus rate coding**
  - Smaller muscles (ex: first dorsal interosseous) rely more on rate coding.
  - Larger muscles of mixed fiber types (ex: deltoid) rely more on recruitment.



# All or non role

- Motor Unit Follows “all-or-none” principle – impulse from motor neuron will cause contraction in all muscle fibers it innervates or none.
- In an electrodiagnostic testing (EMG , electromyography) 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.