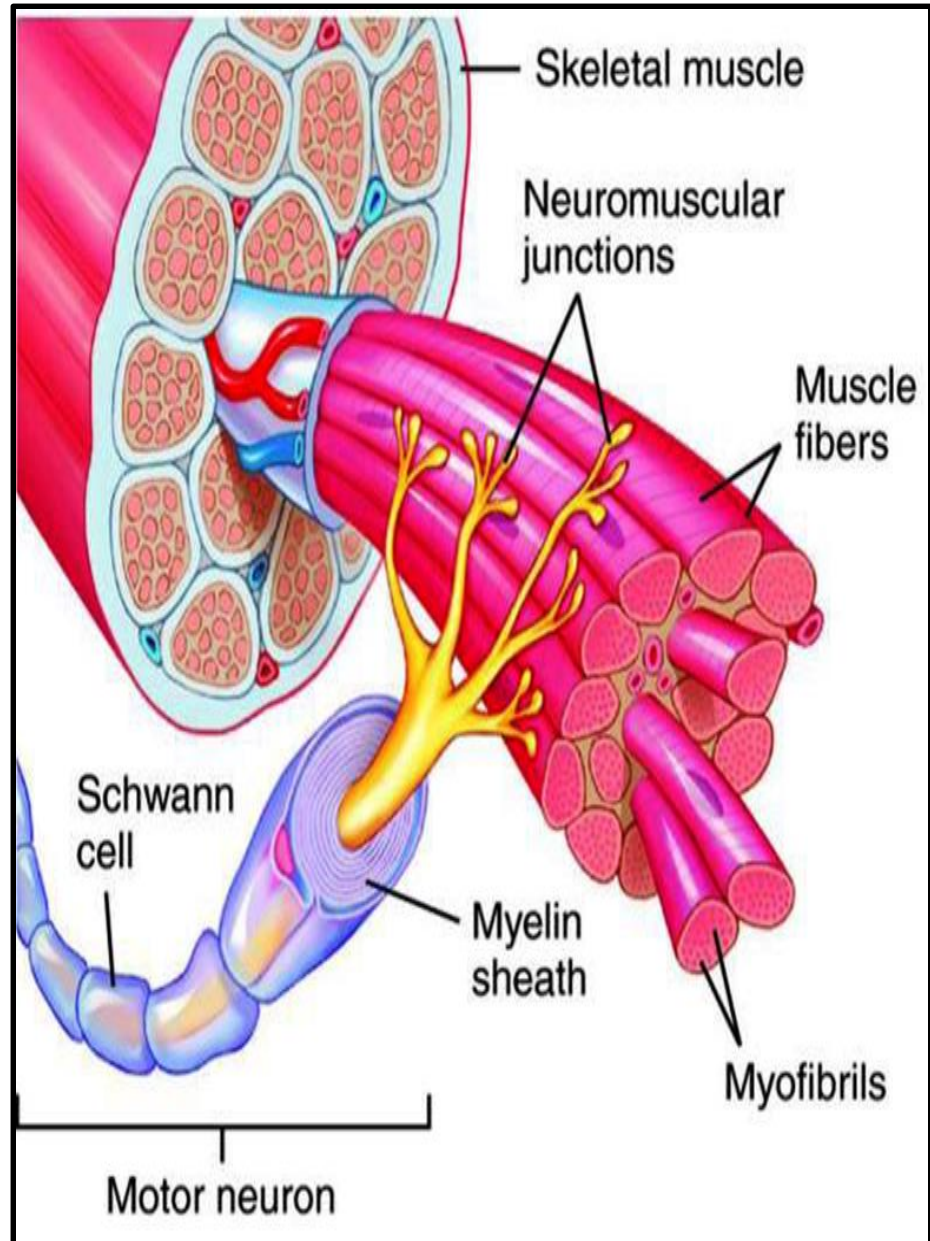


Motor Unit

Dr. Aida Korish
Assoc. Prof. Physiology
KSU

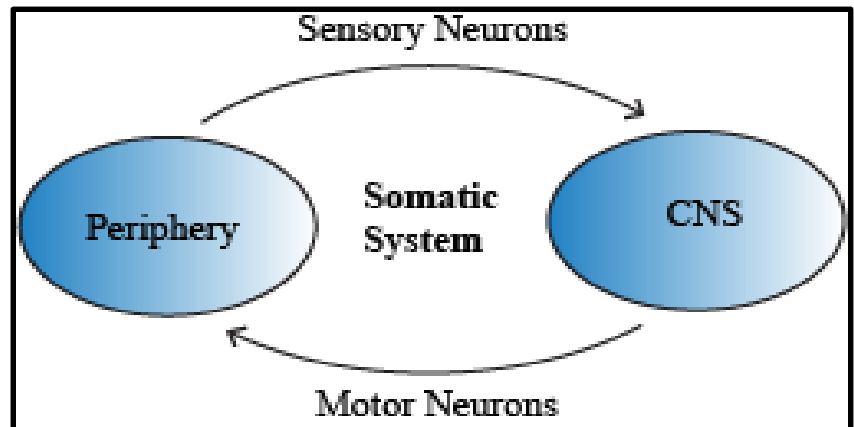
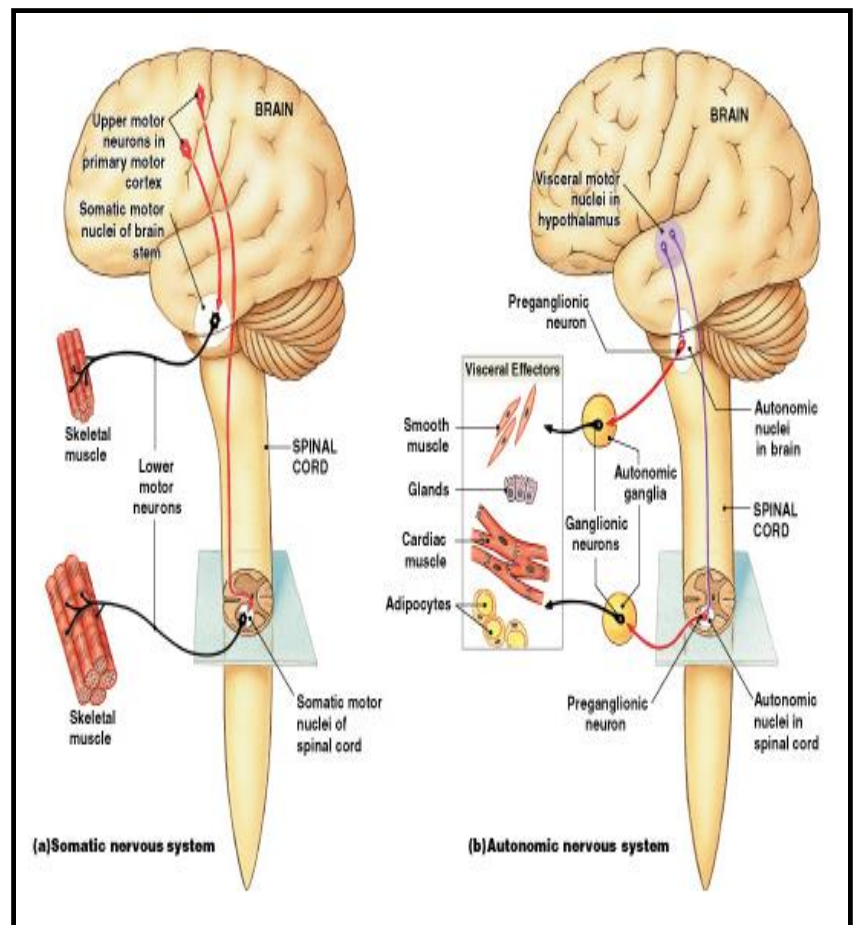
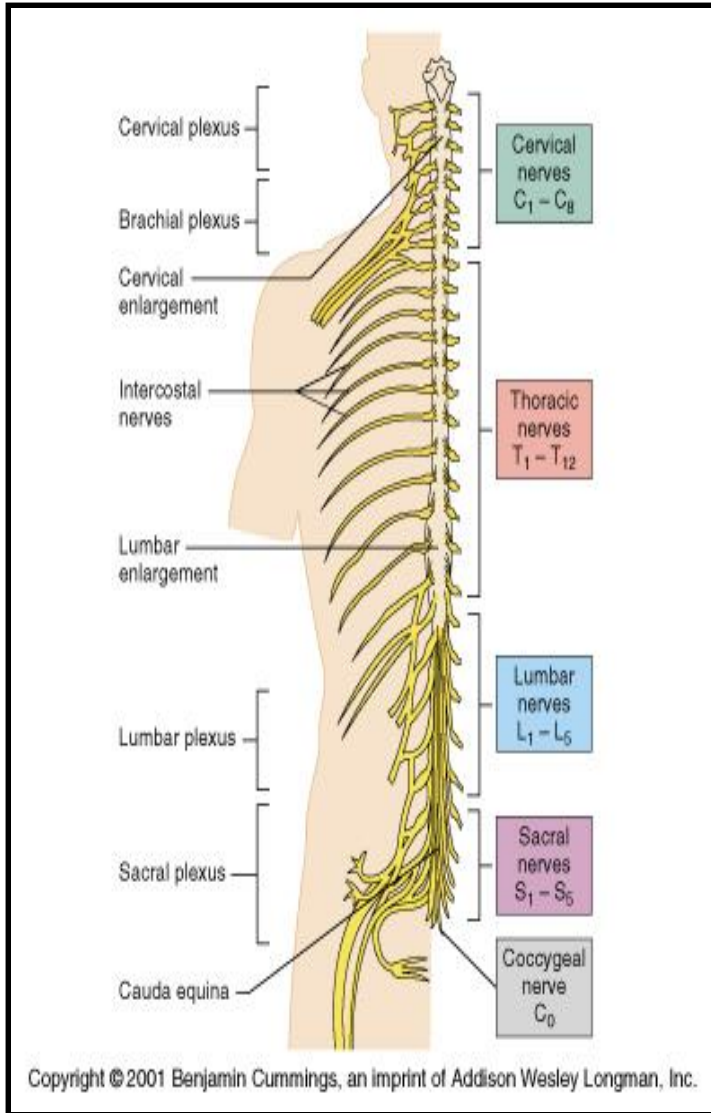


Objectives

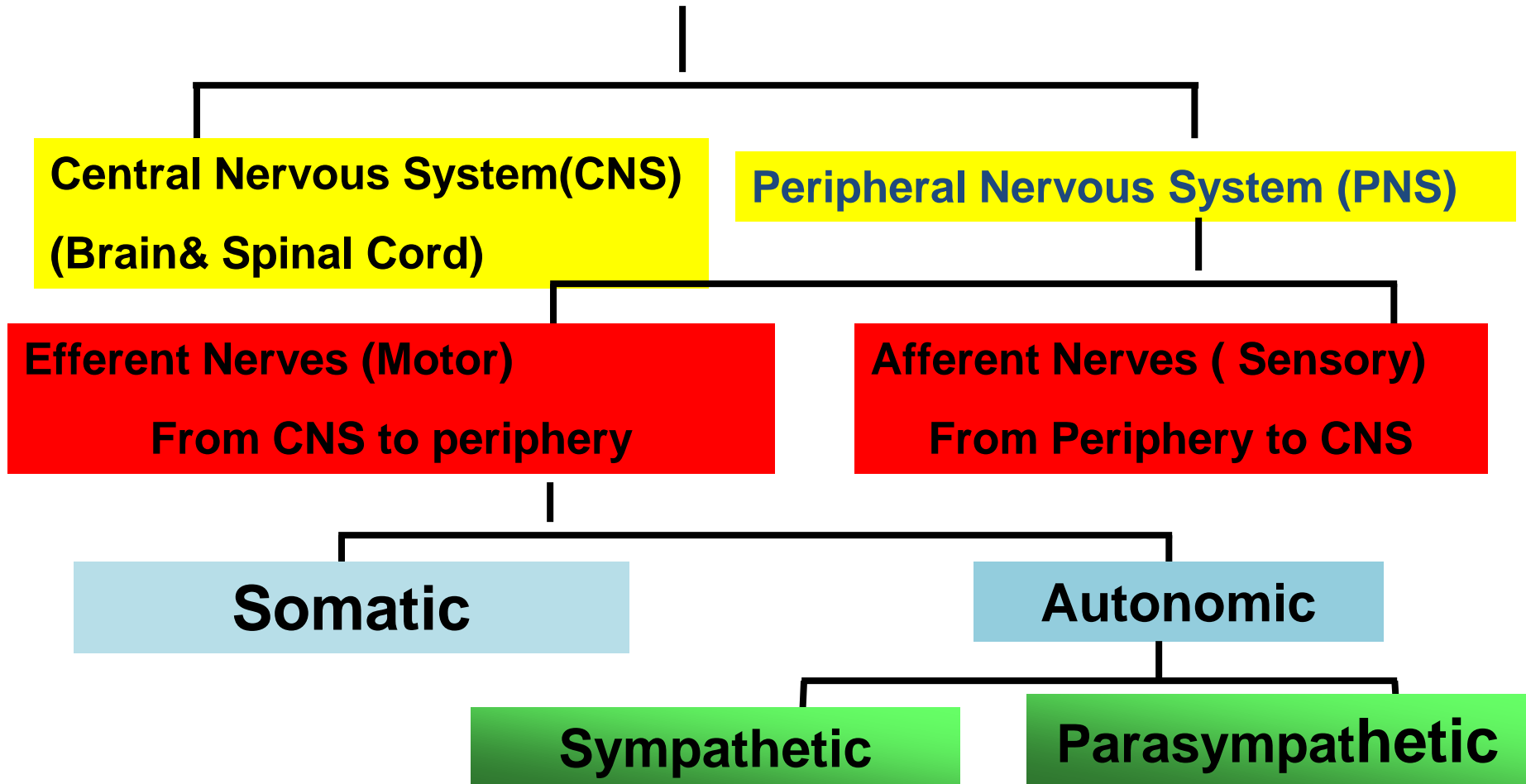
At the end of this lecture you should be able to:

- 1- Recognise the organization of the nervous system.
- 2- Identify the differences between central nervous system (CNS) & 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.

Organization of Nervous System



Organization of The Nervous System



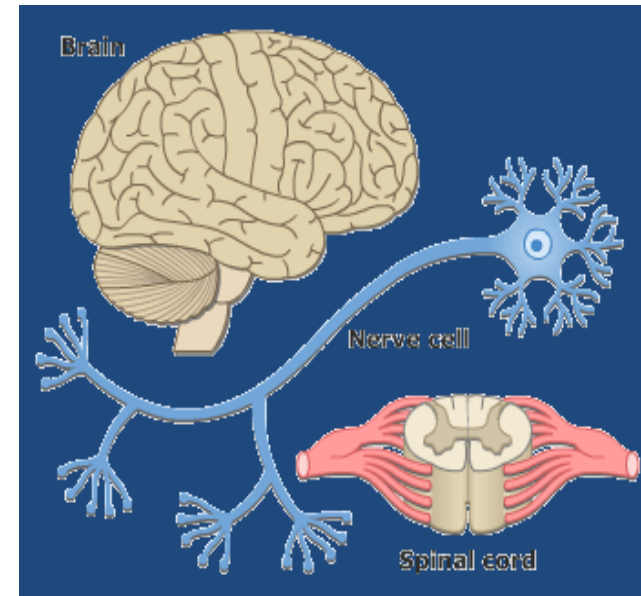
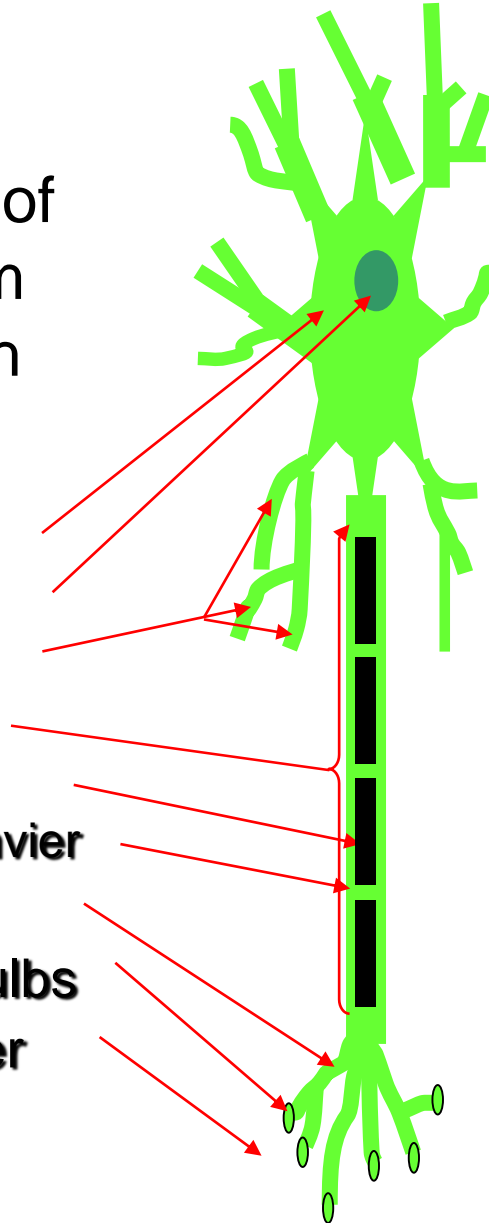
Nerve-Muscle Interaction

- 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 sensors 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.

Neurons

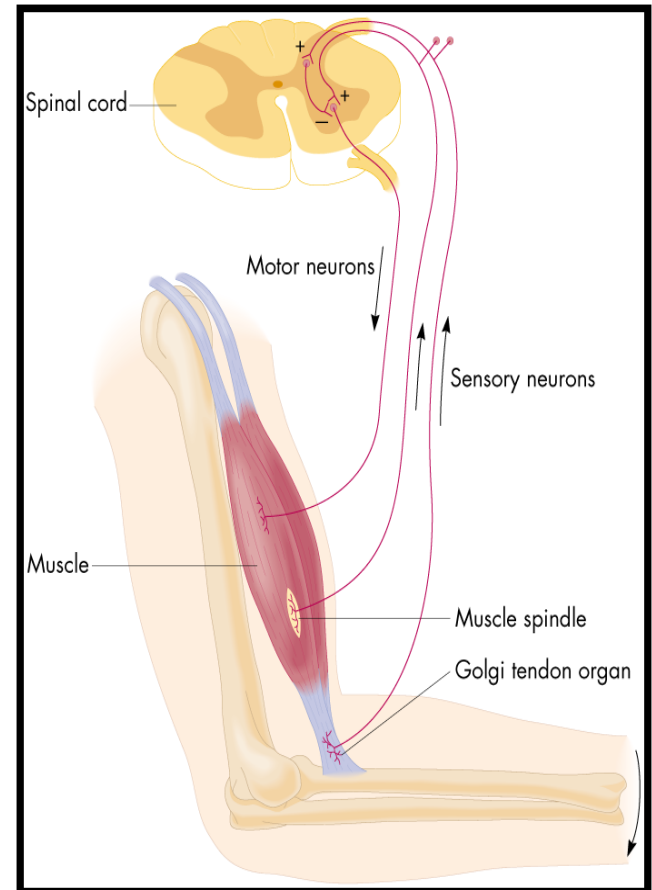
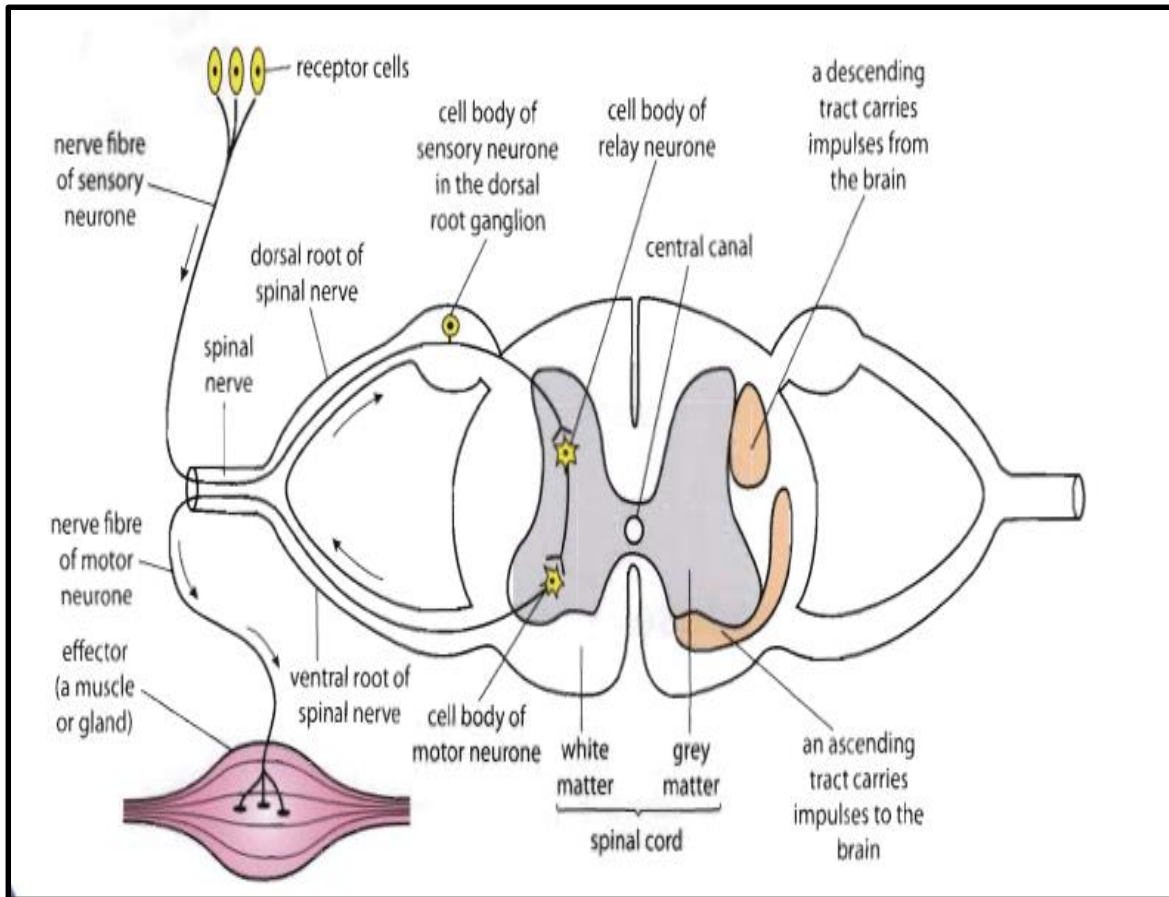
The building unit of the nervous system is the neuron which has

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

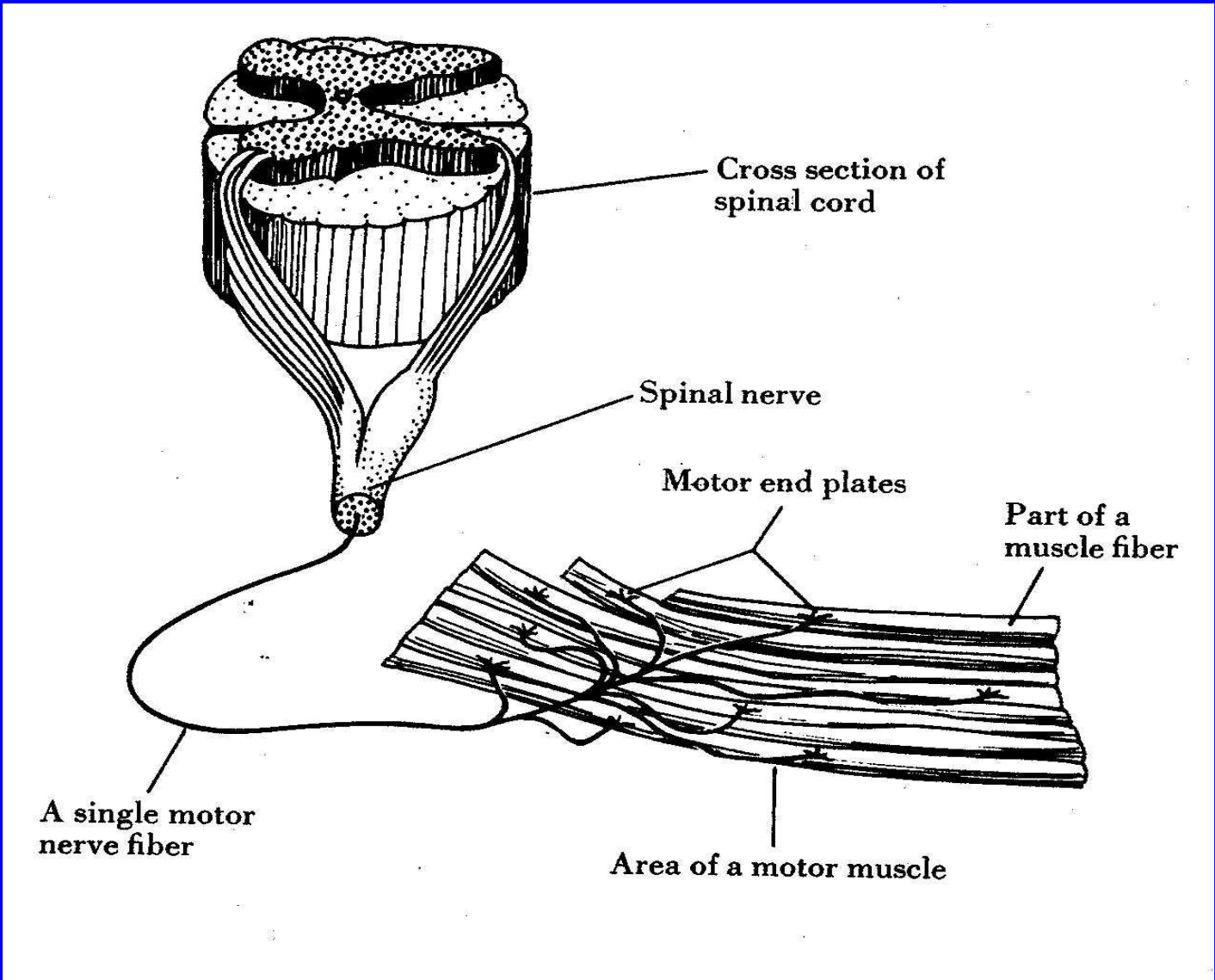


α -motor neuron in the anterior horn cell

A nerve is made up of a group of axons of neurons

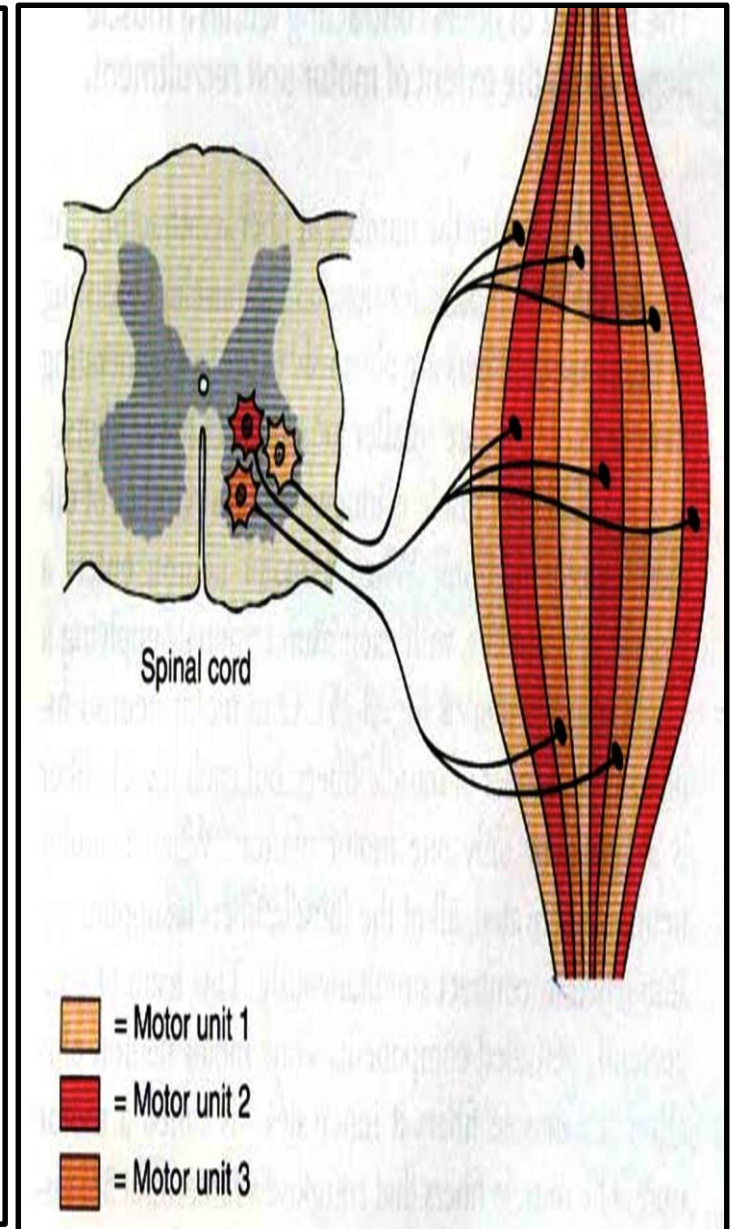


Motor Unit



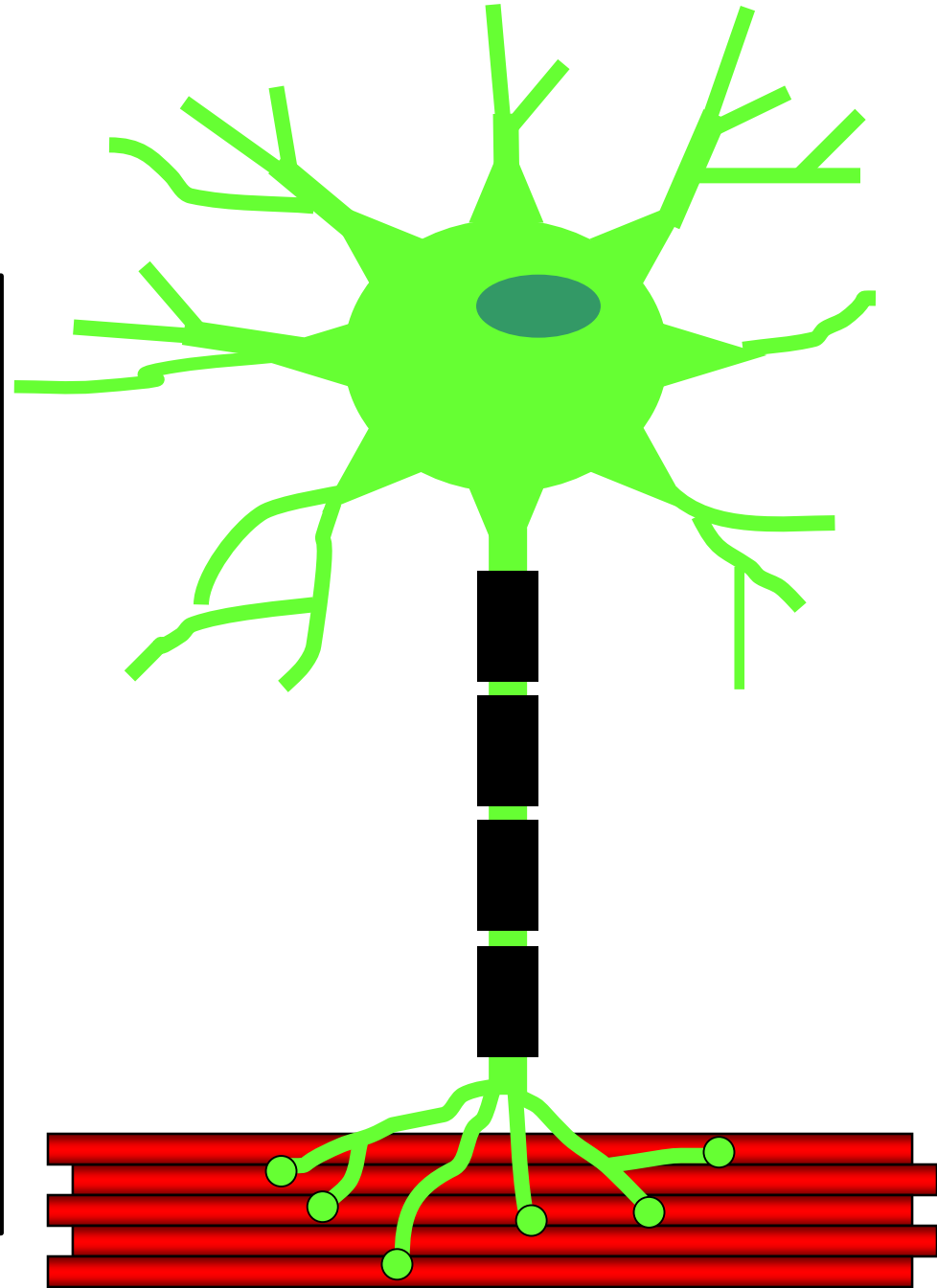
What is a Motor Unit ?

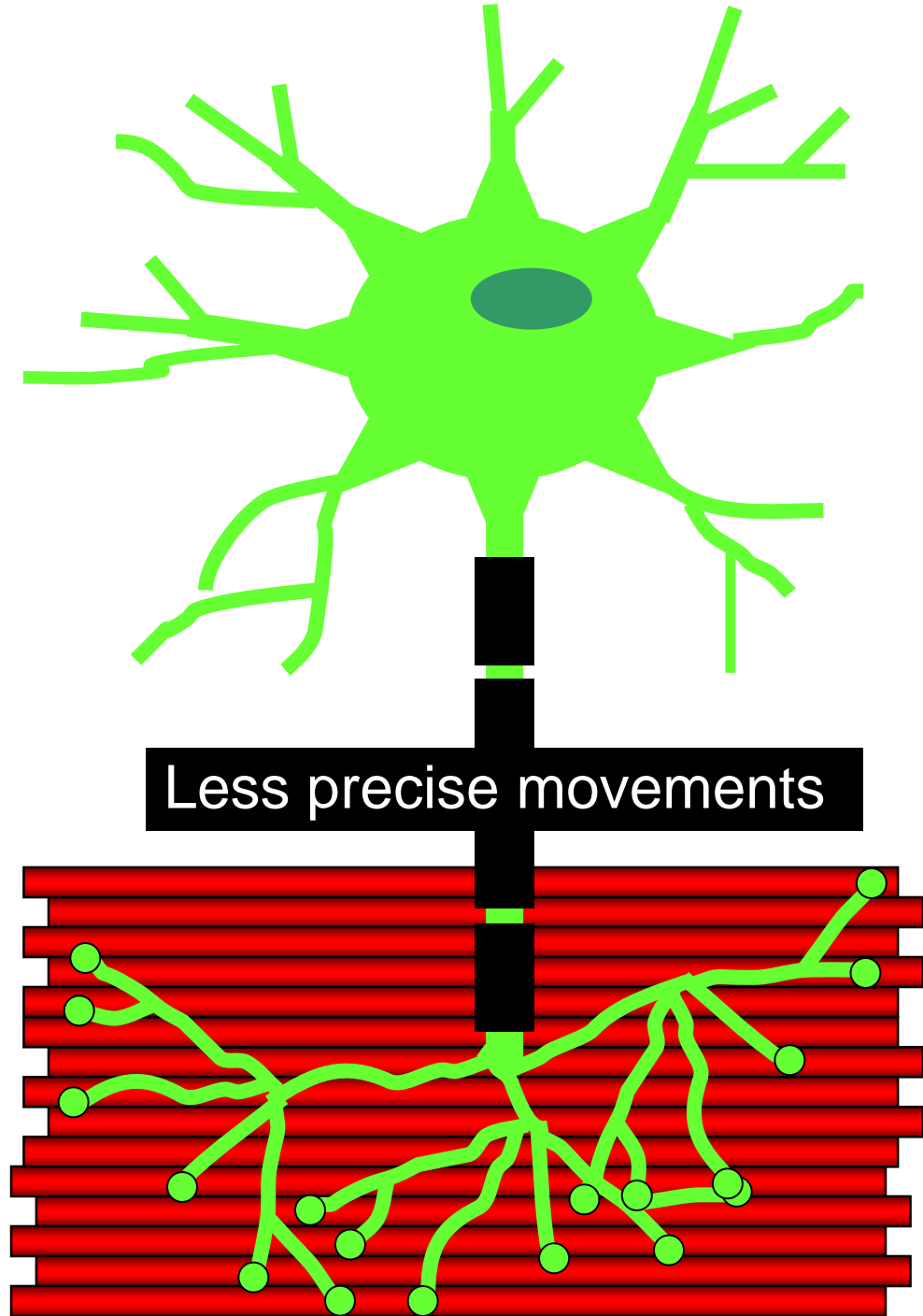
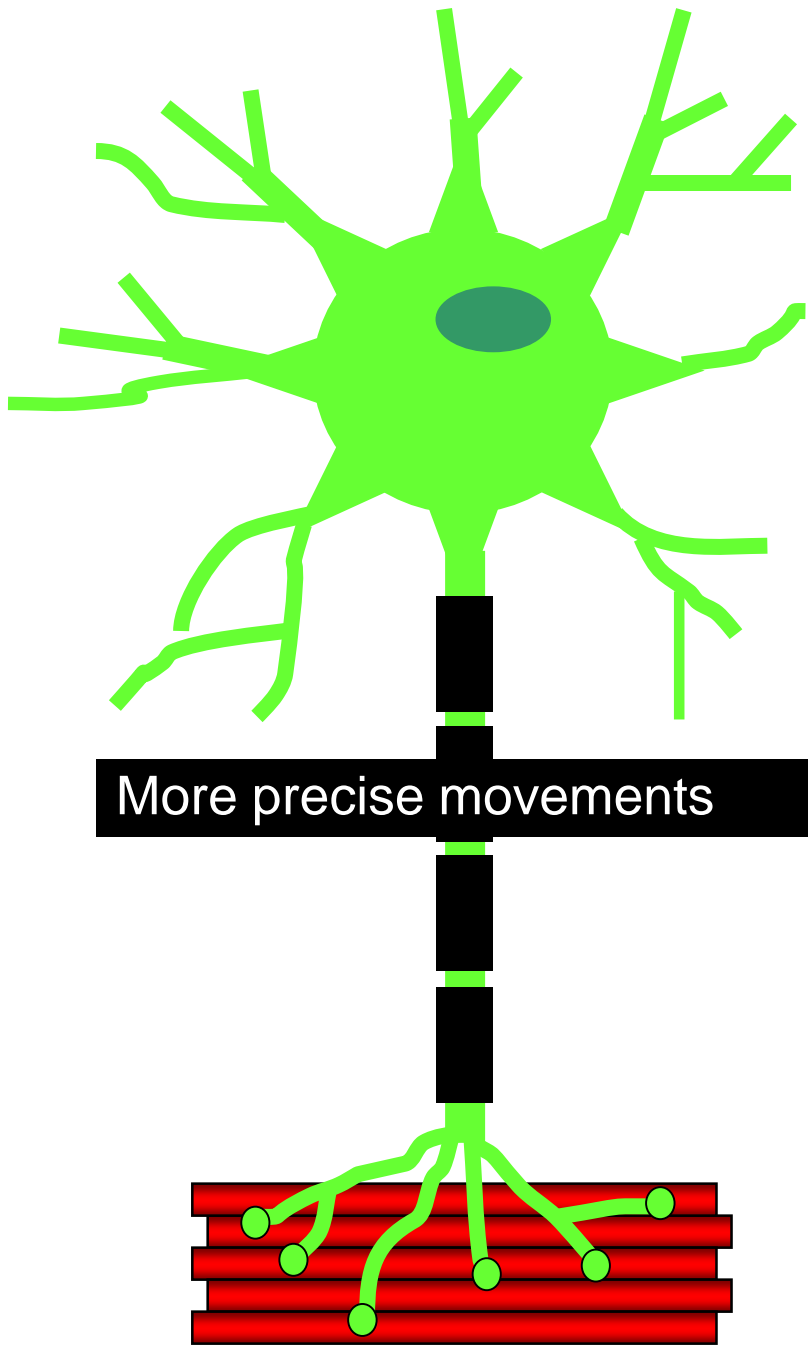
- It is the α -motor neuron in the anterior horn cell (AHC) and all the muscle fibers it innervates (supplies) **تغذيها**
- All of these muscle fibers will be of the same type (either fast twitch or slow twitch).
- Each muscle consist of a number of motor units.
- When a motor neuron is activated, all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



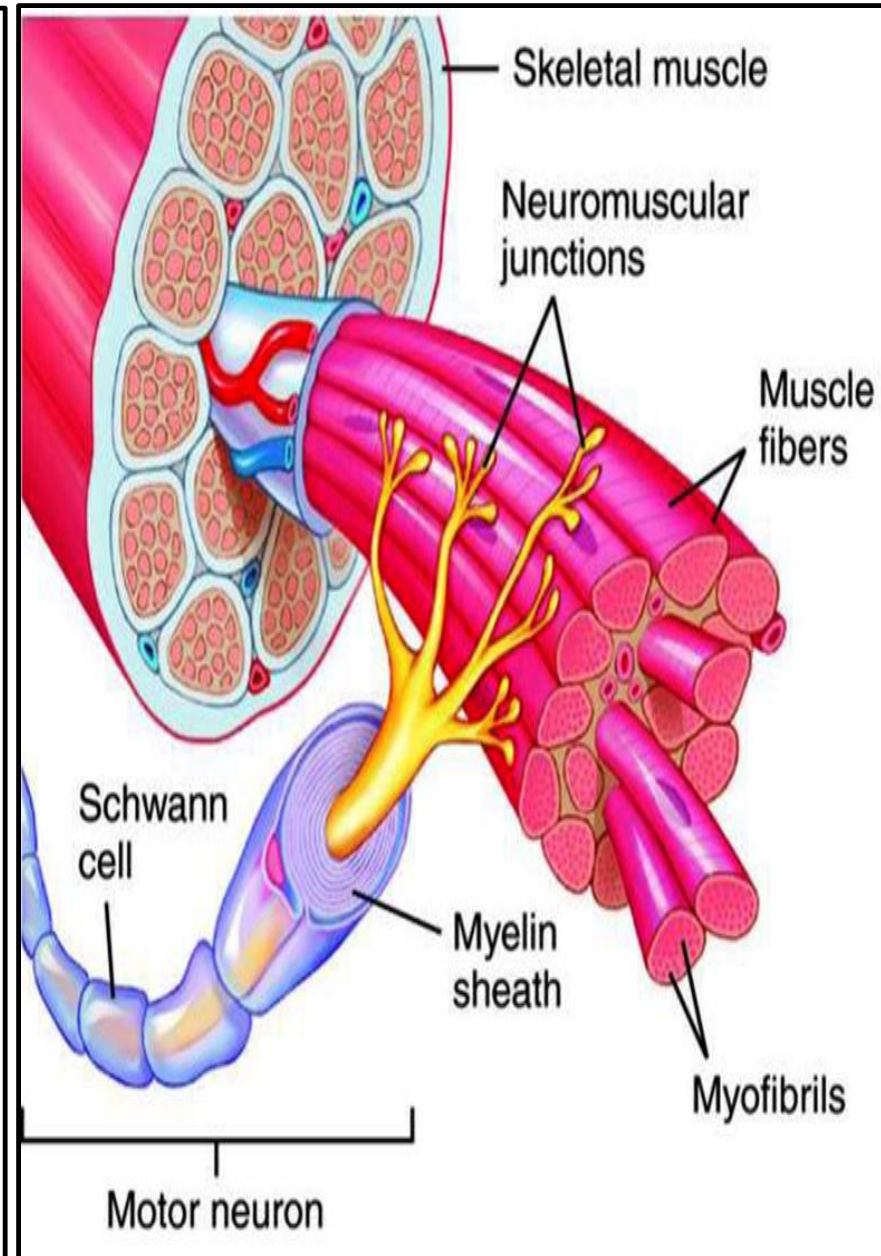
Motor Unit

- The number of muscle fibers in a motor unit innervated by one motor neuron varies
 - Gastrocnemius
 - 2,000 muscle fibers per motor neuron
 - Extra ocular muscles
 - < 10 muscle fibers per motor neuron
- 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.





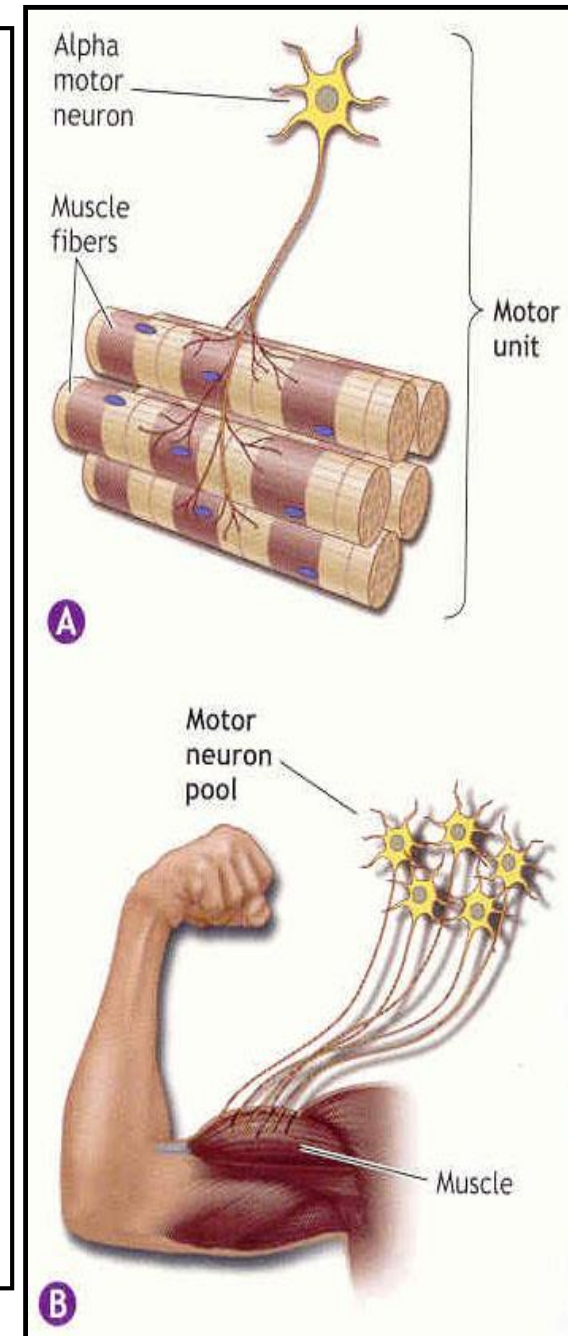
- Groups of motor units often work together to help the contractions of a single muscle.
- The number of muscle fibers within each motor unit can vary.
- Muscles needed to perform **precise movements** generally consist of a large number of motor units and few muscle fibers in each motor unit e.g Hands 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*.

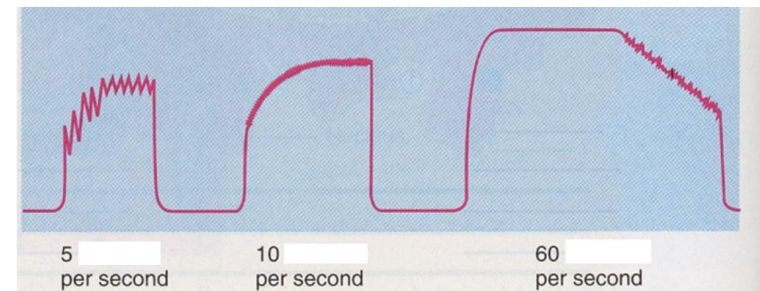
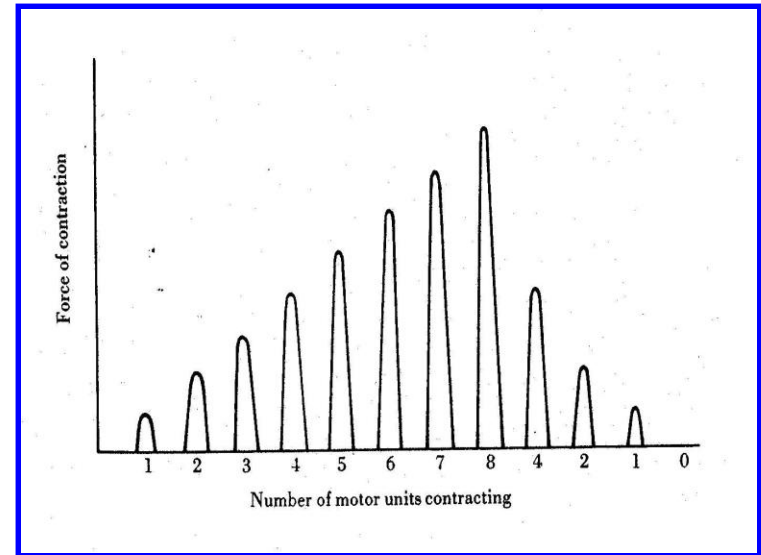
- The two ways the nervous system increases the force production is through
 - 1 - **Recruitment of new motor units** and
 - 2- **Increasing stimulation frequency** (rate coding).
- The activation of one motor neuron will result in a weak muscle contraction.
- The activation of more motor neurons will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



Motor unit recruitment

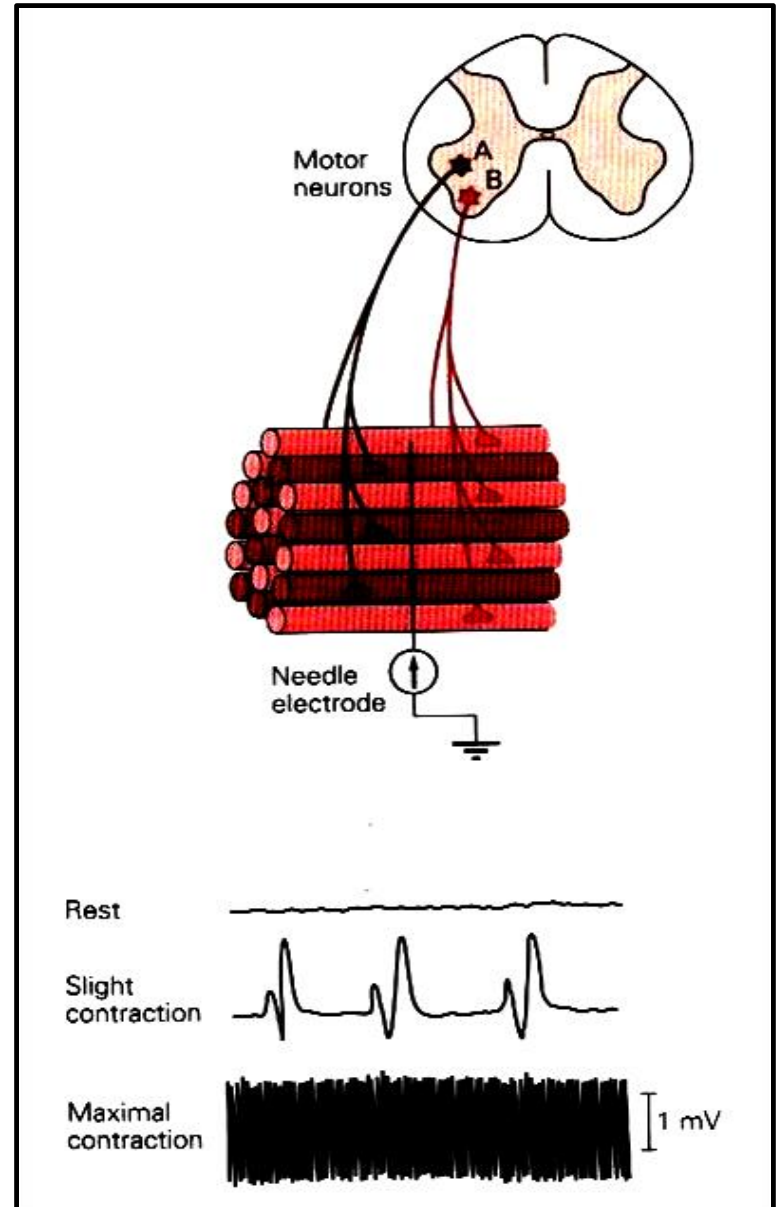
توظيف الوحدات الحركية

- 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.



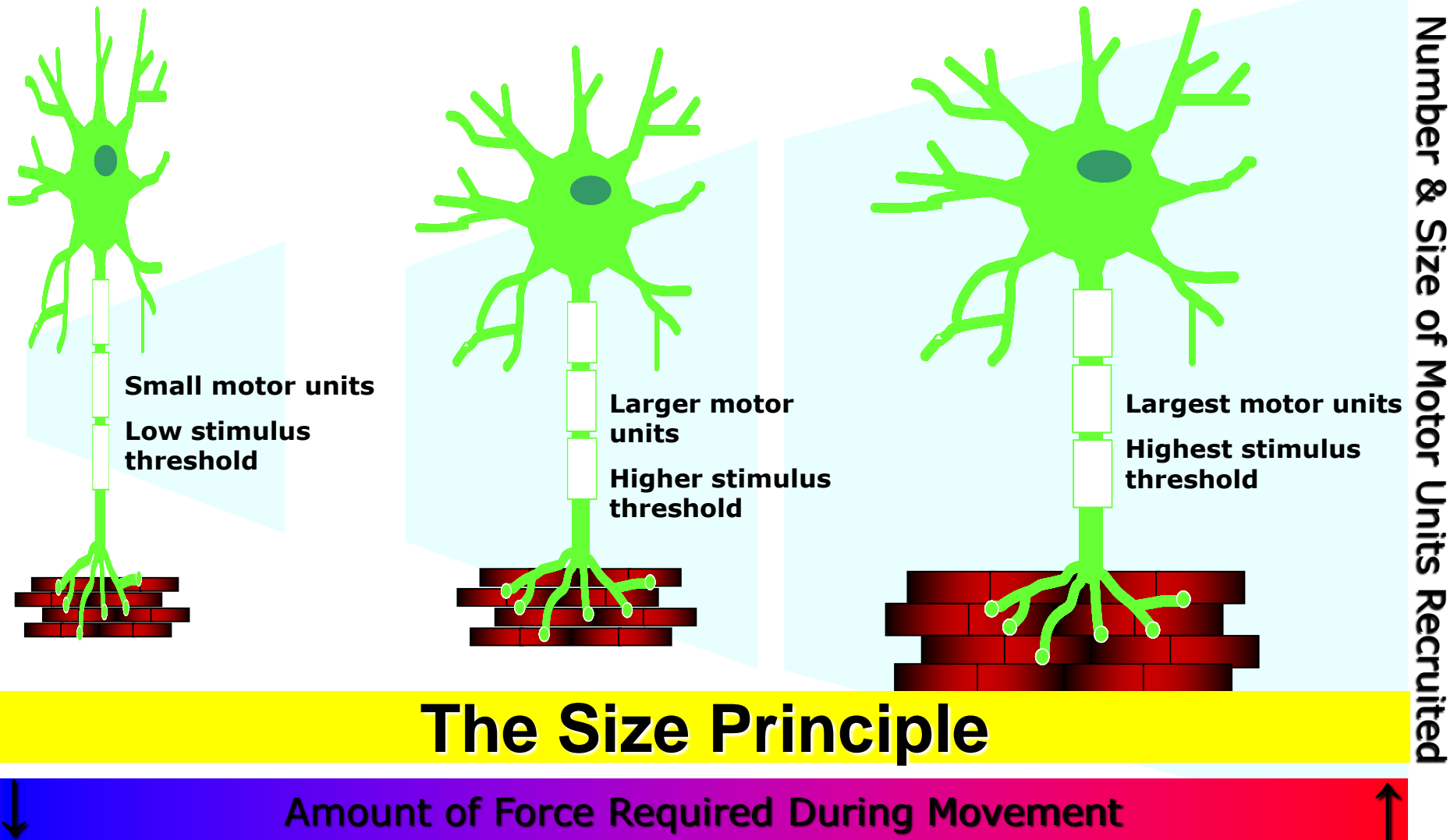
**Increasing frequency of
action potentials
resulting in stronger force of
contraction**

- 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.

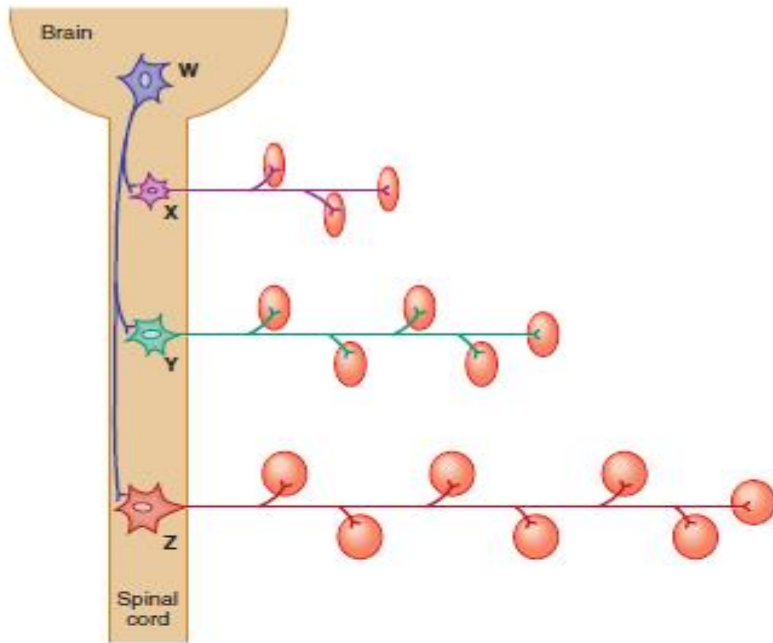


Recruitment

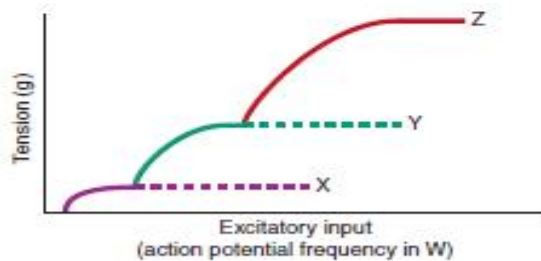
- Varying the number of motor units activated.



Recruitment and Size Principle

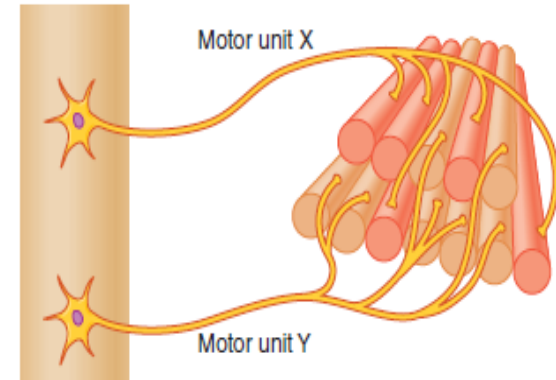


(a)

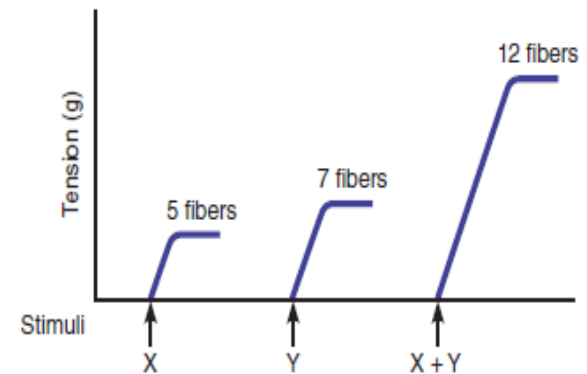


(b)

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 Units 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.