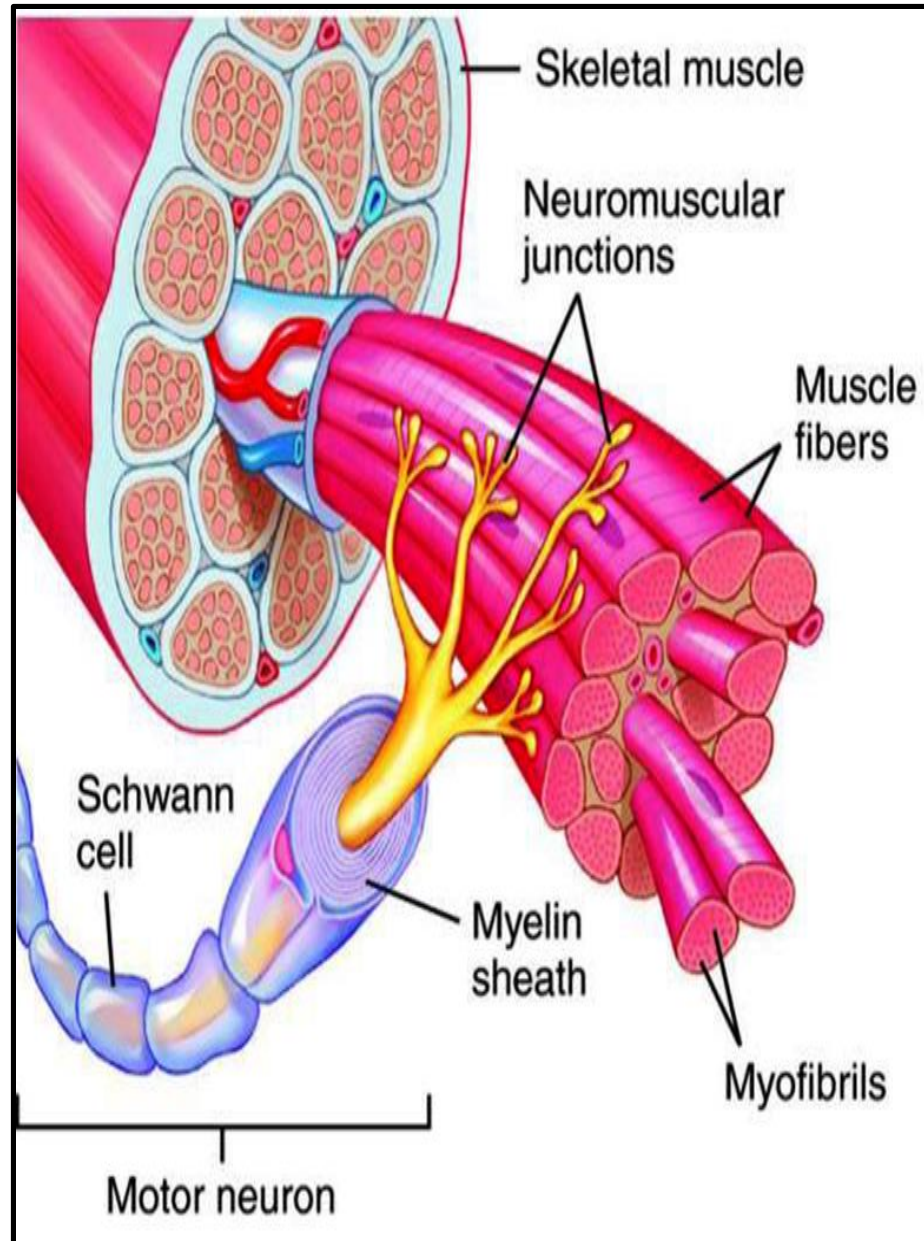


Motor Unit

Dr. Salah Elmalik
MBBS, PhD

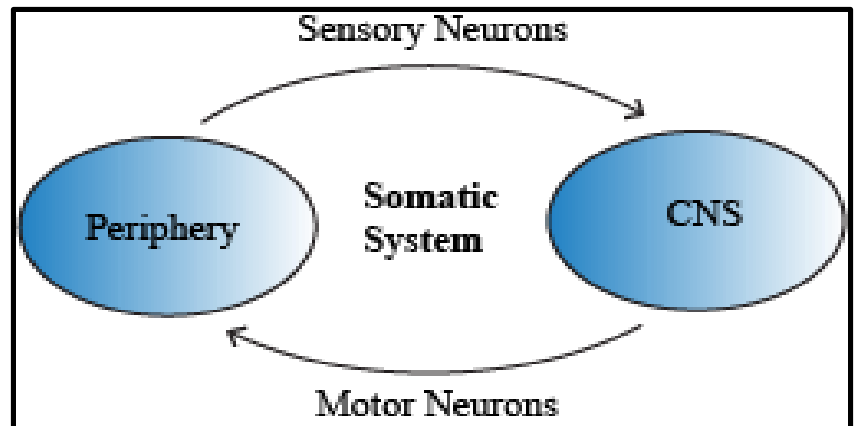
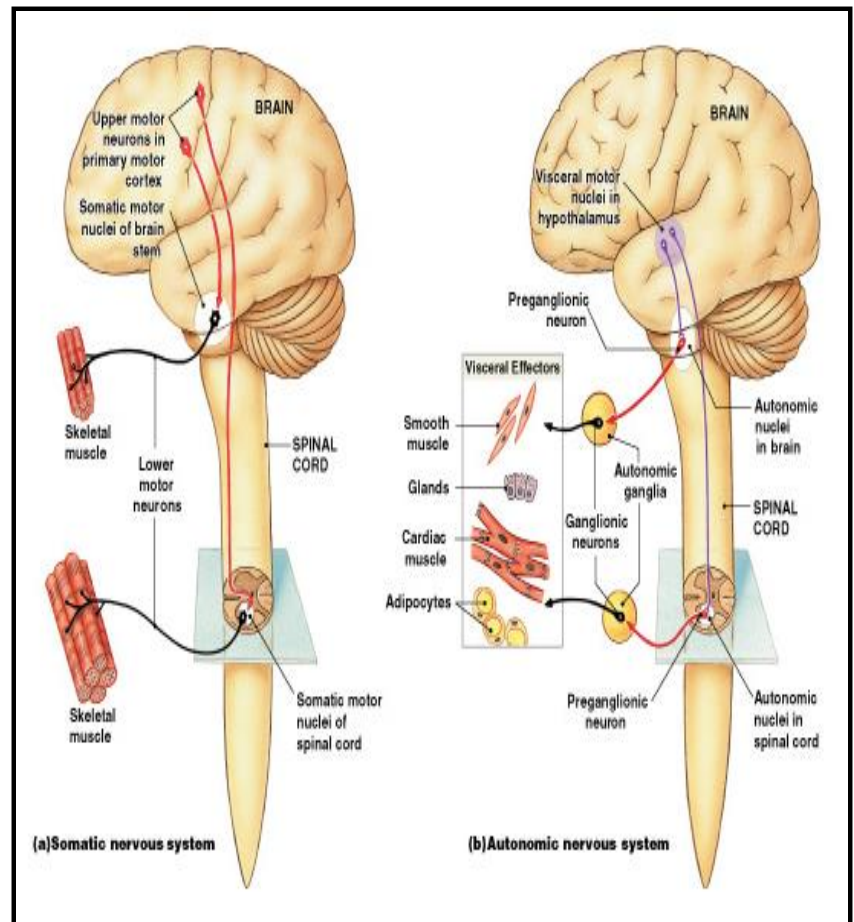
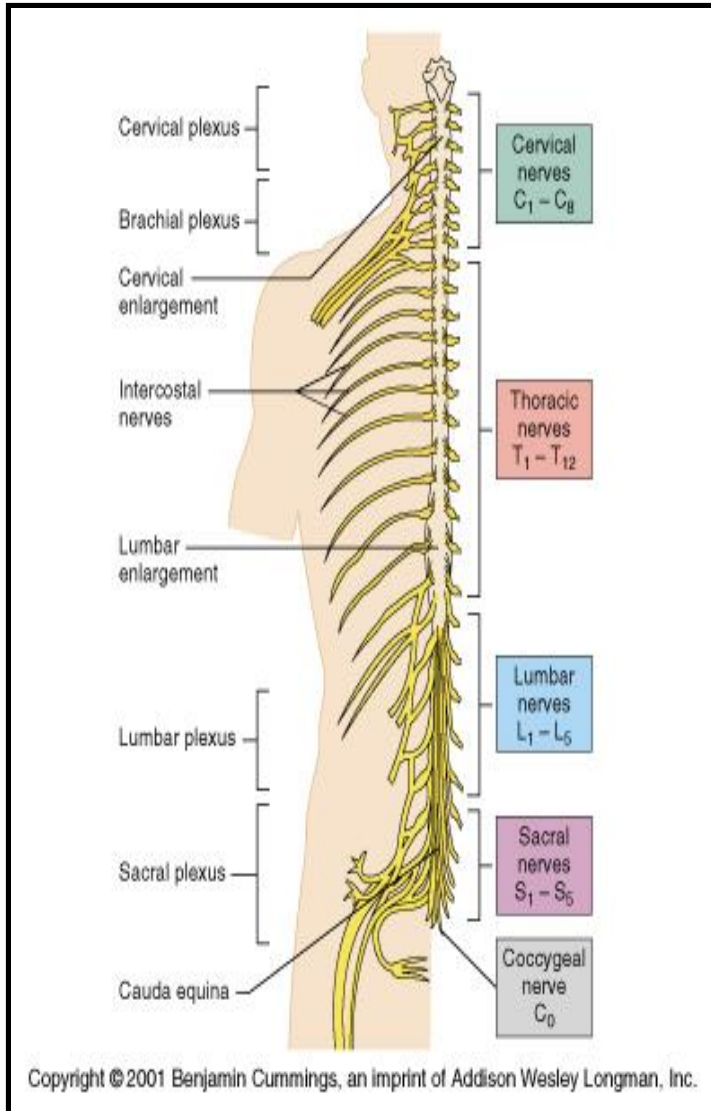


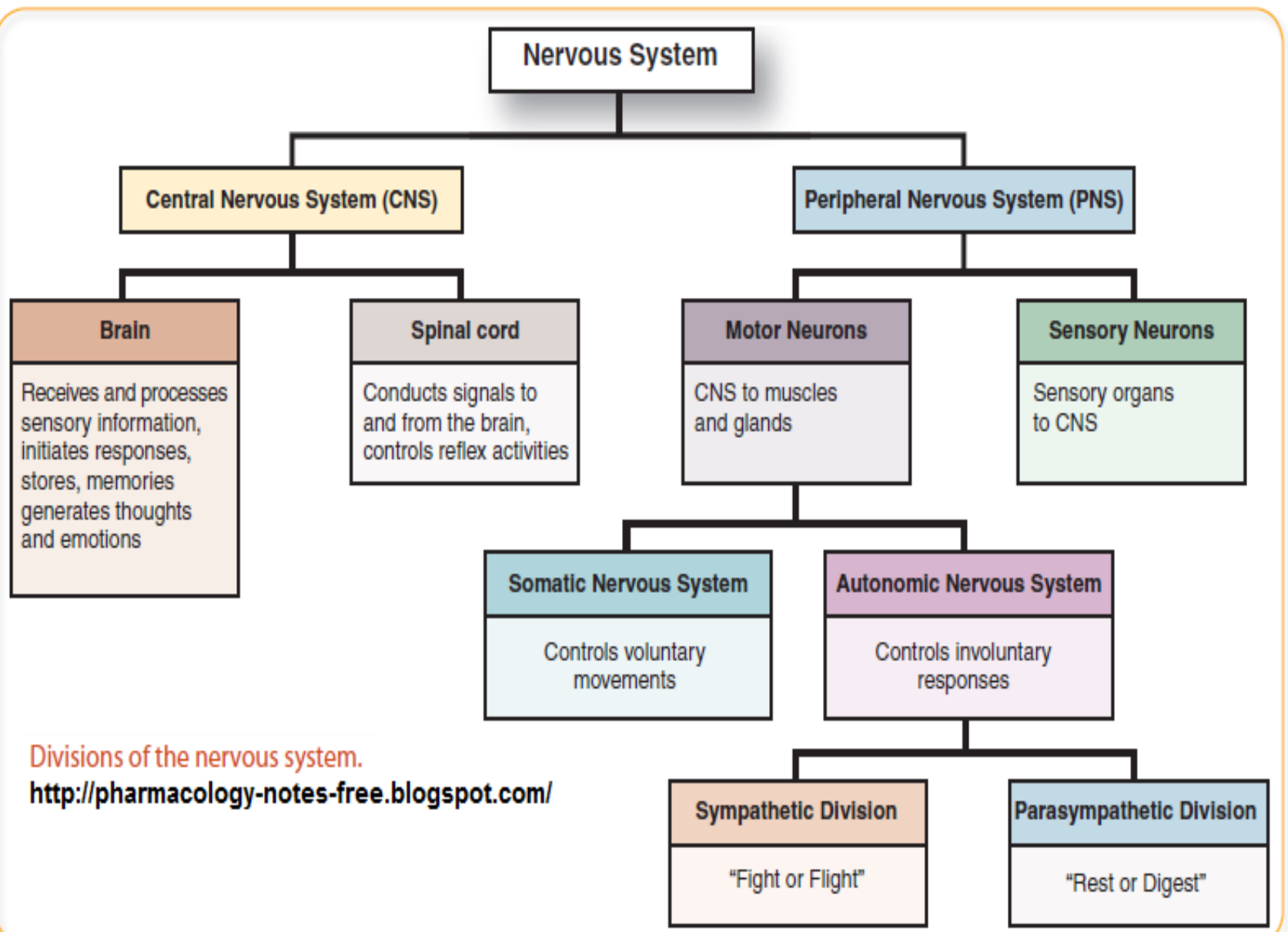
Objectives

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

- ❑ Recognise the organization of the Nervous System
- ❑ Identify the differences between central nervous system (CNS) & peripheral nervous system (PNS)
- ❑ Understand the function & the recruitment of the motor unit. Appreciate effect of motor units number on motor action performance

Organization of Nervous System





Divisions of the nervous system.
<http://pharmacology-notes-free.blogspot.com/>

Nerve-Muscle Interaction

- The nervous system can be divided into central (CNS) and peripheral (PNS)
- It can also be divided in terms of function: motor and sensory activity
- **Sensory Neurons** : collects info from the various sensors located throughout the body and transmits the info to the brain
- **Motor Neurons** : conducts signals to activate muscle contraction
- Skeletal muscle activation is initiated through neural activation

Organization of the Nervous System

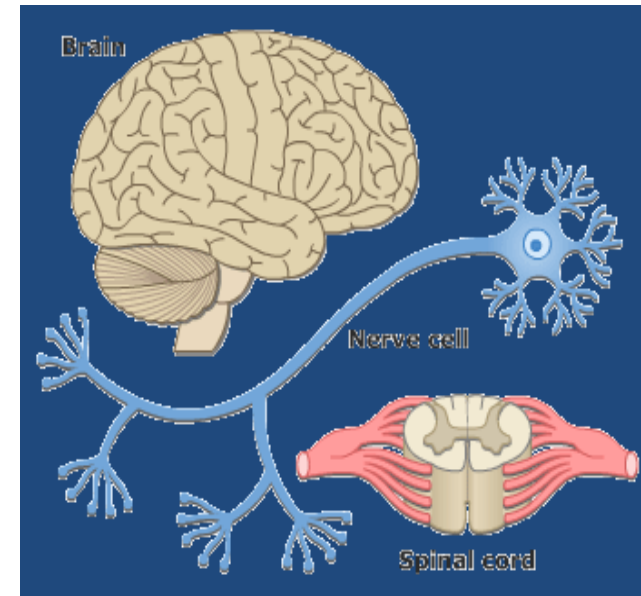
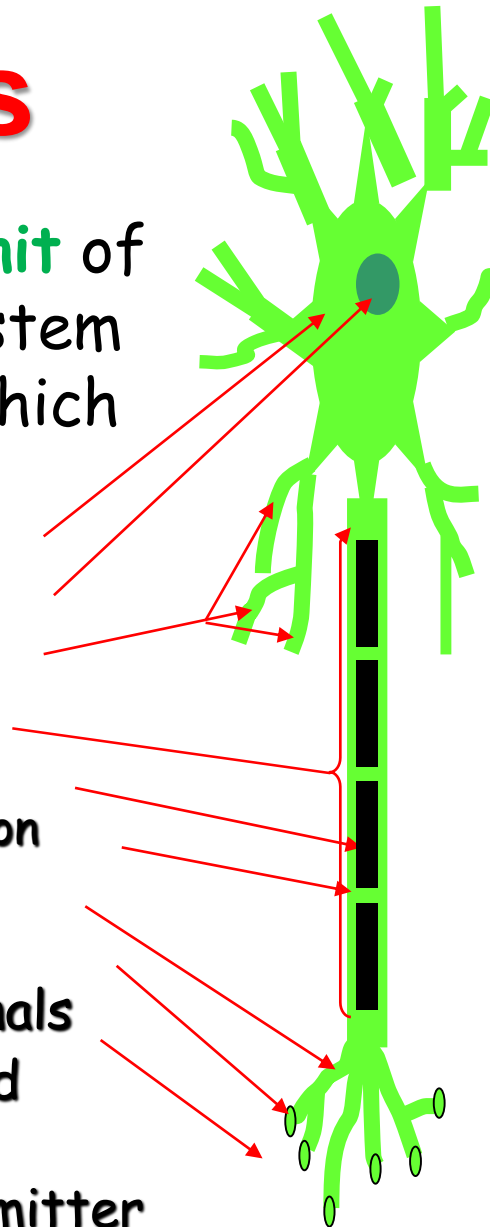
1- Central nervous system (CNS)

- It is the part 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 :-
 - The brain
 - 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

Neurons

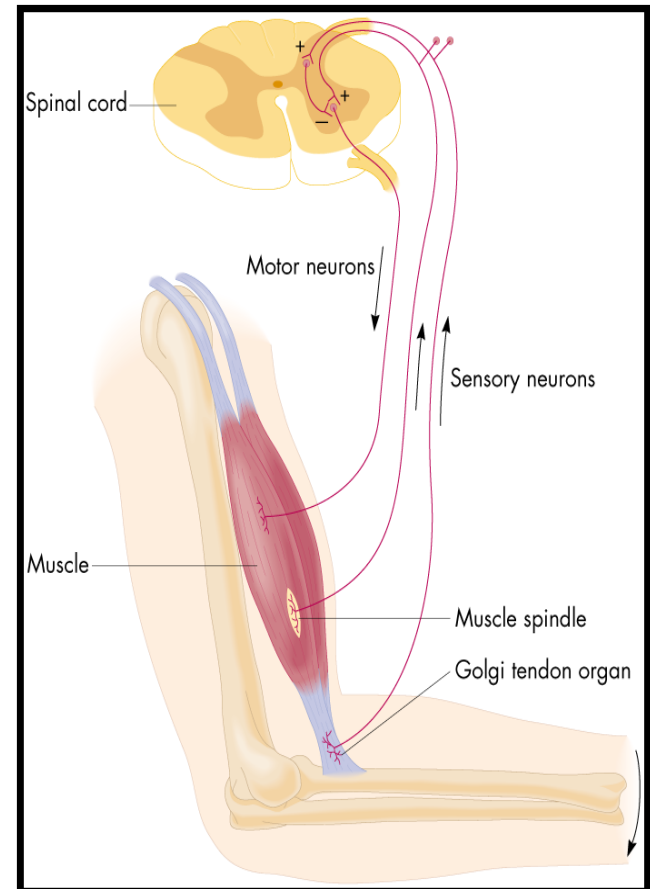
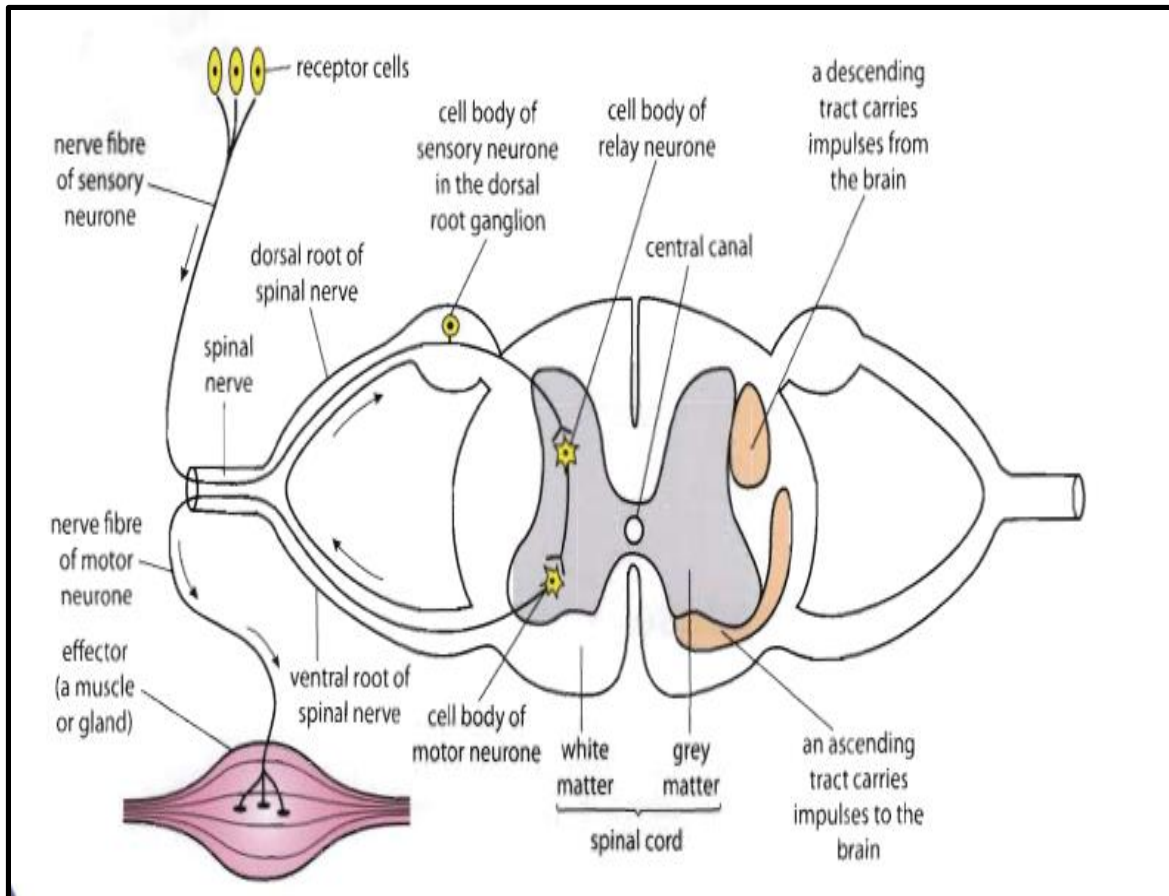
The building unit of the nervous system is the neuron which has

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

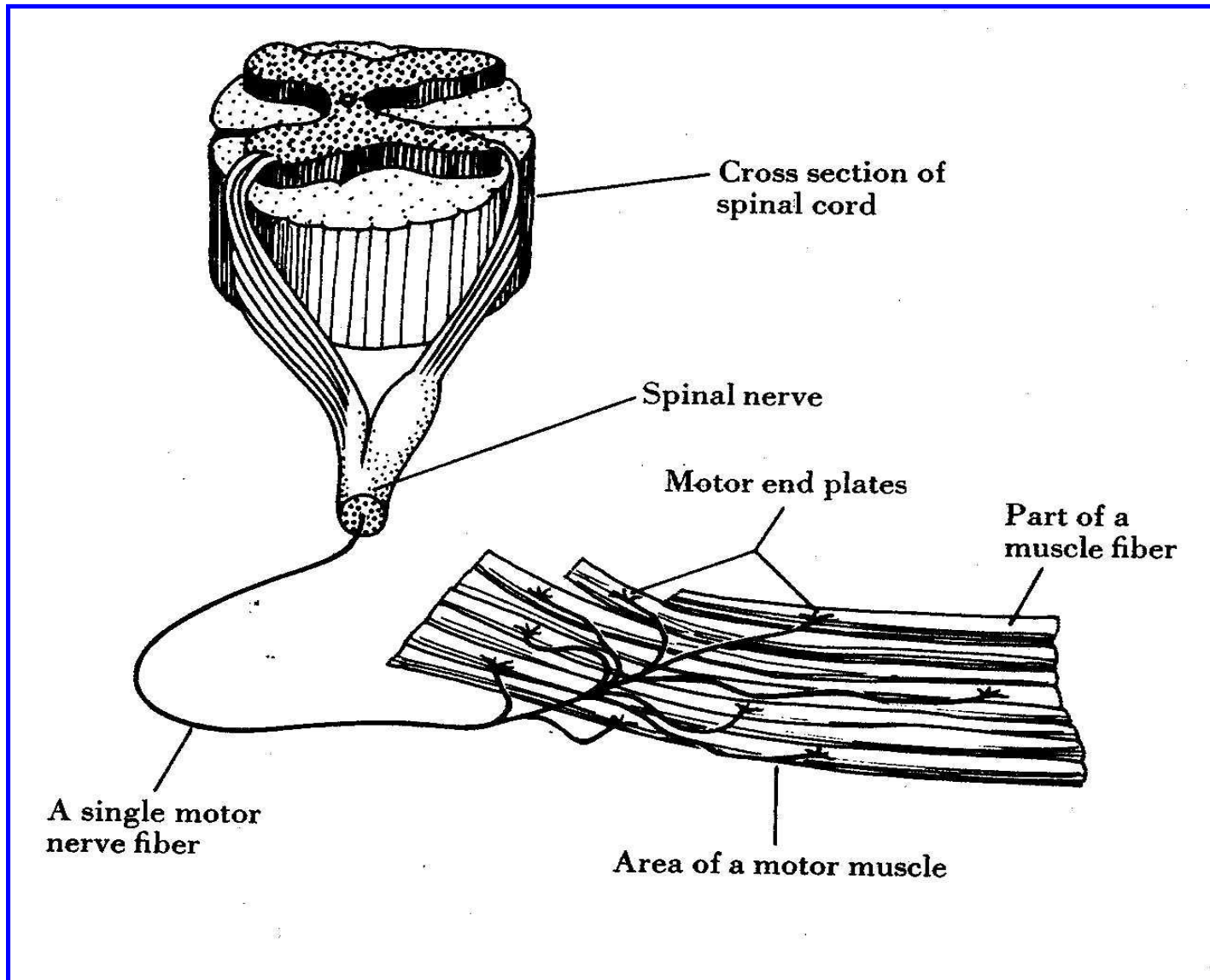


α -motor neuron in the anterior horn cell

A nerve is made of a group of axons of neurons

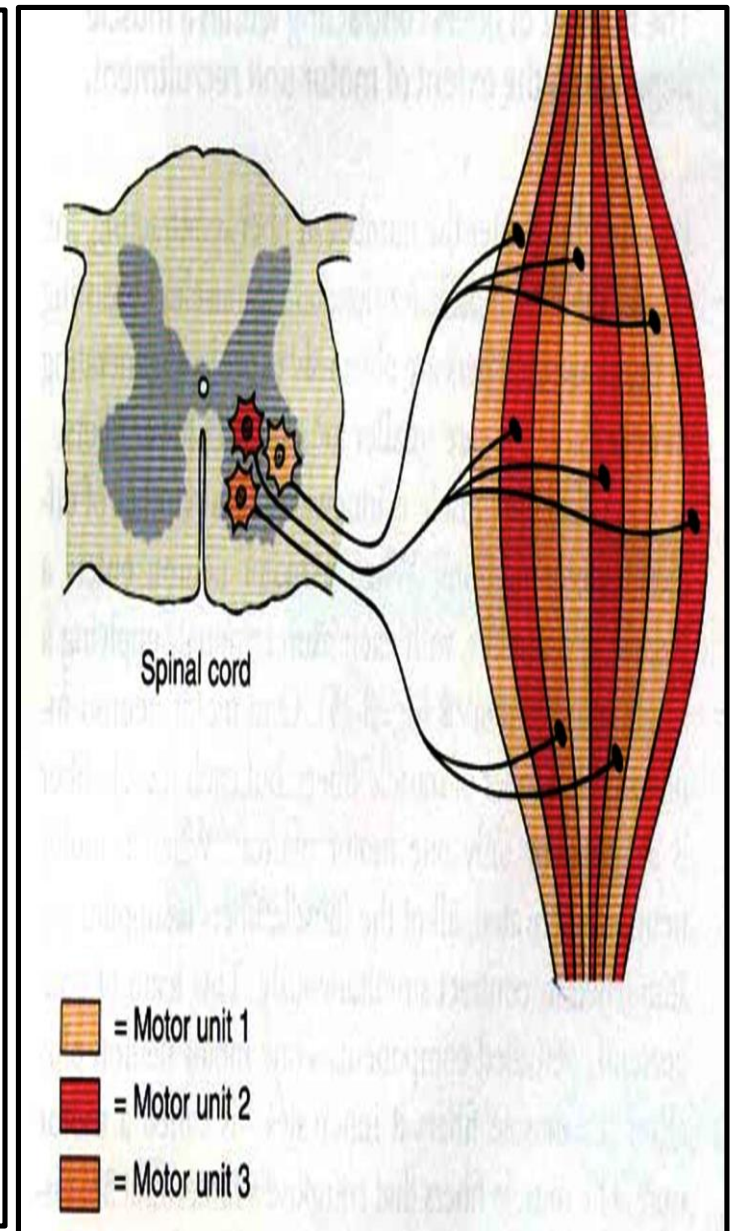


Motor Unit



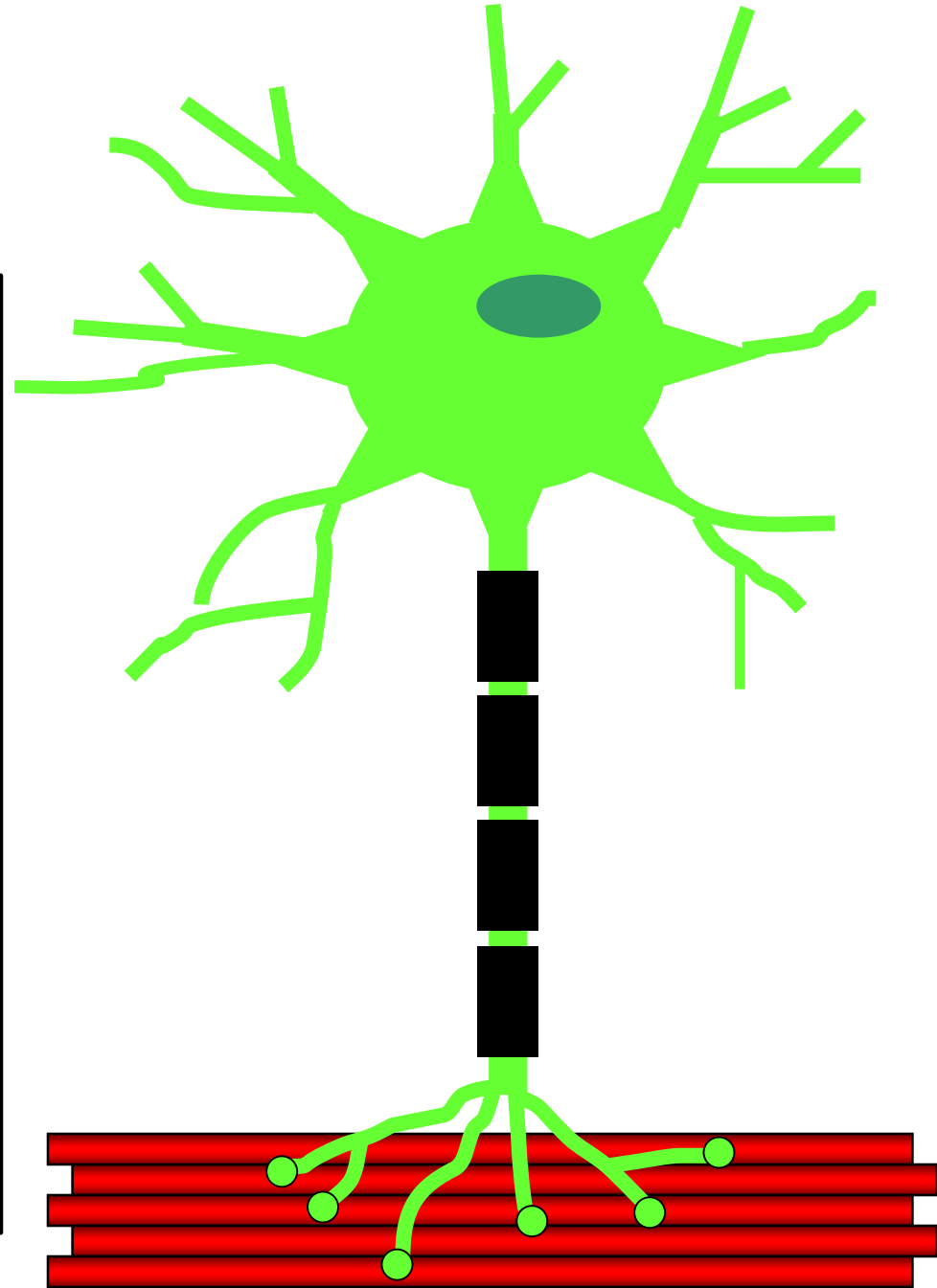
What is a Motor Unit ?

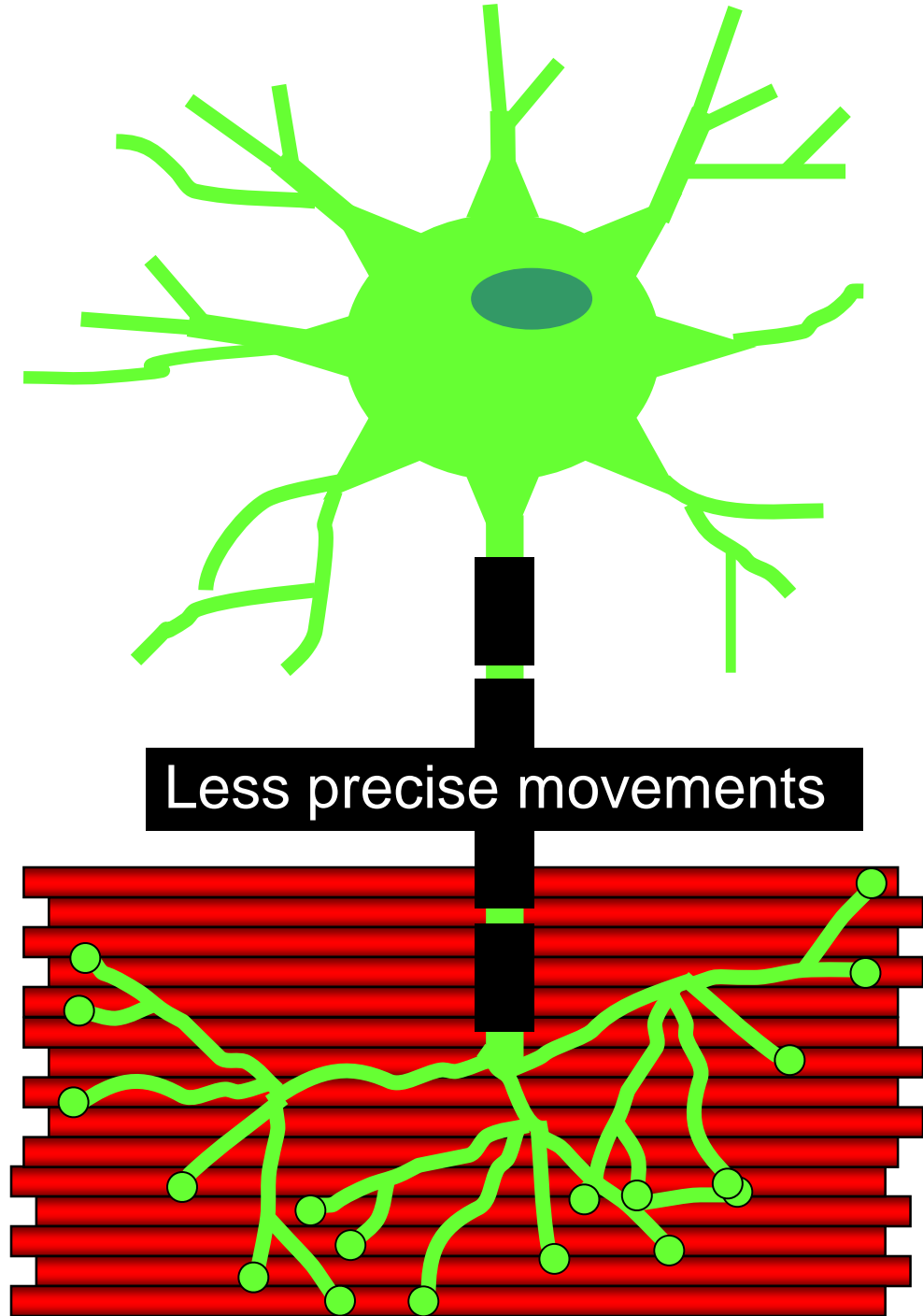
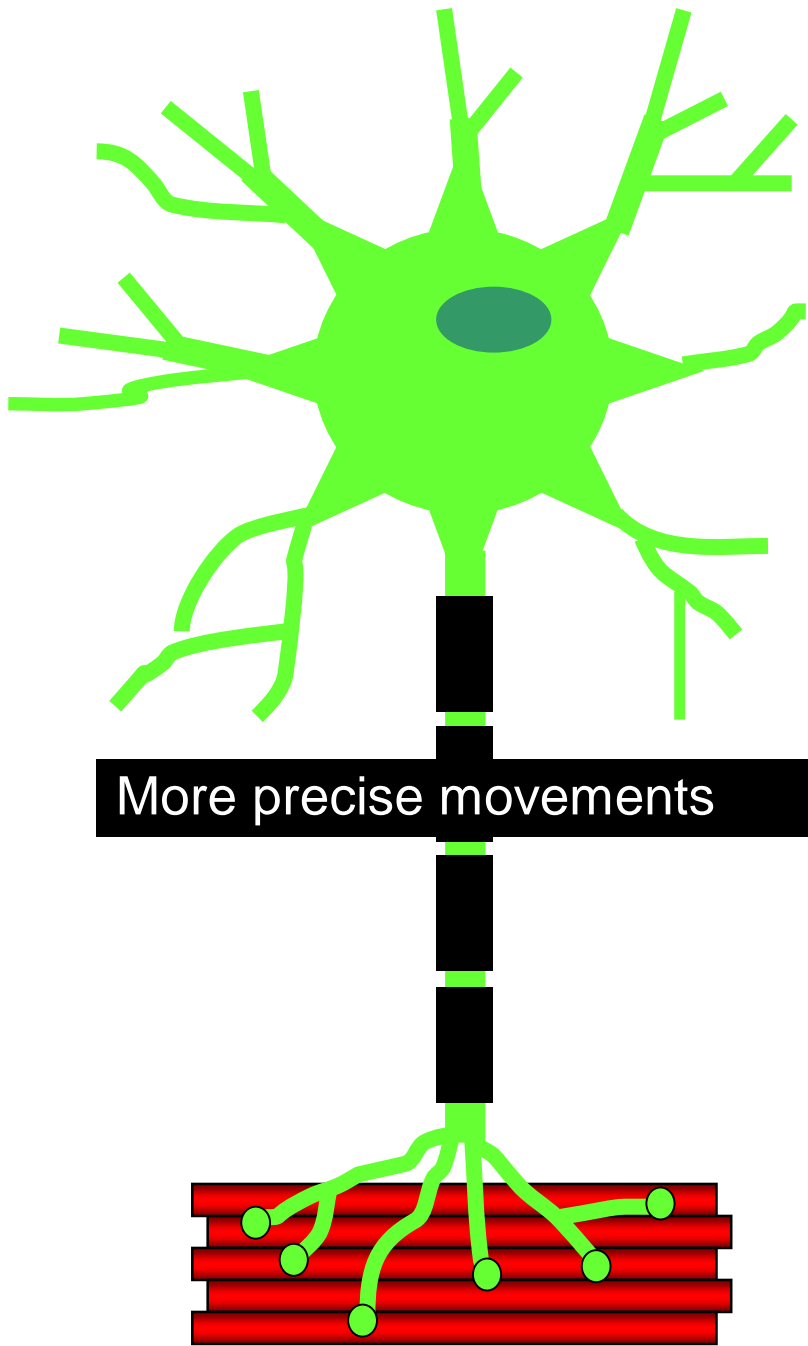
- It is the α -motor neuron in the anterior horn cell (AHC) and all the muscle fibers it innervates (supplies)
- All of these muscle fibers will be of the same type (either fast twitch or slow twitch)
- Each muscle consists of a number of motor units.
- When a motor neuron is activated, all of the muscle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



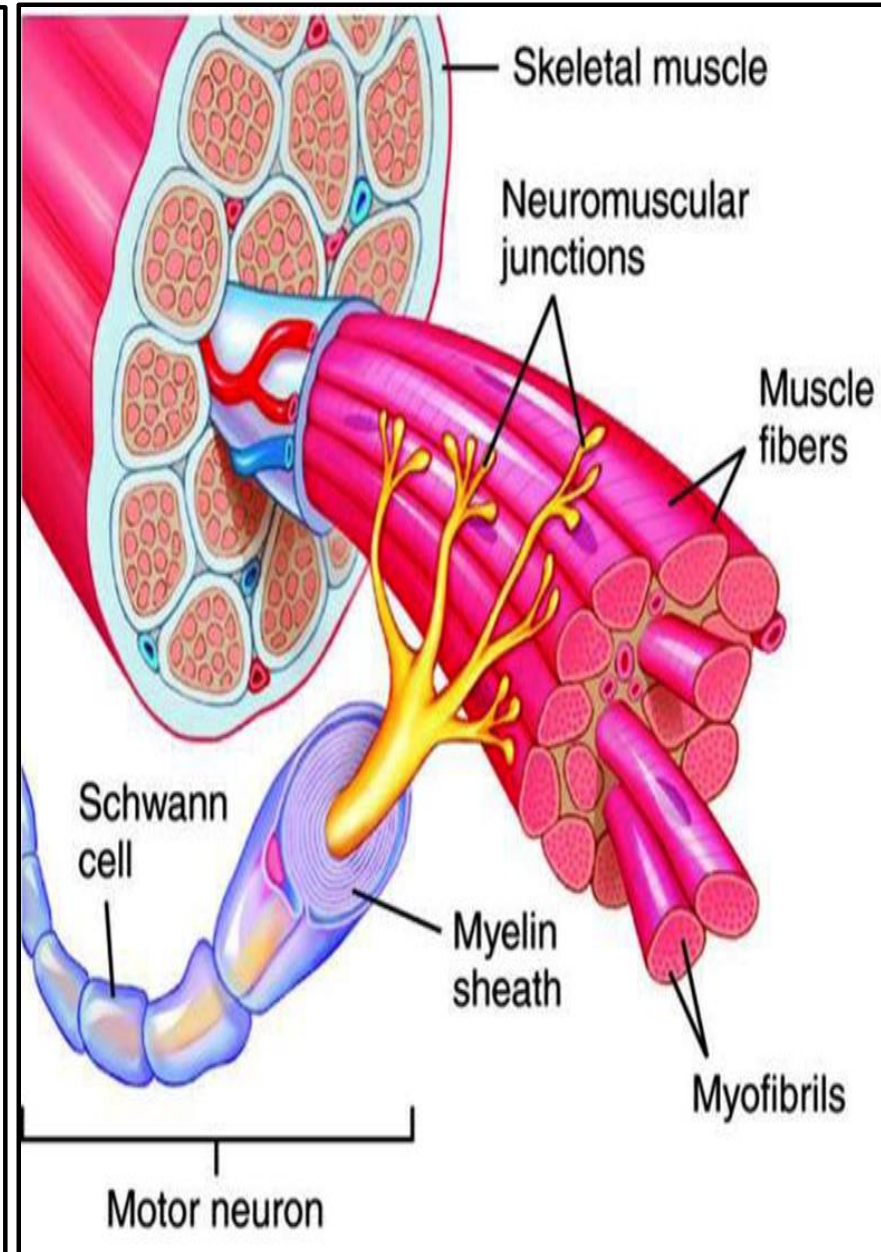
Motor Unit

- The number of muscle fibers in a motor unit (innervated by 1 motor neuron) varies
 - Gastrocnemius
 - 2,000 muscle fibers per motor neuron
 - Extraocular muscles
 - < 10 muscle fibers per motor neuron
- Ratio of muscle fibers to motor neurons
 - Affects the precision of movement





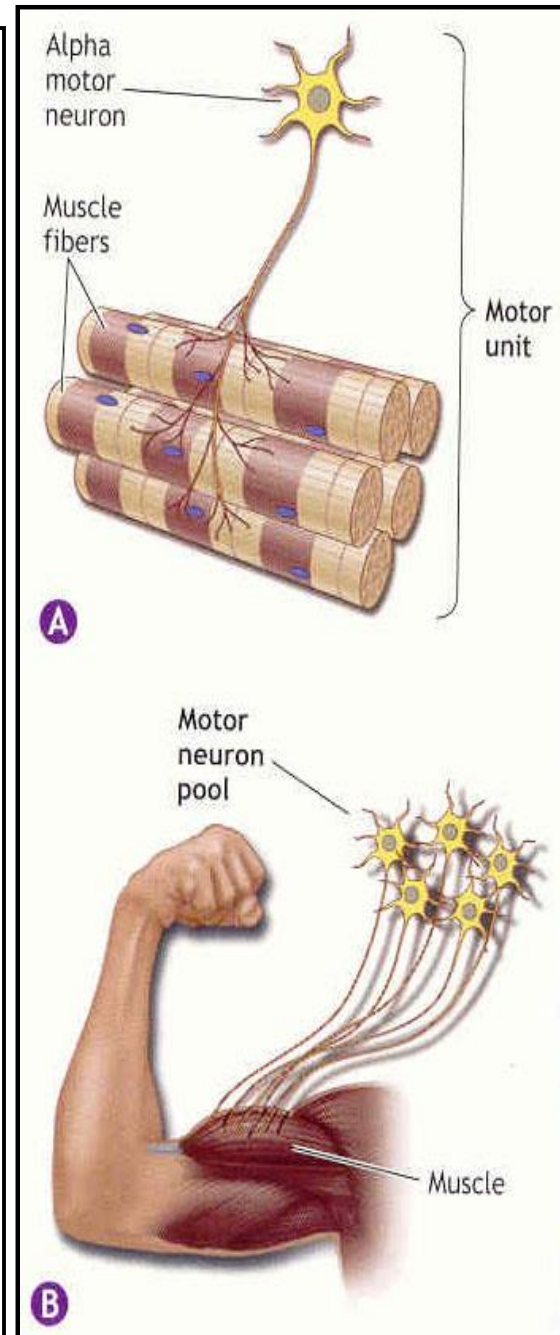
- Groups of motor units often work together to help the contractions of a single muscle .
- The number of muscle fibers within each motor unit can vary.
- Muscles needed to perform **precise movements** generally consist of a large number of motor units and few muscle fibers in each motor unit e.g Hand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

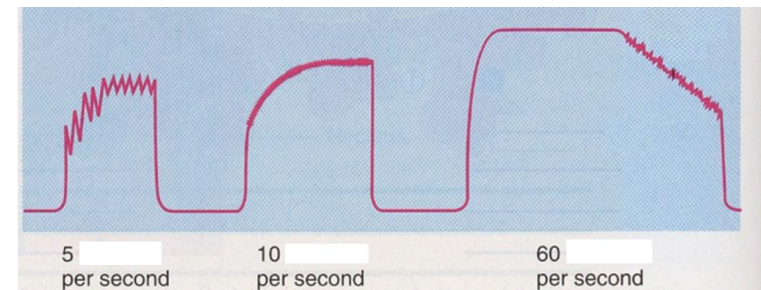
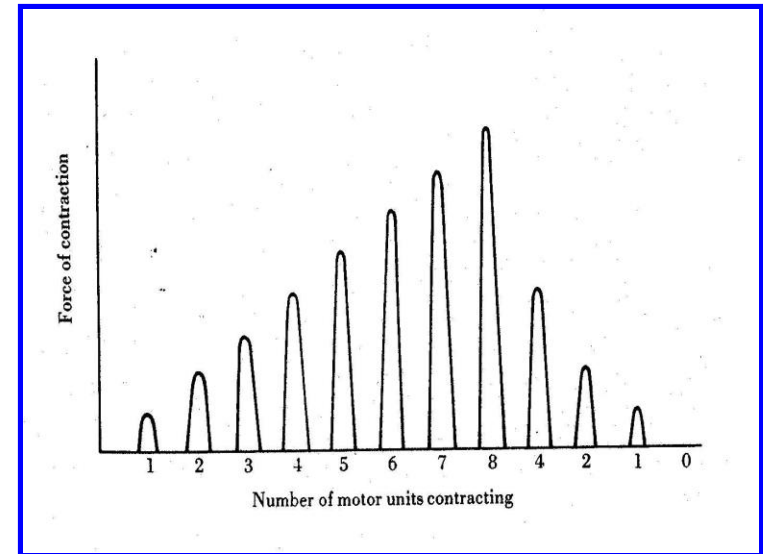
The group of motor units supplying a single muscle are *Motor Unit Pool*

- The two ways the nervous system increases force production is through
 - **recruitment of new motor units
 - ** 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.



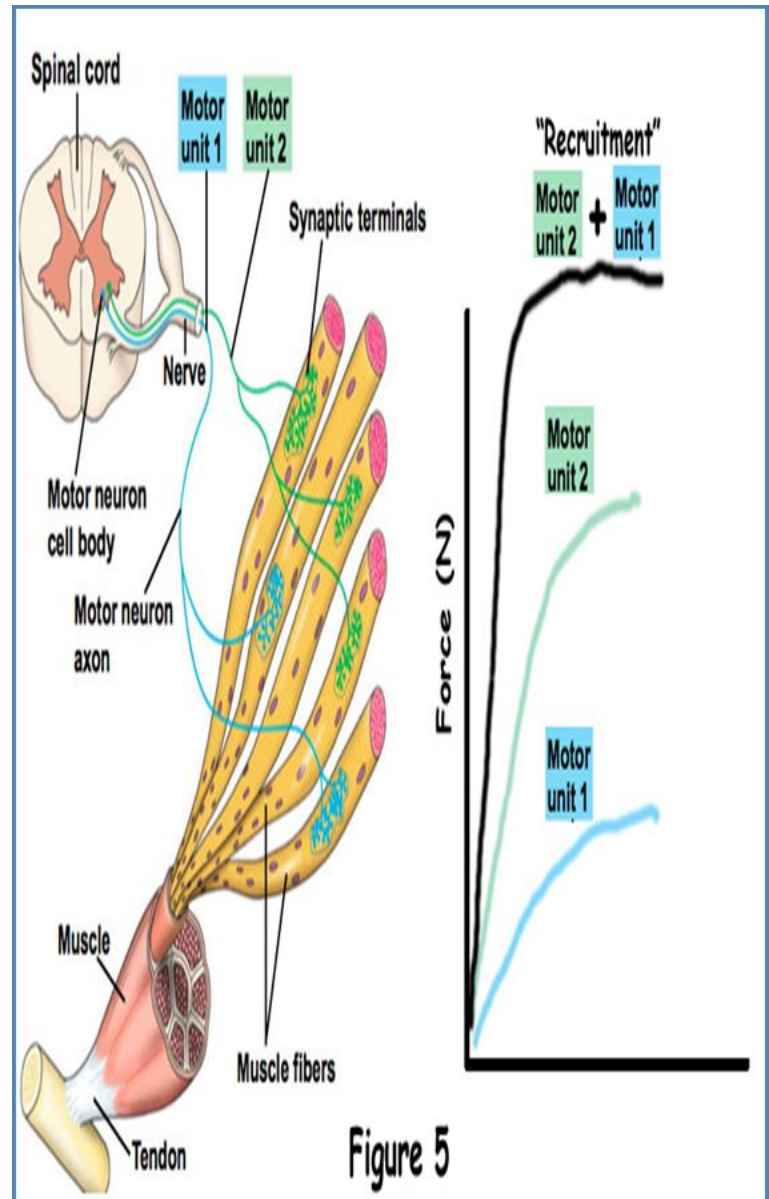
Motor unit recruitment

- 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, &
- (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.

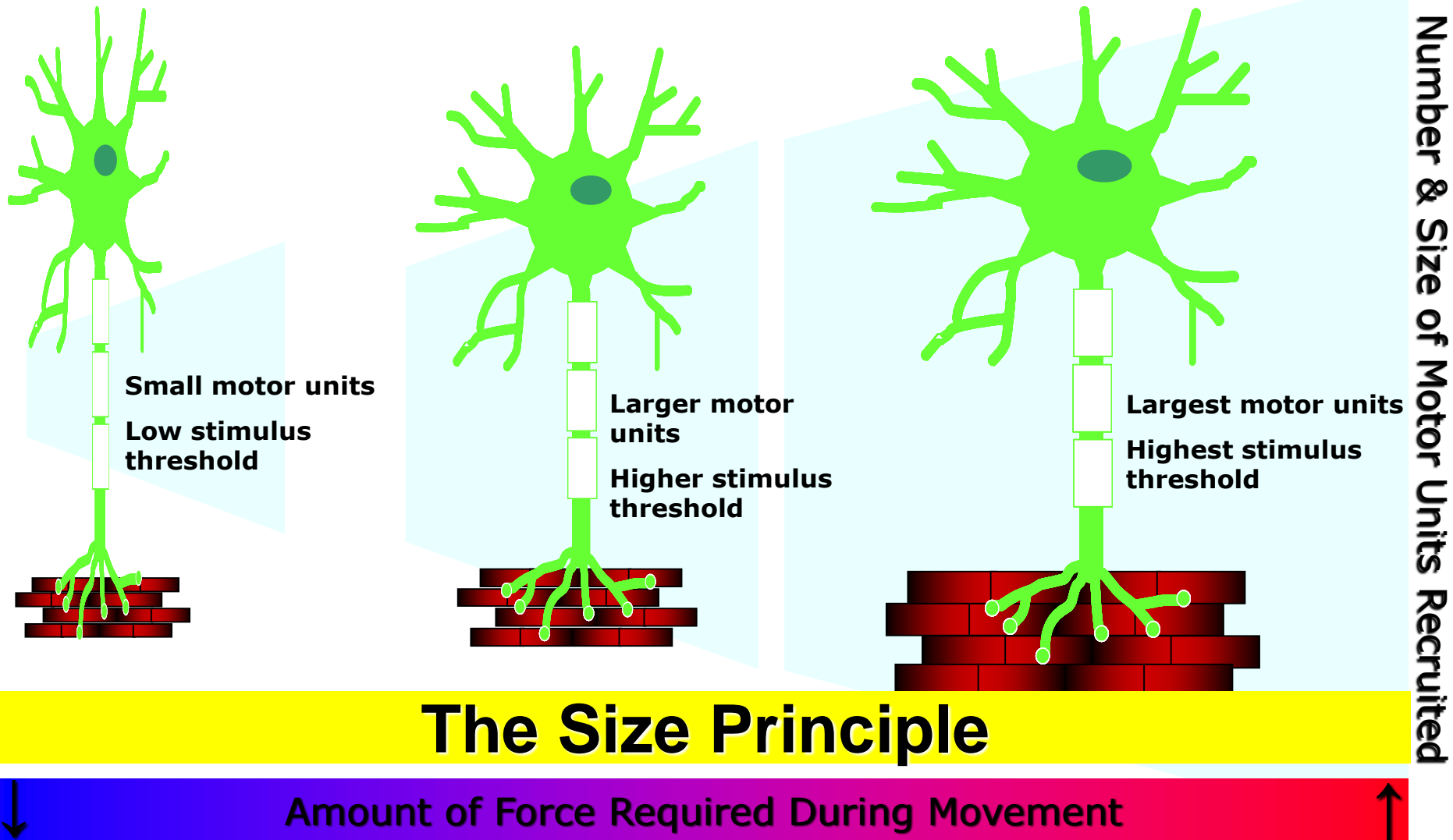


Size Principle

- When CNS send a weak signal to contract muscle , the smaller motor units of the muscle stimulated first.
- Then with increase the strength of signals larger and larger motor units begins to be excited

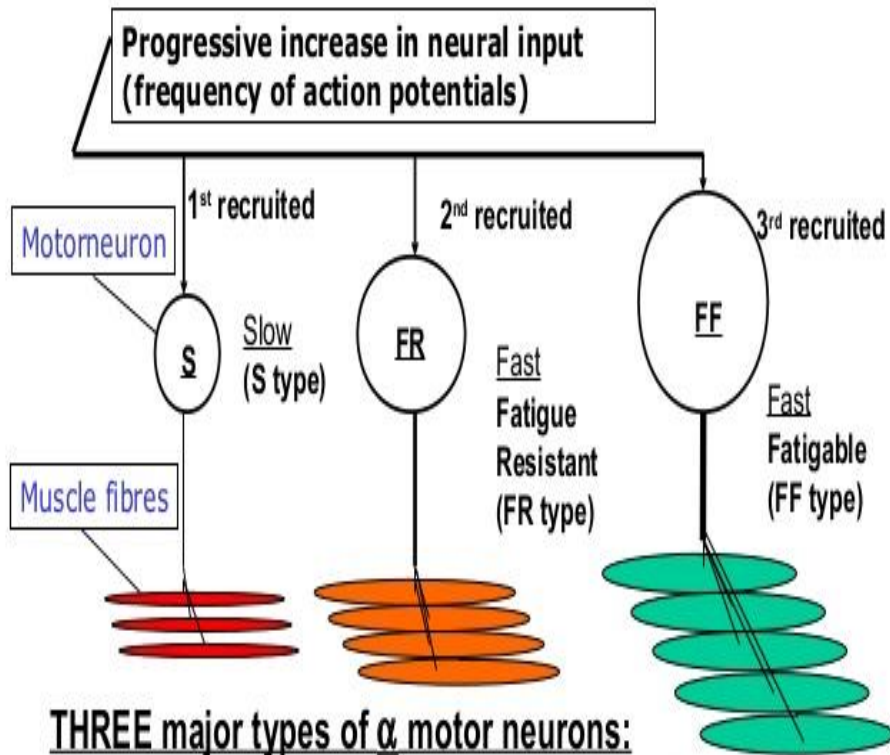
Recruitment

- Varying the number of motor units activated.



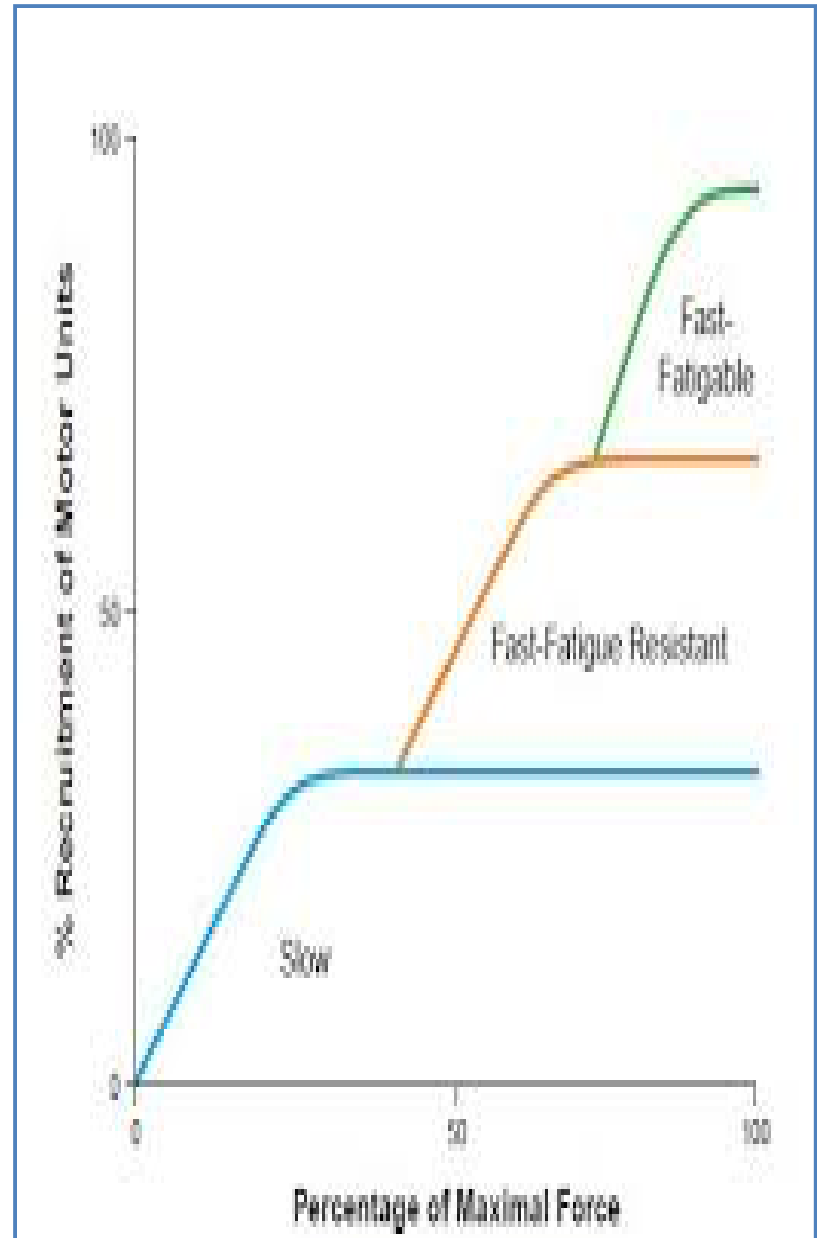
Important rule:

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



THREE major types of α motor neurons:

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



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.

THANK YOU