

Organization of the Nervous System and the Motor Unit

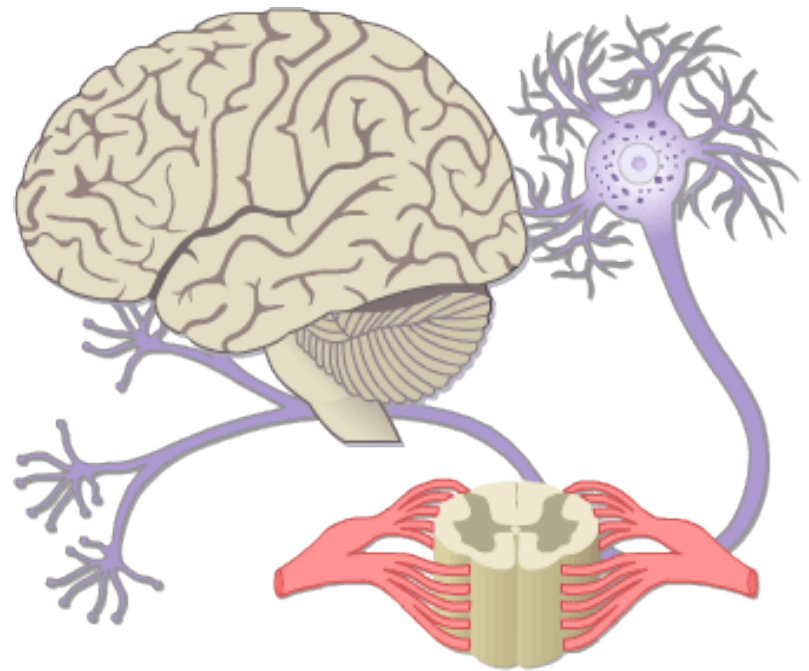
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Objectives of the lecture

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

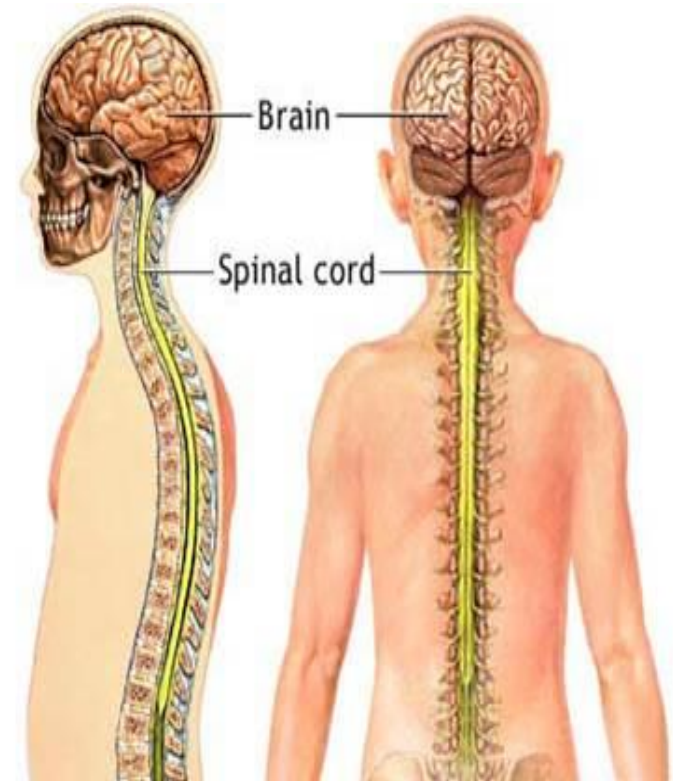
- Recognise the organization of the Nervous System**
- Appreciate differences between both central nervous system (CNS) & peripheral nervous system (PNS)**
- Understand the function & the recruitment of the motor unit**

Classification of the Nervous System

- The **NERVOUS SYSTEM** can be classified in several ways into :
 - **A/** (1) Central, and
(2) Peripheral
 - **B/** (1) Somatic, and
(2) Autonomic
 - **C/** (1) Sensory, and
(2) Motor

A/ Central and Peripheral NS

- **Central Nervous System (CNS)**, consists of **brain** and **spinal cord**
- **Peripheral Nervous System (PNS)**, consists of **peripheral nerves** (whether somatic or autonomic nerves). It comprises 12 pairs of **cranial nerves** and 31 pairs of **spinal nerves**



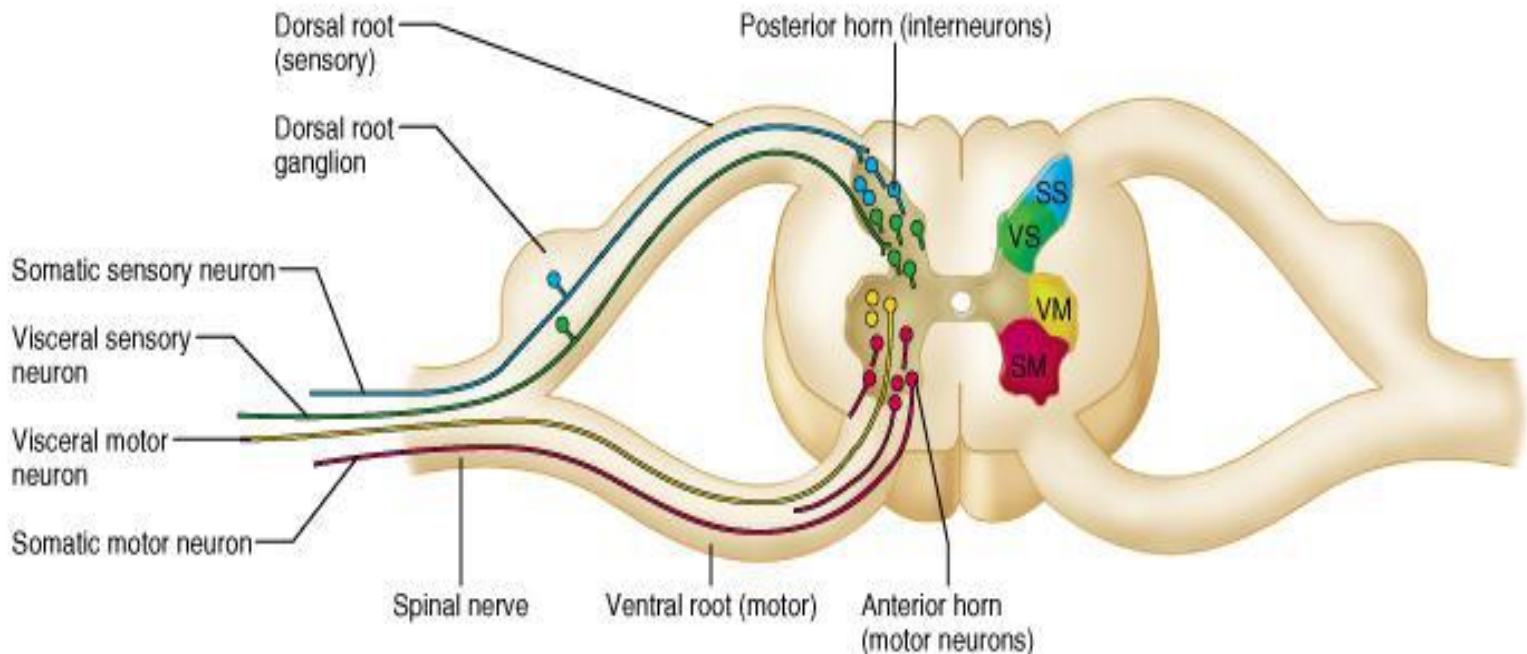
B/ Somatic & Autonomic NS

- **(1) Somatic جسدي NS : Concerned with**
- (i) **somatic sensory** -----» sensations from somatic structure : body surface , skeletal muscle , joints & tendons
- (ii) **somatic motor** (voluntary activity executed by skeletal muscles)

- **(2) Autonomic اللاإرادي NS : Concerned with**
- (i) **visceral sensations** : sensations arising from internal structures (such as the heart , lungs , intestines , etc) ,
- (ii) **involuntary movements** executed by smooth and cardiac muscles
- (iii) **secretion by glands** (endocrine & exocrine) , which is also involuntary .

C/ Sensory & Motor NS

- **Sensory neurons** carry information from the stimulus receptor to the CNS.
- **Motor neurons** emerge from the CNS carrying **motor orders** from the CNS to the effector organs (muscles and glands).



Neurons

• **DIF:** Unit of function of the CNS,
Either sensory or motor

■ Basic components of neurons

– Soma (Cell body)

■ Nucleus

– Dendrites

– Axon

■ Myelination

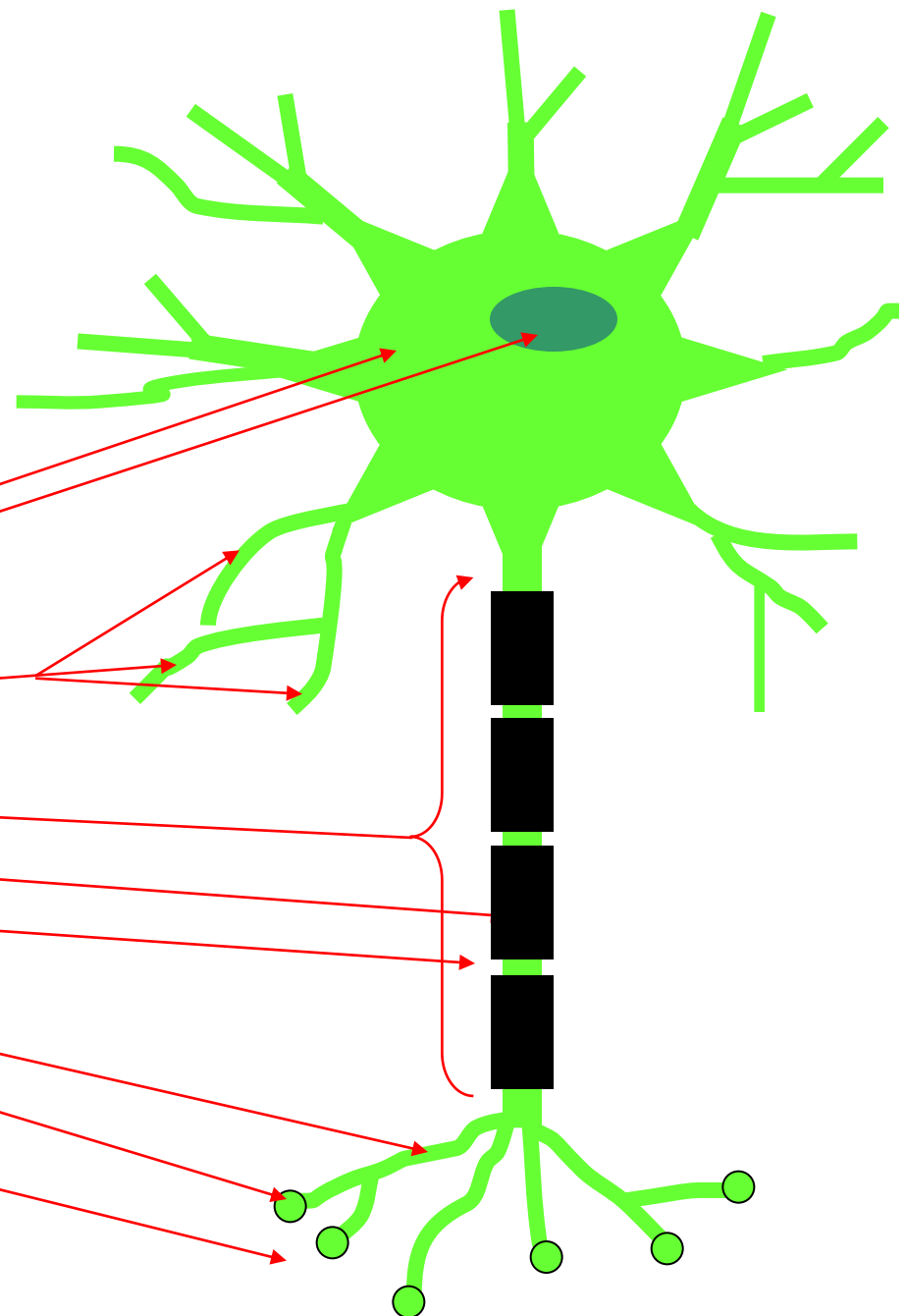
■ Nodes of Ranvier

– Axon terminals

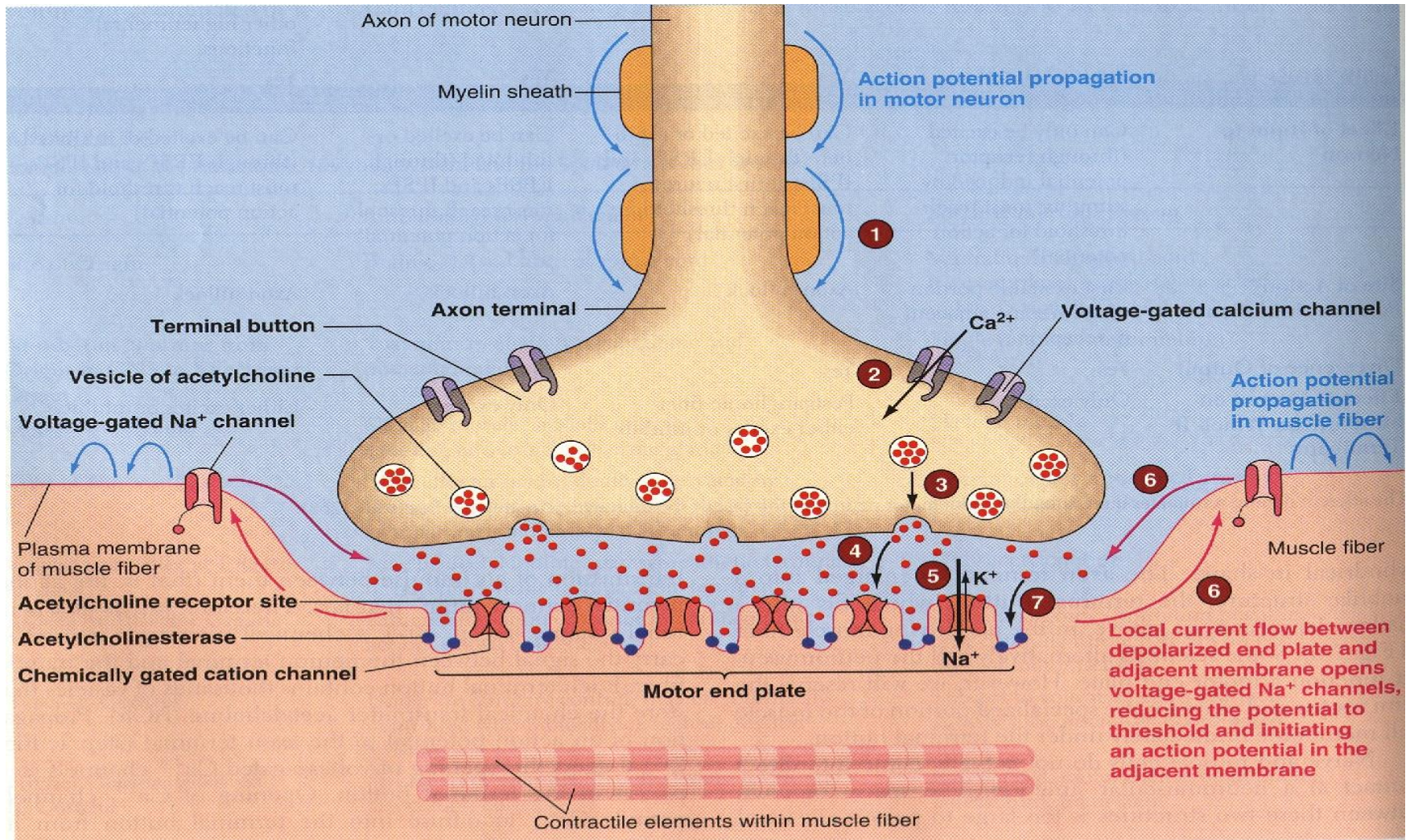
– Synaptic end bulbs

– Neurotransmitter

■ Acetylcholine (Ach)

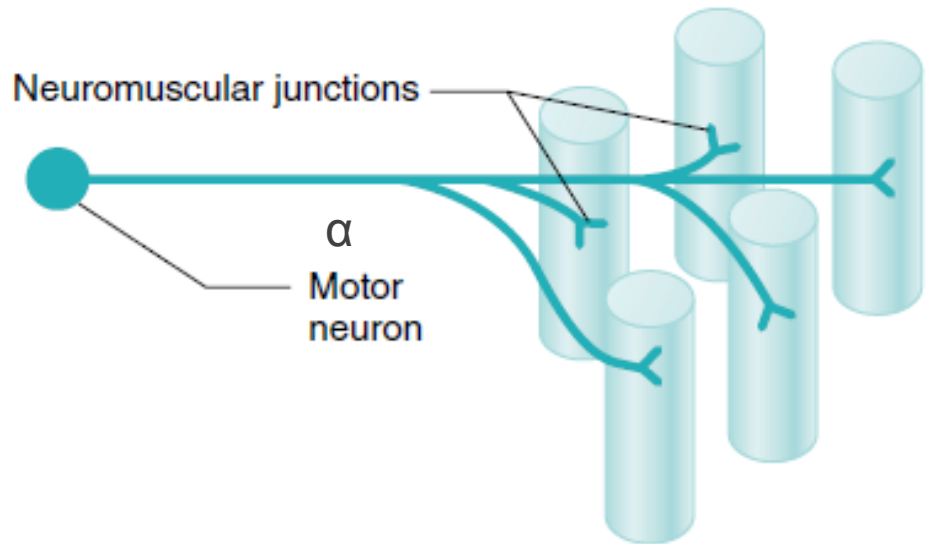


Neuromuscular Junction

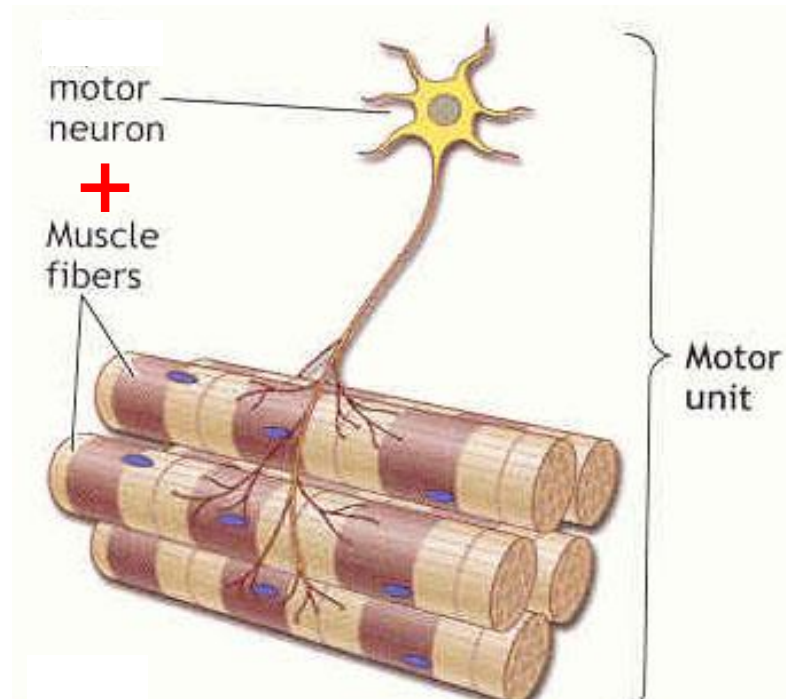


Motor Neuron

- ❖ The nerve cells whose axons innervate skeletal muscle fibers are known as **motor neurons** (or **somatic efferent neurons**), and their cell bodies are located in either the brainstem or the spinal cord.
- ❖ The axons of motor neurons are ***myelinated*** and are the largest diameter axons in the body.



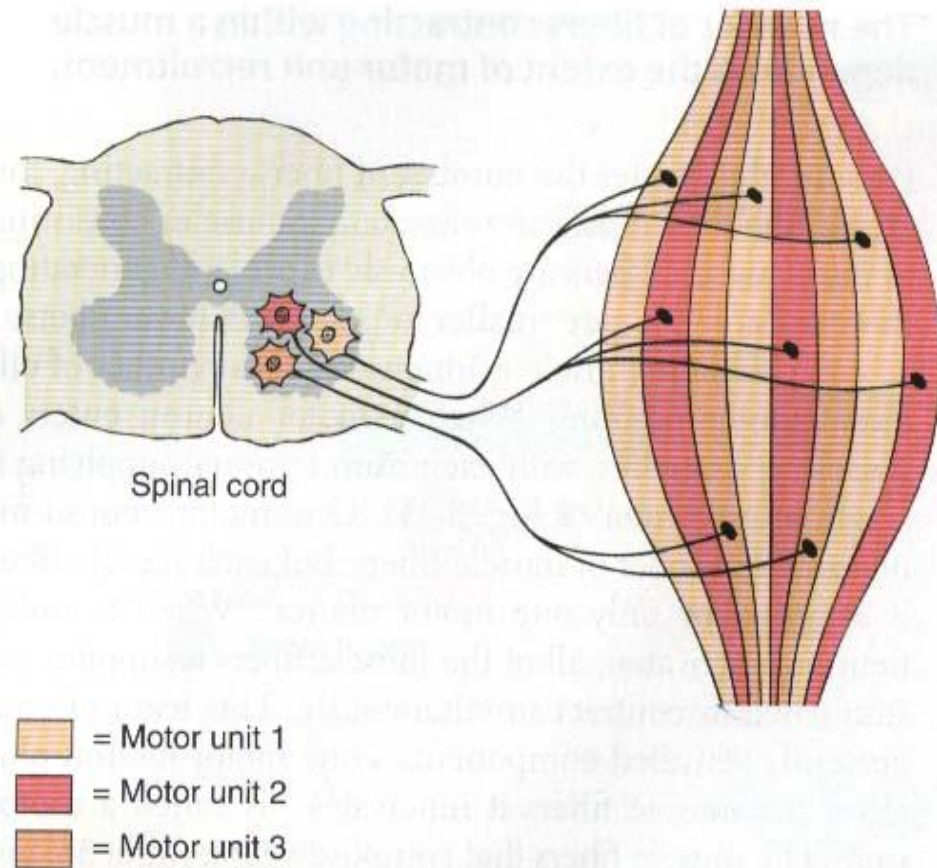
The Motor Unit



Motor Unit

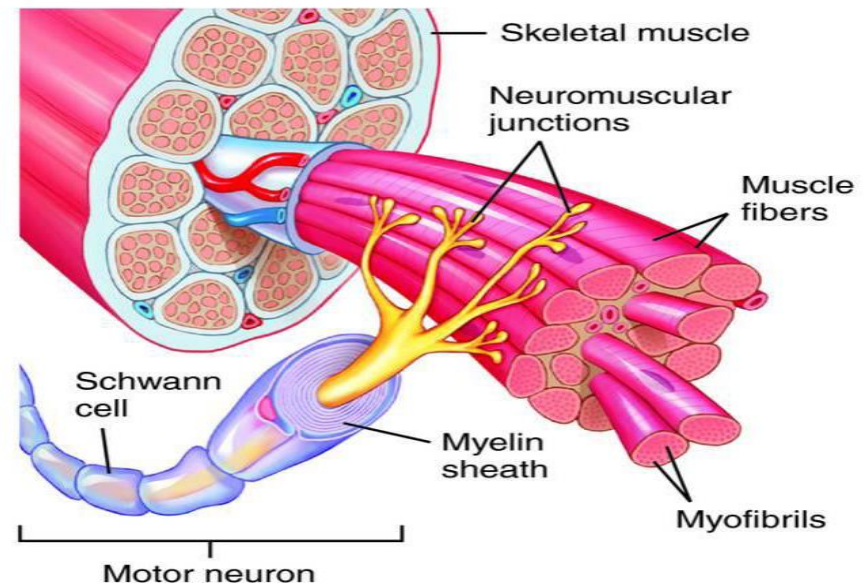
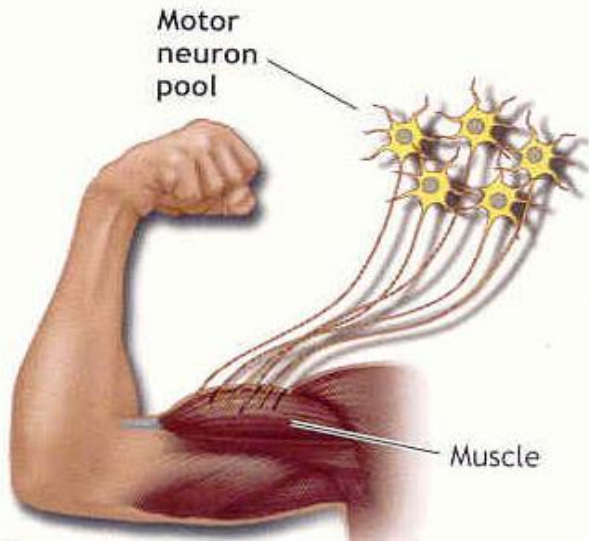
Q:What is a Motor Unit?

- It is the Motor Neuron (Anterior Horn Cell , Axon) and all the muscle fibers it innervates (supplies)



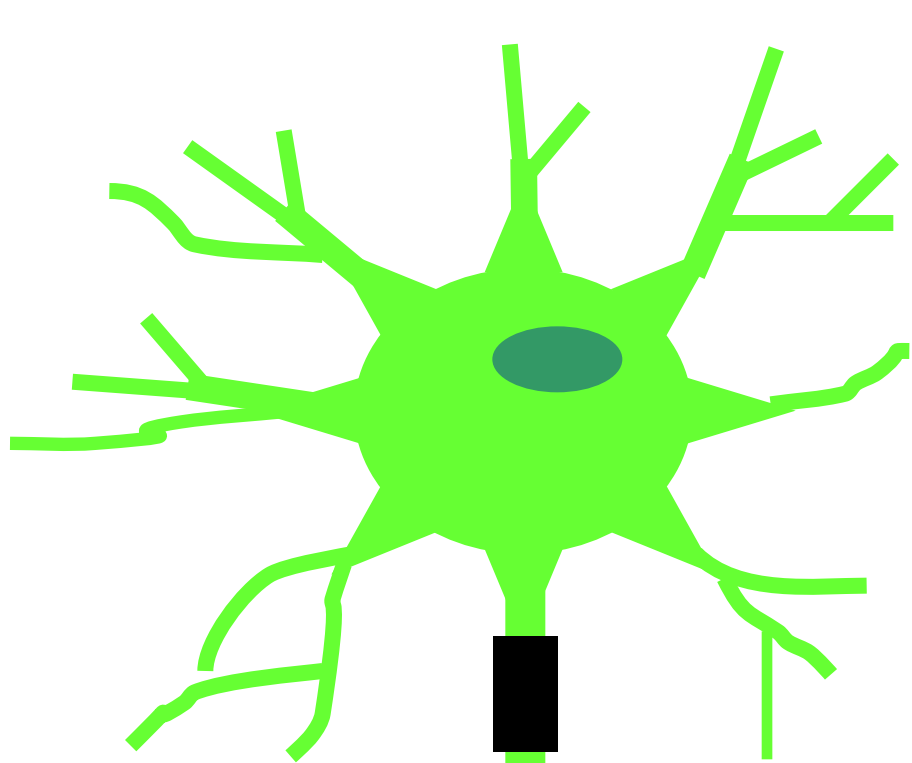
Motor unit

- A motor unit is a single α -motor neuron and all of the corresponding muscle fibers it innervates
- All of these muscle fibers will be of the same type (either fast twitch or slow twitch)
- 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 **تفيد** a single muscle are considered **a motor unit pool**

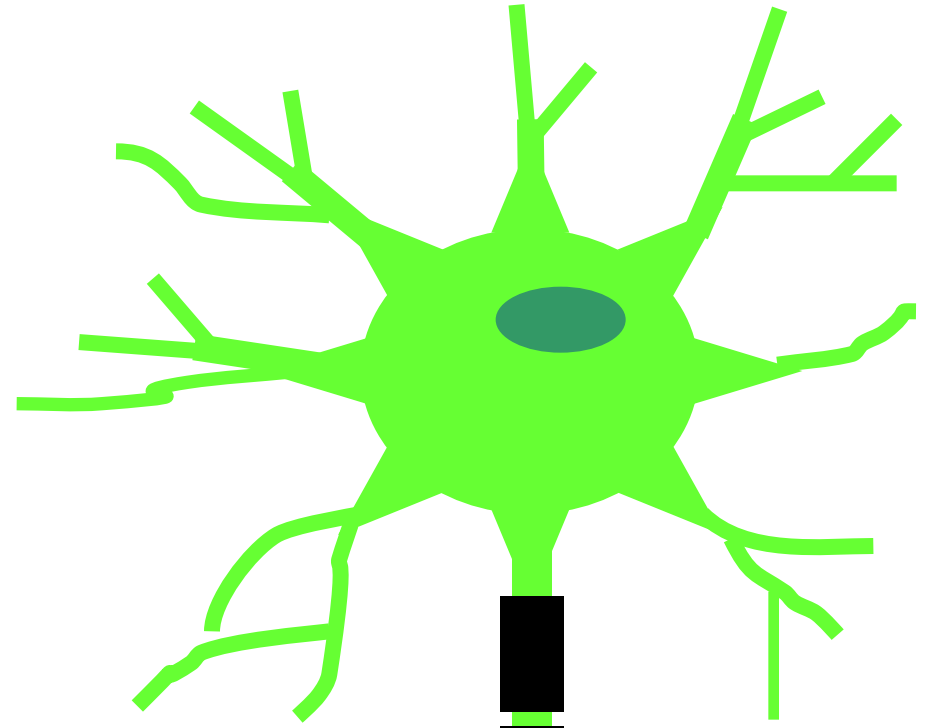
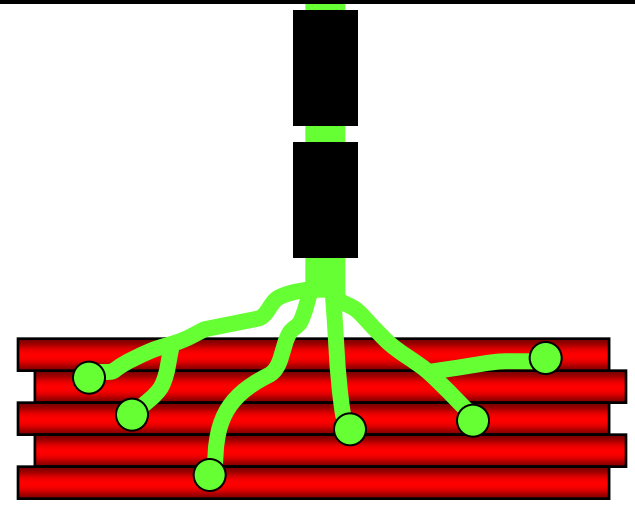


The number of muscle fibers within each motor unit can vary:

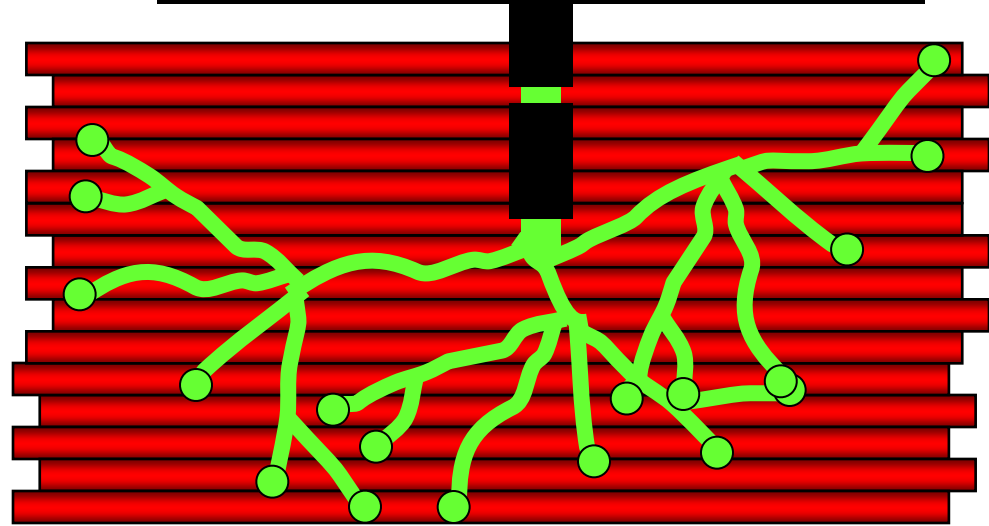
- **Fine movements** / الحركات الدقيقة need motor units that have small number of muscle fibers.
- **Gross movements** / الحركات الجسيمة need motor units that have large number of muscle fibers.
- Thigh muscles can have a thousand of fibers in **each** motor unit.
- A single motor unit for a muscle like the gastrocnemius (calf) muscle (for gross movements) may include 1000-2000 muscle fibers/ motor unit.
- A single motor unit for eye muscle controlling eye movements (**fine movements**) has fewer than 10 muscle fibers.



More precise movements



Less precise movements



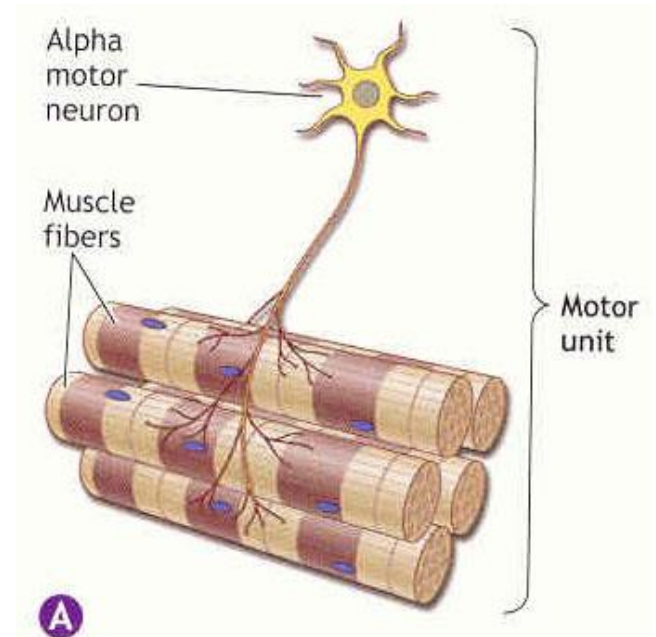
- In general, the number of muscle fibers innervated by a motor unit is a function of a muscle's need for refined motion.
- The smaller the motor unit, the more precise **دقيق** the action of the muscle.
- Muscles requiring more refined motion are innervated by motor units that synapse with fewer muscle fibers.
- In medical **electro diagnostic 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**

Gradation of Muscle Force

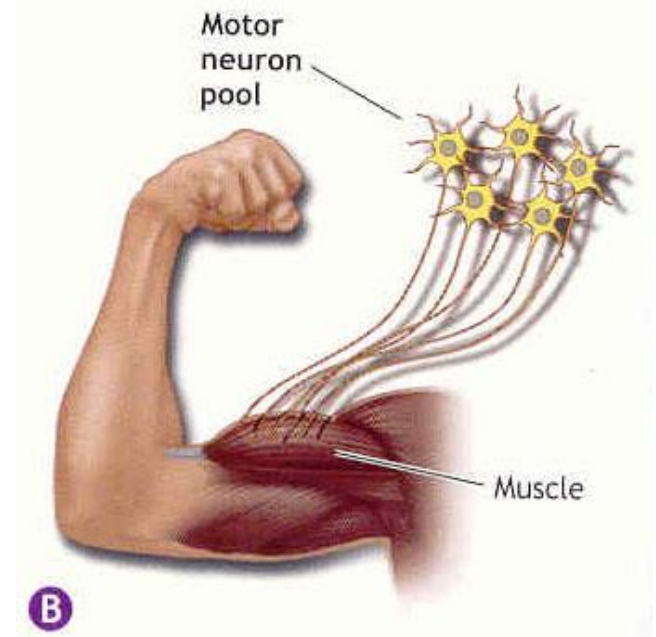
تدرج قوة العضلات

- Two neural mechanisms responsible for force gradations: التدرج:

1. Recruitment
2. Rate coding



A



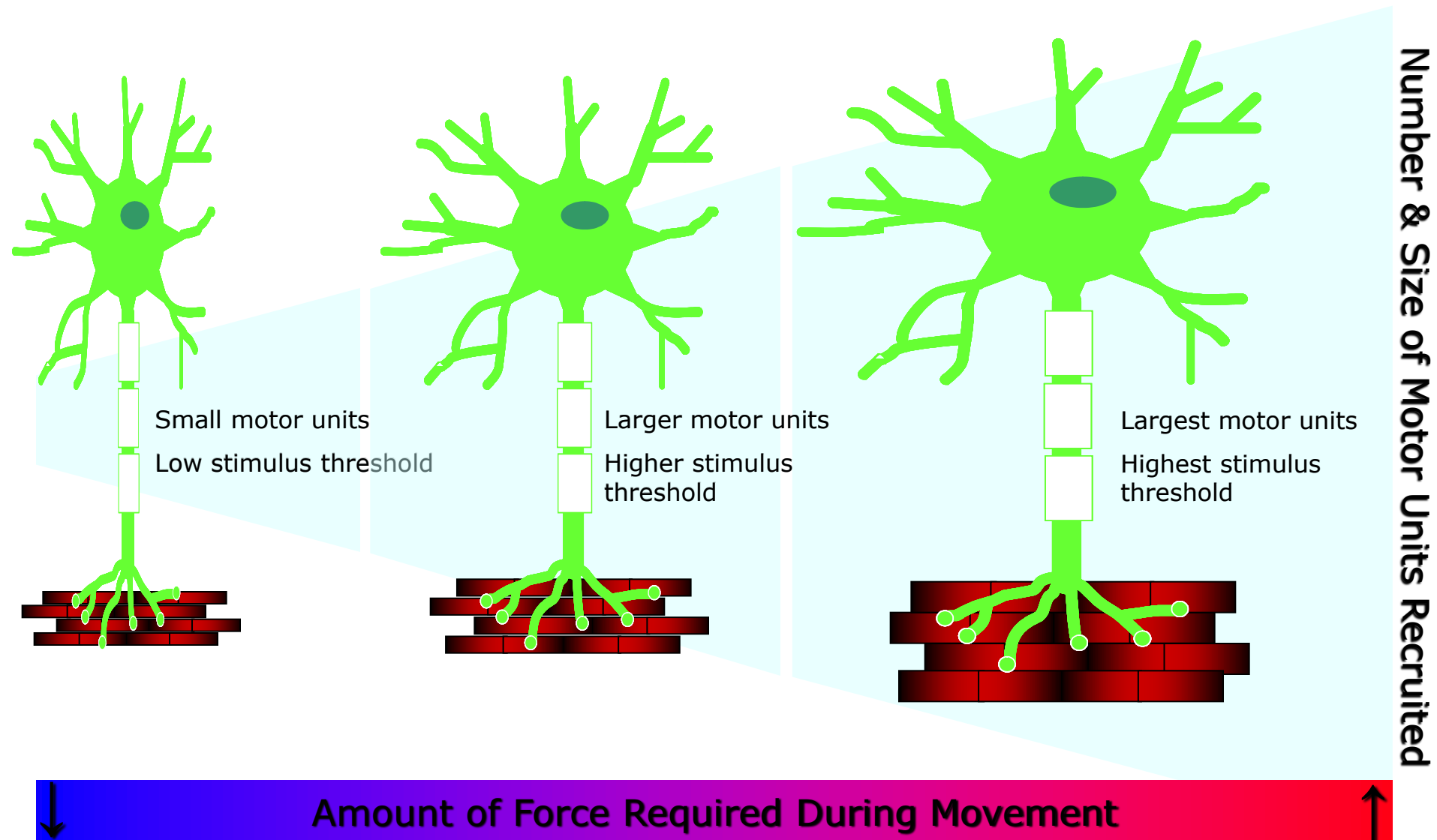
B

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.
- A single muscle consists 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 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.**

Recruitment

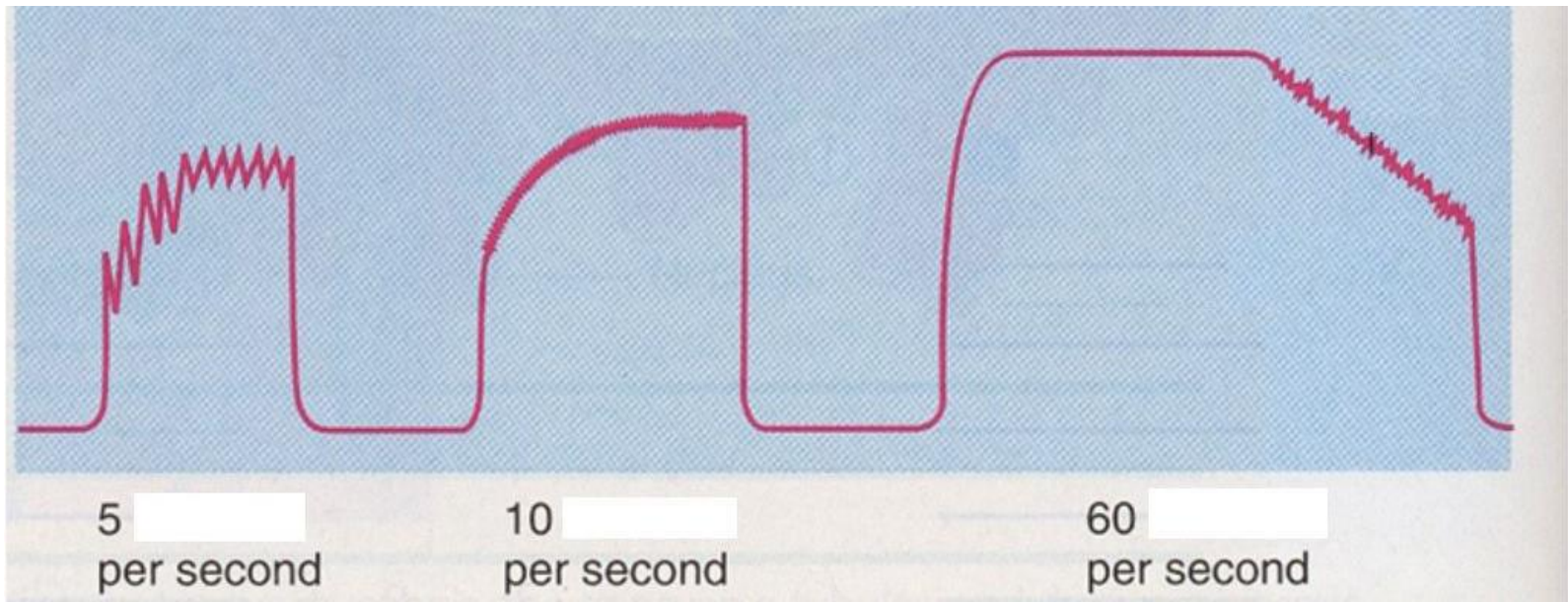
- Varying the number of motor units activated.



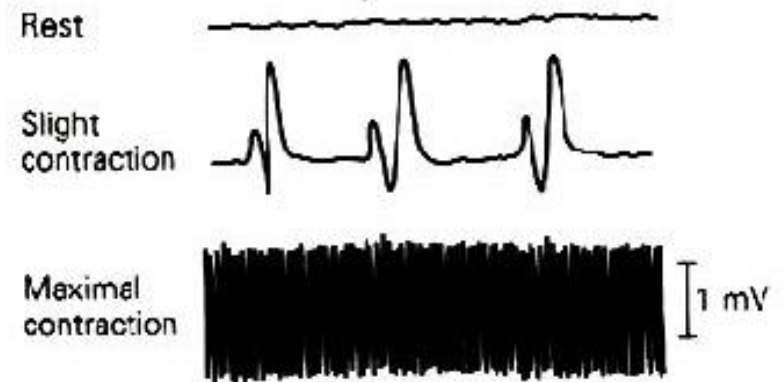
Rate Coding

- Rate coding refers to the **motor unit firing rate**.
 - Active motor units can discharge at higher frequencies to generate greater tensions.
- When the AHC fires at slow rates , MUAPs will be at slow rate & the force of muscle contraction is weak.
- If AHC fires at very fast rates ----» fast MUAPs ----» stronger contraction





Increasing frequency of action potentials resulting in stronger force of contraction



Recruitment vs. Rate coding

- **Smaller muscles** (e.g. first dorsal interosseous) rely more on rate coding
- **Larger muscles** of mixed fiber types (e.g. deltoid) rely more on recruitment

