



Physiology Team

MEDICAL COLLEGE 433

Organization of the Nervous System and the Motor Unit

Color Index

Red = important

Purple = Addition

Orange = Explanation



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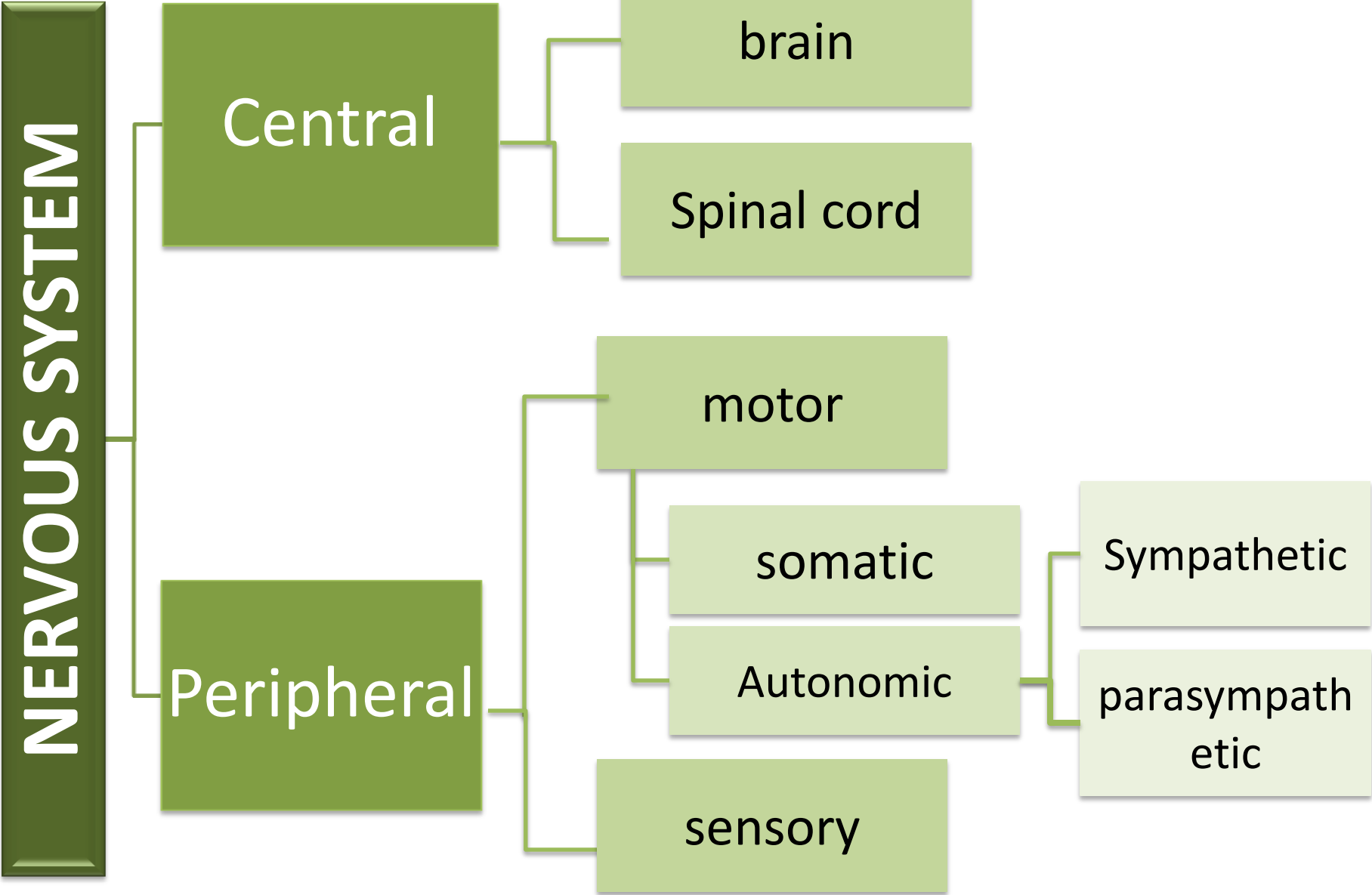
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Objectives :

- Recognize 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



Remember that :



Remember that :

Central Nervous System (CNS)

Peripheral Nervous System (PNS)

Brain

spinal cord

consists of peripheral nerves

(somatic or autonomic nerves)

12 pairs of cranial nerves

31 pairs of spinal nerves

Somatic NS

sensory sensations from somatic structure : body surface , skeletal muscle , joints & tendons

motor voluntary activity executed by skeletal muscles

Autonomic NS

visceral sensations
sensations arising from internal structures

Involuntary movements executed by smooth and cardiac muscles

secretion by glands
(endocrine & exocrine)

Nerve-Muscle Interaction

- ✓ Nervous system is divided into CNS & PNS. It also can be divided in tem of function into:
 - Motor and sensory activity
- ✓ The differences between Voluntary (skeletal muscles)& involuntary (cardiac and smooth muscles) muscles regarding activation of the muscles is :
 - Skeletal muscle activation is initiated through neural activation (neurogenic).
 - Cardiac or smooth muscle activation is initiated from the muscle fibers its self and the neural activation for regulation (Myogenic).

Sensory
neurons

- carry information from the stimulus receptor(throughout the body) to the CNS(brain).

Motor
neurons

- emerge from the CNS carrying motor orders from the CNS to the effector organs (muscles and glands) to activate muscle contraction

Remember that :

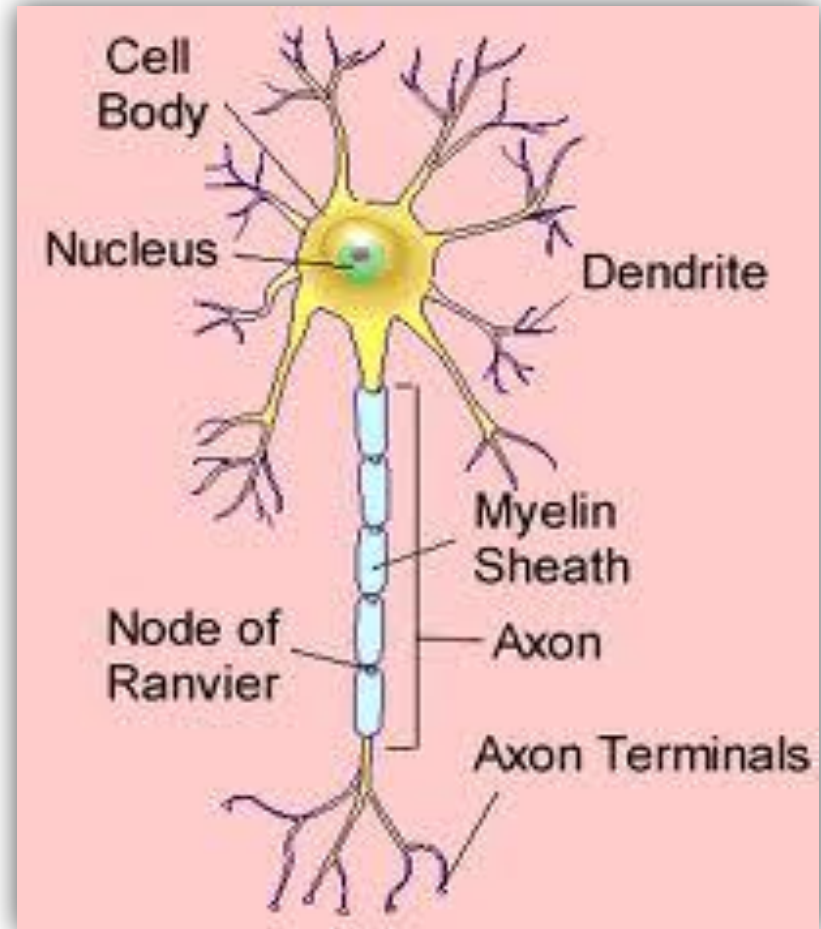
NEURONS

Neurons: Unit of function of the CNS, either sensory or motor

What is the characteristics of Motor Units?

Basic components of neurons:

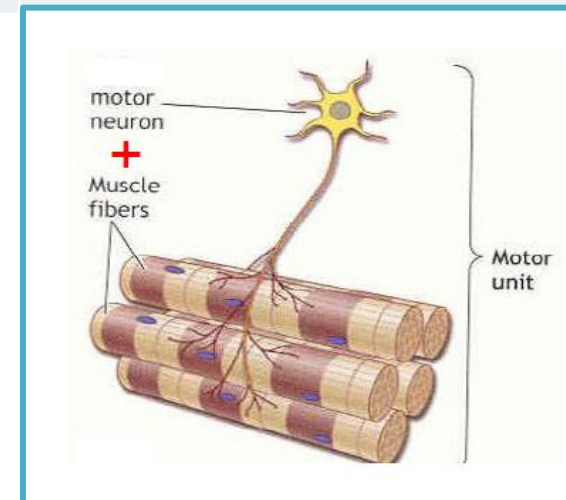
- Soma (cell body)
 - ❖ Nucleus
- Dendrites
- Axon
 - ❖ Myelination
 - ❖ Nodes of Ranvier
- Axon terminals
- Synaptic end bulbs
- Neurotransmitter
 - ❖ **Acetylcholine (ACH)**



MOTOR UNITE

WHAT IS IT?	Features	Variation of muscle fibers
Single α-MOTOR NEURON (in the anterior horn cell,AHC, , Axon) + all the MUSCLE FIBERS it innervates	<ul style="list-style-type: none">✓ Muscle fibers will be the same type (which means, either fast or slow twitch)✓ Each muscle consists of number of motor units(except small muscles can innervated by 1 motor unite).✓ Motor neurons activated \rightarrow muscle fibers(innervated by that neuron)are stimulated \rightarrow contract	Number of muscle fibers in a motor unite varies: <ul style="list-style-type: none">✓ Gastrocnemius (200muscle fibers /motor neuron)✓ Extraocular muscle (<10 muscle fibers /motor neurons) In the next slide the main divisions

- ✓ Ratio of muscle fibers to motor unites affect: **precision of movement**
- ✓ Groups of motor units often work together to coordinate the contractions of a single muscle (All of the motor units that sub serve **تنفيذ** a single muscle are considered a **motor unit pool**)



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

A- Fine movements

- الحركات الدقيقة need motor units that have **small number** of muscle fibers , **eye muscle controlling eye movements**

B- Gross movements

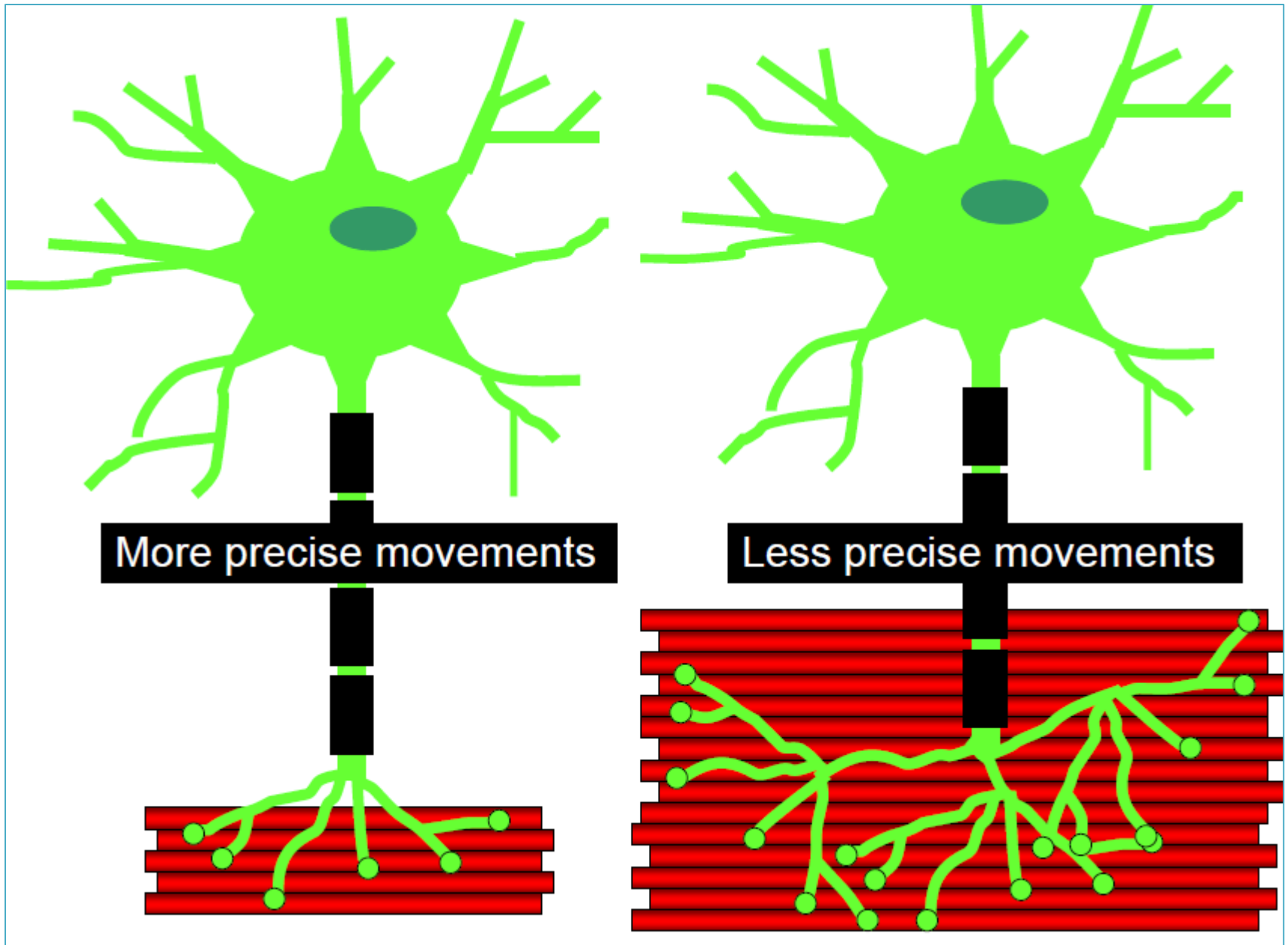
- الحركات الجسيمة need motor units that have **large number** of muscle fibers , **Thigh muscles and gastrocnemius (calf)**

Precise movement

Large no. of motor unites
Few muscle fibers
e.g: Hand and eye muscle (fine movement)

Many : muscle fibers
Fewer : motor unites
e.g: trunk muscle (gross movement)

Less precise movement



- * 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.

❖ The forces produced by a single motor unite is determined by :

- ✓ The number of muscle fibers
- ✓ The frequency (in which the muscle fibers are stimulated by their innervating axon)

This allow 2-4 fold change in force

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 عضلي** from a **neuropathy** **مرض في الأعصاب**

Gradation of Muscle force

(ways in which the nervous system increases forces production)

Two neural mechanism are responsible for force gradation

1) Recruitment

of new motor unites

It happens in the muscles with plenty of motor units by activation of all the motor unites

2) Rate coding

(increase stimulation frequency)

Happens in muscles with fewer motor units

- ✓ Some muscles uses both methods to increase the force of contraction

Motor Unit Recruitment

- **Definition** : 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**.

- The activation of **one** motor neuron → **weak muscle contraction**.
- The activation of **more** motor neurons → more muscle fibers being activated → **stronger muscle contraction**

Rate Coding

- **Definition** Rate coding refers to the motor unit **firing rate**. (Active motor units can discharge at higher frequencies to generate greater tensions).

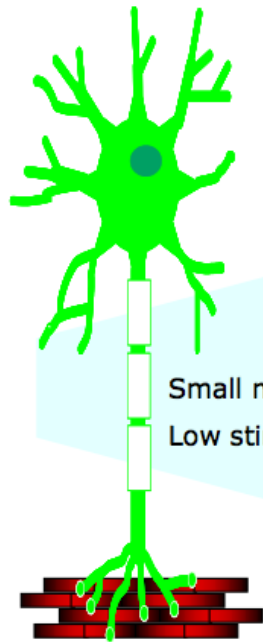
- If AHC fires at **slow** rates → **slow** MUAPs → **weak** contraction
- If AHC fires at **fast** rates → **fast** MUAPs → **strong** contraction

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

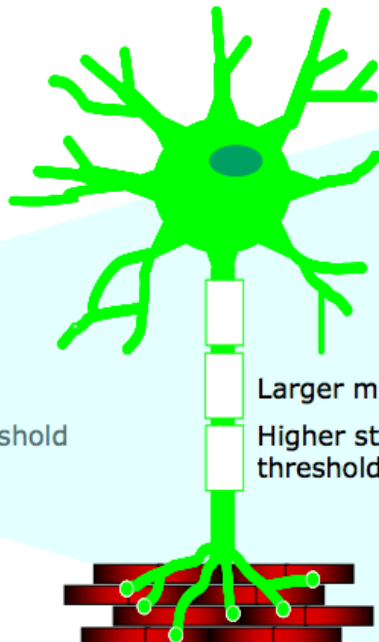


AHC= Anterior Horn Cell
MUAPs= motor unit action potential

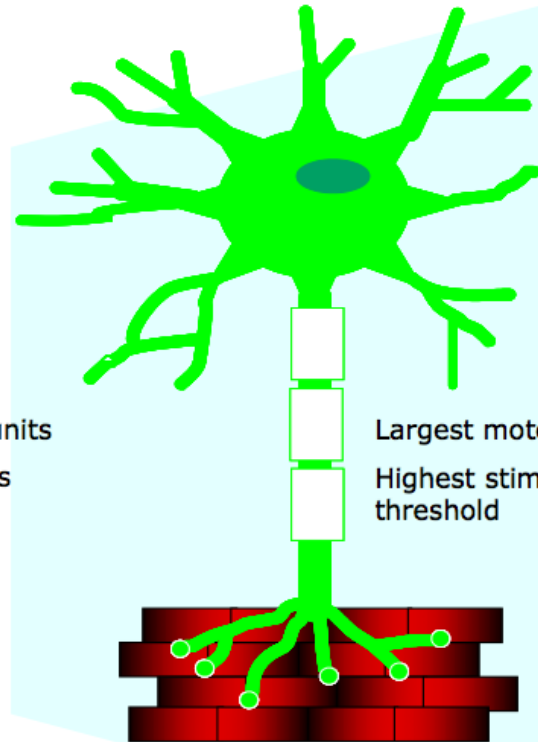
Depends on **number** and **size** of Motor unit recruitment



Small motor units
Low stimulus threshold



Larger motor units
Higher stimulus threshold



Largest motor units
Highest stimulus threshold

Low amount of Force
Required During Movement

Medium amount of Force
Required During Movement

High amount of Force
Required During Movement

Recruitment Vs. Rate Coding

Smaller muscles

- Rely more on **rate coding**
- (e.g. first dorsal interosseous)

Larger muscles

- rely more on **recruitment**
- of mixed fiber types (e.g. deltoid)

ALL OR NONE PRINCIPLE

It is a principle motor units follow, which is: impulse from motor neuron will cause contraction in all muscle fibers it innervates or non

Summary

Nervous system is divided into CNS & PNS ,

PNS is divided into Sensory & Motor , the motor is divided into somatic and autonomic .

PNS consist of 12 pairs of cranial nerves and 31 pairs of spinal nerves

Sensory neurons transmit info from body receptors to the brain , and motor neurons transmit signals from brain to muscles of the body

Neurons is the functional unite of nerves system and its made of : cell body, dendrites, axon, synaptic end bulbs and neurotransmitters

Motor unite is : motor neuron + muscle fibers cause activation of muscles

Variation of muscle fibers and motor unite ratio affect precision of movement

The mechanism which are responsible for force gradation are recruitment and Rate coding

All or non role principle: motor neurons will cause contraction in all muscle fibers or non



Neuromuscular junction - motor unit

[http://www.youtube.com/
watch?v=hzXVe4RS8-A](http://www.youtube.com/watch?v=hzXVe4RS8-A)



Multiple Choice Questions

Q1: which is the most common way to classify the nervous system?

- A) Somatic and autonomic
- B) Central and peripheral
- C) Sensory and motor
- D) None of them

Q2: The only neuron transmitter between the neurons and the muscle (neuron muscular junction) is ?

- A) ACH
- B) Dopamine
- C) Noradrenaline
- D) Adrenaline

Q3: the motor unit composed of?

- A) Motor horn only
- B) Muscle fibers only
- C) single gamma motor neuron + muscle fibers
- D) single alpha motor neuron + muscle fibers

Q4: Which of these works as a motor neuron?

- A) Anterior horn of gray matter
- B) Posterior horn of gray matter
- C) Dorsal root ganglion
- D) None of them

Q5: the fine movements needs motor units with?

- A) Large numbers of muscle fibers (1000-2000)
- B) small numbers of muscle fibers (fewer than 10)

Q6: the eye muscle which control the muscle of the eye will show ?

- A) more precise movements
- B) less precise movements
- C) single motor unit with more than 1000 muscle fibers
- D) None of them

Q7: The high recruitment of motor unit will lead to ?

- A) Muscle relaxation
- B) Weak muscles contraction
- C) Strong muscles contraction
- D) All of them

Q8: when there is a frequency and discharge of the acetylcholine at very fast rates, the will be?

- A) Strong muscle contraction.
- B) Weak muscle contraction.
- C) Relaxation of the muscle.
- D) None of them

Q9: large muscle "deltoid muscle" will depend on ?

- A) Rate Coding
- B) Recruitment