

# Motor Unit



**Red: very important.**  
Green: Doctor's notes.  
Yellow: numbers.  
Gray: notes and explanation.

**Physiology Team 436 – Musculoskeletal Block Lecture 4**

Lecture: If work is intended for initial studying.  
Review: If work is intended for revision.

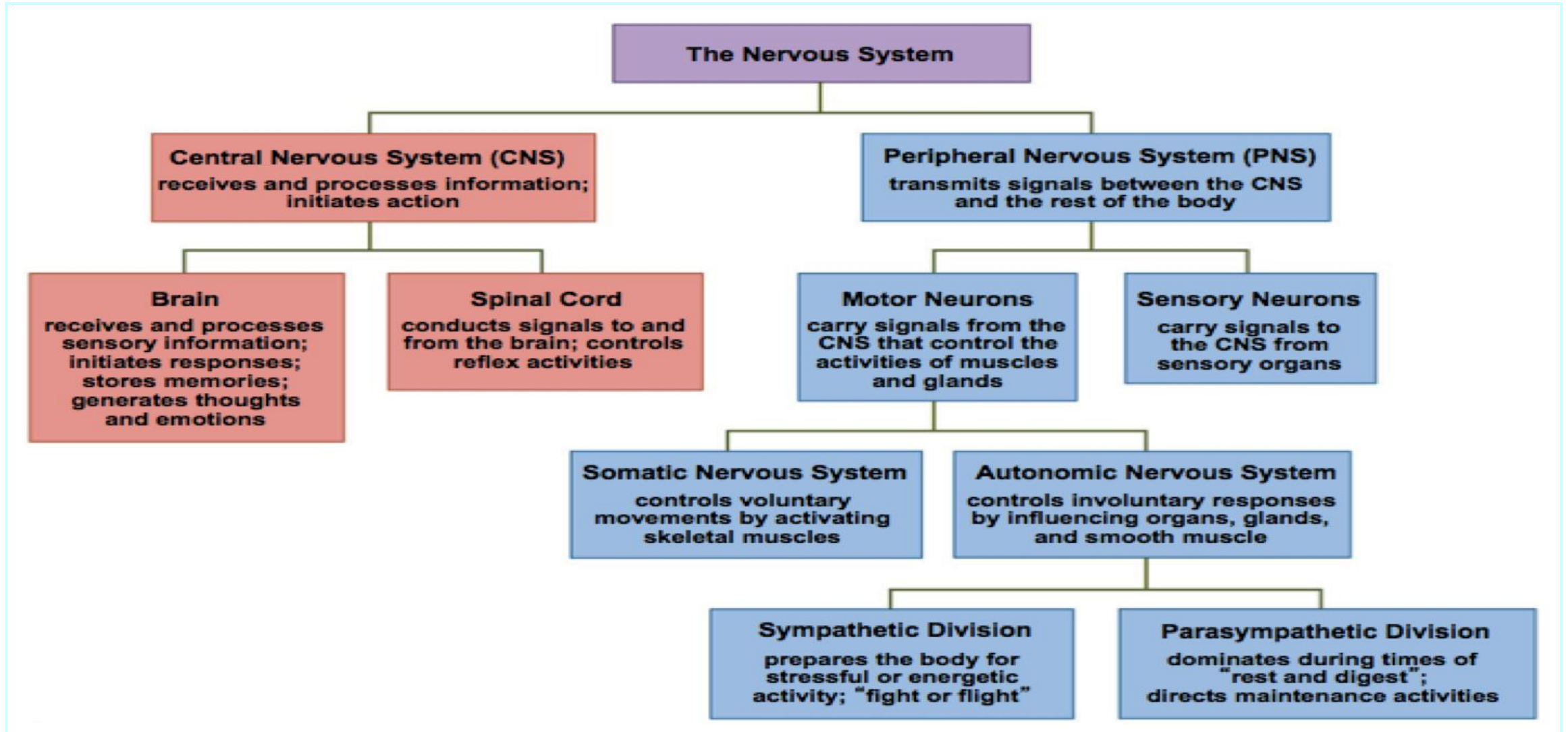
# Objectives

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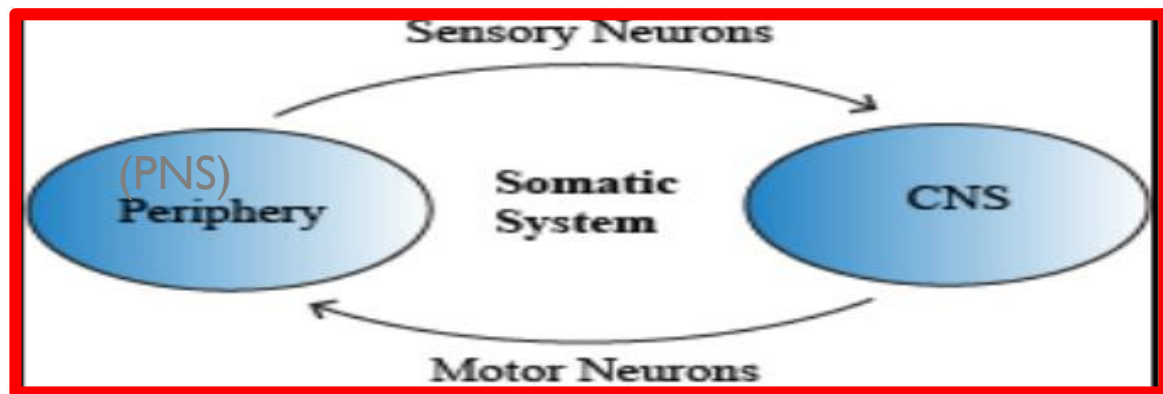
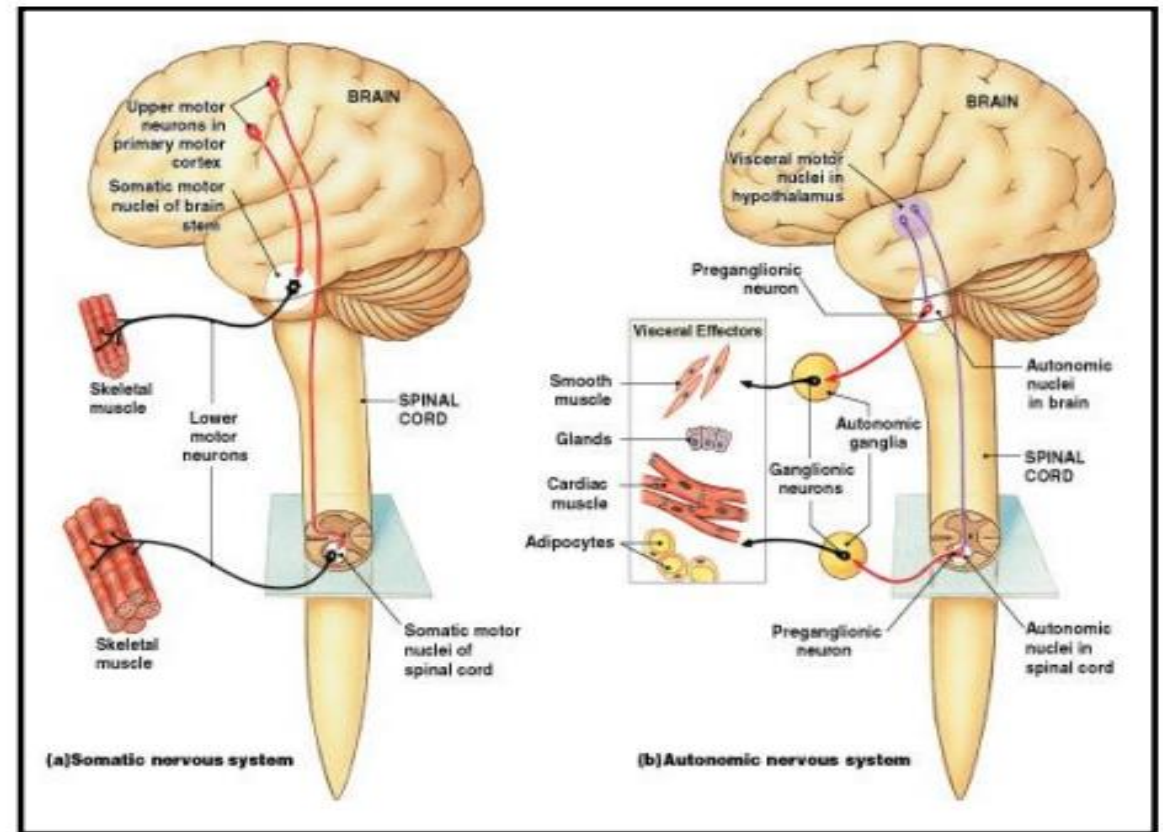
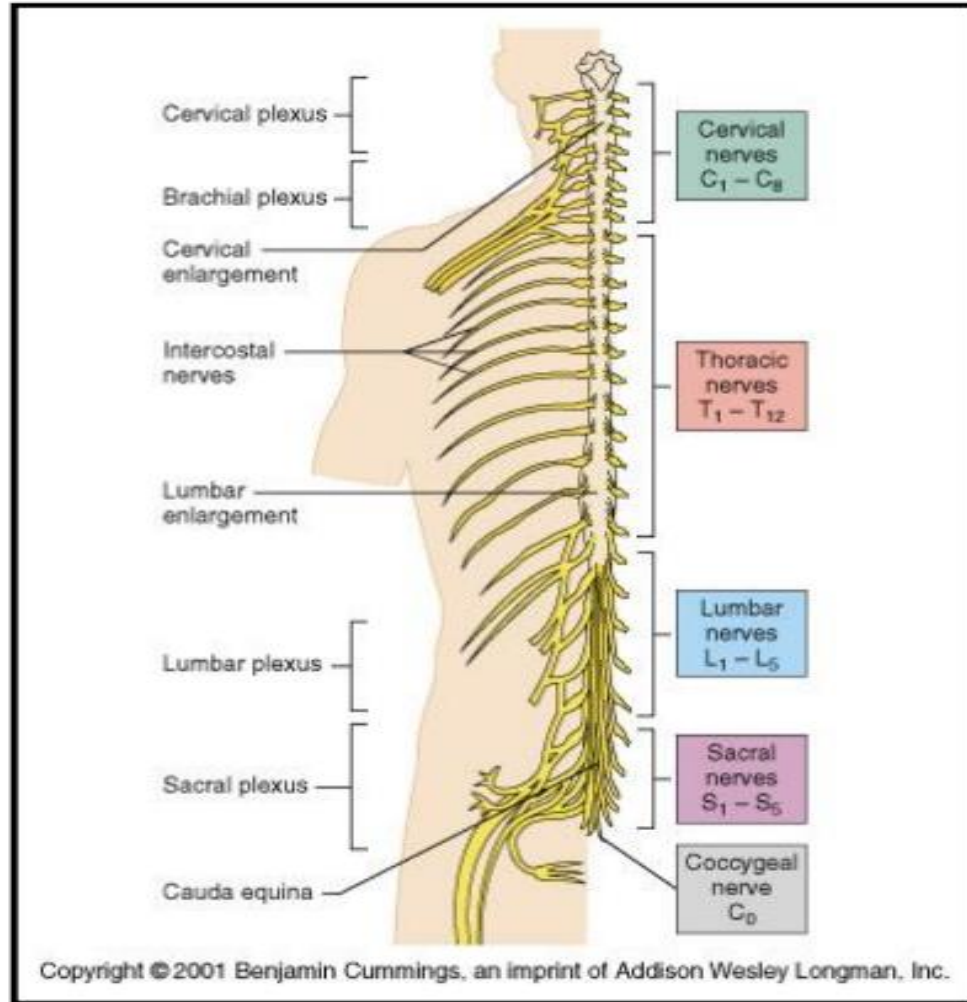
- Recognize the organization of the Nervous System. (slide 3,4)
- Identify the differences between central nervous system (CNS) & peripheral nervous system (PNS). (slide 5)
- Understand the function & the recruitment of the motor unit. (slide 7,12)
- Appreciate effect of motor units number on motor action performance. (slide 8,9,10,11,15,16)

# Organization of the Nervous System

*\*Important\**



# Organization of Nervous System



# Organization of the Nervous System Cont.

The Central Nervous System: It is the part that integrates the sensory information that it receives from different parts of the body, and coordinates the body's activity.

It consists of :

- ❖ The Brain which is protected by the skull.
- ❖ The Spinal cord which is protected by the vertebrae.
- ❑ **Both** are enclosed in the meninges.

The Peripheral Nervous System (PNS): is divided in terms of function:

- ▶ Sensory Neurons : collect information from the various sensors located throughout the body and transmit the information to the brain.
- ▶ Motor Neurons : conduct signals to activate muscle contraction.

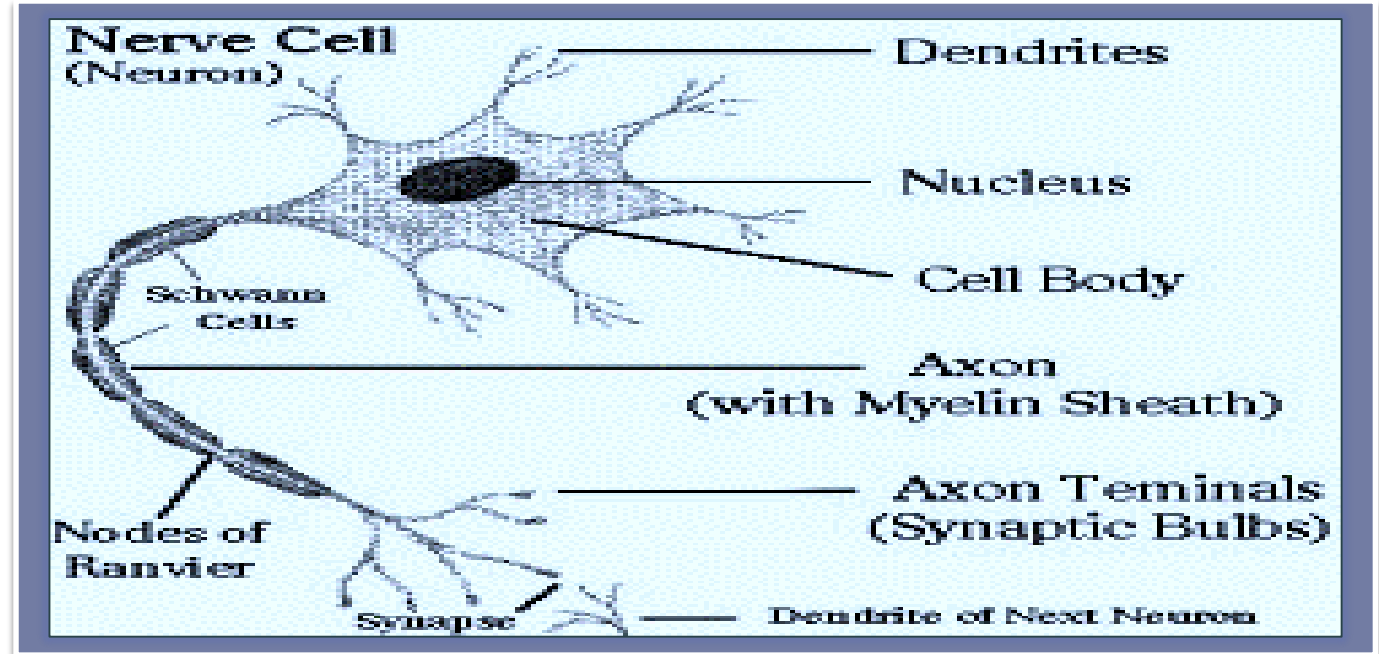
Motor neurons system is subdivided into:

- ▶ Somatic nervous system.
- ▶ Autonomic nervous system.
- ▶ **Skeletal muscle** activation is initiated through neural activation.

# Neurons

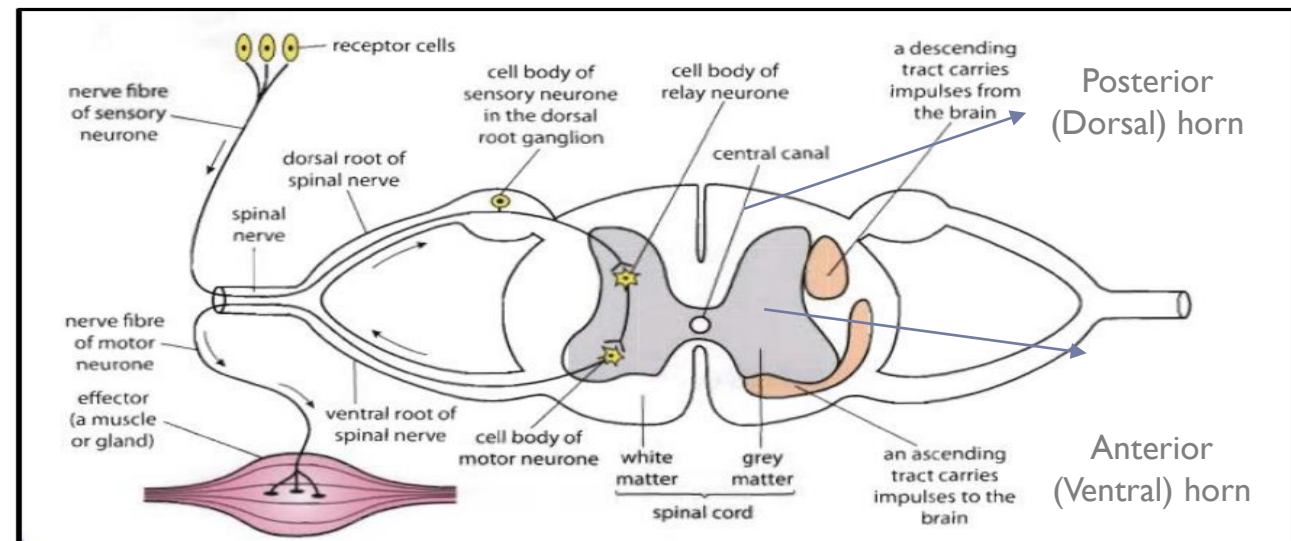
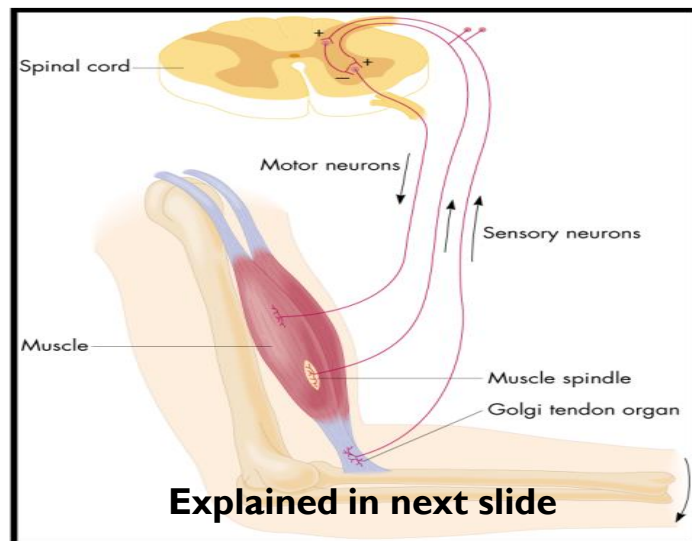
The **neuron** is the building unit of the nervous system which is comprised of:

- ❖ **Cell body:**
  - Nucleus
- ❖ **Dendrites.**
- ❖ **Axon:**
  - Myelination
  - Nodes of Ranvier
- ❖ **Axon terminals (synaptic end bulbs).**
- ❖ **Neurotransmitter:**
  - Acetylcholine (ACH)



# $\alpha$ -Motor Neuron

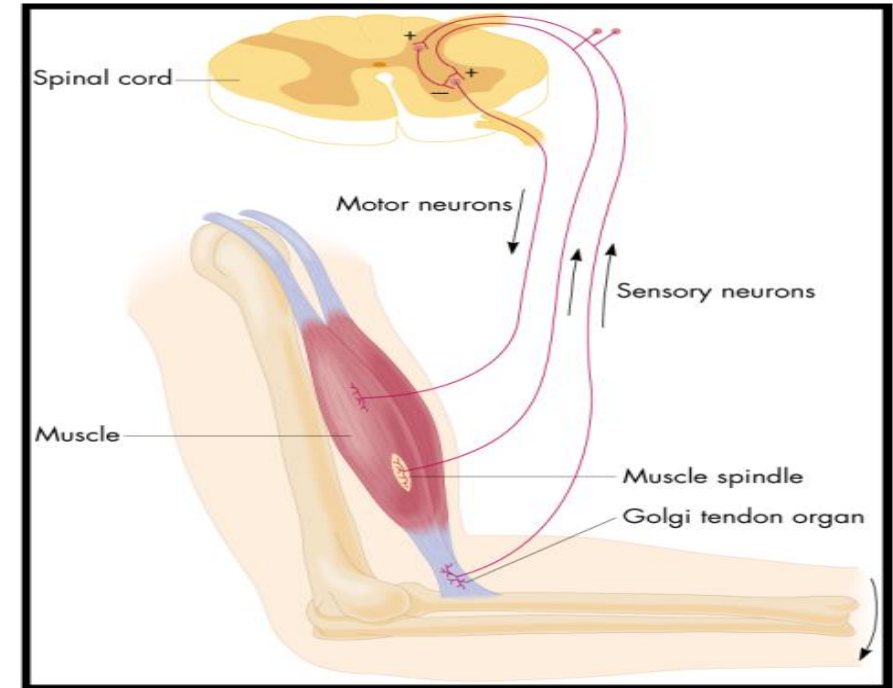
- ❖ **Motor unit** : is an  $\alpha$ -Motor Neuron
- ❖ **Location of  $\alpha$ -Motor Neuron** : in the **anterior horn cell (AHC)** and it is responsible for **innervating the skeletal muscle fibers** and their contraction.
- ❖ **A nerve** is made up of a group of neuron axons.
- ❖ **The function of nerve cells** : is to transmit electrical messages and signals throughout the body.



# Further Explanation of Neurons

(Text: added from external resources based on the doctor's explanation. Picture: from the doctor's slides)

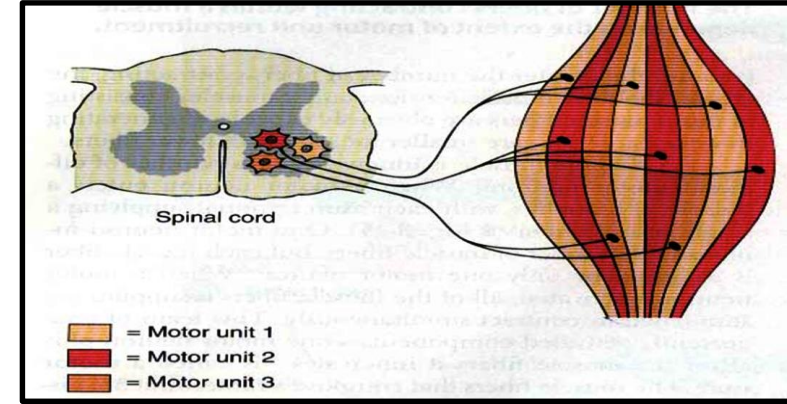
- **Sensory Neurons:**  
Carry signals from the outer parts of your body (periphery) into the central nervous system.
- **Motor Neurons (Motoneurons):**  
Carry Signals from the central nervous system to the outer parts (muscles, skin, glands) of your body.
- **Interneurons:**  
Connect various neurons within the brain and spinal cord.





# Motor Unit

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



**There are two types of muscle fibers:**

**Slow twitch fibers: have low force & high endurance.**

**Fast twitch fibers: have high force & low endurance.**

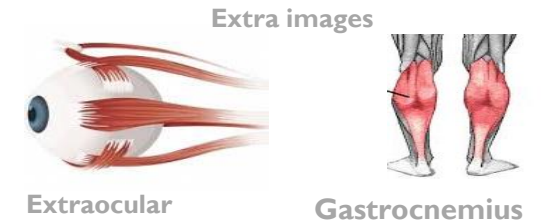
شرح :

- العضلة الواحدة تحتوي على أكثر من وحدة حركية وكل وحدة حركية تغذي عددًا من الألياف العضلية ويجب أن تكون جميع هذه الألياف العضلية من نفس النوع سواءً السريع أو البطيء

- عندما تنشط خلية عصبية "جميع" ال muscle fibers ( المرتبطة بهذه الخلية العصبية ) تنقبض ، لكن هذا لا يعني أن "جميع" ال muscle fibers في العضلة تنقبض بنفس الوقت، حيث أنها ترتبط بخلايا عصبية أخرى.

# Motor Unit

- The number of muscle fibers in a motor unit (innervated by one motor neuron) varies. For example:
  - ▶ **Gastrocnemius**  
2,000 muscle fibers per motor neuron.
  - ▶ **Extraocular muscles**  
Less than 10 muscle fibers per motor neuron.
- Ratio of muscle fibers to motor neurons affects the **precision** (الدقة) of movement:
  - ▶ If the ratio is low → the action is specific ( more precise )
  - ▶ If the ration is high → the action is less specific ( less precise )

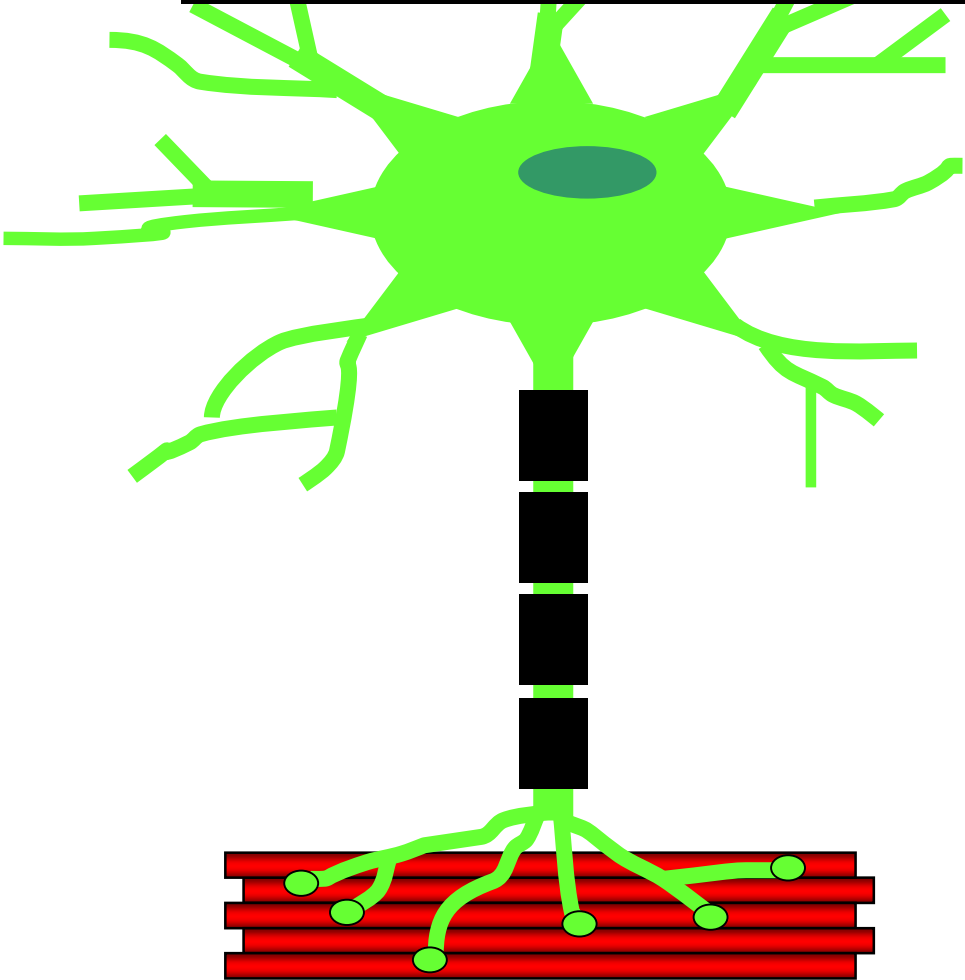


## Explanation:

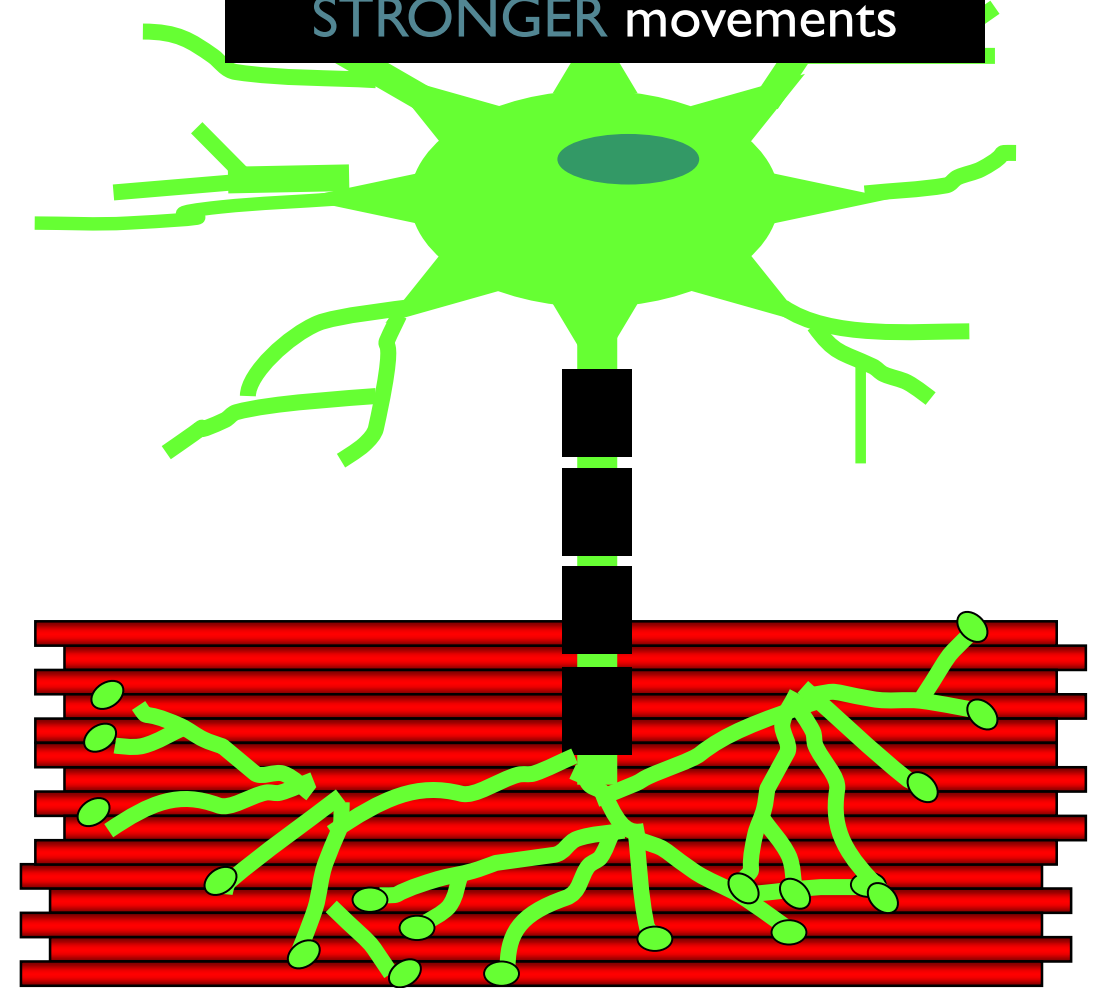
Motor unit X supply 20 muscle fibers / Motor unit Y supply 6 muscle fibers  
The movement of Y muscle is more precise than the movement of X muscle.

# Precision of Movement

More precise movements



Less precise BUT STRONGER movements

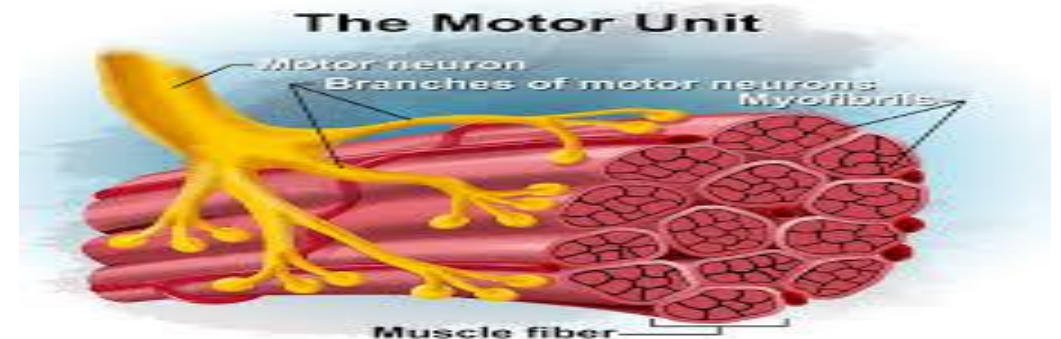


# The Precision (الدقة) of Movement

- ▶ Groups of motor units often work together to help the contractions of a single muscle .  
“the number of muscle fibers within each motor can vary”
- ▶ **precise movements** muscle consist of a large number of motor units and few muscle fibers in each motor unit
- ▶ e.g. Hand and eye muscles. ( **low ratio of muscle fibers to motor neurons** )
- ▶ **Less precise movements** muscles composed of fewer motor units with many fibers per unit
- ▶ e.g. Trunk muscles. ( **High ratio of muscle fibers to motor neurons** )

شرح :

- إذا كانت العضلة تحتاج إلى دقة في العمل ( مثل اليد والعين ) يكون لديها عدد عالي من ال motor unit ، وكل motor unit ترتبط بعدد قليل من ال muscle fibers بحيث تستطيع ال motor unit التحكم الدقيق بهذا العدد القليل من ألياف العصبية



# Motor Unit Recruitment (توظيف الوحدات الحركية)

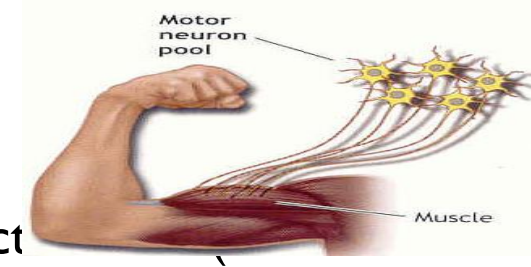
**Motor Unit Pool** :The group of motor units supplying a single muscle.

The nervous system can increase force production in two ways:

➤ **I) Recruitment of new motor units:**

It is the progressive activation of a muscle by successive recruitment of contractile units to accomplish increasing degrees of contractile strength (force).

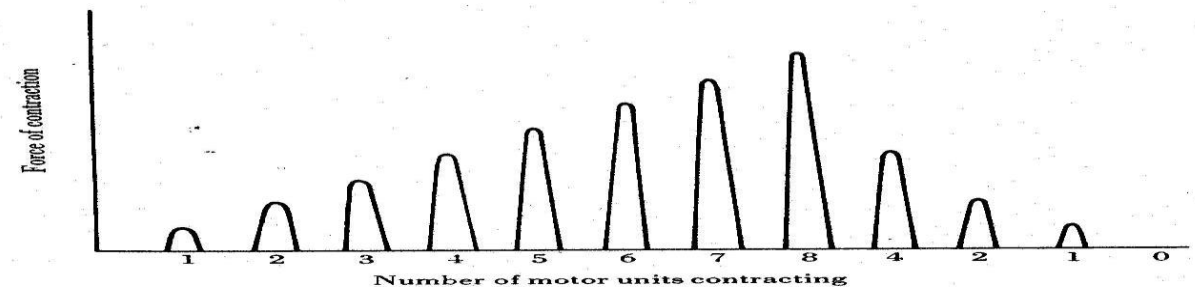
- If the stimulus is low, the small motor units will be activated. (small number of muscle fibers will contract)
- If the stimulus is higher, the large motor units will be activated (more muscle fibers will contract)
- While if the stimulus is highest, the largest motor unit will be activated (the whole muscle will contract)



شرح:

في الحالات الطبيعية عندما لا نحتاج إنقباض عالي لا تكون جميع ال motor unit تشغل، لكن مجرد ما نحتاج لجهد إضافي، يزداد عدد ال motor unit المشغلة، فكل motor unit تشغل ال muscle fibers حقاتها، مما يزيد الانقباض.

إذا باختصار ال motor unit recruitment راح يزيد عدد ال activated motor unit فبالتالي راح تزداد ال muscle contraction.



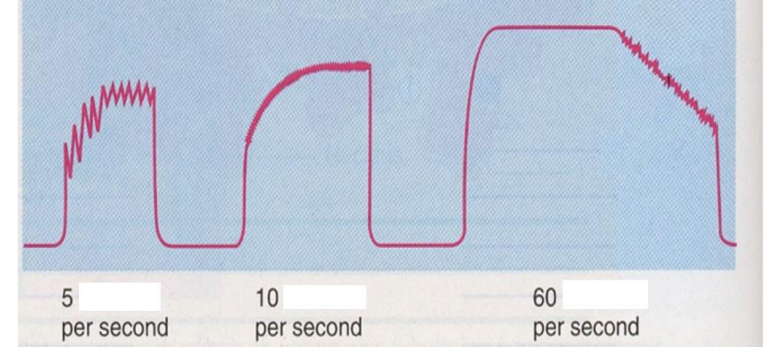
# Increasing Stimulation Force

Second way the nervous system can increase force production:

- **2) Increasing stimulation frequency (rate coding):**  
Increasing frequency of action potentials (by increasing the impulses) will result in a stronger force of contraction.

- If AHCs fire at slow rates → slow MUPs  
→ weaker contraction.
- If AHCs fire at very fast rates → fast MUPs  
→ stronger contraction.

**(MUPs)** : motor unit potentials



شرح:

في البداية كان عدد تكرار ال stimulus , 5 لكل ثانية , في كل مرة يزيد فيها التكرار راح تزيد ال muscle contraction الى ما توصل مرحلة maximum contraction . tetany

شرح :

-في الطريقة الأولى كان يزيد عدد ال motor unit ، طيب فرضاً اشتغلت كل ال motor unit وما زلنا نحتاج إنقباض أعلى ؟ أو انه اساساً العضلة تحتوي عدد قليل من ال motor unit (مثل العضلات ما بين الاصابع) ؟

- تلقائياً راح تزيد عدد Impulses في الثانية الواحدة مما يزيد ال Action potentials فيزداد عندي الانقباض.

- لكن هذه الطريقة تجعل العضلة في حالة إجهاد بدون راحة " contraction without relaxation " فبيكون فيه نقطة قصوى توقف عندها ال Impulses اللي هي ( maximum contraction )

# Force of a Single Motor Unit

- ▶ The force produced by a single motor unit is determined by :
  - The number of muscle fibers in the unit.
    - ( as numbers of muscle fibers increase , the force will be increased )
  - The frequency with which the muscle fibers are stimulated by their innervating axon.

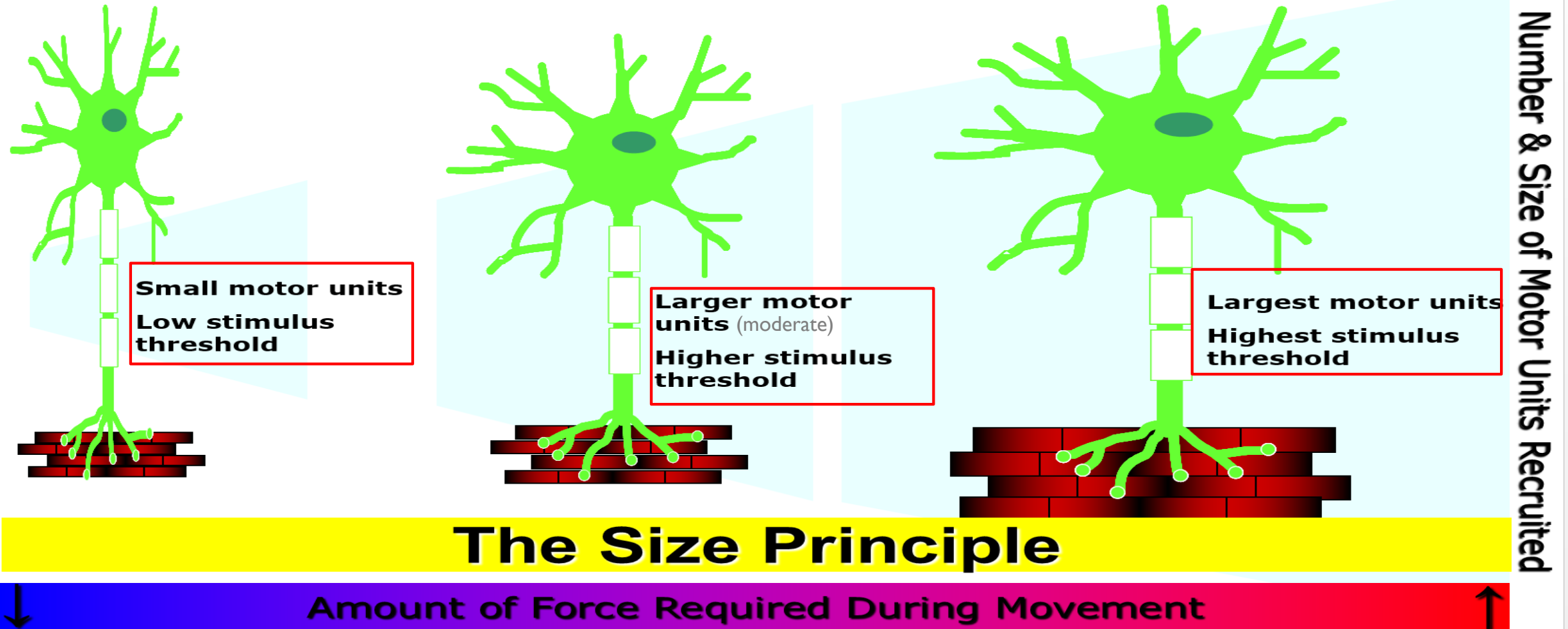
( as the frequency of stimulus increase, the force will be increased )

Generally, this allows a 2 to 4-fold change in force.



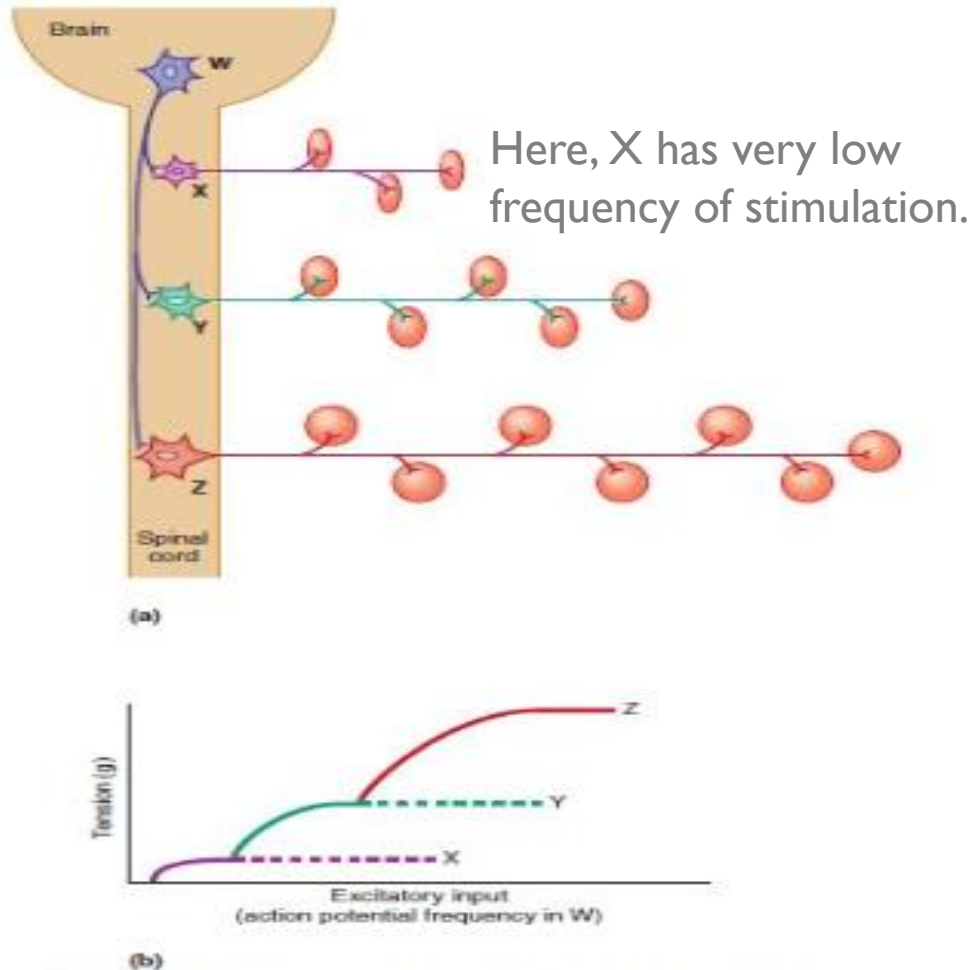
# The Size Principle

- Varying the number of motor units activated.

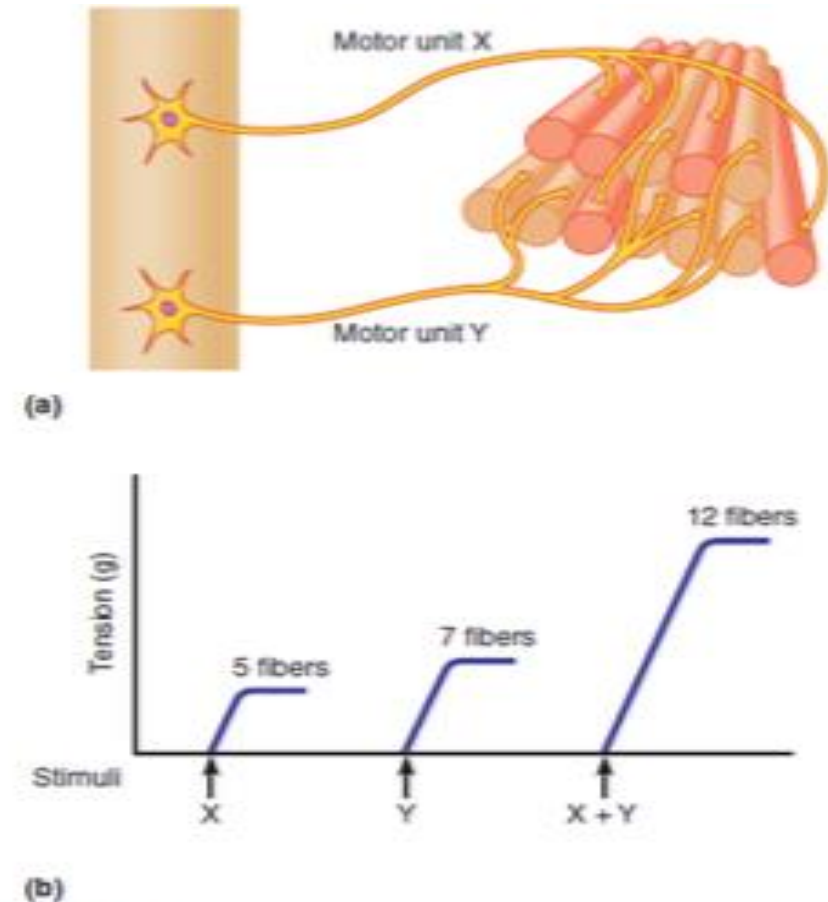




# Recruitment and Size Principle



**Figure 12.10** 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).



**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.

Example: 5 times or 10 times per second for the same motor unit

## Recruitment

- ❖ Large muscles
- ❖ Ex: deltoid
- ❖ Rely more on recruitment of motor units

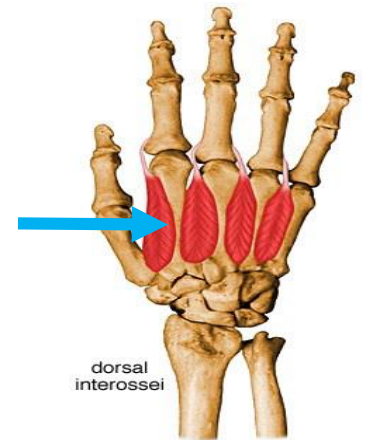
Reason: muscle fibers & motor unit are more.

VS

## Rate Coding

- ❖ Small muscles
- ❖ Ex: first dorsal interosseous
- ❖ Rely more on rate coding (frequency)

Reason: muscle fibers & motor unit are less.



# All or None Role

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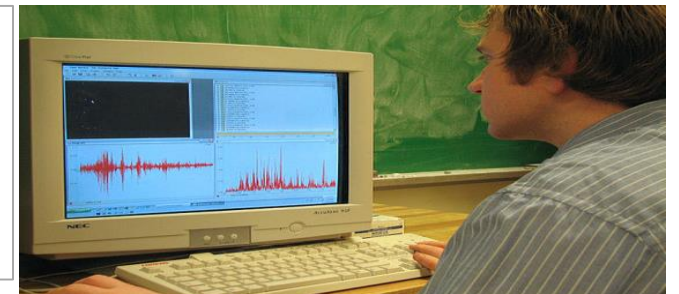
- ▶ Motor Units Follows “all-or-none” principle – impulse from motor neuron will cause contraction in all muscle fibers it innervates or none.

( إذا صار فيه activation of **single** motor neuron , كل الألياف العضلية المرتبطة فيه راح يصير لها contraction , يعني غير ممكن يصير فيه contraction لبعض الألياف والألياف ثانية ما يصير لها شي )

- ▶ **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 (problem in muscle) from a neuropathy (problem in nerve)

Extra info:

EMG is a technique for evaluating and recording the electrical activity produced by skeletal muscles. The signals can be analyzed to detect medical abnormalities, activation level, or recruitment order.



# Quiz

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- ▶ <https://www.onlineexambuilder.com/physiology-motor-unit/exam-116693>

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## [Link to Editing File](#)

(Please be sure to check this file frequently for any edits or updates on all of our lectures.)

### References:

- Girls' and boys' slides.
- Guyton and Hall Textbook of Medical Physiology (Thirteenth Edition.)
- Science.howstuffworks.com

# Thank you!

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اعمل لترسم بسمة، اعمل لتمسح دمة، اعمل و أنت تعلم أن الله لا يضيع أجر من أحسن عملا.

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