

Editing File

Physiology of the Motor Unit

Color Index:
-Main Text -**Important** -Notes
-Boy Slides -Girl Slides -Extra

Objectives

+

01

Recognise the organization of the Nervous System

+

02

Identify the differences between central nervous system (CNS) & peripheral nervous system (PNS)

+

03

Discuss the functions and recruitment of the motor unit

+

04

Interpret the effect of motor units number and size on the motor action performance

+

05

Explain the importance of development of macromotor units in poliomyelitis.

+

06

Compare between rate coding and recruitment. And Define -all or non -principle.

Neurons

Neuron: the building unit of the nervous system.

01

Cell body (soma)

Contains: the nucleus.

02

Dendrites

Short processes

03

Axon Contains: myelination + nodes of ranvier

Long processes

04

Axon Terminals

05

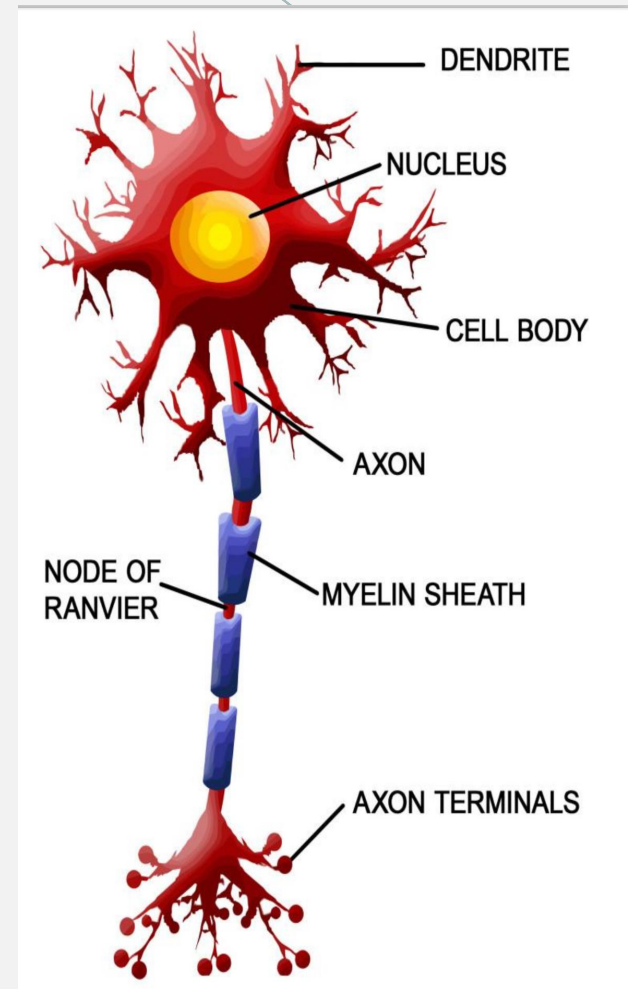
Synaptic End Bulbs

Small structure at the end of the nerve cell

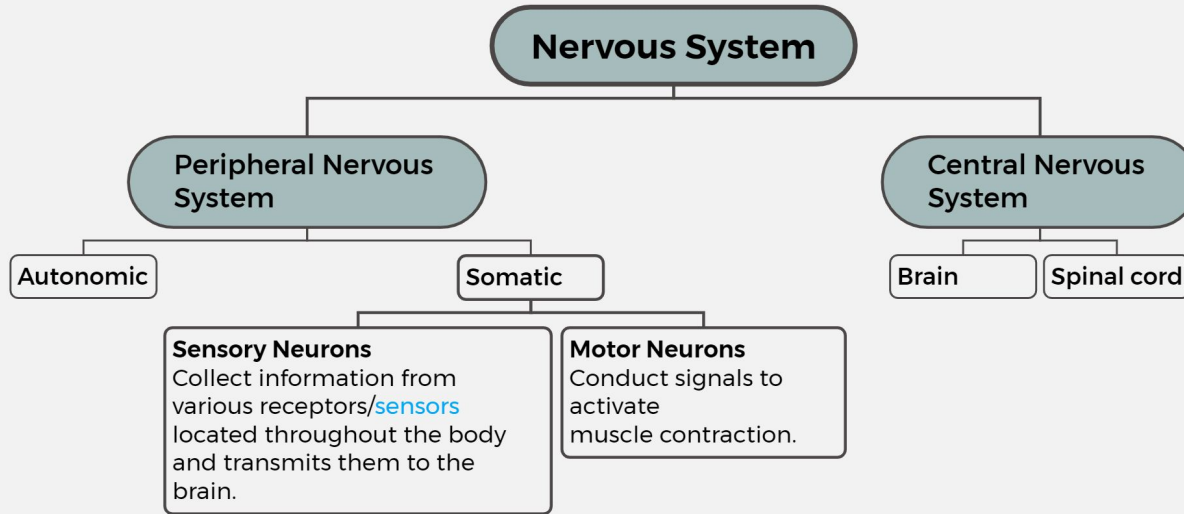
06

Neurotransmitter

Acetylcholine (Ach)

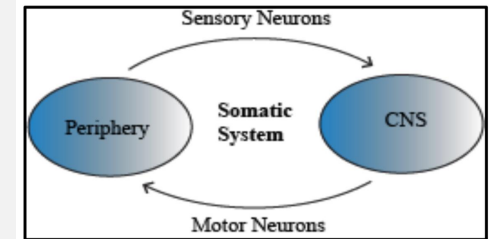
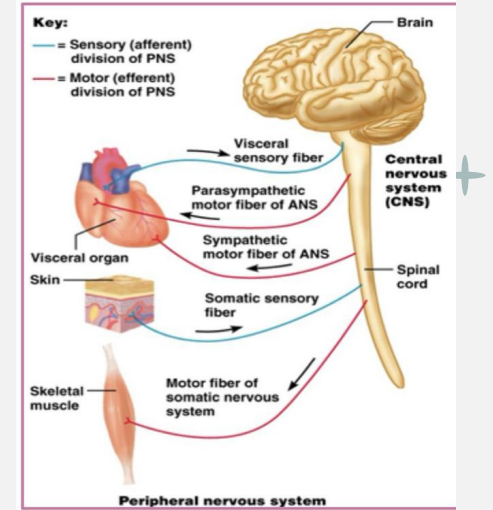


Nerve - Muscle Interaction



Presented with xmind

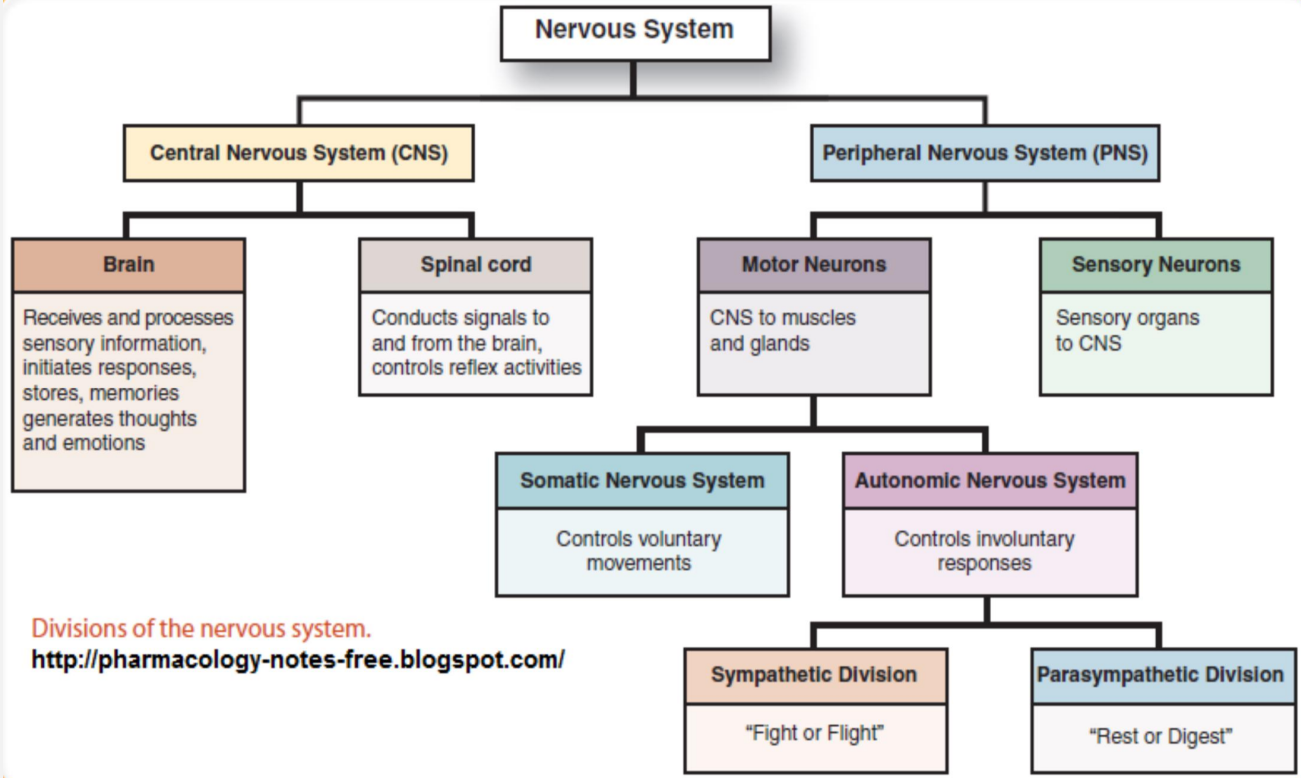
- Division of PNS in terms of function: motor & sensory activities.
- Skeletal muscle activation is initiated through neural activation.
- **Nerve:** made up of a group of axons of neurons.



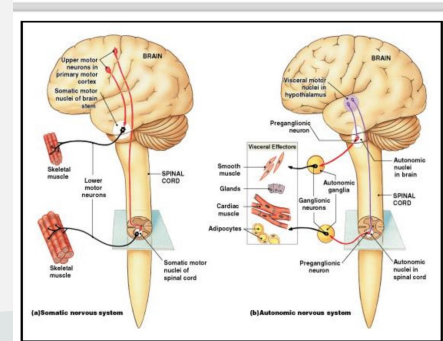
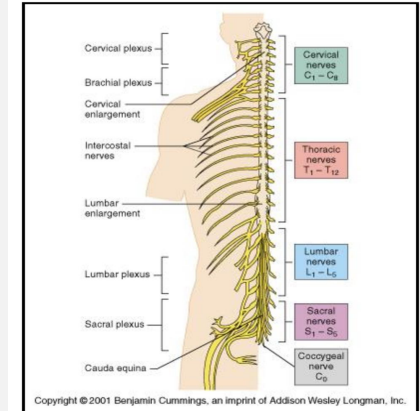
- Skeletal muscles > neurogenic in function (depend on nerve supply) .
- Cardiac muscles > myogenic in function.

Organization of the Nervous System

Male Slides Only



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



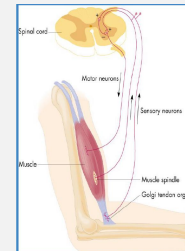
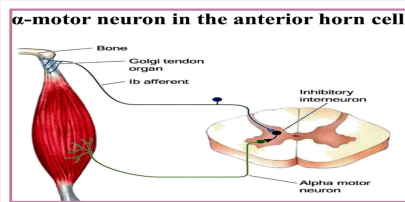
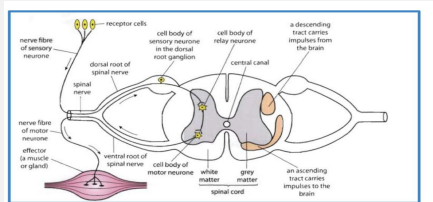
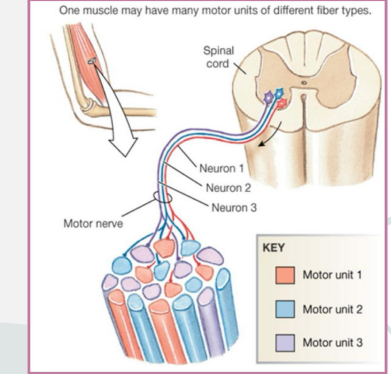
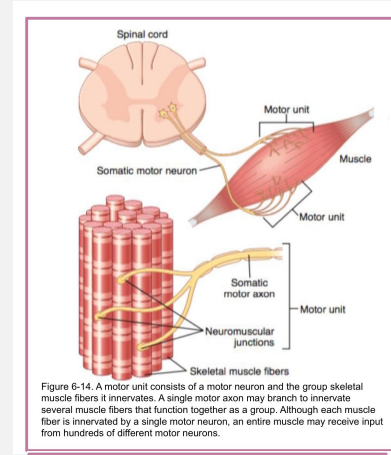
What is a Motor Unit?



VIDEO



- **Motor unit:** α -motor neuron in the anterior horn cell (AHC) + all muscle fibers it innervates (supplies).
- All of these muscle fibers of a motor unit will be of the **same type** (either Fast twitch or Slow twitch)(white or red).
- 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**.
- The muscle fibers in different motor units overlap. Therefore, separate motor units contract in support of one another rather than entirely as individual segments.




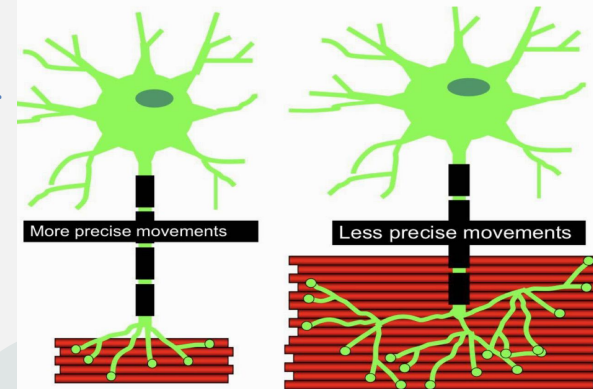
Motor Unit (MU)



The **number** of muscle **fibers** in a motor unit (innervated by one motor neuron) **varies**:-

1. **Extraocular muscles:** < 10 muscle fibers/motor neuron.
 2. **Laryngeal muscles:** 2 - 3 muscle fibers/MU. **It needs precision**
 3. **Leg muscles:** 600 muscle fibers/motor neuron.
 4. Gastrocnemius: 2,000 muscle fibers/motor neuron.
 5. **Average** all over the body: 80-100/MU.
- The number of muscle fibers per each motor unit affects the precision of movement i.e small number is associated with more precise movements and vice versa.
 - Ratio of muscle fibers to motor neurons affects the precision of Movement

 **Extra Info:**
As motor units in a muscle increases, the movement gets more precise.



Motor Unit Pool

Motor unit pool: Groups of motor units often work together to help the contractions of a single muscle.

Muscles needed to perform precise movements (hand & eye muscles) generally consist of:

Large number of MU + few muscle fibers in each MU.

Small number → more precise movement.

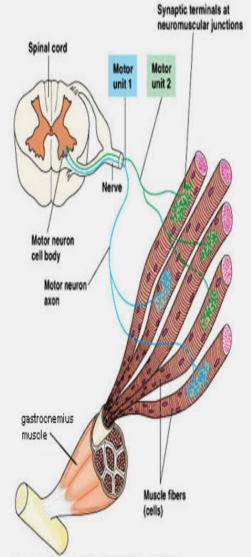
MU are smaller in size

Less precise movements (trunk muscles) consist of:

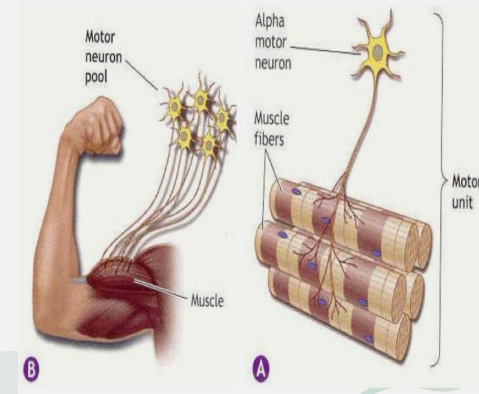
Fewer number of MU + many muscle fibers per unit.

Large number → less precise movement (stronger contraction).

MU are larger in size



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Force Of Contraction

The **force** of contraction produced by a **single motor unit**, is determined by:

Frequency
(times of stimulation/sec)

Number
Of muscle fibers in the unit

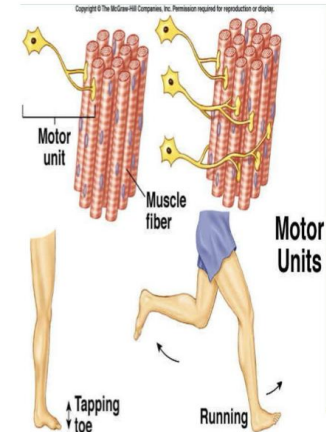
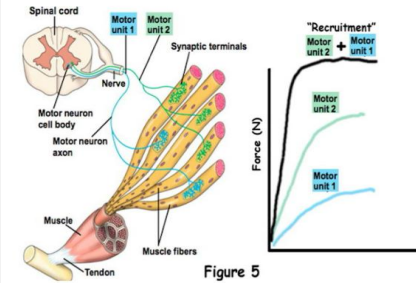
Supply with nerves
to stimulate an
organ or a nerve

with which the muscle fibers are stimulated by
innervating axon generally allows a 2 - 4 fold
change in force (being 4 times as great or as many).

✦ 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.

✦ The **higher** the motor
unit recruitment, the
stronger the muscle
contraction.



Force Summation



Summation: adding together of individual **twitch contractions** to increase the intensity of overall muscle contraction.

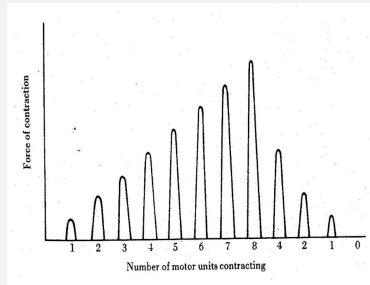
Force Summation

Recruitment: varying the number of motor units activated

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

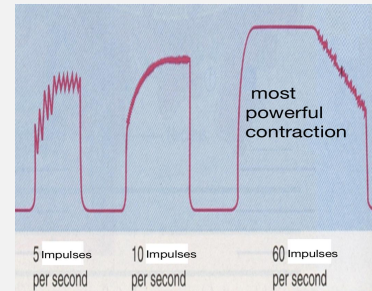
Multiple Fiber Summation (Recruitment of MU)

Increase number of working MU contracting simultaneously.



Frequency Summation (Rate Coding), can lead to tetanization (will be discussed later)

Increase the frequency of contraction.



Rate coding: refers to the motor unit firing rate. Active motor units can discharge at higher frequencies to generate greater tensions (contraction force).

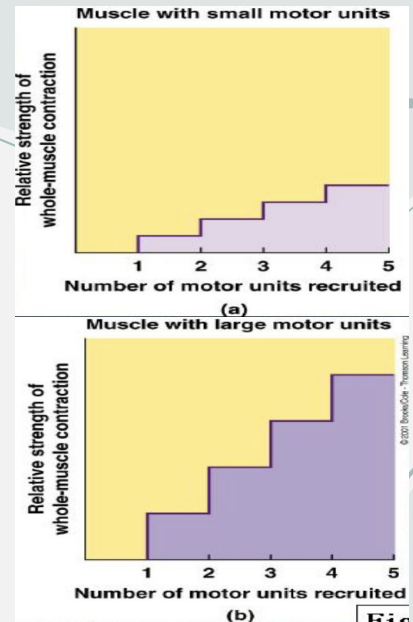
The Size Principle

CNS sends a **weak signal** to contract a muscle → **smaller MU** of the muscle stimulated in preference to larger MU.

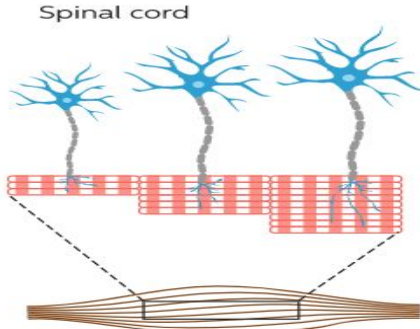
As the strength of the **signal increases**, larger and **larger motor units** begin to be excited as well.

Largest motor units have as much as **50** times the contractile force of the smallest units.

✦ This is the size principle



Recruitment in order based on the size principle

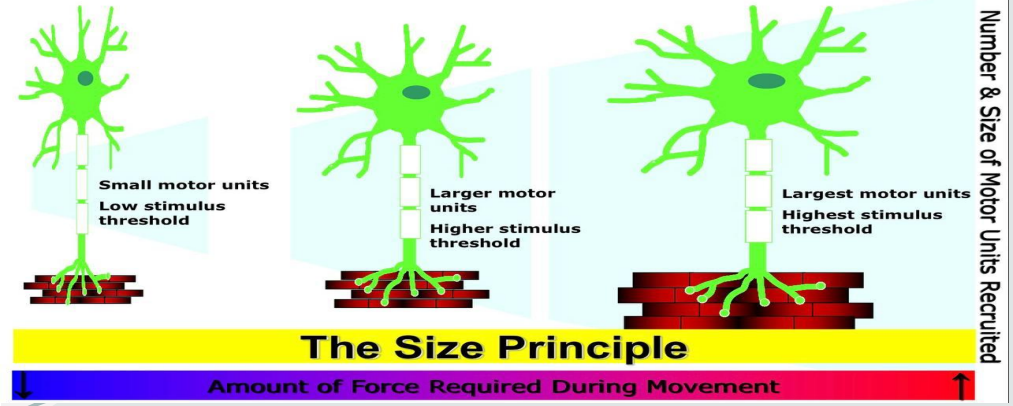


Recruitment order

Small motor unit motor neuron has small cell body & innervates a few type I muscle fibres

↓

large motor unit motor neuron has large cell body & innervates many type II muscle fibres



The Size Principle cont.

Occurs because:

- Smaller MU are driven by small motor nerve fibers.
- Small motor neurons in spinal cord are more excitable than the larger ones → naturally excited first.

Importance:

Allows gradations of muscle force during weak contraction to occur in small steps.

Steps become progressively greater when large amounts of force are required.

- Stimulation increases → motor neurons get activated → increases contraction force.

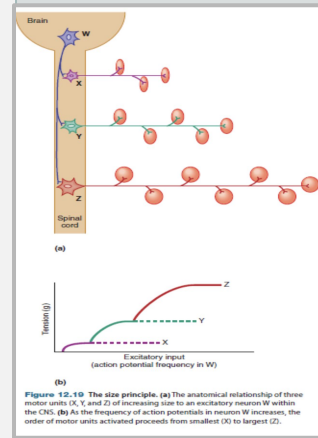


Figure 12.19 The size principle. (a) The anatomical relationship of three motor units (X, Y, and Z) of increasing size to an excitatory neuron W within the CNS. (b) As the frequency of action potentials in neuron W increases, the order of motor units activated proceeds from smallest (X) to largest (Z).

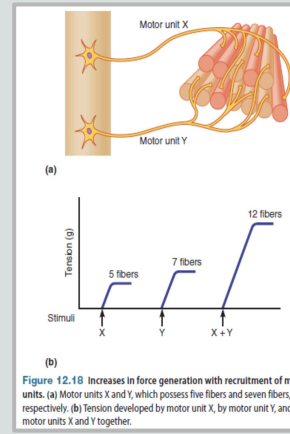
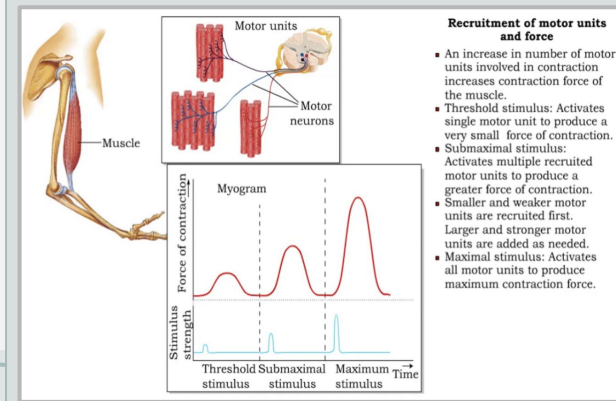


Figure 12.18 Increases in force generation with recruitment of motor units. (a) Motor units X and Y, which possess five fibers and seven fibers, respectively. (b) Tension developed by motor unit X, by motor unit Y, and by motor units X and Y together.



Frequency Summation (Rate Coding)

Individual twitch contractions occur one after another at low frequency of stimulation (**separate twitches**).

As the frequency increases, there comes a point when each new contraction occurs before the preceding one is over (**summation**).

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**.

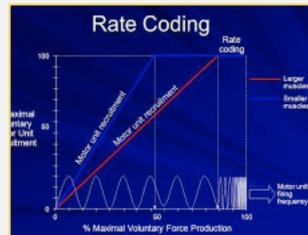
there will be relaxation after each stimulation

Thus the total strength of contraction rises progressively with increasing frequency

Rate Coding vs. Recruitment

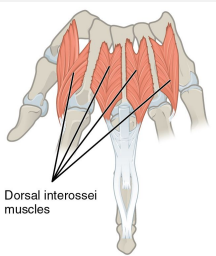
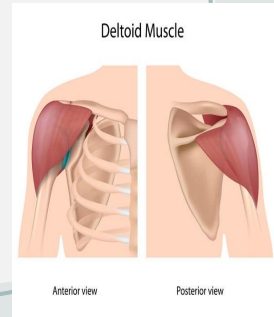
Small muscles rely more on **rate coding**

Example: first dorsal interosseous.



Large muscles of mixed fiber types rely more on **recruitment**

Example: deltoid.



Tetanzation

high frequency of stimulation

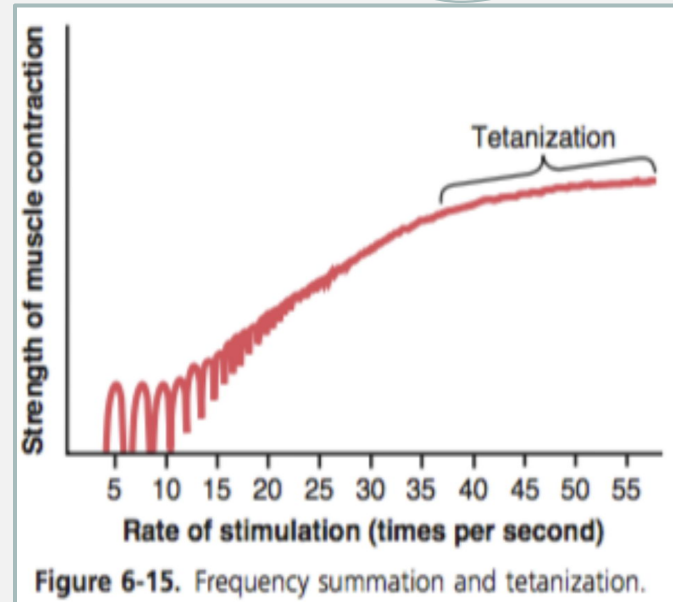
Individual twitch contractions occurring one after another at low frequency of stimulation (separate twitches).

Tetanzation: when **frequency** of muscle stimulation reaches a **critical level** where **successive contractions** become so rapid and fuse together and the muscle contraction appears to be completely smooth and **continuous**.

- Tetany occurs because:

Enough Ca^{++} are maintained in muscle sarcoplasm, even between APs

→ full contractile state is sustained without allowing any relaxation between the APs.



Development of Macromotor Units (Recovery of Muscle Contraction in Poliomyelitis)

When some (but not all) nerve fibers to a muscle are destroyed, (e.g. poliomyelitis), the remaining nerve fibers branch off to form new axons to innervate many of the paralyzed muscle fibers.

This process results in large motor units called macromotor units, that contains up to five times the normal number of muscle fibers for other motoneuron in the spinal cord.

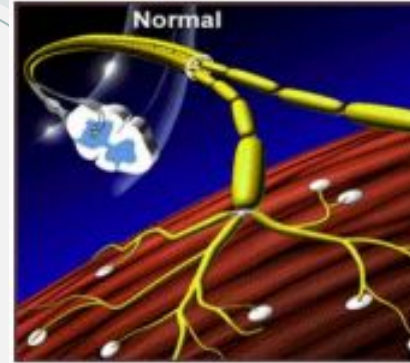
The formation of large motor units decreases the fineness of control one has over the muscles but allows the muscles to regain varying degrees of strength.

💡 Extra Info:

Poliovirus → Cause poliomyelitis

As a form of recovery motor unit adapts:

- 1- some nerve fibers are destroyed (motor unit)
- 2- the surviving motor unit enlarge become (macromotor units) and take on additional Workload to maintain movement and Function



Wiechers and Hubbell propose these new sprouts are indefinitely stable . . .
Wiechers, D. & S.L. Hubbell
Late changes in the motor acute poliomyelitis. Muscle
4: 524-528

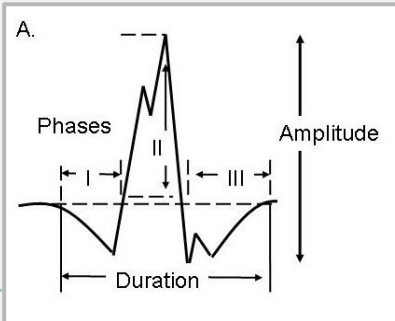
All or None Role

01

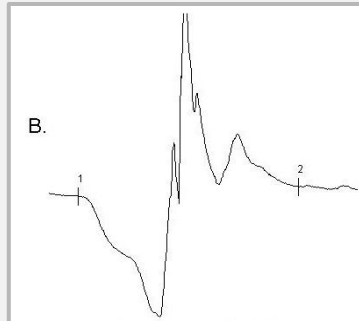
“All-or-none” principle: **impulse** from motor neuron will cause contraction in **all** muscle **fibers** it innervates **or none**. Motor Unit follows “all-or-none” principle.

02

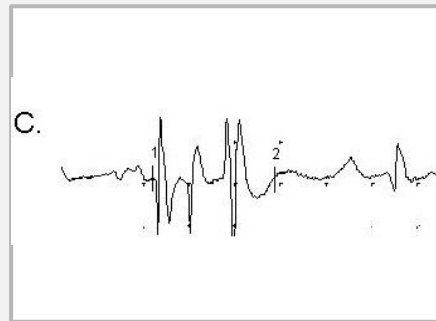
In an **electrodiagnostic** testing (e.g. electromyography - **EMG**) for a patient with weakness, careful **analysis** of the **Motor Unit Action Potential (MUAP)** size, shape, and recruitment pattern can help in **distinguishing** a **myopathy** from **neuropathy**.



Normal MUAP



Neuropathic MUAP



Myopathic MUAP

Typical MUPs characteristics in myopathic, neuropathic & normal muscle

MUP	Myopathy	Normal	Neuropathy
Duration	< 3 msec	3 – 15 msec	> 15 msec
Amplitude	< 300 μ V	300-5000 μ V	> 5 mV
configuration	polyphasic	triphasic	Polyphasic

Check out 443 condensed notes!

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or

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ANKI flashcards

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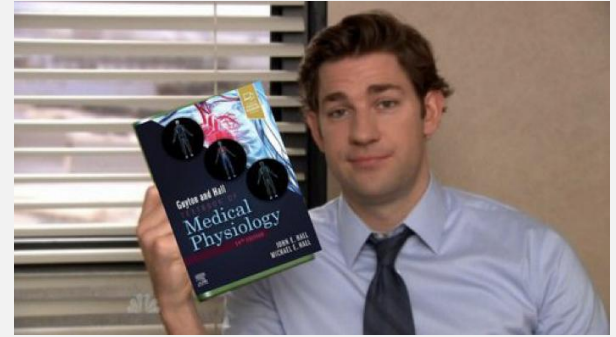


or

[Click HERE](#)

You can find the pages related to this lecture from (Guyton) [here](#)

Note: Guyton has extra information that might not be with us, but if you want to learn more about the topic make sure to check it out :3



MCQs



Q1: The higher the motor unit recruitment:

A- the stronger the muscle dilation

B- the weaker the muscle dilation

C. the stronger the muscle contraction

D- the weaker the muscle contraction

Q2: Less precise movement consists of:

A- fewer number of MU & many muscle fibers per unit

B- fewer number of MU & few muscle fibers per unit

C- greater number of MU & many muscle fibers per unit

D- greater number of MU & few muscle fibers per unit

Q3: Which of the following can lead to tetanization:

A- severe muscle contraction

B- development of macromotor units

C- multiple muscle summation

D- frequency summation

MCQs

Q4: How many muscle fiber per motor unit in leg muscle?

A-500

B- 600

C.900

D-400

Q5: Group of motor units often work together to help the contractions of a single muscle:

A-motor unit

B- motor neuron

C-muscle fibers

D-motor unit pool

Q6:The average motor unit of all the body:

A-80-100

B-500-1000

C-800-1000

D-3000-10000



Ahmad Addas



Nawaf Alshalan



Fawaz Almadi



Khalid Alkanhal



Abdulrahman Khaldi



Khalid Alghamdi



Talal Alrobaian



Abdullah Muhanna



Zyad Alshuhail



Ibrahim Al Bin Ali



Mays Ahmed



Alanoud Alnajawi



Joud Binkhamis



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Lama Almoutairi



Leena Shagrani



Marwah Fal



Rahaf Mohammed



Huda Bassam



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