Organization of the Nervous System and Motor Unit

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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

- <u>1-Central Nervous System (CNS)</u> , consisting of brain and spinal cord (with its somatic and autonomic components) .

- <u>2-Peripheral Nervous System (PNS)</u> , consisting of peripheral nerves (whether somatic or autonomic nerves) .

Central Nervous System (CNS)

- The CNS (brain & spinal cord) constitute the majority of the nervous system.
- The CNS integrates and analyzes يجمع و يحلل the information that it is receives from all parts of the body
- and also it initiates and coordinates the activity
  (motor action) of all parts of the body
- Because they are delicate structures , the brain and spinal cord need to be protected from the external environment (including mechanical injury) .
- the brain is protected by the skull, while the spinal cord is protected by the vertebrae, and both are enclosed in the meninges .

Peripheral Nervous System (PNS)

- Comprises cranial nerves and spinal nerves .
- <u>Cranial nerves :</u>
- Arise from the brain .
- Are 12 pairs (i.e., 12 on either side)
- The first two cranial nerves (Cr nerves I and II) arise from the cerebrum , while the rest of cranial nerves arise from the brainstem
- <u>Spinal nerves :</u>
- Emerge from the spinal cord.
- They are 31 pairs : 8 cervical, 12 thoracic,

5 lumbar, 5 sacral and 1 coccygeal.

B/ Somatic & Autonomic NS

- **(1) Somatic NS** : concerned with

- (i) somatic sensations → sensations from somatic structure : body surface , skeletal muscle , joints & tendons , &

- (ii) voluntary movement (voluntary activity executed by skeletal muscles)

- **(2) Autonomic 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 to the effector organs (muscles and glands) .
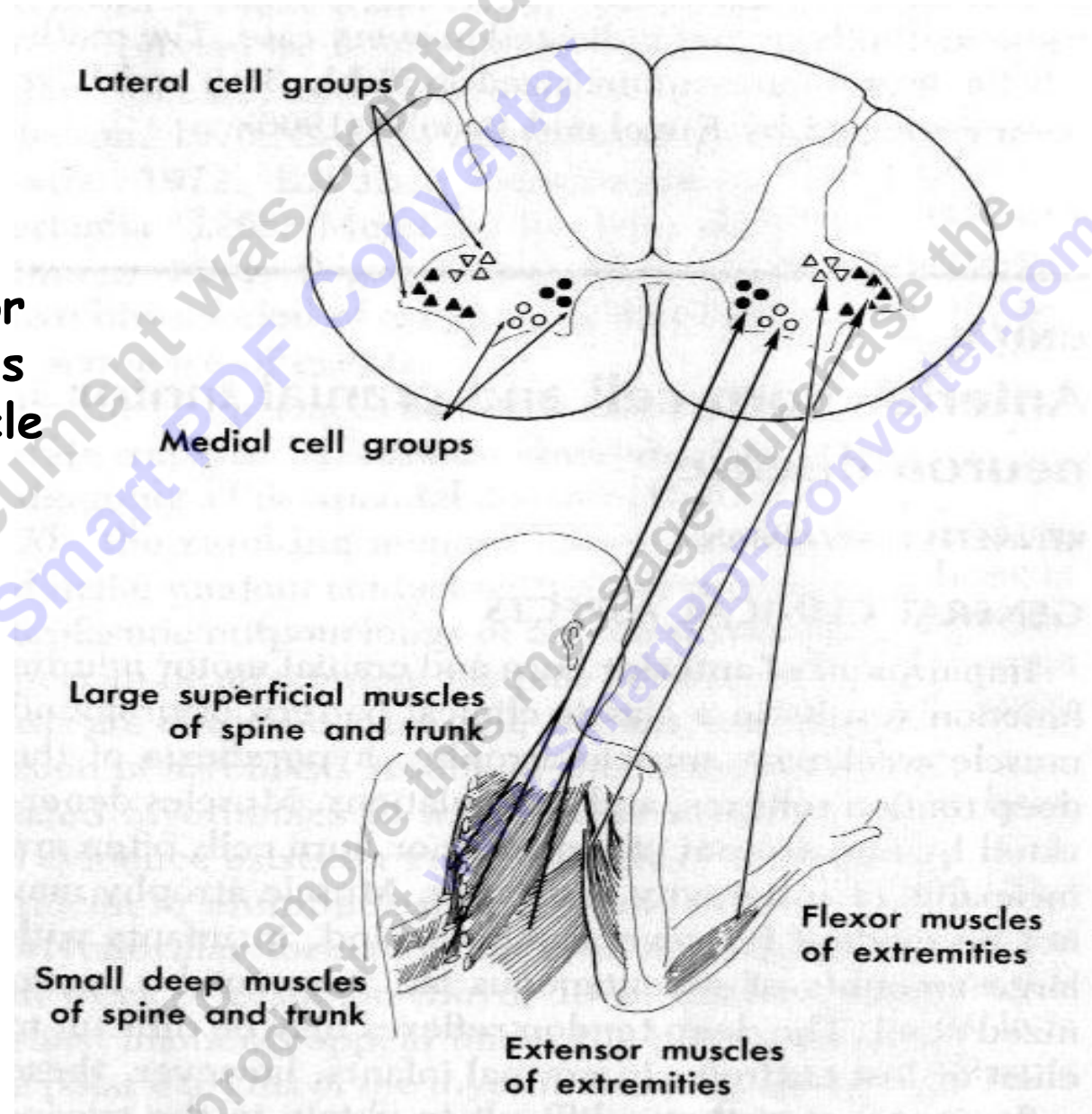
The Motor Unit

Antrior Horn Cell (AHC) ? ما هو عصبون القرن الأمامي

✓AHC is the motor nerve that controls the skeletal muscle cell contraction

Lateral cell groups

Medial cell groups

Large superficial muscles of spine and trunk

Small deep muscles of spine and trunk

Extensor muscles of extremities

Flexor muscles of extremities

- When the axon of the motor nerve enters the muscle , it divides into many branches inside it

- The ending (terminal) of each of these branches is enlarged , contains vesicles of ACh and it supplies (innervates) only one muscle cell (muscle fiber).

- Thus each muscle cell is supplied by only one AHC .

- On the other hand,one AHC , through the branches of its axon , supplies several muscle cells .
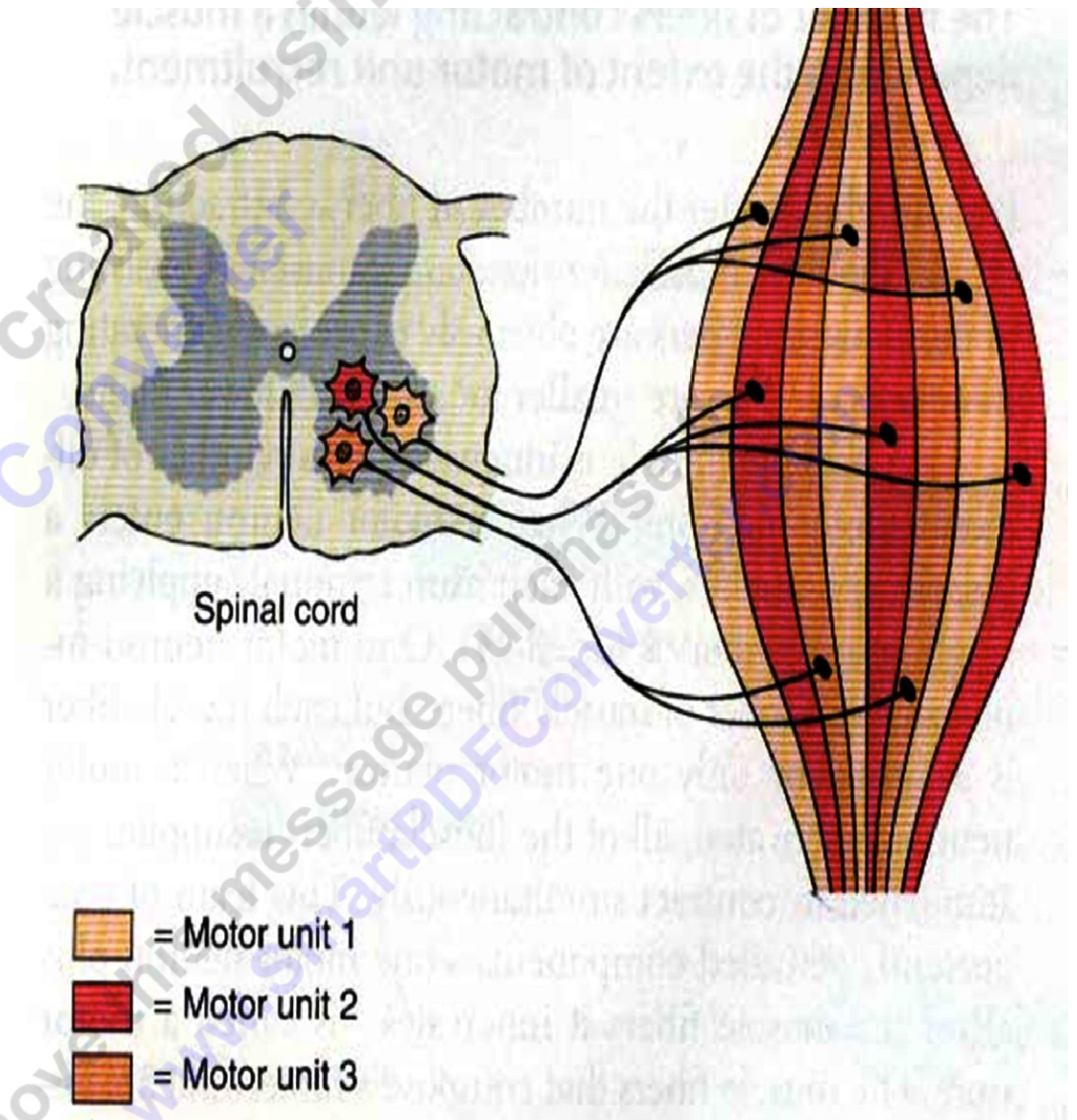
- Q : What is the motor unit ?

- الوحدة الحركية ؟

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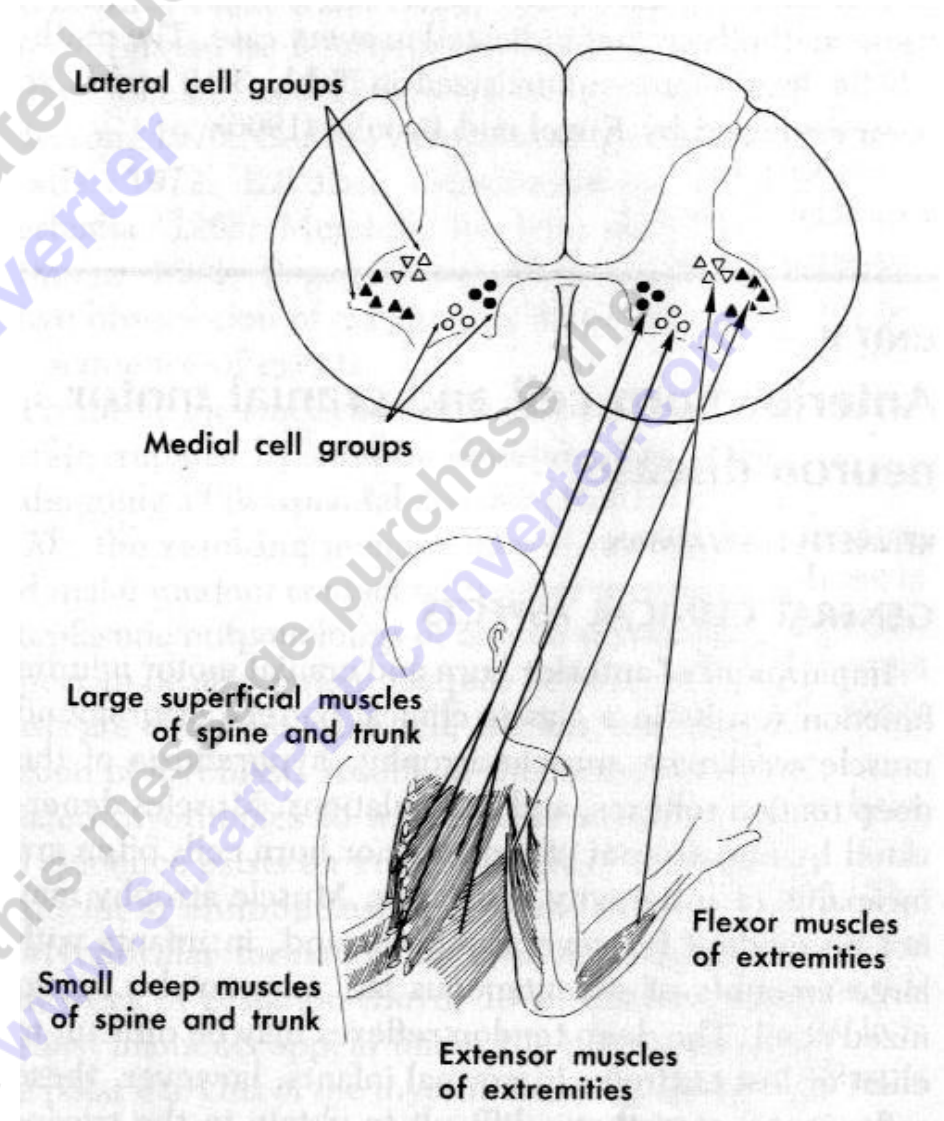
- **Q:What is a Motor Unit ?**
- **It is the Motor Neuron (Anterior Horn Cell , AHC) and all the muscle fibers it innervates (supplies)**

Spinal cord

= Motor unit 1

= Motor unit 2

= Motor unit 3
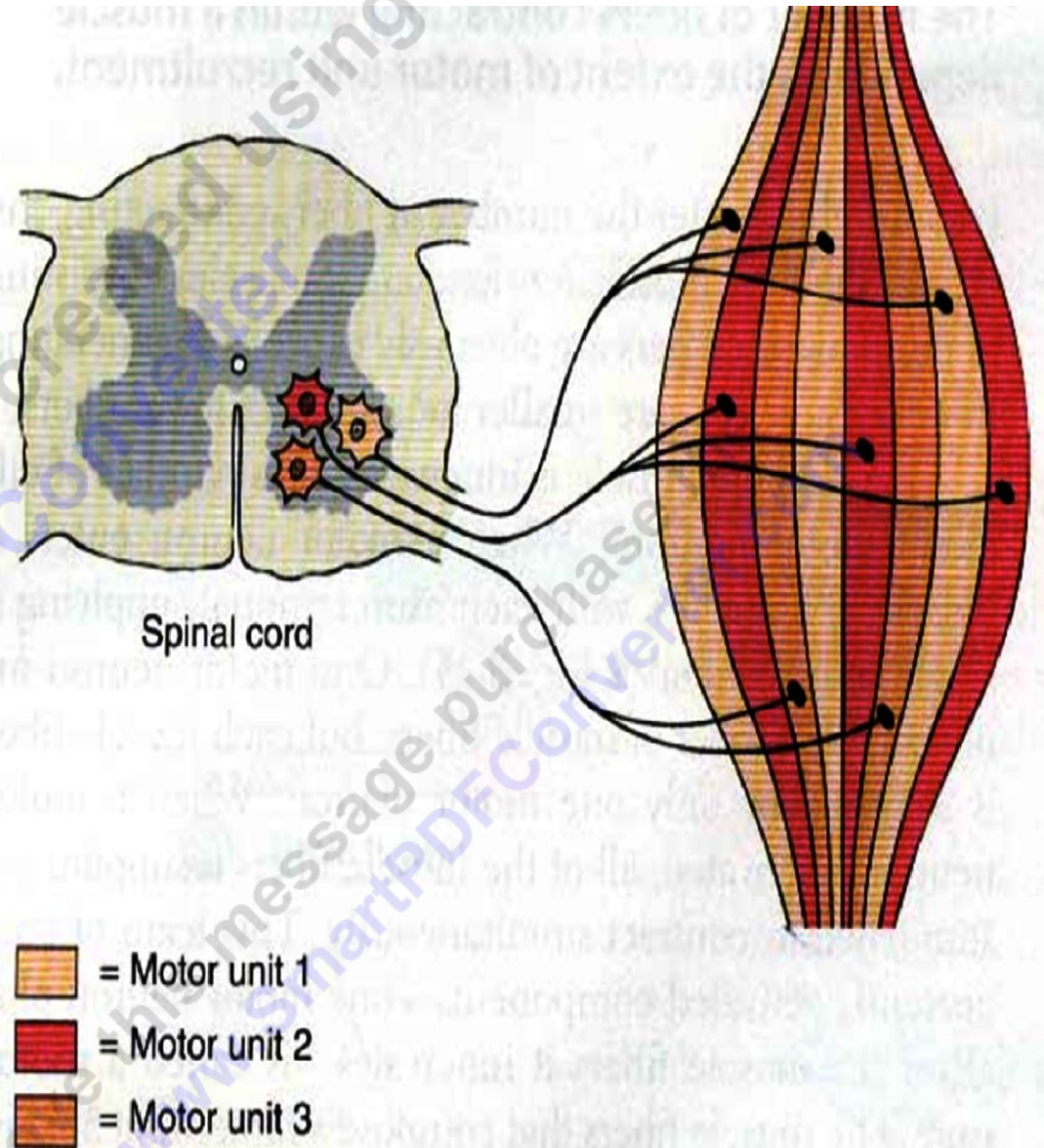
- Q: What is the neuromuscular junction (NMJ) ?
- It is the place where the axon terminal contacts the muscle cell

- What is the chemical transmitter released by the axon of the motor nerve ?
- It is Acetylcholine (ACh

Spinal cord

☐ = Motor unit 1
☐ = Motor unit 2
☐ = Motor unit 3

- Functionally speaking , muscles can be considered as being made of consist of a number of motor units

- A motor unit is the motor neuron and all muscle fibers within the muscle it innervates (supplied with it)

- All muscles consist of a number of motor units and the fibers belonging to a motor unit are dispersed and intermingle amongst fibers of other units.

- All of these fibers will be of the same type (either fast twitch or slow twitch) .
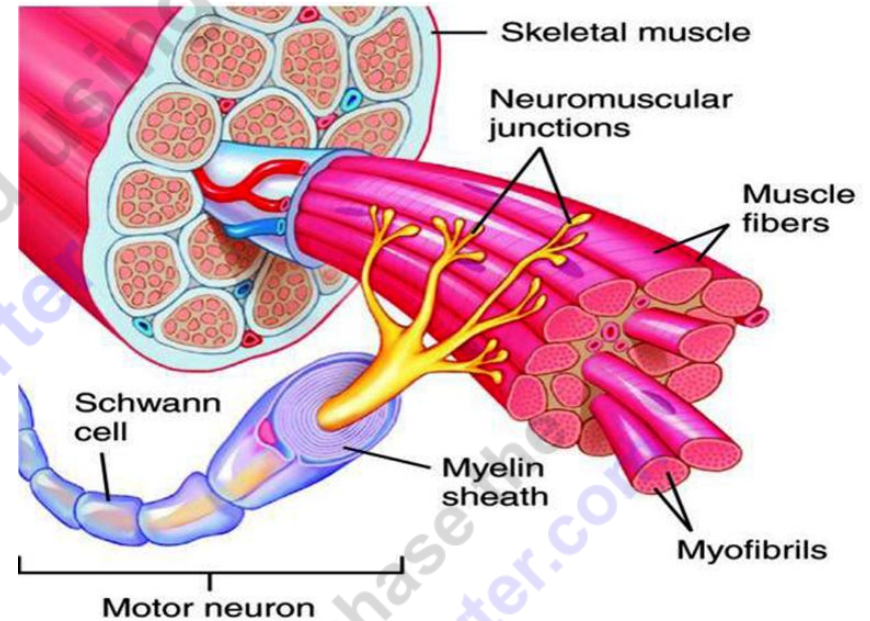
- When a motor unit is activated, all of its fibers contract.

Groups of motor units often work together to coordinate the contractions of a single muscle

- All of the motor units that subserve a single muscle are considered a motor unit pool.

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

- In general , the smaller the motor unit (i.e., the smaller the number of muscle fibers controlled by a single motor neuron in that unit) , the more accurate & precise the action of the muscle which contains that unit .

- Therefore , muscles that carry gross , big movements (e.g., muscles that mediate trunk flexion , extension , etc) have large units (many muscle fibers per one motor neuron).

- Conversely , muscles that carry fine , refined movements (e.g., eye muscles) or skilful , manipulative movements (e.g., hand muscles) or of facial expression ,have small motor units containing relatively small number of muscle fibers per one AHC.
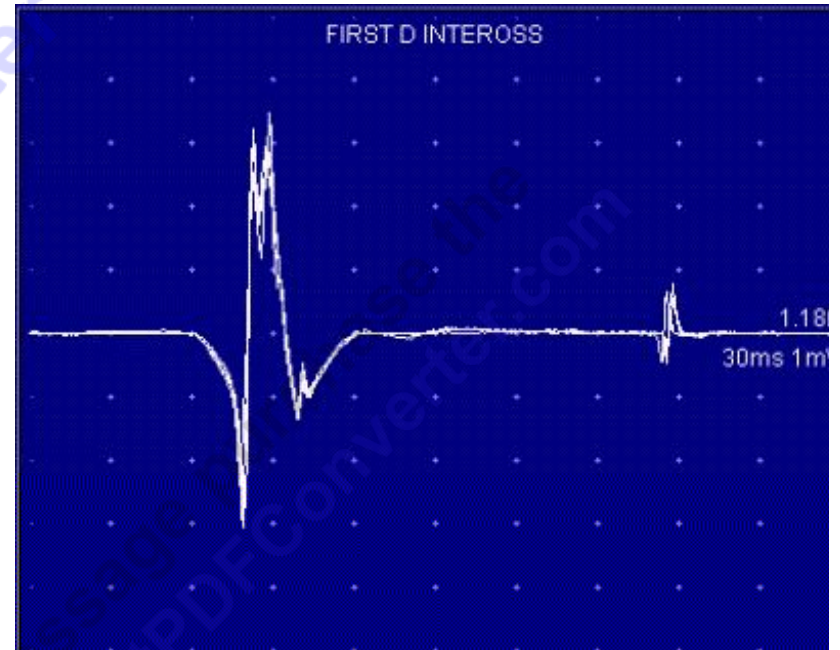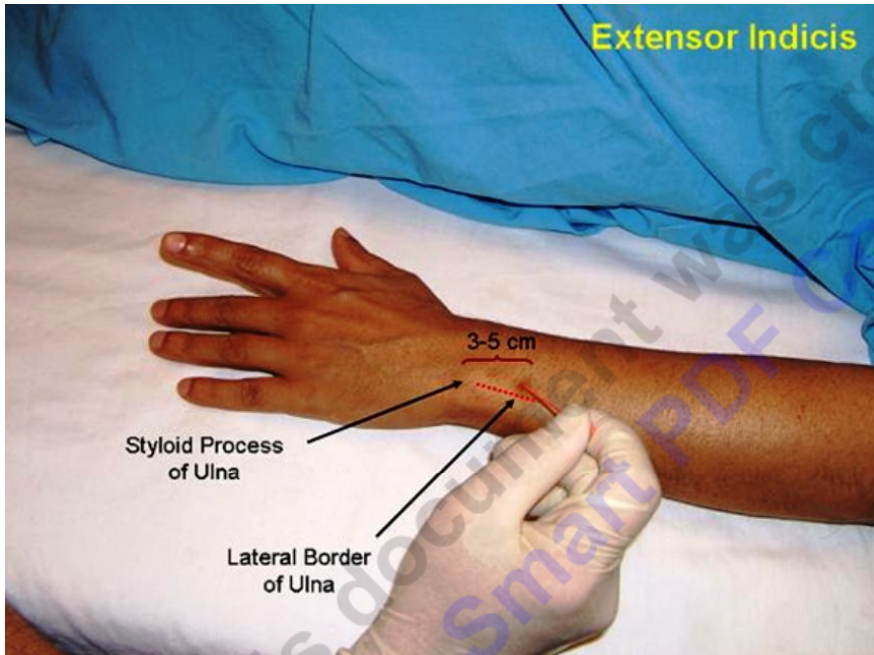
- In electrodiagnostic testing (EMG , electromyography) for a patient with weakness, careful analysis of the motor unit action potential (MUAP) size, shape, and recruitment pattern can help in distinguishing a myopathy from neuropathy.
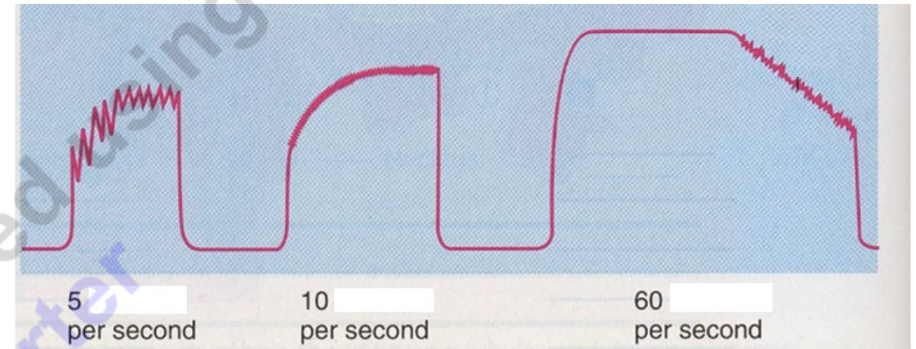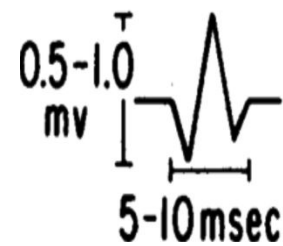

Increasing frequency of action potentials resulting in stronger force of contraction

- **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 a motor neuron is activated, all of the muscle fibers innervated by the motor neuron are stimulated and contract.

- When the AHC fires at slow rates , MUPs will be at slow rtae , & the force of muscle muscle contraction is weak .
- If AHCs fire at very fast rates → fast MUPs → stronger contraction
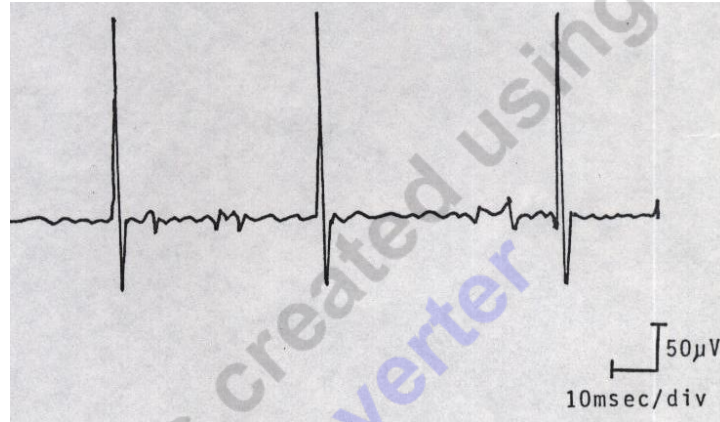- At maximumum effort → we get in the EMG interference pattern .
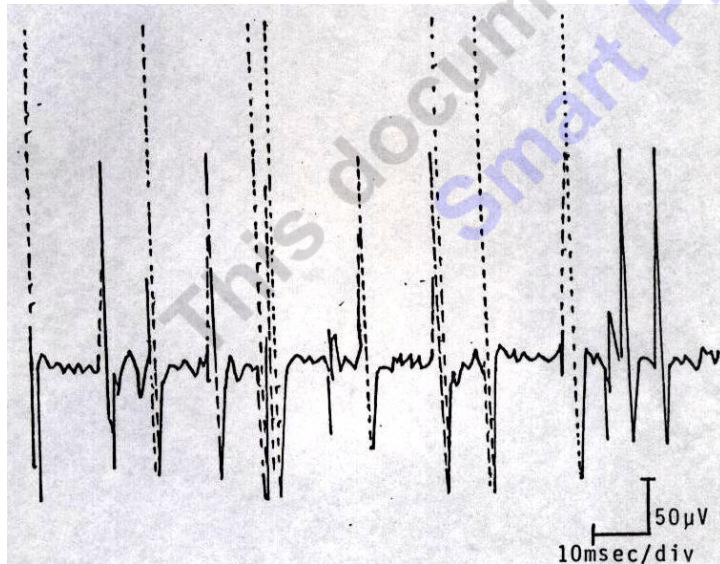
Electromyogram (EMG)

Extensor Indicis

3-5 cm

Styloid Process of Ulna

Lateral Border of Ulna

FIRST D INTEROSS

1.18

30ms 1m

Motor Unit potentials (MUPs)
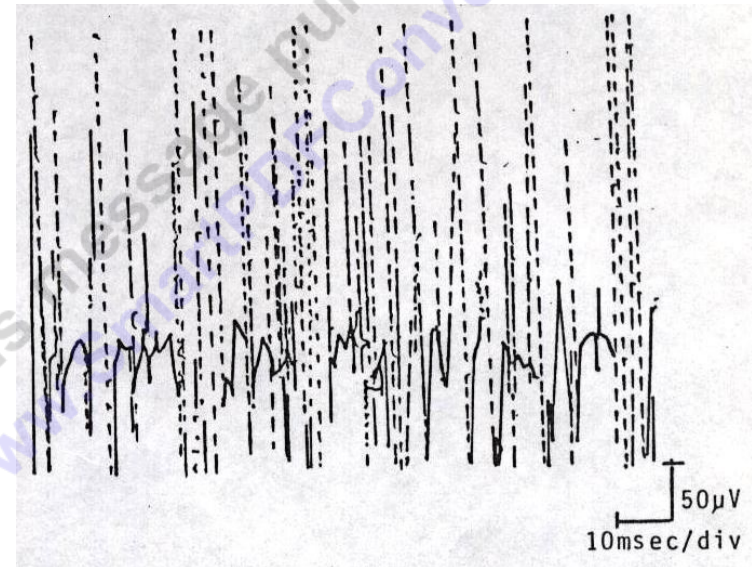

0.5-1.0 mv

5-10msec

**Motor Unit potentials (MUPs) During Mild Effort**

During Moderate Effort

During Maximum Voluntaryn Effort

- The activation of one motor neuron will result in a weak but distributed 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 .

- 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.

Motor neurons

A
B

Needle electrode

Rest

Slight contraction

Maximal contraction

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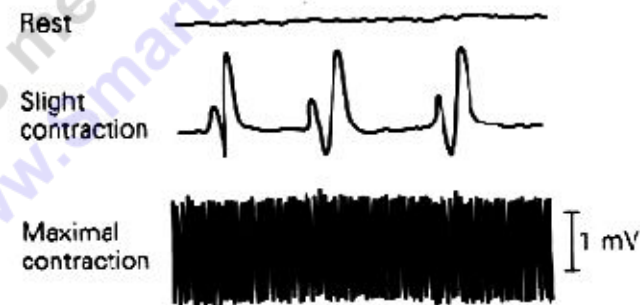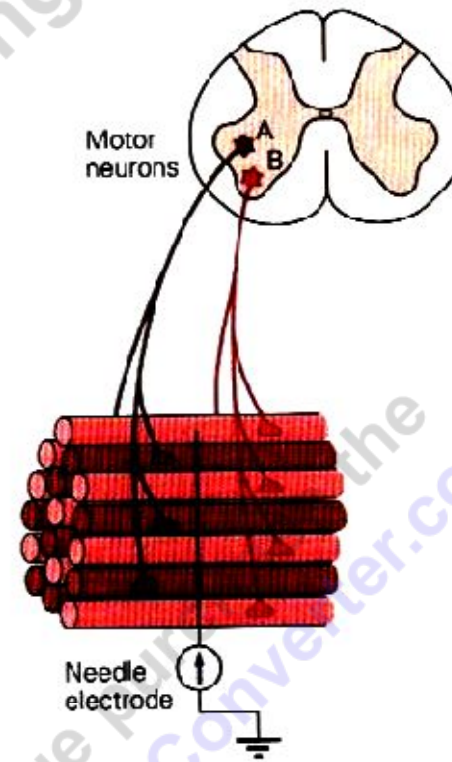
- Generally, this allows a 2 to 4-fold change in force.

•Thanks