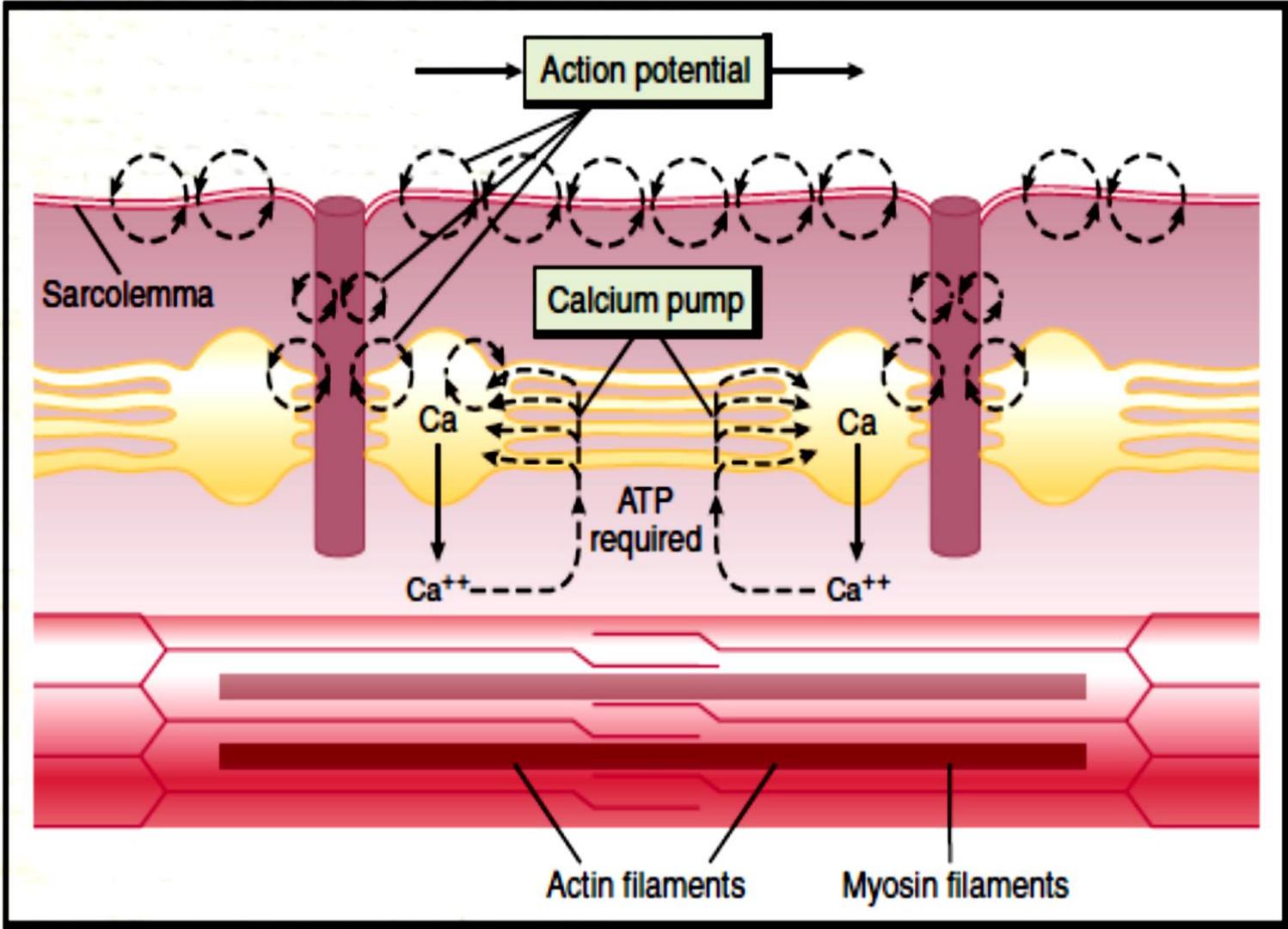
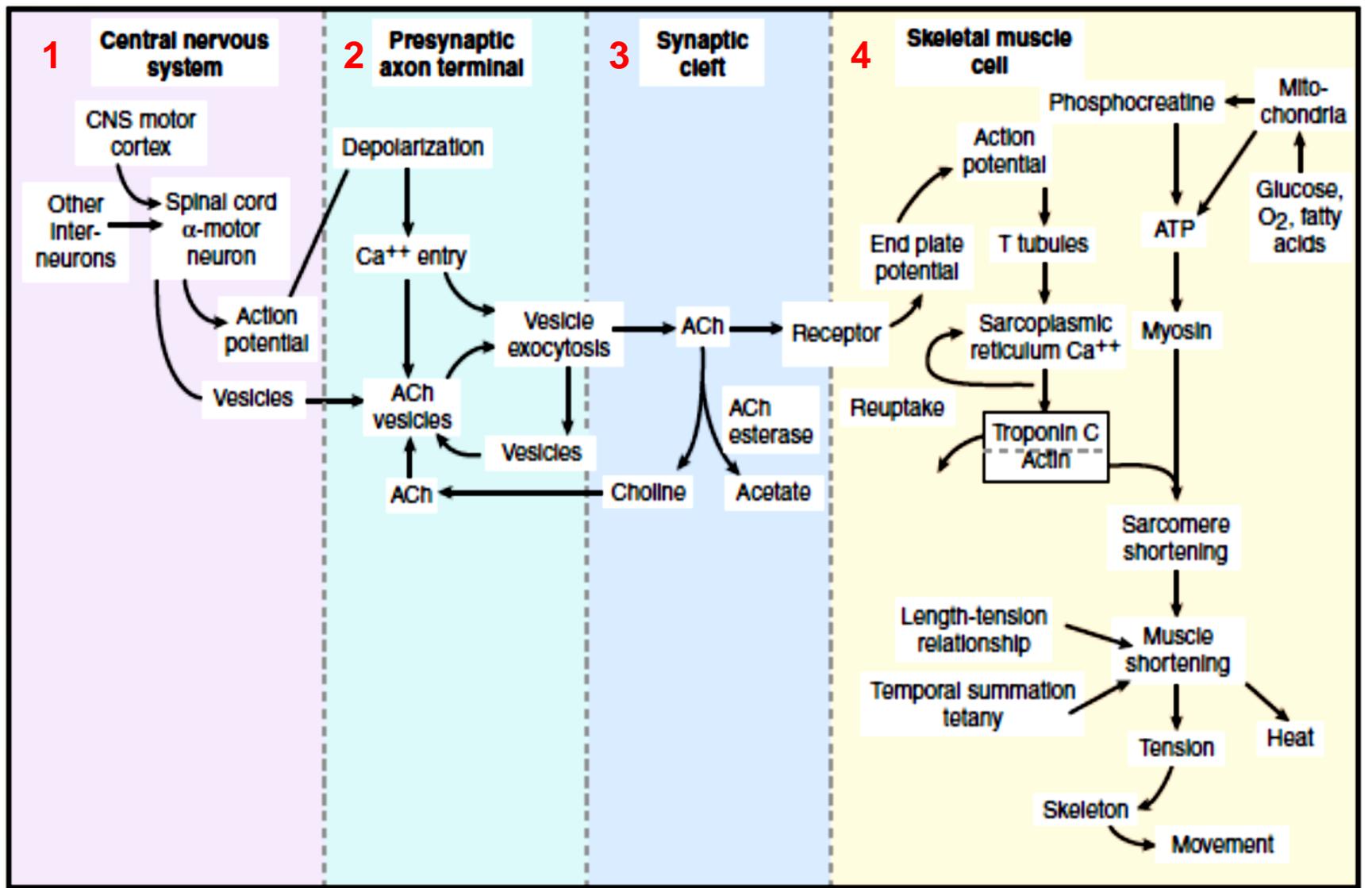




MECHANISM OF SKELETAL MUSCLE CONTRACTION.

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Mechanism of muscle contraction (Excitation - contraction coupling)

It is the process by which depolarization of the muscle fiber initiate contraction.

1-When a nerve impulse reach the MEP, it leads to Ach release from the nerve terminals.

2-Ach combines with the cholinergic receptors on the muscle membrane → ↑ Na⁺ permeability → depolarization of the membrane (**End plate potential**).

3-When the **EPP** reaches the firing level → **action potential** that propagates along the muscle membrane and transmitted to all fibers via the **T tubules**.

4-This action potential triggers the release of Ca⁺⁺ ions from the terminal cisternae of sarcoplasmic R.

5-The concentration of Ca⁺² increases and initiates contraction by binding to troponin-c leading to:

a- Weakness of the binding of **troponin I** to actin.

b- Movement of **tropomyosin** laterally into the groove between the thin filaments → uncovering the binding sites of actin for the myosin heads.

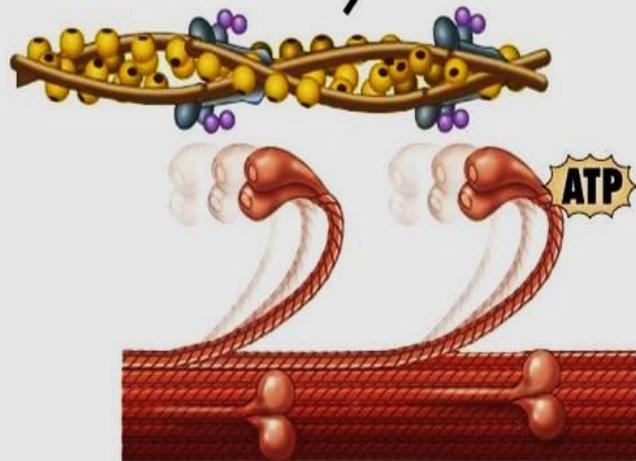
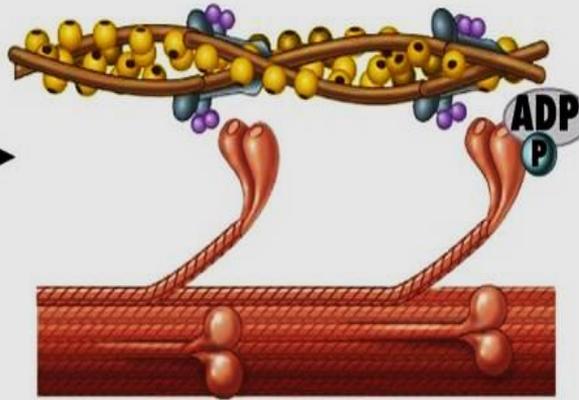
6-The interaction between actin & myosin heads leads to sliding of actin filaments between myosin filaments → muscle contraction.

6-The energy required for this mechanism is provided by breakdown of ATP to ADP by ATPase activity of myosin heads in the presence of Ca⁺⁺ ions.

1 Myosin heads hydrolyze ATP and become reoriented and energized

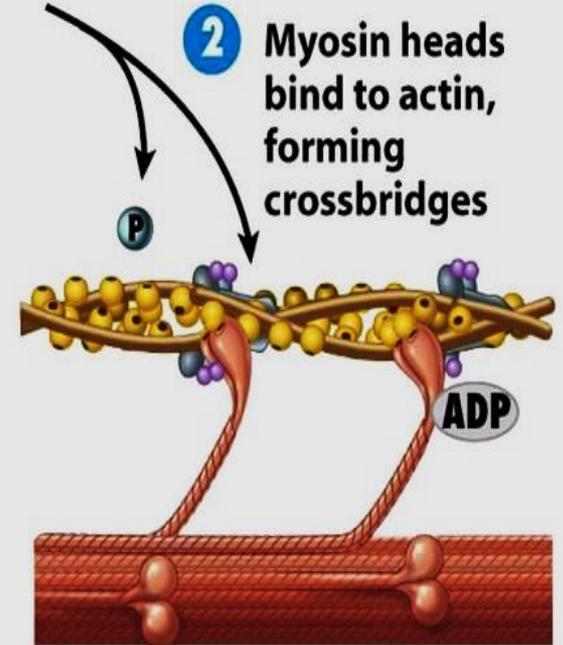
Key:

● = Ca^{2+}

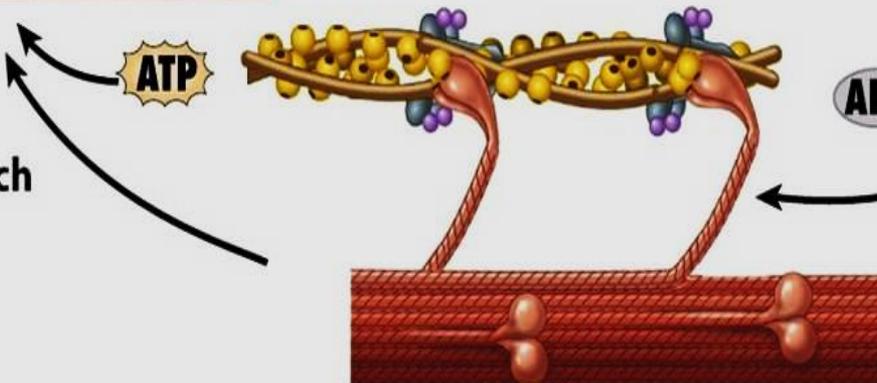


Contraction cycle continues if ATP is available and Ca^{2+} level in the sarcoplasm is high

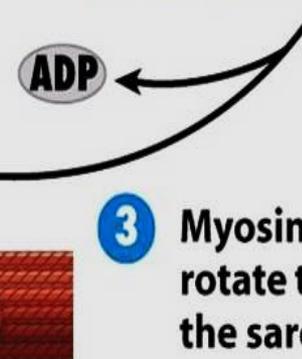
2 Myosin heads bind to actin, forming crossbridges



4 As myosin heads bind ATP, the crossbridges detach from actin



3 Myosin crossbridges rotate toward center of the sarcomere (power stroke)



Results of contraction

-The **Sarcomere** becomes **short**

.

-The width of **I** band is **decreased**.

-The width of **A** band is remained **constant**.

-**H-zone** becomes **narrow**.

-**Mechanical changes:** there are **2 types** of contraction:

-**In isometric cont:** (CE) shortens but (SE) stretched and elongated so the total ms. length is **constant**.

-**In isotonic cont:** CE shortens but (SE) **not stretched** → **shorten** ms.

The simple muscle twitch

Definition: It is the response of the muscle to a single maximal stimulus and consists of:

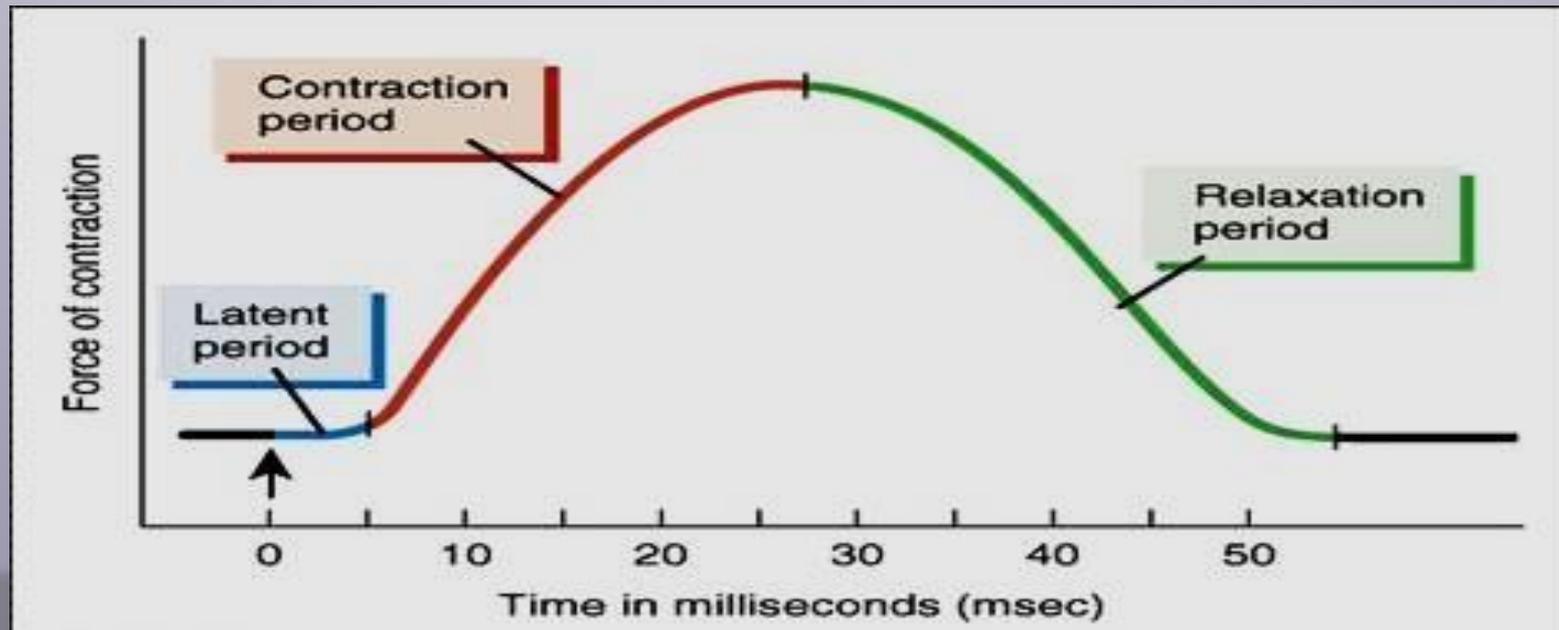
1) Latent period: -It is the time between time of stimulus & response.

-About 0.01 second duration. - Due to: 1- conduction of impulse in nerve 2- production of MEP potential. 3-conduction of impulse in the muscle. 4- contraction and 5- the time of recording.

2) Contraction period: during it the muscle contracts either isometrically or isotonicly.(0.04 sec.)

3) Relaxation period: the muscle relaxed (= 0.05 sec. In isotonic relaxation).

N.B.: The simple muscle twitch can be studied in the nerve muscle preparation (siatic – gastrocnemius frog muscle).



- **Fatigue:**

- **Definition:-** It is the gradual decrease in the muscle contraction and prolonged duration of all phases of the SMT, especially relaxation due to repeated and strong stimulation of the muscle. • **The effect:** decrease strength and prolonged duration of contraction and incomplete or absent relaxation
- **The cause of **fatigue:**** - In case of **indirect** stimulation (via stimulation of its motor nerve) is the gradual exhaustion of Ach at the MEP.

-Also **direct** stimulation of the muscle may lead to **fatigue** due to exhaustion of energy sources (ATP) or accumulation of metabolites.

- In living muscle (after exercise), **fatigue** is caused by:

1-Decrease blood supply to the muscle.

2-Decrease energy sources.

3-Accumulation of metabolites which depress the brain and spinal cord, central effect.

- **Contracture** may occur with fatigue due to decrease in ATP required for separation between the thin and thick filaments and muscle relaxation.

- Stair-case (Treppe) phenomenon:

-It occurs in the skeletal and cardiac muscle.

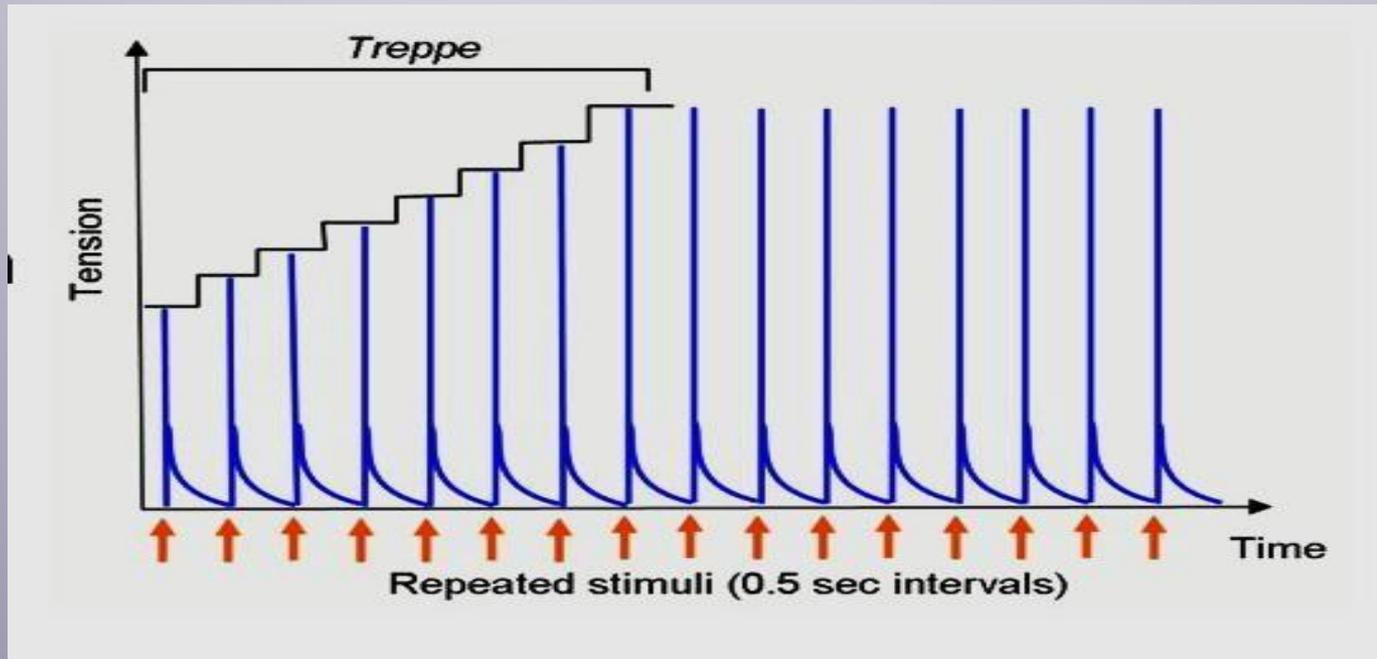
-It is a gradual increase in muscle contraction until plateau.

-This occurs by application of series of maximal stimuli just after relaxation period of each muscle twitch.

-This is due to: 1- accumulation of Ca^{++} intracellular.

2- \uparrow temperature of the muscle.

3- $\downarrow \text{K}^+$ & $\uparrow \text{Na}^+$ intra-cellular $\rightarrow \uparrow \text{Ca}^{+2}$ release from sarcoplasmic reticulum $\rightarrow \uparrow$ contraction.



Summation of muscle contractions

Since the contraction phase in the skeletal muscle starts with the relative refractory period, the muscle respond to another stimulus during either cont. or relaxation → summation of contraction.

(a) Effect of two successive stimuli:

According to frequency of stimulation:

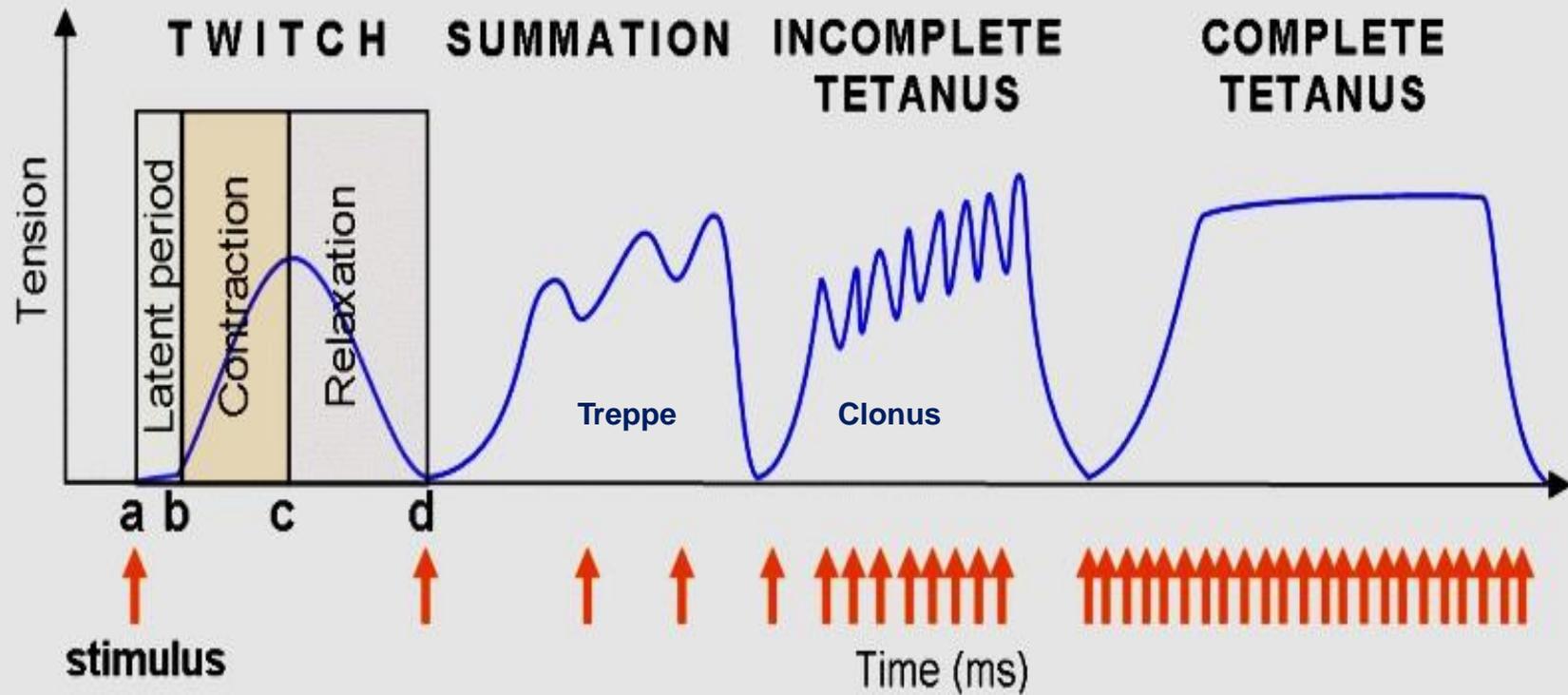
If the **2nd stimulus** falls in relation to preceding one:

- 1- During the **latent period** → no response during (ARP).
- 2- During the **contraction period** → more strong contract.
- 3- During the **relaxation period** → 2 peaks contraction.
- 4- Just **after the relaxation period** → stair-case phenomenon.
- 5 - **After relaxation** → normal second contraction.

(b) Effect of multiple successive stimuli:

- 1 -If the frequency is low → separate twitches with Stair – case phenomenon.
- 2-If the frequency increases and stimuli falls during relaxation phase of preceding twitch → Clonus (incomplete tetanus).
- 3-If the frequency increases more and stimuli falls during contraction phase → sustained contraction (complete tetanus).

N.B.: Cooling, fatigue & anti-cholinesterase (Eserine) change **clonus** into **complete tetanus**.
However, warmness and rest cause the reverse.



Thank You