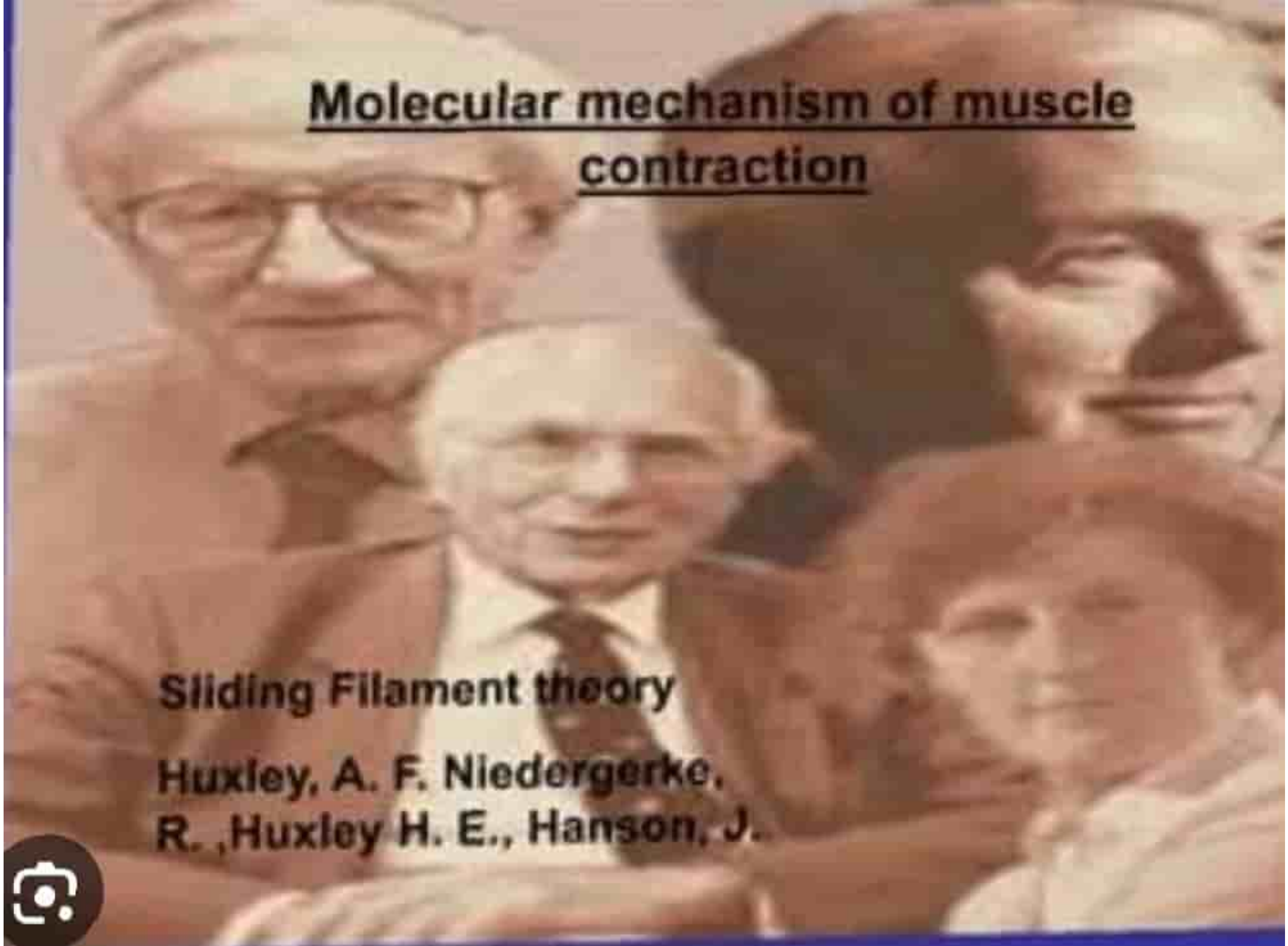
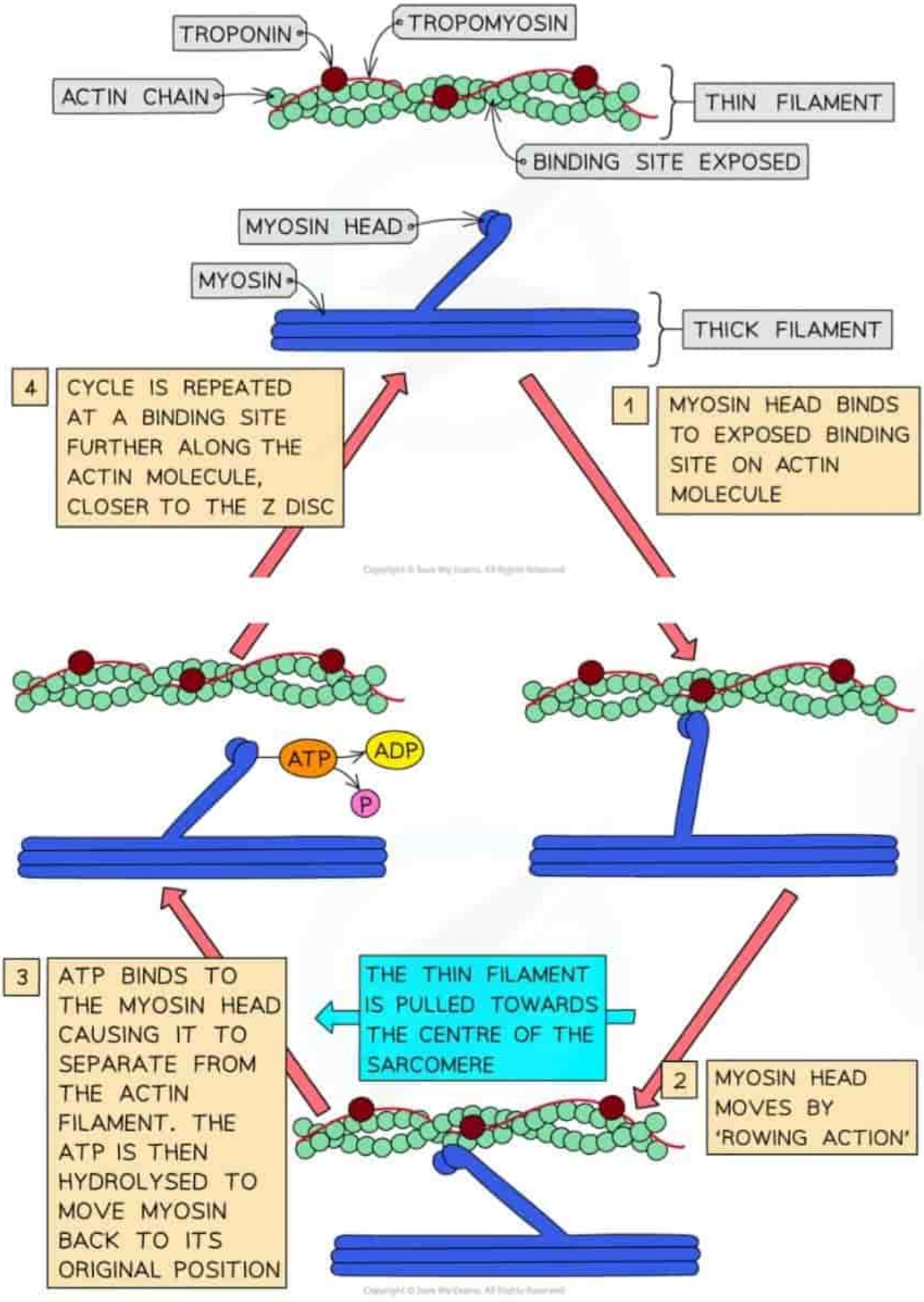
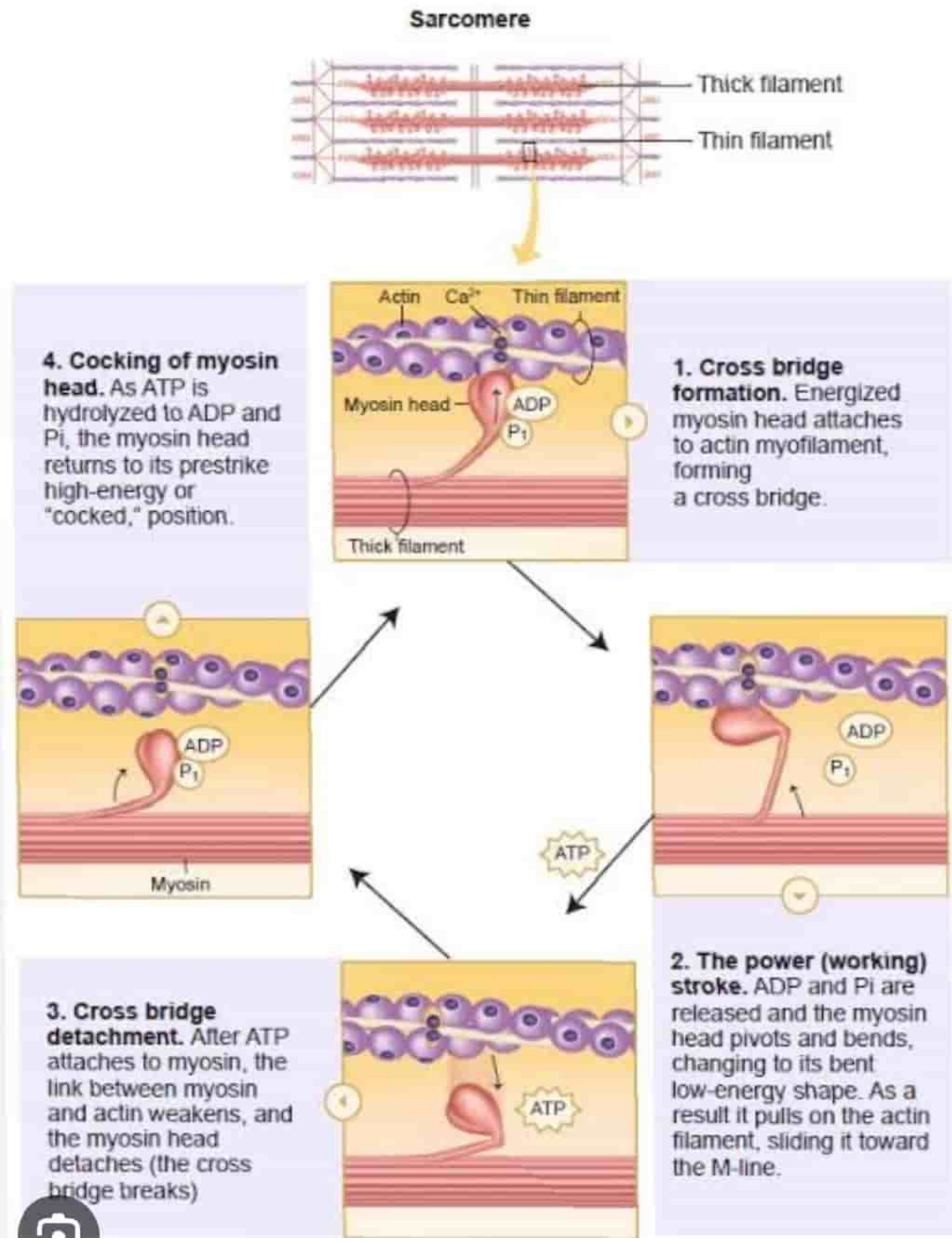

Molecular mechanism of muscle contraction
Sliding Filament theory
Huxley, A. F. Niedergerke, R. ,Huxley H. E., Hanson, J.



The sliding filament model of muscle contraction


Sarcomere
Thick filament
Thin filament
Actin
Ca^{2+}
Thin filament
Myosin head
ADP
P_i
Thick filament
1. Cross bridge formation. Energized myosin head attaches to actin myofilament, forming a cross bridge.
2. The power (working) stroke. ADP and Pi are released and the myosin head pivots and bends, changing to its bent low-energy shape. As a result it pulls on the actin filament, sliding it toward the M-line.
ADP
P_i
ATP
3. Cross bridge detachment. After ATP attaches to myosin, the link between myosin and actin weakens, and the myosin head detaches (the cross bridge breaks)
ATP
4. Cocking of myosin head. As ATP is hydrolyzed to ADP and Pi, the myosin head returns to its prestrike high-energy or "cocked," position.
ADP
P_i
Myosin

THE SLIDING FILAMENT THEORY OF MUSCULAR CONTRACTION

This theory was proposed by **H.E. Huxley** (1969). The theory explains the mechanical and chemical basis of muscular

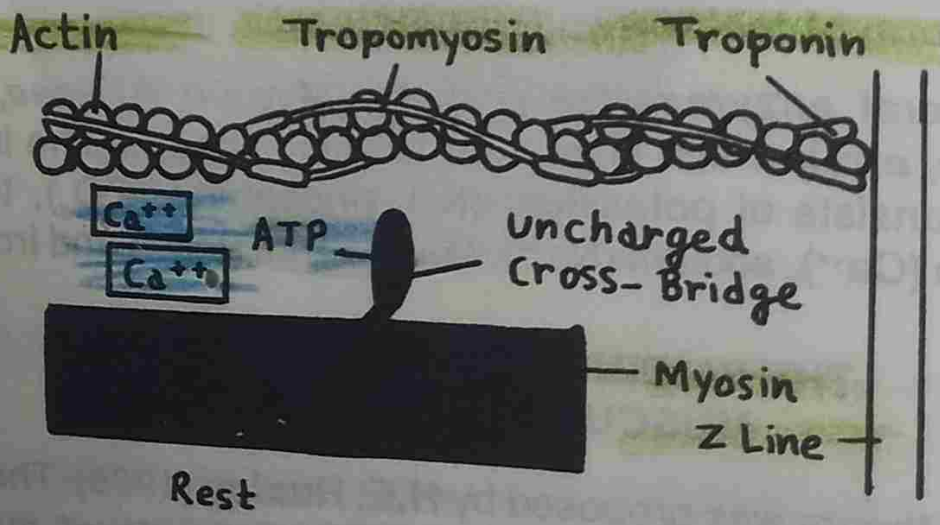
contraction. The length of the actin and myosin filaments does not change during contraction, rather the actin filaments slide over the myosin filament. This theory states that when a muscle is stimulated, through certain physiological and bio-chemical process, the actin filament slides over the myosin filament resulting in the shortening of the muscle.

The mechanical, physiological and biochemical process which are involved in this theory can be dealt in five different phases. These are cited below:

(1) Rest
(2) Excitation - Coupling
(3) Contraction
(4) Recharging
(5) Relaxation

(1) Rest

During the conditions of rest, the myosin cross-bridges extend towards the actin filament but do not form a bond with the actin filament. The calcium ions (Ca^{++}) are stored in the outer vesicles of the sarcoplasmic reticulum. A molecule of ATP is present at the end of the cross-bridge. During rest, this complex is called "uncharged ATP cross-bridge complex." Due to the absence of Ca^{++}, the troponin of the actin filament inhibits the binding of actin with the myosin cross-bridges.



(2) Excitation-Coupling

When a nerve impulse reaches the neuro–muscular junction through the motor nerve, acetylcholine is released. This further stimulates the generation of impulses in the sarcolemma of the muscle fibre. These nerve impulses quickly spread across the fibre through the T-tubules. On the route, the nerve impulses helps in the release of Ca^{++} from the vesicles of the sarcoplasmic reticulum. As soon as the Ca^{++} is released it is immediately taken up by the troponin molecules on the actin filaments. This results in "turning on" of active sites on the actin filament. This is a result of Ca^{++} triggering changes in the structure of both troponin and tropomyosin. The troponin molecule pulls the tropomyosin towards itself, thereby exposing the active sites on the actin filament. The active sites helps in the interaction of the actin and myosin filament.

Simultaneously, the uncharged ATP cross-bridges become charged ATP cross bridge complex. Thus, it leads to the physical–chemical coupling of actin and myosin resulting in a complex called ***actomyosin.***

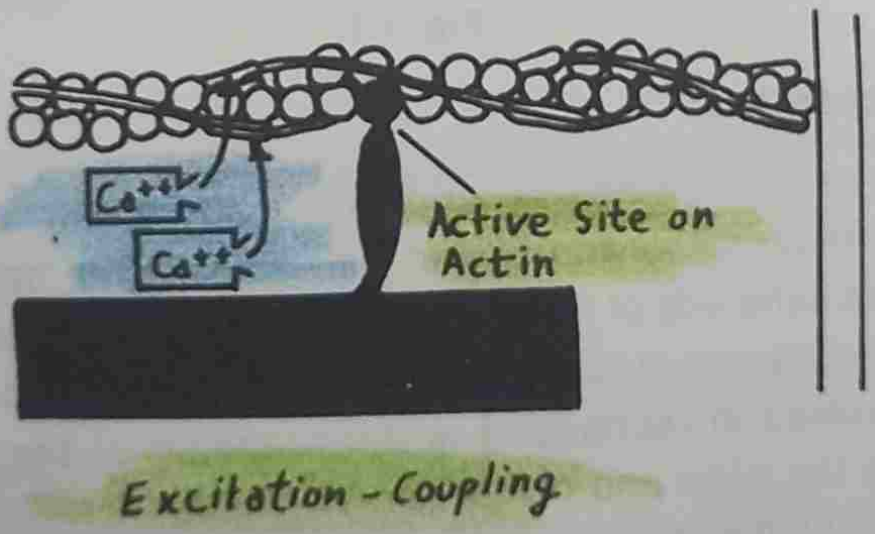


Fig. 3.6:

(3) Contraction

The actomyosin formation activates an enzyme myosin ATPase which is a component of the myosin filament. This enzymes breaks the ATP into ADP and Pi thereby releasing lot

of energy. This released energy allows the cross–bridge to move to a new angle, in such a way that the actin filament to which it is attached slides over the myosin filament towards the centre of the sarcomere. Thus, the tension is developed in the muscle and it shortens. The H-zone disappears as the actin filaments slides over the myosin filament. Shortening of I-band takes place because the actin filament which is attached to Z-lines on either side of the sarcomere are pulled towards the centre. No change in length of A-band occur. No change in the length of the actin and myosin filament takes place because of the sliding mechanism.

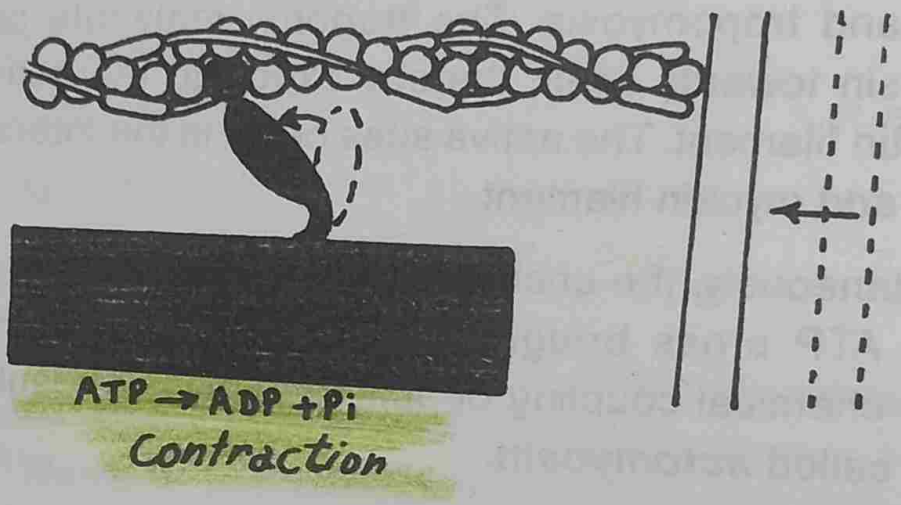


Fig. 3.7:

(4) Recharging

In a period of a one-second contraction the myosin cross-bridges may "make and break" with active sites on the actin filaments hundreds of time. For such process to occur time and again the myosin cross-bridges must be recharged. The first step involved in recharging is the breaking of the old bond between the actin and myosin cross-bridges. This is attained by reloading the myosin cross-bridge with a fresh molecule of ATP through resynthesis. After a new ATP molecule is reloaded, the old bond between the actin and myosin filament is broken; the ATP cross-bridge is freed from actin. Thus, the cross-bridge as well as the new active site is made available for recycling. In other words, there is breaking up of old bond and forming of a new site by reloading a fresh molecule of ATP.

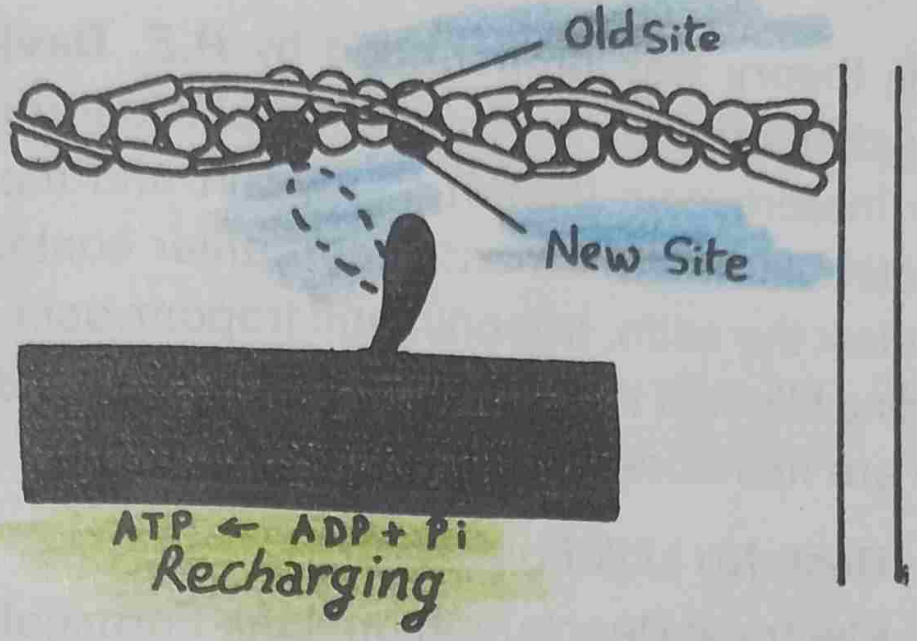


Fig. 3.8:

(5) Relaxation

As the nerve impulse ceases, the Ca^{++} is taken back from troponin and is pumped back to the storage (outer vesicles). Removal of Ca^{++} "turn off" the actin filament and thereby no forming of bond between the myosin cross-bridges and active sites on actin occur. The activity of the myosin ATPase is stopped; and no more ATP is broken down. The muscle filaments return to original positions and thus the muscle relaxes.