Muscles and Muscle Tissue

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Introduction

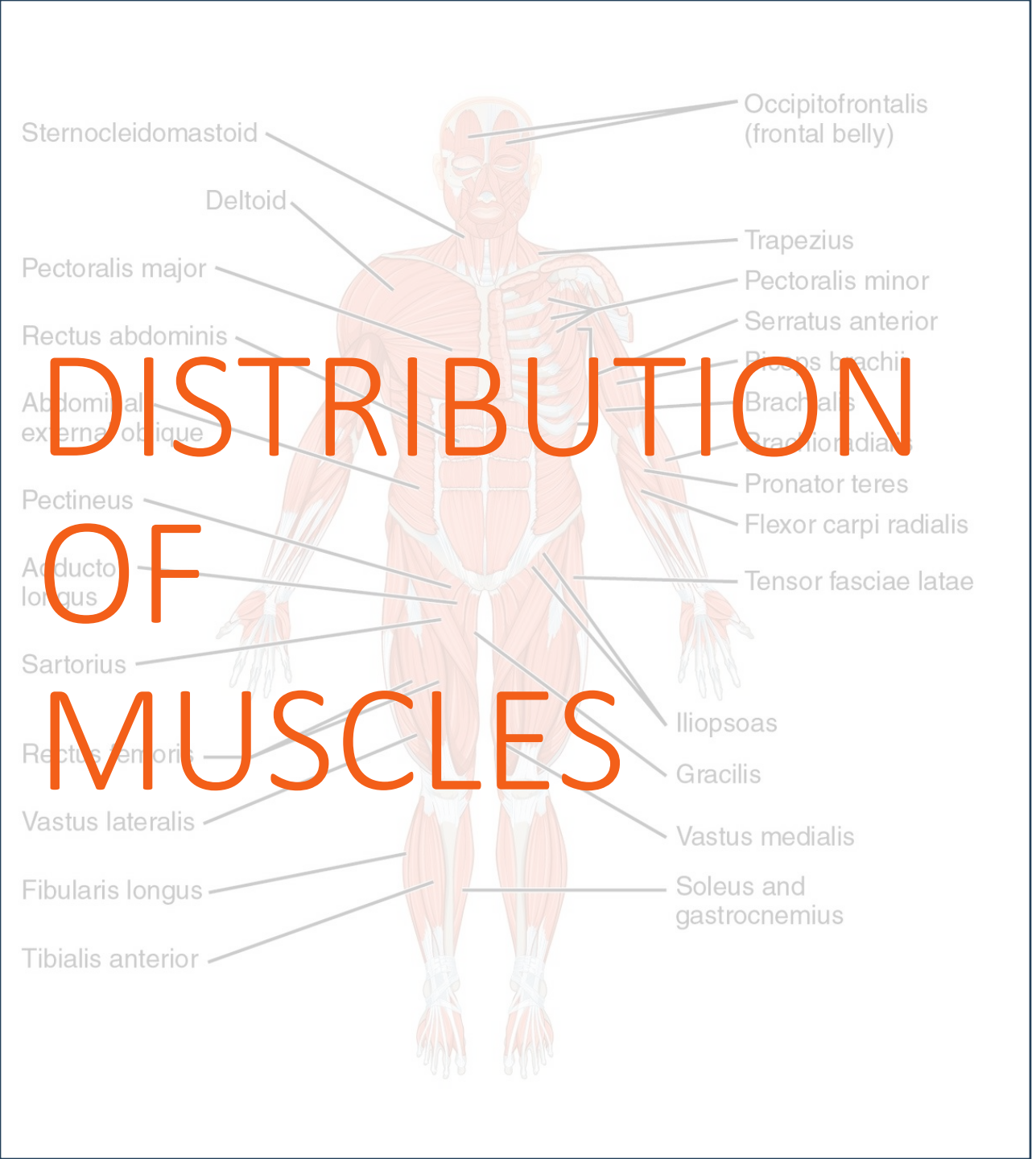
- A band or bundle of fibrous tissue in a human or animal body that has the ability to contract, Producing in or maintaining the position of part of the body.
- Because flexing muscles look like mice scurrying beneath the skin, some scientist long age dubbed the *muscles*, from the Latin word *mus* “little mouse”.
- There is a wide variety of muscle types because there is a wide variety of function to be served by muscles, including movement, maintenance of body posture and orientation, circulatory movements, gastro – intestinal tract movements and so forth.

Muscle Functions

- Producing movement
- Maintaining posture
- Stabilizing joints
- Generating heat

Functional Characteristics of muscle

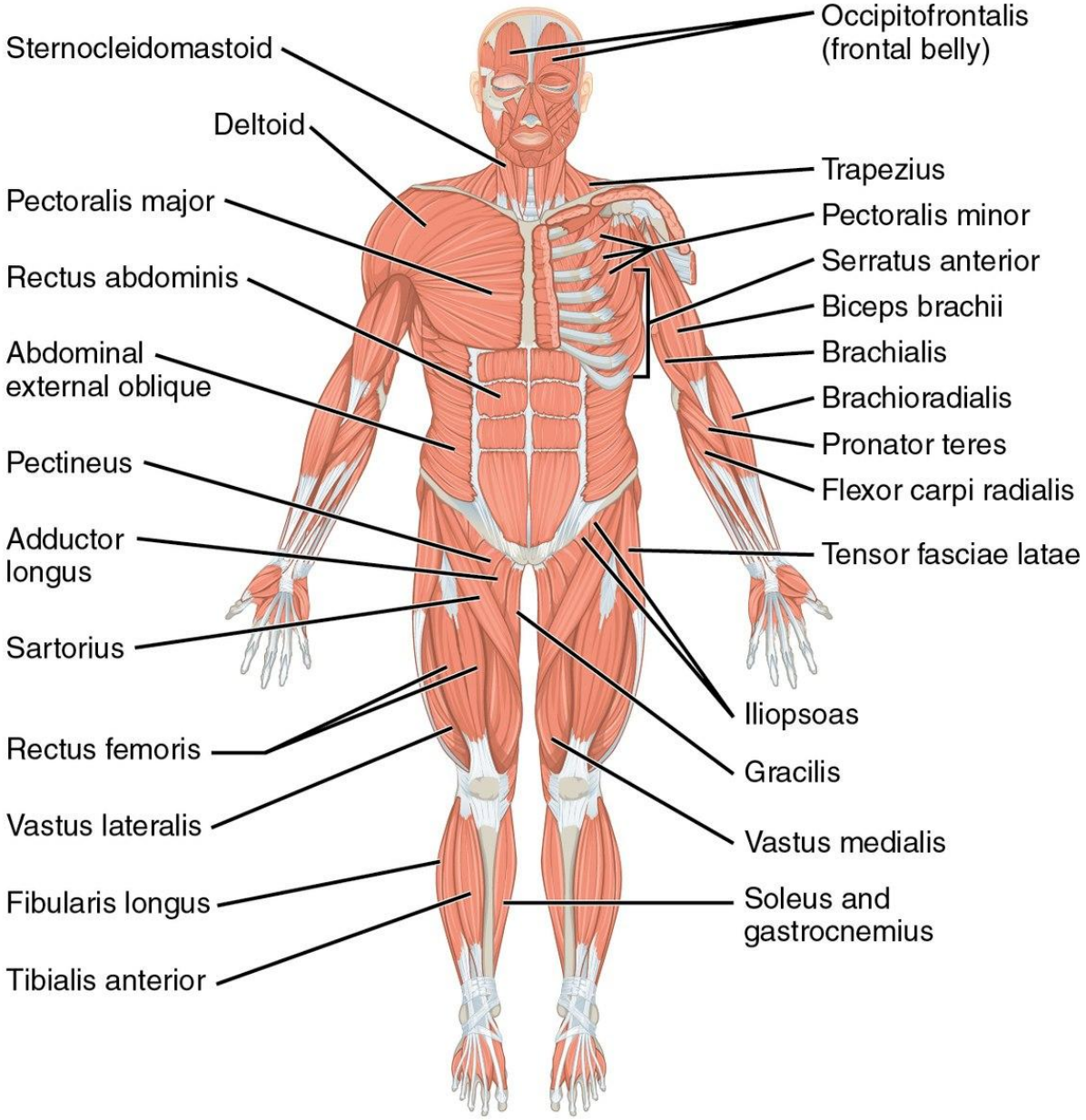
- **Excitability or Irritability** – Ability to receive and respond to a stimulus
- Contractility – ability to shorten forcibly when adequately stimulated
- Extensibility – ability to be stretched or extended
- Elasticity – ability of muscle fibre to resume it's resting length after being stretched



DISTRIBUTION OF MUSCLES

In human beings there are 639 muscles of which 5 are unpaired and 317 are paired. It's showing following distribution

Head	53
Neck	32
Back	180
Breast	54
Belly	15
Legs	124
Arms	98
Viscera	83



In human beings there are 639 muscles of which 5 are unpaired and 317 are paired. It's showing following distribution

MAJOR MUSCLES OF BODY

Head	53
Neck	32
Back	180
Breast	54
Belly	15
Legs	124
Arms	98
Viscera	83

Classification of muscles

Prosser (1960) divided muscles into major groups:

1. **Phasic muscles –** Relatively Rapid in their contractions. The muscles are postural or locomotory with origins and insertions an exo or endoskeleton or on the skin. They are often arranged in antagonistic pairs.
2. **Tonic Muscles –** contract rather slowly and are normally arranged around hollow structure such as the gastro – intestinal tract or urino – genital tract. One part of the muscle often inserting on another part of the muscle. They maybe arranged as paired groups, as in the circular and longitudinal muscles.

Overview of Muscle Tissue

There are three type of muscle tissues

1. Striated/Skeletal/Voluntary **2. Cardiac** **3. Smooth**

Muscle type	Approximate length	Approximate Diameter	Nuclei per cell	General Feature
Skeletal	Up to 10cm	30 - 60µm	Multiple	Thousands Cross striations, normally require nervous stimulation for contraction, generally under voluntary control
Cardiac	100µm	Irregular but usually less then 60µm	2 – 8	Cross – striated, cell syncytially and rhythmically under influence of pace maker cells.
smooth	200µm	Less than 10µm	1	Non striate, under control of autonomic nervous system, but to varying degrees, some cells contract syncytially and rhythmically.

Cardiac muscle cell

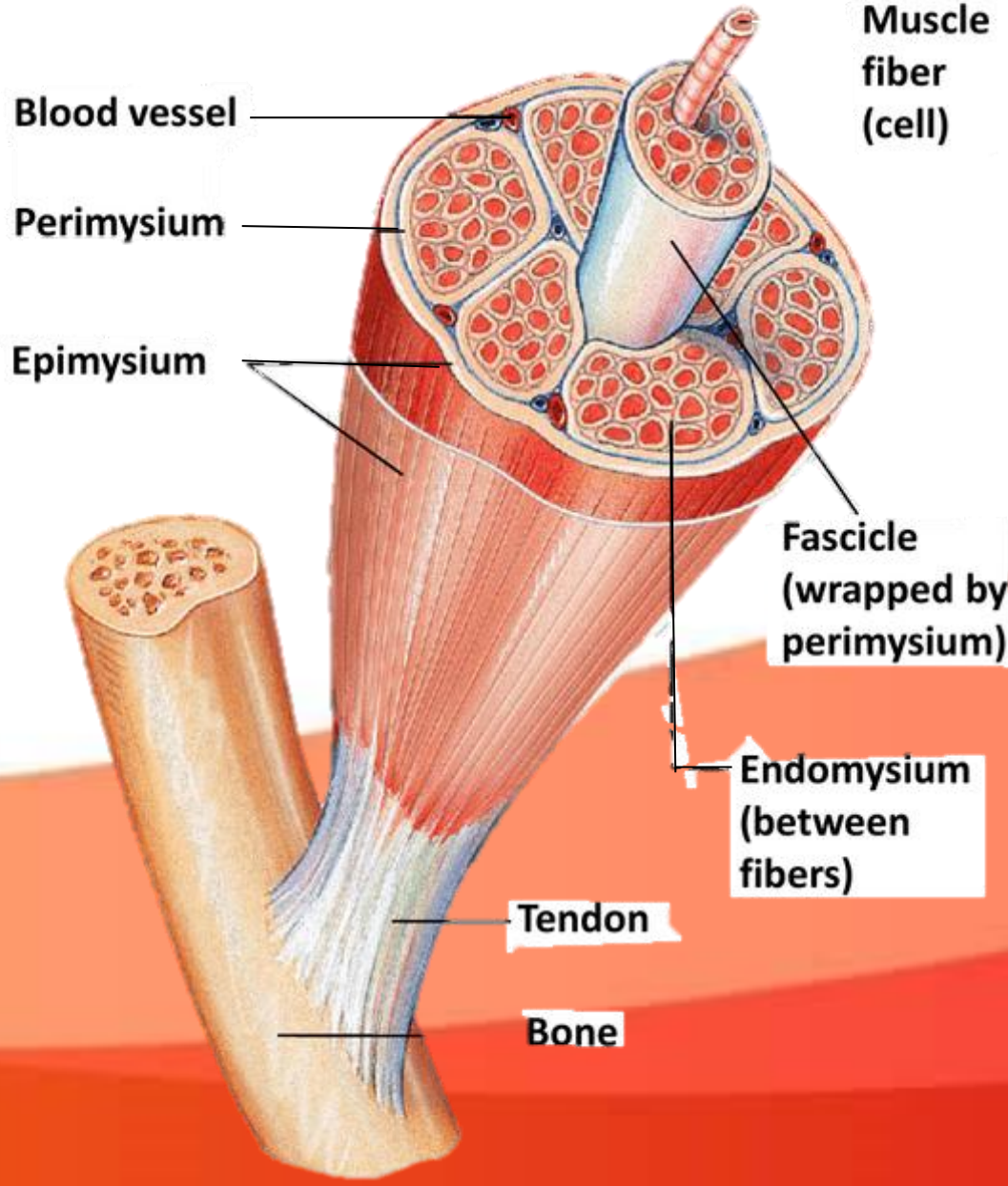
Skeletal muscle cell

Smooth muscle cell

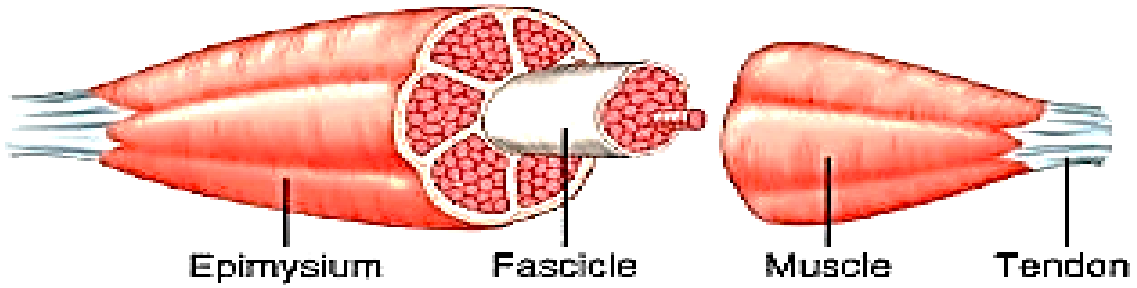
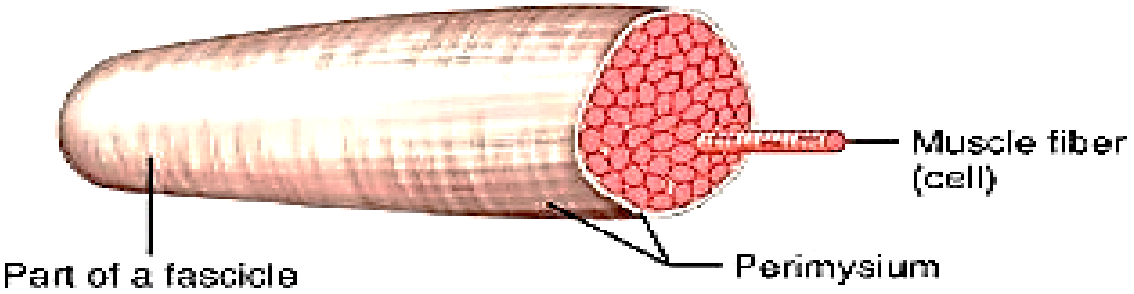
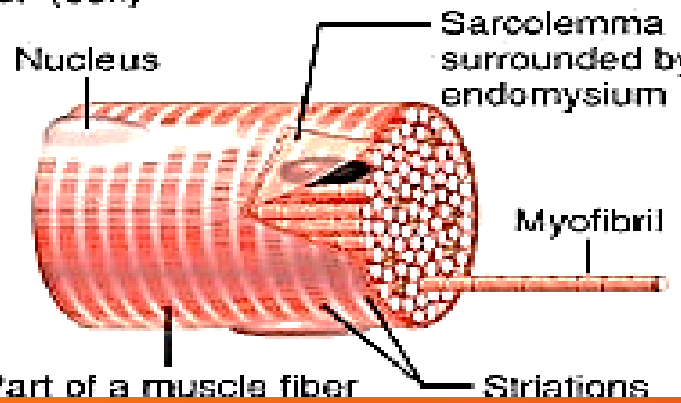
Striated/Skeletal/Voluntary muscle tissue

These muscles form the largest tissue in the body, accounting for 40 – 50% of the total body weight. It contains more than half of the body water and have an extra cellular fluid compartment than is about $1\frac{1}{2}$ times grater than the volume of the muscle arise from the miotomes there by also called ***miotomal*** muscle

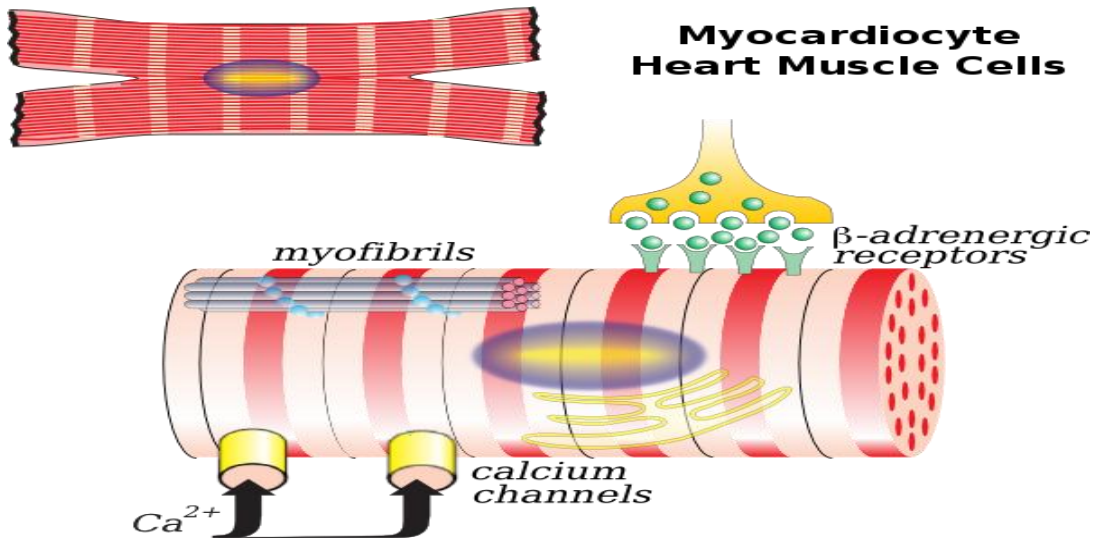
Striated muscle are always in the form of bundles of individual muscle fibres. Connective tissue serve surrounding the individual muscle fibres is known as ***endomysium***. Bundle of muscle fibres are held together by large stand of connective tissue known as ***perimysium*** and yet an other connective tissue membrane, the epimysium surround the entire muscle

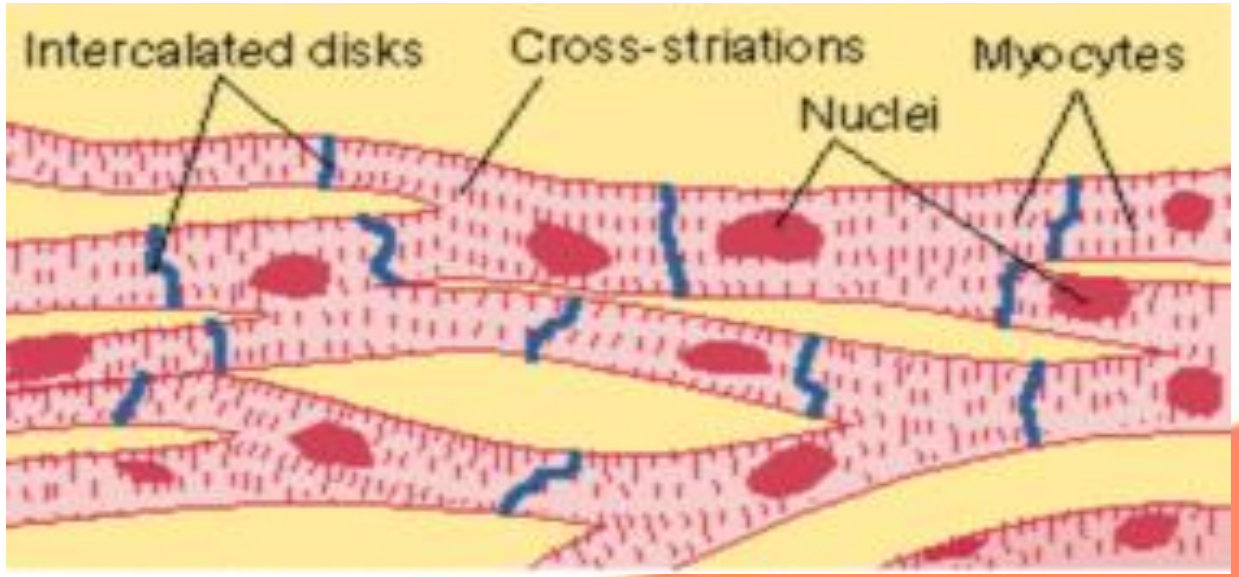


Structure and Organizational Levels of Skeletal Muscle

STRUCTURE AND ORGANIZATIONAL LEVEL	DESCRIPTION	CONNECTIVE TISSUE WRAPPINGS
Muscle (organ)  	Consists of hundreds to thousands of muscle cells, plus connective tissue wrappings, blood vessels, and nerve fibers	Covered externally by the epimysium
Fascicle (a portion of the muscle)  	Discrete bundle of muscle cells, segregated from the rest of the muscle by a connective tissue sheath	Surrounded by a perimysium
Muscle fiber (cell)  	Elongated multinucleate cell; has a banded (striated) appearance	Surrounded by the endomysium

Cardiac muscles





It is an involuntary, striated muscle that constitutes the main tissue of the walls of the heart. The myocardium forms a thick middle layer between the outer layer of the heart wall (the epicardium) and the inner layer (the endocardium), with blood supplied via the coronary circulation. It is composed of individual heart muscle cells (cardiomyocytes) joined together by intercalated discs, encased by collagen fibers and other substances that form the extracellular matrix.

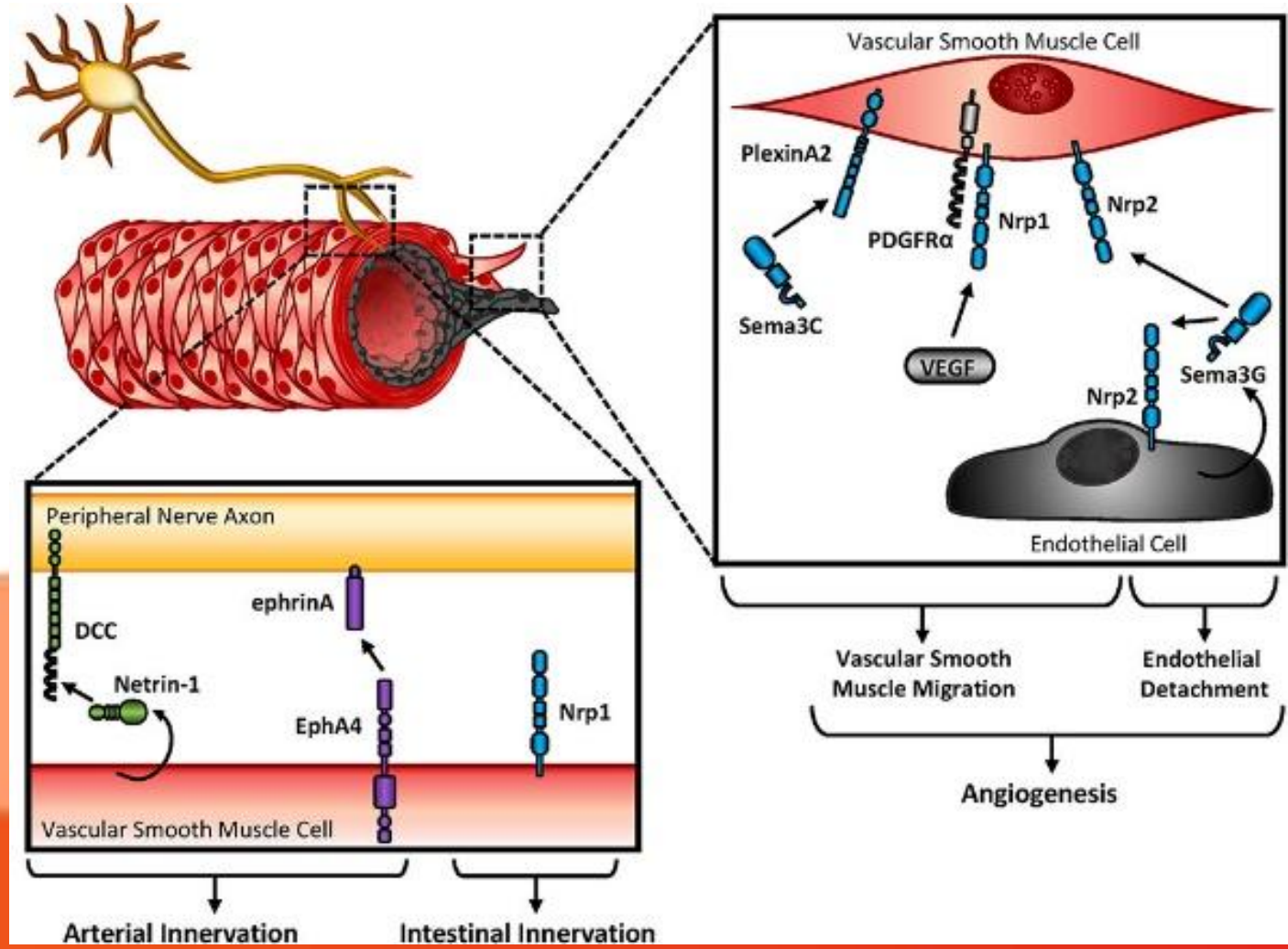
Cardiac muscle contracts in a similar manner to skeletal muscle, although with some important differences. Electrical stimulation in the form of an action potential triggers the release of calcium from the cell's internal calcium store, the sarcoplasmic reticulum. The rise in calcium causes the cell's myofilaments to slide past each other in a process called excitation contraction coupling.

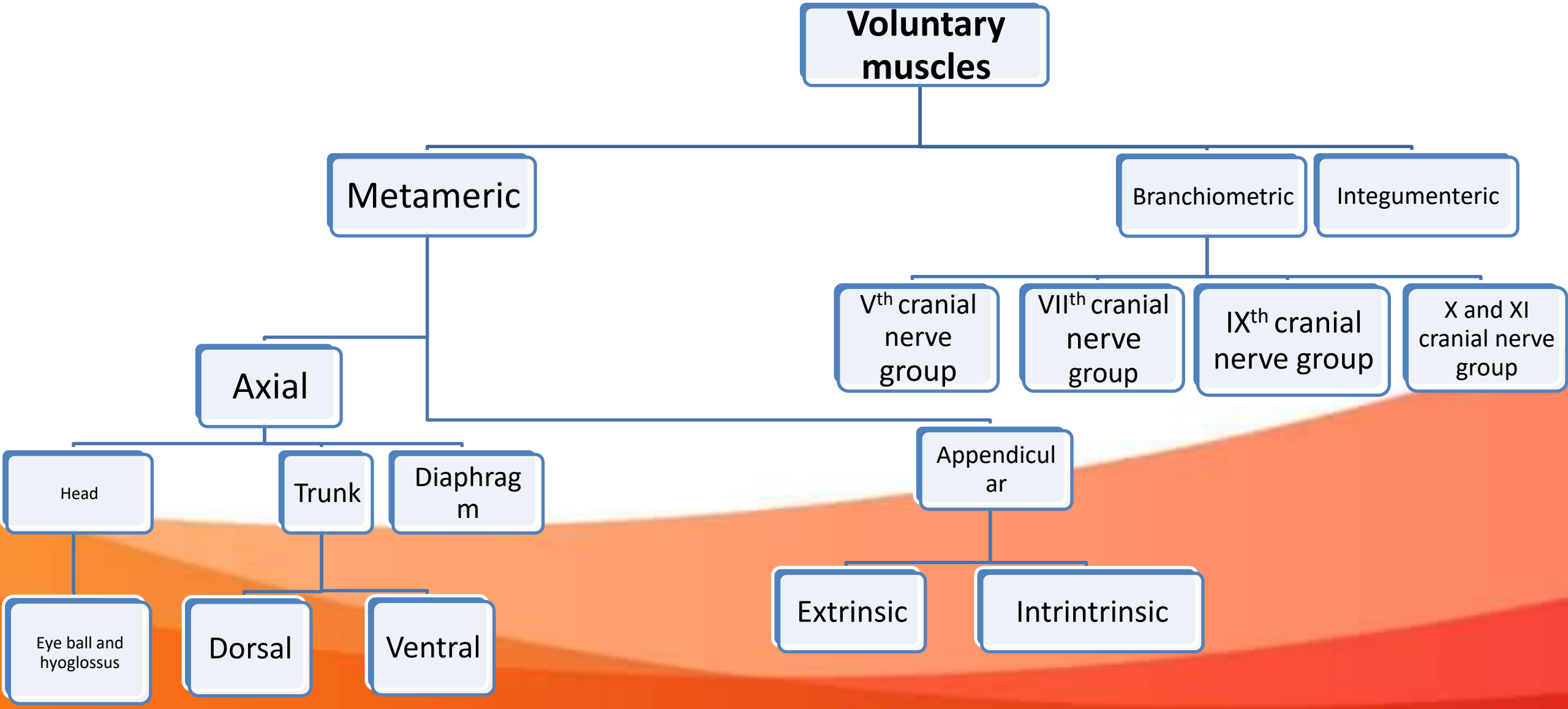
Diseases of the heart muscle are of major importance. These include conditions caused by a restricted blood supply to the muscle including angina pectoris and myocardial infarction, and other heart muscle diseases known as cardiomyopathies.

Smooth muscles

This specialized function of contracting for long periods and hold that force is why smooth muscle has been adapted to many areas of the body. Smooth muscle lines many parts of the circulatory system, digestive system, and is even responsible for raising the hairs on your arm.

Smooth muscle, because of its ability to contract and hold, is used for many function in many places of the body. Besides those listed above, smooth muscle is also responsible for contracting the irises, raising the small hairs on your arm, contracting the many sphincters in your body, and even moving fluids through organs by applying pressure to them. While smooth muscle doesn't contract or release as quickly as skeletal or cardiac muscle, it is much more useful for providing consistent, elastic tension.




Voluntary muscles
Metameric
Branchiometric
Integumenteric
Vth cranial nerve group
VIIth cranial nerve group
IXth cranial nerve group
X and XI cranial nerve group
Axial
Appendicular
Head
Trunk
Diaphragm
Extrinsic
Intrintrinsic
Eye ball and hyoglossus
Dorsal
Ventral

Microscopic structure of skeletal muscle

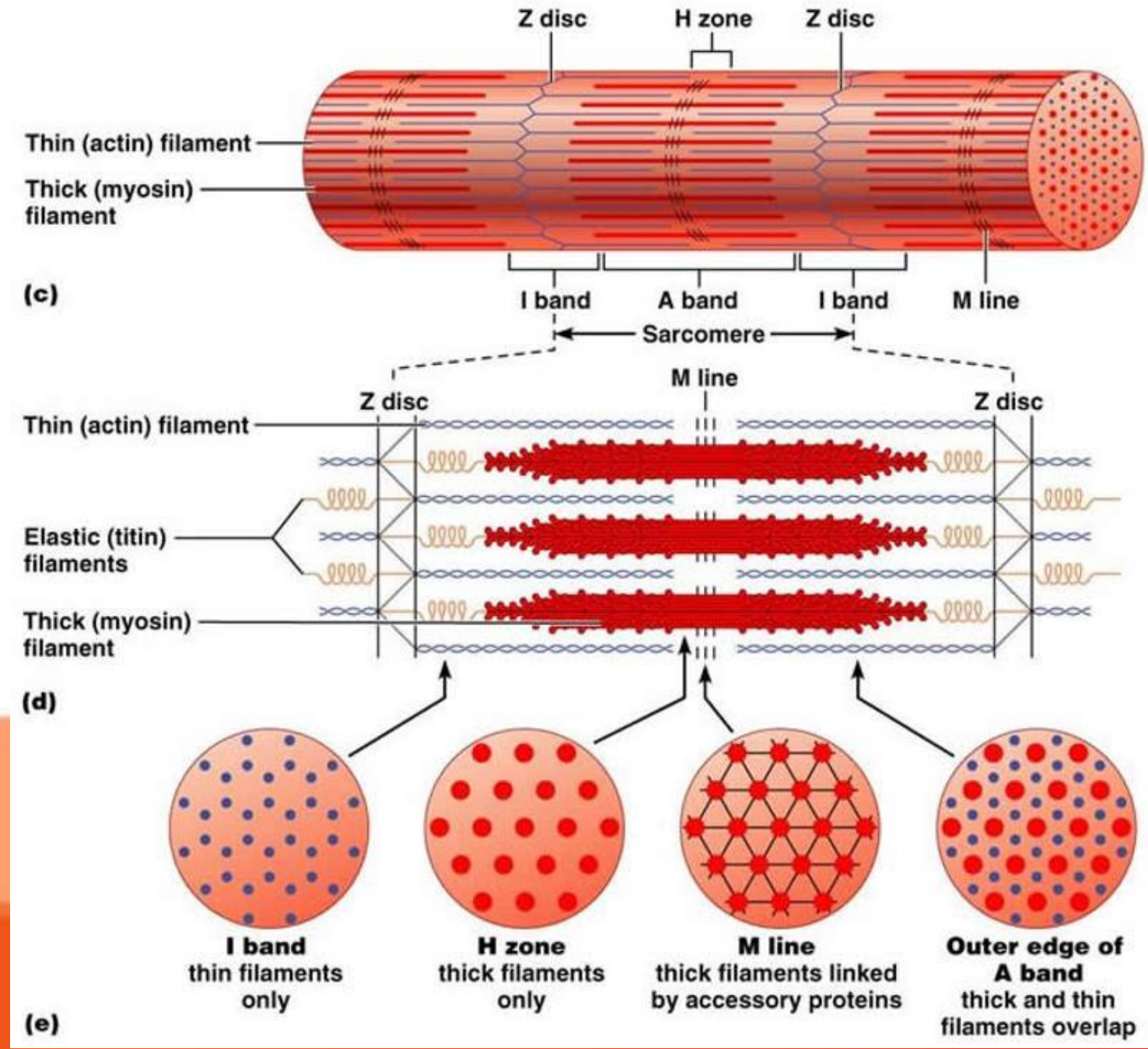
Each skeletal muscle fiber is a long cylindrical cell with multiple oval nuclei arranged just beneath it's **sarcolemma**. The sarcoplasm contains large amount of stored glycogen and a unique oxygen binding protein called ***myoglobin*** that is not found in other cell types. It is similar to haemoglobin and transports oxygen in blood.

Myofibriles – when viewed at high magnification, each muscle fibre is seen to contain a large number of rod like myofibriles. The myofibriles consist to type of smaller structure called myofilaments.

A band – anisotropic – can polarize visible light

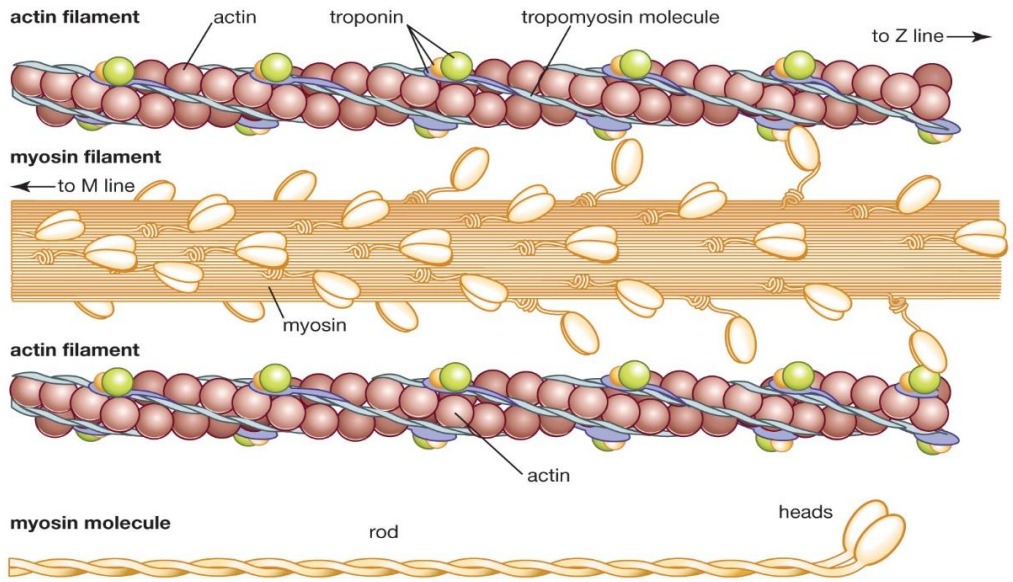
(h zone) – *helle (Bright)* – bisected by *M line*

I band – isotropic – non polarizing



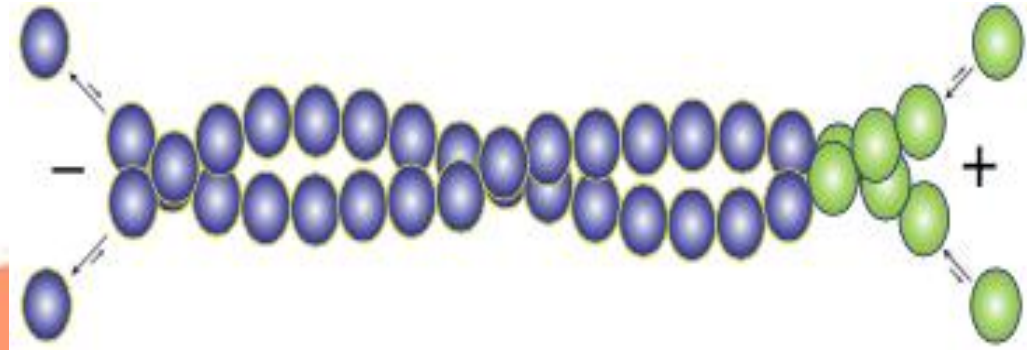
Actin

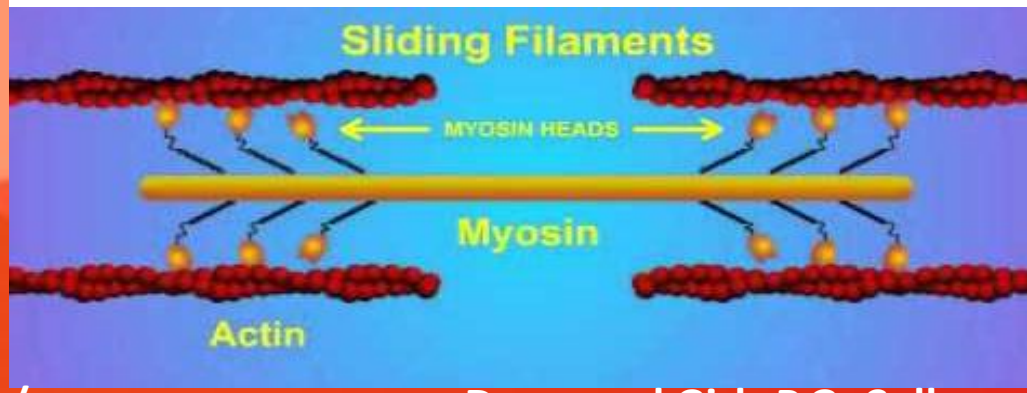
The thin myofilaments mainly consists actin and composed by two strands of actin arranged in a wright handed helix. Each actin filament is in turn composed of many actin monomers joined together.



Myosin

Each thick filament is composed off several hundred myosin molecule packed together in a specific arrangement. It has a golf club like shape with a short compact head and a long shaft.





Tropomyosin

The protein constitutes about 3 – 8% of the total protein contains of the muscle filament.

Molecular weight – 70000

Length - 4000AO

Diameter – 20AO

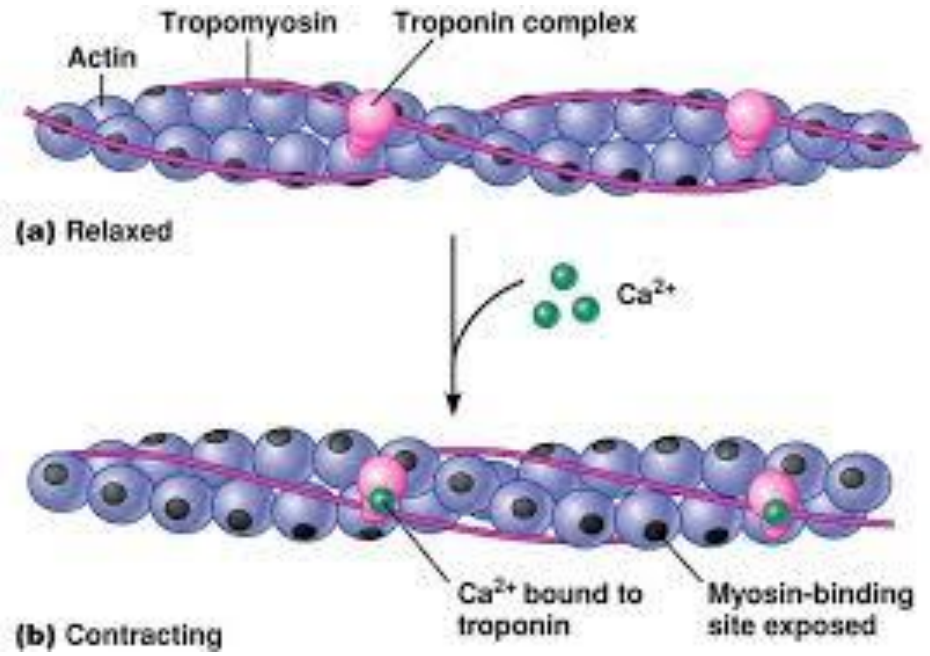
There are 2 known forms of tropomyosin ‘A’ and ‘B’

Troponin

It is a globular protein consisting of 3 subunits, The calcium binding unit(troponin ‘A’ or ‘C’) The inhibitory unit and the Tropomyosin – binding unit. The calcium binding unit can complex with two calcium ions. It Requires two specific sites for It’s binding with the thin filament: one in the actin strand and the other in the tropomyosin strand

Actinin

This is protein having a molecular weight of about 1,60,000. It is present in Z-line. It can strongly react with actin and can form cross linking with F-actin filament.



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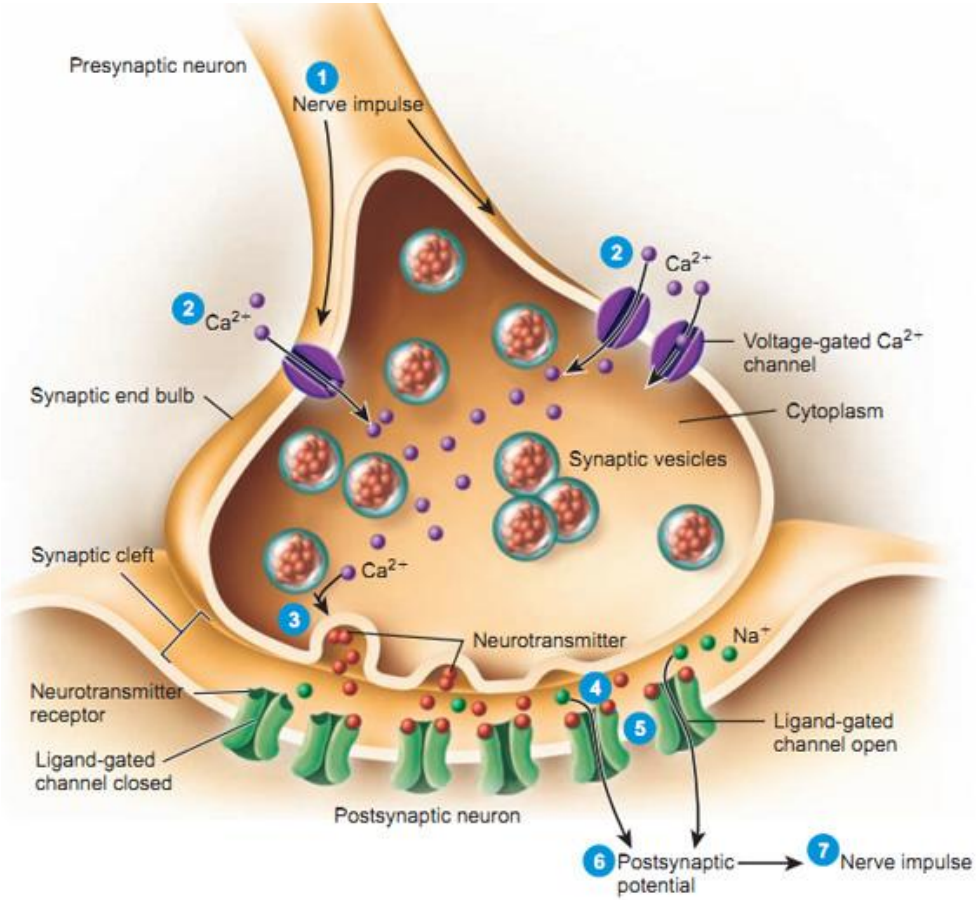
The Neuro muscular junction/coordination

- The contraction of the muscle is under the control of the nervous system. The nerve cell whose axons innervate skeletal muscle fibers are known as motor neurons, and their cells bodies are located in the brainstem or spinal cord.
- The supply of nerve fibre to a muscle is called innervation.



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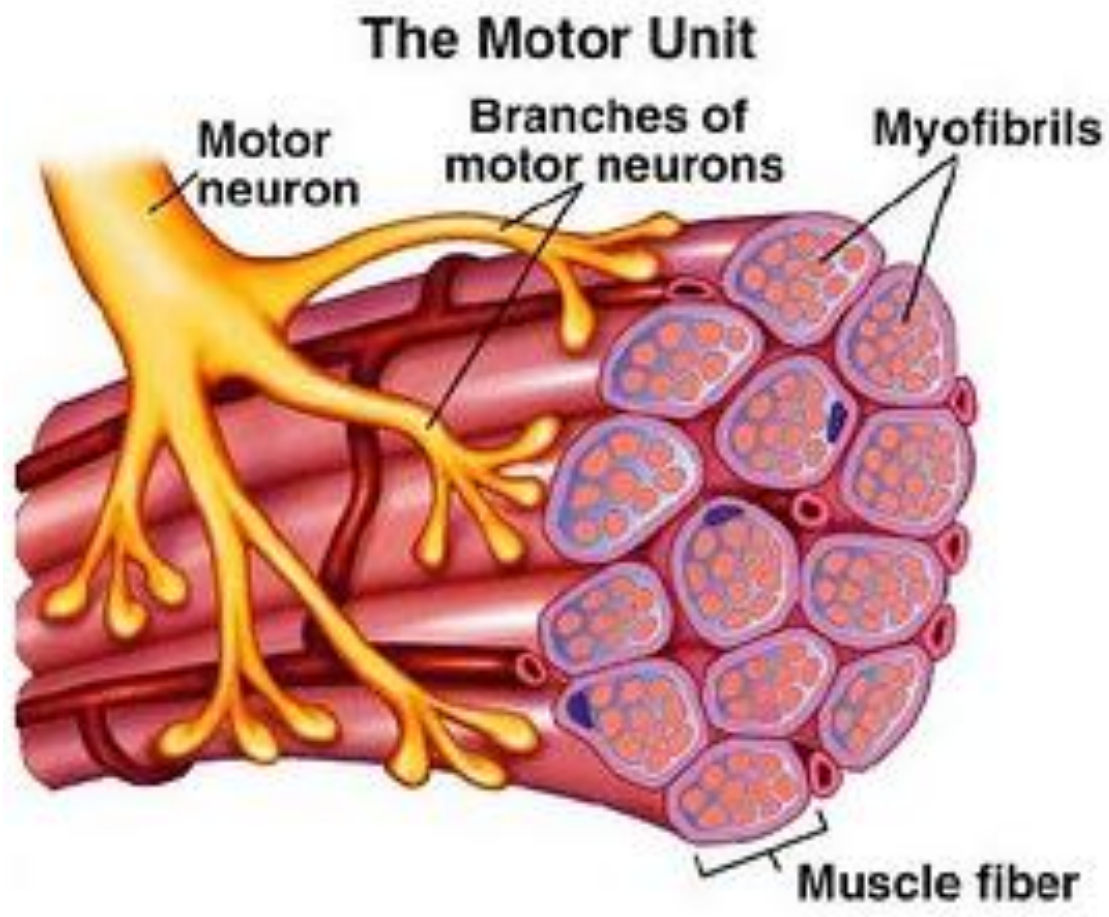
The Neuro muscular junction/coordination

- The area of contact between neuron and muscle fibre is called as neuro - muscular junction. The plate invaginates into the muscle fibre but lies entirely outside the muscle fibre membrane.
- End of the nerve is called sole feet and invagination of membrane called synaptic gutter. Space between the sole foot and fibre membrane is called the synaptic cleft.
- Nerve and muscle cells contain much potassium but little sodium



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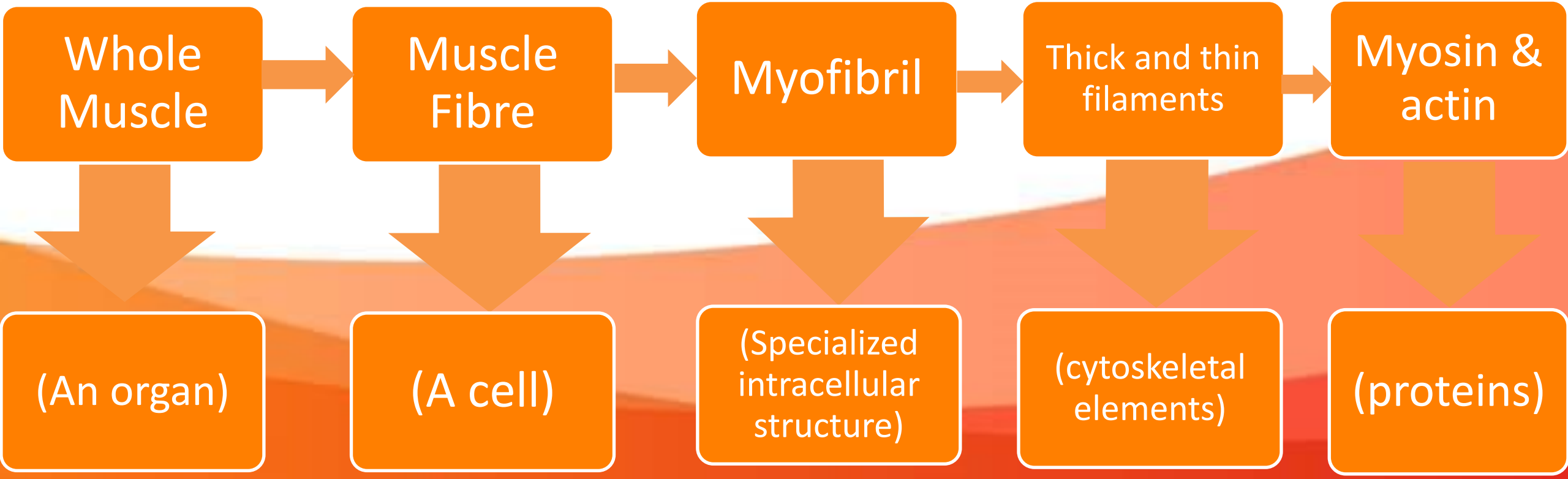
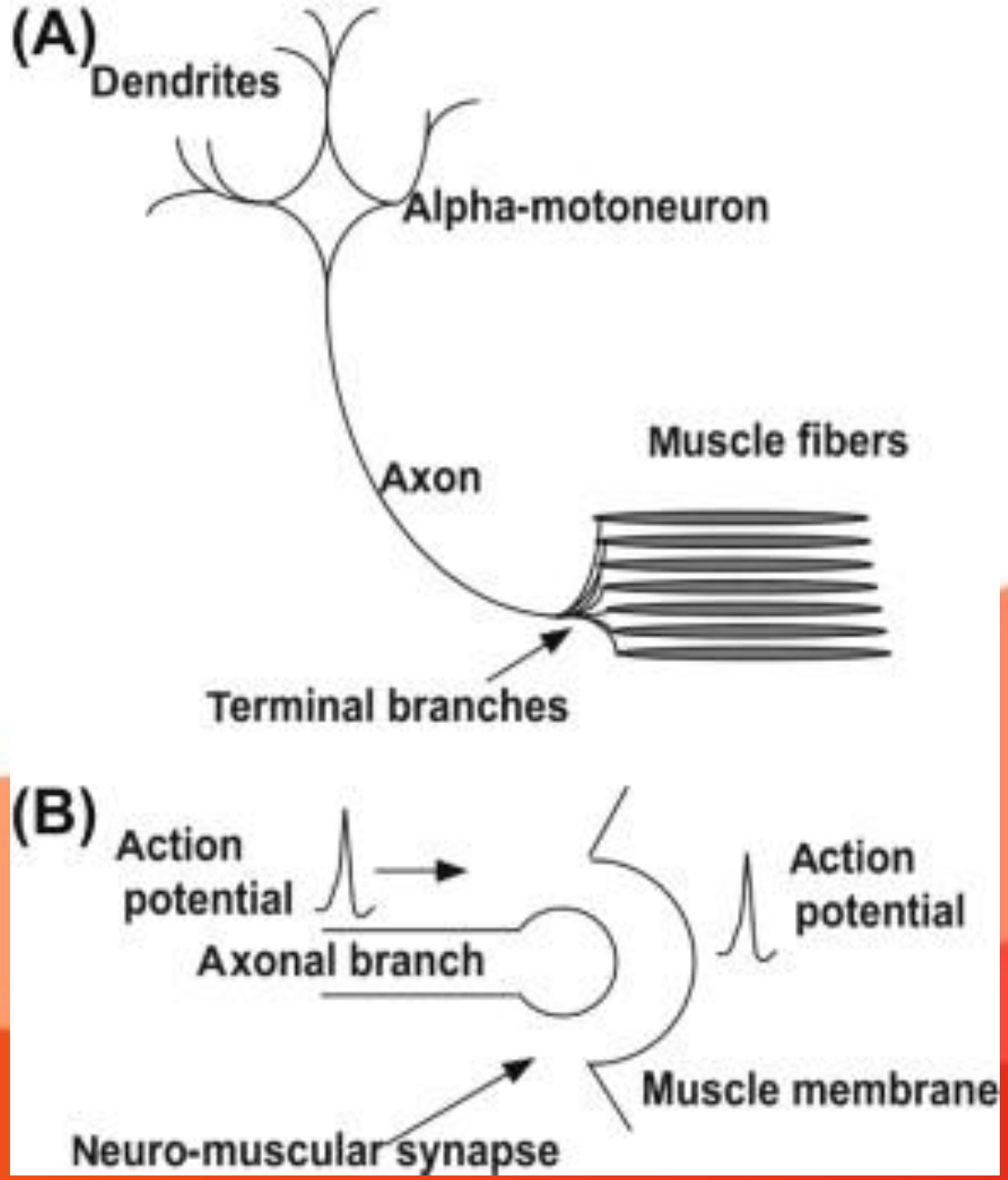
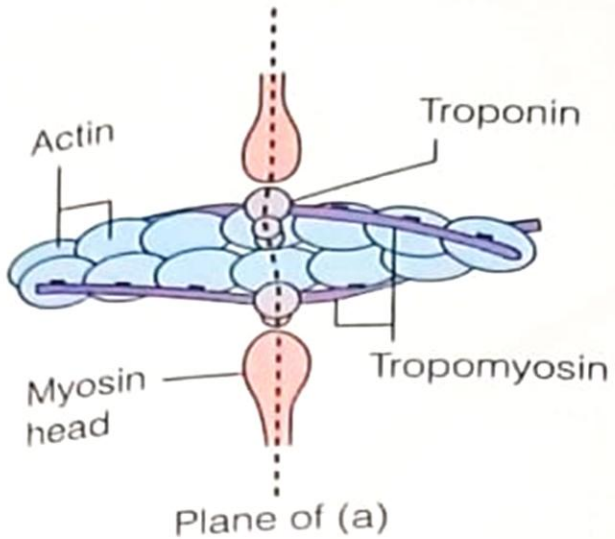
Level of organisation in skeletal muscle

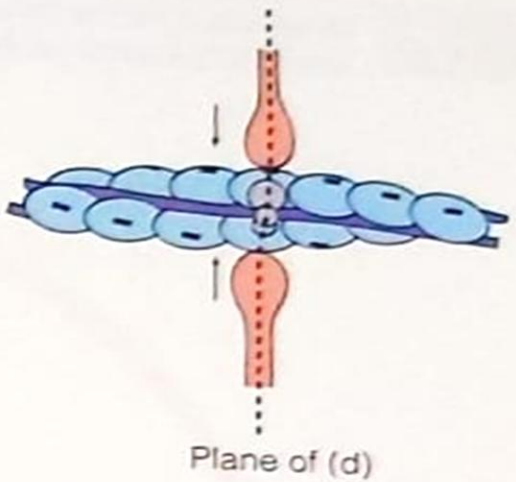


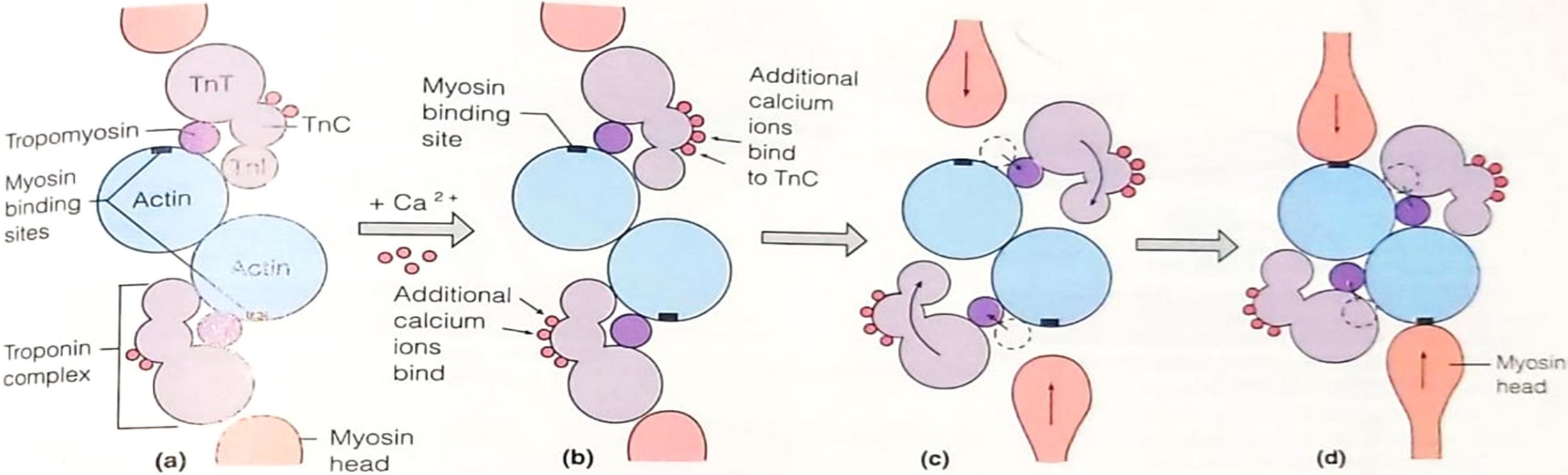
Contraction of a skeletal muscle fibre

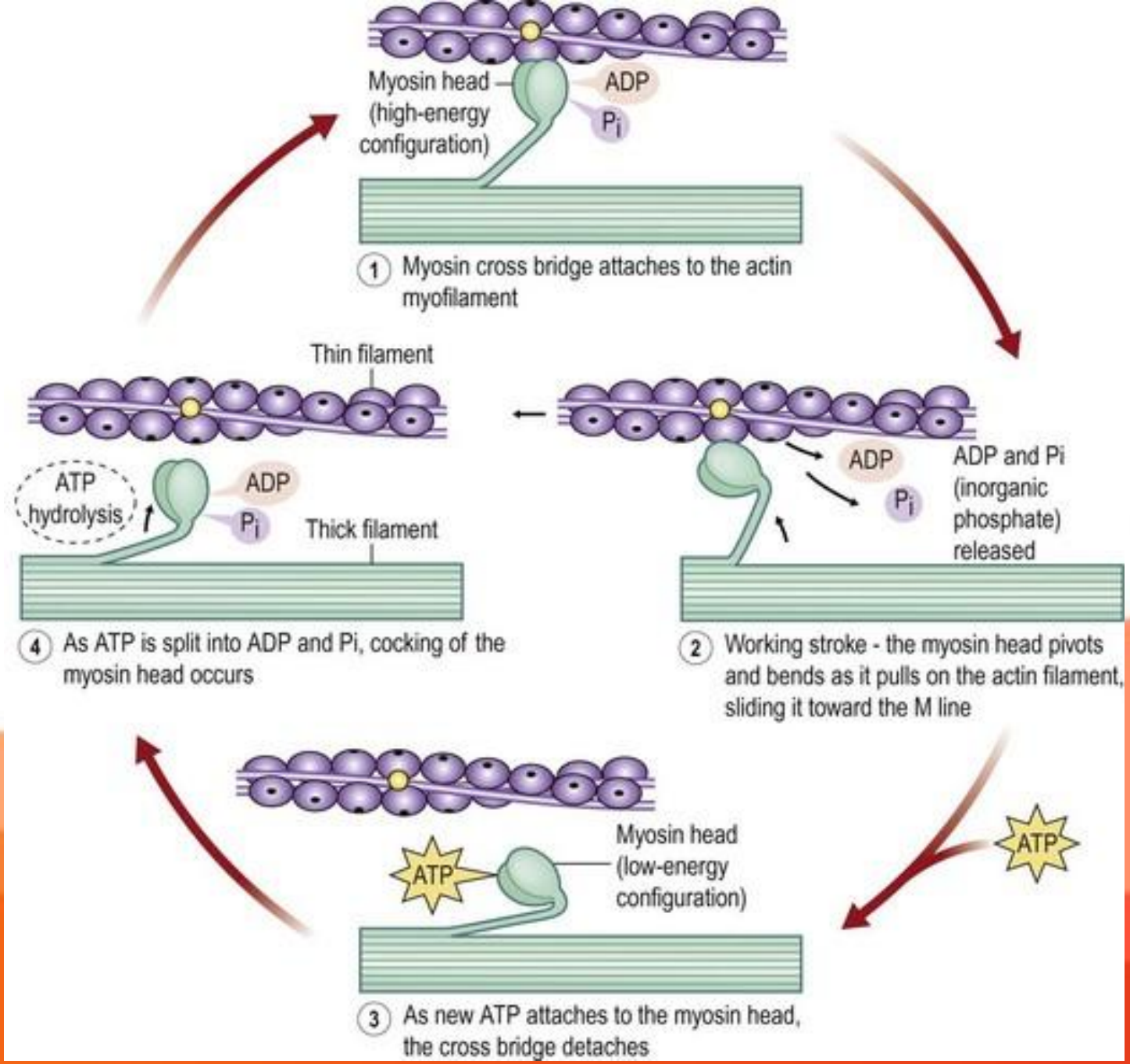
- Muscle contraction causes depolarization of T-tubules and then calcium (Ca2+) release from the sarcoplasmic reticulum, which triggers actin and myosin interaction.
- Muscle contractions consume energy, which is provided by carbohydrates, lipids, and rarely proteins.
- Muscle contraction starts with a neural signal, an action potential arriving along a long neural fiber (the axon) from a neuron in the spinal cord (or in the brainstem, for neck and facial muscles), called an alpha-motoneuron, to a target muscle fiber.



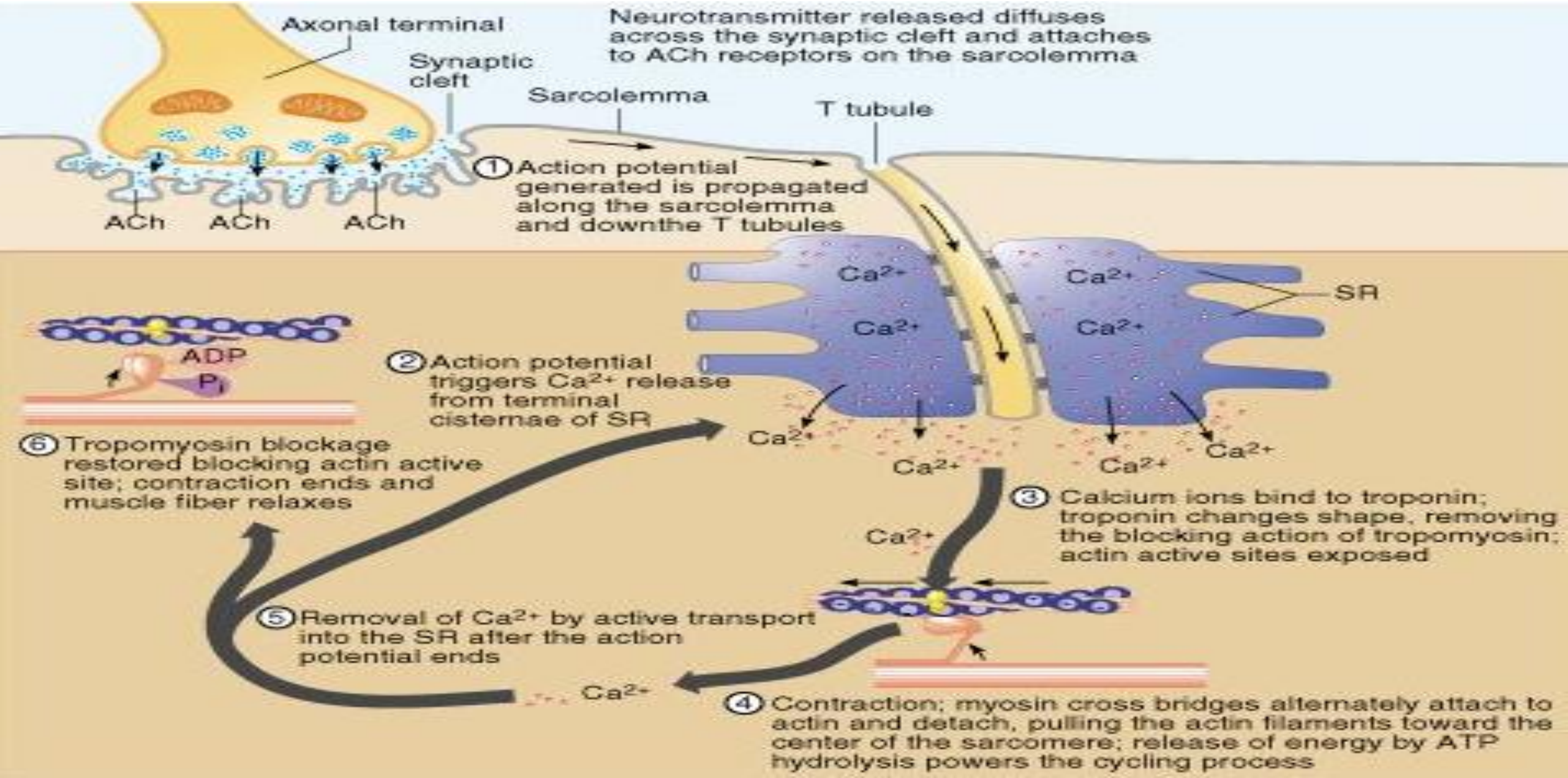

Actin
Troponin
Tropomyosin
Myosin head
Plane of (a)


Plane of (d)

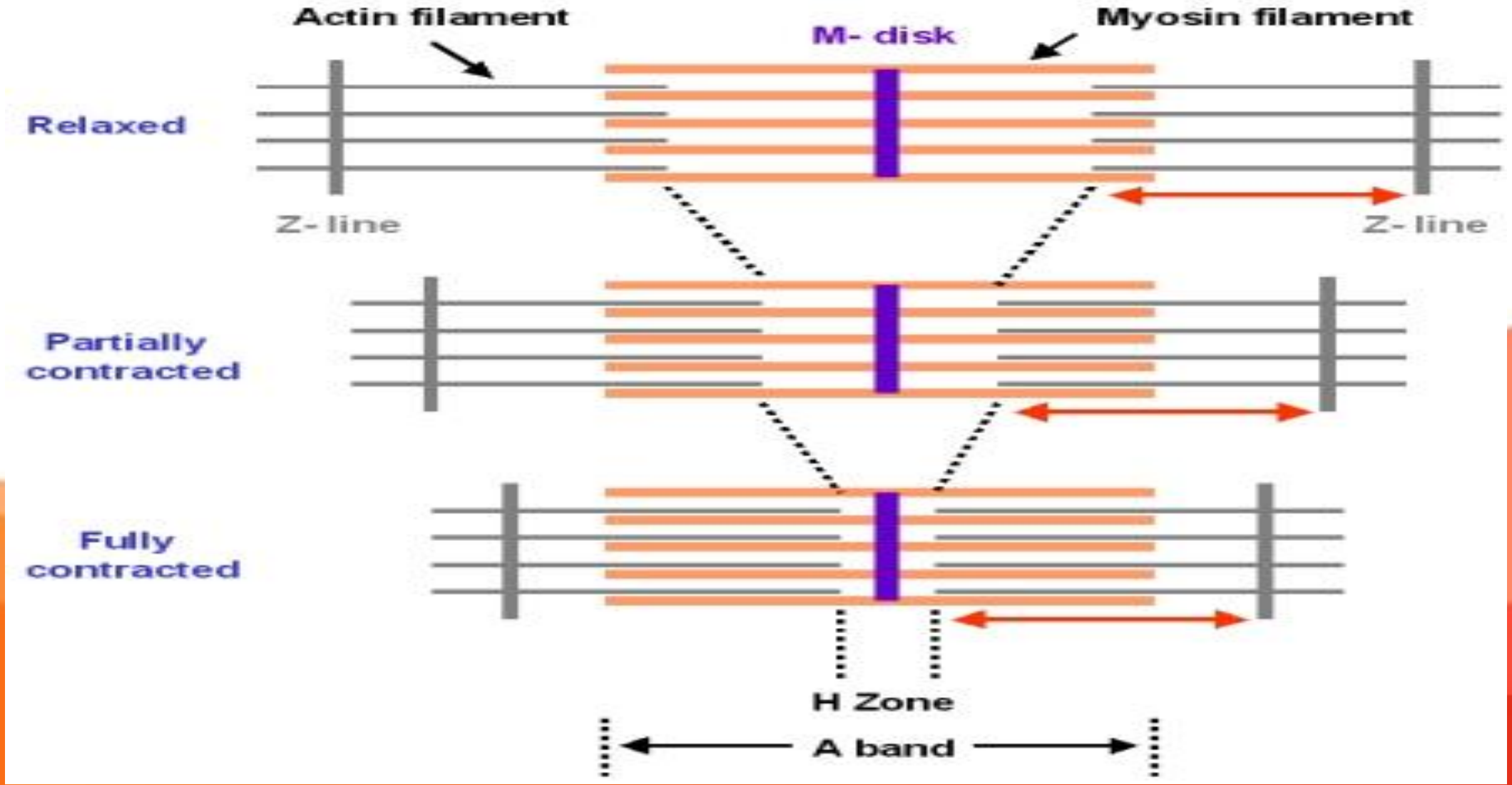

TnT
TnC
Tropomyosin
TnI
Myosin binding sites
Actin
Actin
Troponin complex
Myosin head
(a)
+ Ca 2+
Myosin binding site
Additional calcium ions bind to TnC
Additional calcium ions bind
(b)
(c)
(d)
Myosin head


Myosin head
(high-energy
configuration)
ADP
Pi
1 Myosin cross bridge attaches to the actin myofilament
ADP
Pi
ADP and Pi
(inorganic
phosphate)
released
2 Working stroke - the myosin head pivots and bends as it pulls on the actin filament, sliding it toward the M line
ATP
Myosin head
(low-energy
configuration)
3 As new ATP attaches to the myosin head, the cross bridge detaches
Thin filament
ATP
hydrolysis
ADP
Pi
Thick filament
4 As ATP is split into ADP and Pi, cocking of the myosin head occurs

Sequence of events in excitation contraction coupling



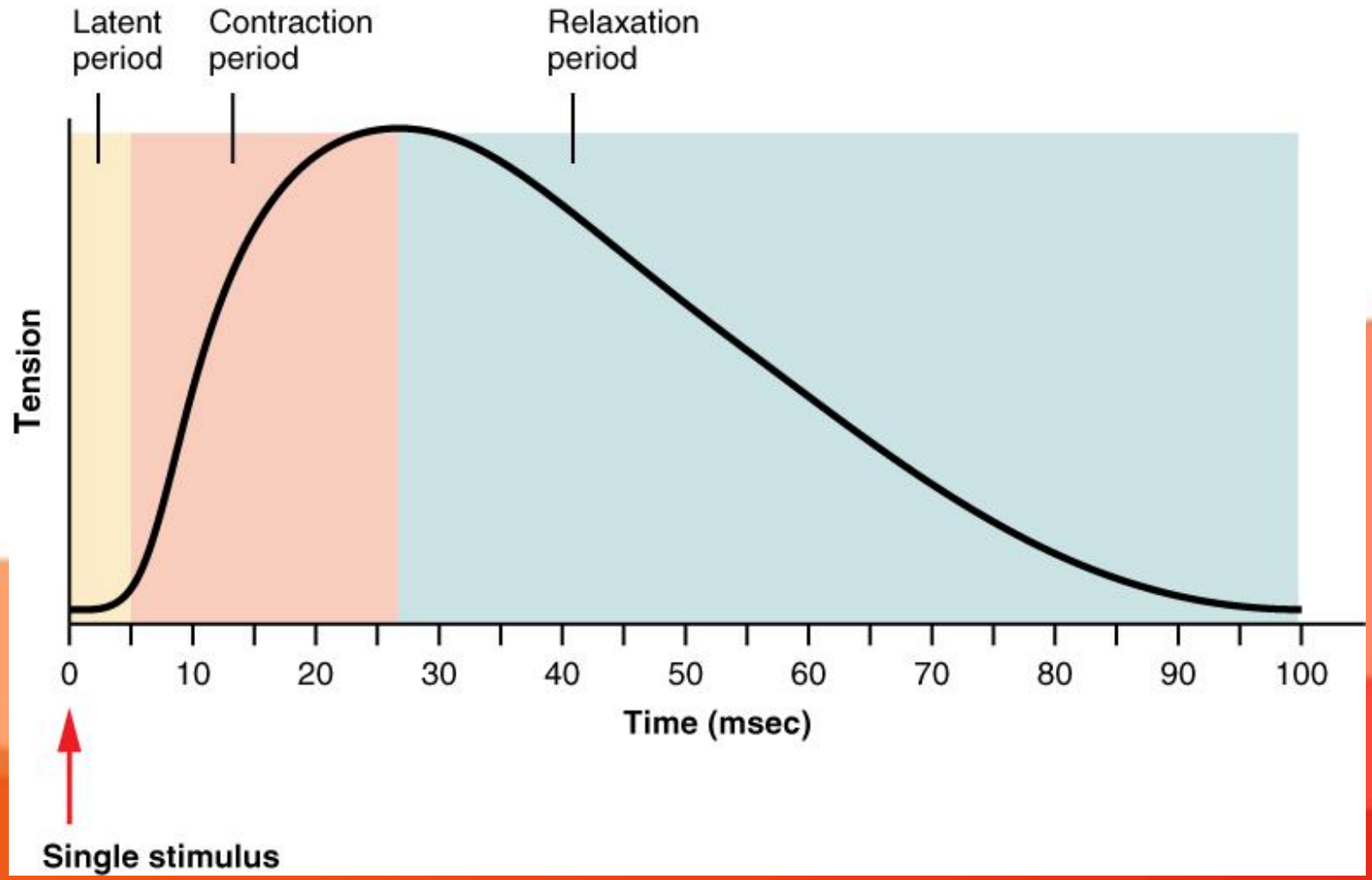
Contraction of a skeletal muscle fibre (Sliding filament mechanism)



Muscle twitch and development of muscle tension

Muscle twitch – the response of a muscle to a single brief threshold stimulus

Latent Period – The few milliseconds following stimulation when excitation contraction coupling is occurring.



Causes of **MUSCLE DISORDERS** include:

- Injury or overuse, such as sprains or strains, cramps or tendinitis
- A genetic disorder, such as muscular dystrophy
- Some cancers
- Inflammation, such as myositis
- Diseases of nerves that affect muscles
- Infections
- Certain medicines

THANK YOU