SNS COLLEGE OF ALLIED HEALTH SCIENCES
SNS Kalvi Nagar, Coimbatore - 35
Affiliated to Dr MGR Medical University, Chennai

DEPARTMENT : PHYSICIAN ASSISTANT

COURSE NAME : NEUROLOGY

UNIT : NERVOUS SYSTEM

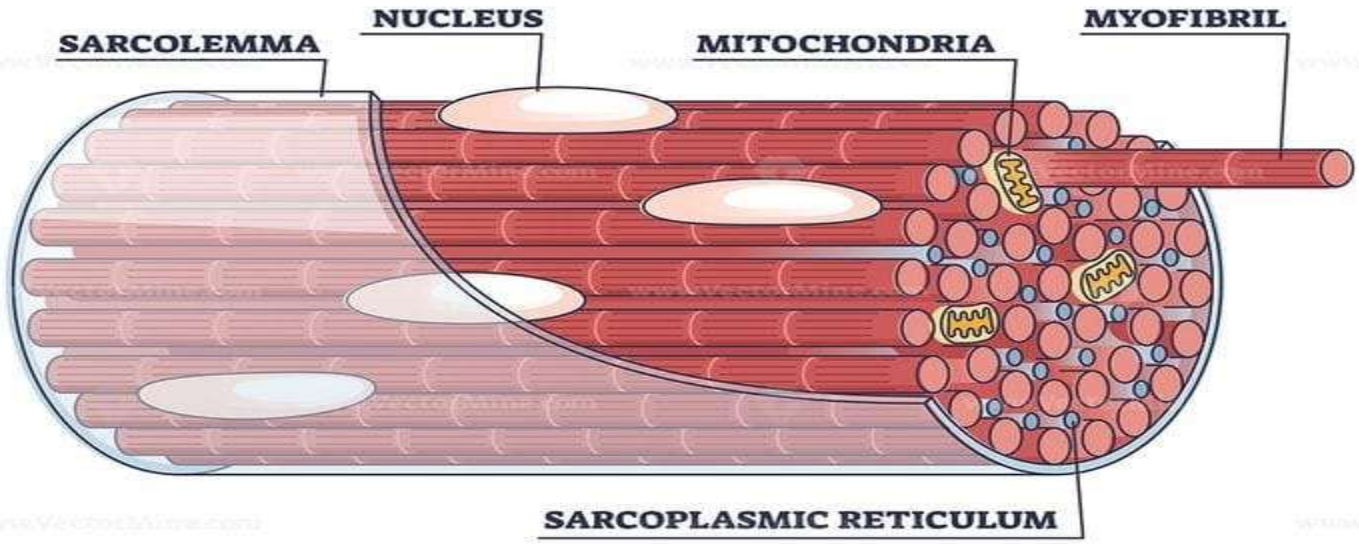
TOPIC : MUSCLE PROTEIN, EXCITATION - CONTRACTION COUPLING, INJURY AND REPAIR OF NERVES AND MUSCLES, WORK PHYSIOLOGY

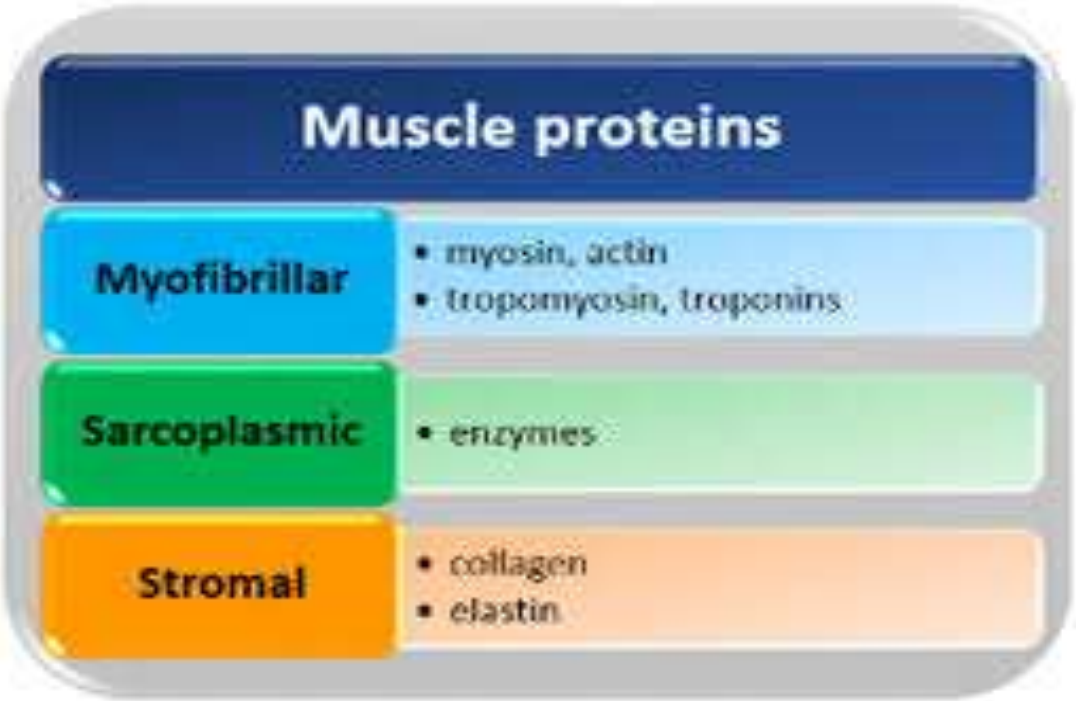
MUSCLE PROTEIN

- Muscle protein" typically refers to the various proteins found within muscle tissue that contribute to its structure, function, and overall health.

- These proteins encompass a wide range of functions, from facilitating muscle contraction to providing structural support and maintaining cellular integrity.

MUSCLE FIBER




Muscle proteins
Myofibrillar
• myosin, actin
• tropomyosin, troponins
Sarcoplasmic
• enzymes
Stromal
• collagen
• elastin

- **Actin:** Actin is a globular protein that polymerizes to form thin filaments in muscle cells. It is composed of G-actin monomers that join together to form F-actin strands.
- Actin filaments are anchored at their minus end to the Z-disc and extend towards the center of the sarcomere.
- During muscle contraction, myosin heads bind to actin, leading to the sliding filament mechanism.

- **Myosin:** Myosin is a motor protein consisting of heavy and light chains.
- The heavy chains form the myosin tail and the myosin head, which contains ATPase activity.
- Myosin heads bind to actin during muscle contraction and utilize the energy released from ATP hydrolysis to generate force and produce movement.

- **Tropomyosin:** Tropomyosin is a filamentous protein that winds around actin filaments in a helical manner.

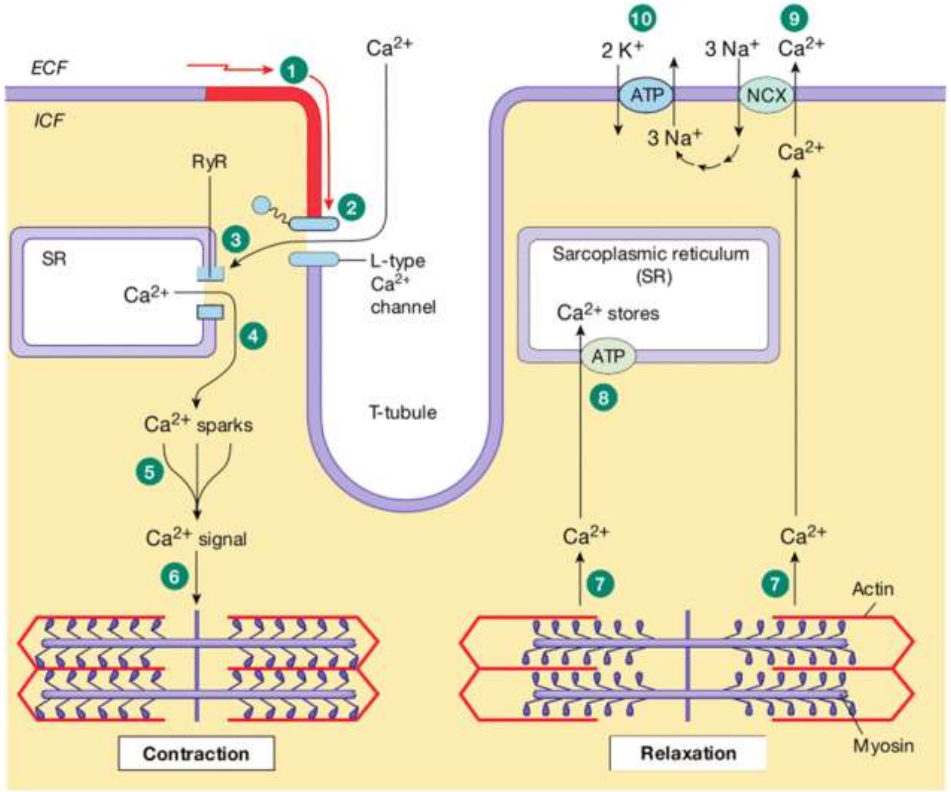
- In resting muscle, tropomyosin blocks the myosin-binding sites on actin, preventing cross-bridge formation and muscle contraction.

- **Troponin:** Troponin is a complex protein consisting of three subunits: troponin C, troponin I, and troponin T. Troponin is bound to tropomyosin and regulates muscle contraction by binding to calcium ions.
- When calcium binds to troponin C, it induces a conformational change in troponin, which moves tropomyosin away from the myosin-binding sites on actin, allowing for cross-bridge formation and muscle contraction.

EXCITATION - CONTRACTION COUPLING

- **Action Potential:** Action potentials are rapid changes in membrane potential that propagate along the sarcolemma (muscle cell membrane) and into the T-tubules.

- Action potentials are initiated at the neuromuscular junction when acetylcholine released from motor neurons binds to nicotinic acetylcholine receptors on the sarcolemma, leading to depolarization.



1. Action potential enters from adjacent cell.
2. Voltage-gated Ca^{2+} channels open. Ca^{2+} enters cell.
3. Ca^{2+} induces Ca^{2+} release through ryanodine receptor-channels (RyR).
4. Local release causes Ca^{2+} spark.
5. Summed Ca^{2+} sparks create a Ca^{2+} signal.
6. Ca^{2+} ions bind to troponin to initiate contraction.
7. Relaxation occurs when Ca^{2+} unbinds from troponin.
8. Ca^{2+} is pumped back into the sarcoplasmic reticulum for storage.
9. Ca^{2+} is exchanged with Na^+ by the NCX antiporter.
10. Na^+ gradient is maintained by the Na^+-K^+-ATPase.

- **T-Tubules (Transverse Tubules):** T-tubules are invaginations of the sarcolemma that penetrate deep into the muscle fiber.

- They allow action potentials to rapidly spread from the surface membrane to the interior of the cell, ensuring synchronous contraction of the entire muscle fiber.

- **Sarcoplasmic Reticulum (SR):** The sarcoplasmic reticulum is a specialized endoplasmic reticulum found in muscle cells.

- It stores and releases calcium ions in response to depolarization of the T-tubules. Calcium release from the SR triggers muscle contraction by binding to troponin and initiating the sliding filament mechanism.

- **Calcium Release:** Depolarization of the T-tubules activates voltage-gated calcium channels in the SR membrane, leading to calcium release into the cytoplasm.

- This increase in cytoplasmic calcium concentration initiates muscle contraction by binding to troponin and exposing the myosin-binding sites on actin.

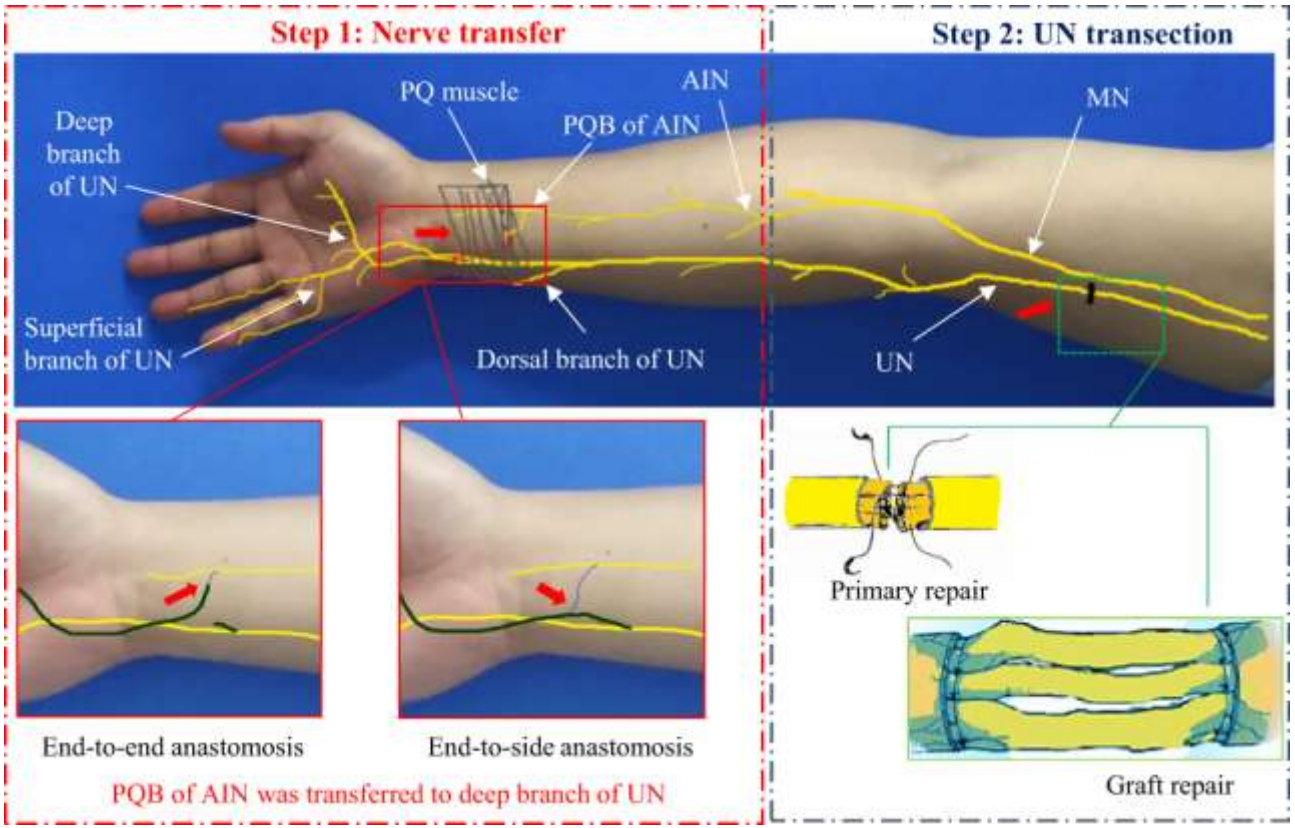
- **Cross-Bridge Formation:** Once the myosin-binding sites on actin are exposed, myosin heads bind to actin, forming cross-bridges.

- ATP hydrolysis by the myosin heads provides the energy necessary for cross-bridge movement, leading to the sliding of actin filaments past myosin filaments and muscle contraction.

INJURY AND REPAIR OF NERVES AND MUSCLES

- **Muscle Injury Types:** Muscle injuries can range from minor strains to severe tears.

- Strains occur when muscle fibers or tendons are stretched or torn, while contusions result from direct trauma to the muscle, causing bruising. Lacerations involve cuts that can damage muscle tissue.


Step 1: Nerve transfer
Step 2: UN transection
PQ muscle
AIN
PQB of AIN
MN
Deep branch of UN
Superficial branch of UN
Dorsal branch of UN
UN
Primary repair
End-to-end anastomosis
End-to-side anastomosis
Graft repair
PQB of AIN was transferred to deep branch of UN

- **Nerve Injury Types:** Nerve injuries can occur due to compression, stretching, or laceration. Compression injuries result from pressure on the nerve, such as in carpal tunnel syndrome.

- Stretch injuries involve excessive stretching of the nerve, leading to damage. Lacerations occur when the nerve is cut or severed.

- **Inflammatory Response:** Following injury, the body initiates an inflammatory response to remove damaged tissue and initiate the healing process.

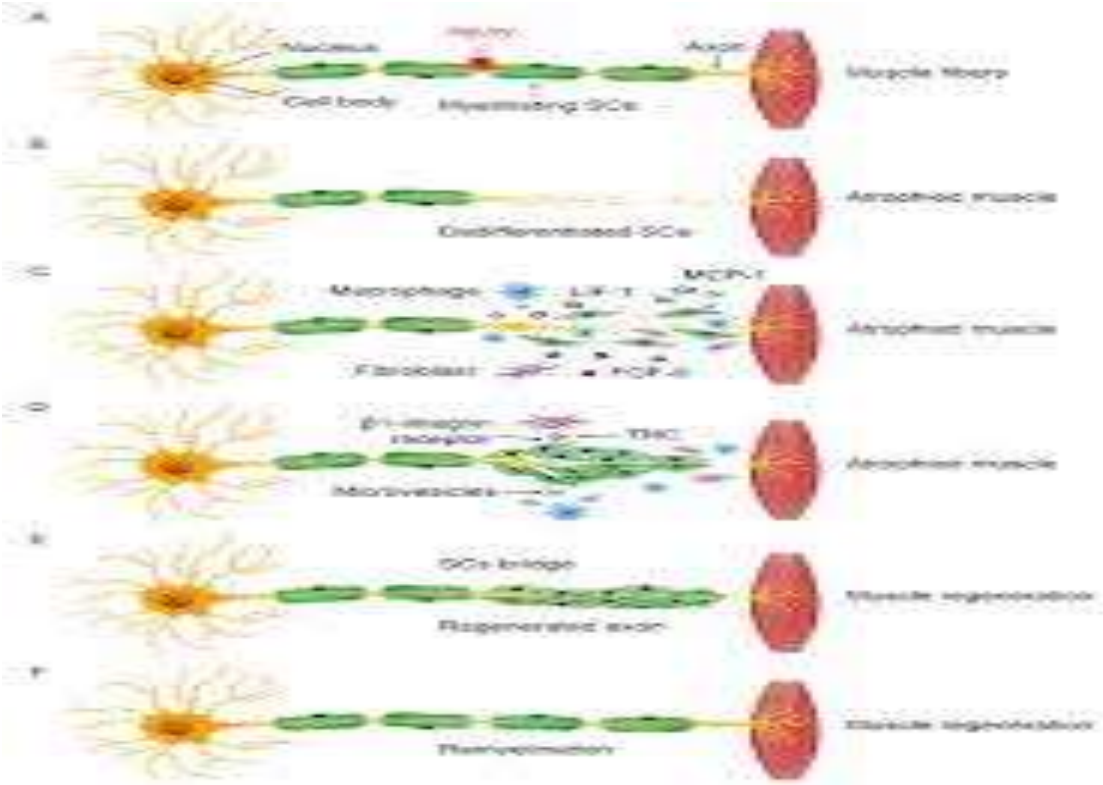
- This involves the release of inflammatory mediators such as cytokines, prostaglandins, and leukotrienes, which promote vasodilation, increase vascular permeability, and attract immune cells to the site of injury.

- **Satellite Cells:** Satellite cells are quiescent muscle stem cells located between the basal lamina and the sarcolemma of muscle fibers.

- Following muscle injury, satellite cells become activated and proliferate to form myoblasts, which differentiate and fuse to repair damaged muscle fibers.

- **Remodeling Phase:** The remodeling phase of muscle repair involves the regeneration and remodeling of damaged tissue. Myoblasts fuse to form new muscle fibers, while connective tissue is laid down to repair the extracellular matrix.

- Nerve regeneration occurs through the growth of axonal sprouts from proximal nerve stumps, guided by Schwann cells and extracellular matrix molecules.

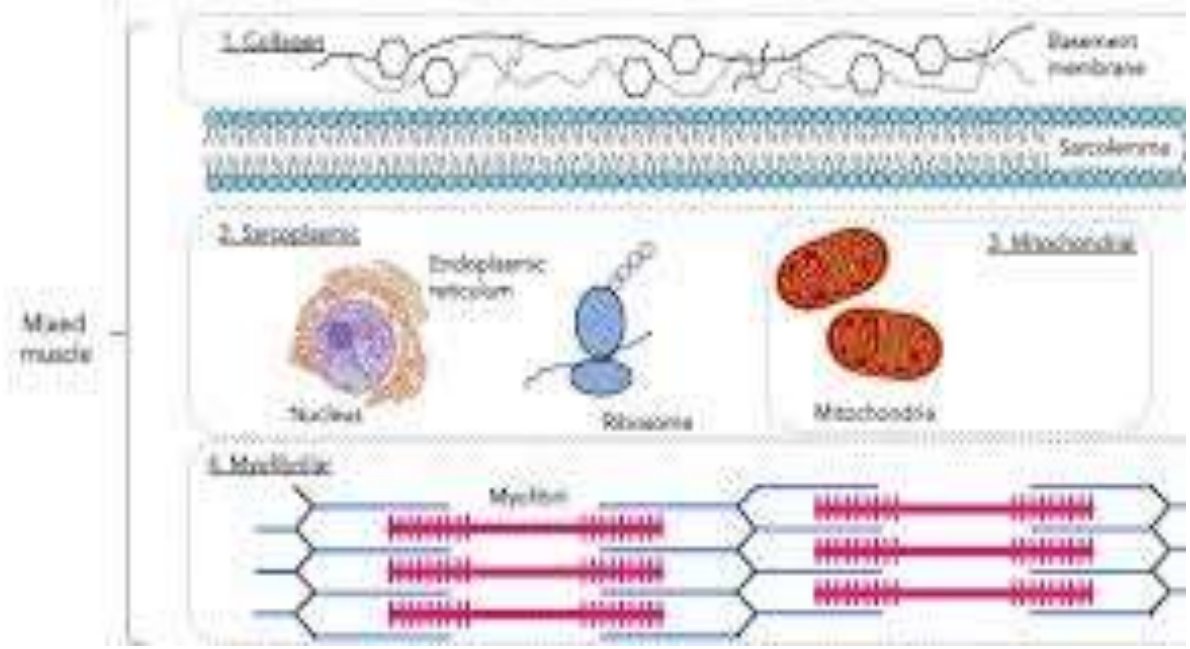


WORK PHYSIOLOGY

- Energy Systems: During physical activity, the body utilizes three main energy systems: the phosphagen system, the glycolytic system, and the oxidative system.

- The phosphagen system rapidly generates ATP through the breakdown of phosphocreatine, providing immediate energy for short-duration, high-intensity activities.

Muscle protein fractions



- The glycolytic system generates ATP through the anaerobic breakdown of glucose, supplying energy for moderate- to high-intensity activities lasting several minutes.
- The oxidative system generates ATP through aerobic metabolism of carbohydrates and fats, providing sustained energy for low- to moderate-intensity activities lasting longer durations.

- **Oxygen Consumption:** Oxygen consumption increases during physical activity to meet the energy demands of working muscles.
- This increase in oxygen consumption, known as the oxygen uptake, is influenced by factors such as exercise intensity, duration, and individual fitness level. Oxygen uptake is commonly measured as VO2 (volume of oxygen consumed per unit of time) and reflects the aerobic capacity of an individual.

- **Lactate Threshold:** The lactate threshold is the exercise intensity at which lactate production exceeds lactate clearance, leading to an accumulation of lactate in the blood.

- This is often associated with the onset of muscle fatigue during intense exercise. Training can increase the lactate threshold, allowing individuals to exercise at higher intensities before experiencing fatigue.

- **VO2 Max:** VO2 max is the maximal rate of oxygen consumption during intense exercise and represents the upper limit of aerobic capacity.

- It is influenced by factors such as cardiac output, oxygen delivery to the muscles, oxygen utilization by the muscles, and pulmonary gas exchange. VO2 max is typically expressed relative to body weight and is considered a key determinant of endurance performance.

- **Training Adaptations:** Regular exercise induces various physiological adaptations in the cardiovascular, respiratory, and musculoskeletal systems, improving overall fitness and performance.

- These adaptations include increases in cardiac output, stroke volume, blood volume, mitochondrial density, capillary density, muscle fiber size, and enzyme activity involved in energy metabolism.

ASSESSMENT

- What is the Function of Muscle Protein ?
- What is Excitation ?