PLUTUS IAS
UPSC/ PCS

# Muscle Unit

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**Batch: Zoology Optional** **Date: 31-Aug-2024**

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| Mains Answer Writing Guidance Programme | |
|---|---|
| **Name** | ADITI CHOUDHARY |
| **Medium** | ENGLISH |
| **Date** | |
| **Subject and Test Number** | ZOOLOGY |

**Instructions:**

1. Please scan your answers and form single pdf and share within 48 hours.
2. Writing in the margins leads to rejection of copy.
3. Kindly take due appointment with coordination team to discuss the answer copy with respective mentor.
4. Copies will be evaluated within 7 days of submission.
5. This is an open-book test. Use all your resources and provide the best answer possible according to your understanding.

| Evaluated | Reviewed |
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| | |

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| Criteria/Parameters | Exellent | Very Good | Good | Average | Poor |
|---|---|---|---|---|---|
| Language and Articulation | | | ✓ | | |
| Content and Conceptual Clarity | | | ✓ | | |
| Number of Questions Attempted | | | ✓ | | |
| Structure and Presentation | | | | ✓ | |
| Coherence and Structuration | | | ✓ | | |

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## Examiner's Feedback

1 Describe the physiology of contraction of Skeletal muscle. (8Marks)

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[Diagram of skeletal muscle] T.S section of Skeletal muscle.

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→ Skeletal muscle contraction is a voluntary process initiated by a nerve impulse.

→ The sliding filament theory explains the mechanism of muscle contraction, involving the interaction between actin and myosin filaments.

→ Calcium ions play a crucial role in regulating muscle contraction by controlling the exposure of myosin binding sites on actin.

→ ATP provides the energy for the power stroke of the myosin head.

⇒ Key steps involved in skeletal muscle contraction are :

(1) Nerve Impulse : An action potential travels down the motor neuron, towards synaptic knob. When the action potential reaches the neuromuscular junction, it causes the release of acetylcholine (a neurotransmitter). Acetylcholine binds to receptors on the muscle fiber's membrane, causing it to depolarize.

(2) Excitation : The depolarization spreads along the muscle fiber's membrane and penetrates deep into the T-tubules. The t-tubules trigger the release of $Ca^{2+}$ ions from the sarcoplasmic reticulum.

(3) Muscle Fibre Contraction :

→ Sliding filament theory : The released $Ca^{2+}$ ions binds to troponin, a protein associated with actin filaments. This exposes the myosin binding sites on the actin filaments.

→ Cross-bridge formation : Myosin heads bind to the exposed binding sites on the actin filaments, forming cross-bridges.

→ Power Stroke : The myosin heads use ATP and pulls the actin filaments towards the center of the sarcomere. This results in the shortening of the muscle fibre.

(4) Muscle Relaxation : When the nerve impulse stops, $Ca^{2+}$ ions are pumped back into the sarcoplasmic reticulum.

Thus, actin & myosin cannot interact and the muscle relaxes.

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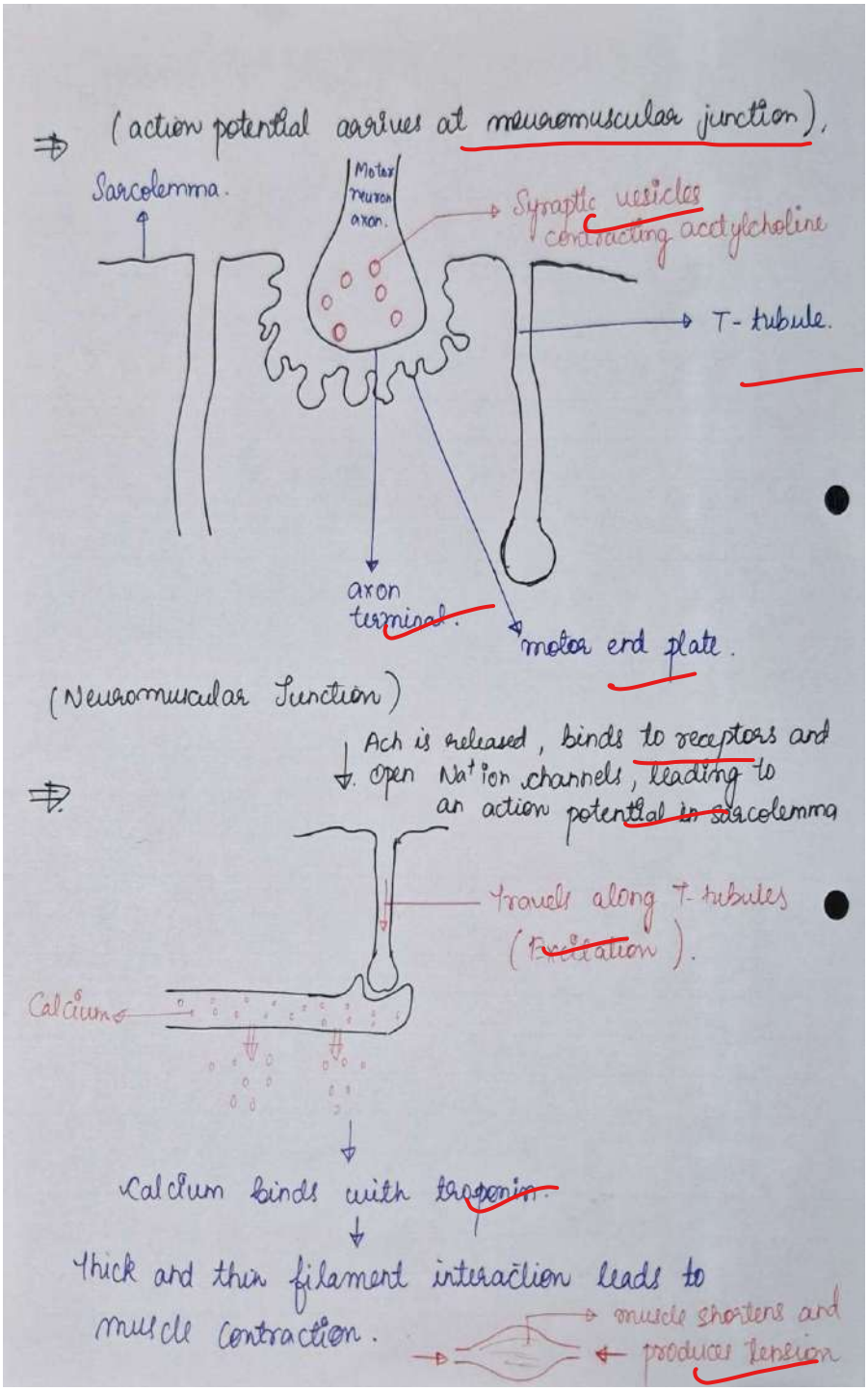

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Distirugists btw Smooth muscle, Striated muscle and Cardiac muscle.

(8 Marks)

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| | SMOOTH MUSCLES (NON-STRIATED) | SKELETAL MUSCLES (STRIATED) | CARDIAC MUSCLE. |
|---|---|---|---|
| LOCATION. | Inner lining of organs, blood vessels and glands. Eg: digestive tract, blood vessels. | Attached to bones, skin and tendons. | Heart. |
| APPEARANCE | No visible striations (no stripes) | Visible striations (stripes) | Striated but with unique features. |
| CHARACTERI-STICS. | - Involuntary contractions. | - Voluntary contractions (under control) | - Involuntary contractions |
| | - Non-Striated. (no sarcomeres) | - Striated (sarcomere present) | - Striated (Sarcomere present) |
| | - Single, spindle-shaped cells. | - Multinucleated, long, cylindrical cells. | - Branching, Interconnected cells. |
| | - Slow contractions. | - Fast contractions. | - Fast contractions. |
| | - Regulated by autonomic nervous system. | - Regulated by somatic nervous system. | - Regulated by autonomic nervous system. |
| | - Example: → Digestion and movement of food. → Blood pressure regulation. | - Example: → Movement, walking, running. → Maintaining posture. → Facial expressions. | - Example: → Pumping blood throughout the body. → Regulating heart rate. |

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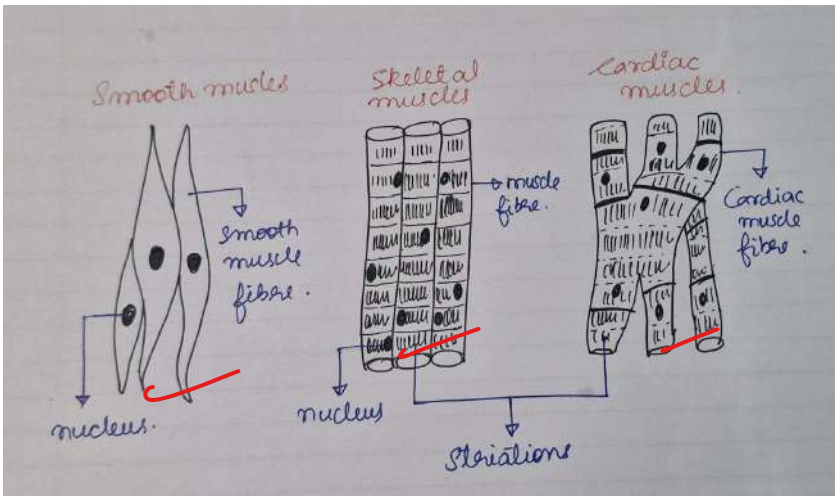


Fig: diagram of smooth, skeletal and cardiac muscles.

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3 Explain Muscle Twitch & Tetanus.

(8 Marks)

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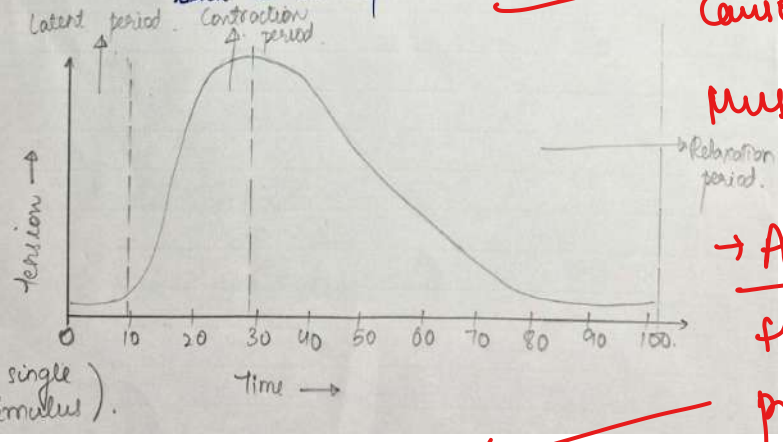
→ A muscle twitch is a single, brief contraction of a muscle fiber in response to a single electrical stimulus

- There are three phases of a muscle twitch:

(a) Latent period: This is the period between the stimulus and the beginning of the contraction. During this, action potential is being propagated along the Sarcolemma. and $Ca^{2+}$ ions are released from the sarcoplasmic reticulum.

(b) Contraction period: During this phase, muscle fibre contracts to shorten in length. $Ca^{2+}$ ions bind to troponin. Myosin head attaches to the actin filament.

(c) Relaxation phase: In this, muscle fibre returns to its resting length. $Ca^{2+}$ ions are pumped back to sarcoplasmic reticulum.




3.5

Explain the cause of muscle twitch

→ Also Mention their prevention & cure.

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→ Tetanus (tetanic contraction) occurs when a muscle receives repeated electrical stimuli at a high frequency that there is no relaxation, resulting in sustained contractions

- During tetanus, $Ca^{2+}$ ions concentration allows the sarcomeres to form cross-bridges and shorten, until the muscle fatigues and can no longer produce tension.
- There are 2 types of tetanus.

**Complete tetanus** → Muscle contracts maximally, with no relaxation between stimuli

**Incomplete tetanus** → muscle contracts partially, with some relaxation between stimuli.

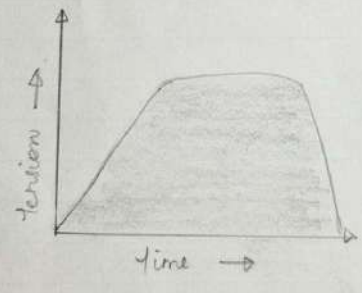


Fig: Tetanic contraction

4 Give ultra structure of Skeletal muscle. (8 Marks)

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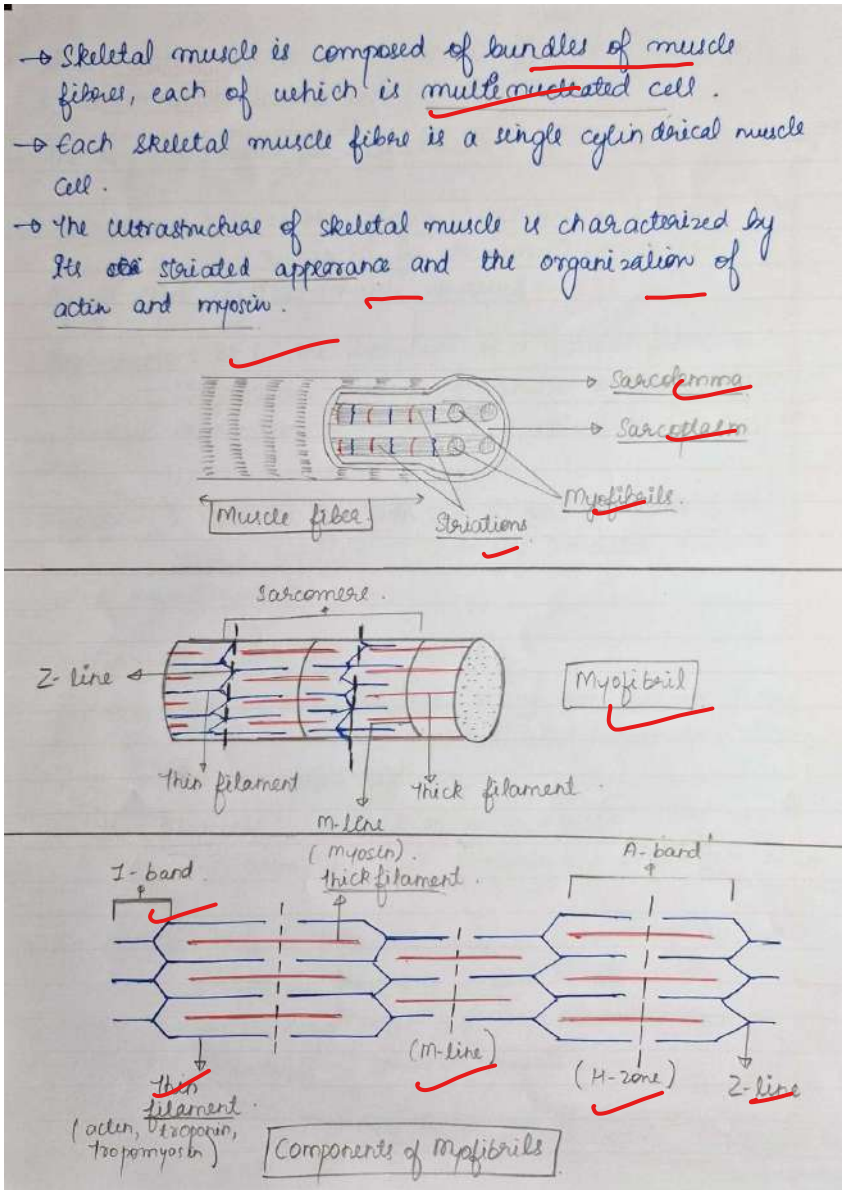
→ Skeletal muscle is composed of bundles of muscle fibres, each of which is multinucleated cell.
→ Each skeletal muscle fibre is a single cylindrical muscle cell.
→ The ultrastructure of skeletal muscle is characterized by its striated appearance and the organisation of actin and myosin.

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→ The key components of ultrastructure of skeletal muscle are:

(a) Sarcolemma : It is the plasma membrane of muscle fiber. It is responsible for transmitting electrical signals that initiate muscle contraction.

(b) Sarcoplasm : It is the cytoplasm of a muscle fiber. It contains various organelles such as mitochondria for energy production; sarcoplasmic reticulum for calcium storage.

(c) Myofibrils : These are the contractile element of muscle fiber. within myofibrils, there are smaller structure called myofilaments.

(d) Myofilaments : These are of 2 types :

(i) Thick filaments : Composed of myosin protein. They have a globular head region and a long tail region.

(ii) Thin filaments : Composed of actin protein. they are associated with troponin and tropomyosin protein.

(e) Sarcomere : This is the basic unit of muscle contraction. It extends from one Z line to the next. It contains overlapping thick and thin filaments which creates the striations of skeletal muscle.

(f) I bands : It is the region of sarcomere that contain only thin filaments.

(g) A band : It is the region of sarcomere that contains both thick and thin filaments.

(h) H-zone : It is the region within A band that contains only thick filaments.

(i) M line : It is a protein structure located in the centre of H-zone.

(j) Sarcoplasmic reticulum : It is a network of membranous tubules that surrounds each myofibril. It stores $Ca^{2+}$ ions.

(k) T-tubules : This carry electrical signals deep into the muscle fibre.

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5 Explain Neuron-Muscular Junction (8 Marks)

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→ Neuron-muscular junction is the specialized connection between a motor neuron and a skeletal muscle fiber.

→ this function is made up of 3 parts:.

(a) motor neuron: End of the motor neuron axon.

(b) motor endplate: Specialized region of muscle febre membrane.

(c) Synaptic cleft: gap between neuve terminal and motor endplate.

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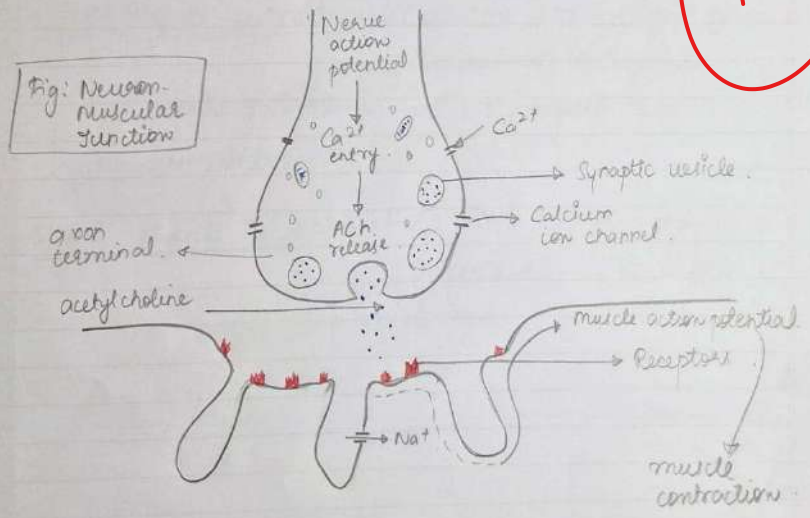


Fig: Neuron-muscular junction

→ the steps included in this function are as follow:.

(i) Neuve impulse arrival: an action potential travels down the motor neuron.

(ii) Neurotransmitter release: $Ca^{2+}$ channels open allowing $Ca^{2+}$ ions to flow in. Acetylcholine is released from synaptic vesicle to synaptic cleft.

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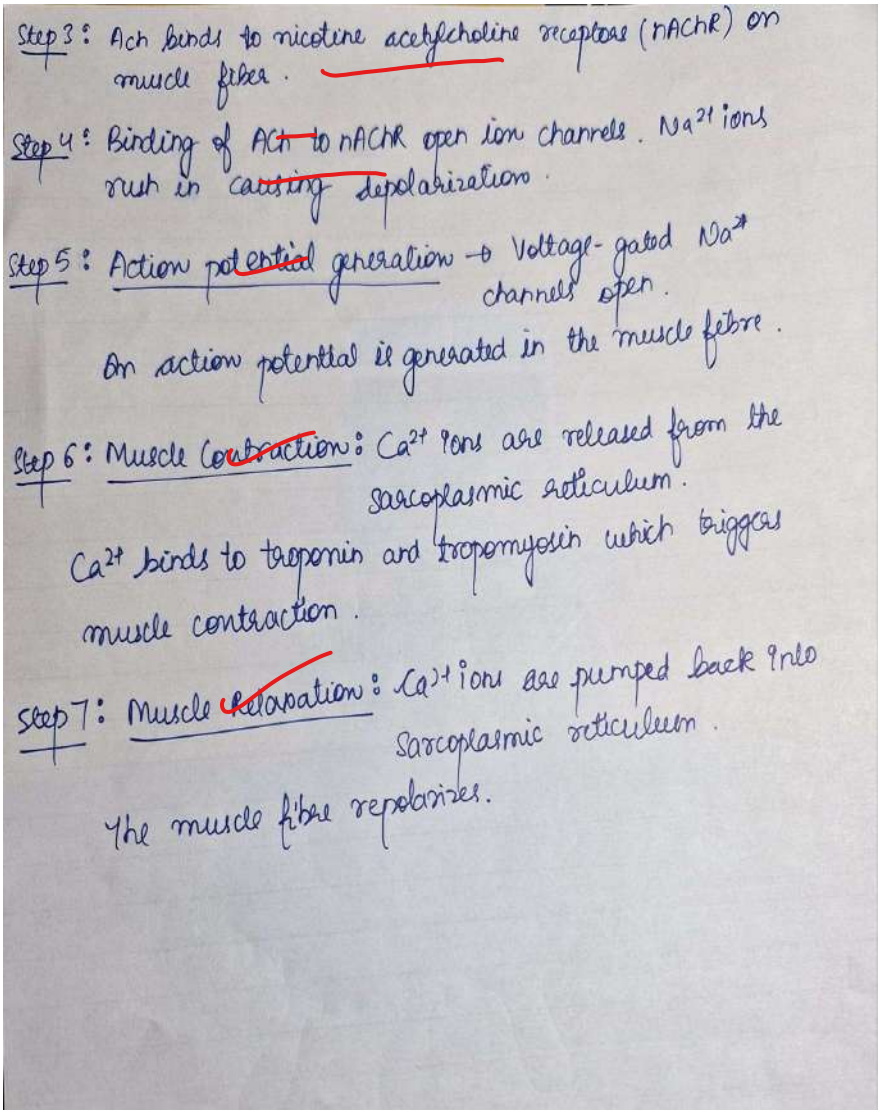

Step 3: Ach binds to nicotine acetylcholine receptors (nAChR) on muscle fiber.

Step 4: Binding of Ach to nAChR open ion channels. $Na^{2+}$ ions rush in causing depolarization.

Step 5: Action potential generation → Voltage-gated $Na^{+}$ channels open.

An action potential is generated in the muscle fibre.

Step 6: Muscle Contraction: $Ca^{2+}$ ions are released from the sarcoplasmic reticulum.

$Ca^{2+}$ binds to troponin and tropomyosin which triggers muscle contraction.

Step 7: Muscle relaxation: $Ca^{2+}$ ions are pumped back into Sarcoplasmic reticulum.

The muscle fibre repolarizes.

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