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Muscle Contraction, Muscle Tissue & Tendons

Study Guide — Musculoskeletal System

60+ Pre-med/IB-style questions on skeletal muscle fiber anatomy, sliding filament theory, excitation-contraction coupling, motor units, energy systems, fiber types, smooth vs cardiac muscle basics, tendons, and biomechanics.

70 items — Study Guide with Answers

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1 Which statement correctly distinguishes a tendon from a ligament?

- A Tendons connect bone to bone; ligaments connect muscle to bone.
- B **Tendons connect muscle to bone; ligaments connect bone to bone.** ✓
- C Tendons are made of smooth muscle; ligaments are made of skeletal muscle.
- D Tendons contain neurons; ligaments contain red blood cells.
- E There is no difference - both terms mean the same structure.

▶ **Explanation:** A tendon transmits force from muscle to bone. A ligament stabilizes joints by connecting bone to bone. The other options swap roles or describe incorrect tissue types.

2 Which order correctly represents the organization from smallest to largest in skeletal muscle?

- A Muscle -> fascicle -> muscle fiber -> myofibril -> myofilament
- B **Myofilament -> myofibril -> muscle fiber -> fascicle -> muscle** ✓
- C Myofibril -> myofilament -> muscle fiber -> fascicle -> muscle
- D Muscle fiber -> myofilament -> myofibril -> fascicle -> muscle
- E Myofilament -> muscle -> fascicle -> myofibril -> muscle fiber

▶ **Explanation:** Myofilaments (actin/myosin) form myofibrils, which pack into a muscle fiber (cell). Fibers bundle into fascicles, and fascicles bundle into the whole muscle.

3 Which connective tissue layer surrounds a fascicle (bundle of muscle fibers) in skeletal muscle?

- A Endomysium

B **Perimysium** ✓

C Epimysium

D Sarcolemma

E Myelin

▶ **Explanation:** Endomysium wraps individual muscle fibers, perimysium wraps fascicles, and epimysium wraps the entire muscle. Sarcolemma is the muscle cell membrane; myelin is for nerves.

4 **The sarcolemma is best described as the:**

A Membrane of the sarcoplasmic reticulum

B **Plasma membrane of a muscle fiber** ✓

C Connective tissue sheath around a fascicle

D Protein that binds calcium on actin

E Space between actin and myosin filaments

▶ **Explanation:** The sarcolemma is the muscle cell membrane. The sarcoplasmic reticulum is an internal membrane network for Ca^{2+} storage, and connective tissue layers are endo-/peri-/epimysium.

5 **A sarcomere is defined as the region between two:**

A M lines

B **Z lines (Z discs)** ✓

C H zones

D A bands

E T-tubules

▶ **Explanation:** The sarcomere is the basic contractile unit: Z line to Z line. M line is the center, and A/I/H bands are regions within a sarcomere.

6 Which pairing correctly matches the main proteins in thick vs thin filaments of skeletal muscle?

- A Thick = actin; Thin = myosin
- B **Thick = myosin; Thin = actin (with troponin/tropomyosin)** ✓
- C Thick = collagen; Thin = elastin
- D Thick = keratin; Thin = tubulin
- E Thick = hemoglobin; Thin = myoglobin

▶ **Explanation:** Thick filaments are mainly myosin. Thin filaments are mainly actin plus regulatory proteins troponin and tropomyosin. Collagen/elastin are connective tissue proteins, not sarcomere filaments.

7 Which muscle type is typically multinucleated (has many nuclei per cell)?

- A **Skeletal muscle fiber** ✓
- B Cardiac muscle cell
- C Smooth muscle cell
- D Neuron
- E Red blood cell

▶ **Explanation:** Skeletal muscle fibers form by fusion of many precursor cells and thus contain multiple nuclei. Cardiac and smooth muscle cells are usually single-nucleated (cardiac can sometimes have two).

8 **Which feature is most directly responsible for the striated appearance of skeletal and cardiac muscle?**

- A Random distribution of actin and myosin
- B **Regular repeating arrangement of sarcomeres** ✓
- C Presence of a myelin sheath
- D High amount of collagen in the cytoplasm
- E Absence of mitochondria

▶ **Explanation:** Striations come from repeating sarcomere patterns (A and I bands). Smooth muscle lacks this highly regular sarcomere organization and is non-striated.

9 **Intercalated discs in cardiac muscle are important mainly because they:**

- A Store calcium for muscle contraction
- B **Provide strong mechanical attachment and electrical coupling between cells** ✓
- C Secrete acetylcholine onto skeletal muscles
- D Make cardiac muscle non-striated
- E Prevent any ions from moving between cardiac cells

▶ **Explanation:** Intercalated discs include anchoring junctions (for strength) and gap junctions (for rapid electrical spread), helping the heart contract in a coordinated way.

10 **Gap junctions in cardiac muscle primarily allow:**

- A **Direct flow of ions and electrical signals between adjacent cells** ✓
- B Oxygen transport from blood to muscle

- C Neurotransmitter storage in vesicles
- D Attachment of tendons to bone
- E Protein synthesis in the nucleus

▶ **Explanation:** Gap junctions form channels between cells, letting ions pass so depolarization spreads quickly. This supports synchronized contraction in cardiac (and some smooth) muscle.

11 During contraction of a skeletal muscle sarcomere, which region stays the SAME length?

- A I band
- B H zone
- C **A band** ✓
- D Distance between Z lines
- E The entire sarcomere always stays the same length

▶ **Explanation:** The A band corresponds to the length of thick (myosin) filaments, which do not change length. The sarcomere shortens (Z lines get closer), and I band/H zone shrink.

12 Which change occurs when a sarcomere contracts normally?

- A **The I band shortens** ✓
- B The A band shortens
- C The myosin filaments shorten
- D The actin filaments shorten
- E The Z lines move farther apart

▶ **Explanation:** In sliding filament theory, filaments slide past each other without changing length. The I band (thin-only region) shortens, and Z lines move closer together.

13 **At very strong contraction, which region may disappear because there is maximal overlap of actin and myosin?**

- A A band
- B **H zone** ✓
- C Z line
- D M line
- E Sarcolemma

▶ **Explanation:** The H zone is the region with only thick filaments (no thin overlap). As thin filaments slide inward, overlap increases and the H zone can shrink to zero.

14 **Which statement best describes the sliding filament theory?**

- A Actin and myosin filaments shorten by breaking into smaller pieces.
- B **Actin filaments slide past myosin filaments, increasing overlap and shortening the sarcomere.** ✓
- C Myosin moves away from actin to lengthen the sarcomere.
- D The sarcomere shortens because the Z lines dissolve.
- E Calcium causes actin to be converted into myosin.

▶ **Explanation:** Contraction occurs by sliding: myosin cross-bridges pull actin inward so overlap increases, shortening the sarcomere without changing filament lengths.

15 **In skeletal muscle, calcium (Ca^{2+}) initiates contraction most directly by binding to:**

- A Tropomyosin
- B **Troponin** ✓
- C Myosin heads
- D Acetylcholine
- E ATP synthase

▶ **Explanation:** Ca^{2+} binds troponin, which shifts tropomyosin away from actin's myosin-binding sites, allowing cross-bridge formation. Ca^{2+} does not bind ACh or ATP synthase for contraction control.

16 **What is the main role of tropomyosin in a relaxed skeletal muscle fiber?**

- A It breaks down ATP to provide energy.
- B **It covers myosin-binding sites on actin, preventing cross-bridge formation.** ✓
- C It pumps Ca^{2+} back into the sarcoplasmic reticulum.
- D It releases acetylcholine at the neuromuscular junction.
- E It forms the thick filament backbone.

▶ **Explanation:** In relaxation, tropomyosin blocks actin's binding sites. When Ca^{2+} binds troponin, tropomyosin moves and allows myosin to attach.

17 **ATP binding to myosin is required most directly for which step of the cross-bridge cycle?**

- A Power stroke (pulling actin)

- B **Detachment of myosin from actin** ✓
- C Exposure of binding sites on actin
- D Release of Ca^{2+} from the sarcoplasmic reticulum
- E Diffusion of oxygen into mitochondria

▶ **Explanation:** ATP binding causes myosin to release actin. Without ATP, myosin remains attached (important in rigor mortis). Ca^{2+} exposure of binding sites is regulated by troponin/tropomyosin, not ATP binding.

18 ATP hydrolysis (ATP -> ADP + Pi) at the myosin head is used mainly to:

- A Pull actin inward during the power stroke
- B Detach myosin from actin
- C **Re-cock (energize) the myosin head into a high-energy position** ✓
- D Bind Ca^{2+} to troponin
- E Create acetylcholine in the motor neuron

▶ **Explanation:** Hydrolysis energizes the myosin head (cocking). ATP binding detaches myosin; then hydrolysis repositions it, ready for the next cycle.

19 The 'power stroke' in skeletal muscle contraction occurs most directly when:

- A ATP binds to myosin
- B **ADP and Pi are released from myosin after it binds actin** ✓
- C Ca^{2+} is pumped into the sarcoplasmic reticulum
- D Acetylcholine is broken down by acetylcholinesterase
- E The action potential reaches the brain

▶ **Explanation:** After myosin binds actin, release of Pi (and then ADP) is linked to the power stroke that moves actin. ATP binding ends the stroke by detaching myosin.

20 Rigor mortis occurs after death primarily because:

- A Too much ATP forces myosin to stay attached to actin
- B **There is no ATP to detach myosin from actin, so cross-bridges remain locked ✓**
- C Acetylcholine is broken down too quickly
- D Actin filaments are destroyed, preventing overlap
- E The sarcomeres permanently lengthen due to excess Ca^{2+} pumping

▶ **Explanation:** ATP is required for myosin to detach from actin. After death, ATP production stops; cross-bridges lock, producing stiffness until proteins degrade.

21 If Ca^{2+} were suddenly removed from a contracting skeletal muscle fiber while ATP remained available, what would happen most immediately?

- A Myosin would keep cycling normally because Ca^{2+} is not needed once contraction begins
- B **New cross-bridges would stop forming because tropomyosin would re-cover binding sites, and the muscle would relax ✓**
- C ATP would instantly disappear
- D The A band would shorten
- E The myosin filaments would disassemble

▶ **Explanation:** Ca^{2+} is required to keep actin binding sites exposed. If Ca^{2+} falls, tropomyosin blocks binding, cross-bridge cycling stops, and the muscle relaxes (as attached bridges finish and detach).

22 **Which protein pump actively transports Ca^{2+} back into the sarcoplasmic reticulum to end contraction?**

- A Na^{+}/K^{+} ATPase
- B **SERCA (Ca^{2+} ATPase)** ✓
- C ATP synthase
- D Myosin ATPase
- E Carbonic anhydrase

▶ **Explanation:** SERCA pumps Ca^{2+} from cytosol back into the sarcoplasmic reticulum using ATP, lowering cytosolic Ca^{2+} and promoting relaxation.

23 **A drug inhibits SERCA pumps in skeletal muscle. Which outcome is most likely?**

- A Faster relaxation because Ca^{2+} is removed more quickly
- B **Slower relaxation and prolonged contraction because cytosolic Ca^{2+} stays high** ✓
- C No change because SERCA is not involved in Ca^{2+} handling
- D Immediate breakdown of actin filaments
- E More acetylcholine release at the neuromuscular junction

▶ **Explanation:** If Ca^{2+} cannot be pumped back into the SR, it remains in the cytosol longer, keeping troponin activated and delaying relaxation.

24 **At the neuromuscular junction, acetylcholine (ACh) binds to receptors that are best described as:**

- A Voltage-gated Na^{+} channels

- B **Ligand-gated cation channels (nicotinic ACh receptors)** ✓
- C G-protein coupled receptors that take minutes to respond
- D ATP-driven pumps that transport ACh into the cell
- E Receptors only found on the presynaptic membrane

▶ **Explanation:** Skeletal muscle uses nicotinic ACh receptors, which are ligand-gated cation channels. Binding opens them quickly, producing an end-plate depolarization.

25 The end-plate potential (EPP) at the neuromuscular junction is best described as:

- A An all-or-none action potential that always has the same amplitude
- B **A graded depolarization that can trigger a muscle action potential if threshold is reached** ✓
- C A hyperpolarization caused by Cl^- influx only
- D A signal that travels down the optic nerve
- E A contraction of the tendon

▶ **Explanation:** An EPP is a local graded depolarization produced by ACh receptor opening. If it reaches threshold, voltage-gated channels open and a muscle action potential occurs.

26 Acetylcholinesterase (AChE) at the neuromuscular junction is important mainly because it:

- A Synthesizes acetylcholine in the muscle fiber
- B **Breaks down acetylcholine in the synaptic cleft to terminate the signal** ✓
- C Pumps Ca^{2+} into the sarcoplasmic reticulum
- D Moves actin over myosin

E Builds the myelin sheath around axons

▶ **Explanation:** AChE degrades ACh in the synaptic cleft, stopping receptor activation so the muscle can relax and be ready for the next signal.

27 If acetylcholinesterase were inhibited at the neuromuscular junction, the most likely immediate effect would be:

A Less stimulation of the muscle fiber and weaker contraction

B **Prolonged stimulation of ACh receptors, causing sustained depolarization and muscle over-activation ✓**

C No effect because ACh breakdown is not required for signaling

D Instant destruction of troponin

E Only the tendon would contract, not the muscle

▶ **Explanation:** Blocking AChE lets ACh accumulate, keeping receptors activated longer. This prolongs depolarization and can lead to spasms and eventually depolarization block/fatigue.

28 T-tubules are important in skeletal muscle because they:

A Store ATP for the cross-bridge cycle

B **Carry the action potential deep into the muscle fiber so Ca^{2+} release occurs throughout ✓**

C Are the site where acetylcholine is made

D Connect muscle to bone

E Prevent any ions from moving within the cell

▶ **Explanation:** T-tubules are invaginations of the sarcolemma that rapidly deliver depolarization into the cell, triggering Ca^{2+} release from the SR throughout the fiber for coordinated contraction.

29 **The sarcoplasmic reticulum (SR) in skeletal muscle is functionally most similar to which organelle?**

- A Golgi apparatus (protein secretion)
- B **Smooth endoplasmic reticulum (Ca^{2+} storage/handling)** ✓
- C Mitochondrion (ATP synthesis)
- D Nucleus (DNA storage)
- E Lysosome (digestion)

▶ **Explanation:** The SR is a specialized smooth ER for Ca^{2+} storage and release in muscle, crucial for rapid control of contraction.

30 **Which event directly links the muscle action potential to the start of cross-bridge cycling in skeletal muscle?**

- A ATP binding to myosin
- B **Ca^{2+} release into the cytosol and binding to troponin** ✓
- C Glucose entering the muscle cell
- D CO2 leaving the muscle cell
- E Protein synthesis in ribosomes

▶ **Explanation:** The action potential triggers Ca^{2+} release from the SR. Ca^{2+} binds troponin, allowing myosin to bind actin and start cross-bridge cycling.

31 **Botulinum toxin causes flaccid paralysis mainly because it prevents:**

A Ca^{2+} binding to troponin inside muscle fibers

B **Release of acetylcholine from the motor neuron terminal** ✓

C ATP production in mitochondria of the muscle

D Action potentials in the spinal cord only

E Formation of tendons during development

▶ **Explanation:** If ACh cannot be released, the muscle end plate is not activated, so no muscle action potential occurs and contraction fails (flaccid paralysis).

32 Curare (a classic neuromuscular blocker) causes muscle weakness primarily by:

A Breaking down acetylcholine too quickly

B **Blocking nicotinic acetylcholine receptors on the muscle end plate** ✓

C Increasing Ca^{2+} release from the SR

D Increasing ATP production in muscle

E Strengthening tendon collagen fibers

▶ **Explanation:** Curare competes with ACh at nicotinic receptors, preventing end-plate depolarization and muscle activation, leading to flaccid paralysis.

33 A motor unit is defined as:

A All the muscles in one limb

B **One motor neuron and all the muscle fibers it innervates** ✓

C One sarcomere and the Z lines around it

D One tendon and the bone it attaches to

E One actin filament plus one myosin filament

▶ **Explanation:** A motor unit is a single motor neuron and all skeletal muscle fibers it controls. Whole muscle force depends on how many motor units are activated and how fast they fire.

34 Which muscle would generally have the SMALLEST motor units for the finest control?

A Quadriceps (thigh)

B **Extraocular muscles (eye movement)** ✓

C Gluteus maximus

D Gastrocnemius (calf)

E Diaphragm (always largest motor units)

▶ **Explanation:** Fine control requires small motor units (few fibers per neuron), typical in muscles for precise movement like eye muscles. Large powerful muscles tend to have larger motor units.

35 A whole muscle can produce graded increases in force mainly by:

A Making individual muscle fibers produce bigger action potentials

B **Recruiting more motor units and increasing firing frequency (summation)** ✓

C Changing the length of actin filaments permanently

D Switching from troponin to calmodulin

E Letting tendons contract independently

▶ **Explanation:** A single fiber's action potential is all-or-none, so force is graded by recruiting more fibers (motor units) and by higher stimulation frequency (temporal summation/tetanus).

36 **Temporal summation in skeletal muscle increases force because:**

- A The muscle fiber action potentials increase in size with repeated stimulation
- B **Ca^{2+} does not fully return to baseline between stimuli, so more cross-bridges can form** ✓
- C Actin filaments grow longer with each stimulus
- D The A band shortens with each stimulus
- E Acetylcholine becomes permanently attached to receptors

▶ **Explanation:** With rapid repeated stimulation, Ca^{2+} stays elevated, maintaining binding-site exposure and increasing the average number of active cross-bridges, raising force.

37 **A sustained maximal contraction caused by high-frequency stimulation with no relaxation is called:**

- A A twitch
- B **Tetanus** ✓
- C Refractory period
- D Accommodation
- E Diffusion

▶ **Explanation:** Tetanus occurs when stimuli arrive so frequently that Ca^{2+} remains high and the muscle cannot relax, producing near-maximal sustained force.

38 **The length-tension relationship implies that maximal active force is produced when:**

A There is no overlap between actin and myosin

B Sarcomere length is optimal for cross-bridge formation (neither too stretched nor too compressed) ✓

C The sarcomere is stretched so far that actin detaches from the Z line

D The sarcomere is maximally shortened so myosin filaments fold

E Force is independent of overlap; only ATP matters

▶ **Explanation:** Too little overlap means fewer cross-bridges; too much shortening causes interference. An intermediate sarcomere length maximizes effective actin-myosin interactions.

39 An isometric contraction is one in which:

A The muscle shortens while force stays constant

B The muscle length stays constant while tension increases or is maintained ✓

C The muscle lengthens with no force produced

D The tendon shortens but the muscle does not

E No cross-bridges form

▶ **Explanation:** In isometric contractions, the muscle produces force but does not change length (e.g., holding a heavy object still). Cross-bridges still cycle.

40 Which description correctly matches concentric vs eccentric contraction?

A Concentric: muscle lengthens; Eccentric: muscle shortens

B Concentric: muscle shortens while producing force; Eccentric: muscle lengthens while resisting a load ✓

C Concentric occurs only in smooth muscle; eccentric only in skeletal muscle

D Eccentric contractions require no ATP

E Eccentric contractions cannot produce high force

▶ **Explanation:** Concentric contractions shorten muscle (lifting). Eccentric contractions lengthen muscle while it still produces force (lowering slowly). Both involve cross-bridges and ATP use.

41 Eccentric contractions are often associated with greater muscle soreness the next day mainly because they:

A Stop Ca^{2+} release from the SR permanently

B **Cause more micro-tears and mechanical stress in muscle fibers while producing high force** ✓

C Prevent oxygen from entering blood

D Destroy actin filaments instantly

E Occur only during sleep

▶ **Explanation:** Eccentric contractions can generate high forces while the muscle lengthens, increasing micro-damage and inflammation, leading to delayed-onset muscle soreness (DOMS).

42 ATP is required in skeletal muscle contraction for BOTH of the following processes:

A **Myosin detachment from actin and Ca^{2+} reuptake into the SR** ✓

B Actin synthesis and oxygen diffusion into blood

C Troponin production and tendon stretching

D Opening of acetylcholine receptors and closing of the pupil

E Breaking down glucose in the intestine and pumping Na^{+} in kidneys

▶ **Explanation:** ATP is needed for myosin to detach and for SERCA pumps to move Ca^{2+} back into the SR. Many confuse ATP use with only 'power stroke,' but detachment and relaxation also require ATP.

43 During the first few seconds of an all-out sprint, the most immediate way muscle regenerates ATP is primarily through:

- A Oxidative phosphorylation in mitochondria
- B **Creatine phosphate (phosphocreatine) donating phosphate to ADP** ✓
- C Conversion of lactic acid into glucose in the intestine
- D Protein breakdown into amino acids for energy
- E Photosynthesis inside muscle fibers

▶ **Explanation:** Phosphocreatine rapidly buffers ATP by transferring a phosphate to ADP. It is a short-term, immediate energy source before slower pathways ramp up.

44 Which statement correctly compares anaerobic glycolysis with aerobic respiration in muscle?

- A Anaerobic glycolysis is slower but yields much more ATP per glucose
- B **Anaerobic glycolysis is faster but yields less ATP per glucose than aerobic respiration** ✓
- C Aerobic respiration produces ATP without oxygen
- D Anaerobic glycolysis happens only in mitochondria
- E Aerobic respiration produces no CO2

▶ **Explanation:** Anaerobic glycolysis is rapid but inefficient (few ATP per glucose). Aerobic respiration is slower to ramp up but produces far more ATP and generates CO2.

45 **A major reason muscles fatigue during intense short-term exercise is that:**

- A ATP is never used during contraction
- B **Accumulation of H^+ (lower pH) can interfere with enzyme function and contraction processes** ✓
- C Actin filaments permanently disappear after a few contractions
- D Myosin turns into collagen
- E The sarcomere becomes longer because ATP stretches it

▶ **Explanation:** High-intensity exercise can increase H^+ (lower pH) and alter ion balance, disrupting enzymes and contraction mechanics. Fatigue is multifactorial, but pH/ion changes are key at this level.

46 **'Oxygen debt' after exercise refers mainly to the extra oxygen needed to:**

- A Convert oxygen into glucose
- B **Restore phosphocreatine stores, process lactate, and replenish oxygen stores in tissues** ✓
- C Break down acetylcholine at the NMJ
- D Increase the number of sarcomeres
- E Make tendons shorter

▶ **Explanation:** After exercise, breathing stays elevated to restore energy stores (like phosphocreatine), clear/process lactate, and re-oxygenate myoglobin and other tissues.

47 **Which skeletal muscle fiber type is generally MOST fatigue-resistant and rich in mitochondria and myoglobin?**

- A **Type I (slow oxidative)** ✓
- B Type IIx/IIb (fast glycolytic)
- C Type II (fast) always has zero mitochondria
- D All fiber types have identical mitochondria and myoglobin
- E Smooth muscle fibers only

▶ **Explanation:** Type I fibers are slow, oxidative, highly aerobic, rich in myoglobin/mitochondria, and resist fatigue - ideal for endurance and posture.

48 Which fiber type is best suited for very fast, powerful movements (e.g., short sprints) but fatigues quickly?

- A Type I (slow oxidative)
- B **Type IIx/IIb (fast glycolytic)** ✓
- C Smooth muscle
- D Cardiac muscle
- E Type I has the highest sprint power

▶ **Explanation:** Fast glycolytic fibers generate high power quickly using anaerobic pathways but fatigue faster. Type I fibers are slower but fatigue-resistant.

49 Endurance training most directly increases which adaptations in skeletal muscle?

- A Decrease in capillary density and mitochondria
- B **Increase in capillary density and mitochondrial content** ✓
- C Replacement of skeletal muscle with smooth muscle
- D Permanent shortening of actin filaments

E Loss of myoglobin to reduce oxygen use

▶ **Explanation:** Endurance training improves aerobic capacity by increasing capillaries and mitochondria (and often myoglobin), enhancing oxygen delivery and ATP production.

50 Strength training typically leads to muscle growth mainly by:

- A Hyperplasia (making many new muscle fibers in large numbers)
- B **Hypertrophy (increasing the size of existing fibers by adding myofibrils/proteins)** ✓
- C Replacing tendons with bone
- D Shortening the A band permanently
- E Turning slow fibers into neurons

▶ **Explanation:** Most muscle growth in humans is hypertrophy: fibers enlarge by increasing contractile proteins and myofibrils. Large-scale hyperplasia is not the main mechanism.

51 According to the 'size principle' of motor unit recruitment during increasing force demands, which motor units are typically activated first?

- A Large fast glycolytic motor units
- B **Small slow oxidative motor units** ✓
- C Only the largest motor units in all cases
- D Motor units are recruited randomly
- E Cardiac motor units

▶ **Explanation:** Small, fatigue-resistant units (often Type I fibers) are recruited first. As more force is required, larger fast units are recruited later.

52 **Which characteristic best fits Type I (slow oxidative) fibers compared with Type II (fast) fibers?**

- A Fewer mitochondria and more fatigue
- B **More mitochondria, more myoglobin, and greater fatigue resistance** ✓
- C Higher maximum shortening velocity and highest power output
- D No capillary supply
- E They contract only when the person is asleep

▶ **Explanation:** Slow oxidative fibers are aerobic, rich in mitochondria/myoglobin/capillaries, and resist fatigue. Fast fibers generally produce higher power but fatigue faster.

53 **Which muscle type is under voluntary control and attached to bones via tendons?**

- A Smooth muscle
- B **Skeletal muscle** ✓
- C Cardiac muscle
- D All muscle types are voluntary
- E No muscle type is voluntary

▶ **Explanation:** Skeletal muscle is voluntary and usually attaches to bones via tendons. Smooth and cardiac muscles are involuntary.

54 **Which statement is correct about smooth muscle contraction regulation compared with skeletal muscle?**

A Smooth muscle uses troponin to move tropomyosin, just like skeletal muscle

B Smooth muscle typically uses Ca^{2+}-calmodulin and myosin light-chain kinase (MLCK) rather than troponin ✓

C Smooth muscle cannot use Ca^{2+} for contraction

D Smooth muscle always has sarcomeres and striations

E Smooth muscle contraction depends on acetylcholine only and never on hormones

▶ **Explanation:** Smooth muscle lacks troponin-based regulation; Ca^{2+} binds calmodulin, activating MLCK, which enables myosin to interact with actin. Smooth muscle is often hormonally and autonomically regulated.

55 A key reason cardiac muscle cannot undergo sustained tetanus like skeletal muscle is that cardiac muscle:

A Has no actin and myosin

B Has a long refractory period that overlaps contraction ✓

C Has no calcium in cells

D Is not excitable electrically

E Cannot produce ATP

▶ **Explanation:** Cardiac muscle action potentials have a long refractory period, preventing rapid restimulation and tetanus. This is essential so the heart can relax and refill between beats.

56 Which statement best compares the source of Ca^{2+} used for contraction in skeletal vs cardiac muscle?

A Both rely only on extracellular Ca^{2+} entering from blood

B Skeletal muscle relies mainly on Ca^{2+} release from the SR; cardiac muscle uses extracellular Ca^{2+} entry to help trigger SR release ✓

C Skeletal muscle cannot store Ca^{2+} in the SR

D Cardiac muscle has no SR at all

E Neither muscle type uses Ca^{2+} for contraction

▶ **Explanation:** Skeletal muscle contraction is driven mainly by SR Ca^{2+} release. Cardiac muscle requires Ca^{2+} entry from outside the cell to trigger further SR release (Ca-induced Ca release).

57 The 'latch state' (important in some smooth muscles) is useful because it allows:

A Rapid powerful contractions at very high ATP cost

B **Sustained tension with relatively low ATP consumption** ✓

C Contraction without any actin or myosin

D Muscles to store oxygen like hemoglobin

E Voluntary control of the heart rate

▶ **Explanation:** Smooth muscle can maintain tone (e.g., in blood vessels) with less ATP use than skeletal muscle, which is energy-efficient for long-lasting contractions.

58 Which receptor detects muscle stretch (length change) and helps trigger the stretch reflex?

A Golgi tendon organ

B **Muscle spindle** ✓

C Pacinian corpuscle (skin pressure)

D Photoreceptor

E Alveolus

▶ **Explanation:** Muscle spindles sense stretch/length changes. Golgi tendon organs sense tension, often helping protect against excessive force.

59 **Golgi tendon organs are most directly specialized to detect:**

- A Muscle fiber membrane potential
- B **Tension/force in the tendon during contraction** ✓
- C Light intensity in the retina
- D Blood glucose concentration
- E Temperature of the skin only

▶ **Explanation:** Golgi tendon organs are located at the muscle-tendon junction and respond to tension, contributing to reflex pathways that can inhibit contraction to prevent injury.

60 **Tendons have high tensile strength mainly because they are composed primarily of:**

- A **Dense regular connective tissue with parallel collagen fibers** ✓
- B Smooth muscle fibers arranged in sarcomeres
- C Cartilage with chondrocytes in lacunae
- D Keratinized epithelial cells
- E Nervous tissue with myelin

▶ **Explanation:** Tendons are dense regular connective tissue: collagen fibers are aligned in the direction of pull, making tendons strong in tension.

61 **An aponeurosis is best described as:**

- A **A flat, sheet-like tendon that attaches muscle to bone or to another muscle** ✓
- B A nerve ending that detects pain in the tendon
- C A type of cartilage at joints
- D The synapse between motor neuron and muscle
- E A region of the sarcomere where only actin is present

▶ **Explanation:** An aponeurosis is a broad, flat tendon-like connective tissue sheet. It transmits muscle force over a wide area.

62 **Which example best illustrates tendons storing and releasing elastic energy to improve movement efficiency?**

- A **Achilles tendon stretching and recoiling during running/jumping** ✓
- B Myosin detaching from actin using ATP
- C Acetylcholine being broken down in the synaptic cleft
- D Ribosomes translating protein in a muscle cell
- E Red blood cells carrying oxygen

▶ **Explanation:** Some tendons (notably the Achilles) behave like springs: they store elastic energy when stretched and release it to aid locomotion, reducing metabolic cost.

63 **In human biomechanics, the biceps brachii acting at the elbow is most commonly considered a third-class lever. This means:**

- A The load is between the fulcrum and effort

- B **The effort is between the fulcrum and load, favoring speed and range of motion over force ✓**
- C The fulcrum is between the load and effort, maximizing force
- D There is no fulcrum in the elbow joint
- E Third-class levers always maximize mechanical advantage for lifting heavy loads

▶ **Explanation:** In a third-class lever, the effort (muscle force) is applied between the joint (fulcrum) and the load (hand/weight). This increases speed and movement range but reduces mechanical advantage.

64 Which statement correctly describes the relationship between tendons and muscles during movement?

- A Tendons actively contract; muscles are passive cables
- B **Muscles generate force; tendons transmit that force to bones to produce movement ✓**
- C Bones generate force; tendons generate ATP
- D Tendons store DNA used to repair muscle
- E Tendons replace the need for motor neurons

▶ **Explanation:** Muscle contraction generates tension, which is transmitted through tendons to bones to rotate joints. Tendons do not actively contract like muscle.

65 Dystrophin (linked to certain muscular dystrophies) is important mainly because it:

- A Carries oxygen in muscle cytoplasm
- B **Links the muscle cell cytoskeleton to the membrane/extracellular matrix, helping protect fibers from damage during contraction ✓**
- C Is the neurotransmitter released at the neuromuscular junction

D Is the enzyme that breaks down acetylcholine

E Is the Ca^{2+} pump of the sarcoplasmic reticulum

▶ **Explanation:** Dystrophin is a structural support protein. Without it, the muscle membrane is more easily damaged during contractions, contributing to progressive weakness.

66 At the neuromuscular junction, what triggers acetylcholine release from the motor neuron terminal?

A **Ca^{2+} influx into the presynaptic terminal when the action potential arrives** ✓

B Na^{+} leaving the motor neuron terminal through ligand-gated channels

C ATP leaving the motor neuron terminal by diffusion

D Ca^{2+} binding to troponin in the muscle fiber

E Chloride entering the muscle cell nucleus

▶ **Explanation:** An arriving action potential opens voltage-gated Ca^{2+} channels in the motor neuron terminal. Ca^{2+} entry triggers vesicle fusion and ACh release by exocytosis.

67 Which statement about neuromuscular junctions in skeletal muscle is generally correct?

A One muscle fiber is normally controlled by many different motor neurons at the same time

B **Each skeletal muscle fiber typically has one neuromuscular junction, but a motor neuron can branch to innervate many fibers** ✓

C Skeletal muscles do not need motor neurons to contract

D Neuromuscular junctions use only electrical synapses (gap junctions)

E Acetylcholine is released from the muscle to stimulate the neuron

▶ **Explanation:** Typically, each skeletal muscle fiber has a single NMJ, but one motor neuron innervates multiple fibers (forming a motor unit). The NMJ is a chemical synapse.

68 Which sarcomere region contains ONLY thin (actin) filaments and no thick filaments?

- A A band
- B **I band** ✓
- C H zone
- D M line
- E All regions contain both filaments equally

▶ **Explanation:** The I band is thin-filament only. The A band contains thick filaments (and overlap regions). The H zone is thick-only (no thin overlap).

69 Which structure anchors thin filaments and forms the boundary of a sarcomere?

- A M line
- B **Z line (Z disc)** ✓
- C H zone
- D T-tubule
- E Intercalated disc

▶ **Explanation:** Thin filaments attach to Z lines, which define the edges of a sarcomere. The M line is in the center of the sarcomere where thick filaments are anchored.

70 **A person completely tears the Achilles tendon. Which statement is MOST accurate about the immediate effect on the associated calf muscles?**

- A The calf muscles cannot generate force at all because actin and myosin stop working
- B **The calf muscles may still contract internally, but their force cannot be effectively transmitted to the foot for normal plantarflexion** ✓
- C Only the bones stop working; tendons are not involved in movement
- D The neuromuscular junction stops releasing acetylcholine immediately because the tendon is torn
- E The sarcomeres in the calf muscles permanently disappear

▶ **Explanation:** A tendon rupture interrupts force transmission from muscle to bone. The muscle's contractile machinery can still activate, but movement is impaired because the 'cable' to the bone is broken.