

Muscle

(revised 2011)

General Principles for Skeletal, Cardiac, and Smooth Muscle

MU 1. Explain the overall transmembrane signaling steps whereby increases in cytosolic calcium initiate crossbridge cycling.

MU 2. Identify the multiple sources, localization, and roles of calcium in muscle contraction and relaxation.

MU 3. Draw a myosin molecule and label the subunits (heavy chains, light chains) and describe the function of the subunits.

MU 4. Diagram the structure of the thick and thin myofilaments and label the constituent proteins.

MU 5. Diagram the chemical and mechanical steps in the cross-bridge cycle, and explain how the cross-bridge cycle results in shortening of the muscle.

MU 6. Explain the relationship of preload, afterload and total load in the time course of an isotonic contraction.

MU 7. Distinguish between an isometric and isotonic contraction.

MU 8. Draw the length versus force diagram for muscle and label the three lines that represent passive (resting), active, and total force. Describe the molecular origin of these forces in the three muscle types.

MU 9. Explain the interaction of the length:force and the force:velocity relationships and how they vary in the three muscle types.

MU 10. List the energy sources of muscle contraction and rank the sources with respect to their relative speed and capacity to supply ATP for contraction and how they are different in the three muscle types.

Skeletal Muscle Structure and Mechanism of Contraction

MU 11. Draw and label a skeletal muscle at all anatomical levels, from the whole muscle to the molecular components of the sarcomere. At the sarcomere level, include at least two different stages of myofilament overlap.

MU 12. Describe the relationship of the myosin-thick filament bare zone to the shape of the active length:force relationship.

Control of Skeletal Muscle Contraction: Excitation-Contraction Coupling and Neuromuscular Transmission

MU 13. List the steps in excitation-contraction coupling in skeletal muscle, and describe the roles of the sarcolemma, transverse tubules, sarcoplasmic reticulum, thin filaments, and calcium ions.

MU 14. Describe the roles of ATP in skeletal muscle contraction and relaxation.

MU 15. Draw the structure of the neuromuscular junction.

MU 16. List in sequence the steps involved in neuromuscular transmission in skeletal muscle and point out the location of each step on a diagram of the neuromuscular junction.

MU 17. Distinguish between an endplate potential and an action potential in skeletal muscle.

MU 18. List the possible sites for blocking neuromuscular transmission in skeletal muscle and provide an example of an agent that could cause blockage at each site.

Mechanics and Energetics of Skeletal Muscle Contraction

MU 19. Distinguish between a twitch and tetanus in skeletal muscle and explain why a twitch is smaller in amplitude than tetanus and the continuum of force development between a twitch and tetanus including the intracellular events.

MU 20. Draw force versus velocity relationships for two skeletal muscles of equal maximum force generating capacity but of different maximum velocities of shortening.

MU 21. Using a diagram, relate the power output of skeletal muscle to its force versus velocity relationship.

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MU 22. Describe the influence of skeletal muscle tendons on contractile function.

MU 23. Define muscular fatigue. List some intracellular factors that can cause fatigue.

MU 24. Construct a table of structural, enzymatic, and functional features of the three major categories (fast-glycolytic, fast-oxidative-glycolytic, and slow-oxidative fiber types) of skeletal muscle fiber types and their relative plasticity.

MU 25. Describe the role of the myosin crossbridges acting in parallel to determine active force and the rate of crossbridge recycling to determine muscle speed of shortening and rate of ATP utilization during contraction.

MU 26. Describe how the origin and insertion of a skeletal muscle to the skeleton can influence mechanical performance of the muscle.

MU 27. Define a motor unit and describe the order of recruitment of motor units during skeletal muscle contraction of varying strengths.

Smooth Muscle

MU 28. Describe the differences in actomyosin regulation of, respectively, smooth and skeletal muscle and indicate the structural similarities in their respective contractile units.

MU 29. Explain why smooth muscles can develop and maintain force with a much lower rate of ATP hydrolysis than skeletal muscle.

MU 30. Distinguish between muscle relaxation from the contracted state and the phenomenon of stress relaxation and give examples of each process.

MU 31. Diagram the intracellular pathways that control contraction and relaxation in smooth muscle. Distinguish between electromechanical coupling and pharmacomechanical coupling.

MU 32. Describe the distinguishing characteristics of multi-unit and unitary smooth muscles.

MU 33. Describe the mechanisms responsible for myofilament calcium sensitization and desensitization.

MU 34. Describe the plasticity of smooth muscle to chronic stimuli such as pregnancy and exercise.

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Cardiac Muscle

MU 35. Diagram the relationship between the timing of the action potential and a twitch in cardiac muscle and explain why this prevents tetanic contraction.

MU 36. Diagram the steps in the excitation-contraction coupling mechanism in cardiac muscle and compare with skeletal muscle including different mechanisms for sarcoplasmic reticulum calcium release.

MU 37. On the length versus force diagram show how an increase in contractility changes the relationship between afterload and amount of shortening.

MU 38. Describe the mechanisms through which inotropic interventions change cardiac contractility.

MU 39. Describe the physiological consequences of the low-resistance, gap junction pathways between cardiac muscle cells.