

**The American Physiological Society  
Medical Curriculum Objectives Project**

Complete curriculum objectives available at:  
<http://www.the-aps.org/education/MedPhysObj/medcor.htm>

## **Muscle**

### **Skeletal Muscle Structure and Mechanism of Contraction**

- MU 1. 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 two different stages of myofilament overlap.
- MU 2. Draw a myosin molecule and label the subunits (heavy chains, light chains) and describe the function of the subunits.
- MU 3. Diagram the structure of the thick and thin myofilaments and label the constituent proteins.
- MU 4. Describe the relationship of the myosin-thick filament bare zone to the shape of the active length:force relationship.
- 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.

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

- MU 6. 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 7. Describe the roles of ATP in skeletal muscle contraction and relaxation.
- MU 8. Draw the structure of the neuromuscular junction.
- MU 9. 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 10. Distinguish between an endplate potential and an action potential in skeletal muscle.
- MU 11. 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 12. Explain the relationship of preload, afterload and total load in the time course of an isotonic contraction.

MU 13. Distinguish between an isometric and isotonic contraction.

MU 14. Distinguish between a twitch and a tetanus in skeletal muscle and explain why a twitch is smaller in amplitude than a tetanus.

MU 15. 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.

MU 16. Explain the interaction of the length:force and the force:velocity relationships.

MU 17. Draw force versus velocity relationships for two skeletal muscles of equal maximum force generating capacity but of different maximum velocities of shortening.

MU 18. Using a diagram, relate the power output of skeletal muscle to its force versus velocity relationship.

MU 19 Describe the influence of skeletal muscle tendons on contractile function.

MU 20. List the energy sources of muscle contraction and rank the sources with respect to their relative speed and capacity to supply ATP for contraction.

MU 21. Define muscular fatigue. List some intracellular factors that can cause fatigue.

MU 22. Construct a table of structural, enzymatic, and functional features of fast-glycolytic and slow-oxidative fiber types from skeletal muscle.

MU 23. 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 24. Discuss the functional consequences of the parallel and series arrangement of myofibrils in a skeletal muscle.

MU 25. Describe how the arrangement of a skeletal muscle to the skeleton can influence mechanical performance of the muscle.

MU 26. Define a motor unit and describe the order of recruitment of motor units during skeletal muscle contraction of varying strengths.

## **Smooth Muscle**

- MU 27. Describe the differences in actomyosin regulation of, respectively, smooth and skeletal muscle and indicate the structural similarities in their respective contractile units.
- MU 28. Compare and contrast the length versus force relationships in skeletal and smooth muscle. Describe the functional implications of the differences observed.
- MU 29. Compare and contrast the force versus velocity relationships in skeletal and smooth muscle. Describe the primary cause for the observed differences in velocity of shortening.
- MU 30. Explain why smooth muscles can develop and maintain force with a much lower rate of ATP hydrolysis than skeletal muscle.
- MU 31. Distinguish between muscle relaxation from the contracted state and the phenomenon of stress relaxation and give examples of each process.
- MU 32. Diagram the intracellular pathways that control contraction and relaxation in smooth muscle.
- MU 33. Describe the distinguishing characteristics of multi-unit and unitary smooth muscles.

## **Cardiac Muscle**

- MU 34. Describe the structure of cardiac muscle cells, comparing and contrasting it with that of smooth and skeletal muscle cells. Describe the physiological consequences of the low-resistance pathways between cardiac muscle cells.
- MU 35. Diagram the relationship between the action potential and a twitch in cardiac muscle and explain why this prevents a tetanic contraction.
- MU 36. Diagram the steps in the excitation-contraction coupling mechanism in cardiac muscle and compare with skeletal muscle.
- MU 37. Diagram the length versus force curve for cardiac muscle and skeletal muscle, showing the active and passive relationships, and indicate the range over which each muscle type performs its physiological function.
- MU 38. Define contractility in cardiac muscle. On the length versus force diagram, indicate the pathway for an isotonic contraction of cardiac muscle and show how an increase in contractility changes the relationship between afterload and amount of shortening.
- MU 39. List some inotropic interventions that could change cardiac contractility.