Characteristics of Skeletal Muscle

striated, voluntary

multiple nuclei

multiple mitochondria

attached to bones of skeleton

makes up 40% of the body in men, 32% in women

clusters of long, thick, cylindrically-shaped cells

(Skeletal Muscle Physiology I Slide 5, 9)

Sarcomere Structural Components

Thick Filament: myosin protein molecules in bundle formation. Elongated fiber arrangment

Myosin: fibrous cytoskeleton protein. Made up of two interconnected components (long intertwinining tail, globular head)

Thin Filament: a structure composed of actin, tropomyosin, and troponin that forms a double-helical strand (double-helical strand is elongated)

Actin: globular cytoskeleton protein consisting of two long chains. The pair of chains are arranged in a double-helical strand formation

Tropomyosin: paired fibrous protein filaments that align to fit into the grooves created by the actin double-helical strand

Troponin: a protein complex consisting of one segment that attaches itself to actin, one sement that attaches itself to tropomyosin, and one segment that adheres to Ca++

Z-Line: defines the sarcomere boundary and acts as a site for thin filament attachment

A Band: region that contains thick filaments. Contains overlapping portions of thin filaments

I Band: portion of thin filaments that lie outside of the A band with zero overlap

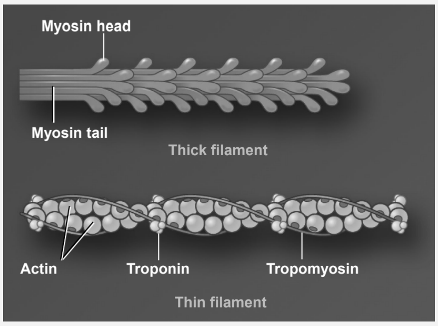
H Zone: only thick filaments present. Area of A band with zero overlap of thin filaments

Sarcomere Structural Components (cont)

M Line: runs through midpoint of A band (down vertically). Lies centrally in the H zone region

(Skeletal Muscle Physiology I; Skeletal Muscle Physiology II)

Thin vs. Thick Filament



Thick filament (myosin) composed of long intertwining tail and a protruding globular head that enables cross-bridge binding. Thin filament (actin) composed of actin, tropomyosin, and troponin
(Skeletal Muscle Physiology I Slide 22)

Skeletal Muscle Energy Metabolism (3 Sources)

1) Creatine Phosphate

2) Oxidative Phosphorylation

3) Glycolysis

(Skeletal Muscle Physiology III Slide 78-79)

Creatine Phosphate

Acts as first energy reserve (quick enery reserve when muscle immediately demands ATP))

Creatine phosphate undergoes hydrolysis (phosphate group broken off). Energy releases from hydrolysis, phosphate is used for ADP and transformed into ATP which can then be used for muscles

Because system is short-lived, it supplies any additional ATP when exercise BEGINS (up to a minute)

(Skeletal Muscle Physiology III Slide 100)

Oxidative Phosphorylation

Requires oxygen (aerobic). Primary energy source for sustained/endurance activities

ATP generation relatively slow, but very efficient (makes lots)

Ideal supply of energy for prolonged muscle exertion/contraction (light to moderate activity at an endured rate)

(Skeletal Muscle Physiology III Slide 101)

Glycolysis

Kicks in when oxidative phosphorylation can't keep up with supplying ATP for exercise/activity

Quick production of ATP, but very inefficient

Supports high-intensity exercise that require short bursts of energy

(Skeletal Muscle Physiology III Slide 102)

Cross-Bridge Activity of Skeletal Muscle

1) Binding: myosin cross bridge connects to the actin. Myosin ATPase splits myosin. ADP and Pi remain stay bound to myosin. Cross-bridge stores energy

2) Power Stroke: thin filament drawn in toward the middle as the cross-bridge bends, pulling it toward center of thick filament. Ca++ is released into sarcoplasm upon excitation. Actin no longer blocked, allowing for attachment of the cross-bridge to occur

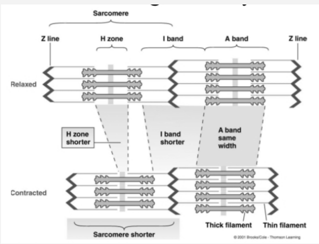
3) Detachment: cross-bridge breaks off once the end of power stroke has been reached, and then returns to initial position. Link between actin and myosin breaks as new ATP binds to myosin cross-bridge. ATP becomes hydrolyzed

4) Binding: cross bridge binds to further actin molecule (not from exact same spot), then the cycle repeats

Cross-Bridge Activity of Skeletal Muscle (cont)

(Skeletal Muscle Physiology I Slide 26; Skeletal Muscle Physiology II Slide 49)

Cross-Bridge Effects on Muscle Contraction



Comparison of cross bridge activity effects on a relaxed muscle versus contracted muscle
(Skeletal Muscle Physiology I Slide 27)

Cross-Bridge Effects on Muscle Contraction

1) Sarcomere shortens

2) H zone shortens

3) I band shortens

4) A band remains the same width

5) Individual actin and myosin fibers maintain the same length

(Skeletal Muscle Physiology I Slide 27)

Role of ATP in Skeletal Muscle Contraction

1) Myosin ATPase splits ATP (energy stored in cross bridge)

2) Excitation allows for release of Ca++, thus relieving actin of any inhibition

3) Power stroke occurs on cross-bridge, releasing ADP and Pi

4) Fresh ATP becomes bound to myosin, breaking the link between myosin and actin

(Skeletal Muscle Physiology II Slide 58)

Excitation-Contraction Coupling

1) Axon releases ACh (axon of motor neuron). ACh binds to motor end plate receptors

2) ACh trigger action potential (caused by binding of ACh to receptors). End plate potential diffuses across membrane, down T-tubules

3) Sarcoplasmic retitculum releases Ca++ (occurs AFTER stimulation of the action potential)

4) Tropomyosin moves to side (out of the way) as Ca++ binds to troponin (on actin filaments). Cross-bridge binding site on actin becomes exposed

5) Myosin cross-bridges bind to actin, causing filaments to pull inward (bending). Bending of actin filaments is powered via ATP

6) Sarcoplasmic reticulum reabsorbs Ca++ (when action potentials are no longer fired)

7) Tropomyosin re-covers cross-bridge binding sites on actin (return to original position)

(Skeletal Muscle Physiology II Slide 57)

Skeletal Muscle Types

1) Slow Oxidative (type I)

2) Fast Oxidative (type IIa)

3) Fast Glycolytic (type IIb)

(Skeletal Muscle Physiology III Slide 82)

Slow Oxidative (type I)

Slow contractions

Heavy reliance on oxidative phosphorylation for ATP

Abundance of mitochondria, high blood supply, high myoglobin levels

(Skeletal Muscle Physiology III Slide 82)

Fast Oxidative (type IIa)

Rapid, relatively efficient contraction

Predominantly fueled via oxidative phosph-orylation/aerobic energy processes

Abundance of mitochondria, high blood supply, rich in myoglobin

(Skeletal Muscle Physiology III Slide 82)

Fast Glycolytic (type IIb)

Very rapid, quick contraction (fastest of the three types)

Heavy reliance on glycolysis as a source of ATP

Low abundance of mitochondria, lower blood supply, lower myoglobin levels, but rich in muscle glycogen

(Skeletal Muscle Physiology III Slide 82)

Works Cited

Skeletal Muscle Physiology I (A. Gomes)

Skeletal Muscle Physiology II (A. Gomes)

Skeletal Muscle Physiology III (A. Gomes)