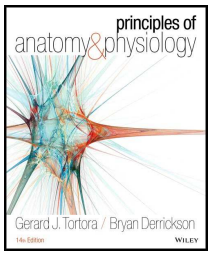


Principles of Anatomy and Physiology

14th Edition

CHAPTER 10
Muscular Tissue

Introduction

The purpose of the chapter is to:

1. Learn about the structure and function of the 3 types of muscular tissue
2. Examine the events at the neuromuscular junction
3. Describe energy use in muscle cells
4. Understand how muscle tension is controlled

3 Types of Muscular Tissue

1. Skeletal muscle
2. Cardiac muscle
3. Smooth muscle

3 Types of Muscle

Anatomy Overview:

- The Muscular System: Skeletal, Cardiac, and Smooth Muscle

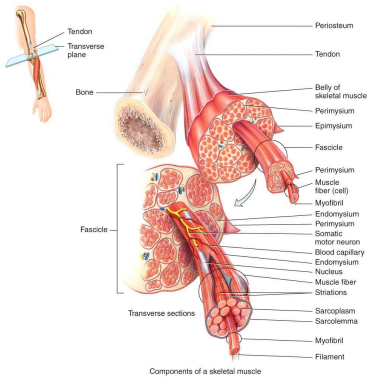
You must be connected to the Internet and in Slideshow Mode to run this animation.

Three Types of Muscular Tissue

	Location	Function	Appearance	Control
Skeletal [Insert skeletal muscle image from Table 10.5, pg 321]	skeleton	move bones	multi-nucleated & striated	voluntary
Cardiac [Insert cardiac muscle image from Table 10.5, pg 321]	heart	pump blood	one nucleus, striated, & intercalated discs	involuntary
Visceral (smooth muscle) [Insert smooth muscle image from Table 10.5, pg 321]	various organs, example: GI tract	various functions, example: peristalsis	one nucleus & no striations	involuntary

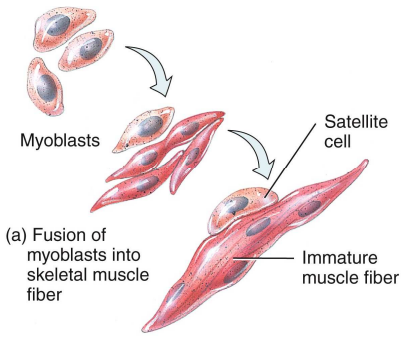
More About Skeletal Muscle Tissue

Muscle Tissue Components

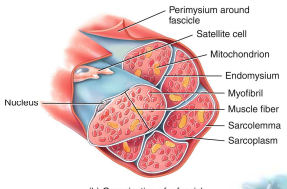


Components of a skeletal muscle

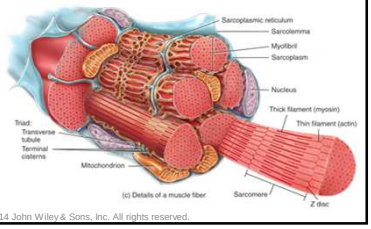
How are Muscles Formed?



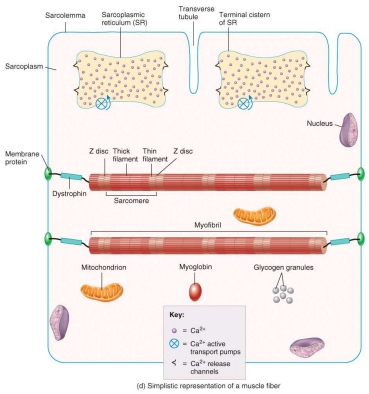
Microscopic Anatomy of a Muscle



(b) Organization of a fascicle

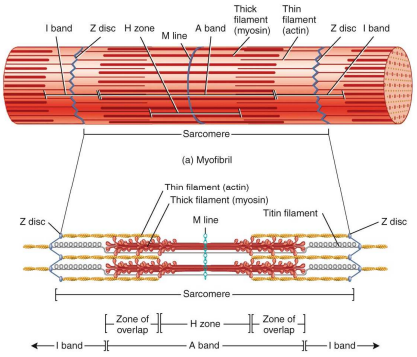


Microscopic Anatomy of a Muscle



(d) Simplistic representation of a muscle fiber

The Arrangement of a Sarcomere



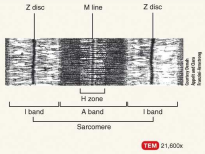
(b) Details of filaments and Z discs

Components of a Sarcomere

TABLE 10.1

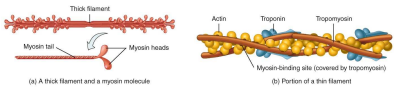
Components of a Sarcomere

COMPONENT	DESCRIPTION
Z discs	Narrow, plate-shaped regions of dense material that separate one sarcomere from the next.
A band	Dark, middle part of sarcomere that extends entire length of thick filaments and includes those parts of thin filaments that overlap thick filaments.
I band	Lighter, less dense area of sarcomere that contains remainder of thin filaments but no thick filaments. A Z disc passes through center of each I band.
H zone	Narrow region in center of each A band that contains thick filaments but no thin filaments.
M line	Region in center of H zone that contains proteins that hold thick filaments together at center of sarcomere.



Muscle Proteins

Contractile	Regulatory	Structural
Myosin	Troponin	Titin
Actin	Tropomyosin	Nebulin
		Alpha-actin
		Myomesin
		Dystrophin

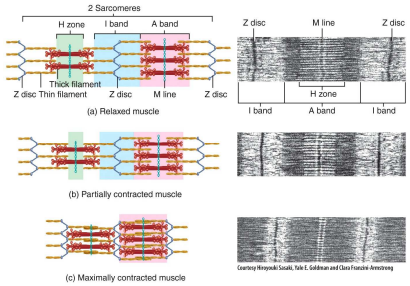


The Sliding Filament Mechanism

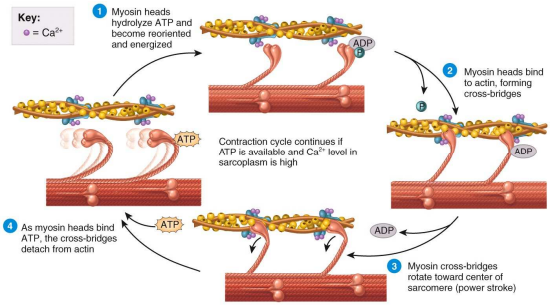
- Myosin pulls on actin, causing the thin filament to slide inward
- Consequently, Z discs move toward each other and the sarcomere shortens
- Thanks to the structural proteins, there is a transmission of force throughout the entire muscle, resulting in whole muscle contraction

Sliding Filament Mechanism

Note the changes in the I band and H zone as the muscle contracts



The Contraction Cycle



The Contraction Cycle

Interactions Animation:

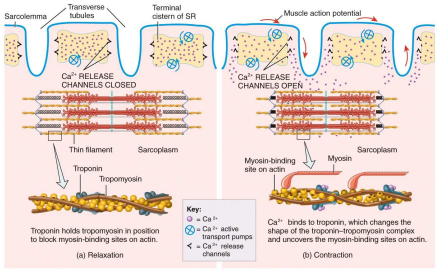
- Contraction of Skeletal Muscle Cells

The neuromuscular junction, parts of a muscle fiber, and the contraction cycle

You must be connected to the Internet and in Slideshow Mode to run this animation.

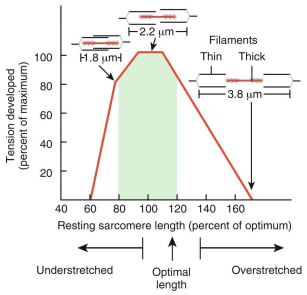
Excitation-Contraction Coupling

This concept connects the events of a muscle action potential with the sliding filament mechanism



Length-Tension Relationship

The force of a muscle contraction depends on the length of the sarcomeres prior to the contraction



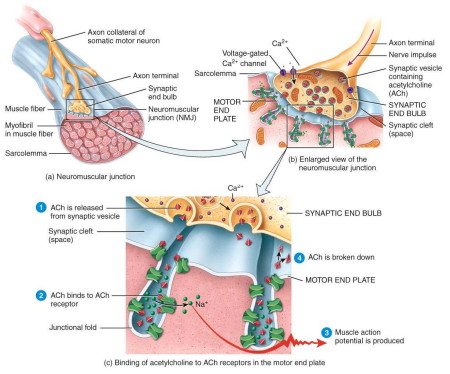
The Neuromuscular Junction (NMJ)

The events at the NMJ produce a muscle action potential

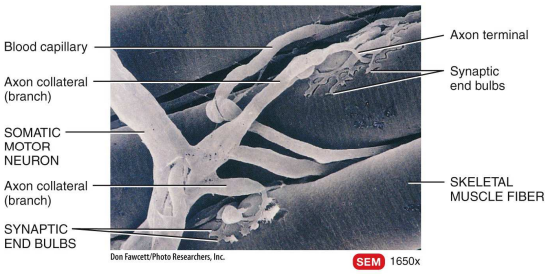
- Voltage-gated calcium channels open resulting in an influx of calcium. This causes exocytosis of neurotransmitter (NT) into the synaptic cleft. NT binds to ligand-gated Na^+ channels on the motor endplate which cause an influx of Na^+ into the muscle. This depolarizes it and results in Ca^{2+} release from the SR
- NT gets broken down

Without this series of events, muscle contraction would not be possible

The Neuromuscular Junction

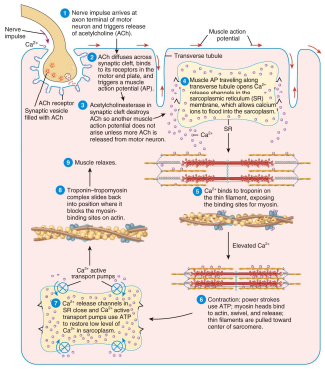


The Neuromuscular Junction



(d) Neuromuscular junction

The Neuromuscular Junction



Events at the NMJ

Interactions Animation:

- Neuromuscular Junctions

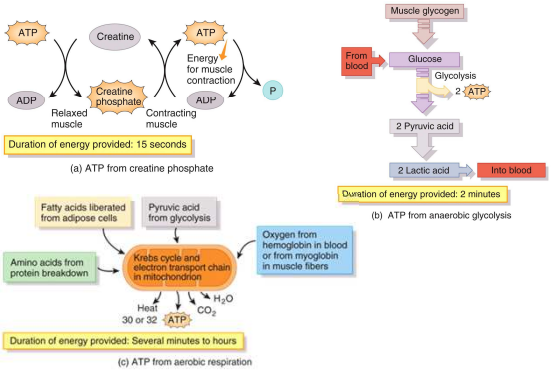
You must be connected to the Internet and in Slideshow Mode to run this animation.

Muscle Metabolism

How do muscles derive the ATP necessary to power the contraction cycle?

- Creatine phosphate
- Anaerobic glycolysis
- Cellular respiration

Production of ATP in Skeletal Muscle



Energy Sources and Fatigue

Interactions Animation:

- Muscle Metabolism

Role of ATP in Muscle Movement and Fatigue

You must be connected to the Internet and in Slideshow Mode to run this animation.

Muscle Fatigue

The inability to maintain force of contraction after prolonged activity

Due to:

- Inadequate release of Ca^{2+} from SR
- Depletion of CP, oxygen, and nutrients
- Build up of lactic acid and ADP
- Insufficient release of ACh at NMJ

Oxygen Consumption After Exercise

Why do you continue to breathe heavily for a period of time after stopping exercise?

Oxygen debt

- Replenish CP stores
- Convert lactate into pyruvate
- Reload O_2 onto myoglobin

Control of Muscle Tension

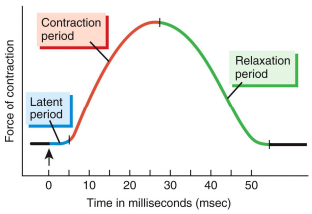
A motor unit consists of a somatic motor neuron and the muscle fibers it innervates

- The strength of a contraction depends on how many motor units are activated

Twitch Contraction

The brief contraction of all muscle fibers in a motor unit in response to a single action potential

- Latent period
- Contraction period
- Relaxation period
- Refractory period



Frequency of Stimulation

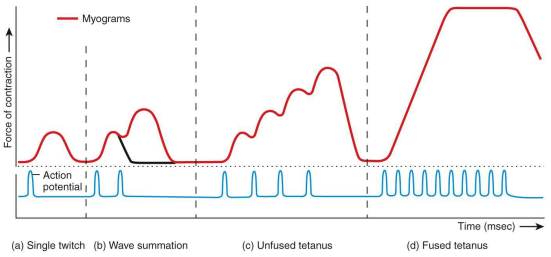
Wave summation occurs when a second action potential triggers muscle contraction before the first contraction has finished

- Results in a stronger contraction

Unfused tetanus

Fused tetanus

Myograms



Motor Unit Recruitment

Motor units recruitment is the process in which the number of active motor units increases

- Weakest motor units are recruited first followed by stronger motor units
- Motor units contract alternately to sustain contractions for longer periods of time

Factors That Influence Tension

Interactions Animation:

- Control of Muscle Tension

You must be connected to the Internet and in Slideshow Mode to run this animation.

Muscle Tone

Even when at rest, a skeletal muscle exhibits a small amount of tension, called tone

- Due to weak, involuntary contraction of motor units

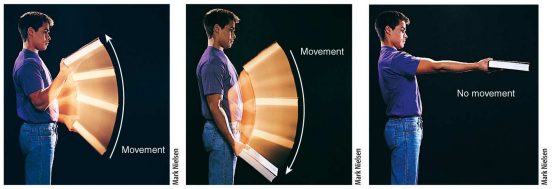
Isotonic vs. Isometric Contractions

Isotonic – tension is constant while muscle length changes

- Concentric
- Eccentric

Isometric – muscle contracts but does not change length

Isotonic vs. Isometric Contractions



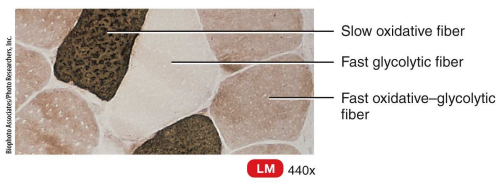
(a) Concentric contraction while picking up a book

(b) Eccentric contraction while lowering a book

(c) Isometric contraction while holding a book steady

Skeletal Muscle Fiber Types

- Slow oxidative
- Fast oxidative glycolytic
- Fast glycolytic



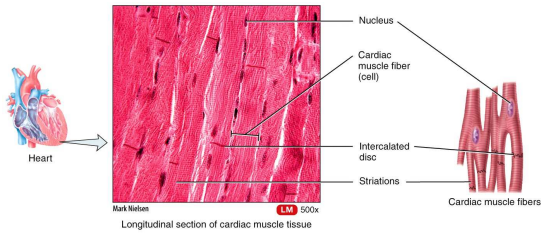
Transverse section of three types of skeletal muscle fibers

Exercise and Skeletal Muscle Tissue

- Stretching
- Strength Training

Cardiac Muscle

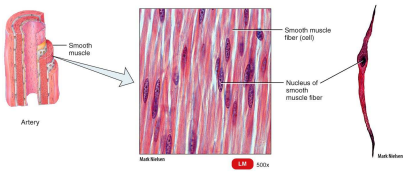
Cardiac muscle has the same arrangement as skeletal muscle, but also has intercalated discs



Longitudinal section of cardiac muscle tissue

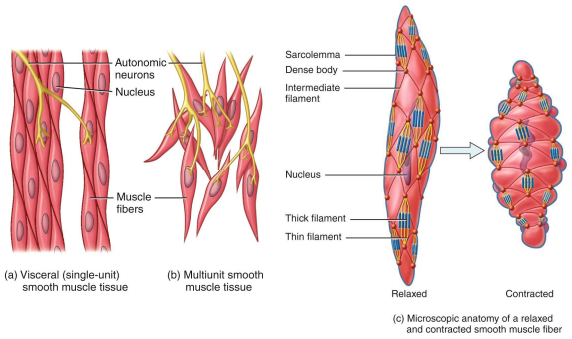
Smooth Muscle

- Smooth muscle contractions start more slowly and last longer than skeletal and cardiac muscle contractions
- Smooth muscle can shorten and stretch to a greater extent



Longitudinal section of smooth muscle tissue

Smooth Muscle

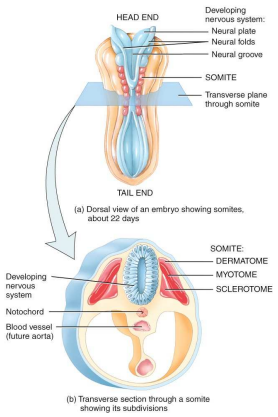


Regeneration of Muscle Tissue

Mature skeletal muscle fibers cannot undergo mitosis

- Hypertrophy
- Hyperplasia
- Smooth muscle and pericytes

Development of Muscle



Aging and Muscle Tissue

Between 30–50 years of age, about 10% of our muscle tissue is replaced by fibrous connective tissue and adipose tissue. Between 50–80 years of age another 40% of our muscle tissue is replaced. Consequences are:

- Muscle strength and flexibility decreases
- Reflexes slow
- Slow oxidative fiber numbers increase

End of Chapter 10