An Introduction to Muscle Tissue

• Muscle Tissue
  – A primary tissue type, divided into
    • Skeletal muscle
    • Cardiac muscle
    • Smooth muscle
An Introduction to Muscle Tissue

• Skeletal Muscles
  – Are attached to the skeletal system
  – Allow us to move
  – The muscular system
    • Includes only skeletal muscles
7-1 Skeletal muscle performs five primary functions
Functions of Skeletal Muscles

• Produce movement of the skeleton
• Maintain posture and body position
• Support soft tissues
• Guard entrances and exits
• Maintain body temperature
7-2 A skeletal muscle contains muscle tissue, connective tissues, blood vessels, and nerves
Skeletal Muscle Structures

- Muscle tissue (muscle cells or fibers)
- Connective tissues
- Blood vessels and nerves
Muscles have three layers of connective tissues

- **Epimysium:**
  - Separates muscle from surrounding tissues

- **Perimysium:**
  - Surrounds muscle fiber bundles (fascicles)

- **Endomysium:**
  - Surrounds individual muscle cells (muscle fibers)
The Organization of a Skeletal Muscle

Figure 7-1
Organization of Connective Tissues

- Muscle attachments
  - Endomysium, perimysium, and epimysium come together:
    - To form a tendon (bundle) or aponeurosis (sheet)
Blood Vessels and Nerves

• **Nerves**
  – Skeletal muscles are voluntary muscles, controlled by nerves of the central nervous system (brain and spinal cord)

• **Blood Vessels**
  – Muscles have extensive vascular systems that:
    • Supply large amounts of oxygen and nutrients
    • Carry away wastes
7-3 Skeletal muscle fibers have distinctive features
Skeletal Muscle Fibers

- **The sarcolemma**
  - The cell membrane of a muscle fiber (cell)
  - Surrounds the *sarcoplasm* (cytoplasm of muscle fiber)
  - A change in transmembrane potential begins contractions

- **Transverse tubules (T tubules)**
  - Transmit *action potential* through cell
  - Allow entire muscle fiber to contract simultaneously
  - Have same properties as sarcolemma
Skeletal Muscle Fibers

• Myofibrils
  – Subdivisions within muscle fiber
  – Made up of bundles of protein filaments (myofilaments):
    • Myofilaments are responsible for muscle contraction
  – Types of myofilaments:
    • Thin filaments:
      – made of the protein actin
    • Thick filaments:
      – made of the protein myosin
• **The sarcoplasmic reticulum (SR)**
  - A membranous structure surrounding each myofibril
  - Helps transmit **action potential** to myofibril
  - Forms chambers (**terminal cisternae**) attached to T tubules
  - **Triad:**
    - Is formed by one **T tubule** and two **terminal cisternae**
    - Cisternae:
      - concentrate Ca^{2+} (**via** ion pumps)
      - release Ca^{2+} into **sarcomeres** to begin muscle contraction
Organization of a Skeletal Muscle Fiber

Figure 7-2a

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Skeletal Muscle Fibers

• **Sarcomeres**
  – The contractile units of muscle
  – Structural units of *myofibrils*
  – Form visible patterns within myofibrils

• **Muscle striations**
  – A striped or *striated* pattern within myofibrils:
    • Alternating dark, **thick filaments** (A bands) and light, **thin filaments** (I bands)
Skeletal Muscle Fibers

• **Sarcomeres**
  – **Zone of overlap:**
    • The densest, darkest area on a light micrograph
    • Where thick and thin filaments overlap
  – **The H Band:**
    • The area around the M line
    • Has thick filaments but no thin filaments
Organization of a Skeletal Muscle Fiber

Figure 7-2 b-c

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Skeletal Muscle Fibers

• Sarcomere Function
  – Transverse tubules encircle the sarcomere near zones of overlap
  – Ca\(^{2+}\) released by SR causes thin and thick filaments to interact
Skeletal Muscle Fibers

• Muscle Contraction
  – Is caused by interactions of thick and thin filaments
  – Structures of protein molecules determine interactions
Skeletal Muscle Fibers

• Thin and Thick Filaments
  – Thin filaments:
    • F-actin (filamentous actin):
      – two twisted rows of globular G-actin
    • Tropomyosin;
      – prevents actin–myosin interaction
    • Troponin:
      – controlled by Ca\(^{2+}\)
  – Thick filaments:
    • Contain twisted myosin subunits
    • Tail:
      – binds to other myosin molecules
    • Head:
      – made of two globular protein subunits
      – reaches the nearest thin filament
Organization of a Skeletal Muscle Fiber

Figure 7-2 c–e
Skeletal Muscle Fibers

• Thin and Thick Filaments
  – $\text{Ca}^{2+}$ binds to receptor on troponin molecule
  – Troponin–tropomyosin complex changes
  – Exposes active site of F-actin
Skeletal Muscle Fibers

• Sliding filament theory
  – Thin filaments of sarcomere slide toward M line, alongside thick filaments
  – The width of the A zone remains the same
  – Z lines move closer together
Figure 7-3
Sarcomere Shortening

Figure 7-3
(b) Contraction and filament sliding

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7-4 Communication between the nervous system and skeletal muscles occurs at neuromuscular junctions
The Neuromuscular Junction

- Action potential (electrical signal)
  - Travels along nerve axon
  - Ends at synaptic terminal:
    - Synaptic terminal:
      - Releases neurotransmitter (acetylcholine or ACh)
      - Into the synaptic cleft (gap between synaptic terminal and motor end plate)
Figure 7-4 a
Structure and Function of the Neuromuscular Junction

Figure 7-4 b

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Figure 7-4
**Figure 7-4**

**STEP 2** Release of acetylcholine

Vesicles in the synaptic terminal fuse with the neuronal membrane and dump their contents into the synaptic cleft.

**STEP 3** ACh binding at the motor end plate

The binding of ACh to the receptors increases the membrane permeability to sodium ions. Sodium ions then rush into the cell.
Figure 7-4

**STEP 4** Appearance of an action potential in the sarcolemma

An action potential spreads across the surface of the sarcolemma. While this occurs, AChE breaks down the ACh.

**STEP 5** Return to initial state

If another action potential arrives at the NMJ, the cycle begins again at step 1.
The Contraction Cycle

• Five Steps of the Contraction Cycle
  – Exposure of active sites
  – Formation of cross-bridges
  – Pivoting of myosin heads
  – Detachment of cross-bridges
  – Reactivation of myosin
Molecular Events of the Contraction Process

Figure 7-5
Molecular Events of the Contraction Process

Figure 7-5

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Molecular Events of the Contraction Process

Figure 7-5

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Molecular Events of the Contraction Process

Figure 7-5
Molecular Events of the Contraction Process

Figure 7-5
Molecular Events of the Contraction Process

Figure 7-5
The Contraction Cycle

• Relaxation
  – $\text{Ca}^{2+}$ concentrations decrease
  – $\text{Ca}^{2+}$ detaches from troponin
  – Active sites are re-covered by tropomyosin
**Steps That Start a Contraction**

1. ACh released, binding to receptors
2. Action potential reaches T tubule
3. Sarcoplasmic reticulum releases Ca^{2+}
4. Active site exposure, cross-bridge formation
5. Contraction begins

**Steps That End a Contraction**

6. ACh broken down by AChE
7. Sarcoplasmic reticulum recaptures Ca^{2+}
8. Active sites covered, no cross-bridge interaction
9. Contraction ends
10. Relaxation occurs, passive return to resting length
7-5 Sarcomere shortening and muscle fiber stimulation produce tension
Tension Production

• The all-or-none principle
  – As a whole, a muscle fiber is either contracted or relaxed

• Tension of a Single Muscle Fiber
  – Depends on:
    • The number of pivoting cross-bridges
    • The fiber’s resting length at the time of stimulation
    • The frequency of stimulation
Frequency of Muscle Fiber Stimulation

- A single neural stimulation produces
  - A single contraction or twitch
  - Which lasts about 7–100 msec
- Sustained muscular contractions
  - Require many repeated stimuli
Frequency of Muscle Fiber Stimulation

• Three Phases of Twitch
  – **Latent period before contraction:**
    • The action potential moves through sarcolemma
    • Causing Ca^{2+} release
  – **Contraction phase:**
    • Calcium ions bind
    • Tension builds to peak
  – **Relaxation phase:**
    • Ca^{2+} levels fall
    • Active sites are covered
    • Tension falls to resting levels
Twitch and Development of Tension

Figure 7-6

- **Stimulus**
- **Resting phase**
- **Contraction phase**
- **Relaxation phase**
- **Latent period**
- **Maximum tension development**
Frequency of Muscle Fiber Stimulation

• Summation and Incomplete Tetanus
  – Wave summation:
    • Increasing tension or summation of twitches
    • Repeated stimulations before the end of the relaxation phase:
      – causes increasing tension or summation of twitches
  – Incomplete tetanus:
    • Twitches reach maximum tension
    • If rapid stimulation continues and muscle is not allowed to relax, twitches reach maximum level of tension
Effects of Repeated Stimulations

Figure 7-7
Frequency of Muscle Fiber Stimulation

• Complete Tetanus
  – If stimulation frequency is high enough, muscle never begins to relax, and is in continuous contraction
Effects of Repeated Stimulations

(c) Complete tetanus

Figure 7-7
Number of Muscle Fibers Activated

• Motor units in a skeletal muscle
  – Contain hundreds of muscle fibers
  – Controlled by a single motor neuron
Number of Muscle Fibers Activated

- **Recruitment (multiple motor unit summation)**
  - In a whole muscle or group of muscles, **smooth motion** and increasing tension are produced by slowly increasing the size or number of motor units stimulated.

- **Maximum tension**
  - Achieved when all motor units reach tetanus
  - Can be sustained only a very short time
Motor Units

Figure 7-8

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Number of Muscle Fibers Activated

- **Muscle tone**
  - The normal tension and firmness of a muscle at rest
  - Muscle units actively maintain body position, without motion
  - Increasing muscle tone increases metabolic energy used, even at rest
Number of Muscle Fibers Activated

• Isotonic and Isometric Contractions
  
  – Isotonic contraction:
    
    • Skeletal muscle changes length:
      – resulting in motion
    
    • If muscle tension > load (resistance):
      – muscle shortens (concentric contraction)
    
    • If muscle tension < load (resistance):
      – muscle lengthens (eccentric contraction)
  
  – Isometric contraction:
    
    • Skeletal muscle develops tension but is prevented from changing length
Number of Muscle Fibers Activated

- **Muscle Elongation Following Contraction**
  - **Elastic forces:**
    - The pull of elastic elements (tendons and ligaments)
    - Expands the sarcomeres to resting length
  - **Opposing muscle contractions:**
    - Reverse the direction of the original motion
    - Are the work of opposing skeletal muscle pairs
  - **Gravity**
    - Can take the place of opposing muscle contraction to return a muscle to its resting state
7-6 ATP is the energy source for muscular activity
ATP and Muscle Contraction

• Sustained muscle contraction uses a lot of ATP energy
• Muscles store enough energy to start contraction
• Muscle fibers must manufacture more ATP as needed
ATP and CP Reserves

• Adenosine triphosphate (ATP)
  – The active energy molecule

• Creatine phosphate (CP)
  – The storage molecule for excess ATP energy in resting muscle

• Energy recharges ADP to ATP
  – Using the enzyme creatine phosphokinase (CPK or CK)
  – When CP is used up, other mechanisms generate ATP
ATP Generation

• Cells produce ATP in two ways
  – *Aerobic metabolism* of fatty acids in the mitochondria
  – *Anaerobic glycolysis* in the cytoplasm
ATP Generation

- **Aerobic metabolism**
  - Is the primary energy source of resting muscles
  - Breaks down fatty acids
  - Produces 34 ATP molecules per glucose molecule

- **Anaerobic glycolysis**
  - Is the primary energy source for peak muscular activity
  - Produces two ATP molecules per molecule of glucose
  - Breaks down glucose from glycogen stored in skeletal muscles
Energy Use and the Level of Muscle Activity

• Skeletal muscles at rest metabolize fatty acids and store glycogen
• During moderate activity, muscles generate ATP through anaerobic breakdown of carbohydrates, lipids, or amino acids
• At peak activity, energy is provided by anaerobic reactions that generate lactic acid as a by-product
Muscle Metabolism

(a) Resting muscle

Figure 7-9
Figure 7-9  (b) Moderate activity
Figure 7-9

(c) Peak activity

Muscle Metabolism
Muscle Fatigue

• When muscles can no longer perform a required activity, they are **fatigued**

• **Results of Muscle Fatigue**
  – Depletion of metabolic reserves
  – Damage to sarcolemma and sarcoplasmic reticulum
  – Low pH (lactic acid)
  – Muscle exhaustion and pain
The Recovery Period

• The time required after exertion for muscles to return to normal
• Oxygen becomes available
• Mitochondrial activity resumes
The Recovery Period

• Lactic Acid Recycling
  – Converts lactic acid to pyruvic acid
  – Glucose is released to recharge muscle glycogen reserves

– Oxygen debt:
  • After exercise or other exertion:
    – The body needs more oxygen than usual to normalize metabolic activities
The Recovery Period

• Heat Loss
  – Active muscles produce heat
  – Up to 70% of muscle energy can be lost as heat, raising body temperature
7-7 Muscle fiber type and physical conditioning determine muscle performance capabilities
Types of Skeletal Muscle Fibers

• Fast fibers
  – Contract very quickly
  – Have large diameter, large glycogen reserves, few mitochondria
  – Have strong contractions, fatigue quickly
Types of Skeletal Muscle Fibers

• **Slow fibers**
  – Are slow to contract, slow to fatigue
  – Have small diameter, more mitochondria
  – Have high oxygen supply
  – Contain **myoglobin** (red pigment, binds oxygen)
Types of Skeletal Muscle Fibers

• The Distribution of Muscle Fibers and Muscle Performance
  – **White muscle:**
    • Mostly fast fibers
    • Pale (e.g., chicken breast)
  – **Red muscle:**
    • Mostly slow fibers
    • Dark (e.g., chicken legs)
  – **Most human muscles:**
    • Mixed fibers
    • Pink
Types of Skeletal Muscle Fibers

• The Distribution of Muscle Fibers and Muscle Performance
  – Physical conditioning:
    • **Anaerobic activities** (e.g., 50-meter dash, weightlifting):
      – use fast fibers
      – fatigue quickly with strenuous activity
    • Improved by:
      – frequent, brief, intense workouts
Types of Skeletal Muscle Fibers

• The Distribution of Muscle Fibers and Muscle Performance
  – Physical conditioning:
    • **Aerobic activities** (prolonged activity):
      – supported by mitochondria
      – require oxygen and nutrients
    • Improved by:
      – repetitive training (neural responses)
      » cardiovascular training
Physical Conditioning

• **Muscle Hypertrophy**
  – Muscle growth from heavy training:
    • Increases diameter of muscle fibers
    • Increases number of myofibrils
    • Increases mitochondria, glycogen reserves

• **Muscle Atrophy**
  – Lack of muscle activity:
    • Reduces muscle size, tone, and power
7-8 Cardiac and smooth muscle tissues differ structurally and functionally from skeletal muscle tissue
Cardiac Muscle Tissue

• Structure of Cardiac Tissue
  – Cardiac muscle is striated, found only in the heart
Cardiac Muscle Tissue

• Intercalated Discs
  – Are specialized contact points between cardiocytes
  – Join cell membranes of adjacent cardiocytes (gap junctions, desmosomes)
  – Functions of intercalated discs:
    • Maintain structure
    • Enhance molecular and electrical connections
    • Conduct action potentials
Cardiac Muscle Tissue

• Five Characteristics of Cardiac Tissue
  – **Automaticity:**
    • Contraction without neural stimulation
    • Controlled by pacemaker cells
  – **Extended contraction time:**
    • Ten times as long as skeletal muscle
  – **Prevention of wave summation** and tetanic contractions by cell membranes:
    • Long refractory period
  – **Calcium comes from SR and ECF**
  – **Use only aerobic metabolism** (high in myoglobin, mitochondria)
Cardiac Muscle Tissue

Figure 7-10a

Intercalated discs
Cardiac muscle cell

LM x 315
Smooth Muscle Tissue

• Smooth Muscle in Body Systems
  – Forms around other tissues
  – In blood vessels:
    • Regulates blood pressure and flow
  – In reproductive and glandular systems:
    • Produces movements
  – In digestive and urinary systems:
    • Forms sphincters
    • Produces contractions
  – In integumentary system:
    • *Arrector pili* muscles cause “goose bumps”
Smooth Muscle Tissue

• Structure of Smooth Muscle
  – Nonstriated tissue
  – Different internal organization of actin and myosin
  – Different functional characteristics
Smooth Muscle Tissue

Figure 7-10b

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Smooth Muscle Tissue

• Functional Characteristics of Smooth Muscle
  – Calcium ions trigger contractions through a different mechanism than that found in other muscle types.
  – Smooth muscle cells are able to contract over a greater range of lengths than skeletal or cardiac muscle.
  – Many smooth muscle cells are not innervated by motor neurons, and the muscle cells contract either automatically (in response to *pacesetter cells*) or in response to environmental or hormonal stimulation.
<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>SKELETAL MUSCLE FIBER</th>
<th>CARDIAC MUSCLE CELL</th>
<th>SMOOTH MUSCLE CELL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiber dimensions (diameter × length)</td>
<td>100 μm × up to 60 cm</td>
<td>10–20 μm × 50–100 μm</td>
<td>5–10 μm × 30–200 μm</td>
</tr>
<tr>
<td>Nuclei</td>
<td>Multiple, near sarcolemma</td>
<td>Usually single, centrally located</td>
<td>Single, centrally located</td>
</tr>
<tr>
<td>Filament organization</td>
<td>In sarcomeres along myofibrils</td>
<td>In sarcomeres along myofibrils</td>
<td>Scattered throughout sarcoplasm</td>
</tr>
<tr>
<td>Control mechanism</td>
<td>Neural, at single neuromuscular junction</td>
<td>Automaticity (pacemaker cells)</td>
<td>Automaticity (pacemaker cells), neural or hormonal control</td>
</tr>
<tr>
<td>Ca²⁺ source</td>
<td>Release from sarcoplasmic reticulum</td>
<td>Extracellular fluid and release from sarcoplasmic reticulum</td>
<td>Extracellular fluid and release from sarcoplasmic reticulum</td>
</tr>
<tr>
<td>Contraction</td>
<td>Rapid onset; tetanus can occur; rapid fatigue</td>
<td>Slower onset; tetanus cannot occur; resistant to fatigue</td>
<td>Slow onset; tetanus can occur; resistant to fatigue</td>
</tr>
<tr>
<td>Energy source</td>
<td>Aerobic metabolism at moderate levels of activity; glycolysis (anaerobic) during peak activity</td>
<td>Aerobic metabolism, usually lipid or carbohydrate substrates</td>
<td>Primarily aerobic metabolism</td>
</tr>
</tbody>
</table>
7-9 Descriptive terms are used to name skeletal muscles
Origins, Insertions, and Actions

• **Origin**
  
  Muscle attachment that remains fixed

• **Insertion**
  
  Muscle attachment that moves

• **Action**
  
  What joint movement a muscle produces
Origins, Insertions, and Actions

• Primary Action Categories
  – *Prime mover (agonist):*
    • Main muscle in an action
  – *Synergist:*
    • Helper muscle in an action
  – *Antagonist:*
    • Opposed muscle to an action
Names of Skeletal Muscles

• Correct names of muscles include the term *muscle*

• Exceptions
  – Platysma
  – Diaphragm
Names of Skeletal Muscles

• Descriptive Names for Skeletal Muscles
  – Location in the body
  – Origin and insertion
  – Fascicle organization
  – Relative position
  – Structural characteristics
  – Action
<table>
<thead>
<tr>
<th>TERMS INDICATING POSITION, DIRECTION, OR MUSCLE FIBER ORIENTATION</th>
<th>TERMS INDICATING SPECIFIC REGIONS OF THE BODY*</th>
<th>TERMS INDICATING STRUCTURAL CHARACTERISTICS OF THE MUSCLE</th>
<th>TERMS INDICATING ACTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior (front)</td>
<td>Abdominis (abdomen)</td>
<td>Origin (two heads)</td>
<td>General</td>
</tr>
<tr>
<td>Externus (superficial)</td>
<td>Anconeus (elbow)</td>
<td>Biceps (three heads)</td>
<td>Abductor</td>
</tr>
<tr>
<td>Extrinsic (outside)</td>
<td>Auricularis (auricle of ear)</td>
<td>Triceps (three heads)</td>
<td>Adductor</td>
</tr>
<tr>
<td>Inferioris (inferior)</td>
<td>Brachialis (brachium)</td>
<td>Quadriceps (four heads)</td>
<td>Depressor</td>
</tr>
<tr>
<td>Internus (deep, internal)</td>
<td>Capitis (head)</td>
<td></td>
<td>Extensor</td>
</tr>
<tr>
<td>Intrinsic (inside)</td>
<td>Carpi (wrist)</td>
<td></td>
<td>Flexor</td>
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<td>Lateralis (lateral)</td>
<td>Cervicis (neck)</td>
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<td>Levator</td>
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<td>Medialis/medius (medial, middle)</td>
<td>Cleido/clavius (clavicle)</td>
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<td>Pronator</td>
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<td>Obliquus (oblique)</td>
<td>Coccygeus (coccyx)</td>
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<td>Rotator</td>
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<td>Posterior (back)</td>
<td>Costalis (ribs)</td>
<td></td>
<td>Supinator</td>
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<tr>
<td>Profundus (deep)</td>
<td>Cutaneous (skin)</td>
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<td>Tensor</td>
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<td>Rectus (straight, parallel)</td>
<td>Femoris (femur)</td>
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<td>Specific</td>
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<td>Superficialis (superficial)</td>
<td>Genio- (chin)</td>
<td></td>
<td>Buccinator (trumpeter)</td>
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<tr>
<td>Superioris (superior)</td>
<td>Glosso/glossal (tongue)</td>
<td></td>
<td>Sisorius (laughter)</td>
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<td>Transversus (transverse)</td>
<td>Hallucis (great toe)</td>
<td></td>
<td>Sartorius (like a tailor)</td>
</tr>
<tr>
<td>TERMS INDICATING POSITION, DIRECTION, OR MUSCLE FIBER ORIENTATION</td>
<td>TERMS INDICATING SPECIFIC REGIONS OF THE BODY*</td>
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<td>TERMS INDICATING ACTIONS</td>
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<tr>
<td>Nasalis (nose)</td>
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<td>Other Striking Features</td>
<td></td>
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<tr>
<td>Nuchal (back of neck)</td>
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<tr>
<td>Oculo- (eye)</td>
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<td>Oris (mouth)</td>
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<tr>
<td>Palpebrae (eyelid)</td>
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<td>Pollicis (thumb)</td>
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<td>Popliteus (behind knee)</td>
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<tr>
<td>Psoas (loin)</td>
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<td>Radialis (radius)</td>
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<td>Scapularis (scapula)</td>
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<td>Temporalis (temples)</td>
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<td>Thoracis (thoracic region)</td>
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<td>Tibialis (tibia)</td>
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<td>Ulnaris (ulna)</td>
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<td>Uro- (urinary)</td>
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<td>Other Striking Features</td>
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<tr>
<td>Alba (white)</td>
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<td>Brevis (short)</td>
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<td>Gracilis (slender)</td>
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<tr>
<td>Lata (wide)</td>
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<td>Latissimus (widest)</td>
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<td>Longissimus (longest)</td>
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<td>Longus (long)</td>
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<td>Magnus (large)</td>
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<td>Major (larger)</td>
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<td>Maximus (largest)</td>
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<td>Minimus (smallest)</td>
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<td>Minor (smaller)</td>
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<tr>
<td>-tendinosus (tendinous)</td>
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<td>Vastus (great)</td>
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</tbody>
</table>

*For other regional terms, refer to Figure 1-6, p. 16, which shows anatomical landmarks.
Muscular System Overview

• Divisions of the Muscular System
  – Axial muscles:
    • Position head and spinal column
    • Move rib cage
    • 60% of skeletal muscles
  – Appendicular muscles:
    • Support pectoral and pelvic girdles
    • Support limbs
    • 40% of skeletal muscles
Overview of the Major Skeletal Muscles

Figure 7-11a

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Overview of the Major Skeletal Muscles

Figure 7-11a

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Overview of the Major Skeletal Muscles

Figure 7-11b

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Overview of the Major Skeletal Muscles

Figure 7-11b

- External oblique
- Gluteus medius
- Gluteus maximus
- Adductor magnus
- Semimembranosus
- Gracilis
- Sartorius
- Gastrocnemius
- Soleus
- Calcaneal tendon
- Calcaneus

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7-10 Axial muscles are muscles of the head and neck, vertebral column, trunk, and pelvic floor
Axial Musculature

• The Axial Muscles
  – Divisions based on location and function:
    • Muscles of head and neck
    • Muscles of spine (vertebral column)
    • Muscles of the trunk
      – Oblique and rectus muscles
    • Muscles of pelvic floor

3D Peel-Away of Muscles of the Head and Neck
Muscles of Head and Neck

Figure 7-12a

- Epicranial aponeurosis (tendinous sheet)
- Frontalis
- Orbicularis oculi
- Zygomaticus
- Orbicularis oris
- Depressor anguli oris
- Temporalis
- Occipitalis
- Buccinator
- Masseter
- Sternocleidomastoid
- Platysma

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Muscles of Head and Neck

Figure 7-12b

(b) Lateral view, pterygoid muscles exposed
Muscles of Head and Neck

Figure 7-12c

Epicranial aponeurosis (tendinous sheet)
Frontalis
Temporalis
Orbicularis oculi
Zygomaticus
Orbicularis oris
Platysma
Sternocleidomastoid
Masseter
Buccinator
Depressor anguli oris
Trapezius
Platysma (cut and reflected)
<table>
<thead>
<tr>
<th>REGION/MUSCLE</th>
<th>ORIGIN</th>
<th>INSERTION</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MOUTH</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buccinator</td>
<td>Maxillary bone and mandible</td>
<td>Blends into fibers of orbicularis oris</td>
<td>Compresses cheeks</td>
</tr>
<tr>
<td>Orbicularis oris</td>
<td>Maxillary bone and mandible</td>
<td>Lips</td>
<td>Compresses, purses lips</td>
</tr>
<tr>
<td>Depressor anguli oris</td>
<td>Anterolateral surface of mandible</td>
<td>Skin at angle of mouth</td>
<td>Depresses corner of mouth</td>
</tr>
<tr>
<td>Zygomaticus</td>
<td>Zygomatic bone</td>
<td>Angle of mouth; upper lip</td>
<td>Draws corner of mouth back and up</td>
</tr>
<tr>
<td><strong>EYE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orbicularis oculi</td>
<td>Medial margin of orbit</td>
<td>Skin around eyelids</td>
<td>Closes eye</td>
</tr>
<tr>
<td><strong>SCALP</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frontalis</td>
<td>Epicranial aponeurosis</td>
<td>Skin of eyebrow and bridge of nose</td>
<td>Raises eyebrows, wrinkles forehead</td>
</tr>
<tr>
<td>Occipitalis</td>
<td>Occipital bone</td>
<td>Epicranial aponeurosis</td>
<td>Tenses and retracts scalp</td>
</tr>
<tr>
<td><strong>LOWER JAW</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Masseter</td>
<td>Zygomatic arch</td>
<td>Lateral surface of mandible</td>
<td>Elevates mandible</td>
</tr>
<tr>
<td>Temporalis</td>
<td>Along temporal lines of skull</td>
<td>Coronoid process of mandible</td>
<td>Elevates mandible</td>
</tr>
<tr>
<td>Pterygoids</td>
<td>Inferior processes of sphenoid</td>
<td>Medial surface of mandible</td>
<td>Elevate, protract, and/or move mandible to either side</td>
</tr>
<tr>
<td>REGION/MUSCLE</td>
<td>ORIGIN</td>
<td>INSERTION</td>
<td>ACTION</td>
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<td>-----------------------------------------------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td><strong>NECK</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platysma</td>
<td>From cartilage of second rib to acromion of scapula</td>
<td>Mandible and skin of cheek</td>
<td>Tenses skin of neck, depresses mandible</td>
</tr>
<tr>
<td>Digastric</td>
<td>Mastoid region of temporal bone and inferior surface of mandible</td>
<td>Hyoid bone</td>
<td>Depresses mandible and/or elevates larynx</td>
</tr>
<tr>
<td>Mylohyoid</td>
<td>Medial surface of mandible</td>
<td>Median connective tissue band that runs to hyoid bone</td>
<td>Elevates floor of mouth and hyoid, and/or depresses mandible</td>
</tr>
<tr>
<td>Sternohyoid</td>
<td>Clavicle and sternum</td>
<td>Hyoid bone</td>
<td>Depresses hyoid bone and larynx</td>
</tr>
<tr>
<td>Sternothyroid</td>
<td>Dorsal surface of sternum and 1st rib</td>
<td>Thyroid cartilage of larynx</td>
<td>As above</td>
</tr>
<tr>
<td>Stylohyoid</td>
<td>Styloid process of temporal bone</td>
<td>Hyoid bone</td>
<td>Elevates larynx</td>
</tr>
<tr>
<td>Sternocleidomastoid</td>
<td>Superior margins of sternum and clavicle</td>
<td>Mastoid region of skull</td>
<td>Both sides together flex the neck; one side alone bends head toward shoulder and turns face to opposite side</td>
</tr>
</tbody>
</table>
Muscles of the Anterior Neck

Figure 7-13

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Muscles of the Spine

• Spinal extensors or **erector spinae muscles** (superficial and deep)
Muscles of the Spine

Figure 7-14

- Semispinalis capitis
- Splenius capitis
- Iliocostalis
- Longissimus
- Spinalis
- Quadratus lumborum
- Erector spinae muscles
<table>
<thead>
<tr>
<th>REGION/MUSCLE</th>
<th>ORIGIN</th>
<th>INSERTION</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SPINAL EXTENSORS</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Splenius capitis</td>
<td>Spinous processes of lower cervical and upper thoracic vertebrae</td>
<td>Mastoid process, base of the skull, and upper cervical vertebrae</td>
<td>The two sides act together to extend the neck; either alone rotates and laterally flexes head to that side</td>
</tr>
<tr>
<td>Semispinalis capitis</td>
<td>Spinous processes of lower cervical and upper thoracic vertebrae</td>
<td>Base of skull, upper cervical vertebrae</td>
<td>The two sides act together to extend the neck; either alone laterally flexes head to that side</td>
</tr>
<tr>
<td>Spinalis group</td>
<td>Spinous processes and transverse processes of cervical, thoracic, and upper lumbar vertebrae</td>
<td>Base of skull and spinous processes of cervical and upper thoracic vertebrae</td>
<td>The two sides act together to extend vertebral column; either alone extends neck and laterally flexes head or rotates vertebral column to that side</td>
</tr>
<tr>
<td>Longissimus group</td>
<td>Processes of lower cervical, thoracic, and upper lumbar vertebrae</td>
<td>Mastoid processes of temporal bone, transverse processes of cervical vertebrae, and inferior surfaces of ribs</td>
<td>The two sides act together to extend vertebral column; either alone rotates and laterally flexes head or vertebral column to that side</td>
</tr>
<tr>
<td>Iliocostalis group</td>
<td>Superior borders of ribs and iliac crest</td>
<td>Transverse processes of cervical vertebrae and inferior surfaces of ribs</td>
<td>Extends vertebral column or laterally to that side; moves ribs</td>
</tr>
<tr>
<td><strong>SPINAL FLEXOR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadratus lumborum</td>
<td>Iliac crest</td>
<td>Last rib and transverse processes of lumbar vertebrae</td>
<td>Together they depress ribs, flex vertebral column; one side acting alone produces lateral flexion</td>
</tr>
</tbody>
</table>
The Axial Muscles of the Trunk

• Oblique and Rectus Muscles
  – Lie within the body wall
  – Oblique muscles:
    • Compress underlying structures
    • Rotate vertebral column
  – Rectus muscles:
    • Flex vertebral column
    • Oppose erector spinae
Oblique and Rectus Muscles and the Diaphragm

(a) Anterior view

- Serratus anterior
- External oblique
- Aponeurosis
- Rectus abdominis
- Internal intercostal
- External intercostal
- External oblique (cut)
- Internal oblique
- Linea alba (midline band of dense connective tissue)
Oblique and Rectus Muscles and the Diaphragm

Figure 7-15b
Oblique and Rectus Muscles and the Diaphragm

Latissimus dorsi

Quadratus lumborum

External oblique

Transversus abdominis

Internal oblique

Rectus abdominis

Psoas major

Linea alba

(c) Horizontal section view

Figure 7-15c

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<table>
<thead>
<tr>
<th>REGION/MUSCLE</th>
<th>ORIGIN</th>
<th>INSERTION</th>
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<tr>
<td><strong>THORACIC REGION</strong></td>
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</tr>
<tr>
<td>External intercostals</td>
<td>Inferior border of each rib</td>
<td>Superior border of next rib</td>
<td>Elevate ribs</td>
</tr>
<tr>
<td>Internal intercostals</td>
<td>Superior border of each rib</td>
<td>Inferior border of the preceding rib</td>
<td>Depress ribs</td>
</tr>
<tr>
<td>Diaphragm</td>
<td>Xiphoid process, cartilages of ribs 4–10, and anterior surfaces of lumbar vertebrae</td>
<td>Central tendinous sheet</td>
<td>Contraction expands thoracic cavity, compresses abdominopelvic cavity</td>
</tr>
<tr>
<td><strong>ABDOMINAL REGION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External oblique</td>
<td>Lower eight ribs</td>
<td>Linea alba and iliac crest</td>
<td>Compresses abdomen, depresses ribs, flexes or laterally flexes vertebral column</td>
</tr>
<tr>
<td>Internal oblique</td>
<td>Iliac crest and adjacent connective tissues</td>
<td>Lower ribs, xiphoid of sternum, and linea alba</td>
<td>As above</td>
</tr>
<tr>
<td>Transversus abdominis</td>
<td>Cartilages of lower ribs, iliac crest, and adjacent connective tissues</td>
<td>Linea alba and pubis</td>
<td>Compresses abdomen</td>
</tr>
<tr>
<td>Rectus abdominis</td>
<td>Superior surface of pubis around symphysis</td>
<td>Inferior surfaces of costal cartilages (ribs 5–7) and xiphoid process</td>
<td>Depresses ribs, flexes vertebral column</td>
</tr>
</tbody>
</table>

*Table 7-6 Axial Muscles of the Trunk*
Muscles of the Pelvic Floor

• Functions of pelvic floor muscles
  – Support organs of pelvic cavity
  – Flex sacrum and coccyx
  – Control movement of materials through urethra and anus
Muscles of the Pelvic Floor

Figure 7-16a

(a) Female

- Urethra
- External urethral sphincter
- Levator ani
- External anal sphincter
- Ischiocavernosus
- Bulbospongiosus
- Vagina
- Transverse perineus
- Anus
- Gluteus maximus
Muscles of the Pelvic Floor

No differences between deep musculature in male and female

External urethral sphincter

(b) Male

Figure 7-16b
Copyright © 2010 Pearson Education, Inc.
| MUSCLE                | ORIGIN                                | INSERTION                                | ACTION                                           |
|----------------------|---------------------------------------|------------------------------------------|                                                 |
| **BULBOSPONGIOSUS:** |                                       |                                          |                                                 |
| Males                | Base of penis; fibers cross over urethra | Midline and central tendon of perineum | Compresses base and stiffens penis; ejects urine or semen |
| Females              | Base of clitoris; fibers run on either side of urethral and vaginal openings | Central tendon of perineum              | Compresses and stiffens clitoris; narrows vaginal opening |
| Ischiocavernosus     | Inferior medial surface of ischium    | Symphysis pubis anterior to base of penis or clitoris | Compresses and stiffens penis or clitoris       |
| Transverse perineus  | Inferior medial surface of ischium    | Central tendon of perineum              | Stabilizes central tendon of perineum           |
| **EXTERNAL URETHRAL SPHINCTER:** |                                       |                                          |                                                 |
| Males                | Inferior medial surfaces of ischium and pubis | Midline at base of penis; inner fibers encircle urethra | Closes urethra, compresses prostate and bulbourethral glands |
| Females              | As above                              | Midline; inner fibers encircle urethra  | Closes urethra, compresses vagina and greater vestibular glands |
| External anal sphincter | By tendon from coccyx                      | Encircles anal opening                  | Closes anal opening                            |
| Levator ani          | Ischial spine, pubis                   | Coccyx                                  | Tenses floor of pelvis, supports pelvic organs, flexes coccyx, elevates and retracts anus |

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7-11 Appendicular muscles are muscles of the shoulders, upper limbs, pelvic girdle, and lower limbs
Appendicular Musculature

- Position and stabilize pectoral and pelvic girdles
- Move upper and lower limbs
- Divisions of Appendicular Muscles
  - Muscles of the shoulders and upper limbs
  - Muscles of the pelvis and lower limbs
Muscles of the Shoulders and Upper Limbs

- Position the pectoral girdle
- Move the arm
- Move the forearm and wrist
- Move the hand and fingers
Muscles that Move the Shoulder

Figure 7-17a
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Muscles that Move the Shoulder

Figure 7-17b
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<table>
<thead>
<tr>
<th>MUSCLE</th>
<th>ORIGIN</th>
<th>INSERTION</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levator scapulae</td>
<td>Transverse processes of first 4 cervical vertebrae</td>
<td>Vertebral border of scapula</td>
<td>Elevates scapula</td>
</tr>
<tr>
<td>Pectoralis minor</td>
<td>Anterior surfaces of ribs 3–5</td>
<td>Coracoid process of scapula</td>
<td>Depresses and protracts shoulder; rotates scapula laterally (downward); elevates ribs if scapula is stationary</td>
</tr>
<tr>
<td>Rhomboid muscles</td>
<td>Spinous processes of lower cervical and upper thoracic vertebrae</td>
<td>Vertebral border of scapula</td>
<td>Adducts and rotates scapula laterally (downward)</td>
</tr>
<tr>
<td>Serratus anterior</td>
<td>Anterior and superior margins of ribs 1–9</td>
<td>Anterior surface of vertebral border of scapula</td>
<td>Protracts shoulder, abducts and medially rotates scapula (upward)</td>
</tr>
<tr>
<td>Subclavius</td>
<td>First rib</td>
<td>Clavicle</td>
<td>Depresses and protracts shoulder</td>
</tr>
<tr>
<td>Trapezius</td>
<td>Occipital bone and spinous processes of thoracic vertebrae</td>
<td>Clavicle and scapula (acromion and scapular spine)</td>
<td>Depends on active region and state of other muscles; may elevate, adduct, depress, or rotate scapula and/or elevate clavicle; can also extend or hyperextend neck</td>
</tr>
</tbody>
</table>
Muscles of the Shoulders and Upper Limbs

- Muscles That Move the Arm
  - **Deltoid:**
    - The major abductor
  - **Supraspinatus:**
    - Assists deltoid
Muscles of the Shoulders and Upper Limbs

- Muscles That Move the Arm:
  - **Subscapularis and Teres major:**
    - Produce medial rotation at shoulder
Muscles of the Shoulders and Upper Limbs

• Muscles That Move the Arm

  – **Pectoralis major**
    • Between anterior chest and greater tubercle of humerus
    • Produces flexion at shoulder joint

  – **Latissimus dorsi**
    • Between thoracic vertebrae and humerus
    • Produces extension at shoulder joint
Muscles That Move the Arm

SUPERFICIAL

Clavicle
Sternum
Deltoid
Pectoralis major

DEEP

Ribs (cut)
Subscapularis
Coracobrachialis
Teres major
Biceps brachii

(a) Anterior view

Figure 7-18a

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Muscles That Move the Arm

**SUPERFICIAL**

- **Vertebra T₁**
- Supraspinatus
- Deltoid
- Latissimus dorsi

**DEEP**

- Supraspinatus
- Infraspinatus
- Teres minor
- Teres major
- Triceps brachii

*(b) Posterior view*

---

Figure 7-18b
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# TABLE 7-9 Muscles That Move the Arm

<table>
<thead>
<tr>
<th>MUSCLE</th>
<th>ORIGIN</th>
<th>INSERTION</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coracobrachialis</td>
<td>Coracoid process</td>
<td>Medial margin of shaft of humerus</td>
<td>Adduction and flexion at shoulder</td>
</tr>
<tr>
<td>Deltoid</td>
<td>Clavicle and scapula (acromion and adjacent scapular spine)</td>
<td>Deltoid tuberosity of humerus</td>
<td>Abduction at shoulder</td>
</tr>
<tr>
<td>Latissimus dorsi</td>
<td>Spinous processes of lower thoracic vertebrae, ribs, and lumbar vertebrae</td>
<td>Intertubercular groove of humerus</td>
<td>Extension, adduction, and medial rotation at shoulder</td>
</tr>
<tr>
<td>Pectoralis major</td>
<td>Cartilages of ribs 2–6, body of sternum, and clavicle</td>
<td>Greater tubercle of humerus</td>
<td>Flexion, adduction, and medial rotation at shoulder</td>
</tr>
<tr>
<td>Supraspinatus*</td>
<td>Supraspinous fossa of scapula</td>
<td>Greater tubercle of humerus</td>
<td>Abduction at shoulder</td>
</tr>
<tr>
<td>Infraspinatus*</td>
<td>Infraspinous fossa of scapula</td>
<td>Greater tubercle of humerus</td>
<td>Lateral rotation at shoulder</td>
</tr>
<tr>
<td>Subscapularis*</td>
<td>Subscapular fossa of scapula</td>
<td>Lesser tubercle of humerus</td>
<td>Medial rotation at shoulder</td>
</tr>
<tr>
<td>Teres minor*</td>
<td>Lateral border of scapula</td>
<td>Greater tubercle of humerus</td>
<td>Lateral rotation at shoulder</td>
</tr>
<tr>
<td>Teres major</td>
<td>Inferior angle of scapula</td>
<td>Intertubercular groove of humerus</td>
<td>Adduction and medial rotation at shoulder</td>
</tr>
</tbody>
</table>

*Rotator cuff muscles
Muscles of the Shoulders and Upper Limbs

• Muscles That Move the Forearm and Wrist
  – Originate on humerus and insert on forearm
    • Exceptions:
      – The major flexor (biceps brachii)
      – The major extensor (triceps brachii)
Muscles of the Shoulders and Upper Limbs

• Muscles That Move the Forearm and Wrist
  – Extensors:
    • Mainly on posterior and lateral surfaces of arm
  – Flexors:
    • Mainly on anterior and medial surfaces
Muscles of the Shoulders and Upper Limbs

- Muscles That Move the Forearm and Wrist:
  - Flexors of the elbow:
    - **Biceps brachii**:
      - flexes elbow
      - stabilizes shoulder joint
      - originates on scapula
      - inserts on radial tuberosity
    - **Brachialis and brachioradialis**:
      - flex elbow
Muscles That Move the Forearm and Wrist

Figure 7-19b
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• Muscles That Move the Forearm and Wrist
  – Extensors of the elbow:
    • Triceps brachii:
      – extends elbow
      – originates on scapula
      – inserts on olecranon
    • Anconeus:
      – opposes brachialis
Muscles That Move the Forearm and Wrist

Figure 7-19a

Triceps brachii
Brachioradialis
Extensor carpi radialis
Extensor carpi ulnaris
Extensor digitorum
Abductor pollicis
Radius
Ulna
Flexor carpi ulnaris
Tendon sheaths
<table>
<thead>
<tr>
<th>MUSCLE</th>
<th>ORIGIN</th>
<th>INSERTION</th>
<th>ACTION</th>
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</thead>
<tbody>
<tr>
<td>PRIMARY ACTION AT THE ELBOW</td>
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<tr>
<td>Flexors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biceps brachii</td>
<td><em>Short head</em> from the coracoid process and <em>long head</em> from the supraglenoid tubercle (both on the scapula)</td>
<td>Tuberosity of radius</td>
<td>Flexion at shoulder and elbow; supination</td>
</tr>
<tr>
<td>Brachialis</td>
<td>Anterior, distal surface of humerus</td>
<td>Tuberosity of ulna</td>
<td>Flexion at elbow</td>
</tr>
<tr>
<td>Brachioradialis</td>
<td>Lateral epicondyle of humerus</td>
<td>Styloid process of radius</td>
<td>As above</td>
</tr>
<tr>
<td>Extensor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triceps brachii</td>
<td>Superior, posterior, and lateral margins of humerus, and the scapula</td>
<td>Olecranon of ulna</td>
<td>Extension at elbow</td>
</tr>
<tr>
<td>Pronators/Supinator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pronator quadratus</td>
<td>Medial surface of distal portion of ulna</td>
<td>Anterior and lateral surface of distal portion of radius</td>
<td>Pronation</td>
</tr>
<tr>
<td>Pronator teres</td>
<td>Medial epicondyle of humerus and coronoid process of ulna</td>
<td>Distal lateral surface of radius</td>
<td>As above</td>
</tr>
<tr>
<td>Supinator</td>
<td>Lateral epicondyle of humerus and ulna</td>
<td>Anterior and lateral surface of radius distal to the radial tuberosity</td>
<td>Supination</td>
</tr>
<tr>
<td>MUSCLE</td>
<td>ORIGIN</td>
<td>INSERTION</td>
<td>ACTION</td>
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<tr>
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<td>------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
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</tr>
<tr>
<td><strong>PRIMARY ACTION AT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>THE WRIST</strong></td>
<td></td>
<td></td>
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<tr>
<td>Flexors</td>
<td></td>
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<tr>
<td>Flexor carpi radialis</td>
<td>Medial epicondyle of humerus</td>
<td>Bases of 2nd and 3rd metacarpal bones</td>
<td>Flexion and abduction at wrist</td>
</tr>
<tr>
<td>Flexor carpi ulnaris</td>
<td>Medial epicondyle of humerus and adjacent surfaces of ulna</td>
<td>Pisiform bone, hamate bone, and base of 5th metacarpal bone</td>
<td>Flexion and adduction at wrist</td>
</tr>
<tr>
<td>Palmaris longus</td>
<td>Medial epicondyle of humerus</td>
<td>A tendinous sheet on the palm</td>
<td>Flexion at wrist</td>
</tr>
<tr>
<td><strong>Extensors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extensor carpi radialis</td>
<td>Distal lateral surface and lateral epicondyle of humerus</td>
<td>Bases of 2nd and 3rd metacarpal bones</td>
<td>Extension and abduction at wrist</td>
</tr>
<tr>
<td>Extensor carpi ulnaris</td>
<td>Lateral epicondyle of humerus and adjacent surface of ulna</td>
<td>Base of 5th metacarpal bone</td>
<td>Extension and adduction at wrist</td>
</tr>
<tr>
<td><strong>ACTION AT THE HAND</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Extensor digitorum</td>
<td>Lateral epicondyle of humerus</td>
<td>Posterior surfaces of the phalanges</td>
<td>Extension at finger joints and wrist</td>
</tr>
<tr>
<td>Flexor digitorum</td>
<td>Medial epicondyle of humerus; anterior surfaces of ulna and radius;</td>
<td>Distal phalanges</td>
<td>Flexion at finger joints and wrist</td>
</tr>
<tr>
<td></td>
<td>medial and posterior surfaces of ulna</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Muscles of the Shoulders and Upper Limbs

• Muscles That Move the Hand and Fingers
  – Also called *extrinsic muscles of the hand*:
    • Lie entirely within forearm
    • Only tendons cross wrist (in synovial tendon sheaths)
Muscles That Move the Forearm and Wrist

Figure 7-19b

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Muscles That Move the Forearm and Wrist

Figure 7-19a

Triceps brachii

Brachioradialis

Extensor carpi radialis

Extensor carpi ulnaris

Extensor digitorum

Abductor pollicis

Flexor carpi ulnaris

Ulna

Radius

Tendon sheaths

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<table>
<thead>
<tr>
<th>MUSCLE</th>
<th>ORIGIN</th>
<th>INSERTION</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRIMARY ACTION AT THE WRIST</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexors</td>
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<td></td>
</tr>
<tr>
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<td>Medial epicondyle of humerus and adjacent surfaces of ulna</td>
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<td>Extensor carpi ulnaris</td>
<td>Lateral epicondyle of humerus and adjacent surface of ulna</td>
<td>Base of 5th metacarpal bone</td>
<td>Extension and adduction at wrist</td>
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<td><strong>ACTION AT THE HAND</strong></td>
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</tr>
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<td>Lateral epicondyle of humerus</td>
<td>Posterior surfaces of the phalanges</td>
<td>Extension at finger joints and wrist</td>
</tr>
<tr>
<td>Flexor digitorum</td>
<td>Medial epicondyle of humerus; anterior surfaces of ulna and radius; medial and posterior surfaces of ulna</td>
<td>Distal phalanges</td>
<td>Flexion at finger joints and wrist</td>
</tr>
</tbody>
</table>
Muscles of the Pelvis and Lower Limbs

• **Pelvic girdle** is tightly bound to axial skeleton
  – Permits little movement
  – Has few muscles
Muscles of the Pelvis and Lower Limbs

• Muscles That Position the Lower Limbs
  – Muscles that move the thigh
  – Muscles that move the leg
  – Muscles that move the foot and toes
Muscles of the Pelvis and Lower Limbs

- Muscles That Move the Thigh
  - Gluteal muscles
  - Lateral rotators
  - Adductors
  - Iliopsoas
Muscles That Move the Thigh

Figure 7-20a

(a) Lateral view
Muscles of the Pelvis and Lower Limbs

- Muscles That Move the Thigh: Gluteal Muscles
  - Cover lateral surfaces of ilia
  - **Gluteus maximus:**
    - Largest, most posterior gluteal muscle
    - Produces extension and lateral rotation at hip
  - **Tensor fasciae latae:**
    - Works with gluteus maximus
    - Stabilizes iliobibial tract
  - **Gluteus medius and gluteus minimus:**
    - Originate anterior to gluteus maximus
    - Insert on trochanter
<table>
<thead>
<tr>
<th>GROUP/MUSCLE</th>
<th>ORIGIN</th>
<th>INSERTION</th>
<th>ACTION</th>
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<tbody>
<tr>
<td><strong>GLUTEAL GROUP</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gluteus maximus</td>
<td>Iliac crest of ilium, sacrum, and coccyx</td>
<td>Iliotibial tract and gluteal tuberosity of femur</td>
<td>Extension and lateral rotation at hip</td>
</tr>
<tr>
<td></td>
<td>Anterior iliac crest and lateral surface of ilium</td>
<td>Greater trochanter of femur</td>
<td></td>
</tr>
<tr>
<td>Gluteus medius</td>
<td>Lateral surface of ilium</td>
<td>As above</td>
<td>Abduction and medial rotation at hip</td>
</tr>
<tr>
<td>Gluteus minimus</td>
<td>Iliac crest and surface of ilium between anterior iliac spines</td>
<td>Iliotibial tract</td>
<td>As above</td>
</tr>
<tr>
<td>Tensor fasciae latae</td>
<td></td>
<td></td>
<td>Flexion, abduction, and medial rotation at hip; tenses fascia lata, which laterally supports the knee</td>
</tr>
</tbody>
</table>
Muscles That Move the Thigh

Figure 7-20b

(b) The gluteal muscle group
Muscles of the Pelvis and Lower Limbs

- **Muscles That Move the Thigh: Adductors**
  - **Adductor magnus:**
    - Produces adduction, extension, and flexion
  - **Adductor brevis:**
    - Hip flexion and adduction
  - **Adductor longus:**
    - Hip flexion and adduction
  - **Pectineus:**
    - Hip flexion and adduction
  - **Gracilis:**
    - Hip flexion and adduction
<table>
<thead>
<tr>
<th>GROUP/MUSCLE</th>
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<th>INSERTION</th>
<th>ACTION</th>
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</thead>
<tbody>
<tr>
<td>ADDUCTOR GROUP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adductor brevis</td>
<td>Inferior ramus of pubis</td>
<td>Linea aspera of femur</td>
<td>Adduction, flexion, and medial rotation at hip</td>
</tr>
<tr>
<td>Adductor longus</td>
<td>Inferior ramus of pubis anterior to adductor brevis</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>Adductor magnus</td>
<td>Inferior ramus of pubis posterior to adductor brevis</td>
<td>As above</td>
<td>Adduction at hip joint; superior portion produces flexion; inferior portion produces extension</td>
</tr>
<tr>
<td>Pectineus</td>
<td>Superior ramus of pubis</td>
<td>Inferior to lesser trochanter of femur</td>
<td>Adduction, flexion, and medial rotation at hip</td>
</tr>
<tr>
<td>Gracilis</td>
<td>Inferior ramus of pubis</td>
<td>Medial surface of tibia inferior to medial condyle</td>
<td>Flexion at knee; adduction and medial rotation at hip</td>
</tr>
</tbody>
</table>
Muscles That Move the Thigh

Figure 7-20c

(c) The Iliopsoas muscle and the adductor group
Muscles of the Pelvis and Lower Limbs

• Muscles That Move the Thigh: Iliopsoas
  – Two hip flexors insert on the same tendon:
    • Psoas major
    • Iliacus
<table>
<thead>
<tr>
<th>GROUP/MUSCLE</th>
<th>ORIGIN</th>
<th>INSERTION</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ILIOPSOAS GROUP</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iliacus</td>
<td>Medial surface of ilium</td>
<td>Femur distal to lesser trochanter; tendon fused with that of psoas major</td>
<td>Flexion at hip and/or lumbar intervertebral joints</td>
</tr>
<tr>
<td>Psoas major</td>
<td>Anterior surfaces and transverse processes of T₁₂ and lumbar vertebrae</td>
<td>Lesser trochanter in company with iliacus</td>
<td>As above</td>
</tr>
</tbody>
</table>
Muscles That Move the Thigh

Figure 7-20c

(c) The Iliopsoas muscle and the adductor group

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Muscles of the Pelvis and Lower Limbs

• Muscles That Move the Leg
  – Flexors of the knee:
    • Originate on the pelvic girdle
  – Extensors of the knee:
    • Originate on the femoral surface
    • Insert on the patella
<table>
<thead>
<tr>
<th>MUSCLE</th>
<th>ORIGIN</th>
<th>INSERTION</th>
<th>ACTION</th>
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</thead>
<tbody>
<tr>
<td>FLEXORS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biceps femoris*</td>
<td>Ischial tuberosity and linea aspera of femur</td>
<td>Head of fibula, lateral condyle of tibia</td>
<td>Flexion at knee, extension and lateral rotation at hip</td>
</tr>
<tr>
<td>Semimembranosus*</td>
<td>Ischial tuberosity</td>
<td>Posterior surface of medial condyle of tibia</td>
<td>Flexion at knee; extension and medial rotation at hip</td>
</tr>
<tr>
<td>Semitendinosus*</td>
<td>As above</td>
<td>Proximal medial surface of tibia</td>
<td>As above</td>
</tr>
<tr>
<td>Sartorius</td>
<td>Anterior superior spine of ilium</td>
<td>Medial surface of tibia near tibial tuberosity</td>
<td>Flexion at knee; flexion and lateral rotation at hip</td>
</tr>
<tr>
<td>Popliteus</td>
<td>Lateral condyle of femur</td>
<td>Posterior surface of proximal tibial shaft</td>
<td>Rotates tibia medially (or rotates femur laterally); flexion at knee</td>
</tr>
</tbody>
</table>
Muscles That Move the Leg

Figure 7-21a

(a) Posterior view
<table>
<thead>
<tr>
<th>MUSCLE</th>
<th>ORIGIN</th>
<th>INSERTION</th>
<th>ACTION</th>
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<tbody>
<tr>
<td><strong>EXTENSORS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rectus femoris</td>
<td>Anterior inferior iliac spine and superior acetabular rim of ilium</td>
<td>Tibial tuberosity by way of patellar ligament</td>
<td>Extension at knee, flexion at hip</td>
</tr>
<tr>
<td>Vastus intermedius</td>
<td>Anterior and lateral surface of femur along linea aspera</td>
<td>As above</td>
<td>Extension at knee</td>
</tr>
<tr>
<td>Vastus lateralis</td>
<td>Anterior and inferior to greater trochanter of femur and along linea aspera</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>Vastus medialis</td>
<td>Entire length of linea aspera of femur</td>
<td>As above</td>
<td>As above</td>
</tr>
</tbody>
</table>

*Hamstring muscles*
Muscles of the Pelvis and Lower Limbs

• Muscles That Move the Foot and Toes
  – Extrinsic muscles that move the foot and toes include:
    • Muscles that produce extension at the ankle
    • Muscles that produce flexion at the ankle
    • Muscles that produce extension at the toes
    • Muscles that produce flexion at the toes
Muscles of the Pelvis and Lower Limbs

- Four Muscles That Produce *Extension (plantar flexion)* at the Ankle
  - Gastrocnemius
  - Soleus
  - Fibularis (group)
  - Tibialis posterior
Muscles of the Pelvis and Lower Limbs

• Muscles That Move the Foot and Toes
  – The Achilles tendon:
    • The calcaneal tendon (Achilles tendon):
      – Shared by the gastrocnemius and soleus
Muscles That Move the Foot and Toes

Figure 7-22a
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Muscles That Move the Foot and Toes

Figure 7-22 b, c

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<table>
<thead>
<tr>
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<th>INSERTION</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorsiflexor</td>
<td>Lateral condyle and proximal shaft of tibia</td>
<td>Base of 1st metatarsal bone</td>
<td>Dorsiflexion at ankle; inversion of foot</td>
</tr>
<tr>
<td>Tibialis anterior</td>
<td>Femoral condyles</td>
<td>Calcaneus by way of calcaneal tendon</td>
<td>Plantar flexion at ankle; inversion and adduction of foot; flexion at knee</td>
</tr>
<tr>
<td>Plantar flexors</td>
<td>Fibula and lateral condyle of tibia</td>
<td>Bases of 1st and 5th metatarsal bones</td>
<td>Eversion of foot and plantar flexion at ankle</td>
</tr>
<tr>
<td>Gastrocnemius</td>
<td>Head and proximal shaft of fibula, and adjacent shaft of tibia</td>
<td>Calcaneus by way of calcaneal tendon</td>
<td>Plantar flexion at ankle; adduction of foot</td>
</tr>
<tr>
<td>Fibularis</td>
<td>Connective tissue membrane and adjacent shafts of tibia</td>
<td>Tarsal and metatarsal bones</td>
<td>Adduction and inversion of foot; plantar flexion at ankle</td>
</tr>
<tr>
<td>Soleus</td>
<td>Connective tissue membrane and adjacent shafts of tibia</td>
<td>Tarsal and metatarsal bones</td>
<td>Eversion of foot and plantar flexion at ankle</td>
</tr>
</tbody>
</table>

**ACTION AT THE TOES**

**Flexors**

- Flexor digitorum longus
  - Posterior and medial surface of tibia
  - Inferior surface of phalanges, toes 2–5
  - Flexion at joints of toes 2–5

- Flexor hallucis longus
  - Posterior surface of fibula
  - Inferior surface, distal phalanx of great toe
  - Flexion at joints of great toe

**Extensors**

- Extensor digitorum longus
  - Lateral condyle of tibia, anterior surface of fibula
  - Superior surfaces of phalanges, toes 2–5
  - Extension at joints of toes 2–5

- Extensor hallucis longus
  - Anterior surface of fibula
  - Superior surface, distal phalanx of great toe
  - Extension at joints of great toe
7-12 With advancing age, the size and power of muscle tissue decreases.
Effects of Aging on the Muscular System

- Skeletal muscle fibers become smaller in diameter
- Skeletal muscles become less elastic
  - Develop increasing amounts of fibrous tissue (fibrosis)
- Decreased tolerance for exercise
- Decreased ability to recover from muscular injuries
7-13 Exercise produces responses in multiple body systems
Exercise and Other Systems

• Cardiovascular system
  – Delivers oxygen and fuel
  – Removes carbon dioxide and wastes

• Respiratory system
  – Responds to oxygen demand of muscles

• Integumentary system
  – Disperses heat from muscle activity

• Nervous and endocrine systems
  – Direct responses of all systems
The Muscular System in Perspective

FIGURE 7-23
Functional Relationships Between the Muscular System and Other Systems
The Integumentary System

removes excess body heat; synthesizes vitamin D₃ for calcium and phosphate absorption; protects underlying muscles

The Muscular System’s skeletal muscles pulling on skin of face produce facial expressions
The Skeletal System maintains normal calcium and phosphate levels in body fluids; supports skeletal muscles; provides sites of attachment.

The Muscular System provides movement and support; stresses exerted by tendons maintain bone mass; stabilizes bones and joints.
The Nervous System controls skeletal muscle contractions; adjusts activities of respiratory and cardiovascular systems during periods of muscular activity.

The Muscular System’s muscle spindles monitor body position; facial muscles express emotion; muscles of the larynx, tongue, lips and cheeks permit speech.
The Endocrine System

hormones adjust muscle metabolism and growth; parathyroid hormone and calcitonin regulate calcium and phosphate ion concentrations.

The Muscular System’s skeletal muscles provide protection for some endocrine organs.
The Cardiovascular System delivers oxygen and nutrients; removes carbon dioxide, lactic acid, and heat.

The Muscular System’s skeletal muscle contractions assist in moving blood through veins; protects deep blood vessels.
The Lymphatic System

The Lymphoid System defends skeletal muscles against infection and assists in tissue repairs after injury.

The Muscular System protects superficial lymph nodes and the lymphatic vessels in the abdominopelvic cavity.
The Respiratory System provides oxygen and eliminates carbon dioxide.

The Muscular System’s muscles generate carbon dioxide; control entrances to respiratory tract, fill and empty lungs, control airflow through larynx, and produce sounds.
The Digestive System provides nutrients; liver regulates blood glucose and fatty acid levels and removes lactic acid from circulation.

The Muscular System protects and supports soft tissues in abdominal cavity; controls entrances to and exits from digestive tract.
The Urinary System removes waste products of protein metabolism; assists in regulation of calcium and phosphate concentrations.

The Muscular System’s external sphincter controls urination by constricting urethra.
The Reproductive System’s reproductive hormones accelerate skeletal muscle growth.

The Muscular System’s contractions of skeletal muscles eject semen from male reproductive tract; muscle contractions during sex act produce pleasurable sensations.