Muscle

A tissue that (a) causes movement by contracting (shortening), (b) holds body posture, and (c) helps generate body heat

- Muscle fiber = a muscle cell

Fig 4.2

Overview of muscle contraction:

- Muscles contract only when they receive signals from the nervous system
- Muscle cells contain actin (thin) and myosin (thick) protein filaments
    - √ The cell contracts by sliding the filaments on top of each other
- Muscles only generate force through contracting (never by getting longer)

Fig 10.10

There are three types of muscles: skeletal, smooth, and cardiac

	Skeletal	Smooth	Cardiac
Location	Attached to bone (by tendons)	Hollow organ walls	Heart
Function:	Moves body parts by applying forces on the skeleton	Moves substances through hollow organs by squeezing on the substance in the organ	Pumps blood by squeezing on blood in the heart
Voluntary:	Yes	No	No
Cell shape	Long, cigar-shaped	Short, pointed ends	Branched
Cell features	Striations Multiple nuclei	No striations	Striations Intercalated discs

Fig 10.2; Table 4.2

Smooth muscle

Involuntary muscle for propelling substances through hollow organs

Figs 10.2 and 10.23; Table 4.2

Cardiac muscle (heart muscle)

Involuntary muscle that propels blood through circulatory system

- Intercalated discs = Round structures at the ends of cardiac muscle cells that join the cytoplasm of each cell to its neighbors

Figs 10.2, 10.21, and 10.22; Table 4.2

Skeletal muscle

Voluntary muscle tissue that moves body parts

- Each end is attached to a bone by a tendon
- Each muscle cell is wrapped in a sheath of connective tissue
- Fascicle = A bundle of muscle cells wrapped in a connective tissue sheath
- Each muscle organ is a bundle of fascicles wrapped in a connective tissue sheath

√ The outermost sheath is continuous with muscle's tendons

Fig 10.3; Table 4.2

Skeletal muscle cell structure

- Sarcomere = A stack of myosin with stacks of actin (held by Z-discs) on its left and right sides

- Myofibril = A chain of sarcomeres

- Skeletal muscle cell = A long cigar-shaped cell containing many myofibrils and many nuclei

- A bands = Dark striations caused by myosin stacks

    √ H zone = a small light band in middle of A band where the mysosin and actin don't overlap

- I band = Light striations caused by actin stacks

    √ Z line = line in I band where sarcomeres meet

Figs 10.4, 10.5, and 10.10

Muscle cell contraction:

- When a sarcomere contracts, the mysosin proteins pull the actin proteins inward

- The mysosin proteins have heads at each end that bind to actin and pull it inward

  √ The myosin heads use ATP as their energy source

- Actin proteins have binding sites for the mysosin heads

  √ The binding sites are blocked by troponin and tropomyocin proteins when the muscle is relaxed

  √ This prevents the mysosins from pulling the actins inward

- Nerve signals causes the muscle to release stored Ca^{2+} internally

  √ Ca^{+2} causes the troponin and tropomyocin proteins to leave

- The myosin heads can now bind the actin and pull it inward

  √ This makes the sarcomere contract

Figs 10.5, 10.8, 10.10, and 10.11

ATP for muscle contraction

- Only enough ATP in muscle for about 6 seconds of contractions
- Creatine phosphate in muscle can recharge ATP
  - √ Only enough creatine phosphate for about 20 seconds
- Aerobic respiration of glucose can recharge ATP continuously during rest, light exercise, or medium exercise
  - √ $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ (glucose)
  - √ This reaction recharges 32 ATP molecules per glucose
- Anaerobic respiration of glucose can recharge ATP during bursts of intense exercise (when insufficient O_2 for aerobic respiration)
  - √ $C_6H_{12}O_6 \rightarrow 2\ C_3H_6O_3$ (glucose) (lactic acid)
  - √ This reaction recharges 2 ATP molecules per glucose
  - √ The body soon increases breathing and heart rate to return to aerobic respiration

Fig 10.12

Muscles use a mixture of aerobic and anaerobic respiration to provide themselves with energy during exercise

- Muscles always use some aerobic respiration, but the more intense the exercise, the more anaerobic respiration the muscle uses

Muscle fatigue

The decrease in a muscle's force as it is being exercised

- The major causes of muscle fatigue are (1) depletion of the muscle's glycogen stores, and (2) Increase in lactic acid in the muscle

  √ Both of these causes are the results of anaerobic respiration

Aerobic exercise

Exercise consisting of sustained activity at increased breathing and heart rate

- Increases endurance and cardiovascular health (but not muscle size)

Fig 10.18

Resistance training

Exercise consisting of short but intense muscle contractions against heavy resistance

- Muscles mostly use anaerobic respiration during resistance training
- Increases muscle size (more actin and myosin per cell) and power

  √ Does not increase cardiovascular health

Fig 10.19

Graded response

A muscle's ability to generate different amounts of force (tension)

- The greater the number of cells being contracted, the greater the force

- The higher the frequency of nerve signals to a cell, the greater the force

  √ A twitch = A muscle cell's contraction to one single nerve signal

  √ A single twitch does **not** completely contract a muscle cell's sarcomeres, so the cell's force is not at maximum

  √ Only a rapid series of twitches can fully contract the sarcomeres (a state called tetanus) for maximum force

Fig 10.16

Some generalizations about how skeletal muscles cause movement:

a) Skeletal muscles cause movement at joints by pulling on the bones

- The muscle attaches (via tendons) to both bones of the joint, but one bone is more moveable than the other
- Origin = The muscle's attachment to the less movable bone
- Insertion = The muscle's attachment to the more movable bone

b) Contraction of the muscle pulls the insertion towards the origin

c) Movement of the joint is usually controlled by two muscles, attached to opposite sides of the bones

- These muscles are located on the proximal bone of the joint
- One muscle moves the joint in one direction, the other muscle moves the joint in the opposite direction
  - The muscle that makes the joint angle smaller is located on the inside of the joint angle
  - The muscle that makes the joint angle larger is located on the outside of the joint angle

Teams of muscles control most body movements:

- Antagonists = Muscles that cause opposite movements
  - √ Example: The bicep and tricep muscles are antagonists because they move the forearm in opposite directions

- Prime mover = The muscle that provides most of the force for a movement

- Synergists = Muscles that assist prime movers
  - √ Some synergists pull in same direction as the prime mover

  - √ Fixators = Synergists that prevent movement of the origin

Fig 11.2

Types of movement at joints:

Flexion and extension:

- Flexion = Movement that (from anatomical position) decreases a joint angle in the sagital plane
  - √ "Curling up" body parts

- Extension = The movement opposite of flexion (increasing the joint angle in the sagital plane)
  - √ Hyperextension is extension beyond anatomical position

Abduction and adduction:

- Abduction = Movement that (from anatomical position) moves body parts away from the medial line of body in the frontal plane
  - √ "Spreading apart" body parts

- Adduction = The opposite of abduction (moving body parts toward the medial line of the body in the frontal plane)

- Abduction/adduction can also occur in the transverse plane

Figs 9.12 and 9.13

Muscles of the face:

- Frontalis = Muscle that covers the forehead
- The masseter (originates in cheek bone) and the temporalis (originates in temporal bone) close the jaw (for chewing)
    - √ Both insert into the mandible
- Orbicularis oculi (circular muscles surrounding the eye orbits) allows eye lids to shut or squint
- Orbicularis oris (a circular muscle surrounding the mouth) moves the lips
- Zygomaticus (runs from the cheekbone to the corner of the mouth) is used for smiling

Figs 11.7, 11.8, and 11.10; 11.5. Table 11.4

Muscles of the neck:

- Platysma (covers front of neck) is used for frowning
- Sternocleidomastoids (a pair of muscles, one on each side of neck) are used to flex the head down (as in praying) and to rotate the head (as in saying "no")
- The trapezius (covers the back of the neck) is used to extend the head up

Figs 11.14, 11.15, and 16.11; Table 11.5

Anterior trunk muscles:

- Pectoralis majors = a pair of chest muscles

  √ Flex arms and adduct arms in the transverse plain

- Abdominal girdle muscles = 4 layers of muscles that form a wall around the abdomen (each layer runs in a different direction). They flex the spine (bend forward), twist the upper trunk, and protect the abdominal organs

  The 4 layers of abdominal muscles (from most superficial to most deep):

  √ External oblique = Runs diagonally downward toward the medial line

  √ Rectus abdominis = Runs vertically

  √ Internal oblique = Runs diagonally upward toward the medial line

  √ Transversus abdominis = Runs horizontally

Fig 11.16a

Posterior trunk muscles:

- Trapezius = A pair of muscles of upper back and neck
  - √ Shrug shoulders and extend head
- Latissimus Dorsi = A pair of muscles of the midback
  - √ Extend arms and adduct arms in the frontal plain
- Deltoids = A pair of muscles of the shoulders
  - √ Abduct arms in frontal and transverse planes

Fig 11.22, 11.23a, 11.23b, and 11.24; Table 11.8

Muscles on the arm (all move the forearm by inserting into the forearm bones):

- Biceps brachii = Anterior muscle of arm
  - √ Flexes forearm
- Triceps brachii = Posterior muscle of arm
  - √ Extends forearm

Figs 11.25 and 11.26

Muscles on the forearm

There are many muscles in the forearm. Most of them move the wrist or the fingers

- Their names usually include “flexor” or “extensor” (depending on their action) and “carpi” or “digitorum” or "pollicis" (depending on whether they move the wrist, the fingers, or the thumb finger, respectively)

Fig 11.25

Muscles of the pelvis (all move the thigh by inserting into the femur):

- Gluteus maximus = Muscle that covers the back of the pelvis (the buttocks)

  √ Extends the thigh

- Gluteus medius = Muscles that cover the sides of the pelvis

  √ Abduct the thigh

- Iliopsoas = Muscles that cover front of the pelvis

  √ Flex the thigh

- Adductors = Muscles of the inner thigh and groin

  √ Adduct the thigh

Figs 11.16b, 11.29, and 11.30; Table 11.6

Muscles of the thigh (all move the leg by inserting into the tibia)

- Quadriceps = A group of anterior thigh muscles that extend the leg

  √ The rectus femoris is in the center of the group, flanked by the vastus lateralis and the vastus medialis

- Hamstrings = A group of posterior thigh muscles that flex the leg

  √ The biceps femoris, the semimembranosus, and the semitendinosus

- Sartorius = A long thin muscle that runs diagonally across the thigh

  √ The sartorius is used to cross the leg

Figs 11.29 and 11.31

Muscles of the leg (all move the foot)

- Gastrocnemius and the soleus = Major muscles of the posterior leg (the calf)

  √ Flexion onto ball of foot (plantar flexion)

Tibialis anterior = Major muscle of the anterior leg

√ Flexion onto heel of foot (dorsiflexion)

Figs 9.13h, 11.32, and 11.33

Muscular development

- Newborns have all muscles and nerves but lack coordination skills
- Testosterone (male hormone) causes increased muscles in males
  - √ "Anabolic steroids" = Synthetic testosterone taken to increase muscles
  - √ Banned by most sports due to health risks
- Muscles naturally atrophy (get smaller and weaker) if not exercised
- Aging muscles lose muscle cells, gain connective tissue

Fig 10.20

Degenerative muscular disorders

- Duchenne muscular dystrophy = A fatal degenerative muscle disease of children
- Myasthenia gravis = A neuromuscular autoimmune disease of adults