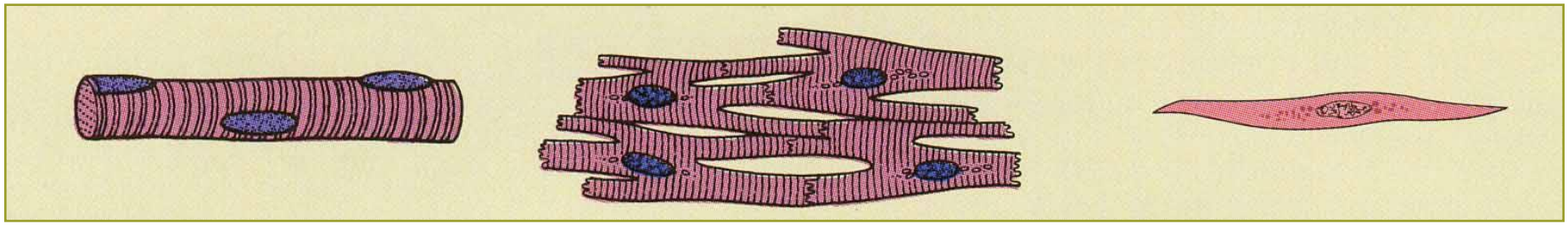
Animal Anatomy and Physiology 1

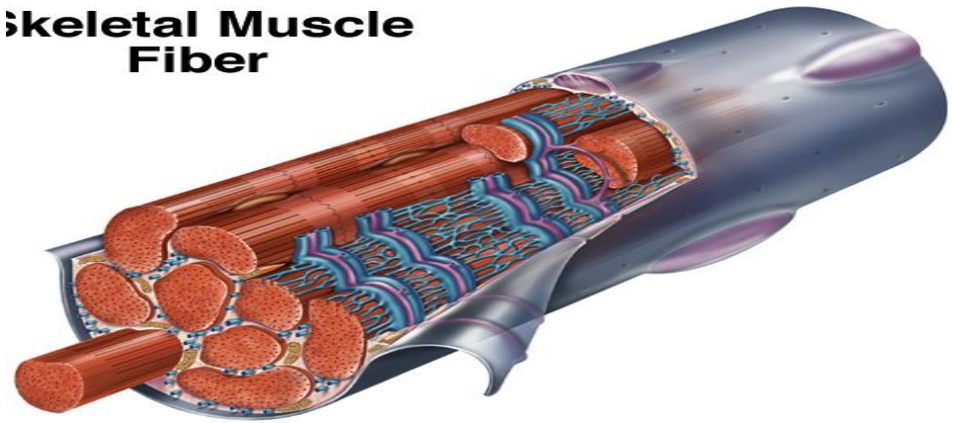
Webinar Chapter 7

Muscular System



The Muscular System

Chapter 7 – Pages 191-204



Skeletal Muscle

Cardiac Muscle

Smooth Muscle

Textbook Learning Objectives

Chapter 7 – Page 191

- List the three types of muscle and describe the general characteristics of each type
- Describe the structure and function of tendons, aponeuroses, and ligaments
- Differentiate between prime mover, antagonist, synergist, and fixator muscles
- List the locations and actions of the muscles of the head and neck
- List the locations and actions of the muscles of the abdomen, thoracic limb, and pelvic limb
- List the locations and actions of the muscles of respiration
- Describe the microscopic anatomy of skeletal muscle, smooth muscle, and cardiac muscle cells
- List the components of a neuromuscular junction and describe the function of each component
- List and describe the roles of the connective tissues in skeletal muscles
- Describe the events that occur in skeletal muscle cells during muscle contraction and relaxation
- Differentiate between visceral smooth muscle and multiunit smooth muscle

Muscle

- One of the four basic tissues of the body
- Made up of cells that can shorten or contract
- Three different types of muscle
  1. Skeletal muscle
  2. Cardiac muscle
  3. Smooth muscle

Comparison of Muscle Features

Table 7-1, Page 193

Feature	Skeletal Muscle	Cardiac Muscle	Smooth Muscle
Location	Skeletal muscles	Heart	Internal organs, blood vessels, eye
Action	Move the bones, generate heat	Pump blood	Produce movements in internal organs and structures
Nuclei	Multiple	Single	Single
Striations	Present	Present	Absent
Cell shape	Long, thin fiber	Branched	Spindle
Nerve supply	Necessary for function	Modifies activity, not necessary for function	Visceral—modifies activity, not necessary for function Multiunit—necessary for function
Control	Voluntary	Involuntary	Involuntary

Comparison of Muscle Features

Table 7-1, Page 193

Table 7.2 Comparison of Muscle Types

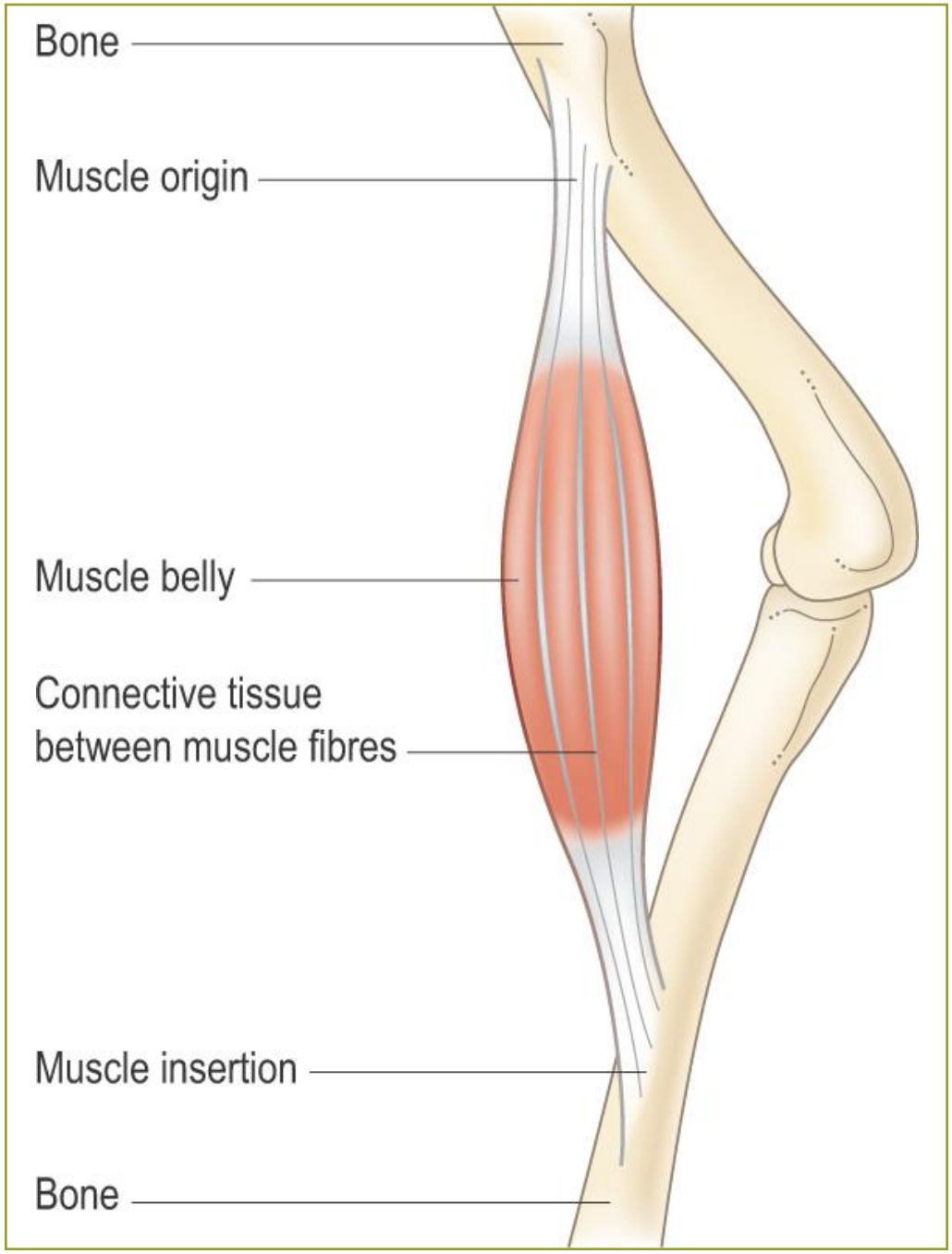
Feature	Skeletal Muscle	Cardiac Muscle	Smooth Muscle
			
Location	Attached to bone	Heart	Wall of hollow organs, blood vessels, and glands
Appearance			
Cell shape	Long, cylindrical	Branched	Spindle-shaped
Nucleus	Multiple, peripheral	Usually single, central	Single, central
Special features		Intercalated disks	Cell–cell attachments
Striations	Yes	Yes	No
Autorhythmic	No	Yes	Yes
Control	Voluntary	Involuntary	Involuntary
Function	Move the whole body	Heart contraction to propel blood through the body	Compression of organs, ducts, tubes, etc.

Skeletal Muscle Gross Anatomy

Pages 193-198

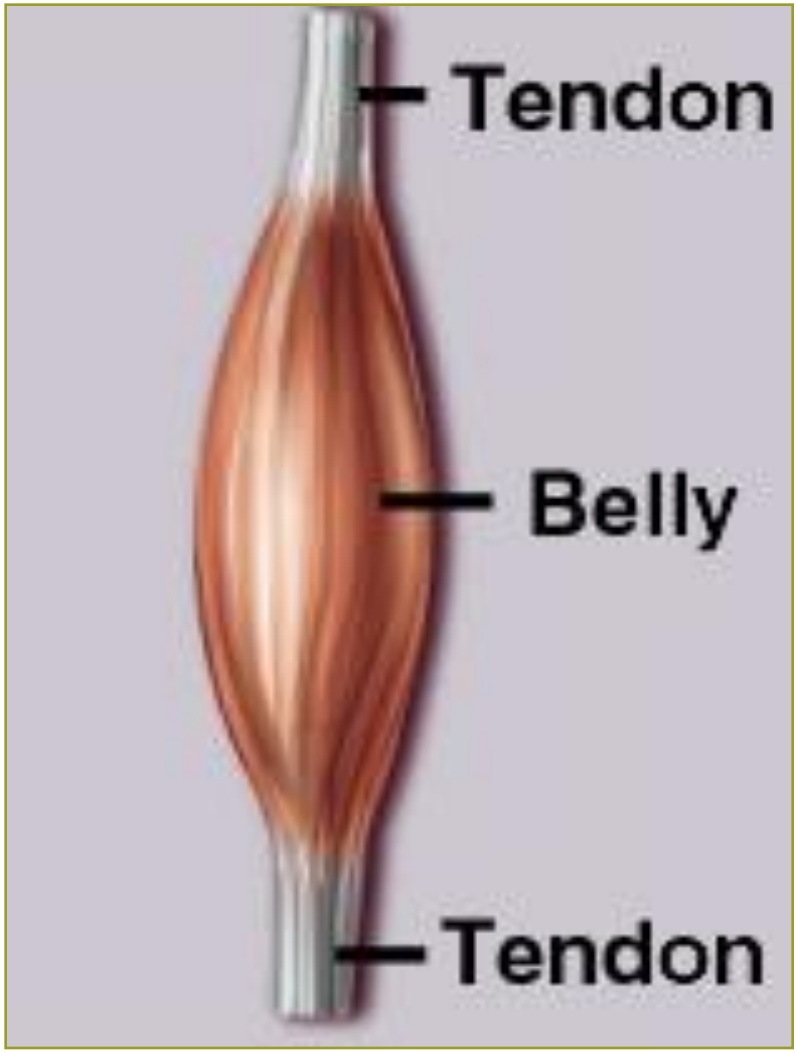
- **Tendons**: fibrous connective tissue bands
- **Aponeuroses**: sheets of fibrous connective tissue
- **Origin**: the more stable of a muscle's attachment sites
- **Insertion**: site that undergoes most of the movement when a muscle contracts

Bones, Joints, & Muscles



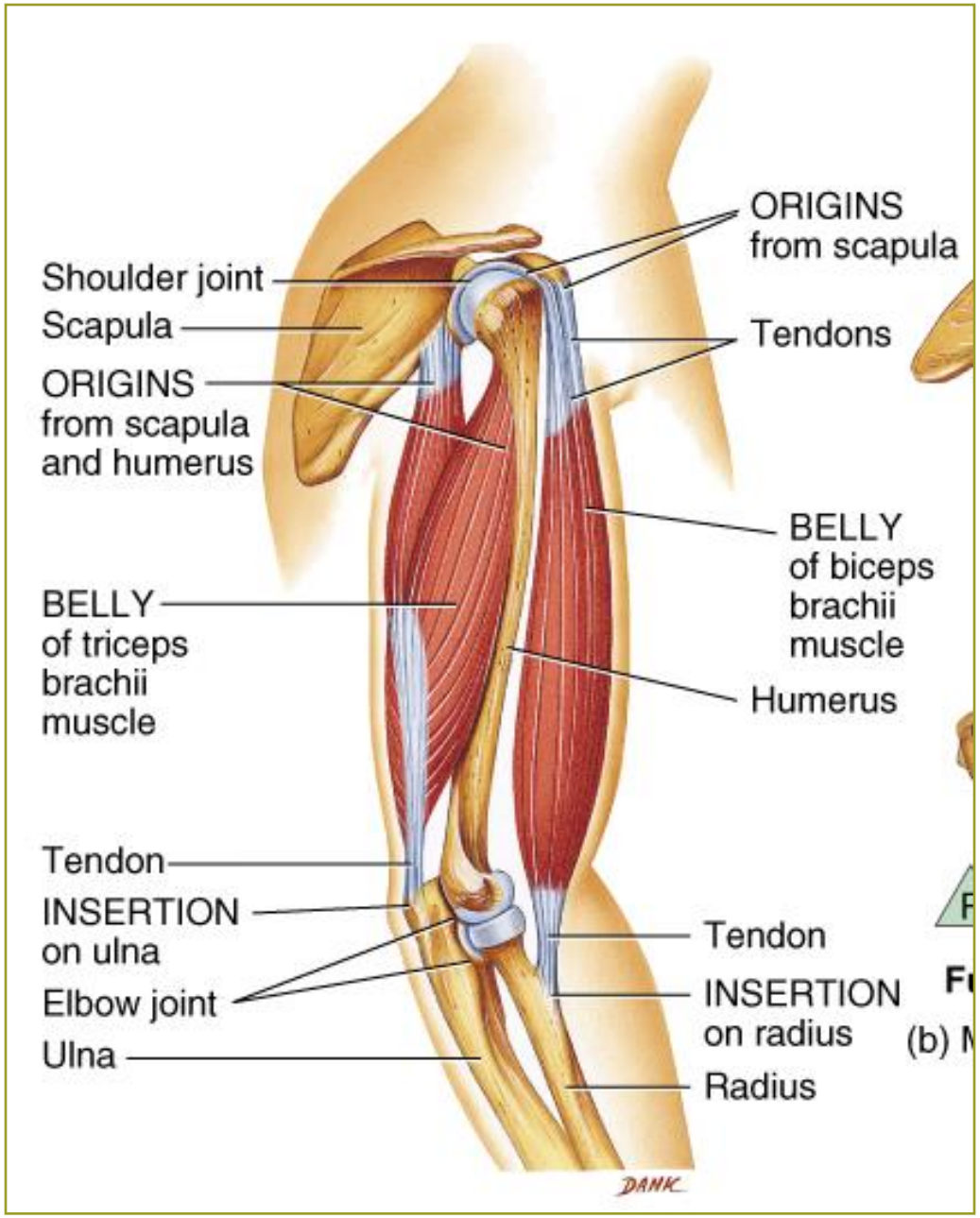
Gross Anatomy of Skeletal Muscle

- Muscle fibers
- Fibrous connective tissue
- “Belly”
- Tendon
- Periosteum



How Skeletal Muscles Work

- Origin
- Insertion
- Action
- Tendons



Skeletal Muscle

- Striated
- Voluntary
- Needs a functional nerve supply
- Rapid contractions
- Most attached to bones
- Up to ½ of body weight

Muscle Actions

- Prime mover (agonist): a muscle or muscle group that directly produces a desired movement
- Antagonist: a muscle or muscle group that directly opposes the action of a prime mover

Muscle Actions

- Synergist: a muscle that contracts at the same time as a prime mover and assists it in carrying out its action
- Fixator: muscles that stabilize joints to allow other movements to take place

Skeletal Muscle Physiology

- 2 functions
  - Movement
  - Glycogen storage
- Muscle use (Secret of Life!!!)
  - Hypertrophy
  - Atrophy
    - Loss of nerve supply
    - Disuse

Characteristics of Muscle Contraction

All-or-nothing principle

- When stimulated, individual muscle fiber either contracts completely or not at all
- Nervous system controls number of muscle fibers it stimulates for particular movements
  - Small, fine movements – few muscle fibers
  - Larger, more powerful movements – contraction of many muscle fibers

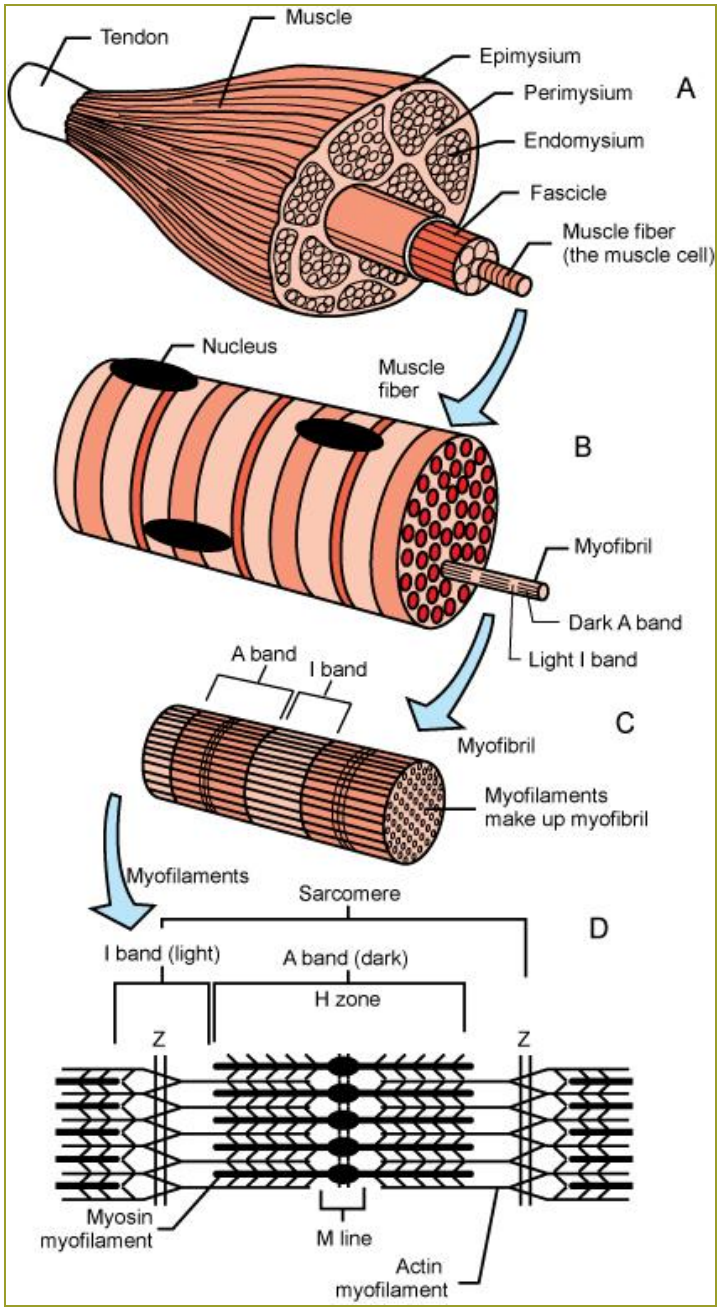
Heat Production

- Muscle activity generates heat
- **Panting or sweating** – mechanisms to eliminate excess heat
- **Shivering** – spasmodic muscle contractions that increase heat production

Skeletal Muscle Cells

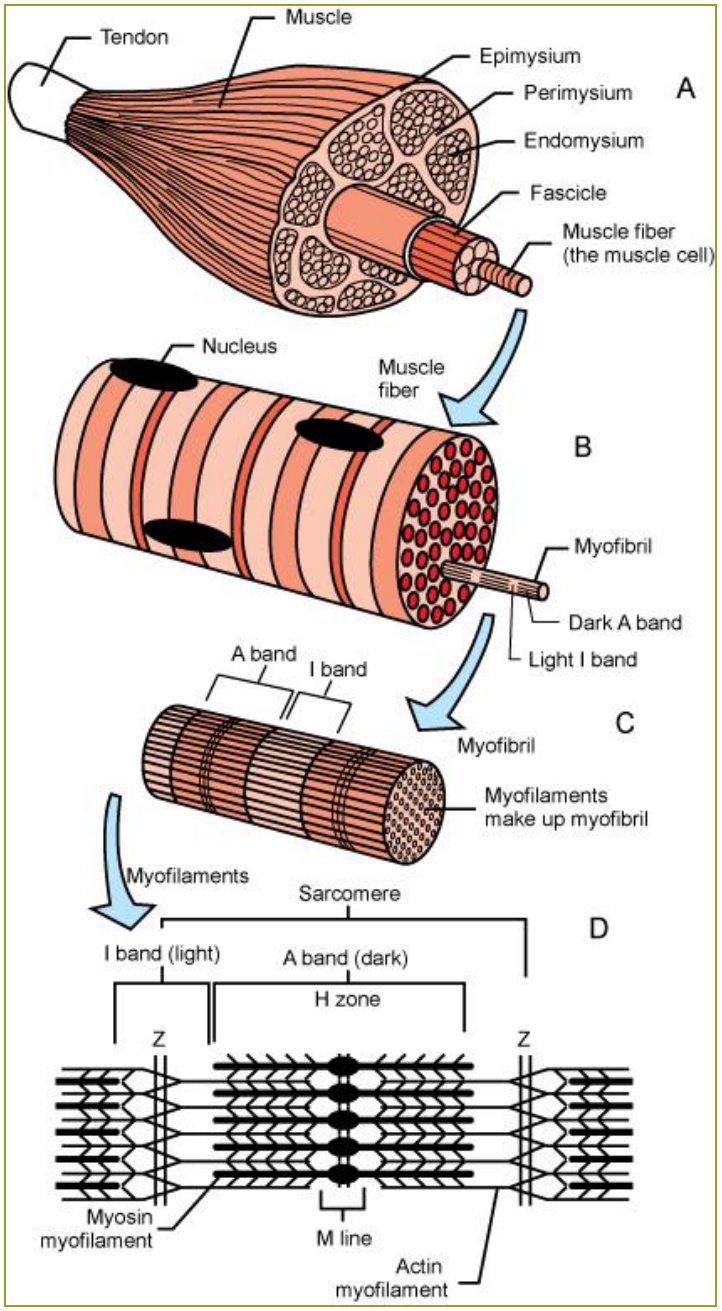
Figure 7-4, Page 198

- Very large
- Multinucleate
- Numerous **myofibrils** made of **actin** and **myosin**
- Network of sarcoplasmic reticulum



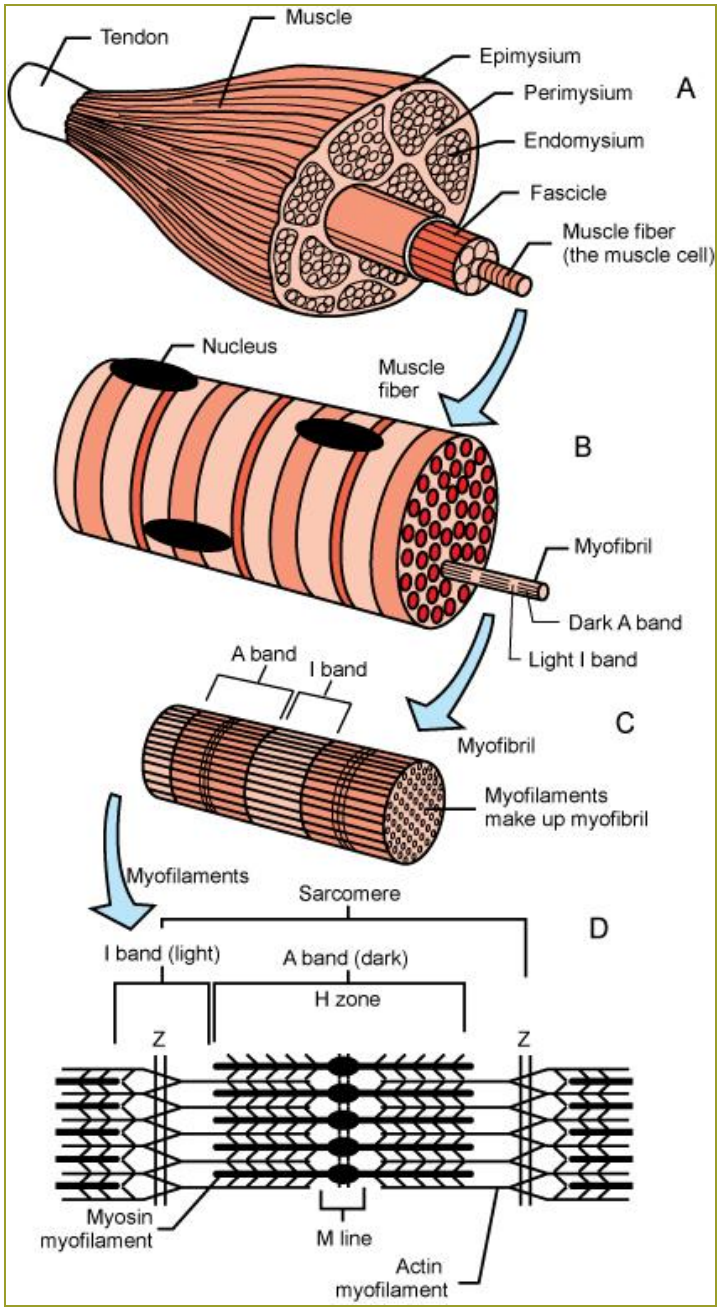
Skeletal Muscle Cells

- A bands: thick myosin filaments
- I bands: thin actin filaments
  - Dark line in the center of the I band is the Z line
  - Disk that is the attachment site for the actin filaments



Skeletal Muscle Cells

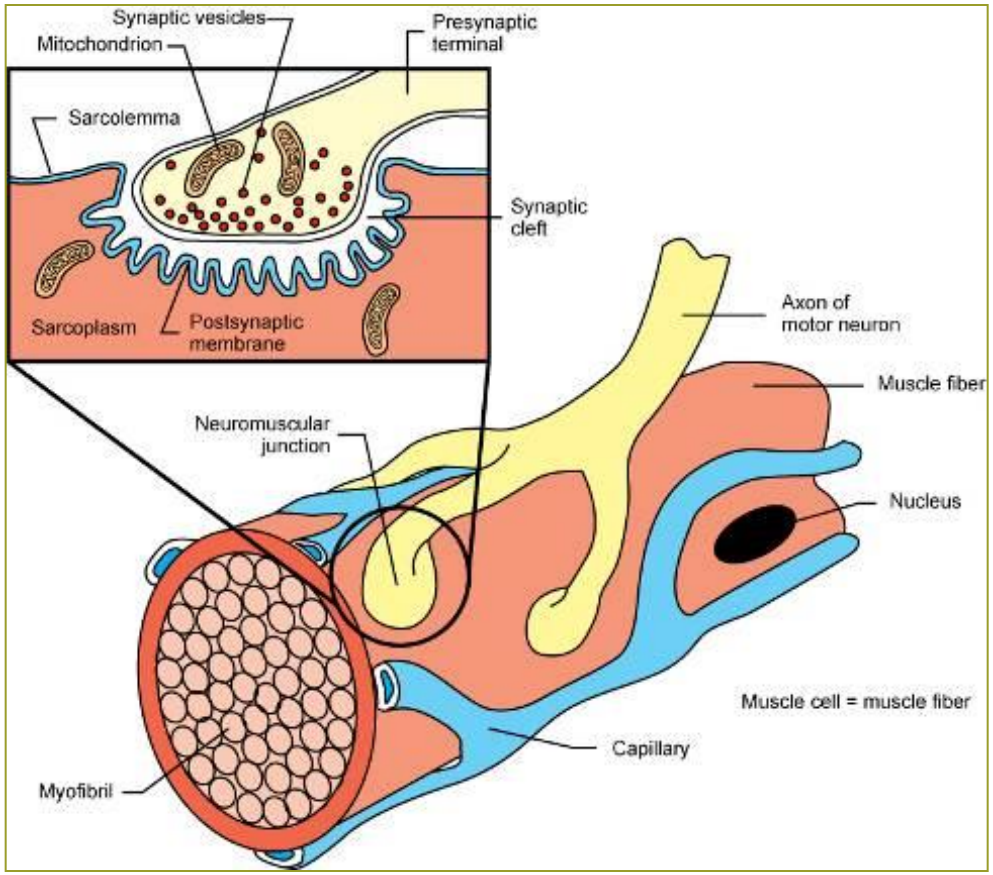
- **Sarcomere** – basic contracting unit of skeletal muscle
- Area from one Z line to next Z line
- Each **myofibril** is made up of many sarcomeres lined up end to end



Neuromuscular Junction

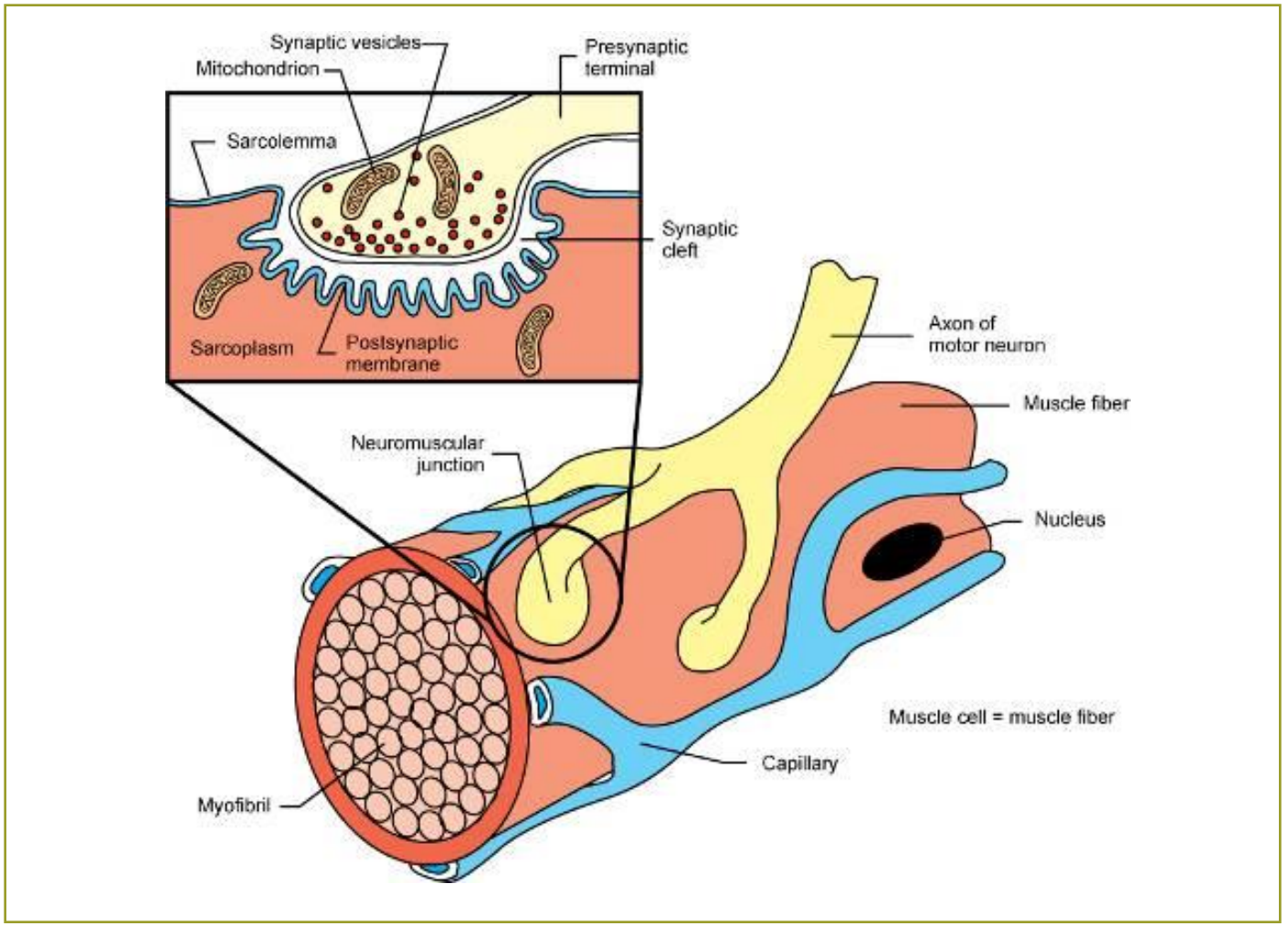
Figure 7-5, Page 200

- Nerves and muscles separated by the synaptic space
- **Synaptic vesicles** – sacs at the end of a nerve fiber; contain acetylcholine
  - **Acetylcholinesterase** – enzyme in the synaptic space that removes acetylcholine



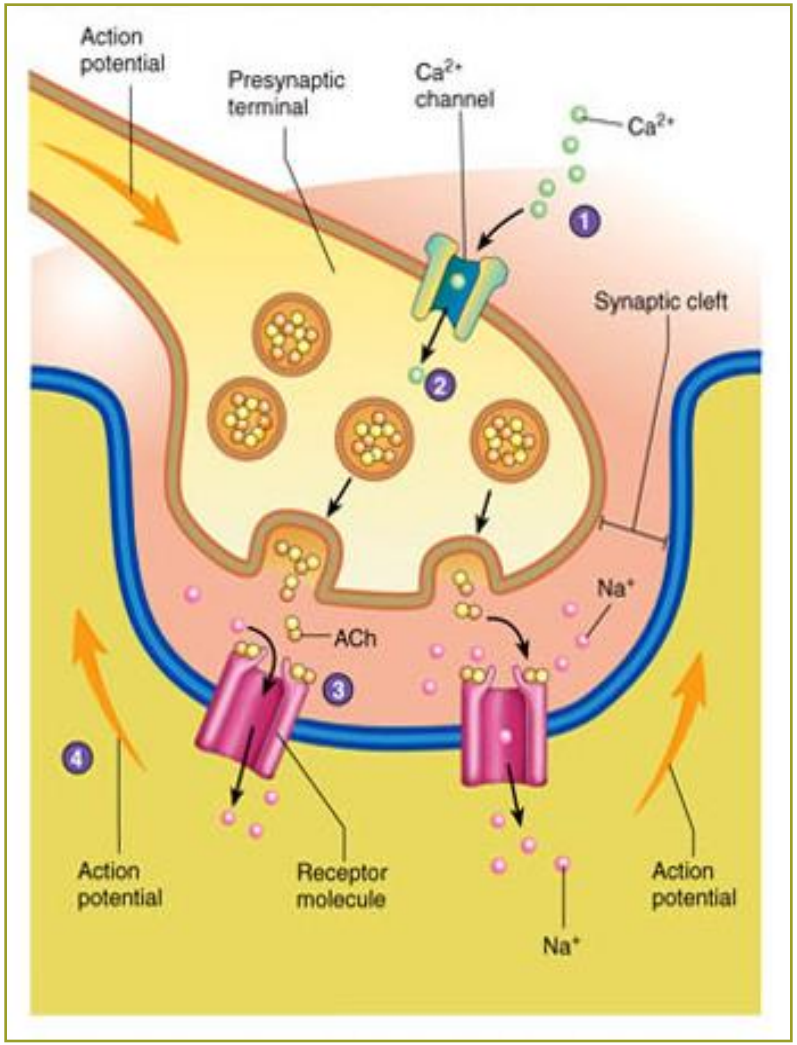
Neuromuscular Junction (NMJ)

Figure 7-5, Page 200

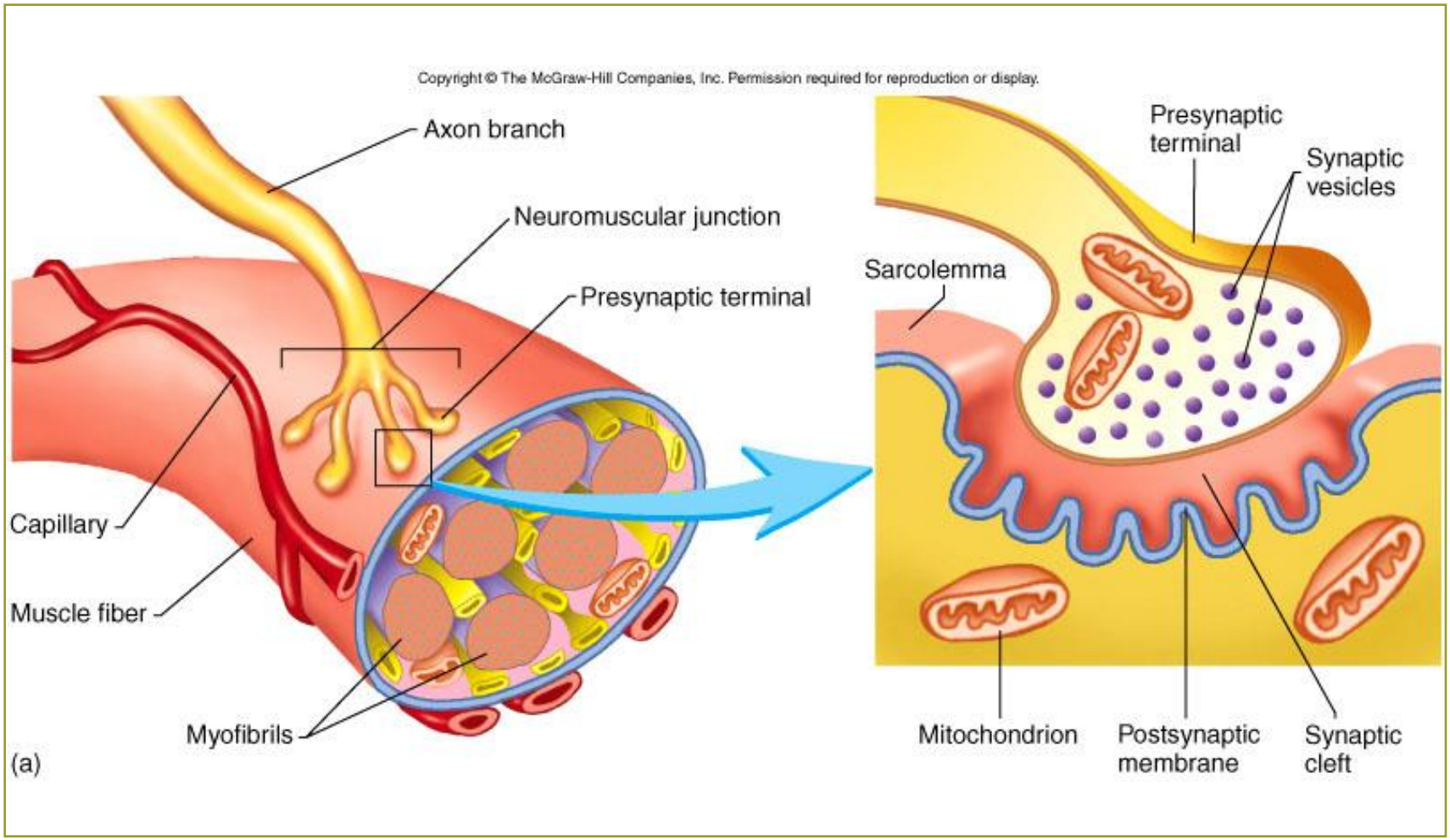


Neuromuscular Junction (NMJ)

- Motor neuron axon (nerve fiber)
  - Synaptic vesicles
- Muscle fiber
  - Receptor sites
- Synaptic space (cleft)
  - Acetylcholine (ACh)



Neuromuscular Junction (NMJ)

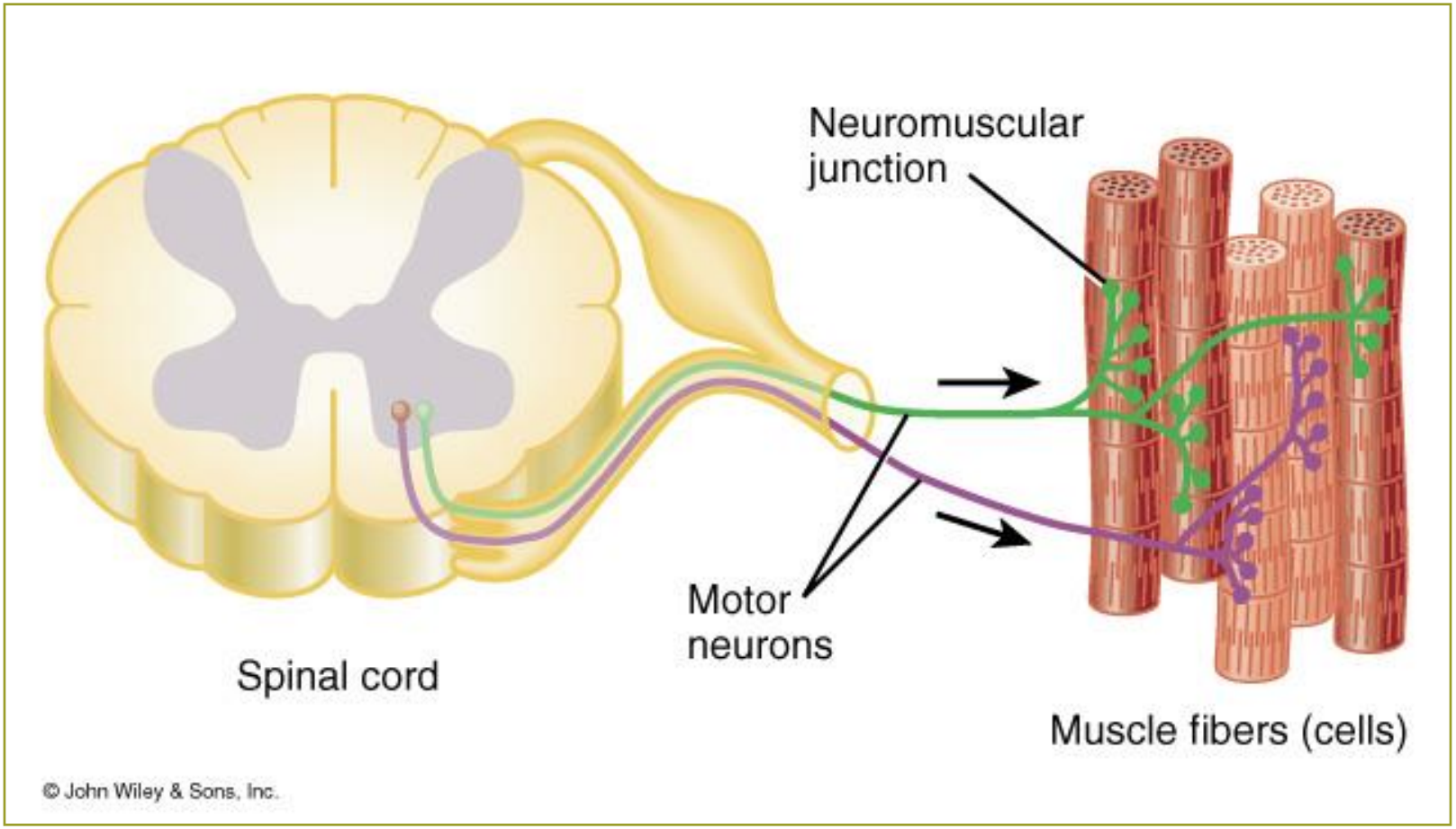


Motor Unit

- One **motor nerve fiber** (**axon**) and all muscle fibers it innervates
- Muscles that make small, delicate movements have few muscle fibers per nerve fiber in each motor unit
- Large, powerful muscles may have 100 or more muscle fibers per motor unit

Motor Unit

Figure 7-5, Page 200



Connective Tissue Layers

- Hold components of muscle together
- Contain blood vessels and nerve fibers that supply muscle fibers (muscle cells)
- **Continuous with tendons** or aponeuroses that connect muscle to bones or other muscles

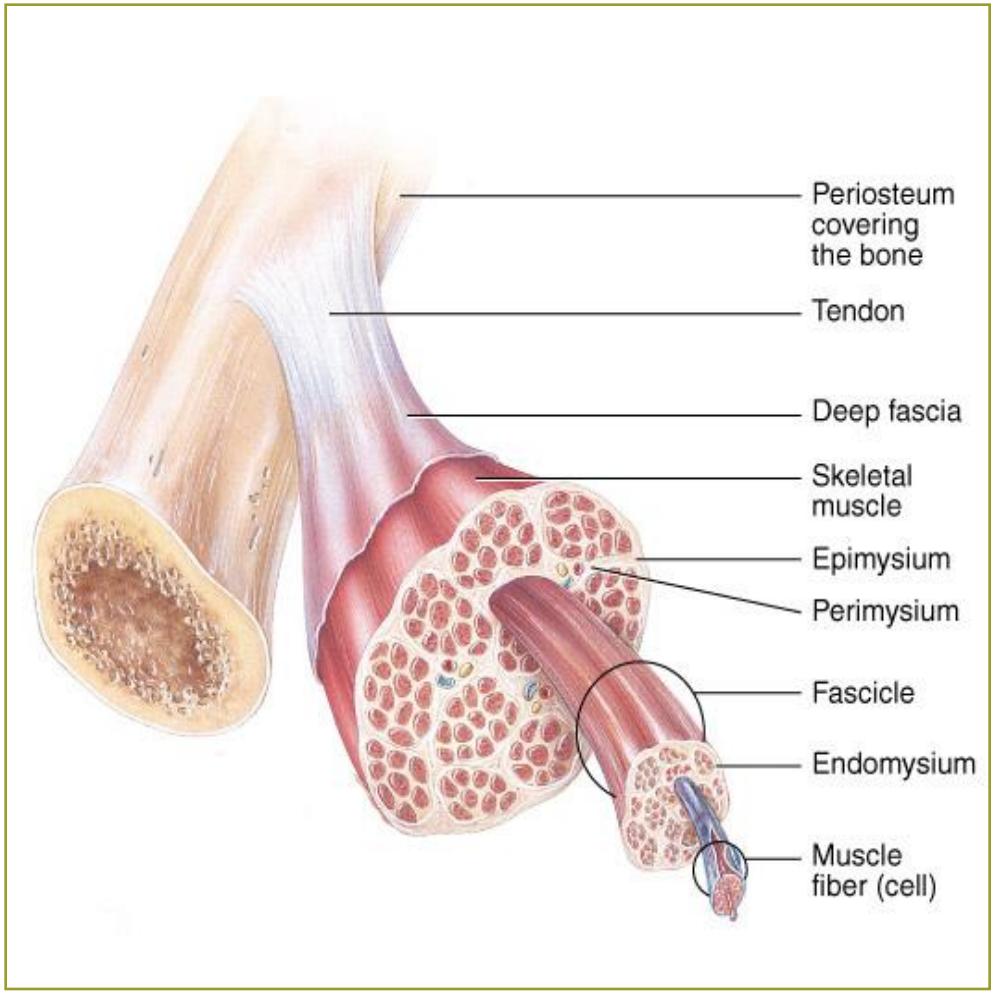
Connective Tissue Layers

- Endomysium – surrounds each muscle fiber (muscle cell)
- Fascicles – groups of skeletal muscle fibers (muscle cells)
- Perimysium – surrounds fascicles
- Epimysium –surrounds groups of muscle fascicles

Histology of Skeletal Muscle

Figure 7-4, Page 198

- Muscle fiber
  - Endomysium
- **Fascicle**
  - Perimysium
- Muscle
  - Epimysium
    - Superficial
    - Deep



Mechanics of Muscle Contraction

- Relaxed muscle fibers have **actin** and **myosin** filaments that slightly overlap
- When stimulated to contract, crossbridges on **myosin filaments slide back and forth**

Mechanics of Muscle Contraction

- Actin filaments on both sides are pulled toward the center of the myosin filaments
- This shortens the sarcomere
- Shortening of all the end-to-end sarcomeres in a muscle fiber results in a muscle contraction

Characteristics of Muscle Contraction

All-or-nothing principle

- When stimulated, an individual muscle fiber either contracts completely or not at all
- Nervous system controls the number of muscle fibers it stimulates for a particular movement
  - Small, fine movements require only a few muscle fibers to contract
  - Larger, more powerful movements require contraction of many muscle fibers

Muscle Contraction

Three phases:

1. Latent phase - time between nerve stimulus and beginning of contraction (about 10 ms)
2. Contracting phase - lasts about 40 ms
3. Relaxation phase - lasts about 50 ms

Muscle Contraction

- Maximum contraction efficiency occurs if nerve impulses arrive about 0.1 second apart
- Results in a series of complete muscle fiber twitches
- Careful timing of the nerve impulses to motor units of the muscle is needed to make muscle contract smoothly

Chemistry of Muscle Contraction

- ATP provides energy to allow the sliding of the actin and myosin filaments
- Creatine phosphate converts ADP back to ATP
- Glucose and Oxygen - help produce ATP & CP
  - Glucose stored in muscle as glycogen
  - Oxygen stored as myoglobin

Chemistry of Muscle Contraction

- Anaerobic metabolism – used if oxygen need exceeds oxygen supply
  - Results in lactic acid formation
  - Lactic acid accumulation causes discomfort

Heat Production

- Muscle activity generates heat
- Panting or sweating – mechanisms to eliminate excess heat
- Shivering – spasmodic muscle contractions that increase heat production

Muscle Contraction & Relaxation

- Nerve impulse reaches the end bulb of the motor nerve fiber
- Acetylcholine is released into the synaptic space
- Acetylcholine molecules bind to receptors on the surface of the sarcolemma
- Impulse travels along the sarcolemma and through the T tubules to the interior of the cell

Muscle Contraction & Relaxation

- Impulse reaches the sarcoplasmic reticulum
- Calcium ions (Ca^{++}) are released into the *sarcoplasm*
- Ca^{++} diffuses into the myofibrils and starts the contraction process

Muscle Contraction & Relaxation

- Sarcoplasmic reticulum begins pumping Ca^{++} back in again
- Ca^{++} is pulled out of the myofibrils
- Contraction stops, muscle returns to its original length

Muscle-Naming Conventions

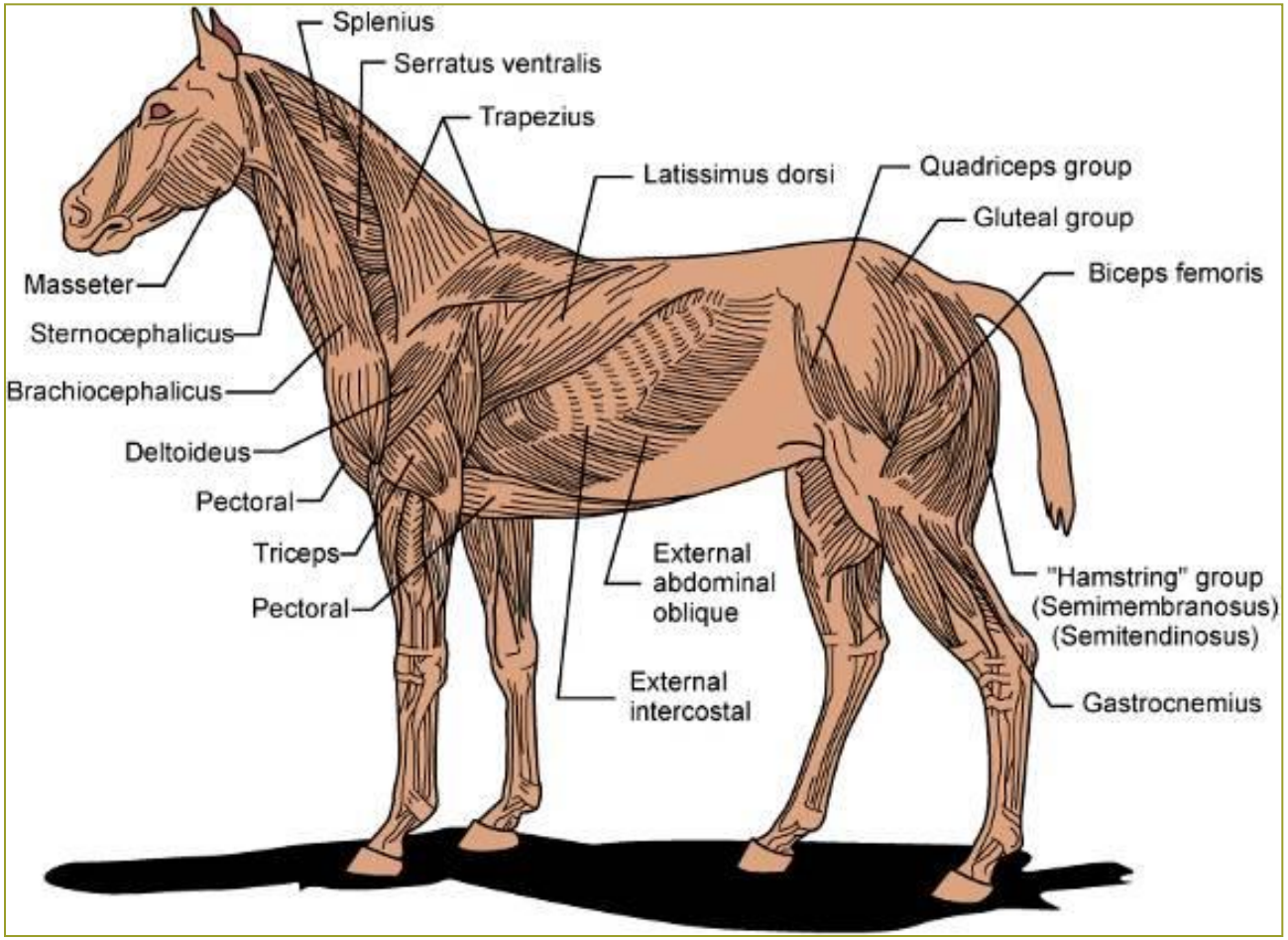
- Action: e.g., flexor muscles; extensor muscles
- Shape: e.g., *deltoid* means “triangular shaped”
- Location: e.g., biceps brachii muscle is located in the brachial region
- Direction of fibers: e.g., *rectus* means “straight”

Muscle-Naming Conventions

- Number of heads or divisions: *-cep* means “head”; biceps brachii muscle has two heads
- Attachment sites: e.g., origin of the sternocephalicus muscle is the sternum and insertion is the back of the head

Muscles of Horse

Figure 7-3, Page 195



Horse – What an Athlete! ☺

Muscle Actions

- Prime mover (Agonist): a muscle or muscle group that directly produces a desired movement
- Antagonist: a muscle or muscle group that directly opposes the action of a prime mover

Muscle Actions

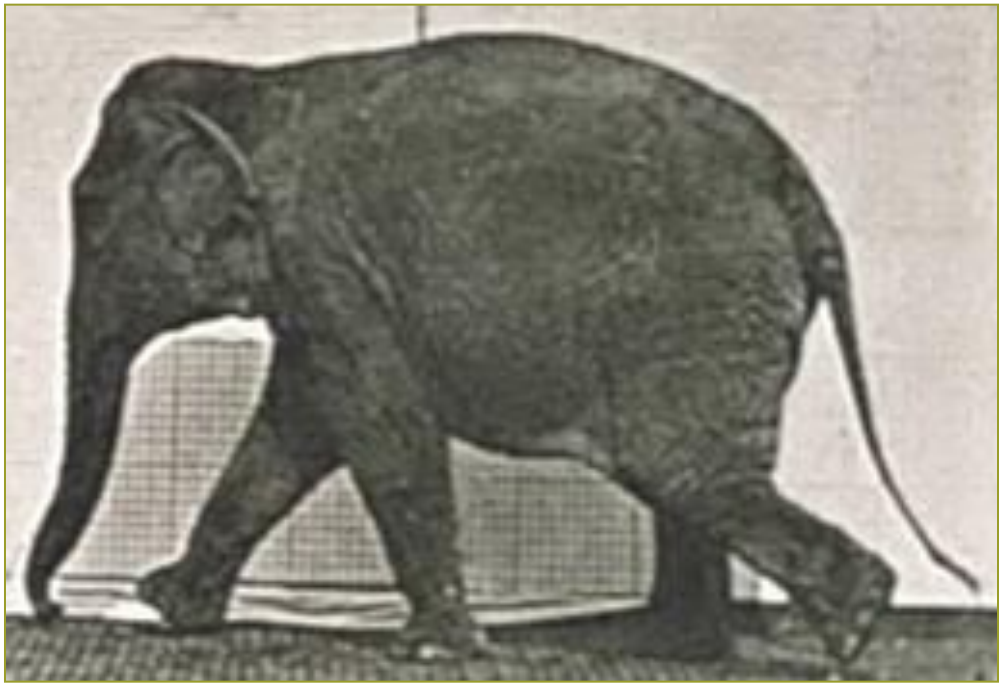
- Synergist: a muscle that contracts at the same time as a prime mover and assists it in carrying out its action
- Fixator: muscles that stabilize joints to allow other movements to take place

Tonus – Muscle Tone

- Involuntary contraction of small number of motor units
- Keeps muscles firm though relaxed
- Clinical importance
  - Measurement of depth in anesthesia

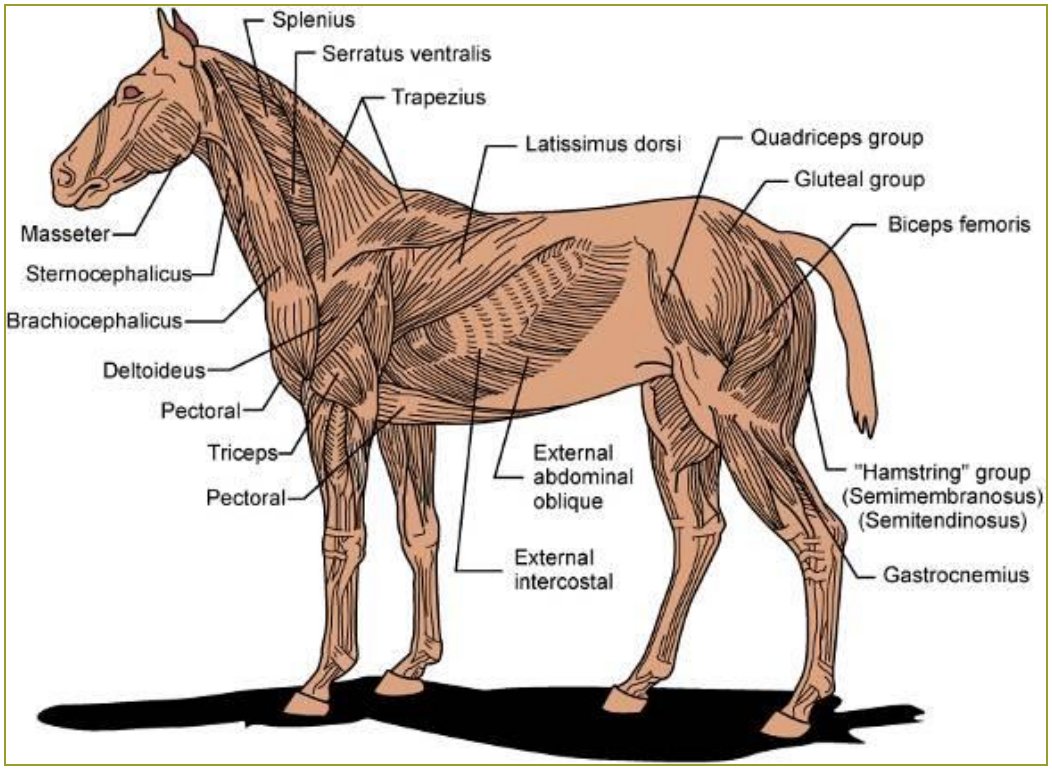
Gait

- Definition – the pattern of movement of the limbs of animals during locomotion
- Types of gait in animals
  - Plantigrade
  - Digitigrade
  - Unguligrade



Gait

- Plantigrade – walking with metatarsal bones flat on the ground
  - Examples – primates (humans too!), bears, rodents, raccoons, kangaroos
- Digitigrade – stands or walks on its digits, or toes
  - Examples – birds, Canidae, Felidae, elephants? ☺
- Unguligrade – hoofed animals walking on the tips of their toes
  - Examples – cattle, horses, pigs, goats, sheep



Topic 24

Describe the various muscle groups in the animal body

Cutaneous Muscles

- Thin, broad, superficial muscles
- Found in the fascia just beneath the skin
- Little or no attachment to bones
- Serve to twitch the skin

Head and Neck Muscles

- Control facial expressions
- Enable mastication
- Move structures such as eyes and ears
- Support the head
- Allow the head and neck to flex, extend, and move laterally

Abdominal Muscles

Functions

- Support the abdominal organs
- Help flex the back
- Participate in various functions that involve straining
- Play a role in respiration

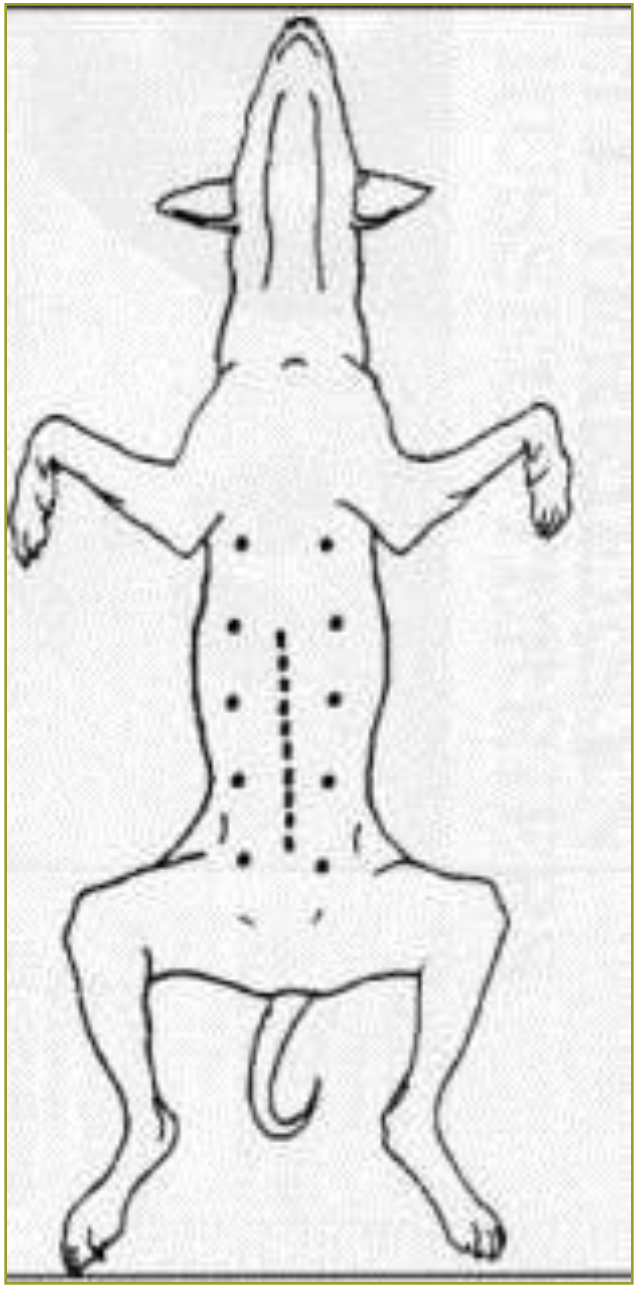
Abdominal Muscles

- Arranged in layers
- Left and right parts of each muscle come together on the ventral midline at the linea alba

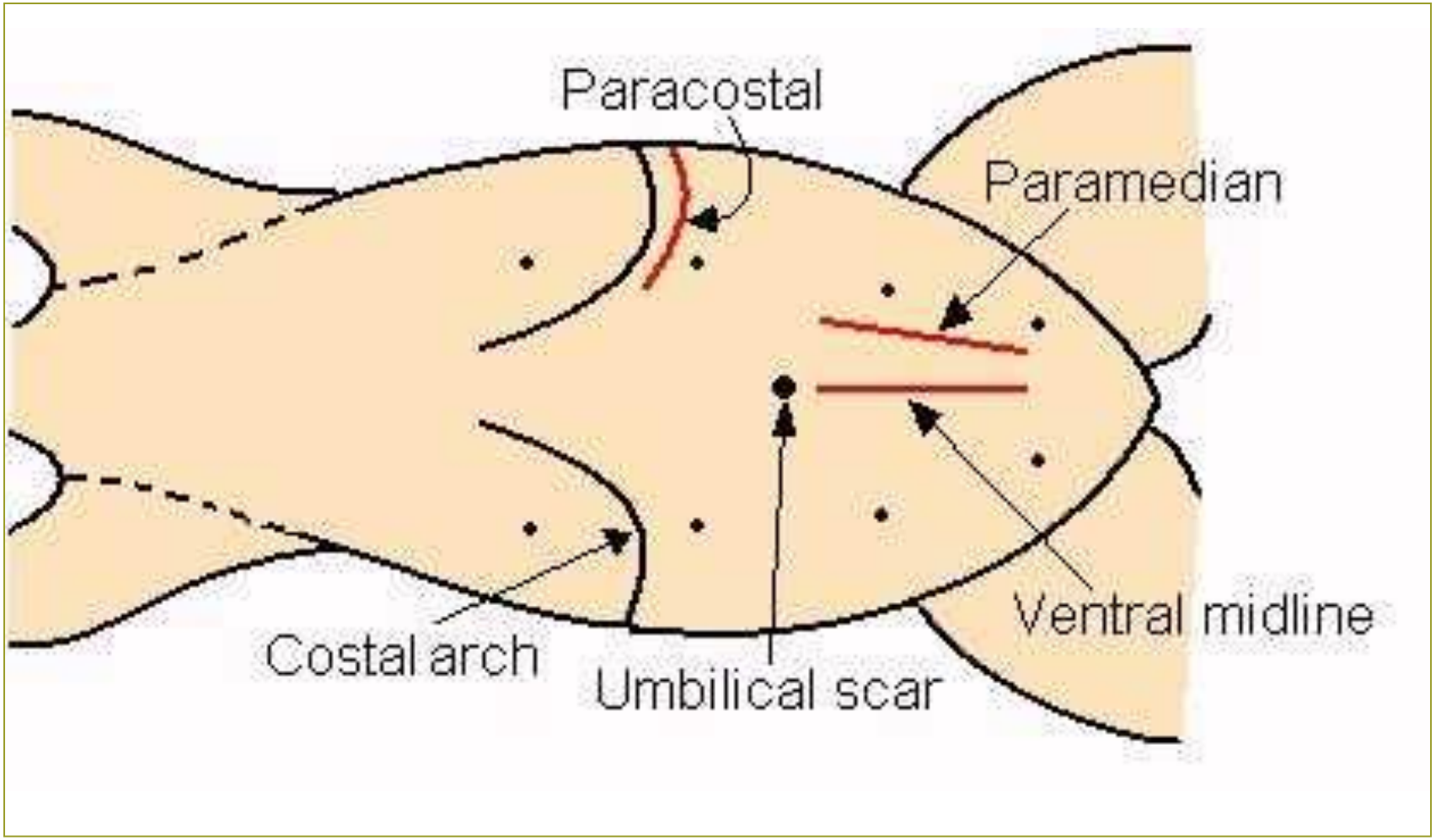
Abdominal Incisions

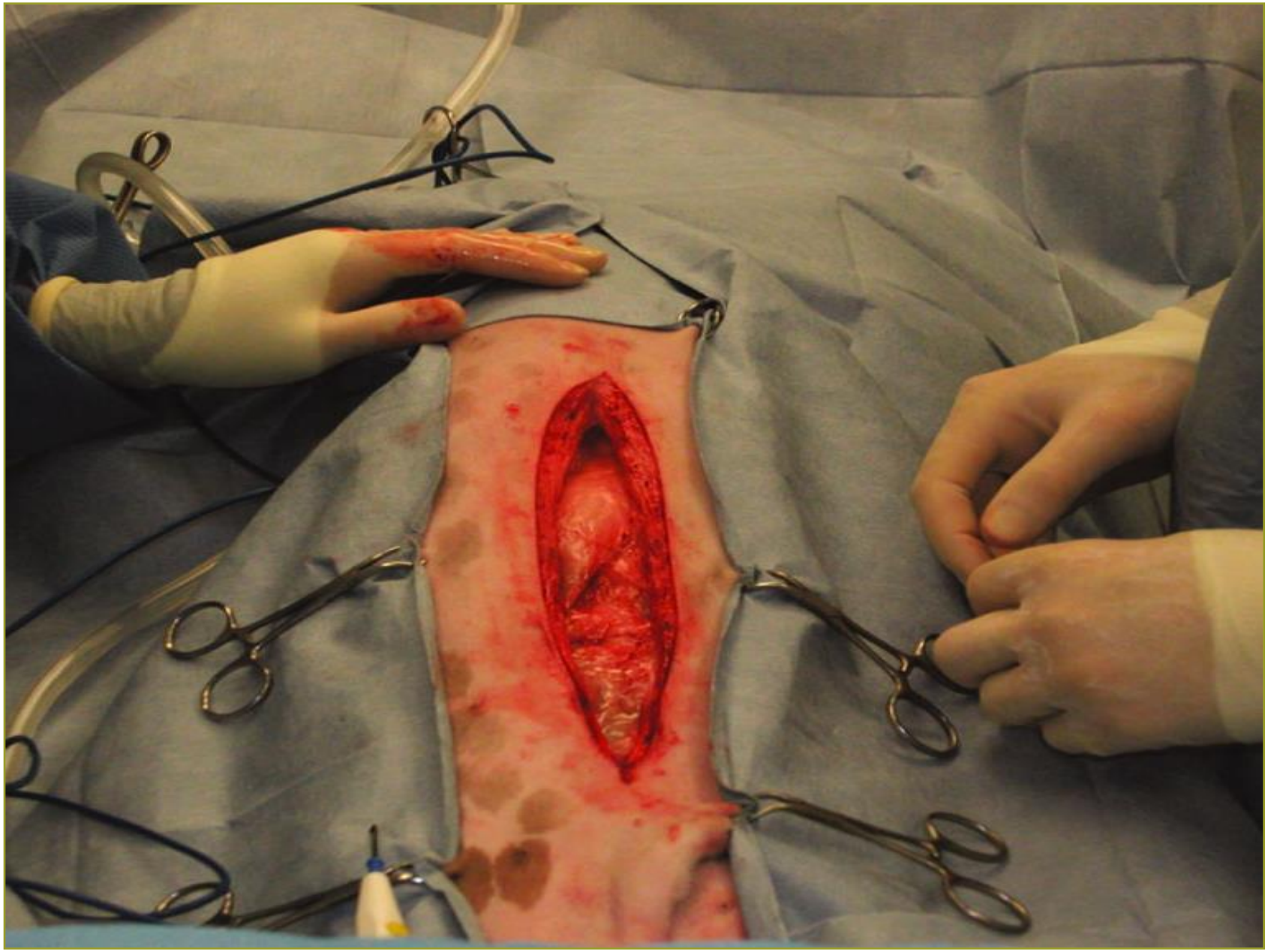
Clinical Application, Page 259

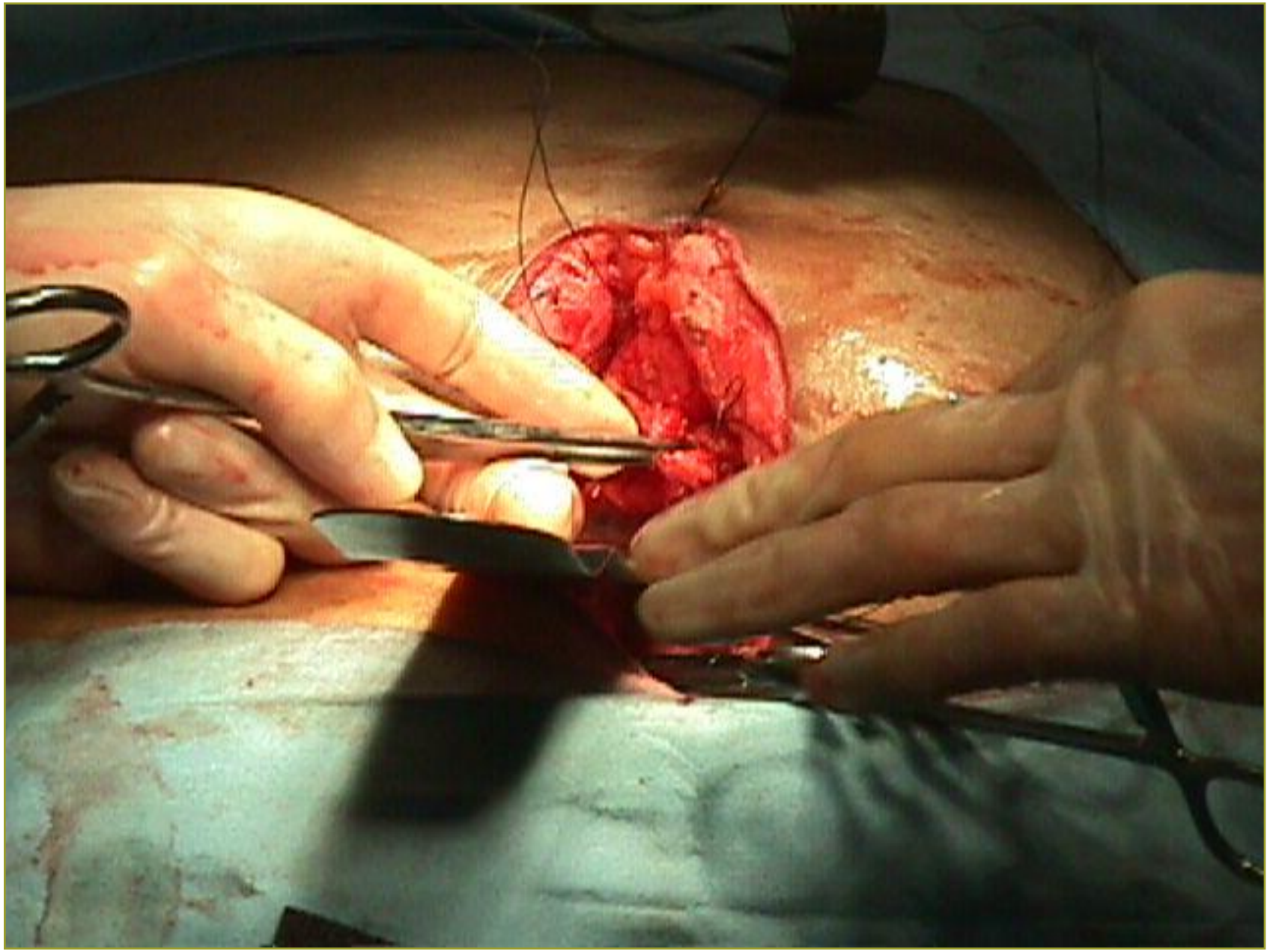
- Linea alba
- Layers of closure
  - Peritoneum
  - Muscle
  - Subcutaneous layer
  - Skin



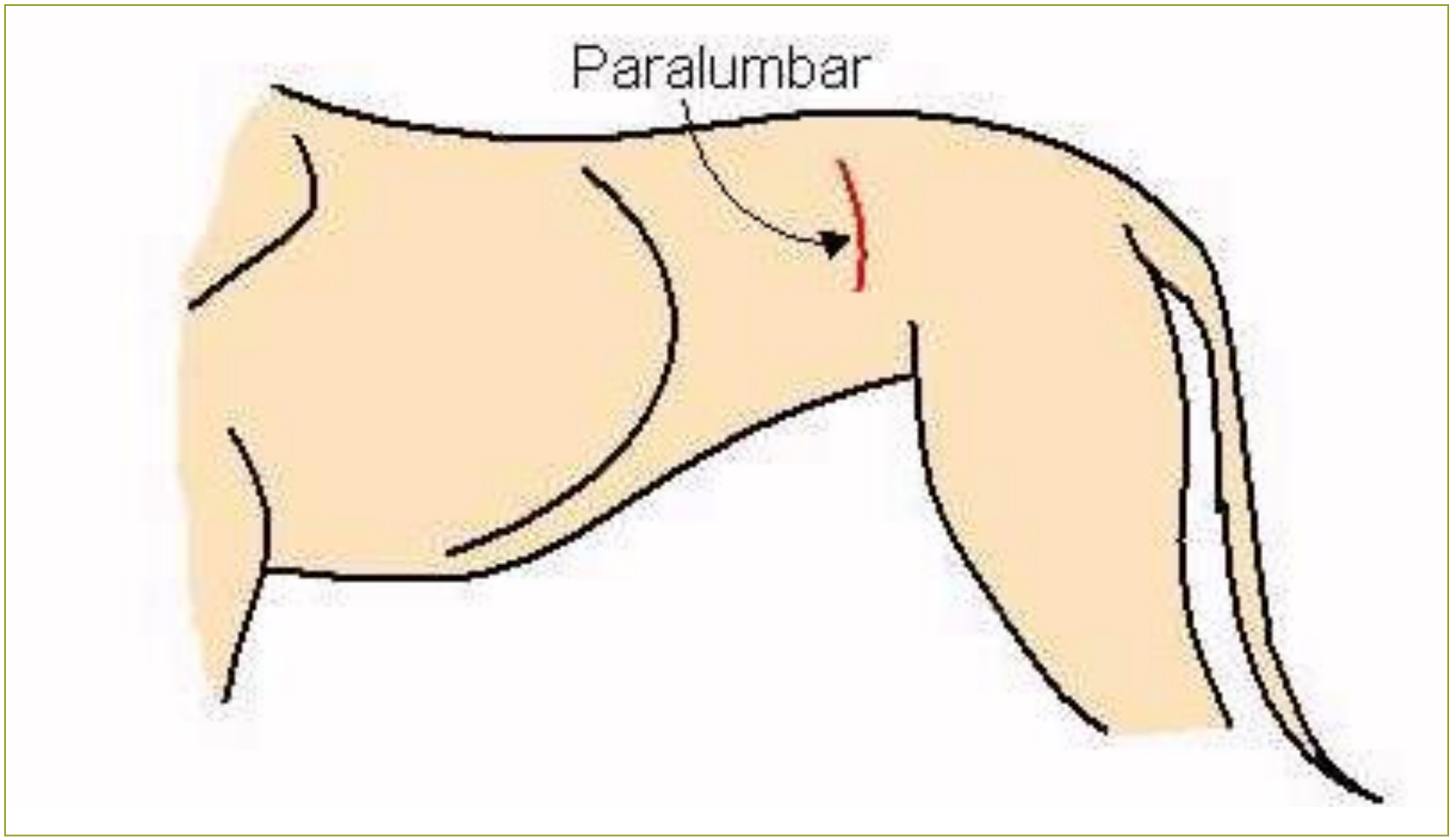
Surgical Incisions







“Flank” Spay Incision



Thoracic Limb Muscles

- Brachial muscles
  - Biceps brachii muscle – **flexes** the elbow joint
  - Triceps brachii muscle – **extends** the elbow joint
- Carpal and digital muscles

Pelvic Limb Muscles

- Gluteal muscles – **extensor** muscles of the hip
- "**Hamstring**" muscle group – extend the hip joint; main **flexors** of the stifle joint
  - Biceps femoris muscle
  - Semimembranosus muscle
  - Semitendinosus muscle

Pelvic Limb Muscles

- Quadriceps femoris muscle – main extensor muscle of the stifle joint
- Gastrocnemius muscle – extensor muscle of the hock
  - Achilles tendon – attaches to tuber calcis of calcaneus bone of tarsus

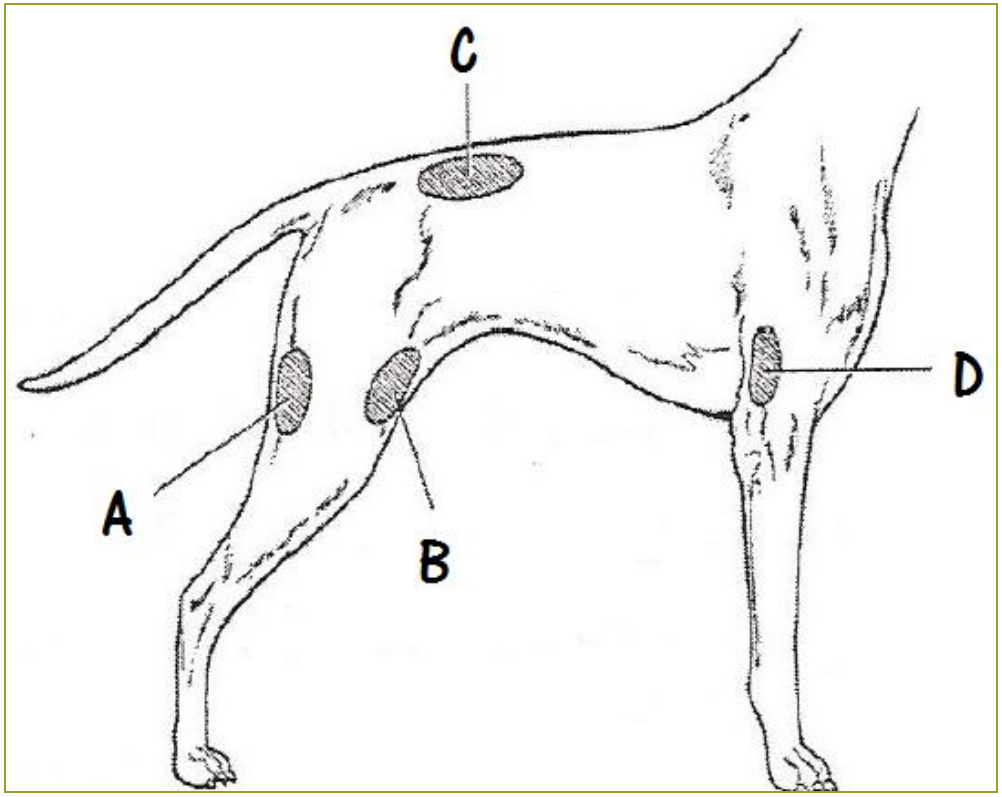
Muscles of Respiration

- Increase and decrease the size of the thoracic cavity
  - Inspiratory muscles
    - Diaphragm
    - External intercostal muscles
  - Expiratory muscles
    - Internal intercostal muscles
    - Abdominal muscles

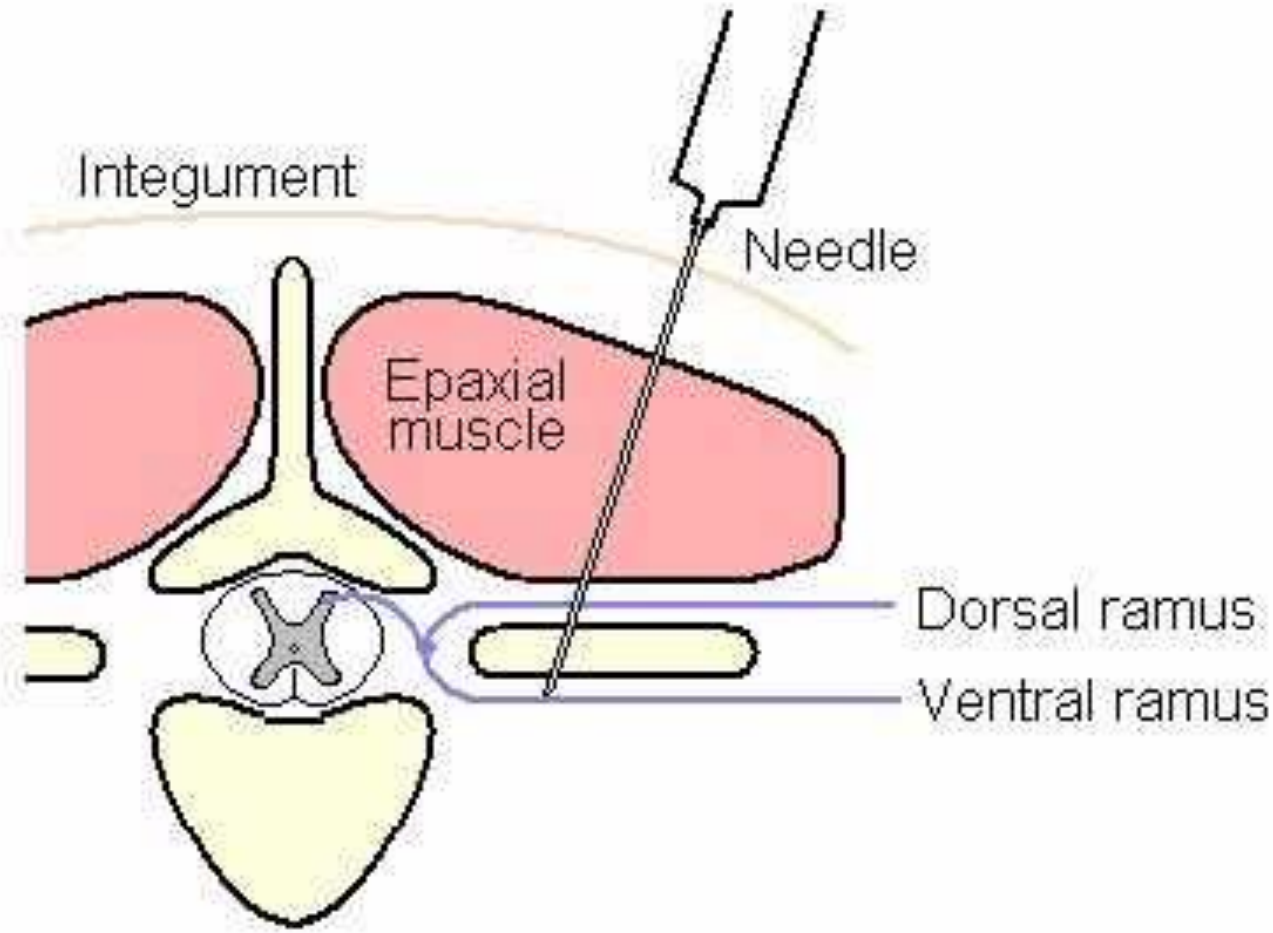
Intramuscular (IM) Injection Sites

Clinical Application, Page 197

- Dogs & cats
  - Biceps femoris
  - Quadriceps femoris
  - “Lumbar” muscles
  - Biceps brachii
- Large animal sites
  - Gluteal muscles
  - Neck muscles

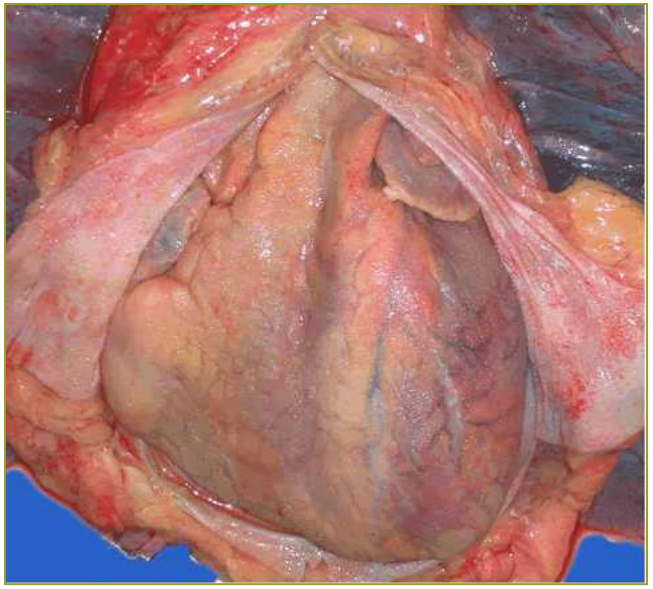


Lumbar (Epaxial) Muscles



Cardiac Muscle

- Striated
- Involuntary
- Needs no functional nerve supply
- Rapid contractions
- Heart only
- Purkinje fibers
  - NOT nervous tissue, but modified cardiac muscle
  - Specialized cells that conduct electricity through the heart (heartbeat)



Physiology of Cardiac Muscle

- Cardiac cells contract without any external stimulation
- Groups of cardiac muscle cells contract at the rate of the most rapid cell in the group
- Contractions are rapid and wavelike

Physiology of Cardiac Muscle

Cardiac Conduction System

- Sinoatrial (SA) node
  - Generates the impulse that starts each heartbeat
  - Located in the wall of the right atrium
- Impulse follows a controlled path through the conduction system of the heart
- Structures in the system transmit, delay, and redirect

Nerve Supply

- Heart is innervated by nerves from both the sympathetic and parasympathetic systems
- Sympathetic fibers stimulate the heart to beat harder and faster as part of the "fight or flight response”
- Parasympathetic fibers inhibit cardiac function, causing the heart to beat more slowly and with less force

Smooth Muscle Gross Anatomy

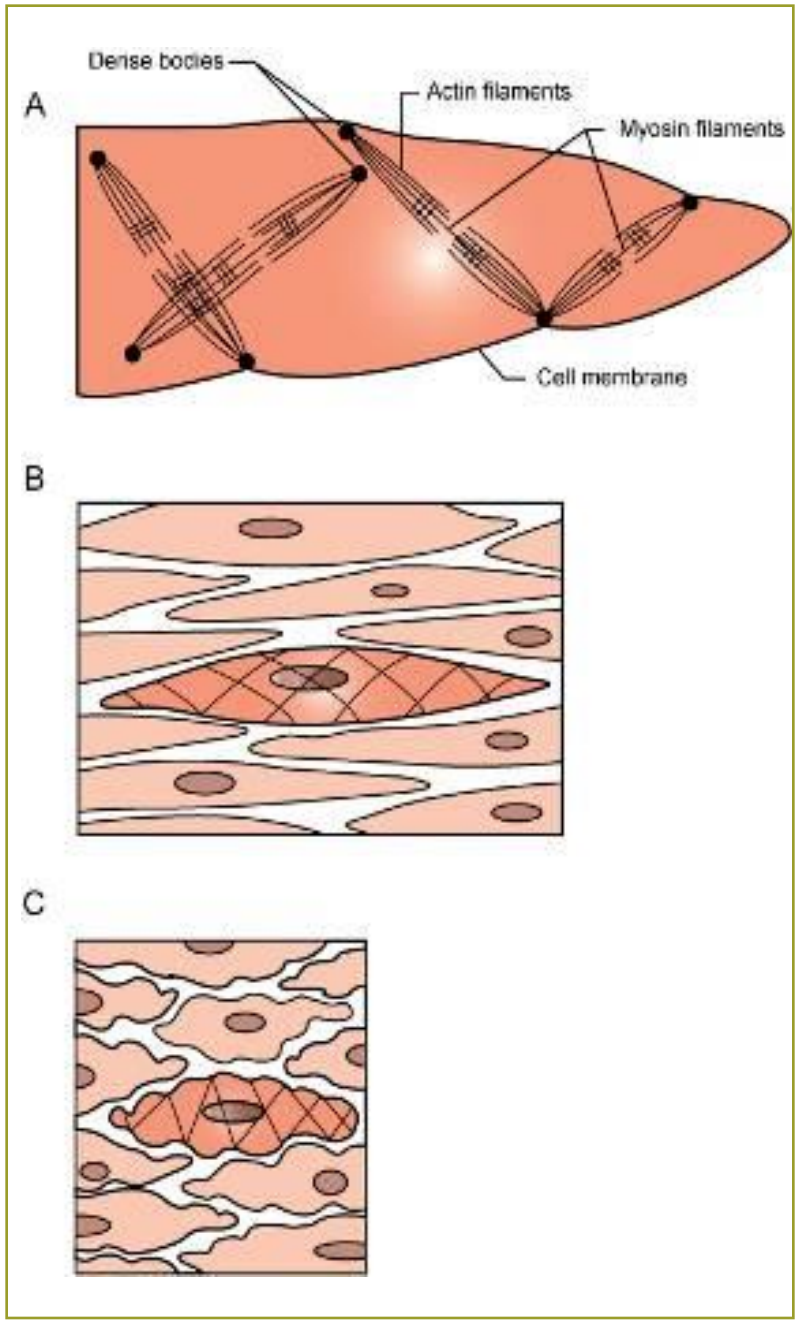
Two main forms

- Visceral smooth muscle
  - Large sheets of cells in the walls of some hollow organs
- Multiunit smooth muscle
  - Small, discrete groups of cells

Smooth Muscle

Figure 7-6, Page 204

- Nonstriated
- Involuntary
- Needs no functional nerve supply
- Slow contractions
- Mostly inside of body
  - Blood vessels
  - Hollow organs in ventral cavity



Visceral Muscle

- Found in the walls of many internal organs (e.g., stomach, intestines, uterus, urinary bladder)
- Contracts in large, rhythmic waves
- Contracts without external stimulation
  - Reacts to stretching by contracting more strongly
  - Innervated by nerves from both the sympathetic and parasympathetic systems
  - Sympathetic stimulation decreases activity; parasympathetic stimulation increases activity

Multi-Unit Smooth Muscle

- Individual smooth muscle cells or small groups of cells
- Found where small, delicate contractions are needed (e.g., iris, walls of small blood vessels)
- Contraction requires autonomic nervous system impulse

Test Yourself
KNOW THESE IN EVERY CHAPTER!

Pages 193, 199, 201, 203, 204

Clinical Applications

Pages 196, 197, 202