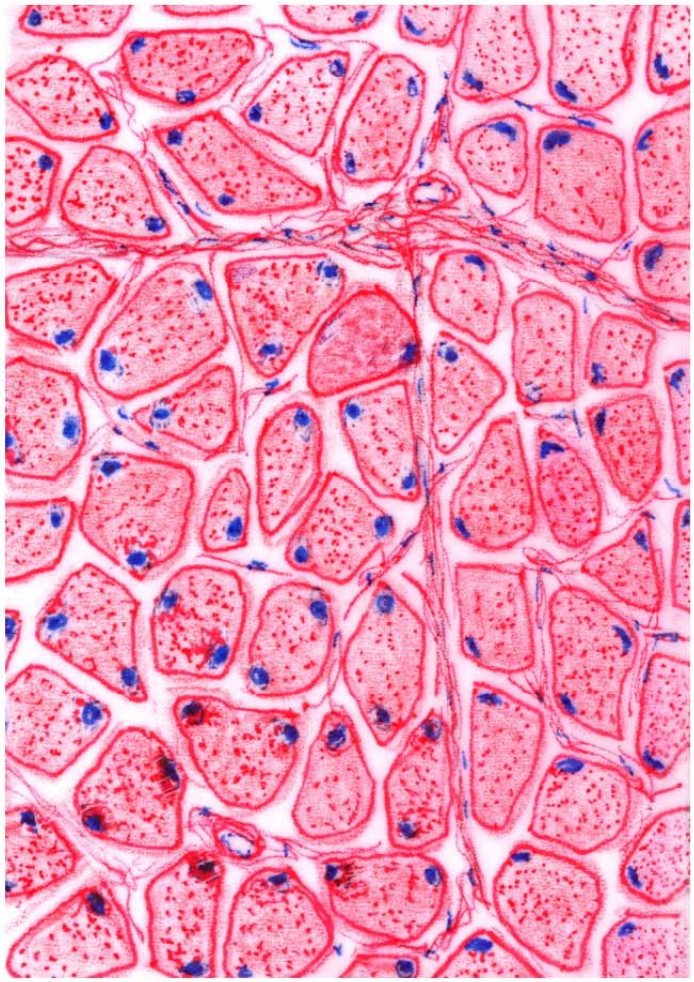
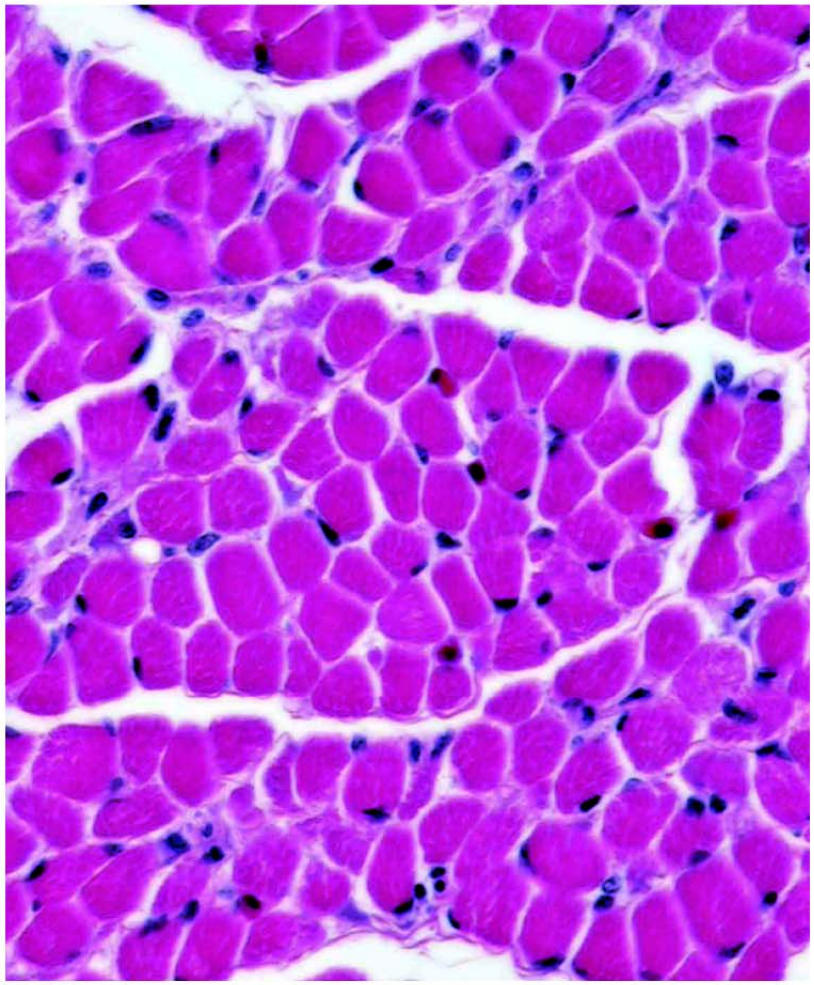
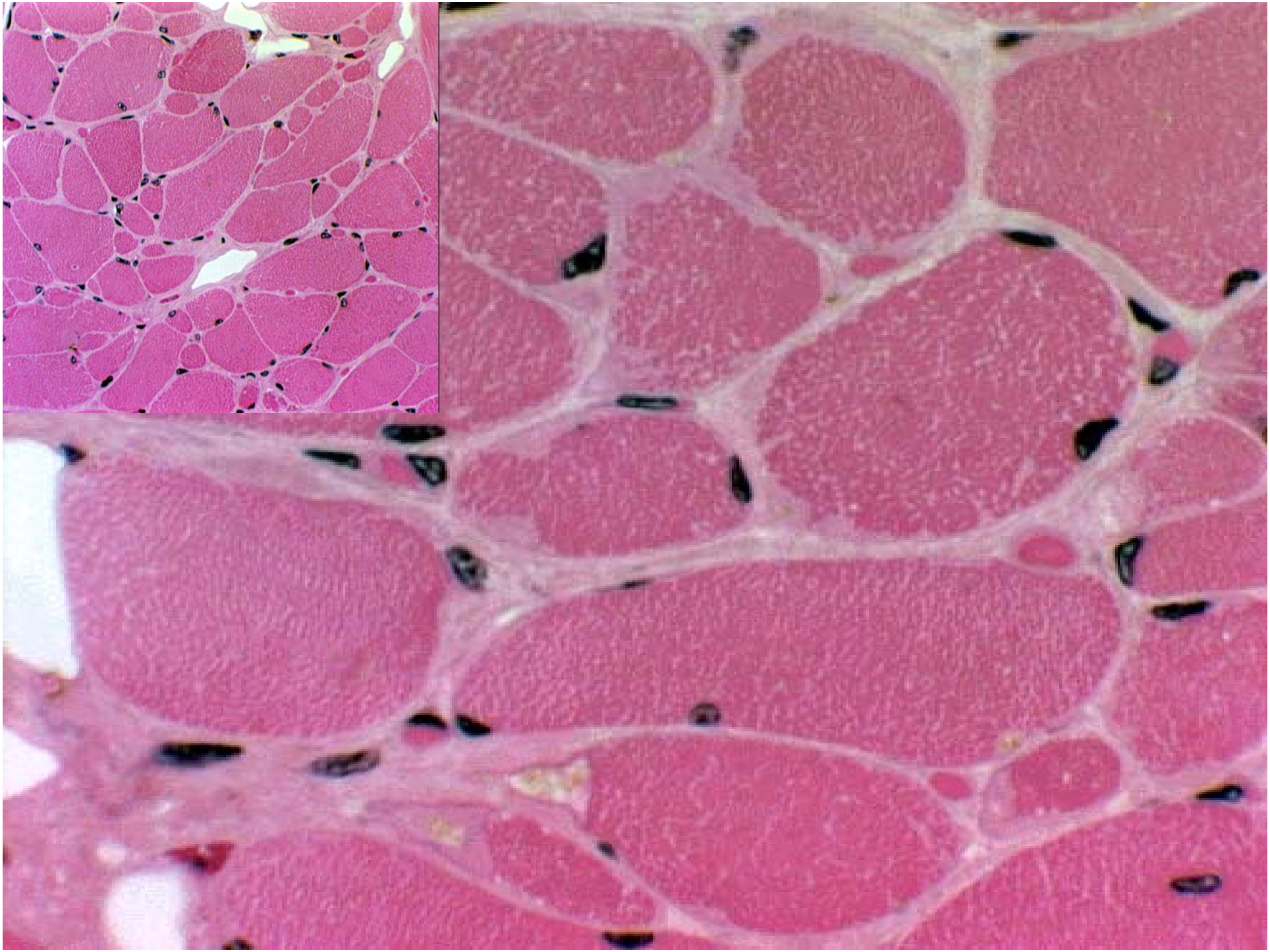
MUSCLE INTRO PART 2

D.HAMMOUDI. MD

SKELETAL MUSCLE IN CROSS SECTION







SKELETAL MUSCLE

I. CELLS (FIBERS)
1) Very long compared with most other cells, up to several cm long, 10-100 micrometers in diameter
2) Multinucleate, nuclei are located peripherally
3) Development:
Mesenchymal cell ---> Myoblast (proliferative) ---> Myotubule ---> Muscle Cell

II. ARRANGEMENT OF FIBERS - similar to tendon arrangement
- Blood vessels, lymph vessels, and nerves penetrate muscle with perimysium
- Endomysium contains capillaries and nerve fibers

III. STRIATION ULTRASTRUCTURE (Fibers ---> Myofibrils ---> Myofilaments)
- Proteins are *actin* (thin filaments) and myosin (thick filaments), also tropomyosin and troponin are associated with thin filaments

contoso

Skeletal muscles are composed of fibers(cells) bound together by connective tissue.

•**Connective tissue** associated with muscle [endomysium,perimysium,epimysium, fascia]

Muscle attachments

•Tendons are bands of dense connective tissue attaching muscle to bone.

•***Most moveable attachment is insertion***

•***Least moveable attachment is origin***

•**Aponeurosis**is a flattened sheet like muscle attachment.

•Four principal fiber patterns in skeletal muscle

1.Parallel fibers [rectus abdominus]

2.Convergent fibers [pectoralismajor]

3.Circular fibers [orbicularis oris]

4.Pennatefibers [rectus femoris]

•Muscle cells contract when stimulated by nerve impulses•Isotonic & Isometric Contractions

•Motor Unit is a motor neuron + muscle fibers it innervates

•Myoneural Junction is the contact site between the end of the motor neuron and muscle fiber

•Motor End Plate is the portion of the sarcolemma in contact with motor neuron.

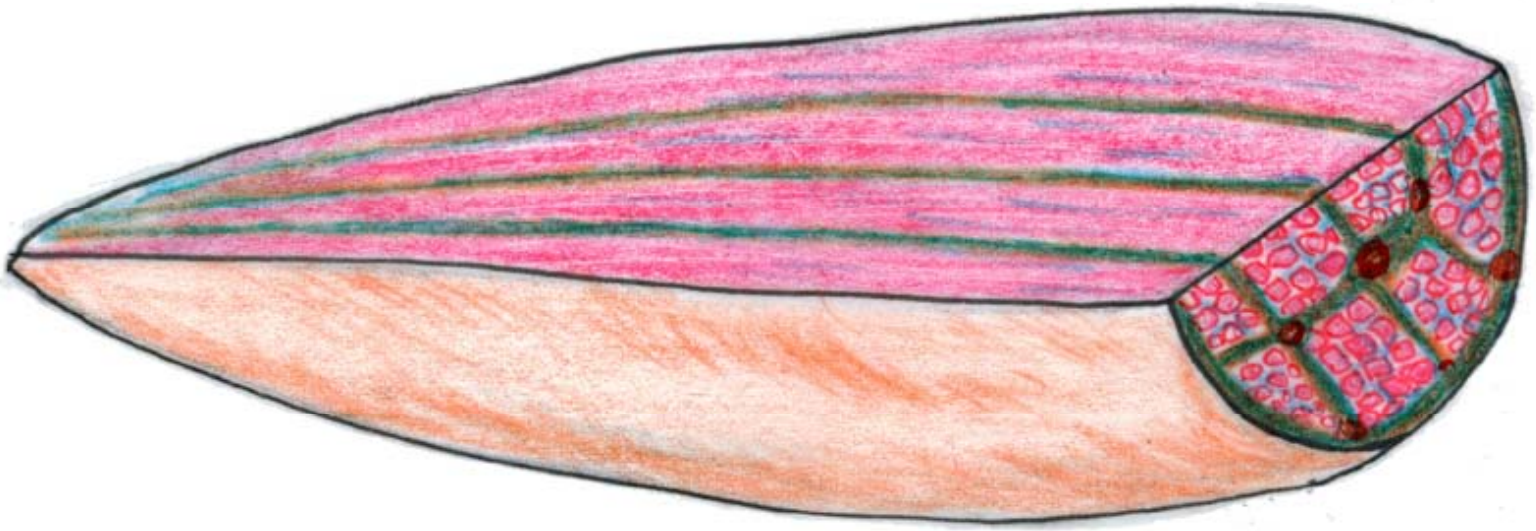
contoso

The three connective tissue sheaths are:

Endomysium – fine sheath of connective tissue composed of reticular fibers surrounding each muscle fiber

Perimysium – fibrous connective tissue that surrounds groups of muscle fibers called fascicles

Epimysium – an overcoat of dense regular connective tissue that surrounds the entire muscle



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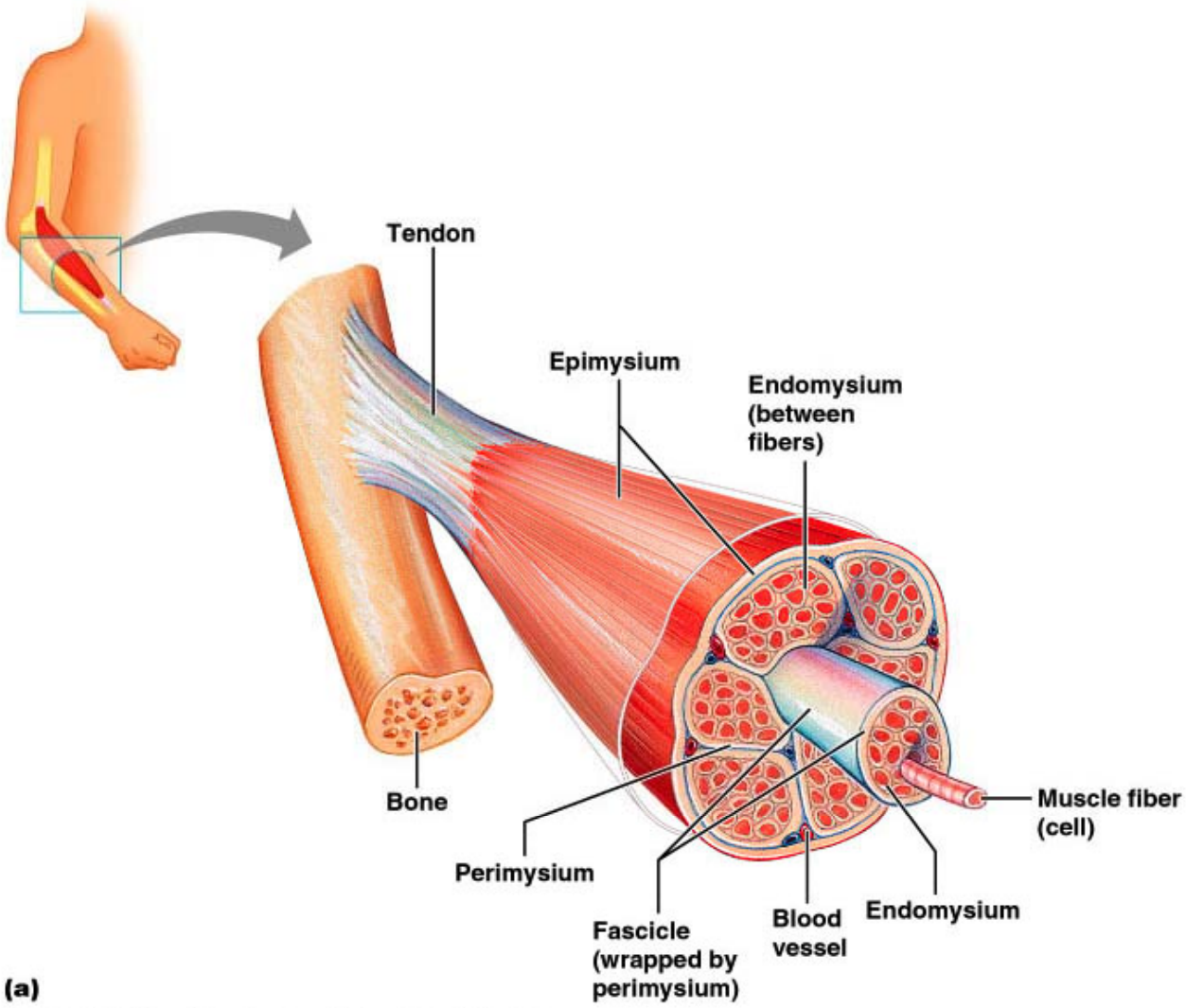
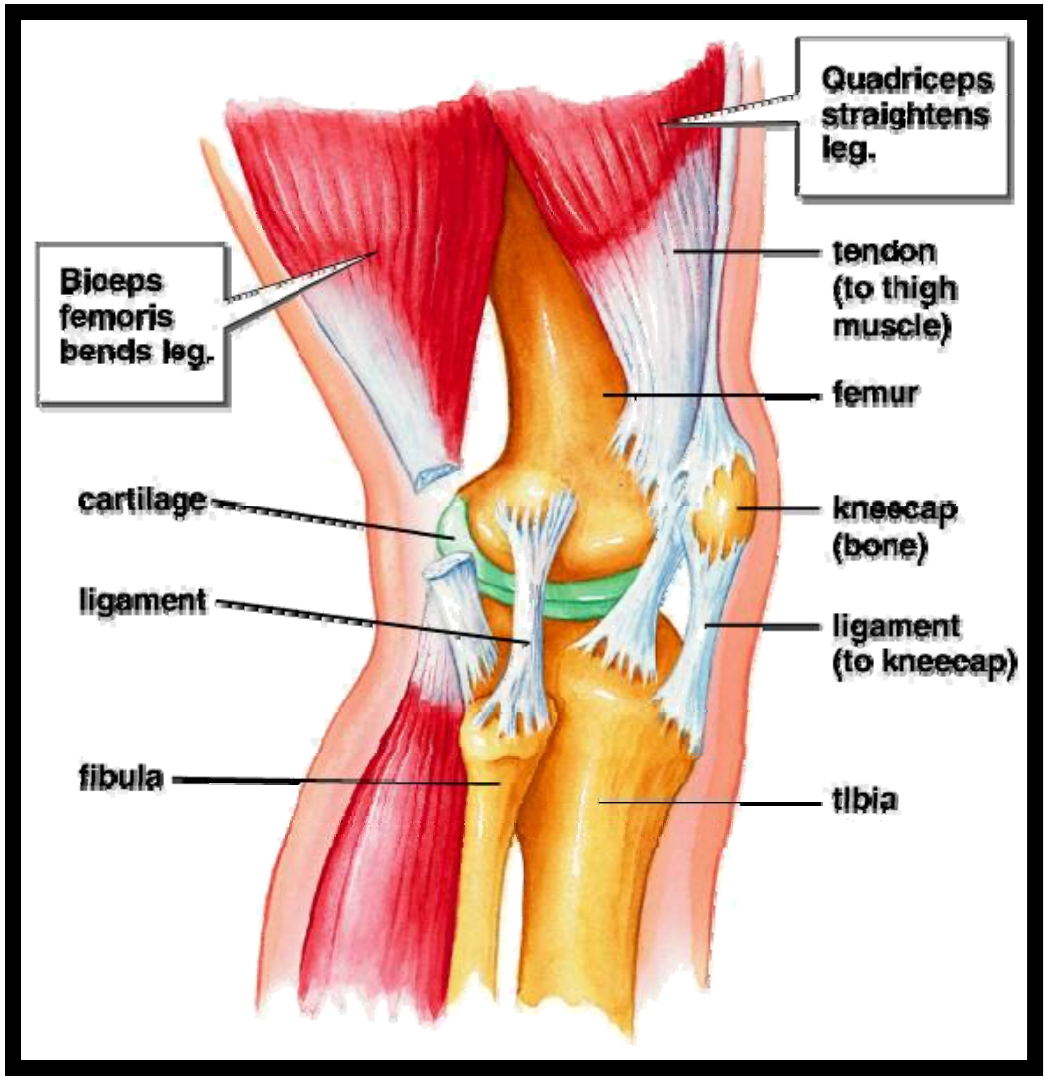


PLAY

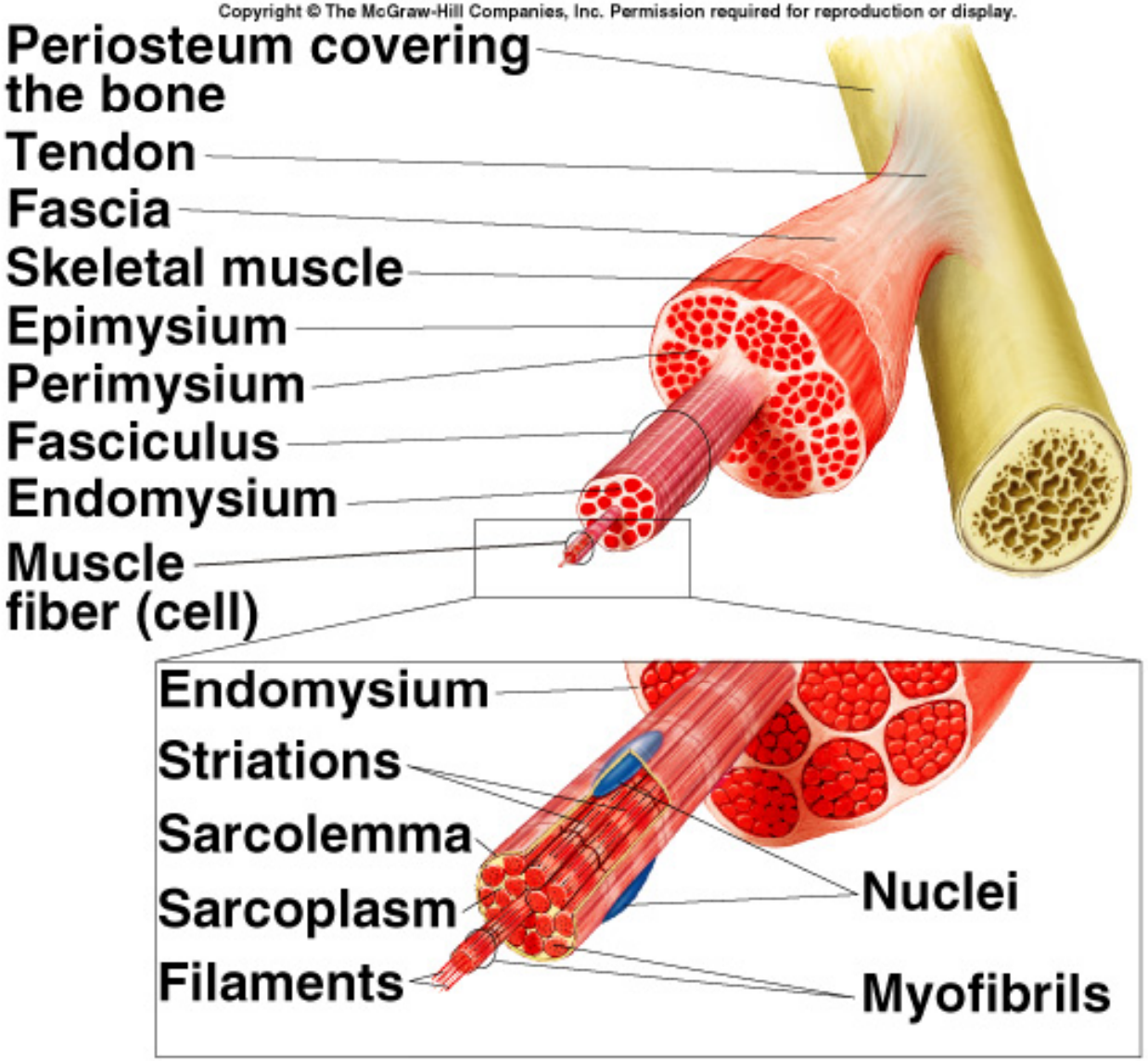
InterActive Physiology ®:

Anatomy Review: Skeletal Muscle Tissue, pages 4-6

Figure 9.2a


Quadriceps straightens leg.
Biceps femoris bends leg.
tendon (to thigh muscle)
femur
cartilage
kneecap (bone)
ligament
ligament (to kneecap)
fibula
tibia

contoso



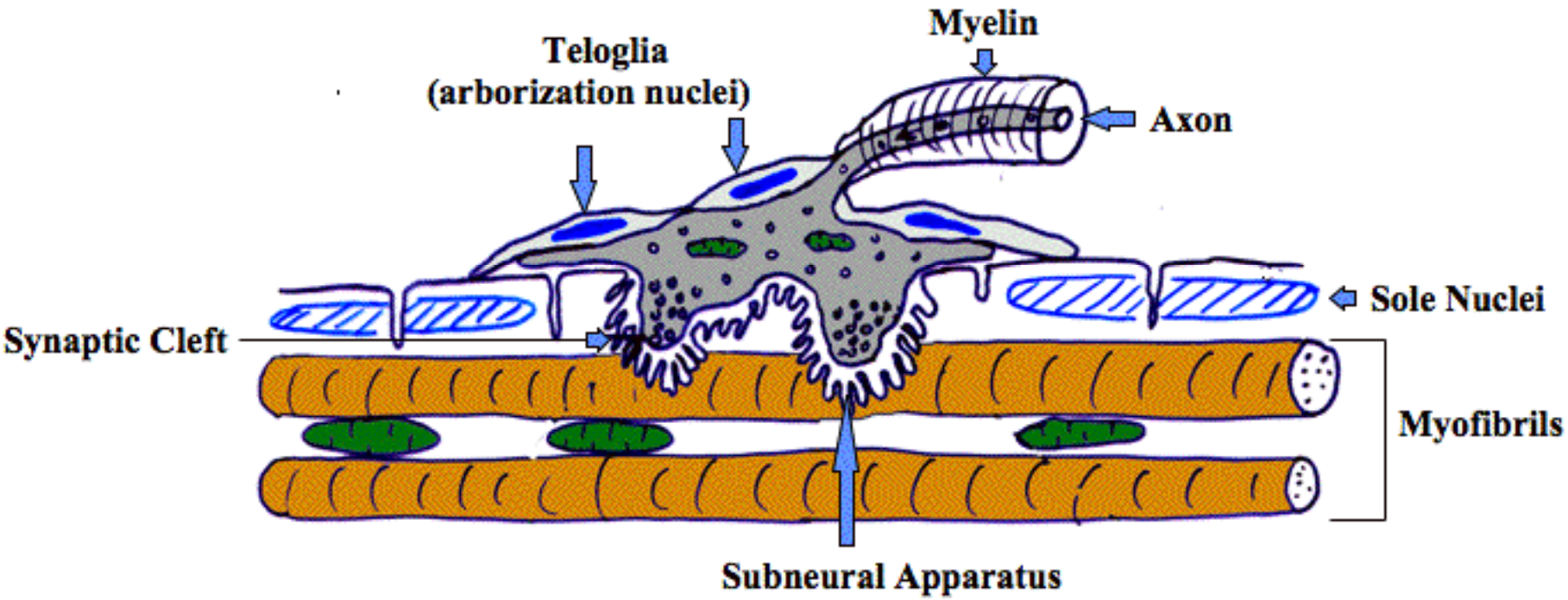
Motor end plate= sarcolemma at neuromuscular junction

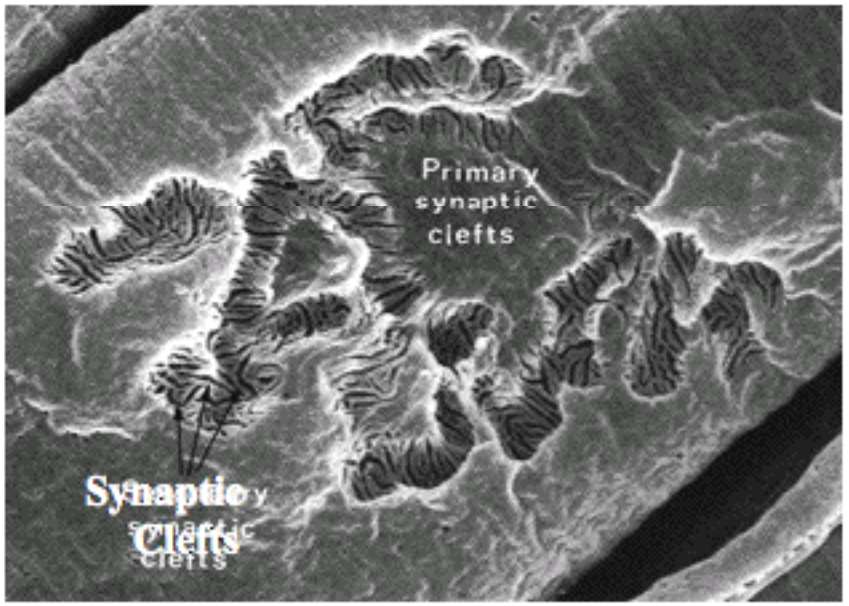
Motor unit= myofibers innervated by same motor neuron

Muscles:

Graded contractions by how many motor units contract.

MYONEURAL JUNCTION



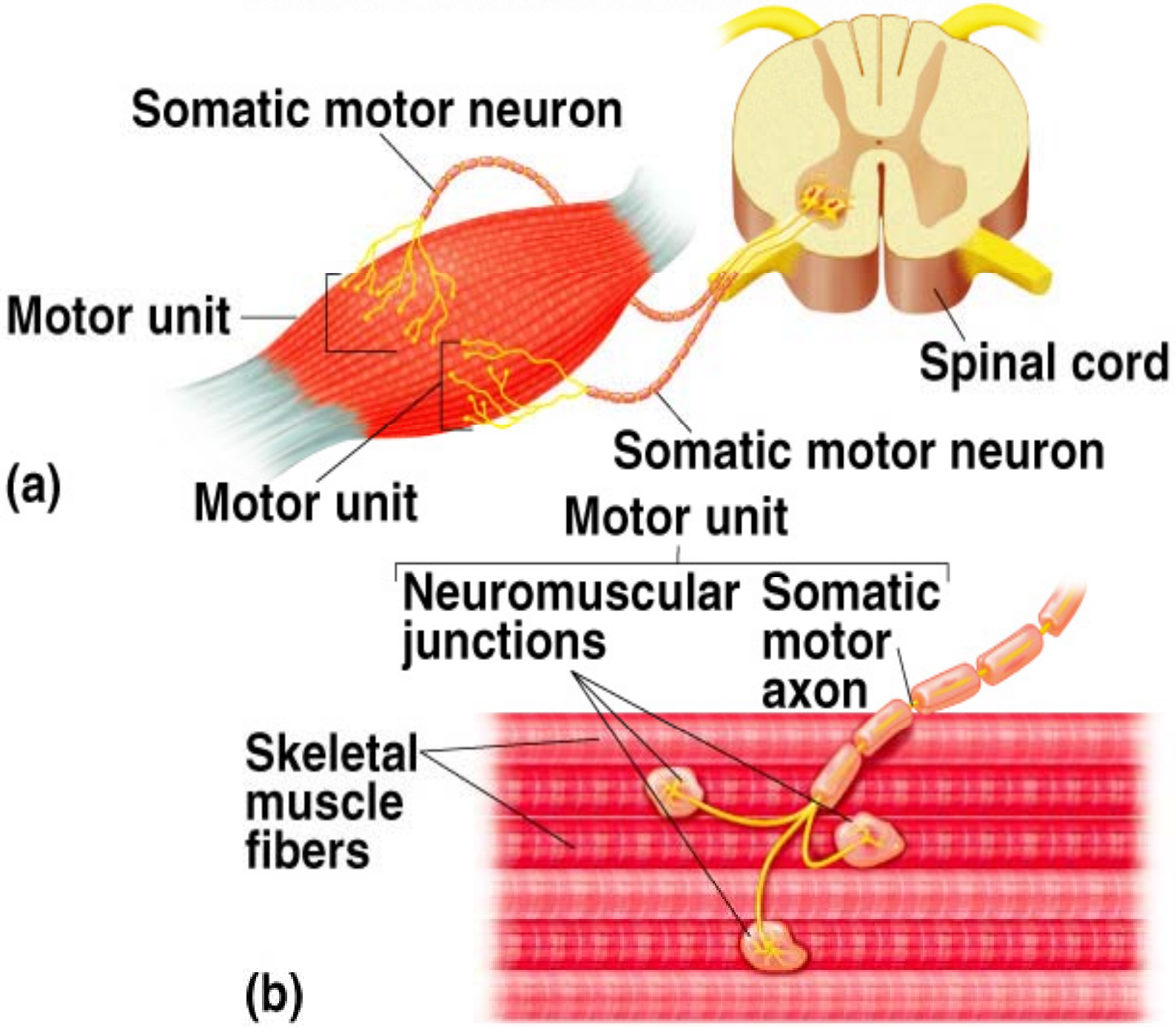


Sarcoplasm has numerous glycosomes and a unique oxygen-binding protein called **myoglobin**

Fibers contain the usual organelles, myofibrils, sarcoplasmic reticulum, and T tubules

Microscopic Anatomy of a Skeletal Muscle Fiber

contoso



Twitch = muscle contraction

Summation:

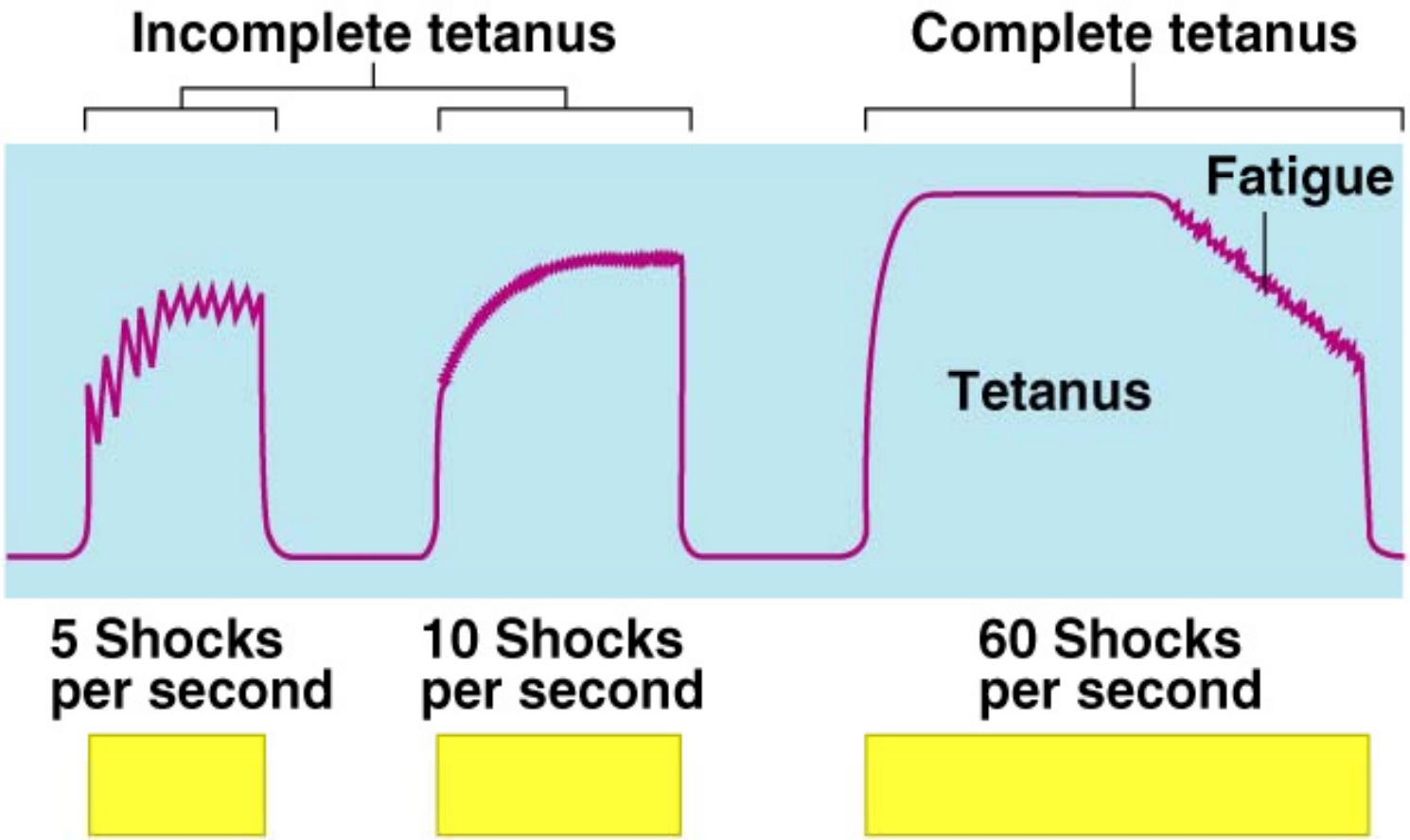
If second stimulus is administered before complete relaxation of muscle.

Complete tetanus:

Fusion frequency of stimulation.

No visible relaxation between twitches.

Smooth sustained contraction.



Treppe:

Second stimulus elicits a stronger response

Perhaps due to increase in intracellular Ca^{2+}.

Isotonic contractions:

Force of contraction remains constant throughout the shortening process.

Isometric contractions:

Length of muscle fibers remain constant.

Eccentric contractions:

Force exerted on a muscle to stretch is greater than the force of muscle contraction.

Running downhill

Tendons:

Have elasticity.

Display recoil.

Spring back to resting length.

During some exercise: ATP used faster than can be renewed through cell respiration.

So: **Phosphocreatine reservoir**!

ADP + phosphocreatine -> ATP + creatine

SKELETAL MUSCLE

Contraction speed:

- Slow-twitch.
- Fast-twitch.

due to different myosins.

Red/white meat…!

Individual Fiber Types

Fast fibers

- **Type IIb**
  - - Fast Fast-twitch fibers twitch fibers
  - - Fast Fast-glycolytic glycolytic fibers fibers
- **Type IIa**
  - - Intermediate fibers Intermediate fibers
  - - Fast Fast-oxidative oxidative glycolytic glycolytic fibers

Slow fibers

- **Type I fibers**
  - - Slow Slow-twitch fibers twitch fibers
  - - Slow Slow-oxidative oxidative fibers

Slow-twitch:

Red fibers.

High oxidative capacity for aerobic respiration.

Many: mitochondria, capillaries

Myoglobin (like hemoglobin) for oxygen.

Postural muscles

Fast-twitch (type IIX fibers):

White fibers.

respire anaerobically.

much glycogen.

Fast-twitch oxidative (type IIA fibers):

Also white fibers.

People vary genetically in proportion of fast- and slow-twitch fibers in their muscles.

Weight lifting: hypertrophy.

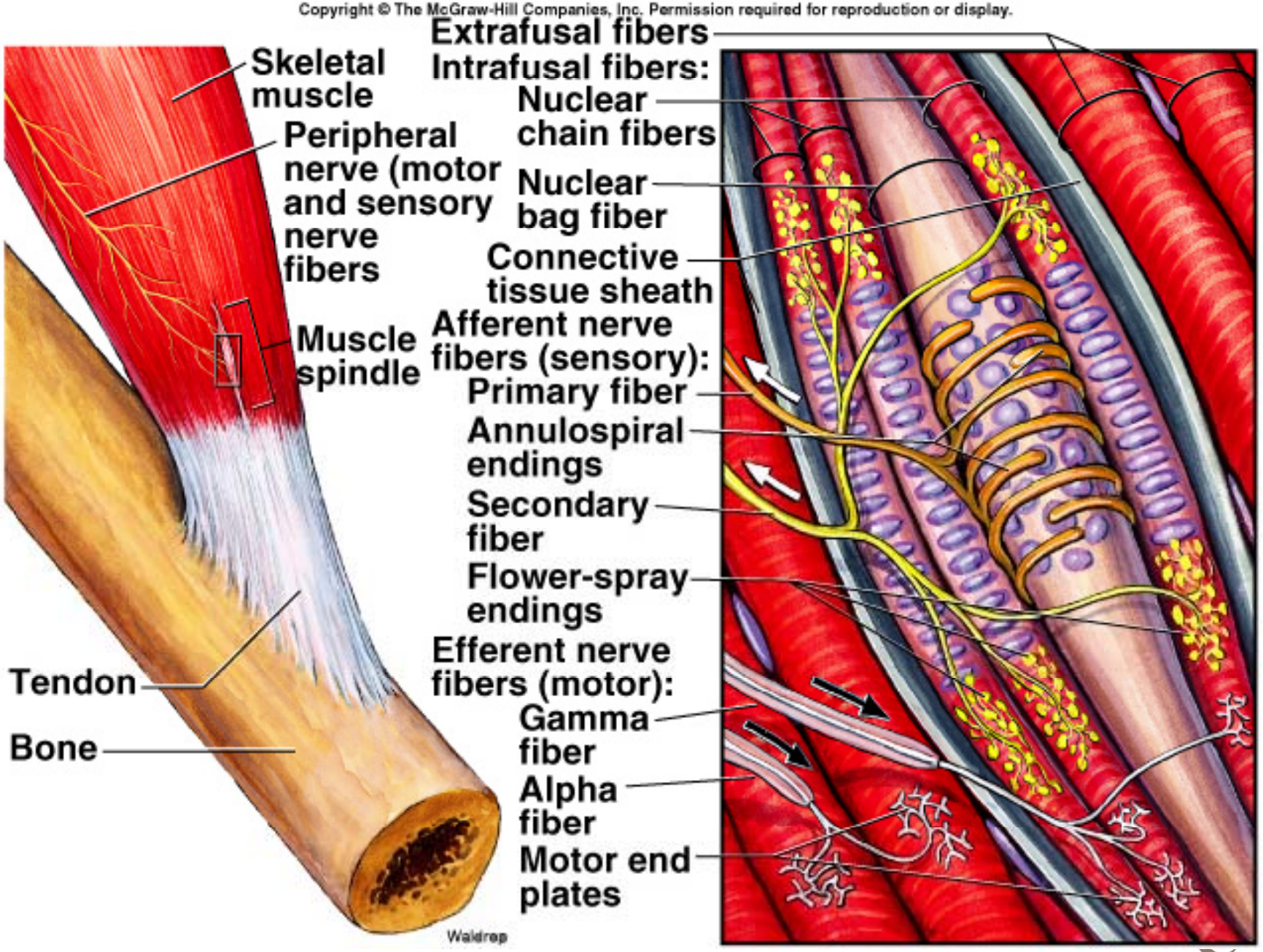
Endurance training: more mitochondria.

Muscle spindle apparatus

Length detector.

1. Contains thin muscle cells called intrafusal fibers.
2. Reflex contraction in response to rapid stretch.
3. Stimulated by γ motor neurons from spinal cord.
4. Helps maintain muscle tone (resting muscle length and state of tension).

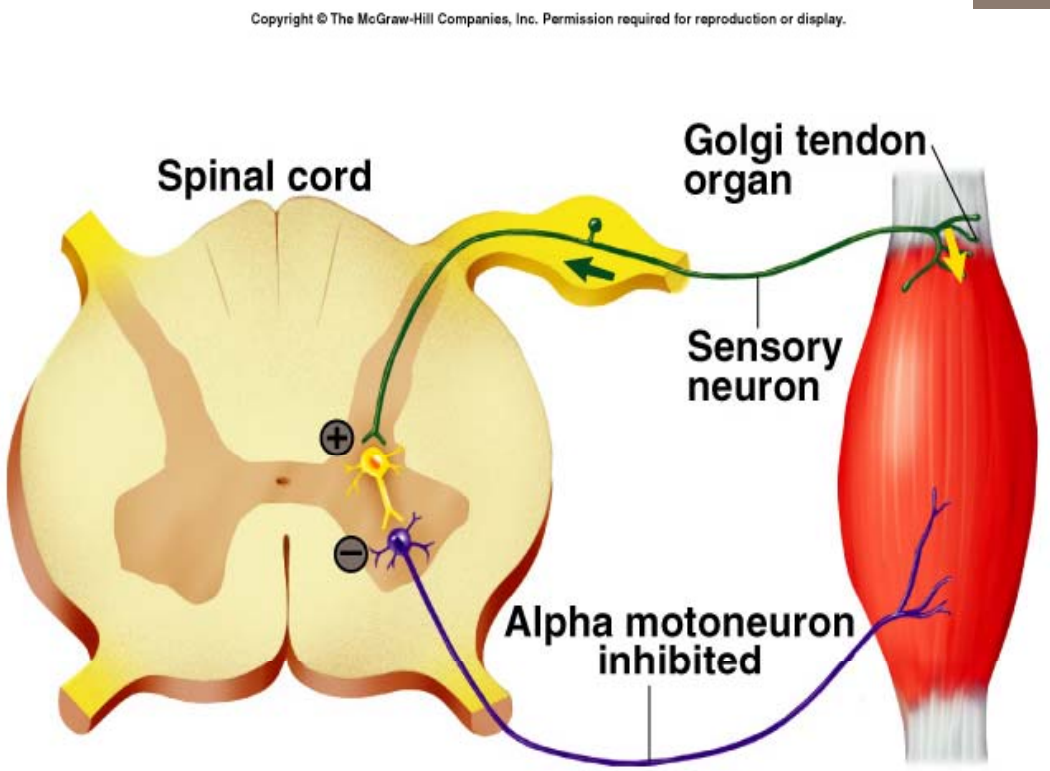
5. Extrafusal fibers (rest of muscle!): stimulated by α motor neurons from spinal cord.



Golgi tendon organ

Helps prevent excessive muscle contraction or excessive passive muscle stretching.

A reflex.



Agonist muscle:

Prime mover.

Antagonist muscle:

Flexors and extensors that act on the same joint to produce opposite actions.

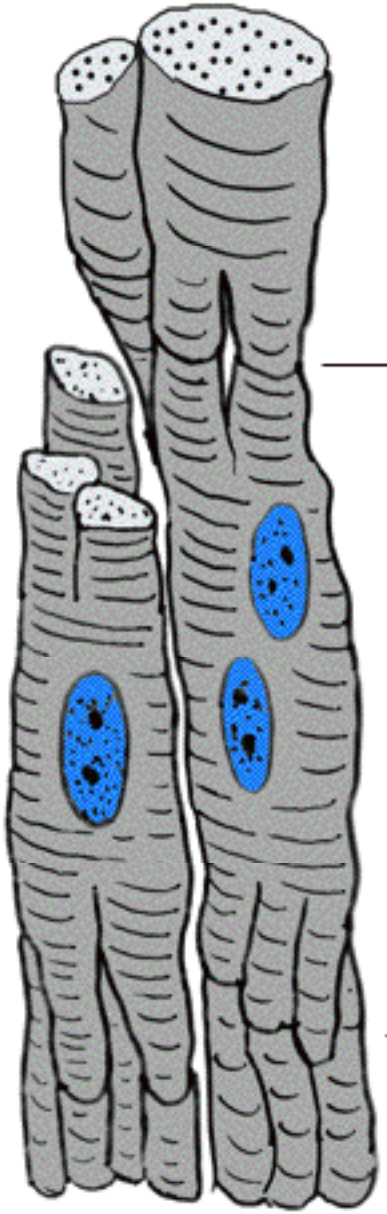
Reciprocal innervation:

motor neurons of antagonistic muscles inhibit each other (through interneurons) so they don't both contract simultaneously.

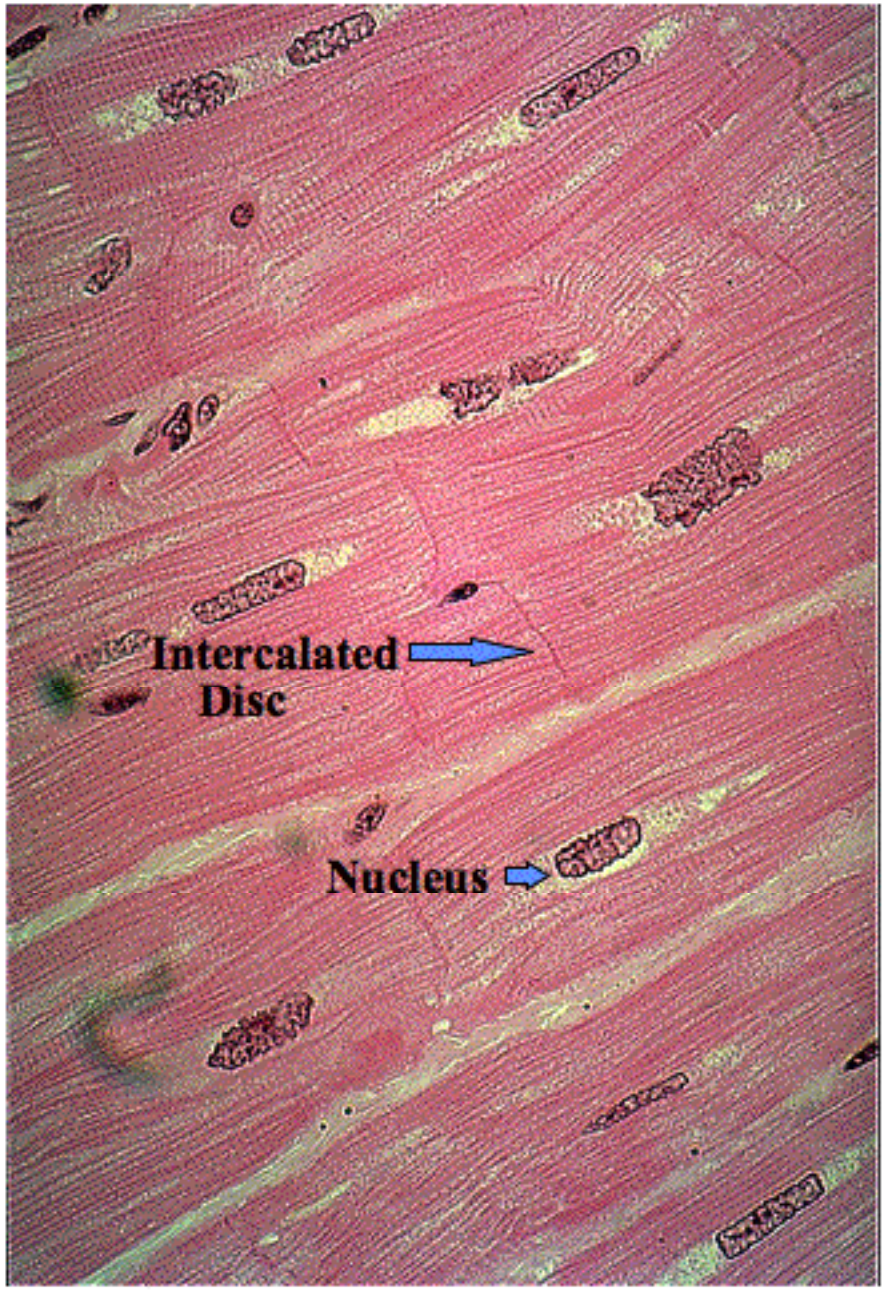
When limb is flexed, antagonistic extensor muscles are passively stretched.

CARDIAC MUSCLE

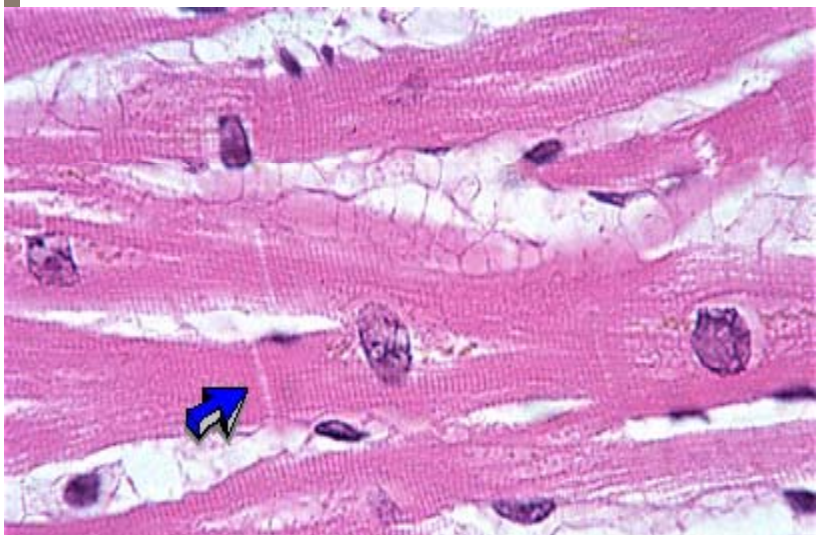
CARDIAC MUSCLE

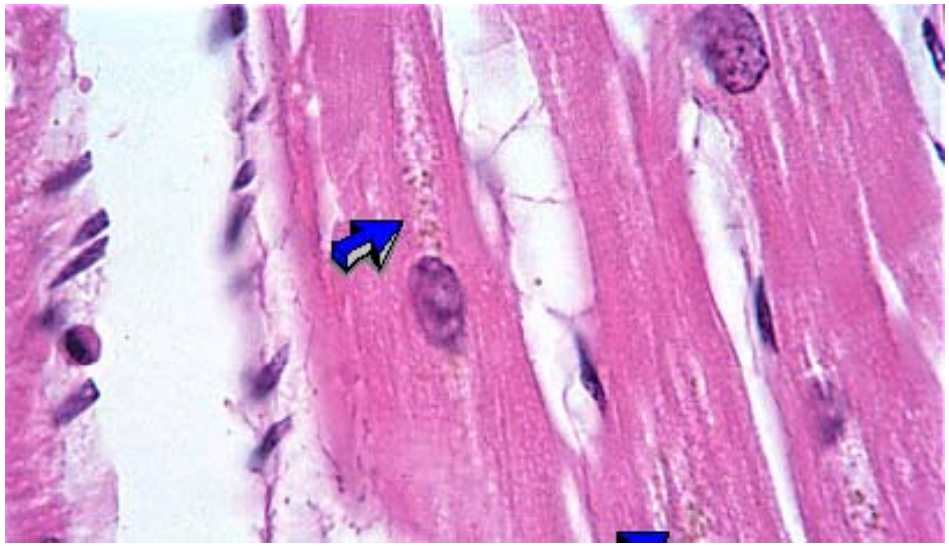


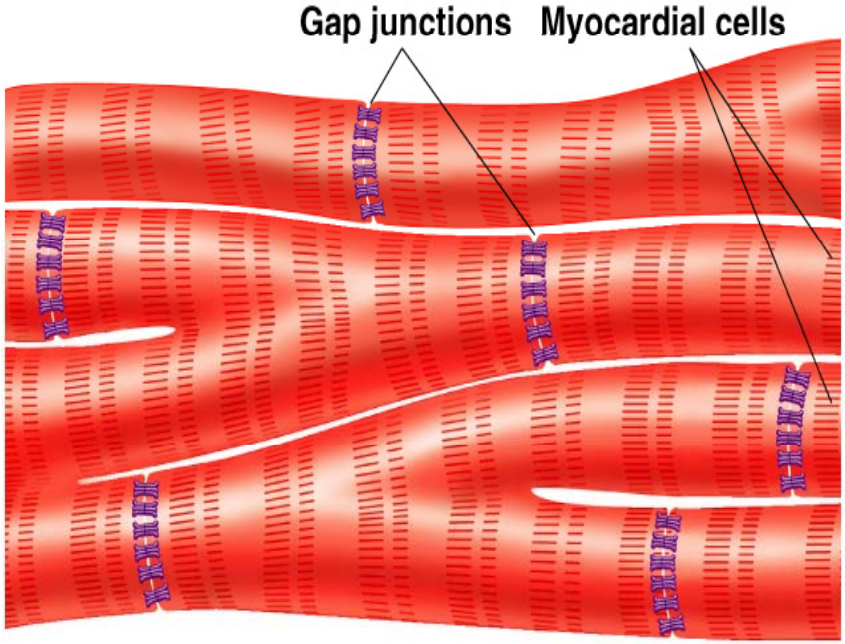
Cardiac
Muscle
Fiber



Cardiac Muscle







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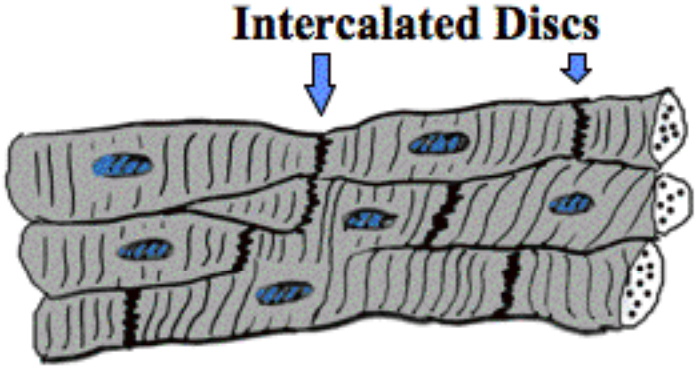
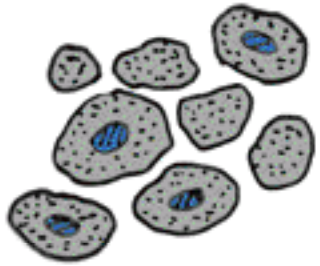
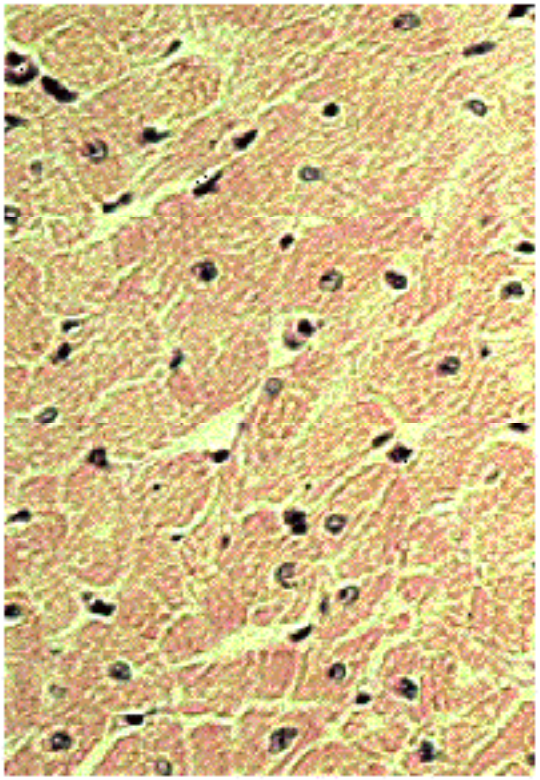
INTERCALATED DISCS

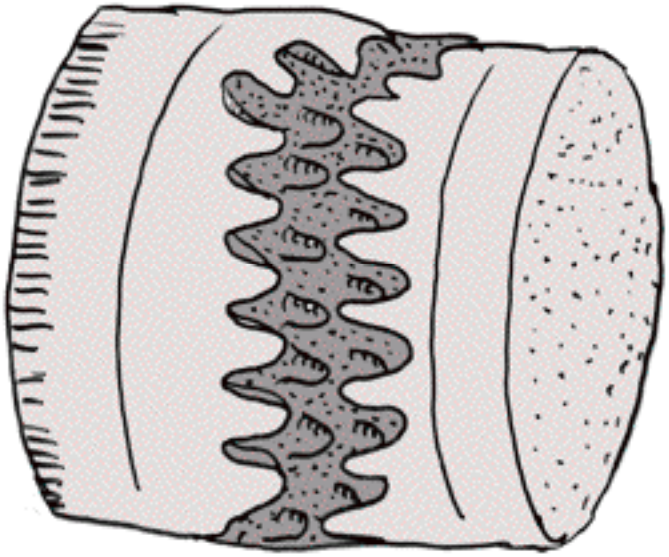


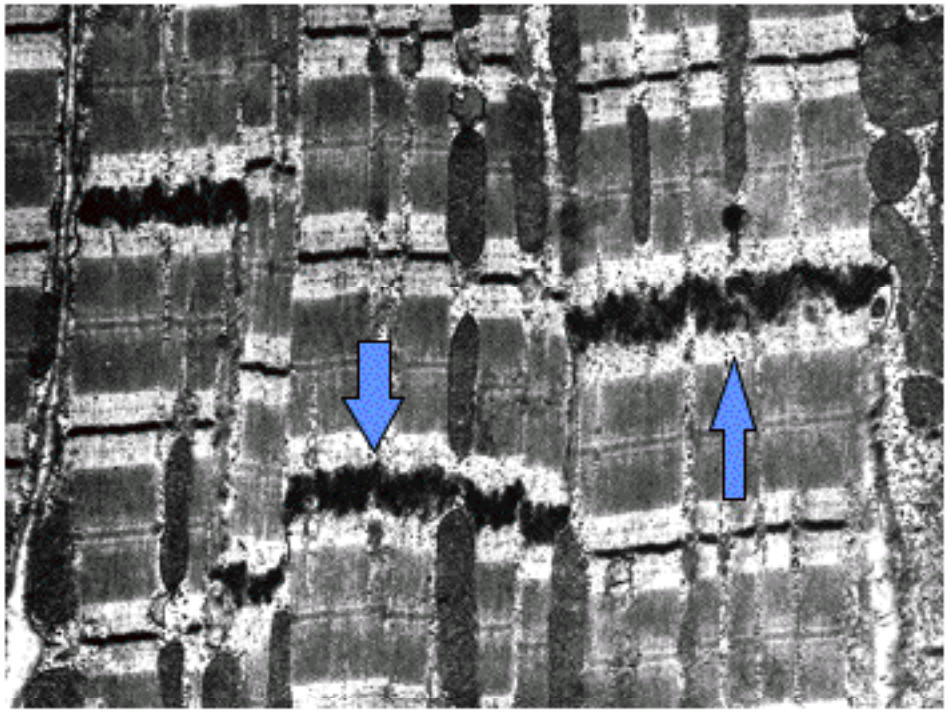


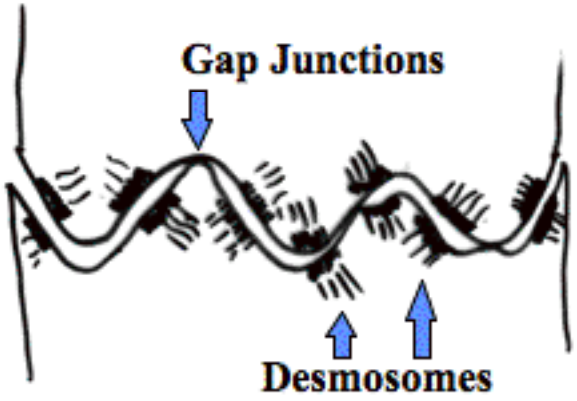
Cardiac Muscle Fibers
(transverse section)

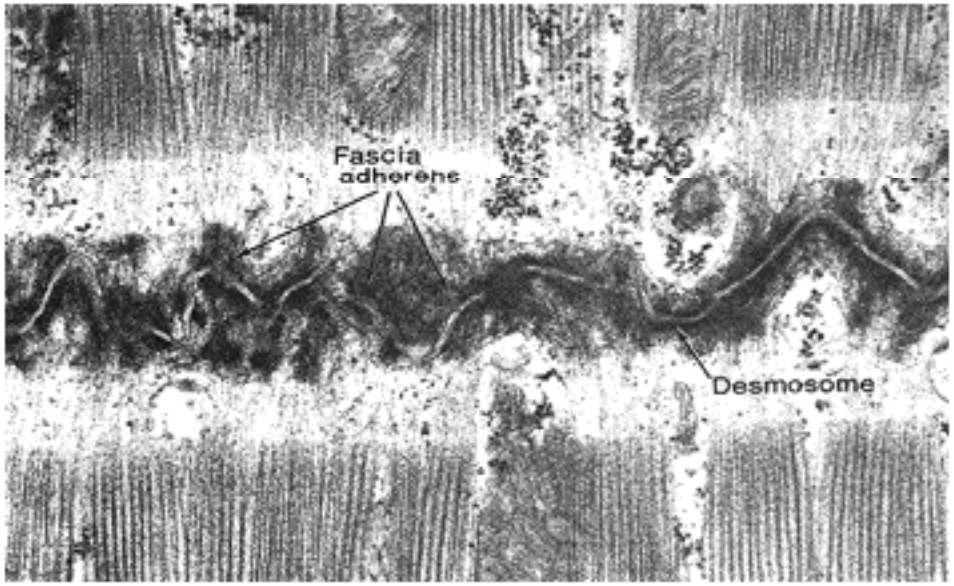


INTERCALATED DISCS



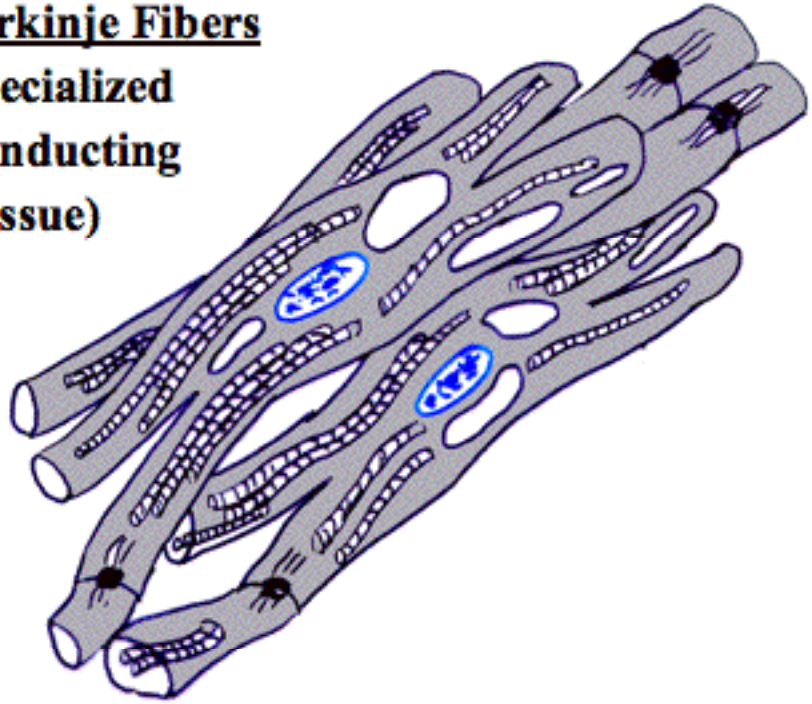




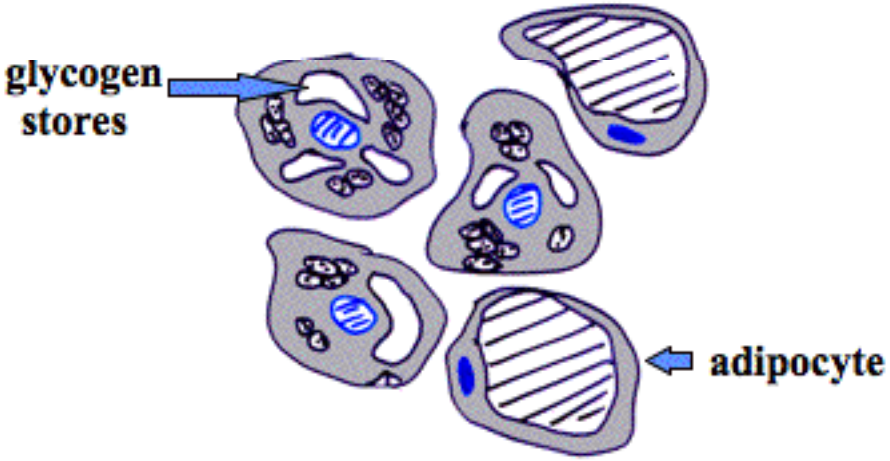


PURKINJE FIBERS

Purkinje Fibers
(specialized conducting tissue)



Purkinje Fibers (trans. section)



Like skeletal muscle:

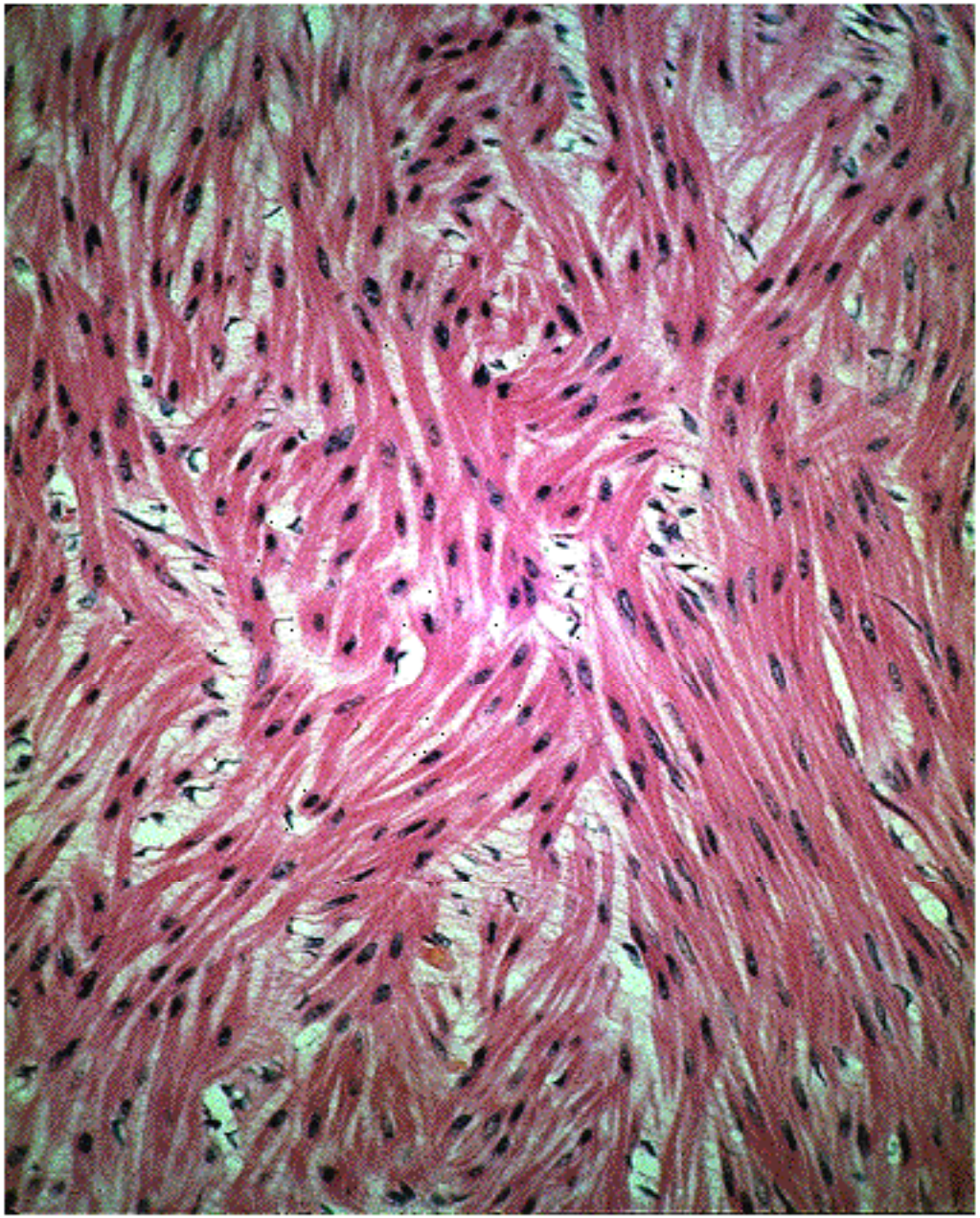
- striated: actin and myosin in sarcomeres.
- contract via sliding-filament mechanism.

Unique to cardiac muscle:

- Adjacent myocardial cells joined by gap junctions= intercalated discs=electrical synapse.

SMOOTH MUSCLE

LOCATIONS OF SMOOTH MUSCLE



DIGESTIVE TRACT

DUCTS OF GLANDS

RESPIRATORY PASSAGES

URINARY & GENETAL TRACT

ARTERIES AND VEINS

PILIERECTOR MUSCLES

IRIS & CILIARY BODY

UTERUS

BLADDER

STOMACH

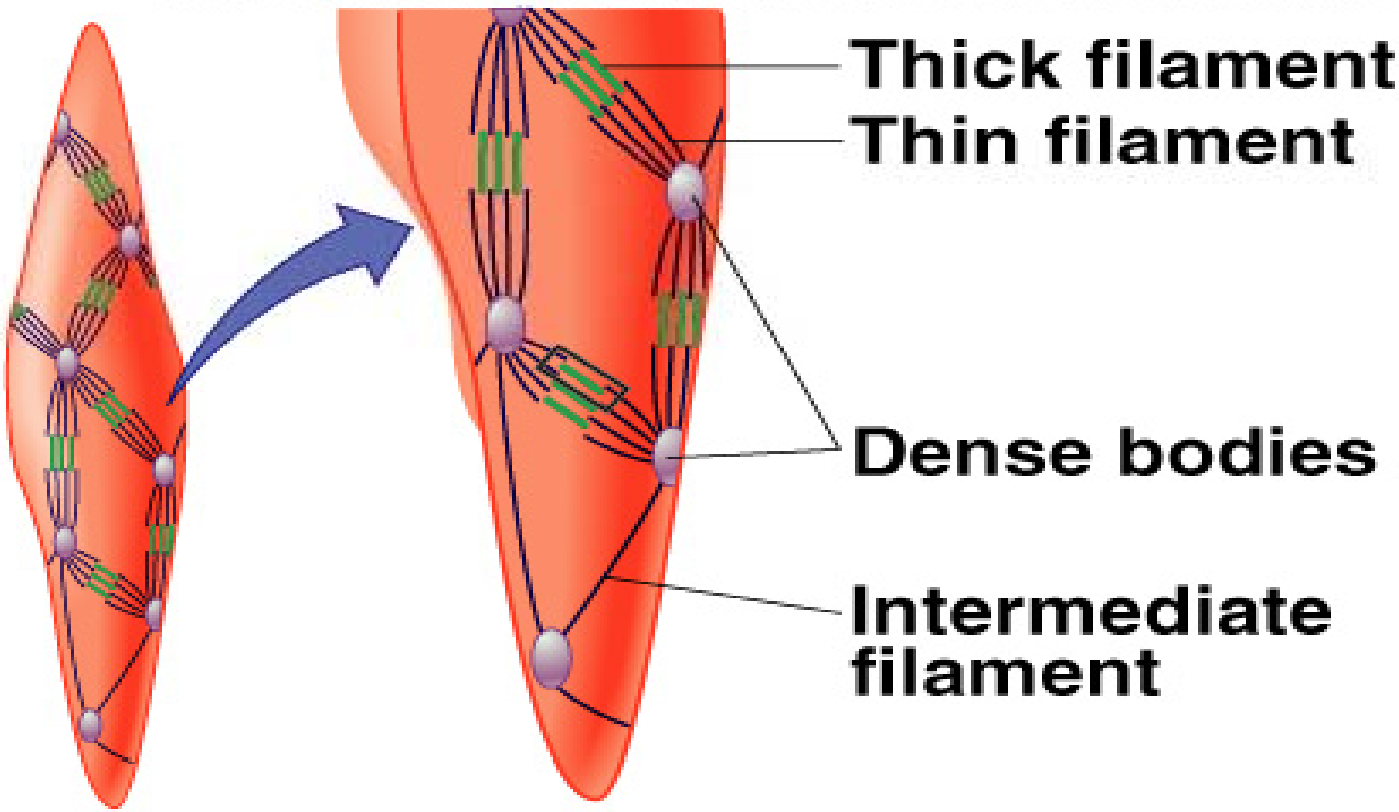
Not striated.

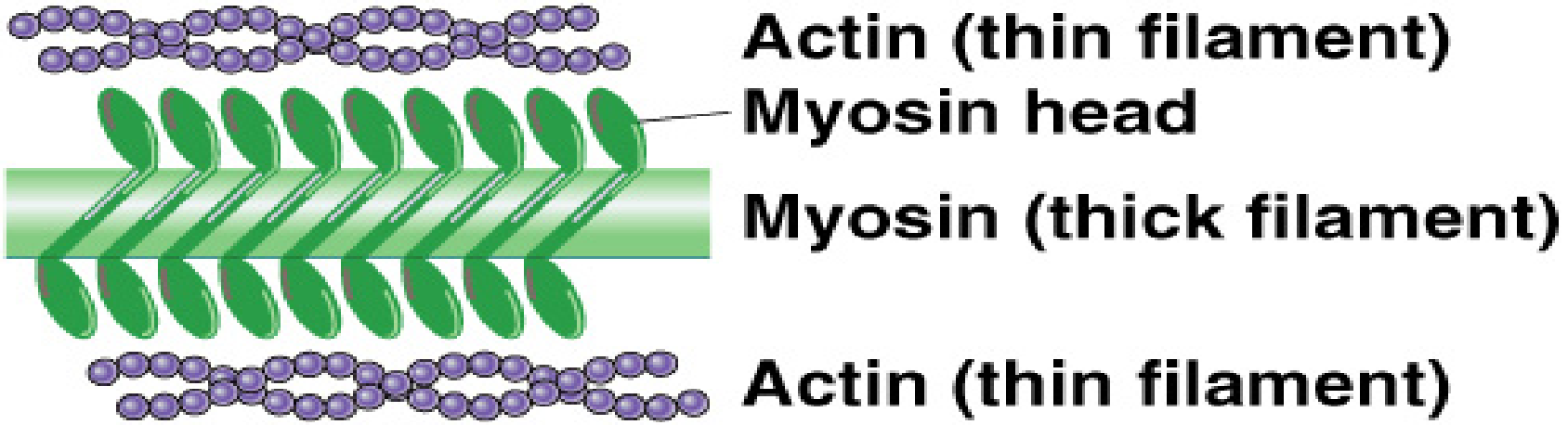
NO sarcomeres.

Lots of actin, some myosin

Can contract even when very stretched.

Graded contractions



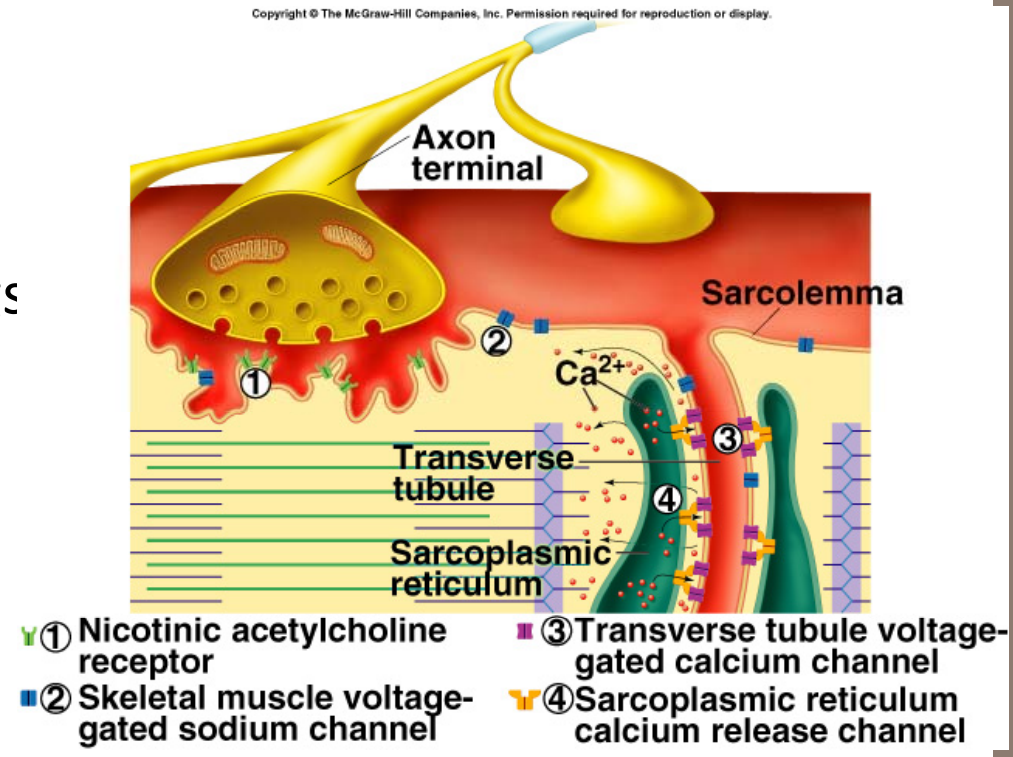


Actin all over the cell, linked by myosin (web-like pattern, not striations).

Rise in Ca^{2+} -> Ca^{2+} binds with **calmodulin** -> activates **MLCK (**a kinase) -> Myosin heads are phosphorylated and can bind to actin.

Sarcoplasmic reticulum lies next to T tubules.

Transverse tubules= infoldings of sarcolemma.



The Overload Principle

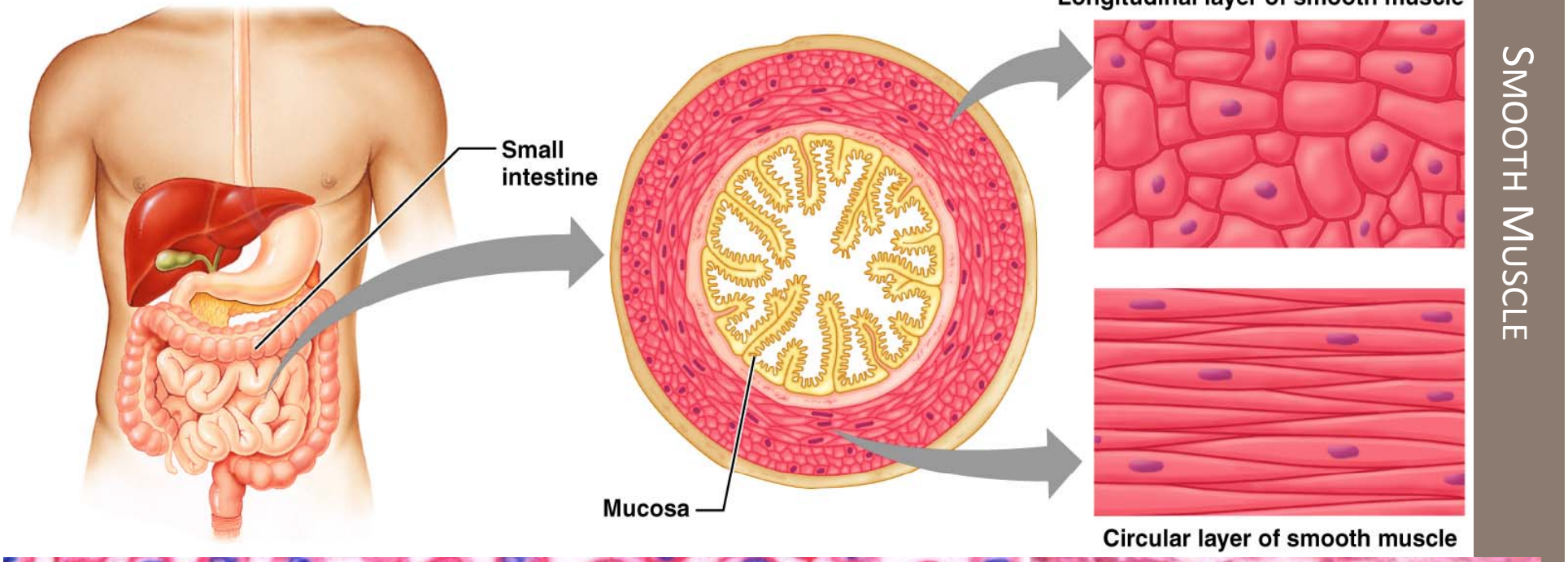
- Forcing a muscle to work promotes increased muscular strength
- Muscles adapt to increased demands
- Muscles must be overloaded to produce further gains

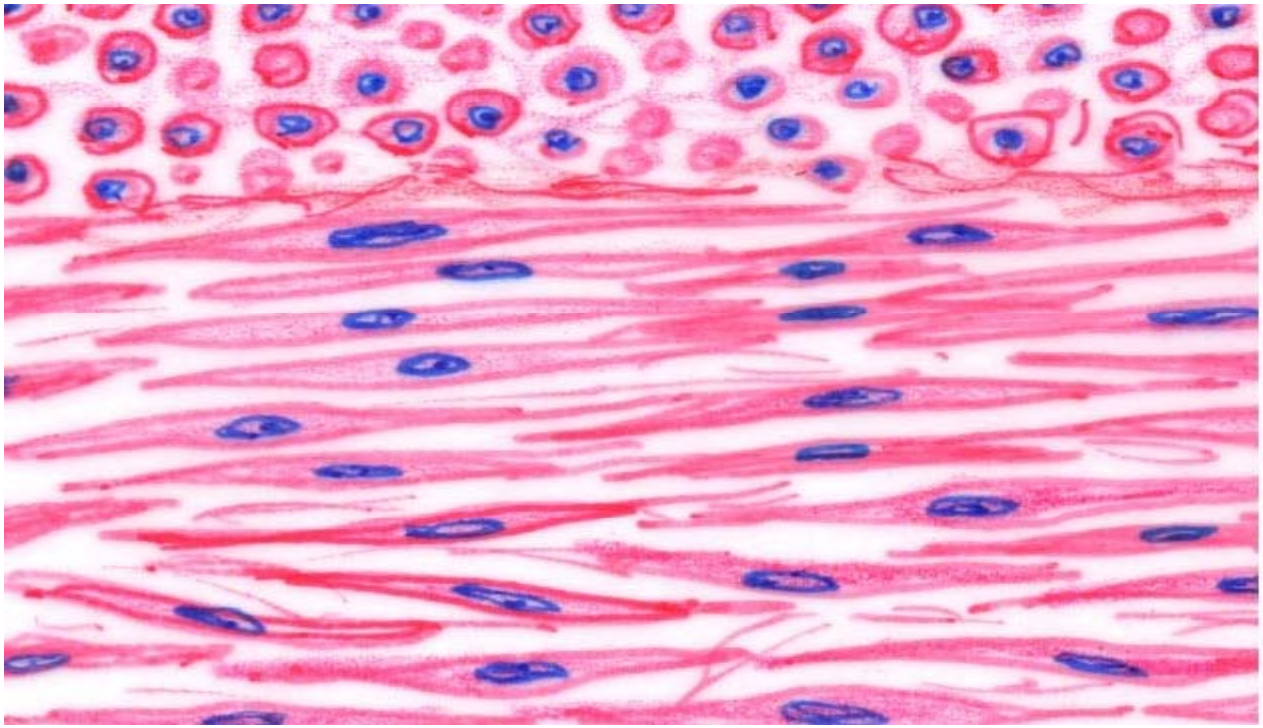
contoso

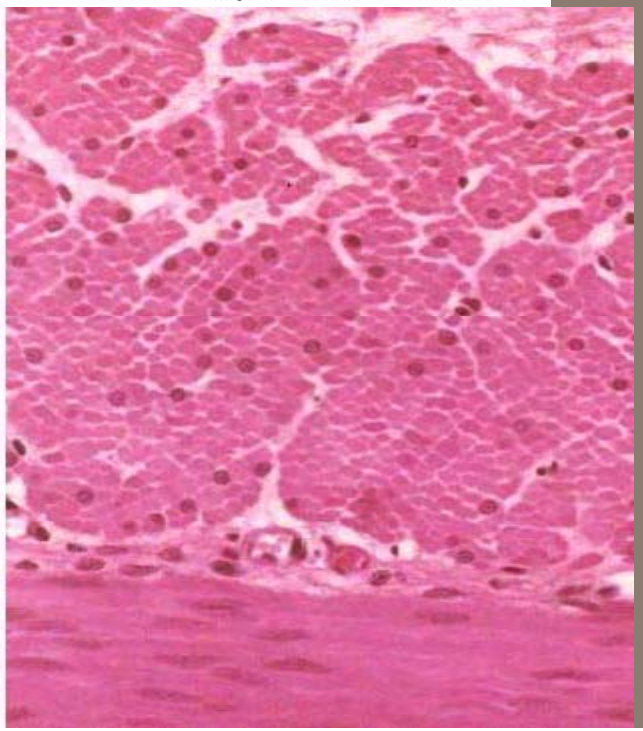
- Composed of **spindle-shaped fibers** with a diameter of 2-10 μm and lengths of several hundred μm
- Lack the coarse connective tissue sheaths of skeletal muscle, but have fine endomysium
- Organized into two layers (longitudinal and circular) of closely apposed fibers

- Found in walls of hollow organs (except the heart)
- Have essentially the same contractile mechanisms as skeletal muscle

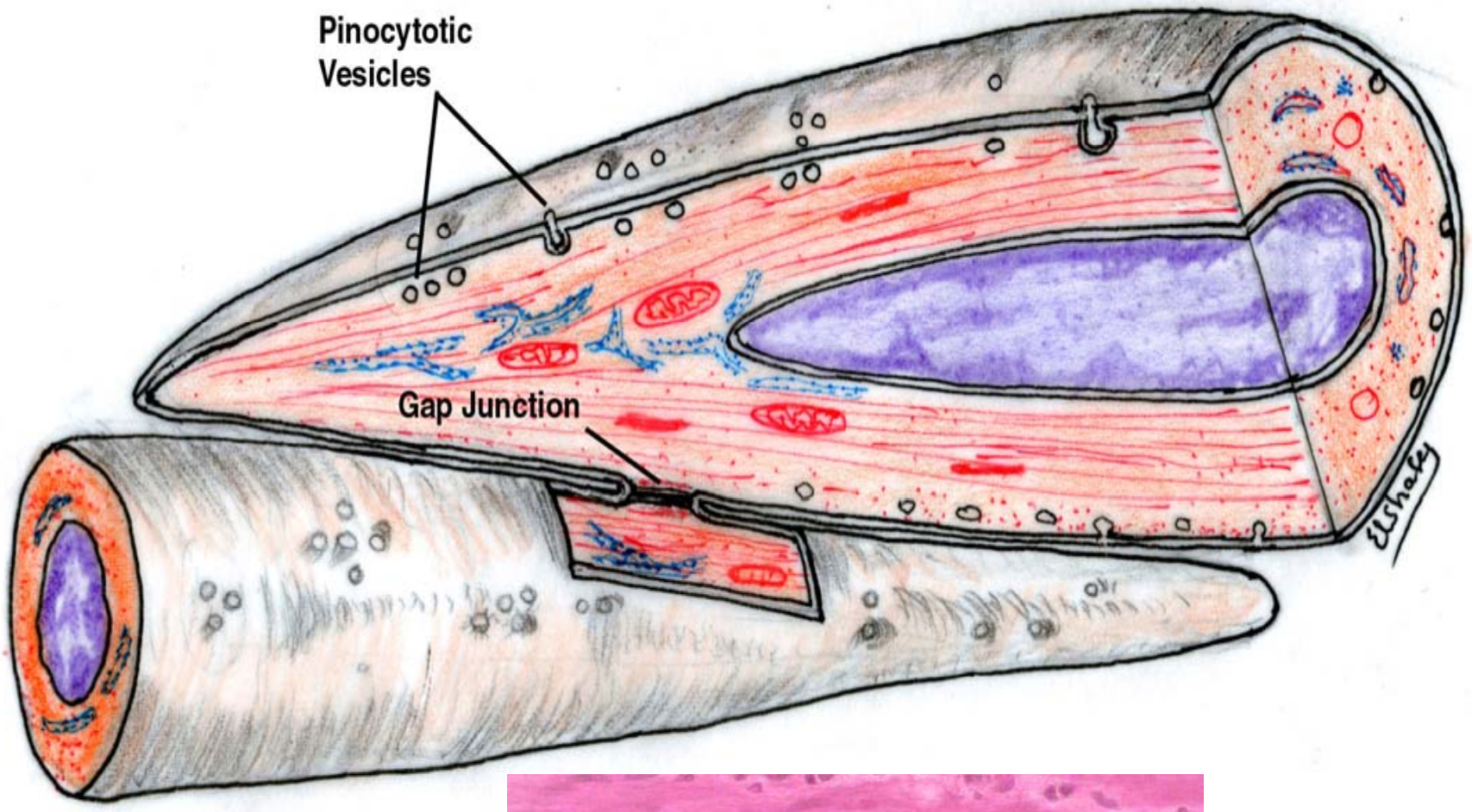
Smooth Muscle

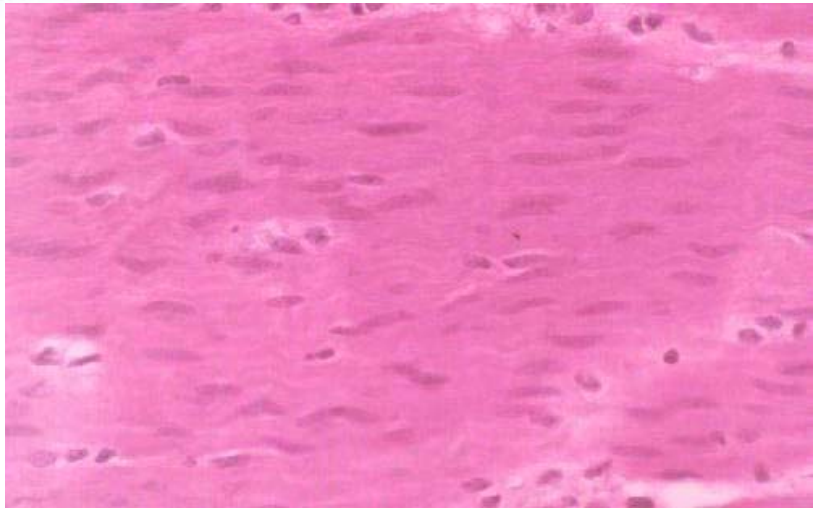






SMOOTH MUSCLES





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When the longitudinal layer contracts, the organ dilates and contracts

When the circular layer contracts, the organ elongates

Peristalsis – alternating contractions and relaxations of smooth muscles that mix and squeeze substances through the lumen of hollow organs

Smooth muscle lacks neuromuscular junctions

Innervating nerves have bulbous swellings called varicosities

Varicosities release neurotransmitters into wide synaptic clefts called diffuse junctions

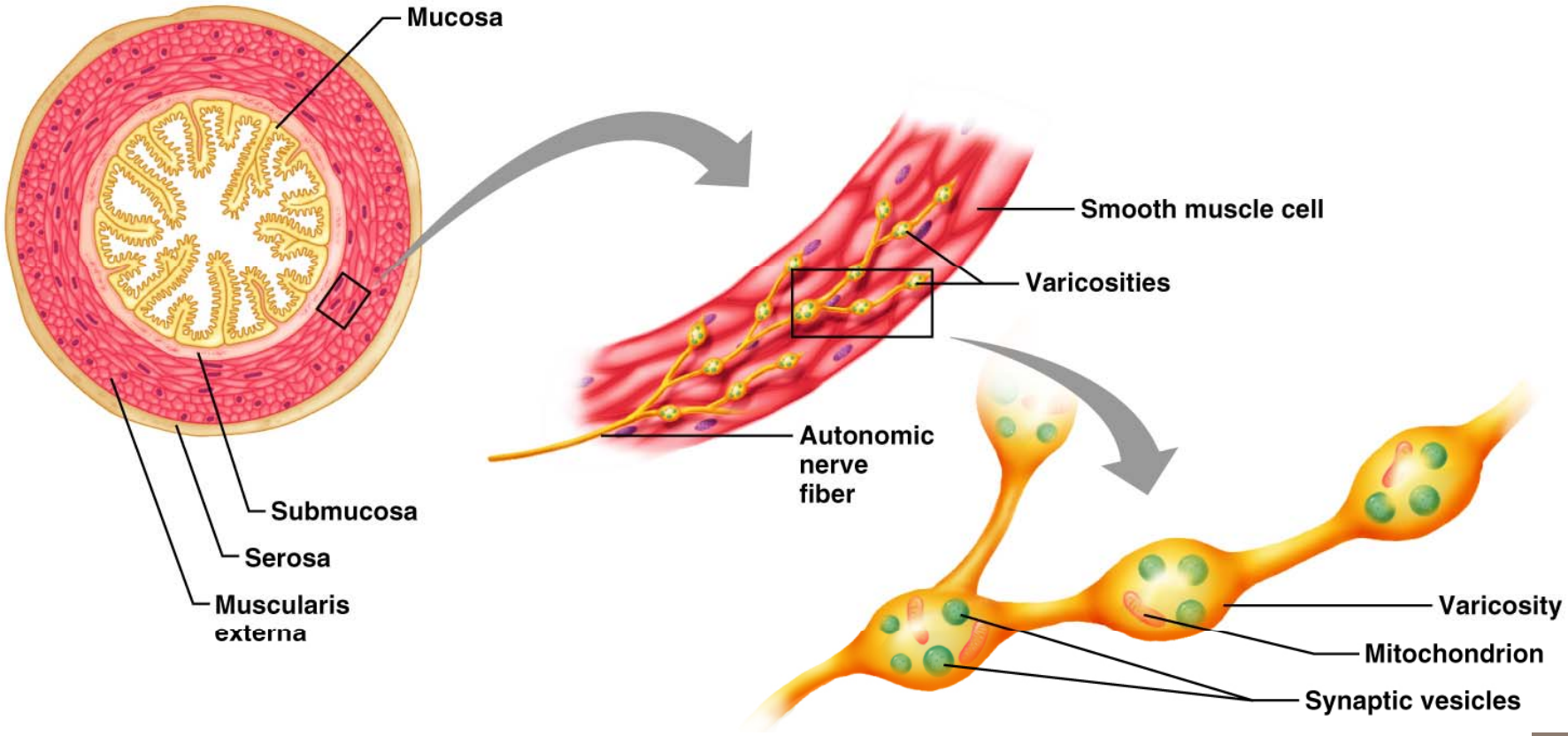

Mucosa
Submucosa
Serosa
Muscularis externa
Smooth muscle cell
Varicosities
Autonomic nerve fiber
Varicosity
Mitochondrion
Synaptic vesicles

Figure 9.25

- SR is less developed than in skeletal muscle and lacks a specific pattern
- T tubules are absent
- Plasma membranes have pouchlike infoldings called caveoli

Ca2+ is sequestered in the extracellular space near the caveoli, allowing rapid influx when channels are opened

There are no visible striations and no sarcomeres

Thin and thick filaments are present

- Thick and thin filaments are arranged diagonally, causing smooth muscle to contract in a corkscrew manner
- Noncontractile intermediate filament bundles attach to dense bodies (analogous to Z discs) at regular intervals

Certain smooth muscles can divide and increase their numbers by undergoing hyperplasia

This is shown by estrogen's effect on the uterus

At puberty, estrogen stimulates the synthesis of more smooth muscle, causing the uterus to grow to adult size

During pregnancy, estrogen stimulates uterine growth to accommodate the increasing size of the growing fetus

TABLE 9.3 Comparison of Skeletal, Cardiac, and Smooth Muscle

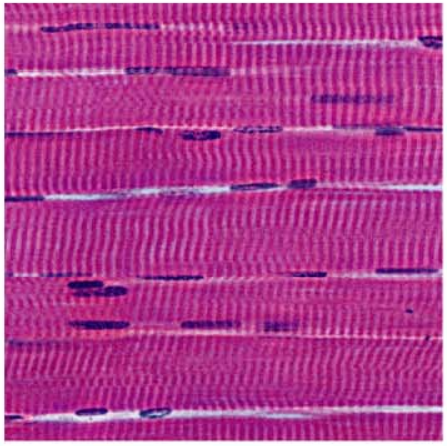
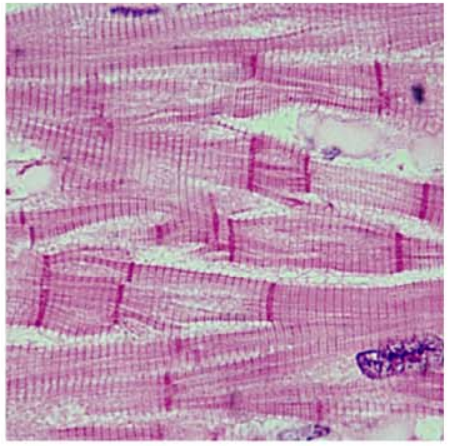
CHARACTERISTIC	SKELETAL	CARDIAC	SMOOTH
Body location	Attached to bones or (some facial muscles) to skin 	Walls of the heart 	Single-unit muscle in walls of hollow visceral organs (other than the heart); multiunit muscle in intrinsic eye muscles, airways, large arteries 
Cell shape and appearance	Single, very long, cylindrical, multinucleate cells with obvious striations 	Branching chains of cells; uni- or binucleate; striations 	Single, fusiform, uninucleate; no striations 

Table 9.3.1

Comparison of Skeletal, Cardiac and Smooth Muscle Cells

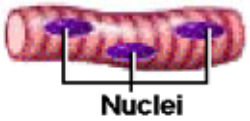
Skeletal Muscle Cell:

Elongated Cells

Multiple Peripheral Nuclei

Visible Striations

Voluntary



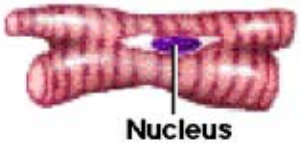
Cardiac Muscle:

Branching Cells

Single Central Nucleus

Visible Striations

Involuntary



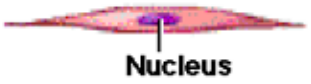
Smooth Muscle Cell:

Spindle-Shaped Cell

Single Central Nucleus

Lack Visible Striations

Involuntary



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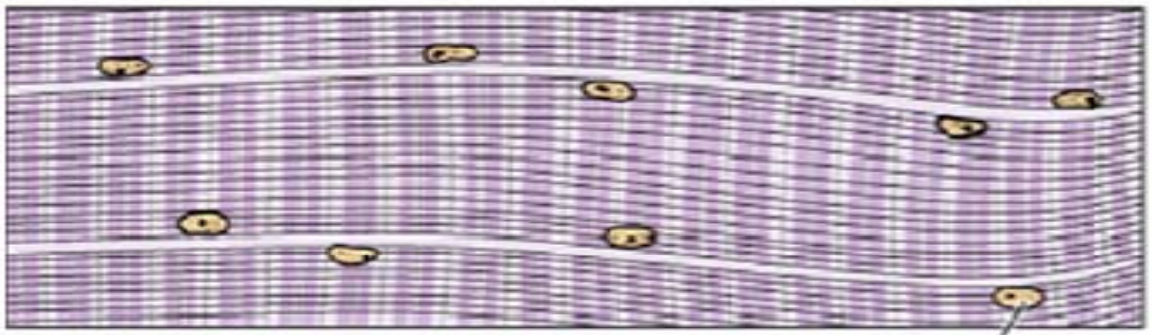
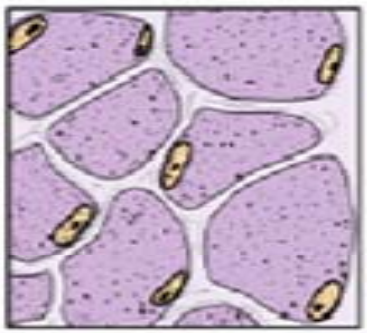
Muscle types

Activity

Skeletal muscle



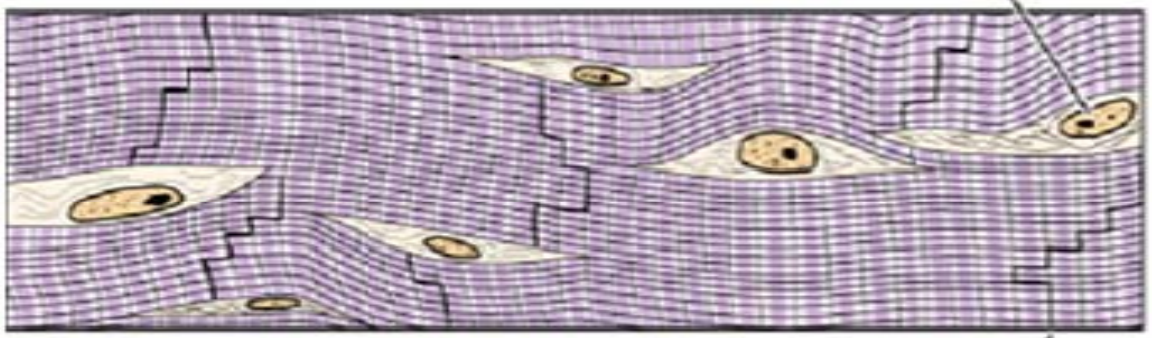
Cross sections

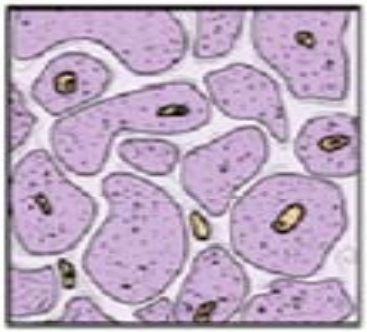


Strong, quick discontinuous voluntary contraction

Nuclei

Cardiac muscle

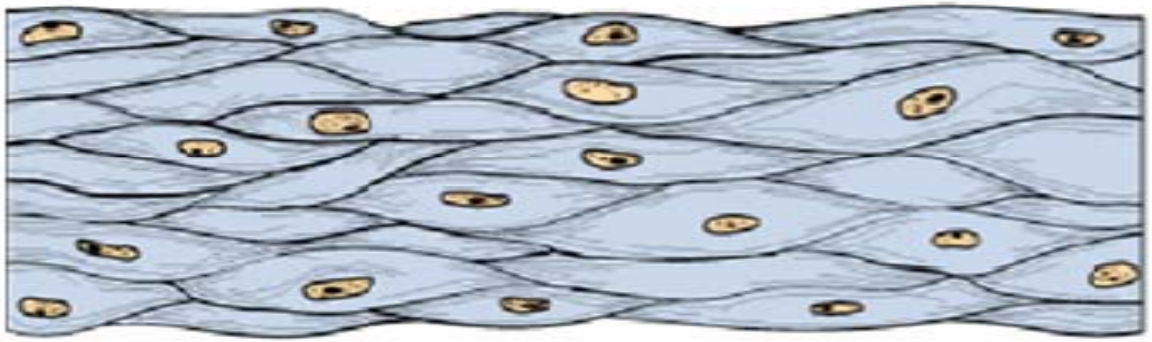


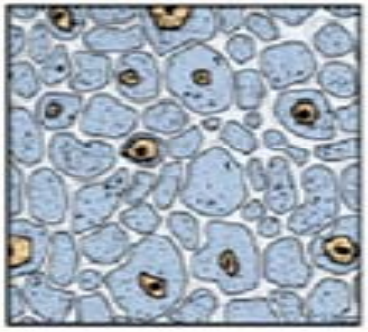


Strong, quick continuous involuntary contraction

Intercalated disks

Smooth muscle





Weak, slow involuntary contraction

TABLE 9.3 Comparison of Skeletal, Cardiac, and Smooth Muscle

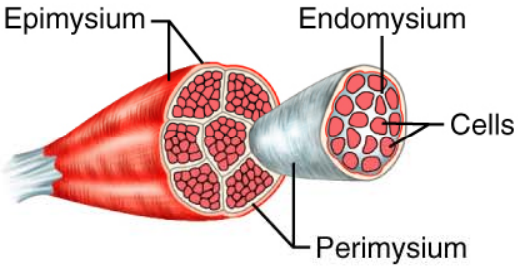
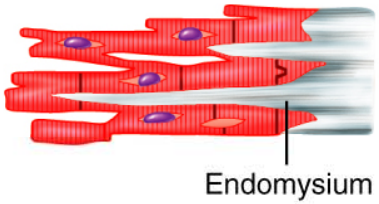
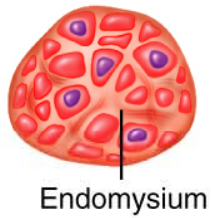
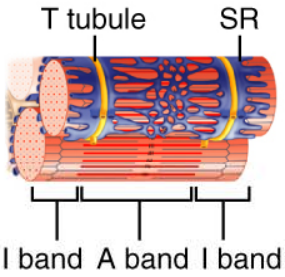
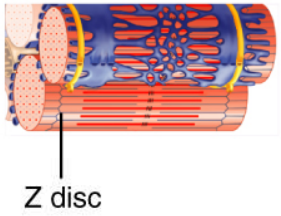
CHARACTERISTIC	SKELETAL	CARDIAC	SMOOTH
Connective tissue components	Epimysium, perimysium, and endomysium 	Endomysium attached to fibrous skeleton of heart 	Endomysium 
Presence of myofibrils composed of sarcomeres	Yes	Yes, but myofibrils are of irregular thickness	No, but actin and myosin filaments are present throughout; dense bodies anchor actin filaments
Presence of T tubules and site of invagination	Yes; two in each sarcomere at A-I junctions 	Yes; one in each sarcomere at Z disc; larger diameter than those of skeletal muscle 	No; only caveolae
Elaborate sarcoplasmic reticulum	Yes	Less than skeletal muscle (1–8% of cell volume); scant terminal cisternae	Equivalent to cardiac muscle (1–8% of cell volume); some SR contacts the sarcolemma

TABLE 9.3 Comparison of Skeletal, Cardiac, and Smooth Muscle

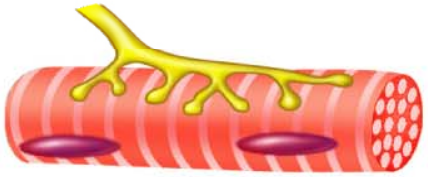
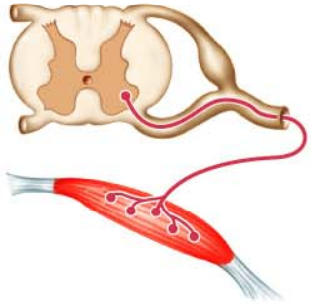
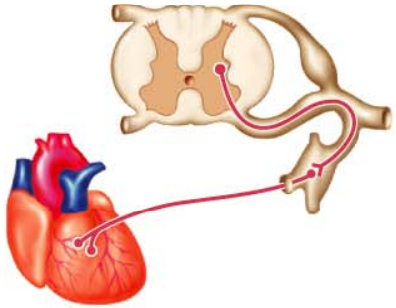
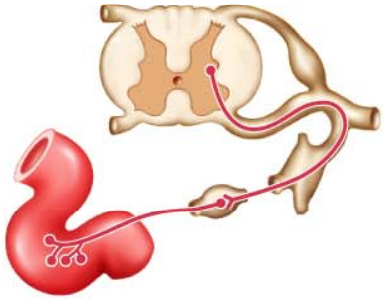
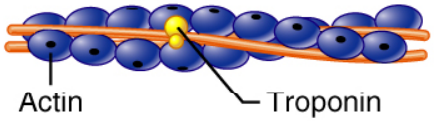
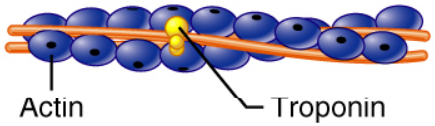
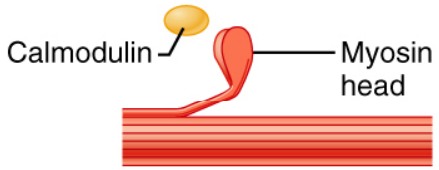
CHARACTERISTIC	SKELETAL	CARDIAC	SMOOTH
Presence of gap junctions	No	Yes; at intercalated discs	Yes; in single-unit muscle
Cells exhibit individual neuromuscular junctions	Yes	No	Not in single-unit muscle; yes in multiunit muscle
			
Regulation of contraction	Voluntary via axon terminals of the somatic nervous system	Involuntary; intrinsic system regulation; also autonomic nervous system controls; hormones; stretch	Involuntary; autonomic nerves, hormones, local chemicals; stretch
			
Source of Ca^{2+} for calcium pulse	Sarcoplasmic reticulum (SR)	SR and from extracellular fluid	SR and from extracellular fluid

TABLE 9.3 Comparison of Skeletal, Cardiac, and Smooth Muscle

CHARACTERISTIC	SKELETAL	CARDIAC	SMOOTH
Site of calcium regulation	Troponin on actin-containing thin filaments	Troponin on actin-containing thin filaments	Calmodulin in the sarcoplasm
			
Presence of pacemaker(s)	No	Yes	Yes (in single-unit muscle only)
Effect of nervous system stimulation	Excitation	Excitation or inhibition	Excitation or inhibition
Speed of contraction	Slow to fast	Slow	Very slow
			
Rhythmic contraction	No	Yes	Yes in single-unit muscle
Response to stretch	Contractile strength increases with degree of stretch (to a point)	Contractile strength increases with degree of stretch	Stress-relaxation response
Respiration	Aerobic and anaerobic	Aerobic	Mainly aerobic

Muscle Enzymes

- CPK (classic)
  - MM skeletal muscle
  - MB Cardiac muscle
  - BB brain
- Aldolase
- SGOT
- SGPT
- LDH

High CK Levels

- Racial differences
- Trauma (sharp or blunt)
- Exercise (anaerobiic, aerobiic)
- Drugs
- Toxins
- Carrier state
- Pre-disease
- Asymptomatic (benign) hyper-CK-emia