MUSCULAR SYSTEM

Learning Objectives

1. To know basic anatomy of muscle
2. Knowledge regarding nomenclature/ classification of muscles
3. Knowledge regarding basic facts of functioning of muscles

Muscles are responsible for all types of body movement – they contract or shorten and are the machine of the body

Three basic muscle types are found in the body

- Skeletal muscle
- Cardiac muscle
- Smooth muscle

Head and Neck Muscles

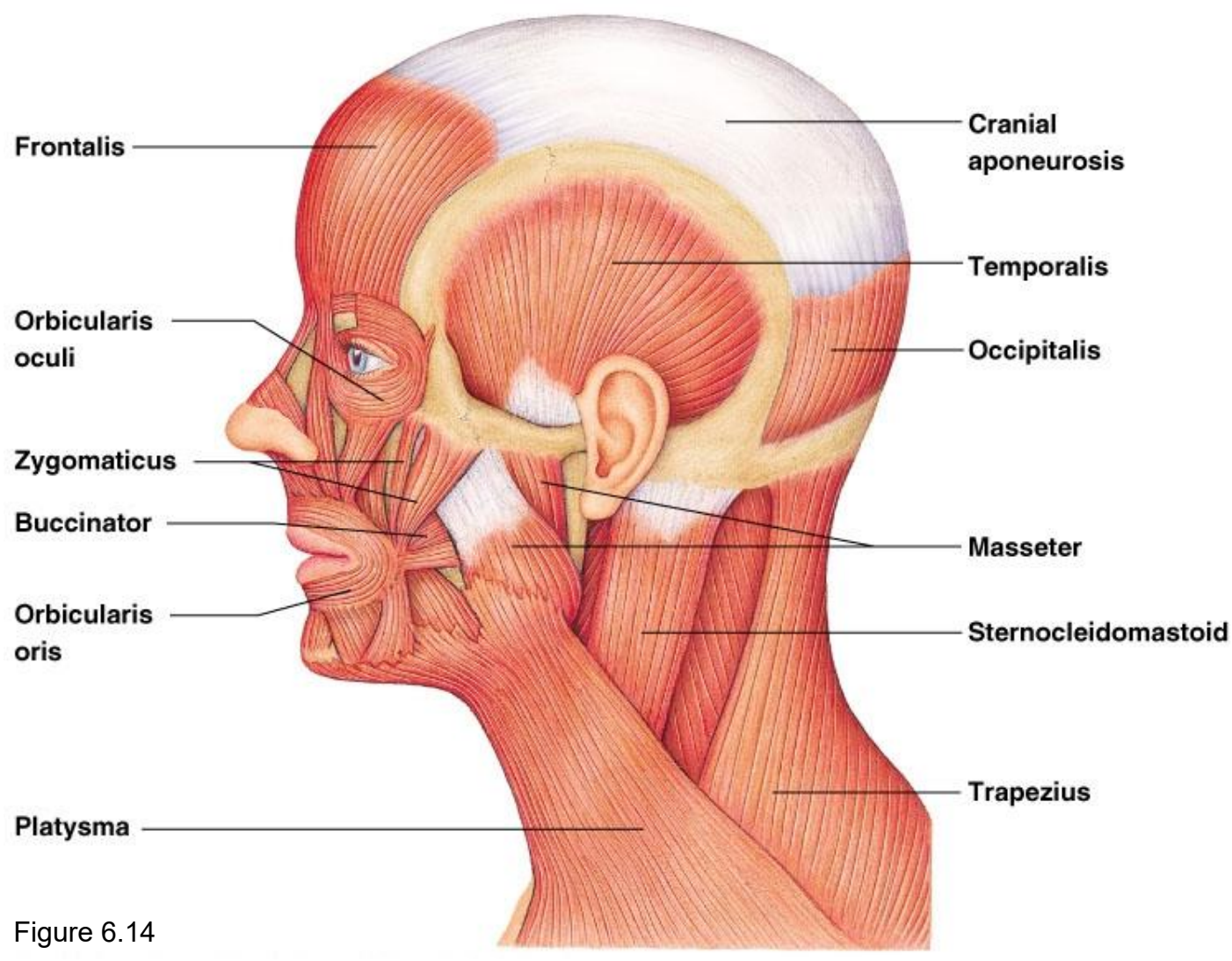


Figure 6.14

Slide 6.38

Trunk Muscles

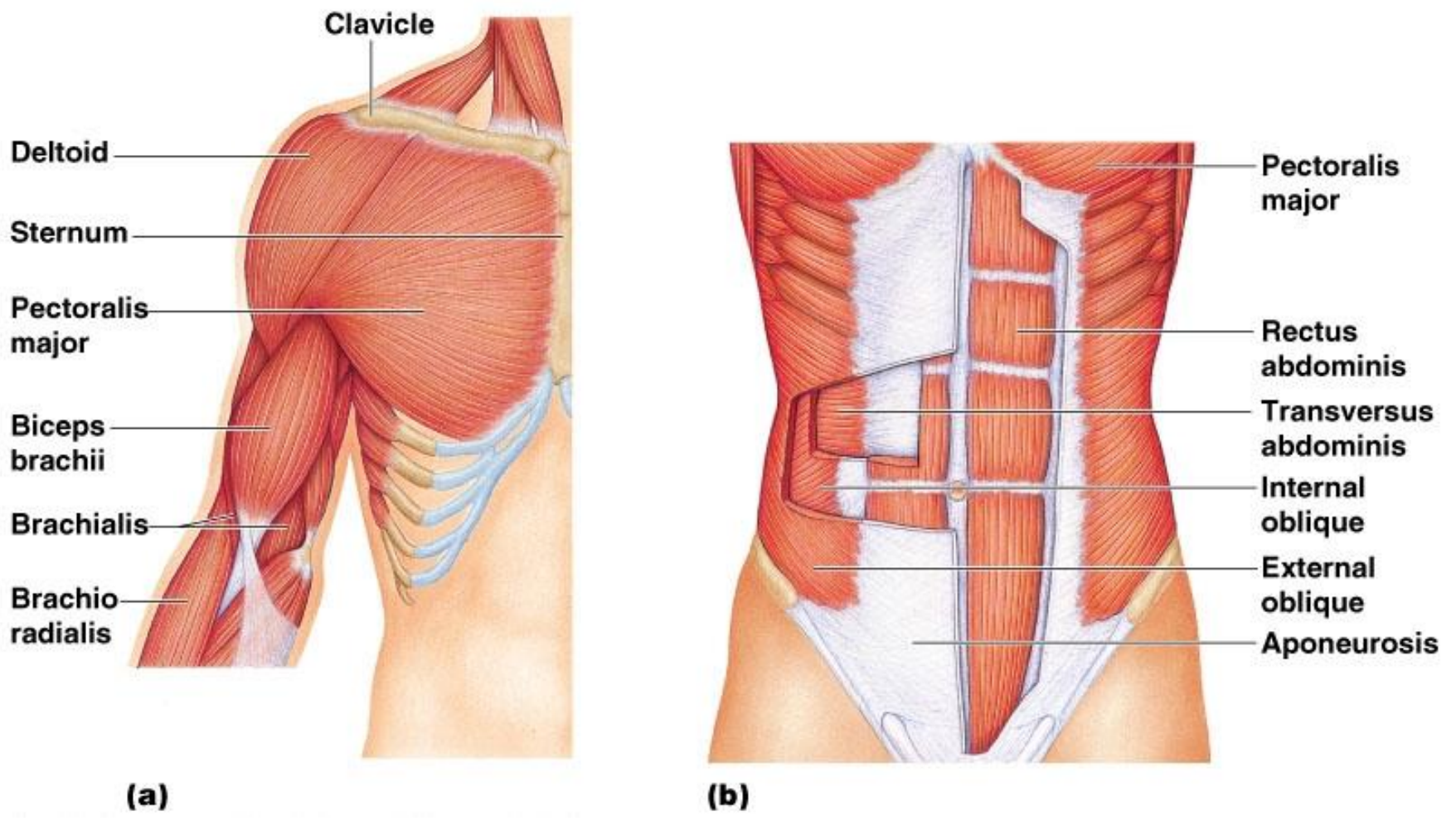


Figure 6.15

Slide 6.39

Deep Trunk and Arm Muscles

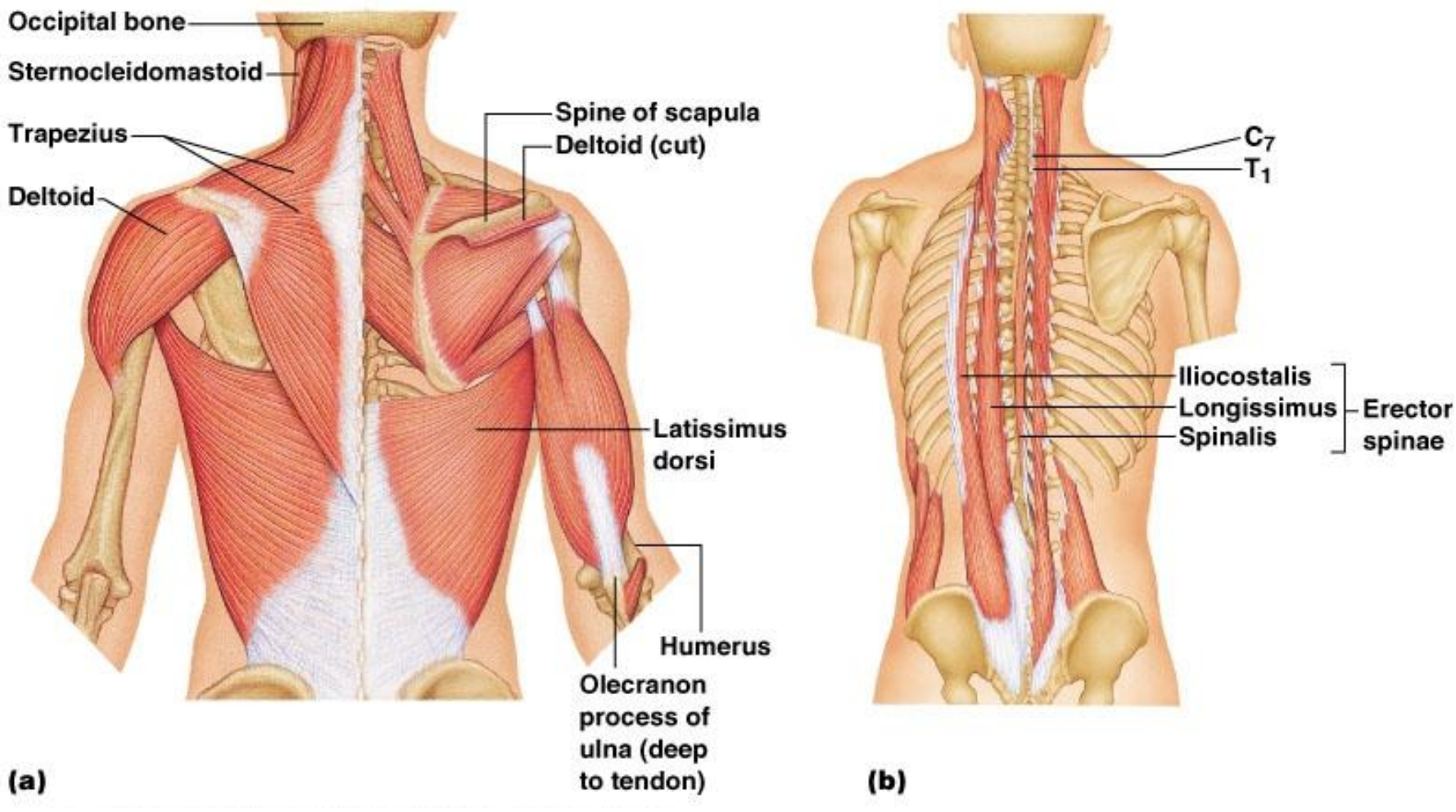


Figure 6.16

Slide 6.40

Muscles of the Pelvis, Hip, and Thigh

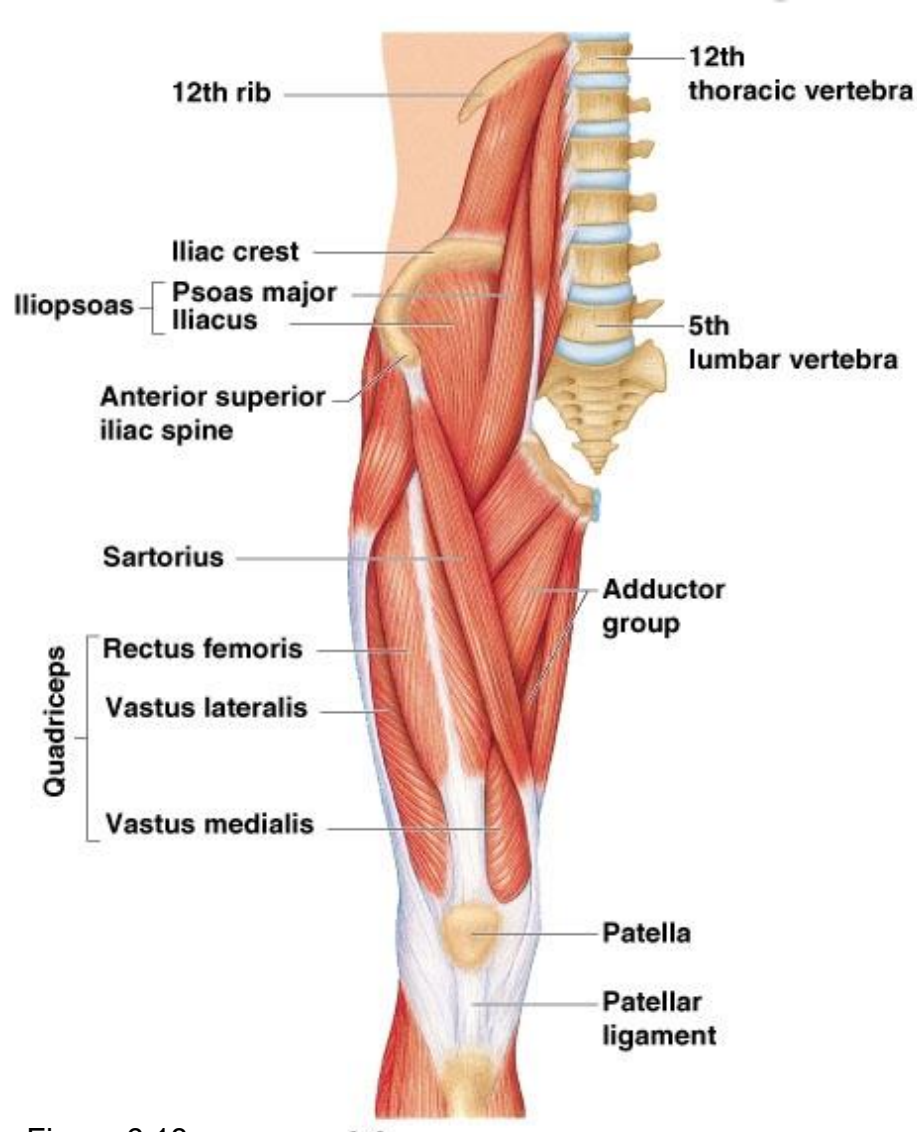


Figure 6.18c

Slide 6.41

Superficial Muscles: Anterior

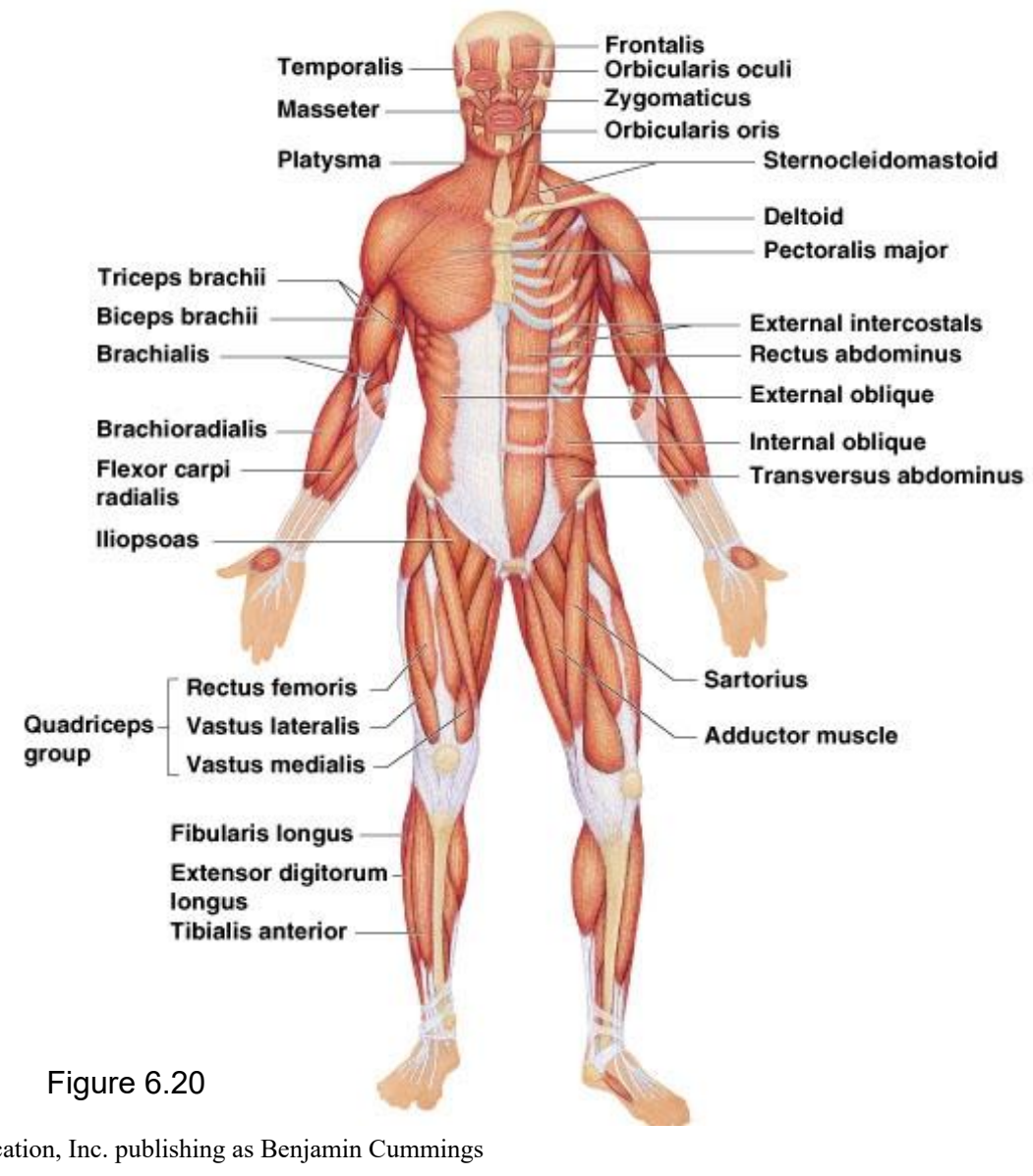


Figure 6.20

Slide 6.43

Superficial Muscles: Posterior

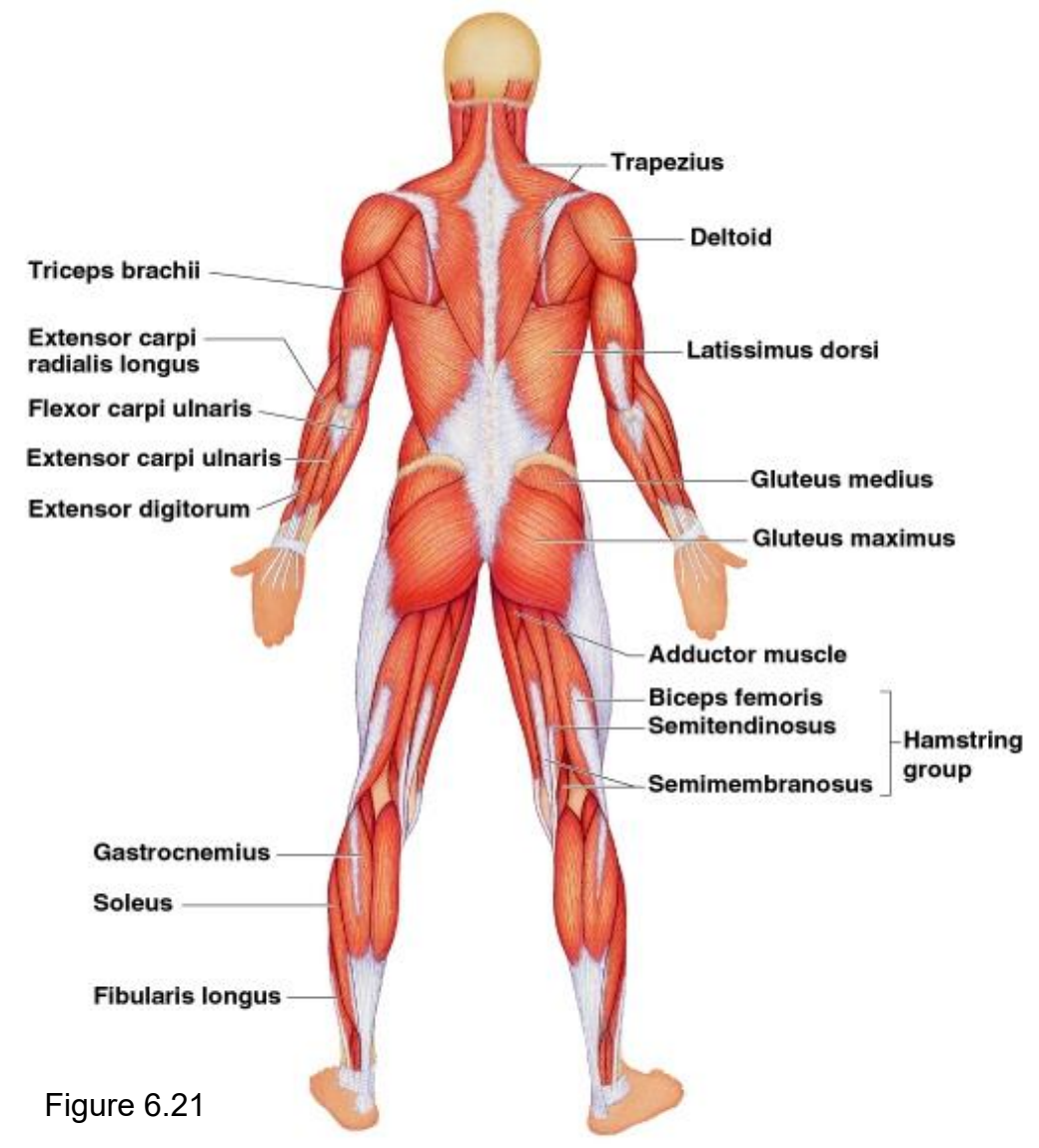
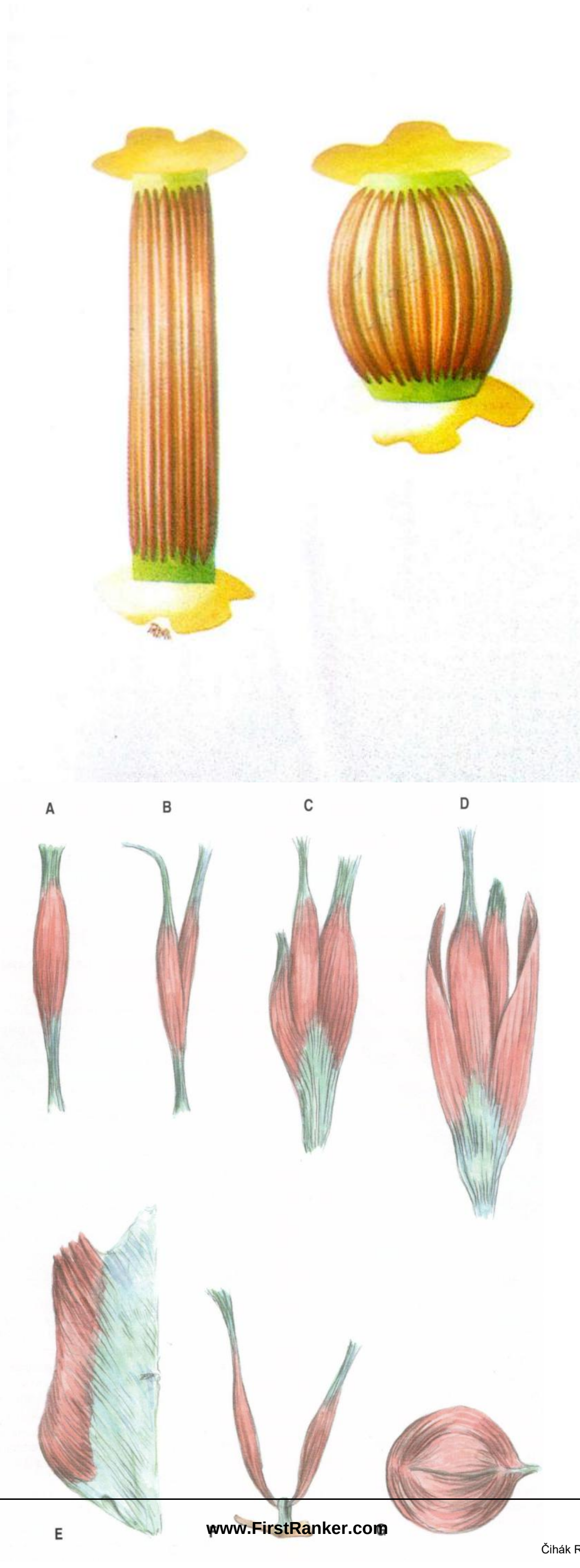
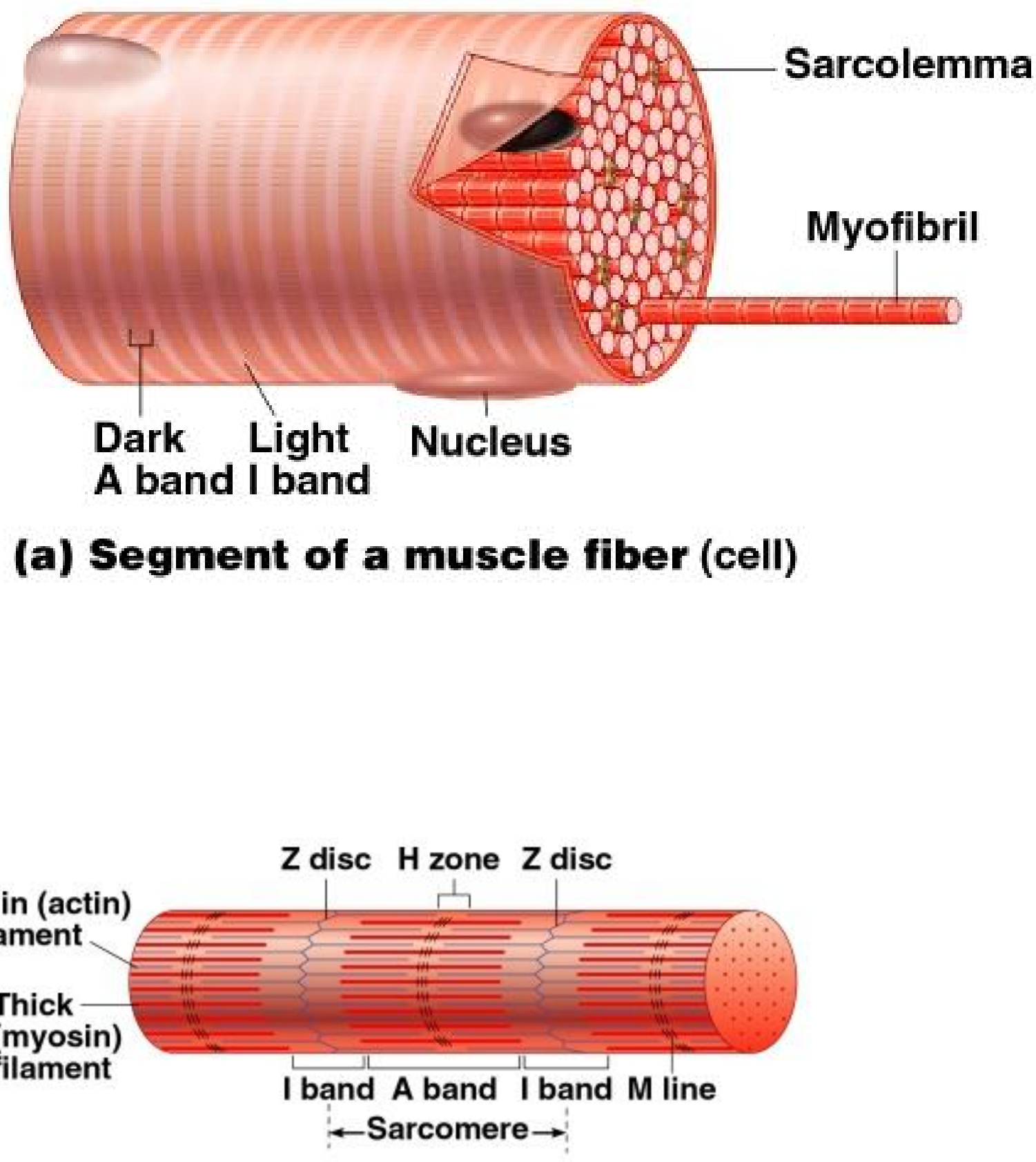


Figure 6.21

Slide 6.44





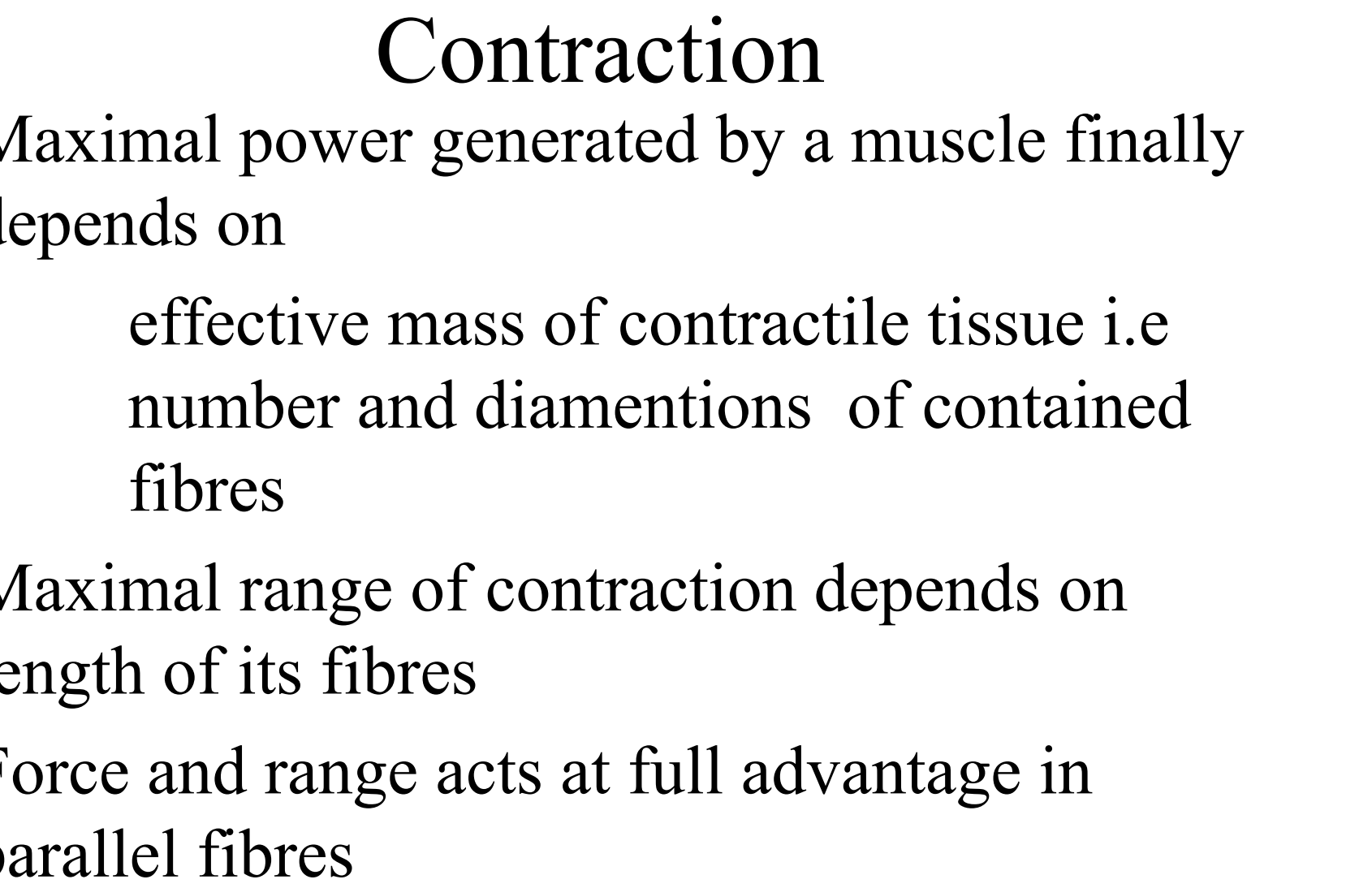
Power & Range- Muscle Contraction

Maximal power generated by a muscle finally depends on

- effective mass of contractile tissue i.e number and diamentions of contained fibres

Maximal range of contraction depends on length of its fibres

Force and range acts at full advantage in parallel fibres



5.17 Simple mechanical considerations related to the actions of (A) strap, and (B) bipennate muscles. (For details of the actions of these different muscle types consult text.)

Classification Of Muscles

A. By Fascicular Orientation

1.Parallel

2.Pennate

3 Spiral

4 Cruciate

1. Parallel (Relative to muscle direction of pull)

(a) Quadrilateral- Quadratus lumborum,Thyrohyoid

(b)Long and strap like- Sartorius

(c) Strap like with tendinous intersection Rectus abdominis

(d) Fusiform- Biceps brachii

2. Pennate muscles

(a) Unipennate – Flexor Pollicis longus

(b)Bipennate- Rectus femoris, Dorsal interossei of hand

(c)Multipennate - Deltoid

(d)Circumpennate- Tibialis anterior

Classification Of Muscles

3. Spiral

Supinator

4. Cruciate

Sternocledomastoid, Masseter

Classification Of Muscles

B. By Type Of Skeletal Muscle Fibre

1. Slow or Red fibres or type I fibres

2. Fast or White fibres or type II fibres

Classification Of Muscles

C. By Insertion near or away from joint

1. Shunt Muscle(Away from Joint)

2. Spurt Muscle (Near Joint)

Nomenclature of Muscles

On Basis of :

1.Shape of muscle

Deltoid, Quadratus, Rhomboid, Lumbricals

2.Size

Major , minor , longus , brevis

3. Number Of Head

Biceps , triceps, Quadriceps femoris, Digastric

Nomenclature

4. Position

Supraspinatus, Infraspinatus, Abdominis, Oculi, oris

5.Depth

External oblique, Internal oblique

Flexor D. Superficialis, Flexor D. Profundus

Nomenclature

6. Attachment : Sternocledomastoid, coracobrachialis
7. Action : Flexor, Extensor, Abductor

Connective Tissue Wrappings of Skeletal Muscle

- Endomysium – around single muscle fiber
- Perimysium – around a fascicle (bundle) of fibers

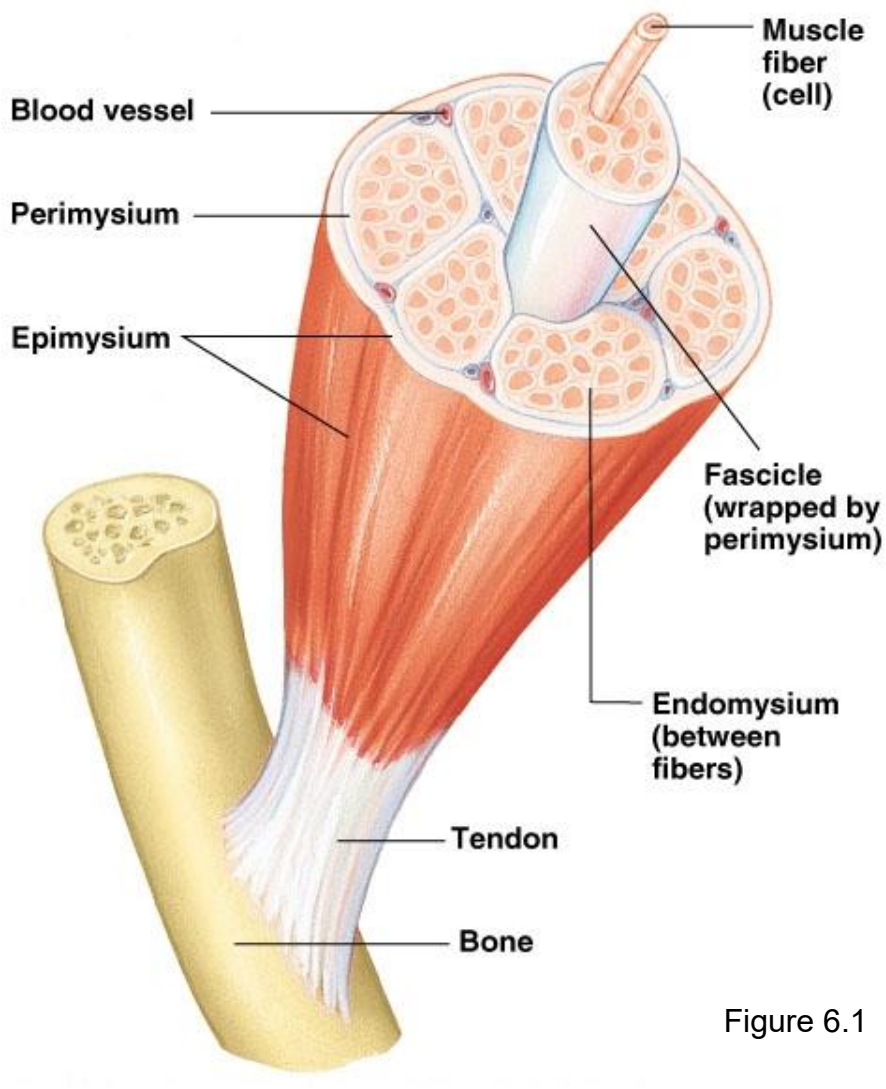


Figure 6.1

Slide 6.4a

Connective Tissue Wrappings of Skeletal Muscle

- Epimysium – covers the entire skeletal muscle
- Fascia – on the outside of the epimysium

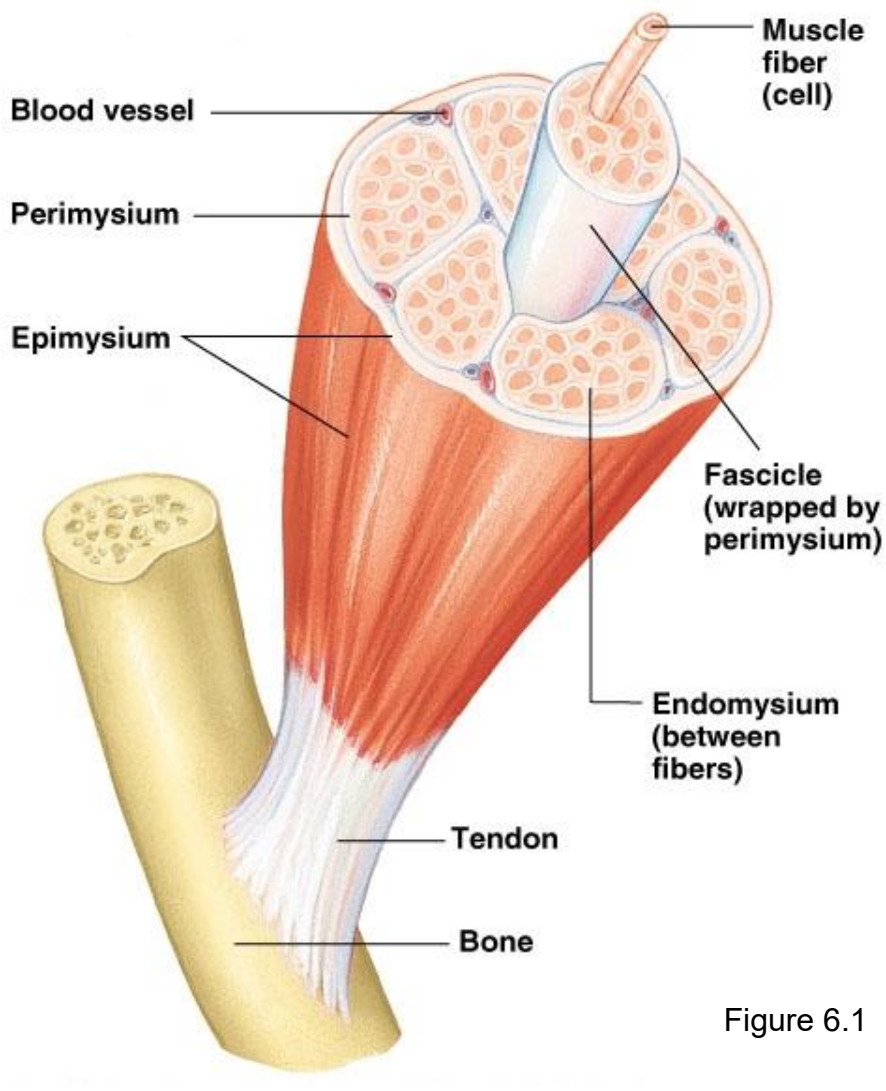


Figure 6.1

Slide 6.4b

Skeletal Muscle Attachments

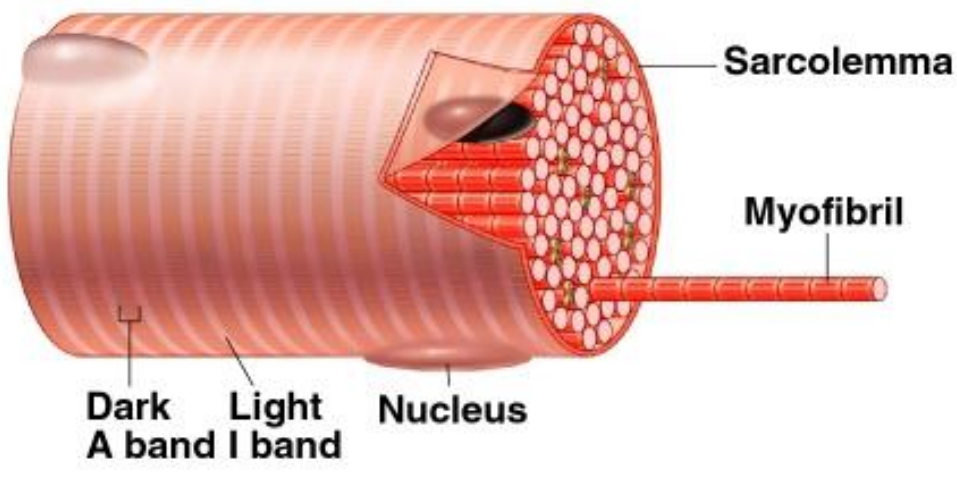
- Epimysium blends into a connective tissue attachment
  - Tendon – cord-like structure
  - Aponeuroses – sheet-like structure
- Sites of muscle attachment
  - Bones
  - Cartilages
  - Connective tissue coverings

Function of Muscles

- Produce movement
- Maintain posture
- Stabilize joints
- Generate heat

Microscopic Anatomy of Skeletal Muscle

- Cells are multinucleate
- Nuclei are just beneath the sarcolemma

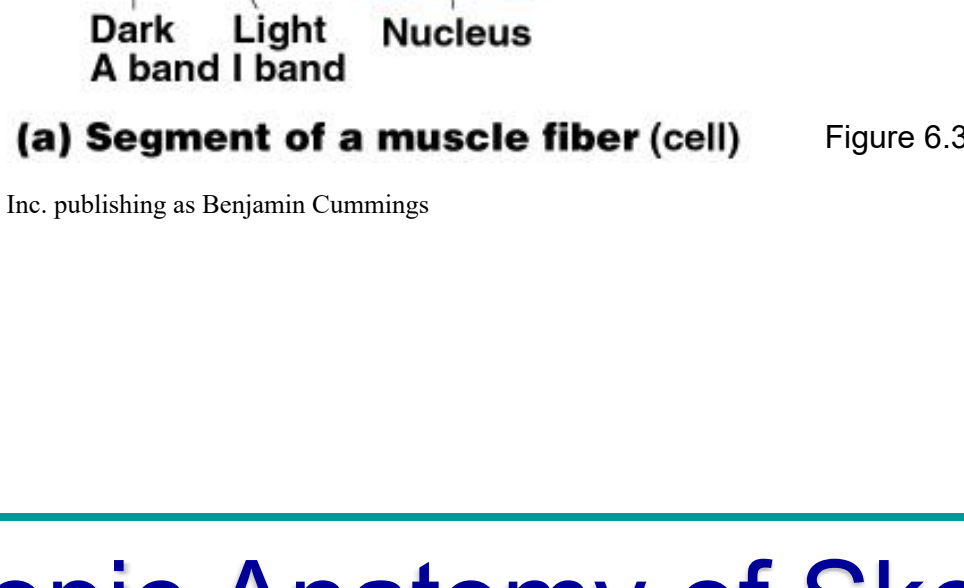


(a) Segment of a muscle fiber (cell)

Figure 6.3a

Microscopic Anatomy of Skeletal Muscle

- Sarcolemma – specialized plasma membrane
- Sarcoplasmic reticulum – specialized smooth endoplasmic reticulum

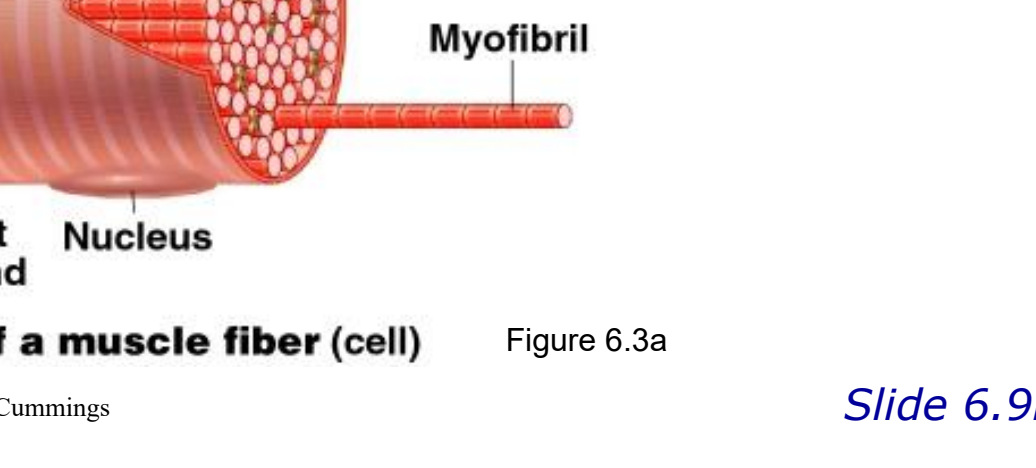


(a) Segment of a muscle fiber (cell)

Figure 6.3a

Microscopic Anatomy of Skeletal Muscle

- Myofibril
  - Bundles of myofilaments
  - Myofibrils are aligned to give distrinct bands
    - I band = light band
    - A band = dark band

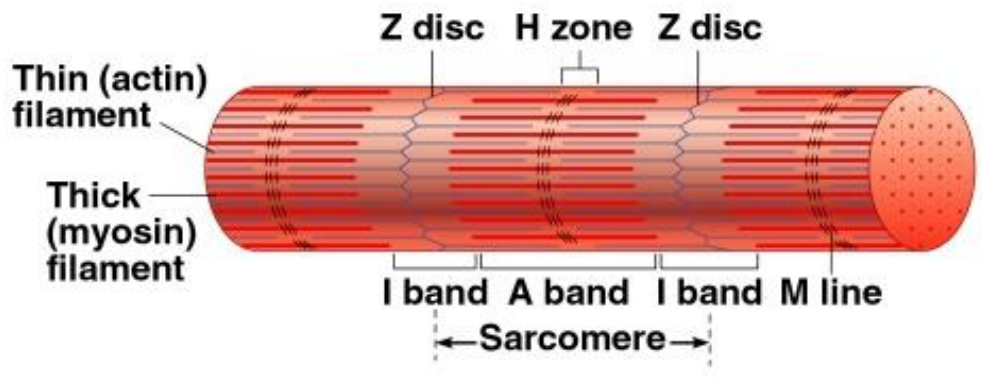


(b) Myofibril or fibril (complex organelle composed of bundles of myofilaments)

Figure 6.3b

Microscopic Anatomy of Skeletal Muscle

- Sarcomere
  - Contractile unit of a muscle fiber



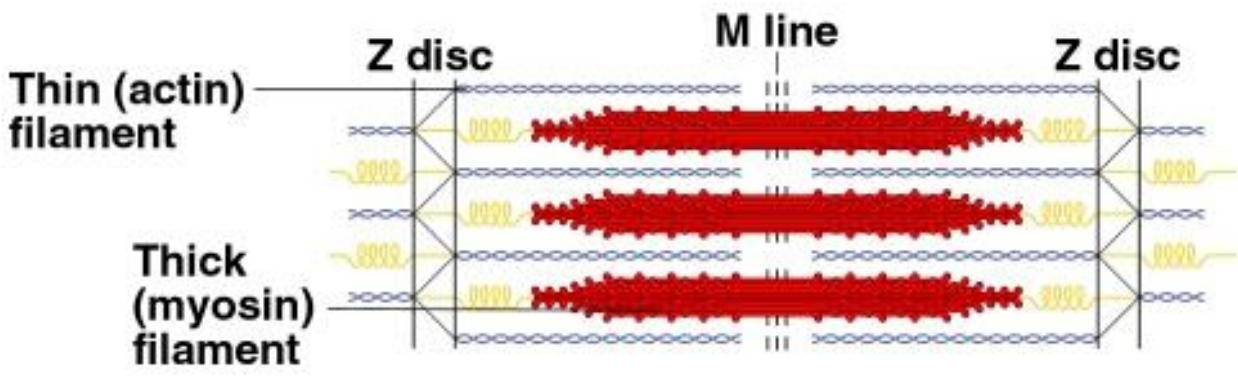
(b) Myofibril or fibril (complex organelle composed of bundles of myofilaments)

Figure 6.3b

Slide 6.10b

Microscopic Anatomy of Skeletal Muscle

- Organization of the sarcomere
  - Thick filaments = myosin filaments
    - Composed of the protein myosin
    - Has ATPase enzymes



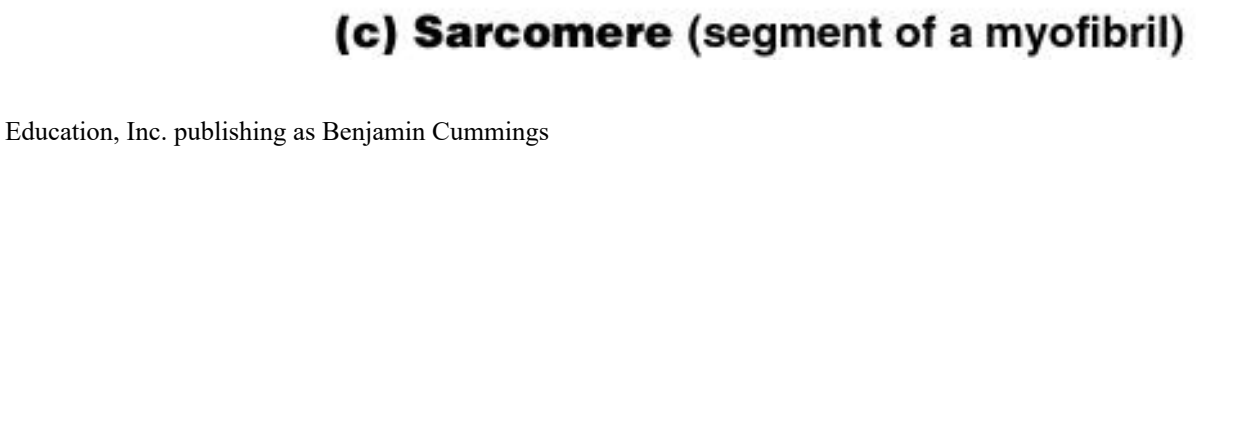
(c) Sarcomere (segment of a myofibril)

Figure 6.3c

Slide 6.11a

Microscopic Anatomy of Skeletal Muscle

- Organization of the sarcomere
  - Thin filaments = actin filaments
    - Composed of the protein actin



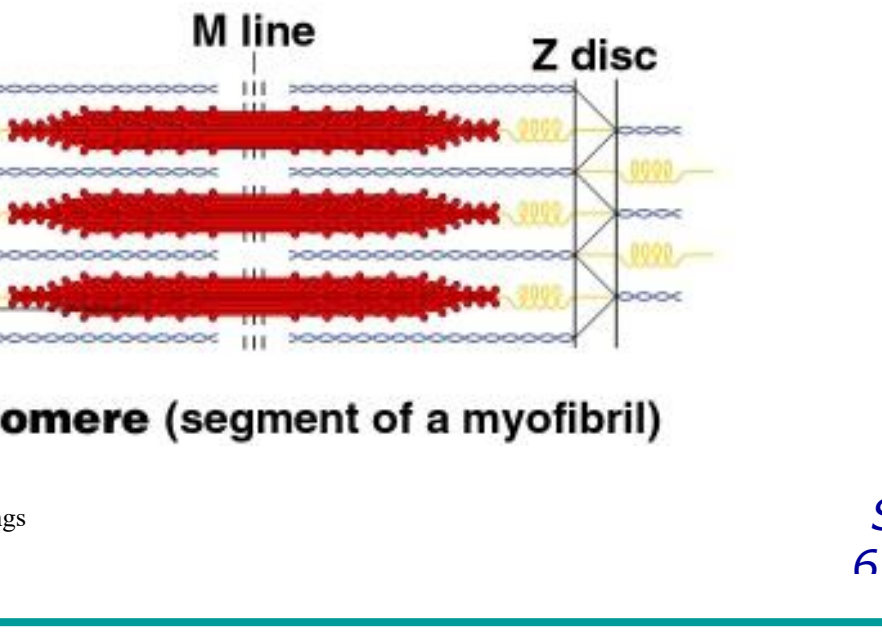
(c) Sarcomere (segment of a myofibril)

Figure 6.3c

Slide 6.11b

Microscopic Anatomy of Skeletal Muscle

- Myosin filaments have heads (extensions, or cross bridges)
- Myosin and actin overlap somewhat



(d) Myofilament structure (within one sarcomere)

Figure 6.3d

Slide 6.12a

Nerve Stimulus to Muscles

- Skeletal muscles must be stimulated by a nerve to contract (motor neruron)
- Motor unit
  - One neuron
  - Muscle cells stimulated by that neuron

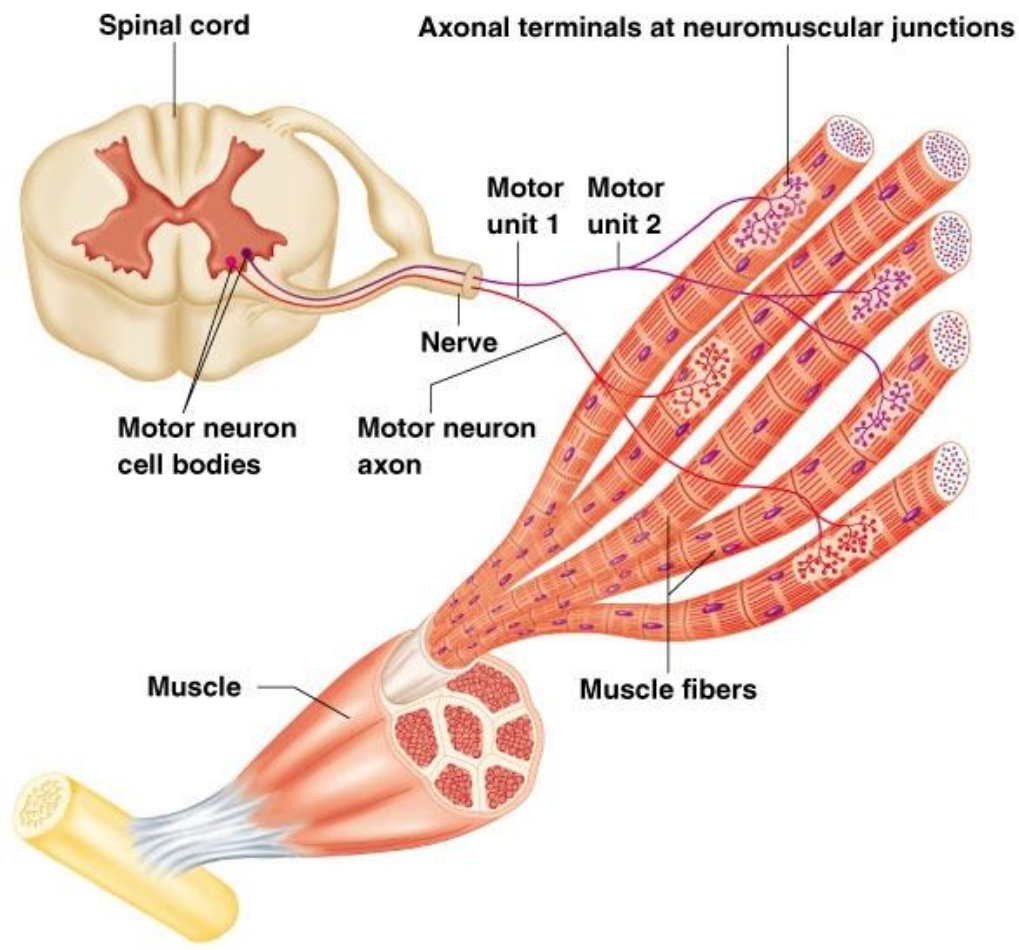


Figure 6.4a

Slide 6.14

Muscle Response to Strong Stimuli

- Muscle force depends upon the number of fibers stimulated
- More fibers contracting results in greater muscle tension
- Muscles can continue to contract unless they run out of energy

Slide 6.22

Muscles and Body Movements

- Movement is attained due to a muscle moving an attached bone

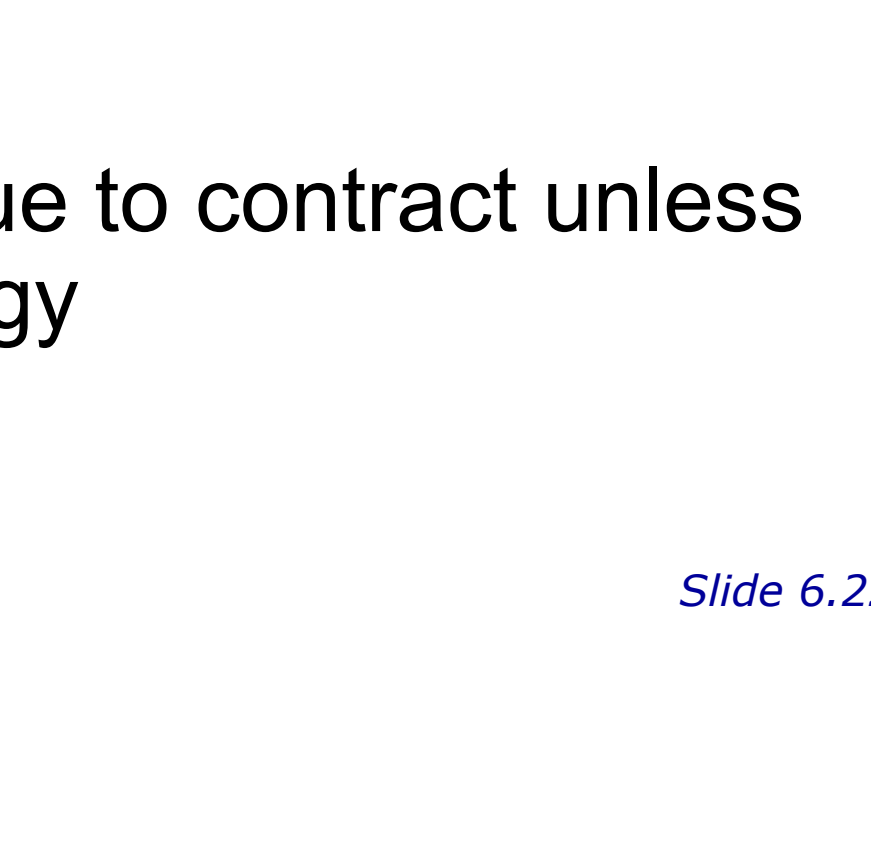
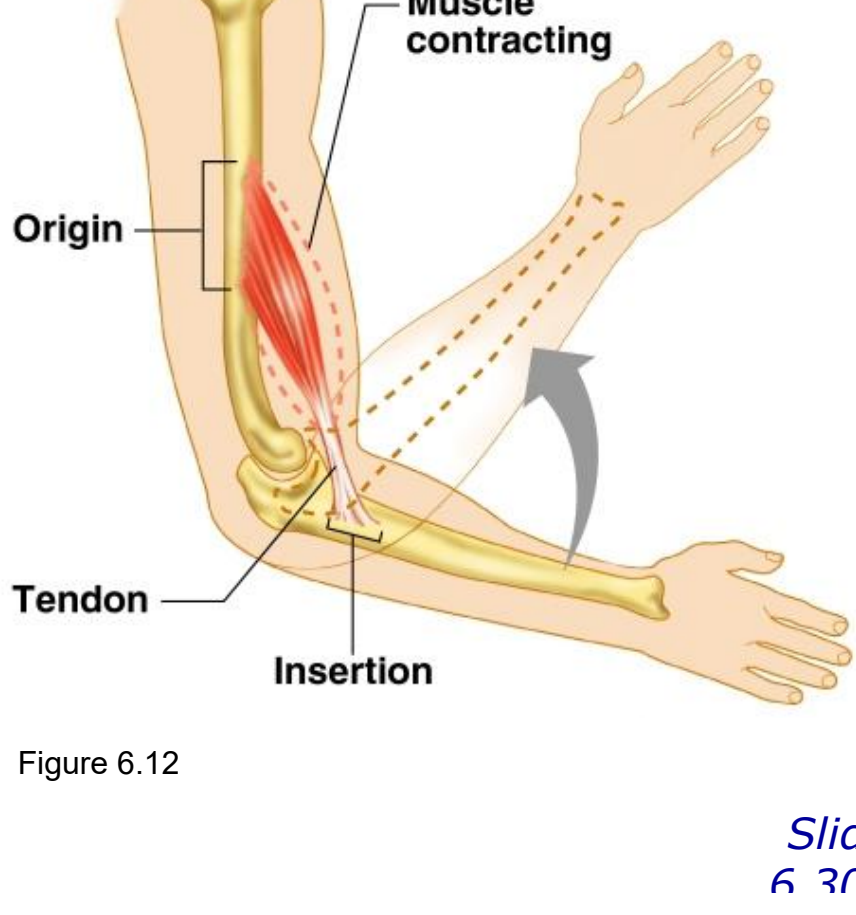


Figure 6.12

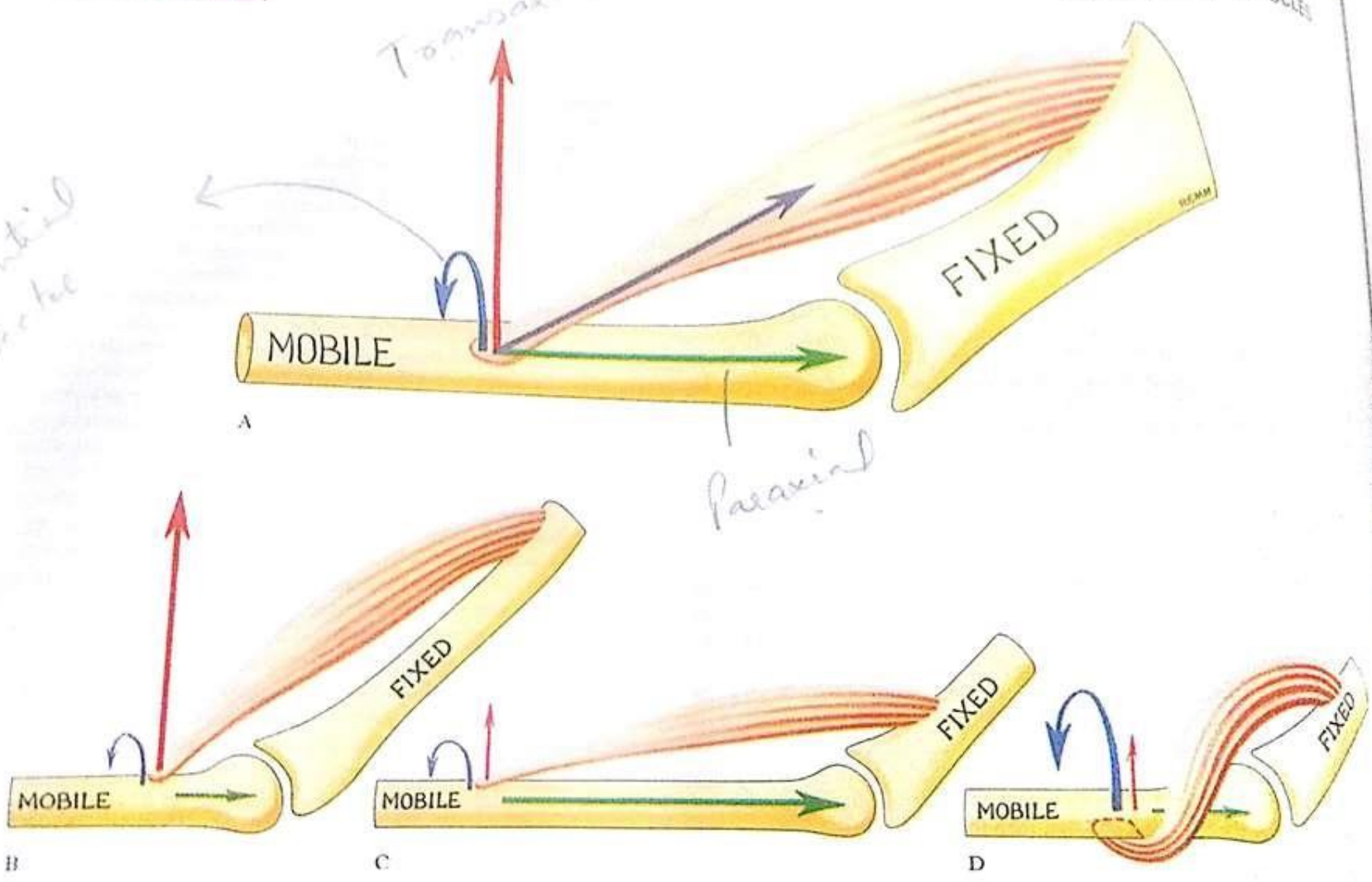
Slide 6.30a

Muscles and Body Movements

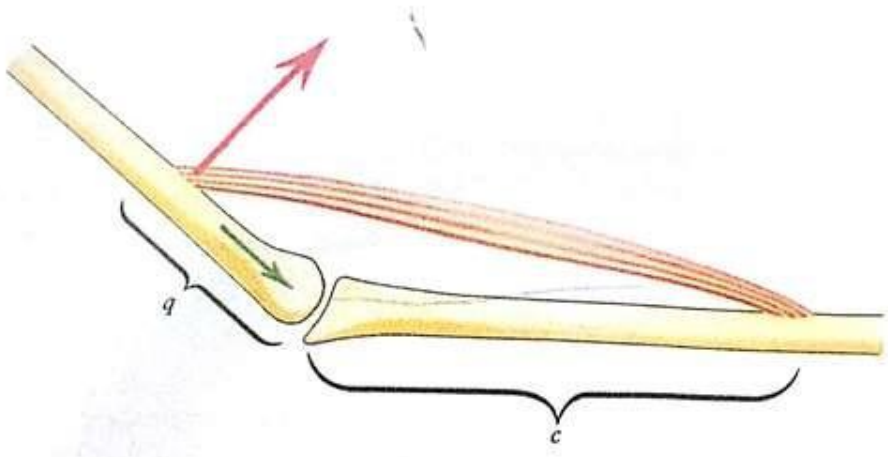
- Muscles are attached to at least two points
  - Origin – attachment to a immoveable bone
  - Insertion – attachment to an movable bone

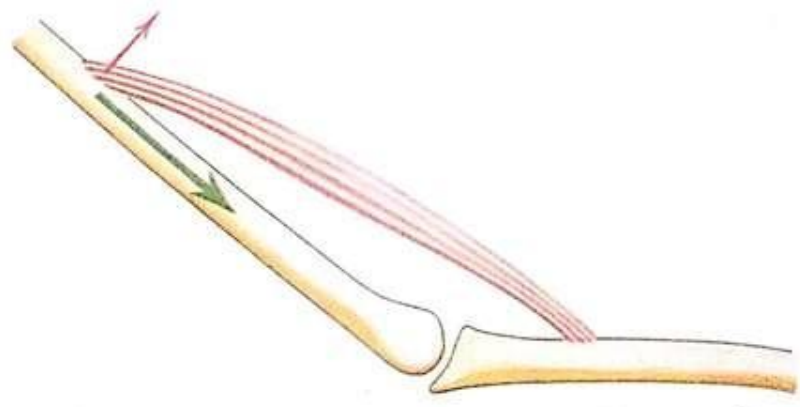


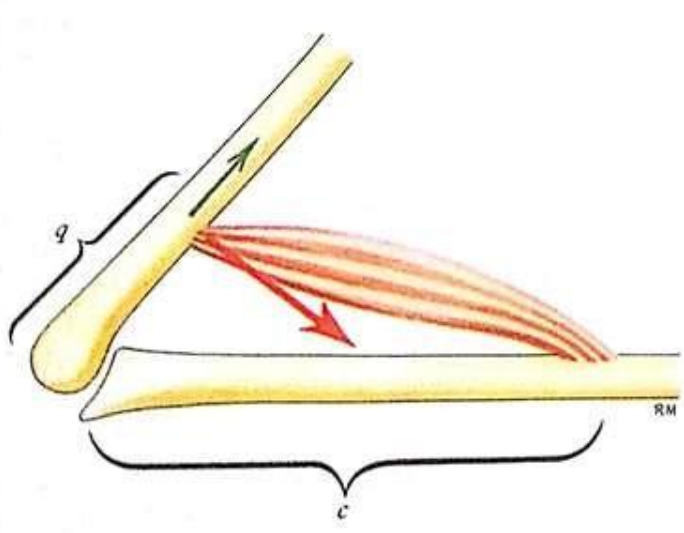
Slide 6.30b



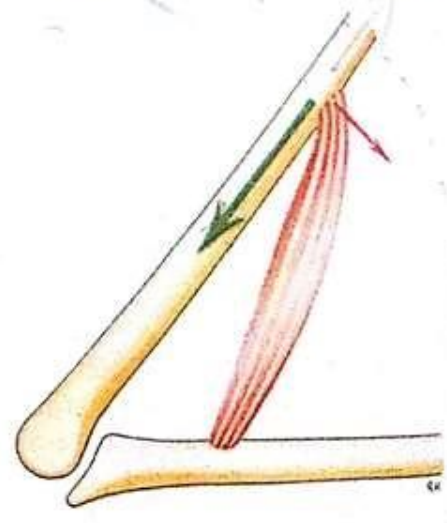
5.18 A. Vectorial analysis of the *force* of contraction generated by a muscle which is attached to a fixed base, crosses a single multi-axial joint and is attached eccentrically to the shaft of a mobile bone. Colour code of arrows: purple = muscle force; red = transaxial 'swing' vector; green = paraxial 'shunt' vector; blue = tangential 'spin' vector. Similar analyses relating to muscles which are *predominantly* (B) 'spurt', (C) 'shunt' and (D) 'spin' in their actions. It should be appreciated that these diagrams have been constructed to illustrate certain principles discussed in the text; they do *not* represent any specific human bone or muscle. It is also clear that (in B and C), if the fixity and mobility of the two bones were interchanged, B would now operate as a 'shunt' muscle and C as a 'spurt' muscle.







5.19A Some features of a 'spurt' muscle. Note that it has a large 'swing' component of its force which acts to impart an angular acceleration to the mobile bone. Its small 'shunt' component acts towards the joint up to 90° of flexion and thereafter away from the joint. c = cisarticular length; q = transarticular length.



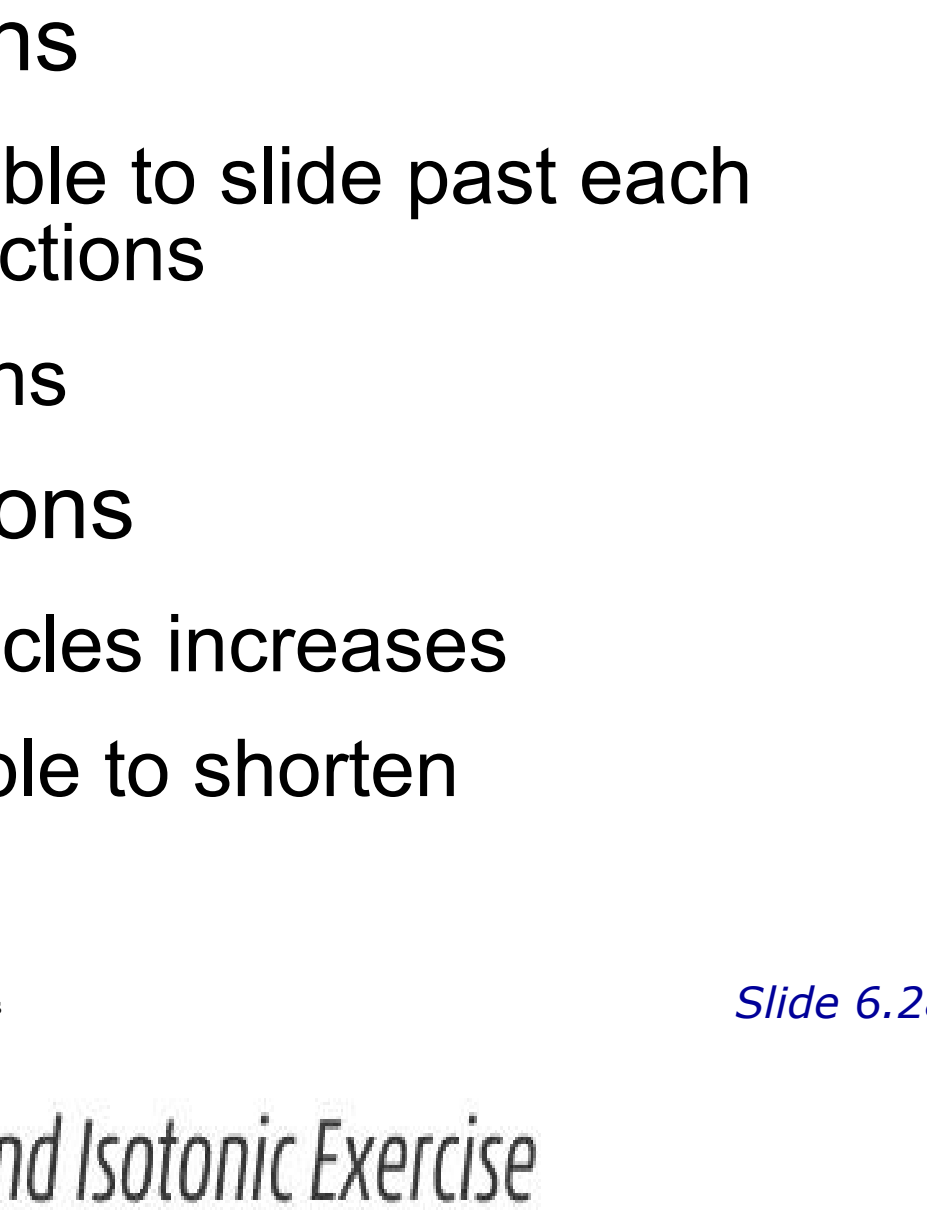
5.19B Some features of a 'shunt' muscle. The large shunt component of its force acts towards the joint in all positions. In Fig. 5.19A and B no specific human muscle or bone is intended; in each case it is clear that the right bone is regarded as fixed whilst the left bone is mobile. Clearly their mobilities (and designations) could be interchanged.

Types of Muscle Contractions

- Isotonic contractions
  - Myofilaments are able to slide past each other during contractions
  - The muscle shortens
- Isometric contractions
  - Tension in the muscles increases
  - The muscle is unable to shorten

Isometric And Isotonic Exercise

- **Isotonic Contractions**
  - Concentric – muscle shortens and does work
  - Eccentric – muscle generates force as it lengthens
- **Isometric Contractions**
  - Tension builds but muscle neither shortens or lengthens
  - Maintains posture



Muscle Tone

- Some fibers are contracted even in a relaxed muscle
- Different fibers contract at different times to provide muscle tone
- The process of stimulating various fibers is under involuntary control

Effects of Exercise on Muscle

- Results of increased muscle use
  - Increase in muscle size
  - Increase in muscle strength
  - Increase in muscle efficiency
  - Muscle becomes more fatigue resistant

Types of Ordinary Body Movements

- Flexion – decreases angle of joint and brings two bones closer together
- Extension- opposite of flexion
- Rotation- movement of a bone in longitudinal axis, shaking head “no”
- Abduction/Adduction (see slides)
- Circumduction (see slides)

Types of Muscles

- Prime mover – muscle with the major responsibility for a certain movement
- Antagonist – muscle that opposes or reverses a prime mover
- Synergist – muscle that aids a prime mover in a movement and helps prevent rotation
- Fixators

Naming of Skeletal Muscles

- Direction of muscle fibers
  - Example: *rectus* (straight)
- Relative size of the muscle
  - Example: *maximus* (largest)

Naming of Skeletal Muscles

- Location of the muscle
  - Example: many muscles are named for bones (e.g., *temporalis*)
- Number of origins
  - Example: *triceps* (three heads)

Naming of Skeletal Muscles

- Location of the muscles origin and insertion
  - Example: *sterno* (on the sternum)
- Shape of the muscle
  - Example: *deltoid* (triangular)
- Action of the muscle
  - Example: *flexor* and *extensor* (flexes or extends a bone)

Smooth Muscle Characteristics

- Has no striations
- Spindle-shaped cells
- Single nucleus
- Involuntary – no conscious control
- Found mainly in the walls of hollow organs
- Slow, sustained and tireless

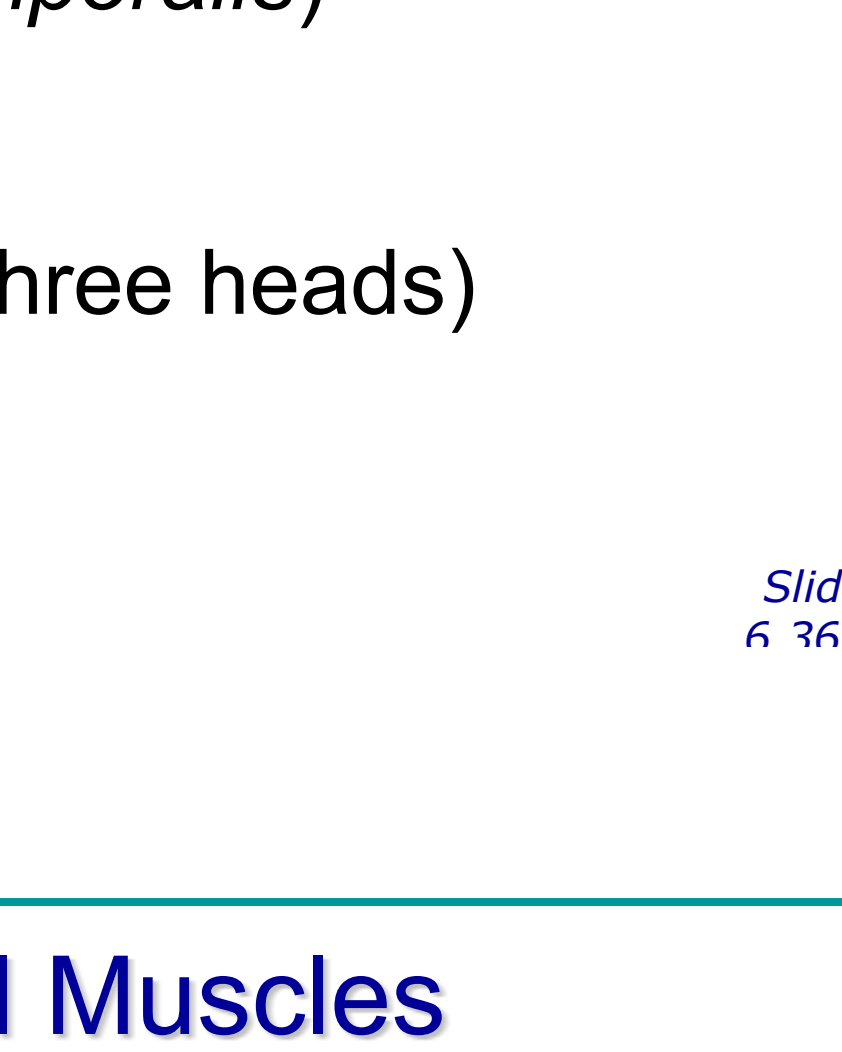


Figure 6.2a

Cardiac Muscle Characteristics

- Has striations
- Usually has a single nucleus
- Joined to another muscle cell at an intercalated disc
- Involuntary
- Found only in the heart
- Steady pace!

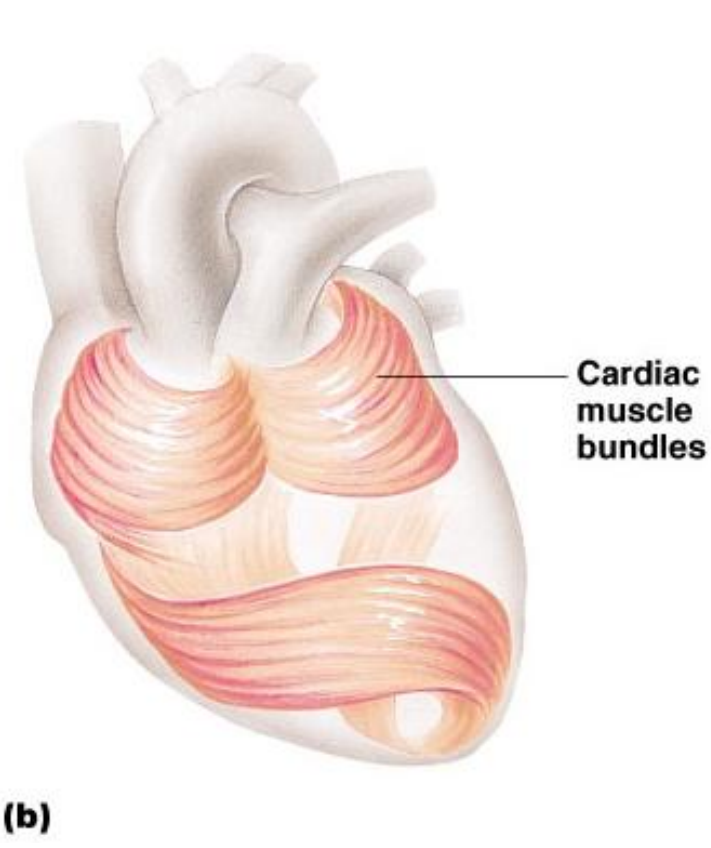
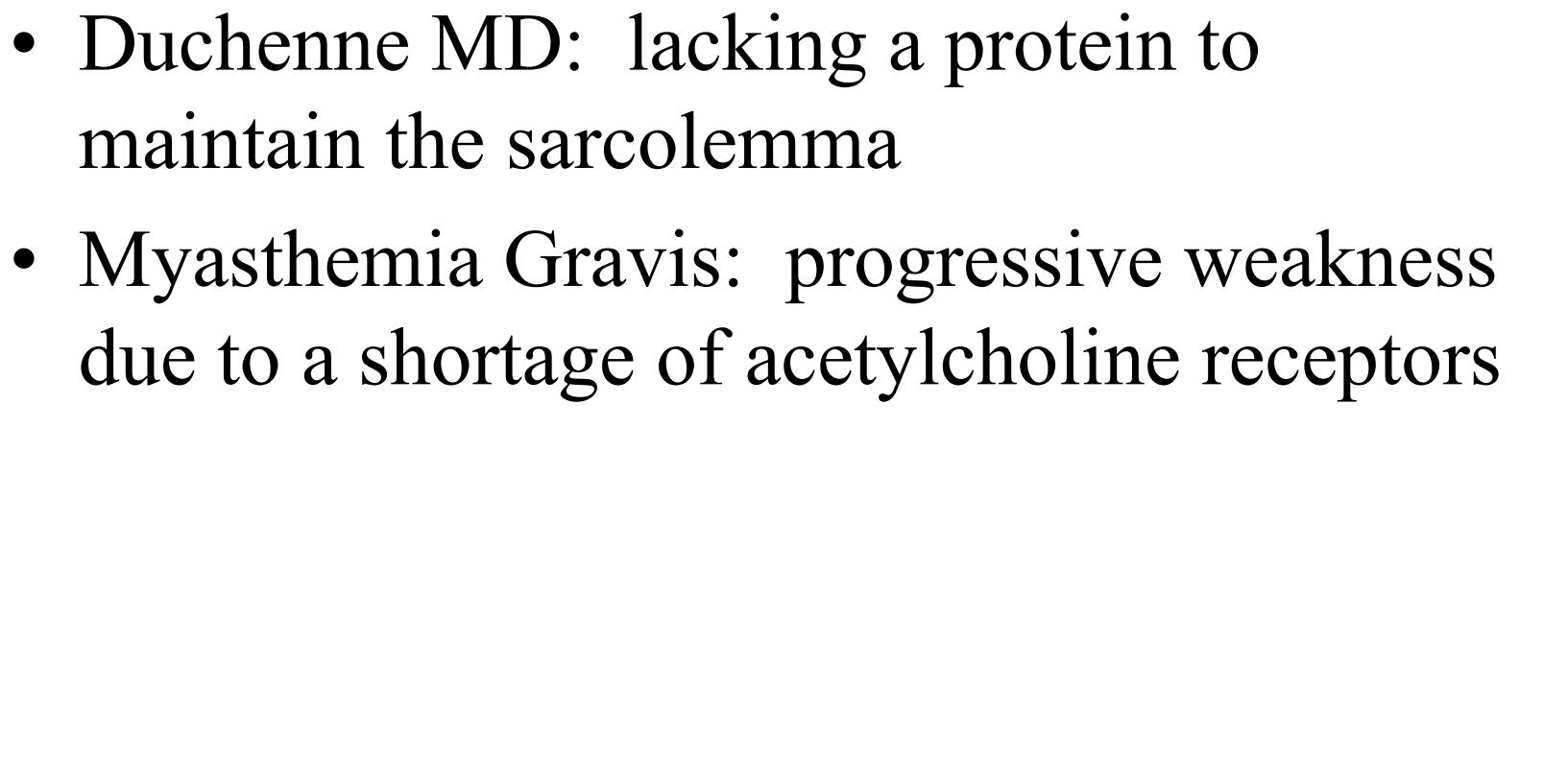


Figure 6.2b

Disorders relating to the Muscular System

- Muscular Dystrophy: inherited, muscle enlarge due to increased fat and connective tissue, but fibers degenerate and atrophy
- Duchenne MD: lacking a protein to maintain the sarcolemma
- Myasthemia Gravis: progressive weakness due to a shortage of acetylcholine receptors

Cardiac muscle tissue



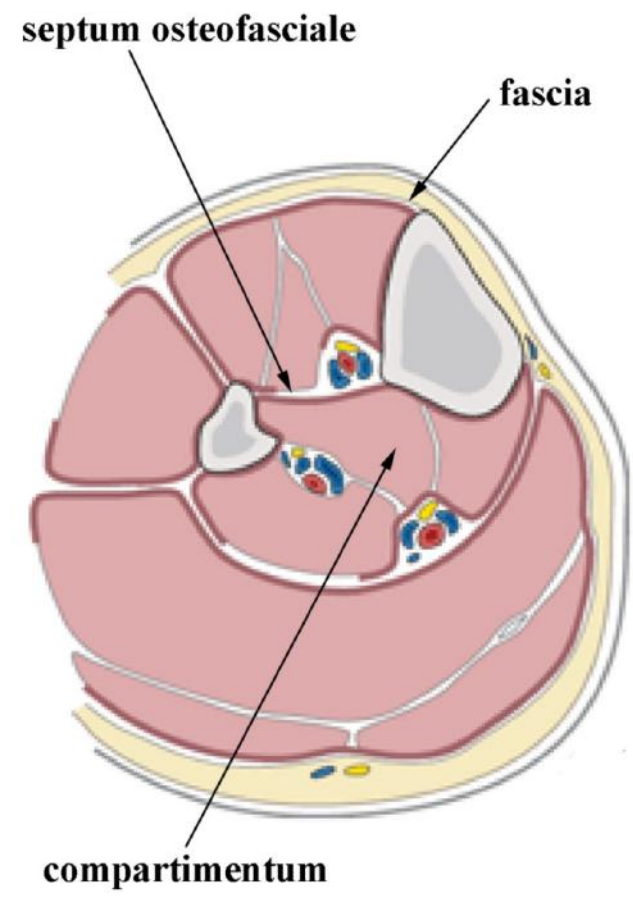
Eis, Jelínek, Špaček, Histopatologický atlas, Praha 2006

Abnormal contraction

- *spasm* – involuntary contraction of one muscle
  - cramp – painful spasm
  - tetanus – multiple spasms of skeletal muscles
- *tic* – involuntary twiches of muscles, usually under voluntary control
- *tremor* – rhythmical, involuntary contractions of opposite groups of muscles
- *fasciculations* – involuntary, short twiches on motor unit visible under the skin
- *fibrilace* – spontaneous contractions of fibres of one muscle that aren´t visible under the skin

Special muscle structures I

- **fascia** (= *perimysium externum*)
  - fibrous envelope of muscle or muscle group
  - barrier for spreading of inflammation in that specific area
- **osteofascial septum** *(= septum osteofasciale)*
  - fascial divider from the superficial fascia to the periosteum
  - separates the space for muscle groups – **compartment** *(compartimentum)*



https://www2.aofoundation.org/wps/portal/!ut/p/c0/

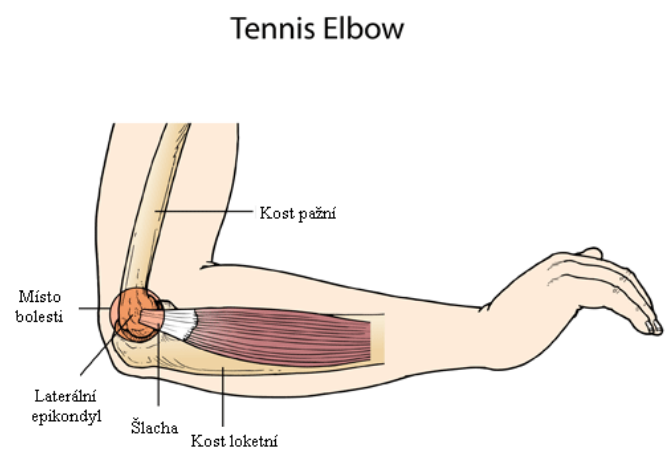
Growing old and musle tissue

- skeletal muscle tissue starts to be replaced by fibrous and fatty tissue around the age of 30
- reflexes slowdown, loss of flexibility and decrease of strength
- change of muscle fibres from quick to slow

Enthesopathy

- illness of muscle and tendinous insertions
- usually caused by repeated overstraining
- *e.g. tennis elbow*

http://www.fyzioterapie-stepankavojtova.cz/bolestivyloket.html



http://compex.zdravi-cz.eu/tenisovy-loket.php

- Select the trait that does not characterize muscle tissue in general.
- A) irritability
- B) contractility
- C) extensibility
- D) All of these are traits of muscle.

- Individual fibers of skeletal muscle have fine sheath of connective tissue called a(n) _____.
- A) epimysium
- B) perimysium
- C) endomysium
- D) fascia

- Sarcomeres run from _____.
- A) A band to A band
- B) Z line to Z line
- C) H zone to H zone
- D) I band to I band

- What muscle has its origin on the sternum and inserts on the mastoid process of the temporal bone?
- A) sternocleiodomastoid
- B) splenius capitis
- C) semispinalis capitis
- D) trapezius

- What is the deepest of the four abdominal muscles?
- A) rectus abdominis
- B) external abdominal oblique
- C) transversus abdominis
- D) internal abdominal oblique

- The _____ muscle is a deep, lateral muscle of the forearm that flexes the thumb joints and assists in grasping.
- A) flexor pollicis longus
- B) flexor carpi ulnaris
- C) superficial digital flexor
- D) deep digital flexor

- Which of these muscles is an adductor?
- A) gluteus medius
- B) tensor fascia lata
- C) pectineus
- D) iliacus

- Choose the muscle that does not belong to the quadriceps femoris group of the anterior thigh.
- A) rectus femoris
- B) vastus lateralis
- C) vastus medialis
- D) biceps femoris

- The thenar and hypothenar muscles are located where?
- A) in the foot
- B) within the hand
- C) in the forearm
- D) in the lower leg