



## 2. attachments

a. direct - fascicles appear to attach directly to bone

b. indirect - tendon attaches muscle to bones

tendon - cord of dense fibrous regular c.t.

aponeurosis - sheet of dense fibrous irregular c.t.

## B. histological structure

1. sarcolemma - plasma membrane

a. motor end plate - part of neuromuscular junction

highly folded

contains receptors for the neurotransmitter acetylcholine

b. t-tubules - invaginations of the sarcolemma

adjacent to terminal cisternae of sarcoplasmic reticulum

carry depolarization to interior of cell

t-tubule membrane contains voltage-sensitive proteins called DHP

receptors

cause release of Ca from sarcoplasmic reticulum

2. sarcoplasmic reticulum (SR) - modified smooth endoplasmic reticulum
  - interconnecting tubules surround myofibrils
  - store  $\text{Ca}^{2+}$
  - terminal cisternae line up near ends of sarcomeres
  - SR membrane contains Ca channels attached to and controlled by the DHP receptors

3. myofibril - cylindrical bundle of myofilaments (proteins) arranged in a specific pattern

sarcomere - segment of myofibril

myofilament = small bundle made of contractile and regulatory proteins

thick - myosin

thin - actin + troponin complex + tropomyosin

NOTE: the sarcolemma surrounds (is outside of) the sarcoplasmic reticulum (SR), and the SR surrounds the myofibrils

## C. sarcomere structure

### 1. components

- a. thin filaments
- b. thick filaments
- c. titin

### 2. alignment and striations

Z disc - ends of sarcomere

I zone - thin filaments only at both ends of A zone

A zone - thick and thin filaments

H zone - region in center of A zone containing thick filaments only

M line - middle of H zone

#### D. types of skeletal muscle cell

most muscles contain all three types  
proportions differ among muscles

##### 1. red slow twitch

- high myoglobin content
- many mitochondria and capillaries
- contract slowly
- aerobic metabolism
- fatigue resistant
- found in postural muscles

##### 2. white fast twitch

- little myoglobin
- few mitochondria or capillaries
- contract rapidly
- anaerobic metabolism
- abundant glycogen stores
- fatigue quickly
- powerful - larger diameter

##### 3. intermediate fast twitch

- myoglobin and mitochondria
- contract quickly
- aerobic metabolism
- fatigue resistant

#### E. skeletal muscle contraction and relaxation

calcium ions bind to troponin

troponin changes shape

tropomyosin moves

binding sites on actin are exposed

myosin heads bind to sites

myosin heads swivel towards center of sarcomere (power stroke)

myosin head releases actin  
myosin heads reposition themselves - powered by ATP  
sarcolemma and t-tubules repolarize  
DHP receptors close Ca release channels  
pump in membrane of SR uses ATP to move Ca back into SR

#### F. changes in skeletal muscle

1. atrophy - decrease in cell diameter
2. hypertrophy - increase in cell diameter
3. new muscle cells may be formed from satellite cells

#### G. cardiac muscle

located in wall of heart  
function is to create pressure that pushes blood through the blood vessels  
cells branch and interconnect  
one or two nuclei; central  
use aerobic metabolism to make ATP  
fatigue resistant  
fibers joined end to end at intercalated discs  
    gap junctions  
    desmosomes  
    fascia adherens  
control  
    intrinsic - autorhythmic cells generate impulses  
    extrinsic - ANS controls rate

#### H. smooth muscle

located in organs of the respiratory, digestive, urinary and reproductive systems;  
the skin; the eye; the walls of blood vessels  
function is to move material through an organ, to control the diameter of an  
organ, or to move another body part  
short, spindle-shaped cells

one central nucleus  
myofilaments not lined up - no striations  
no t-tubules  
organized into sheets: longitudinal, circular, or oblique

generate alternate waves of contraction and relaxation called peristalsis  
control:

- no innervation
- single-unit innervation
- multiunit innervation