Functions of the Muscular System

skeletal muscle	make up"flesh" of the body, maintain posture, voluntary movement, aid in breathing/eating/speech, provide facial expression, generate reflexes, produce body heat

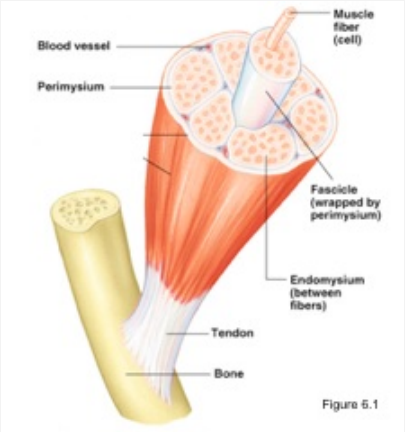
Skeletal muscle tissue development

Step 1 (embryonic mesoderm cells)	Embryonic mesoderm cells undergo cell division (to increase number) and enlarge
Step 2 (myoblasts)	Several myoblasts fuse together to form a myotube
Step 3 (myotube)	Myotube matures into skeletal muscle fiber
Step 4	Mature skeletal muscle fiber

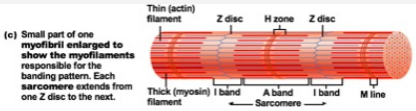
Connective Tissue of Skeletal

Endomysium	around single muscle fiber
Perimysium	around a fascicle (bundle) of fibers
Epimysium	covers the entire skeletal muscle
Fascia	on the outside of the epimysium
Tendon	attachment, cord-like structure
Aponeurosis	attachment, sheet-like structure

Connective Tissue of Skeletal



Sarcomere



Energy Sources

Three Types of Muscle Fibers

Slow oxidative fibers (slow)	Red color due to myoglobin, obtain energy from aerobic metabolic reactions, contain a large # of mitochondria, richly supplied w/ cappilaries, contract slowly and resist fatigue, fibers are small in diameter

Three Types of Muscle Fibers (cont)

Fast oxidative fibers (intermediate)	Have an **intermediate** diameter, contract quickly like fast glycolytic fibers, oxygen dependent, high myoglobin content and rich supply of capillaries, kinda fatigue resistant, more powerful than slow oxidative fibers

Three Types of Muscle Fibers (cont)

Fast glycolytic fibers (fast)	Contain little myoglobin and few mitoch-ondria, about twice the diameter of slow-oxidative fibers, contain more myofil-aments and generate more power, depend on anaerobic pathways, contract rapidly and tire quickly

Overview of mus. contraction steps

Step 1	Nerve impulse travels down the axon and reach axon terminal
Step 2	Calcium VGC open > calcium influx into axon terminal
Step 3	Exocytosis of ACh into synaptic cleft (calcium dependent event)

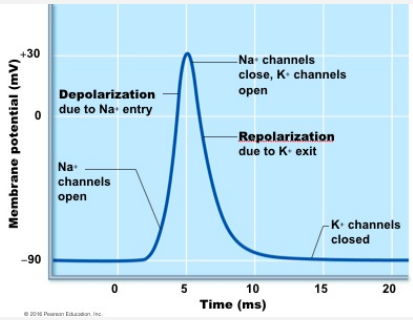
Overview of mus. contraction steps (cont)

Step 4	ACh interaction with Na+/K+ channels on sarcolemma > opening of the channels
Step 5	Na+ influx at higher rate than K+ efflux > leads to depolarization
Step 6	Spreading of the depolarization in the muscle fiber through t-tubules
Step 7	Opening of the calcium VGC associated with the T-tubules and release of calcium into sarcoplasm
Step 8	Interaction of calcium with regulatory protein troponin
Step 9	Eventual muscle contraction

Main Steps of Muscle Contraction

1. Electrical impulse of neuron
2. Electrical impulse in skeletal muscle
3. Muscle contraction

Action Potential Graph



Graded Muscle Response

Muscle response to changes in stimulus strength

Recruitment works on *size principle*

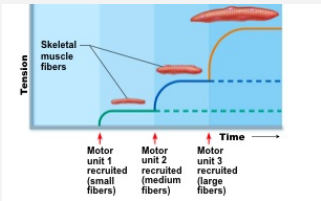
Motor units w/ smallest muscle fibers are recruited first

Motor units with larger and larger fibers are recruited as stimulus intensity increases

Largest motor units are activated only for the most powerful contractions

Motor units in muscle usually contract asynchronously

The Size Principle of Recruitment



Graded Muscle Response

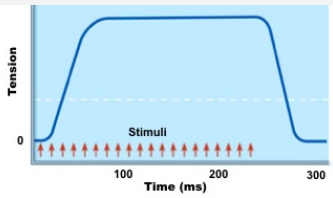
Muscle response to changes in stimulus frequency

If stimuli frequency increases, muscle tension reaches maximum

Referred to as **fused (complete) tetanus** bcuz contractions "fuse" into one smooth sustained contraction plateau

Prolonged muscle contractions lead to *muscle fatigue*

Fused (complete) tetanus mus. response



High stimulation frequency: fused (complete) tetanus. At higher stimulus frequencies, there is no relaxation at all between stimuli. This is fused (complete) tetanus.

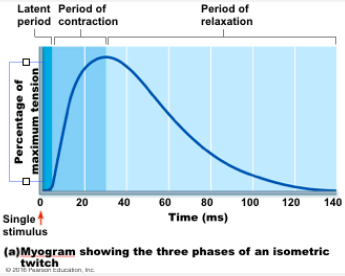
The Muscle Twitch

Latent Period	events if excitation-cont-raction coupling (no muscle tension seen)
Period of Contra-ction	cross bridge formation (tension increases)

The Muscle Twitch (cont)

Period of Relaxation	Ca^{2+} reentry into SR (Tension declines to zero)

Isometric Twitch Myogram



(a)Myogram showing the three phases of an isometric twitch

Muscle Relaxation

Removal of ACh by AChE

Electrical impulse from neuron must cease

ATP?

Calcium must be removed by pumps (active process vs. channel [passive])

Sliding Filament Model

What is it?	The shortening of the sarcomeres in a myofibril produces the shortening of a myfribril
I Band	Narrows/shortens

Sliding Filament Model (cont)

H zone	Narrows/shortens
A band	Unaffected
Z disk	unaffected

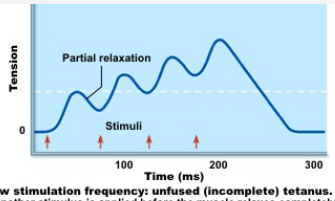
In Depth Relaxation

Step 1	ACh is broken down by AChE, ending action potential generation in the sarcolemma
Step 2	The SR reabsorbs calcium ions, and the concentration of calcium ions in the sarcoplasm declines
Step 3	When calcium ion concentrations approach normal resting levels, the troponin-tropomyosin complex returns to its normal position. This change recovers the active sites and prevents further cross-bridge interaction

In Depth Relaxation (cont)

Step 4	Without cross-bridge interactions, further sliding cannot take place, and the contraction ends
Step 5	Muscle relaxation occurs, and the muscle returns passively to its resting length

Unfused (incomplete) tetanus mus. stim



Low stimulation frequency: unfused (incomplete) tetanus.
If another stimulus is applied before the muscle relaxes completely, then more tension results. This is wave (or temporal) summation and results in unfused (or incomplete) tetanus.

Action Terminology for Muscles

Dorsiflexion	Lift up toes
Plantarflexion	move toes down
Inversion	when sole of foot point inward
Eversion	when sole of foot points outward
Protraction	to move anteriorly; shoulders, madible

Action Terminology for Muscles (cont)

Retraction	to move part posteriorly
Elevation	to raise part superiorly; shoulders
Depression	to lower part; open mouth
Rotation	pivot on an axis; shake head no, can rotate head and shoulder
Circumduction	to draw a circle with body part; shoulder, head
Pronation	turn hand downward
Supination	refers to arms; supinate; want a bowl of soup