Muscular system

MOVE ME!
MUSCLES

Day 1  Nov 13 and 16

TYPES OF MUSCLES, STRUCTURE AND FUNCTIONS.
FUNCTIONS of MUSCLE

• Movement
• Maintains posture
• Stabilize joints
• Generates heat
  • Byproduct of muscular contraction
Three Types of Muscle

• Skeletal
  • Associated with bones

• Cardiac
  • Makes your heart

• Smooth
  • Tubular, common in intestines, blood vessels
Three muscle types

A. Skeletal muscle fibers
   - Striations
   - Nuclei

B. Cardiac muscle fibers
   - Striations
   - Nucleus
   - Intercalated disks

C. Smooth muscle fibers
   - Nucleus
Three types at the cellular level

- SKELETAL
- CARDIAC
- SMOOTH
CARDIAC MUSCLE

- Only found in your heart
- Striated (striped)
- Involuntary (can’t control it)
- Multinucleated
Cardiac Muscle
SMOOTH MUSCLE

• Involuntary and
• Not striated (striped)
• Not multinucleated
• Makes up vessels, intestines, bladder, stomach
  • Moves “stuff” through the body
• Slow smooth contractions
Smooth muscle

(a) Small intestine

(b) Mucosa

Circular layer of smooth muscle

Longitudinal layer of smooth muscle

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Smooth muscle cells

Single smooth muscle cell
SKELETAL MUSCLE

• Voluntary
• Striated (striped)
• Multinucleated
• Fast strong contractions

• Human body contains over 400 skeletal muscles
  • 40-50% of total body weight
Longest muscle - sartorius

Strongest muscle

Largest muscle – gluteus maximus
Three muscle types

A. Skeletal muscle fibers
   - Striations
   - Nuclei

B. Cardiac muscle fibers
   - Striations
   - Nucleus
   - Intercalated disks

C. Smooth muscle fibers
   - Nucleus
MUSCLES

Day 2  Nov 17 and 18

NAMING MUSCLES AND HOW THEY MOVE YOU
Structure of Skeletal Muscle

• Muscle Fiber is a muscle cell
• Fibers up to a foot long

• Strong due to connective tissue that surrounds groups of muscle fibers and becomes tendons
Structure of a Skeletal Muscle

- Bone
- Tendon
- Epimysium
- Perimysium
- Endomysium
- Muscle fiber
- Fascicle
- Blood vessel
Structure of skeletal muscle

- Muscle – many fascicles
- Fascicle – many muscle fibers/cells

BIG TO SMALL
1. Muscle
2. Fascicles
3. Muscle fibers/cells
4. Myofibrils
5. (Sarcomeres) discuss later
Figure 1: Muscle belly split into various component parts (from Essentials of Strength Training & Conditioning, National Strength & Conditioning Association)
TENDONS

- CONNECT MUSCLE TO BONE

- THE (FASCICLE) MEMBRANE AROUND THE BUNDLES OF MUSCLE FIBERS/CELLS COME TOGETHER TO FORM TENDONS
The real thing – a bit gross
HOW MUSCLES CONNECT TO BONES

• All muscles connect to bones at a minimum of TWO places
  1. Point of origin
  2. Point of insertion

WHEN A MUSCLE CONTRACTS THE ORIGIN GETS CLOSER TO THE INSERTION

Muscles only PULL, they never PUSH
Point of Origin and Insertion
Some ways that muscles can move

- **Flexion**
  - Decreases the angle of the joint

- **Abduction**
  - Away from the midline

- **Extension**
  - Increases the angle of the joint

- **Adduction**
  - Towards the body

- **Rotation**
  - In a circular motion
Extension and Flexion

Diagram showing the difference between relaxed and contracting muscles, highlighting the triceps and biceps.
aBduction and aDduction

Abduction

Adduction
Rotation

30-40°

Note how the central line twists

+ neck rotation
MUSCLES

Day 3 NOV 19 AND 20

No Notes (Finish posters, steroid article)
MUSCLES

Day 4  Nov 23 and 24

Muscles at the cellular level
Structure of skeletal muscle

- Muscle – many fascicles
- Fascicle – many muscle fibers/cells
- Muscle fibers/cells – many myofibrils
- Myofibrils – many sarcomeres

BIG TO SMALL
1. Muscle
2. Fascicles
3. Muscle fibers/cells
4. Myofibrils
5. Sarcomeres
Figure 1: Muscle belly split into various component parts (from Essentials of Strength Training & Conditioning, National Strength & Conditioning Association)
Inside a SINGLE muscle fiber/cell
Histology
How contraction occurs

• Myofibrils
  • The dark and light bands of the myofibrils move together when a skeletal muscle contracts.

• REMEMBER! Muscles always pull, never push
SLIDING FILAMENT THEORY

• THE RED PROTEINS GRAB THE BLUE PROTEINS AND PULL THEM TOGETHER.

• WHOLE MUSCLE GETS SHORTER
The Sliding Filament Model of Muscle Contraction
1. Muscles are made of many muscle fibers/cells
2. Inside each muscle cell are myofibrils
3. The myofibrils are striated (striped) with light and dark bands
4. One set of light and dark bands is a sarcomere
5. When the proteins in the bands pull on each other each sarcomere gets shorter.
6. When hundreds of sarcomeres in a myofibril get shorter, the whole muscle gets shorter.
7. The muscle pulls on the bone and you move
MUSCLES

Day 5  Dec 1 and 2

How nerves move muscles
IN SUMMARY

1. Muscles are made of many muscle fibers/cells
2. Inside each muscle cell are myofibrils
3. The myofibrils are striated (striped) with light and dark bands
4. One set of light and dark bands is a sarcomere
5. When the proteins in the bands pull on each other each sarcomere gets shorter.
6. When hundreds of sarcomeres in a myofibril get shorter, the whole muscle gets shorter.
7. The muscle pulls on the bone and you move.
What causes muscles to move?

- You think (or instinctively just do it) I want to move a muscle
- Your brain sends a signal to the muscle
- The muscle responds to that signal by contracting
- You move

- But how does that signal work?
Spinal cord to muscle

1. A nerve in the spinal cord sends a message to a bunch of muscle fibers (this is a motor unit)
2. Where the nerve reaches the muscle is called the neuromuscular junction.
Motor Unit
Motor Unit - examples

• Single motor neuron & muscle fibers it stimulates
• Eye muscles – 1:1 muscle fiber/nerve ratio
• Hamstrings – 300:1 muscle fiber/nerve ratio
The Neuromuscular Junction

Site where motor neuron meets the muscle fiber/cell

1. A chemical signal is released by the neuron. (neurotransmitter/acetylcholine)
2. The muscle receives this signal, causing the muscle to contract.
MUSCLES

Day 6  Dec 3 and 4

Exercise, Oxygen Debt and Fatigue
A few random things

• A muscle fiber/cell contraction is all or nothing.

• A stronger contraction is caused by using more muscle fibers/cells
Hypertrophy and Hyperplasia

Arnold Schwarzenegger
• Increase in size of each muscle fiber/cell

Bruce Lee
• Increase in number of muscle fibers/cells
Muscle Fatigue

• Fatigue means tired
  • Muscle fatigue is when a muscle won’t contract even though a nerve is telling it to
    • Not enough oxygen is main factor

• Not enough oxygen means your body has trouble making ATP
Making ATP

Aerobic respiration

• Requires Oxygen
• Makes a LOT of ATP per glucose
• Better way to power muscles

Normally occurs

Anaerobic respiration

• Doesn’t require oxygen
• Makes less ATP for every glucose.
• Produces Lactic Acid (muscle burn)

Necessary with low Oxygen
MUSCLES

Day 7  Dec 7 and 8

Case study about muscle fatigue and disease
slides I’m not using
Types of Muscle Contraction

- **Isometric**
  - Muscle exerts force without changing length
  - Pulling against immovable object
  - Postural muscles

- **Isotonic (dynamic)**
  - Concentric
    - Muscle shortens during force production
  - Eccentric
    - Muscle produces force but length increases
Age-Related Changes in Skeletal Muscle

- Aging is associated with a loss of muscle mass
  - Rate increases after 50 years of age
- Regular exercise training can improve strength and endurance
  - Cannot completely eliminate the age-related loss in muscle mass
Alteration of Fiber Type by Training

• Endurance and resistance training
  • Cannot change fast fibers to slow fibers
  • Can result in shift how efficiently they use oxygen
Force Regulation in Muscle

- Types and number of motor units recruited
  - More motor units = greater force
  - Fast motor units = greater force
Fiber Types and Performance

- **Power athletes**
  - Sprinters
  - Possess high percentage of fast fibers

- **Endurance athletes**
  - Distance runners
  - Have high percentage of slow fibers

- **Others**
  - Weight lifters and non-athletes
  - Have about 50% slow and 50% fast fibers
The Neuromuscular Junction

• Site where motor neuron meets the muscle fiber
  • Separated by gap called the neuromuscular gap

• Acetylcholine is released from the motor neuron
  • Causes depolarization (electrical change) of the muscle fiber
  • Runs down the sarcolemma – almost instantaneous because it is just one membrane.
Some vocabulary

• Muscle – a bunch or bundle of muscle fibers.

• Muscle fiber or muscle cell –
  • Multinucleated - many - nuclei
  • Long and skinny

• Myo and sarco-
  • Prefixes that mean muscle
Structure of Skeletal Muscle

• Further divisions of myofibrils
  • Z-line
  • Actin
  • Myosin

• Within the Muscle fiber
  • Sarcoplasm
  • Sarcoplasmic reticulum
    • Storage sites for calcium
  • Sarcomere
Cross-Bridge Formation in Muscle Contraction
Isotonic and Isometric Contractions

(a) Muscle contracts and shortens
(b) Muscle contracts but does not shorten