Chapter 9
Muscle Tissue

Alternating contraction and ___________________________ of cells
________________________ changed into mechanical energy

3 Types of Muscle Tissue

• Skeletal muscle
  – attaches to __________________________
  – striated with light & dark bands visible with scope
  – __________________________ of contraction & relaxation

• Cardiac muscle
  – striated in appearance
  – ___________________________ control
  – __________________________ because of built in

• Smooth muscle
  – attached to __________________________ in skin
  – in walls of __________________________ organs -- blood vessels & GI
  – __________________________ in appearance
  – Involuntary __________________________

Functions of Muscle Tissue

• Producing body __________________________
• __________________________ body positions

• Regulating __________________________
  – bands of smooth muscle called __________________________

• Movement of __________________________ within the body
  – blood, lymph, urine, air, food and fluids, sperm

• __________________________ heat
  – involuntary contractions of skeletal muscle (shivering)

Properties of Muscle Tissue

• __________________________
  – respond to chemicals released from nerve cells

• C __________________________
  – ability to propagate electrical signals over membrane

• C __________________________
  – ability to shorten and generate force

• E __________________________
  – ability to be stretched without damaging the tissue

• E __________________________
  – ability to return to original shape after being stretched
Skeletal Muscle -- Connective Tissue

- ___________ is loose connective tissue & fat underlying the skin
- ___________ = dense irregular connective tissue around muscle
- Connective tissue components of the muscle include
  - ___________ = surrounds the whole muscle
  - ___________ = surrounds bundles (fascicles) of 10-100 muscle cells
- **Fasciculi** are distinct muscle ___________
  - ___________ = separates individual muscle bundles
- All these connective tissue layers extend beyond the muscle and narrows to form the tendon
- **Connective tissue is mostly made of ___________.**

Connective Tissue Components

Muscle Fiber structure or ___________

- Muscle cells are long, ___________
- ___________ = muscle cell membrane which covers muscle
- **Sarcoplasm** = the ___________ in muscles
- Each cell is filled with tiny threads called ___________

- **Sarcomeres** = tiny structure in myofibrils which ___________
  - ___________ = ___________(protein molecules actin and myosin)
- Muscle cells have high amounts of ___________ stores to meet their extra energy needs
- Skeletal muscles can be several cm in length and ___________
  - When damaged, stem cells (satellite cells) divide to make new tissue to repair the muscle.

Nerve and Blood Supply

- Each skeletal muscle is supplied by a nerve, an artery and ___________
- Each motor neuron supplies ___________ (neuromuscular junction)
Myoneural (or Neuromuscular) junction or Synapse

• NMJ = ______________
  – Single ______________ with several branches leading to many ______________
  – One impulse causes all muscle cells to contract

The Motor Unit

• Motor unit =
  & all the skeletal muscle cells (fibers) it stimulates
  – Muscle fibers normally scattered throughout belly of muscle
  – One nerve cell supplies on average ______________ that all contract in unison.
• Total strength of a contraction depends on ______________

• Tetany = smooth, strong, ______________ produced by high frequency stimulation

Events Occurring at a myoneural junction

How does an action potential get from nerve to muscle?

1. Arrival of an action potential (nerve impulse) at ______________ causes release of a Transmitter substance (______________)

2. ACh binds to ______________ on muscle motor end plate opening the ___ ______________ so that ____ can rush into the muscle cell

3. This starts the stimulation of muscle cell contraction

4. Acetylcholinesterase, or cholinesterase, ______________ so the muscle action potential will cease and the muscle cell will __________

Filaments and the Sarcomere

- ______________ filaments overlap each other in a pattern that creates ______________
  - The ______________ region contains only ____ filaments.
  - They are arranged in compartments called ______________ separated by ___ discs.
  - In the overlap region, ____________ filaments surround each thick filament

Thick & Thin Myofilaments

• Supporting proteins (M line, ____________ and Z disc help ____________ the thick and thin filaments in place)
The Proteins of Muscle -- Myosin
- Thick filaments are composed of ____________
  - each molecule resembles two ________________ twisted together
  - myosin heads (____________________) extend toward the thin filaments
- Held in place by the _______________________

The Proteins of Muscle -- Actin
- __________ filaments are made of ____________________
  - The myosin-binding site on each ___________ molecule is covered by ______
    _____________________________
  - The thin filaments are held in place by _______________. From one Z line to
    the next is a _______________________.
  - C________________________ is the actual “trigger” for muscle contraction

Sliding Filament Mechanism Of Contraction
- Myosin cross bridges _________________________
- Thin filaments _____________________________
  - _______________ come toward each other
  - _______________. The muscle fiber shortens. The muscle shortens
- Notice : Thick & thin filaments do not change in length

Depolarization (action potential) of muscle cells
- The stimulation of muscle cell by ___________________________.
  (charged ions moving across a membrane.)
- Impulse (____________________) must pass through the sarcolemma and reach the
  ___________________________.
- The action potential gets deep into the muscle cell through the ______________
  - T-system is a series of _______________________ in muscle cells

Steps in Depolarization or action potential (Mother of all Essays!!)

Outside cell starts off ________________
- outside (__) due to (________) ions being pumped out
- inside is (__) due to (________) ions being held in by active transport.
  *(K+) is also held_____________. The cell is said to be polarized at this
  time.

1. ________________ touches the cell membrane and causes it to_______
   __________________. Na+ ___________________ and the cell changes from
   negative to positive. The cell then becomes depolarized.

2. + ions coming in cause a propagation (_________) of ________________
   along the cell sarcolemma.
3. The depolarized cell reacts by \( \text{ SR} \) into the cytoplasm.
   - This causes the myofilament___________________.
   - Later Ca moves back into ______
   - K+ quickly leaves the cell and makes the outside ____ again. This causes the Na+/K pumps to work ______________________ polarization.
   - \( \text{ Cl}^- \) never ___________________ during this process.

4. The calcium ions released from the SR ____________________________

5. Troponin _______________ shape

6. ______________________ changes shape and moves into the groove between ___________________ exposing the ________________ on actin.

7. Myosin heads ______________________ on actin molecules

8. Myosin heads ______________________(power Stroke) and slide them toward the center of the ______________________

9. ______________________ are released from the thick filament.

10. A new ATP binds to the ________________ filament

11. Myosin cross bridges ______________________

12. ATP is ________________

13. Myosin heads return to their ______________________ shape, ready for the next power stroke

14. Cycling will continue until the calcium ions are ______________________

**Steps in the Contraction Cycle**
• Notice how the myosin head attaches and pulls on the thin filament with the energy released from ATP

**Overview: From Start to Finish**
• Nerve ending
• Neurotransmitter
• Muscle membrane
• Stored Ca+2
• ATP
• Muscle proteins
Effects of toxins on NMJ

- Blocks release of ACh so muscle contraction can not occur
- **Curare** (plant poison from poison arrows)
  - Causes by blocking the ACh
- Anticholinesterase agent
  - Blocks from receptors so strengthens weak muscle contractions of myasthenia gravis
  - Also an antidote for curare after surgery is finished
- **Tetanus** - neutralizes
- **Strychnine** – blocks
- **Nerve Gas** – Stops

Muscle Metabolism: Production of ATP in Muscle Fibers

- Muscle uses at a great rate when active
- **Muscle cells store glycogen so glucose is present for**
- ATP is produced from which takes place in
- When energy is needed ATP breaks only lasts for few seconds

  - **3 sources of ATP production within muscle**
    - C
    - A
    - A

Creatine Phosphate

- Excess within resting muscle used to form creatine phosphate
  - Its quick breakdown provides energy for
  - It makes the cell
  - Sustains maximal contraction for
- Athletes tried creatine supplementation

Aerobic Cellular Respiration

- ATP for any activity
  - If sufficient oxygen is available, enters the mitochondria to generate
  - Fatty acids and amino acids can also be used by the
  - During rest muscles get ATP. But during exercise energy comes from
- **Respiration provides** if activity lasts more than 10 minutes
Myoglobin
• Chemical similar to _______________. Found in muscle and ______
___________ from the blood.
  – myoglobin is ______________ by the buildup of lactic acid in the
cell.
  – Myoglobin also ______________ for strong muscular contractions
in places the blood can’t circulate.

Anaerobic Cellular Respiration
• ATP produced from _______________ into pyruvic acid during __
______________
  – In the ______________ of oxygen
  – pyruvic converted to _______________ which diffuses into
the blood
• Glycolysis can continue anaerobically to provide ATP for _______________
______________
• Uses _____ times more glucose than aerobic respiration

Muscle Fatigue
• _______________ to contract after prolonged activity caused by
  – a build up of _______________
  – depletion of _______________
  – decline of _______ ions within the sarcoplasm

Oxygen Consumption after Exercise
• Recovery oxygen uptake
  – elevated ______________ use after exercise (oxygen debt)
  – lactic acid is converted back to ______________
______________ and muscles

(FYI) Exercise-Induced Muscle Damage
• Intense exercise can cause muscle damage
  – electron micrographs reveal torn sarcolemmas, damaged _______________
______________
  – increased blood levels of ______________ phosphate
found only inside muscle cells
• Delayed onset muscle soreness
  – 12 to 48 Hours after strenuous exercise
  – stiffness, tenderness and ______________ due to microscopic cell
damage
Classification of Muscle Fibers

- **Slow oxidative** ( )
  - _______ in color (lots of mitochondria, myoglobin & blood vessels)
  - prolonged, sustained contractions for

- **Fast** (fast-twitch red fibers)
  - red in color (lots of mitochondria, myoglobin & blood vessels)
  - split _________ fast rate; used for

- **Fast** (fast-twitch white fibers)
  - _________ in color (few _________ & BV, low myoglobin)
  - anaerobic movements __________________________, or used for weight-lifting

Rigor Mortis

- Rigor mortis is a state of muscular _____________ that begins _________ and lasts about 24 hours
- After death, __________________________ out of the SR and allow ___________
  __________________________
- Since ATP synthesis has ceased, __________________________ until __________________________ begin to digest the decomposing cells.

Regeneration of Muscle

- **Skeletal muscle fibers cannot divide after 1st year**
  - growth is
  - repair
  - __________________________ & bone marrow produce some new cells

- **Cardiac muscle fibers**
  - all healing is done by __________________________ (scar formation)

- **Smooth muscle fibers** ( )
  - cells can grow in size (________________________)
  - some cells (uterus) can divide (hyperplasia)

The End