8 - Muscular System

Introduction
Taft College Human Physiology
Muscular System - Introduction

- The bones provide the levers and structure of the skeleton but it is the **muscles** that **cause movement**.
- **Motion results from the contraction and relaxation of muscles**.
- Muscles account for 40-50% of total body weight.
- 40% of body weight is due to **skeletal muscle**.
- 10% due to cardiac & smooth muscle combined.
- The muscles change chemical energy (ATP) into mechanical energy to generate force and perform work.
- We will discuss this process over the next few weeks.
- The scientific study of muscles is known as **myology**.
Functions of Muscle Tissue

- Muscle tissues have a specialized property—contractility, the capability of shortening.
- Through the contraction and relaxation of muscles, 4 functions can be described:
  1. **Motion** such as walking, running, grasping.
  2. **Propulsion** of materials through the body (blood, ingested food).
  3. **Maintain body posture and sphincter control**.
  4. **Thermogenesis** (generating heat).

These movements rely on the integrated function of bones, joints, and skeletal muscles. The muscles are connected to the skeleton and pull to cause movement.

Examples: Cardiac muscle contracts to pump blood to all body tissues.
Smooth muscle contractions aid in the movement of food through the GI tract, urine through urinary system.
Skeletal muscle helps return venous blood to the heart.

Examples: Skeletal muscle contractions maintain the body in stable positions as when standing.
Sustained contraction of smooth muscles (sphincters) prevent outflow of contents of a hollow organ, as in the urinary bladder, colon, or stomach.

Heat is a byproduct of muscle contraction. Muscle generates about 85% of body heat.
When more heat is needed to maintain body temperature, involuntary muscle contraction (shivering), can increase thermogenesis by several 100%. 
Contractile Proteins

• Movement in living cells involves special protein molecules, **contractile proteins**. Ex. Actin and Myosin
• Contractile proteins can **convert chemical energy like ATP**, into the **mechanical energy** of motion.
• Surprisingly, contractile proteins have been found in many types of cells other than muscle cells. They account for things like:
  • 1. Movement of chromosomes in cell division.
  • 2. Movement of WBCs.
  • Movement of cilia and flagella (as in sperm).
• **Therefore, muscle tissue is not unique in its possession of contractile proteins** but muscle tissue is distinguished by its **high concentration of contractile proteins**.
3 Types of Muscle Tissue

- 1. Skeletal muscle.
- 2. Smooth (visceral) muscle.
- 3. Cardiac muscle.
1. **Skeletal Muscle**

- **Skeletal Muscle** is the muscle that is typically attached to the skeleton and is responsible for the movement:
  - a: of the skeleton.
  - b: of the diaphragm in breathing.
  - c. **Sphincters**- circles of skeletal muscle important in voluntary release of urine and feces.

- Contraction of skeletal muscle occurs by way of **nerve impulses**. You have **voluntary control** of the contraction of skeletal muscle. Therefore sometimes called, **voluntary muscle**.

- Skeletal muscle is the **largest tissue of the body**, approximately **40%** of body weight.
2. **Smooth (visceral) muscle**

- **Smooth (visceral) muscle**— viscera refers to internal organs of chest and abdomen.
- Smooth muscle surrounds the hollow tubes and chambers of the body.
- Found in organs of digestive system, reproductive, urinary, and blood vessels.
- a. Smooth muscle functions to **propel things through tubes peristalsis** = wave like contractions of smooth muscle
- b. May change size (diameter) of an organ, important in maintaining blood flow and pressure.
- Do you have voluntary control over contraction of smooth muscle? No, therefore it is also called **Involuntary muscle**.
- Contraction of smooth muscle is inherent (automatic or involuntary). Contraction of smooth muscle may be altered by:
  1. **Physical pressure** (stretching).
  2. **Nerves** (via neurotransmitters)
  3. **body chemicals** (several hormones, chemical changes (pH, O₂, CO₂)).
3. **Cardiac muscle**

- **Cardiac muscle** - cardiac muscle is the muscle of the heart. It serves to pump (propel) the blood.
- Cardiac muscle **contractions are inherent**, but may be altered by nerves and chemicals (hormones).
- Cardiac and smooth muscle **together** makeup about **10%** of body weight.
- In this exam, we will discuss skeletal muscle and smooth muscle. We will not discuss heart muscle until we get to the cardiovascular system.
Microscopic Functional Anatomy of Skeletal Muscle

- Over **600 skeletal muscles** have been identified on the human body.
- They are attached to bone by bundles of C.T. called **tendons**.
- If we examine a **skeletal muscle** we see that it is composed of **elongated cells or fibers**.
- **Muscle cell = muscle fiber**.
- Let's examine the structural organization of a skeletal muscle:
Functional Anatomy of Skeletal Muscle

- Why stretch prior to exercise?
- To stretch C.T., not muscle tissue!

Muscle Fibers = Muscle Cells = Myofibers 100’s or 1000’s per muscle
Functional Anatomy of Skeletal Muscle

- **Muscle notes** - a skeletal muscle is surrounded by dense, irregular C.T. that strengthens and protects the muscle.
- The C.T. extends beyond the muscle at each end to form a tendon that attaches to periosteum of a bone.
- Individual muscle fibers run longitudinally (parallel to each other) though the muscle. They number from 100s to 1000s in a muscle.
- **Muscle Fiber = Muscle Cell = Myofiber**
Skeletal Muscle Fiber = Muscle Cell = Myofiber

Myofibrils
Striations in Myofibrils
Multiple Nuclei

Sarcolemma = Muscle cell membrane
Myofibrils
Sarcoplasm = Muscle cell cytoplasm

Muscle Fiber = Muscle Cell = Myofiber

To Next Fig.
**Muscle Fiber = Muscle Cell = Myofiber**

- **Muscle fiber notes**-
- **Skeletal muscle cells** are the largest cells (but formed from many myoblasts during development) **in the body**. Each cell has numerous nuclei.
- Notice the nuclei are at the periphery out of the way of the contractile elements.
- Does the nucleus have a difficult time controlling such a large cell? No. They cheat, they are **multinucleated**!
- The plasma membrane is called the **sarcolemma**.
- The cytoplasm is called **sarcoplasm**.
- The muscle fiber is stuffed with tiny threads called **myofibrils**. They extend lengthwise within the muscle fiber. They stain with alternating light and dark bands giving a **striated** appearance.
- These bands are called **cross-striations**, which give rise the reference to **striated muscle**.
Myofibril

Dark Bands = A Bands
Light Bands = I Bands
Z Discs
Sarcomere Sarcomere Etc.
Myofibril Notes

• Each myofibril is made up of a series of repeated units called sarcomeres.
• Z discs serve as the border for adjacent sarcomeres.
• Sarcomeres are the smallest unit of muscle contraction.
• Light = I bands (isotropic) and Dark = A bands (anisotropic) are more evident at this magnification.
Myofibril Notes

• A myofibril in turn is made up of myofilaments = contractile proteins.
• There are 2 major contractile proteins:
  • 1. Myosin- thick filament, MW = 500,000.
  • 2. Actin- thin filament, MW = 60,000.
• A band (dark) consists mostly of myosin and portions of actin that overlap thick filaments.
• I band (light) consists of actin only.
• The Z disc passes through the center of each I band, and anchors the thin filaments. = Border for sarcomere
• The narrow H zone in the center of each A band contains myosin only.
(a) Relaxed muscle

(c) Maximally contracted muscle
Components

- A Band (Dark) = Actin and Myosin
- I Band (Light) = Actin only
- H Zone = Myosin only

- **Elastic filaments**
- **Elastic filament notes**- The 3rd most common muscle protein is a non contractile filament, the *elastic filament*.
  - The elastic filament is composed of the stretchy protein called **titan** (huge MW).
  - **Titan** is especially important in returning contracted muscle back to it’s original position to begin contraction again
Summary of Changes During Contraction

- The **A band (dark) is unchanged in width**.
- The **I band (light) is reduced or absent**.
- The **H zone is absent**.
(a) Myofibril

(b) Details of filaments and Z discs
Physiology Quiz 2.1

Due ______

Draw and label the microscopic anatomy of skeletal muscle as per lecture.

1. Label the following in 2 adjacent sarcomeres for both a relaxed and a contracted muscle if present:
   - Sarcomere
   - A band (dark)
   - I Band (light)
   - H zone
   - Actin
   - Myosin
   - Z disc
   - titan

2. State the components of the A band, I band, and H zone.