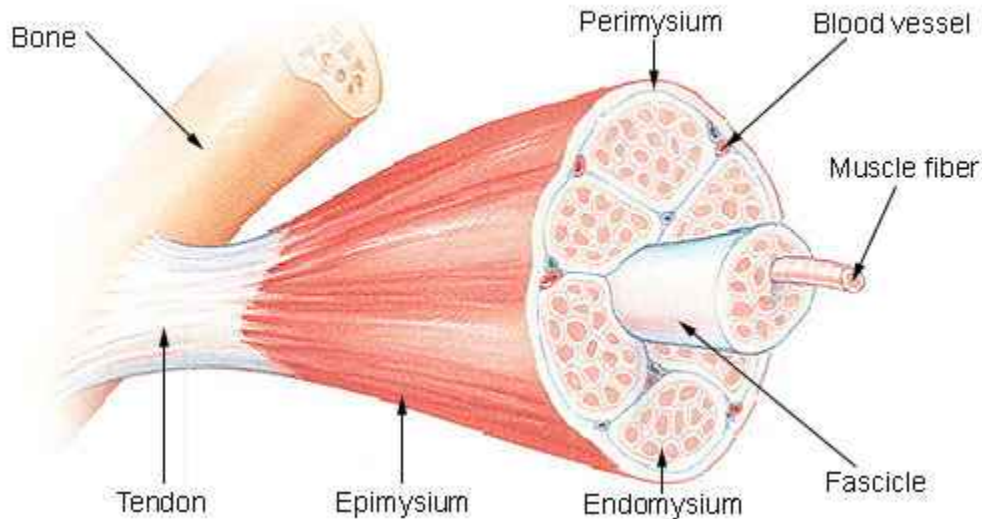


## 6 THE MUSCULAR SYSTEM

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### Overview

**Structure of a Skeletal Muscle**



The **muscular system** is the biological system of humans that allows them to move. The muscular system, in vertebrates, is controlled through the nervous system, although some muscles, like cardiac muscle, can be completely autonomous.

**Muscle** is contractile tissue and is derived from the mesodermal layer of embryonic germ cells. Its function is to produce force and cause motion, either locomotion or movement within internal organs. Much of muscle contraction occurs without conscious thought and is necessary for survival, like the contraction of the heart or peristalsis, which pushes food through the digestive system. Voluntary muscle contraction is used to move the body and can be finely controlled, such as movements of the finger or gross movements that of the biceps and triceps.

Muscle is composed of muscle cells (sometimes known as "muscle fibers"). Within the cells are myofibrils; myofibrils contain sarcomeres which are composed of actin and myosin. Individual muscle cells are lined with endomysium. Muscle cells are bound together by perimysium into bundles called fascicles. These bundles are then grouped together to form muscle, and is lined by epimysium. Muscle spindles are distributed throughout the muscles, and provide sensory feedback information to the central nervous system.

Skeletal muscle, which involves muscles from the skeletal tissue, is arranged in discrete groups. An example of which includes the biceps brachii. It is connected by tendons to processes of the skeleton. In contrast, smooth muscle occurs at various scales in almost every organ, from the skin (in which it controls erection of body hair) to the blood vessels and digestive tract (in which it controls the caliber of a lumen and peristalsis).

There are approximately 650 skeletal muscles in the human body (see list of muscles of the human

body). Contrary to popular belief, the number of muscle fibers cannot be increased through exercise; instead the muscle cells simply get bigger. It is however believed that myofibrils have a limited capacity for growth through hypertrophy and will split if subject to increased demand.

The ten types of muscle have significant differences. However, all but three use the movement of actin against myosin to create Muscle contraction|contraction and relaxation. In skeletal muscle, contraction is stimulated by action potential|electrical impulses transmitted by the nerves, the motor nerves and motoneurons in particular. All skeletal muscle and many smooth muscle contractions are facilitated by the neurotransmitter acetylcholine.

Muscular activity accounts for most of the body's energy consumption. Muscles store energy for their own use in the form of glycogen, which represents about 1% of their mass. This can be rapidly converted to glucose when more energy is necessary.

## Types

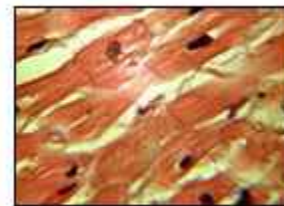
There are three types of muscle:



Skeletal muscle



Smooth muscle



Cardiac muscle

- **Smooth muscle** or "involuntary muscle" is a spindle shaped muscle found within the walls of organs and structures such as the esophagus, stomach, intestines, bronchi, uterus, ureters, bladder, and blood vessels. Smooth muscle contains only one nucleus, and no striations.
- **Cardiac muscle** is also an "involuntary muscle" but it is striated in structure. Like Smooth muscle, cardiac muscle contains only one nucleus. Cardiac muscle is found only within the heart.
- **Skeletal muscle** or "voluntary muscle" is anchored by tendons to the bone and is used to affect skeletal movement such as locomotion. Skeletal muscle is multinucleated the nucleus is peripherally located, and the skeletal muscle is striated. Functions of the skeletal muscle include:
  - Support of the body
  - Aids in bone movement
  - Helps maintain a constant temperature throughout the body
  - Assists with the movement of cardiovascular and lymphatic vessels through contractions
  - Protection of internal organs and helps to stabilize joints

Cardiac and skeletal muscle are striated in that they contain sarcomere and are packed into highly-regular arrangements of bundles; smooth muscle has neither. Striated muscle is often used in short, intense bursts, whereas smooth muscle sustains longer or even near-permanent contractions.

Skeletal muscle is further divided into several subtypes:

- Type I, slow oxidative, *slow twitch*, or "red" muscle is dense with capillaries and is rich in mitochondria and myoglobin, giving the muscle tissue its characteristic red color. It can carry more oxygen and sustain aerobic activity.
- Type II, *fast twitch*, muscle has three major kinds that are, in order of increasing contractile speed:
  - a) Type IIa, which, like slow muscle, is aerobic, rich in mitochondria and capillaries and appears red.
  - b) Type IIx (also known as type IIc), which is less dense in mitochondria and myoglobin. This is the fastest muscle type in humans. It can contract more quickly and with a greater amount of force than oxidative muscle, but can sustain only short, anaerobic bursts of activity before muscle contraction becomes painful (often attributed to a build-up of lactic acid). N.B. in some books and articles this muscle in humans was, confusingly, called type IIB
  - c) Type IIb, which is anaerobic, glycolytic, "white" muscle that is even less dense in mitochondria and myoglobin. In small animals like rodents or rabbits this is the major fast muscle type, explaining the pale color of their meat.

For most muscles, contraction occurs as a result of conscious effort originating in the brain. The brain sends signals, in the form of action potentials, through the nervous system to the motor neuron that innervates the muscle fiber. However, some muscles (such as the heart) do not contract as a result of conscious effort. These are said to be autonomic. Also, it is not always necessary for the signals to originate from the brain. Reflexes are fast, unconscious muscular reactions that occur due to unexpected physical stimuli. The action potentials for reflexes originate in the spinal cord instead of the brain.

There are three general types of muscle contractions, skeletal muscle contractions, heart muscle contractions, and smooth muscle contractions.

## Muscular System Working With Other Body Systems

1. Homeostasis
2. Protection
3. Calcium Metabolism
4. Maintaining Body Temperature

## Skeletal Muscle Contractions

Steps of a skeletal muscle contraction:

- An action potential reaches the axon of the motor neuron.
- The action potential activates voltage gated calcium ion channels on the axon, and calcium rushes in.
- The calcium causes acetylcholine vesicles in the axon to fuse with the membrane, releasing the acetylcholine into the cleft between the axon and the motor end plate of the muscle fiber.
- The skeletal muscle fiber is excited by large myelinated nerve fibers which attach to the

neuromuscular junction. There is one neuromuscular junction for each fiber.

- The acetylcholine diffuses across the cleft and binds to nicotinic receptors on the motor end plate, opening channels in the membrane for sodium and potassium. Sodium rushes in, and potassium rushes out. However, because sodium is more permeable, the muscle fiber membrane becomes more positively charged, triggering an action potential.
- The action potential on the muscle fiber causes the sarcoplasmic reticulum to release calcium ions( $\text{Ca}^{++}$ ).
- The calcium binds to the troponin present on the thin filaments of the myofibrils. The troponin then allosterically modulates the tropomyosin. Normally the tropomyosin physically obstructs binding sites for cross-bridge; once calcium binds to the troponin, the troponin forces the tropomyosin to move out of the way, unblocking the binding sites.
- The cross-bridge (which is already in a ready-state) binds to the newly uncovered binding sites. It then delivers a power stroke.
- ATP binds the cross-bridge, forcing it to conform in such a way as to break the actin-myosin bond. Another ATP is split to energize the cross bridge again.
- Steps 7 and 8 repeat as long as calcium is present on thin filament.
- Throughout this process, the calcium is actively pumped back into the sarcoplasmic reticulum. When no longer present on the thin filament, the tropomyosin changes back to its previous state, so as to block the binding sites again. The cross-bridge then ceases binding to the thin filament, and the contractions cease as well.
- Muscle contraction remains as long as  $\text{Ca}^{++}$  is abundant in sarcoplasm.

#### Types of Contractions:

- Isometric contraction--muscle does not shorten during contraction and does not require the sliding of myofibrils but muscles are stiff.
- Isotonic contraction--inertia is used to move or work. More energy is used by the muscle and contraction lasts longer than isometric contraction.
- Twitch--exciting the nerve to a muscle or by passing electrical stimulus through muscle itself. Some fibers contract quickly while others contract slowly.

#### The Efficiency of Muscle Contraction:

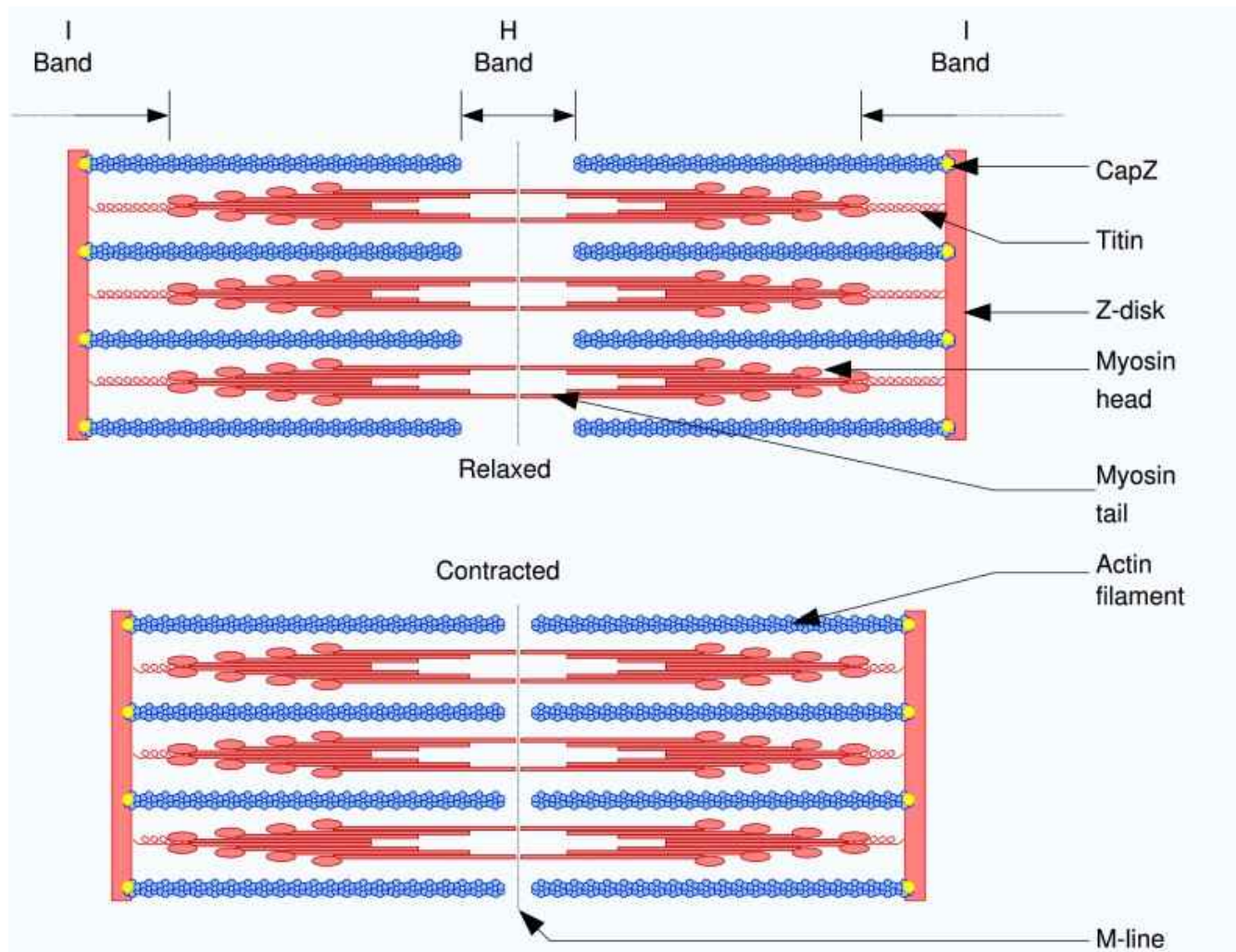
- Only about 20% of input energy converts into muscular work. The rest of the energy is heat.
- 50% of energy from food is used in ATP formation.
- If a muscle contraction is slow or without movement, energy is lost as maintenance heat.
- If muscle contraction is rapid, energy is used to reduce friction.

Summation of Muscle Contraction: It is the adding together of individual muscle twitches to make strong muscle movements.

- Multiple motor unit summation--increasing number of motor units contracting simultaneously.
- Wave summation--increasing rapidity of contraction of individual motor units.
- Tetanization--higher frequency successive contractions fuse together and cannot be distinguished from one another.

## Sliding Filament theory

When a muscle contracts, the actin is pulled along myosin toward the center of the sarcomere until the actin and myosin filaments are completely overlapped. The H zone becomes smaller and smaller due to the increasing overlap of actin and myosin filaments, and the muscle shortens. Thus when the muscle is fully contracted, the H zone is no longer visible (as in the bottom diagram, left). Note that the actin and myosin filaments themselves do not change length, but instead slide past each other.



*Sliding myofibril (GFDL - Slashme)*

## Cellular Action of Skeletal Muscles

During cellular respiration the mitochondria, within skeletal muscle cells, convert glucose from the blood to carbon dioxide and water in the process of producing ATP (see [cell physiology](#)). ATP is needed for all muscular movement. When the need of ATP in the muscle is higher than the cells can produce with aerobic respiration, the cells will produce extra ATP in a process called anaerobic respiration. The first step of aerobic respiration (glycolysis) produces two ATP per glucose molecule. When the rest of the aerobic respiration pathway is occupied the pyruvate molecule can be converted to lactic acid. This method produces much less ATP than the aerobic method, but it does it faster and allows the muscles to do a bit more than if they relied solely on ATP production from aerobic



respiration. The drawback to this method is that lactic acid accumulates and causes the muscles to fatigue. They will eventually stop contracting until the breakdown of lactic acid is sufficient to allow for movement once again. People experience this most noticeably when they repeatedly lift heavy things such as weights or sprint for a long distance. Muscle soreness sometimes occurs after vigorous activity, and is often misunderstood by the general public to be the result of lactic acid buildup. This is a misconception because the muscle does fatigue from lactic acid buildup, but it does not stay in the muscle tissue long enough to cause tissue breakdown or soreness. During heavy breathing, following exercise, the cells are converting the lactic acid either back into glucose or converting it to pyruvate and sending it through the additional steps of aerobic respiration. By the time a person is breathing normally again the lactic acid has been removed. The soreness is actually from small tears in the fibers themselves. After the fibers heal they will increase in size. The number of mitochondria will also increase if there is continued demand for additional ATP. Hence, through exercise the muscles can increase in both strength and endurance.

Another misconception is that as the muscle increases in size it also gains more fibers. This is not true. The fibers themselves increase in size rather than in quantity. The same holds true for adipose tissue--fat cells do not increase in number, but rather the amount of lipids (oil) in the cells increase.

Muscle fibers are also genetically programmed to reach a certain size and stop growing from there, so after awhile even the hardest working weightlifter will only reach a certain level of strength and endurance. Some people will get around this by taking steroids. The artificial steroids cause all sorts of trouble for the person. They can cause the adrenal glands to stop producing corticosteroids and glucosteroids. This leads to the atrophy of the gland's medulla and causes permanent loss of the production of these hormones. The testicles may also atrophy in response to steroids. Eventually the testes will stop making testosterone and sperm, rendering the male infertile.

One of the more serious problems associated with abnormal gain of muscle mass is heart failure. While for most people gaining muscle and losing fat is desirable, a body builder is at risk of producing more muscle mass than the heart can handle. One pound of fat contains about 3.5 miles of blood vessels, but one pound of muscle has about 6.5 miles. Hence, additional muscle causes the heart to pump more blood. Some people that have too much muscle will be very strong but will not have a healthy aerobic endurance, in part because of the difficulty of providing oxygenated blood to so much tissue.

### Sliding filament theory

This link shows the animation of the sliding filament theory.

### explanation and image of sliding filament theory

this link gives a better demonstration of the theory with the explanation.

## Involuntary Muscle Movement

### Spasms

When Smooth and skeletal muscles go through multiple spasms it is referred either as seizure or convulsion.

### Cramps

Strenuous activities can cause painful spasms that are long, this is referred to as cramps.

## Injury

### Sprain

A injury to a joint that involves a stretched or torn ligament.

### Muscle Strain

A strain occurs when a muscle or the tendon that attaches it to the bone is overstretched or torn. Muscle strains are also called pulled muscles.

## Who gets it?

Anyone can strain a muscle. However, people involved in sports or other forms of strenuous exercise are more likely to strain a muscle.

## What causes it?

Muscles are bunches of fibers that can contract. Muscle strains usually occur during activities that require the muscle to tighten forcefully. The muscle is strained either because it is not properly stretched, or warmed up, before the activity; it is too weak; or because the muscle is already injured and not allowed time to recover. So, many muscle strains occur during exercise or sports activities. They can also occur when lifting heavy objects. What are the symptoms?

When a muscle is strained, it hurts and is difficult to move. You may also feel a burning sensation in the area of the injured muscle, or feel as though something has "popped." Sometimes the area of the strained muscle looks bruised or swells. A strained muscle might spasm, which means it contracts suddenly and involuntarily, causing severe pain. How is it diagnosed?

To diagnose a muscle strain, your doctor will examine the painful area, and ask how and when the injury happened. He or she may order other diagnostic tests, such as x-rays, to rule out any injury to the bone.

## What is the treatment?

Muscle strains are treated with rest, ice, compression, and elevation, or RICE. You will be told to rest the injured area to reduce pain and swelling. If the strain is in the leg or foot area, you may need to use crutches. Ice packs are recommended at regular intervals (as recommended by your doctor) over the first few days after the injury. Ice causes the blood vessels to constrict, which reduces inflammation and pain. Anti-inflammatory medications might also be used to relieve pain. Compression and elevation help to reduce swelling. Your doctor may also recommend physical therapy to speed your recovery. You should avoid the type of activity that caused the injury until the muscle is completely healed. Self-care tips

You can prevent muscle strains by warming up for at least 10 minutes before participating in any strenuous exercise or heavy lifting. When you warm up, you increase the blood circulation to the muscle and prepare it for exercise. When starting any new exercise program or sport, it's important to begin gradually so your muscles are conditioned for the activity.

## Steroids

Anabolic steroids, which are synthetic versions of the primary male sex hormone testosterone, can be injected, taken orally, or used transdermally. These drugs are Controlled Substances that can be prescribed to treat conditions such as body wasting in patients with AIDS, and other diseases that occur when the body produces abnormally low amounts of testosterone. However, the doses prescribed to treat these medical conditions are 10 to 100 times lower than the doses that are abused for performance enhancement.

Let me be clear:- while anabolic steroids can enhance certain types of performance or appearance, they are dangerous drugs, and when used inappropriately, they can cause a host of severe, long-lasting, and often irreversible negative health consequences. These drugs can stunt the height of growing adolescents, masculinize women, and alter sex characteristics of men. Anabolic steroids can lead to premature heart attacks, strokes, liver tumors, kidney failure and serious psychiatric problems. In addition, because steroids are often injected, users risk contracting or transmitting HIV or hepatitis.

Abuse of anabolic steroids differs from the abuse of other illicit substances because the initial use of anabolic steroids is not driven by the immediate euphoria that accompanies most drugs of abuse, such as cocaine, heroin, and marijuana, but by the desire of the abuser to change their appearance and performance, characteristics of great importance to adolescents. These effects of steroids can boost confidence and strength leading the abuser to overlook the potential serious long-term damage that these substances can cause.....

Government agencies such as NIDA support research that increases our understanding of the impact of steroid abuse and improves our ability to prevent abuse of these drugs. For example, NIDA funding led to the development of two highly effective programs that not only prevent anabolic steroid abuse among male and female high school athletes, but also promote other healthy behaviors and attitudes. The ATLAS (targeting male athletes) and ATHENA (targeting female athletes) programs have been adopted by schools in 29 states and Puerto Rico. Both Congress and the Substance Abuse and Mental Health Services Administration have endorsed ATLAS and ATHENA as model prevention programs, which could and should be implemented in more communities throughout the country.

In addition to these prevention programs and other research efforts, also has invested in public education efforts to increase awareness about the dangers of steroid abuse. We have material on our website about steroid abuse at [www.steroidabuse.gov](http://www.steroidabuse.gov) and in April 2005 we again will distribute a "Game Plan" public service announcement designed to bring attention to abuse of anabolic steroids.

Research has shown that the inappropriate use of anabolic steroids can have catastrophic medical, psychiatric and behavioral consequences.

I hope that students, parents, teachers, coaches and others will take advantage of the information on our website about anabolic steroids abuse and join us in our prevention and education efforts. Participating in sports offers many benefits, but young people and adults shouldn't take unnecessary health risks in an effort to win. (Nora D. Volkow, M.D.)

-Human-made substances related to male sex hormones. Some athletes abuse anabolic steroids to enhance performance. Abuse of anabolic steroids can lead to serious health problems, some of which are irreversible.



Major side effects can include liver tumors and cancer, jaundice, high blood pressure, kidney tumors, severe acne, and trembling. In males, side effects may include shrinking of the testicles and breast development. In females, side effects may include growth of facial hair, menstrual changes, and deepened voice. In teenagers, growth may be halted prematurely and permanently.

The therapeutic use of steroids can be realized by patients and their doctors by using them in a manner that is beneficial to the person.

## Smooth Muscle Contraction

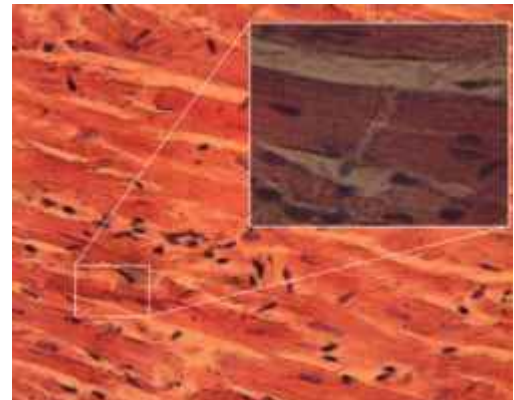
- Contractions are initiated by an influx of calcium which binds to calmodulin.
- The calcium-calmodulin complex binds to and activates myosin light-chain kinase.
- Myosin light-chain kinase phosphorylates myosin light-chains, causing them to interact with actin filaments. This causes contraction.

The calcium ions leave the troponin molecule in order to maintain the calcium ion concentration in the sarcoplasm. As the calcium ions are being actively pumped by the calcium pumps present in the membrane of the sarcoplasmic reticulum creating a deficiency in the fluid around the myofibrils. This causes the removal of calcium ions from the troponin. Thus the tropomyosin-troponin complex again covers the binding sites on the actin filaments and contraction ceases.

## Cardiac Muscle

Cardiac muscle cells within the myocardium are arranged in layers that completely encase the chambers of the heart. The contraction of these cells pressurizes the blood inside the chambers of the heart so that the blood can travel out of the heart to the rest of the body. Cardiac muscle contains elements of both striated skeletal muscle and smooth muscle. The striated structure of cardiac muscle is due to the arrangement of thick myosin and thin actin filaments which are similar to the arrangement of skeletal muscle. Compared to skeletal muscle, cardiac muscle is much shorter and

has several branching processes. **Intercalated disks** join the ends of cardiac muscle cells to each other. **Gap junctions** are situated adjacent to intercalated disks which is similar to those found in many smooth muscle cells. One percent of cardiac cells do not contract because the non-contracting cells have specialized features that aid in heart excitation. The non-contracting cells form a network known as the conducting system and contact other cardiac muscle cells at gap junctions. The conduction system begins the heartbeat and assists in spreading the contraction impulse rapidly through out the heart. Certain cardiac muscle cells also secrete **atrial natriuretic peptide (ANP)**<sup>[1]</sup> which inhibits sodium reabsorption in the kidneys.



## ATP in the Human Body

Muscle cells, like all cells, use ATP as an energy source. The total quantity of ATP in the human body at any one time is about 0.1 Mole. The energy used by human cells requires the hydrolysis of 200

to 300 moles of ATP daily. This means that each ATP molecule is recycled 2000 to 3000 times during a single day. ATP cannot be stored, hence its consumption must closely follow its synthesis. On a per-hour basis, 1 kilogram of ATP is created, processed and then recycled in the body. Looking at it another way, a single cell uses about 10 million ATP molecules per second to meet its metabolic needs, and recycles all of its ATP molecules about every 20-30 seconds.

## Lactic Acid

Catabolized carbohydrates is known as glycolysis. The end product of glycolysis, pyruvate can go into different directions depending on aerobic or anaerobic conditions. In aerobic it goes through the Krebs cycle and is anaerobic it goes through the Cori cycle. In the Cori cycle pyruvate is converted to lactate, this forms lactic acid, lactic acid causes muscle fatigue. In the aerobic conditions pyruvate goes through the Krebs cycle. For more about Krebs cycle refer to chapter 2 Cell Physiology.

## Muscle Disorders

**DERMATOMYOSITIS AND POLYMYOSITIS** — Dermatomyositis and polymyositis cause inflammation of the muscles. They are rare disorders, affecting only about one in 100,000 people per year. More women than men are affected. Although the peak age of onset is in the 50s, the disorders can occur at any age.

**Signs and symptoms** — Patients complain of muscle weakness that usually worsens over several months, though in some cases symptoms come on suddenly. The affected muscles are close to the trunk (as opposed to in the wrists or feet), involving for example the hip, shoulder, or neck muscles. Muscles on both sides of the body are equally affected. In some cases, muscles are sore or tender. Some patients have involvement of the muscles of the pharynx (throat) or the esophagus (the tube leading from the throat to the stomach), causing problems with swallowing. In some cases, this leads to food being misdirected from the esophagus to the lungs, causing severe pneumonia.

In dermatomyositis, there is a rash, though sometimes the rash resolves before muscle problems occur. A number of different types of rash can occur, including rashes on the fingers, the chest and shoulders, or on the upper eyelids (show picture 1-3). In rare cases, the rash of dermatomyositis appears but myopathy never develops.

Other problems sometimes associated with these diseases include fever, weight loss, arthritis, cold-induced color changes in the fingers or toes (Raynaud phenomenon), and heart or lung problems.

## Muscle Atrophy

Alternative names : Atrophy of the muscles, Muscle wasting, Wasting

The majority of muscle atrophy in the general population results from disuse. People with sedentary jobs and senior citizens with decreased activity can lose muscle tone and develop significant atrophy. This type of atrophy is reversible with vigorous exercise. Bed-ridden people can undergo significant muscle wasting. Astronauts, free of the gravitational pull of Earth, can develop decreased muscle tone and loss of calcium from their bones following just a few days of weightlessness.

Muscle atrophy resulting from disease rather than disuse is generally one of two types, that resulting from damage to the nerves that supply the muscles, and disease of the muscle itself. Examples of diseases affecting the nerves that control muscles would be poliomyelitis, amyotrophic lateral sclerosis (ALS or Lou Gehrig's disease), and Guillain-Barre syndrome. Examples of diseases affecting primarily the muscles would include muscular dystrophy, myotonia congenita, and myotonic dystrophy as well as other congenital, inflammatory or metabolic myopathies.

Even minor muscle atrophy usually results in some loss of mobility or power.

### Common Causes

- some atrophy that occurs normally with aging
- cerebrovascular accident (stroke)
- spinal cord injury
- peripheral nerve injury (peripheral neuropathy)
- other injury
- prolonged immobilization
- osteoarthritis
- rheumatoid arthritis
- prolonged corticosteroid therapy
- diabetes (diabetic neuropathy)
- burns
- poliomyelitis
- amyotrophic lateral sclerosis (ALS or Lou Gehrig's disease)
- Guillain-Barre syndrome
- muscular dystrophy
- myotonia congenita
- myotonic dystrophy
- myopathy

## Muscular Dystrophy

Muscular dystrophy (MD) is a group of rare inherited muscle diseases in which muscle fibers are unusually susceptible to damage. Muscles, primarily voluntary muscles, become progressively weaker. In the late stages of muscular dystrophy, fat and connective tissue are often replaced by muscle fibers. In some types of muscular dystrophy, heart muscles, other involuntary muscles and other organs are affected.

The most common types of muscular dystrophy appear to be due to a genetic deficiency of the muscle protein dystrophin. There's no cure for muscular dystrophy, but medications and therapy can slow the course of the disease.

# Medical Mysteries

## Sleep Twitches

The twitching phenomenon that happens in the early stage of sleep is called a hypnagogic massive jerk, or simply a hypnic jerk. It has also been referred to as a sleep start. There has been little research on this topic, but there have been some theories put forth. When the body drifts off into sleep, it undergoes physiological changes related to body temperature, breathing rate and muscular tone. Hypnic jerks may be the result of muscle changes. Another theory suggests that the transition from the waking to the sleeping state signals the body to relax. But the brain may interpret the relaxation as a sign of falling and then signal the arms and legs to wake up. Electroencephalogram studies have shown sleep starts affect almost 10 percent of the population regularly, 80 percent occasionally, and another 10 percent rarely.

Muscle movement or twitching also may take place during the Rapid Eye Movement, or REM, phase of sleep. This also is the time when dreams occur. During the REM phase, all voluntary muscular activity stops with a drop in muscle tone, but some individuals may experience slight eyelid or ear twitching or slight jerks. Some people with REM behavioral disorder, or RBD, may experience more violent muscular twitching and full-fledged activity during sleep. This is because they do not achieve muscle paralysis, and as a result, act out their dreams. Researchers think that people with RBD lack neurological barriers that define the different stages of sleep. New research done by the Mayo Clinic and published in the July 2003 issue of Sleep Medicine shows that melatonin can help lessen RBD symptoms.

### Resources:

Sleep twitches, or myoclonic jerks, as they are sometimes called, are explained in easily understood language on this website.

Learn more about REM Behavior Disorder, or RBD, and treatment for sufferers.

View information about various sleep disorders such as insomnia, apnea, and narcolepsy.

## Microbiology

### *Clostridium tetani*

#### Tetanus

Normally a nerve impulse initiates contraction of a muscle. At the same time, an opposing muscle receives the signal to relax so as not to oppose the contraction. Tetanus toxin blocks the relaxation, so both sets of muscle contract. The usual cause of tetany is lack of calcium, but excess of phosphate (high phosphate-to-calcium ratio) can also trigger the spasms.

### *Clostridium botulinum*

Infant botulism (floppy baby syndrome) the most common form of botulism in the U.S. of the four forms of botulism.

If ingested, the toxin is absorbed in the intestine, goes to the blood, and on to the nervous system. It acts on the peripheral nervous system by blocking the impulse that is normally passes along to the nervous system. By clocking the impulse that is normally passed along to motor end plates so the muscle contraction can be released, resulting in paralysis.

## Glossary

### Actin

A protien that forms a long polymer rods called microfilaments; Interacts with myosin to cause movement in muscles.

### ATP

"Adenosine Triphosphate" is a nucleotide that comes from adenosine that takes place in muscle tissue. This provides a large source of energy for cellular reactions.

### Cardiac muscle

is also an "involuntary muscle" but it's a specialized kind of muscle found only within the heart.

### Clostridium botulinum

A pathogen that causes botulism, gram stain positive, morphology is rod shaped, grows in anaerobic conditions, and produces spores.

### Clostridium tetani

A pathogen that causes lock jaw, gram stain positive, morphology is tennis racket shaped rod, grows in anaerobic conditions, and produces spores.

### Cori cycle

In anaerobic conditions produces lactic acid.

### Cramp

A localized muscle spasm that happens after strenuous activity.

### Glycogen

Glucose that has been converted for energy storage. Muscles store energy for their own use in this form.

### Lactic acid

Causes muscle fatigue.

### Muscle

Contractile tissue that is derived from the mesodermal layer of embryonic germ cells.

### Muscular Dystrophy

A hereditary disease characterized by progressive atrophy of muscle fibers

### Myosin

The fibrous motor protein that uses ATP to drive movements along actin filaments.

### Sarcoplasmic Reticulum

Smooth-surfaced tubules forming a plexus around each myofibril that function as a storage and release area for calcium ions ( $Ca^{+2}$ ).

### Skeletal muscle

this "voluntary muscle" is anchored by tendons to the bone and is used to affect skeletal



movement such as locomotion.

#### Smooth muscle

this "involuntary muscle" is found within the walls of organs and structures such as the esophagus, stomach, intestines, bronchi, uterus, ureters, bladder, and blood vessels.

#### Sprain

Injuries that involves a stretched or torn ligament.

#### Strain

A injury to the muscle or tendon attachment

## Review Questions

### 1. Smooth Muscle is

- A) Voluntary and Spindle Shaped
- B) Voluntary and Striated
- C) Involuntary and Spindle Shaped
- D) Involuntary and Striated

### 2. Skeletal Muscle is

- A) Voluntary and Spindle Shaped
- B) Voluntary and Striated
- C) Involuntary and Spindle Shaped
- D) Involuntary and Striated

### 3. Cardiac Muscle is

- A) Voluntary and Spindle Shaped
- B) Voluntary and Striated
- C) Involuntary and Spindle Shaped
- D) Involuntary and Striated

### 4. Which type of muscle cell is multinucleated?

- A) Cardiac
- B) Smooth
- C) Skeletal
- D) All of the Above

### 5. What is an example of a smooth muscle?

- A) Masseter (Face)
- B) Bladder
- C) Heart
- D) Pronator Teres (Forearm)

E) Rectus Abdominis (belly)

6. Each myosin filament is surrounded by \_\_\_\_ actin filaments.

- A) Two
- B) Four
- C) Six
- D) Eight
- E) Seven

## References

- Van De Graaff (2002) *Human Anatomy 6th ed.* McGraw-Hill Higher Education
- Windmaier, P.W. Raff, H. Strang, T.S. (2004) *Vander, Sherman, & Luciano's Human Physiology, the Mechanisms of Body Function 9th ed.* McGraw-Hill

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