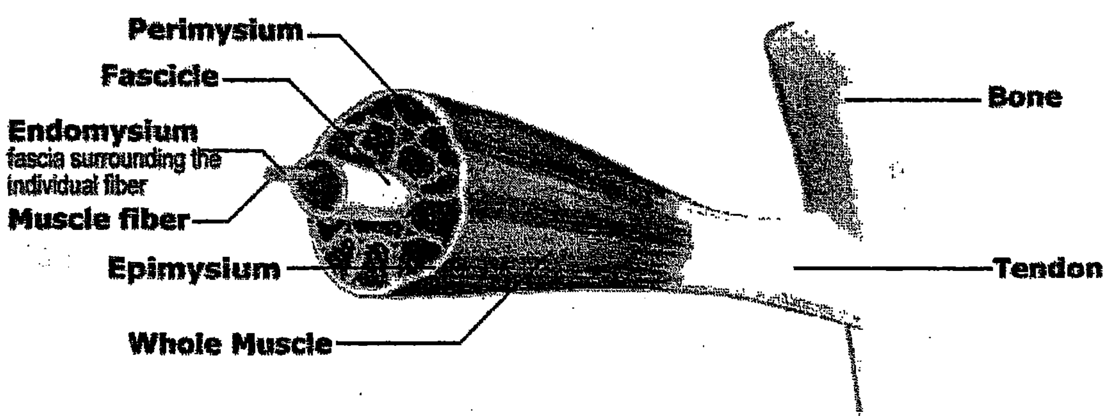
Skeletal Muscle Function

- **Movement** Muscular contractions assist in the movement of the entire body or body parts. In addition, muscular contractions assist in respiration, circulation and other body processes.
- **Stability** Muscles assist in maintaining body posture through continuous low intensity contractions.
- **Stabilizing Joints** As muscles contract to move the body, they increase joint stability.
- **Heat Production** The skeletal muscle system produces as much as 85% of the body heat. This heat production is critical to maintaining normal body temperature.
- **Protection** Skeletal muscles offer protection to the underlying tissue and organs.

Skeletal Muscle Structure

Skeletal muscle is composed of individual muscle cells (fibers) wrapped together by connective tissue. Each skeletal muscle consists of three layers of connective tissue or fascia: epimysium, perimysium and endomysium.

- **Epimysium** The entire muscle is surrounded by the epimysium. This connective tissue separates the muscle from the surrounding tissue and joins with the **tendon** to attach muscle fibers to the bone.
- **Perimysium** This connective tissue separates the skeletal muscle into separate bundles of muscle fibers called a fasiculus. The number of fascicles contracted (recruited) at one time determines the amount of force generated.
- **Endomysium** Individual muscle fibers in the fascicleus are surrounded by the endomysium.
- **Tendon.** Attaches the muscle to the bone.



Microscopic Structure of a Skeletal Muscle Fiber

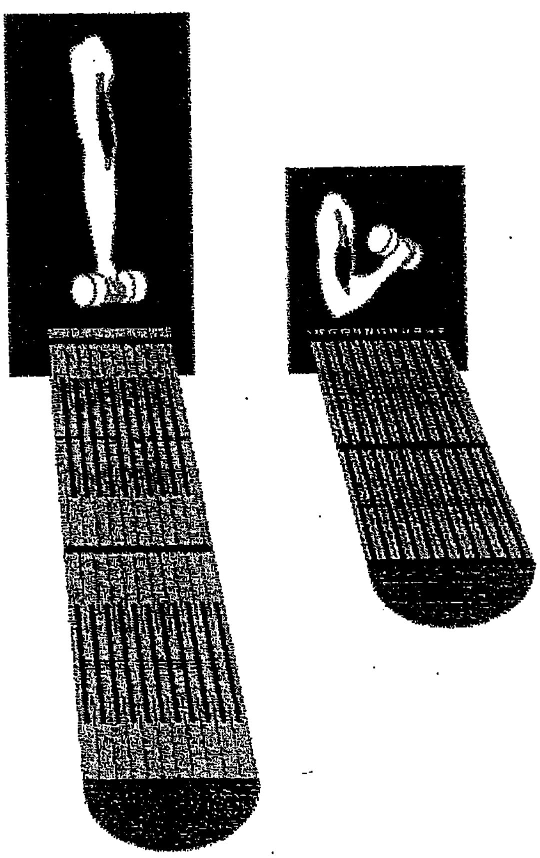
Muscle cells (fibers) look considerably different from the other cells of the body. The most obvious difference is the size. A skeletal muscle fiber can be long (e.g. the hamstring group is 30-40 cm in length). In addition, skeletal muscle cells have many **nuclei** which are responsible for directing protein synthesis in the muscle following exercise. The outer wrapping or membrane around a muscle fiber is the **sarcolemma**, and encloses the internal material or **sarcoplasm.** Within the sarcoplasm of muscle fibers are thousands of string-like structures called **myofibrils.**

Myofibrils are composed of protein **myofilaments**: **actin,** and **myosin.** It is the arrangement of the two myofilaments that gives skeletal muscle the striped or striated appearance. The actin and myosin myofilaments are arranged into small functional units called **sarcomeres** where the actual force production and shortening takes place. (*See figure 8-29 for more detail*).

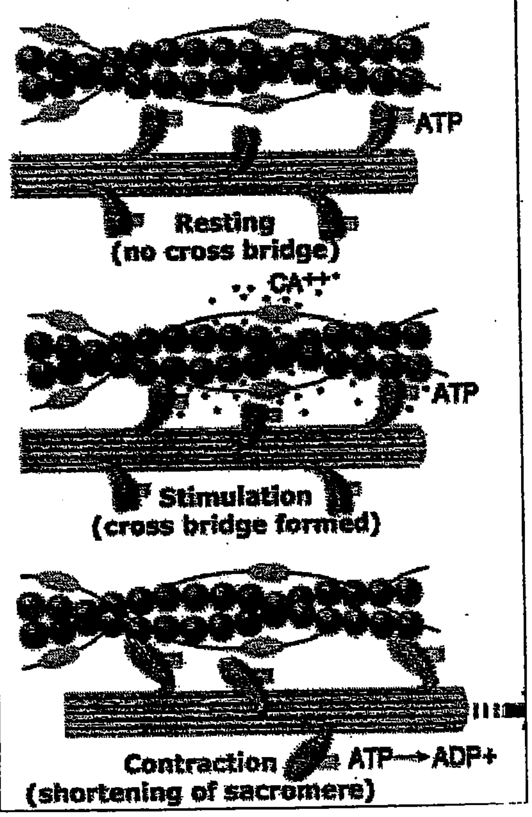
Sarcomere Shortening

When the myosin (thick) filament has energy (ATP) and is stimulated by the nervous system, it will bind to the actin filament and form **cross bridges.** Once this cross bridge is formed, the myosin swivels and pulls on the actin. This binding pull causes shortening of the sarcomere and the thin filament (actin) slides toward the center of the sarcomere. The **Z lines** (ends of the individual sarcomere) move closer together. This process of sacromere shortening due to movement of the myofilaments is named the **sliding filament theory.**

Diagram of the microscopic construction of a muscle cell (fiber)



Graphic illustration of actin/myosin cross bridge formation which results in muscle contraction; process shown in three stages.



Nerve and Blood Supply of Muscles

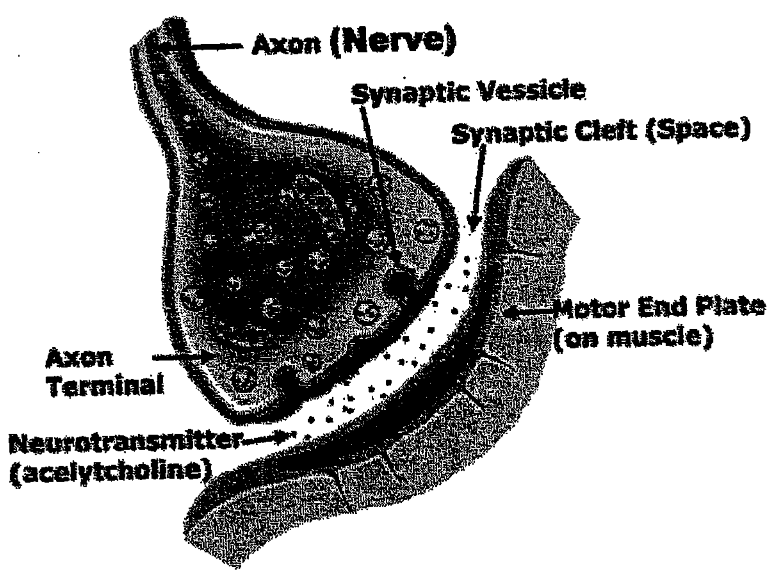
Each skeletal muscle fiber is stimulated to contract by a nerve **(motor neuron)** that passes from the outer epimysium to the inner endomysium. In addition to nerve stimulation, the contracting muscle fibers need a continuous blood supply to deliver oxygen, and fuel for production of ATP. ATP is the energy source that allows muscle contraction.

Control of the Muscle Contraction

Skeletal muscle contracts when signaled to do so by nerve impulses. The nerve impulse (action potential) travels along the motor neuron and stimulates the muscle to contract in the following process.

The communication between the nerve and muscle takes place at the **neuromuscular junction (NMJ).** The nerve carries the signal or **action potential** to the NMJ. The nerve and muscle never actually touch each other so there is a small space or **cleft** between the two structures.

- **Step 1.** As the nerve impulse travels down the nerve it arrives at the NMJ and releases a chemical, **acetylcholine (Ach),** into the cleft.
- **Step 2.** Acetylcholine is a **neurotransmitter**, and carries the nerve signal across the cleft (gap) to the membrane of the muscle (motor end plate).
- **Step 3.** The nerve impulse, which has now arrived at the membrane **(sarcolemma)** of the muscle, then carries the impulse deep into the muscle to cause the release of calcium from storage.
- **Step 4. Calcium** travels to the actin myofilament in the sarcomere and permits **cross bridges** to be formed between actin and myosin.
- **Step 5.** Finally, in the presence of **ATP** (energy), sliding of the myofilaments takes place and the muscle contracts.
- **Step 6.** To cause a muscle to **relax** after a contraction, the nerve impulse ceases, calcium returns to its storage location inside the muscle and the sarcomere returns to its resting length as the cross bridges between actin and myosin separate.



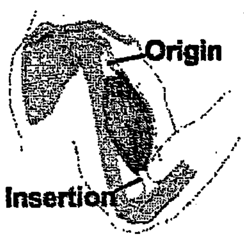
Motor Unit and Fiber Recruitment

A motor nerve and the muscle fibers it stimulates to contract is a motor unit. Although some motor nerves stimulate one muscle fiber to contract, many nerves stimulate hundreds or thousands of fibers. It is the size of the motor unit (i.e. how many fibers the individual nerves stimulate), that determines the force of the muscle movement. A very precise movement, such as playing the piano, may require activation of only three or four muscle fibers in each motor unit. The large muscles of the leg needed for posture and support during the day may have one nerve stimulating 100-2000 muscle fibers. When performing a specific skill or movement pattern, progressively more muscle fibers are **stimulated and recruited** until the desired force has been produced. **Recruiting the maximal number of muscle fibers at one time produces maximum force.**

Muscle Tone

At any point in time, some of the motor units in a muscle are active, while others are resting. When this happens there may be insufficient force to cause contraction of the muscle, but enough force to produce **muscle tone and firmness.** Muscle fibers, regularly recruited and overloaded, will **hypertrophy** (increase in size). Muscle fibers that are not stimulated on a regular basis will **atrophy** (decrease in size).

Attachments of Muscles



Most skeletal muscles attach to the skeleton in two locations. When muscles shorten the moveable bone (**insertion**) moves toward the fixed bone (**origin**).

Muscle Action

Individual muscles seldom work independently, but rather work together with other muscles to produce the desired muscle action.

Prime Mover (agonist)
The muscle or group of muscles primarily responsible for the movement, (e.g. the quadriceps muscle is the prime mover during the leg extension exercise).

Antagonist
The muscle which opposes the action of the prime mover, (e.g. hamstring group is the antagonist to the quadriceps during the leg extension exercise).

Synergist
A synergist muscle assists the prime mover in contraction or in stabilizing the point of origin to make the movement more efficient. If the synergist muscle is primarily anchoring or stabilizing a body part, it is called a **fixator or stabilizer**.