

36–2 The Muscular System



The function of the muscular system is movement. More than 40% of the mass of the average human body is muscle.

Types of Muscle Tissue



–What are the three types of muscle tissue?



–There are three different types of muscle tissue:

- **skeletal**
- **smooth**
- **cardiac**

–Skeletal Muscles

Skeletal muscles:

- are usually attached to bones.
- are responsible for voluntary movements.
- have many nuclei.
- are sometimes called striated muscles.

–Smooth Muscles

Smooth muscles:

- are usually not under voluntary control.
- are spindle-shaped.
- have one nucleus.
- are not striated.
- are found in many internal organs and blood vessels.

Most smooth muscle cells can function without nervous stimulation.

They are connected by gap junctions that allow electrical impulses to travel among muscle cells.

–Cardiac Muscle

Cardiac muscle:

- is only found in the heart.
- is striated.
- may have one or two nuclei.

Cardiac muscle cells are connected to each other by gap junctions.



Muscle Contraction

The fibers in skeletal muscles are composed of smaller structures called myofibrils.

Each myofibril has smaller structures called filaments.

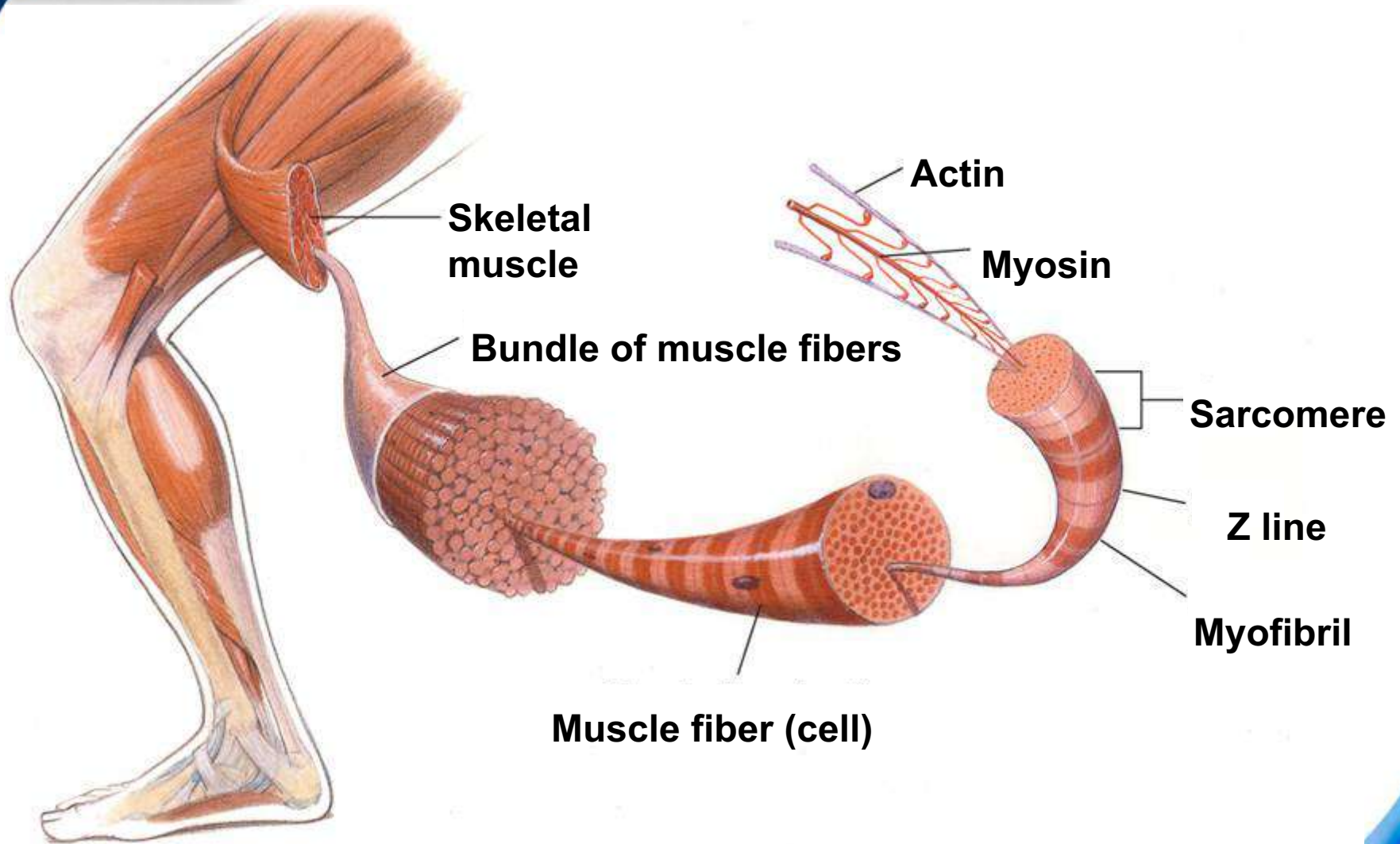
The thick filaments contain a protein called **myosin**.

The thin filaments contain a protein called **actin**.

Filaments are arranged along the muscle fiber in units called sarcomeres.

Sarcomeres are separated by regions called Z lines. When a muscle is relaxed, there are no thin filaments in the center of a sarcomere.

movie
click to start





–How do muscles contract?

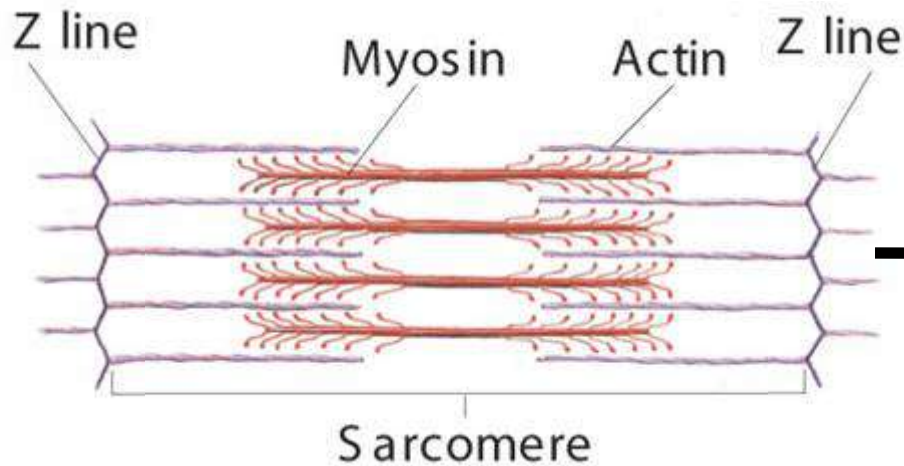


–A muscle contracts when the thin filaments in the muscle fiber slide over the thick filaments.

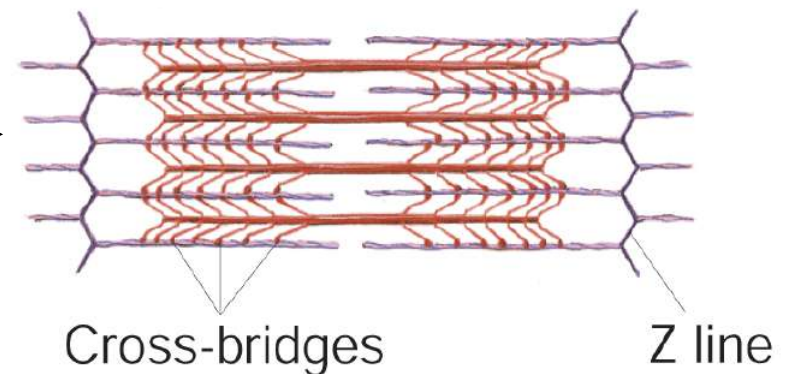
–This process is called the sliding filament model of muscle contraction.

During muscle contraction, the actin filaments slide over the myosin filaments, decreasing the distance between the Z lines.

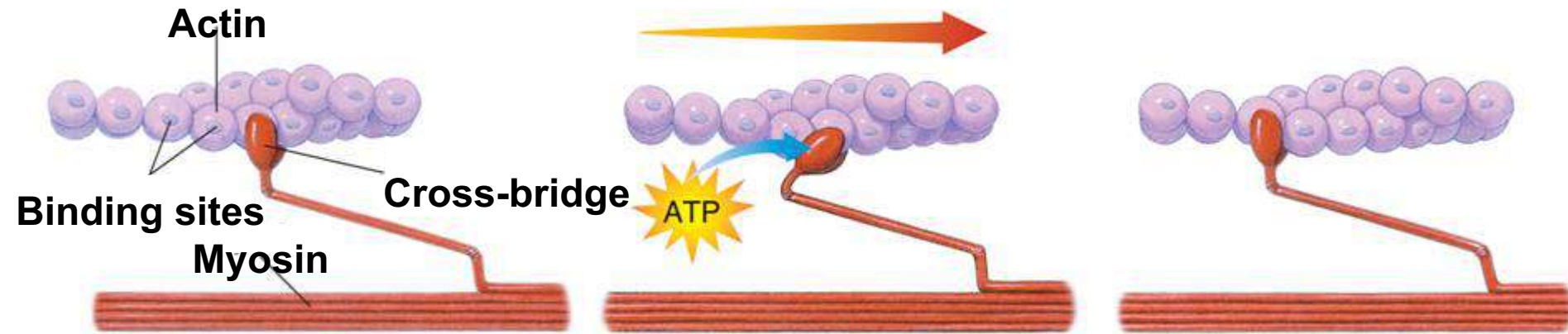
Relaxed Muscle



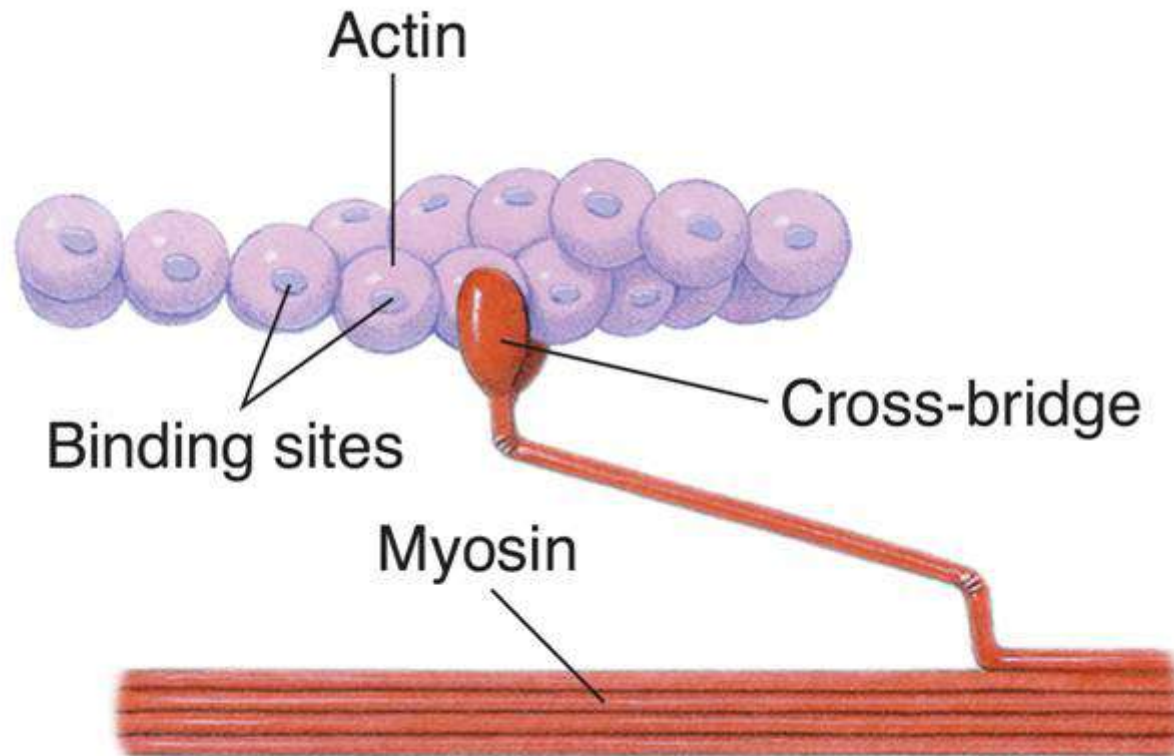
Contracted Muscle



Movement of Actin Filament

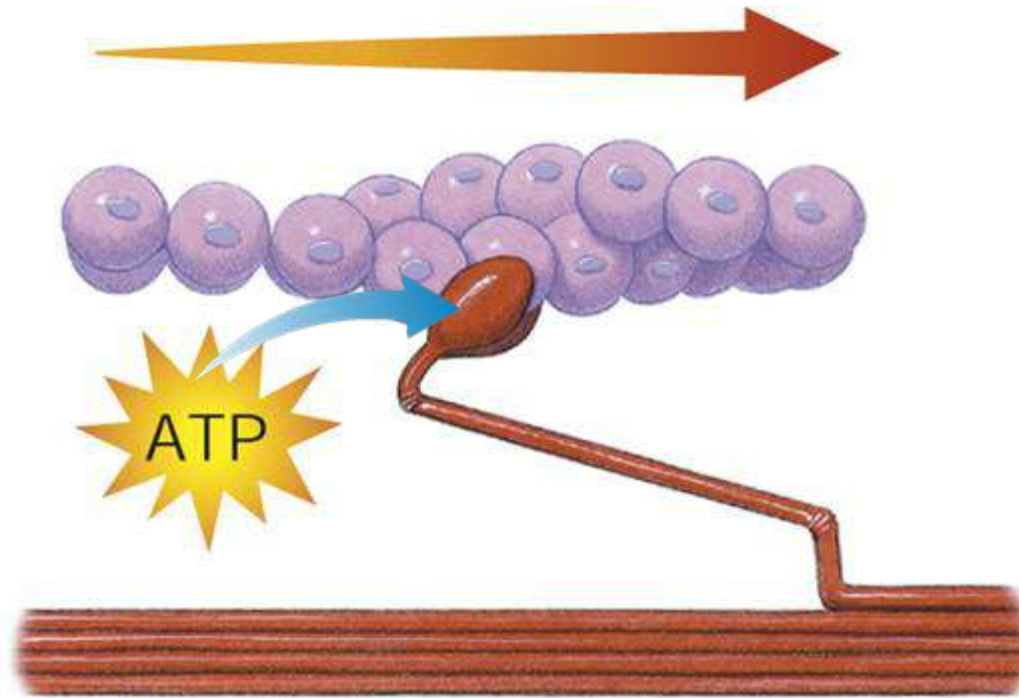


–During muscle contraction, the head of a myosin filament attaches to a binding site on actin, forming a cross-bridge.

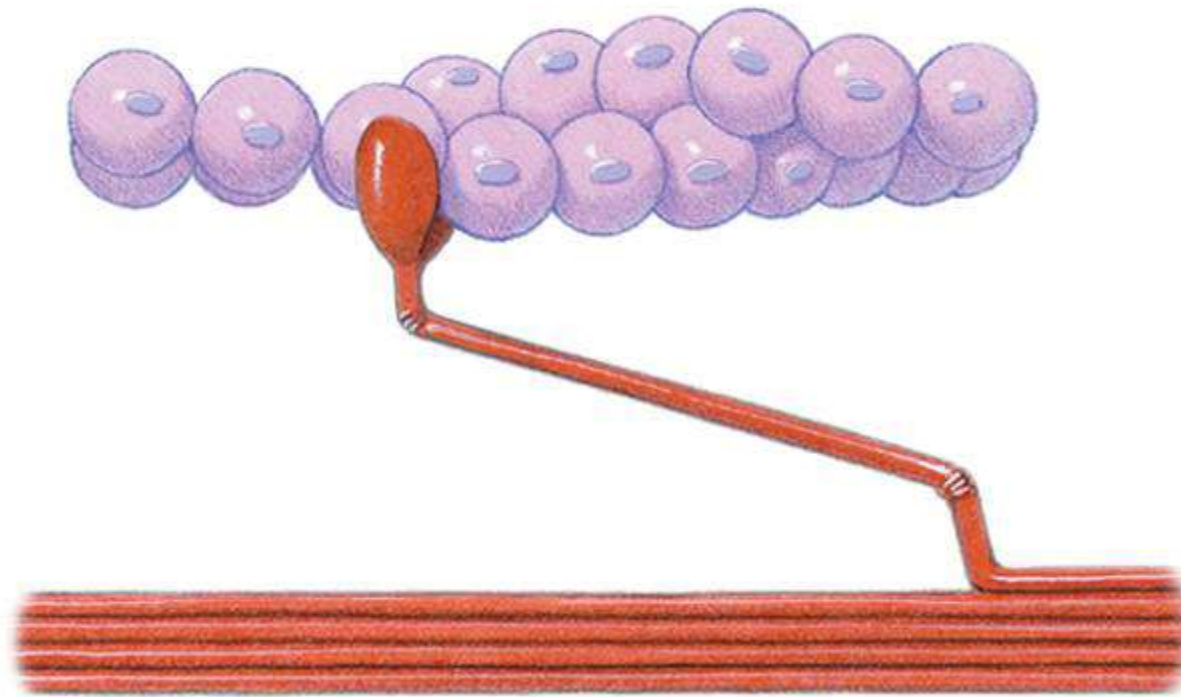


–Powered by ATP, the myosin cross-bridge changes shape and pulls the actin filament toward the center of the sarcomere.

Movement of Actin Filament



–The cross-bridge is broken, the myosin binds to another site on the actin filament, and the cycle begins again.



When many myosin cross-bridges change shape in a fraction of a second, the muscle fiber shortens with considerable force.

The energy for muscle contraction is supplied by ATP.

Control of Muscle Contraction

Impulses from motor neurons control the contraction of skeletal muscle fibers.

A **neuromuscular junction** is the point of contact between a motor neuron and a skeletal muscle cell.

Vesicles in the axon terminals of the motor neuron release a neurotransmitter called **acetylcholine**. Acetylcholine produce an impulse in the cell membrane of the muscle fiber.

The impulse causes the release of calcium ions within the fiber.

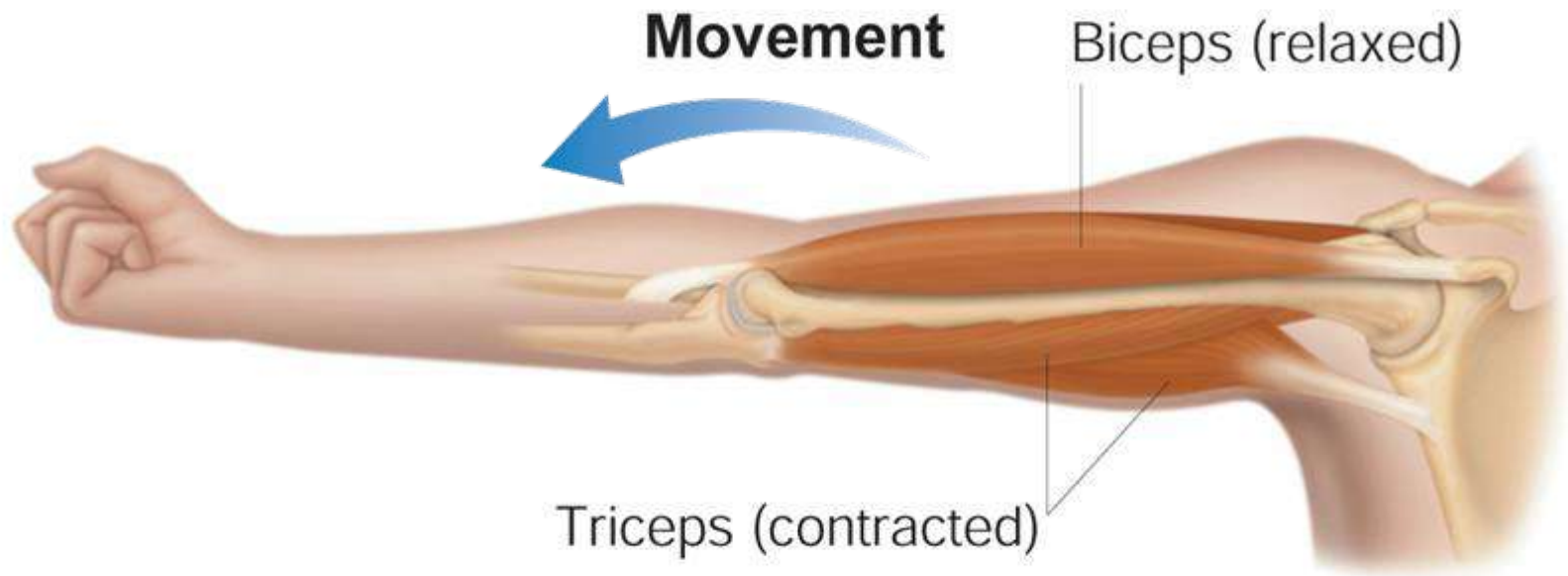
The calcium ions affect regulatory proteins that allow actin and myosin filaments to interact.

A muscle cell remains contracted until the release of acetylcholine stops and an enzyme produced at the axon terminal destroys any remaining acetylcholine. Then, the cell pumps calcium ions back into storage, the cross-bridges stop forming, and contraction ends.

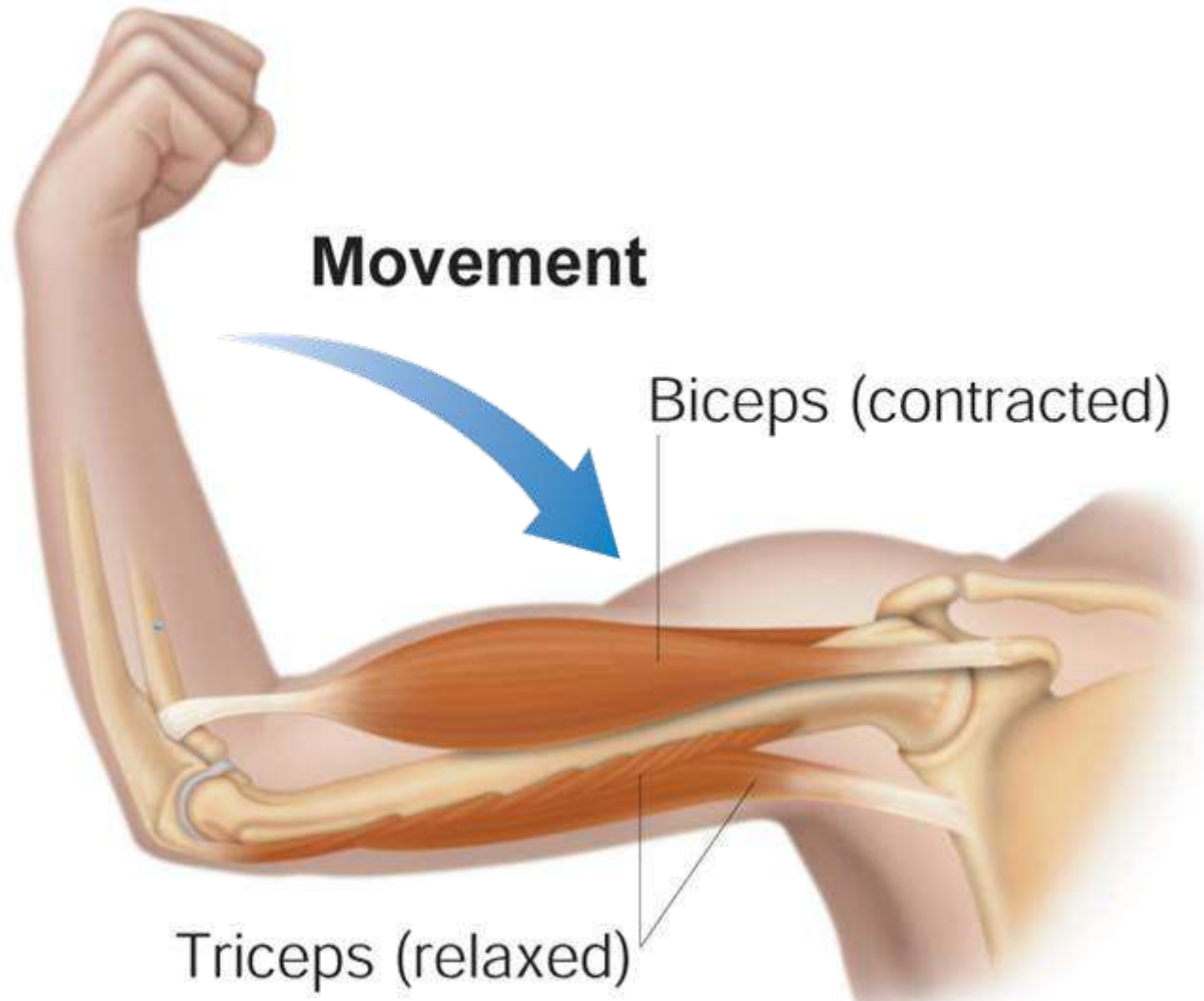
How Muscles and Bones Interact

Skeletal muscles are joined to bones by **tendons**.
Tendons pull on the bones so they work like levers.
The joint functions as a fulcrum.
The muscles provide the force to move the lever.

Opposing Muscles Contract and Relax



Opposing Muscles Contract and Relax



A controlled movement requires contraction by both muscles.