Muscular system

The muscular system is n [organ system](https://en.wikipedia.org/wiki/Organ_%28anatomy%29) consisting of [skeletal](https://en.wikipedia.org/wiki/Skeletal_muscle), [smooth](https://en.wikipedia.org/wiki/Smooth_muscle) and [cardiac](https://en.wikipedia.org/wiki/Cardiac_muscle) [muscles](https://en.wikipedia.org/wiki/Muscle). It permits movement of the body, maintains posture and circulates blood throughout the body.[[1]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:0-1) The muscular systems in [vertebrates](https://en.wikipedia.org/wiki/Vertebrate) are controlled through the [nervous system](https://en.wikipedia.org/wiki/Nervous_system) although some muscles (such as the [cardiac muscle](https://en.wikipedia.org/wiki/Cardiac_muscle)) can be completely autonomous. Together with the [skeletal system](https://en.wikipedia.org/wiki/Skeletal_system), it forms the [musculoskeletal system](https://en.wikipedia.org/wiki/Musculoskeletal_system), which is responsible for movement of the [human body](https://en.wikipedia.org/wiki/Human_body).[[2]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-2)



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Muscles

There are three distinct types of muscles: [skeletal muscles](https://en.wikipedia.org/wiki/Skeletal_muscle), [cardiac or heart muscles](https://en.wikipedia.org/wiki/Cardiac_muscle), and [smooth (non-striated) muscles](https://en.wikipedia.org/wiki/Smooth_muscle). Muscles provide strength, balance, posture, movement and heat for the body to keep warm.[[3]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:1-3)

**Skeletal muscle**

*Main article:*[*Skeletal muscle*](https://en.wikipedia.org/wiki/Skeletal_muscle)

*See also:*[*List of muscles of the human body*](https://en.wikipedia.org/wiki/List_of_muscles_of_the_human_body)

Skeletal muscles, like other [striated muscles](https://en.wikipedia.org/wiki/Striated_muscle), are composed of [myocytes](https://en.wikipedia.org/wiki/Myocytes%22%20%5Co%20%22Myocytes), or muscle fibers, which are in turn composed of [myofibrils](https://en.wikipedia.org/wiki/Myofibrils), which are composed of [sarcomeres](https://en.wikipedia.org/wiki/Sarcomere%22%20%5Co%20%22Sarcomere), the basic building block of striated muscle tissue. Upon stimulation by an [action potential](https://en.wikipedia.org/wiki/Action_potential), skeletal muscles perform a coordinated contraction by shortening each sarcomere. The best proposed model for understanding contraction is the [sliding filament model](https://en.wikipedia.org/wiki/Sliding_filament_model) of muscle contraction. Within the sarcomere, [actin](https://en.wikipedia.org/wiki/Actin%22%20%5Co%20%22Actin) and [myosin](https://en.wikipedia.org/wiki/Myosin) fibers overlap in a contractile motion towards each other. Myosin filaments have club-shaped heads that project toward the actin filaments.[[1]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:0-1)[[3]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:1-3)[[4]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:2-4)

Larger structures along the myosin filament called myosin heads are used to provide attachment points on binding sites for the actin filaments. The myosin heads move in a coordinated style; they swivel toward the center of the sarcomere, detach and then reattach to the nearest active site of the actin filament. This is called a ratchet type drive system.[[4]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:2-4)

This process consumes large amounts of [adenosine triphosphate](https://en.wikipedia.org/wiki/Adenosine_triphosphate) (ATP), the energy source of the cell. ATP binds to the cross bridges between myosin heads and actin filaments. The release of energy powers the swiveling of the myosin head. When ATP is used, it becomes [adenosine diphosphate](https://en.wikipedia.org/wiki/Adenosine_diphosphate) (ADP), and since muscles store little ATP, they must continuously replace the discharged ADP with ATP. Muscle tissue also contains a stored supply of a fast acting recharge chemical, [creatine phosphate](https://en.wikipedia.org/wiki/Creatine_phosphate%22%20%5Co%20%22Creatine%20phosphate), which when necessary can assist with the rapid regeneration of ADP into ATP.[[5]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:3-5)

[Calcium ions](https://en.wikipedia.org/wiki/Calcium_ions) are required for each cycle of the sarcomere. Calcium is released from the [sarcoplasmic reticulum](https://en.wikipedia.org/wiki/Sarcoplasmic_reticulum%22%20%5Co%20%22Sarcoplasmic%20reticulum) into the [sarcomere](https://en.wikipedia.org/wiki/Sarcomere%22%20%5Co%20%22Sarcomere) when a muscle is stimulated to contract. This calcium uncovers the actin binding sites. When the muscle no longer needs to contract, the calcium ions are pumped from the sarcomere and back into storage in the [sarcoplasmic reticulum](https://en.wikipedia.org/wiki/Sarcoplasmic_reticulum%22%20%5Co%20%22Sarcoplasmic%20reticulum).[[4]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:2-4)

There are approximately 639 skeletal muscles in the human body.

Skeletal muscles, viewed from the front

Skeletal muscles, viewed from the back

**Cardiac muscle**

*Main article:*[*Heart muscle*](https://en.wikipedia.org/wiki/Heart_muscle)

Heart muscles are distinct from skeletal muscles because the [muscle fibers](https://en.wikipedia.org/wiki/Muscle_fibers) are laterally connected to each other. Furthermore, just as with smooth muscles, their movement is involuntary. Heart muscles are controlled by the [sinus node](https://en.wikipedia.org/wiki/Sinus_node) influenced by the [autonomic nervous system](https://en.wikipedia.org/wiki/Autonomic_nervous_system).[[1]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:0-1)[[3]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:1-3)

**Smooth muscle**

*Main article:*[*Smooth muscle*](https://en.wikipedia.org/wiki/Smooth_muscle)

Smooth muscles are controlled directly by the [autonomic nervous system](https://en.wikipedia.org/wiki/Autonomic_nervous_system) and are involuntary, meaning that they are incapable of being moved by conscious thought.[[1]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:0-1) Functions such as heartbeat and lungs (which are capable of being willingly controlled, be it to a limited extent) are involuntary muscles but are not smooth muscles.

Physiology

**Contraction**

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|  | This section **does not**[**cite**](https://en.wikipedia.org/wiki/Wikipedia%3ACiting_sources)**any**[**sources**](https://en.wikipedia.org/wiki/Wikipedia%3AVerifiability). Please help [improve this section](https://en.wikipedia.org/w/index.php?title=Muscular_system&action=edit) by [adding citations to reliable sources](https://en.wikipedia.org/wiki/Help%3AReferencing_for_beginners). Unsourced material may be challenged and [removed](https://en.wikipedia.org/wiki/Wikipedia%3AVerifiability#Burden_of_evidence). *(October 2016) (*[*Learn how and when to remove this template message*](https://en.wikipedia.org/wiki/Help%3AMaintenance_template_removal)*)* |

[Neuromuscular junctions](https://en.wikipedia.org/wiki/Neuromuscular_junctions) are the focal point where a [motor neuron](https://en.wikipedia.org/wiki/Motor_neuron) attaches to a muscle. Acetylcholine, (a [neurotransmitter](https://en.wikipedia.org/wiki/Neurotransmitter) used in skeletal muscle contraction) is released from the axon terminal of the nerve cell when an action potential reaches the microscopic junction called a [synapse](https://en.wikipedia.org/wiki/Synapse). A group of chemical messengers cross the synapse and stimulate the formation of electrical changes, which are produced in the muscle cell when the acetylcholine binds to receptors on its surface. Calcium is released from its storage area in the cell's sarcoplasmic reticulum. An impulse from a nerve cell causes calcium release and brings about a single, short [muscle contraction](https://en.wikipedia.org/wiki/Muscle_contraction) called a [muscle twitch](https://en.wikipedia.org/wiki/Muscle_twitch). If there is a problem at the neuromuscular junction, a very prolonged contraction may occur, such as the muscle contractions that result from [tetanus](https://en.wikipedia.org/wiki/Tetanus). Also, a loss of function at the junction can produce [paralysis](https://en.wikipedia.org/wiki/Paralysis).[[4]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:2-4)

Skeletal muscles are organized into hundreds of [motor units](https://en.wikipedia.org/wiki/Motor_unit), each of which involves a motor neuron, attached by a series of thin finger-like structures called [axon terminals](https://en.wikipedia.org/wiki/Chemical_synapse#Anatomy_and_physiology). These attach to and control discrete bundles of muscle fibers. A coordinated and fine tuned response to a specific circumstance will involve controlling the precise number of motor units used. While individual muscle units contract as a unit, the entire muscle can contract on a predetermined basis due to the structure of the motor unit. Motor unit coordination, balance, and control frequently come under the direction of the [cerebellum](https://en.wikipedia.org/wiki/Cerebellum) of the brain. This allows for complex muscular coordination with little conscious effort, such as when one drives a car without thinking about the process.[[4]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:2-4)[[6]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-6)

**Tendon**

*Main article:*[*Tendon*](https://en.wikipedia.org/wiki/Tendon)

A tendon is a piece of connective tissue that connects a muscle to a bone.[[7]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-7) When a muscle contracts, it pulls against the skeleton to create movement. A tendon connects this muscle to a bone, making this function possible.

**Aerobic and anaerobic muscle activity**

At rest, the body produces the majority of its [ATP](https://en.wikipedia.org/wiki/Adenosine_triphosphate) aerobically in the [mitochondria](https://en.wikipedia.org/wiki/Mitochondria)[[8]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-8) without producing [lactic acid](https://en.wikipedia.org/wiki/Lactic_acid) or other fatiguing byproducts. During exercise, the method of ATP production varies depending on the fitness of the individual as well as the duration and intensity of exercise. At lower activity levels, when exercise continues for a long duration (several minutes or longer), energy is produced aerobically by combining oxygen with [carbohydrates](https://en.wikipedia.org/wiki/Carbohydrate) and [fats](https://en.wikipedia.org/wiki/Fat) stored in the body.[[5]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:3-5)[[9]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-9)

During activity that is higher in intensity, with possible duration decreasing as intensity increases, ATP production can switch to anaerobic pathways, such as the use of the [creatine phosphate](https://en.wikipedia.org/wiki/Phosphocreatine%22%20%5Co%20%22Phosphocreatine) and the phosphagen system or anaerobic [glycolysis](https://en.wikipedia.org/wiki/Glycolysis%22%20%5Co%20%22Glycolysis). Aerobic ATP production is biochemically much slower and can only be used for long-duration, low-intensity exercise, but produces no fatiguing waste products that can not be removed immediately from the [sarcomere](https://en.wikipedia.org/wiki/Sarcomere%22%20%5Co%20%22Sarcomere) and the body, and it results in a much greater number of ATP molecules per fat or carbohydrate molecule. Aerobic training allows the oxygen delivery system to be more efficient, allowing aerobic metabolism to begin quicker. Anaerobic ATP production produces ATP much faster and allows near-maximal intensity exercise, but also produces significant amounts of [lactic acid](https://en.wikipedia.org/wiki/Lactic_acid) which renders high-intensity exercise unsustainable for more than several minutes. The phosphagen system is also anaerobic. It allows for the highest levels of exercise intensity, but intramuscular stores of [phosphocreatine](https://en.wikipedia.org/wiki/Phosphocreatine%22%20%5Co%20%22Phosphocreatine) are very limited and can only provide energy for exercises lasting up to ten seconds. Recovery is very quick, with full creatine stores regenerated within five minutes.[[5]](https://en.wikipedia.org/wiki/Muscular_system#cite_note-:3-5)