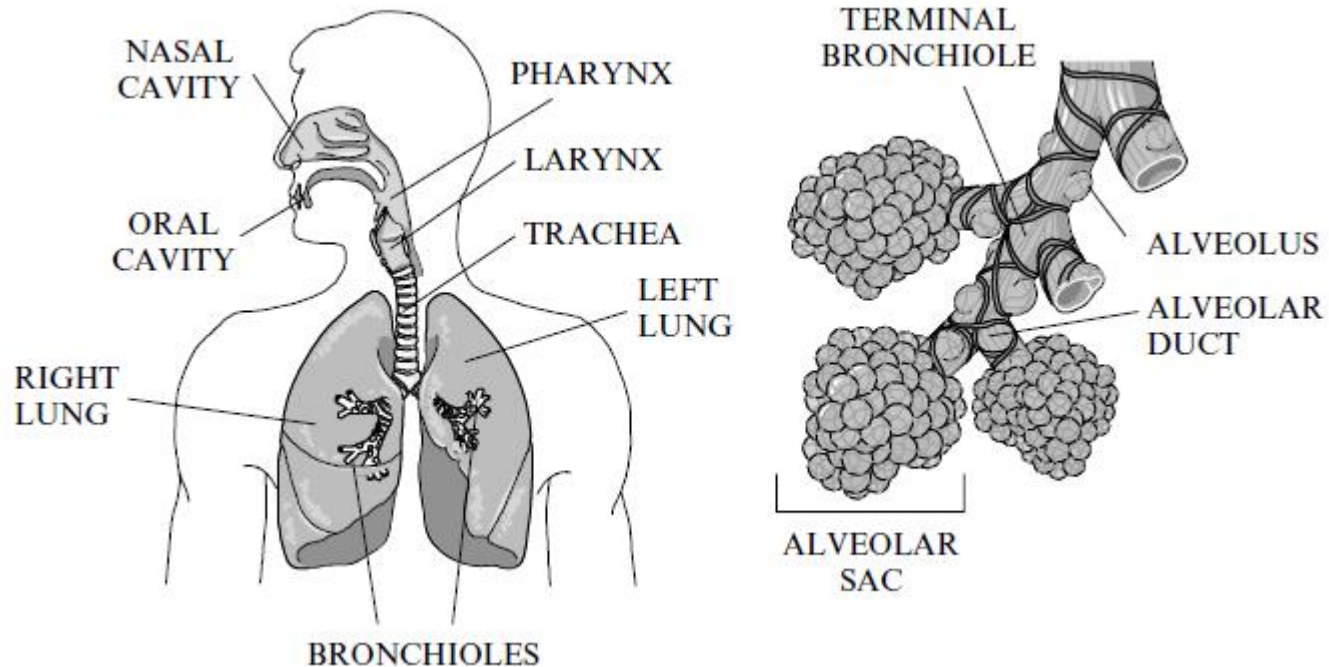
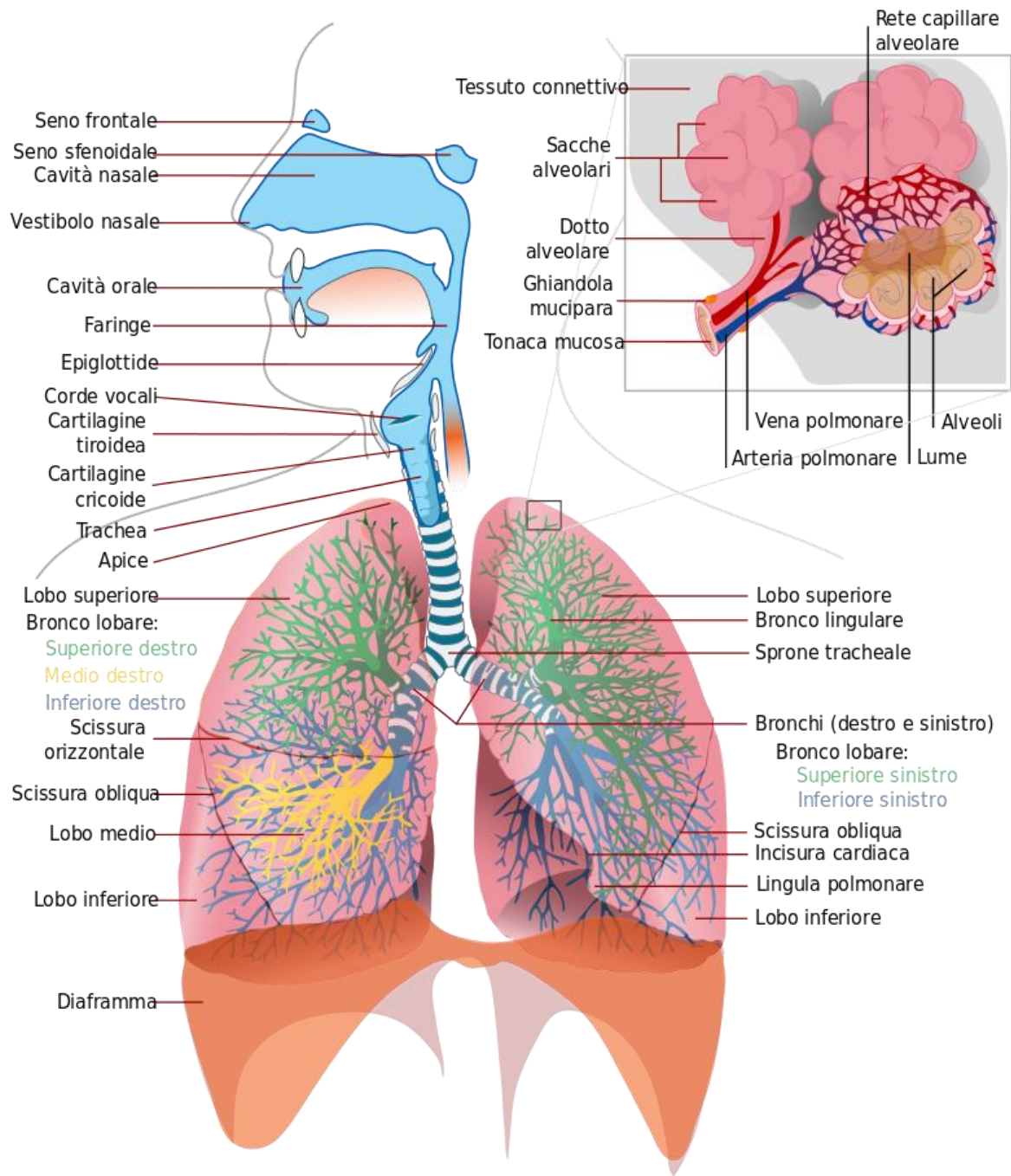


Respiratory System

The respiratory system moves air to and from the gas exchange surfaces in the body where diffusion can occur between air and the circulating blood. It includes the **conduction** zone and the **respiratory** zone.





In **the conduction zone** (mouth, nose, sinuses, pharynx, trachea, bronchi, and bronchioles), the air that enters the body is warmed, humidified, filtered, and cleaned. Mucus is secreted by cells in the conduction zone and **traps small particles** ($> 6 \mu\text{m}$) before they can reach the respiratory zone.

1

The respiratory zone, consisting of respiratory bronchioles with outpouchings of alveoli and terminal clusters of alveolar sacs, is where gas exchange between air and blood occurs. The respiratory zone comprises most of the mass of the lungs.

2

Breathing, or ventilation, is the mechanical process by which air is moved into (inspiration) and out of (expiration) the lungs.

A normal adult takes about 15 to 20 breaths per minute.

During inspiration, the inspiratory muscles contract and enlarge the thoracic cavity, the portion of the body where the lungs are located. This causes the alveoli to enlarge and the alveolar gas to expand. As the alveolar gas expands, the partial pressure within the respiratory system drops below atmospheric pressure by about **3mm Hg** so that air easily flows in (Boyle's Law).

During expiration, the inspiratory muscles relax and return the thoracic cavity to its original volume. Since the volume of the gas inside the respiratory system has decreased, its pressure increases to a value that is about **3mm Hg** above atmospheric pressure. Air now moves out of the lungs and into the atmosphere.

Lung capacities contain two or more volumes.

The tidal volume (TV) is the amount of air that moves in and out of the lungs during normal breathing.

The total lung capacity (TLC) is the amount of gas contained within the lungs at the end of a maximum inspiration.

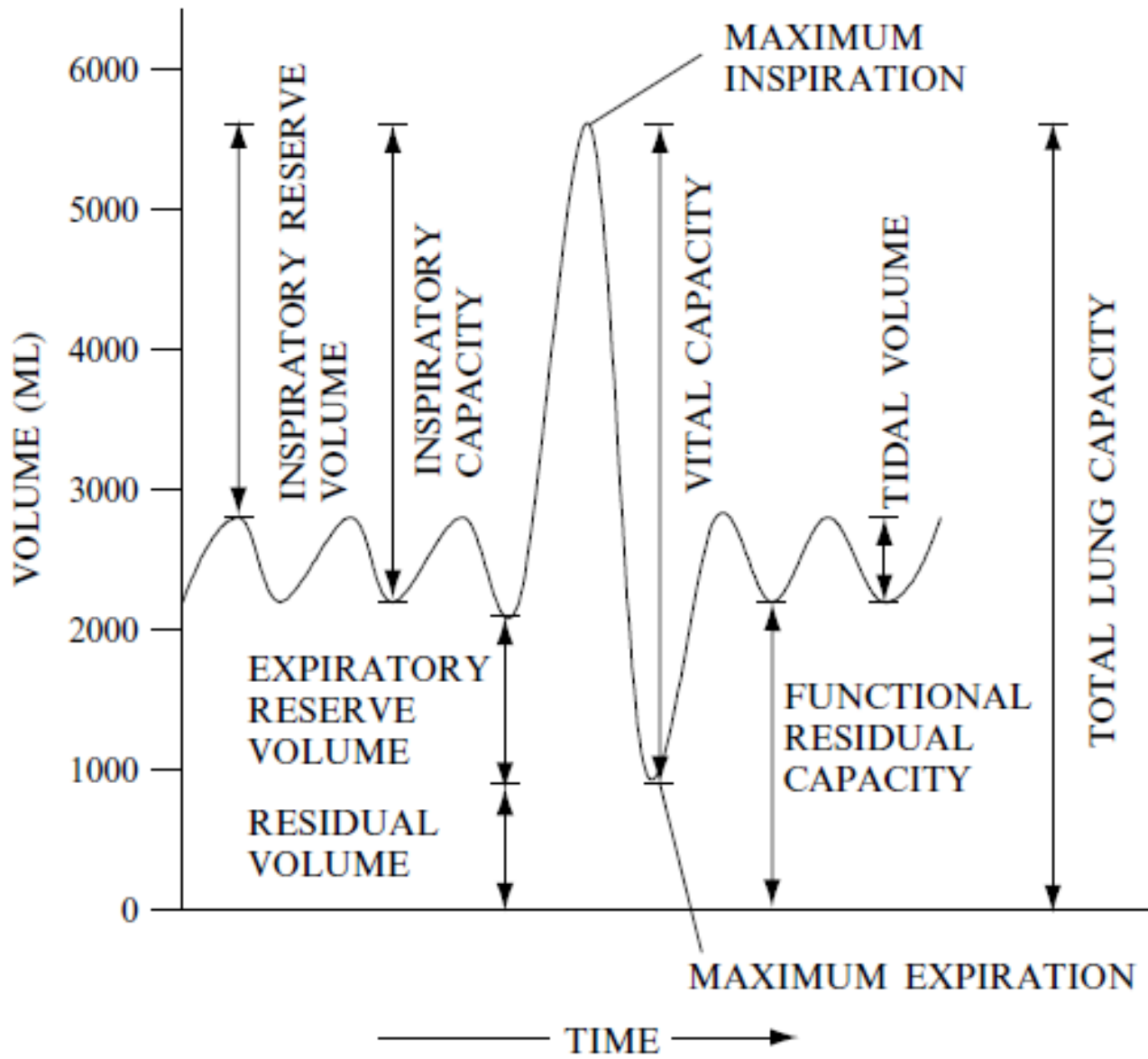
The vital capacity (VC) is the maximum amount of air that can be exhaled from the lungs after inspiration to TLC.

The residual volume (RV) is the amount of gas remaining in the lungs after maximum exhalation.

The amount of gas that can be inhaled after inhaling during tidal breathing is called the **inspiratory reserve volume** (IRV).

The amount of gas that can be expelled by a maximal exhalation after exhaling during tidal breathing is called the **expiratory reserve volume** (ERV).

The **inspiratory capacity** (IC) is the maximum amount of gas that can be inspired after a normal exhalation during tidal breathing, and the **functional residual capacity** (FRC) is the amount of gas that remains in the lungs at this time.



The **TLC** can be measured using the gas dilution technique.

In this method, patients inspire to TLC from a gas mixture containing a known amount of an inert tracer gas such as helium.

During this time, the inert gas becomes evenly distributed throughout the lungs and airways.

Due to conservation of mass, the product of initial tracer gas concentration times the amount inhaled equals the product of final tracer gas concentration (which is measured during expiration) times the TLC.

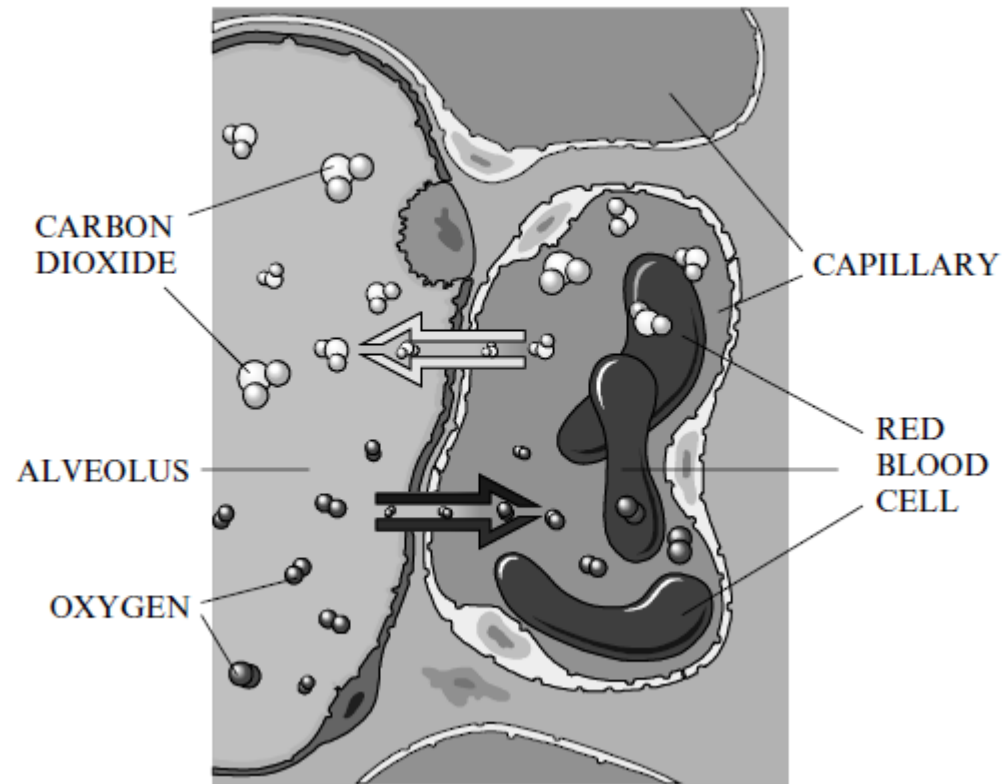
External respiration occurs in the lungs when gases are exchanged between the blood and the alveoli.

Each adult lung contains about **3.5 10^8 alveoli**, which results in a large surface area (**60 – 70m²**) for gas exchange to occur.

Each alveolus is only one cell layer thick, making the air-blood barrier only two cells thick (an alveolar cell and a capillary endothelial cell) which is about 2 μm .

The partial pressure of oxygen in the alveoli is higher than the partial pressure of oxygen in the blood so oxygen moves from the alveoli into the blood.

The partial pressure of carbon dioxide in the alveoli is lower than the partial pressure of carbon dioxide in the blood so carbon dioxide moves from the blood into the alveoli.



During internal respiration, carbon dioxide and oxygen move between the blood and the extracellular fluid surrounding the body's cells. The direction and rate of movement of a gas depend on the **partial pressures of the gas in the blood and the extracellular fluid, the surface area available for diffusion, the thickness of the membrane that the gas must pass through, and a diffusion constant that is related to the solubility and molecular weight of the gas.**

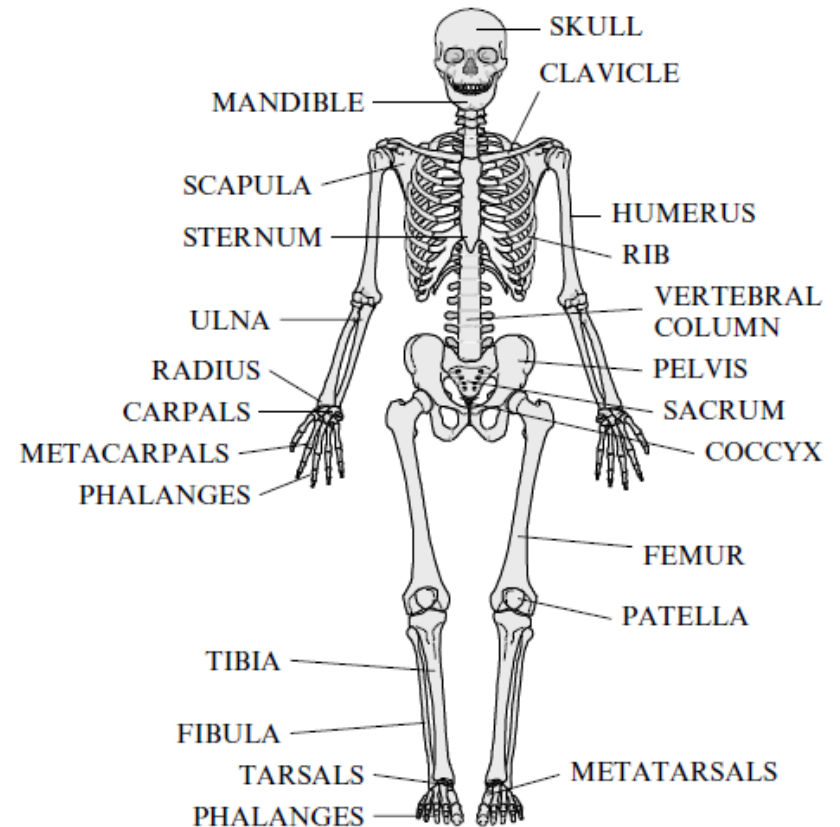
Skeletal System

The average adult skeleton contains **206 bones**, but the actual number varies from person to person and decreases with age as some bones become fused.

The skeletal system is divided into two parts: the **axial** skeleton and the **appendicular** skeleton.

The axial skeleton contains 80 bones (skull, hyoid bone, vertebral column, and thoracic cage), whereas the appendicular skeleton contains 126 (pectoral and pelvic girdles and upper and lower extremities).

The skeletal system protects and supports the body, helps with movement, **produces blood cells**, and stores important minerals.



Bones are classified as **long**, **short**, **flat**, or **irregular** according to their shape.

Long bones, such as the femur and humerus, are longer than they are wide.

Short bones, such as those found in the ankle and wrist, are as broad as they are long.

Flat bones, such as the sternum and the bones of the skull, have a relatively thin and flattened shape.

Irregular bones do not fit into the other categories and include the bones of the vertebral column and the pelvis.

Bones make up about 18% of the mass of the body and have a density of **1.9 g cm³**. There are two types of bone: spongy and compact (cortical). Spongy bone forms the ends (epiphyses) of the long bones and the interior of other bones and is quite porous.

Compact bone forms the shaft (diaphysis) and outer covering of bones and has a tensile strength of **120N/mm²**, compressive strength of **170N/mm²**, and Young's modulus of **1.8×10⁴N/mm²**. The medullary cavity, a hollow space inside the diaphysis, is filled with fatty, yellow marrow or red marrow that contains blood-forming cells.

The bones of the skeletal system are attached to each other at **fibrous, cartilaginous, or synovial joints**.

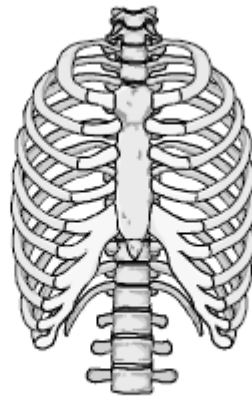
The articulating bones of fibrous joints are bound tightly together by fibrous connective tissue. These joints can be rigid and relatively immovable to slightly movable. This type of joint includes the suture joints in the skull.

Cartilage holds together the bones in cartilaginous joints. These joints allow limited motion in response to twisting or compression and include the joints of the vertebral system and the joints that attach the ribs to the vertebral column and to the sternum.

Synovial joints, such as the knee, are the most complex and varied and have fluid-filled joint cavities, cartilage that covers the articulating bones, and ligaments that help hold the joints together.



a

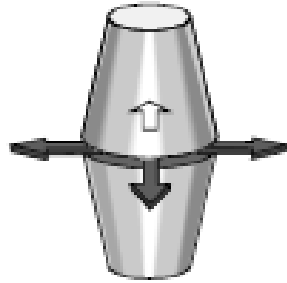


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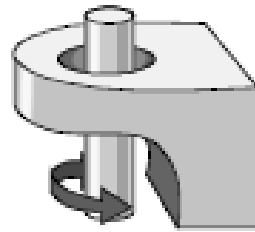


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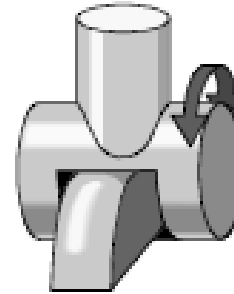
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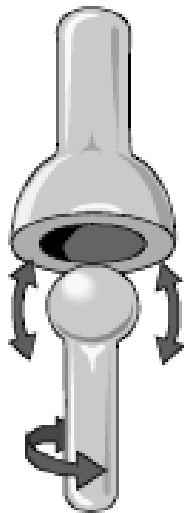
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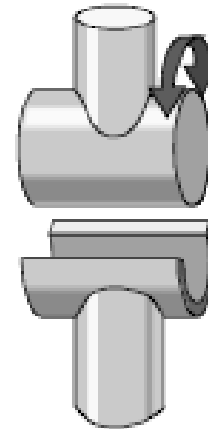
BALL-AND-SOCKET



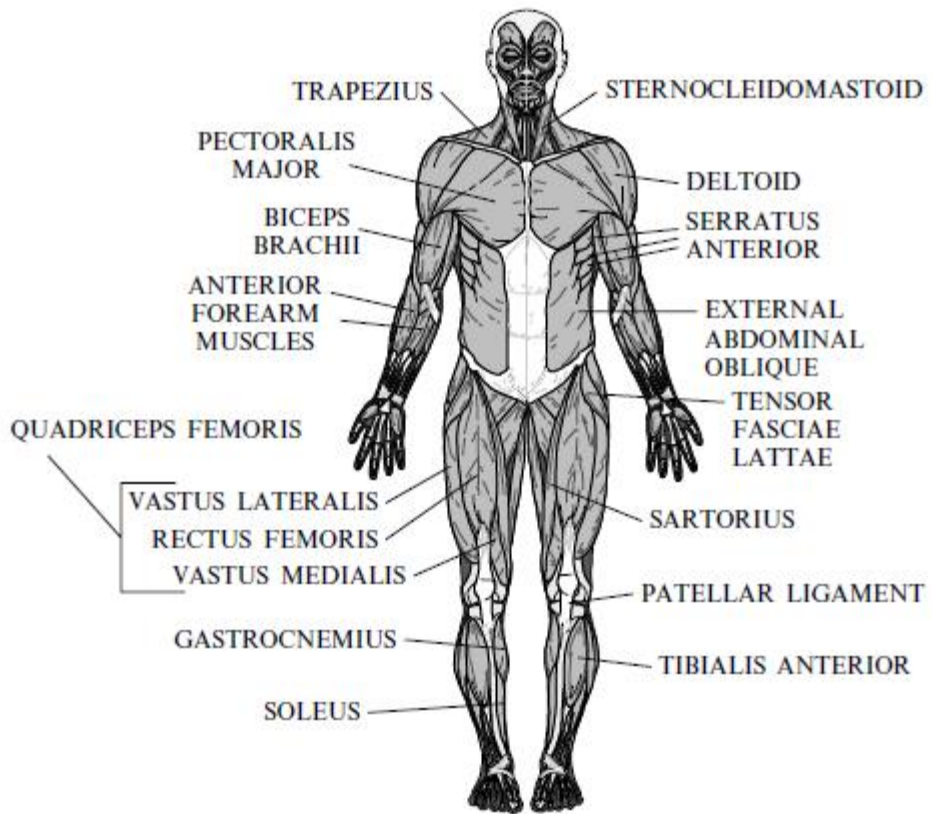
CONDYLOID



HINGE



Muscular System



The skeletal muscles in the muscular system maintain posture, generate heat to maintain the body's temperature, and provide the driving force that is used to move the bones and joints of the body and the skin of the face.

Muscles that play a major role in accomplishing a movement are called prime movers, or **agonists**.

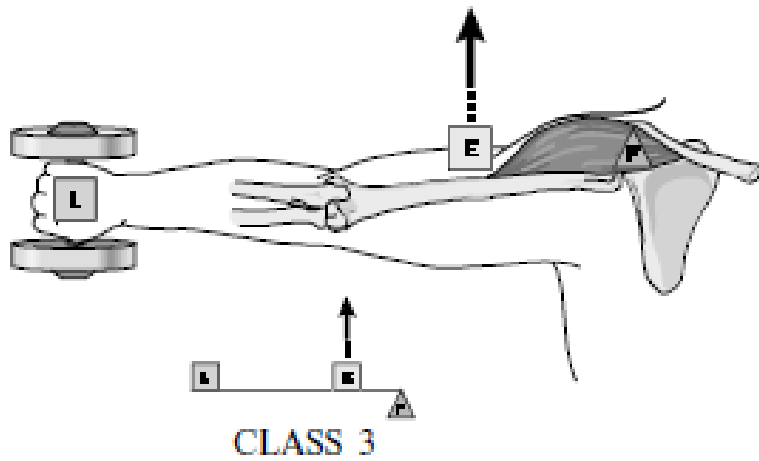
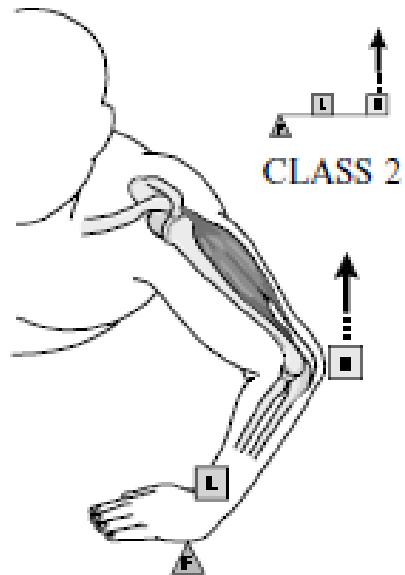
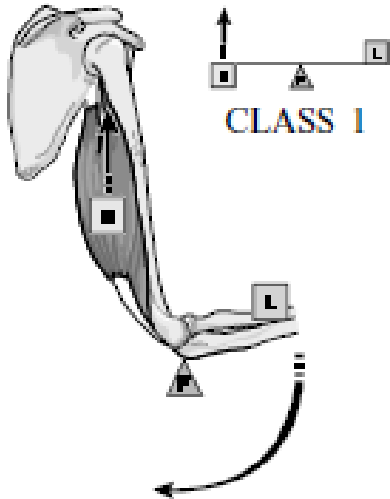
Muscles that act in opposition to a prime mover are called **antagonists**, whereas muscles that assist a prime mover in producing a movement are called **synergists**.

The **continual contraction** of some skeletal muscles helps maintain the body's **posture**. If all of these muscles relax, which happens when a person faints, the person collapses.

A system of levers, which consist of rigid lever arms that pivot around fixed points, is used to move skeletal muscle.

Two forces act on every lever: the weight to be moved (i.e., the resistance to be overcome) and the pull or effort applied (i.e., the applied force).

Bones act as lever arms and joints provide a fulcrum. The resistance to be overcome is the weight of the body part that is moved and the applied force is generated by the contraction of a muscle or muscles at the insertion, the point of attachment of a muscle to the bone it moves.

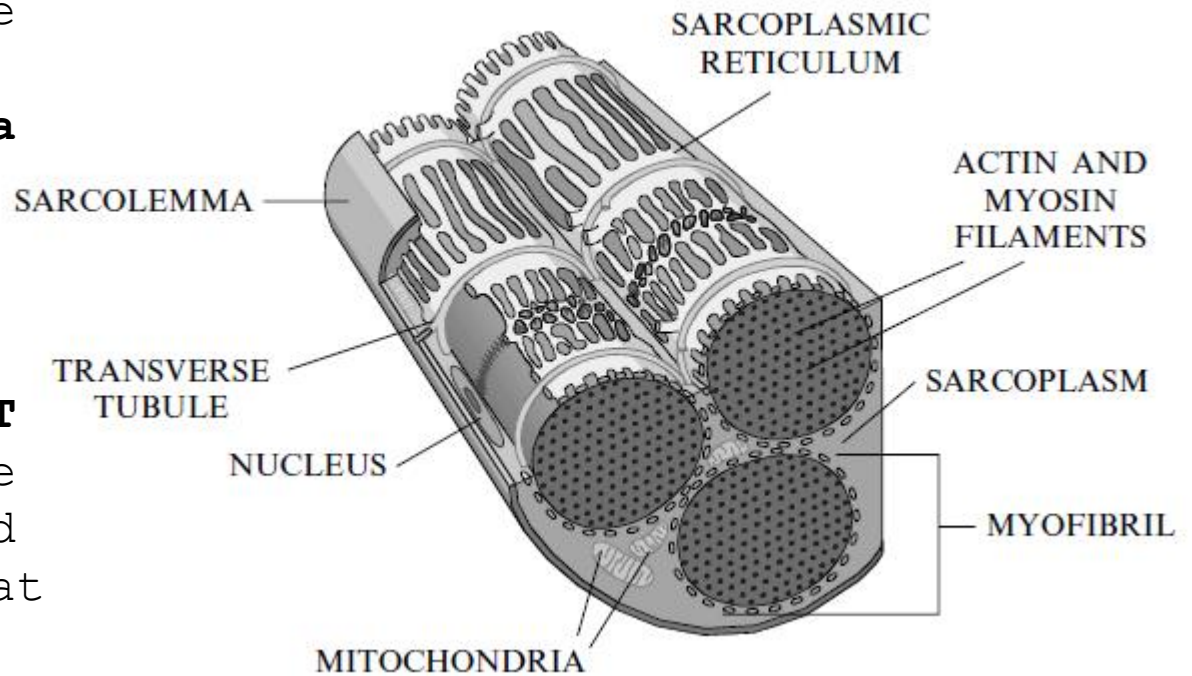


In muscle fibers, the plasma membrane is called the **sarcolemma** and the cytoplasm is called the **sarcoplasm**.

Transverse tubules (**T tubules**) begin at the sarcolemma and extend into the sarcoplasm at right angles to the surface of the sarcolemma.

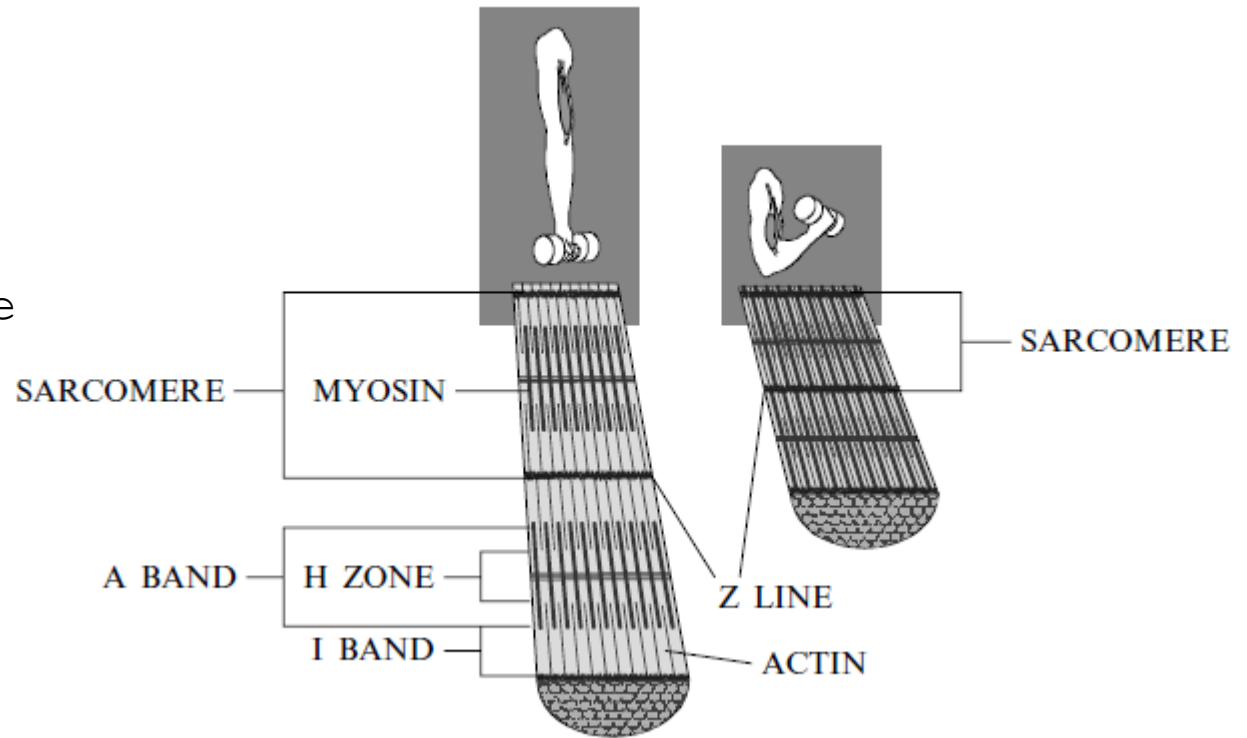
The T tubules, which play a role in coordinating contraction, are filled with extracellular fluid and form passageways through the muscle fiber.

They make close contact with expanded chambers, cisternae, of the sarcoplasmic reticulum, a specialized form of the ER.



The sarcoplasm contains cylinders: myofibrils.

The myofibrils are responsible for muscle fiber contraction.

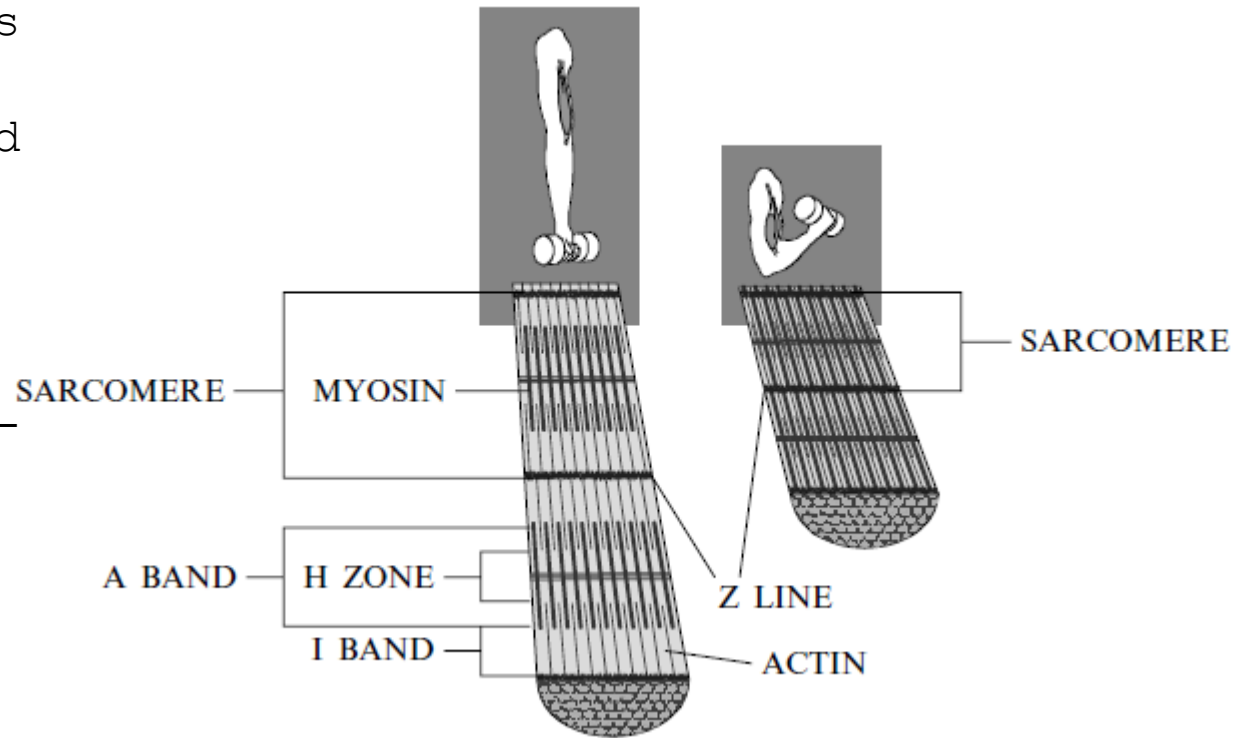


Myofilaments—protein filaments consisting of primarily actin and myosin make up myofibrils.

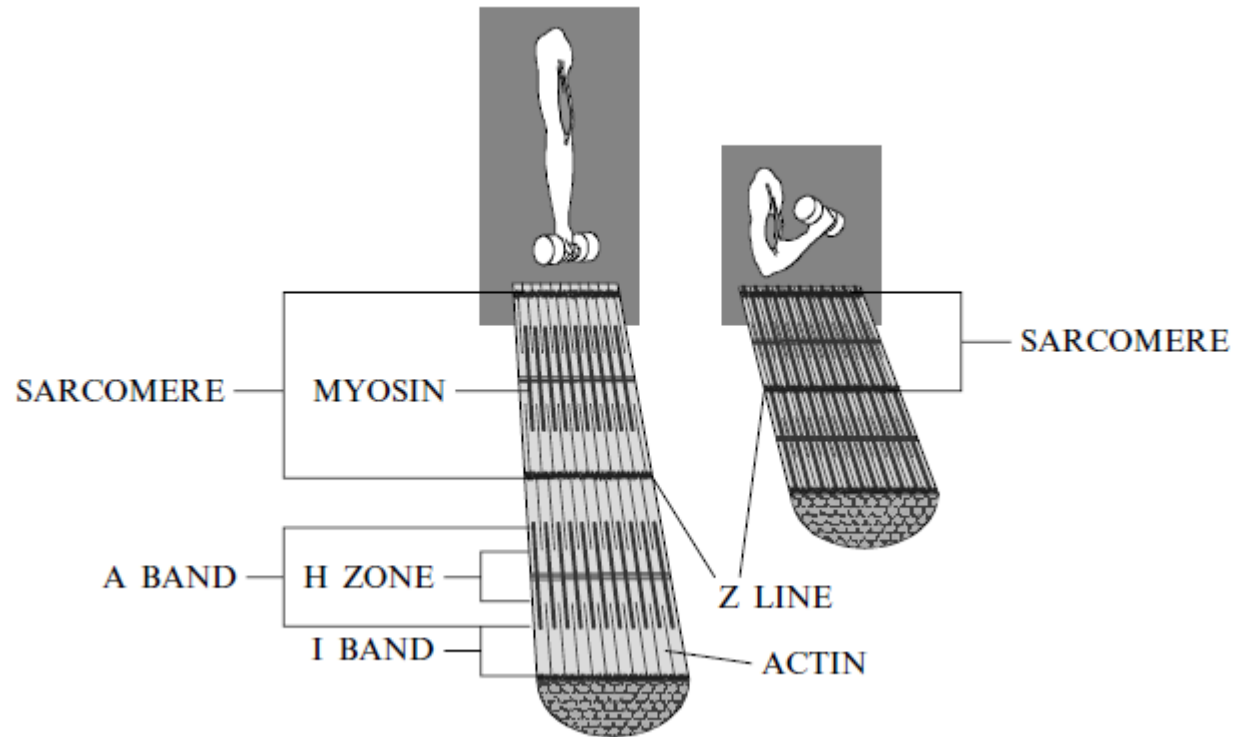
Repeating functional units of myofilaments are called sarcomeres.

The sarcomere is the smallest functional unit of the muscle fiber.

The thin filaments are attached to dark bands, called Z lines, which form the ends of each sarcomere. Thick filaments containing double-headed myosin molecules lie between the thin ones.



It is this overlap of thin and thick filaments that gives skeletal muscle its banded, striated appearance. The I band is the area in a relaxed muscle fiber that just contains actin filaments, whereas the H zone is the area that just contains myosin filaments. The H zone and the area in which the actin and myosin overlap form the A band.



The sliding filament mechanism, is driven by ATP energy and results in shortening of the muscle. Shortening of the muscle components (contraction) results in bringing the muscle's attachments (e.g., bones) closer together

1. Muscle fibers have connections with **nerves**
2. **Sensory nerve endings**
3. **motor nerve endings** receive impulses from the brain and spinal cord that lead to excitation and contraction of the muscle
4. **Each motor axon** branches and supplies several muscle fibers
5. When the nerve is stimulated, **vesicles in the axon terminals** release a **neurotransmitter**, Acetylcholine
6. Acetylcholine diffuses across the **synapse** and binds to receptors of the **sarcolemma**
7. This causes the **sodium channels** in the sarcolemma to open up, and an **action potential** is produced in the muscle fiber
8. The resulting action potential triggers a sudden massive **release of calcium**
9. **Calcium** triggers the production of active sites on the thin filaments so that crossbridges with myosin can form and **contraction** occurs