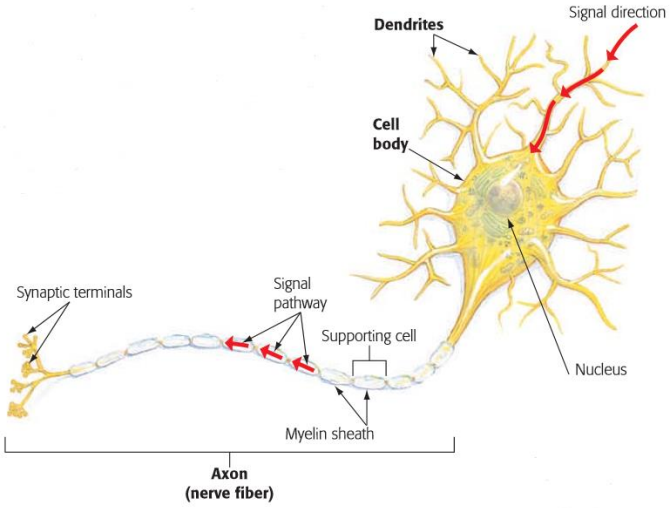
# Review

## Chapter 27. Nervous, sensory, and locomotor systems

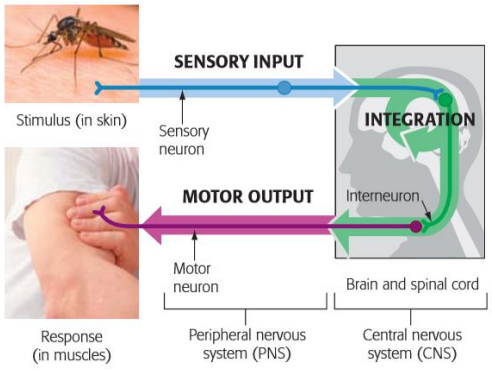
### An overview of animal nervous systems

Nervous system forms a communication and coordination network throughout an animal's body.

- **Neurons (神经元):** Nerve cells that carry electrical signals from one part of the body to another.




  - ✧ **Dendrites (树突):** It receives incoming messages from other neurons and convey this information toward the cell body.
  - ✧ **Cell body:** It houses the nucleus and other organelles.
  - ✧ **Axon (nerve fiber: 轴突):** It transmits signals toward a receiving cell.
  - ✧ **Synaptic terminal (突触末梢):** It relays signals to a receiving cell.
  - ✧ **Myelin sheath (髓鞘):** A chain of bead-like supporting cells that wrap around and insulate nerves.
- **Organization of nervous systems**
  - ✧ **The central nervous system (CNS 中枢神经系统):** It consists of the brain and spinal cord.
  - ✧ **The peripheral nervous system (PNS 外围神经系统 ):** It made up mostly of nerves in the rest of the body that carry signals into and out of the CNS.

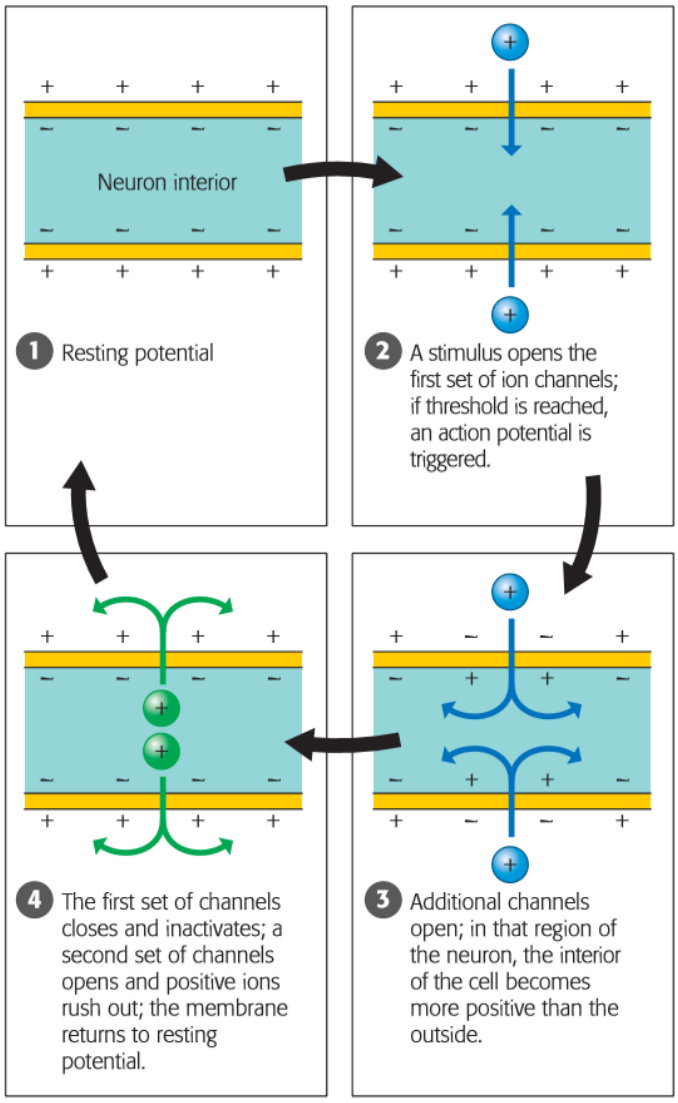


**(1) Sensory input (感官输入):** The process of sending signals from external or internal stimuli to the CNS. → **Sensory neurons (感觉神经元)**: Nerve cells located in the PNS that convey information about a stimulus to the CNS.

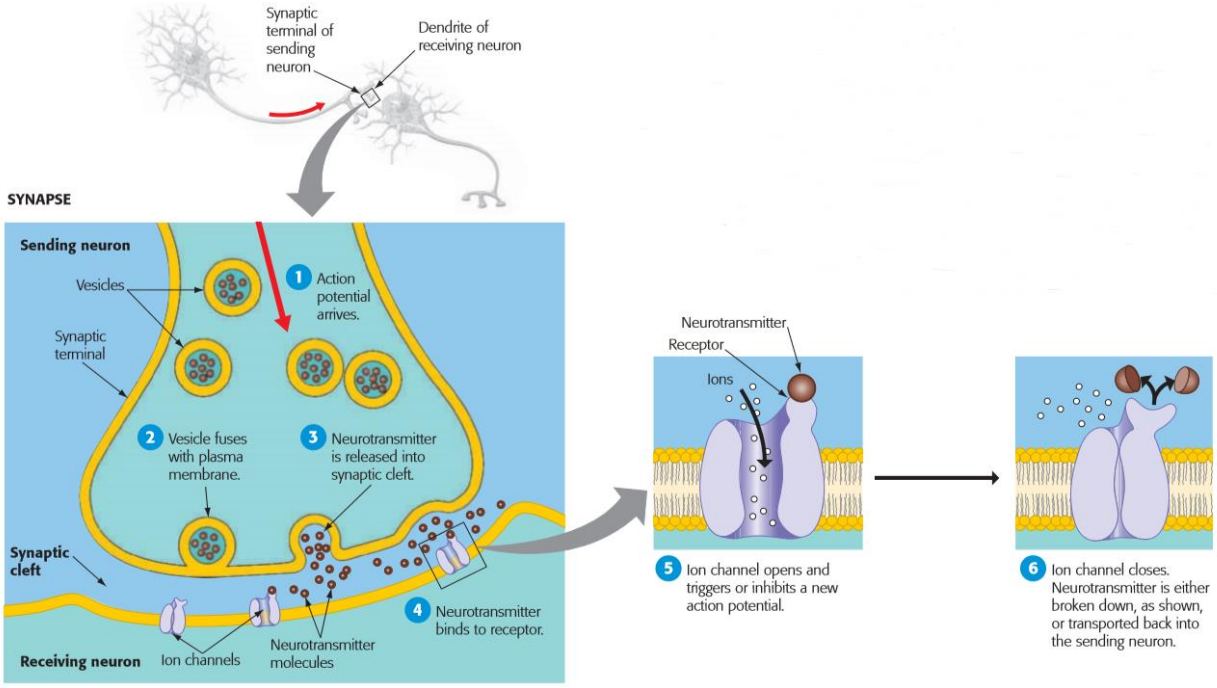
**(2) Integration:** Sensory signals are interpreted and appropriate responses are planned. → **Interneurons (中间神经元):** Nerve cells located in the CNS that integrate the sensory input.

**(3) Motor output (动作输出):** The sending of signals from the CNS to the PNS that result in the body's response. → **Motor neurons (运动神经元):** Nerve cells that carry output signals to muscles and glands of the body.

- **Sending a signal through a neuron**
  - ✧ **Resting potential:** The difference in charge (voltage) that exists across the plasma membrane of a resting neuron. Positively charged outside and negatively charged inside.
  - ✧ **Action potential:** A nerve signal that carries information along a neuron. The signal is actually a self-propagating change in the voltage across the plasma membrane.
  - ✧ **Propagation of the signal**

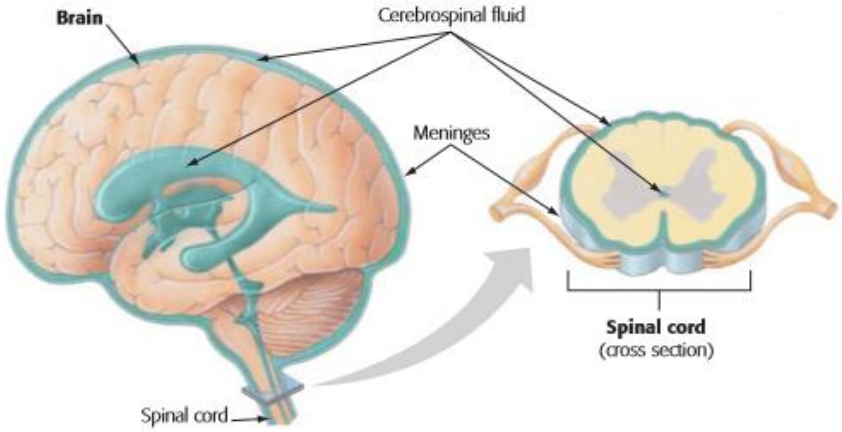


- **Passing a signal from a neuron to a receiving cell**
  - ✧ **Synapse (突触):** A relay point between a neuron and a receiving cell.
  - ✧ **Electrical synapse:** Electrical currents pass directly from one neuron to the next and provide very rapid responses.
  - ✧ **Chemical synapse:** Synaptic cleft (突触间隙) + neurotransmitter (神经递质)
    **Synaptic cleft:** A narrow gap that separating the synaptic terminal of the sending neuron from the receiving cell.
    **Neurotransmitter:** A chemical "messenger" that carries information from a nerve cell to a receiving cell.

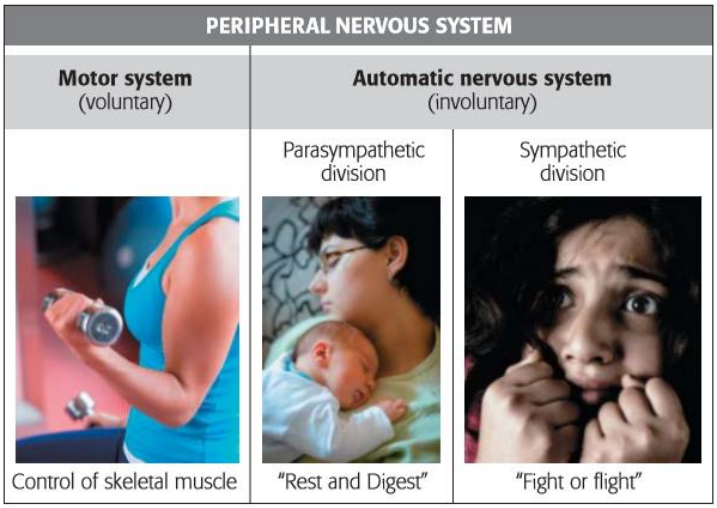



## The human nervous system

- **The central nervous system**
  - ✧ **Brain:** It functions as the master control center for the nervous system, integrating data from the sense organs and sending out commands from motor control centers.
  - ✧ **Spinal cord (脊髓):** A bundle of nerve fibers running through the bony spinal column, acting as a communication conduit between the brain and the rest of the body.
  - ✧ **Cerebrospinal fluid (脑脊液):** The fluid surrounding the brain and spinal cord. It supplies nutrients and hormones to the CNS and carries away wastes, before draining into the veins.
  - ✧ **Meninges (脑膜):** Layers of connective tissue the protecting the brain and spinal cord.




- **The peripheral nervous system**
  - ✧ **Motor system:** It carries signals to skeletal muscles, mainly in response to external stimuli.
  - ✧ **Autonomic system:** It regulates the internal environment by controlling smooth and cardiac muscles and the glands of several body systems.
    **Parasympathetic division (副交感神经部分):** It primes the body for activities that gain and conserve energy for the body.
    **Sympathetic division (交感神经部分):** It tends to have the opposite effect, preparing the body for intense, energy-consuming activities.



- **The human brain**

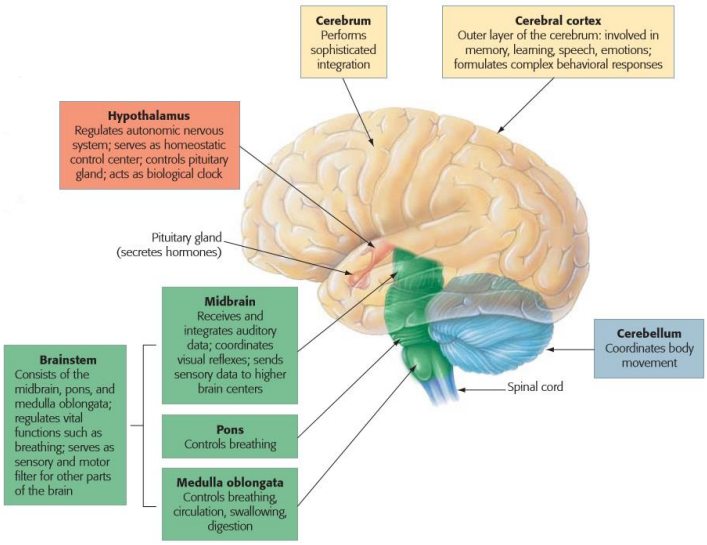
  **Four major areas of the brain:** the brainstem (脑干), the cerebellum (小脑), the hypothalamus (下丘脑), the cerebrum (大脑)

  **(1) Brainstem:** The core of the brain, and it receives and sends information to other major regions. It regulates some very vital and basic functions, including breathing and consciousness. Structures of the brainstem, including the medulla oblongata, the pons, and the midbrain.

  **(2) Cerebellum:** It serves as a planning center for body movements. Individuals who have damage to their cerebellum often have trouble with coordinated movements.

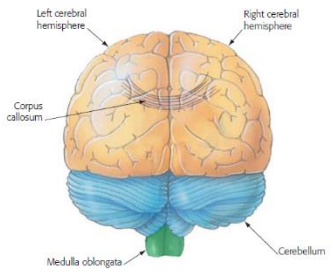
  **(3) Hypothalamus:** It regulates the autonomic nervous system and controls the secretion of hormones from the pituitary gland and other organs. The functions of the hypothalamus affect body temperature, blood pressure, hunger, thirst, sex drive, and the fight-or-flight response. The hypothalamus also helps us experience emotions, such as rage and pleasure.

  **(4) Cerebrum:** The largest and most sophisticated part of our brain. The outer layer of the cerebrum, the **cerebral cortex (大脑皮层)**, is a thin, highly folded ("wrinkled") layer of tissue that accounts for over 80% of the total brain mass yet is thinner than the width of a pencil.

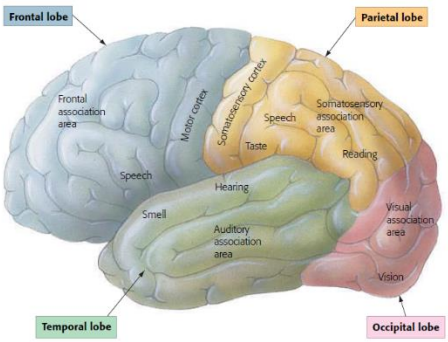



- **The cerebral cortex:**

  ✧ It is divided into right and left hemispheres. Each half receives information from and controls the movement of the opposite side of the body. The **corpus callosum (胼胝体)**, a thick cable of nerve fibers, bridges the two sides and enables them to process information together.



- ✧ **The cerebral cortex have four major lobes:** the frontal (额叶), parietal (顶叶), temporal (颞叶), and occipital lobes (枕叶)



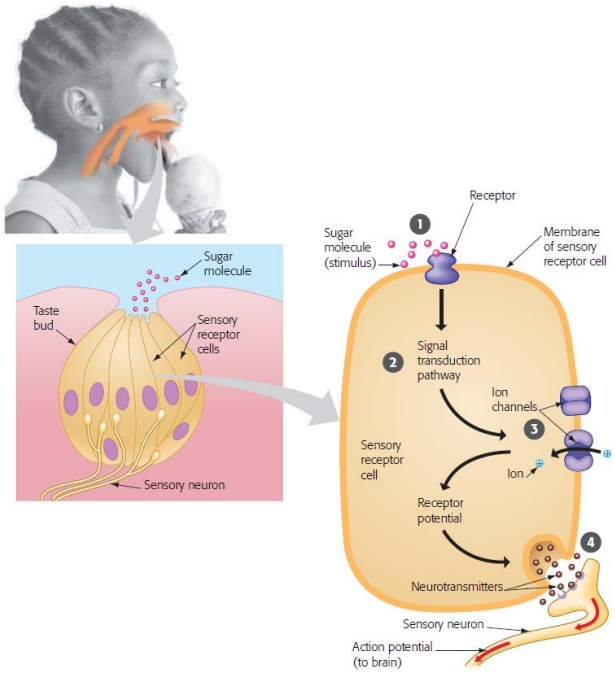

- **Neuroplasticity (神经可塑性):** The ability of the brain to reorganize its neural connections.
- **Neurological disorders:**
  - ✧ **Alzheimer's disease (阿尔兹海默症, 老年痴呆症):** A form of mental deterioration, or dementia, characterized by confusion, memory loss, and a variety of other symptoms. One particularly common characteristic of Alzheimer's disease is the loss of neurons in the temporal lobe.
  - ✧ **Chronic traumatic encephalopathy (CTE 慢性创伤性脑部病变)**: CTE is caused by repeated brain trauma, particularly concussions. The frontal lobe and temporal lobes show significant deterioration.
  - ✧ **Depressive illness**: People with **major depression (抑郁症)** may experience sadness, loss of interest in pleasurable activities, changes in body weight and sleep patterns, and suicidal thoughts. Major depression is extreme and persistent, leaving the sufferer unable to live a normal life. **Bipolar disorder (躁郁症)**, or manic-depressive disorder, involves extreme mood swings. The manic phase is characterized by high self-esteem, increased energy, a flood of thoughts and ideas, as well as behaviors that often involve increased risk taking. The depressive phase is marked by sleep disturbances, feelings of worthlessness, and decreased ability to experience pleasure.

## The senses

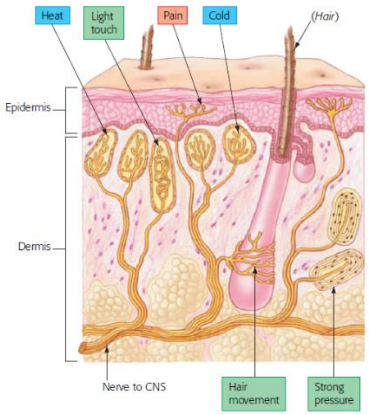
- **Sensory input**
  - ✧ **Converting a stimulus to an electrical signal**

(1) When the sugar molecules first come into contact with the taste bud, they bind to membrane receptors of the sensory receptor cells.
(2) This binding triggers a signal transduction pathway
(3) that causes some ion channels in the membrane to close and others to open. Changes in the flow of ions ( + ) alter the membrane potential. This change in membrane potential is called the receptor potential. In contrast to action potentials, which are all-or-none phenomena, receptor potentials vary in intensity; the stronger the stimulus (the more sugar present), the stronger the receptor potential.
(4) each receptor cell forms a synapse with a sensory neuron. When there are enough sugar molecules, a strong receptor potential is triggered. This receptor potential

makes the receptor cell release enough neurotransmitter to increase the rate (frequency) of action potential generation in the sensory neuron (more action potentials in a given time). The brain interprets the intensity of the stimulus from the rate at which it receives action potentials. It gains additional information about stimulus intensity by keeping track of how many sensory neurons it receives signals from.




- ✧ **Sensory adaptation:** The tendency of some sensory receptors to become less sensitive when they are stimulated repeatedly. When receptors become less sensitive, they trigger fewer action potentials, causing the brain to receive fewer stimuli. Sensory adaptation keeps the body from continuously reacting to normal background stimuli. Without it, our nervous system would become overloaded with unnecessary information.
- ✧ **Types of Sensory Receptors:** pain receptors, thermoreceptors (sensors for heat and cold), mechanoreceptors (sensors for touch, pressure, motion, and sound), chemoreceptors (sensors for chemicals), and electromagnetic receptors (sensors for energy such as light and electricity).



(1) **Pain receptors** may respond to excessive heat or pressure or to chemicals released from damaged or inflamed tissues.

(2) **Thermoreceptors** in the skin detect either heat or cold. Other temperature sensors located deep in the body monitor the temperature of the blood. The body's major thermostat is the hypothalamus. Receiving action potentials both from surface sensors and from deep sensors, the hypothalamus keeps a mammal's or bird's body temperature within a narrow range.

(3) **Mechanoreceptors** are highly diverse. Different types are stimulated by different forms of mechanical energy, such as touch and pressure, stretching, motion, and sound. All these forces produce their effects by bending or stretching the plasma membrane of a receptor cell. When the membrane changes shape, it becomes more permeable to positive ions, and the mechanical energy of the stimulus is transduced into a receptor potential.

(4) **Chemoreceptors** include the sensory cells in your nose and taste buds, which are attuned to chemicals in the external environment, as well as some internal receptors that detect chemicals in your body's internal environment.

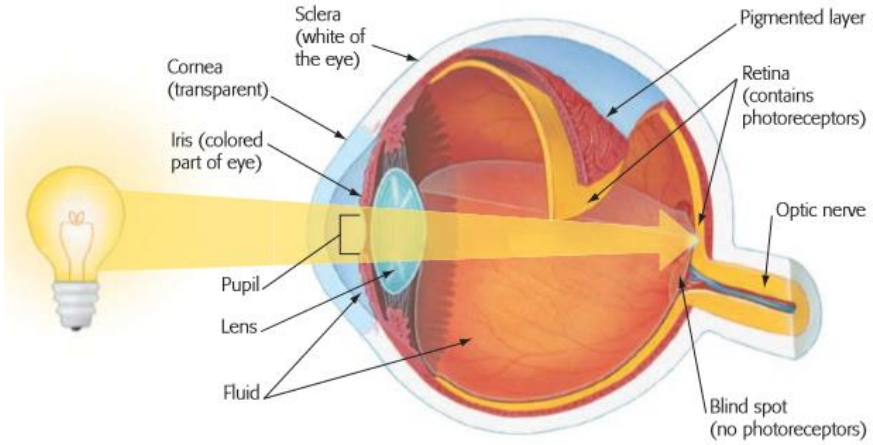
(5) **Electromagnetic receptors** are sensitive to energy of various wavelengths, which takes such forms as magnetism and light.

✧ **Five human senses:** hearing, smell, taste, touch, and vision.

- **Vision**

The human eye is a remarkable sense organ, able to detect a multitude of colors, form images of objects both near and far, and respond to minute amounts of light energy.

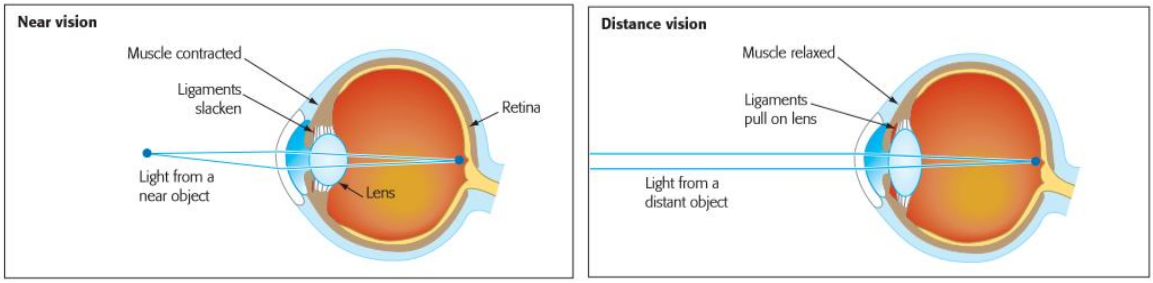
✧ **Lighting the Retina**




retina: 视网膜　　sclera: 巩膜　　cornea: 角膜　　iris: 虹膜

pupil：瞳孔　　lens: 晶状体　　optic nerve: 视神经　　blind spot: 盲区

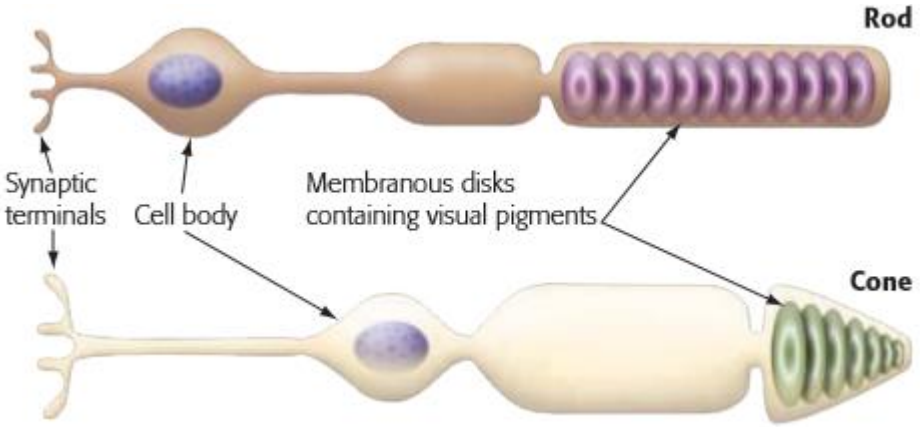
✧ **How the lens of the eye focuses light**



✧ **Photoreceptors**

**(1) Rods (视杆细胞):** Extremely sensitive to light and enable us to see in dim light, though only in shades of gray. Rods contain a visual pigment called rhodopsin, which absorbs dim light well.

**(2) Cones (视锥细胞):** Stimulated by bright light and can distinguish color but contribute little to night vision. Cones contain visual pigments called photopsins, which absorb colored, bright light. There have three types of cones, each containing a different type of photopsin that absorbs blue, green, or red light. Colorblindness (色盲) results from defects in genes producing proteins involved in one or more types of cones.

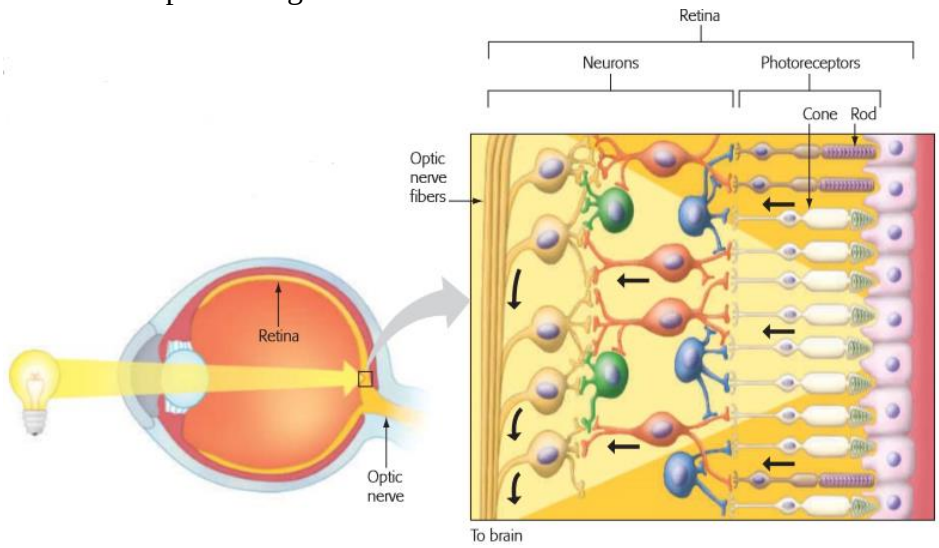



✧ **Photoreceptors stimulated by light transmit electrical signals to the optic nerve**

(1) As photoreceptors absorb light, rhodopsin and photopsin change chemically, and the change alters the permeability of the cell's membrane.

(2) The resulting receptor potentials trigger a complex integration process that begins in the retina. Other retinal neurons start to integrate the receptor potentials and in doing so produce action potentials.

(3) These action potentials (arrows in the figure) travel along the optic nerve, which connects the retina with the brain. The optic nerve carries the partly integrated information into the brain. Three- dimensional perceptions (what we actually see) result from further integration in several processing centers of the cerebral cortex.

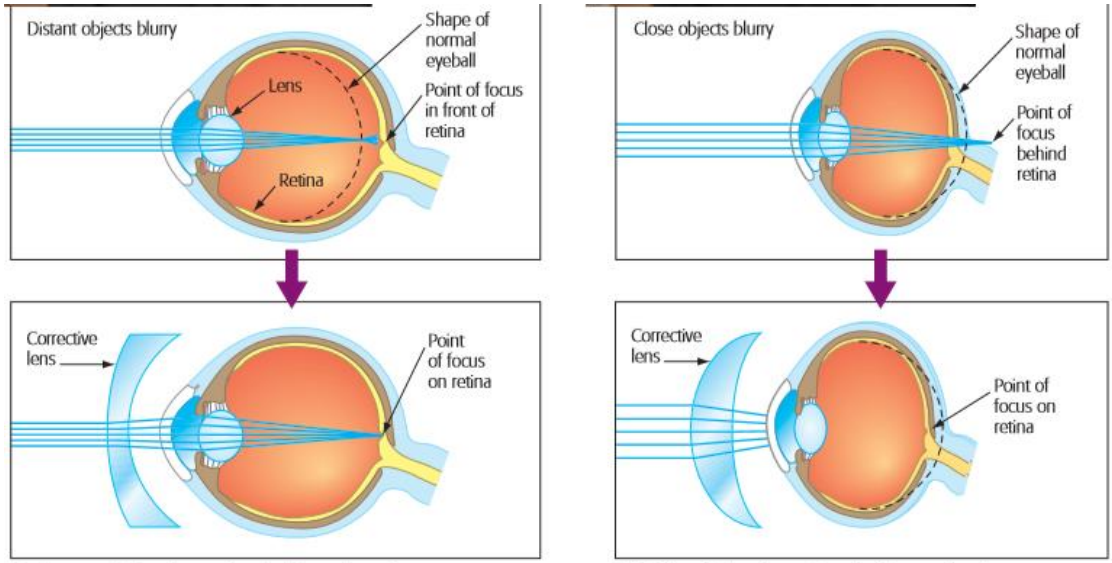


✧ **Vision Problems and Corrections**

**(1) Nearsightedness:** People with nearsightedness cannot focus well on distant objects, although they can see well at short distances. A nearsighted eyeball is longer than normal, and it focuses distant objects in front of the retina instead of on it.

**(2) Farsightedness:** People with farsighted can see distant objects normally, but they can't focus on close objects. Farsightedness occurs when the eyeball is shorter than normal, causing the lens to focus images behind the retina

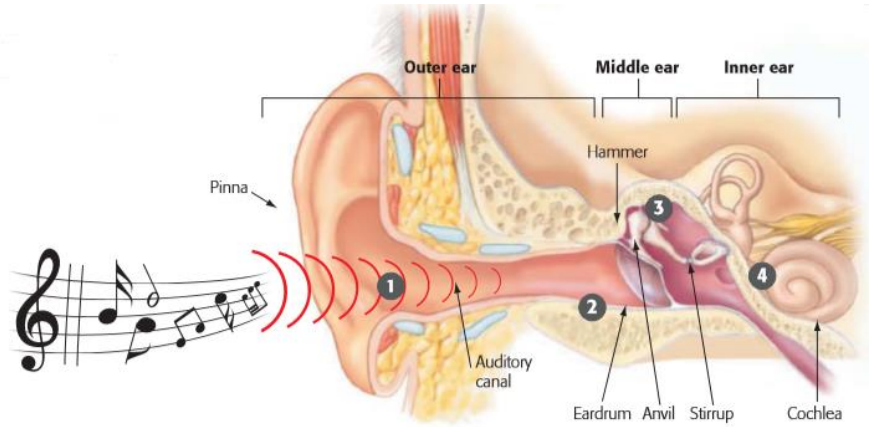
**(3) Astigmatism (散光):** A stigmatism is blurred vision caused by a misshapen lens or cornea. Any such distortion makes light rays converge unevenly and not focus at any one point on the retina.




**(a) A nearsighted eye (eyeball too long).** Nearsightedness is corrected by lenses that are thinner toward the middle.

**(b) A farsighted eye (eyeball too short).** Farsightedness is corrected by lenses that are thicker in the middle.

- **Hearing**




**(1)** The bendable structure—ear, the pinna (耳廓), acts like a funnel focusing sound waves into the auditory canal (耳道). The pinna and auditory canal are considered the outer ear (外耳).

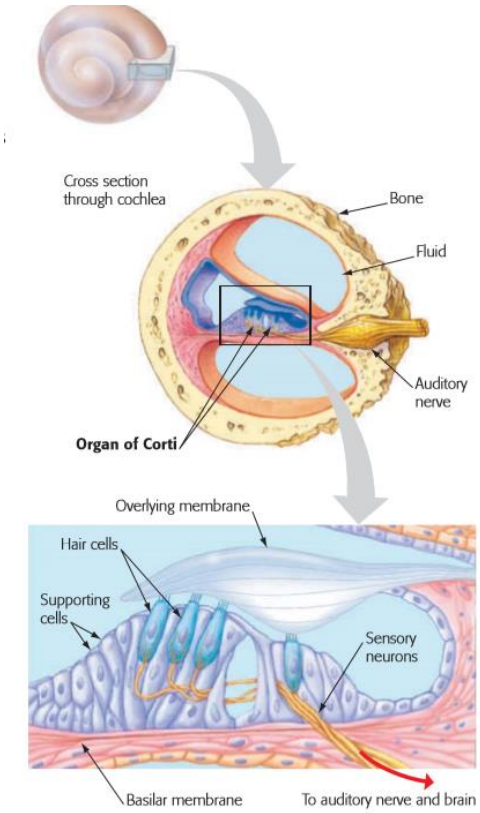
**(2)** The sound waves then reach a sheet of tissue called the eardrum (耳膜), which separates the outer ear from the middle ear (中耳). The sound waves cause the eardrum to vibrate.

**(3)** From the eardrum, the vibrations are concentrated as they pass through the hammer (锤

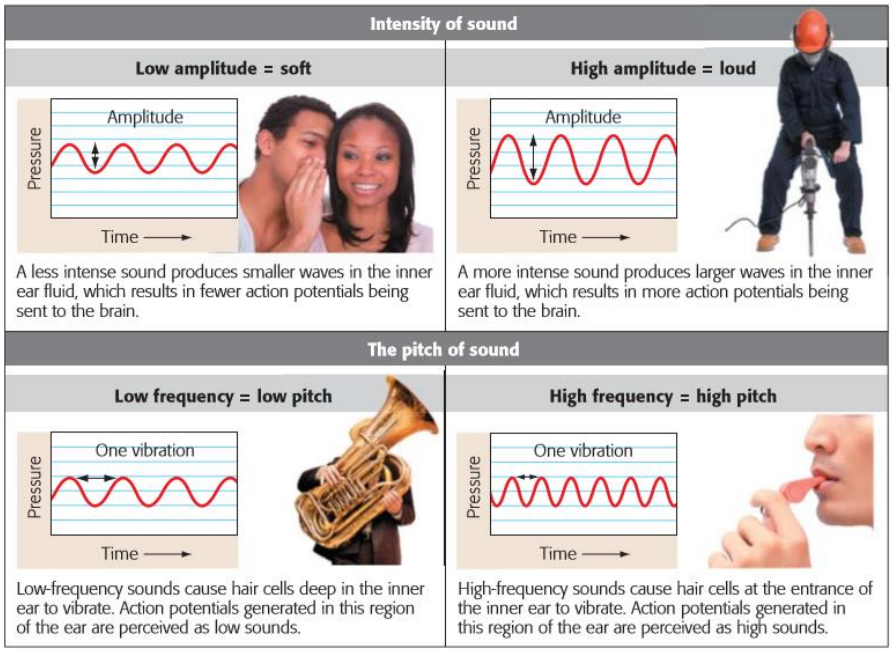
骨), anvil (砧骨), and stirrup (镫骨)—three bones of the middle ear.

**(4)** The stirrup transmits the vibrations to a sheet of tissue between the middle ear and the third part of the ear, the inner ear (内耳). As the bones vibrate, they push on the membrane to generate vibrations in the fluid that fills the inner ear. A component of the inner ear is the cochlea (耳蜗), a coiled, fluid-filled structure containing our hearing organ, where sensory receptors are located and sound is detected.

✧ **The organ of Corti**



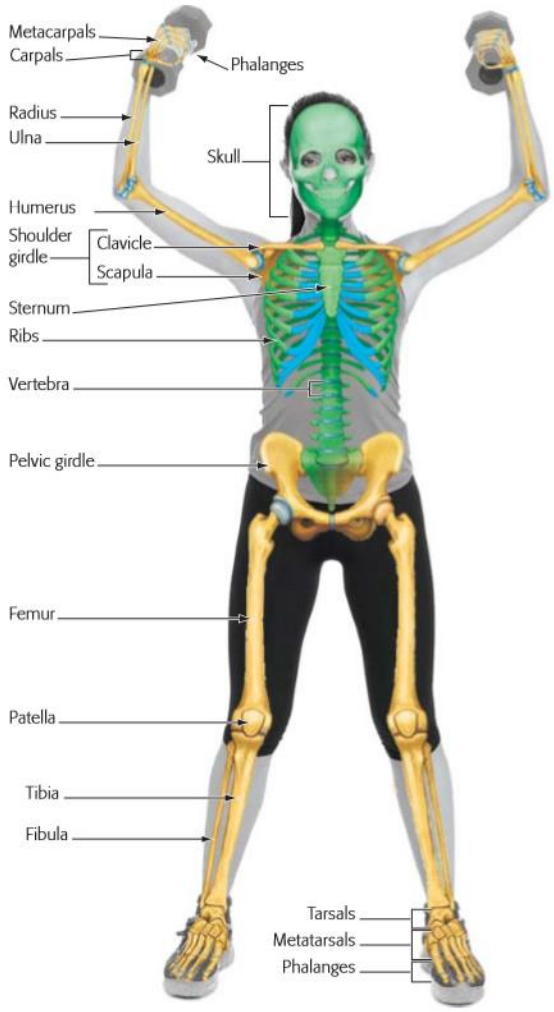

✧ **The characteristics of sound affect how we perceive volume and pitch.**



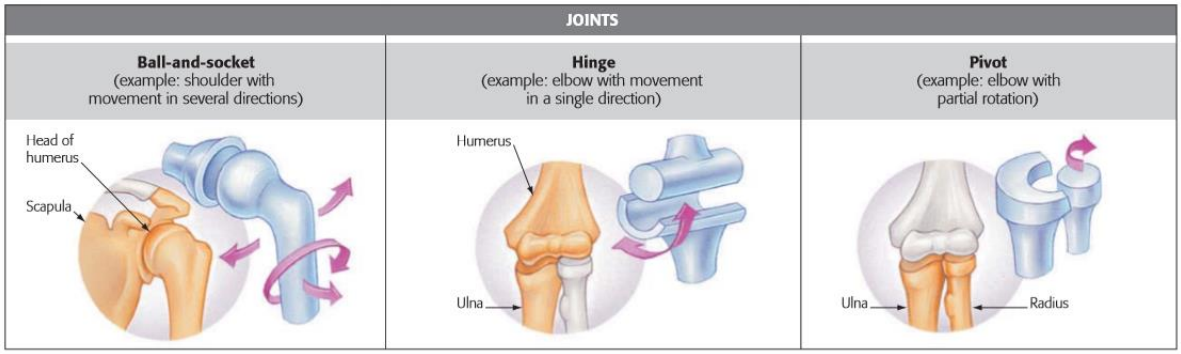
## Locomotor systems

- **The Skeletal System:** The skeletal system provides support, protection, and anchoring.
  - ✧ **Organization of the Human Skeleton**

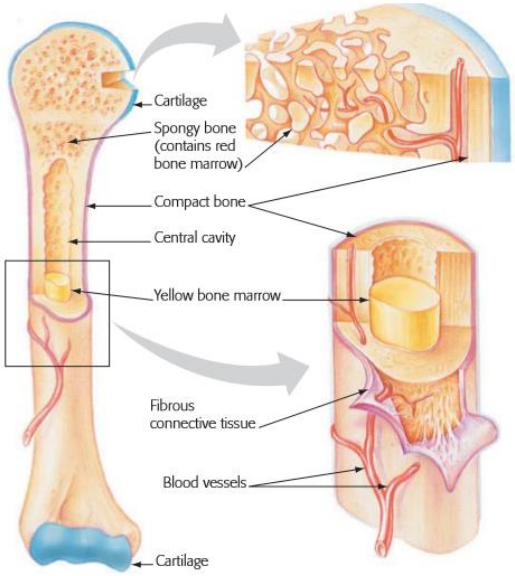
  **(1)** The bones of the skeleton are held together at movable joints by strong fibrous tissues called **ligaments (韧带)**.




**(2)** Three types of movable joints (动关节): **Ball-and-socket joints (球窝关节)** in the shoulder and the hip; In the elbow, a **hinge joint (铰链关节)** permits movement in a single direction; A **pivot joint (枢轴关节)** enables us to rotate our forearms at the elbow and to turn our heads side to side.



✧ **The Structure of Bones**



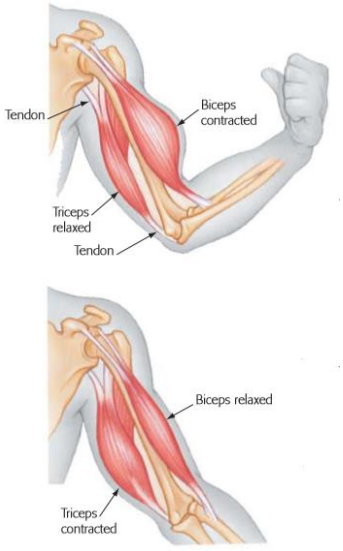

✧ **Skeletal Diseases and Injuries**

**(1) Arthritis (关节炎):** Inflammation of the joints. The joints become stiff and sore, and often swell as the cartilage between the bones wears down. Sometimes the bones thicken at the joints, restricting movement. This form of arthritis is irreversible but not crippling in most cases, and moderate exercise, rest, and over-the-counter pain medications usually relieve most symptoms.

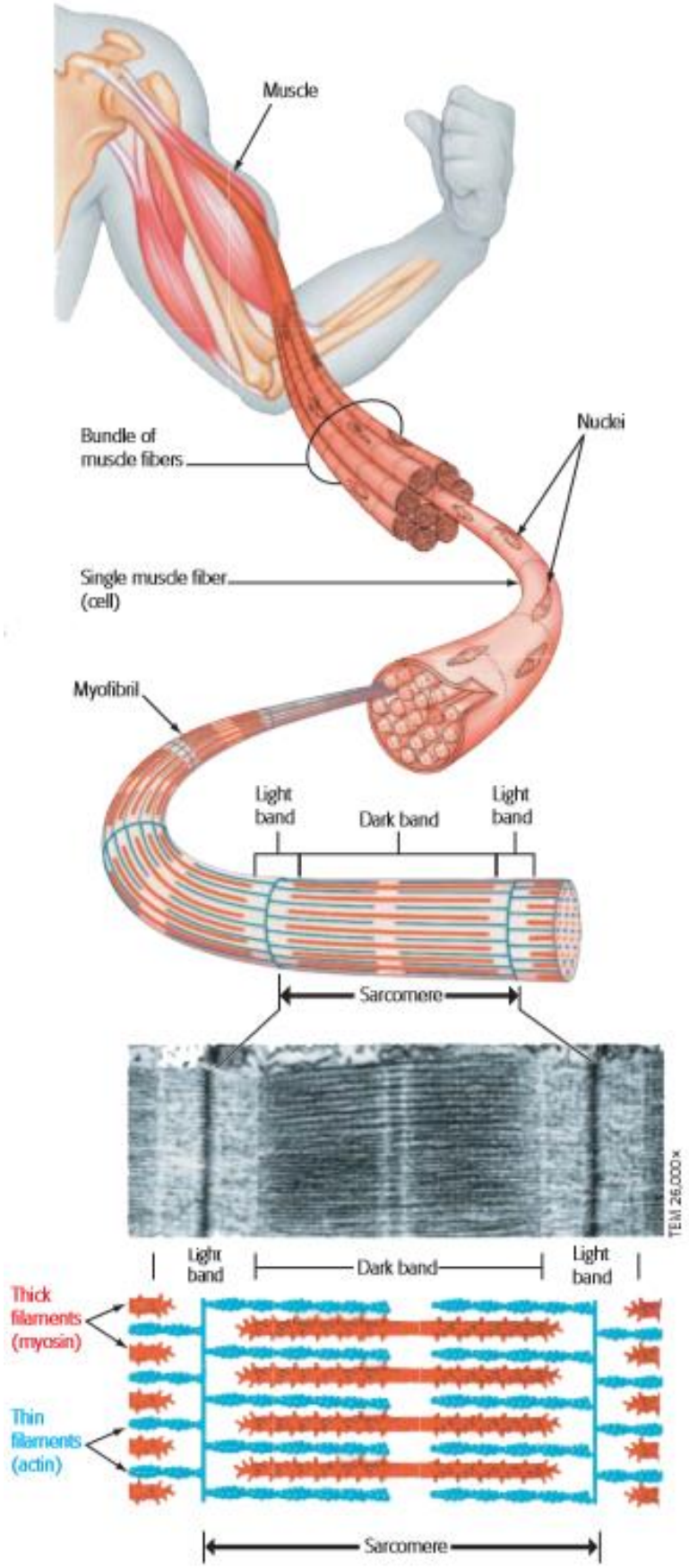
**(2) Rheumatoid arthritis (类风湿性关节炎):** A debilitating autoimmune disease. The joints become highly inflamed, and their tissues may be destroyed by the body's immune system.

**(3) Osteoporosis (骨质疏松症):** It is most common in women after menopause: Estrogen contributes to normal bone maintenance, and with lowered production of the hormone, bones may become thinner, more porous, and more easily broken.

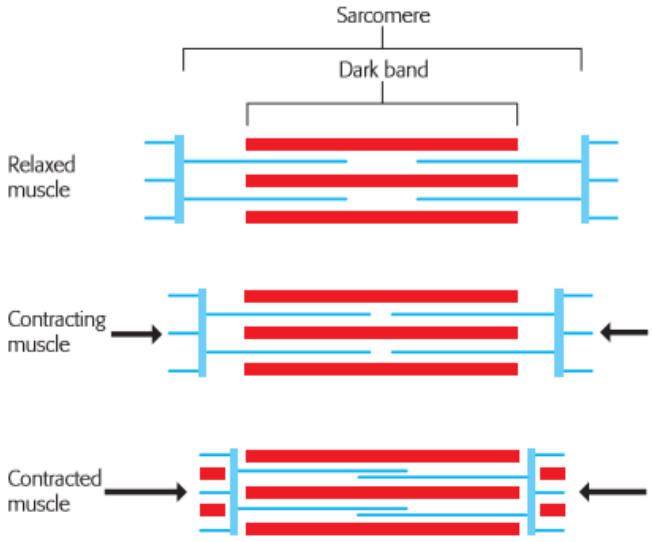
- **The Muscular System:** It is made up of all the skeletal muscles in the body. Skeletal muscles are attached to the skeleton and produce voluntary body movement by interacting with it.

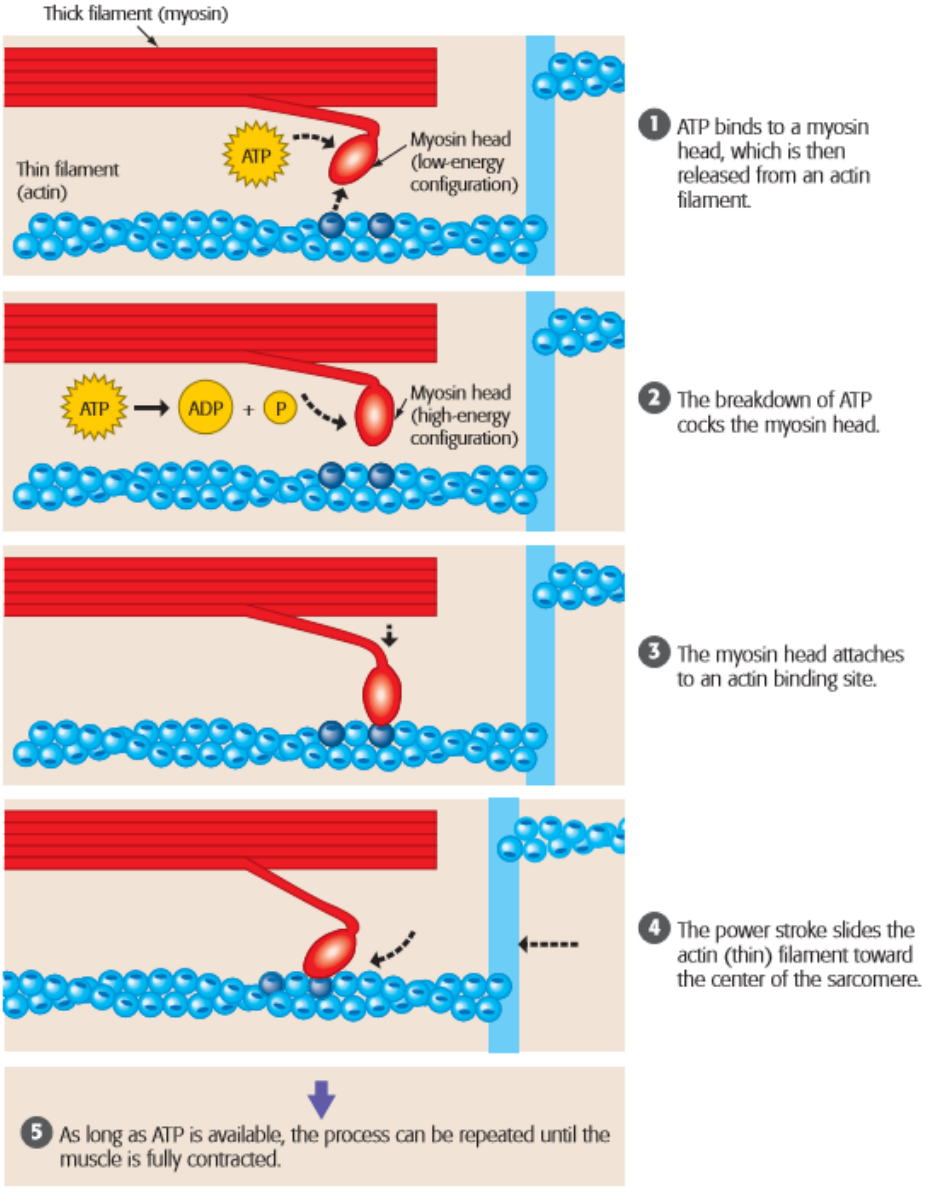


## ✧ The Cellular Basis of Muscle Contraction



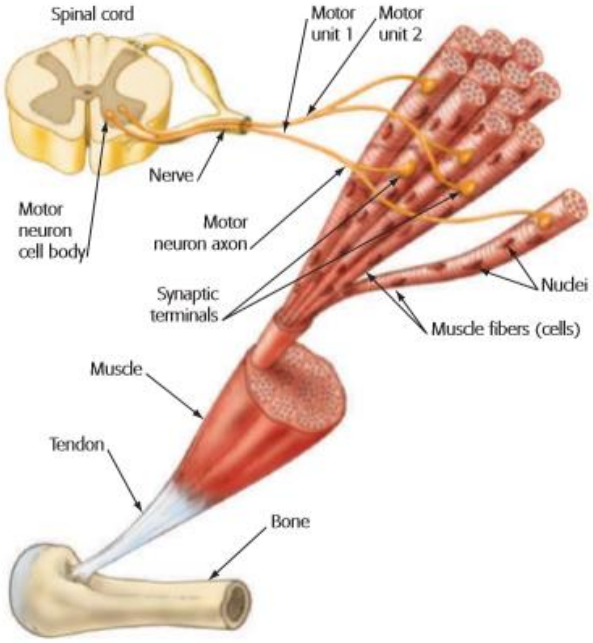
## ✧ The sliding-filament model of muscle contraction



✧ **Motor Neurons: Control of Muscle Contraction**

The sarcomeres of a muscle fiber are stimulated to contract by motor neurons. Responding to a signal sent from the brain via the spinal cord a motor neuron releases a neurotransmitter, which causes the muscle fiber to contract. A typical motor neuron can stimulate more than one muscle fiber because each neuron has many branches.




✧ **Stimulus and Response: Putting It All Together**

Sensory input → nervous system integration → locomotor response.