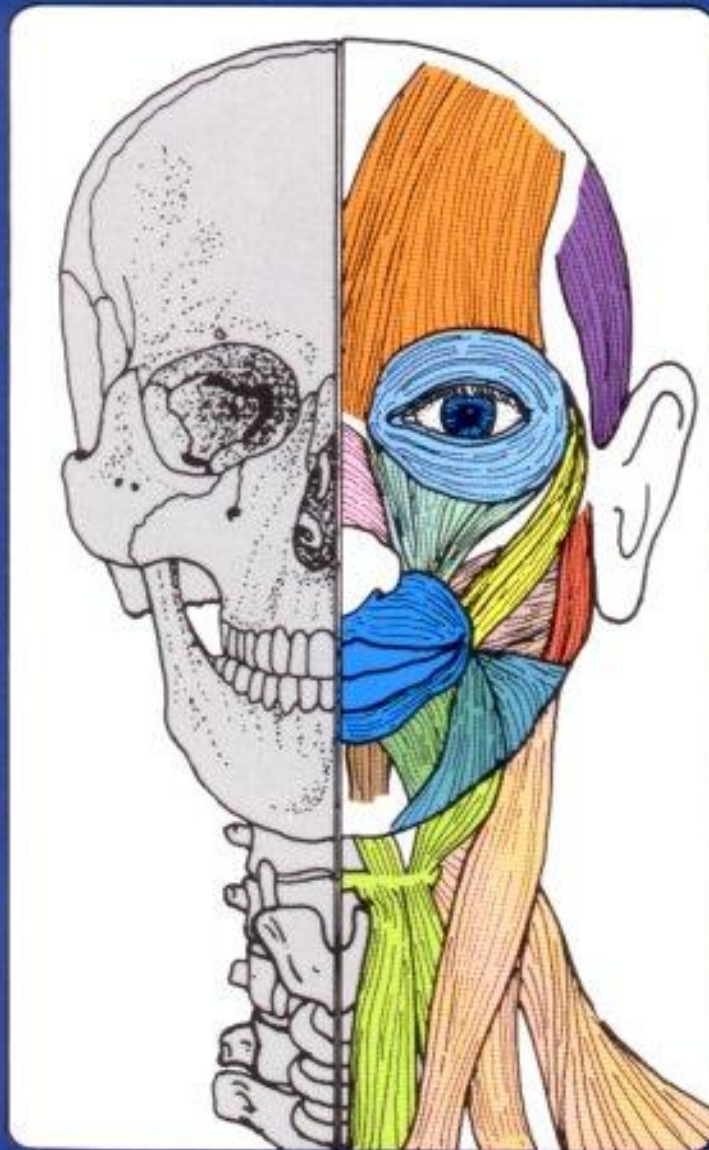
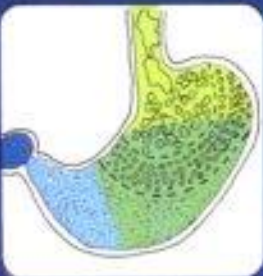
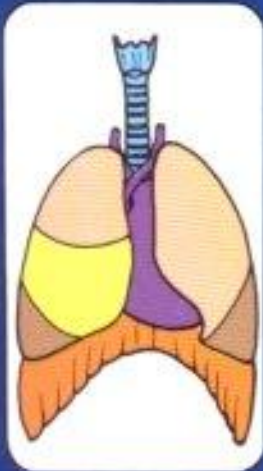
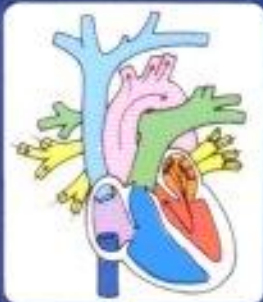


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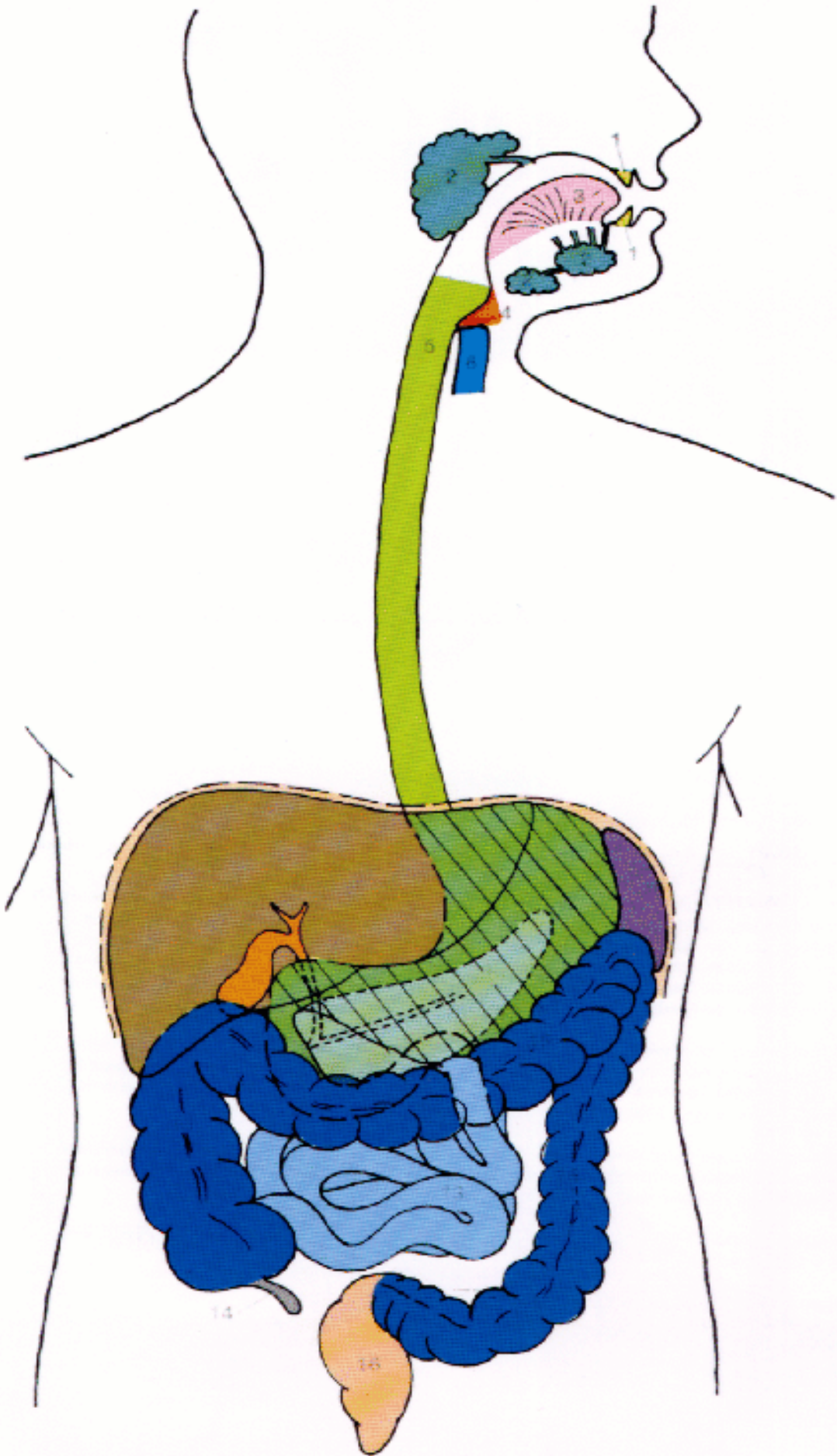
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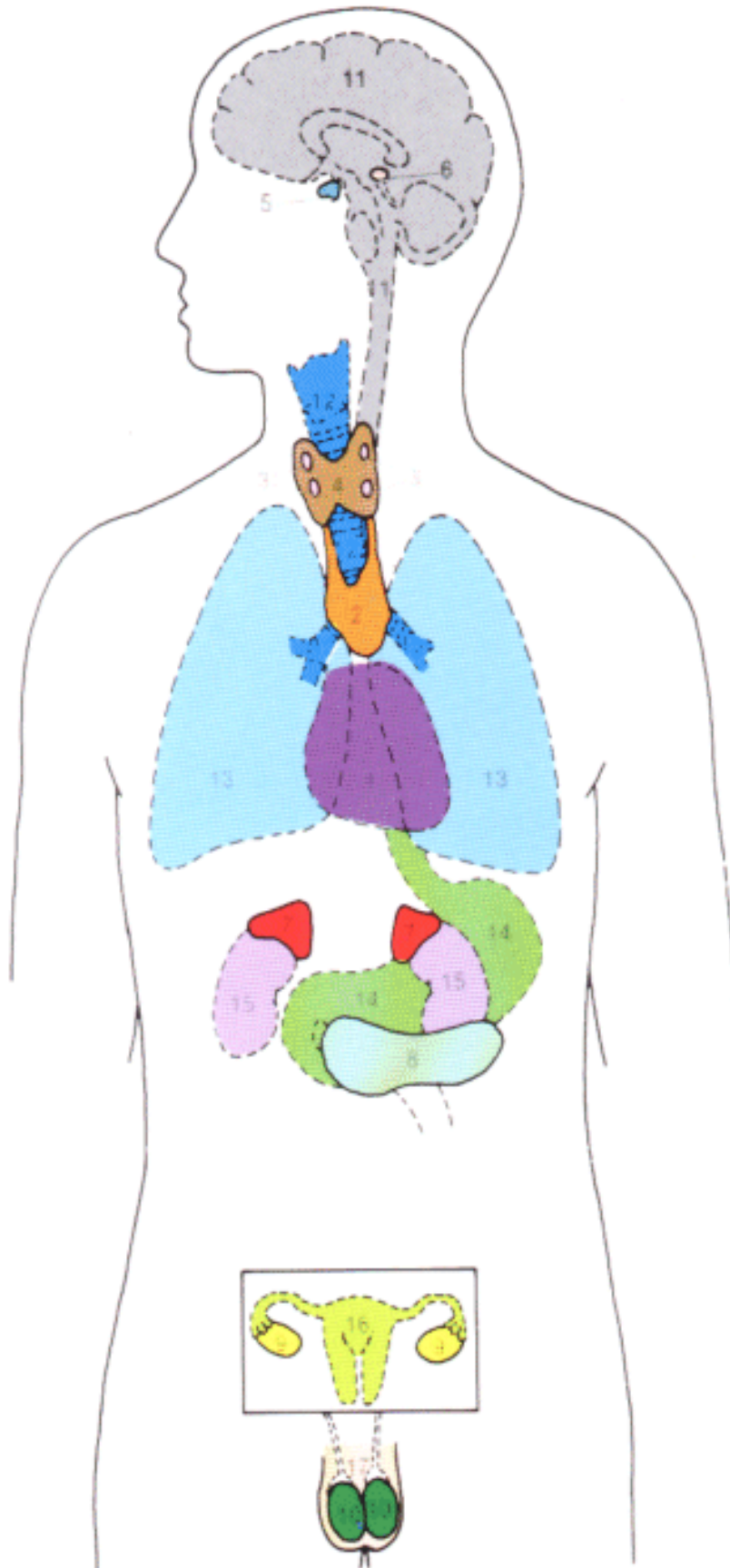
HUMAN ANATOMY Coloring Book

Text by Joe Ziemian



An entertaining and instructive guide to the human body—





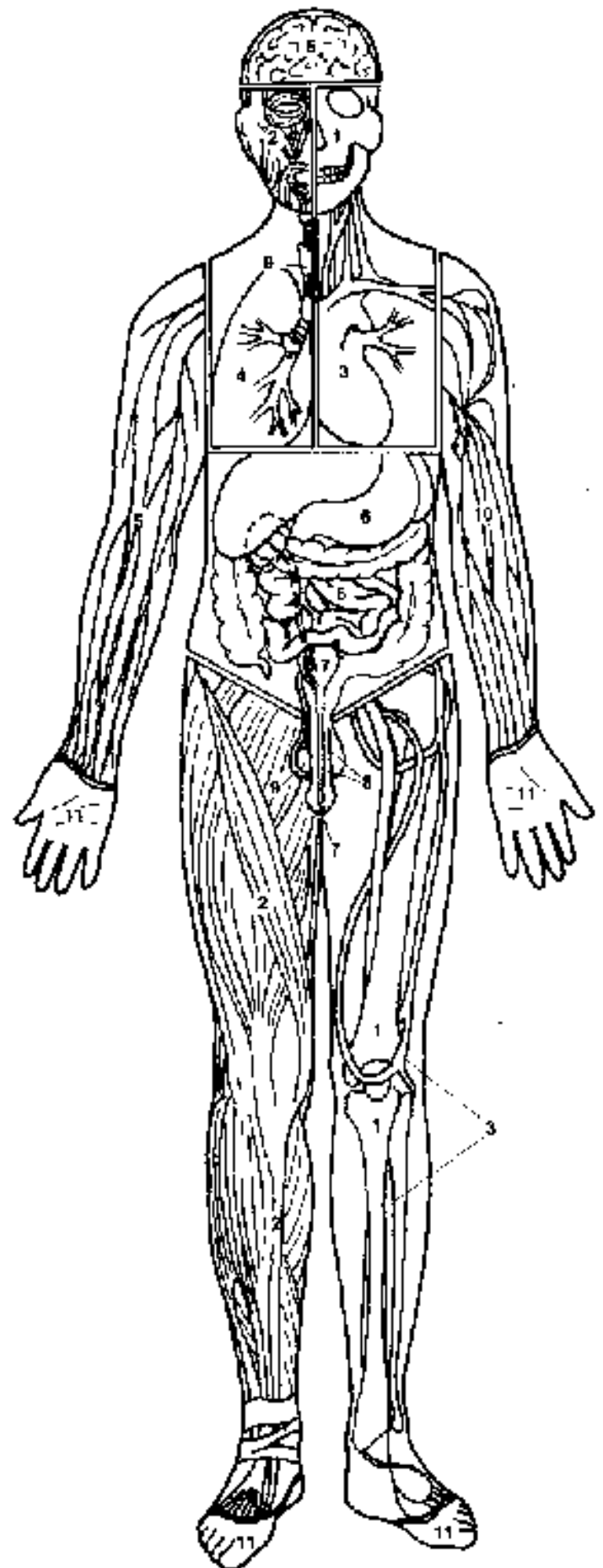
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SYSTEMS OF THE HUMAN BODY

The human body is marvelously complex, and the greatest wonder is, complex as it is, how well it works most of the time. For purposes of study, we can divide the body into systems, though we should not forget that each system is itself highly complex and the dividing line between systems may not be distinct. All of the systems have specialized functions, but they are also closely related to one another; indeed their successful interaction is absolutely necessary for our survival.

The *skeletal system* refers chiefly to the bones that support and protect the body. All the muscles that push and pull the skeleton make up the *muscular system*. The *circulatory system* consists of the heart and the tubes—arteries and veins—that transport blood. We breathe with our *respiratory system*, which supplies oxygen to the body's tissues and removes some wastes. The *nervous system*, whose primary components are the brain and the spinal cord, is our "master control," regulating all of our internal functions and providing us with information about the environment. We process food and eliminate some wastes with the *digestive system*. The *urinary system* is responsible for the elimination of most of the body's liquid chemical wastes. The *reproductive system* consists of those organs that characterize the sexes and enables us to conceive, bear, and give birth to offspring. The secretion of hormones, which regulate the body's functions chemically, is the job of the *endocrine system*. The *lymphatic system* works with the veins in draining fluid from tissues and helps defend the body against infection. The *skin*, the body's largest organ, encloses and protects all the body's systems.



CHOOSE YOUR OWN COLORS

1. SKELETAL
2. MUSCULAR
3. CIRCULATORY
4. RESPIRATORY
5. NERVOUS
6. DIGESTIVE
7. URINARY
8. REPRODUCTIVE
9. ENDOCRINE
10. LYMPHATIC
11. SKIN

SKELETAL SYSTEM

The skeletal system in the adult consists of 206 bones and the strong elastic tissue that forms ligaments, tendons, and cartilages, which tie bones together and form the nose, larynx, trachea, bronchial tubes, and the outer ear. The skeleton provides a strong framework for the body, gives it its basic shape, and permits us to stand upright. The skeletal system also supports and restrains

soft internal organs and shields fragile organs such as the brain and lungs. Certain bones, connected by flexible joints, form a combination of levers that allow coordinated movement. Bones also provide a firm anchor for skeletal muscles and produce red blood cells in their marrow cavities.

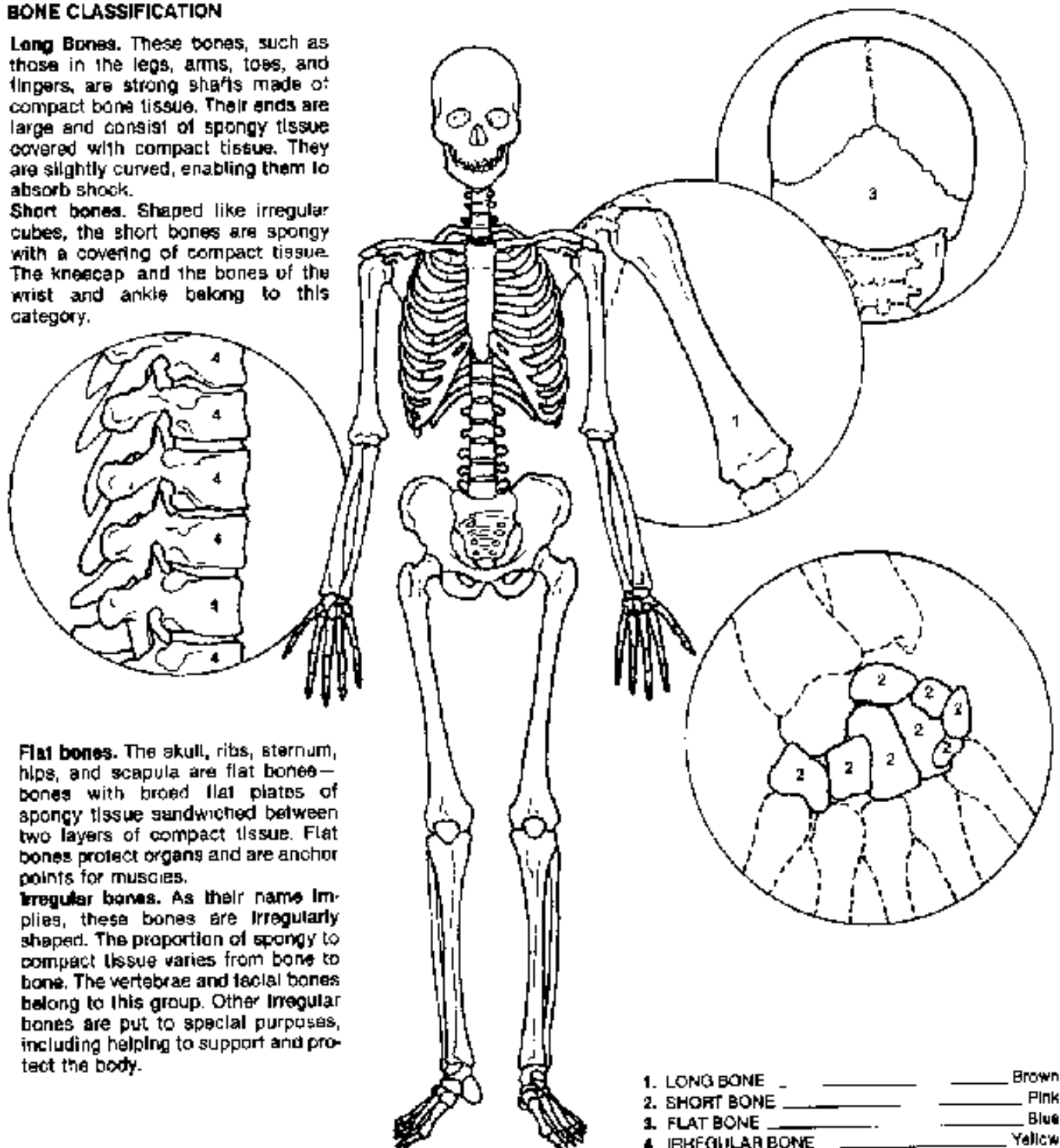
BONE CLASSIFICATION

Long Bones. These bones, such as those in the legs, arms, toes, and fingers, are strong shafts made of compact bone tissue. Their ends are large and consist of spongy tissue covered with compact tissue. They are slightly curved, enabling them to absorb shock.

Short bones. Shaped like irregular cubes, the short bones are spongy with a covering of compact tissue. The kneecap and the bones of the wrist and ankle belong to this category.

Flat bones. The skull, ribs, sternum, hips, and scapula are flat bones—bones with broad flat plates of spongy tissue sandwiched between two layers of compact tissue. Flat bones protect organs and are anchor points for muscles.

Irregular bones. As their name implies, these bones are irregularly shaped. The proportion of spongy to compact tissue varies from bone to bone. The vertebrae and facial bones belong to this group. Other irregular bones are put to special purposes, including helping to support and protect the body.

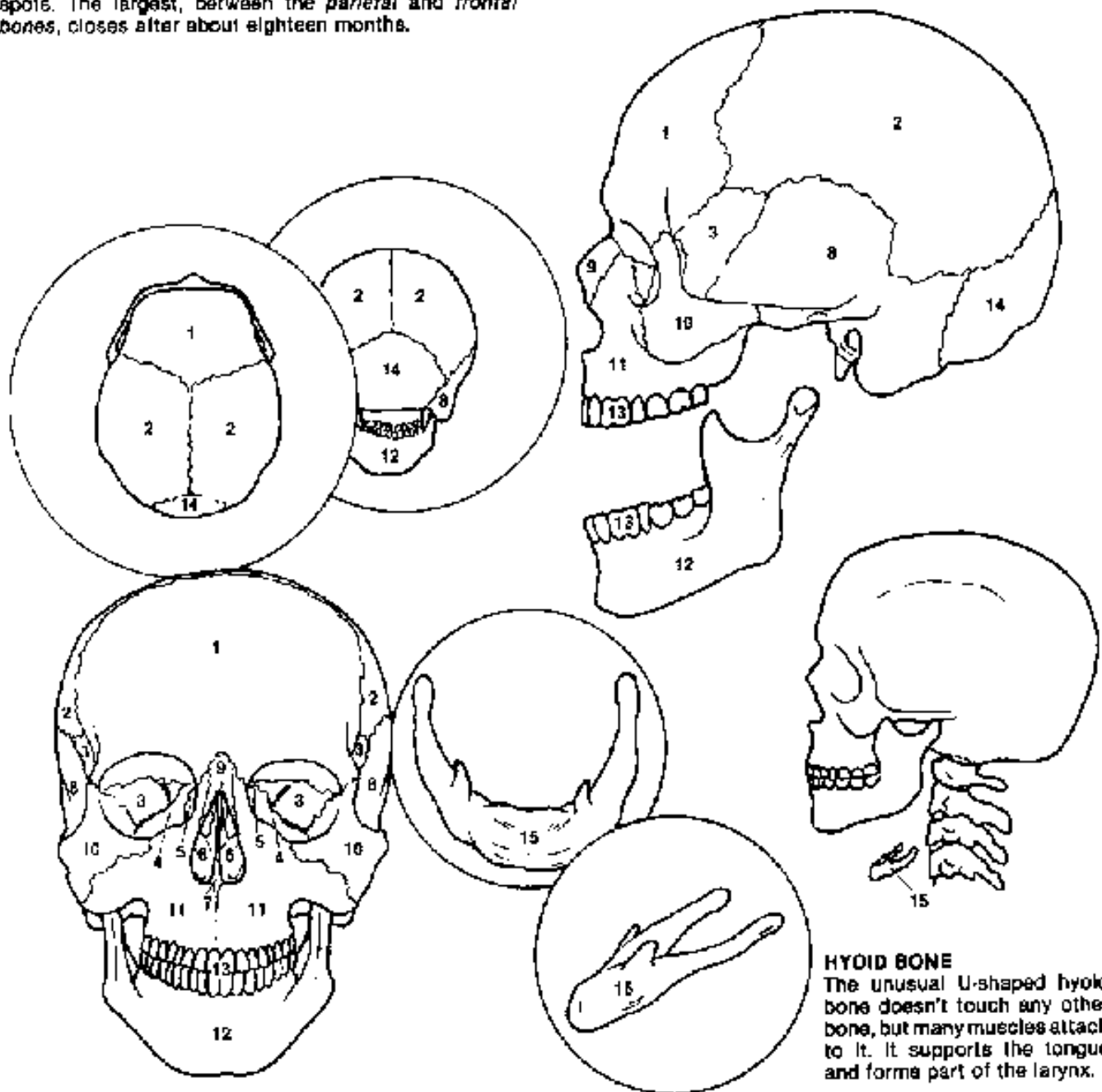


SKULL

The skull is the protective case for the brain and the organs of sight, taste, smell, hearing, and balance. It rests and pivots on the upper or superior end of the vertebral column. The skull has two main parts: the *cranium* or brain case and the *facial bones*. The base of the skull is much thicker and stronger than the sides and top and has many openings for nerves, blood vessels, and tubes to pass through. The facial bones enclose the front of the brain and form the openings for the eyes and the nasal and oral cavities. The *mandible* or jawbone is the only movable bone of the skull.

As the fetus develops, the cartilaginous membranes of the cranium *ossify* or turn into bone. At birth the ossification is not complete and membrane-filled spaces between the bones, the *fontanelles*, remain as soft spots. The largest, between the *parietal* and *frontal* bones, closes after about eighteen months.

- | | | |
|---------------------|-------|--------------|
| 1. FRONTAL BONE | _____ | Pink |
| 2. PARIETAL BONE | _____ | Turquoise |
| 3. SPHENOID BONE | _____ | Gray |
| 4. ETHMOID BONE | _____ | Brown |
| 5. LACRIMAL BONE | _____ | Green |
| 6. NASAL TURBINATES | _____ | Red |
| 7. VOMER | _____ | Light Blue |
| 8. TEMPORAL BONE | _____ | Blue |
| 9. NASAL BONE | _____ | Light Purple |
| 10. ZYGOMATIC BONE | _____ | Orange |
| 11. MAXILLA | _____ | Yellow-Green |
| 12. MANDIBLE | _____ | Gray |
| 13. TEETH | _____ | Yellow |
| 14. OCCIPITAL BONE | _____ | Light Green |
| 15. HYOID BONE | _____ | Light Brown |



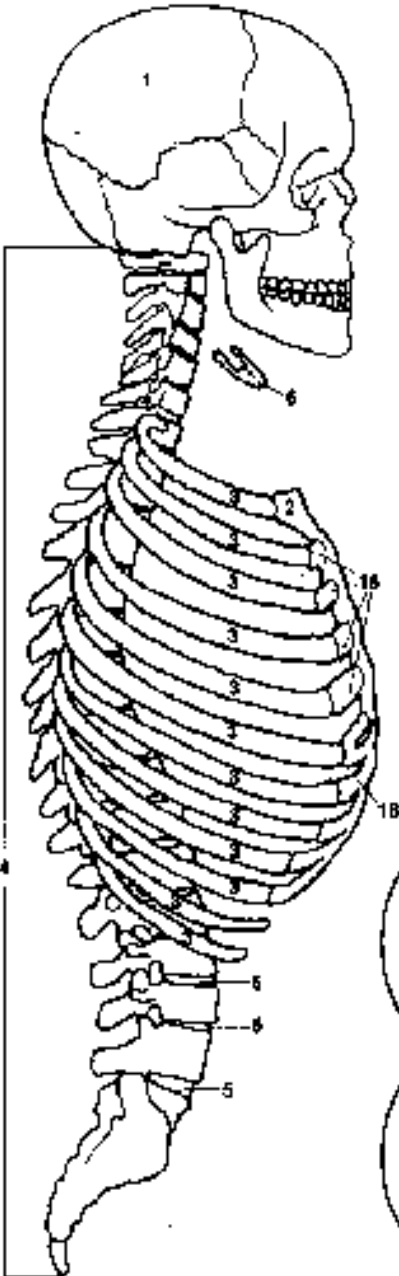
HYOID BONE
The unusual U-shaped hyoid bone doesn't touch any other bone, but many muscles attach to it. It supports the tongue and forms part of the larynx.

VERTEBRAL COLUMN – SPINE

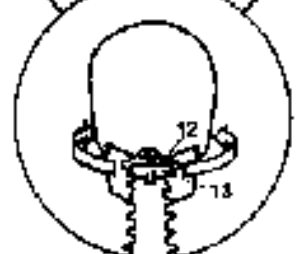
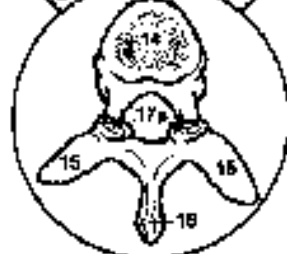
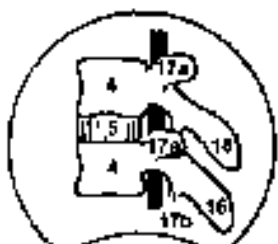
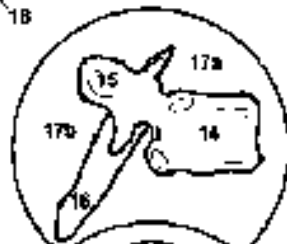
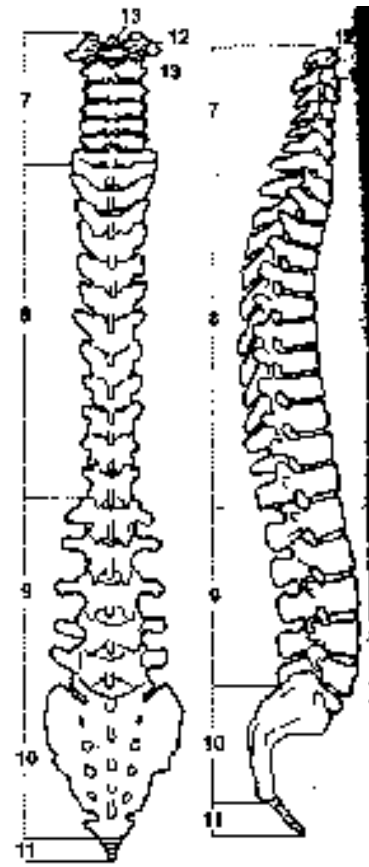
A stack of 33 irregular vertebrae or bones, all held tightly together by ligaments, forms the strong, flexible column known as the spine. It can be divided into five regions. The cervical area forms the neck and supports the skull. The thoracic region, together with the ribs, forms the thorax or chest. The lumbar section makes up the lower back. The sacrum consists of five vertebrae fused into one triangular bone and forms part of the hip. The bottom four vertebrae, a remnant of the tail humans lost in evolutionary history, comprise the coccyx.

The lumbar vertebrae are the largest and thickest; the cervical are the smallest. All vertebrae have a thick body to bear weight and two wing-like lamina that join and form a ring, the vertebral arch. The ring opening is called the vertebral foramen. The openings are placed together to form an armored tube for the spinal cord, the vertebral or spinal canal. Each vertebra has seven processes or fingers that serve as anchors for muscles, contact points for vertebrae above and below, and overlapping shields to protect the spinal cord.

As a child grows, curves develop in the spine that give it strength and spring. These curves, together with the disks or cartilage pads between the vertebrae, protect the vertebral column by absorbing shock and concussion. The painful or numbing condition known as a pinched nerve occurs (usually in the lower back and occasionally in the neck) when a disk is crushed or ruptured in an accident or from lifting a heavy weight. The flattened or ruptured disk presses against or "pinches" nerves where they branch off from the spinal cord.



- | | |
|---|--------------|
| 1. SKULL | Gray |
| 2. STERNUM | Green |
| 3. RIBS | Yellow |
| 4. VERTEBRAL COLUMN | Light Purple |
| 5. INTERVERTEBRAL DISKS | Flesh |
| 6. HYOID BONE | Light Brown |
| 7. CERVICAL VERTEBRAE | Light Blue |
| 8. THORACIC VERTEBRAE | Purple |
| 9. LUMBAR VERTEBRAE | Pink |
| 10. SACRUM | Red |
| 11. COCCYX | Orange |
| 12. ATLAS | Blue |
| 13. AXIS | Dark Blue |
| 14. VERTEBRA BODY | Light Orange |
| 15. TRANSVERSE PROCESS | Yellow-Green |
| 16. SPINOUS PROCESS | Light Green |
| 17. a. SUPERIOR and b. INFERIOR ARTICULAR PROCESS | Turquoise |
| 18. COSTAL CARTILAGE | Brown |

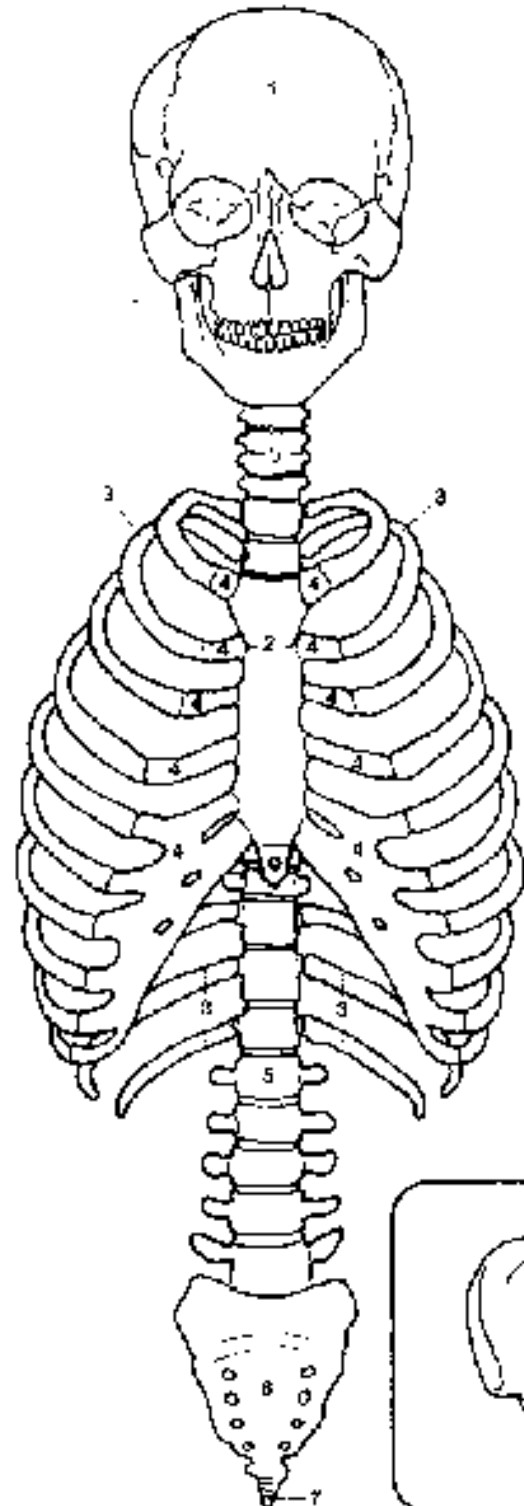


AXIAL SKELETON

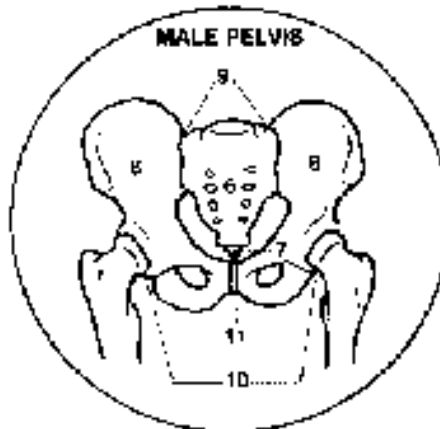
The axial skeleton consists of the *skull*, the *vertebral column*, the *sternum*, and the *thorax* or rib cage and serves to hold the body erect. It also protects most of the body's vital organs such as the heart, lungs, and liver, which the thorax encloses. The thorax is a bony and somewhat flexible cage made up of two ve pairs of thin, curved ribs, the head of each of which joins or articulates with one or two

vertebrae. The first seven pairs of ribs, the "true" ribs, are directly attached to the sternum by a strip of costal cartilage. The other five pairs, the "false" ribs, consist of the eighth, ninth, and tenth pairs, which are attached to each other and the seventh pair by cartilage, and the "floating" ribs (pairs eleven and twelve), which are not tied to the sternum at all but to the muscles of the abdominal wall. The elasticity of the cartilage and the flexible joints at the spine allow the ribs to flex in and out, reducing or enlarging the volume of the thorax.

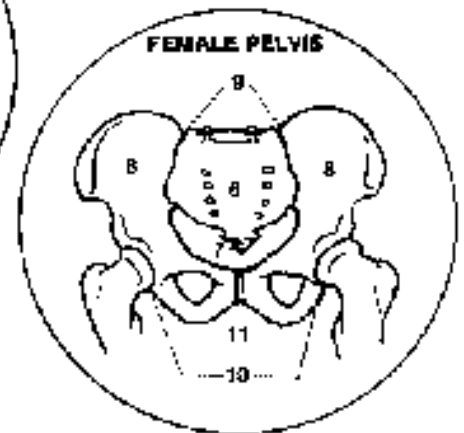
The sternum develops in the child as three separate bones, but the three fuse into one in the adult around age 25. Pushing down on the lower third of the sternum compresses the heart and creates a pumping action that is the basis of cardiopulmonary resuscitation.



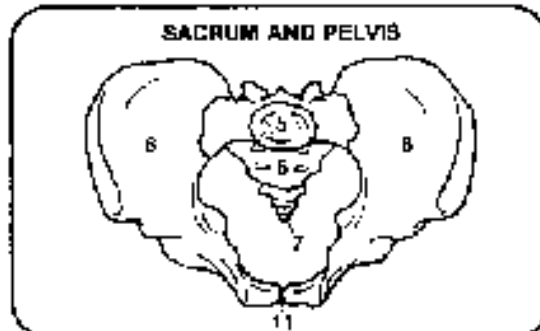
- | | | |
|--|-------|--------------|
| 1. SKULL | _____ | Gray |
| 2. STERNUM | _____ | Green |
| 3. RIBS | _____ | Yellow |
| 4. COSTAL CARTILAGE | _____ | Brown |
| 5. VERTEBRAE | _____ | Light Purple |
| 6. SACRUM | _____ | Red |
| 7. COCCYX | _____ | Orange |
| 8. HIP BONE | _____ | Pink |
| 9. SACROILIAC JOINT | | |
| 10. ACETABULUM (hip joint) | | |
| 11. PUBIS SYMPHYSIS (interpubic joint) | | |



MALE PELVIS
Heart shaped and narrow, the male pelvis is stronger and heavier than the female's. The pubic angle is less than 90°.

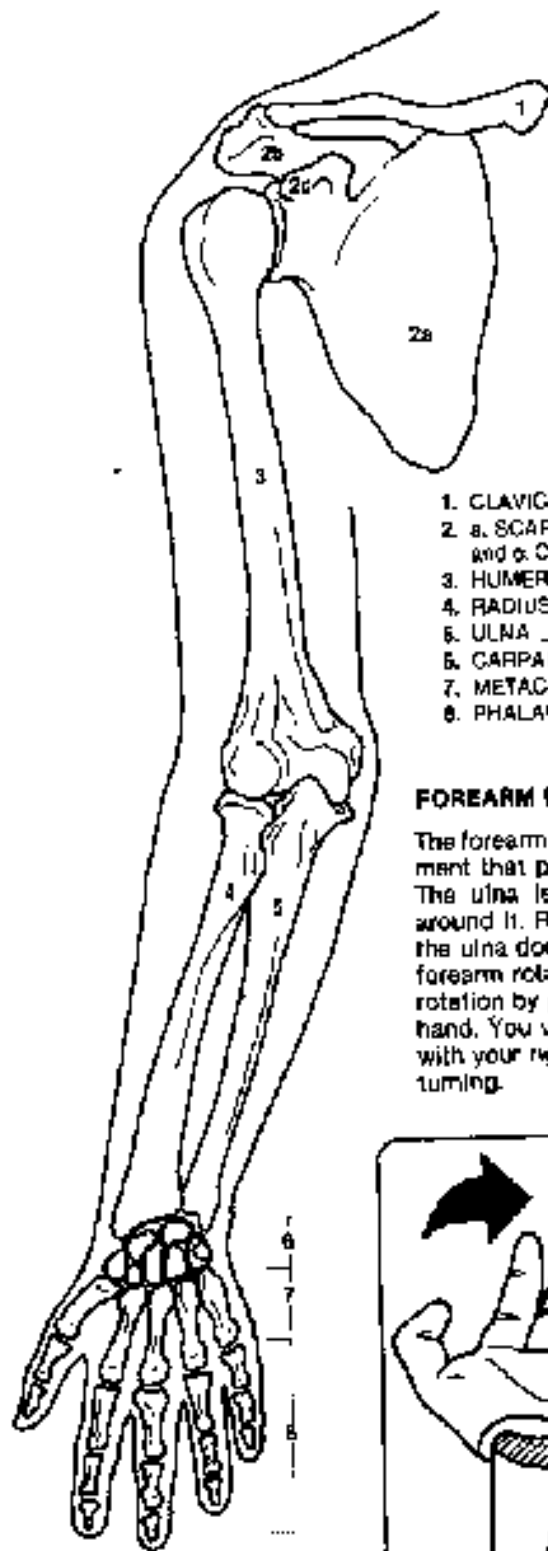


FEMALE PELVIS
Wider, smoother, and more bowl-like than the male's in order to accommodate the fetus during pregnancy and childbirth, the female pelvis is also smaller and structurally weaker than the male's. The pubic angle is greater than 90°.



SACRUM AND PELVIS
The sacrum forms a strong, interlocking keystone for the pelvis, which is subject to more stress than any other structure in the body.

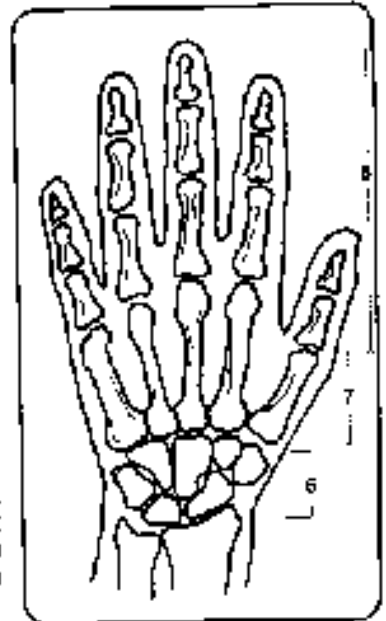
APPENDICULAR SKELETON – UPPER EXTREMITIES



The combination of simple joints and levers that make up the arm and hand produce an astounding range of movements—baseball pitchers and jewelers both employ the complex arm and hand for very different purposes. The arm is supported by the *pectoral girdle*, which consists of the *scapula* or shoulder blade and the *clavicle* or collar bone. The scapula is held in place only by muscles; hence it is free floating and capable of considerable movement.

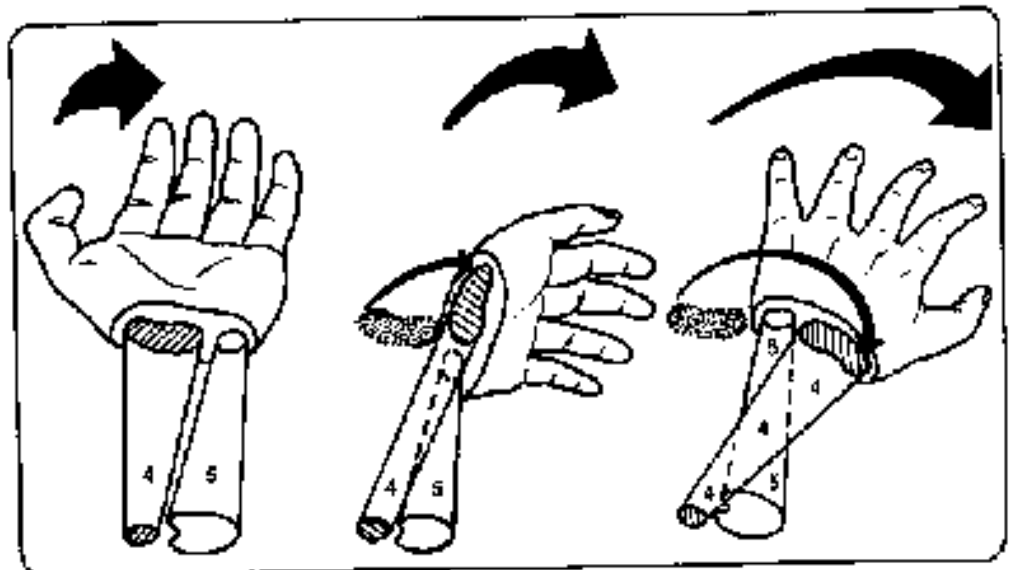
There is a ball at the top of the upper arm bone or *humerus* that rotates in a socket in the scapula. The forearm consists of the *ulna* and *radius*, which join the hand at the eight wrist bones or *carpals*; *intercarpal ligaments* tie the carpals together. The *metacarpals*, the five long bones that form the palm of the hand, join with the carpals. Beginning with the thumb, the metacarpals are numbered 1 to 5. The *knuckles* are the heads of the metacarpals. The finger bones or *phalanges* articulate with the metacarpals. Each finger has three bones, except for the thumb, which has two.

- | | |
|---|-----------|
| 1. CLAVICLE | Green |
| 2. a. SCAPULA, b. ACROMIAL PROCESS, and c. CORACOID PROCESS | Pink |
| 3. HUMERUS | Purple |
| 4. RADIUS | Turquoise |
| 5. ULNA | Grey |
| 6. CARPALS | Yellow |
| 7. METACARPALS | Brown |
| 8. PHALANGES | Blue |

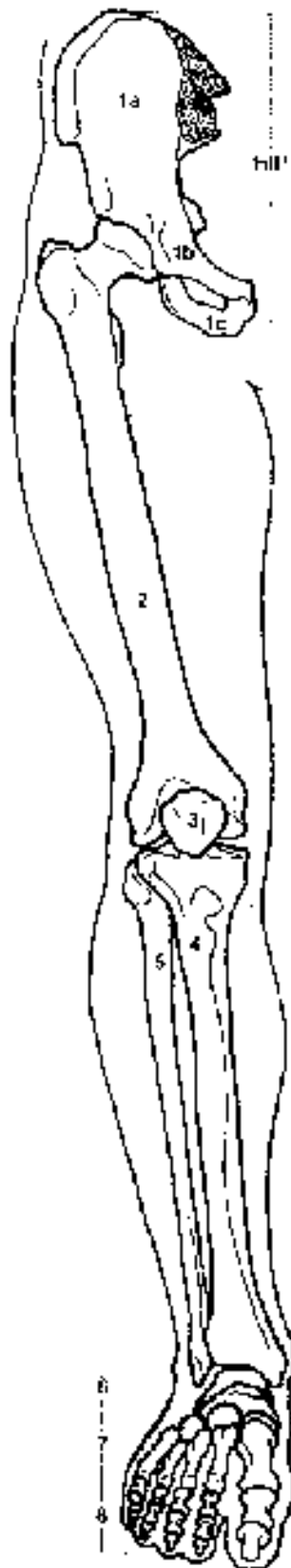


FOREARM ROTATION

The forearm has an interesting mechanical arrangement that permits it to rotate and gives it power. The ulna is a stationary axle; the radius turns around it. Rotate your hand and you will see that the ulna doesn't move. To appreciate the power of forearm rotation, all you need do is try to prevent rotation by grasping your left wrist with your right hand. You will have to exert a great deal of force with your right hand to stop your left forearm from turning.



APPENDICULAR SKELETON – LOWER EXTREMITIES



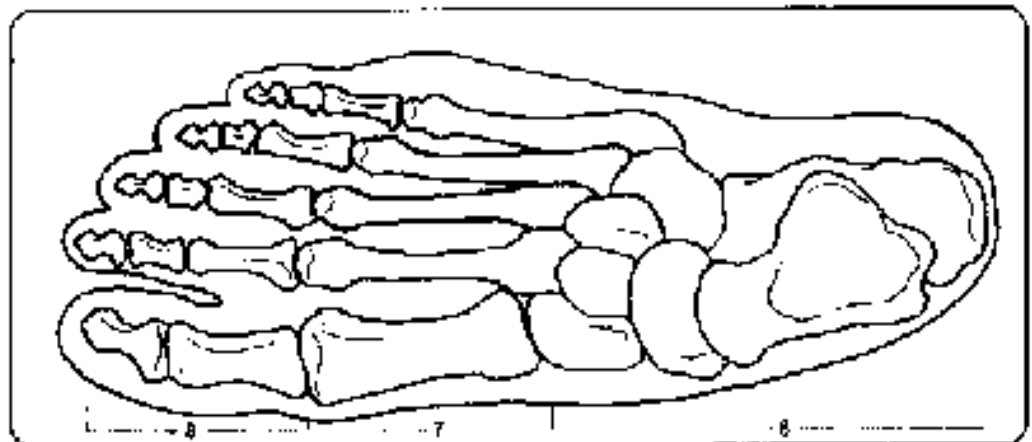
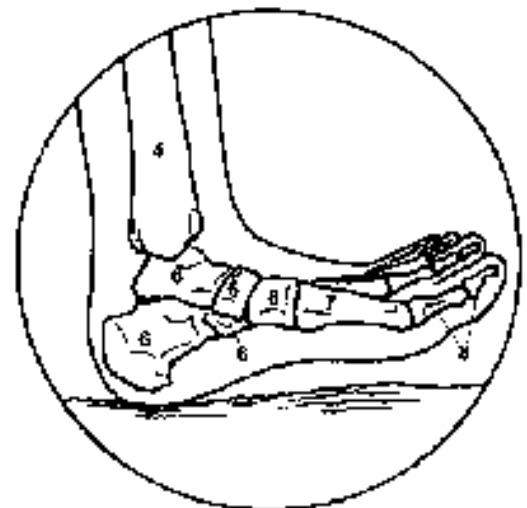
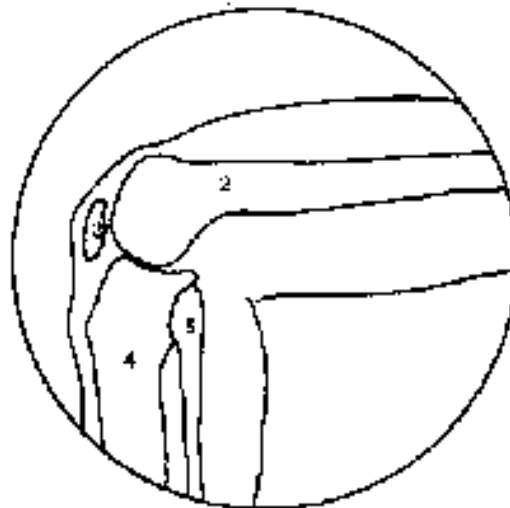
The bones of the lower and upper extremities are similar in many respects, but they serve different functions and, hence, have some structural differences. The leg bones must support the body's weight and are thus more solid than the arm bones, but the leg bones have a smaller range of movement.

At birth the hip has three bones—the *ilium*, *pubis*, and *ischium*—which later unite into a single bone, the *os coxae*. The left and right *coxae* join in the front at the *symphysis pubis* and with the *sacrum* in the back to form the bowl-shaped *pelvis*. The hip bone is connected to the thigh bone or *femur*, which has a ball-like head that rotates in the hip socket and a slight inward curve that aligns the body vertically with the knees and ankles. This alignment is important for the body to maintain its center of gravity. The lower femur and the *tibia* or shin form the knee. The small bone called the *patella* protects the knee; it is held in place by a tendon and surrounded by a *bursa*, a sac filled with fluid. Parallel to and outside of the *tibia* is the *fibula* or calf bone, whose lower end

forms the outer ankle bone or *tarsus metatarsus*. The *tibia* and *fibula* articulate with the *talus*, the uppermost of the seven *tarsal* bones. The *tarsals* and the five *metatarsals* (numbered 1 to 5, beginning with the big toe) form two arches that act as a spring, distributing weight and helping to balance the body. The *phalanges* of the foot are similar to those of the hand in number and arrangement—two phalanges for the big toe, three for each of the other toes.

The condition known as fallen arches or "flat feet" results from the weakening of the ligaments and tendons that hold up the arches.

- | | |
|--|-----------|
| 1. HIP; a. ILIUM, b. PUBIS, and c. ISCHIUM | Pink |
| 2. FEMUR | Purple |
| 3. PATELLA | Orange |
| 4. TIBIA | Gray |
| 5. FIBULA | Turquoise |
| 6. TARSALS | Yellow |
| 7. METATARSALS | Brown |
| 8. PHALANGES | Blue |

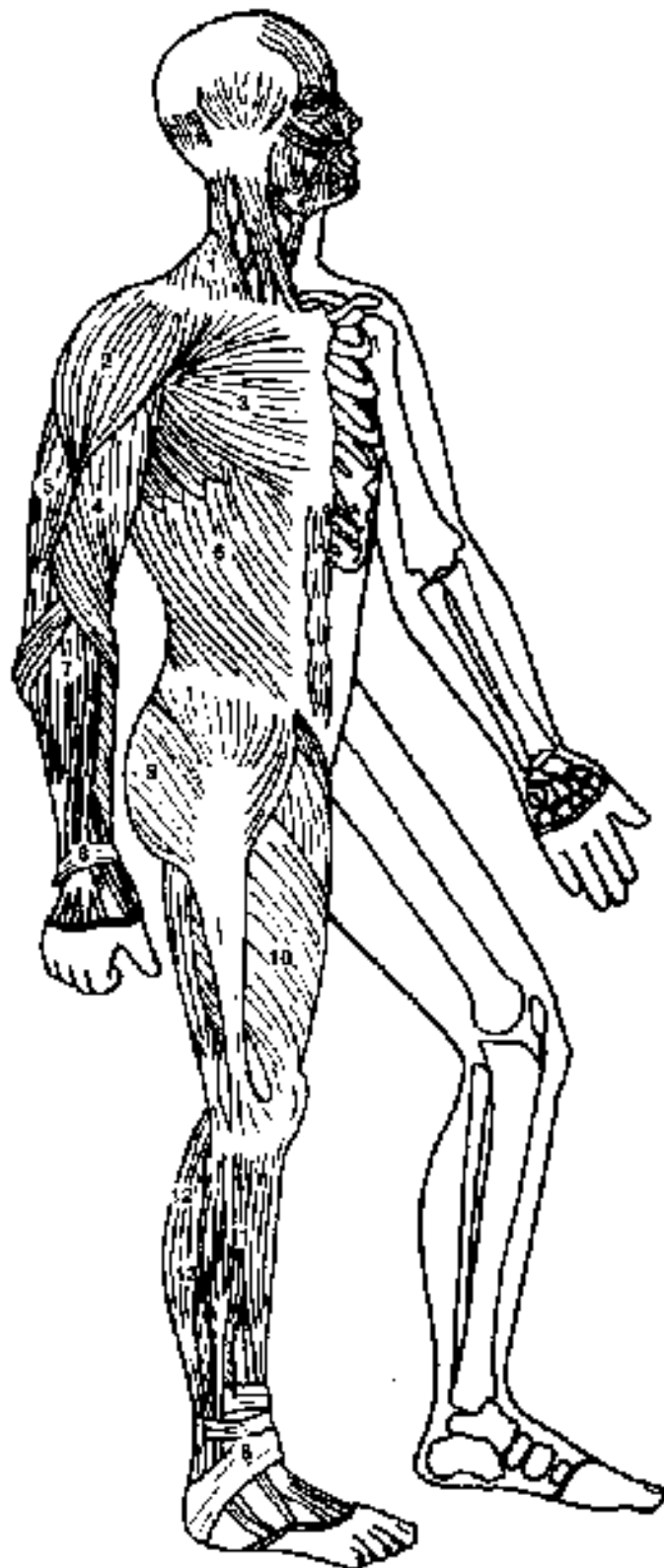


MUSCULAR SYSTEM

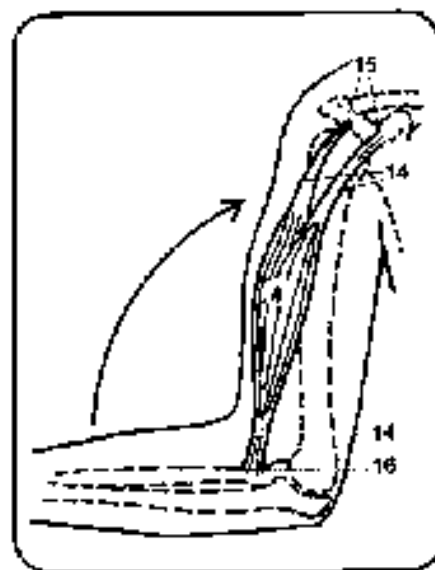
Muscles are tissues that contract, and the human body has almost seven hundred of them, which are divided into three kinds. *Skeletal muscles* are responsible for the voluntary movement of the bones. *Smooth muscles* are involuntary; they include blood vessels, intestines, and the lungs. There is only one *cardiac muscle*—the heart.

The term *muscular system* is used only for the skeletal muscles, which are the long, slender fibers arranged in parallel bundles that give our arms, legs, torso, neck, and face much of their shape. The large part of the muscle is called the *belly*. The ends of the skeletal muscles are attached by ligaments to two different bones, only one of which moves when the muscle contracts. The *origin* is where the muscle meets the bone that doesn't move. The origin is always closer to the torso than the *insertion*, where the muscle meets the bone that does move. Muscles that bend joints and pull limbs toward the body are called *flexors*. Muscles that straighten joints are *extensors*.

Movement usually involves the coordinated action of several muscles. The muscle that initiates the action is the *agonist* or *prime mover*. As the agonist contracts, another muscle, the *antagonist*, relaxes or yields to it. Other muscles, *synergists* or *fixators*, help the prime mover by dampening unwanted movement or holding a limb or joint steady during the action.



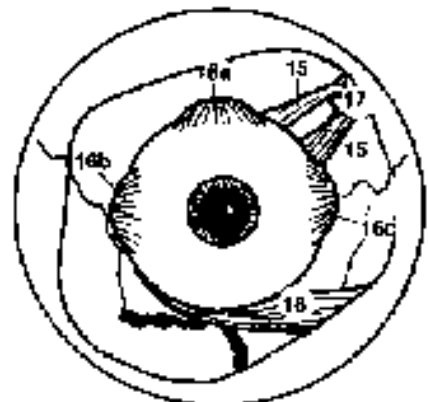
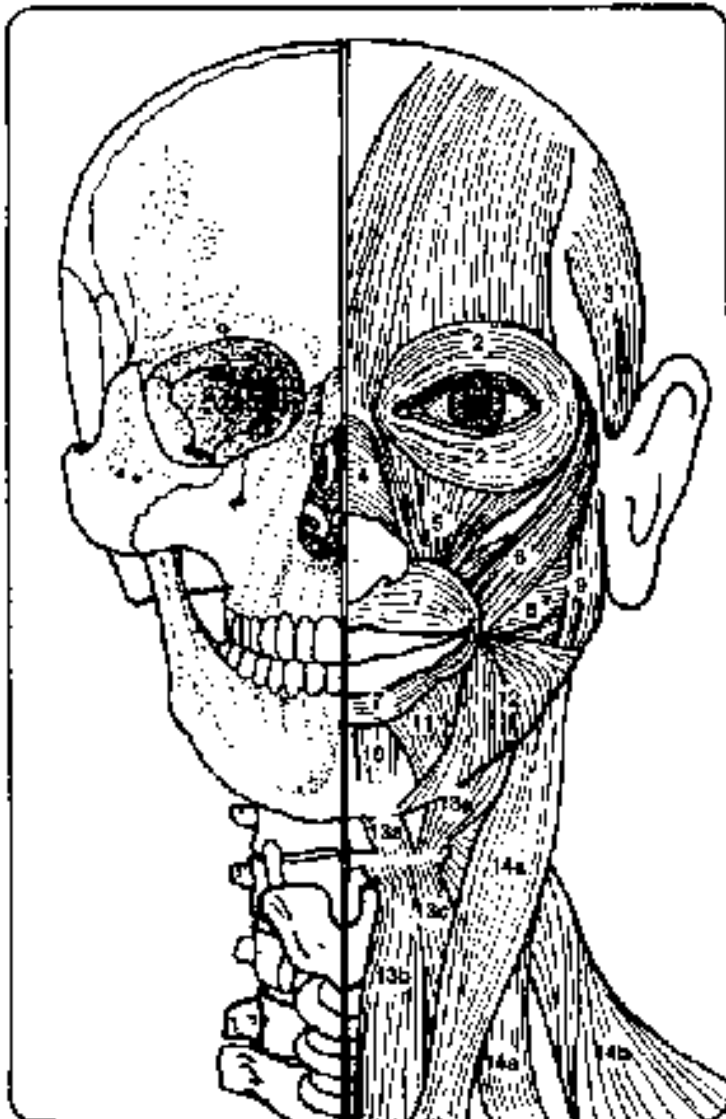
- | | | | |
|-------------------------|-------|-------|--------------|
| 1. TRAPEZIUS | _____ | _____ | Pink |
| 2. DELTOID | _____ | _____ | Orange |
| 3. PECTORALIS | _____ | _____ | Light Blue |
| 4. BICEPS | _____ | _____ | Green |
| 5. TRICEPS | _____ | _____ | Turquoise |
| 6. EXTERNAL OBLIQUE | _____ | _____ | Light Brown |
| 7. EXTENSORS | _____ | _____ | Yellow |
| 8. ANNULAR LIGAMENT | _____ | _____ | Gray |
| 9. GLUTEUS MAXIMUS | _____ | _____ | Purple |
| 10. QUADRICEPS | _____ | _____ | Red |
| 11. PERONEUS | _____ | _____ | Blue |
| 12. GASTROCNEMIUS | _____ | _____ | Pink |
| 13. SOLEUS | _____ | _____ | Yellow-Green |
| 14. TENDON | _____ | _____ | Fluff |
| 15. ORIGIN OF MUSCLE | _____ | _____ | |
| 16. INSERTION OF MUSCLE | _____ | _____ | |



MUSCLES OF THE FACE, HEAD, AND NECK

The complex muscles of the head and neck are capable of rotation and powerful movement as well as the minute coordinated actions that express slight emotional changes in the face. Unlike most skeletal muscles, the face and head muscles are not attached to a moving limb. Instead they insert either into the flat bones of the skull or face or into head tissue such as the lip or skin of the chin. The *muscles of facial expression*, located near the skin (superficial muscles), register emotion and also help you chew and speak. The *muscles of mastication* move the lower jaw primarily for chewing, but they also are necessary for speaking. The *muscles of the tongue* help with chewing and swallowing and are extremely important for making the complex movements required for human speech. Some of the tongue muscles have both their origin and insertion at the hyoid bone; others insert into the tongue. The *muscles of the neck* arise primarily from the sternum and clavicle and as far down as the sixth vertebra. Neck muscles permit you to rotate and extend your head.

1. FRONTALIS _____ Orange
2. ORBICULARIS OCULI _____ Light Blue
3. TEMPORALIS _____ Purple
4. COMPRESSOR NARIS _____ Pink
5. LEVATOR LABII SUPERIORIS _____ Light Green
6. ZYGOMATICUS _____ Yellow
7. ORBICULARIS ORIS _____ Blue
8. BUCCINATOR _____ Light Brown
9. MASSETER _____ Red
10. MENTALIS _____ Brown
11. DEPRESSOR LABII INFERIORIS _____ Green
12. TRIANGULARIS _____ Turquoise
13. a. DIGASTRICUS, b. STERNOHYOIDEUS, and c. OMOHYOIDEUS _____ Yellow Green
14. a. STERNOCLEIDOMASTOIDEUS and b. TRAPEZIUS _____ Light Orange
15. SUPERIOR OBLIQUE _____ Gray
16. a. SUPERIOR, b. LATERAL, and c. MEDIAL RECTUS _____ Light Purple
17. TROCHLEA (pulley) _____ Dark Blue
18. INFERIOR OBLIQUE _____ Flesh

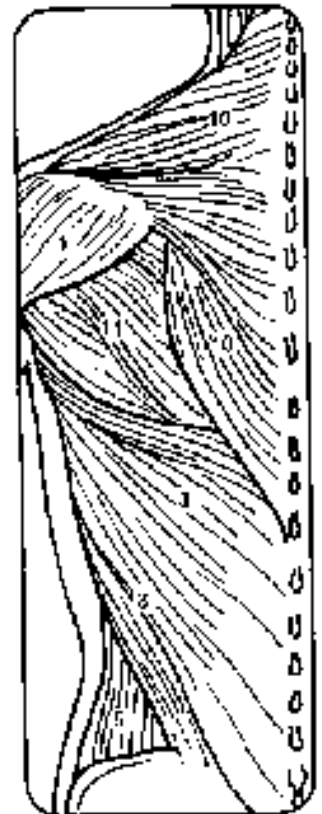
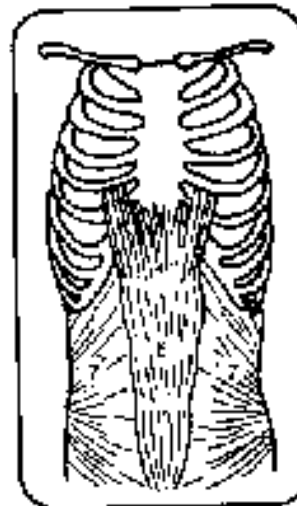
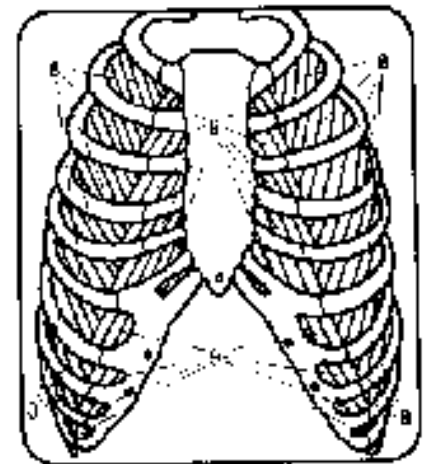
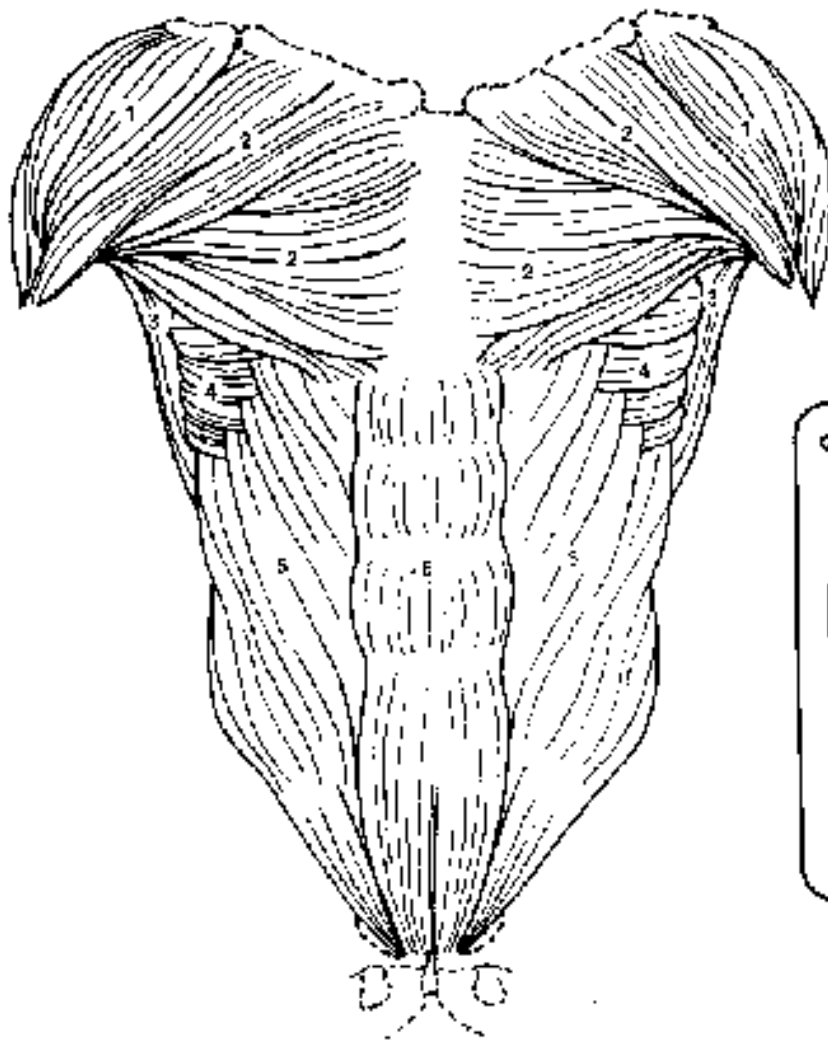


MUSCLES OF THE TORSO

The muscles that encase the torso hold the body erect, allow it to flex, assist in breathing, and restrain the intestines. The back muscles that control the torso's forward and backward movement originate primarily along the upper crest of the hip, the sacrum, and the lumbar vertebrae and rise vertically and diagonally into the ribs and vertebrae at various levels. Although the lumbar vertebrae can flex freely in all directions, the movement of the thoracic vertebrae and their correspondent ribs is very limited, which insures that the lungs are not compressed and have room to expand during breathing. A web of large muscles that restrains the abdominal contents, bands the spine, and assists in breathing passes vertically, horizontally, and diagonally across the abdominal cavity. For example, *obliquus externus* (external oblique) compresses the abdominal cavity during forced exhalation. If the external oblique muscle on only one side of the body contracts, the spine bends sideward. The muscles used in breathing enlarge and reduce the size of the thoracic cavity, which decreases and increases in turn the air pressure in the lungs. The *diaphragm*, which forms the floor of the thoracic cavity, contracts downward to increase the length and therefore the volume of the thorax. Two sets of *intercostal* muscles placed side by side fill the spaces between the ribs. The external or outer intercostals, which raise the ribs and enlarge the

cavity during inspiration, angle downward and forward away from the spine. The internal or inner set are cast down and back toward the spine and serve to draw the ribs down to reduce the volume of the thoracic cavity for exhalation.

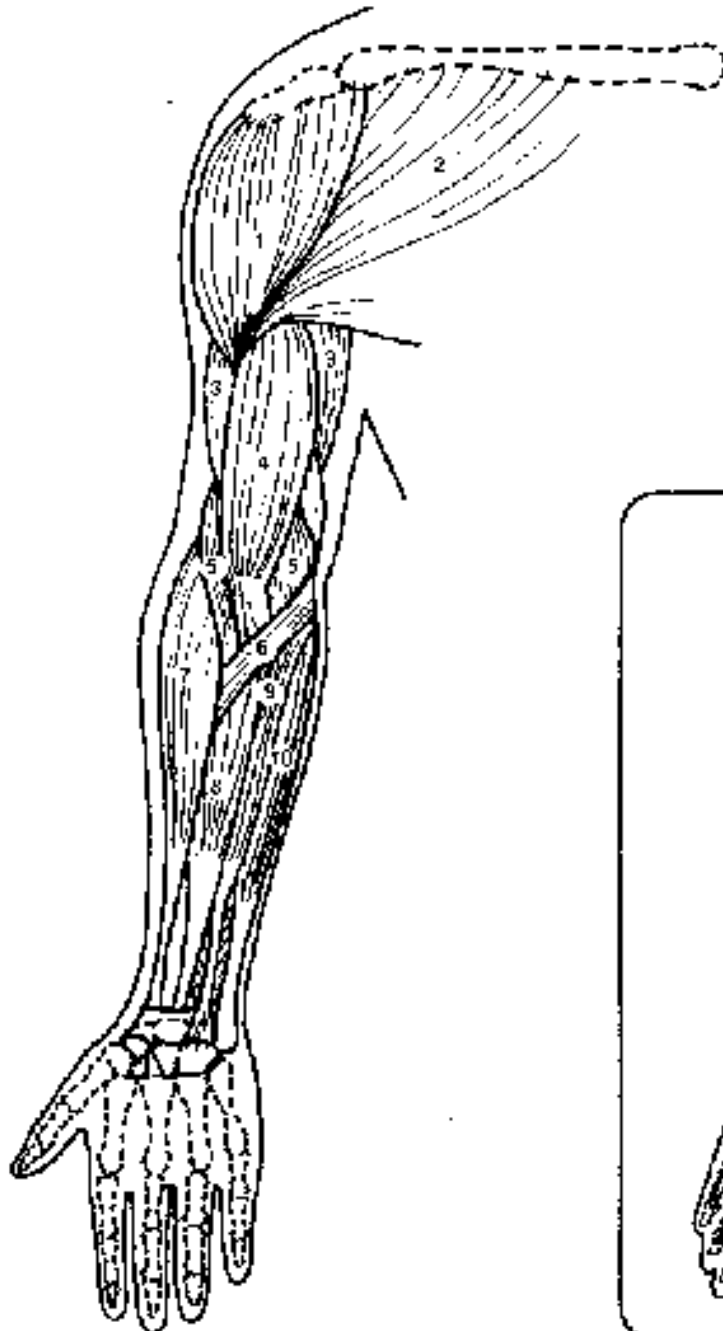
1. DELTOID _____ Orange
2. PECTORALIS MAJOR _____ Light Blue
3. LATISSIMUS DORSI _____ Red
4. SERRATUS ANTERIOR _____ Gray
5. EXTERNAL OBLIQUE _____ Light Brown
6. RECTUS ABDOMINIS _____ Turquoise
7. INTERNAL OBLIQUE _____ Brown
8. EXTERNAL INTERCOSTAL _____ Yellow
9. INTERNAL INTERCOSTAL _____ Green
10. TRAPEZIUS _____ Pink
11. TERES MAJOR _____ Yellow-Green



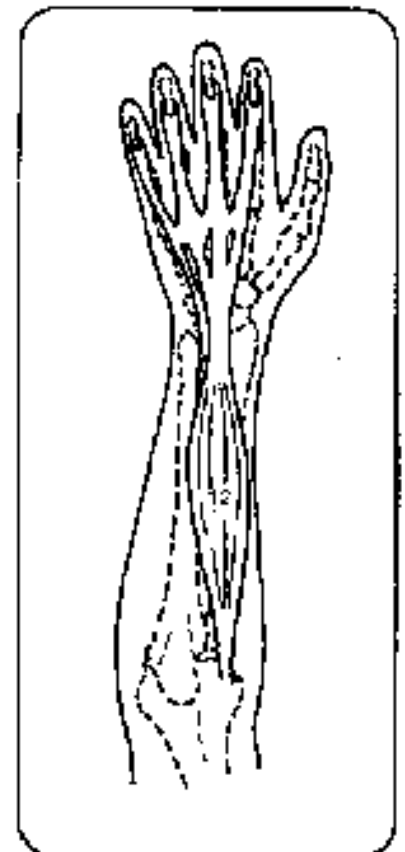
MUSCLES OF THE UPPER LIMBS

A complex group of strong opposing muscles move the arm. These muscles, which arise from the scapula, clavicle, sternum, ribs, lower vertebrae, and hips, form the only attachment between the arm and shoulder and the axial skeleton and hold the humerus in its socket. By contracting and relaxing in combination, the shoulder muscles are able to rotate, extend, and flex the arm at the shoulder. The *brachialis*, *biceps brachii* (which has two heads or origins), and *triceps brachii* (three heads), all muscles of the upper arm, flex the elbow joint and move the forearm. The two rotating actions, *supination* (as

when you turn a key) and *pronation* (as in turning the palm down) are generated by muscles that arise in the humerus and wrap around the radius and ulna like a window shade around its roller. The forearm and lower humerus are the origin for the primary muscles of the wrist, hand, and fingers. The fingers are connected by long tendons, which you can see in the back of your hand, that run from the forearm muscles. Muscles on the underside of the forearm bend the fingers; muscles on the upper side extend them. The hand has small muscles that spread the fingers and perform the complex and very important opposable thumb action, which man alone among primates is capable of.



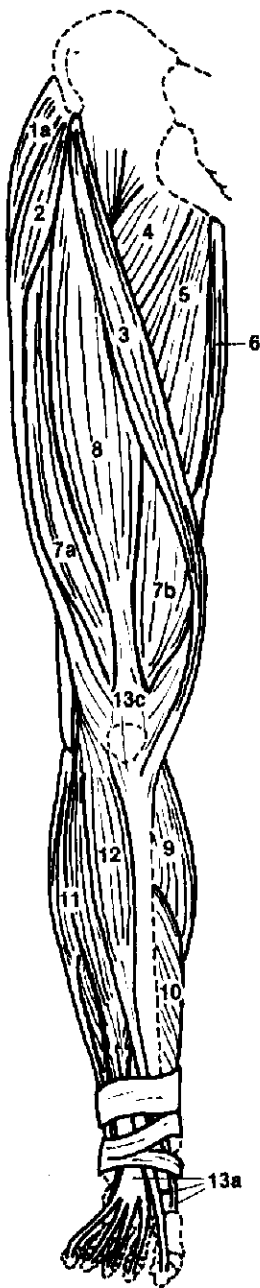
- | | |
|------------------------------------|--------------|
| 1. DELTOID | Orange |
| 2. PECTORALIS MAJOR | Light Blue |
| 3. TRICEPS | Pink |
| 4. BICEPS | Green |
| 5. BRACHIALIS | Light Brown |
| 6. PRONATOR TERES | Gray |
| 7. BRACHIORADIALIS | Light Purple |
| 8. FLEXOR CARPI RADIALIS | Yellow |
| 9. PALMARIS LONGUS | Turquoise |
| 10. FLEXOR CARPI ULNARIS | Red |
| 11. FLEXOR DIGITORUM SUPERFICIALIS | Light Green |
| 12. EXTENSOR DIGITORUM and INDICIS | Light Orange |



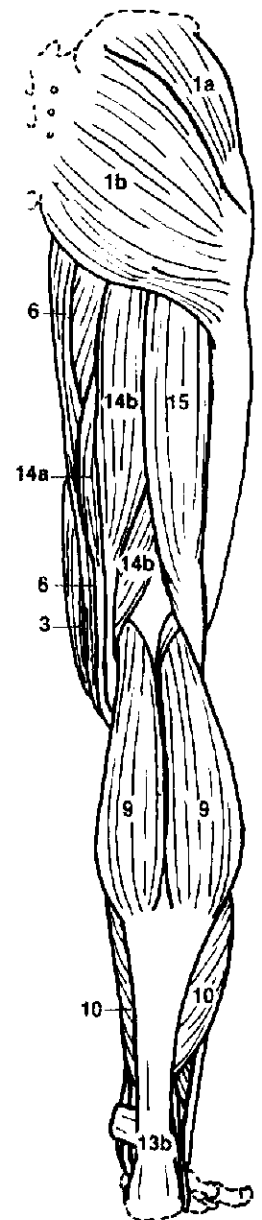
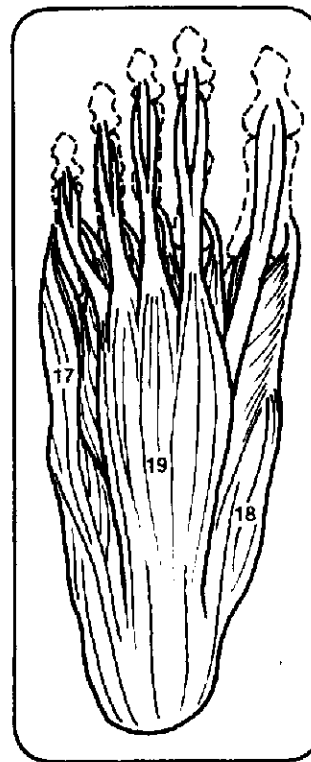
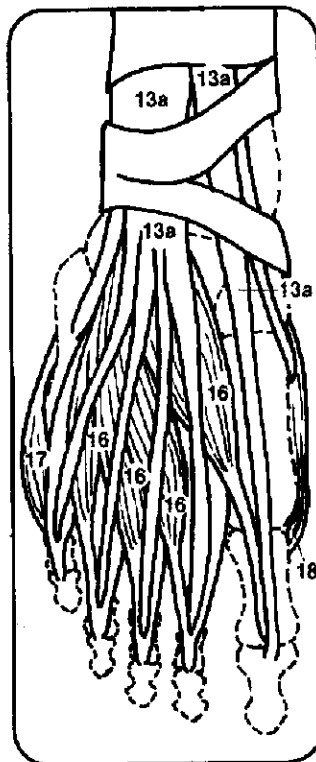
MUSCLES OF THE LOWER LIMBS

The leg is far more powerful than the arm, but its motion is more limited. The upper leg is moved and rotated by large muscles that arise from the front, side, and back of the hip and sacrum. The *gluteus* or *buttock muscles* principally extend, rotate, and elevate the femur. The thigh muscles move the knee. Four muscles, *quadriceps femoris*, which form the front of the thigh, join in a strong tendon just above the knee. The tendon inserts at the top of the tibia; the patella is embedded in it. The *sartorius*, the longest muscle of the body, arises in the ilium, crosses the quadriceps, and inserts into the inner side of the tibia. Running down the back of the thigh is a group of muscles, the *hamstrings*, that extend and flex both the knee and hip. You can feel their large tendons under your knee when you sit down.

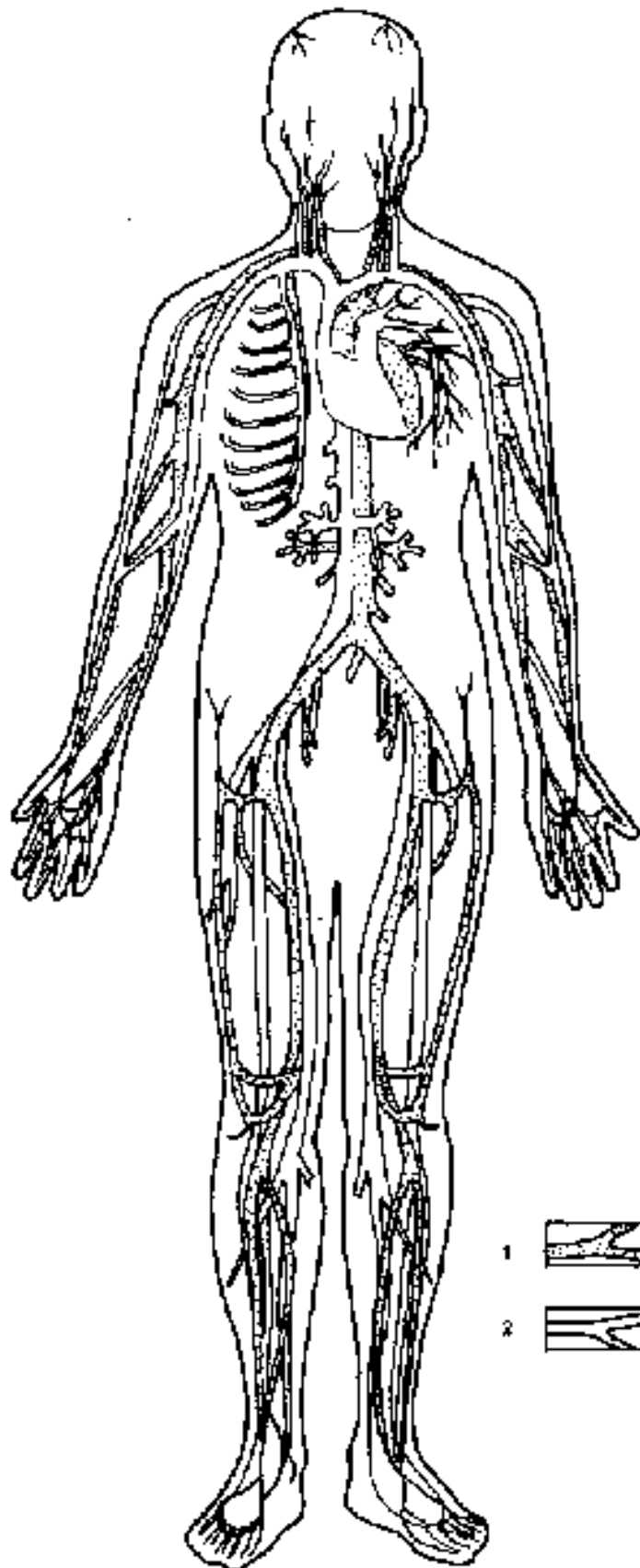
The calf muscles rotate and flex the foot and extend the toes. The lower leg muscles have long tendons that pass over the ankle and insert into the metatarsals and phalanges. Although the foot is relatively fragile, it can withstand strong forces through the progressive distribution of the body's weight from the heel to the shock-absorbing arch and ball. When you walk, the *dorsiflexors* rotate your foot upward, concentrating the majority of your weight on the heel bone as it strikes the ground. Two calf muscles, *gastrocnemius* and *soleus*, lift the heel through the *achilles tendon (tendocalcaneus)* and roll the foot forward, thus distributing your weight onto the metatarsal heads and toes. The foot has a number of small muscles that help support the toes and balance the body.



1. a. GLUTEUS MEDIUS and b. MAXIMUS _____ Purple
2. TENSOR FASCIAE LATAE _____ Flesh
3. SARTORIUS _____ Yellow-Green
4. PECTINEUS _____ Gray
5. ADDUCTOR LONGUS _____ Light Green
6. GRACILIS _____ Pink
7. a. VASTUS LATERALIS and b. MEDIALIS _____ Red
8. RECTUS FEMORIS _____ Light Blue
9. GASTROCNEMIUS _____ Green
10. SOLEUS _____ Orange
11. PERONEUS _____ Blue
12. TIBIALIS ANTERIOR _____ Brown
13. a. TENDONS, b. TENDOCALCANEUS, and c. TENDON OF QUADRICEPS FEMORIS _____ Yellow
14. a. SEMIMEMBRANOSUS and b. SEMITENDINOSUS _____ Turquoise
15. BICEPS FEMORIS _____ Light Purple
16. EXTENSOR DIGITORUM BREVIS _____ Light Brown
17. ABDUCTOR DIGITI MINIMI _____ Dark Blue
18. ABDUCTOR HALLUCIS _____ Dark Green
19. FLEXOR DIGITORUM BREVIS _____ Light Orange

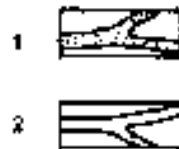


CIRCULATORY SYSTEM



The circulatory system supplies oxygen and nutrients to every cell of the body and removes wastes and carbon dioxide. The system consists of *blood*, which carries the nutrients and wastes; the *heart*, which pumps the blood; and a closed system of tubes (*arteries* and *veins*) that carries the blood to and from the body tissues. The arteries transport blood enriched with oxygen and nutrients; the veins carry depleted blood. The artery that leaves the heart is very large, but it divides again and again into smaller and smaller branches. The tiniest of these branches are called *capillaries*, which are only seven to nine microns wide—so small that blood cells must pass through in single file. The capillaries are the site of the exchange of nutrients and wastes between the blood and the tissue cells. Interlacing capillary beds are found throughout the body except in the cartilages, cuticles, nails, hair, and the cornea of the eye. The depleted blood moves back toward the heart through the *venous* system. First the tiniest blood vessels unite in the capillary beds to form *venules*, then the venules combine again and again until they form the largest veins. The heart pumps the depleted blood to the lungs, where carbon dioxide is exchanged for oxygen, and to the liver and kidneys, which remove wastes.

Large arteries provide direct "express" service to major areas of the body such as the brain, lungs, arms, and abdomen; these arteries don't begin to subdivide until they reach the appropriate area. Press your finger against one of these arteries and you will feel the pump stroke or beat of the heart. This is the *pulse*.



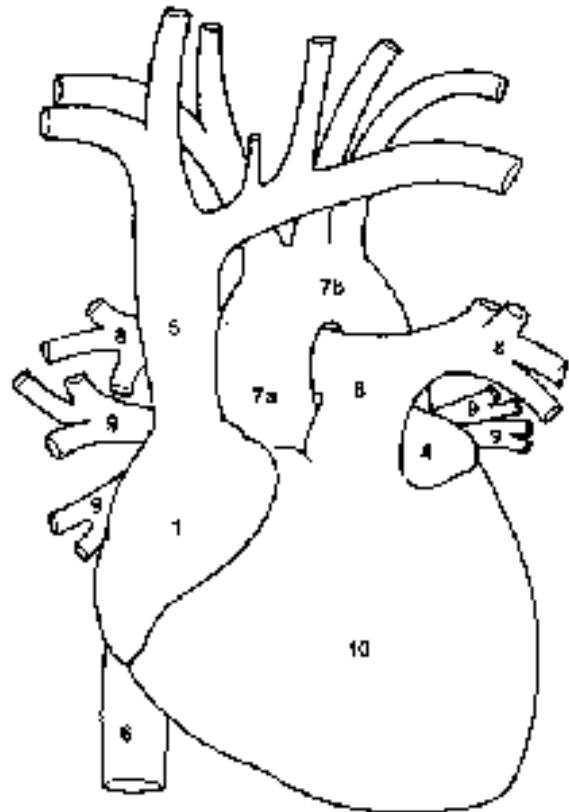
1. ARTERIAL CIRCULATION _____ Red
2. VENOUS CIRCULATION _____ Blue

HEART

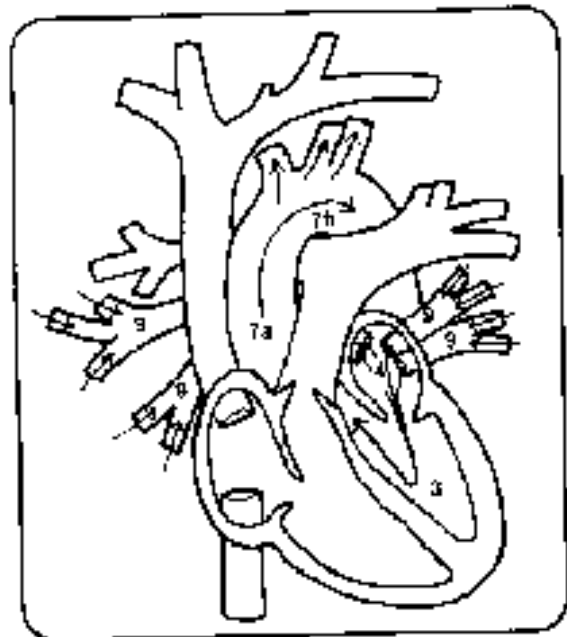
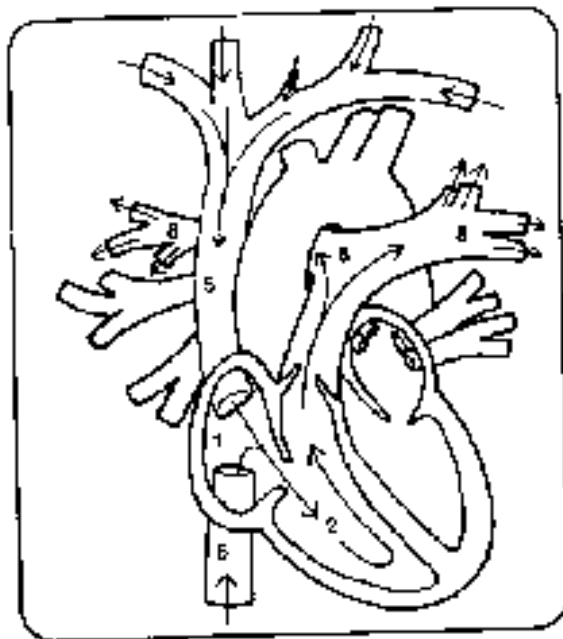
The heart is the key organ of the circulatory system. It is a bit larger than a man's fist—about twelve centimeters long, nine centimeters wide, and six centimeters thick. This hollow muscle is located to the left of the sternum between the second and fifth ribs and is enclosed in the *pericardium*, a membranous sac with a fibrous layer outside and a serous one inside, which protects the heart and anchors it in place. Between the two layers is a watery lubricant that minimizes friction when the heart beats. The heart is surrounded by the lungs, each of which has a notch, the *cardiac impression*, the heart fits into.

Each half of the heart has two chambers, the *atrium* (upper) and the *ventricle* (lower). Blood returning to the heart enters the right atrium from three veins: the *superior vena cava*, which runs from the upper torso and limbs; the *inferior vena cava*, which carries blood from the lower torso and limbs; and the *coronary sinus*, which circulates venous blood from the walls of the heart. The blood is pumped through the *tricuspid valve* (which has three cusps or flaps) into the right ventricle. From there it goes to the *pulmonary artery*, the only artery that carries unoxygenated blood, which carries it to the lungs. In the lungs the blood exchanges carbon dioxide for oxygen. The enriched blood then goes to the left atrium, where it passes through the strong *bicuspid* or *mitral valve* into the left ventricle. Finally the blood leaves the heart through the *aortic semilunar valves* and flows into the *aorta* and through the body.

The heart beats involuntarily, that is, the brain doesn't have to command it to pump blood. Instead various sensors monitor the body's activities and the consequent demands for more or less blood. For example, there are pressure receptors in the aorta that respond to changes in arterial pressure. The *carotid reflex* slows the heart when the pressure gets too high; the *carotid sinus reflex* increases the heart rate when the pressure becomes too low in the arteries that serve the brain. Chemoreceptors increase the heartbeat if they detect a lack of oxygen or an increase of carbon dioxide.



- | | | | |
|--|-------|-------|--------------|
| 1. RIGHT ATRIUM | _____ | _____ | Light Purple |
| 2. RIGHT VENTRICLE | _____ | _____ | Blue |
| 3. LEFT VENTRICLE | _____ | _____ | Red |
| 4. LEFT ATRIUM | _____ | _____ | Orange |
| 5. SUPERIOR VENA CAVA | _____ | _____ | Light Blue |
| 6. INFERIOR VENA CAVA | _____ | _____ | Dark Blue |
| 7. a. ASCENDING AORTA and b. AORTIC ARCH | _____ | _____ | Pink |
| 8. PULMONARY ARTERY | _____ | _____ | Green |
| 9. PULMONARY VEIN | _____ | _____ | Yellow |
| 10. HEART | _____ | _____ | Purple |

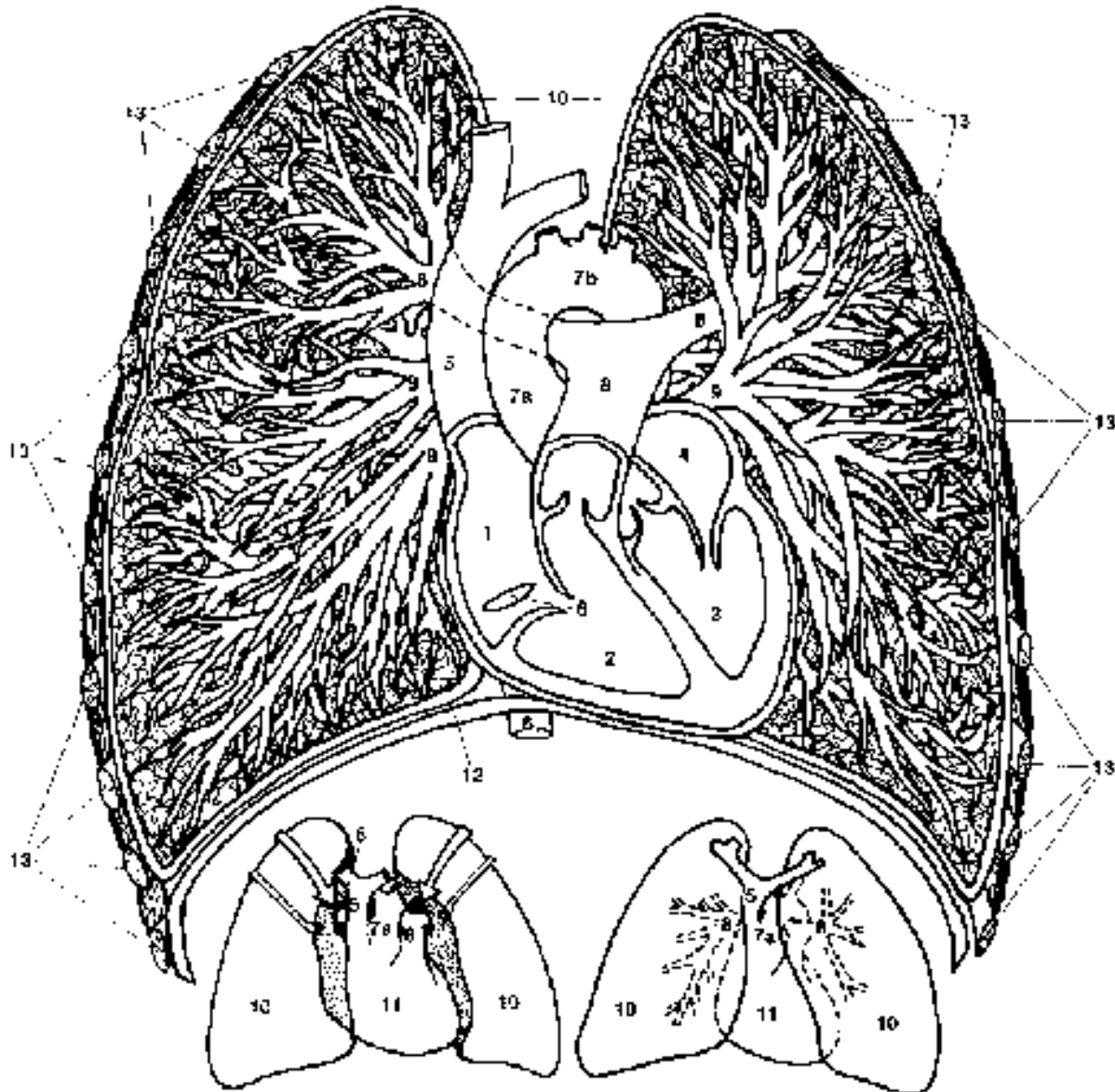


PULMONARY CIRCULATION

Pulmonary circulation is the movement of blood from the heart to the air sacs in the lungs and back to the heart. This circulation is necessary for the blood to exchange carbon dioxide for oxygen. The right ventricle of the heart pumps un-oxygenated blood into the *pulmonary artery*, which divides in two to form the *right* and *left pulmonary arteries*. The right artery, which supplies the larger lung, the right (which has three lobes), is wider and longer than the left artery (which services the two-lobed left lung). The arteries enter the lungs at the *hilus*, a vertical slit. Then the arteries divide and pass through each lobe. Sub-division follows subdivision until massive capillary beds are formed that surround the *alveoli* or small air sacs. At this point there is only a thin membrane separating each capillary from the air sac. As a blood cell passes down a capillary, carbon dioxide diffuses through the membrane into the alveoli; then oxygen passes from the alveoli to the blood cell. The oxygenated blood moves out of the capillary bed into the increasingly larger pulmonary

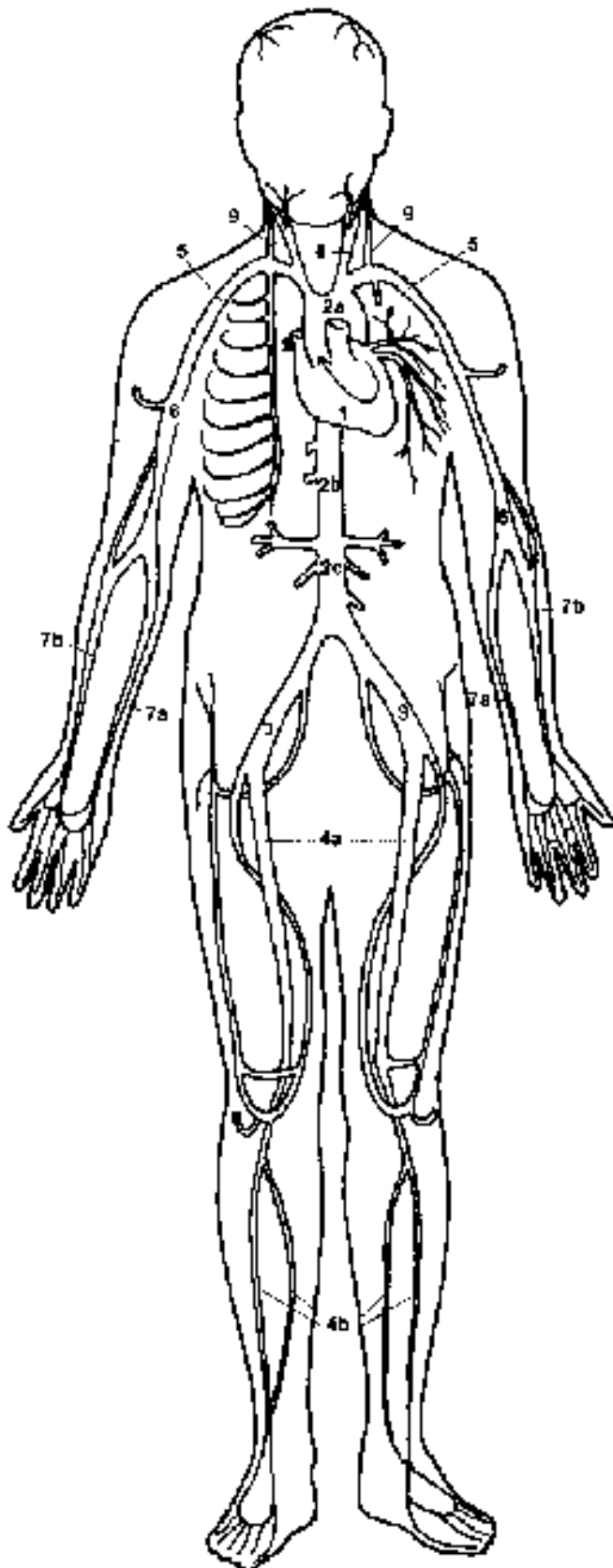
veins. These veins unite to form four main trunks (two for each lung) and empty into the left atrium of the heart. The heart then pumps the oxygenated blood on its path through the body.

- | | |
|--|--------------|
| 1. RIGHT ATRIUM _____ | Light Purple |
| 2. RIGHT VENTRICLE _____ | Blue |
| 3. LEFT VENTRICLE _____ | Red |
| 4. LEFT ATRIUM _____ | Orange |
| 5. SUPERIOR VENA CAVA _____ | Light Blue |
| 6. INFERIOR VENA CAVA (opening) _____ | Dark Blue |
| 7. a. ASCENDING AORTA and b. ARCH of AORTA _____ | Pink |
| 8. PULMONARY ARTERY _____ | Green |
| 9. PULMONARY VEIN _____ | Yellow |
| 10. LUNG _____ | Grey |
| 11. HEART _____ | Purple |
| 12. DIAPHRAGM _____ | Brown |
| 13. RIBS _____ | Light Brown |

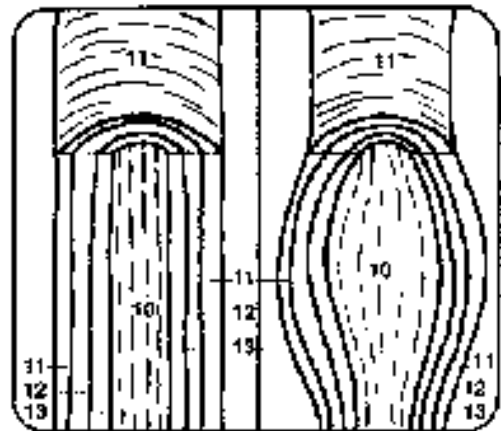


ARTERIES

The arteries carry blood from the heart to the capillaries, dividing and then subdividing on the way until they become smaller and smaller and more and more numerous, and end in the capillary beds located in the body tissues. The *aorta* is the first and largest of the arteries. Adults have about seven thousand square miles of capillaries. If laid end to end, all the elements of the vascular (blood vessel) system—arteries, capillaries, and veins—would extend about seventy thousand miles. The arteries have three layers—muscle tissue, elastic fibers, and connective tissue—and expand and contract in coordination with the flow of blood passing through them. Each heartbeat pushes blood into the arteries, which expand to hold the blood and then contract behind it as the heart pumps the blood to the next section of the vascular system. The arteries' structure prevents them from collapsing when broken, but the arteries will constrict to reduce the size of the opening and thereby diminish the loss of blood. Many parts of the body are served by more than one artery, a system called *collateral circulation*. Thus if a blood vessel serving such an area is damaged or restricted, the flow of blood will not stop completely.



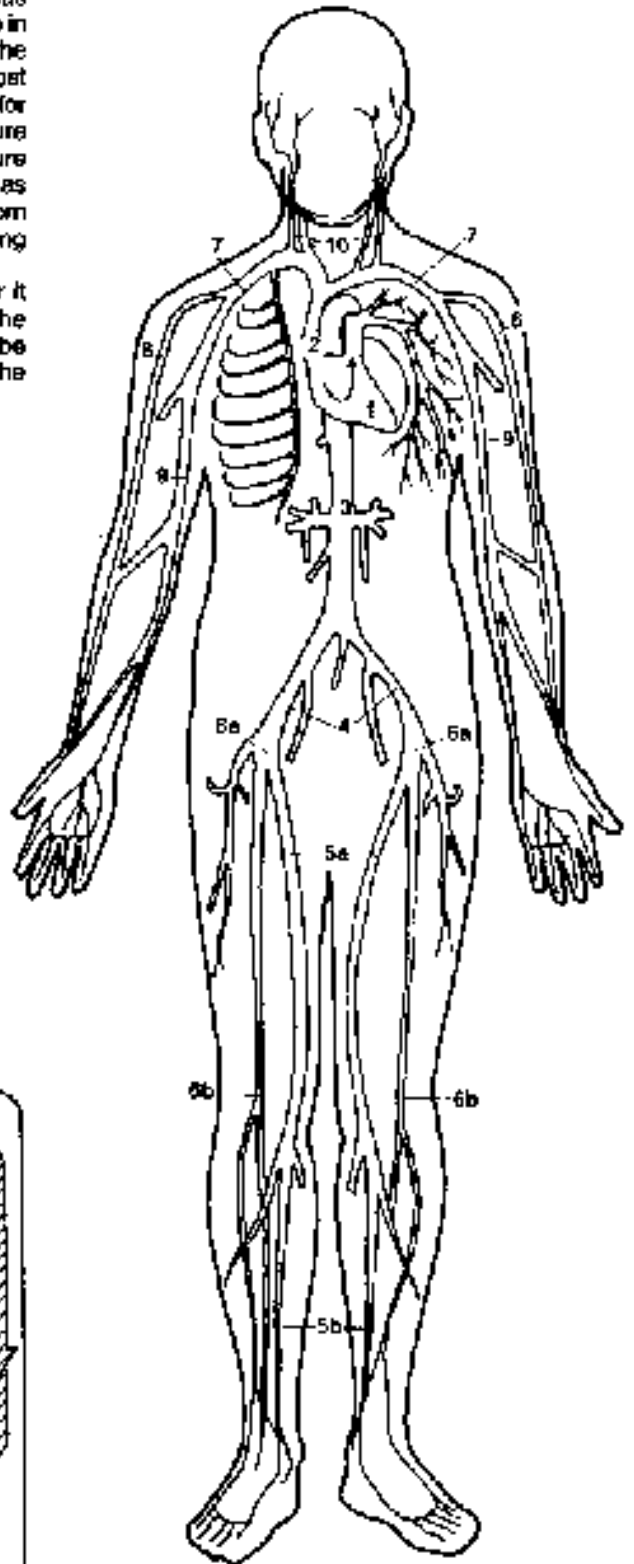
- | | | |
|---|-------|--------------|
| 1. HEART | _____ | Purple |
| 2. a. ARCH OF AORTA b. THORACIC AORTA, and c. ABDOMINAL AORTA | _____ | Pink |
| 3. COMMON ILIAC | _____ | Orange |
| 4. a. FEMORAL and b. TIBIAL | _____ | Light Brown |
| 5. SUBCLAVIAN | _____ | Yellow |
| 6. AXILLARY AND BRACHIAL | _____ | Green |
| 7. a. ULNAR and b. RADIAL | _____ | Light Green |
| 8. CAROTID | _____ | Light Orange |
| 9. VERTEBRAL | _____ | Brown |
| 10. ARTERIAL BLOOD | _____ | Red |
| 11. CONNECTIVE TISSUE | _____ | Light Purple |
| 12. SMOOTH MUSCLE TISSUE | _____ | Turquoise |
| 13. SEROUS MEMBRANE | _____ | Flesh |



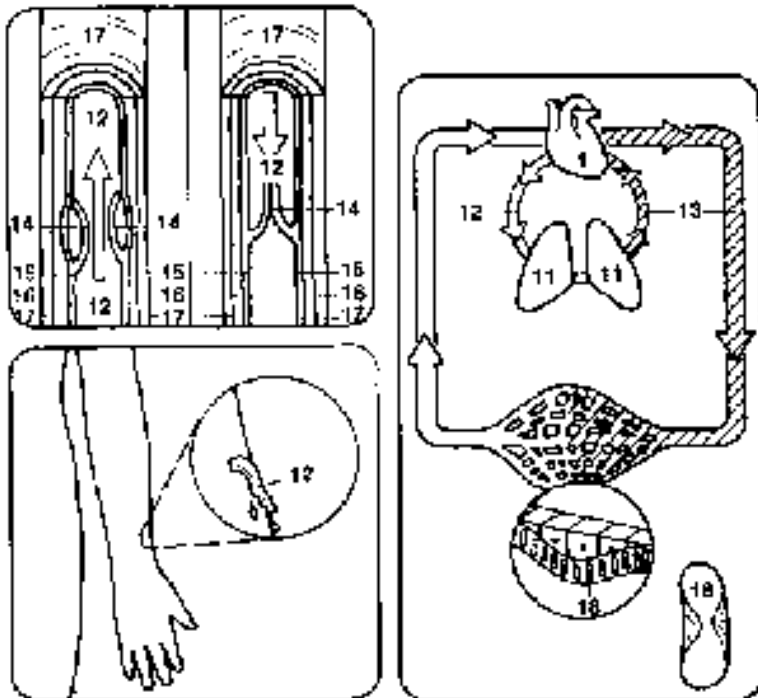
VEINS

The veins bring depleted, unoxygenated blood from the capillary beds back to the heart. Un-oxygenated blood is deep red. Blood turns bright red when it is exposed to oxygen in the air sacs of the lungs. The veins' structure is similar to that of the three-layered arteries, but the blood pressure in the veins is much less than in the arteries; thus the venous walls are thinner and less rigid and will collapse if they are not filled with blood. Although the venous walls are expandable, they are not as elastic as arterial walls. The pressure in the veins that pushes the blood back to the heart can barely overcome the pull of gravity. To prevent blood from flowing backward or pooling, veins most affected by gravity and the weight of the blood (veins of the lower leg, for example) have valves with double flaps that hold the blood until the pressure builds up sufficiently to move the blood toward the heart. When the pressure drops, the weight of the blood forces the valves shut. The condition known as varicose veins occurs, usually with age, when the valves weaken from constant stretching, which destroys the veins' elasticity, thereby permitting blood to leak downward and expand the walls of the veins.

Unlike arterial blood, venous blood does not spurt from a cut; rather it flows steadily. To stop the flow, apply pressure on the vein on the side of the cut furthest from the heart. The spurting blood from a cut artery must be stopped the opposite way, by applying pressure between the heart and the cut.

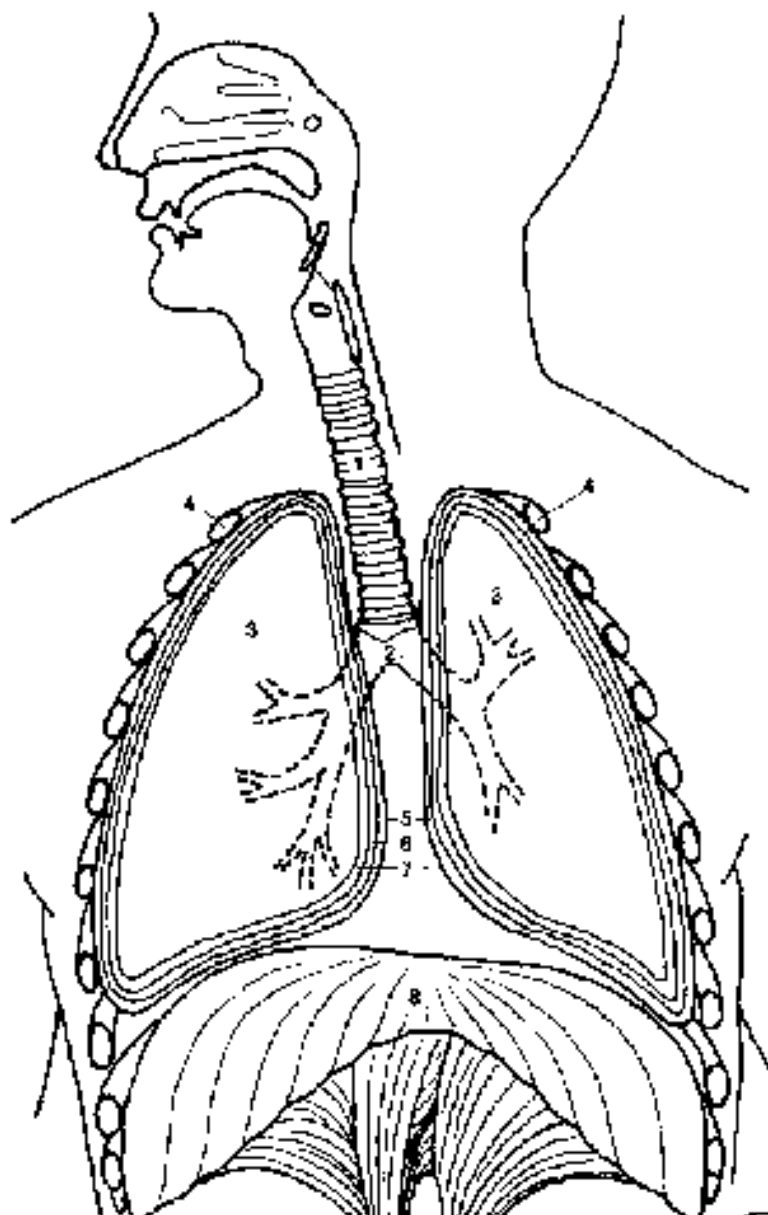


- | | |
|---------------------------------------|--------------|
| 1. HEART | Purple |
| 2. SUPERIOR VENA CAVA | Light Blue |
| 3. INFERIOR VENA CAVA | Dark Blue |
| 4. COMMON ILIAC | Orange |
| 5. a. GREATER and b. LESSER SAPHENOUS | Brown |
| 6. a. FEMORAL and b. DEEP FEMORAL | Light Brown |
| 7. SUBCLAVIAN | Yellow |
| 8. CEPHALIC | Light Green |
| 9. AXILLARY and BRACHIAL | Green |
| 10. INTERNAL and EXTERNAL JUGULAR | Light Orange |
| 11. LUNG | Gray |
| 12. UNOXYGENATED BLOOD | Deep Red |
| 13. OXYGENATED BLOOD | Bright Red |
| 14. VALVES | Yellow-Green |
| 15. SEROUS MEMBRANE | Flesh |
| 16. SMOOTH MUSCLE TISSUE | Turquoise |
| 17. CONNECTIVE TISSUE | Light Purple |
| 18. RED CORPUSCLE IN CAPILLARY | Pink |

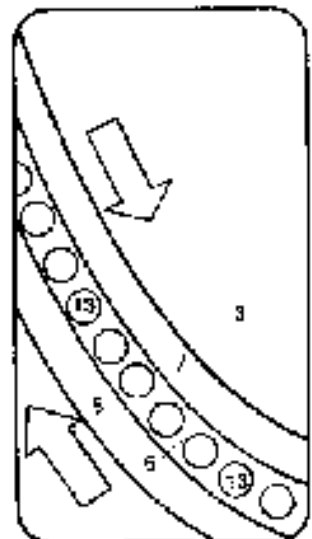
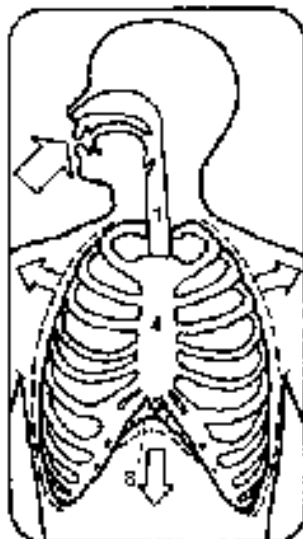
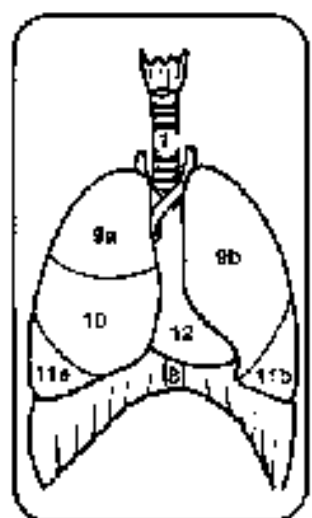


RESPIRATORY SYSTEM

Every cell in the body converts oxygen to energy and generates carbon dioxide as a waste product. *Ventilation* is the term for the process of breathing oxygen in and carbon dioxide out. The respiratory system consists of the nose; *nasal cavities*, which filter and condition incoming air; the *pharynx* or throat; the *larynx* or voice box; the *trachea* or windpipe; the *lungs*; the *bronchi* or branching air tubes in the lungs; and the *air sacs*, the actual site of the oxygen-carbon dioxide exchange. The lungs are protected by the strong rib cage and, underneath, the diaphragm; they are surrounded by two *serous membranes*, the *visceral pleurae*. The lungs in turn surround the *mediastinum*, an interpleural space that contains the heart; in its pericardial sac and parts of the trachea, bronchus, esophagus, blood vessels, and nerves. The thoracic cavity is lined by a membrane called the *parietal pleura*; between it and the visceral pleurae is a potential space, the *intrapleural space*, containing only a thin fluid that acts as a lubricant for the pleurae, which thus slide frictionlessly as the lungs move. The lungs open their inner air chambers to the outside atmosphere; thus when the lungs are at rest the air pressure is the same inside and outside the body. As inhalation begins, the ribs, thoracic muscles, and diaphragm increase the size of the thoracic cavity, thereby lowering the air pressure in the lungs. The higher pressure outside the body then forces more air into the lungs to equalize the air pressure inside and outside. During exhalation the muscles and ribs compress the lungs, raising the air pressure inside until it exceeds the pressure outside – and the air rushes out.



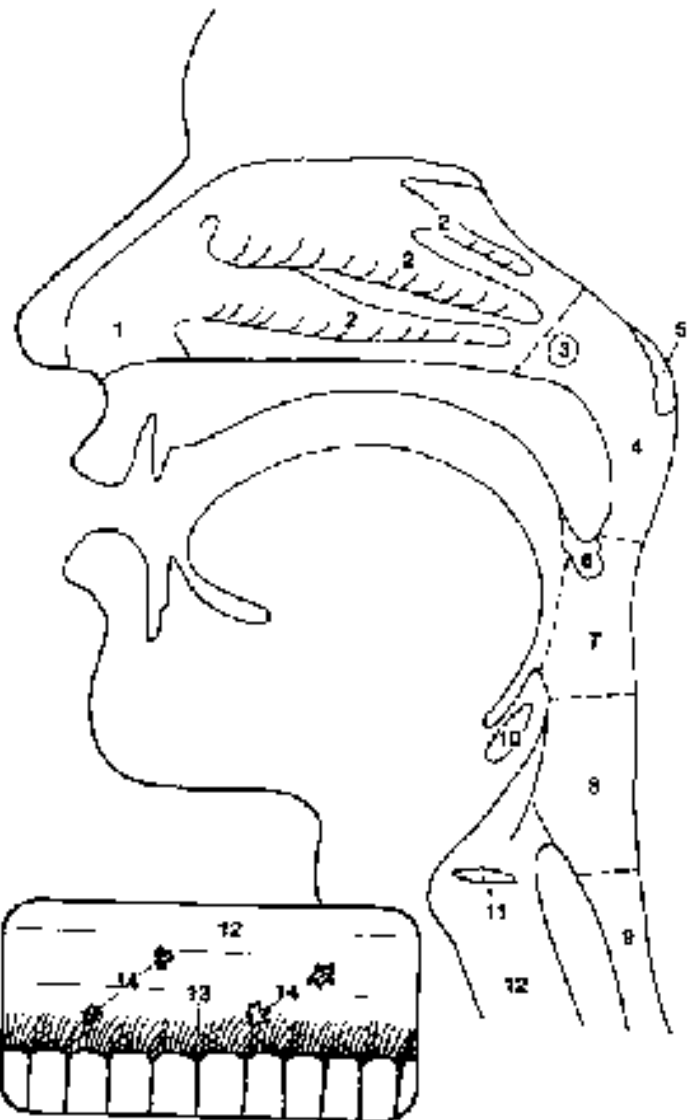
- 1. TRACHEA _____ Blue
- 2. BRONCHUS _____ Light Blue
- 3. LUNG _____ Gray
- 4. RIB CAGE _____ Yellow
- 5. PARIETAL PLEURA _____ Pink
- 6. INTRAPLEURAL SPACE _____ Yellow-Green
- 7. VISCERAL PLEURA _____ Orange
- 8. DIAPHRAGM _____ Red
- 9. a. RIGHT SUPERIOR and
b. LEFT SUPERIOR LOBES _____ Light Orange
- 10. RIGHT MIDDLE LOBE _____ Light Green
- 11. a. RIGHT INFERIOR and
b. LEFT INFERIOR LOBES _____ Light Brown
- 12. HEART _____ Purple
- 13. LUBRICATING FLUID _____ Green



NOSE, NASAL CAVITIES, AND PHARYNX

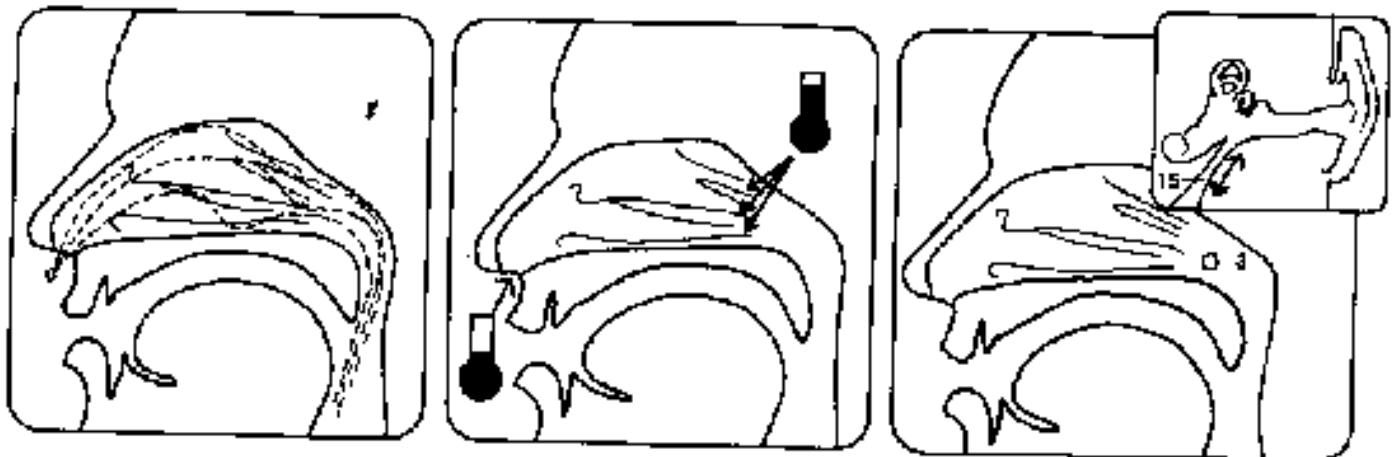
The air you inhale passes through a series of chambers and passageways that clean and condition it before it reaches your lungs. First the air enters the body through the two *nostrils*, which open into two large chambers, the nasal cavities. The cavities are separated from each other by the *septum*, a cartilage divider. Sticky mucous membranes line the walls of the cavities. The *cilia*, millions of hair-like projectors that cover the membranes, sweep trapped particles toward the throat to be swallowed. Each cavity also has a set of three curved bones, the *turbinates* or *conchae*, that serve as airfoils, causing air passing through them to swirl and change direction. Larger airborne particles that can't follow the airstream get thrown on the sticky membranes. The nasal cavities can trap almost all particles over ten microns wide. The nasal passages also warm incoming air almost to body temperature and humidify it by adding moisture from the mucous membranes and drainage from various sinuses. As much as 350 to 400 milliliters of water per day is used to humidify dry air. The nasal cavities are also protected by the *sneezing mechanism*, which is triggered when irritants stimulate a reaction from the brain to command the deep inhalation and explosive exhalation that carries away the foreign matter.

Both food and air pass into the body through the pharynx or throat, which is located just behind the nasal cavities and mouth and is made of skeletal tissue and lined with mucous membranes. It has three parts: the *nasopharynx* is on the top near the nasal cavities; the *oropharynx* is in the middle behind the oral cavity; and the *laryngopharynx* is located above the voice box and esophagus. The *eustachian* or *auditory tubes* open into the pharynx. They drain secretions from the middle ear and connect the middle ear, nasopharynx, and the atmosphere in order to equalize pressure on both sides of the eardrum.



- | | |
|-------------------------------|--------------|
| 1. NASAL CAVITY | Light Green |
| 2. TURBINATE BONES | Green |
| 3. OPENING OF EUSTACHIAN TUBE | Dark Blue |
| 4. NASOPHARYNX | Orange |
| 5. ADENOIDS | Brown |
| 6. TONSILS | Gray |
| 7. OROPHARYNX | Light Orange |
| 8. LARYNGOPHARYNX | Light Brown |
| 9. ESOPHAGUS | Yellow-Green |
| 10. EPIGLOTTIS | Red |
| 11. LARYNX | Yellow |

- | | |
|---------------------|------------|
| 12. TRACHEA | Blue |
| 13. CILIA | Purple |
| 14. DUST | Dark Green |
| 15. EUSTACHIAN TUBE | Light Blue |



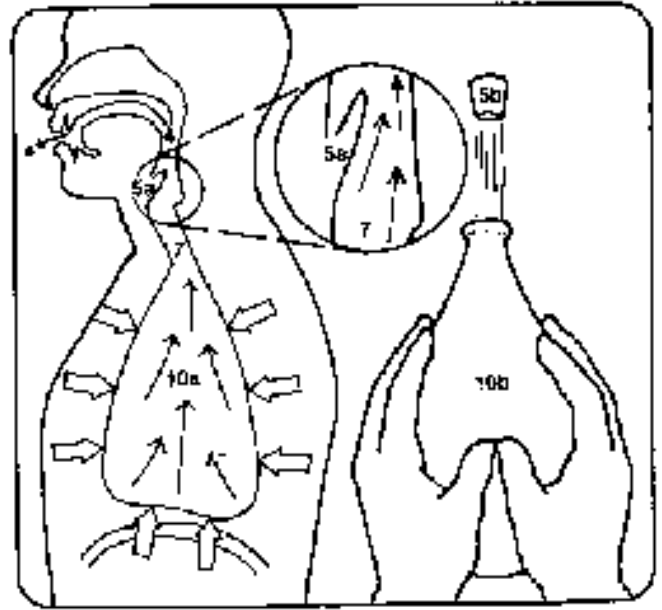
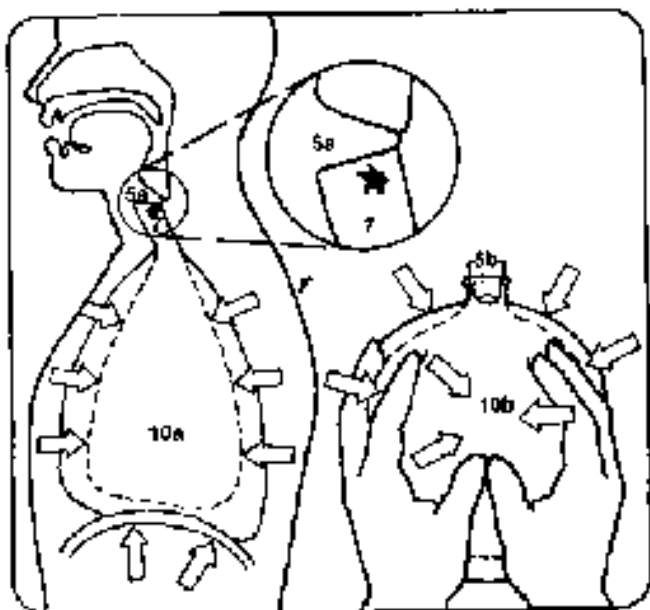
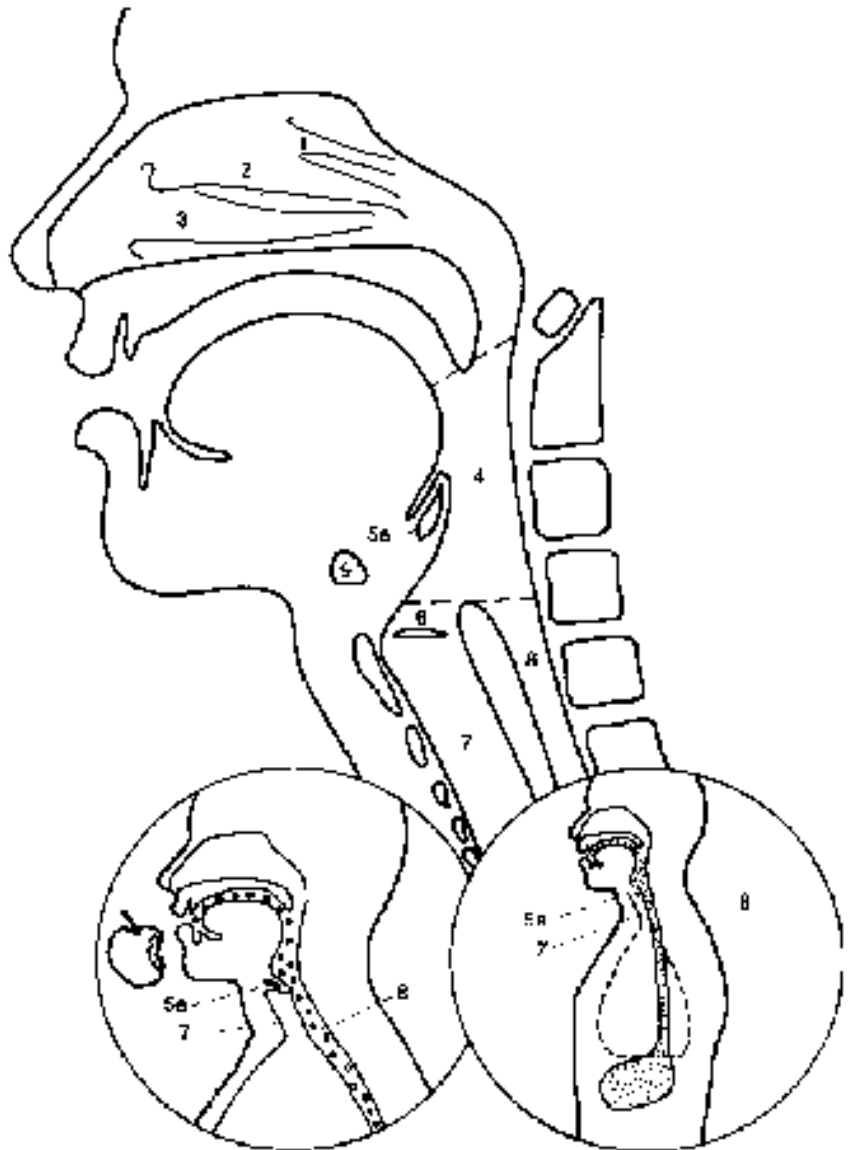
MECHANICS OF BREATHING AND SWALLOWING

The *laryngopharynx* is shared by air, solid foods, and liquids passing into the body. The *larynx* and the *esophagus* open into it. A type of mucous membrane, *stratified squamous epithelium*, coats its walls. Sensors in the epithelium act as traffic controllers that allow only air to enter the *trachea*. When solids or liquids stimulate these touch receptors, the *epiglottis*, a small flap over the trachea opening, snaps shut. At the same time swallowing begins to carry the material into the stomach.

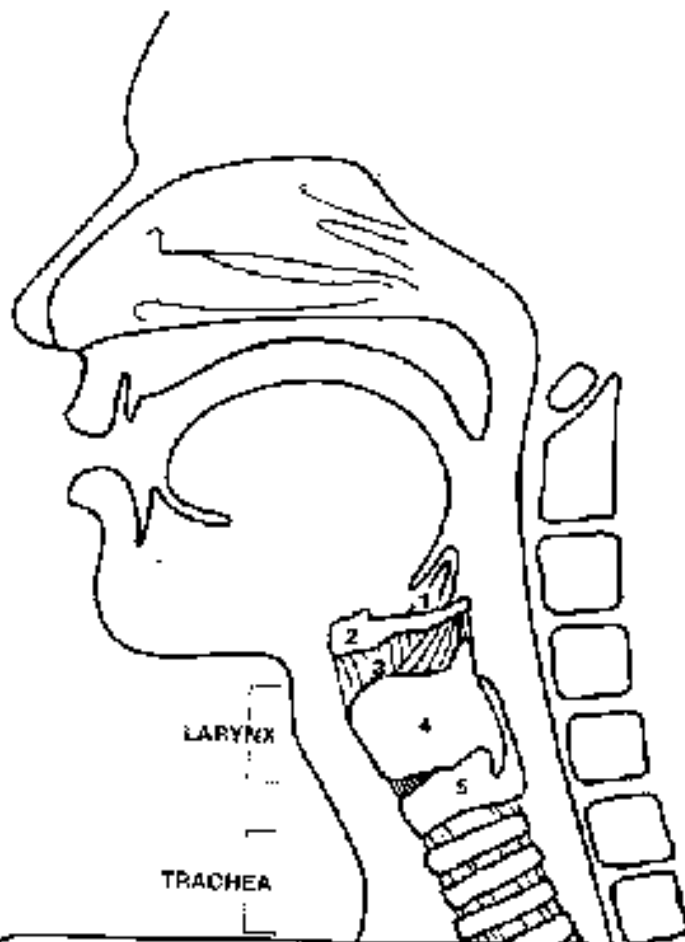
- 1. SUPERIOR CONCHA _____ Light Green
- 2. MIDDLE CONCHA _____ Green
- 3. INFERIOR CONCHA _____ Dark Green
- 4. PHARYNX _____ Orange
- 5. a. EPIGLOTTIS and b. CORK _____ Red
- 6. LARYNX _____ Yellow
- 7. TRACHEA _____ Blue
- 8. ESOPHAGUS _____ Yellow-Green
- 9. HYOID BONE _____ Light Brown
- 10. a. AIR IN LUNGS and b. BALLOON _____ Light Blue

COUGH SEQUENCE

Even minute particles can block air passages in the lungs. The walls of the trachea are lined with cilia and mucous membranes that trap dust not caught in the upper cavities. Large particles stimulate touch sensors that trigger the brain to send out a cough reaction signal. The lungs fill with air, the epiglottis closes, and the ribs and diaphragm are pushed sharply against the lungs, thereby increasing the lungs' pressure - it's like squeezing a balloon. The epiglottic flaps open and air rushes out at almost the speed of sound, dislodging the particle and carrying it out.



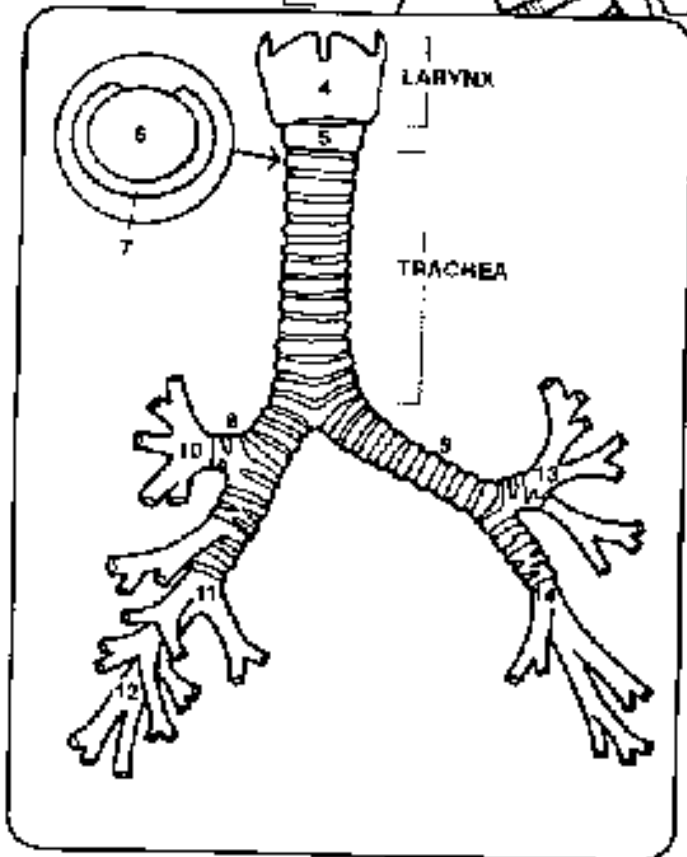
LARYNX AND TRACHEA



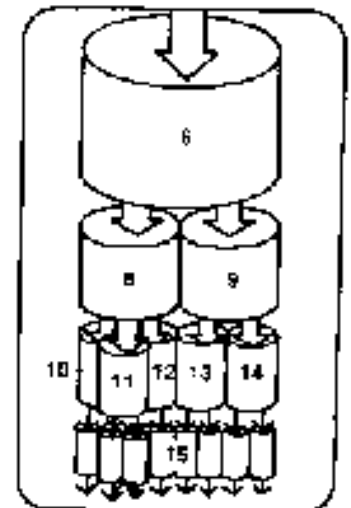
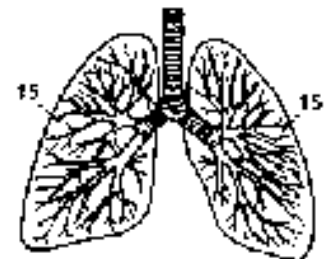
The larynx or voice box connects the pharynx with the top of the trachea. The larynx is made of nine cartilages, all tied together by ligaments and moved by muscles, and two pairs of mucous membrane folds. The lower or inferior folds are the *true vocal folds* or *cords*; the upper or superior folds are the *false vocal folds* or *cords*. Only the true cords create sound; they vibrate like violin strings in the airstream. The *glottis*, which consists of the true cords and the opening between them, permits a variable amount of air to pass through the voice box. The false folds prevent solids from entering the larynx, and they also come into play when you hold your breath.

The trachea or windpipe extends from below the larynx and toward the lungs. It is reinforced by a column of C-shaped cartilages and coated with mucous membranes and cilia that trap and sweep minute dust particles upward to the pharynx. The trachea divides into two *bronchi*, one for each lung, which are structurally similar to the trachea. The right bronchus is the wider, shorter, and more vertical of the two. The bronchi divide and subdivide continuously, becoming smaller and more numerous. As they become smaller they change from cartilage rings to cartilage plates to smooth muscles. These are the muscles that spasm during an asthma attack, closing off air passageways and making breathing difficult.

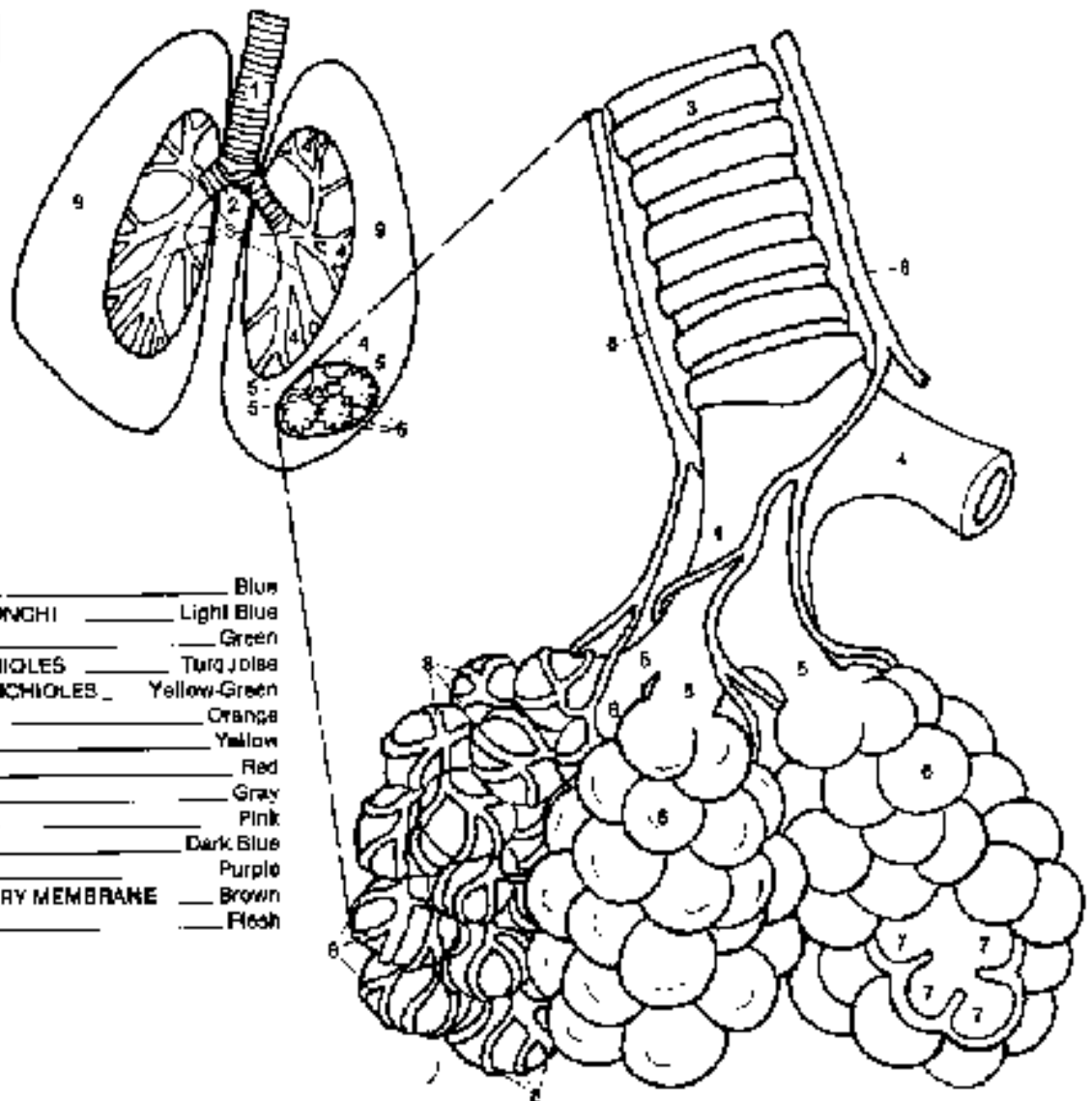
There is little change in velocity and pressure of the air as it moves through the bronchial system. This is because the number of tubes increases even as the size of each individual tube decreases. It takes just a little bit of muscular force to create a vacuum in the tubes for inhalation or high pressure for exhalation.



1. EPIGLOTTIS _____ Red
2. HYOID BONE _____ Light Brown
3. LIGAMENTS _____ Orange
4. THYROID CARTILAGE _____ Green
5. CRICOID CARTILAGE _____ Gray
6. TRACHEA _____ Blue
7. TRACHEAL CARTILAGE _____ Light Purple
8. RIGHT PRIMARY BRONCHUS _____ Light Blue
9. LEFT PRIMARY BRONCHUS _____ Dark Blue
10. RIGHT UPPER LOBAR BRONCHUS _____ Dark Green
11. RIGHT MIDDLE LOBAR BRONCHUS _____ Pink
12. RIGHT LOWER LOBAR BRONCHUS _____ Yellow-Green
13. LEFT UPPER LOBAR BRONCHUS _____ Light Green
14. LEFT LOWER LOBAR BRONCHUS _____ Yellow
15. BRONCHIOLES _____ Turquoise

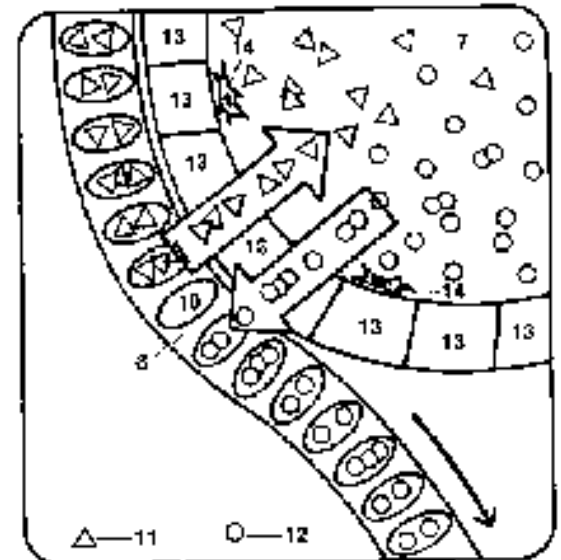


ALVEOLI



- | | | |
|---------------------------------|-------|--------------|
| 1. TRACHEA | _____ | Blue |
| 2. LEFT and RIGHT BRONCHI | _____ | Light Blue |
| 3. BRONCHI | _____ | Green |
| 4. TERMINAL BRONCHIOLES | _____ | Turquoise |
| 5. RESPIRATORY BRONCHIOLES | _____ | Yellow-Green |
| 6. ALVEOLAR SAC | _____ | Orange |
| 7. ALVEOLI | _____ | Yellow |
| 8. BLOOD VESSELS | _____ | Red |
| 9. LUNG | _____ | Gray |
| 10. BLOOD CORPUSCLE | _____ | Pink |
| 11. CARBON DIOXIDE | _____ | Dark Blue |
| 12. OXYGEN | _____ | Purple |
| 13. ALVEOLAR-CAPILLARY MEMBRANE | _____ | Brown |
| 14. MACROPHAGE | _____ | Flesh |

The three lobes of the right lung and the two of the left are all served by secondary bronchi. Like arteries, the bronchi divide again and again, becoming more numerous, narrower, and shorter with each subdivision. The final and smallest of the bronchial air tubes are the terminal bronchioles. Even smaller than the terminal bronchioles are another kind of tube, the respiratory bronchioles, which are made of a smooth layer of ciliated epithelium, and which turn into the atrium, an elongated sac-like opening. (Epithelium is the term for the cellular tissue covering an internal or external surface.) The alveoli or air cells, small projections that number about three hundred million in an adult, line the respiratory bronchioles. The enormous area of the alveoli (if spread out, the alveoli would almost cover a football field) is protected from airborne irritants and organisms and kept sterile by the macrophages, specialized cells in the alveolar wall that surround and digest unwanted particles smaller than one micron. In the alveoli only the thin alveolar-capillary membrane separates the air from the blood-carrying capillaries. When you breathe in, the air in the alveoli is 21 percent oxygen, .04 percent carbon dioxide, and 79 percent nitrogen; but the blood cells coming back to the lung have already given up some of their oxygen to tissues throughout the body and thus carry less oxygen and more carbon dioxide—a chemical imbalance on the two sides of the alveolar-capillary membrane. Thus the two gases try to equalize their pressures: oxygen passes from the alveoli through the membrane and to the blood, and carbon dioxide diffuses through the membrane to the air sac. The large area of the alveoli makes for a very efficient exchange: oxygen is replenished in about one-fifth of a second.

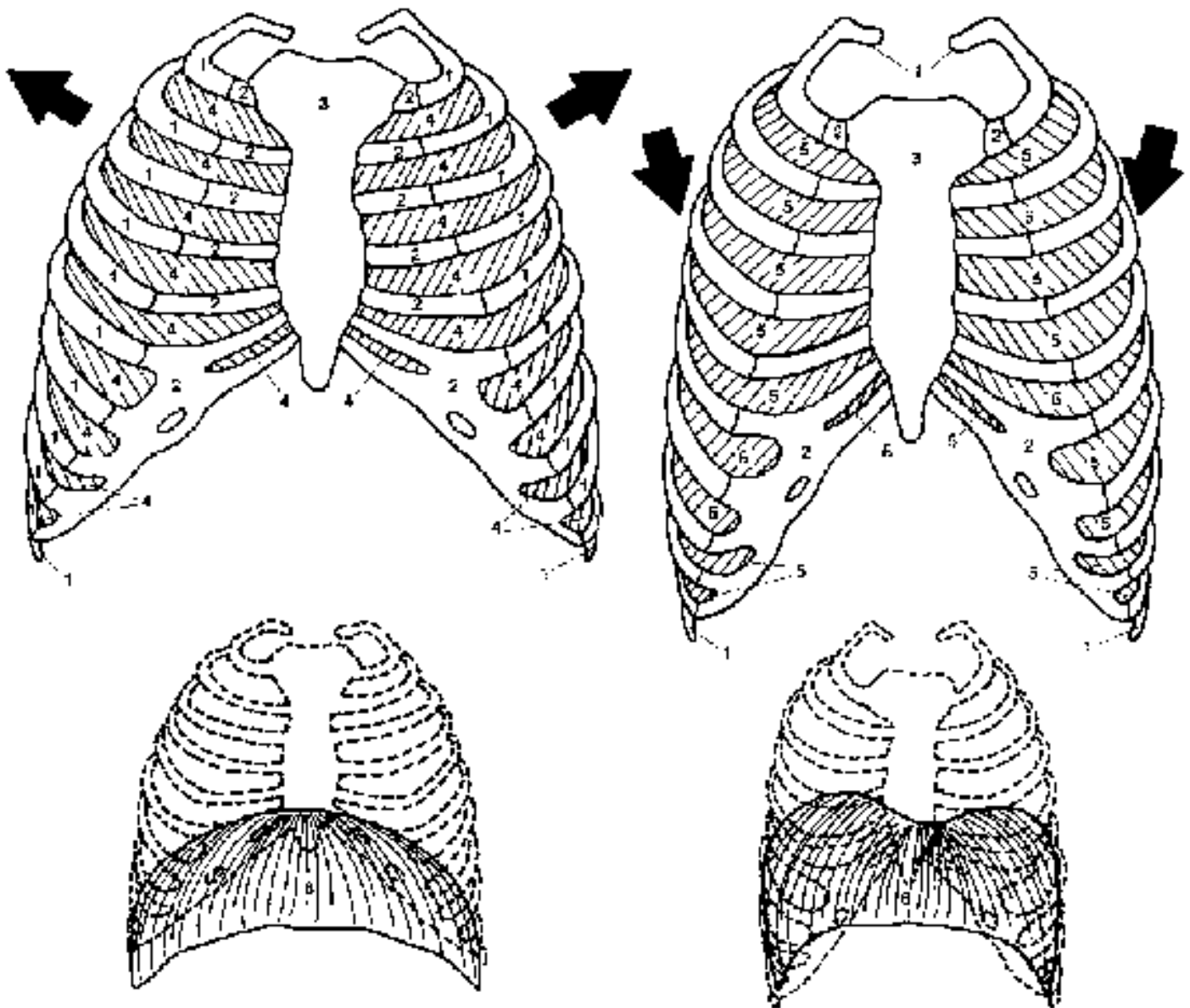


BREATHING MECHANISM

No conscious muscle force is required for *inspiration* (breathing in) or *expiration* (breathing out). Before the breathing cycle begins your lungs are at rest and the air pressure in them equals the pressure outside. Then the diaphragm contracts, which increases the vertical measure of the thorax. The central tendon pulls downward and flattens the diaphragm. The external intercostal muscles pull the ribs upward and outward; this increases the diameter of the rib cage. During deep inhalation the neck and back muscles help elevate the ribs. As a result of all this, the lungs are pulled by the parietal and visceral pleurae and expand – it's like having your hands glued to a balloon and pulling it wider. The air molecules inside the lungs now must fill a larger volume, which reduces the air pressure. The relatively higher pressure of air outside the body forces air into the body's airways and the lungs in order to equalize the pressure inside and outside.

During expiration the diaphragm and external intercostals relax and the elastic lungs attempt to spring back to the smaller size they were before inspiration. As the air space in the lungs gets smaller, the pressure in the lungs increases until it exceeds the air pressure outside the body. The cycle ends when the air rushes out of the lungs to equalize the pressure within and without, carrying with it the waste gas carbon dioxide.

- | | | | | |
|---------------------------------|-------|-------|-------|--------------|
| 1. RIBS | _____ | _____ | _____ | Yellow |
| 2. COSTAL CARTILAGE | _____ | _____ | _____ | Yellow Green |
| 3. STERNUM | _____ | _____ | _____ | Green |
| 4. EXTERNAL INTERCOSTAL MUSCLES | _____ | _____ | _____ | Orange |
| 5. INTERNAL INTERCOSTAL MUSCLES | _____ | _____ | _____ | Pink |
| 6. DIAPHRAGM | _____ | _____ | _____ | Red |



NERVOUS SYSTEM

The nervous system is a control and communication system, consisting of the *brain, spinal cord, nerve cells, and nerve fibers*, that runs throughout the body. It originates and coordinates physical reactions to the environment and controls involuntary muscles and organs such as the heart and lungs. It also maintains *homeostasis*, that is, a balanced state within the body.

CENTRAL NERVOUS SYSTEM (CNS)

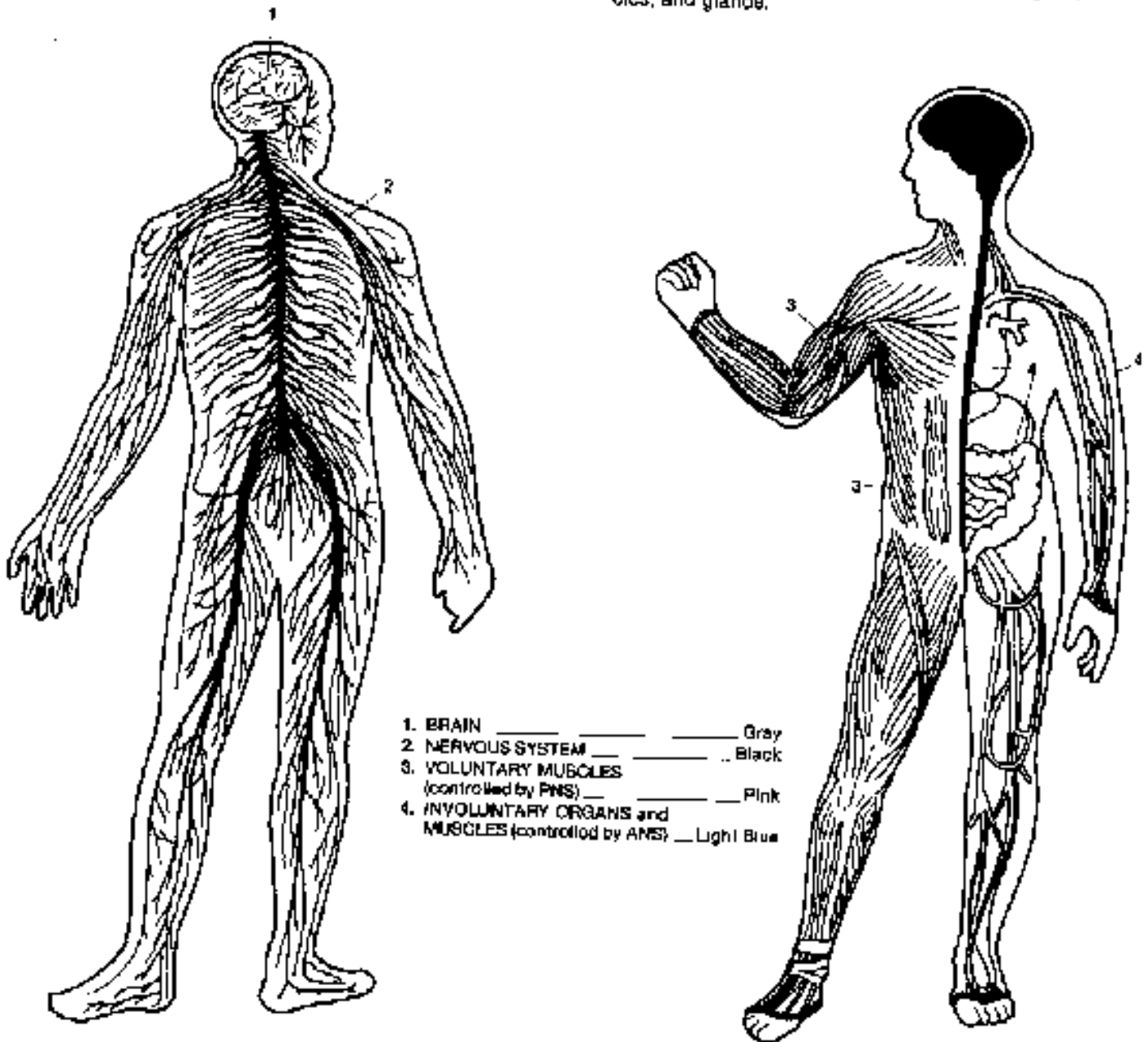
The brain and spinal cord make up the CNS, the control center for the movement and actions of the entire body. Messages from outlying receptors and sensors arrive at the CNS, where they are interpreted; the CNS then sends out reaction impulses.

PERIPHERAL NERVOUS SYSTEM (PNS)

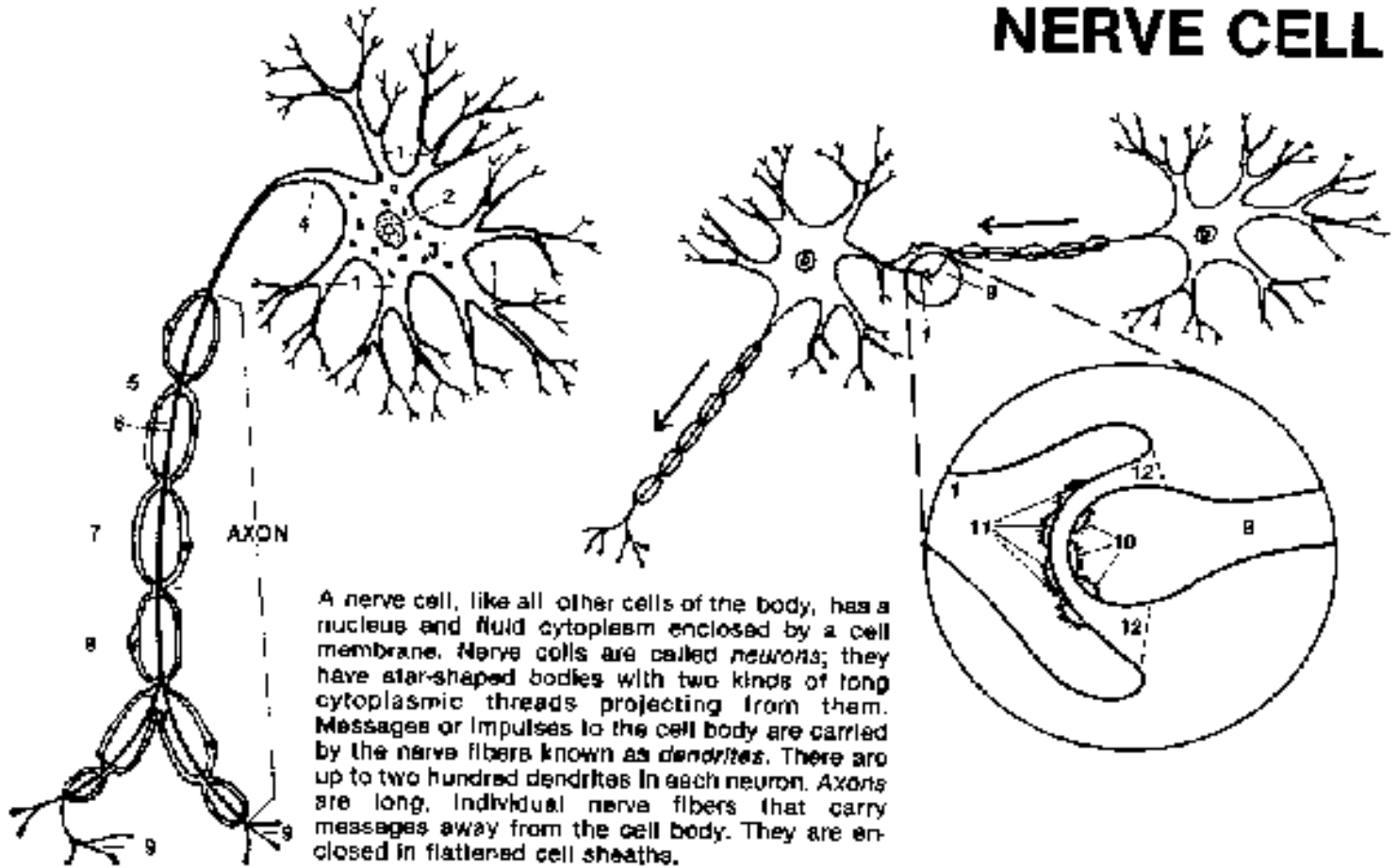
The first of the two parts of the PNS is the *afferent system*, which carries messages from the sensors to the CNS for processing. The second part, the *efferent system*, carries the CNS's commands to the muscles and organs.

AUTONOMIC NERVOUS SYSTEM (ANS)

The ANS regulates the involuntary internal organs, muscles, and glands.



NERVE CELL



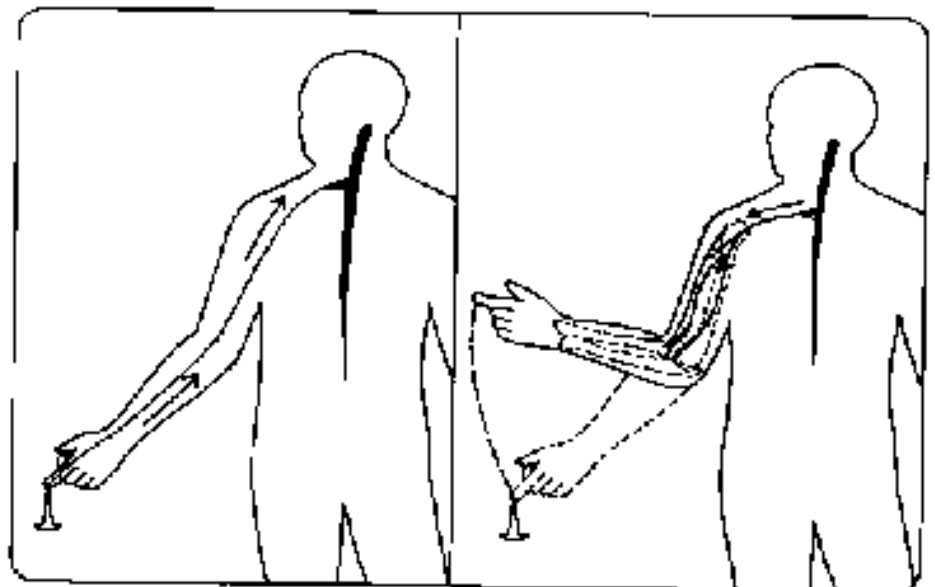
A nerve cell, like all other cells of the body, has a nucleus and fluid cytoplasm enclosed by a cell membrane. Nerve cells are called *neurons*; they have star-shaped bodies with two kinds of long cytoplasmic threads projecting from them. Messages or impulses to the cell body are carried by the nerve fibers known as *dendrites*. There are up to two hundred dendrites in each neuron. *Axons* are long, individual nerve fibers that carry messages away from the cell body. They are enclosed in flattened cell sheaths.

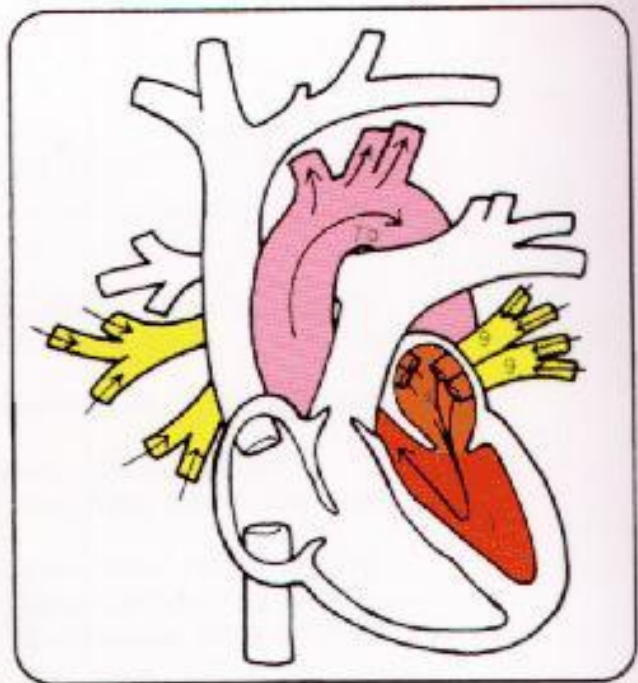
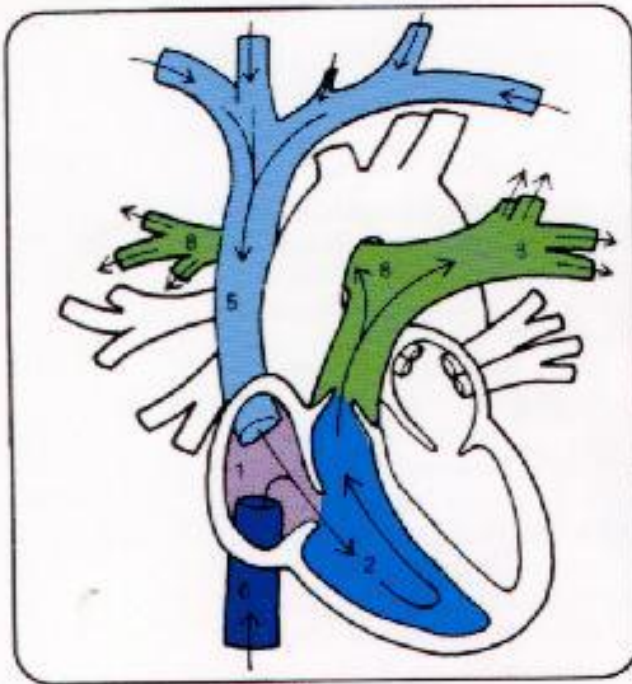
The neurons and their fibers form a network that covers the entire inside of the body and all of the skin. The dendrites receive stimuli from receptor organs or other nerve fibers; an axon then carries the message from the cell body to another neuron or to the organ that is to be effected (called the *effector*) such as a muscle. Neurons that carry messages from sensory organs to the CNS are *sensory neurons*; those that carry messages from the CNS or other nerve centers to muscles or organs are *motor neurons*. The long fibers of neurons are arranged in bundles called *nerves*. The fibers of one neuron never touch those of another, although they do meet at a place called a *synapse*. The nerve impulse is transferred electrochemically through the synapse in an instant.

- | | | |
|------------------------------|-------|-------------|
| 1. DENDRITE | _____ | Blue |
| 2. NUCLEUS | _____ | Green |
| 3. CELL BODY | _____ | Light Blue |
| 4. AXIS CYLINDER | _____ | Dark Blue |
| 5. NODE OF RANVIER | _____ | Orange |
| 6. MYELIN SHEATH | _____ | Yellow |
| 7. SHEATH OF SCHWANN'S CELL | _____ | Red |
| 8. NUCLEUS OF SCHWANN'S CELL | _____ | Black |
| 9. TERMINAL BRANCHES | _____ | Pink |
| 10. PRESYNAPTIC MEMBRANE | _____ | Gray |
| 11. POSTSYNAPTIC MEMBRANE | _____ | Brown |
| 12. SYNAPTIC CLEFT | _____ | Light Green |

REFLEX ACTION

It takes only a brief moment for an impulse to reach the brain, be evaluated, and return as a muscle command to the appropriate part of the body, but even so that may be too long in times of danger. The reflex action is a safety shortcut. A pain impulse from touching a hot pot or a sharp object, for example, can go from your finger to your spinal cord, where it is transferred to an association neuron that connects directly to the motor neuron. A stimulus is instantly dispatched to jerk your arm away. Had the message travelled to the brain first, there may have been more serious damage to your finger. Blinking, sneezing, coughing, and ducking are all reflex actions.





Margaret Matt

HUMAN ANATOMY Coloring Book

Text by Joe Ziemian

From a biological point of view, the human body is an infinitely complex marvel of fine design, superbly adapted to its functions by eons of evolutionary development. Hundreds of specialized organs, bones, muscles, nerve fibers, blood vessels and other anatomical features comprise an interdependent network of bodily systems that enables the human organism to survive. Now the component parts of this intricate flesh-and-blood machine can be absorbed and understood by means of an ingenious format: the coloring book.

Human Anatomy Coloring Book contains careful, scientifically accurate line renderings of the body's organs and major systems: skeletal, muscular, nervous, digestive, reproductive, etc. A total of 43 plates (often with several illustrations to a page) offers numerous views, cross-sections, diagrams and detailed closeups, labelled and numbered to correspond with suggestions for coloring. These suggestions are specially designed to emphasize the structural relationships in the body. By working through each system, the reader will gain not only an intimate knowledge of the location, appearance and role of the body parts, but will be laying the groundwork for more sophisticated studies of anatomy.

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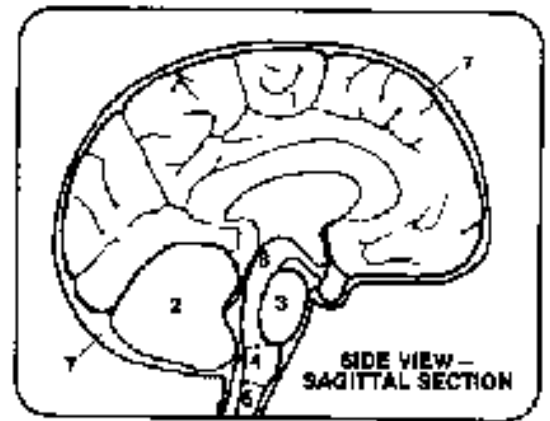
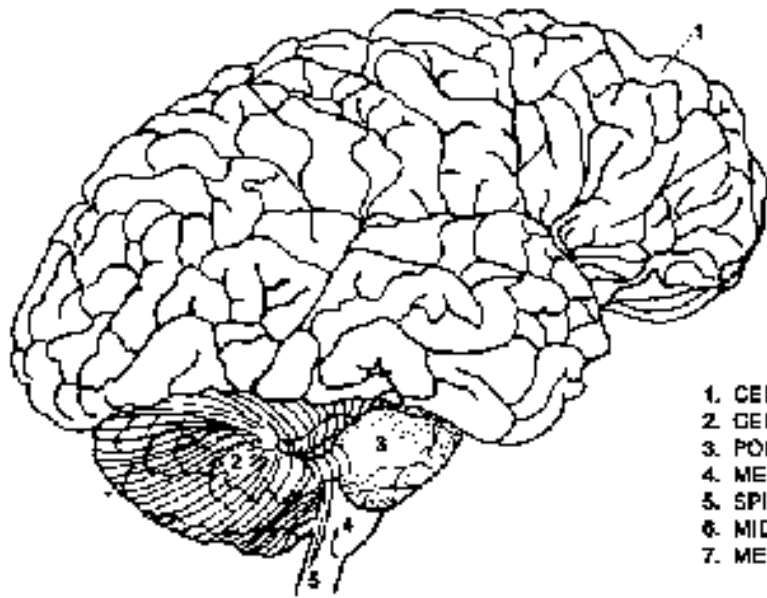


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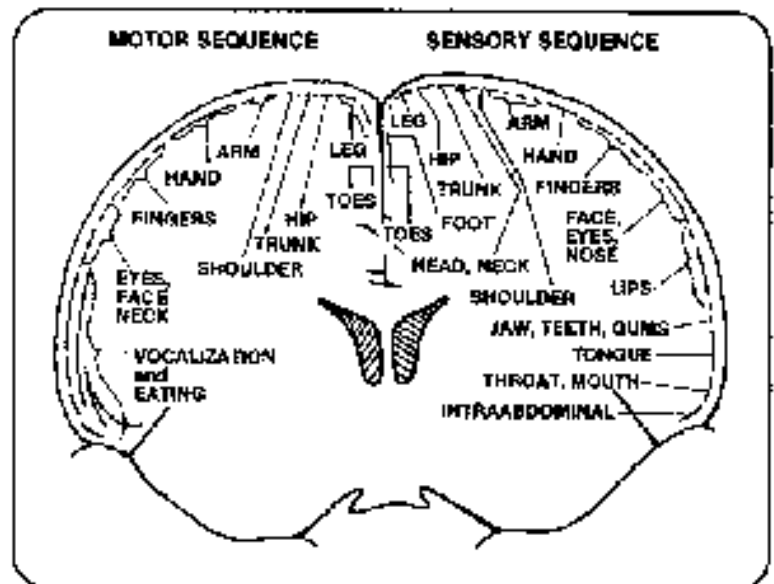
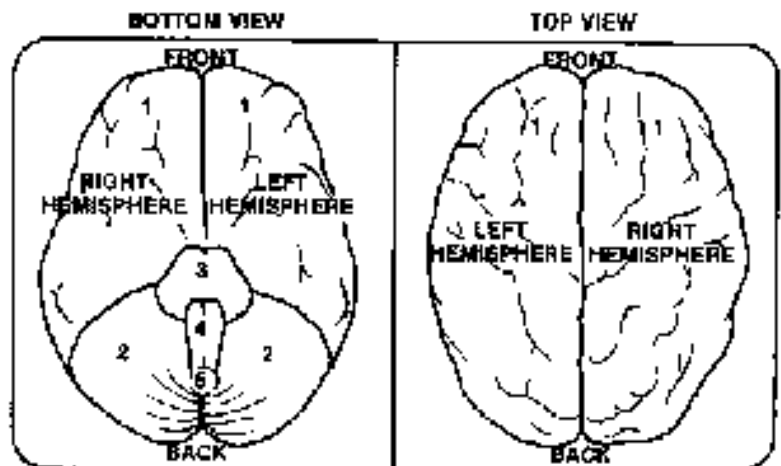
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BRAIN



- | | | |
|----------------|-------|--------------|
| 1. CEREBRUM | _____ | Gray |
| 2. CEREBELLUM | _____ | Light Blue |
| 3. PONS | _____ | Light Orange |
| 4. MEDULLA | _____ | Light Green |
| 5. SPINAL CORD | _____ | Pink |
| 6. MIDBRAIN | _____ | Yellow |
| 7. MENINGES | _____ | Red |

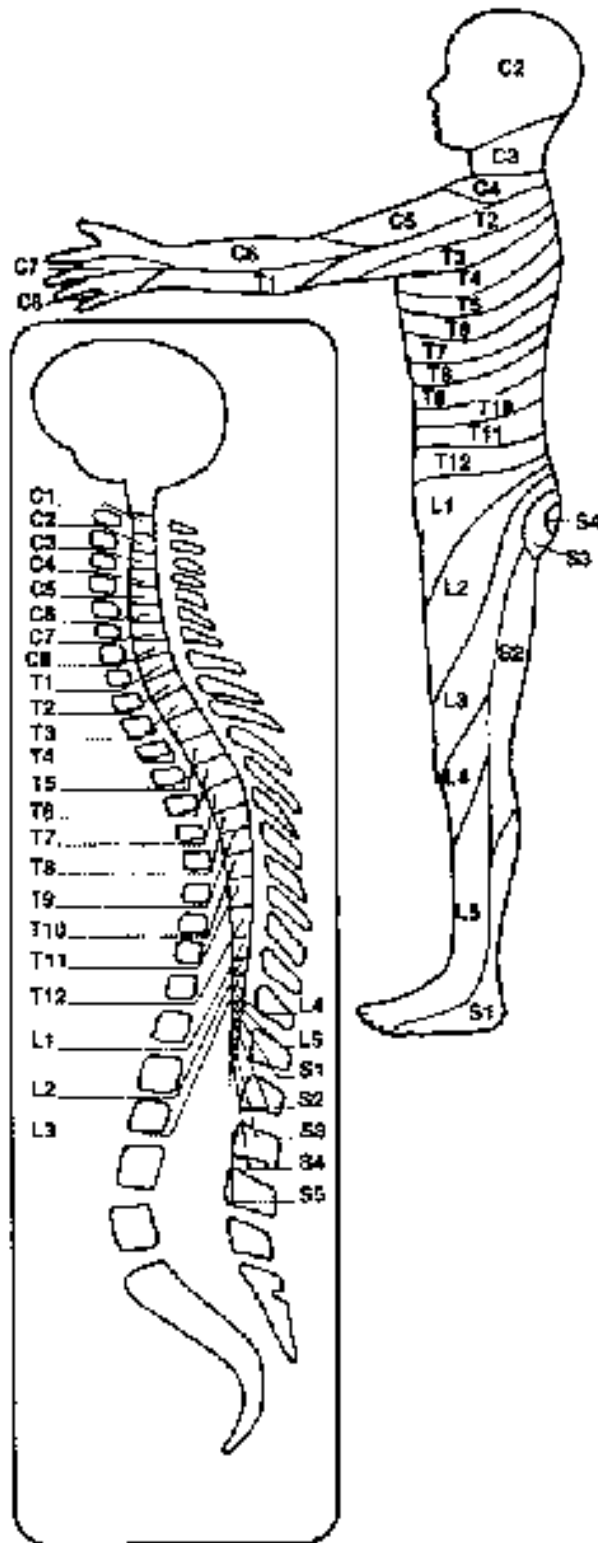
The brain is the most complex and specialized organ of the body. It is covered by three protective membranes, the *meninges*, that also extend downward to encase the spinal cord. The main part of the brain, the *cerebrum*, is divided into right and left halves, the *hemispheres*. The outer surface of the cerebrum is the *cortex*. It is wrinkled and irregularly shaped, with deep furrows that increase the brain's surface area. The *forebrain*, located in the front of the cerebrum, is the site of the most complex functions of human thought and action. These functions include memory, judgment, reasoning, speech, and the formation of words. The forebrain also is the seat of emotions and what we know as personality traits, and receives and sends messages to the other parts of the brain that control less complex functions. The *midbrain* controls vision and eye reflexes, many visceral or involuntary muscle activities, and motor responses of the head and torso. The midbrain connects the forebrain to the *hindbrain*, which consists of the *cerebellum* and *pons* and is located behind and below the cerebrum. The *hindbrain* is responsible for coordinating muscular activity and amplifying cerebral stimuli on their way to the muscles. It cannot initiate a muscular contraction, but it can keep muscles in a state of partial contraction. The pons is a pathway between the two halves of the cerebellum and a relay between the midbrain and the *medulla*. Within the pons is the *pneumofaxic center*, which plays a role in breathing. The *medulla oblongata*, an elongation of the base of the brain that joins with the spinal cord, controls the activity of internal organs, including respiratory and digestive organs, the heart, and glands.



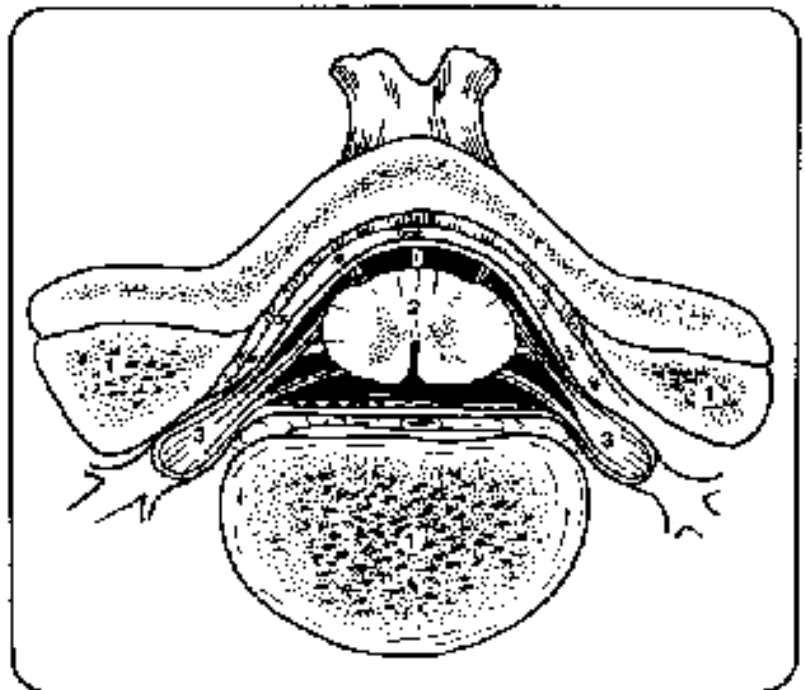
SPINAL CORD

The spinal cord descends from the medulla oblongata into the protective armored canal formed by the vertebrae. The center region of the cord is white matter made up of numerous sheathed nerve fibers. The interior is gray matter. The cord has two functions: it serves as the sensory-

motor mechanism for reflex actions, and as the two-way transmitter of impulses, reactions, and stimuli triggered by various internal and external conditions. Thirty-one pairs of spinal nerves, the *peripheral nervous system*, branch out from the vertebrae to the right and left sides of the body. These nerves are large cables of sensory and motor fibers. The first nerve pair arises from the medulla, the others from the cord. Each nerve pair controls a particular area of the body and is identified by the number of the vertebra over which it leaves the spinal cord. Outside the cord each nerve divides to form several branches or *rami*, which control general areas of the body. The *dorsal rami* control the muscles and the skin of the back; the *ventral rami* innervate all the structures of the limbs and torso; the *meningeal* or *recurrent* branches return to the spine and vertebrae. The ventral rami and adjacent nerves form networks or *brads* called *plexuses* that go to general areas. The *cervical plexus* serves the neck, upper shoulders, and the diaphragm via the phrenic nerve; the *brachial plexus* goes to the upper limbs and the neck and shoulder muscles; the *lumber plexus* controls the abdominal area and part of the legs; and the *sacral plexus* serves the buttocks area and lower legs. Each plexus is like a large cable of nerve bundles—it goes directly to a certain part of the body and specific nerves branch out when the plexus passes the muscle, organ, or tissue it controls.



- | | |
|-------------------------|-------------|
| 1. VERTEBRA | Light Brown |
| 2. SPINAL CORD | Yellow |
| 3. SPINAL GANGLION | Orange |
| C1-C8. CERVICAL NERVES | Light Blue |
| T1-T12. THORACIC NERVES | Purple |
| L1-L5. LUMBAR NERVES | Pink |
| S1-S5. SACRAL NERVES | Red |



SENSATION SITES

You keep in touch with the outside world with your sensory organs and their nerves and receptors on the surface of your body.

1. SIGHT

Light enters the eye through the lens and is focused on the retina, which is lined with photoreceptor neurons called rods and cones. Rods respond to dim light; cones are stimulated by bright light and are specialized to detect color. The photoreceptors send impulses to ganglia (a group of nerve cell bodies) near the front of the retina. The ganglia lead to the optic nerve, which in turn transmits impulses to the visual center in the occipital lobe of the brain.

2. SENSATIONS OF THE SKIN

Touch sensors are closest to the skin's surface on your fingertips and near strands of hair. Pressure sensors lie deeper. Pain sensors are bare dendrites. Heat and cold sensors are different from one another and appear randomly over the entire body.

3. SMELL

The olfactory nerve cells detect particles given off by objects. The particles generate an impulse that travels over the olfactory tract to the cortex of the brain. After con-

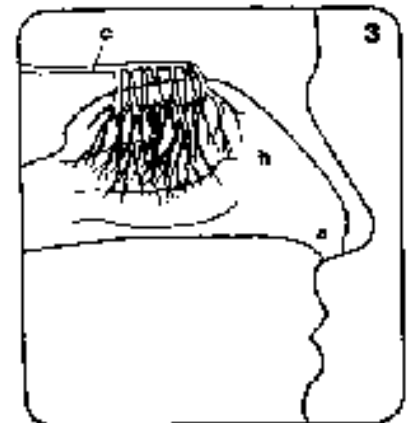
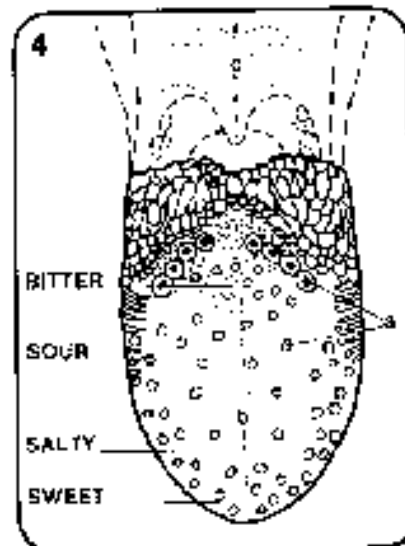
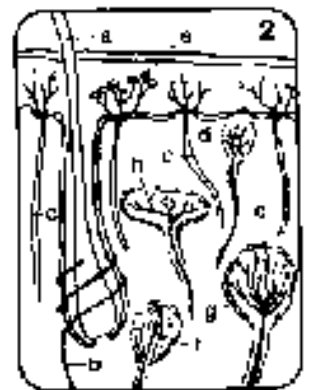
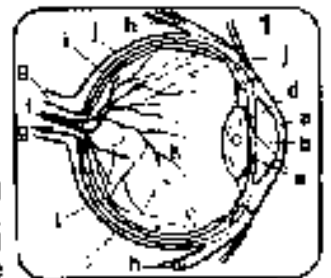
stant exposure to an odor, our olfactory nerves become temporarily deadened.

4. TASTE

Food mixes with saliva and enters pores, the *lingual papillae*, on the tongue. Embedded beneath these pores are the chemical receptors that distinguish sweet, salty, bitter, and sour.

5. HEARING

Sound waves enter the auditory canal and vibrate the *tympanic membrane* or eardrum. Three tiny bones—the *hammer*, *anvil*, and *stirrup*—link the inside of the eardrum to the *cochlea*, which is filled with fluid and lined with nerve endings. The vibrations move through the liquid to the sensors and are transmitted to the brain as sound impulses. The *semicircular canals* help to establish our sense of balance.



1. SIGHT

- a. CORNEA _____ Yellow
- b. ANTERIOR CHAMBER _____ Light Brown
- c. LENS _____ Pink
- d. IRIS _____ Blue
- e. PUPIL _____ Gray
- f. RETINAL BLOOD VESSELS _____ Red
- g. OPTIC NERVE _____ Green
- h. RECTUS MUSCLE _____ Purple
- i. RETINA _____ Light Green
- j. SCLERA (white of eye) _____ White
- k. POSTERIOR CAVITY _____ Light Orange

2. SENSATIONS OF THE SKIN

- a. HAIR _____ Brown
- b. ROOT OF HAIR PLEXUS (touch) _____ Black
- c. PAIN RECEPTOR _____ Green
- d. MEISSNER'S CORPUSCLE (touch) _____ Pink
- e. MERKEL'S DISCS (touch) _____ Orange
- f. PACINIAN CORPUSCLE (pressure) _____ Light Blue
- g. END BULB OF KRAUSE (cold) _____ Yellow
- h. END ORGAN OF RUFFINI (heat) _____ Gray

3. SMELL

- a. NASAL CAVITY _____ Pink

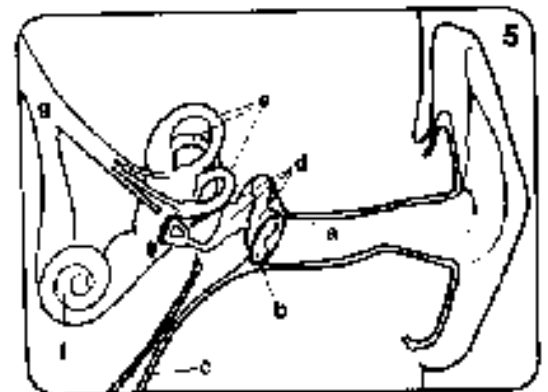
- b. OLFACTORY NERVE FIBERS _____ Green
- a. OLFACTORY NERVE TRACT _____ Yellow

4. TASTE

- a. PAPILLAE _____ Orange
- b. BODY OF TONGUE _____ Pink
- a. PALATE _____ Gray

5. HEARING

- a. EXTERNAL AUDITORY CANAL _____ Flesh
- b. TYMPANIC MEMBRANE (eardrum) _____ Red
- c. EUSTACHIAN TUBE _____ Orange
- d. AUDITORY BONES _____ Light Brown
- e. SEMICIRCULAR CANALS _____ Yellow
- f. COCHLEA _____ Blue
- g. AUDITORY NERVES _____ Green

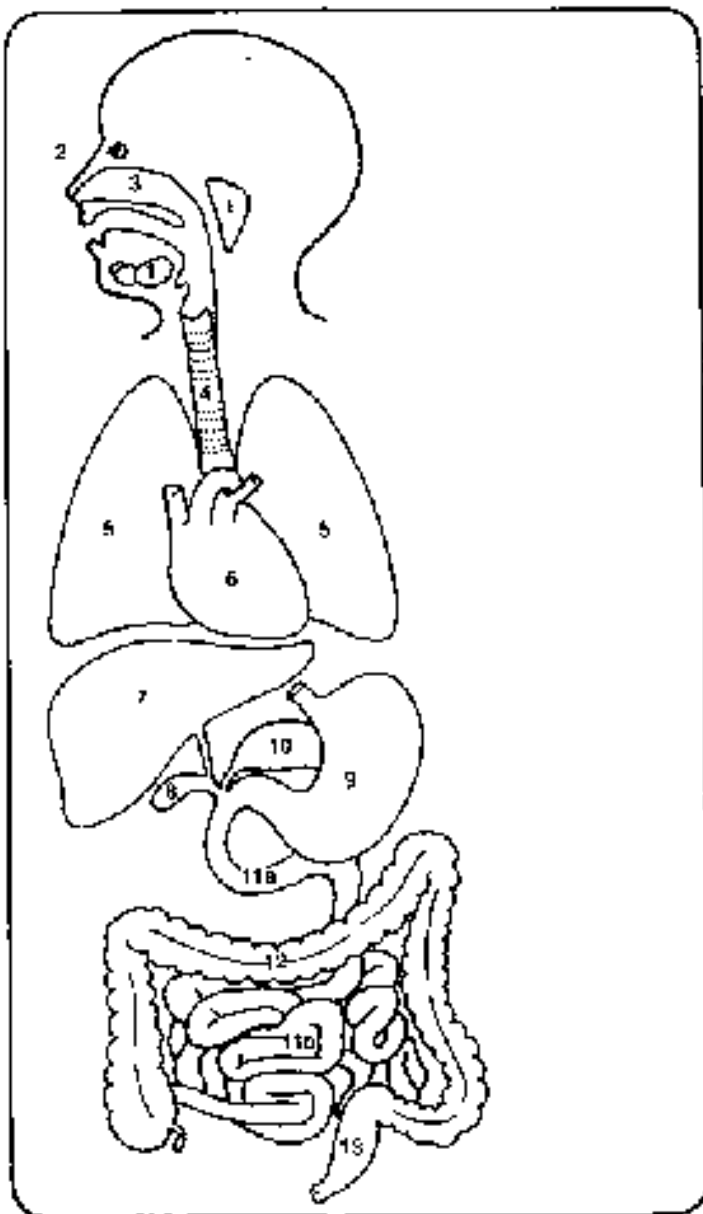


AUTONOMIC NERVOUS SYSTEM

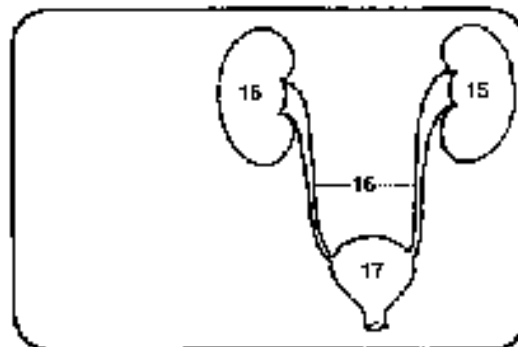
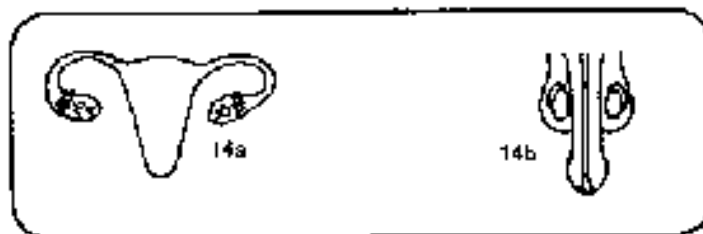
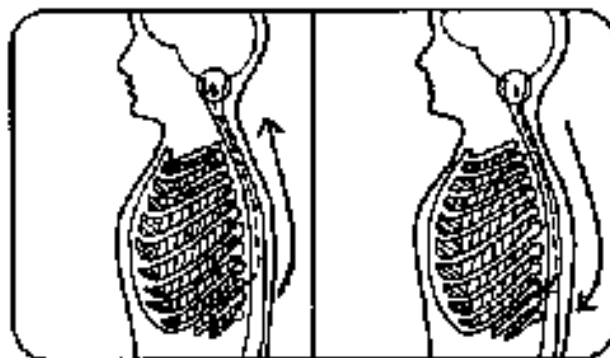
You can blink or move your finger at different speeds, but you can't change how fast your stomach digests food. The stomach, like other internal organs and the smooth muscle tissue of blood vessels, functions involuntarily and is under the control of the autonomic nervous system (ANS). This system regulates the body's life-sustaining functions almost independently of the central nervous system (CNS), which consists of the brain and spinal cord. The ANS is also the division of the peripheral nervous system (PNS) that conveys messages from the

CNS outward to produce responses in involuntary muscles and tissues.

There are two main parts to the system: the *sympathetic* and *parasympathetic* systems. Many organs have nerves coming from both systems; these nerves produce opposite reactions. For example, one nerve may respond to low blood pressure by increasing the heartbeat; the other nerve will slow the heartbeat when the blood pressure is too high. Similarly, when the level of carbon dioxide in the blood increases, the cerebral spinal fluid becomes more acidic. The acidity activates chemoreceptors that stimulate the respiratory center of the medulla, which increases the rate of breathing. Increased breathing in turn eliminates excess carbon dioxide, thereby bringing the level in the blood back to normal. If too much carbon dioxide is eliminated, however, the chemoreceptors initiate a slower breathing to increase the level of carbon dioxide.



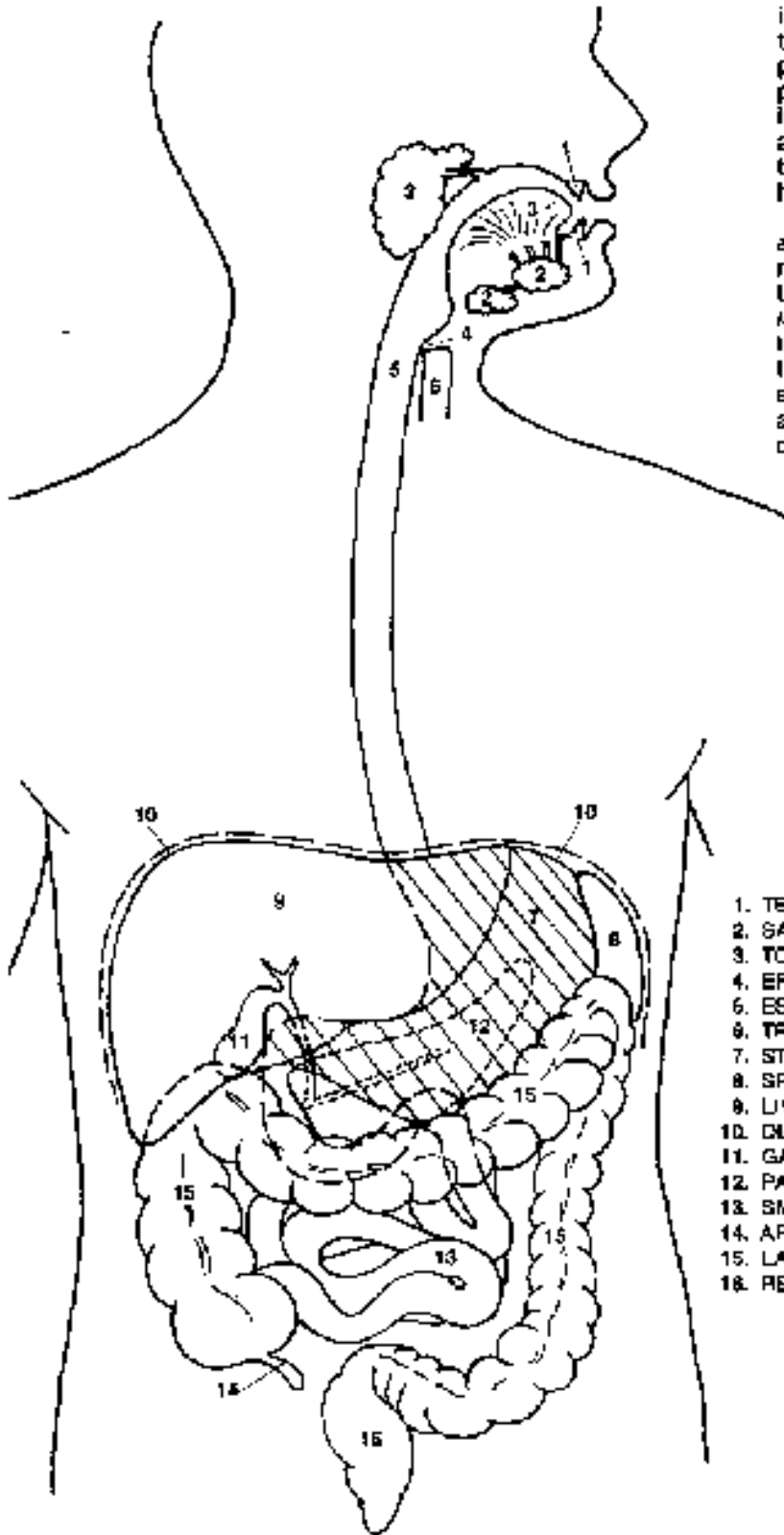
- | | | |
|---|-------|--------------|
| 1. GLANDS | _____ | Yellow-Green |
| 2. EYE | _____ | Light Brown |
| 3. NASAL MUCOSA | _____ | Flesh |
| 4. TRACHEA | _____ | Blue |
| 5. LUNGS | _____ | Gray |
| 6. HEART | _____ | Purple |
| 7. LIVER | _____ | Brown |
| 8. GALLBLADDER | _____ | Orange |
| 9. STOMACH | _____ | Green |
| 10. PANCREAS | _____ | Turquoise |
| 11. a. DUODENUM and b. SMALL INTESTINE | _____ | Light Blue |
| 12. LARGE INTESTINE | _____ | Dark Blue |
| 13. RECTUM | _____ | Light Orange |
| 14. a. FEMALE and b. MALE REPRODUCTIVE ORGANS | _____ | Yellow |
| 15. KIDNEYS | _____ | Light Purple |
| 16. URETERS | _____ | Light Green |
| 17. BLADDER | _____ | Pink |



DIGESTIVE SYSTEM

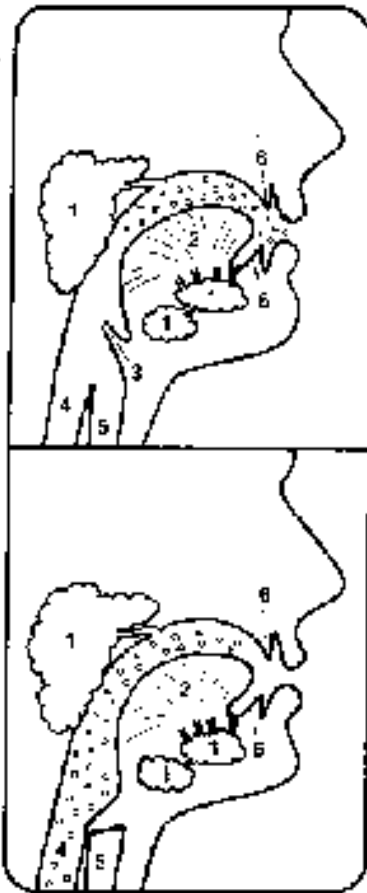
The body cannot use food in the form it ordinarily comes in because the pieces are too large and some foods, such as fats, are not water soluble and therefore cannot be absorbed into the bloodstream or pass into the tissue cells. The chemical complexity of most foods is also more than the body can handle. The role of the digestive system is to reduce large and complex foods to the water-soluble substances the cells can use. The process is both physical — as when the teeth chew meat into tiny bits — and chemical — as when the enzyme ptyalin helps to change starches into smaller compounds. The timing of the digestive system is very important: food must move slowly enough so that all the necessary changes can occur and absorption can take place, but fast enough to prevent harmful decomposition.

There are two parts to the digestive system. The *alimentary canal* is a tube about nine meters long running from the *mouth* to the *anus* and includes the *throat*, *esophagus*, *stomach*, and the *small* and *large intestines*. The organs and the glands that aid in the digestive process are the *accessory organs*: the *teeth*, *tongue*, *salivary glands*, *pancreas*, *liver*, and *gallbladder*. They reduce food mechanically and chemically to a simple form the body can process.

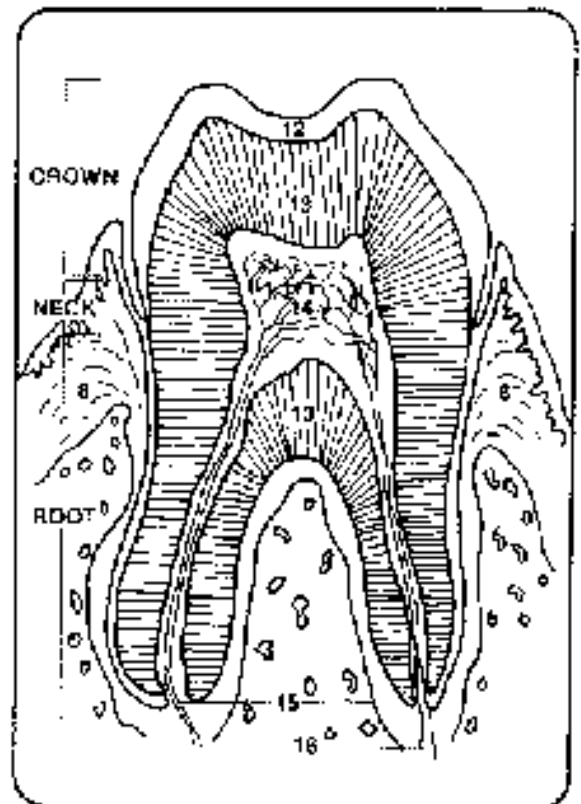
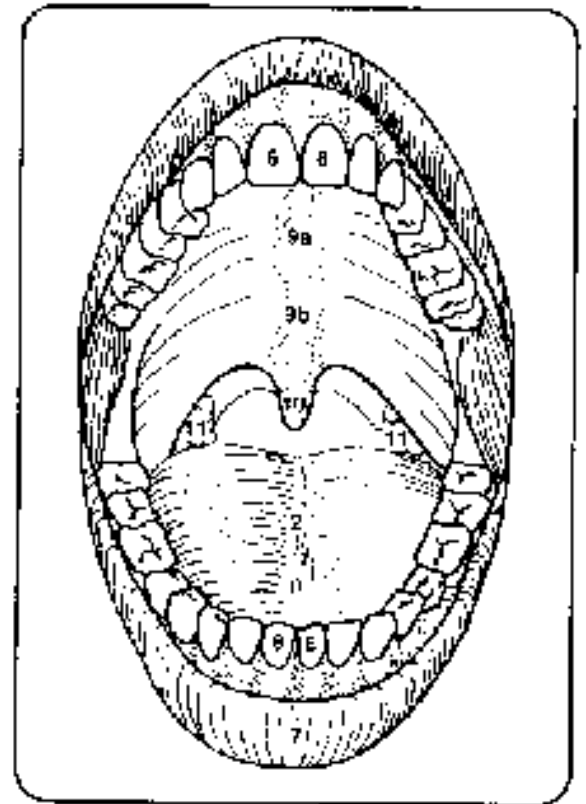


- | | | |
|---------------------|-------|--------------|
| 1. TEETH | _____ | Yellow |
| 2. SALIVARY GLANDS | _____ | Turquoise |
| 3. TONGUE | _____ | Pink |
| 4. EPIGLOTTIS | _____ | Red |
| 6. ESOPHAGUS | _____ | Yellow-Green |
| 9. TRACHEA | _____ | Blue |
| 7. STOMACH | _____ | Green |
| 8. SPLEEN | _____ | Purple |
| 9. LIVER | _____ | Brown |
| 10. DIAPHRAGM | _____ | Flesh |
| 11. GALLBLADDER | _____ | Orange |
| 12. PANCREAS | _____ | Light Green |
| 13. SMALL INTESTINE | _____ | Light Blue |
| 14. APPENDIX | _____ | Gray |
| 15. LARGE INTESTINE | _____ | Dark Blue |
| 16. RECTUM | _____ | Light Orange |

MOUTH AND ESOPHAGUS

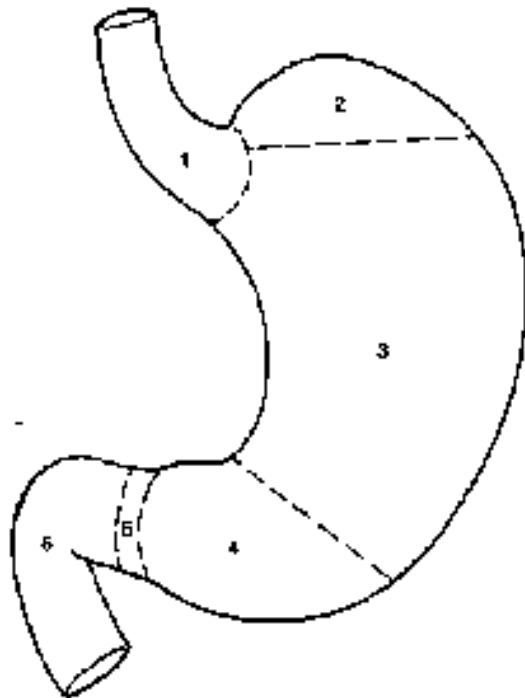


The mouth's primary role is to help digest food by reducing its size. The mouth includes the *tongue*, *teeth*, and the *hard* and *soft palates*. There also are three sets of glands that secrete saliva to aid in chewing food: the *parotid glands* are located in front of the ears; the *sublingual glands* are embedded under the sides of the tongue; and the *submaxillary glands* are positioned near the rear of the jawbone. The teeth cut and crush food. The tongue acts as a taste organ and it also mixes saliva with food and moves it toward the rear of the *pharynx* or throat. As food enters the pharynx, the *epiglottis*, a cartilaginous lid that hangs over the larynx to prevent food from entering it, closes and the wave-like swallowing movement begins in the *esophagus*. The esophagus is a food tube twenty-five to thirty centimeters long that begins at the pharynx and descends through the mediastinum and diaphragm into the stomach. A circular sphincter muscle, located where the esophagus joins the stomach, opens to let food pass and closes behind it to prevent it from flowing back from the stomach.



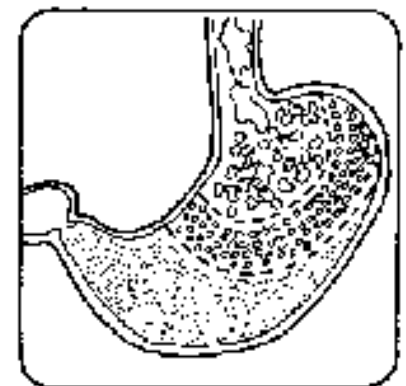
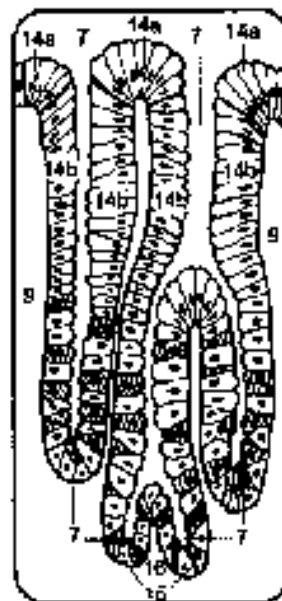
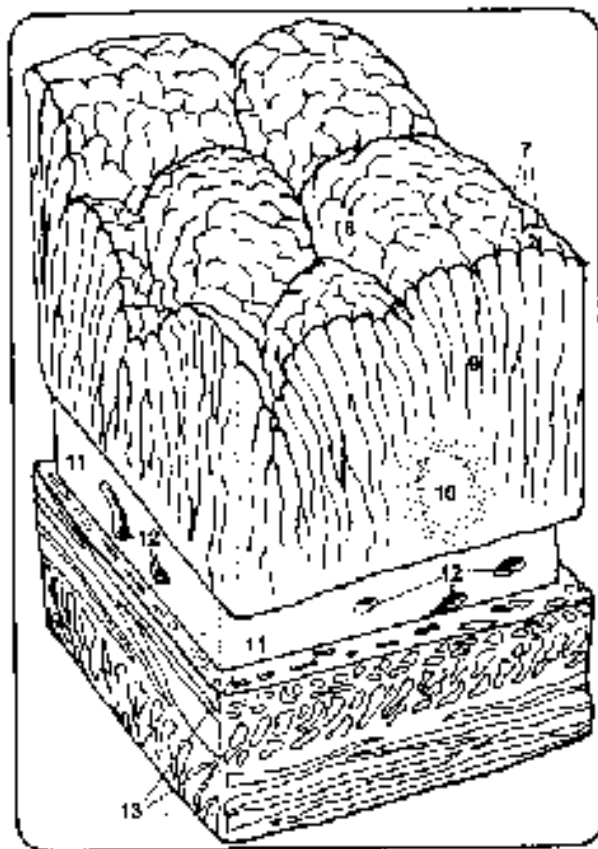
- | | | |
|--------------------------------|-------|--------------|
| 1. SALIVARY GLANDS | _____ | Turquoise |
| 2. TONGUE | _____ | Pink |
| 3. EPIGLOTTIS | _____ | Red |
| 4. ESOPHAGUS | _____ | Yellow-Green |
| 5. TRACHEA | _____ | Blue |
| 6. TEETH | _____ | White |
| 7. LIPS | _____ | Flesh |
| 8. GINGIVA (gums) | _____ | Orange |
| 9. a. HARD and b. SOFT PALATES | _____ | Light Blue |
| 10. UVULA | _____ | Dark Blue |
| 11. TONSIL | _____ | Dark Green |
| 12. ENAMEL | _____ | White |
| 13. DENTIN | _____ | Green |
| 14. PULP CAVITY | _____ | Light Brown |
| 15. ROOT CANAL | _____ | Light Orange |
| 16. NERVE FIBERS | _____ | Brown |

STOMACH



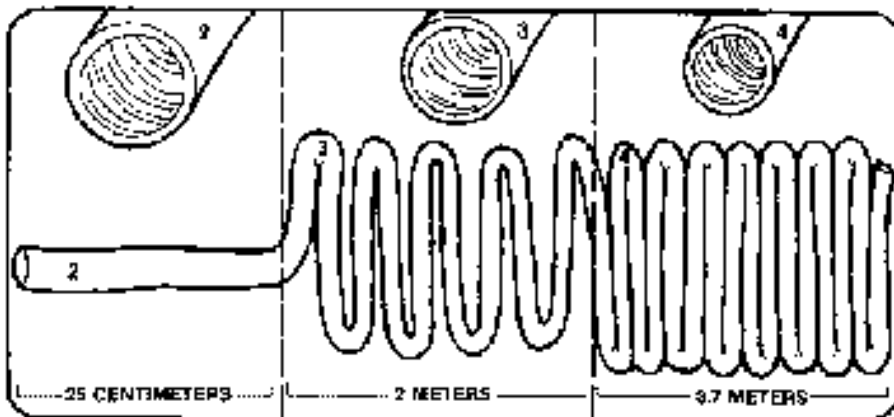
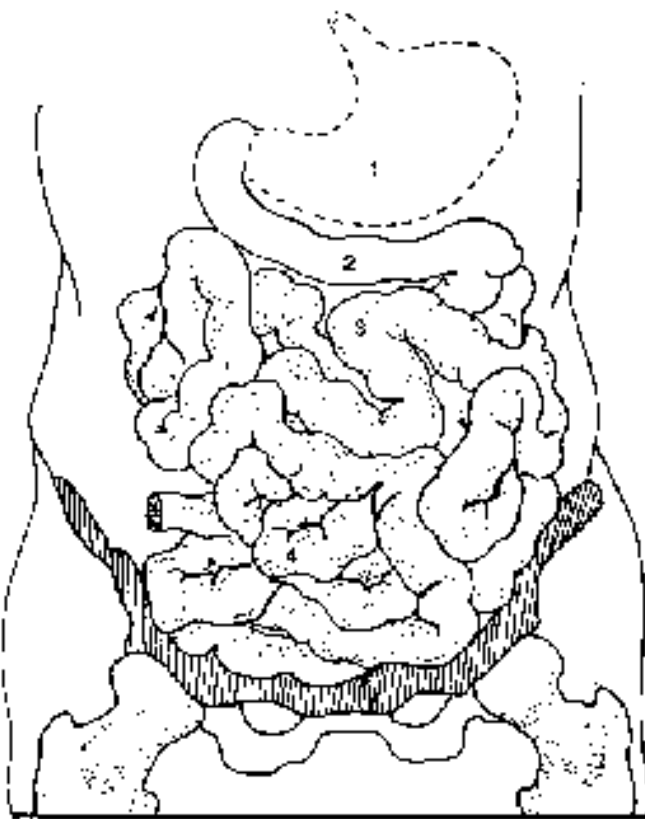
The stomach continues the process that began in the mouth of reducing the size of food, but its primary role is storage. The stomach's walls have three layers of smooth muscle—*longitudinal, circular, and oblique*—and contractions of these muscles create a twisting, kneading action that breaks up food. The stomach lining is a thick convoluted membrane with many gastric glands embedded in its folds, which form tiny tubes. There are three kinds of glands: *zymogenic* or *chief cells* secrete the enzyme pepsinogen; *mucous cells* secrete mucus and intrinsic factor, which is vital to the absorption of vitamin B₁₂; and *parietal cells* secrete hydrochloric acid, which activates the enzyme and mucous cells. These various secretions begin to digest proteins; during the process, the mucus protects the stomach wall from the acid and pepsinogen. Food moving through the stomach toward the *pyloric antrum* is progressively reduced to finer particles. When the food reaches the pyloric region, a slight pressure builds up that helps meter it through the sphincter valve into the small intestine.

- | | | |
|-----------------------------------|-------|--------------|
| 1. ESOPHAGUS | _____ | Yellow-Green |
| 2. FUNDUS | _____ | Light Green |
| 3. BODY | _____ | Green |
| 4. PYLORUS | _____ | Light Blue |
| 5. PYLORIC SPHINCTER | _____ | Blue |
| 6. DUODENUM | _____ | Dark Blue |
| 7. GASTRIC GLANDS | _____ | Yellow |
| 8. RUGAE | _____ | Light Orange |
| 9. LAMINA PROPRIA | _____ | Orange |
| 10. LYMPH NODULE | _____ | Brown |
| 11. SUBMUCOSA | _____ | Pink |
| 12. BLOOD VESSELS | _____ | Red |
| 13. LAYERS OF SMOOTH MUSCLES | _____ | Flesh |
| 14. a. SURFACE and b. MUCUS CELLS | _____ | Light Brown |
| 15. CHIEF CELL | _____ | Light Purple |
| 16. PARIETAL CELL | _____ | Gray |

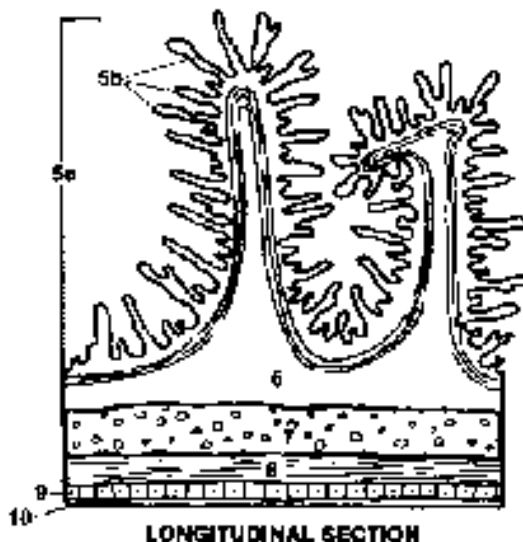
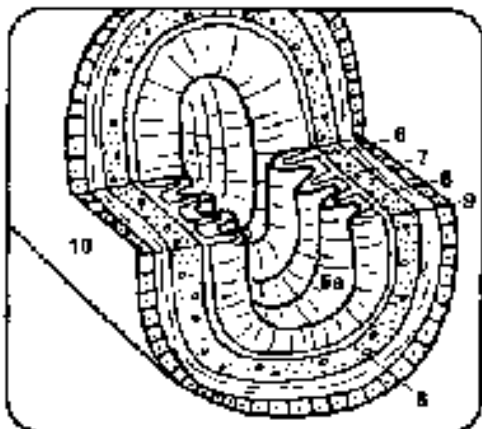


SMALL INTESTINE

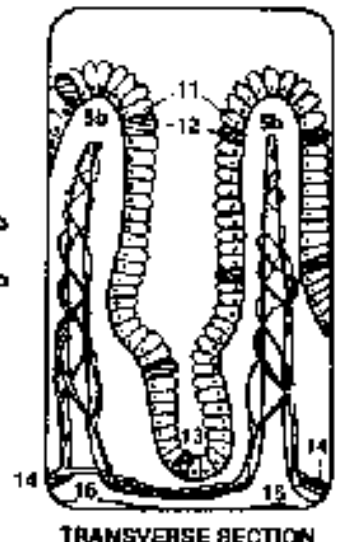
Partially broken-down food leaves the stomach and enters the small intestine, a coiled tube about seven meters long that has three very similar sections: the *duodenum*, *jejunum*, and, the longest, the *ileum*. The four layers or coats of the intestinal walls are very much like those of the stomach. The walls of the duodenum and of most of the jejunum are arranged in circular folds that increase the surface area of the intestines. This increased surface area makes a greater number of glands available to secrete digestive juices and it also enlarges the area for the absorption of soluble nutrients. The glands, tube-like folds that open onto the surface, secrete enzymes that combine with others from the liver and pancreas. Together these enzymes break food down completely into the simple sugars, fatty acids, triglycerides, and amino acids that can be absorbed into the blood and lymph for distribution to the body's tissues. The intestines are lined with four to five million tiny finger-like projections called *villi*. These move and sway with the intestine's pulsations to mix the food and also to provide a structure for bringing the blood and lymphatic vessels close to the surface. Glycerol and fatty acids enter the villi and are carried away by the lymph. Sugars and amino acids are absorbed into the blood and carried to the liver.



1. STOMACH _____ Green
2. DUODENUM _____ Dark Blue
3. JEJUNUM _____ Light Blue
4. ILEUM _____ Blue
5. a. CIRCULAR FOLD with b. VILLI _____ Light Green
6. MUCOSAL MUSCLE _____ Orange
7. SUBMUCOSA _____ Light Brown
8. CIRCULAR MUSCLE _____ Pink
9. LONGITUDINAL MUSCLE _____ Light Purple
10. SEROSA _____ Gray
11. ABSORPTIVE CELLS _____ Turquoise
12. GOBLET CELLS (mucus-secreting) _____ Yellow-Green
13. INTESTINAL GLANDS _____ Yellow
14. BLOOD VESSELS _____ Red
15. LYMPHATIC VESSEL _____ Brown



LONGITUDINAL SECTION



TRANSVERSE SECTION

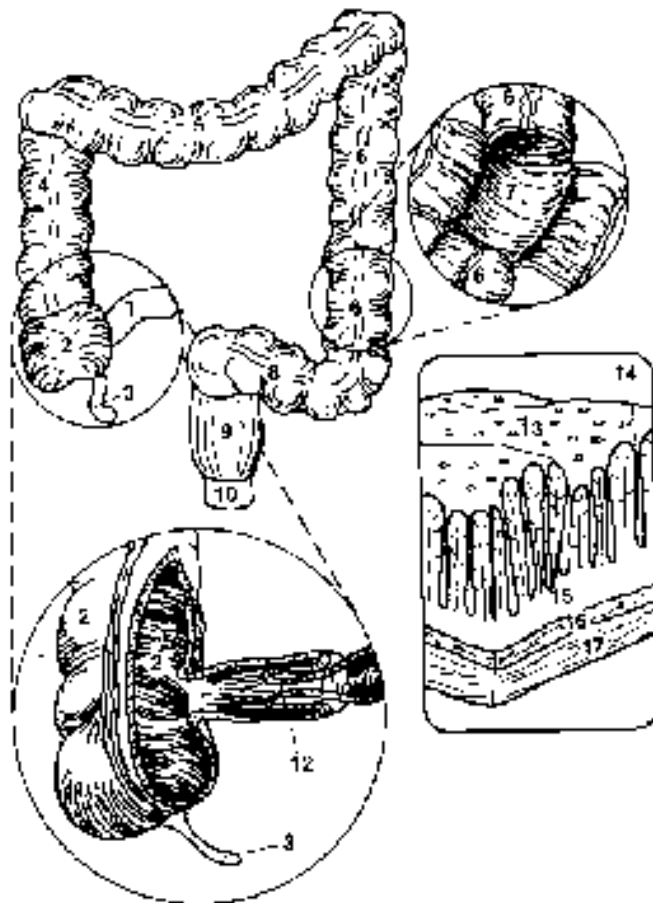
LARGE INTESTINE

The *large intestine* is 1.5-1.8 meters long and about 7.5 centimeters in diameter. The walls of the large and the small intestines are similar except that the large intestine's have no villi and absorb no nutrients. The most important function of the large intestine is the reabsorption of water and essential electrolytes or salts.

The large and small intestines join in the lower right quadrant of the abdomen. Just below this juncture is the *cecum*, which has a finger-like extension, the *verruiform appendix*, that can become inflamed, a condition known as *appendicitis*. The opening between the ileum and the large intestine is formed by the *ileocecal valve*, two pro-

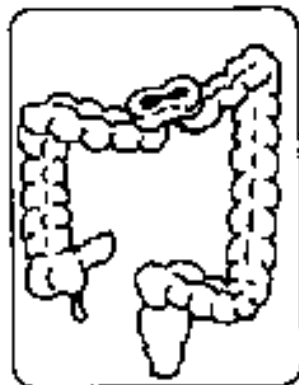
jecting lips that prevent material from flowing back into the small intestine. The large intestine is sometimes called the *colon*, though that term is properly reserved for the portion of the intestine between the cecum and the *rectum*, a muscular tube at the intestine's end. The colon is shaped like an inverted U with an S-curve at its lower end and is divided into four sections: the *ascending colon* runs up the right side of the abdominal cavity; it turns left abruptly to become the *transverse colon*, which runs across the top of the cavity. The transverse colon plunges on the left side to form the *descending colon*; and finally the colon ends with the S-curve, the *sigmoid colon*. The colon receives a watery mass of undigested food within two to five hours after eating; as this mass passes through it, much of the water is absorbed. This mass, called *feces*, becomes more dehydrated and passes into the rectum for elimination. There are internal and external sphincter valves at the end of the rectum that remain tightly closed except during defecation.

If injury or disease prevents the intestine and rectum from being used, the colon can be opened surgically to allow waste removal, an operation called a *colostomy*. For a temporary condition, the abdomen is slit and the colon is brought to the surface, cut open, and drained into a bag-like container. When the problem is over, the colon is sutured together and reembedded in the abdomen. A permanent condition requires that the colon be cut and a single end be brought to the surface to be fitted with an adaptor and bag for waste drainage.

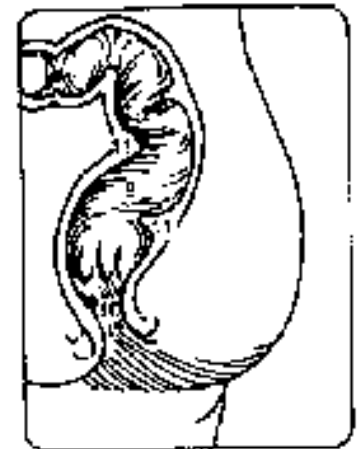
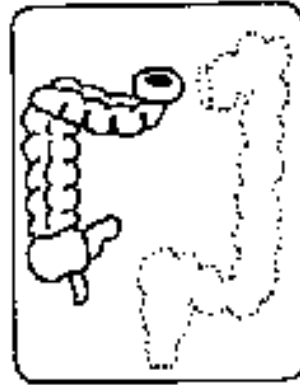


- | | |
|------------------------------------|--------------|
| 1. ILEUM | Blue |
| 2. CECUM | Yellow |
| 3. APPENDIX | Gray |
| 4. ASCENDING COLON | Yellow-Green |
| 5. TRANSVERSE COLON | Light Green |
| 6. DESCENDING COLON | Green |
| 7. INTERIOR OF DESCENDING COLON | Light Blue |
| 8. SIGMOID COLON | Turquoise |
| 9. RECTUM | Light Orange |
| 10. ANAL CANAL and ANUS | Orange |
| 11. RECTAL TRANSVERSE FOLDS | Pink |
| 12. ILEOCECAL (or ICI) VALVE | Dark Blue |
| 13. EPITHELIUM | Flesh |
| 14. INTESTINAL GLANDS and OPENINGS | Brown |
| 15. LAMINA PROPRIA | Purple |
| 16. SUBMUCOSA | Light Brown |
| 17. SMOOTH MUSCLE | Light Purple |

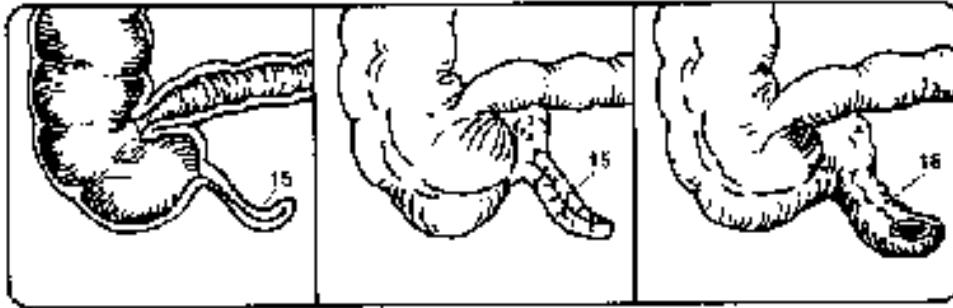
DOUBLE-BARREL COLOSTOMY (TEMPORARY)



COLOSTOMY (PERMANENT)



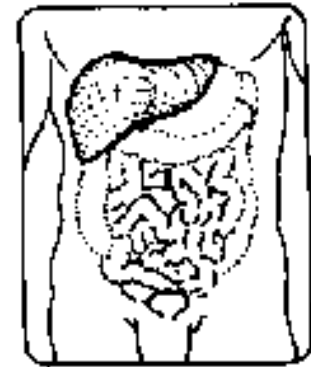
ACCESSORY ORGANS OF DIGESTION



NORMAL APPENDIX

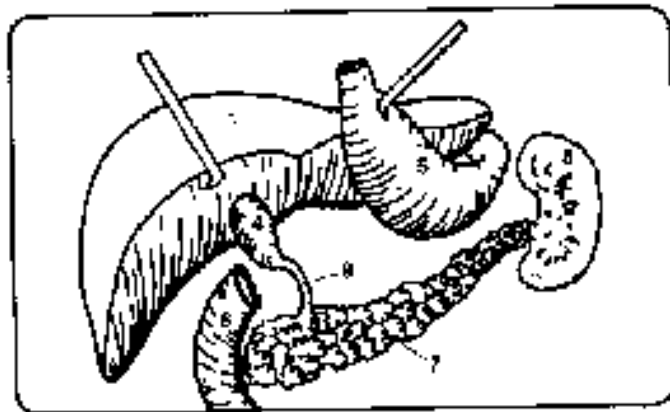
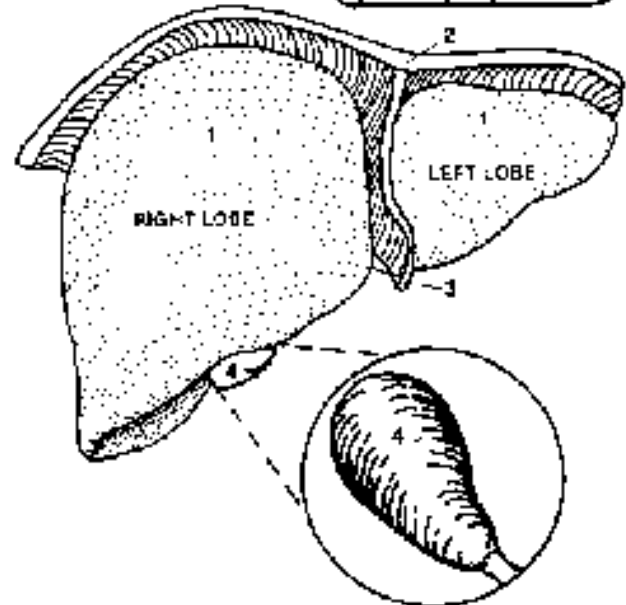
INFLAMED APPENDIX

RUPTURED APPENDIX



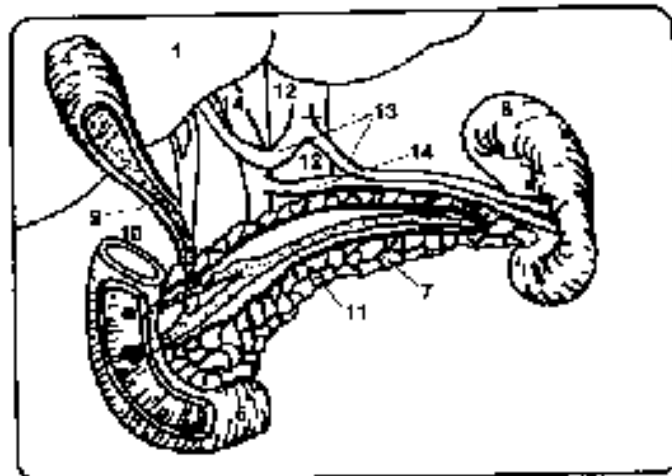
The human appendix does not serve as an accessory organ of digestion, but it does play a role in digest on in the animals from which humans evolved. The appendix may become inflamed and even rupture.

The liver is the body's largest gland. It weighs 1.26 kilograms and secretes *bile*, a fluid that increases the solubility of fats in water. The *bile ducts* form a large Y-shaped tube; bile travels down one leg of the Y to the duodenum and up the other for storage in the *gallbladder*. A large amount of venous blood goes to the liver. The liver's most important job is to reduce or remove toxic chemicals from the bloodstream. The *spleen* assists the liver by removing damaged blood cells.



The *pancreas*, located behind the stomach and above the intestine, produces a fluid with three enzymes that breaks down all classes of organic nutrients and unites with bile in the *common bile duct*, from where it is secreted into the intestine. The pancreas also secretes *insulin* from the special beta cells of the *islets of Langerhans*. Without insulin, sugar collects in the blood instead of reaching the tissues, a condition known as *sugar diabetes*.

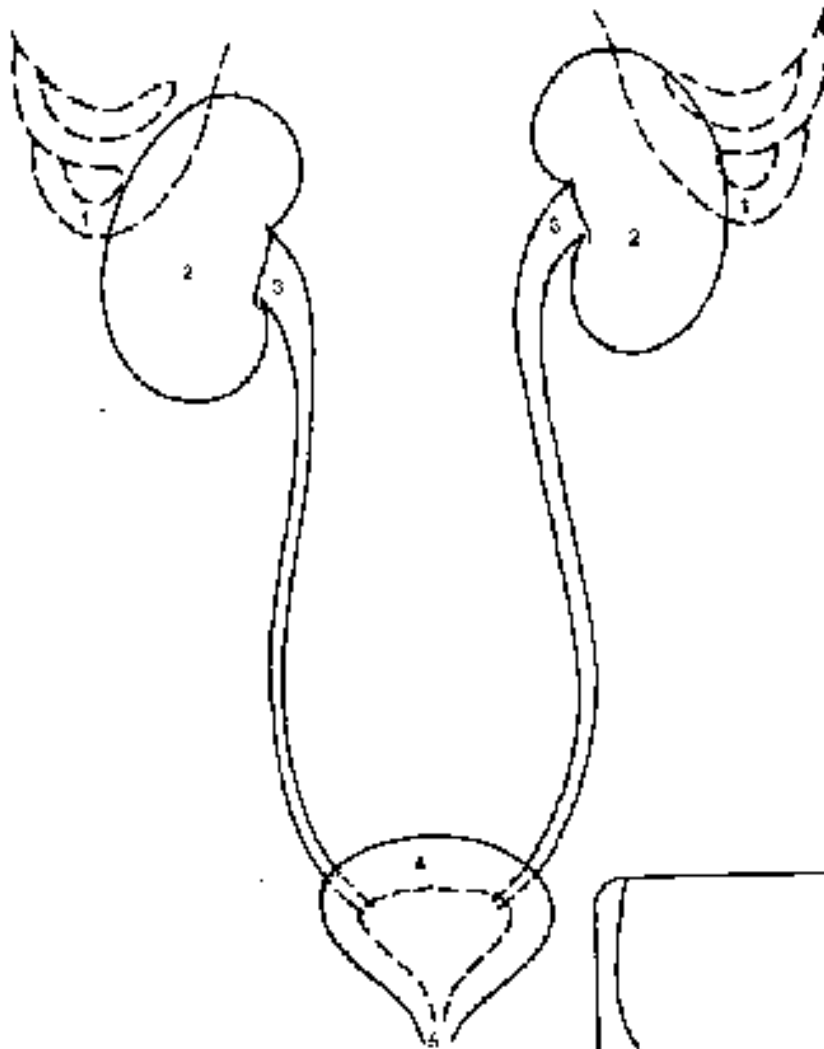
The *gallbladder* is a pear-shaped sac on the underside of the liver. It receives most of the liver's bile and stores it until needed, reacting quickly when acidic gastric juices and fatty foods enter the small intestine.



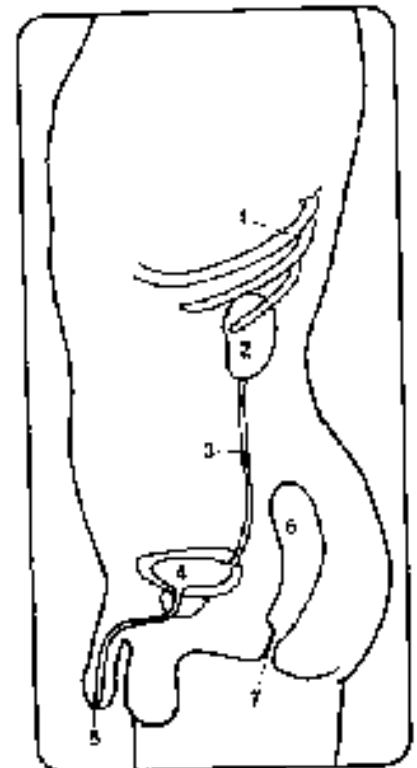
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|---|-------|--------------|
| 1. LIVER | _____ | Brown |
| 2. DIAPHRAGM | _____ | Red |
| 3. FALCIFORM LIGAMENT | _____ | Flesh |
| 4. GALLBLADDER | _____ | Orange |
| 5. STOMACH | _____ | Green |
| 6. DUODENUM | _____ | Dark Blue |
| 7. PANCREAS | _____ | Light Green |
| 8. SPLEEN | _____ | Purple |
| 9. CYSTIC DUCT | _____ | Light Orange |
| 10. COMMON BILE DUCT | _____ | Yellow |
| 11. PANCREATIC DUCT | _____ | Yellow-Green |
| 12. AORTA | _____ | Light Purple |
| 13. CELIAC, SPLENIC, and HEPATIC ARTERIES | _____ | Pink |
| 14. SPLENIC and HEPATIC PORTAL VEINS | _____ | Light Blue |
| 15. APPENDIX | _____ | Gray |

URINARY SYSTEM

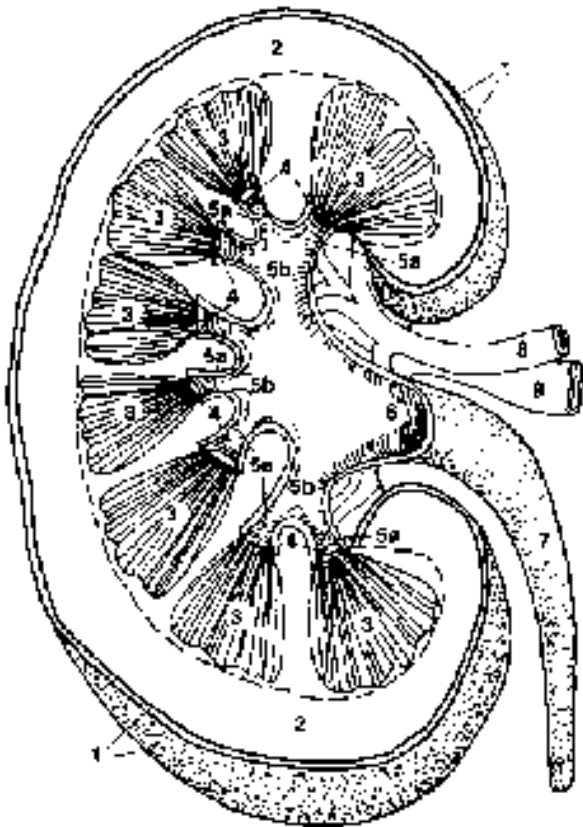
The body constantly produces not only solid wastes but also very complex and often toxic chemical compounds. Tissues filled with these wastes cannot absorb food or oxygen. The excretory organs of the urinary system eliminate liquid wastes. Each of the body's cells discharges its wastes into the bloodstream. The blood carries the acids and salts to the bean-shaped *kidneys* located on either side of the spine in the lumbar area. Each kidney has about 1,250,000 *nephrons* or filters that control the chemical composition of the blood. The nephrons filter the blood; remove nitrogen-compound wastes, excess water, and salts; and return necessary substances and fluids to the blood. The waste-filled fluids migrate through small nephron tubules to larger tubules in the kidney and finally into the *ureter*, a long tube that descends into the *urinary bladder*. The bladder is a hollow muscular organ. When it fills with the slightly acidic yellow fluid called *urine* (about 1,200-1,500 milliliters are produced every day), a reflex action relaxes the inner sphincter muscle in the lower bladder. *Micturition*, the act of expelling urine, is voluntarily started by relaxing the external sphincter. In the female the urethra empties in the area between the clitoris and the vaginal opening. In the male the urethra is about twenty centimeters long and runs through the penis.



- | | | | |
|------------|-------|-------|--------------|
| 1. RIBS | _____ | _____ | Yellow |
| 2. KIDNEY | _____ | _____ | Light Purple |
| 3. URETER | _____ | _____ | Light Blue |
| 4. BLADDER | _____ | _____ | Pink |
| 5. URETHRA | _____ | _____ | Purple |
| 6. RECTUM | _____ | _____ | Light Orange |
| 7. ANUS | _____ | _____ | Orange |

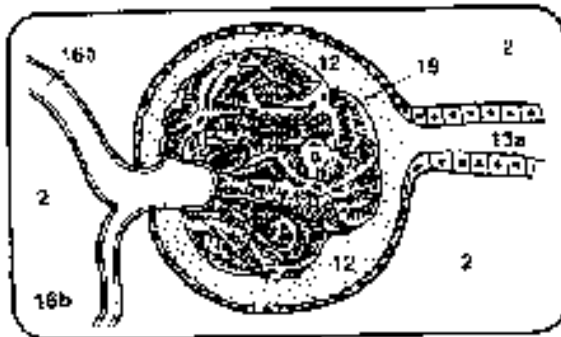


KIDNEYS

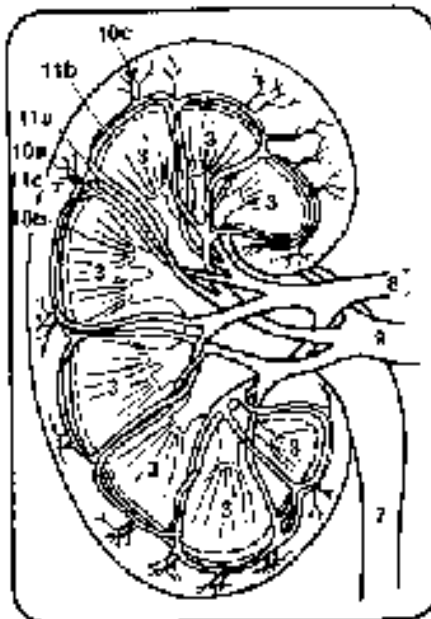
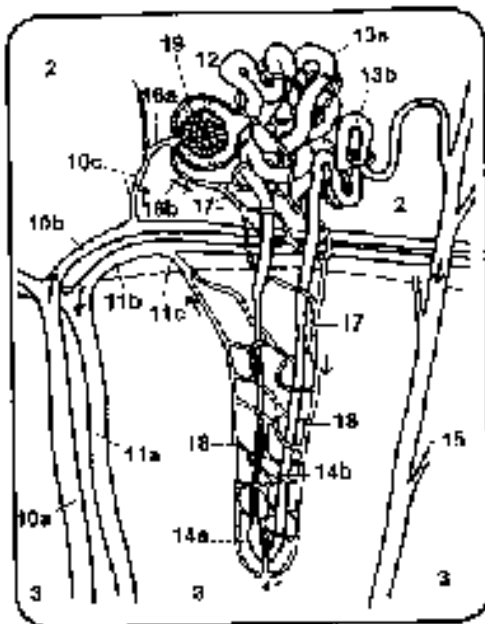


The two kidneys filter out chemicals and electrolytes from the bloodstream. Blood enters each kidney from the large *renal artery* that comes directly from the aorta. The artery divides and subdivides into a maze of arterioles, and each arteriole ends in a coil of capillaries, a *glomerulus*. The coils insert into a cup-like part of the nephron, *Bowman's capsule*. A great deal of water, wastes, glucose, and salts are filtered into each capsule. From the capsule the fluid enters a tubule that passes through a network of capillaries. Many of the fluids, compounds, and minerals diffuse back into the blood and return to the bloodstream. Nitrogenous wastes, excess water, and salts pass into increasingly larger tubules and flow into the *renal pelvis* as urine. Blood returning from the kidney to the bloodstream has very few impurities in it.

The kidneys have a great deal of extra capability. If one kidney is destroyed or removed, the other becomes enlarged and can provide the filtration of the original two. The kidneys also help to maintain the body's delicate acid-alkaline balance by excreting or reabsorbing acidic hydrogen or alkaline bicarbonate ions.



1. RENAL CAPSULE _____ Light Purple
2. CORTEX _____ Flesh
3. MEDULLA (pyramid) _____ Orange
4. PAPILLA _____ Yellow
5. a. MINOR and b. MAJOR CALYCES _____ Green
9. RENAL PELVIS _____ Light Blue
7. URETER _____ Light Blue
8. RENAL ARTERY _____ Red
9. RENAL VEIN _____ Dark Blue
10. a. INTERLOBAR, b. ARCUATE, and c. INTERLOBULAR ARTERIES _____ Red
11. a. INTERLOBAR, b. ARCUATE, and c. INTERLOBULAR VEINS _____ Blue
12. BOWMAN'S CAPSULE _____ Gray
13. a. PROXIMAL and b. DISTAL CONVOLUTED TUBES _____ Light Brown
14. a. DESCENDING and b. ASCENDING HENLE'S LOOPS _____ Brown
15. COLLECTING DUCT _____ Light Orange
16. a. AFFERENT and b. EFFERENT ARTERIOLES _____ Red
17. ARTERIOLE _____ Red
18. VENULE PECTAE _____ Blue
19. GLOMERULAR CAPILLARIES _____ Purple

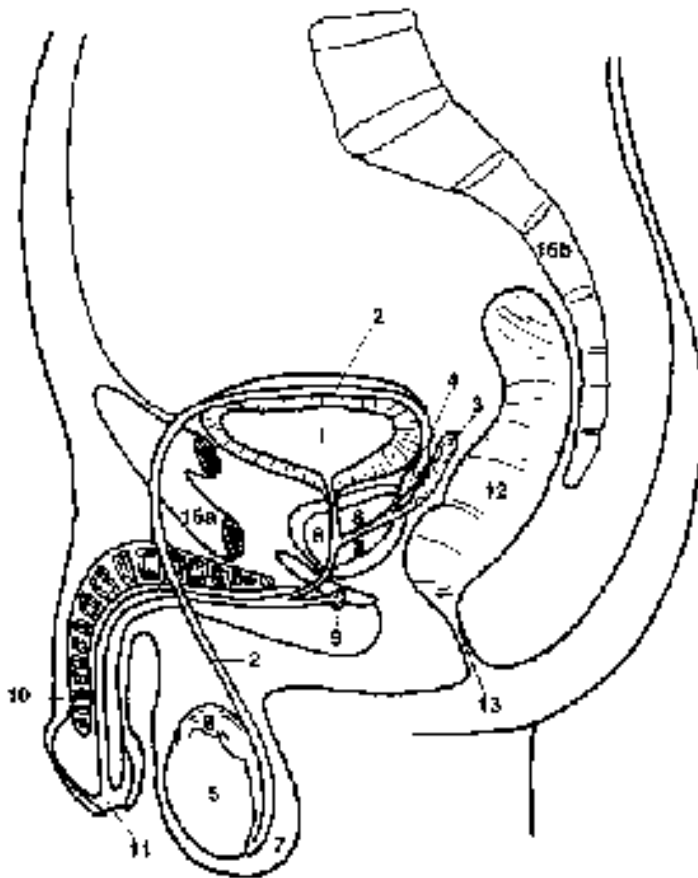


REPRODUCTIVE SYSTEM

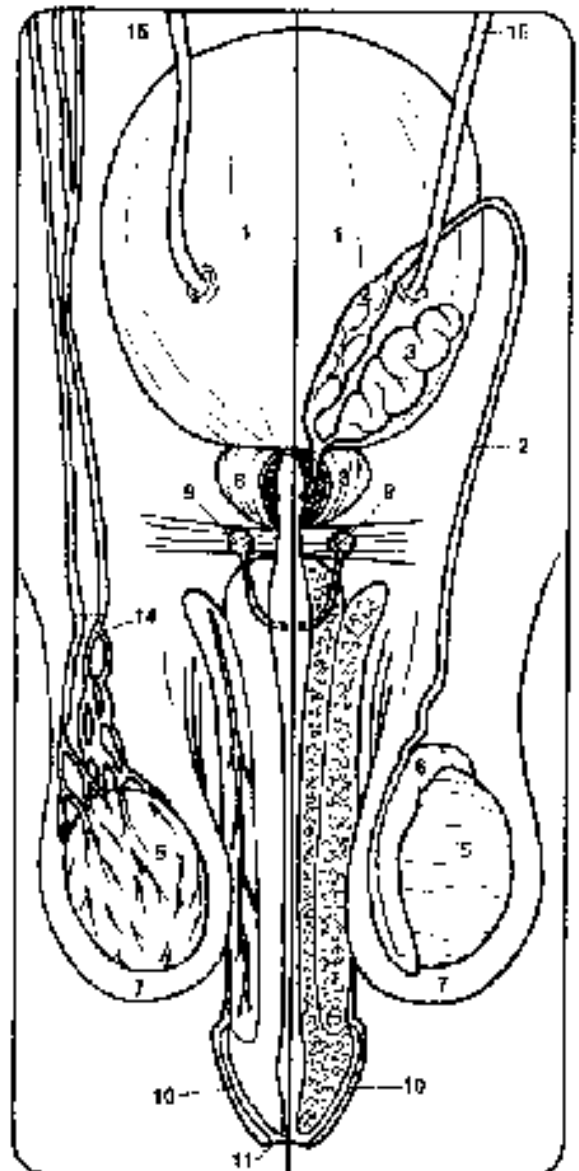
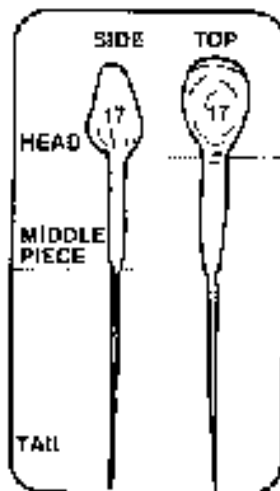
The organs of the reproductive system create human offspring by combining genes from the male and female. These organs also help to develop and nurture the genetically unique fetus. The male and female reproductive organs differ in function and appearance. During sexual intercourse the male provides the sperm cell that fertilizes the female's egg, from which the fetus will develop.

MALE REPRODUCTIVE SYSTEM

Sperm are produced in the two testes or male gonads, which are contained in the scrotum, a pouch suspended outside the body. The sperm are stored in the epididymis and pass through the vas deferens, ducts that lead to the seminal vesicles on each side of the bladder. During the sexual act the penis enlarges and becomes rigid or erect and the sperm passes through the prostate gland, which secretes a milky fluid that enhances the sperm's movement, and Cowper's gland, which secretes a protective and lubricating mucus. The sperm and these fluids together are called semen. The semen is ejaculated into the urethra and penis and, from there, into the female's vagina. Although only one sperm cell is needed to fertilize the egg, there are millions in each ejaculation, which greatly increases the possibility that fertilization will occur during a particular instance of intercourse.



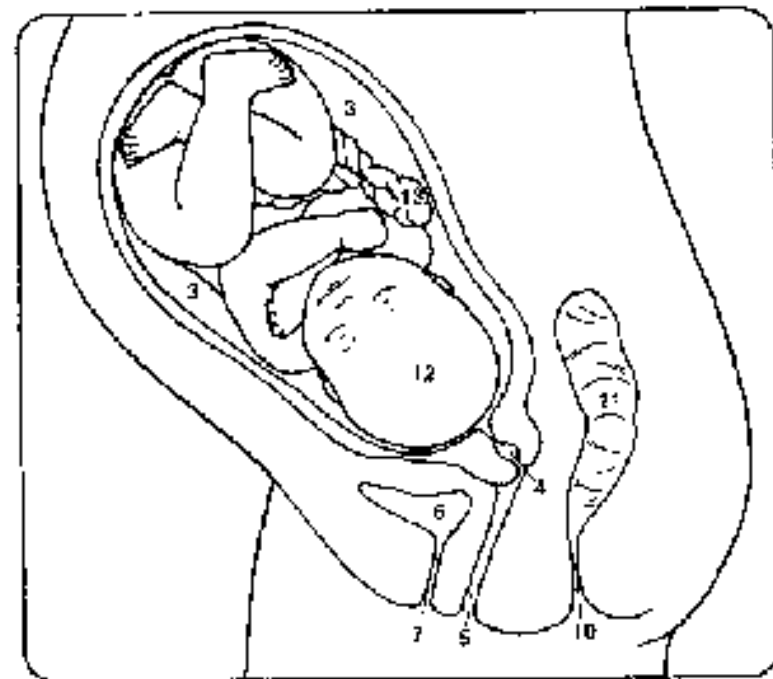
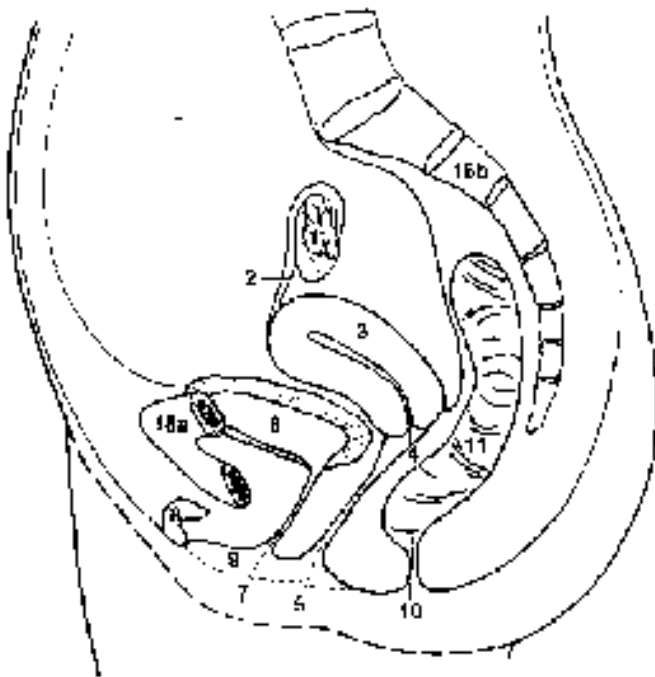
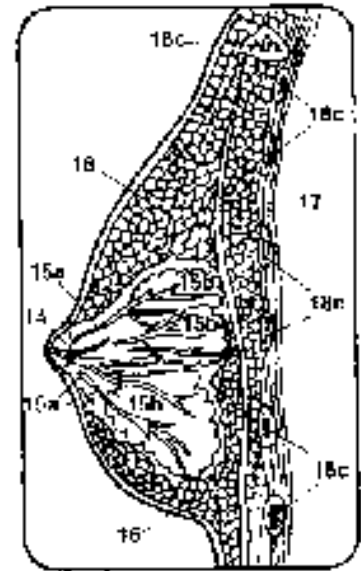
- | | |
|-----------------------------------|--------------|
| 1. BLADDER | Pink |
| 2. VAS DEFERENS | Yellow-Green |
| 3. SEMINAL VESICLE | Yellow |
| 4. AMPULLA OF VAS DEFERENS | Green |
| 5. TESTIS | Light Green |
| 6. HEAD OF EPIDIDYMIS | Turquoise |
| 7. SCROTUM | Light Purple |
| 8. PROSTATE GLAND | Brown |
| 9. COWPER'S GLAND | Blue |
| 10. PENIS | Flesh |
| 11. URETHRA | Purple |
| 12. RECTUM | Light Orange |
| 13. ANUS | Orange |
| 14. BLOOD VESSELS | Red |
| 15. URETER from KIDNEY | Light Blue |
| 18. a. PUBIS BONE and
b. SPINE | Light Brown |
| 17. SPERM | Gray |



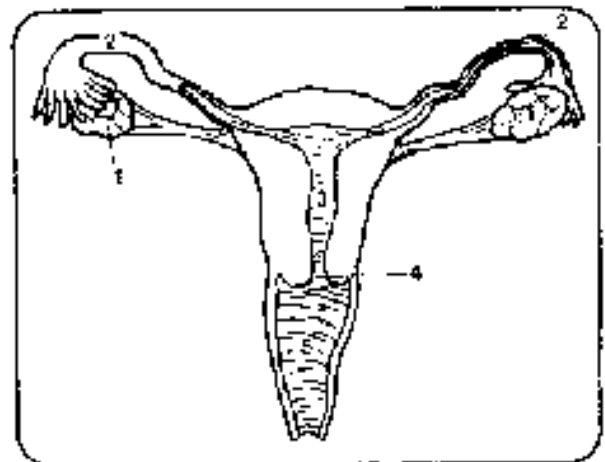
FEMALE REPRODUCTIVE SYSTEM

The *vagina*, a tube-like potential space seven to ten centimeters long, receives the sperm from the male. The group of external organs surrounding the vagina are the *vulva*. The sperm must reach the *uterus* or womb, a hollow pear-shaped organ, through the *cervix*, the narrow end of the uterus. The uterus is lined with a mucous membrane and has small glands and many capillaries. At a certain time during the twenty-eight-day *menstrual cycle*, a *follicle* in the ovaries produces an *ovum* or egg, which is then carried into the *fallopian tubes* by ciliated cells in the tubes' lining. The cilia also assist the sperm as they swim up the tubes toward the egg. If a sperm enters the egg, a membrane that keeps out other sperm forms around the fertilized egg, now called a *zygote*. The zygote passes into the uterus in three to five days and becomes attached to its lining. The cells begin to multiply and develop into a fetus. During the nine months of gestation, the fetus is enclosed in the *placenta*, a membranous sac, and is nourished by and receives oxygen

from the mother's blood passing through the membrane via the *umbilical cord*. Wastes return through the placenta to the mother and are eliminated through her respiratory and excretory systems. As the fetus is developing, the mother's two *mammary glands* in her breasts begin to enlarge. These glands are composed of adipose as well as glandular tissue and secrete milk after the baby is born.



- | | | |
|---|-------|--------------|
| 1. OVARY | _____ | Light Green |
| 2. FALLOPIAN TUBE | _____ | Yellow-Green |
| 3. UTERUS | _____ | Green |
| 4. CERVIX | _____ | Blue |
| 6. VAGINA | _____ | Light Blue |
| 6. BLADDER | _____ | Pink |
| 7. URETHRA | _____ | Purple |
| 8. CLITORIS | _____ | Brown |
| 9. LABIA | _____ | Yellow |
| 10. ANUS | _____ | Orange |
| 11. RECTUM | _____ | Light Orange |
| 12. FETUS | _____ | Flesh |
| 13. UMBILICAL CORD | _____ | Light Purple |
| 14. NIPPLE | _____ | Red |
| 15. a. MAMMARY DUCTS and
b. LOBES | _____ | Turquoise |
| 16. FAT IN SUPERFICIAL FASCIA | _____ | Gray |
| 17. PECTORALIS MAJOR (muscle) | _____ | Dark Blue |
| 18. a. PUBIS BONE, b. SPINE, and
c. RIBS | _____ | Light Brown |



ENDOCRINE SYSTEM

Hormones are essential to our understanding of the body's metabolism or normal functioning. Endocrine glands secrete hormones directly into the bloodstream, not just to a special organ; thus these secretions reach every part of the body. Hormones influence the flow of substances through cell membranes and often work together, which means that a hormonal imbalance may interfere with normal body functions.

THYMUS

The thymus is not always classed as an endocrine gland. It becomes most developed during a child's early years. Apparently its purpose is to initiate antibody formation in the blood.

THYROID

The two lobes of the thyroid gland are located on either side of the trachea and secrete iodine-based hormones that regulate physical and mental growth, oxidation, heart rate, blood pressure, temperature, glucose absorption, and the utilization of glucose.

PARATHYROID

There are four parathyroid glands, all located next to the thyroid. Their secretions control the use of calcium in bone growth, muscle tone, and nervous activity.

PITUITARY

Located at the base of the brain, the pituitary gland secretes hormones that influence other glands. The pituitary gland regulates skeletal growth, the development of the reproductive organs, secretions from the ovaries and testes, the stimulation of the mammary glands to provide milk, blood pressure, the performance of smooth muscles, the reabsorption of water in the kidneys, and the functioning of the adrenal cortex, which becomes more active during times of stress. Pituitary disorders may result in gigantism or dwarfism.

PINEAL

The function of the pineal gland is unknown, but it is very active metabolically. It is about the size of a pea and located at the base of the brain.

ADRENAL

Located above the kidneys, the adrenal gland secretes cortisol, which regulates the metabolism and the balance between salt and water levels. During emergencies it also secretes adrenaline (epinephrine), which increases the heart rate and stimulates the liver and nervous system.

PANCREAS

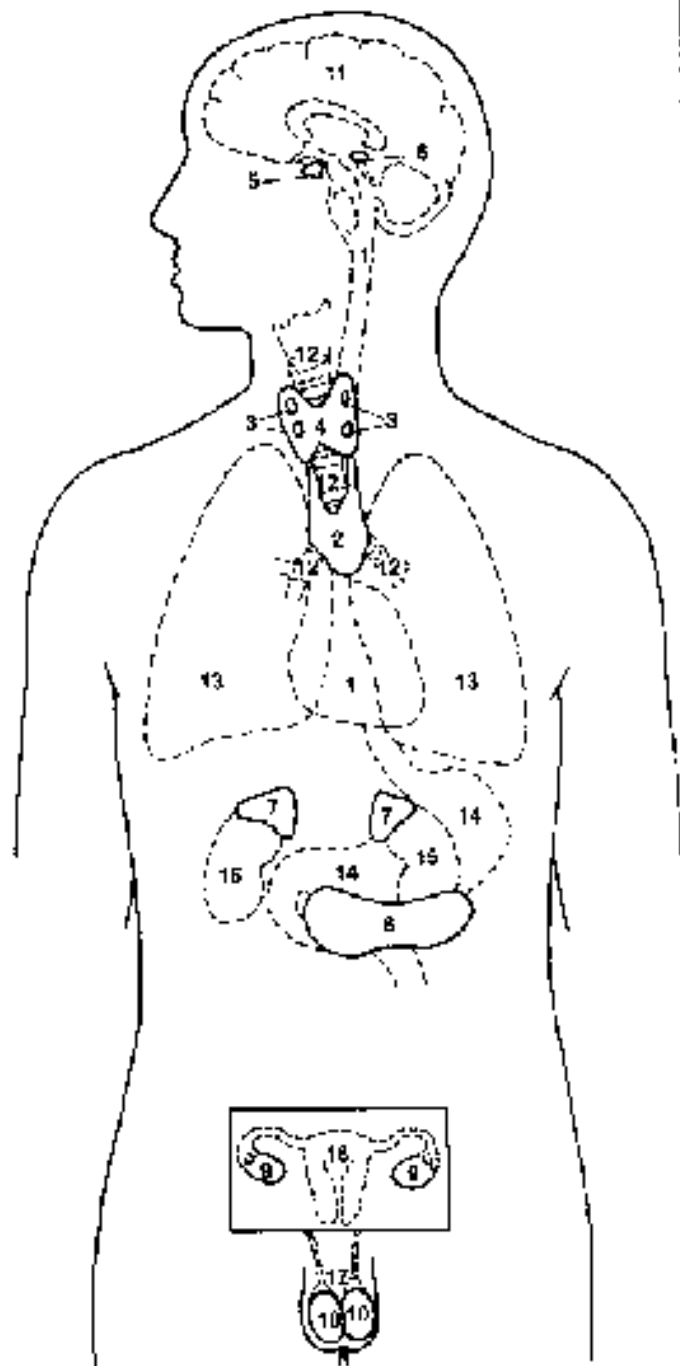
The level of sugar in the blood is controlled by the pancreas's secretion, insulin. Sugar diabetes results when the level of insulin in the blood is relatively low.

OVARIES

Ovaries are found only in women. They secrete the two female hormones—estrogen, which produces female characteristics and initiates female bodily functions; and progesterone, which affects the endometrial lining of the uterus.

TESTES

Only men have testes. They secrete testosterone, the male hormone, which controls the growth of body hair and beard, body size, and the deepening of the voice.



- | | |
|--------------------------------|--------------|
| 1. HEART | Purple |
| 2. THYMUS GLAND | Orange |
| 3. PARATHYROID GLAND | Pink |
| 4. THYROID | Brown |
| 5. PITUITARY GLAND | Turquoise |
| 6. PINEAL GLAND | Light Brown |
| 7. ADRENAL GLAND | Red |
| 8. PANCREAS | Light Green |
| 9. OVARIES | Yellow |
| 10. TESTES | Dark Green |
| 11. BRAIN and SPINAL CORD | Gray |
| 12. TRACHEA and BRONCHUS | Blue |
| 13. LUNGS | Light Blue |
| 14. STOMACH | Green |
| 15. KIDNEYS | Light Purple |
| 16. UTERUS and FALLOPIAN TUBES | Yellow-Green |
| 17. SCROTUM | Flesh |

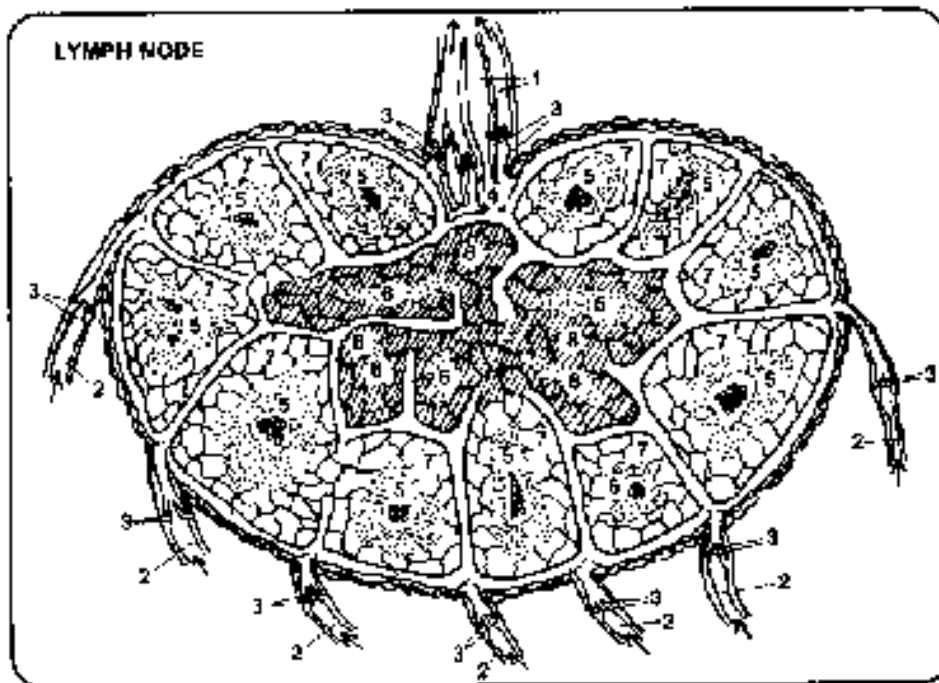
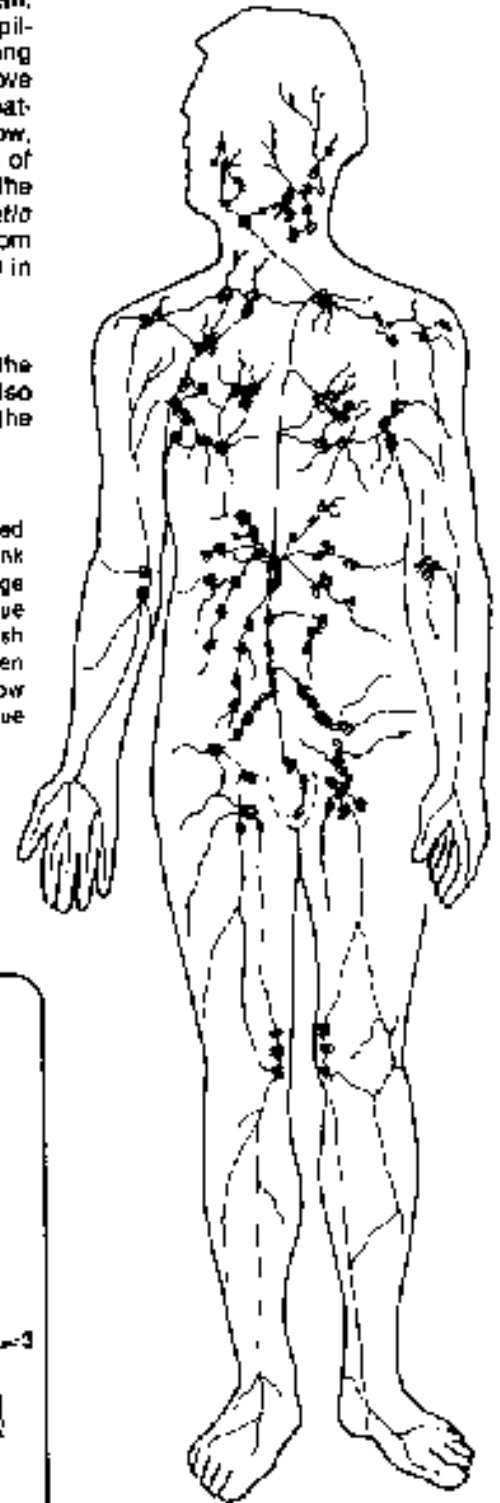
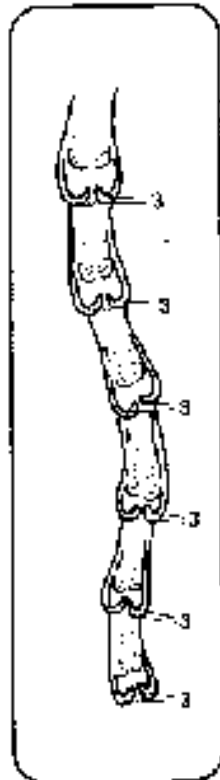
LYMPH SYSTEM

Surrounding the cells is a fluid that picks up colloids, particles, electrolytes, and wastes that are unable to return to the blood. The lymph system, a system of tubes like the venous system (their vessels have similar walls and valves to prevent the backflow of fluid), drains the fluid, which is called *lymph* when it enters the system. The microscopic lymph capillaries are larger and more permeable than blood capillaries. Lymph vessels unite to form larger and larger lymphatics. At intervals along the system, the vessels form *lymph nodes* that strain and purify lymph and remove infectious organisms and bacteria before the lymph returns to the blood. The greatest concentration of nodes is in the neck, armpit, elbow, and groin. The *tonsils* and *adenoids* are also masses of lymphatic tissue. Lymphatics from the right side of the head, neck, and right arm flow from the *right lymphatic duct* into the *right subclavian vein*. The lymphatics from the rest of the body drain into the *thoracic duct*, which in turn flows into the *left subclavian vein*.

SPLEEN

The spleen stores large quantities of blood and, in the fetus and newborn child, forms red blood cells. It also removes damaged cells, bacteria, and debris from the blood.

- | | | |
|------------------------------|-------|------------|
| 1. EFFERENT LYMPHATIC VESSEL | _____ | Red |
| 2. AFFERENT LYMPHATIC VESSEL | _____ | Pink |
| 3. LYMPHATIC VALVE | _____ | Orange |
| 4. HILUM | _____ | Light Blue |
| 5. PRIMARY LYMPH NODULE | _____ | Flesh |
| 6. MEDULLARY CORD | _____ | Green |
| 7. CORTEX | _____ | Yellow |
| 8. MEDULLA | _____ | Blue |



SKIN

The waterproof and airtight skin, the body's largest organ, completely encases the other organs and tissues. Skin protects you from many infectious organisms and harmful light rays, and it also converts light to vitamin D, helps to control the body's temperature, and eliminates certain wastes. Sensors in your skin detect pressure, pain, and the temperature outside your body.

The outer layer of the skin is called the *epidermis*; the thicker inner layer is the *dermis*. The epidermis has a different number of sublayers depending on how much wear it must take. The palms of the hands and soles of the feet have five sublayers; elsewhere there are four. Cells germinate at the innermost layer, the *stratum germinativum*. As the cells multiply, they move upward and undergo chemical changes until they dry and die and flake off. This upward movement and the transformation from moist to dry permits the inner tissues to be surrounded by fluid even though your body exists in the relatively dry air.

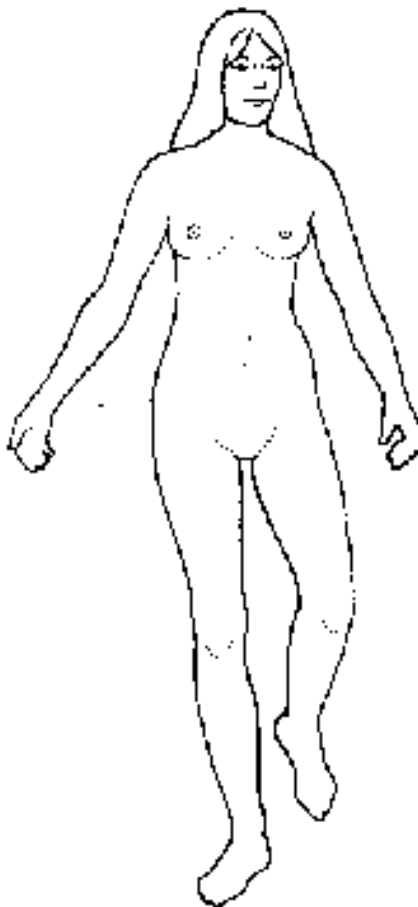
The dermis contains numerous blood vessels, nerves, glands, and hair follicles. Fibers from the dermis extend into the subcutaneous layer and anchor the skin.

SEBACEOUS (Oil) GLANDS

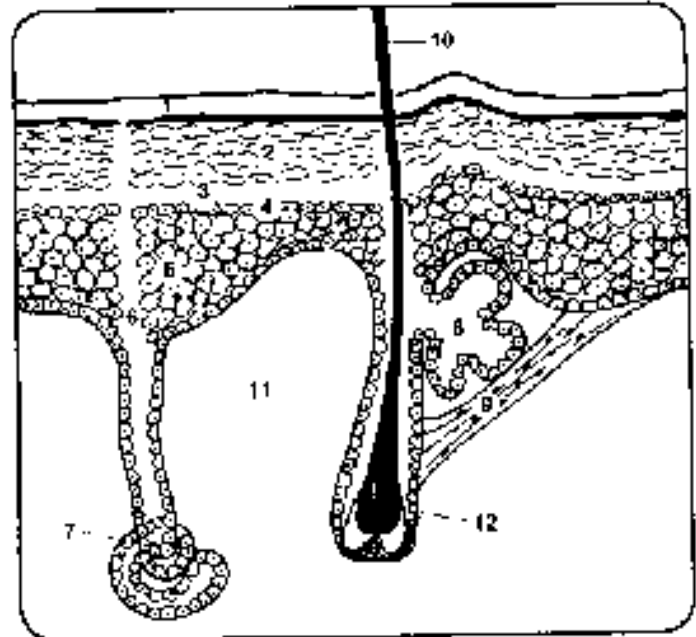
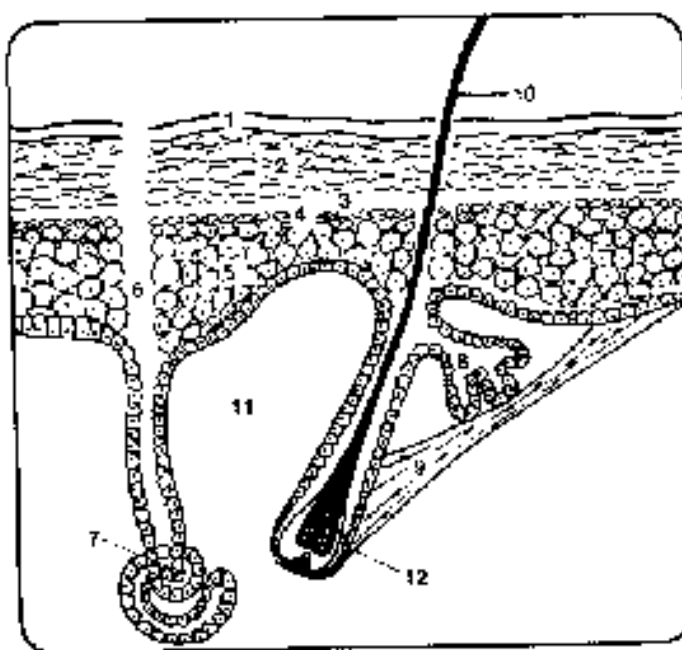
The sebaceous glands are located all over the body except on the palms and soles. They are connected to hair follicles by a short duct and secrete *sebum*, an oil that keeps skin soft and hair from drying and becoming brittle. When you are cold or frightened, a muscle (*arrector pili*) attached to the hair follicle pulls the hair erect, which ejects oil onto the skin to prevent evaporation and heat loss. When pushed up, the glands form goose bumps.

SUDORIFEROUS (Sweat) GLANDS

Sweat glands are found over the entire skin, but they are most numerous in the palms, soles, forehead, and armpits. Each gland is a single coiled tube that originates in the subcutaneous tissue, passes through the dermis, and opens as a pore in the epidermis. Its base is surrounded by capillaries from which it extracts the salts, water, and acids from the blood that then are excreted as perspiration.



- | | | |
|-------------------------------|-------|--------------|
| 1. LAYER OF OIL | _____ | Light Green |
| 2. STRATUM CORNEUM | _____ | Flesh |
| 3. STRATUM LUCIDUM | _____ | Orange |
| 4. STRATUM GRANULOSUM | _____ | Pink |
| 5. STRATUM GERMINATIVUM | _____ | Light Orange |
| 6. SWEAT GLAND DUCT (pore) | _____ | Yellow-Green |
| 7. SUDORIFEROUS (sweat) GLAND | _____ | Yellow |
| 8. SEBACEOUS (oil) GLAND | _____ | Green |
| 9. MUSCLE (arrector pili) | _____ | Red |
| 10. HAIR | _____ | Black |
| 11. DERMIS | _____ | Light Brown |
| 12. HAIR FOLLICLE | _____ | Gray |



SCARRING, NAILS, AND COOLING

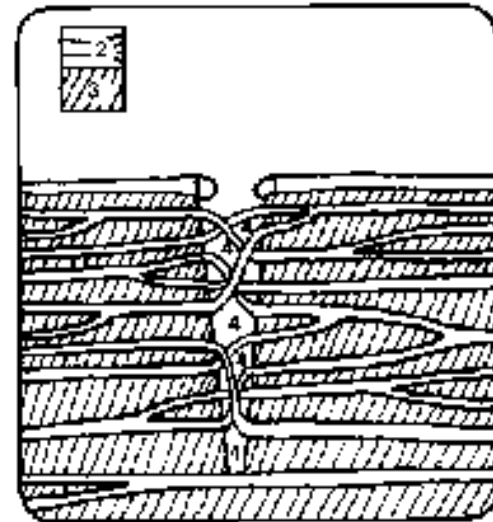
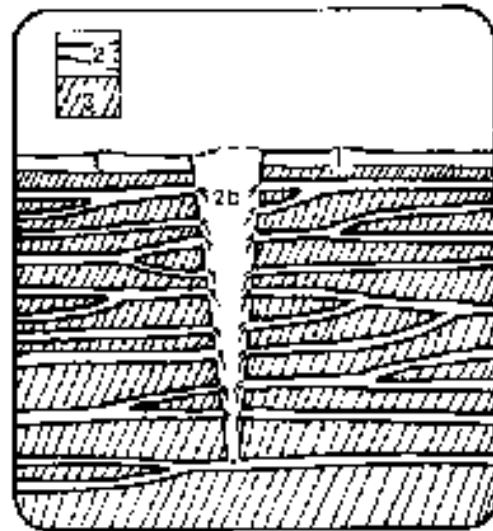
Normal skin tissue does not grow back after a large wound; scar tissue forms instead. When a wound occurs, blood rushes in to clean and seal it by clotting and forming a scab. Then the area begins to fill with granular tissue made of blood vessels and newly formed, hard connective tissue. The epidermis bridges the top. After the wounded tissue is replaced, the vessels wither, stopping the supply of blood. The absence of blood makes the scar tissue whitish.

NAILS

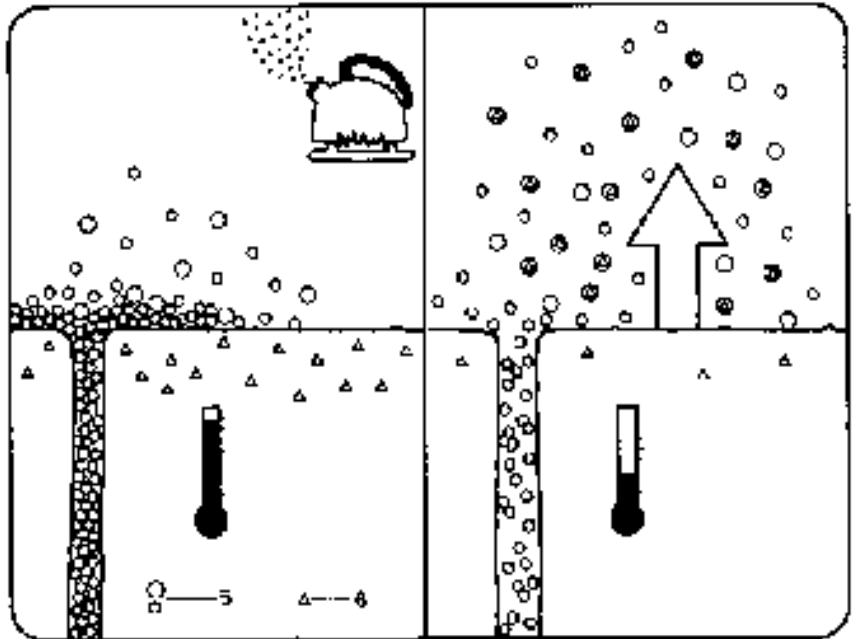
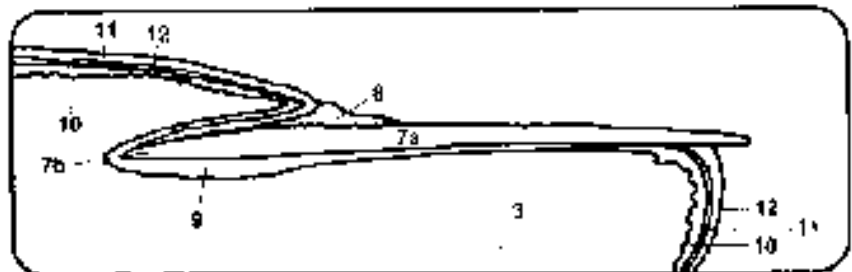
Look at your fingers. The base of each nail, the *nail root*, is hidden beneath skin. As a nail grows, it slides forward over the *nail bed*, which looks pink because of the blood in the capillaries just beneath it. A white crescent appears at the base of the nail because the capillaries there are not close to the skin's surface. The visible part of the nail is the *nail body*. Fingernails grow about one millimeter a week; toenails more slowly.

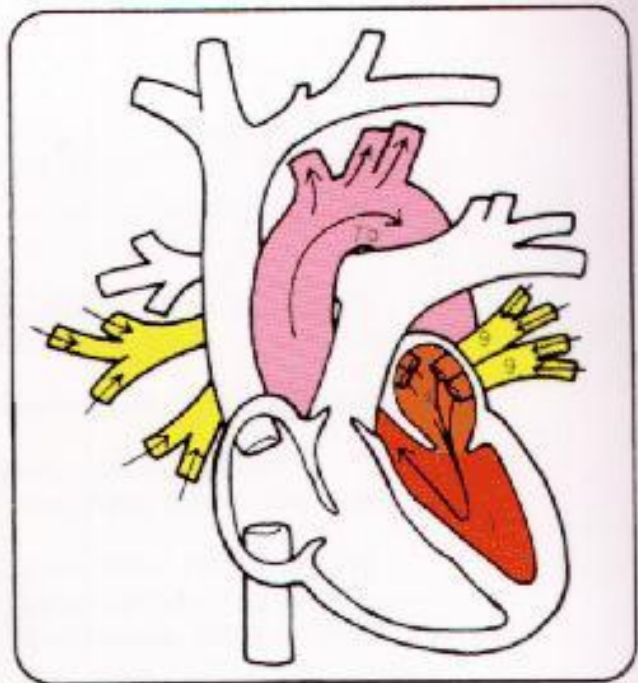
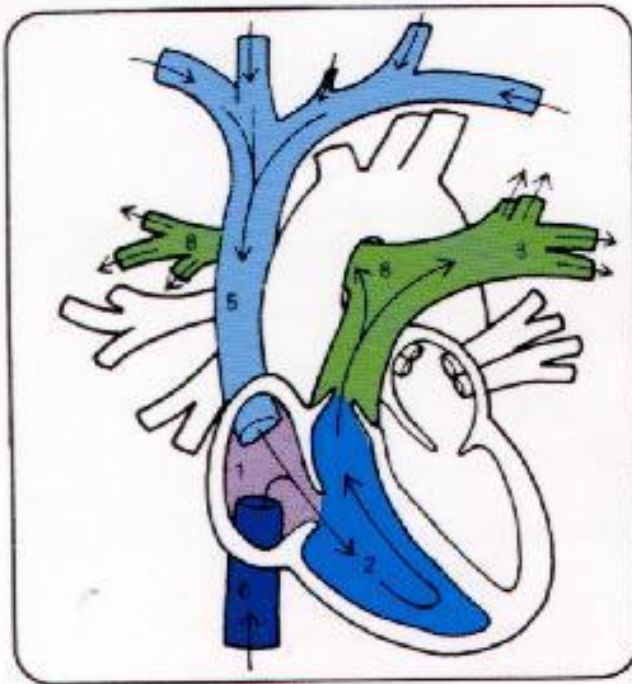
COOLING BY PERSPIRATION

The evaporation of perspiration cools the body because as water turns into water vapor, the vapor draws off excess heat. A similar thing happens to your tea kettle: your skin is like the burner that gives heat to the water until the water changes into a vapor and leaves the surface, taking the heat with it.



1. EPIDERMIS _____ Flesh
2. a. BLOOD VESSELS and
b. BLOOD _____ Red
3. DERMIS _____ Pink
4. GRANULAR TISSUE _____ Yellow
5. PERSPIRATION _____ Blue
6. HEAT _____ Orange
7. a. NAIL BODY and
b. NAIL ROOT _____ Yellow-Green
8. EPONYCHIUM (cuticle) _____ Green
9. NAIL MATRIX _____ Purple
10. STRATUM GERMINATIVUM _____ Light Purple
11. STRATUM GRANULOSUM _____ Light Brown
12. STRATUM CORNEUM _____ Light Orange
13. SCAR TISSUE _____ WHITE





Margaret Matt

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Text by Joe Ziemian

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