

- objects; and by a light in front of the unshaded eyes.
8. Show that the iris protects the retina against too strong light.
 9. Show that the lens must change its shape to accommodate itself to near vision and to far vision.
 10. Tell the condition of the lens and the remedy in *far* sight; in *near* sight; and in *astigmatism*.
 11. Describe a cataract and its remedy.
 12. Show how two eyes aid in the judgment of form and position.
 13. Describe the condition of the eye muscles in a cross-eyed person, and tell how vision is affected.
 14. Show how reading upon a moving railway train and reading while lying down overwork the eye muscles.
 15. Tell how to care for an eye which runs matter, and how to remove a speck of dirt from under the lid.
 16. Show that rubbing a sore eye is always liable to do harm.
 17. Show that irritation of the eye may produce false sensations of sight; and that sight memories may seem to be real again.
 18. Describe the *X* rays.
 19. Describe the effects of alcohol and tobacco on the eye.
 20. Describe the eye in lower animals; in insects; and in a leech.

p348-

CHAPTER XXXVI

THE VOICE

627. **The larynx.** — The basis of the voice is a sound made in the larynx during expiration. The larynx is a triangular box about three quarters

of an inch across, made of cartilages. It connects the trachea and pharynx.

Its two sides are formed of a flat cartilage, bent sharply backward, and called the *thyroid* cartilage.

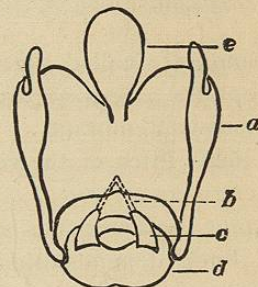
The upper end of the fold projects slightly from under the chin and is called the *Adam's apple*.

Underneath the thyroid cartilage is a circular cartilage whose back part projects upward so as partly to fill in

space between the back edges of the thyroid cartilage. In form and size it resembles a large finger ring,

and is called the *cricoid* cartilage.

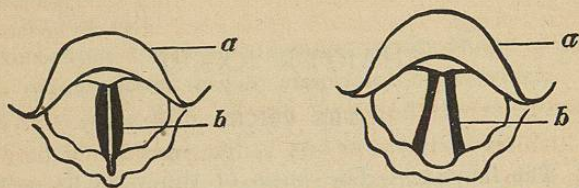
On top of the back part of the cricoid cartilage are two small cartilages, shaped like triangular pyramids, and so arranged that they can turn sidewise. One lower corner of each projects forward. From it a flat band extends across the larynx, and, with its fellow from the opposite side, attaches itself to the lower part of the thyroid cartilage. Muscles can tighten them and bring them close



Back view of the larynx.

- a thyroid cartilage.
- b vocal cords.
- c movable cartilage for the attachment of the vocal cords.
- d cricoid cartilage.
- e epiglottis.

together. Expiring air between these bands, while they are tight and close together, causes them to vibrate and produce a sound which is called the *voice*. Hence the



Top view of the larynx, with the vocal cords closed, as in speaking.
a epiglottis. b vocal cords.

Top view of the larynx, with the vocal cords open, as in breathing.
a epiglottis. b vocal cords.

bands are called the *vocal* cords. The whole larynx, except the edges of the vocal cords, is covered with loose mucous membrane.

628. Pitch of the voice. — All sound has the four characteristics of *pitch*, *intensity*, *quality*, and *duration*. The same characteristics apply to the voice.

Pitch depends upon the number of vibrations which occur each second. In order that the vibrations of the air shall blend into a musical note they must occur at the rate of sixteen times a second, but until they reach a rate of fifty the sound is more like a buzz than music. Upper C of the bass voice which corresponds to lower C of a soprano, is produced by 256 vibrations per second. The shorter or tighter the vocal cords are, the higher will be the pitch. In men the cords are longer than in women, making a man's voice an octave lower in pitch. The larynx and voice of a boy resemble those of a girl. At about the age of fifteen the voice of a boy becomes like a man's, while in a girl it remains unchanged.

629. The intensity of the voice depends upon the force with which air is expelled through the larynx. In making

a very loud sound, the great force of the air current causes the vibrations of the vocal cords to be painful.

630. The muscles of the larynx will grow strong by judicious practice, so that a person can be heard across a hall in which he formerly could not be heard a few feet away. If the voice becomes husky, or causes a cough, or if the throat begins to feel painful, the vocal cords are being overworked and should be rested.

631. Quality of the voice. — A string stretched between the hands produces a faint unpleasant sound; but if it is stretched over a hollow box, like the body of a violin, the whole box will vibrate and greatly magnify the sound and also will make it full and pleasant.

The vibrations of the vocal cords alone produce a faint and almost squeaking sound very unlike that of the voice; but below the larynx are the hollow trachea and lungs. Above it are the hollow mouth, nose, and frontal sinuses. All these vibrate with the vocal cords, and so the quality of the voice is modified. Each person's voice has a peculiar quality of its own which is at once recognized.

When a person sings with the nose stopped, we say that he sings through the nose. In reality, a nasal voice is due to the absence of vibrations in the nose.

632. Ventriloquism. — The quality of sound is modified by distance, so that one can judge accurately whence it comes. It is possible to imitate the quality of distant sounds, so that there seems to be another person talking in a remote part of the room or inside of the real talker. This is called *ventriloquism*.

633. Speech. — Speaking consists mainly in rapid changes in the quality and duration of vocal sounds. In singing or crying out, single sounds are more or less prolonged, but in forming spoken words, the sounds are cut off by the tongue and lips several times a second. It is not even necessary to form a sound with the larynx. In whispering,

air is simply breathed through the mouth, while the tongue and lips cut it off at intervals as though a sound were being made.

634. A simple sound continuously uttered is a *vowel* sound. If the mouth is simply opened without effort, the sound formed will be that of *a* as in *father*. When the mouth is closed the most, it forms the sound *oo* as in *room*. A consonant sound is a vowel sound suddenly modified in either its beginning or ending. For instance, when the tip of the tongue is held against the palate just back of the teeth, and a vowel sound is begun by forcibly blowing it away, the sound will be either *t*, *d*, or *th*.

635. Rate of talking. — A public speaker will ordinarily utter 125 words a minute. On an average each word will be composed of, at least, four different sounds. Thus the vocal organs must make 600 separate adjustments each minute, or 10 each second.

636. Relation of sound and speech. — Words spoken must first be heard. So no matter what the race of a child, it will speak exactly the speech which it hears. If a child is brought up in company with an ignorant nurse girl, its speech will be her brogue. On the other hand, if the child is brought up among educated and refined persons, it will speak an elegant tongue.

A deaf person has great difficulty in learning to speak at all, for he can have no idea of the sound which he should make. Without special instruction deaf persons would never learn to speak at all, but by letting them see or feel the position of the lips and tongue in forming words, they learn to place their own parts in the same position and so finally learn to talk.

637. Necessity of the tongue in speech. — The tongue is usually considered to be so necessary in speech that the language itself is called a *tongue*. As man's mouth is constructed the tongue does do the most important part of forming words, but if the organ is removed as far back as possible, the stump can still form intelligible words. Sometimes the front part of the tongue is bound down or "tied" so that it cannot move so freely as it should. This is supposed to hinder a child in talking, but in reality it does not.

638. Benefits of vocal exercise. — In singing and lecturing, the breathing must be regular and deep. The abdominal muscles must act, and often a sound must be prolonged until the air in the lungs is exhausted. The respiratory muscles must act continuously and strongly and for long periods of time. Thus an increased amount of oxygen will be taken into the body. Voice training is one of the best modes of exercise, especially for a weak person who cannot endure long walks or gymnastic exercises. It is all the more valuable because a person does not think of the exercise, but directs the mind to an interesting and useful occupation.

639. Diseases of the larynx. — In a cold in the throat the mucous membrane becomes tender and swollen. Then the movements of the vocal cords are impeded and painful, so that only a hoarse sound, or no sound at all, can be produced. By repeatedly overworking the vocal cords, they and the muscles of the larynx become flabby and tender so that their vibrations are painful or impossible. Then the voice is reduced to a whisper. Sometimes the nerves of the larynx are paralyzed so that no motor orders can reach the muscles. Then no sound can be formed.

640. In mouth breathing, the air is drawn directly into the larynx without being purified, warmed, and moistened in the nose. This irritates the larynx and vocal cords so that the voice is made weaker and harsher. A mouth breather can seldom become a good singer or speaker.

641. Tobacco. — Tobacco smoke may produce such an irritation that there is a constant hacking cough. Cigarettes are especially bad for the voice, for the smoke is deeply inhaled. Alcohol interferes with the voice by inducing indigestion and weakness of the muscles.

SUMMARY

1. The larynx is a box of cartilage across which two strong bands called *vocal cords* are stretched.
2. When the vocal cords are tightened and air is expelled between them, a sound called the *voice* is made.
3. The pitch of the voice will depend upon the tightness and length of the cords.
4. The intensity of the voice depends upon the force with which the air is expired.
5. The quality of the voice is imparted to it by vibrations of the air in the lungs, mouth, and nose.
6. In speech sounds are modified mainly by the lips and tongue.
7. A man must first hear the sound of speech, and then learn to imitate it. Special means must be employed to teach a deaf person to talk.
8. If the vocal apparatus is overworked or becomes inflamed, the voice is injured.

DEMONSTRATIONS

150. Procure a larynx from a butcher's shop. Notice the large flat thyroid cartilage, and under it the ring-shaped cricoid cartilage. Notice the white vocal cords passing forward to the lower part of the thyroid. Notice the loose mucous membrane above the vocal cords. Grasp the thyroid cartilage so as to move the cricoid forward and backward, and note how the movements tighten and relax the vocal cords. Notice the muscles which move the larynx. Test the pyramidal cartilages to which the vocal cords are attached.

151. If possible, get a physician to show the vocal cords in action upon a living person. He will do it by means of a small mirror held in the back part of the mouth.

152. Have the pupils feel each other's chests while counting one, two, three, and note the marked vibrations. In the same way feel of

the larynx and of the nose and teeth. Explain that these vibrations also produce sound and give quality to the sound in the larynx. Then compress the nose and note the nasal quality of the voice.

153. Show how the different vowel sounds are formed. Make a continuous sound as of *e* in *need*. Without changing the pitch or intensity change the mouth to a position to utter in succession the sounds *a* as in *made*, *a* as in *mat*, *ah* as in *father*, *o* as in *note*, and *oo* as in *room*. Note how the sounds glide into each other.

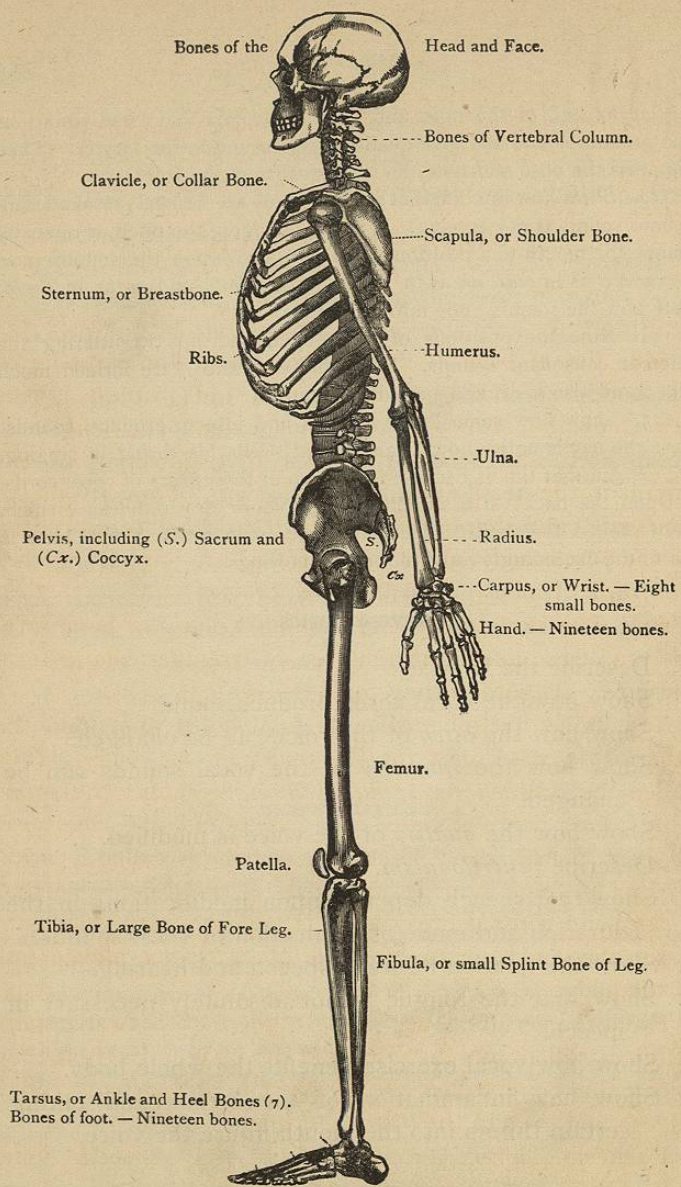
154. Note the positions of the tongue and lips in uttering the different consonant sounds. Note that *p*, *b*, and *f* are formed much alike; and also *k*, *ch*, and *g*; and *t*, *d*, and *th*.

155. Show how some lower animals and insects produce sounds. Have the pupils notice how a canary bird swells his throat in singing, and explain that this is because it has two or three pairs of vocal cords.

Upon the backs of a katydid's wings show the drumheads, which, when rubbed together, produce its sound. Show that a fly's buzz is due to the exceedingly rapid motion of its wings.

REVIEW TOPICS

1. Describe the larynx.
2. Show how the vocal cords produce sound.
3. Show how the *pitch* of the voice can be changed.
4. Show how the *intensity* of the vocal sounds can be changed.
5. Show how the *quality* of the voice is modified.
6. Describe *ventriloquism*.
7. Show that speech depends upon modifications in the duration and mode of production of vocal sounds.
8. Show the relation between speech and hearing.
9. Show that the tongue is not absolutely necessary in speech.
10. Show how vocal exercise benefits the whole body.
11. Show how inflammation of the larynx and taking certain things into the mouth injure the voice.



The human skeleton, showing position of bones.

CHAPTER XXXVII

BONES.

642. Use of bone. — Bones give shape and support to the body and impart to it strength and stiffness. Like beams of the strongest oak, they extend the length of every limb, and form arches for the protection of the organs in the head, chest, and abdomen. They are of various sizes and shapes, as are suited to the different parts. In the whole body, about two hundred are jointed together to form its framework, called the *skeleton*.

643. The skeleton. — Eight rounded plates of bone form the top of the head, and fourteen of irregular shape form the face. Together, they form the *skull*.

Twenty-six irregular rings of bone piled one upon the other form a support for the trunk of the body. It is called the *backbone* or *spinal column*, or simply the *spine*. The lowest bone is called the *coccyx*, and the one next above it, the *sacrum*. Each ring of bone is called a *vertebra*. The spine is made of a series of small bones so that it can bend without breaking. It is gently curved so as to lessen the jarring in running and other violent movements of the body.

From the vertebræ, beginning at the eighth, twelve pairs of bones called *ribs* curve around the body. In front they join a flat bone called the *sternum* or *breastbone*. They inclose and protect the heart and lungs.

Each shoulder is formed in front by a slender bone

called the *collar bone* or *clavicle*, and behind by a flat bone called the *shoulder blade* or *scapula*. Their outer ends meet and form a support for the arm.

The upper arm has one long bone called the *humerus*. The forearm has a long bone on its thumb side called the *radius*, and another on its little finger side called the *ulna*. The wrist has eight rounded bones called *carpal* bones. The palm of the hand has five long bones

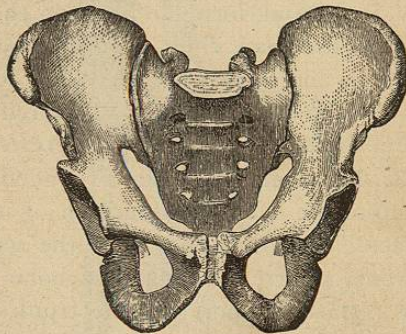


The spinal column.

called *metacarpal* bones. The fingers have fourteen slender bones called *phalanges*.

Two irregular and massive rings of bone form the *hip* bones. With the sacrum they form a ring called the *pelvis*. The body sits upon the lower part of each hip bone. The pelvis forms the bottom of the abdomen.

The bones of the leg have nearly the same plan and arrangement as those of the arm. The thigh has one long bone called the *femur*. In front of the knee is a flat bone



The pelvis.

called the *patella*. The shin is formed by one long bone called the *tibia*, upon the outside of which is a very slender bone called the *fibula*. The lower end of the fibula forms the outer ankle bone, while a projection from the tibia forms the inner ankle bone.

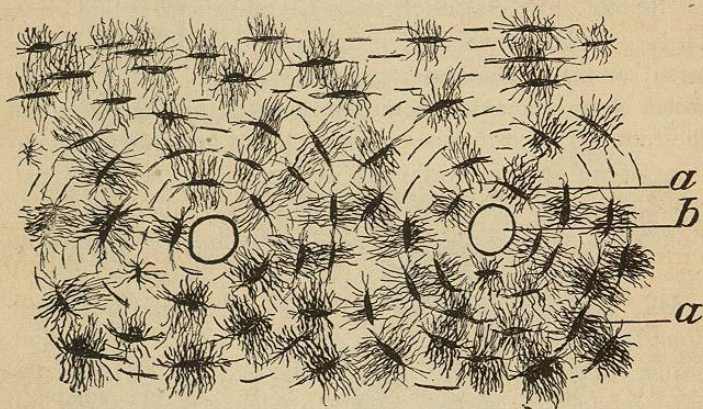
Seven rounded bones, called *tarsal* bones, form the instep of the foot. Five slender bones beyond them, called *metatarsal* bones, form the ball of the foot. The tarsal and metatarsal bones are bound together so as to form an arch which bears upon the ground only at the heel and ball of the foot. The arch is somewhat elastic and prevents jarring of the body in walking. It sometimes becomes flattened, producing the painful deformity called *flat foot*. Fourteen slender bones, called *phalanges*, form the toes.

644. Structure of bones. — Bones are dense and brittle upon the outside. All are covered with a very tough membrane, called the *periosteum*. In flat or rounded bones the hard outside surfaces are scarcely thicker than paper, and the two surfaces are connected together by a network of bone which looks like a honeycomb, and is called *cancellous* bone.

In long bones, the central shaft is composed of a thick shell of hard bone surrounding a cavity filled with fat; their ends consist of a thick shell of hard bone covering a large mass of cancellous bone.

A bone is about twice as strong as a piece of oak of the same size. It is elastic and can bend considerably without breaking. Any given weight of a substance is stronger when made into a hollow shaft, like a bicycle frame, than when formed into a solid rod of the same length. So the strength of a bone is still further increased by its being either hollow, as in the shaft of a long bone, or else braced with cancellous bone, as in a flat bone and the ends of a long bone.

645. Microscopic appearance. — Bone is composed of branching connective tissue cells and fibers, which are arranged in circles around minute tunnels called *Haversian canals*. Each Haversian canal contains arteries, veins, and nerves. Lime is mixed with the cells and canals like starch among the fibers of linen, and imparts to them their



Thin slice of bone ($\times 200$).

a bone cells. *b* Haversian canal, containing blood tubes and nerves.

hardness and rigidity. Lime forms about two thirds of the bone by weight.

646. The periosteum carries arteries and nerves which enter minute openings in the bone. During childhood, or when a bone is diseased, the cells of its inner layer are very active in reproducing themselves and in forming new bone. Bone stripped of its periosteum is apt to die, but when the bone dies the periosteum usually remains alive and soon reproduces new bone. The periosteum also affords an attachment for muscles.

647. Cartilage. — The bones of very young animals contain little or no lime, but are soft and pliable. In this

condition they are called *cartilage*. As age advances, lime is deposited among the cells, and they become hard and brittle, forming true bone. A layer of cartilage remains to cover the ends of most bones. Late in life it may take up lime and so become like bone.

648. Rickets. — Sometimes a child's bones contain too little lime; then under the influence of continual pressure of standing, the bones of the leg may gradually grow into a bowed shape. This disease is called *rickets*, and is due to too little nourishment. When fed on a sufficient amount of proper food, the bones soon grow rigid again, and as the child's legs grow longer, their curves become less noticeable.

649. Broken bones. — Bones are often broken. Then the cells are injured, and blood tubes and nerves are torn across. So there will be great pain and tenderness. When a bone is broken, its cells reproduce themselves and fill in the space with new connective tissue. In course of a few weeks, lime is deposited in the new tissue, and the union is complete. When a bone is broken, the surgeon pulls its ends in place and binds them to stiff splints until healing is complete.

If a bone is broken, the limb should be at once bound to a board or stick with handkerchiefs or strips of cloth. Take care not to tie the bands tightly enough to stop the flow of blood.

As a person grows older, more lime is deposited in his bones, and they become harder and more brittle. Then they are more likely to be broken and are less able to grow together again. Often a child's bone will bend until it breaks, but its ends still hold together like a broken green stick. In older people it snaps like a dry twig.

650. Diseases of bones. — Bruises or consumption or other causes of disease may produce inflammation and abscesses of the bone as in any other part of the body. Then the bone is very painful and tender and may die. Then the periosteum will form a new bone. If a large piece of bone dies, it wastes away more slowly than new bone is formed. All fourfooted animals have nearly the same bones arranged

in the same way as man. A bird's wing is bone for bone almost like a man's arm and hand. A turtle's shell is its ribs, while the bones of its limbs are like those of man.

SUMMARY

1. About 200 bones give the body form and strength.
2. The outside of all bone is a hard plate, while the inside is either a fine network of bone or else is hollow.
3. The hollow form of bone combines strength with lightness.
4. Bone is composed of living cells and fibers nourished by arteries and endowed with sensibility by nerves. Lime is mixed with the cells like starch with linen.
5. Bone is covered with a tough membrane called the *periosteum*, which carries the blood tubes and nerves to the bone, and forms new bone during the period of growth or when the bone is diseased.
6. Cells and fibers resembling those in bone, but containing no lime, form *cartilage*.

DEMONSTRATIONS

156. Show a complete skeleton of at least a small animal. Point out the different shapes of the bones and how they are adapted to their positions and work. Point out in the living body where the different bones can be felt.

157. Procure a fresh beef bone, and another similar one dried. Note the bright pink color of the fresh bone, and the white or brown color of the dried specimen. Notice that the periosteum can be stripped from the bone. Notice the soft cartilage which covers the ends of the bone.

158. Saw a long bone in two crosswise and then saw one half in two lengthwise. Notice the hollow cavity in the shaft of the bone and the fat or marrow which fills it. Notice the honeycombed appearance of the inside of the ends of the bone.

159. Procure a specimen of bone mounted for the microscope. Using a power of at least fifty diameters, notice the circles of bone cells

and the numerous fine branches of the cells. Notice the Haversian canal in the center of each circle. Examine also a specimen of cartilage.

160. Procure two slender bones which are exactly alike. Place one in a hot fire for a few hours. This will burn out the cells and fibers and leave only the lime. The bone is now very brittle and easily crumbles to pieces. Place the other in a bottle containing one part of muriatic acid and ten of water. After a week this acid will have removed the lime, leaving only the cells and fibers. The bone can now be twisted and bent like a piece of flesh.

161. Boil a leg bone of a half-grown animal until the flesh is removed. Notice that a disk of cartilage extends nearly through the shaft very near the ends. Possibly the end beyond it will come off. Explain that the cartilage forms new bone which increases the length of the shaft as long as the bone continues to grow.

REVIEW TOPICS

1. Show why bones are needed in the body.
2. Describe the bones of the skull; of the spine; of the ribs; of the arms; of the pelvis; and of the legs.
3. Describe the appearance of a bone when sawed in two both lengthwise and crosswise.
4. Show the advantage of having some of the bones hollow.
5. Describe the microscopic appearance of bone.
6. Give the uses of periosteum.
7. Describe cartilage.
8. Describe the changes which occur in bones with advancing age.
9. Describe rickets.
10. Describe the condition of a bone when broken, and tell how it is repaired, and how to care for a broken limb.
11. Show how a bone can become inflamed; and how dead bone is replaced.