we could make a section of the larynx containing the vocal shelves as they actually exist, and if by some mechanical measures we could reproduce their actual movements of adduction during tone production, and also at the same time set them into vibration by artificial means, we should then be able to get the primary tonal element of the voice. The vocal shelves hold the same relation to the organs of voice that the strings of a violin hold to the instrument itself. The tones that we hear from the violin are the result not alone of the vibrations of the strings, but of the effect that these vibrations make upon the whole instrument, and so the human voice is the result of vibrations originating at the vocal shelves and modified not only by the larynx itself, but, to some extent at least, by the entire organism. The human voice, therefore, is the result of various complex conditions. People differ, as do violins, both in their composition and in their structure, and as the tones of violins differ, so for the same reason, and to a greater extent, do voices differ one from the other. The simplest tone of the voice reaches the ear as one of the so-called vowel sounds, or as some modification of them. The vowel sounds, therefore, are the purely vocal elements of speech and song. The tone originating in the glottis immediately begins to take on the quality of one of the six physiological vowel sounds, or some combination of them, according to the adjustment of those portions of the respiratory tract which are situated above the glottis. Concerning the mechanism of the production of the vowel sounds there have been numerous theories. It has been generally conceded that the vowel sounds are the results of various combinations of the laryngeal with certain other so-called resonance tones. Helmholtz claimed that the vocal apparatus resembles the pipe organ, the vocal shelves corresponding to the reeds, and the pharyngeal and oral cavities to the pipes; and that, as the reeds of the organ vibrate in wholes for the fundamental tone, and halves, thirds, etc., for the harmonics (overtones), each of the various pipes of the organ selecting the particular harmonic to which its vibratory calibre corresponds, and thus determining the characteristic note of the organ, so the vocal shelves vibrate in wholes for the fundamental tone, in halves, thirds, etc., for the harmonics, and the pharyngeal and oral cavities, being flexible and capable of many variations in shape and size, adjust themselves to correspond to the particular overtone the combination of which with the fundamental tone is characteristic of the vowel sound to be produced.

Up to the present time this has been the theory accepted by the majority of writers and teachers of the subject, but there appear to be decided objections to it, and it does not accord with more recent investigations. Notwithstanding the great flexibility of the laryngeal, pharyngeal, and oral cavities it is probably impossible for them to be adjusted in size and shape to meet the requirements of Helmholtz's harmonic or overtone theory.

Antedating the theory of Helmholtz, and opposing it in some respects, is the theory of Willis. He claims that the resonance tones are independent of the laryngeal tones in respect to pitch. This theory was strengthened by the later experiments of Hermann and others, and it seems about to be verified by extensive investigations now being carried on by Prof. E. W. Scripture, of Yale University.

These investigations are being made with care and accuracy and they cannot fail to be of great scientific value. By means of complicated machinery, enlarged tracings of the curves of speech are taken from gramophone plates, and the character of the vowel sounds is computed by accurate measurements of these tracings. The result will probably change some of the hitherto accepted views concerning the elements of speech and clear up disputed points with reference to voice production. The tracings appear to show that the glottic tone is the result not of actual vibrations of the vocal shelves, but of a succession of respiratory puffs through the glottic chink, and that the resonance tones are the result of free, in contradistinction to forced, vibrations in the cavities above and below the glottis; or, in other words, that the resonance tones are the result of vibrations set up in these cavities by a more or less irregular succession of blows from the vocal shelves.

These investigations also show that the resonance tones are composed of a series of tones that may have a different pitch the one from the other, and that the pitch of the resonance tones does not necessarily change with that of the glottic tone, and therefore that the resonance tones cannot be overtones of the glottic tone, as is commonly supposed. They show, also, that the vowel sounds as they appear in good speech are of almost constantly varying pitch.

This analytical method of studying the curves of speech is only in its infancy, but it is so distinctly scientific in its nature as to warrant this brief description of it, and the interesting results thus far obtained. Whatever may be the truth with reference to these disputed points, we know that the vowel sounds are the result of the proper blending of the glottic with the resonance tones. The principal resonance chambers are the tracheal, upper laryngeal, pharyngeal, oral, and nasal cavities. With the exception of the tracheal and nasal cavities these resonance chambers are flexible and capable of numerous changes not only in their size and shape, but also in the muscular rigidity of their walls, and together they form what have been called the moulds of speech, each vowel sound having its individual resonance mould, which varies more or less continuously in respect both to its shape and its size and to the rigidity of its walls.

Vowels.—It is the manipulation of the mould that determines the character of each vowel sound and that distinguishes one vowel sound from another. The resonance mould may be shortened more than an inch, by the elevation of the larynx and the retraction of the lips. Several of its diameters may also be shortened by the contraction of the lateral walls of the larynx and pharynx, and by the various movements of the epiglottis, velum palati, tongue, lower jaw, and lips. Some of these parts have points of actual contact, thus dividing the mould into several smaller and more or less well-defined compartments with or without communicating passageways. Each compartment has its individual vibrations, and it is the various admixtures of the resultant tones combined with the glottic tone that produce the characteristic elements of speech.

For the sound of *EE* in feet, the mould is shortened by the elevation of the larynx and the retraction of the lips, and it is flattened and narrowed in the linguo-palatal region by the elevation of the tongue and its contact with the lateral molar teeth. Its diameters are also shortened in the region of the ventricular bands and the aryepiglottic folds.

The sound of *A* in ate, requires a somewhat longer mould and a larger labial and linguo-palatal aperture for the beginning of the sound, and for the ending of the sound it approximates the mould for the sound of *E*.

The sound of *Ah*, or *A*, in father, requires a still longer mould and a wider aperture in the labial and linguo-palatal regions.

The sound of *Aw*, as in awe, requires a still longer mould.

In the sound of *O* in old, the long diameter of the mould is considerably increased by lowering the larynx and protruding the lips. The linguo-palatal, pharyngeal, and laryngeal diameters are also considerably increased.

In the sound of *OO* in boot, the lips are somewhat farther protruded and the labial aperture diminished in size.

It will be observed that for the *six* physiological vowel sounds, named in their order as above, the resonance mould grows progressively longer beginning with *EE* as its shortest and ending with *OO* as its longest diameters.

It must be apparent that the above is merely a brief outline of some of the important adjustments of the vowel moulds, and that a precise description of them, for

even a single vowel, would be impossible, because they differ not only in different individuals, but in the same individual during different intellectual and emotional states of mind.

PHYSIOLOGICAL ALPHABET.

Consonants.

	Voiceless oral.	Voiced oral.	Voiced nasal.	
Labials	P Wh	B W	M	Paul Brown made white wax.
Labio-dentals	F	V	....	Full voice.
Linguo-dentals	Th′	Th″	....	Think thou.
Anterior linguo-palatals.	S Sh T	Z Zh D L R	.... N	Some zealous sheep leisurely took down nine large rails.
Posterior linguo-palatals.	K H	G Y	Ng	Can girls bring home yeast?

Vowels.		Coalescents.	
ā ā le ă ă t ä ä lms a̤ a̤ ll ȧ ȧ sk ē ē ve ĕ ĕ lk	ō ō ld ŏ ŏ n o͞o o͞o ze o͝o l o͝o k ĭ ĭ t ŭ ŭ p	ār f ār e är f är ēr h ēr e ĕr h ĕr	ōr f ōr e ŏr f ŏr o͞or p o͞or ŭr p ŭr r

Consonants.—There are twenty-three so-called consonant sounds in the English language, and they may be classified, as in the accompanying table, first, according to the particular parts of the resonance mould actively employed in their production (Fig. 3160), and secondly, according to the character of the sounds (see table). It has been observed that the sounds of the five consonants, *P, B, M, Wh,* and *W*, are made by the lips, and, therefore, they have been classified as labials, and that the sounds of *B, W,* and *M* are voiced sounds while those of *P* and *Wh* are voiceless or merely breath sounds. The sounds of *F* and *V* are made with the lower lip and upper teeth and are named labiodentals, the first one being a voiceless, and the second a voiced sound. The sound of *Th*, as in think, and *Th*, as in thou, are made with the tip of the tongue and the upper teeth, and are called linguo-dentals, the first one being voiceless, and the second voiced.

The sounds of *S, Z, Sh, Zh, T, D, N, L,* and *R* are made by the tongue and the anterior portion of the hard palate, and are called anterior linguo-palatals, the *S, Sh,* and *T* being voiceless, and the *Z, Zh, D, N, L,* and *R* being voiced.

The sounds of *K, G, Ng, H,* and *Y* are made by the dorsum of the tongue and the velum palati, and are called posterior linguo-palatals, the *K* and *H* being voiceless, and the *G, Ng,* and *Y* being voiced. In considering the elements of speech it must be borne in mind that the names of the letters of the alphabet do not always indicate the sounds of the letters. For instance, the letter *B* is composed of two elementary sounds, *B* and *E*; *G* is composed of three elementary sounds,—*D, Zh,* and *E*; and the letter *W* is composed of six elementary sounds,—*Dŭblyo͞o.* Hence it has been found necessary to construct an alphabet of sounds. This was done in 1827 by Dr. Neil Arnott, and his alphabet was modified, during the last decade, by Dr. John Wyllie, of Edinburgh, who gave it the name of physiological alphabet. It is reproduced here with some important additions and alterations. This revised physiological alphabet contains forty-four sounds, and it will be found useful as a standard for comparison in cases of marked defective speech.

Registers of the Voice.—The singing voice has a certain range of pitch that seems to be adapted to a fixed adjustment of the larynx, and in order to increase the range of pitch it is necessary to make a somewhat different adjustment. These changes are accomplished chiefly by the action of the extrinsic muscles, and in going from one adjustment to another it has seemed to be necessary to make a slight break in the voice. This fact has given rise to the so-called upper, lower, and middle registers of the voice, each register having its own particular adjustment of the larynx, and being separated by a more or less marked interruption of the tone, consequent upon the readjustment of the laryngeal mechanism. One great test of the excellence of a vocal method seems to be its power to enable the singer to make the readjustments for

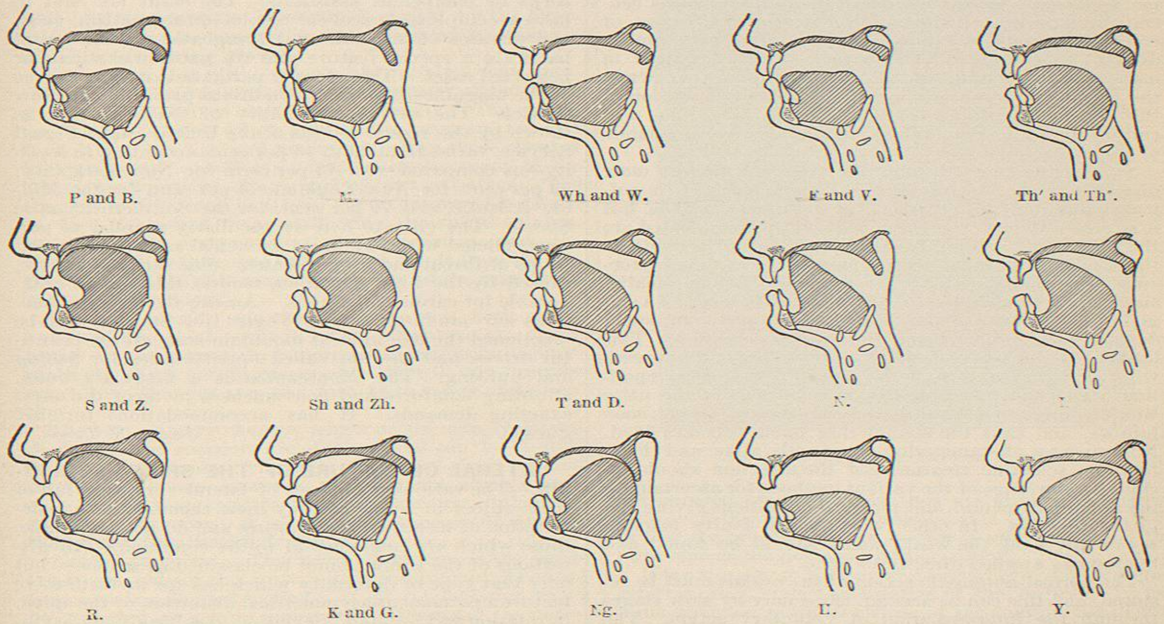

FIG. 3160.—Showing Approximately the Position of the Organs in the Articulation of the English Consonant Sounds.

the different registers with the least possible interruption. If these interruptions or breaks, as they are named, could be eliminated entirely there would be no necessity for the use of the term registers, and this is the position taken by many of the best vocalists and physiologists. It seems entirely within the bounds of reason to suppose that, in the thoroughly trained larynx, the various adjustments of its parts, complicated though they may be, would be accomplished with sufficient smoothness to enable the singer to go from the lowest to the highest pitch with no appreciable break, and that there would therefore be but one vocal register.

The Falsetto Voice.—The thin upper tones of the voice, containing no appreciable resonance from the chest or other large resonance chambers, have been named the falsetto or false voice, in contradistinction to the well-rounded voice resulting from a combination of the laryngeal with all the various resonance tones. The name for this quality of voice is unfortunate, because it has its place both in singing and in speaking, and it differs from the so-called true voice only in the fact that it contains fewer of the resonance tones.

Whispering.—Another quality of voice that must be considered is that of whispering. It is also the result of a combination of laryngeal with resonance vibrations. But the laryngeal tones arise from a free efflux of breath through a comparatively open glottis, and it is quite probable that the ventricular bands also take some part in this fricative sound. The laryngeal vibrations, however, are not of such a nature as to set up additional vibrations in all the resonance chambers. The whispering voice, therefore, is the result of fricative laryngeal vibrations re-enforced by imperfect resonance vibrations.

Defective Speech.—In the majority of cases the immediate cause of defective speech is a faulty construction of the moulds of speech. The remote causes are often more difficult to determine. In their origin they are either central or peripheral, and cases of long standing are both central and peripheral. A cleft palate, for instance, always results in defective speech, and the primary cause is peripheral, but the effort to adapt the faulty organs to the requirements of speech develops a defective action in the motor and auditory centres of the brain which marks the case as coming under the head of both a central and a peripheral affection. The central affection, of course, is purely functional, but it is often exceedingly difficult to eradicate. The patient must be taught to make correct moulds, and it has been found that, when the peripheral organs are intact, a frequent repetition of this process, continued for a sufficiently long time, will correct the faulty cerebral action and improve the habits of speech.

Stammering.—A somewhat less frequent, though more distressing, affection of speech is stammering. Its primary cause may also exist in the peripheral organs, but it is more often of cerebral origin. So complicated are the nervous processes of speech that the only wonder is that the disorder is not more common. The motor processes of normal speech are for the most part automatic, and a slight weakening, for any reason whatever, of a single muscle or nerve, even for an instant, may completely destroy for the time being the automatic action. This leads to a confusion of mind more or less pronounced, which in turn makes extremely possible a speedy repetition of the faulty action, the consciousness of the utter lack of power to control the mechanisms of speech soon follows, and thus the stammering habit becomes fixed. No two cases of stammering are exactly alike, and therefore the scientific treatment of the affection should include a knowledge of the various methods for ascertaining the abnormal mental and physical conditions giving rise to the affection. In other words, as in faulty machinery of any kind, the weak points should be found and the remedy applied directly to them.

The normal automatic action of the organs must be restored, and this can be accomplished only by slow stages through the intermediation of voluntary action. The patient must first learn to recognize, through the auditory and perceptive centres of the brain, the nature of normal speech, and then he must learn to recognize the sensations attendant upon the motor processes of speech.

G. Hudson Makuen.

LAS CRUCES. See *New Mexico.*

LAS VEGAS HOT SPRINGS.—San Miguel County, New Mexico.

POST-OFFICE.—Las Vegas Hot Springs. Hotel.

ACCESS.—Viâ Atchison, Topeka and Sante Fé Railroad to Las Vegas, thence by branch line six miles to springs. Through Pullman sleeping-cars pass Las Vegas twice a day in both directions. These springs are situated upon the southeastern slope of the Santa Fé range of the Rocky Mountains at an altitude of 6,767 feet above the sea-level. They are about forty in number, and vary in temperature from ice-cold to very hot, the thermal springs ranging from 110° F. to 140° F. The following analysis of the waters of the largest of the latter, flowing 1,250 gallons per hour, was made by Dr. Walter L. Haines, professor of chemistry at Rush Medical College, Chicago:

SPRING NO. 6 (LAS VEGAS HOT SPRINGS).

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	0.89
Magnesium carbonate	.15
Sodium carbonate	8.38
Potassium carbonate	.28
Sodium sulphate	3.35
Sodium chloride	14.68
Silica	3.50
Alumina	.10
Volatile and organic matter	.32
Lithium carbonate	Traces.
Sodium bromide	Traces.
Total	31.65

In its chemical composition this water resembles in many respects that of the famous hot springs of Toeplitz, in Austria. The water is conducted to a commodious bath house, where, under supervision of the resident physician, all varieties of baths are administered by a corps of competent assistants. The baths are said to have accomplished excellent results in rheumatism, gout, and diseases of the skin and lymphatic system. Mud baths are a special feature and are used in obstinate or neglected cases. This vicinity partakes in a large degree of the magnificent climatic conditions prevailing in New Mexico. The average humidity of New Mexico, as shown by the recent reports of the United States Signal Service, varies from 29 to 43 per cent. according to locality—as compared with 72 per cent. for New York City, 73 per cent. for New England, 74 per cent. for the Middle Atlantic, and 79 per cent. for the Southern Atlantic States. The climate here is peculiarly adapted to persons afflicted with hay fever, bronchial asthma, and most forms of throat and lung diseases. The rarity of the air, caused by the high elevation, renders this region unfavorable for cardiac affections. Among the many attractions surrounding the Las Vegas Hot Springs may be mentioned the magnificent mountain scenery, the beautiful drives, and the unrivalled opportunities for fishing and hunting. The Montezuma is a first-class hotel, affording comforts and conveniences to meet the most exacting demands. It has accommodations for 250 guests.

James K. Crook.

LATERAL CURVATURE OF THE SPINE; SCOLIOSIS.—The various definitions of lateral curvature fail of their object in so far as they limit themselves to a description of its superficial features and do not emphasize those which are fundamental to the condition. All distortions of the trunk cannot be classified as scoliosis, but only that type of deformity which has for its distinctive feature a permanent asymmetrical distortion of the spine, in rotation and in lateral deviation, resulting in an asymmetry of the two lateral halves of the trunk. Lateral

curvature may therefore be defined as a permanent asymmetrical distortion of the trunk in which the spine plays the fundamental part.

In its initial stages the deformity differs from the various normal positions of the figure only in the origin of these positions and in the permanency of any given one of them. In the more advanced stages the distortions become more pronounced in character, and their perma-

FIG. 3161.—Experiment Showing Lateral Bending.

nency or resistance to correction is caused by the alterations in structure consequent upon the adaptive changes which occur during growth.

The movements of the spine which are in a pure antero-posterior plane do not produce asymmetry of the figure since the two halves move symmetrically. The movements of the spine which result in asymmetry proceed from lateral bending and torsion, effecting those changes in figure which would come from a displacement of the symmetrical position of any part of the two halves. The changes which occur in lateral curvature may be classed as, first, the spinal or those affecting the spinal column, which may be designated as primary, and, second, the figure contour changes or those which result from the displacement of the spine, and which, therefore, may be regarded as secondary.

We have already said that these changes, both spinal and contour, which occur in lateral curvature, are, in the initial stages, normal in range and direction but abnormal as to origin and permanency. We will now describe what these changes are; and first, as to range and direction.

The two primary changes which occur, namely, lateral deviation and rotation, are distinct and can be studied separately, although clinically they are always found associated. Since, however, they are not always associated in the same relative degree (whence result the various types of curves), it is better for clearness of description to consider them independently.

Lateral Deviation.—The lateral deviation is the bending to one side of the spine, either throughout its entire length or in a limited section. If lateral deviation could be regarded as a pure movement, all parts of the vertebræ would be carried equally to the side, so that a line drawn through the centre of any of the vertebræ would be in the direct antero-posterior plane of the body. This lateral deviation may affect any portion of the spine and to any degree, or it may affect two different portions of the spine each in a different degree and in a different direction. It resembles lateral bending in that it is a movement in the lateral plane; but differs in that it is a bending of a portion of the spine on itself without necessary displacement of either extremity, whereas lateral bending is a bending of the spine to one side on the pelvis, away from the median plane of the body.

Rotation.—Rotation is a turning on the vertical axis of all the vertebræ participating in the curve; the amount of displacement for each vertebra being different, and being greatest at the middle of the curve. The axis of rotation is in about the posterior third of the vertebra, the movement of the anterior part of the vertebra being in the opposite direction from that of the posterior. The length of the anterior portion in front of the axis of rotation being greater than the posterior, the amount of deviation from the normal of the bodies is necessarily greater than that of the spinous processes. The rotation of the spine necessarily involves those parts of the skeleton which are attached to it, as the ribs, and the result may be seen in the shape of the thorax. If rotation occurred as a distinct movement, the axis of its rotation would then remain in the centre of the trunk, the bodies would describe a curve upon one side and the spinous processes a curve of a smaller arc on the other. This rotation, like the lateral deviation, may affect the whole of the spinal column, or only a portion, or two sections in different directions.

Although these two distortions, rotation and lateral deviation, may be studied independently, it must be

FIG. 3162.—Experiment Showing Rotation.

remembered that clinically they are always associated. Moreover, they are always associated in the same relation, in that the rotation of the bodies is always toward the same side as the deviation of the column.

It is necessary to remember, in relation to deviation and rotation, that, since the rotation of the bodies is in the same direction as the deviation of the column, the degree of divergence of the body of any vertebra from the