OPINIONS OF THE PRESS

ON THE AUTHOR'S TREATISE ON

VOCAL PHYSIOLOGY AND HYGIENE

Of which the present Work is an Abridgment.

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THE SCIENCE

OF

VOICE PRODUCTION

AND

VOICE PRESERVATION

FOR the USE of SPEAKERS and SINGERS

BY

GORDON HOLMES

PHYSICIAN TO THE MUNICIPAL THROAT AND EAR INFIRMARY
FORMERLY CHEF-DE-CLINIQUE AT THE HOSPITAL
FOR DISEASES OF THE THROAT, ETC.

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τοῦ καὶ ἀπὸ γλώσσης μέλιτος γλυκίων ῥέεν αὐδή

'Voice sweeter than honey flowed from his tongue'

Iliad, i. 249

PREFACE.

THE OBJECT of this work is to furnish persons who make an artistic or professional use of the vocal organs, with a concise account of those relations of the voice to physical and medical science which are only cursorily alluded to, or passed over altogether, in treatises on elocution and singing. It is an abridgment of my 'Treatise on Vocal Physiology and Hygiene' for the use of those who do not require to study the subject in all its technical and theoretical bearings.

G. H.

27*a*, FINSBURY SQUARE, E.C.
February, 1880.

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CHAPTER I.

SOUND AND VOICE.

TRANSMISSION OF SOUND—VIBRATION—SYMPATHETIC RESONANCE—QUALITIES OF SOUND AS DISTINGUISHED BY THE EAR—SOUNDS GENERATED IN TUBES OR PIPES—REED INSTRUMENTS.

Definition of Sound.—Sound, in our apprehension, is that which is heard, and therefore our only means of recognizing its existence is through the sensation it produces on our ear. Various nerves have various faculties of appreciating external influences, as exemplified by sight, touch, &c., but the auditory nerve alone can perceive sound.

Transmission of Sound.

The physical source of sound is impulse or shock of some material substance. But unless something intervenes between our ear and the sounding body nothing can be heard. Sound, therefore, cannot travel in empty space. To illustrate this fact a bell may be placed under the exhausted receiver of an air-pump, viz., in a vacuum. On striking the clapper against the sides no sound is audible. For the same reason, sound produced in rarefied air is greatly diminished in intensity. As we ascend from the surface of the earth, the atmosphere becomes gradually thinner and lighter. On the top of high mountains, such as Mont Blanc, the air is so attenuated, that a pistol-shot sounds like a mere cracker,[1] and the voice also is much weakened. Were it not for the deep silence that usually reigns over such localities, from an absence of all the activities of nature and the bustle of animal life, persons could only hear each other speak at very short distances. But the most striking proof that the voice requires air of a certain density for its normal production may be furnished by inhaling hydrogen. If we empty our chest of air and refill it with this, the lightest of all gases, our voice-power will be found to have almost vanished, and with considerable exertion we can only succeed in producing hollow, faint, and muffled tones.

The rapidity with which sound travels varies according to the medium through which it passes. In air it moves at the rate of about 1,090 feet per second, but in water it travels four times, in pine wood ten times, and in iron seventeen times as fast.

[1] Tyndall, *Lectures on Sound*, 1869, p. 8.

Sound-Waves.

The mode in which sound propagates itself from one point to another is one of the most interesting questions in acoustics. Sir Isaac Newton first suggested that it moves by exciting undulations or waves in the substance which carries it, and this theory is still upheld and believed to be correct. In order to understand this explanation it is necessary to know exactly what waves are. For this purpose we have only to watch the surface of a sheet of water when the wind is blowing. Every one is familiar with the appearance of the waves as they roll along, of greater or lesser size, according to the force of the breeze. If a wave comes to a chip of wood, a cork, or a boat, they rise up one side of the wave to its crest and glide down the other side, but when the wave has passed they remain in the same place as before. This shows us that waves do not consist of ridges of water that roll over the water beneath as a ball rolls along the ground, but truly of a motion transmitted through the water from one particle to another. To illustrate this point in a most palpable manner we have only to take one end of a long piece of string, attached to something at the other end, and, holding it loosely, shake it so as to produce a kind of serpentine or wavy motion. Here we can see waves running along the string, backwards and forwards, whilst the ends always remain at the same distance from each other. The water in waves performs, therefore, only an upward movement, and has no onward motion whatever.

The surface of water may be agitated not only by ranks of waves all proceeding in the same direction one after the other, but also by many series of waves, moving at the same time all in different ways, and crossing each other at angles of every degree in a manner too complex for description. In order to observe this, let us select a piece of still water and throw a stone into it. We see a system of small waves, a ripple, in fact, produced around the spot, which spreads out in an ever widening circle until it is lost to sight or dies out. Let us now throw in several stones near each other. Immediately numerous circular systems are created which meet each other and cross at many points, dividing the surface of the water into a multiplicity of squares, triangles, and diamond-shapes, to an extent too complicated for the eye to follow.

Precisely similar to what takes place in the water is the state of the air when disturbed by sound-waves, either single or many, propagated from various points. Whenever anything is sounded in air it acts like a stone thrown into water, and creates a circular system of waves which spread rapidly in all directions. But as the sound-wave moves on all sides at the same time, it must be considered as a spherical layer of condensed air, continually enlarging and becoming gradually less condensed until lost. When a series of sound-waves are spreading around, the intervals between each are formed of spherical layers of rarefied air. A soap-bubble blown till it bursts would picture the progress of a single wave to the eye.

In the following passage Professor Helmholtz[1] draws a beautiful parallel between the motions of sea-waves and of waves of sound as impelled through the atmosphere :—' It is seldom possible to survey a large surface of water from a high point of sight, without perceiving a great multitude of different systems of waves, mutually overtopping and crossing each other. This is best seen on the surface of the sea, viewed from a lofty cliff when there is a lull after a stiff breeze. We first see the great waves advancing in far-stretching ranks from the blue distance, here and there more clearly marked out by their white foaming crests, and following each other at regular intervals towards the shore. From the shore they rebound in different directions according to its sinuosities, and cut obliquely across the advancing waves. A passing steamboat forms its own wedge-shaped wake of waves, or a bird darting on a fish excites a small circular system. The eye of the spectator is easily able to pursue each one of these different trains of waves, great and small, wide and narrow, straight and curved, and observe how each passes over the surface as undisturbedly as if the water over which it flits were not agitated at the same time by other motions and other forces. I must own that whenever I attentively observe this spectacle it awakens in me a peculiar kind of intellectual pleasure, because it bares to the bodily eye what the mind's eye grasps only by the help of a long

[1] *Die Lehre der Tonempfindungen als physiologische Grundlage für eine Theorie der Musik*, or *The Sensations of Tone as a Physiological Basis for a Theory of Music;* translation by A. J. Ellis, p. 40.

series of complicated conclusions for the waves of the invisible atmospheric ocean.'

'We have to imagine a perfectly similar spectacle proceeding in the interior of a ball-room, for instance. Here we have a number of musical instruments in action, speaking men and women, rustling garments, gliding feet, clinking glasses, and so on. All these causes give rise to systems of waves which dart through the mass of air in the room, are reflected from its walls, return, strike the opposite wall, are again reflected, and so on till they die out. We have to imagine that from the mouths of the men, and the deeper musical instruments, there proceed waves of from eight to twelve feet in length, from the lips of the women waves of two to four feet in length, from the rustling of the dresses a fine small crumple of wave, and so on; in short, a tumbled entanglement of the most different kinds of motion, complicated beyond conception.'

The Echo.—Having grasped the fact that sound consists of waves of air travelling past us, it may naturally occur to us that if by any means those same waves could be made to return towards our ear, we should hear the sound over again without its being produced a second time. This is just the point that is illustrated by the well-known phenomenon of the echo. If we stand opposite the face of a tall cliff and speak with sufficient loudness, the waves from our voice will rebound from the rock and come back to us, as if it were repeating the words we said. The only things to be considered, in order to ensure the production of the echo, are (1) that if we stand too near the rock the echo comes back so fast as to blend into one with our voice, and (2) that if the face of the cliff does not look straight towards us the sound may be reflected in some other direction, just as a ball thrown against an uneven wall does not come back to us, but hops off obliquely some other way.

VIBRATION.

Sounding bodies are in a state of motion termed vibration. If we move a finger from side to side it is vibration, but unless the vibrations are executed with a certain degree of force the waves of air produced do not reach, or do not strike with sufficient impulse on our ear, and no sound is audible.

Vibrations may be *simple* or *compound*. A body performs simple vibrations when it moves regularly from side to side like a pendulum. Hence simple vibrations are also called pendulum vibrations. But a vibrating body may execute several eccentric motions simultaneously, as does the string of a piano when struck, and in this way compound vibrations arise. Thus, a string if stretched horizontally may vibrate not only up and down, but also from side to side, diagonally, and in segments at the same time. Those points or *nodes*, as they are called, at which a vibrating string divides into segments remain at rest, as can be proved by experiment. Vibrational forms can be demonstrated very clearly by observing the motions of heavy and light dust, such as sand and lycopodium, when sprinkled over the surface of a plate of metal or glass fixed by one end horizontally and thrown into vibration by drawing a violin-bow along its edge at different points.

Even air itself, in a body partially confined by a cavity or in a stream impelled forcibly onwards, may be thrown into vibration and generate sound-waves in the circumambient atmosphere. Many wind instruments exemplify this fact.

Sympathetic Resonance.

The power of exciting sympathetic resonance is a property of sounding bodies, and at first sight might seem identical with the echo. For example, if we lift the dampers from the strings of a piano by means of a pedal and sound rather strongly a certain note with the voice or an instrument, we shall hear the corresponding string vibrating audibly in the piano after we cease. Or one key may be pressed down gently, so as merely to lift the damper from the string, when by singing the corresponding note we can provoke its repetition from the instrument. It is to be observed that no string can be excited in this way unless we sound exactly its own note. As a further illustration we may take a tuning-fork, and, having struck it, hold it to the mouth of a wide-mouthed bottle. If the cavity of the bottle is of such a size as to give a note in unison with the tuning-fork, a distinct tone is heard. If we take a rather large bottle it can be tuned to the proper pitch by pouring in water gradually, and testing it at each step with the tuning-fork. Or a sounding tuning-fork will even excite a quiescent one of the same pitch.

In order to understand sympathetic resonance we must suppose that each sound-wave moves slightly anything against which it impinges in its course. If a file of waves meets anything, such as a string or a body of air, which can vibrate so as to produce waves precisely similar to those that strike it, each successive wave increases the impulse of its predecessor, till a fresh sound is given forth. Thus the body on being struck moves at first forwards, then backwards beyond its original position, then again forwards, but to a lesser extent than at first, and so on until the motion is lost. But if a succession of even slight impulses arrive with such regularity that each one moves the body forwards as it is starting itself in that direction from having retained some of the preceding impulse, the result is an accumulation of force which drives the body to take considerable excursions. We can see this kind of progressive motion if we set a pendulum swinging from our hand by a number of slight jerks properly timed. Helmholtz[1] illustrates sympathetic resonance by the manner in which a heavy church bell may be rung by a boy who pulls at the rope attached to it periodically in such a way as to increase the effect of each preceding pull.

The quality of the various tones of the voice has important connections with the sympathetic resonance of the cavities of the mouth, nose, &c., which will be discussed in another chapter.

[1] Op. cit. p. 57.

Qualities of Sound as Distinguished by the Ear.

Our ear readily enables us to divide sounds roughly into two great classes, viz., into *music* and *noise.* A musical sound strikes us as being even, smooth, and melodious, like the tones of all musical instruments; but a mere noise has the opposite characteristics, viz., irregularity, harshness, grating on our senses, such as the rattle of carriages in the street, the confused din of a crowd of people talking or shouting, the rushing of wind, &c.

Furthermore we can distinguish sounds from each other by three striking qualities, which are especially observable in musical tones. They are :—

1. Pitch, or relative height;
2. Force, or intensity;
3. Timbre.

The first two qualities are sufficiently indicated by their names; but by *timbre,* it may be explained, is meant the peculiar distinctiveness between tones, even if of the same pitch, when produced by different instruments, such as the voice, violin, clarionet, &c.

The difference between these various kinds of sound has been very clearly explained by acoustic researches. Scientifically sounds are separated into *simple* and *compound.*

In a *simple sound* we have a single atmospheric wave or a number of single waves following each other in a given direction. A single sound-wave strikes the ear as a short sound, such as the crack of a whip; a file of waves is heard as a continuous sound, such as a musical tone.

Regularity of wave-formation is the characteristic of musical sounds; irregularity, that of noise. Simple sounds will generally strike the ear as musical, because their waves must be regular, but not if they are so low in pitch as to be a mere drone, like the deepest organ-pipes; or so high as to be painfully shrill; or too sudden and powerful, like the report of a gun.

Simple sounds are not very easy to produce, and are seldom heard in nature. As nearly approaching such may be instanced the chirp of the grasshopper, whistling with the mouth, the sounds of tuning-forks, flue organ-pipes, flutes, &c.

In *compound sounds* a number of waves, each formed by the coalescence of two or more sound-waves having different qualities, are in motion. Compound sounds are musical if their waves proceed together with regularity of relation, whence harmony; but if they disturb each other, giving rise to confused and unperiodic wave-motions, a discord, sometimes amounting to mere noise, is produced, as may be illustrated by striking together a number of adjacent notes on the piano. Different sets of sound-waves may even interfere with each other to such an extent that the result is silence. Thus two simultaneous sounds may so nullify one another that nothing is heard.

It is a peculiarity of our ear, however, as pointed out by G. S. Ohm, to resolve compound sounds into their simple constituents, and to hear them all separately though in the same period of time. Within the ear is a peculiar arrangement, called Corti's organ, which consists of a number of microscopical rods (about 3,000), each of which is tuned, as it is surmised, to vibrate responsively to a certain note and to none other. By their means we are enabled, after a little practice in directing our attention to the matter, to recognise the several component notes of any chord that may be sounded.

Pitch and Intensity—The Siren.

In order to study sound and understand its physical properties we must have recourse to certain acoustic instruments, one of the most important of which is called the *siren*. The simplest form of siren is that known as Seebeck's, and consists merely of a thin disc of wood or metal with a circular series of equidistant holes pierced around it near the edge. In order to use it, it must be arranged so that it can be made to revolve rapidly, and at the same time a small bellows must be fixed so as to blow through each of the holes successively according as the disc rotates. When it goes slowly we hear a number of consecutive puffs or pulses of air, which may be considered as separate sound-waves, but as soon as a certain speed is reached they become fused together and a continuous musical note is heard. The great value of the siren consists in its enabling us to explain the most signal of all the qualities of sound, without which music would not exist, at least according to our present acceptance of the term, viz., varying pitch, or the difference between comparatively low or high notes. In experimenting with the siren we perceive that the puffs do not appear to form a continuous sound until they succeed each other with a certain rapidity, which theoretically should be about sixteen puffs in every second. We also observe the interesting fact that, according as we make the disc revolve faster and faster, the sound rises gradually from a very low note to a pitch higher and higher, until, if the mechanical arrangements are sufficiently perfect, we can produce notes high up in the musical scale.[1] This teaches us that the pitch of a note depends on the rapidity with which the sound-waves, or vibrations, follow each other, viz., on the number of waves produced by the sounding body per second. Thus, if our siren has sixteen holes in its circumference, and we make it revolve at the rate of once in a second, we have sixteen sound-waves produced in each second, viz., one for each hole. The sound which proceeds from this rate of wave-formation corresponds to a very low note, such as would proceed from a 32-foot open organ-pipe, and one octave below the lowest *,,C*[2] on our pianos.[3] In order to make our

[1] The siren can produce about three octaves of good notes, viz., from *A*  to *a''* .

[2]  The letter notation used throughout the work will be understood on referring to the table at p. 57.

[3] The pitch, however, of the notes on pianos varies a little in different countries, and also according to the maker of the instrument. The London Philharmonic concert-pitch gives 455·2 vibrations (sound-waves) per second for *a'* in the second space of the treble clef.

siren sound the octave above the note produced by one revolution we must make it perform two revolutions per second; for the next octave higher, four revolutions; for the next, eight, and so on. The octave of any given note contains therefore exactly twice the number of sound-waves (vibrations), so that in the present case the series would run as 16, 32, 64, 128, &c. The lowest octave or two are, however, hardly distinguishable by the ear as musical sounds, as may be proved by striking the deepest notes of the piano, or listening to those of the organ, which has some deeper still. There is also a boundary to the audibility of sound in the opposite direction, and very high notes cannot be heard, or at least cannot be produced beyond a certain limit. The extent of our sense of hearing seems, however, to be more difficult to define in the upper extreme of the scale than in the lower. Thus Despretz produced and heard the d''''''', three octaves above the highest d'''' on our pianos, having 38,076 vibrations in the second, by exciting small tuning-forks with a violin-bow. The range of notes audible as musical sounds comprises about ten or eleven octaves, but varies more or less in different persons, according to the delicacy of their ear.

In order to find out the precise number of vibrations in any note of the scale, sirens of more or less complexity, such as those of Cagniard de la Tour, Dove, Helmholtz, &c., have been constructed, in which, by means of clockwork, the revolutions are registered on a graduated dial with hands.

The nature of varying *intensity* of sound can also be demonstrated by the aid of the siren, so as to render intelligible the difference between loud and weak sounds. Thus, according as the instrument rotates, we can make the note louder by blowing harder; but no amount of hard blowing will raise the pitch, unless the wheel revolves with greater speed, so as to produce more sound-waves in the same time. Hence we must infer that loudness of sound depends on the height of the sound-waves; not on their length, because that depends on the rapidity with which they follow each other, but on the distance of the crests of the waves from the bottom of the trough between each one. Loud sounds, therefore, consist of very tall waves with pointed crests and deep furrows between them, but weak sounds are formed only by low air-waves, which have no crests, and pass along like mere undulations or curves on the surface of water.

In order to calculate the *length of wave* proceeding from any given note, we have only to divide the rate at which sound travels in air, 1,090 feet per second, by the vibrational number of the note. Thus, if we take the middle c' on the piano, with 264 vibrations in each second, we obtain 4 feet $1\frac{1}{2}$ inches as the length of its wave. Because the first wave given off by the note must be at the distance of 1,090 feet at the moment the 264th is generated, and the line of intervening waves will therefore divide the distance into 264 equal parts.

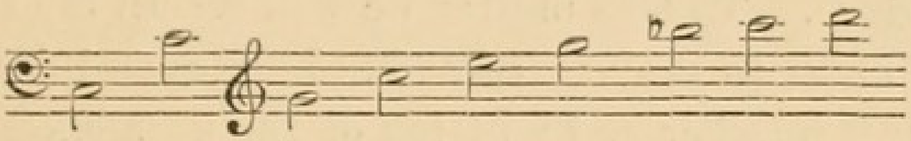
Further on we shall see that the manner in which the siren when revolving throws the current of air into vibration is similar in principle to what takes place in our own throats every time we speak or sing. Thus, as we drive the air out of our lungs, the mechanism of our vocal organs enables us to divide the stream into a series of puffs, with a variable and almost inconceivable rapidity according to the note produced.

Timbre[1]*—Upper Partial Tones.*

The next point we have to consider is the nature of timbre, and this leads us to a further study of compound tones. Formerly it was thought that the peculiarity of the sounds emitted by various instruments was due entirely to distinctive shapes of their vibrations. But Helmholtz has lately proved that a particular timbre is not rigidly productive of a single form of vibration, but that this quality of sounds is essentially dependent on the measure of certain supplementary tones which are heard in conjunction with the fundamental tone on almost all instruments. The fact, to which allusion has already been made, has long been known, that strings in vibrating do not only swing as a whole, but have also several secondary motions, each of which produces a sound proper to itself. A string, when struck, vibrates first in its entire length; secondly, in two segments; thirdly, in three; fourthly, in four; and so on. All of these motions are simultaneous, and the sounds proceeding from them are blended into one note. The lowest note is the loudest, and is called the fundamental or

[1] The Germans call a compound tone a *Klang*, and timbre *Klangfarbe* (tone-colour), which Professor Tyndall has anglicised by *clangtint*. Mr. Ellis, in translating Helmholtz, prefers the expression *quality of tone*. A third writer suggests *acoustic colour* (*Encyclopædia Britannica*, art. *Acoustics*). I have used the French *timbre*, as it is so commonly employed and so well understood in this country.

prime tone, and the others are called overtones, upper partial tones, or harmonics. These overtones invariably bear certain definite relations to the lowest note of the string, and constitute an ascending series which contains twice, three times, four times, five times, etc., as many vibrations as the fundamental tone. They are therefore separated by a constantly decreasing interval from the lowest to the highest. The relative succession of the first eight overtones of a string, taking *c* as the prime tone, is exemplified by the following scale:—



The first upper partial is the octave, containing twice as many vibrations as the fundamental tone, the second, the twelfth, containing three times as many; the third, the second octave, with four times the number, and so on; in some cases as high as the fifteenth or twentieth remove, where they do not lie as much as a semitone apart. From this fact, it at once appears that the higher overtones of a string must give rise to a discord, and thus render the timbre disagreeable. They can, however, be got rid of by striking the string in a certain point, which prevents their formation.

As with the notes of strings, so with the tones of almost all instruments. Harmonics are present, but by no means in the same number or position in the series in all cases. Thus one instrument may be particularly rich in the higher overtones, another in the lower ones, whilst a third may select, as it were, a proportion of both, omitting those intervening. In every instance, however, they must bear the direct relation to the fundamental tone of having twice, three, or four times, etc., as many vibrations. On the number of harmonics present and their intensity, according to Helmholtz, depends the proper timbre of any instrument by which we can recognise it from others of a different class. The voice especially is very rich in overtones, and not only possesses a complete series as high as the seventeenth or twentieth, but has probably the power of varying them according to the quality of tone it is desired to produce. To this matter we will return later on.

In order to analyse compound tones and determine the exact number and position of the harmonics proper to any particular timbre, Helmholtz has taken advantage of sympathetic resonance. He has had constructed a series of glass globes to act as resonators, each with a rather wide mouth on one side, and on the opposite drawn into a short perforated tube which fits the entrance of the ear. Each globe in the series is tuned to a certain simple tone, and resounds sympathetically to that and no other. Whenever the proper tone of any one is sounded, it can, if placed to the ear, be heard to sing into it very distinctly. Thus a delicate means is furnished of ascertaining the presence or absence of simple sounds of any particular pitch in complex combinations of tones. Even amidst the numerous and confused noises of the streets, Helmholtz relates, the proper tones of these resonators may often be heard cropping up.

Reed Instruments.

The production of musical sounds by means of vibrating reeds claims our attention, as instruments of this class bear the nearest analogy to the voice. The reed always covers an aperture which, in vibrating under pressure of air, it alternately closes and leaves partially open for the passage of the current, on a principle identical with that of the siren.

Reeds produce tones, therefore, by dividing the air into a series of puffs, the rapidity of which determines the pitch. Their notes are powerful and highly composite, having distinctly recognisable overtones as high as the nineteenth or twentieth of the series.

Reeds are divided into *striking* and *free* reeds.[1] The former, whilst vibrating, strike the margin of the opening at each excursion, the latter fit the aperture so as exactly to close it without touching the edges.

Reeds may further be separated into two classes, according as they are used with tubes, as in reed organ-pipes, the clarionet, etc.; or as they act only in conjunction with their aperture, that is, like the tongues of harmoniums, concertinas, etc.

Tube reeds, in material, are generally *woody* or *membranous*.

[1] A *reed* is, of course, a kind of tubular grass, and the reed of an organ-pipe is, in fact, a small semi-cylinder against the open side of which the vibrating tongue is fitted. But the latter is the essential part of all reed instruments, and therefore the vibrating lamina, which is the actual agent in producing the sound, has come to be termed a reed.

Woody reeds are used either singly or doubly. The clarionet will serve as an example of a tube-instrument with a single woody reed, which belongs to the class of striking reeds, though arranged so as not actually to strike. The tube of a medium-sized clarionet (C) is about twenty inches long, producing for its fundamental tone *e*,[1] with a wave four times its own length, and following, therefore, the law of stopped pipes. The column of air in this tube overpowers the reed and forces it to vibrate sympathetically with it. The reed does not, therefore, emit its proper tone, but merely serves to make the tube speak by its power of rendering the stream of air intermittent. A scale is formed by shortening the tube (by opening side-holes), the amount of shortening required to raise any given note a musical tone being more than an inch. For a compass of an octave, therefore, a shortening of nine or ten inches is necessary. At the same time the reed must also be shortened by pressure with the lips. The timbre of this instrument somewhat resembles that of the soprano voice, probably on account of its nasal character.

The hautboy or oboë is blown by means of double woody reeds, fixed so that the air rushes through a chink alternately opened and closed by their approximated extremities when vibrating. In the production of notes instruments of this class follow the law of open pipes. The fundamental note of the hautboy is, therefore, an octave above that of a clarionet with the same length of pipe.

1 

As *membranous reeds* we have the human lips in sounding brass instruments, such as the horn, trombone, etc. The lips, placed in apposition against the mouthpiece of the tube, generate sound very much like the mechanism by which voice is produced, but their vibrations are commanded by those of the tube. Being thus blown with double reeds, brass instruments follow the acoustic law of open pipes, and produce sound-waves of twice the length of their tube. They have usually very long tubes, for reasons connected with the progression of the harmonic series; and in order to vary the pitch of any note by a musical tone, an alteration in the length of the tube of two or three inches or even more is required, according to the size of the instrument.

The brass springs or reeds of harmoniums and similar instruments have no tube, and render, therefore, the notes proper to their own vibrational number. Each reed is fixed at its aperture, and no alteration in their rate of vibration can be effected. A separate reed is consequently required for each note of the scale. The differences of pitch are obtained by using springs of varying length, breadth, and thickness. In a harmonium of a compass of five octaves the lowest note is produced by a tongue about $3\frac{1}{2}$ inches long, the highest by one of half an inch. In the lowest notes the varying dimensions of the successive reeds are most apparent, but in the highest octave the difference in size of adjacent springs is barely appreciable by the eye. The power and timbre of the tones are well known.

In the organ separate reeds are also used for each note; but a tube of fixed length, which sounds in unison with the reed, is added in order to render the tone more powerful.

In studying the production of musical scales by reeds we observe that, when tubes are superadded, the vibrations of the reeds can only be commanded by pipes of considerable length, which require very manifest shortenings to raise their pitch, following, in fact, the natural acoustic laws as determined for vibrations in tubes. On the other hand we see that if reeds are used separately, very slight modifications in their size produce remarkable alterations of pitch. Thus, we shorten a tube by an inch or two, and obtain a rise of only one tone or perhaps a semitone; but if we diminish the length of a reed by a much less amount, the result is a leap of two or three octaves.

The Vocal Reeds.

The economy of nature, taking advantage of the peculiar adaptability of reeds for producing musical tones, and the slight material modifications they require in order to yield a scale of notes, has given us a pair of membranous reeds, the so-called vocal cords, as the essential part of our vocal apparatus. But, compared with artificial reed instruments, the voice appears to exceed them as much in complexity as it does in beauty, combining more or less the mechanism and qualities of them all, and having, in addition, a surplus of powers peculiar to itself.[1]

To brass instruments sounded by the lips compressed

[1] See Hullah, *Cultivation of the Speaking Voice*, p. 9.

together and tightened gradually in ascending the scale, a close likeness is borne by the vocal reeds associated with their tube, which, however, influences not the pitch of their note, but only its timbre.

And again, as the vocal reeds alter their size and shape almost indefinitely, according to the pitch of their vibrations, it may be considered that the vocal scale is formed by a series of separate reeds like those of the harmonium. But, within their own compass, the vocal reeds are infinitely more versatile in giving gradations of pitch than the fixed series of springs of that instrument.

To analyse their peculiarities of constitution, and the delicacies of their action, forms our principal subject for the next two chapters.

CHAPTER II.

ANATOMY OF THE VOCAL ORGANS.

ACOUSTIC CLASSIFICATION OF THE VOCAL ORGANS—THE CHEST, OR THORAX—THE LARYNX—THE VOCAL TUBE, OR RESONANCE APPARATUS—THE TONGUE, LIPS, AND TEETH.

Acoustic Classification of the Vocal Organs.

The anatomical parts concerned, directly and indirectly, in the formation of voice and speech are numerous and complex, whilst most of them present the peculiarity of having often to fulfil several functions in the same moment of time. On this account the ostensible machinery, so to speak, of voice presents an entanglement, in which it is difficult to perceive the essential components, as distinguished from those which merely act in concert with them in relation to other offices.

A mechanical description of the vocal organs, from a purely acoustic point of view, is all that will be here given. With this object they may be separated primarily into two great classes, viz., the organs which produce sound, and those which only afterwards modify it. Both these classes, however, require subdivision, because in the former case we have, firstly, the organs which furnish a current of air, and, secondly, those which by re-active vibration divide it into sound-waves; and in the latter case we have the parts which influence purely the musical quality of the tones, and also the organs which stand, psychologically, at the head of the vocal series, *i.e.*, those which form the instrument of articulation.

On these principles the classification of the vocal organs is shown in detail as follows:—

I. ORGANS WHICH COMBINE THEIR ACTION TO GENERATE SOUND.

1. *The air-chamber commanding the motor element.* The chest-walls, with their proper muscles; the lungs; the bronchial tubes; and the trachea or windpipe.
2. *The larynx, containing the vibrating element.* The laryngeal cartilages sustaining the vocal reeds, and the intrinsic and extrinsic muscles acting on them.

II. ORGANS WHICH MERELY MODIFY SOUND.

1. *The resonance apparatus or vocal tube.* The ventricles and vestibule of the larynx, the pharynx, mouth, and nose with its accessory cavities. Also certain moveable parts of the boundaries of the vocal tube, viz., the epiglottis, soft palate, and lower jaw.
2. *The articulating instrument.* The tongue, lips, soft-palate, teeth, and lower jaw.[1]

[1] It may be objected to this classification that the lungs and larynx also modify sound the former in force or intensity, the latter

The consonant action of all these parts is required for the perfect formation of voice and speech; but the first class, in their proper functions, are essentially independent of the second, whilst the second class can only perform their office with the co-operation of the first. Secondary relations of a similar character exist between the first and second groups of organs in each pair of subdivisions.

THE CHEST, OR THORAX.

The chest-walls consist of a bony and cartilaginous framework, of which the various apertures are covered in by numerous muscles and membranes. The osseous portion is formed by the twenty-four ribs, twelve on each side, which are seamed together, behind by the spinal column, and in front by the breast-bone and costal cartilages. Above and in front the collar-bone, or clavicle, and behind the shoulder-blades also contribute to the bony consolidation of the chest-walls. In front the ends of the ribs are joined to the breast-bone by several slips of cartilage, except the last or lowest two on each side, which are therefore called floating ribs.

The space thus partly enclosed has a somewhat conical shape, being broad and open below at the abdomen, and narrow and almost shut above at the neck. The reason of this is that the opposite pairs of ribs increase gradually in length and embrace successively a

in pitch. The main acoustic action of both is, however, to produce sound, and as regards the larynx every note must, I think, be considered as a separate production, and not as a modification of sound, primarily existing in another form.

larger circle from the first or highest to the last two or three.

The joints of the ribs with the spine admit of a considerable degree of motion; the articulations of the cartilages with the breast-bone are also moveable, but to a lesser extent, and not at all in old age.

The ribs are well clothed with muscles, which perform the double duty of completing the closure of the chest and altering the dimensions of its cavity by their contractions. They consist of two classes, viz., muscles of *inspiration* and of *expiration*. Both classes are also subdivided into two groups, namely, *abdominal* and *costal*, according as they enlarge the chest towards the abdomen, or by expanding the ribs. There is only one muscle of the abdominal class, viz., the *diaphragm*, or muscular partition, between the chest and abdomen. The costal group are numerous, and are divided into an *ordinary* and an *extraordinary* set.

The chest contains the *lungs*, *bronchial tubes*, *heart*, etc. At the top of the chest the windpipe, or trachea, divides into two bronchial tubes, one for each side, which pass outwards from each other for a few inches and then divide gradually into numerous small branches, like those of a tree. The ultimate branches are no thicker than a pin, and terminate each in a group of little cells, called air-cells. All these little tubes and cells are collected and connected together into a mass on each side of the chest form the lungs, which are thus of a spongy nature. They are also very elastic, and if distended with air will re-contract to their previous size.

THE LARYNX.

The windpipe is about 4½ inches long and at the upper part of the throat undergoes expansion and modification so as to form the essential organ of voice, the larynx. Under the chin the larynx can be seen and felt as the prominence called 'Adam's apple.' It consists of

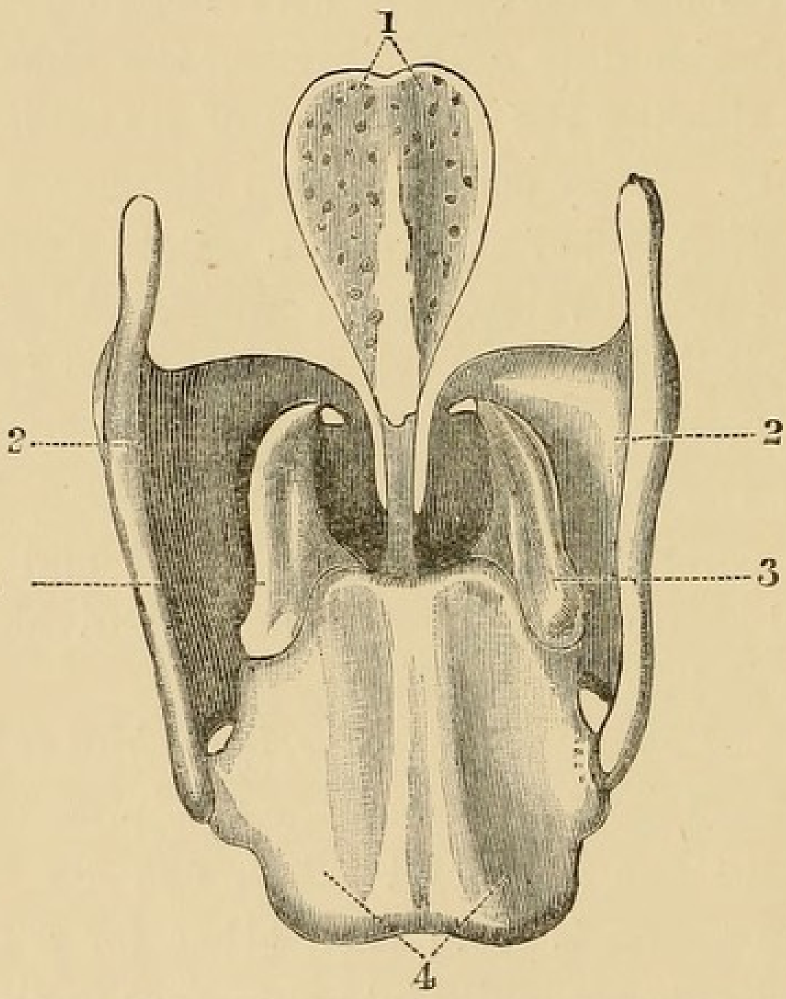


FIG. 1.—THE CARTILAGES OF THE LARYNX SEEN FROM BEHIND.

1. The epiglottis. 2. The thyroid cartilage, its wings and horns. 3. The arytænoid cartilages tipped with the cartilages of Santorini. 4. The cricoid cartilage, its body.

five principal cartilages, namely, the *epiglottis*, the *thyroid*, or shield cartilage, the *cricoid*, or ring-cartilage, and two *arytænoid* cartilages.[1]

[1] These names are of Greek origin, *i.e.*, from ἐπιγλωττίς, *that which covers the glottis*, or space between the vocal reeds; θυρεός, *a*

The *epiglottis* is the highest cartilage, and stands erect against the back of the tongue, above and in front of the other parts of the larynx. In shape it much resembles a leaf, being broad and expanded above and dwindled below into a stalk-like extremity.

The *thyroid* cartilage is the largest, and forms the front and sides of the larynx. It is quite open behind, where its wings, as they are termed, terminate in rounded margins, which are prolonged upwards and downwards into horns, four in number, two on each side, two above and two below. In front it is cloven down the centre for half its length, and the rest of the central part has a peculiarly elastic structure and gives attachment inside to the vocal bands.

The *cricoid* cartilage is very like a signet-ring, with a broad, thick part behind and forming a slender half hoop in front, just under the lower edge of the thyroid cartilage. At this place an elliptical chink exists between the two which are thus separated for about a third of an inch from above downwards at the widest part. Behind, the lower horns of the thyroid cartilage embrace the thick part or body of the cricoid like two short fingers, and a hinge-like joint is thus formed. The back part of the cricoid, therefore, projects upwards, not quite half way, into the open space of the thyroid.

The *arytænoid* cartilages are a pair, and form two small, irregular, three-sided pyramids, about half an inch in height. Their apices are above, and their bases rest,

shield; κρίκος, *a ring*; ἀρύταινα, a vessel of a doubtful kind, probably *a spouted ladle*. In the latter instance the resemblance is most likely that of the whole upper outlet of the larynx, the epiglottis forming the spout.

about a third of an inch apart, on the upper thick edge of the body of the cricoid, where two smooth surfaces or *facets* are prepared for them. They stand between and close to the posterior margins of the thyroid cartilage, and thus tend to fill up still more its open space. In front and below they run into rather long points, called the vocal processes, because the vocal bands spring from them. They turn and glide freely on the smooth part of the cricoid, to which they are fastened by ligamentous fibres.

In addition to these great cartilages there are also several small ones, called *sesamoid*, some not larger than a pin's head. Two such (*Capitula Santorini*) form the apparent apices of the arytænoid cartilages. Another pair (*Cartilagines Wrisbergii*) lie in the folds of membrane (*ary-epiglottic*) which form laterally the upper margin of the larynx. The others will be noticed wherever they appear to bear on the mechanism of voice.

The soft parts of the larynx consist of the vocal bands, muscles, blood-vessels, nerves, etc., the whole being clothed with mucous membrane,[1] which induces a smoothness and uniformity of surface.

The *vocal bands*,[2] or *reeds*, to which all the other structures are subservient, consist at their edges, which move from side to side, to and from each other, of strong, whitish, and highly elastic tissue. Behind, they are at-

[1] The red, moist membrane which covers the internal surfaces of the body is called *mucous membrane*.

[2] Generally called vocal *cords* in this country; but, as this term conveys a false idea of their acoustic nature (see p. 22), it seems to me preferable to call them vocal *bands* (like the German *Stimmbanden*) or *reeds*.

tached to the vocal processes of the arytænoid cartilages, and in front to the thyroid cartilage, quite close together, running into each other in fact. The space between them, the glottis, is therefore triangular in shape, because the vocal bands can be drawn widely apart pos-

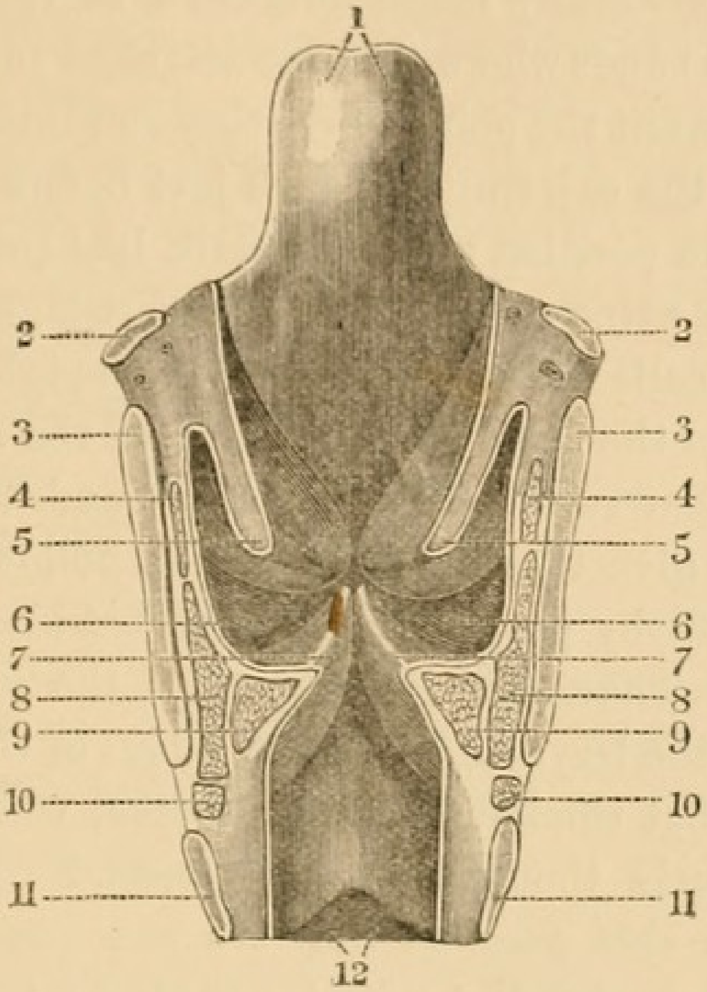


FIG. 2.—TRANSVERSE VERTICAL SECTION OF THE LARYNX SEEN FROM BEHIND.

1. Epiglottis. 2. Tongue-bone. 3. Thyroid cartilage. 4. Thyro-ary-epiglottic muscles. 5. Ventricular bands. 6. Ventricles. 7. Vocal bands. 8. Ext. and sup. thyro-arytænoid muscles. 9. Int. ditto. 10. Lateral crico-arytænoid muscles. 11. Cricoid cartilage. 12. Trachea.

teriorly, but are fixed to the one spot anteriorly. A space exists between each vocal band and the inside of the wings of the thyroid cartilage, which is filled up with muscle. Taken with this muscle, which is intimately connected with them, the vocal bands resemble a pair of prisms, fixed by their base, horizontally and parallel to each other, to the cartilaginous side walls of the larynx, and projecting towards one another with their free sharp edges. Three of the little cartilages mentioned are generally found imbedded in the substance of the vocal bands where they are attached to the thyroid cartilage, one at the point where they run into each other, and one at the extremity of each just before they join.

Near the position where the stalk-like process of the epiglottis is attached to the thyroid cartilage there is an eminence, called the cushion of the epiglottis, which projects over the anterior extremities of the vocal bands.

The upper surfaces of the vocal bands are flat, and in order to give them breadth a deep hollow is scooped out of the fleshy part of the larynx, just above them on each side. These cavities are called the *ventricles*, or pockets of the larynx. The upper edges of the ventricles are somewhat thickened and cord-like, wherefore they were formerly thought to be a second pair of vocal cords. On this account they are now generally called *false vocal cords*. But a better name for them is 'ventricular bands.'[1]

The larynx has several muscles attached to it, which may be considered in two sets, *i.e.*, an *intrinsic* and an *extrinsic*, or the muscles which move the vocal bands and those which draw the whole larynx up and down in the throat. The names of these muscles usually imply the cartilages to which they are attached.[2]

[1] Like the German *Taschenbanden* (pocket bands).

[2] It may be mentioned here that generally muscle must be fastened to something by each end. Its action is to bring the two

Variations of the Larynx in Age and Sex.—The larynx undergoes a great and rapid increase of size in the male sex, in about the fifteenth year of life. The voice then 'breaks,' and descends in pitch by nearly an octave. The same phenomena occur in females, but not to a marked extent, and the depression of vocal pitch is only about a tone or two. In adult age the male larynx is always much larger than that of the female; its cartilages are much firmer, and are pronouncedly angular in shape. The female larynx is more delicate in the structure of its cartilages, which are also curved in their outlines. The average length of the ligamentous portion of the vocal reeds is in the male nine, and in the female six lines.[1] After middle life the laryngeal cartilages gradually undergo ossification, whence in old age they become so rigid that much of the power of varying the tension of the vocal bands and inflecting the voice is lost.

points of its attachment closer together by its power of contracting or shortening its length, at the same time increasing in thickness, rigidity, and also in temperature.

[1] The preparations in the Museum of the Royal College of Surgeons illustrate very well the variation of size in different larynges. See, for example, No. 939 P, a female larynx with ventricles that appear as mere chinks, and No. 939 P,a, a male larynx, the ventricles of which are almost large enough to contain the first joint of the little finger. For tables showing numerous comparative measurements of various parts of the larynx, see Béclard, *Dictionnaire Encyclopédique des Sciences Médicales*, Paris, 1868, art. *Larynx*, p. 555 &c.

The Vocal Tube, or Resonance Apparatus.

This consists mainly of the pharynx, mouth, and the double set of passages in the nose. The soft-palate, pillars of the fauces, and lower-jaw may also be mentioned in this connection. There are also some auxiliary cavities, such as the portion of the larynx, about three-quarters of an inch deep, above the vocal cords, into which the ventricles open, and also some chambers in the thick bones of the head and face. Further, even the trachea and lungs may be ranged under this heading.

The *pharynx* extends from the upper part of the larynx to the base of the skull, forming the open space at the back of the mouth, and also at the back of the nose. Its dimensions vary in different persons. On an average it may be said to be 4½ inches from top to bottom, 2½ from side to side, and 1½ from behind forwards at its widest part opposite the base of the tongue. Its size and shape can be altered by movements of the various parts by which it is bounded.

The *mouth* requires no special description. Its capacity can be greatly varied by the action of the tongue and lower-jaw.

The cavity of the *nose* is peculiar, and may be regarded as a collection of six small tubes. Each nostril is separated into three channels, running horizontally from before backwards to the upper part of the pharynx, by projections on its external wall formed by ridges of spongy[1] bone. The floor of the nose is formed by the upper surface of the hard-palate, or roof of the mouth.

The *soft-palate* is attached to the back of the hard-palate, and hangs down towards the back of the tongue, separating the mouth and pharynx. From its centre depends the *uvula*, a small body like a grape, as its name implies. The pillars of the fauces are two ridges of muscle on each side of the pharynx. They terminate above in the soft-palate, of which they form the greater part in arching across to unite with each other from opposite sides. Between them on each side lie the large glands called tonsils. The pair of posterior pillars consist of the muscles before-mentioned (*Palato-pharyngei*), which spring from the hind edges of the thyroid cartilage, and converge towards each other in passing upwards to unite at the palate over the uvula. The lower-jaw assists to open and shut the mouth, thereby altering its capacity and resonance properties.

The Tongue, Lips, and Teeth.

The tongue, lips, and teeth superadded to the oral portion of the vocal tube render possible articulate speech. The tongue and lips are almost wholly composed of muscular substance, which, being capable of infinite combinations of contractions, bestows on them a great versatility of motion. They, with the soft-palate and lower-jaw, may be considered as the active organs

[1] 'Spongy' in appearance only, being of a cellular structure, but not capable of being squeezed like a sponge.

of articulation. The teeth take a passive part, acting as a kind of fulcrum for the tongue and lips.

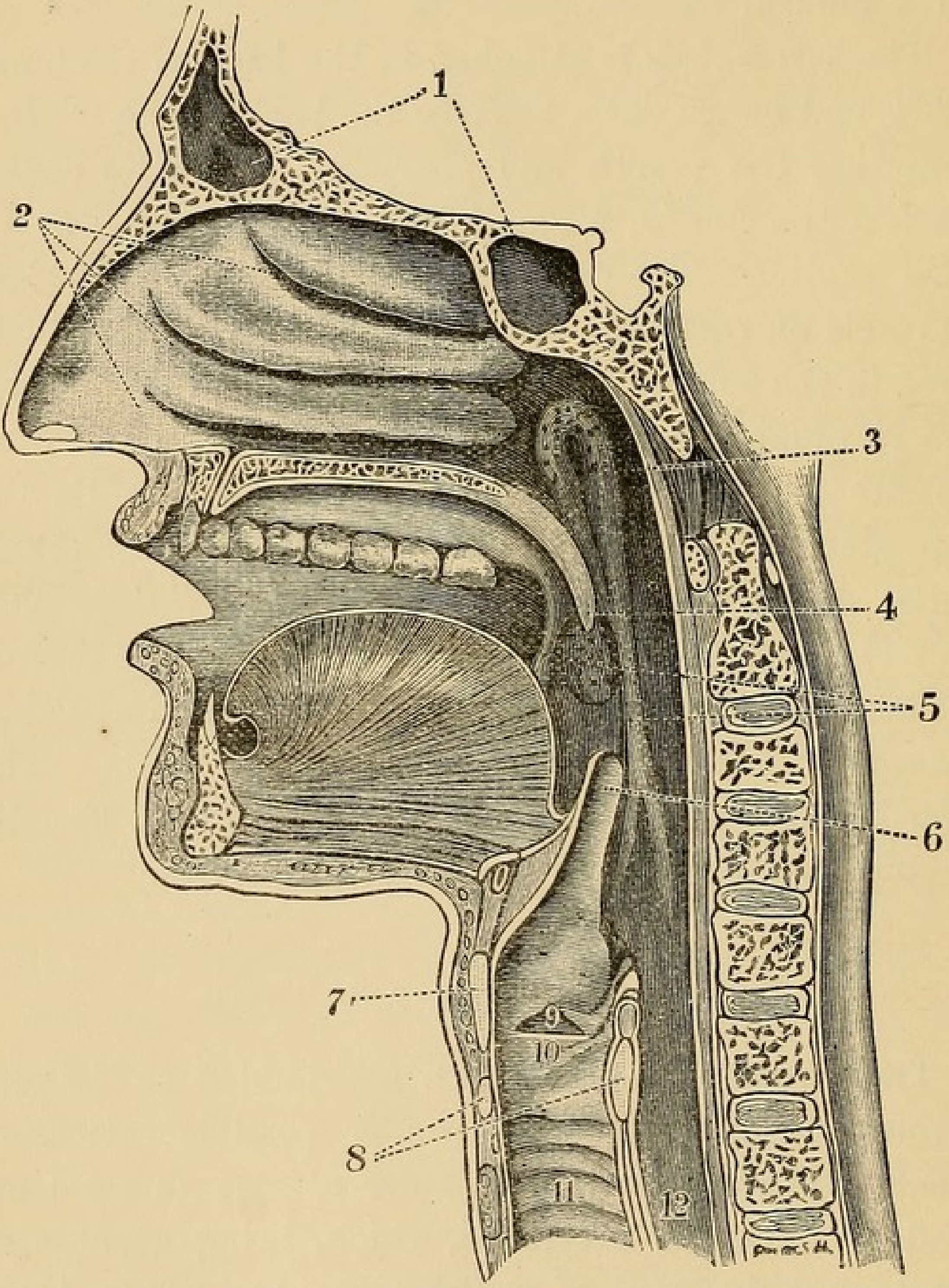


FIG. 3.—ANATOMICAL SECTION SHOWING THE RELATIONS OF THE ORGANS OF VOICE.

1. Cavities in the bones of the head (frontal and sphenoidal cells). 2. The channels of the nose (sup., mid., and inf. meatus). 3. Entrance of Eustachian tube (leading to ear). 4. Uvula. 5. Pillars of the fauces with the tonsil between them. 6. Epiglottis. 7. Thyroid cartilage. 8. Cricoid cartilage. 9. Ventricle of larynx. 10. Vocal band. 11. Trachea (windpipe). 12. Œsophagus (gullet).

CHAPTER III.

PHYSIOLOGY OF THE VOCAL ORGANS.

ACTION OF THE AIR-CHAMBER (RESPIRATION)—ACTION OF THE VIBRATING ELEMENT (VOCAL REEDS)—THE RESONANCE APPARATUS (VOCAL TUBE)—COMPASS OF THE VOICE: INDIVIDUAL AND SEXUAL DIFFERENCES: REGISTERS—ARTICULATING APPARATUS.

In this chapter we have to consider the share taken by the various parts of the body just described in the production of voice and speech. In accordance with the classification adopted, the action of the thorax—the air-chamber or wind-chest—which initiates the giving forth of sound, first claims notice.

The Air-Chamber (Respiration).

The muscles attached to the chest-walls have the power of enlarging the cavity of the thorax, so as to draw air through the windpipe into the lungs, which thus become inflated. The lungs have not in themselves any ability to increase their capacity, and are merely blown out by force of the air which rushes into them, according as the chest expands, in order to prevent the formation of a vacuum. As there are two principal ways in which the thorax can be enlarged, inspiration is divided into (1) *abdominal* and (2) *costal.*

In *abdominal breathing* inspiration is performed by means of the diaphragm, which, when relaxed, projects upwards into the chest. By contracting it greatly diminishes the amount of its upward projection, thus rendering the chest more capacious below, at the same time that it presses downwards the stomach and other abdominal viscera. When it again relaxes the tendency of the abdominal organs to return to their former position is sufficient to thrust it up and expel the air introduced. In men ordinary quiet breathing is chiefly diaphragmatic ; but in women this muscle is used to a much less extent.

Costal, or *rib breathing,* is accomplished by raising the ribs, each of which can move, as on a pivot, at its joint with the spine. During this action the ribs are drawn up closer together in front and at the sides, so as to lessen the vertical measurement of the spaces between them, and the breast-bone is made to advance. Behind, of course, the ribs merely rotate on their heads, and cannot approach nearer to each other, owing to the nature of their vertebral articulation. The lower ribs also move much more than the upper ones, the first rib being, in fact, almost fixed. In costal inspiration the thorax is enlarged laterally and in front, because the larger ribs in being raised are made to occupy the place of the smaller ones. The ordinary costal muscles are generally sufficient for respiratory purposes, and only in taking a long breath—in forced inspiration—is the action of the extraordinary set required. The extraordinary muscles of inspiration are nearly all attached to the shoulder, and their real object is to regulate the motions of that part. If, however, the shoulders be elevated, they can raise the ribs, but only to a comparatively small extent, because their power is mostly exerted over the upper ribs, which have little freedom of motion. In some diseased conditions the movements of the diaphragm and lower ribs are very much restricted, and in compensation the upper ribs are called on to work to their utmost. This is sometimes called *clavicular breathing*, because the motions of the chest are principally in the region of the collar-bone or clavicle.

With respect to *expiration*, when all the muscles of inspiration relax, the ribs fall by their own weight, the abdominal viscera returning to their position thrust back the diaphragm, and the lungs by contracting assist to drive out the superfluous air that is in them. Much of the act is therefore automatic; but if more force is wanted the muscles which pass from the lower ribs down the abdomen and flank can pull the ribs down strongly, and at the same time can press the abdominal organs up against the bottom of the chest. In this manner a forcible expiration can be performed.

The air of respiration may be divided into four different complements. In the first place we have the air which passes continually in and out of the lungs during quiet breathing. This is called *tidal air*. Next we have that which can be forced into the lungs when expanded to their full extent by drawing a deep breath. This gives the *vital capacity* of the chest. Thirdly, there is the complement of air that can be pressed out of the lungs when emptied by a strong effort of expiration, called *residual air*; and lastly there remains some air which cannot be squeezed out by any exertion during life, nor even after death, without the direct application of such mechanical force to the lungs as would rupture their air-cells. Hence it may be called *fixed air*, or air which cannot be removed.

The Vibrating Element (Vocal Reeds).

The column of air as it rushes out of the lungs through the trachea is rendered sonorous by the vibrations of the vocal reeds. Without these membranous bands man would be voiceless, or at least could only speak in a whisper, as is frequently seen in cases where they are paralysed or destroyed through disease.

Great obscurity prevailed as to the actual action of the larynx in emitting voice until within the last half-century. The interest of such questions has always led many to attempt their solution, whilst the former deficiencies of anatomical and acoustic science and the difficulties of empirical observation rendered the numerous conjectures conflicting and many of them baseless.

About 1830, however, Johannes Müller, a great German physiologist, made a series of most exhaustive and ingenious experiments with the natural detached larynx and artificial imitations of it. His researches showed conclusively that a compass of a couple of octaves could be drawn from the vocal bands merely by varying their tension when approximated.

The Laryngoscope and its Revelations.

After the researches of Müller but little was left in the way of direct experiment to be done by his successors, although conflicting theories of voice were still held, owing to the difficulty of obtaining the absolute demonstration or ocular proof of any one set of deductions. The increase of acoustic science gradually threw a light over many obscure points, but it was only on the discovery of the laryngoscope that most of the doubts and absurdities were finally resolved and laid to rest. Many unsuccessful, or perhaps disregarded, attempts to see the action of the living larynx had been made prior to 1854, when Manuel Garcia, a teacher of singing, actually caught sight of his own vocal bands in a small dentist's mirror pushed into the back of his mouth. Continuing his observations on his own throat, he was at the end of a year enabled to read a paper at the Royal Society on the formation of voice as elucidated by means of his invention. Garcia's device did not, however, attract much immediate notice; and it was only at the end of two years that Czermak, a German medical professor, commenced a systematic practice with the instrument, on himself and on patients, and showed finally the feasibility and facility of viewing the living larynx. As soon as Czermak had satisfied himself as to the actual value of the invention, he travelled into the chief cities of Europe, and, by giving laryngoscopic demonstrations before the principal physicians and surgeons of each town, achieved the introduction of the laryngoscope into medicine as an indispensable adjunct to the local study of disease.

The laryngoscope, as now used, consists simply of a small mirror, from half an inch to an inch in diameter, fixed at the end of a stem of sufficient length to allow it to be passed to the back of the mouth (middle part of pharynx). It is held there at such an inclination as to reflect the parts of the throat below. Some practice is required in order to be able to place it quickly at the proper angle, which in fact differs somewhat in almost every individual, and also in order to manipulate it so delicately as not to irritate by pressure the tongue, palate, and other parts adjacent. The tongue should be protruded during the examination, as the larynx is thus drawn up higher in the throat. It may be held out gently with a small cloth. Of course a strong light must be thrown on the surface of the mirror, and for this purpose various kinds of accessory apparatus are employed.

The Vocal Reeds.—On inspecting the larynx with the laryngoscope, the rim of its upper outlet, surmounted in front by the epiglottis which generally stands erect against the back of the tongue, is plainly visible. But the most striking objects are the vocal bands which are seen at a short distance below, projecting opposite each other from the sides of the inner wall of the larynx, and of a pearly whiteness which contrasts strangely with the redness of the surrounding parts. Between them is the oblong aperture through which the air continually passes to and fro, the glottis, of dimensions varying at every moment, for the vocal reeds are never absolutely at rest during breathing, but with deep inspiration separate widely until they almost disappear from sight behind the ventricular bands, and with expiration gradually approach each other, so as sometimes almost to touch. If the person under observation speaks in an ordinary tone of voice they draw together so closely as to reduce the glottis to a mere thread-like fissure, and as the sound issues forth the eye can perceive that they are in a state of vibration. At one point they touch, viz., posteriorly, where they join the tips of the vocal processes of the arytænoid cartilages. Behind this the chink of the glottis is continued backwards for a short distance, about three lines, between the inner edges of the base of the arytænoid cartilages (*cartilaginous glottis*), but this portion is probably incapable of vibration, and cannot properly be considered as forming part of the vocal reeds.

The theory of the generation of sound by our vocal bands is as follows:—By the contraction of the expiratory muscles of our chest we propel a stream of air from our lungs through our windpipe. Impinging against the closed glottis from below, the current drives the vocal bands apart sufficiently for a puff to escape. This relieves momentarily the pressure of the air below, and the vocal bands at once spring back towards each other by their own resiliency. The glottis is thus again shut, the pressure re-accumulates below, and a second puff escapes. By a continuance of this action the current of our breath is divided into a series of puffs, and a tone is produced in like manner as is observed to occur when experimenting with the siren.

THE LARYNX AS VIEWED WITH THE LARYNGOSCOPE.

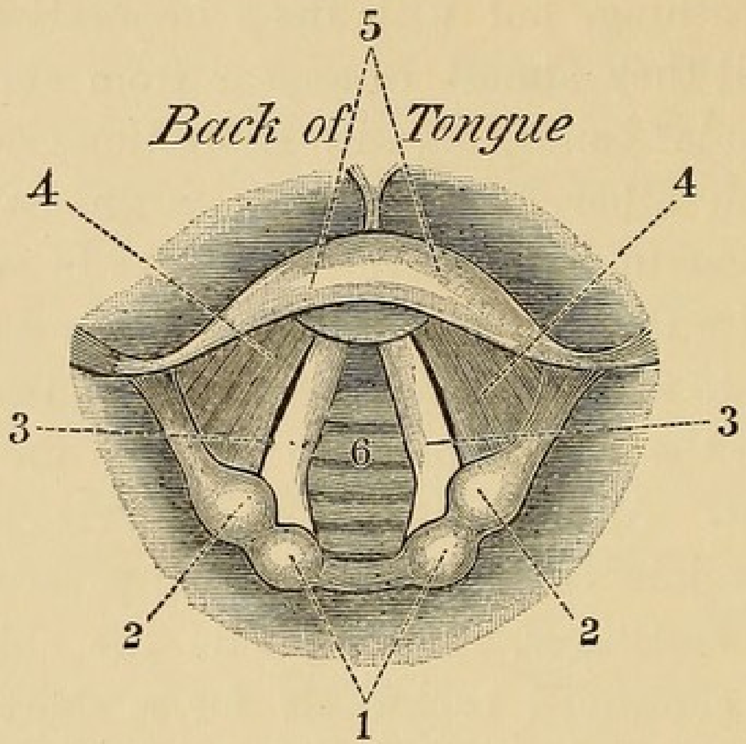


FIG. 4.—THE LARYNX DURING QUIET BREATHING.

1. Arytænoid cartilages. 2. Cartilages of Wrisberg. 3. Vocal bands. 4. Ventricular bands. 5. Epiglottis with its cushion below. 6. Trachea.

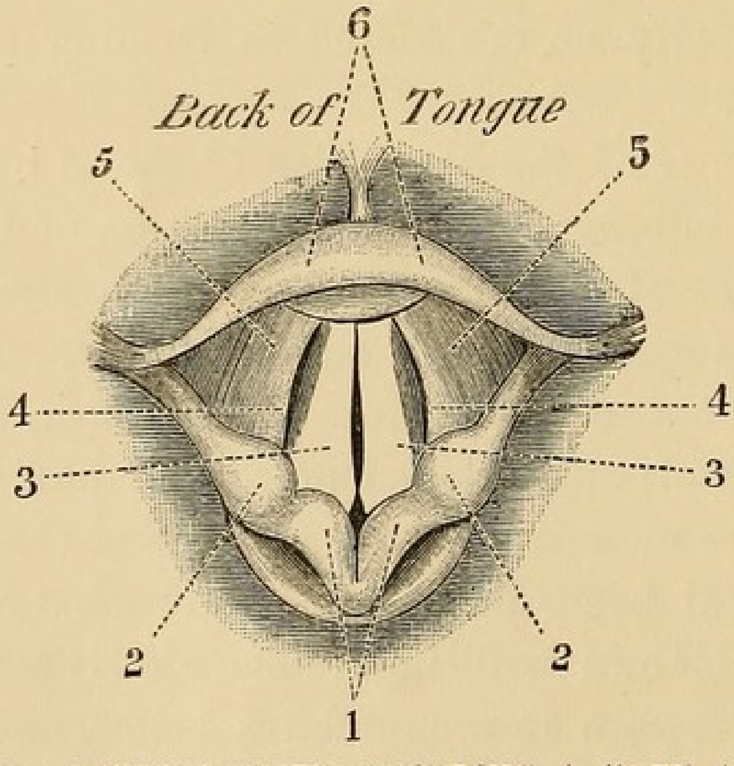


FIG. 5.—THE LARYNX WHEN SOUNDING A NOTE ABOUT THE LEVEL OF THE ORDINARY SPEAKING VOICE.

1. Arytænoid cartilages. 2. Cartilages of Wrisberg. 3. Vocal bands. 4. Entrance of ventricles. 5. Ventricular bands. 6. Epiglottis.

Considerable alterations take place in the appearance of the vocal reeds and the upper outlet of the larynx during the production of a scale of notes from the lowest to the highest pitch. Whilst sounding the deepest notes of the *chest-register* the glottis is open in its whole length, and forms an elliptical slit, which, in a bass voice, may measure as much as a line at its widest part when the vibrations strike outwards. After ascending two or three tones the tips of the vocal processes become visible, projecting towards each other across the chink, and on a rise of two or three tones more they come by degrees into contact. At this moment the glottis is seen to consist of two parts; the main portion in front, forming a linear fissure between the vocal reeds of from a third to half-an-inch in length, and a small triangular space behind separating the arytænoid cartilages. This condition of the glottis occurs about the level of the ordinary speaking voice. In mounting a few notes higher, the posterior triangular space diminishes until at last it is quite closed, and in this state it remains during the emission of the upper three or four chest-notes. At the same time the progressive narrowing of the anterior fissure, the actual vibratory glottis, continues until it is reduced to a mere dark line between the borders of the vocal reeds. Concomitant with these changes the vocal bands seem to be lengthened; they are so in fact by being stretched; but greater than their real is their apparent lengthening, which depends on their coming more into sight in the laryngeal mirror, according as the gamut is ascended. Their actual lengthening may be about a line, their apparent increase of length twice or three times that amount. In the lowest notes the epiglottis generally conceals from view the front of the glottis; in the middle notes the cushion of the epiglottis still covers the anterior ends of the vocal bands, but at the top of the chest-register their tension is very evident, and

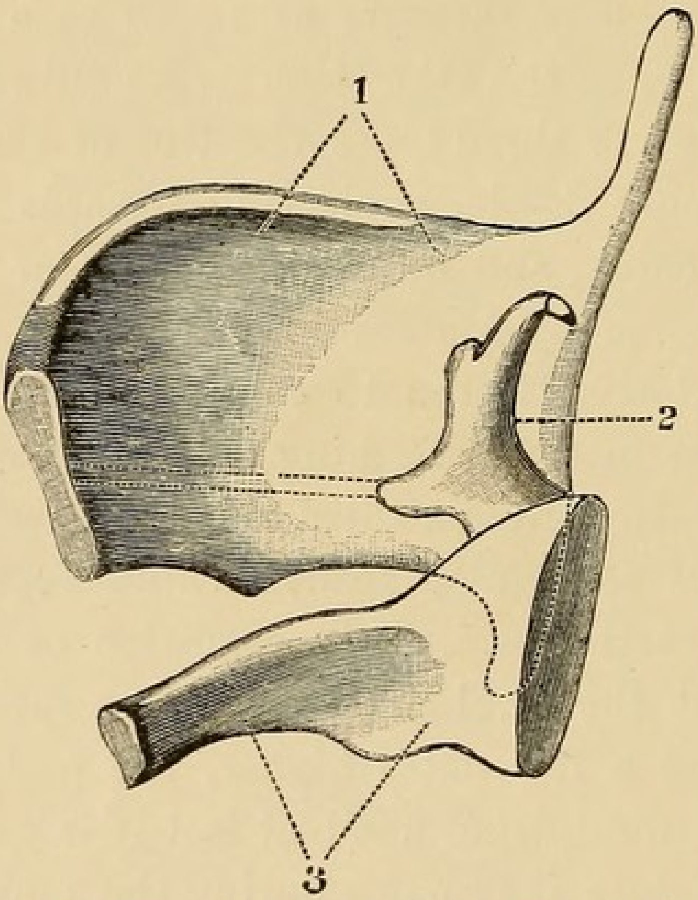


FIG. 6.—SECTION OF THE LARYNGEAL CARTILAGES SHOWING HOW LONGITUDINAL TENSION OF THE VOCAL BANDS IS EFFECTED.

1. Thyroid cartilage. 2. Arytænoid cartilage. 3. Cricoid cartilage. The dotted lines from the vocal process of the arytænoid cartilage to the thyroid indicate the position of the edge of the vocal band, which is tightened by progressive closure of the chink below, between the thyroid and cricoid cartilages.

appears to draw them away from their attachment to the thyroid cartilage, so as to bring their full length into sight. In mounting the scale of chest-notes, therefore, the outlet of the larynx undergoes enlargement, and its margins expand so as to afford a complete view of the interior. When a note is swelled to its maximum of loudness, the vocal reeds perform more ample vibrations in the same period of time, their edges cannot be seen in such sharp definition, and the glottic aperture assumes a hazy appearance.

In the *falsetto register*, the laryngoscopic appearances are in many respects the reverse of those just described. The rim of the larynx, instead of becoming dilated, suffers a progressive and marked constriction

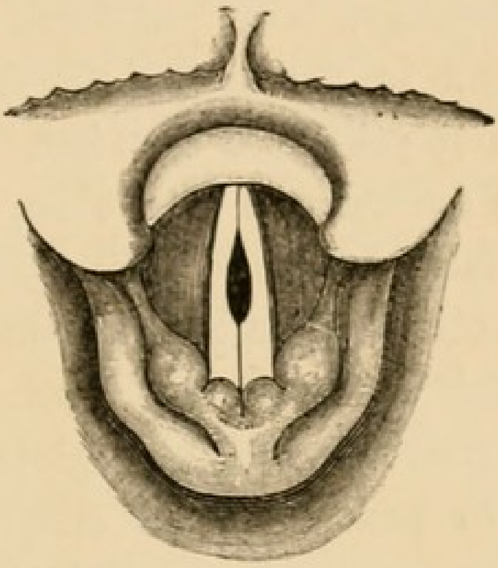


FIG. 7.—THE LARYNX DURING THE EMISSION OF FALSETTO NOTES (MIDDLE OF RANGE).

in proportion as the pitch rises, until at last only the edges of the vocal bands can be seen through the narrow orifice that remains. The object of the movements seems to be to shorten the glottis and limit the vibrating portion of the vocal reeds as much as possible. As soon as their tension can be increased no further by the means resorted to for the formation of chest-notes, a change occurs in the physiological mechanism for the purpose of obtaining a higher scale of tones by gradually reducing the size of the reeds. The aperture during the emission of the lower falsetto notes occupies the centre of the ligamentous glottis, and appears to be from a quarter to a third of an inch in length, but somewhat wider and more elliptical than at the highest level of the chest-register. It diminishes in length as the sound mounts up, but at the same time its width, if anything, rather increases. At a certain elevation of pitch, which of course varies considerably in different individuals, the power of ascending any higher is lost.

Many theories have been put forward as to the action of the larynx in producing the falsetto notes, and the question is not yet quite decided. On the whole I think it most in accordance with observed facts to suppose that the falsetto range is produced by a truly sphincter-like action of all the constrictive glottic muscles. In such case the effect would be a progressive concentric narrowing of the glottis, during which it would tend to pass from an elliptic to a circular shape. Thus the aperture, until it had attained the circle, would be seen to diminish in length and increase in breadth during the ascent of the scale, and elevation of pitch could proceed, *cæteris paribus*, until the reduction of the opening to a mere pin-hole. The remarkable delicacy and elasticity of the cartilages of the female larynx is precisely the condition most favourable to such an operation, and an explanation would thus be afforded of the extraordinary range in the highest register so often met with in female voices.[1]

[1] See page 88.

Resonance Apparatus (Vocal Tube, etc.).

The Ventricles.

The existence of these small cavities appears necessary in order to allow a proper breadth to the vocal reeds. In man, their acoustic influence on the voice must be unappreciable on account of their limited area; but in the *mycetes*, or howling monkey, they communicate with several large pouches on each side of the throat, and with excavations in the body of the tongue-bone, so as to impart to the cries of these animals a degree of resonance which renders them louder than the roaring of lions. On the other hand, that they are absolutely unessential in conferring an extraordinary voice-power, is proved by the fact that the lion, tiger, ox, and many other animals that do not lack in this respect, have neither ventricles nor ventricular bands.

The Epiglottis.

Viewed with the laryngoscope, the epiglottis presents considerable variability of size, shape, and position in different persons. Sometimes it forms a mere projection of the anterior margin of the larynx of less than three-quarters of an inch, and stands erect against the back of the tongue; or it may extend backwards over the larynx, like a roof, for nearly an inch, so that its surfaces are almost horizontal. It may appear round, square, or folded so that its upper edge resembles a horse-shoe. In singing the scale it seems to have little or no proper motion, but the movements of the larynx make it apparently shift its place. Approximation of the vocal bands draws the posterior margin of the larynx slightly towards it. In the lowest notes the larynx moves downwards and forwards, so as to cause it to intercept the view, whilst in the upper range of the chest-register the larynx is seen to pass away from it in a direction upwards and backwards as the glottis comes into full sight. During the contraction of the vestibule of the larynx, of which it forms the anterior part, in the falsetto scale it becomes gradually doubled up, and its lateral edges approach nearly in the highest notes. At the same time it is drawn more over the glottis than at the top of the chest-register, but if naturally erect its upper edge remains everted towards the back of the tongue. Being closely connected with this organ, it follows its movements during articulation. Thus it is depressed when the vowel-sound *aw* (as in *law*) is pronounced, and drawn away from the glottis by the enunciation of *ee* (as in *feel*).

This valve is capable of closing the upper outlet of the larynx, to which it acts as a kind of operculum or lid, if pressed down upon it, as occurs during the act of swallowing, when the larynx is drawn upwards and forwards, so that the base of the tongue rolls over it. Food and drink are thus prevented from passing into the windpipe. Such is certainly the physiological purpose of the epiglottis; but in those animals which have well-developed ventricular bands it appears to be superfluous, unless we can regard it as a vocal appendage.

The presence, however, of an ample epiglottis in animals for the most part voiceless, such as marsupials (kangaroo, etc.), and cetaceans (whale, dugong, etc.), argues against this supposition, which is further controverted by its small size and comparative immobility during phonation in man. It has been suggested that it acts as a 'tuner,' a resonator, and that it modifies the timbre of the voice. But the vocal reeds, with almost infinitesimal powers of altering their tension and dimensions, do not seem to stand in need of such a tuner, whilst their great resonator is the concavity of the hard-palate, the roof of the mouth. It may modify timbre, and give something of the peculiarity of voice by which we recognise different persons, as when it is large and depressed, or small and erect; but, apart from lingual articulation, it has no motion to enable it to vary the quality of any particular note. It certainly, however, has the office of directing the sound-waves against the back of the pharynx, to be thence reflected, under the variable arch of the soft-palate, on to the hard-palate, especially when the most resonant vowel-sounds, such as *aw* (as in *law*), are pronounced.

The Pharynx.

The share taken by this cavity in voice-production is scarcely capable of separate definition. The vibrations of the vocal reeds do not appear to derive any special modification from it, except in the utterance of certain guttural speech-sounds. It allows of the extrinsic movements of the larynx necessary for the elaboration of a musical scale. The tongue encroaches on or recedes from it during articulation of vowels. Under ordinary circumstances it extends, with the laryngeal vestibule, directly from the vocal reeds to the back entrance of the nasal channels; but by the action of the soft-palate it may be caused to pass most directly into the mouth, with which it usually forms a single resonance chamber. The alterations of its capacity, so evident to any one who observes it during singing, induced some former physiologists and physicists to believe that it bore the same relation to the voice as the tube of a flute or clarionet to the sounds generated at the embouchure. A knowledge of the acoustic laws of sonorous vibrations in tubes and cavities has, however, reduced this hypothesis to a nullity.

The Mouth.

The most harmonious tones of the voice are obtained by the action of the mouth, as resonance chamber. In this cavity the power and volume of the voice are greatly augmented by secondary vibrations, to the formation of which the solid arch of the hard-palate mainly contributes. The highly composite clang proceeding from the vocal reeds is reinforced in those upper partial tones which are nearest and most consonant to the prime, namely, its octave, the fifth above that, and the second octave, etc. Such is probably the succession of overtones which are brought out distinctly when the most resonant of vowel-sounds are pronounced or sung. But the reinforcement of the upper partial tones is altered by every motion of the tongue, lips, etc., during articulation, and hence results a pleasing diversity of timbre which prevents the ear being fatigued by monotonous repetition.

The Nose.

The office of the nasal cavity in phonation is also to give increased intensity to upper partial tones. Consisting, however, of a number of small channels which have little intercommunication, its own proper sounds must be high and shrill. The overtones, therefore, that it can reinforce lie generally at a great distance above the prime tone of the vocal reeds; not nearer probably in any part of the chest-register, than the eighth or tenth in the harmonic series, *i.e.*, more than three octaves from the fundamental note of the voice. Beyond this height the rapidly diminishing intervals between the successive overtones soon render them dissonant, both with each other and with the prime tone. When, therefore, the voice resounds fully in the nose, the fundamental note is impoverished and nearly drowned by the predominance of high partial tones Hence the well-known discordance, the jarring 'twang,' of an exalted nasal intonation which, disagreeable in speaking, is utterly ruinous to melodious singing. A due proportion, however, of the nasal harmonics must generally be present (invariably with *m* or *n*), and when the gap is bridged over by a proper preponderance of oral resonance they are of real value in adding to the brilliancy and variety of vocal timbre.[1]

[1] The cavities in the bones about the nose, viz., the antrum, and

The Soft-Palate.

The use of this pendulous and mobile portion of the palate is to cut off the communication between the upper part of the pharynx and the nasal cavity during the act of swallowing or in phonation. To effect this purpose its muscles draw it backwards and slightly upwards till it meets the back wall of the pharynx. Whilst singing a scale, this movement goes on progressively, from the deepest chest-note to the highest limit of the falsetto, when the retraction is nearly complete. A sufficient opening, however, remains almost to the last to allow of some nasal resonance. For every note of different pitch, therefore, the soft-palate occupies a separate position, which is determined by the direction of the sound issuing from the glottis. In ascending the scale, the successive changes of place of the larynx tend to project the column of aërial vibrations, so that they rebound from the back of the pharynx more and more vertically upwards towards the posterior nares. Step by step the motions of the soft-palate counteract this tendency and divert the course of the sound-waves to the arch of the hard-palate. It is quite possible to sing all the chest-notes without moving the soft-palate, but, as a consequence, there is a great loss of resonance and an insupportable predominance of nasal timbre. The effect is somewhat similar to blowing a trumpet from which the bell has been removed; a 'tin-kettle,' or

the frontal and sphenoidal sinuses, have a certain, though undetermined, effect on voice. When they are undeveloped, as in many of the Australian aborigines, a noticeable want of vocal resonance has been observed.

'cracked-pot' tone is the result. But when the falsetto scale is reached it is no longer practicable to restrain the retraction of the soft-palate, although these notes would probably suffer least from a surplus of nasal harmonics. The action of the palato-pharyngeus muscle seems indispensable, in order to approximate the wings of the thyroid cartilage, and consequently the falsetto register cannot be produced without the palatal motions. In cases, however, where the soft-palate has been destroyed by disease, the power of producing the falsetto notes is not abolished, as the lateral parts of the palato-pharyngeus and the inferior constrictor are still able to fulfil their office. It is thus demonstrated that the gradual occlusion of the posterior nares in this register is merely an accidental phenomenon without any acoustic necessity for its occurrence.

Compass of the Voice—Individual and Sexual Differences—Registers.

The compass of the voice from the lowest note of the male to the highest of the female includes about four octaves, viz., from *E*[1] to *c‴*.[2] Many gifted singers can, however, exceed both these extremes by several tones, and males may even descend to *,F*,[3] whilst females can sometimes attain *f‴*,[4] a range of five octaves. The

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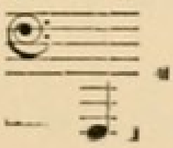
3 

4 

voices of individuals, of infinite variety as regards timbre, present also numerous diversities in compass, but they can always be relegated to some one of six different classes, the precise extent of which is not strained. Men's voices are termed *bass*, *baritone*, and *tenor*; and women's *contralto*, *mezzo-soprano*, and *soprano*, in regular succession, from the bottom to the top of the vocal scale.[1] The bass and soprano are more than an octave apart, whilst the tenor and contralto lie for the most part over the same notes. The range of each kind of voice is shown in the adjoining table, according to the conventional acceptance. The compass here apportioned to the various voices is, however, only such as the composer would regard when writing music for different classes of singers, and is far from representing the physiological limits of each kind. From merely acoustic considerations, for instance, we might suppose that the bass voice would be capable of producing not only the deepest notes, but also those of the highest pitch, on the same principle that an imitation of the violin can be performed on the violoncello, though the notes are not of the same musical value as the proper tones of the instrument. In either case, the only faculty required is an unlimited power of shortening and tensing the strings or vocal reeds. The truth of this hypothesis is exemplified, as regards voice, in the fact that a bass or

[1] In determining to what class a voice belongs, attention is often directed more to its timbre than to its actual compass. A first-rate baritone, for instance, may be able to deliver *g′*  from the chest, whilst a good tenor may be unable to rise beyond that note. But an unmistakable difference of timbre at once decides the question.

COMPARATIVE SCALE OF DIFFERENT CLASSES OF VOICES.

NAMES OF NOTES— *English and German.*

E F G A B c d e f g a b c' d' e' f' g' a' b' c'' d'' e'' f'' g'' a'' b'' c'''

French.

mi$_1$ *fa*$_1$ *sol*$_1$ *la*$_1$ *si*$_1$ *ut*$_2$ *re*$_2$ *mi*$_2$ *fa*$_2$ *sol*$_2$ *la*$_2$ *si*$_2$ *ut*$_3$ *re*$_3$ *mi*$_3$ *fa*$_3$ *sol*$_3$ *la*$_3$ *si*$_3$ *ut*$_4$ *re*$_4$ *mi*$_4$ *fa*$_4$ *sol*$_4$ *la*$_4$ *si*$_4$ *ut*$_5$

VIBRATIONS[1]—
80. 85. 96. 107. 120. 128. 144. 160. 170. 192. 214. 240. 256. 288. 320. 341. 384. 427. 480. 512. 576. 640. 682. 768. 854. 960. 1024.

[1] The vibrational numbers here given are those of the so-called natural scale, which assumes the lowest sound audible as a musical note, to have sixteen vibrations per second—fractions are omitted. In the French notation the above numbers would be doubled, as in France the to-and-fro motions of a vibrating body are reckoned separately.

baritone singer may have such an extent of falsetto notes as to be able to counterfeit the vocal performances of a soprano.[1] Similarly the male alto voices employed in cathedrals for choral service are generally, if not always, of bass or baritone range fundamentally, but with an unusual facility for falsetto singing. In these instances the upper voice may embrace ten or twelve notes.[2]

Male and female voices differ not merely in degree, *i.e.*, in lower or higher pitch, but also in kind. They are characterised by a peculiarity of timbre, so that the dullest ear is in no danger of mistaking a man's voice for that of a woman, even on notes of the same pitch. The falsetto tones of a male voice have little resemblance to their equivalents in the musical scale when sung by a female, and the woman's voice is remarkably more brilliant and full in its sound. The causes here are obscure, but one of the greatest is undoubtedly superior resonance. The air-chambers connected with the female larynx are better adapted to reinforce high tones. The circumstance that the retraction of the soft-palate cuts off the nasal part of the vocal tube in woman to a lesser extent for notes of similar pitch than in man may have some influence. But principally we must regard the fact that the female larynx is formed for a treble instrument and produces tones naturally and with ease

[1] 'Dans une scène *de la Prova d'un opéra seria*, Lablache, imitant un soprano, chante une cavatine entière en voix de fausset.' Ségond, *Hygiène du Chanteur*, Paris, 1846, p. 86.

[2] From *a*  to *d''* 

which the male organ can only emit, if at all, with more or less of a strain. A man singing in falsetto is, therefore, in a position somewhat similar to a violinist who should endeavour to draw the highest notes from the fourth or lowest string of his instrument.

Having dealt with the question as to the mechanical formation of the chest and falsetto notes, it remains to consider at what level of the voice the break[1] between the two usually occurs. We should naturally expect that this point would bear a similar relation to the bottom of the chest-register in every individual, not occurring at any determinate point in the musical scale, but movable according to the notes embraced within the compass of each particular class of voice. Anatomical and physiological observations point clearly to such a conclusion. Amongst singing-masters, however, it is usually considered that the falsetto scale commences at or near *g′*,[2] whatever the kind of voice and whether the singer be male or female. I do not know whence this hypothesis originated, but it appears to rest on the basis that in women's voices there is often a break more or less pronounced in that position, and a marked difference of timbre between the ascending and descending series of notes. In many cases, on the other hand, the break and change of timbre are scarcely perceptible. It is difficult to believe that the finest notes of the soprano

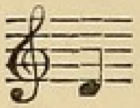
[1] The falsetto register can generally be carried down two or three notes below the highest level of the chest-scale. Some tones can, therefore, be produced with either quality of voice. In this position the so-called 'mixed voice' is said to occur.

[2] 

voice are produced in a manner strictly analogous to the falsetto tones of the male, and the fact that the female voice presents a second break near its upper limit, where the so-called 'head' voice begins, renders the proposition extremely doubtful. Such a view would also allow no falsetto notes to a bass singer who could not rise beyond d',[1] from the chest, whilst it would give only three or four chest-notes to the soprano. As might be expected, this conception of the registers is involved in some controversy, even amongst teachers of music, some of whom argue for the physiological view of the subject.[2] It is probable, however, that there are differences, as yet undefined, in the manner of forming or managing the vocal tones habitual to the two sexes, which prevent their voices being reduced to one category with the same precision as a pair of musical instruments, identical except as regards size and pitch. Further investigations in this direction are much needed.

Articulating Instrument.

Speech is produced by modifying the capacity of the vocal tube and by altering the size and position of, or entirely closing its outlets, through the instrumentality of the mobile parts contained within it or forming its boundaries. The various sounds or phases of sounds, which are joined together in almost endless combinations to build up words, are represented in written

[1] 

[2] For a detailed argument on this point, see Lunn, *The Philosophy of Voice*, 1875.

language by letters, and classified according to the peculiarities of their formation. Almost at first consideration letters fall naturally into two great divisions. The first comprises those that consist of continuous sounds of characteristic timbre, called *vowels*; and the second embraces the series of interruptions or complete stoppages, enunciative or terminal, of the current of breath or sound, named *consonants*.

Nature of Vowel-Sounds and Mechanism of their Production.

In 1780 the Imperial Academy of St. Petersburg awarded a prize to Kratzenstein for an essay on the nature of vowels, illustrated by a reed instrument of purely empirical design which sounded a recognisable imitation of them. About the same time Kempelen [1] pursued an inquiry of a similar kind, and published a treatise containing his results. In 1828 Willis, treating the question more scientifically, made a series of experiments by attaching cylindrical chambers to a reed-pipe, and showed that the prime tone could be thus modified, so as to produce a number of sounds closely resembling the vowels of speech. Some few years later a consideration of these phenomena led Wheatstone to suggest that in such instances the vowels are formed by the feeble vibrations arising in the short tube, which, most markedly when its reso-

[1] These were not, however, the first or only attempts to construct a talking machine. Albertus Magnus, Friar Bacon, the Abbé Mical, and others made, or are accredited with having made, heads that could utter sentences.

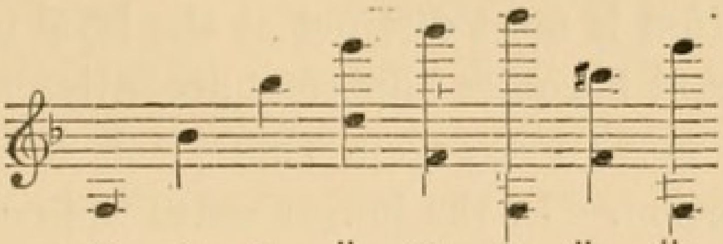
nance corresponds to one of the multiples (*i.e.*, overtones) of the prime tone given by the reed, confers the effect of a superadded musical note. A further step was gained in 1857 by Donders, who discovered that for the various vowels the cavity of the mouth is tuned to different pitches by observing the whistling noise produced in whispering.

Subsequently many investigators directed their attention to the subject, but for the most complete experimental elucidation hitherto we are indebted to Helmholtz. According to this physicist, the essential origin of vowel timbre is the reinforcement of a fundamental tone by the superadded note of a resonance chamber, which for the same vowel always yields the same note, although the fundamental tone may undergo a considerable, but not unlimited, change of pitch. When the note of the resonance chamber corresponds to one of the partials of the fundamental tone, the vowel is best heard; but in proportion as it recedes from this measure the vowel loses character, until it becomes imperceptible.

Thus, in the case of spoken vowels, the pharynx and mouth constitute a short tube, which resounds during phonation, not so as to yield a distinctly separate musical note, but only so that a weak secondary sound of determinate pitch is heard blended with the laryngeal tones. Within certain limits the capacity of this vocal tube can be altered to any required extent by the action of the tongue and lower-jaw, with the effect of lowering or heightening its proper note, the pitch of which is still further governed by the size of the orifice circumscribed by the lips. The smaller the aperture of the mouth, the lower the resonance pitch of its cavity.

For the vowel U (*oo* in *pool*) the vocal tube is arranged to give its lowest pitch of resonance ; the tongue is collected into the smallest space at the bottom of the mouth, and the lips are protruded so as to lengthen the cavity, at the same time that they leave a narrower opening than for any other vowel. Under these circumstances the shape of the vocal tube corresponds to that of a bottle with a small orifice and without a neck. For O (*o* in *note*) the lips retract and enlarge the opening, so that the pitch of cavity is considerably raised. For A (*a* in *father*) the oral aperture is still further increased in size, and for A (*a* in *bath*) the mouth is wide open. The elevation of the resonance pitch of the vocal tube, taken as a whole, has now been brought to its maximum, and beyond this point we pass into another register, so to speak, of vowel-sounds. To produce A (*a* in *fate*) a part of the tube is cut off by the tongue, which was quiescent hitherto, rising near to the hard-palate, whilst the lips remain so far separated that the front of the mouth loses all power of resonance. The shape of the vocal tube now resembles a bottle with a narrow and rather long neck, as the tongue forms with the roof of the mouth an elongated channel which leads back to the more capacious pharynx. As a consequence of this adjustment of the articulating apparatus, a double vowel resonance arises, because a comparatively low tone is generated in the pharyngea cavity and a higher one in the narrow pipe which leads out of it in front. For I (*ee* in *feet*) the tongue is applied to the hard-palate, so as to reduce the anterior channel to the smallest possible dimensions, and the highest limit of vowel resonance is reached. Diphthongs are sounded by the rapid consecutive formation of two different capacities, and other vowels (such as are used in Continental languages) are obtained by various gradations of the positions described. In the speech of every nation, and even in that of provincials and individuals, distinctions of vowel timbre are found, which, of course, depend on the production of diversities in the size and resonance of the vocal tube. The vowel-sounds distinguishable as separated by the ear may, therefore, be considered as more numerous than consonants, although in each language they are always relatively few.

Various efforts have been made to determine the precise note to which the vocal cavity resounds for each vowel as pronounced by the natives of different countries. The results for vowel-sounds, the same or almost similar, coincide very nearly according to some authors, but diverge considerably according to others. The best and most trustworthy experiments have been performed by Helmholtz by means of his resonators, which he has employed to ascertain what upper partials are reinforced most strongly whilst different vowels are sung. He also uses tuning-forks, which, on being struck, are held close to the opening of the lips when the mouth is shaped for the emission of each vowel. The vocal tube thus acts as a resonance chamber, which will reinforce sympathetically the vibrations of a tuning-fork that sounds the same note, speaking for itself, as it were, in this way as to its own pitch. After repeated observations by the combined aid of both these methods, which, however, in the case of the highest and lowest vowels, had to be supplemented by aural observation, Helmholtz is inclined to fix the pitch of the mouth for the various vowels used by the North Germans according to the following notation:—



U O A Ä E I Ö Ü[1]

Helmholtz has found the pitch of the mouth for the same vowels invariable in all ages and sexes. In women and children the want of capacity of the vocal tube is compensated by diminishing the opening at the lips.

An interesting point in the consideration of the subject is the existence of an antagonism between certain combinations of vowel and laryngeal sounds. Helmholtz, whilst confessing the incompleteness of his observations on this side, advances the proposition, implied above in the enunciation of his theory, that particular vowels cannot be sounded properly on certain notes of the voice because of an acoustic difficulty in producing a vowel resonance concomitantly with a laryngeal tone, which does not afford it a sufficient base in the natural series of partials. The evidence is too incomplete to follow

[1] The first six of these vowels are most nearly represented in English by the six described in the preceding paragraph, in the same order. The last two are unpronounceable in English, and correspond nearly, *ö* to the French *eu* in *peuple*, and *ü* to *u* in *pu*.

this question further here, and it will suffice to allude to the well-known fact, to singers at least, that all voices find a difficulty in forming vowels and syllables at the extremes of their compass. From my own observation, I am led to conclude that the obstacle in this case is in great part, if not altogether, of a mechanical nature. Pronunciation is most distinct at the level of the speaking voice, and becomes imperfect according as the laryngeal notes move away from this pitch in an upper or lower direction. In the lowest notes the contraction of one group of the extrinsic muscles of the larynx fixes the base of the tongue and greatly impedes the motions required for articulation. In the highest notes the tongue is also tied down by muscular activity, whilst the constriction of the pharynx and isthmus of the fauces hinders still more the various and rapid modifications of the vocal tube necessary for fluent speech.

Consonants—Their Formation and Classification.

Consonants, as their name signifies, can only be sounded in conjunction with a vowel. They comprise in fact a number of methods, each characteristic, of putting on or cutting off more or less completely the current of vocal sound, modified to the timbre of some one of the various vowels. The most obvious means of classifying consonants is derived from acoustic considerations, and from this point of view they admit of division into *explosives*, *aspirates*, *resonants*, and *vibratives*. They may be further subdivided by regarding the anatomical disposition of the articulating apparatus required for their enunciation. Hence they are also arranged as *labials*, *dentals*, and *gutturals*. Finally, consonants possess a third characteristic, which admits of their being distinguished as *breathed* and *voiced*.

I. 1. In *Explosives* the vocal tube is, for a moment, completely closed at some part of its course during phonation. Their enunciation is therefore accompanied by a kind of burst or explosion, occasioned by the sudden release of the confined air which is forced against the point of constriction by the chest. The explosive consonants form a class specially distinct from the rest, which, in opposition, may be grouped together under the term *continuous*.

2. In *Aspirates* the vocal tube is only partially stopped and the breath pours out, accompanied by a faint wind-rush, through the point of constriction.

3. In *Resonants* the vocal tube is completely closed at some position of its main, *i.e.*, oral, channel in the same way as occurs during the formation of explosives, but a free secondary passage is still left by the inaction of the soft-palate, and the voice passes out with a peculiar resonance through the nose. These consonants might also, therefore, be called *nasals*.

4. In *Vibratives* the action of the articulating apparatus is a combination of that required in pronouncing explosives and aspirates; *i.e.*, at one moment the breath is stopped, and at the next allowed to force its way through, in continued alternation. They consist, therefore, of a series of explosions, and the opposing surfaces at the point of constriction act as membranous reeds (like the vocal reeds themselves), which, however, vibrate too slowly and momentarily to give the sensa-

tion of a musical note. A kind of 'purr' is all that is heard.

II. 1. In *labials* the vocal tube is closed by the approximation of the lips, or by the lower lip being pressed against the upper row of teeth.

2. In *dentals* the tip of the tongue is pressed against the back of the upper front teeth, or against the part of the hard-palate which borders on them.

3. In *gutturals* the back of the tongue is approximated to the soft-palate.

III. The difference between *breathed* and *voiced* consonants is, that the former are accompanied at the moment of their pronunciation merely by a wind-rush, whilst the latter have a base of audible laryngeal vibration. These qualities are not so easily determined as the distinguishing characteristics between the various consonants of the explosive class on account of their momentary duration, but continuous consonants can easily be recognised as breathed or voiced by attentively observing their sound when prolonged indefinitely. Testing in this way, for example, S and Z, the former, when prolonged, is found to consist of a mere 'hiss,' whilst the latter has a strong foundation of tone proceeding from the larynx. Otherwise their formation is precisely similar.

After this description of the various qualities of consonants the following table, showing them ranged according to their respective groups, will be intelligible :—

EXPLOSIVES.

	Breathed.	Voiced,
Labials ...	P ..	B
Dentals ...	T ...	D
Gutturals ...	K ...	G

ASPIRATES.

	Breathed.	Voiced.
Labials ...	F	V
Dentals ...	S,L,Sh,Th (hard, Greek θ)	Z,L,J,Th (soft)
Gutturals ...	Ch (German, Greek χ)	Y (beginning a word)

RESONANTS.

	All voiced.
Labial	M
Dental	N
Guttural	NG

VIBRATIVES.

Labial (not used as a definite letter).

Dental	R
Guttural	R

A few words of explanation are required respecting some letters which are omitted in this table, and also as to some others which have special characteristics.

H is a breathed aspirate, but differs from all other letters in being formed in the larynx itself by the glottis, narrowed so as to produce a wind-rush, but not sufficiently so as to allow the vocal reeds to be thrown into vibration. It is therefore called the *spiritus asper*, or 'rough breathing'—denoted in Greek by a comma turned the reverse way (')—whilst words beginning with a vowel that are pronounced without this preparatory wind-rush are said to have the *spiritus lenis*, or 'smooth breathing.'

C is redundant, having at one time the power of K, at another that of S; also Q, which is equivalent to K, but is only used before the vowel U; and X, which is the same as Ks at the end of a syllable, and as Z when beginning a word.

L is formed by the passage of the mouth being left permeable at both sides of the tongue whilst the centre is stopped by the tip of the organ being pressed against the hard-palate. The English L is always voiced; the breathed L is used by the Welsh and is represented by the Ll, so well known in their local names of places.

Sh is the breathed equivalent of the voiced J, as it occurs in the French word *jamais*.

Th is formed by placing the front edge of the tongue between the two rows of teeth; the voiced Th would be more decidedly represented by Dh. They can be sounded less distinctly by pressing the tip of the tongue against the back of the upper front teeth, when they tend towards S and Z.

The English Ch is not a guttural aspirate, but a consonantal diphthong, sounding when breathed as TSh, when voiced as DZh or rather DJ. The latter is the sound of the English G soft, and also of J.

The dental R is produced by trilling the tip of the tongue against the hard-palate at the rate of about thirty vibrations in the second; the guttural R is formed by the uvula vibrating about nineteen times in the second against the back of the tongue.[1]

In *whispering* the vocal reeds are approximated so as to produce a wind-rush, like the *spiritus asper* continued indefinitely. This suffices to render recognisable the pitch of the note to which the mouth is tuned for the various vowels, and articulation is carried on in the same manner as in sonorous phonation. The distinction, however, between breathed and voiced consonants is for the most part lost, and B becomes P; D, T; etc., if entirely deprived of laryngeal tone.

[1] See Donders, *De Physiologie der Spraaklanken.* Utrecht, 1870, p. 18.

CHAPTER IV.

THE PHYSIOLOGICAL PRINCIPLES OF VOCAL CULTURE.

MANAGEMENT OF THE MOTOR ELEMENT (RESPIRATION)—MANAGEMENT OF THE VIBRATING ELEMENT—MANAGEMENT OF THE RESONANCE APPARATUS—MANAGEMENT OF THE ARTICULATING APPARATUS.

MANAGEMENT OF THE MOTOR ELEMENT.

(RESPIRATION).

Measure of Breathing.

DURING quiet respiration the chest expands and contracts, *i.e.*, we breathe, about seventeen times in every minute, as the tidal air flows in and out of the lungs. Under these circumstances inspiration and expiration occupy each less than two seconds, whilst the chest is seldom filled to its vital capacity or emptied of its residual air. But phonation completely alters this process, because voice is only produced during expiration. In speaking or in singing it is necessary, for the continuity of sentences or phrases of music, that expiration should be prolonged as much as possible. And lest utterances of words or notes intended to be delivered in close succession should be separated by an intolerable gap, which would give a disjointed character to a whole speech or song, it is also required that inspiration should be performed as quickly as possible. And further, as breath cannot be drawn in at any moment, but advantage must be taken of places where a pause occurs in the flow of words or stream of melody, the acts of respiration during phonation are of unequal length in contrast to the regularity of ordinary breathing.

Hence we see that in speaking or singing the function of respiration, instead of being carried on by a number of short breaths in which inspiration and expiration are duly proportioned, consists of a few long breaths, five or six in the minute, or even less, where the relations of inspiration and expiration are very disproportionate. In such cases the balance as regards the quantity of air required by the lungs for their vital operations is maintained by supplying them more copiously each time, and the chest is expanded more by inspiration, and generally parts with some of its residual air during expiration. And moreover voice production occasions a greater activity of the respiratory muscles during expiration than mere breathing, for if a soft tone is desired, the tendency of the chest-walls and lungs to contract has to be counterbalanced by the action of the muscles of inspiration, whilst the expiratory muscles are called on to labour vigorously whenever loudness of voice is required.

Under these circumstances the taking of breath demands the direct attention of the speaker or singer at every moment, and on his judgment and training depends the accomplishment of the function with ease and absence of embarrassment. On the one hand, he must be quick to notice the occurrence of all the pauses, and must even look out for them beforehand; and, on the other, he ought to be well acquainted with the capacity of his own chest in order to decide when the opportunities may be taken and when he can afford to let them pass by. It is in music especially that the artistic management of the breath is of the greatest importance, because in speaking the attention of the audience is not so much concentrated on sound as on sense. If the singer neglects a proper occasion he may have to squeeze all the residual air out of his chest before he can find another, or else mar the effect of a phrase of melody by a cacophonous gasp. And the evil may not terminate in a momentary difficulty if the chest is exhausted, for it must afterwards be replenished by a very long breath in order to prevent a repetition of the same trouble. A pause, however, which will allow of an extraordinary inspiration may not occur, and the vocalist may be kept for the rest of his song breathing at the lowest limit of his respiratory capacity. Now the expulsion of the residual air from the chest demands a considerable muscular effort, which increases up to the point where the lungs are emptied of all but their fixed air. In such case the stream of air cannot be propelled with sufficient steadiness through the larynx, a wavering sound will be produced, and it will be evident to the audience that the singer is straining himself. Such muscular straining, of course, soon creates fatigue, and as the consequence of a single mistake the singer may not regain his freedom of breath through a whole song, or perhaps during the length of an evening. And such awkward management of the breath may be habitual with vocalists who have not had the advantage of technical training, and they may exhaust their lungs unnecessarily, through inexperience, on each occasion that they sing.

The converse of the preceding proposition may also be considered, viz., the practice of filling the lungs too full at each inspiration, and singing always with a chest expanded almost to its vital capacity. The result here is nearly similar to that just described. Powerful muscular contractions are required in order to inflate the chest to the utmost, and of course the chest-walls, when released, tend to return with great force to their state of normal equilibrium. Consequently, the command over the current of air, to be thrown into sonorous vibration as it passes the glottis, is lessened, and the singer quickly becomes tired through over-exertion.

The foregoing remarks apply also to the speaker, but not always with equal force. For the orator or actor, during passionate declamation, may exhaust his breath, whilst the evident severity of his labour will only serve to constrain the attention and rouse the feelings of the auditors, so as to impress them most strongly with the importance or reality of the theme. Yet the actor will perhaps do better by imitating vividly the appearance of natural excitement, than if, by yielding entirely to the force of his representation and identifying himself with the presented character, he agitates and tires his system as violently as if torn by the convulsions of a veritable passion. For in the one case, indeed, he seems to practise that art which can conceal art, but in the other to abandon himself to an irrational phrenzy. And though the orator may sometimes allow himself to be carried away by the depth and sincerity of his impulses or the loftiness of his subject, on ordinary occasions, such as lecturing, for example, on a scientific topic, he must manage his breath with as much delicacy as a singer. Because when the understanding alone of the audience is addressed they will be more attentive to a smooth and consecutive flow of sentences, whilst their taste may be offended by an abrupt and gasping delivery.

Mode of Breathing.

We have seen that there are three sets of muscles which are capable of enlarging the thoracic cavity in different directions for inspiration. Now, in practising respiration with the mind turned towards the mechanism of the act, it is possible to use one or two of these sets almost to the exclusion of the remaining respiratory muscles, and it therefore happens that, on false theoretical grounds, or by accidental proclivity, a vicious habit of breathing, the so-called 'clavicular,' may be adopted. Thus a departure occurs from what ought to be the standard rule, *i.e.*, to breathe always naturally and to fill the chest in the manner which comes easiest. If this simple rule were invariably adhered to, there would be no occasion to compare the various kinds of breathing, and to decide from physiological data which is the most proper to be chosen. This question, however, must be briefly discussed here, in order to show why clavicular breathing should be generally prohibited.

During *abdominal respiration* the expansion of the thorax is obtained with the least expenditure of muscular energy. The only muscle concerned is the diaphragm, which descends by contraction, and thus shifts the lower chest-wall farther down into the abdomen. The opposition to this act is but slight, as the only parts moved are the abdominal viscera, which gravitation assists to carry downwards. Therefore this mode of breathing can be employed for a long time without fatigue, and by man, in fact, for an indefinite period, because the diaphragm, through constant action, gains an amount of endurance practically inexhaustible. But in woman the diaphragm is not brought so continually into play, for physiological (obstetric) reasons, of which, however, the potency, under ordinary circumstances, is probably considerably over-estimated. We may, indeed, conclude that the custom of confining the waist with a rigid corset, which compels the upper part of the abdomen in its whole circumference and probably the last two ribs to inaction, has generally the greatest share in restricting the abdominal breathing of females.

Costal or *lateral respiration*, where most of the ribs have to be raised *en masse* proportionately to the increase required in the capacity of the chest, is accompanied by no small degree of muscular effort. But, as the ribs to be elevated are sufficiently mobile and not hampered by superincumbent parts, this kind of breathing can be accomplished to its full extent without any excess of strain being put on the muscles engaged. Consequently it forms a salutary exercise for the chest and for the body generally, so that it may be practised habitually, though not exclusively, with advantage to health. The respiratory capacity included in the range of combined abdominal and costal breathing gives air enough for all the requirements of the artistic exercise of the voice, and a well-trained speaker or singer can rarely be obliged to exceed such limits.

Clavicular respiration, as already stated, is performed by a number of muscles which are not primarily intended to move the chest-walls. Their position and attachments constitute a kind of respiratory reserve which nature presses into service, if at any time an extraordinary effort of breathing be demanded, or when disease obstructs the motions of the diaphragm or lower ribs. And as these muscles act chiefly on the upper ribs, which not only possess little mobility on account of their size and stiff joints, but are, moreover, restrained by the bones and soft parts of the shoulders and neck being superimposed on them, clavicular breathing can only be effected by a kind of a struggle. For the muscles which are capable of lifting the shoulders off the upper part of the chest must first contract before room can be obtained for the elevation of the superior ribs. The consequence of such labour is rapidly supervening fatigue, which is greatly disproportionate on the side of excess to the trivial amount of respiratory movements executed. Hence we can perceive the error and injury of attempting to substitute clavicular breathing for the more natural and facile methods. And it may also be affirmed with confidence that no speaker or singer can practise it to any extent without showing a marked deficiency of endurance, which must lead to a complete defeat of his strength if called on to use his voice for a lengthened period, such as when engaging energetically in a protracted debate, sustaining a leading part in a five-act play, or singing through an opera.

Clavicular breathing is always betrayed by the motion it necessarily gives to the shoulders, which are alternately drawn up towards the ears and depressed. Should the habit be formed, it must then be got rid of by paying attention to keeping the shoulders immovable during respiration. Any difficulty in attaining this object may be surmounted by practising breathing with the back to a wall having projecting ledges, which can fix the shoulders and prevent their moving upwards, or the same purpose may even be effected by crossing the arms behind a chair and holding on to the rail behind.[1]

Respiratory Gymnastics.

Every action of the body accelerates the circulation, and is also, therefore, an exercise for the chest, because the more rapid flow of blood through the lungs causes them to demand a larger supply of air. This demand

[1] Mandl was the first to demonstrate the evil of clavicular breathing—*Gazette médicale de Paris*, 1855, pp. 244, 275, 294. Previously many teachers of note actually encouraged this mode of respiration, and the Paris *Conservatoire* promulgated the absurdity that in singing the breath should not be taken in the same manner as in speaking. 'Quand on respire pour parler ou pour renouveler simplement l'air des poumons, le premier mouvement est celui de l'aspiration, alors le ventre gonfle et sa partie postérieure s'avance un peu. . . . Au contraire, dans l'action de respirer pour chanter, en aspirant il faut aplatir le ventre et le faire remonter avec promptitude en gonflant et avançant la poitrine.'—*Méthode de chant du Conservatoire de musique*, p. 2.

may, however, be met simply by quickened respiration, so that instead of seventeen breaths in the minute, thirty, forty, or even more may be taken. In such case there is no influence at work which can increase the lung capacity, and it therefore becomes necessary to organise a system of gymnastics with the direct object of developing the chest.

The first point to which attention must be directed is to obtain a proper position of holding the chest, whereby the ribs may be allowed, as much as practicable, a free and extensive mobility. For when the muscles of the trunk are not vigorous, the various parts which it is their office to support are abandoned to gravitation, and a stooping posture is maintained. Thus the shoulders, with the arms dependent from them, droop forward and lie passively on the top and upper parts of the sides of the chest, whilst the spine, instead of preserving its forward curve at the hinder part of the abdomen (small of the back), relaxes to verticity, so as to lower the thorax, laterally and in front, until the last ribs rest on the pelvis (hips). In this way, as the pelvis rests on a seat or through the legs on the ground, the muscles are relieved in great part from their task of sustaining the body erect. But, as a consequence, the chest is built up in such a manner by its contiguous structures that its osseous case is rendered nearly immobile.

Hence it appears that the preliminary action in respiratory gymnastics should be *to draw the shoulders backwards, and to advance the chest forwards and upwards, by giving the spine a strong forward curve* *at the hinder part of the abdomen.* At the same time the arms should not be allowed to hang against the sides of the chest.

The next proceeding should be to practise the different modes of breathing. The activity of the diaphragm, as evidenced by the power of protruding and retracting the abdomen during inspiration and expiration, whilst the ribs are retained nearly motionless, should be encouraged. And when the pupil has drawn a full abdominal breath, costal inspiration may follow, and occasionally, at the last, the chest may be expanded to the utmost by a clavicular effort. But the natural sequence of the different kinds of respiration should never be disturbed. It should be seen that the abdomen is first expanded, then the lower ribs, and only at the extremity of inspiration should any motion of the shoulders be permitted, so that the lungs may be inflated to the maximum extent. As a rule the exercise should be restricted to the abdominal and costal breathing; but an occasional clavicular inspiration in its proper place may be allowed, in order that the pupil, by being accustomed to the highest limit of chest expansion, may be enabled to practise the intermediate movements with more facility.

Furthermore, it is important to observe that this factitious breath-taking should not, especially at the commencement of a course of training, be pushed too far at each lesson. After every two or three efforts it ought to be alternated with movements of the arms, and with pacing up and down for a few steps with an erect carriage. By thus engaging the pupil in a positive muscular exercise, a natural incentive is obtained to increased respiration, and the breath training will proceed more effectually. Otherwise, to draw a number of long breaths for reasons that are purposeless as regards the immediate requirements of the animal economy, cannot fail to upset the pulmonary and vascular equilibrium and to produce a transient exhaustion.[1]

Management of the Vibrating Element (Vocal Reeds).

Whilst our knowledge of the physiology of the larynx is incomplete, a considerable part of this division of our subject must be given up to empirical treatment, and the ear must be guided by results to act as chief arbiter of the utility of many practices relating to voice training. In all cases the ultimate appeal must be to the ear, but a basis for the successive steps of any process of voice development must nevertheless be sought for in physiology. Where such a basis is wanting, the result often fails to justify the means adopted, and the object which from the first was aimed at is not attained.

The cultivation of the laryngeal powers has for its purpose, (1) *to augment the force of the sounds that can be produced*, (2) *to modify their timbre*, (3) *to extend their compass, and* (4) *to increase the executive faculty of the laryngeal muscles.*

In training the speaking voice power and timbre

[1] The most accurately systematised series of breathing exercises, very much in accordance with the principles enunciated in the text, will be found in Monroe's *Vocal and Physical Training*, Philadelphia, 1869, p. 19 et seq.

only, so far as the larynx is concerned, claim close attention, because the sounds employed are concrete and the range of pitch is limited. Thus the voice glides up and down without marking the intervals that form notes, whilst its excursions seldom comprise the compass of an octave.

In singing, on the contrary, discrete sounds are emitted, so that changes of pitch are effected by leaps of not less than a semitone,[1] whilst the entire range of notes of which the voice is capable is often traversed. Hence every activity that the larynx possesses is called into play, and the physical training of the organ is, therefore, of a much more complicated description.

Force and Timbre.[2]

Force and timbre, as far as the vocal reeds are concerned, may be treated of together, because in the larynx they are practically inseparable, and only modifiable by identical and simultaneous efforts. Force of voice depends very much on the firmness and elasticity of the vocal reeds and on the accuracy with which their opposing edges fit together, as they are thus most apt for the isochronous vibration which is the characteristic of

[1] A glide, called *portamento*, is, however, occasionally admissible in singing. Quarter tones are used in Oriental music.

[2] Loudness of sound may be considered as a compound quality, constituted by two factors, viz., intensity and volume. In voice, intensity is primarily governed by breadth of the vocal bands, and volume by capacity of the resonance chambers. In persons, therefore, with a powerful voice the laryngoscope will show a remarkable width of the upper surfaces of the vocal reeds, and a striking amplitude of the pharynx, mouth, and nasal cavities will also be observed. In he opposite case the appearances will be the reverse.

musical tone. They must be homogeneous in density, and the muscular contractions which hold them together and regulate their tension must be exactly balanced, so that all their parts may respond alike to the current of air issuing from the lungs. Should their edges be uneven, their substance hard in one spot and soft in another, or their tension dissimilar on opposite sides, the pressure of the air has a different effect according to the part at which it strikes, irregular sets of vibrations are generated, and, instead of a tone of fulness and volume, a harsh, jarring sound, a mere noise in fact, is produced. As far as physical inequalities of the vibrating element are concerned these phenomena may be dismissed without further notice here, because in the normal state the vocal reeds are always homogeneous in structure and symmetrical in form.[1] One of the chief causes of a rough, unmusical voice is disparity of action between the various pairs of laryngeal muscles. The tone of the voice is, therefore, governed almost wholly by the will of the speaker, and according to the delicacy of his ear will be tuneful or the reverse. That the ear is mainly instrumental in producing refinement of vocal tone is proved by the example of persons who, being born incurably deaf, have been taught to speak, as in such cases the voice remains harsh to the highest degree. On this account the voice becomes an index of mental and social status, by which we can distinguish the uneducated from persons of culture, as the aural perceptions are generally

[1] An elevation of the edge of one of the vocal bands, causing an unsteadiness of pitch when singing, sometimes exists without any evidence of past or present disease.

in a state of development proportionate to that of the other senses.

Persons in trying to speak with a sonorous voice too frequently strain the muscles of the chest and pharynx by violent efforts to expel the air with excessive force, whilst the action of the vocal reeds is entirely disregarded. But the best way to fill a large hall is to contrive to press as many regular and ample vibrations as possible into each syllable uttered,[1] on which account the words should be somewhat more prolonged than in ordinary conversation. In singing, though the same fault may occur, it is guarded against to a great extent, because so much more watchfulness is demanded over the musical quality of the notes.

In voice practice, therefore, with the view of obtaining a full and pure tone, attention should at first be mainly fixed on the laryngeal vibrations. For this purpose the exercise of vocalisation, *i.e.*, the exclusive emission of vowel-sounds, as adopted by the old Italian school of singing, and still kept up by many modern teachers, seems most plausible. By this means the observation can be concentrated on the character of the laryngeal tones without being turned aside at every moment by other actions, because the vocal tube and articulating organs either remain completely at rest or execute very slight movements according as a single vowel or a succession of vowels is employed.

An action of the vocal reeds, encouraged by many

[1] Allowing, of course, for pitch. Apart from the choice of resonant vowels, such is the only mode I can conceive physiologically of producing the so-called 'orotund' voice.

teachers of singing, and termed the 'stroke of the glottis' (*coup de glotte*), appears well adapted to steady the working of their muscles either for speech or song. Usually at the beginning of phonation the vocal reeds approach during expiration and commence to vibrate as soon as they come near enough to interrupt without absolutely breaking the continuity of the issuing stream of air.[1] But in practising the stroke of the glottis the vocal reeds are first tightly approximated, so that a condensation of the air in the thoracic cavity precedes the emission of tone, which consequently commences by a slight explosion, arising thus in a manner mechanically similar to the explosive consonants. The notes begun in this way strike the ear with an initial sharpness of definition and firmness of tone which add to their musical effect. This stroke of the glottis should, of course, be produced without any more marked effort than occurs in the pronunciation of *p* or *b* by the lips. To attain the perfect execution of it the pupil should first learn to explode the glottis on whispered vowels, for which purpose the short *u* in *up*, as recommended by Monroe, appears specially adapted.

Extension of Compass.

The extension of vocal compass may be obtained by specially practising the voice at the extremes of its

[1] In speaking, however, Helmholtz thinks the vocal bands act as striking reeds. In holding the breath the ventricular bands are brought together tightly and the ventricles are inflated, as first observed by Galen (apud Oribasium, lib. xxiv. cap. 9), and recently confirmed by Wyllie. The same action is probably necessary for the proper execution of the *coup de glotte* as suggested by Lunn (op. cit.)

natural scale. If a gain in the lowest notes is desired, it is necessary to produce an extraordinary relaxation of the vocal reeds. As, however, there is great difficulty in making them vibrate harmoniously, or even at all, when much slackened,[1] one or two notes will usually represent the whole sum of success in this direction, but at the same time the tone of deep notes already existent may be considerably developed.

At the top of the chest-register we have seen that a kind of dead-lock occurs when the crico-thyroid chink is closed and the opposing margins of the cartilages come into contact. Hence it is evident that an almost insuperable obstacle exists in the way of pushing the voice upwards in this register. To try to do so is to attempt the compression of the dense cartilaginous material which, if at all practicable, must call forth a hazardous amount of muscular strain. As far as the vocal reeds are concerned they would probably bear more tension than is ever put on them ; but since the cartilages interfere, it will doubtless be wisest to be content with improving the qualities of the chest-notes actually possessed. When this has been done, an upward gain of a semitone or two will generally be found within easy reach.

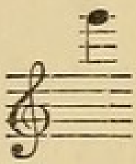
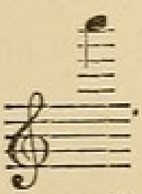
To the upward extension of the falsetto register there would appear to be less opposition, acoustic or physiological, than in either of the instances just noticed. For here, indeed, it seems that the vocal reeds should still be able to vibrate strongly, though excessively shortened by

[1] Müller instances the deep croak of frogs to show what grave tones can be drawn from short membranous reeds when greatly relaxed.

constrictive action, whilst the curtailment of their length is not quickly checked by a mechanical impediment, but is ruled more remotely by power of muscular contractility. And these considerations are practically exemplified by the extraordinary falsetto range for which many celebrated singers, mostly females, have been noted, some of whom could attain to a pitch even an octave above the usual limits of voice.[1] The main obstacle, therefore, to the upward development of the voice in this register must be sought for in the natural constitution of the vocal organs with respect to vigour and tonicity in various individuals. Should the pupil be endowed with perfect soundness and strength of all the parts engaged, an acquisition of two or three tones, or even more, may be the reward of careful and assiduous practice. Under the contrary conditions, however, the vocal organs will break down under the strain if the exercise be not kept strictly within the boundary prescribed by the natural gifts.

Vocal Execution.

A rapid execution is probably more frequently a positive acquirement than any other of the qualities displayed in singing, and flexibility of voice may be looked on as the special prize of diligent practice. The

[1] *E.g.*, Mara could sing *e'''* ; Catalani *g'''* ; and Aguiari *c''''* . The last fact rests on the testimony of Mozart. See Fétis, *Biographie universelle des musiciens*, Paris, 1860–65, sub nominibus.

laryngeal muscles deserve to be signalised beyond all others for power of making minute movements with extraordinary exactitude—a property which is doubtless derived from their being able to rely on so delicate a guide as the ear. They can determine the amount of their contractions with the utmost precision, and can pass with preconception between degrees farthest apart either instantly, through a succession of equal intervals, or by the most complicated irregularity of distances. A wide field is here open for the ingenuity of the composer or teacher of singing to systematise solfeggi or vocal exercises, which shall contain every possible transition between the various notes in ascending or descending the scale, commencing with the simplest movements, and advancing insensibly to the greatest complexity. An important point to be kept in view during this kind of practice is to facilitate the passage from one register to another by endeavouring to amalgamate the notes in the vicinity of the break, especially those that can be sung in either voice at will. It should, however, be carefully ascertained at what points breaks actually do occur in each voice that comes under notice. It cannot but be injurious to force all voices indiscriminately to make a change of register at one and the same position in the musical scale.

Management of the Resonance Apparatus (Vocal Tube).

The questions here involved relate mainly to pronunciation of vowels. There are, however, some superadded qualities, individual or national, of vocal timbre which may be treated of separately. Thus a *guttural* or *nasal* character may be given to every vowel-sound, though otherwise well defined, by an improper predominance of pharyngeal or nasal resonance.

In the first case the fault lies in the pharynx and mouth not communicating by a sufficiently capacious opening. The causes of such a condition depend either on anatomical conformation or on peculiar and habitual muscular action. The tonsils may be enlarged so as to block up the upper part of the pharynx, or the soft-palate and uvula may be elongated, so as almost to reach the posterior surface of the tongue. Or the individual may be in the habit during speaking of maintaining the tongue in a position arched upwards and backwards, so that it approaches the soft-palate too closely, whilst there may be at the same time an excessive contraction of the muscles of the fauces. Under these circumstances the laryngeal tones will be almost deprived of oral resonance, and, not having a free passage for exit, will have a guttural and muffled sound. In such instances the remedy must be adapted to remove the cause, and if the tonsils or uvula are abnormally large, a part of them may be removed by a simple and momentary surgical operation. And the effect of excision of the tonsils may not only be to render the voice clear and sonorous, but may also allow the compass to be extended one or two notes higher.[1] For the action of the extrinsic muscles of the

[1] It is stated that 'many of our greatest singers, from Madame Patti downwards, have undergone the operation' with the best results.—Browne, *Medical Hints on the Singing Voice*, 1877, p. 30.

larynx, which is so essential in the production of high notes, is greatly impeded when the pharynx is blocked up by an enormous pair of tonsils. But when the vicious tone of the voice is due to injudicious management of the muscles of the tongue and pharynx, a course of gymnastic training of the parts will soon induce them to the habitual assumption of the proper positions.

With respect to excess of nasal timbre, its causes are also twofold, and it may arise from a deficiency of the soft-palate, which renders the occlusion of the posterior nares impossible, or it may be simply the result of an imperfect action of the same organ. In the former instance the fault will often be irremediable as far as regards purity of tone ; but when it is merely a question of muscular control, the pupil should be made to observe the action of the soft-palate, and to practise its elevation before a mirror. If, at the same time, the attention of the ear is thoroughly awakened, the voice may soon be freed from the objectionable timbre.

Another point which deserves notice here relates to a practice by no means uncommon, viz., the keeping the teeth shut during speaking or singing. A considerable loss of resonance is the consequence, because the cavity of the mouth is never placed in the best position for reinforcing the laryngeal tones, and also because the sound-waves cannot issue with sufficient freedom to the external air. It is only necessary to recognise the habit, where existent, in order that the inclination to it may be overcome by the will.

Management of the Articulating Organs.

Vowel Timbre.

We have seen that the difference between the various vowel-sounds is not one of kind, but merely of degree, and that they depend on the pitch of the note proper to the resonance cavity formed by the pharynx and mouth. As this cavity can be reduced by infinite gradations from its greatest to its least capacity, whilst the procession of vowels used in any one language advances by steps of about an octave, it follows that the lowest can be made to pass insensibly into the highest through all the other members of the series successively. It is, therefore, possible to produce as many vowels as will correspond to each note, or rather degree of pitch, obtainable from the vowel-cavity. According as our ear recognises them to approach nearest to one or another of the vowels familiar to us, we class them as varieties of those they most resemble. Hence arises mainly the endless diversity of pronunciation observed in individuals, provincials, and nationalities.

With these facts in view it is easy to understand how many shades of timbre the voice can be made to yield at will. Of these some add sonorousness, some brightness, others softness; whilst others, again, are disagreeable. Thus, in the emission of *a* (as in *father*) the fullest volume of vocal tone can be generated, because the dimensions of the buccal cavity and the size of the oral aperture are most favourable to the formation of strong vibrations. And for the reverse reasons the vowel *e* (*ee* in *feet*) deprives the lower tones of the voice of power, though, on account of its sharpness, it renders high notes penetrating. The choice, however, of vowels, or modifications of them, is a complex matter which must be decided by the taste of the pupil or his teacher.[1] It is sufficient to have indicated here the principles on which change of vocal timbre is made. In accordance with these principles, an exercise may be devised for practising the enunciation of all the grades of vowel timbre. A good understanding of the state of the vocal tube for the different vowels, and the custom of directing the attention to it, will greatly facilitate the accurate imitation of the peculiar vowels found in foreign languages.

Consonants.

A rapid and well-defined pronunciation of the various consonants, either in speaking or singing, requires a considerable amount of lingual and labial dexterity. The tongue or lips may be naturally clumsy and awkward in their movements or the reverse. In order to attain to a good execution in articulating consonants, it is usually only necessary to practise the utterance of numbers of syllables containing every pronounceable combination and succession of them[2] under the empirical guidance of the ear. But, of course, a correct idea of the positions of the parts concerned in the formation of each letter will render the task more easy. In a certain

[1] See Ellis, *Pronunciation for Singers*, 1877.

[2] See Hullah, op. cit. Appendix, and Bell's *Standard Elocutionist*, p. 29.

class of persons, however, the action of the vocal organs is specially defective, so that speech, even for ordinary purposes, becomes a matter of great, and occasionally of almost insuperable, difficulty. This leads us to the consideration of defects of speech.

Stammering and Stuttering, or Psellism.

Such affections have been well known from the earliest times, and are often alluded to by Hippocrates;[1] but nevertheless it is only within the present century that systematic endeavours have been made to discover their causes, and to invent suitable modes of treatment. Already considerable success has been attained with respect to the latter object, although no wholly satisfactory explanation of their intrinsic nature has yet been furnished to us. It is evident, however, that a multiplicity of causes are at work, and that the disability of any of the organs of voice, from the chest to the lips, is sufficient to disturb the consentaneous action of the entire series, and produce the phenomena of psellism.

Stammering may be defined to be indistinctness of pronunciation, arising from the letters of the alphabet not being properly formed by the organs of articulation. It most frequently arises from a muscular defect, giving rise to a clumsiness in getting the tongue round one or more letters, which are, therefore, so imperfectly enunciated as to be unrecognisable; or one letter may even be habitually substituted for another; or the difficulty may only be in combining the sounds of certain letters.

[1] *Præceptiones*, c. 6; *Aphorismi*, s. vi. 32; etc.

In some cases stammering may be the result of mere carelessness or too great eagerness in speaking, so that the words are clipped and successive syllables are allowed to run into one another in a confused manner. In a few instances, however, a decided malformation of the speech organs exists, such as cleft-palate, abnormal enlargement of the tonsils, or shortness of the *frænum linguæ*. A classification of stammering has been attempted according to the character of the defect noticed in different cases. Thus faulty pronunciation of *g* is termed *gammacism*, of *l*, *lambdacism*, of *r*, *rhotacism*, of *j*, *iotacism*, lisping, *sigmatism*, etc.

The *treatment* of stammering is simple and obvious. The pupil should be made to repeat the alphabet slowly, and a note taken of every letter that is ill-formed, and he should also be made to read aloud. From such experience, a series of suitable exercises in pronunciation must be given him to practise. The instructor should be a good practical orthoepist, and should see that the tongue, lips, etc., are put in the proper position for each letter. He should show the pupil, in his own person, the action of the articulating organs, and desire him to imitate them. If the stammering arises from hasty and impetuous speech, a slow and distinct delivery must be inculcated. Of course, if there is a malformation, surgical assistance must be sought.

Stuttering[1] is a much more important disorder and more complicated in its physiological relations. Here

[1] The distinction between stammering and stuttering is not always accurately drawn, and the terms are often employed interchangeably both in speaking and writing.

we have rapid repetitions of a letter, usually one of the explosive consonants, convulsive stoppages of articulation, and sometimes even contortions of the face and limbs before the utterance of each sentence, or possibly of every word. Notwithstanding the attention that many eminent observers have given to these phenomena, their nature is still in great part obscured, and conflicting theories are held by some of the most exact investigators.

The subject of psellism has been dealt with by a crowd of authors, each of whom has classified the subject and modified the treatment in accordance with his own peculiar mental bias. Of these Hunt[1] may be cited as the writer of the most elaborate and systematic treatise. But the most able and important of the recent literary contributions in this field is due to Guillaume,[2] who, from having suffered himself, has had special practical advantages in studying the affection. The measures in which he places his confidence are, (1) keeping the tongue steadily raised to the palate, (2) taking an ample inspiration at the beginning of each sentence, and (3) careful attention to ensure correct movements of the lips. He further counsels the use, when necessary, of a small wedge to keep the teeth apart, and dwells with considerable weight on the practice of whispering exercises.

From observation of various cases and examination of the chief theories that have been propounded relative

[1] *A Treatise on Stammering and Stuttering.* London, 1870.

[2] *Dictionnaire Encyclopédique des Sciences Médicales.* Paris, 1868, art. *Bégaiement.*

to stuttering and the modes of treatment that have been adopted, it is manifest that the affection is one of great complexity, and to which, according to circumstances, diverse remedies must be applied with considerable judgment. Thus, to summarise the subject as far as practicable, we see that five principal groups of muscles may be implicated, separately or in various combinations, viz., the muscles (1) of the chest, (2) of the larynx, (3) of the tongue, (4) of the jaw, and (5) of the lips. And the nature of the disorder may be either *spasmodic*, so that the muscles take up a fixed position which can only be overcome by a strong and often prolonged effort of the will; or *choreic*, so that when called on to act they perform a series of eccentric and involuntary movements instead of being instantly subservient to the wish of the speaker. And beyond all this, there is still a mental influence, a nervousness or timidity, which must be banished before the vocal organs can be ruled by the volition into a perfectly concerted action. Hence the first object in treating a case must be to obtain the co-operation of the pupil, and his anxiety must be aroused to conquer the defect. This done, a great step in advance will have been made, as is evidenced by the fact that a marked amelioration of stuttering usually occurs on arrival at adult age, whilst occasionally the affection quite disappears about that time of life. This circumstance no doubt arises from the awakening of the reasoning faculties and the confirmation of the powers of the mind, which then assumes a more discretionary control over the impulses of the body. As soon as the pupil has been engaged to assist the teacher with his own endeavours, an attempt to discover the main spring of the disorder may be made, and such of the exercises above mentioned as seem most suitable to the case put in practice. The system of Guillaume promises the best results; but every voice-trainer will have to draw largely on his own judgment, and, in the present state of our knowledge, empiricism will sometimes guide most directly to the desired end.

The *originating causes* of stuttering are not well ascertained, and in many cases where it appears to date from infancy it can only be attributed to some accidental organic defect. But sex predisposes very markedly to the affection, and a striking majority of the examples met with occur in males. Thus, of all the instances observed by Colombat and Hunt, only about 10 or 12 per cent. were females. The latter author also endeavoured to discover the origin of 200 cases that he treated, and found that 7½ per cent. dated from convalescence after illness, such as fever, measles, whooping-cough, etc.; 5 per cent. were the result of fright or ill-usage at school; 4 per cent. were caused by voluntary, and 9 per cent. by involuntary, imitation; 10 per cent. were stated to be inherited from the father, and 5 per cent. from the mother; whilst the remainder, 49½ per cent., could not be accounted for.

The numerical relation of stutterers to the whole population is reckoned by Colombat to average about 1 to 5,397. Hunt, however, and some other observers make the proportion much higher, viz., 3 per 1,000.

CHAPTER V.

THE HYGIENE OF THE VOICE.

SPECIAL HYGIENE OF THE VOCAL ORGANS—GENERAL HYGIENE IN ITS RELATION TO THE VOICE.

Scope of the subject.—The relations of the voice to the general health of the body are of the most intimate and complete description. The hygiene of the voice in its fullest sense is, therefore, the hygiene of the whole animal economy; and the spirit of the well-known proverb, which sets forth how closely is interwoven the integrity of mind and of body, might with equal propriety be applied to the voice in the form of '*vox sana in corpore sano.*' At the same time, however, the voice, like the mind, has a sphere of its own, within which it may be affected, for good or il!, without immediate reference to the state of the constitution. Hence its sanity may be treated of under the twofold aspects of a general and a special hygiene. The latter, as the more immediate, though less familiar and less investigated, may be first discussed.

SPECIAL HYGIENE OF THE VOCAL ORGANS.

In this section we may consider how far the state of the vocal organs with respect to soundness and vigour may be influenced by their own actions, *i.e.*, by the exercise, moderated or exaggerated, of the voice; whilst at the same time some appropriate rules may be laid down of preservative and remedial hygiene. In the professional use of the voice the parts concerned are urged to perform their functions to a much higher degree than is ever exacted by the ordinary exigencies of social life, and they are, therefore, subjected to a marked intensifying of the conditions, both intrinsic and extrinsic, under which they usually act, whence a signal alteration may be effected in their physical structures.

Voice is generated mainly as the result of two consecutive and specially combined movements, the one primary and vital, namely, activity of muscle, the other secondary and material, viz., motion of air. To these two relations may be traced all the physiological effects of vocal exercise.

Direct Results of Muscular Activity.

The systematised daily use of the various groups of muscles called into action during phonation impels them to gain in size and strength as long as the efforts made do not exceed from time to time their proper powers. Hence follows increasing ease in performing the respiratory functions and extension of the initial faculties of mobility of the larynx and articulating apparatus. The nutrition of the local muscles and all the contiguous structures is carried on with more than ordinary energy; they glow with health and their growth is accelerated.

Precisely the opposite phenomena are produced by over-exertion. In this case the muscles become exhausted and diminished in bulk and vigour because the waste of their tissues entailed by the excessive action is pressed beyond the reparative powers of the vital forces, and fresh material cannot be laid down in an equal quantity to that which passes away as effete. At the point when labour becomes inordinate fatigue is felt, and rest becomes a necessity, whilst in the interval of cessation from work the parts that had suffered from too much wear and tear are restored to their normal state.

Over-exertion may be of two kinds. Thus it may consist in sudden and violent effort, or in a prolongation of ordinary movements until endurance is completely spent. In the former case the harm partakes more of the nature of an injury; some of the tender fibrils of the muscle, and of the minute blood-vessels or capillaries which traverse it, may be torn across. Hence there may be soreness, pain, and swelling, or even inflammation, the results in fact commonly recognised as occurring from a strain or sprain. Recovery from such a condition is often protracted. In violent vocal efforts the muscles engaged may suffer in this way, whence the chest may for some time after feel sore to the touch and during respiration. But the muscles most likely to be strained are those of the larynx, because they are called on to contract very forcibly in order that the vocal bands may resist by their steady approximation the impetuous rush of air from the lungs. Hence results what is sometimes spoken of as 'a strain of the vocal cords.'[1] Such an accident is soon betrayed by hoarseness, which, however, generally disappears spontaneously after a few days of rest. But weakness of voice may often be a troublesome symptom for a considerable time.

The consequences of persistent speaking or singing, in spite of great fatigue being felt, are somewhat similar to those just described, but of a less pronounced character. On single occasions, therefore, recovery is usually rapid and complete after a short interval of repose. The evils, however, to be here considered are those attendant on repeated and habitual exertion of the vocal organs beyond the enduring power of the individual. In such instances the fundamental cause at work is generally some vice of voice-production—that is to say, a well-trained voice can seldom suffer from over-fatigue, because the vocalist has learned by precept and experience how to make the best of his natural gifts. Thus, even a feeble voice can be saved, by judicious management, from the consequences of oft-repeated fatigue. Such a result depends mainly on well-regulated respiration and attention to the formation of the laryngeal tones.[2] But when clavicular or other improper modes of breathing

[1] Positive strains of the voice are now rarely met with, but were common enough in classical times, when the *phonasci* had to force their voice to the utmost in order to fill the enormous theatres. Thus Galen: 'Phonasci, qui magno vocis exercitio utuntur, quum contendendo oblæserint vocem. . . . balneis multis utuntur, et cibos lenes, ac laxantes edunt.'—*De Compositione Pharmacorum secundum Locos*, l. vii. c. 1. According to Q. Serenus Sammonicus, Hortensius strained and permanently lost his voice from declaiming intemperately in the Roman forum.—*Præcepta de Medicina*, c. 15.

[2] See last Chapter.

are employed, the muscles of the chest-walls soon become tired out. And the evil tends to augment on every subsequent occasion, because the use of the voice, instead of being a tonic exercise for the chest, becomes a debilitating one. Hence the voice loses in fulness and steadiness, and becomes weak and trembling. So far, then, a radical exhaustion of the respiratory muscles sets in, and this is one phase in the convergence of contingencies under which a voice may be worn out.

But the most striking and frequent troubles are those which follow faulty usage of the laryngeal and pharyngeal muscles. When the individual, instead of throwing his vocal bands into even and ample vibration by equable and carefully-moderated expiration, continually resorts to blowing a powerful blast of air through the glottis, both the intrinsic and extrinsic muscles of the larynx must be maintained in an almost constant state of vigorous contraction. Under these circumstances, as in all overtaxed muscles, the overplus of effete products generated by the exertion cannot be removed readily by the proper channels, but accumulates. As a consequence, the substance of the muscles becomes turgid, the capillary vessels traversing it are partially obstructed, and much of the blood sent to the part, instead of flowing through measuredly, collects there and increases the intumescence. Such is the condition generally described as congestion. When occurring in the laryngeal or pharyngeal muscles, hoarseness invariably results, because the delicate movements necessary to regulate the tension and approximation of the vocal bands are clogged and cannot be executed with precision. Unequal vibrations are therefore produced. At the same time, there may be little or no appearances of disease, because the mucous membrane which forms the surface and invests the affected muscles may remain intact. Such, when induced by fatigue of the voice, appears to be the incipient stage of the malady, formerly called *Dysphonia clericorum*, or clergyman's sore throat, but now, through a better knowledge of its etiology and nature, more properly termed 'glandular sore throat.'

After repeated congestions, however, the mucous membrane becomes deeply implicated, and more or less chronicity then characterises the disease. In this stage its chief features consist in the swelling of numerous minute glands,[1] which dot the surface of the larynx and pharynx. Their office is to secrete and discharge the lubricating fluid which is so essential to keep the inside of the throat moist and supple. As soon as they participate in the congestion, their orifices become choked and the fluid collects in them. They then appear like granules or small grains of shot, studding the surface of the mucous membrane. Still later on the secretion distends them to such an extent that they re-open or burst, so as to let it exude. It has then become so altered from its natural state, being thickened and of a chalky whiteness, that it remains at the opening whence it issues as a small white patch, or even projects or hangs down from it like the end of a white thread.

The symptoms of sensation which accompany these

[1] Called 'racemose,' from their resemblance to a miniature luster of grapes.

phenomena are a feeling of irritation or pricking, heat, and slight soreness in the throat. A short cough is sometimes present.

The effects on the voice are marked, and generally destructive as regards its artistic use. Hoarseness, more or less pronounced, is present, and singers especially complain of a loss of their high notes. This latter consequence arises from the thickening of the mucous membrane, which in the larynx prevents the vocal bands from being properly approximated and tensed, and in the pharynx interferes with the action of the extrinsic muscles, which draw up the larynx and fix and compress the wings of the thyroid cartilage.

A less frequent consequence of abuse of the vocal powers is to provoke the growth of polypi, or warts, on or near the vocal reeds. Such new formations are likely to be engendered by tissues which are irritated by being kept in a state of constant congestion. So with the larynx when the voice is frequently over-exerted. The existence of anything of the kind in the larynx is almost immediately felt by the singer, because so slight an alteration in the normal condition of the parts disturbs the formation of the high notes. But the speaker may often go on until the growth attains a considerable size without suffering much inconvenience. If not properly remedied, polypi of the larynx sometimes lead to complete loss of voice.

Influences of Aerial Motion.

We have already seen how a violent effort of the expiratory muscles is transmitted by the body of air in the chest so as to provoke a tantamount action of those of the larynx. Thus, the one set of muscles strives to expel, and the other to confine, the current of breath.

A further phenomenon of such compression of air in the thoracic cavity has to be considered here, viz., its effect on the lungs themselves. In this connection we find another cause of loss of respiratory power; for the delicate air-cells of the lungs yield suddenly or gradually before the pressure and become dilated. The consequence is immediate laceration and subsequent obliteration of the complex arrangements of fine blood-vessels on their walls which necessarily exist in order to allow of the performance of the essential pulmonary functions. By such an occurrence a portion of the lung is irrecoverably lost as regards respiration, and if the injury is at all extensive a decided dyspnœa, or shortness of breath, results, which of course may be translated into an equivalent diminution of vocal power.

The *mode of inspiration* adopted or necessitated in speaking or singing, as already dwelt on in one connection, forms one of the most important hygienic relations of professional voice practice. It has still, however, to be dealt with under another aspect, which draws our attention to the distinction between breathing through the nose or mouth. As a rule, we inspire through the nose, and there are cogent reasons why that method of breathing should be regarded as beneficial and protective.

In the first place, the atmosphere is almost always much colder than the blood, and for this reason, if it were allowed to impinge in a direct current on the lining membrane of the air-passages or lung-cells, such a disturbance of function would be likely to ensue as would lead to inflammation of those parts. It is therefore indicated that the air, before arriving in the windpipe and lungs, should be warmed. This requirement is usually fulfilled by the nose. For as the breath is drawn through the several narrow nasal channels, into which each nostril subdivides, its temperature is considerably augmented, and by the time that it has passed down the whole length of the pharynx to the larynx it has arrived nearly at blood-heat.

In the next place, the atmosphere is full of impurities which ought to be eliminated from it before it passes into the interior of the body. As may be seen in a sunbeam, numberless particles of an infinite smallness are continually floating around us, and these being collected and examined by the microscope are found to consist of substances derived from every kingdom of nature. The fine dust of metals and of minerals is mingled with the pollen grains of the highest orders of plants, with the germs of the very simplest forms of vegetation, algæ and fungi, and even with the living bodies of minute animalcules.[1] The air is also contaminated by diverse gaseous emanations, such as the carbonic acid proceeding from animal respiration, putrid effluvia from drains,

[1] See Parkes, *Manual of Practical Hygiene*, p. 93. The air is so crowded with active germs that if a vessel of the purest water be left exposed to it, it will soon swarm with countless growing atoms of animal and plant life; to such an extent, that formerly it was believed that the agency at work could be none other than spontaneous generation. See Tyndall, *On Dust and Disease*, in *Fragments of Science*, 1875, p. 126.

marsh miasmata, etc., and by various subtile essences, incapable of being recognised by scientific tests, generated by diseased processes in the human body. The atmosphere forms, therefore, a rich reservoir whence injurious matters may find their way into the animal economy. In passing through the nose, however, the air becomes very much purified, because almost all dust is arrested in the narrow and tortuous *meatus*, especially so on account of the lining membrane (pituitary) being generally covered with a superabundance of fluid secretion in which the foreign particles may adhere and accumulate, and with which they may be afterwards expelled from the body.

Such facts indicate clearly that nasal inspiration exerts an important protective power, local and general, over the health. Hence we can understand the fervour with which Professor Tyndall exclaims that if he could leave a perpetual legacy to mankind he would embody it in the words, 'KEEP YOUR MOUTH SHUT.' But in addressing an audience it is difficult, and in singing probably impossible, to avoid inspiring habitually through the open mouth. Because, as before pointed out,[1] in the professional use of the voice, in order that expiration may be prolonged as much as possible, the lungs must be inflated to a much greater extent than in ordinary breathing. And at each inspiration the replenishment of the chest must be effected by a rapid gush through the mouth, because the nostrils will only permit the passage of a small stream of air. Under these circumstances the inside of the throat, and perhaps the lungs,

[1] See page 74.

may suffer in three ways, *i.e.* (1) from the coldness of the air, (2) from its drying influence as it rushes in a large body over the mucous membrane, which in this situation does not, like that of the nose, contain glands sufficiently active and numerous to keep the surface moist if exposed to a moving atmosphere, and (3) from lodgment of dust. By such pernicious influences the mucous membrane is irritated and may become congested, whilst the muscles beneath lose their vigour and become relaxed. Hence arises sore and relaxed throat which interferes with the activity of the vocal organs and deteriorates the qualities of the voice; or troublesome dryness, causing stiffness of the throat, may be produced with equally damaging results as regards voice. And according to some observers, breathing through the mouth is a principal exciting clause of glandular sore-throat. For the muciparous glands, before mentioned, suffer from the congestion of the mucous membrane in which they are situated, and also because they are stimulated to an abnormal excess of function in order to preserve the rapidly drying surface in a state of moisture. Thus they inflame, swell, become choked, and present all the phenomena described in the last section.

The foregoing observations make it plainly visible that every precaution should be taken in order to reduce to a minimum the evil of inspiring through the mouth. In speaking, the nostrils will usually furnish enough air, unless in occasional declamations where great vehemence is demanded. That the orator will find assiduous attention to breathing through the nose, whenever practicable, a most effective agent for the preservation of his voice, may be considered as proved by experience on the testimony of numerous eminent teachers of elocution.[1] We even find that in the last century the knowledge of this hygienic fact, then only recognised by experts, was believed to be of such value to the professional speaker, that it was often sold for a large sum under a pledge of secrecy.[2]

To the singer, nasal breathing is of equal moment, in order to maintain the sanity of the throat and the purity of the voice. The exigencies of vocal melody, however, scarcely allow of any exception to the rule that inspiration must always be performed rapidly through the mouth. Nevertheless, this disadvantage of the singer, as contrasted with the orator, is counterbalanced by the fact that, whereas a speech or lecture may entail incessant use of the voice for a couple of hours or more, a song rarely lasts more than a few minutes, and even the most arduous *rôle* in an opera is composed of detached songs, between which there are usually ample intervals of rest. In such intervals, the mucous membrane of the throat has an opportunity to return to its natural state, if it has become in any degree irritable or dry during singing. The vocalist should remember this fact, so that when off the scene or platform, he may not engage too much in conversation, especially if he has any throat sensations which indicate irritation of the part. He should also be on his guard against being led into the habit of breathing constantly through the

[1] See Plumptre, *King's College Lectures on Elocution*, 1876, p. 59.
[2] Ibid. p. 62.

mouth, because compelled to do so while singing his part. Inattention to these matters has doubtless been the ruin of many good singers, and it is only those gifted by nature with excessive strength, constitutional and of the vocal organs, who can sometimes afford to disregard them and escape with impunity.[1] Such rare examples, however, should not be allowed to mislead others into running unnecessary risk.

Singers should generally beware of singing in the open air, especially in cold or damp weather. Singing on the water in the evening has sometimes been followed by disastrous consequences as regards the voice.

Simple Voice Remedies with Local Action.

Almost all persons who use the voice professionally resort to swallowing from time to time some local application, with the view of keeping the throat cool and moist whilst speaking or singing. Such remedies usually partake more of a dietetic than of a medicinal nature, and vary according to the taste and fancy of the individual. It is only certain that the irritation of the throat, caused by its exercise and exposure, can be relieved and the vocal powers assisted, by bringing some

[1] It is a well-observed fact that the greatest singers rarely have anything the matter with their voices, and it is equally well assured that this is not always to be attributed to the judicious care which they take of their health. They owe their pre-eminence chiefly to great physical strength and soundness of the vocal organs, and to the same cause may be ascribed this comparative immunity from disease. The vocalists who suffer most are those of medium rank, sometimes from carelessness and faulty voice-production, sometimes from the natural tone of the vocal organs being unequal to the tax put on them by professional singing.

suitable substance in contact with the mucous membrane at proper intervals. Slight throat symptoms, arising from tiring the voice, are also frequently treated in a homely fashion by some popular medicaments or nostrums. A few remarks and recommendations are, therefore, called for here respecting these classes of remedies.

At the head of the list stands the traditional glass of cold water of the speaker. Notwithstanding its simplicity, I am inclined to believe that sipping of cold water is one of the worst habits that could be contracted with the object of keeping the voice in good order. My reasons for arriving at this decision are two. In the first place, when the throat is dry the wetting power of water is very slight, because it will scarcely adhere to a parched mucous membrane. Secondly, if there is congestion of the throat, as betrayed by a feeling of heat, the effect of a douche of cold water is ultimately to increase that congestion, for the blood is only momentarily driven away, and returns in a few minutes, by reaction, in a larger quantity. The familiar example of the cold bath, which is generally the best of all possible means for making the skin glow, will illustrate this point. In the case of the throat, a temporary relief is of course experienced, but reactive congestion quickly sets in, and the demand for a draught of cold water is greater than ever. For these considerations, therefore, I think it advisable that orators should discard the use of cold water whilst speaking.

Better than plain cold water, is the *eau sucrée*, that is such a favourite beverage with the French, or gum-water, rice-water, whey, milk, or thin beef tea, as occasionally used by some speakers. Nor can we disapprove of the tragacanth draughts[1] to which the ancient sophists had recourse, because all these liquids have some consistency and an adhesive power, so that after they are drunk, the lining membrane of the throat may be covered and protected for some little time by a thin, moist film. But, under all circumstances, the coldness should be got rid of, and whatever is drunk during speaking, or in the intervals of singing, should have a temperature near, but below, that of the body, viz., 98° Fahr., or at least it should not be colder than 60° Fahr. The proper degree of heat can best be determined by sensation, and if the drink feels at all chilly whilst passing down the throat, it may be decided to be too cold. At the same time it should not be too warm; a neutral temperature, so to speak, should be obtained. In warm weather, of course, the drink will not require to be warmed; but a special warning must be entered against taking iced water, or anything iced, whilst the voice is being exercised. The amount of liquid taken should also be limited to a small quantity, so as to avoid any chance of overcharging the stomach. Much difference as to the amount of drink required exists in various persons; some, indeed, have naturally so much moisture in the throat as to want little or none at all. Beer or wines, as containing alcohol, call for consideration in another place.

[1] As related by Synesius in *Dion*. The compound tragacanth powder of the British Pharmacopœia, containing equal parts of tragacanth, starch, and sugar, may be used to make a lubricating drink for the throat. About a teaspoonful may be added to a pint of water. It should first, however, be well mixed with a little water and then diluted.

Another class of remedies for lubricating the throat have more of a solid character. To this division may be relegated eggs beaten up, and all kinds of gelatinous or gummy fruits, and bonbons. As a rule, such substances should be avoided as likely to clog the throat and stomach. They are particularly unsuited to persons whose mouth and fauces are naturally dry; but those who have a copious flow of saliva may sometimes use them with more advantage than liquids. In such cases, the act of chewing or sucking stimulates the salivary glands, so that the substance is completely dissolved and the throat is well moistened. To persons for whom remedies of this class are suitable, I should recommend lozenges or jujubes of pure glycerine or gum.[1]

[1] It may be interesting and not uninstructive to read the following information which the *Pall Mall Gazette* (1869, vol. ii. pp. 676, 714) reproduces from a Vienna paper as to the refreshments taken by some distinguished opera singers to 'keep their voices in good order' during the performance. 'Each, it appears, has his or her own peculiar specific. The Swedish tenor, Labatt, takes "two salted cucumbers" for a dose, and declares that this vegetable is the best thing in the world for strengthening the voice and giving it "the true metallic ring." The other singers, however, do not seem to be of this opinion. Sontheim takes a pinch of snuff and drinks cold lemonade; Wachtel eats the yolk of an egg beaten up with sugar; Steger, "the most corpulent of tenors," drinks "the brown juice of the gambrinus;" Walter, cold black coffee; Nieman, champagne; and Tichratchek, mulled claret. Ferenczy, the tenor, smokes one or two cigars, which his colleagues regard as so much poison. Mdlle. Braun-Brini takes after the first act a glass of beer, after the third and fourth a cup of *café-au-lait*, and before the great duet in the fourth act of "The Huguenots," always a bottle of Moët Crêmant Rosé. Nachbaur munches bonbons during the performance; Rübsam, the baritone, drinks mead; Mitterwurzer and Kindermann suck dried plums; Robinson, another baritone, drinks soda-water;

So far, I have only spoken of adjuvants to the voice in health, while undergoing exertion. In many instances, however, when slight hoarseness or weakness of the vocal organs is present, the sufferers have recourse to remedies with more or less decided medicinal properties. The various voice or cough lozenges that are sold belong to this class. Of these there are about four kinds, viz., those that contain (1) cayenne, (2) cubebs, (3) some expectorant, and (4) opium or morphia. Their applicability may be discussed separately.

1. The effect of cayenne on the throat is to stimulate or irritate the mucous membrane, by which more

Formes takes porter, and Arabanek Gumpoldskirchner, wine! The celebrated baritone Beck, on the other hand, takes nothing at all, and refuses to speak. Draxler smokes Turkish tobacco, and drinks a glass of beer. Another singer, Dr. Schmid, regulates his diet according to the state of his voice at the time. Sometimes he drinks coffee, sometimes tea, and a quarter of an hour afterwards lemonade, mead, or champagne, taking snuff between whiles, and eating apples, plums, and dry bread.' . . . 'Malibran never sang better than when she had drank at least a pot of porter out of the pewter pot—the more difficult the music the larger the quantity. Grisi drank always bottles of Dublin stout between the acts, and if she had to sing a stormy character the dose was strengthened. French singers prefer simply *eau sucrée*; the Spaniards take strong cups of chocolate, followed by glasses of water sugared and lemoned. The Italians like eggs beaten up simply, or with wine.' As a rule, operatic singers are described as very temperate, 'they dine early on the day they sing, they take as little as possible, and they receive very few visitors before they have to sing.' Mandl (*Hygiène de la voix*, p. 66), from another paper culls the further information that 'Mdme. Sontag takes, in the *entr'actes*, sardines; Mdme. Desparre, warm water; Mdme. Cruvelli, Bordeaux mixed with champagne; Mdme Ad. Patti, seltzer-water; Mdme. Nilsson, beer; Mdme. Cabel, pears; Mdme. Ugalde, prunes; Mdme. Trebelli, strawberries; Troy, milk; Mario smokes; Mdme. Borghi-Mamo takes snuff; and Mdme. Dorus-Gras used to eat cold meat behind the scenes.'

blood is sent to the part, *i.e.*, some congestion is produced. Such action would be highly injurious if some disorder of voice were present which actually arose from congestion. On the other hand, should there be a weakness of the voice dependent on an anæmic or bloodless state of the throat, cayenne might be a very serviceable application. As, however, it is too much to expect an unskilled observer in disease to distinguish between the two conditions, especially in his own person, I can only advise that lozenges containing cayenne be discarded as a popular voice remedy.

2. Cubebs is often valuable where there is a great deal of expectoration. If the throat be at all dry, it is most likely to do harm. Lozenges manufactured with cubebs may generally be recognised by a biting, bitter taste—it is a weak kind of pepper in fact.

3. Cough lozenges are generally composed of harmless ingredients, unless they contain (4) opium or its active principle, morphia. Opium, in any form, should never be taken without medical advice. It usually has a parching effect on the throat, and throws the digestive system into disorder. In most instances, it is, therefore, likely to exert a deleterious influence over the vocal powers.

From the foregoing observations it may be inferred that popular medicinal remedies should be generally eschewed; not that they are an unalloyed evil in the abstract, but because any drug indiscriminately applied will probably injure as many cases as it benefits.

General Hygiene in its Relations to the Voice.

Under this heading we may discuss, in the first place, how far the health of the body may be affected by the systematic exercise of the voice; and secondly, to what extent the voice may derive benefit or suffer from the general habits and surroundings of the individual.

Effects of Regular Vocal Exercise on the Animal Economy.

The ancient physicians believed, from experience, that a vigorous course of declamation was one of the most salutary and health-preserving exercises that could be practised, and they therefore prescribed it systematically as an important curative agent in many debilitating diseases. Although modern practitioners have not exactly followed their example, the principle that increased respiratory movements are highly beneficial in the treatment of invalids from pulmonary maladies is fully recognised. Some efforts have also been made, and are still in course of maturation, to inflate the lungs in certain affections beyond their ordinary capacity, by means of artificial instruments, such as the compressed-air apparatus of Waldenburg, and promising results have already been obtained.

There is, indeed, considerable statistical evidence to prove that the professional use of the voice exercises an important prophylactic influence against the development of consumption, and several investigators have shown by statistical evidence that a remarkably small relative percentage of singers, orators, public criers, &c., fall a victim to that disease.

The general well-being of the constitution is promoted by voice-practice, because the wider chest-movements accelerate the circulation of the blood, at the same time that they cause a more ample flow of fresh air in and out of the lungs. The obstacle to expiration offered by the contraction of the glottis during phonation, confers a greater penetrating power on the pulmonary air, which therefore permeates the minute bronchi, and distends the air-vesicles of the lungs more effectively.[1] Thus the blood attains a higher oxygenation and greater purity, by which qualities it gains in power of stimulating the vital activities of the various tissues of the body as it courses through them. Effete matters are freely cast off, and new wholesome material is assimilated in increased amount. The appetite, so to speak, of the various corporeal structures becomes more keen, and they are thus subjected to an exalted nutrition. And, moreover, these effects have a certain permanency on account of the gains to the thoracic capacity derived from the habitual increase of lung expansion necessitated by constant vocal exercise.

The mode in which the voice is used alters, of course, considerably the sanitary aspects of the exercise, and a proper method of voice-production, according to the indications already given, must be pursued. A division of another kind may also, however, be regarded here,

[1] Cuvier, according to Combe (*Physiology applied to Health*, pp. 121, 206), believed that he was saved from incipient consumption by receiving a professorship which obliged him to lecture for some hours daily.

and the four degrees of voice-practice, viz., conversing, reading aloud, declaiming, and singing, may be alluded to in relation to their gymnastic efficiency. Thus in ordinary conversation, the vital activities are stimulated least of all; in reading aloud, fatigue is apt to supervene rapidly, because the posture, especially if the person be seated, is somewhat constrained, and freedom of action is limited by the attention being concentrated on the text; in declamation and singing, on the other hand, there is ample scope for respiratory play and appropriate gesture or carriage of the body.

The ill effects of exaggerated vocal labour on the health are, generally, those of any kind of overwork, *i.e.*, lassitude, depression, loss of appetite and sluggish performance of the various vital functions. Specially, they are the result of any particular accident that may occur, such as emphysema, by which a portion of the lung is lost to respiration, and a permanent diminution of thoracic capacity, with consequent impairment of the constitution, results. Or a vein in the lungs may be ruptured, and loss of blood occasion a long illness, with subsequent obstinate debility. Or an overflow of blood to the head, inducing congestion of the brain, apoplexy, etc., may arise from a violent vocal, as from any other inordinate, effort.[1] Lastly, the forcible compression

[1] Antigonus Doson, King of Macedonia (Plutarch, in *Vita Cleomenis*), and Valentinian I., Roman emperor (Suidas, sub Λείας), are reported to have died in giving vent to an excited exclamation. In the former case a blood-vessel burst, and blood issued from the mouth; and in the latter some kind of a fit supervened. Seneca seems to allude to accidents of this class as if they were of frequent occurrence.—*De Brevitate Vitæ*, c. 2. Blowing a violent blast on a

of the abdominal organs may cause some of the viscera of that cavity to protrude beyond the limits assigned to them by nature, forming the condition known as *hernia*.

Influences of Mode of Life on the Voice.

Man, in order to live and preserve health, must conform to certain natural laws, which impel him to take food, to sleep, to take exercise, etc. He is also subjected to various terrestrial influences derived from diverse conditions of earth and air, which affect him potently with respect to his health. Such esoteric and exoteric forces do not, however, hold him in fast servitude, but, whilst allowing him a considerable freedom of choice, merely instigate him gently towards the course he should select. He is called on, therefore, constantly to exert his judgment, and he enjoys extensive powers of avoiding evil, and of taking refuge in good. To such contingencies hygiene owes its existence, and it may thus be defined as the science which teaches the recognition and practice of what is best for health. Amidst the many ramifications of this wide subject we may notice here with brevity the bearing of the principal factors that make up life on the function under examination.

I. *Alimentation.*—Every action of the animal body, whether mental or muscular, is accomplished at the expense, and accompanied by the destruction, of a portion of the fabric of which it is composed. That which is destroyed is at once carried away and cast off from the

wind-instrument has also caused sudden death in a similar manner. For instances, see Lucian, *Harmonides*, and Ramazzini, *De Morbis Artificum*, Ultrajecti, 1703, c. xl.

body, and in its place fresh material supplied by the blood is laid down. Hence the desire for aliment, which is received into the stomach and, if solid, is there digested until brought to such a state of fluidity that the suitable part of it may be conveyed into the blood, as the whole mass passes through the long tract of intestine. Thus the stomach and intestines feed the blood, and the blood feeds the tissues. The material primarily introduced into the stomach may be of two kinds, viz., food and drink, which may be considered separately.

1. *Food.*—About two-thirds of the body of man is composed of water, and the remaining one-third consists of substances supplied by the solids of the food naturally taken by him. These latter may be conveniently distributed into four classes, *i.e.*, into (1) nitrogenous substances, richest in flesh or meat, (2) fatty or oleaginous matters, (3) starchy or saccharine (sugar) compounds, and (4) mineral matters, or salts. A supply of all these different kinds of food is necessary to maintain the body in health, and they are, therefore, found in proper proportion in the natural provision of milk. Thus, cheese is a nitrogenous substance, butter a fatty matter, lactose, or sugar of milk, represents the starchy or saccharine class, and there are also abundant salts, the whole being dissolved in water.

Although meat or animal food is richest in nitrogen, there exists an abundant quantity of that element in many vegetables, such as wheat, beans, peas, etc. It is consequently practicable to live in health without eating any meat, and on this account some persons advocate a purely vegetable diet. As far as the comparative nutritiveness of meat and vegetables is concerned, there appears to be little distinction, if we may judge by contrasting carnivorous animals with those who are entirely herbivorous. Thus the lion and tiger, though fiercer, more combative, and more agile, because of the actions they have to perform in order to supply themselves with food, are not in reality stronger or more enduring than the more docile horse, ox, or elephant. The inference to be drawn from such observations is that each animal should have the kind of food to which its mode of life has accustomed it, because its digestive organs obtain by habit facilities for disposing of certain substances, whilst their healthy action is likely to be disturbed by strange sorts of aliment.

European races have mostly used a mixed diet of flesh and vegetables for as long as there are any records to prove the fact, and it seems therefore unadvisable to attempt any change in this respect. Another point, however, which deserves consideration is that a mixed diet is more economical, because it affords most nearly a due proportion of the various classes of solid aliment mentioned above. Thus, in order to obtain a proper amount of each of these, a man, if restricted to meat, would have to eat about seven pounds daily. On the other hand, he could subsist on a less quantity of bread, viz., about four pounds in the twenty-four hours. But when taking both combined, a much smaller aggregate weight would suffice, namely, about one pound of meat and a pound and a half of bread. Hence the duty of the stomach would be lightened, and the abdominal viscera would not be loaded with a large quantity of refuse matters. If, however, eggs and milk be added to a diet otherwise of vegetable products, meat may be almost superseded as far as bulk is concerned.

An important question in dietetics relates to the digestibility of the various substances used as food. Some kinds of food only require to be acted on for an hour or two before they are brought to a state to yield up their nutrition to the blood; whilst others remain as long as four or five hours in the stomach, or pass out of the body unchanged, being indigestible. Tender meat, well masticated, is soon digested; whereas tough meat, swallowed without being well divided by the teeth, remains several hours in the stomach. The digestibility of meat also varies according to the manner of cooking. When boiled or stewed it is, as a rule, more easily digested than when roasted or baked. From various experiments that have been made it has been ascertained that rice, tripe, whipped eggs, sago, tapioca, barley, boiled milk, raw eggs, white fish, venison, lamb, parsnips, mashed and baked potatoes, and fricasseed chicken, in the order given, are the most easily digested substances. Thus rice disappears from the stomach in one hour, and fricasseed chicken in about two hours and three quarters. Less readily digested are beef, pork, mutton, oysters, butter, bread, veal, and boiled and roasted fowls. Beef passes out of the stomach in three, and roast fowl in four hours. Salt beef and salt pork require more than four hours to be digested, whilst fungi, such as truffles and mushrooms, are in great part indigestible. Nutritious soups, such as beef tea, mutton broth, chicken broth, etc., are often valuable when the digestive system is delicate.

As regards the precautions in alimentation to be observed with a view to preserving the integrity of the voice, it is obvious, in the first place, that a choice should be made of those articles of diet which do not tax excessively the powers of the stomach to get rid of them. Should the stomach be habitually subjected to digestive over-exertion, it will soon become inefficient in the performance of its functions, and the condition termed dyspepsia, or imperfect digestion, will be brought on. In such case, the direct consequence is that the blood does not receive a proper amount of nutrition, and the body is badly nourished. Loss of flesh ensues, the muscles diminish in tone and vigour, and the strength is impaired. Amongst the rest, the muscles of the vocal organs suffer, and lose the faculty of firm and ready contractility. The respiratory apparatus cannot expel the air with steadiness and force, and the laryngeal muscles act defectively. Hence the voice becomes wanting in tone and timbre, and sounds weak and wavering. More or less enervation is also produced, and therefore the manner lacks energy. Thus the individual appears apathetic, whilst his speech is irresolute and his delivery shows indecision.

Such are the evils, variable in degree according to circumstances, of dyspepsia, which may arise in several other ways, such as irregularity of meal times, taking cold, excesses of all kinds, etc.

Another point to be observed, is to avoid exerting the voice when the stomach is full. When the process of digestion has reached its height, about an hour after eating a substantial meal, the stomach is not only distended with food, but is also swollen through the determination to it of a large quantity of blood. This state of congestion is necessary, in order to enable it to pour out the gastric juice, which is an indispensable agent in bringing the food to a proper fluidity. At this time, therefore, the proximity of the firm and bulky stomach to the under-surface of the diaphragm, greatly impedes the contractions of that muscle, and thus reduces the abdominal type of respiration within narrow limits. A further effect of the distended stomach is to compress the aorta or main trunk of the blood-vessels, which are distributed to the lower extremities. Hence arises a plethora of the lungs, which also interferes with respiration. For these reasons, even when the body remains in a state of repose, a certain shortness of breath is sometimes experienced after eating. Such arrangements should always, therefore, be made as to allow an interval of three or four hours or more to elapse before the voice is exerted after a full meal.[1]

Somewhat similar to the last mode of interference with the vocal powers is the operation of corpulence. The connection, indeed, between fatness and scantness of breath, is almost proverbial.[2] Here we have the ab-

[1] It is also asserted that exercise after eating is injurious, because it draws the blood away from the stomach to the parts that are in activity, and so interferes with digestion. Combe, *The Physiology of Digestion*, 1800, ch. xi.

[2] Thus Shakespeare :—

K. Our son shall win.

Q. He's fat and scant of breath.

Hamlet, Act v. Sc. 2.

dominal organs rendered almost immobile by the deposition of fat between and around them, and they are thus built up against the diaphragm, so as to prevent its descent. The effects of obesity on respiration are not, however, confined to this quarter, but the motions of the ribs are also probably restricted by the chest being wrapt round with a thick layer of fat. And should the action of the heart be impeded by the growth of fat within the thoracic cavity, the circulation of the blood will be retarded, and a consequent congestion of the lungs will create a difficulty of breathing. Or the course of the blood through the various tissues of the body may be interrupted with a like result. Thus, there are manifold reasons why a deterioration of voice should be induced by obesity.

The tendency to corpulence can be combated very effectively by paying strict attention to the regulation of diet and exercise. As regards diet, the great point is the avoidance, as far as possible, of all kinds of food appertaining to the second and third classes, which are included under the term carbo-hydrates. Partial or complete abstinence is, therefore, necessitated from all fatty matters, such as fat of meat, cream, and butter; from starchy substances, such as white bread, potatoes, corn flour, etc.; and from saccharine aliments, such as sugar, beet-root, parsnips, etc. A considerable variety of dietary may, however, still be indulged in, and lean meat, poultry, game, white fish, brown bread, turnips, green vegetables, and a small allowance of milk, may all be taken at choice. Such is the system to which a good deal of notoriety was given some years ago by

Mr. Banting, a gentleman who by following it had been greatly benefited.[1]

Such *condiments* as contain irritating principles, *i.e.*, pepper, mustard, curry, the many hot sauces, &c., are open to the same objections as have already been urged against cayenne in 'voice lozenges.' They are likely to produce congestion, which may ultimately lead to thickening of the lining membrane of the throat, and thus damage temporarily or permanently the purity of the voice. Pale and delicate persons, however, often find that they afford a valuable stimulus to digestion, and in such instances, as the opposite condition to congestion mostly prevails, they may often be taken without harm, or even with some benefit to the vocal powers.

A few remarks may here be made as to the effects of *tobacco*. The action of this herb on the animal fabric is constitutional and local. Thus nicotine, the name

[1] By adherence to the following routine of dietary for twelve months he reduced his body-weight from 202 to 156 lbs. and his girth by $12\frac{1}{4}$ inches. '*Breakfast.*—Four or five ounces of beef, mutton, kidneys, boiled fish, bacon, or any cold meat (except pork), a large cup of tea (without milk or sugar), and one ounce of dry toast. *Dinner.*—Five or six ounces of any fish (except salmon or eels), any meat (except pork), any vegetables (except potatoes or rice), one ounce of dry toast, fruit out of any pudding, any kind of poultry or game, and two or three glasses of good claret, sherry, or Madeira (champagne, port, or beer forbidden). *Tea.*—Two or three ounces of fresh fruit, or a rusk or two, and a cup of tea without milk or sugar. The tea may be very much enjoyed when taken in the Russian fashion, *i.e.*, with a thick slice of lemon floating on the top instead of milk. *Supper.*—Three or four ounces of meat or fish, similar to dinner, with a glass or two of claret. *Nightcap*, if required, a tumbler of grog (gin, whisky, or brandy, without sugar), or a glass or two of claret or sherry.' For a fuller discussion of the dieting of corpulence see Pavy, *Food and Dietetics*, 1875, p. 459.

given to its active principle, exerts a powerful depressant influence over the nervous system, being in fact a virulent poison, a very small quantity of which, when pure, would suffice to cause death by prostration. Persons, therefore, who indulge to excess in smoking are likely to become nervous, so that their hand trembles, and the command of the brain over the muscles generally is lessened, whilst there is a tendency to palpitation of the heart and oppressed breathing. As a natural consequence, there is a failure to some extent of the vocal powers, and a hesitation in delivery, the results, on the one hand, of the lack of respiratory vigour, and, on the other, of enervation. Habit, however, usually produces such a tolerance of tobacco, that the constitutional effects of moderate smoking are most frequently imperceptible, unless in delicate individuals.

As regards the local injury that may be sustained from tobacco, it consists in dryness and congestion of the mucous membrane of the mouth and pharynx from their coming in contact with the hot and often acrid smoke. Should the membrane be naturally very active in furnishing the necessary lubricating secretions, it will probably escape unscathed, unless subjected to an incessant play of smoke from full-flavoured cigars. But in the opposite case it is likely to become soon parched, whence some hoarseness or roughness of voice may arise. In taking snuff the voice may suffer similarly if the particles of tobacco pass backward from the nostrils, and become lodged continually on the pharyngeal mucous membrane.

A further disadvantage of smoking is waste of saliva, of which the fumes of tobacco provoke in some persons a profuse flow into the mouth Under these circumstances the salivary glands become exhausted from time to time, and do not supply the proper amount of fluid during mastication of food. Hence some disorder of digestion may arise with a chronic dyspeptic tendency, which may tell indirectly on the voice in the way already noticed. Persons, therefore, who are obliged to expectorate much during smoking should be on their guard against the abuse of the habit.

2. *Drink.*—Tea, coffee, and cocoa or chocolate contain active principles, termed respectively thein, caffein, and theobromin, which have identical properties as dietetic substances. In small quantities they stimulate the nerves, and are refreshing after fatigue; but if taken to excess they often produce nervousness and tremour. Over-indulgence in strong tea is a frequent cause of palpitation of the heart and oppressed breathing. Those who make a professional use of the voice should remember, therefore, that moderation, even in these apparently harmless beverages, is required in order to preserve the integrity of the vocal organs.

We now come to the all-important class of *alcoholic drinks*, the evil effects of the abuse of which are so familiar to almost every one, that they call for very little comment, except from the point of view of scientific inquiry. Taken in moderation by a healthy person, spirituous liquors may be considered as a kind of agreeable stimulus of the nature of a luxury, which, if seldom beneficial, is still not absolutely harmful. It is difficult, however, to determine the precise amount that may be consumed habitually without injury, especially as it doubtless varies according to the fundamental constitutional strength of each individual. From some careful scientific observations Parkes[1] has concluded that the average male adult may take from one to one-and-a-half fluid ounces of pure alcohol daily without any resultant injury to health. In order to apply this calculation practically, it is necessary to estimate the percentage of alcohol contained in the different classes of liquors commonly used. Thus beer and the weaker wines (clarets) contain about 6 per cent., the stronger wines (port, sherry, &c.) about 15 per cent., and spirituous liquors (brandy, whisky, etc.) 50 or 60 per cent., or even more, of alcohol. Hence we may decide that a man desiring strictly to avoid excess may drink in the twenty-four hours—

Of brandy	$2\frac{1}{2}$	ounces.[2]
Of sherry or port (strong wines)	5	,,
Of claret or hock (weak wines)	10	,,
Of beer	20	,,

For females the above amounts should be reduced to one-half or two-thirds, on account of the lessened power of resistance of their physical economy. In addition to alcohol, wines and beer contain a small quantity of certain nutritive and tonic principles, which have an invigorating effect on the constitution. For general

[1] Op. cit. p. 277.

[2] An ordinary wine-glass holds about $2\frac{1}{2}$ ounces, a beer glass about 10 ounces.

consumption or for invalids they possess, therefore, an important advantage over the various kinds of spirits.

Considered specially with reference to the voice, too much stress cannot be laid on the warning against making too free a use of alcoholic drinks. 'The voice,' as Brouc[1] judiciously observes, 'is the hygrometer of sobriety.' Alcohol exerts a degenerative influence over every organ and tissue of the body, and nowhere more markedly than on the mucous lining of the cavities. Here it produces constant congestion, which soon leads to thickening of the membrane. In the throat such a condition is betrayed sooner than elsewhere, because so slight a physical alteration is sufficient to induce a perceptible modification in the delicate tones of the voice. Thus hoarseness, at first slight, but always steadily progressive, is one of the earliest symptoms that over-indulgence in alcoholic beverages has commenced to undermine the constitution. And when once unsoundness has been induced in any of the organs of the body, they lack the vigorous vitality necessary to protect them against the exciting causes of disease, or to promote a facile recovery, should they be actually attacked. Thus a mild malady, of properly ephemeral character, may gain a firm footing and deepen into a serious affection, through the insufficient potency of the recuperative forces of the body. A slight sore-throat, instead of getting well in a day or two, is likely to be the precursor of inflammatory or ulcerative ravages that may permanently injure the voice; or an ordinary cough,

[1] *Hygiène philosophique des artistes dramatiques*, Paris, 1836, tom. ii. p. 109.

which seldom calls for other than domestic treatment, may be the premonitory sign of an intense lung mischief, prostrating in its attack, protracted in its course towards convalescence, and the parent of shattered health ever afterwards.

It is especially important to observe that the ill effects of intemperance are not necessarily confined to those cases in which there is frequent and positive excess. Oft-repeated, though small, draughts of alcohol are in proportion as pernicious as large quantities taken at longer intervals, whilst in the former case, as the psychical influence of the spirit may be scarcely, if at all, felt, the individual may be wholly unconscious of running any risk. Hence the practice of drinking many separate glasses of beer, stout, or wine, as a support against fatigue and a stimulant to further exertion, must be strongly condemned. Such a habit once contracted soon becomes a necessity, because every period of briskness arising from artificial stimulation is followed by a corresponding interval of depression, which can only be banished by resorting again to the alcoholic spring. Thus a state of decided, but almost imperceptible, inebriation is perpetually kept up, which, like an insidious disease, incessantly preys upon the life-holds of the body, and presses on a premature decay and death.[1]

[1] The fact that Grisi and Malibran had recourse to draughts of stout whilst sustaining their parts has often, I have no doubt, been regarded by other singers as a precedent for doing likewise. The first-named *artiste* by keeping to a strict moderation appears to have escaped without harm, but the circumstance should be recorded with emphasis that the career of Malibran was unusually short, and that she died at the early age of twenty-eight. See Fétis, op. cit. s. n. The presumption is too immediate to be passed over that her consti-

II. *Exercise.*—Whilst the greater portion of the substance of our body, the muscular system, exists for the direct purpose of conferring the power of voluntary motion, it is evident that exercise must form an integral and irremovable part of the phenomena that make up our life. For, in accordance with a well-ascertained law, no organs of the animal body can possess qualities which are absolutely purposeless, but they must perform the functions for which by their structure they are designed, or else lose their distinctive characters, or dwindle to a rudimentary state. Thus our muscles, through disuse, become at first soft and flaccid, and subsequently diminish progressively in bulk, until partially or completely atrophied. Concomitantly, most of the other organs of the body, including the brain and nerves, undergo, by a parallel process, a similar change, because their activity is, in great part, the result, on the one side, of the demand of the working and thriving muscular system for a regular supply of nutrition and nervous energy, and, on the other, of the office of removing effete matters generated by exertion. Hence a sedentary life induces feebleness of body and may also give rise to apathy of mind.

A moderate amount of exercise is, therefore, a vital necessity. To the beneficial effects of systematically-sustained muscular movements some reference has already more than once been made. We have seen the value of vocal exercise directly on the organs of voice, and generally on the constitution. Exercise should not,

tution succumbed to inconsiderate efforts to maintain an artificial excitement.

however, be confined to any particular part, if it is desired to preserve a full integrity of wind and limb. Free action of all the members should be encouraged, and in no way can this object be better attained than by walking daily in the open air. The motions called forth in walking are sufficiently forcible and general, without requiring anything like effort—an error on the side of excess—for their performance. A daily walk of at least four or five miles should be taken by every person in health. This would be about equivalent to walking for two hours, not necessarily consecutive, at a rather slow pace. And the fact must not be lost sight of that a supply of air as fresh and pure as can be obtained, is essential during exercise, in order that the full advantage may be gained. For thus the blood, stimulated by the exercise to a swifter course through its vessels, attains its highest qualities, and is enabled to nourish the tissues most energetically.

With reference to special exercises, such as running, rowing, swimming, and the system of operations that make up 'training,' they are useful within carefully defined limits, both to develop the vital forces of those that are naturally delicate, and to maintain the muscular activity of the more robust, at the same time that they counteract the tendency to corpulence.

A well-regulated course of training, which includes a carefully-ordered diet, generally effects an increase of breathing power, with a strengthening of the circulatory system, an enlargement of the muscles, and altogether a state of more vigorous health.[1] If carried to excess,

[1] See Maclaren, *Training in Theory and Practice*, 1874.

however, such a course may be injurious, and it is, moreover, uncertain whether in any case the advantages derived are permanent. For if the exercise is not kept up, the body soon readapts itself to the ordinary mode of life, and returns to its former condition. The best rule to be adopted, is that each person should take as much exercise as appears best suited to his normal physical development. Thus the delicate may restrict themselves to exertion, gentle, but sufficiently prolonged, such as walking, whilst the vigorous should have recourse to more decided muscular efforts, such as feats of a gymnastic character.

It is worth while to notice here a peculiar bearing of general bodily motion on the artistic use of the voice. This relates to the familiar circumstance of being out of breath after making any unusual exertion—a condition which is the direct consequence of the quickened flow of blood through the lungs, and the increased respiratory action thereby occasioned. At such a time singing, or speaking with the measured delivery of rhetoric would, of course, be impossible. On this account, care should be taken to avoid all superfluous movement, whilst it is necessary to make a sustained use of the voice, for, otherwise, fatigue of the vocal organs is likely to arrive rapidly through interference of hurried breathing with phonation. This remark applies particularly to the orator, as, during histrionic singing or dramatic declamation, there are always intervals of rest sufficiently long and frequent. The speaker should, therefore, as Becquerel observes, avoid energetic contractions of the muscles of the lower limbs and trunk, and make free use only of the arms and shoulders, in order to confer the requisite animation and expression on his utterances.

III. *Care of the Skin.*—The skin does not form merely a covering for the body, but it also has important functions to perform, which afford an indispensable aid in maintaining the health of the organisation. For this purpose it contains in its thickness an almost countless number of minute glands, each of which opens by a microscopic orifice on its surface for the purpose of discharging its proper secretion.[1] These glands are of two kinds, termed respectively *sudoriparous*, or perspiratory, and *sebaceous*, or oil-elaborating. The perspiratory glands purify the blood by removing from it effete matters, which they discharge, dissolved in water, on the surface of the skin. The water evaporates at a rapidity proportionate to the degree of heat of the external air, and thus regulates the temperature of the body, keeping it cool in warm weather or during exercise, when it exudes in greatest quantity. The solid portion of the perspiration, consisting of organic and mineral matters, remains and collects on the skin, and if not removed by some means, interferes with the con-

[1] Each gland consists of a fine convoluted tube about $\frac{1}{4}$ inch long, and the average number of pores marking their openings in a square inch of skin is computed at 2,800. The area of the surface of the body in a man of ordinary stature is about 2,500 square inches, and hence the total number of pores may be reckoned at 7,000,000. As to each pore corresponds a gland, we should thus have 1,750,000 inches of tubing, equal to 145,833 feet, or 48,611 yards, or nearly twenty-eight miles.

tinuance of its action. The sebaceous glands lubricate the skin, so as to prevent its becoming dry and cracked, and on this account they are especially numerous in natives of tropical climates. A further function of the skin, of the highest moment, is the oxygenation of, and removal of carbonic acid from, the blood, as it circulates through the capillary vessels near the exterior of the body.

Thus, it may be seen that the office of the skin is, to a great extent, similar to that of the lungs, and, therefore, there exists a *cutaneous* as well as a *pulmonary* respiration. And should the eliminative action of the skin be interrupted, it follows that the lungs would be called on to perform an increased amount of duty, which would be likely to provoke hurried and difficult breathing. At the same time the accumulation of the solid effete matters in the blood would necessitate an inordinate activity of other internal organs, especially the kidneys, and a general constitutional disturbance would arise. Should the function of the skin be completely suspended, as would occur if it were coated with some impermeable substance, such as varnish, death would supervene in a few hours, with symptoms resembling those of suffocation—a fact which has been ascertained by some experiments that have been made on animals.

From the above observations it is easy to perceive the general importance of keeping the skin in a healthy state, as well as the direct influence that its derangement may exert over the soundness of the vocal powers. Attention to the health of the skin comprises the judicious employment of *clothing*, *ablutions*, and *cosmetics*.

1. *Clothing.*—The variable temperature of the atmosphere, arising from circumstances of climate, season, and habitation, necessitates the use of apparel, in order to obtain an equilibrium of the external influences which tend at one time to overheat, and at another to chill, injuriously the surface of the body. In order to carry out this indication most economically, regard must be paid to the quantity, the quality, and the colour of the clothing employed. Thus the heat of the body is better preserved in proportion to the thickness of the garments worn; but their power in this way also depends very much on the material of which they are made. The principal substances used in the manufacture of clothes are linen, silk, cotton, and wool.

Linen is composed of fine, hard fibres, which conduct heat with comparative rapidity. Clothes made of linen are therefore cool and suitable for warm weather.

Silken fabrics are also cool, but still form a warmer covering than linen.

Cotton materials are much warmer, and softer to the touch, than either linen or silk.

Wool conducts heat most slowly of all the substances which enter into the composition of clothing, and as a covering to the skin, thus causes, to a maximum degree, the retention of the animal heat evolved by the vital activities. Woollen garments are, therefore, the most suitable for cold climates. They are also especially valuable and protective against taking cold when persons are obliged to experience sudden transitions of temperature, either through dwelling in changeable climates, such as our own, or by reason of their occupation compelling them to emerge frequently from heated rooms or halls into a comparatively colder external air. Under these circumstances, flannel should be worn habitually as underclothing. This rule applies very forcibly to dramatic artists, who are often obliged to wear light or heavy clothing on the stage, irrespective of the actual exigencies of temperature. A further important property of wool is to condense and absorb perspiration. For this reason it is valuable as a covering when rest is taken immediately after exercise, as it prevents the body cooling too rapidly by continued evaporation. The application of this fact would, of course, not need to be observed in hot and calm weather.

As regards colour, it need only be mentioned that white fabrics resist much longer than dark materials the passage through them of heat rays from refulgent bodies. They should generally, therefore, form the outer attire of persons when exposed to the glare of the sun in hot seasons or climates.

The evils of insufficient clothing to maintain the skin at a normal temperature are very marked, and are manifested by enervation, depression, and general sluggishness of the vital functions. Such a condition is the result of impoverishment and defective nutrition of the various structures near the surface of the body, owing to the proper supply of blood being kept out of them by the constringent action on the peripheral capillaries of the persistent cold. At the same time, the internal organs also suffer from being passively congested by an excess of blood, which is driven inwards instead of being distributed equally throughout the whole circulatory system. In such case, if disease is not directly produced, the constitution is enfeebled, and laid unusually open to the numerous exciting causes of maladies to which we are perpetually exposed. Hence the fallacy becomes palpable of wearing insufficient clothing under the impression that the constitution can thereby be rendered more hardy and vigorous. The dress should be carefully adapted to every variation of indoor and outdoor temperature, and also to periods of exercise and repose. The skin should be invariably kept comfortably warm, but at the same time, the error of excessive wrapping up should be avoided. In the latter case, indeed, a delicacy or exaggerated susceptibility of the surface to slight thermometrical changes may be engendered, which may be a constant source of mild catarrhal affections, the forerunners, possibly, of serious inflammatory attacks in the throat or lungs.

As a protection against sharp winds, the best clothing is something wholly impervious, such as waterproof cloth, or leather in the form of strong skins with or without fur. The objection to this class of garments is that they prevent the evaporation of the perspiration, and the body thus remains in a state of continual dampness. For this reason they should generally be dispensed with during exercise, unless required to keep out rain.

With respect to the *corset*, enough has already been said in order to show how detrimental its improper use may be to the free play of the chest, and consequently to the artistic employment of the voice.[1] As a covering

[1] See page 77.

for the skin, its place could easily be supplied by any looser vestment of similar substance.

Whilst alluding to tight articles of female apparel, a word of warning may be spoken against the wearing of rigid and narrow cravats amongst the male sex. A dangerous compression of the superficial blood-vessels of the neck, causing congestion of the brain or even fatal apoplexy, has not unfrequently been laid to the charge of a neckerchief drawn so tight as to become an unintentional instrument of strangulation.

2. *Ablutions* (*Baths*).—The systematic cleansing of the skin, which is carried out even by many of the lower animals through an impulse of instinct, is in man both a social and a sanitary necessity. The products of perspiration, as well as any foreign matters derived from the dust of the atmosphere, which tend to accumulate on the skin, are thereby removed, and the pores are opened so as to allow the various sets of glandules to carry on unhindered their office of excretion. The universal detergent is water, which is applied most effectively to the surface of the body in the form of a bath. Water baths are of various kinds, and differ either in temperature or by holding in solution some mineral substance, wherefore they may have other hygienic actions besides their cleansing properties.

Pure water baths may be cold, tepid, or warm.

The cold bath, generally at about 60° Fahr., has a tonic and stimulating effect on the skin and constitution of persons in ordinary health. It causes the blood to rush inwards momentarily, whence, however, it is soon again driven outwards if the circulatory apparatus is moderately vigorous. A comfortable glow of the surface is then felt, which is termed 'reaction.' This reaction is the index to the benefit derived from the bath, and the skin is thereby stimulated to a more energetic performance of its functions. On the contrary, should it not occur, the skin remains pale and cold, whilst the internal organs are injuriously congested, especially the lungs, and there is evidence that the cold bath is harmful. On such an event the reaction should be encouraged by friction of the surface with a rough towel or with flesh gloves, but the bather should in future refrain from the use of a decidedly cold bath. It must also be observed that in no case should the cold bath be taken when the skin is cold, as there is then hardly any possibility of provoking a reaction, and injury may even result from increasing the already existing congestion of internal organs. Moreover, it is a standard rule not to bathe after a meal, as a disturbance of the circulation is then inadmissible.

The tepid bath, at about 90° Fahr., has no particular effect on the circulation, and is, therefore, suitable for delicate persons who merely desire to fulfil the duty of washing.

The warm bath, 100° to 120° Fahr., determines a flow of blood to the surface of the body and increases the cutaneous action. At the same time it relaxes all the muscular structures and renders the flow of the blood through its channels more laboured—a tendency which is met by greater contractile efforts of the heart, whence arises a quickened respiration. The warm bath, when short, supplies a salutary stimulus and alterative to the vital activities, but if indulged in too long or too often has a debilitating influence on the system which loses in tone on account of the excessive or repeated relaxations. After a warm bath the bather should remain at rest and well covered for a short time until the circulation has regained its normal course.

Of mineral baths, cold sea-water need only be mentioned here. Sea-bathing has always been considered tonic and invigorating; the motion of the water, the exercise taken whilst immersed in it, the stimulating atmosphere, and possibly the absorption by the skin of some of the mineral salts held in solution, combine to exert a peculiarly beneficial action on the system. Most persons can generally, therefore, bathe in the sea with marked advantage, except the very delicate and timid.

Another class of baths deserves a short notice, viz., the dry hot-air bath and the Turkish bath, of which it is the chief part. By the dry and hot air the glands of the skin are solicited to a very energetic action, and they respond by a copious flow of perspiration. A purifying effect on the blood is thus obtained, which is often highly salutary in the robust, especially if there be an inclination to corpulence. In the Turkish bath the perspiration is checked by a cold-water douche, and a reaction is then brought about by friction, shampooing, etc. These baths should, however, be taken with caution, as they are too powerful to be advisable in all cases. As a rule, they should never be persevered in without a medical recommendation.

3. *Cosmetics.*—The chief of cosmetics is soap, a combination of oil and alkali, which is indispensable to every toilet on account of its solvent power over all foreign matters that may coat the skin. It may be made more agreeable to the sense of sight and smell by clarification and admixture with various odoriferous oils or balsams, but beyond this there is usually but little choice to be exerted in the selection of so universal a commodity. The simplicity and cheapness of the articles that enter into its composition generally ensure a sufficient purity. Certain medicated soaps, containing tar, carbolic acid, sulphur, etc., are sometimes used, but are unnecessary unless when there is some structural disease of the skin, for the relief of which the special ingredient is intrinsically suited.

This term also includes the various applications used for the skin, such as violet-powder, rouge, hair-oils, various lotions for the complexion, eau-de-Cologne, etc., which are employed mostly about the face only for the sake of appearance. Such substances should always be used guardedly, unless their precise composition is known, as they are sometimes compounded with poisonous drugs, notably lead and arsenic, which may act perniciously both locally and generally.

IV. *Climatic Influences.*—The hygienic estimation of climate resolves itself almost entirely into a consideration of the state of the atmosphere in different parts of the earth, as to temperature, humidity, density, movement, and any foreign element that may permeate it, such as marsh miasma. The action of the air on the health of the body is determined by the degree in which it possesses these qualities, which spring from terrestrial and solar influences.[1]

1. *Hot Climates.*—In excessively hot weather (80° to 90° Fahr., or higher), if the air is dry, the skin is stimulated to provide a large quantity of perspiration, and the body is kept cool by rapid evaporation. At the same time respiration is quickened because the rarefied air contains less oxygen, and a larger supply of it is therefore required for breathing purposes. The increased rush of the dry air through the vocal channels tends to parch the mucous membrane—an effect which may deteriorate the quality of the voice. Moreover, the heat relaxes the muscular system, so as to reduce the aptitude for exertion. Under these conditions, therefore, the voice may lose in power and purity.

Should the air be unusually moist, although the parching effect is not present, the heat is more than

[1] Méliot conceives that climate exerts a peculiar influence over voice. He states that in hot countries there are finer voices than in cold regions, and that high voices are also more common there than deep voices. Thus in Italy more tenors than basses are found, and in Germany more basses than tenors. In France Picardy furnishes most bass voices. Languedoc and especially Toulouse and its environs are celebrated for tenor voices. Burgundy and Franche-Comté (Jura, Doubs, and Haute-Saône) supply most female voices. —*La musique expliquée aux gens du monde*, Paris, 1867 (quoted by Mandl, *Traité pratique*, etc., 1872, p. 294.) History, however, appears to indicate that musical gifts of voice are rather phylogenetic in their origin. Thus Italy, so prolific in our own times with fine singers, was not remarkable in the same manner in the age of the Romans; seemingly, indeed, the reverse. And in the classical period Greece and Asia Minor, which do not now produce singers of note, probably furnished the most esteemed vocalists.

ever depressing, because the normal temperature of the body cannot be preserved by perspiratory evaporation.

When wind is present it facilitates evaporation. It therefore increases the molestation if the air be already too hot and dry, but lessens the evil of humidity with elevation of temperature.

It is only in hot weather that marsh miasmata are potent for harm. They arise from low-lying tracts of land covered with decaying vegetable matter, but cannot emanate so as to pervade the general atmosphere, unless aided by a temperature above 60° Fahr. They engender the class of fevers called intermittent or agues, and in thus disturbing the animal economy interfere, of course, with the artistic exercise of the voice. These noisome exhalations consist of heavy gases which hug the ground, being unable to ascend into the higher regions of the air. On this account they can be avoided by living up hills,[1] should there be any, in the infected districts.

In hot climates the vicinity of the sea-coast is generally more healthful than the inland districts. The marine air has stimulating and tonic properties owing to its being impregnated with iodine, bromine, and various saline principles. It contains the largest amount of oxygen, allowing for temperature, because it has the greatest density; for the sea-level being the lowest, atmospheric pressure is there at its maximum. Its humidity is generally of an average measure according to the temperature, whilst miasmata, in infected localities, are

[1] The height, however, at which safety is obtained varies in dif-erent parts of the world. 400 ft. may suffice, but it may be neces-y to ascend 2,000 ft. See Parkes, op. cit. p. 411.

lessened on the shore and absent on the water at a short distance from it. The sea-side is, therefore, a valuable and ready refuge against many of the evils encountered in tropical climates.

2. *Cold Climates.*—Very cold weather (25° to 40° Fahr.), if the air is dry, is invigorating. It renders the function of the lungs more active, in order that a greater amount of animal heat may be evolved, with the object of preserving the normal degree of temperature. But the breathing is not consequently hurried or oppressed, because the cold air, being condensed, contains a comparatively large quantity of oxygen. The dryness of the atmosphere creates little tendency to parching of the air-passages, because it is counterbalanced by the cold which checks evaporation. On the whole, therefore, a cold, dry climate is favourable to vocal exercise, or at least is not injurious to the integrity of the voice.

The combination of cold and damp is notorious for its pernicious influence on health, though why it should act so injuriously is not quite certain. It may be taken for granted, however, that the exhalation of watery vapour, by the skin or lungs, or by both, is a vital necessity; probably because the water holds in solution certain fœtid organic matters which exert a poisonous effect on the system, and which cannot be otherwise removed.[1] In cold and damp air we have the conjunction of the two atmospheric conditions most potent in their antagonism to evaporation. In such case little or no aqueous vapour can be given off by the cutaneous or

[1] See Parkes, op. cit. p. 98.

pulmonary surfaces; and the fœtid organic matters, therefore, accumulate in the blood and tissues, tending to originate disease, mostly of a rheumatic character. But cold and damp also greatly exaggerate the liability to congestion of internal organs, and are prolific generators of inflammatory affections of the air-passages, such as quinsy, laryngitis, bronchitis, etc.

Fogs generally occur in cold, often in frosty, weather. They consist of molecules of water, which float about, suspended in the air. They are evidence of excessive dampness, and they are also particularly noxious in cities, as they there entangle and fix fuliginous or sooty particles in the stratum of air near the earth. The effect is, that persons involved in such fogs are obliged to inhale damp smoke, which has an irritating action on the air-passages. In foggy weather it will generally be found that the nasal discharges and expectorated matters have a blackened appearance.

It has been asserted that the gravity of the voice is increased in a cold and humid atmosphere,[1] but the statement needs proof. Retention of moisture in or about the vibrating portion of the vocal apparatus might, indeed, by increasing the density of the vocal

[1] The following incident would appear scarcely credible did it not rest on a high authority. When Grassini came to England the hygrometric influence of the climate caused her voice to descend in pitch by an octave. Its quality was not, however, deteriorated by this curious change; on the contrary, she had a great success in her lyric achievements until, by her becoming accustomed to the climate, her voice regained its normal compass. She then actually lost her popularity here, though her vocal powers had returned to the condition to which she previously owed her fame.

bands, lower their tones. Singers certainly feel the effect of chill and damp weather, and are then seldom in good voice.

Persons who are obliged to be out of doors in chilly and moist weather should be especially careful to breathe through the nose, as the air, being thus considerably warmed, will be enabled to carry off more watery vapour from the lungs. The mucous lining of the throat is also thus guarded from the ill effects of the cold. Should breathing through the nose be difficult from any cause, a *respirator* should be worn. This instrument is worn over the mouth, in order to warm the air and catch any particles of dust during inspiration. It supplies, in fact, the place of the nasal channels for those who are obliged to breathe through the mouth.

The action of wind in dry, cold weather is to cause the cold to be disagreeably felt. A cold, but dry climate is usually, indeed, well tolerated or even pleasant, when a uniform calmness of the air is the prevailing condition. In chilly, damp weather a brisk movement of the air increases the evaporation, but, in doing so, also augments the cold, which is then most painfully felt. Although winds are often favourable in maintaining atmospheric purity, and will dispel fogs, it seems that, on the whole, in decidedly cold weather, their influence is not precisely hygienic.

The *sea-air*, even in cold climates, retains its tonic properties. Its humidity on or near the shore is generally uniform, as far as terrestrial influences are concerned, because the soil in the vicinity of the ocean is usually of a sandy nature.

3. *Temperate Climates.*—The characteristic of most temperate climates is their variability; for, whilst their summer may be almost tropical, their winter is not unfrequently of polar severity. And the junction of these two extremes is not affected by insensible gradation, so as to amalgamate the seasons imperceptibly; but sudden changes of temperature to the extent of 20° or 30° Fahr. may occur in the course of a single day. At one time dryness, and at another humidity, of the air, may be present to a marked degree. This mutability is chiefly due to the action of winds, which, if they come from the north, have no opportunity to become heated; or, if from the south, are not exposed to any cooling influences before reaching the temperate zone.

The hygienic qualities of temperate climates are in direct relation with their variability, and the rapid transitions from heat to cold are especially inducive of catarrhal and inflammatory maladies, such as usually result from taking cold. Diseases of the throat are, therefore, frequent, and the inhabitants have some difficulty in preserving the purity of voice required for its professional use. On this account they are obliged to be particularly careful in adapting their clothing to the manifold emergencies of weather.

Notwithstanding these circumstances, it is in the temperate zone that some of the most agreeable and salubrious districts for dwelling in may be found. For, as the solar influences, if undisturbed, would generally confer a well-poised mean of temperature, it is only necessary to neutralise the action of the winds in order to obtain a stable climate free from hurtful extremes. This requirement is effected in many localities on the south coasts of temperate lands, such as Torquay, the Riviera, San Francisco, etc., where a mountainous chain intercepts the northern blasts, whilst the marine evaporation cools the sultry air blowing from the south. Such are the localities which are best adapted for the residence of invalids, as the constitution is not disturbed by the necessity of perpetually readapting itself to altered conditions of climate, whilst the weather is so equable as seldom or never to debar the taking of outdoor exercise. Life in the open air is, indeed, the most potent reinvigorator of those afflicted with consumptive tendencies.

4. *Mountain Air.*—The air of mountains or elevated plateaus has a favourable effect on the health of the animal economy, either from its purity or from its lightness. As the atmosphere is considerably attenuated on account of the altitude, it contains less oxygen, and consequently the breathing is hastened and the circulation of the blood accelerated. This change is salutary, and not attended with any sensation of pulmonary oppression, because the diminution of the atmospheric pressure on the surface of the body and the lessened force of gravitation facilitate exercise and increase the activity of the limbs. In hot climates the mountain air has also the advantage of being cool,[1] whilst in cold regions it is beneficial on account of its dryness. Life

[1] The decline of temperature according as we ascend may be roughly estimated at 1° Fahr. for every 300 ft. of elevation.

on the slopes of a mountain, at a height of from 3,000 to 7,000 feet, is now considered as an eminently curative agent in the treatment of many debilitating diseases, especially scrofula and consumption.[1] In cases of mild constitutional depression, such as continued fatigue from overwork, when a change of air is required, no better choice could be made than of residence for a few weeks in a temperate and elevated situation amongst the hills.

[1] See Weber, *Climate of the Swiss Alps*, 1864.

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114-15. Singing and dict.

Holmes
The science of voice production
and voice preservation