The Management of the Eye, Ear, and Throat.

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BY

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THE EYE AND SIGHT.

The sense of sight is so valuable, the variety, extent, and importance of the knowledge it affords is so much greater than that supplied by the other senses, that its loss, or even impairment, is always acutely felt. Young and old, rich and poor, are equally interested in its preservation, for its failure places the sufferer at the mercy of others, renders him more liable to accident, more open to deception, and, as a rule, unfits him for the discharge of the active duties of life, or, at least, enables him to perform them only at a great disadvantage to the rest of mankind. The rich man may indeed substitute the eyes, the hands, and the voice of others to assuage his affliction, to inform him of what is passing around him, and to protect him from injury; but he loses all those uncommunicable charms, both of nature and of art, that his higher culture fits him to appreciate and enjoy, and that are yielded by form, colour, movement, and expression, by the play of light and shade, and the infinite variety of visual sensations. The poor man suffers still more acutely; for, unless endowed with more than common energy, he feels that he has lost the means of subsistence, and that he has become a burden on his family, whilst he is at the same time destitute of those resources which are afforded by memory and reflection.

The greatest of our poets supplies those touches that make the whole world kin in the pathetic scene in which Arthur pleads to Hubert for his sight; whilst he depicts the utter helplessness of the blind in making Gloster, the statesman and the courtier, dependent for his guidance on poor mad Tom. Even Milton, who might have been expected to have found in the resources of his richly endowed intellect and well-stored memory all the alleviation that knowledge and learning and piety could give, sometimes bewails his condition in tones of unmitigated grief, and regards it as the consummation of human misery to be blind amongst enemies; and although at an early period of his affliction he could write to his friend Cyriac, "I argue not against Heaven's hand or will, nor bate a jot of heart or hope, but still bear up and steer right onward," it is not possible to read the numerous passages in which he refers to his calamity without perceiving how keenly its loss was felt, whilst the frequency with which he reverts to it shows how constantly it was present in his mind.

The possession of good vision is of immense importance in the early years of life. The receptive faculties of the brain are then in their highest state of activity; impressions are then received and images stored up which are never acquired with equal clearness in after years; and if the vision at this period be seriously impaired, the whole system of education, as usually carried out in this country, is practically stopped. Indeed, it may be said that in some respects, so far as education is concerned, a child who is absolutely blind is in a better position than one whose sight is seriously impaired. The blind child, though wisdom is at one entrance quite shut out, is yet encouraged to the exercise of his other senses, which acquire, by constant practice, a marvellous acuteness of perception—an acuteness that enables them, to a large extent, to supply the place of that which is wanting. The blind child's education, in one or other of the numerous blind-schools scattered through the country, is systematic and continuous; and, upon the whole, his life is happy and enjoyable. But it is otherwise with the child who has only impaired vision. Months and years are often allowed to elapse in the hope, not always realised, that improvement will take place, that he will some day be able to receive an ordinary school education and acquire the common information that children possess; and in the meantime, left to himself, and neglected at the most critical period of his life, he grows up ignorant of the rudiments of knowledge; and if, as time passes on, he is fortunate enough to recover useful vision, he still finds himself placed at an immense disadvantage as compared with those around him who can see well.

The importance of sight in mid-age need not be dwelt on. It is equally valuable and essential to the bread-winner and to the mother of the family. Nor is good sight less valued as age advances: nay, it is perhaps then most appreciated. The merchant, the barrister, the physician, or the soldier who has attained the highest rank in his business or profession, is, with failing vision, instantly made sensible of the precarious tenure of his position: instantly feels that the active work of his life is done, and that even if, by surgical measures or medical advice, his sight can be restored, others will have, in the meantime, stepped into his vacant place.

It may be remarked in passing, that the eye is an organ that has undergone evolution as the result of the action of light upon the body; and that when light is withdrawn it gradually wastes, and at length wholly disappears. Every form of animal life is susceptible to the action of light, but in the lowest forms no special organ is developed; the surface of the body generally responds to it. In animals very low in the scale, however, one or more—sometimes very many—parts of the body become coloured; and as the scale is ascended, whilst the number of these is reduced, fresh structures are added, each giving its possessor an advantage in the struggle that is perpetually waged for existence; till, at length, the complex eye of the insect, and that of the bird or mammal is reached. When light is feeble, as at great depths of the ocean, the eye sometimes becomes of portentous size, clearly with the object of gathering in all the rays that penetrate those dark regions. But if the mode of life of the animal be such that it is seldom or never exposed to luminous rays, one by one these parts waste away, the whole organ becomes more rudimentary, and at length entirely disappears. The mole, the proteus which inhabits the subterranean streams of Styria, and the eyeless insects and even spiders of the caves of Kentucky, show how, by disuse, the process of degeneration advances, till ultimately even predatory animals have to depend for their sustenance on other senses which there is every reason to believe have, in the course of ages, undergone a correlative increase in acuteness. Such slow changes may be and are actually in progress without extinction of the race; but it remains no less true that loss of vision effected in the lifetime of the individual is always disastrous, and, in the case of the animals below man, is practically fatal; for an animal thus afflicted is not only incapable of obtaining its own food, but is immediately exposed to the attacks of others, to which it soon falls a victim.

Sight having thus been shown to be serviceable to all, and indispensable to the great majority of animals and of men, it is obvious that a knowledge of the means by which it may be preserved, and by which injurious influences may be avoided, should form part of general information; and it is the object of the following pages to supply some rudimentary instruction on these points, and thus to assist the succeeding generation to preserve a thoroughly healthy organ, which may enable them to pursue their avocations without fear or anxiety. That such knowledge is of real value cannot be better demonstrated than by a reference to the German race of the present day, in which short-sightedness has become a national evil of great magnitude, the causes of which have only recently begun to be understood, but which has attracted an extraordinary amount of attention, leading to the adoption of many improvements in the system of education hitherto pursued.

The Structure of the Eye.

Before entering into any details as to the best means of preserving good vision to an advanced period of life, it will be expedient to give an account, though it must necessarily be very compressed, of the structure of the eye: to show how it is protected, how moved, in what way the image of the outer world is formed on the retina, and what are the arrangements by which we are enabled to adapt our vision for distant and near objects respectively. The diagram showing a section of the eye (Fig. 1, page 17) represents the principal points to which reference will be made.

The human eye is a nearly spherical body, about an inch in diameter, occupying the fore part of the hollow of the orbit, by which it is enclosed on every side except the front. It is kept in position by various muscles and blood-vessels, and by the optic nerve (O P), which conducts the impressions made upon the retina to the brain, and which is attached to it behind, a little to its inner side.

The eye is remarkably protected from injury. The bones of the nose, of the brow, and of the cheek collectively form a kind of outwork, defending it from direct blows of all rounded and blunt instruments, unless directed with extreme violence. It rests upon a bed or cushion of fat, which not only facilitates its movements, but permits it to yield to pressure of moderate degree. The acute sensibility of the eyelids and of the lashes with which they are fringed enables the approach of small objects, such as insects, to be perceived in time to close the lids, and thus prevent their entrance. The eyebrows turn the drops of sweat by which man has to obtain his daily bread to the side, whilst the discharge of tears excited by any irritation applied to the surface of the eye protects it from the harm that might result from the entrance of dust, sand, or other objects borne on the wind, which, though too small to be seen and avoided, are yet capable of producing much discomfort, or even of exciting acute inflammation. In addition, the rapidity with which movements of the head can be made in response to impressions of sense enables us in many instances to escape danger to the eyes which would otherwise be inevitable. Each eye is moved by six muscles, which are attached to it in such a manner that they can roll it in any direction; and the movements of the two eyes effected by these muscles are among the best examples of harmony and co-ordination, or concordant action, of muscles in the body, the least deviation from absolute symmetry being productive of double vision. Four of these muscles are named the straight, or recti, muscles, and turn the eye upwards, downwards, inwards, and outwards; whilst the two remaining ones, named the superior and inferior oblique muscles, respectively roll the eye downwards and outwards, and upwards and outwards, besides slightly modifying the action of the straight muscles. In many animals, as the sheep, ox, and horse, an additional muscle, the retractor of the eye, is found, the use of which is to draw the eye back into the socket, and thus more effectually to protect it in plunging through thickets or in the fights to which the males are prone. In front, the eye is covered by a delicate membrane, named the conjunctiva. This membrane forms the soft velvety layer that lines the lids, is reflected from them to the white of the eye, and extends in the form of a very delicate and transparent layer of cells over the cornea, or glass of the eye. The smooth, moist, opposed surfaces of this membrane which are constantly lubricated with tears and thin mucus, permit the rolling movements of the eye to take place with the least possible friction. It is important to notice that in a healthy young person the portion of the conjunctiva lining the lids is of a delicate pink or reddish colour, whilst where it covers the white of the eye it is very pale, and only streaked here and there with a few large vessels, chiefly situated at the inner and outer angles of the eye. As age advances slight inflammatory troubles are not uncommon, and the portion of the membrane lining the lids assumes a fiery red appearance, whilst that which covers the globe of the eye loses its pearly hue, and becomes more or less streaked with distinct large or leashes of small vessels.

As this membrane is the most exposed to external injury, so is it the most frequently inflamed, and many of the minor troubles, as well as some of the more serious diseases of the eye which not unfrequently terminate in blindness, are due to inflammation of its structure.

The outer coat of the eye (A B) is a strong, dense membrane, and though continuous throughout, is divisible into two portions, of which the front part, or cornea (A), is transparent, whilst the back part, or sclerotic (B), is opaque. The cornea forms about one-fifth of the circumference of the globe, and the sclerotic forms the remaining four-fifths.

The sclerotic coat, which forms the white of the eye, is a strong dense cup, well fitted to enclose and protect the delicate structures in its interior. It is formed of a close web of fibres, with comparatively few and small blood-vessels, the absence of which accounts to some extent for its pearly aspect. Behind, it presents an opening for the passage of the optic nerve. In front, it is continuous with the cornea, and however different these two parts may appear to be in physical character, they nevertheless pass into each other by gradations that are almost imperceptible in sections examined with the microscope. The sclerotic fulfils several purposes. It gives to the eye its firmness and power of resisting pressure: a fact that is particularly well exemplified in the eye of the whale; for in the profound depths of the ocean to which this animal descends the pressure exerted upon the eye, as upon all the external parts of the body, is immense. The thick coating of fat by which the body generally is covered enables it, amongst other purposes, to resist this pressure with impunity, but the eye requires a special provision, and this is found in an enormous increase

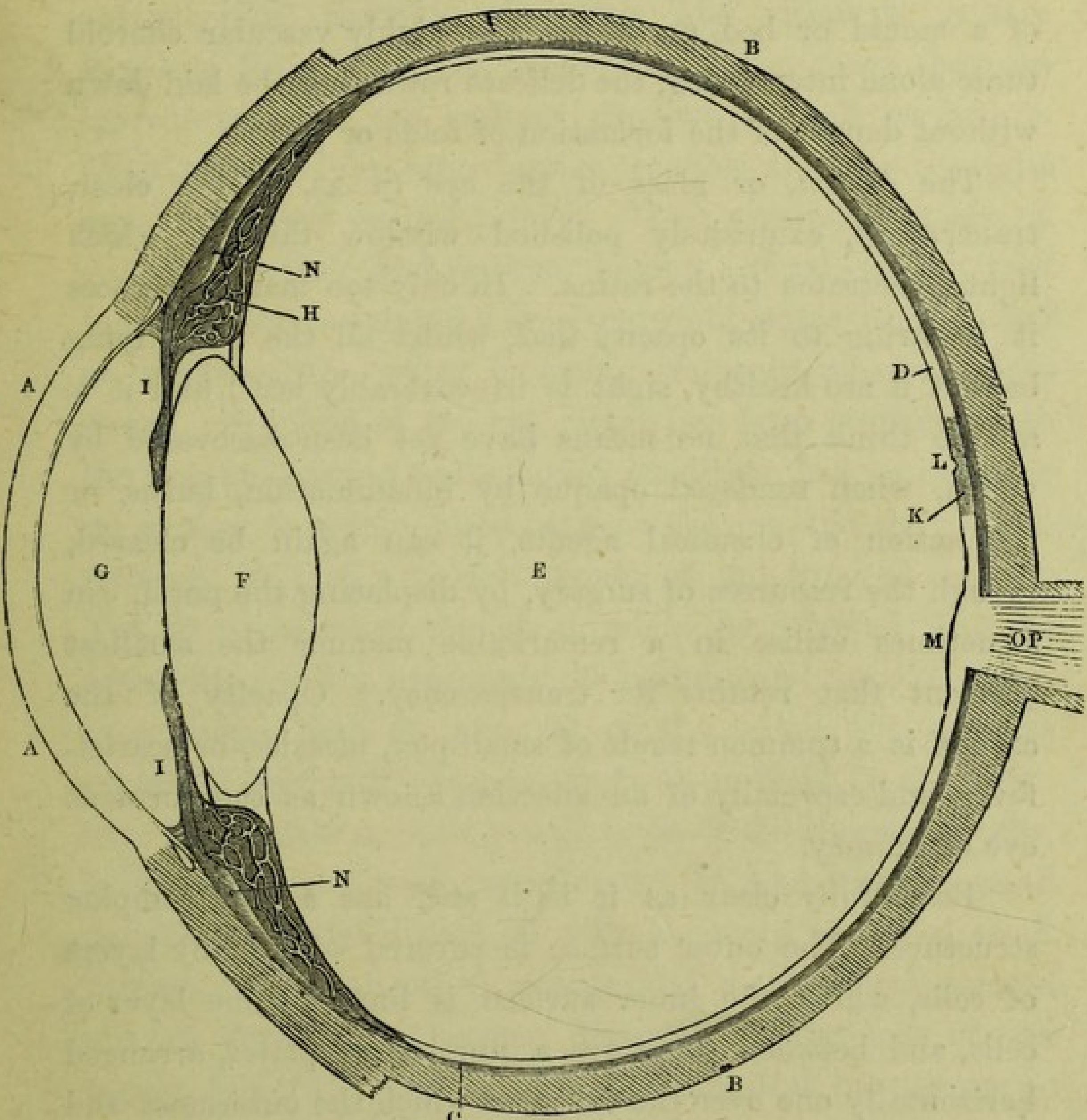


Fig. 1.—Section of the Eye in Man.

A A, Cornea; B B, Sclerotic; C, Choroid; D, Retina; E, Vitreous Humour; F, Lens; G, Aqueous Humour; H, Ciliary Processes; I I, Iris; K, Yellow Spot; L, Fovea Centralis; M, Optic Papilla; N N, Ciliary Muscle; O P, Optic Nerve

of the sclerotic, which at its posterior part attains in the whale a thickness of nearly half an inch. In addition, the sclerotic forms a solid crust or shell to the eye, into which the muscles by which the rolling movements are effected may be implanted. Lastly, its solidity and strength, as well as its uniform curvature, admirably adapt it to play the part of a mould or bed, on which, the highly vascular choroid tunic alone intervening, the delicate retina may be laid down without danger of the formation of folds or plaits.

The *cornea*, or glass of the eye (A A), is the clear, transparent, exquisitely polished window through which light penetrates to the retina. In only too many instances it is owing to its opacity that, whilst all the parts lying behind it are healthy, sight is irrecoverably lost; and it is sad to think that no means have yet been discovered by which, when rendered opaque by inflammation, burns, or the action of chemical agents, it can again be cleared, though the resources of surgery, by displacing the pupil, can sometimes utilise in a remarkable manner the smallest segment that retains its transparency. Opacity of the cornea is a common result of small-pox, measles, or scarlet-fever, and especially of an affection known as the purulent eye of infancy.

Beautifully clear as it is, it still has a very complex structure. The outer surface is covered with many layers of cells, whilst the inner surface is lined by one layer of cells, and between these are a number of plates, arranged horizontally one over the other, of which the outermost and innermost are particularly elastic. In health it has no blood-vessels, since these would render it opaque, though it often becomes bloodshot in disease—an appearance that is due in part to minute pre-existing channels widening so as to permit blood-corpuscles to enter, and probably in part also to the development of altogether new vessels. The value of the cells in front of the cornea is very great. They are structures which, if spoilt, can be reproduced. Hence, in many cases of inflammation, though they are partially lost through ulceration, and vision is greatly impaired for a time, yet, as recovery takes place they are reproduced, and the sufferer can see as well as before. Their capacity for reproduction enables the eye to resist apparently very serious injury. Thus, several cases are on record in which lead-workers having poured molten lead into a cavity containing a drop or two of water have caused an explosion, the water becoming suddenly converted into steam. A splash of the hot metal has been propelled into the eye, and, owing to its liquid condition, has spread over its surface as a thin plate between the eye and the eyelids, forming, in fact, a perfect mould of the front of the eye. Yet, in some cases, though it might be inferred that the destruction of the eye would be certain and speedy, it has been found that on removal of the metal the eye has remained perfectly clear, or, at most, suffered from temporary inflammation, with loss of some of the superficial cells, which have been soon reproduced. In like manner, small particles of metal struck off with hammers, wings of small beetles, and many other minute and more or less pointed objects, are apt to become impacted in the cells of the cornea, but if removed by a light and skilful hand leave no permanent defect behind.

The next coat, or tunic, of the eye is the *choroid* (c, Fig. 1), (*c d*, Fig. 2), which distantly resembles a cup of black velvet, with the pile surface turned inwards. In velvet the pile consists of short fibres standing vertically on a base of coarser threads; but in the choroid the coarser threads are blood-vessels, some of which convey blood to the part, and are named arteries (*a c*, Fig. 2), whilst others convey it away and return it to the heart, and are named veins (*x*, Fig. 2). The pile of the choroid, instead of consisting of solid single fibres like that of velvet, is composed of myriads of loops of minute blood-vessels, or capillaries (*d d*, Fig. 2), which establish a connection between the arteries and veins, and in which a constant stream of blood is flowing to bring nourishment and oxygen to the retina and adjoining parts, and to carry away the materials which have been used up, and are no longer of service in the act of vision. Intermingled with the vessels are delicate fibres of supporting tissue, with a large number of pigment cells, the office of which is to absorb those rays of light that do not actually form the image; their value is shown by the difficulty experienced by albinos, in whom they are absent, of seeing in the bright light of day.

The choroid has been described as a cup. Now, if we imagine the edge of the cup to be plaited, or pinched up into folds for a certain distance, and then becoming smooth again, to turn in till they almost meet in the centre, leaving only a small round hole, we shall obtain an idea of the mode in which the fore part of the choroid forms the ciliary processes (H, Fig. 1; *l*, Fig. 2) and the iris (I, Fig. 1; *h*, *k*, Fig. 2), with its central aperture, or pupil. The ciliary processes, which are about seventy in number, are arranged regularly around the eye, close to the junction of the cornea and sclerotic, and consist of masses of small blood-vessels, bringing the materials of nourishment into moderate proximity to the lens. The reason of their large numbers is not difficult to give. Most organs of the body

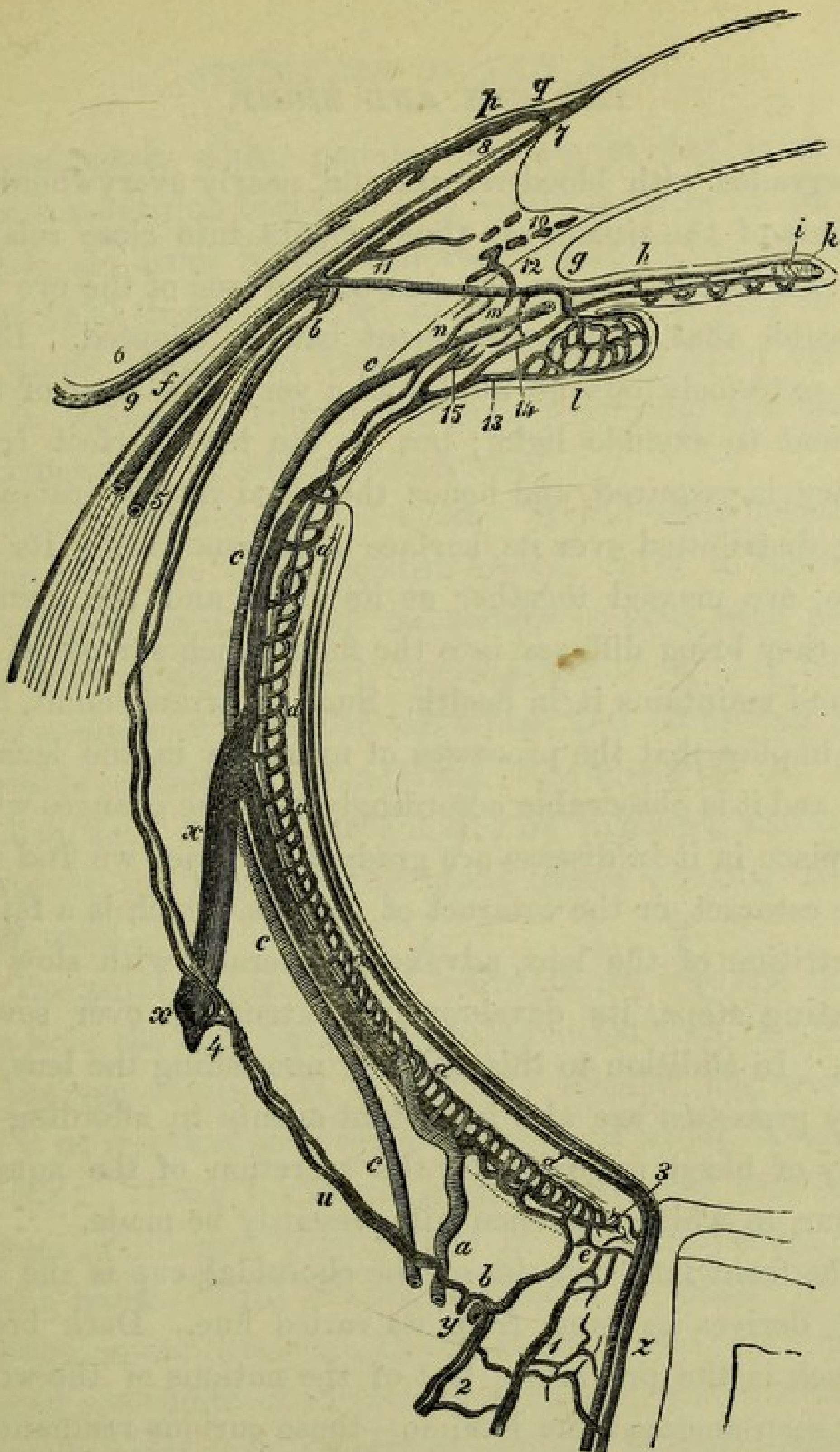


Fig. 2.—Diagram showing the Arrangements of the Blood-vessels of the Eye.

a, *b*, *c*, ciliary arteries; *d*, *d*, the fine loops of capillary vessels; *f*, one of the straight muscles; *g*, *h*, *i*, *k*, iris; *l*, ciliary processes; *m*, *n*, small vessels communicating both with external and internal vessels of the eye; *p*, *q*, conjunctival vessels; *x*, one of the venæ vorticosæ; *u*, ciliary vein; *z*, central artery and vein of the retina; 1, 2, short ciliary artery and vein; 3, communication between central artery of retina and ciliary vessels; 4, vein conveying blood to vena vorticosa; 5, subconjunctival vessel; 6, episcleral vessel; 7, communication between conjunctival and muscular vessel; 8, 9, conjunctival vein; 10, canal of Schlemm; 11, communication between outer and inner vessels of eye; 12, position of canal of Fontana; 13, 14, 15, vessels of the ciliary processes.

are pervaded with blood-vessels, and nearly everywhere the elements of the tissues are thus brought into close relation with the blood; but in the case of the lens of the eye it is impossible that this arrangement can be adopted. Blood is an extremely opaque fluid, and a very thin layer of it is sufficient to exclude light; but in the lens perfect transparency is required, and hence the blood-vessels, instead of being distributed over its surface and penetrating its substance, are massed together at its sides, and the nourishment they bring diffuses into the fluid which surrounds the lens and maintains it in health. Such an arrangement, however, implies that the processes of nutrition in the lens are slow, and it is observable accordingly that the changes which take place in it in disease are gradual. Hence we find that senile cataract, or the cataract of old age, which is a failure of nutrition of the lens, advances generally with slow and hesitating steps, its development extending over several years. In addition to this office of nourishing the lens, the ciliary processes are also important agents in affording the supply of blood requisite for the secretion of the aqueous humour, to which reference will presently be made.

The front inturned rim of the choroidal cup is the *iris*, which derives its name from its varied hue. Dark brown or black is the prevailing tint of the nations of the world, being seen amongst the Eskimo—those curious remnants of an ancient race—the Chinese, Americans, and almost all the people inhabiting India, Southern Europe, and the continent of Africa, whilst grey and blue irides are characteristic of the Teutonic races. The surface, if closely examined with a hand-glass, presents radii, which are interrupted near the pupil by a slight thickening; and at various times, when popular excitement has existed or when superstition has been rife, words or letters have, with a little aid from fancy, been read on the surface. Thus, about 1830 there was a girl in Paris who was said to have the words "Napoléon Empereur" inscribed upon her iris, but in whom the supposed letters were only the natural markings read by willing believers.

The two irides are not always of the same colour, one being blue, the other reddish-brown, or of a lighter or darker tint; and it is not uncommon to meet with persons who have reddish or dark brown spots on a blue iris, the spots sometimes being of large size, and occupying a considerable portion of the surface. In albinos the iris is of a reddish tint, due to the absence of pigment, and to the colour of the blood in the blood-vessels shining through their walls.

The pupil is a hole in the centre of the iris, and through this hole the only light which is admitted into the interior of the eye enters. It is perfectly circular, and when the iris is at rest has an average diameter of about one-sixth of an inch. Great variations, however, are met with in this respect in different persons, and in the same person at different times. Thus in some, especially in those who are of a sanguine temperament, the diameter of the pupil may not exceed one-eighth of an inch, or even less, whilst in those of sluggish habit it is sometimes as much as one-fourth of an inch. The iris, though chiefly composed of blood-vessels, possesses two sets of muscular fibres, one set being arranged concentrically to the pupil, the other radiating from the pupil towards the circumference. The variations in size which the pupil presents are dependent on the action of these muscular fibres: when the circular fibres contract, it is diminished; when the radiating fibres contract, it enlarges; and the action of these two sets of muscular fibres is chiefly brought into play by differences in the degrees of light. When the eye is exposed to bright light the circular fibres contract, and the pupil is reduced to the size of a hole made by a large pin, whilst in darkness it dilates to its utmost extent. The object of these changes is sufficiently apparent, for the entrance of a powerful beam of light into the eye harms the retina, confuses the images cast upon it, exhausts its powers, and impairs its perceptive faculty, rendering it for some time incapable of receiving other impressions. The pupil is, therefore, contracted to its narrowest dimensions, to allow as small a beam as possible to enter. On the other hand, when light is deficient it is important that all the rays falling upon the eye should be admitted, and hence the pupil enlarges. In man these variations in the size of the pupil are quite involuntary, and constitute typical examples of what are termed reflex acts with consciousness. The succession of events is that light falling on the retina constitutes a stimulus which produces a sensory impulse that is conveyed to the brain by the optic nerve, where it awakens consciousness by exciting certain nerve cells; these are connected with others which possess the power of directing motor impulses to the circular muscular fibres of the iris. There is, therefore, a kind of reflection at the brain—a change of a sensory impression into a motor impulse, which has led to its being termed a reflex act. When consciousness is wholly lost, as in persons deeply under the influence of chloroform, the pupil is usually somewhat dilated, but does not become smaller when light is allowed to fall on the eye. In many animals, but especially in those that are of nocturnal habits, as the owl and the cat, the movements of the pupil are not altogether involuntary, but are partly dependent upon the will of the animal; so that if one of these nocturnal predaceous animals be examined for a short time, it will be seen that the pupil enlarges and contracts quite independently of any variation in the amount of light that enters it; and it is probable that it is correlated with the requirements of the visual power when the animal is in pursuit of its prey.

But the size of the pupil is not, even in man, exclusively due to the amount of light that falls upon the retina; it depends in part on the accommodation of the eye for objects at varying distances. Thus, if a remote object be looked at, the pupil is of moderate or normal width; but if the eyes be now suddenly made to converge upon an object not more than a few inches distant from it, the pupil will be observed to contract. This appears to be due to the circumstance that its contraction corrects the spherical aberration of the lens: that is to say, that since those rays of light which traverse the outer or marginal part of the lens come to a focus sooner than those which pass through it near its centre, the contraction of the iris, and the consequent smaller size of the pupil, by cutting off the outermost rays of the cone of light falling upon the lens, and permitting only the central rays to traverse it, necessarily contributes to the formation of sharper and better-defined images upon the retina.

The size of the pupil, again, varies with mental emotions; and the large pupil which accompanies the emotion of fear is very characteristic of that condition of the mind. And yet, again, the size of the pupil is, to some extent, a tell-tale of the state of the bodily health and general vigour of system; for it may be observed to be large and languid in its movements in those who are depressed and exhausted by long illness or protracted watching, whilst it is smaller, and certainly contracts and dilates more actively, in those who are healthy and strong.

Lastly, the size of the pupil can be powerfully influenced by various poisons; the belladonna plant, for example, as well as many others belonging to the natural order *Solanaceæ*, contains an alkaloid named atropine, or some closely allied compound, which, even when applied to the eyes in almost inappreciable quantities, possesses the remarkable power of effecting great dilatation of the pupil, which will remain immovable for hours; whilst eserine, an alkaloid obtained from the Australian tree named *Physostigma venenosum*, is capable of effecting its contraction to a very minute hole. The opposed action of these two substances, which are easily applied to the eye, and produce little or no pain, renders them invaluable agents to the ophthalmic surgeon in various conditions of disease. The average distance of the centres of the two pupils from each other is two inches and one-third.

The third coat, or tunic, of the eye is the retina (D, Fig. 1), which is the specially modified termination of the optic nerve. It is an exquisitely delicate transparent layer, which lines the back part of the eye. It was long thought to be colourless, but researches made during the last few years have shown that in the living body it possesses a pink or rosy hue. The complexity of the retina is very great; and no less than ten strata have been shown to exist in it, the uses of some of which have not at present been ascertained, or even conjectured. The outermost stratum, or layer, consists of a series of rods arranged side by side, so that when seen upon the flat they present the aspect of a mosaic. Their uniformity is interrupted here and there by a larger, but shorter, body, called, from its shape, a cone; and it is remarkable that the cones are exclusively present at that part of the retina which is most sensitive, namely, the yellow spot (K, Fig. 1).

The smallest object that can be seen forms an image on the retina that is about the diameter of one of the cones. The other layers of the retina consist of specially modified nerve and connective tissue; but it is unnecessary to enter into minute details in regard to them.

The tint of the retina is due to a red colouring matter, which can be obtained in a separate state, and has been named rhodopsin, or visual purple; and some interesting facts have been determined in respect to it. It exists chiefly in the outer part of the rods and cones; it is soluble in water and various other liquids, and is rapidly bleached when exposed to light. If the eye of an animal killed in a dark room, or in one illuminated only by monochromatic light, such as that of burning sodium, be quickly removed from the head and examined, it is found to be of a bright rose-red; but on admitting the light of day, it rapidly becomes paler, then changes to the hue of chamois leather, and finally assumes a dull grey tint. If it be now covered up from sunlight, and kept for some time in a dark chamber, a tinge of colour reappears; and it seems probable that the colouring matter is formed from material actually present in the rods and cones. This is, of course, soon used up after death; but during life we may suppose that it is constantly being renewed, and that as fast as exposure to light bleaches it new material for its restoration is brought by the blood circulating in the vessels of the retina.

It is impossible not to recognise the similarity that the eye, as a whole, presents to a photographic apparatus. The globe itself is the camera obscura, from which rays of light other than those passing through the lens, and destined to form the picture of the outer world, are carefully cut off by the pigment of the choroid and the opaque iris. The retina is the sensitised plate on which the picture is received, the lights bleaching it according to their intensity more or less rapidly, whilst the shadows produce but slight change in it. In health, however, there is no fixing of the image and retaining it for future use. The picture, if retained at all, is written on the tablets of the brain, whence it can be recalled by an act of memory. But that the bleaching action above referred to really occurs has been demonstrated by placing the eye of a rabbit with widely dilated pupil before a window. For, the animal being quickly killed, and the retina exposed under monochromatic light, the image has been fixed by plunging it into a little weak alum and water, and after the lapse even of a day or two, if preserved from light, the retina has exhibited the cross-bars of the window. This experiment gave rise to the absurd story current some years ago, to the effect that, in cases of murder, the assailant might be recognised by the image preserved on the retina of the victim. It will, however, be seen from the above account that it would be necessary that the light of day should be immediately excluded, and that special measures should be adopted to preserve the picture.

The humours of the eye are three in number, though one of them at least scarcely deserves that appellation—the aqueous, the lens, and the vitreous. The aqueous humour occupies the spaces marked 4 and 15, Fig. 3 (p. 35), and named the anterior and posterior chambers, which communicate with each other through the pupil. There are about ten drops of this watery fluid, and it is very clear and transparent. It contains a very small quantity of salts. It is probably produced by the ciliary processes, and is discharged into the posterior chamber of the eye, from which it passes into the anterior chamber, and then drains away through channels situated near the margin of the cornea.

The use of the aqueous humour is to maintain a uniform tension of the eye, so that no injurious pressure may be exerted upon the sensory nervous apparatus with the varying amounts of blood that enter or escape from the eye; and, in accordance with this, we find that a quick circulation takes place in it, blood or other colouring matter injected into the anterior chamber being rapidly washed away, whilst if it is allowed to escape, as by puncture of the cornea—a proceeding often adopted for the relief of tension in the treatment of ophthalmic diseases—it is quickly reproduced.

The second humour of the eye is the lens F, Fig. 1, often called the crystalline lens, from its brightness and transparency. When removed from the eye, it is a body of about one-third of an inch in diameter and one-fourth of an inch in thickness. It is perfectly circular, and occupies a depression in the fore part of the vitreous humour. The iris rests upon its front surface, and all rays of light entering the eye through the pupil must traverse it. It is enclosed in a kind of bag, or capsule, and is kept in position by a membrane which is attached to its edge, or margin, named the suspensory ligament. The lens is highly elastic, and differs in consistence in different parts, its outer surface being thin and jelly-like, whilst the centre is harder, and of the consistence of cheese.

The use of the lens is to cause the rays of light emitted by any luminous body to be brought to a focus upon the retina, and its transparency, therefore, is essential to the performance of the work it has to do. The slightest cloud or haziness of its surface or substance impairs its function, and by impeding the entrance of light interferes with clear vision. It is then said to be cataractous. An opaque lens is a cataract; and it is obvious that no spectacles or other means will aid the vision of a person whose lens is perfectly opaque any more than a pair of opera-glasses will assist a person with good vision to see objects on the other side of a ground-glass screen. Remove the screen from the one, and the lens from the other, and the objects previously obscured will at once become visible, though in the latter case an appropriate glass, making up for the lens he has lost, will be required.

The third humour is the vitreous humour (E, Fig. 1), which constitutes the greater part of the eye, and is of gelatinous consistence. It may be regarded as a medium destined to support the lens, which fits into a hollow of its surface, and to maintain it at such a distance from the back of the eye as to permit the rays of light passing through it to form distinct images on the retina. It is but slightly liable to disease, but is often the seat of the deposit of small particles of pigment, which, without being dangerous, are troublesome, and indicate in most instances that the eye has been overtaxed.

The Functions of the Eye.

We have now completed our account of the anatomy of the eye, and may proceed to consider how it acts in the performance of its work; and the first question that arises is, How are the images of external objects formed upon the retina?

The mode in which an accurate image of distant external objects is formed upon the retina is not difficult to understand. It is only requisite to bear in mind that light travels in straight lines, and that the physical conditions of the humours of the eye are such that parallel rays falling upon the eye, and entering through the pupil, are brought to a focus upon the retina. Those rays that come from any object situated in the upper part of the field of vision are focussed on the lower part of the retina; those that are situated in the lower part of the field of vision are focussed on the upper part of the retina. Thus, an inverted image of every external object is formed on the retina, and an inverted image of precisely similar character can be obtained with the greatest ease on a sheet of white paper by simply holding an ordinary lens two or three inches away from it. The trees and sky will then be seen to be inverted, and the chimneys of the opposite houses will point downwards.

It has just been stated that the healthy eye when at rest is adapted for bringing parallel rays to a focus upon the retina. In point of fact, however, there are no such parallel rays in nature. Even those which emanate from the sun or from stars, the most distant objects with which we are acquainted, are only approximately parallel, and are, in reality, slightly divergent. But for all practical purposes of vision, rays which proceed from an object more than twenty *feet* distant may be regarded as parallel, and all such rays the normal eye can, without effort, bring to a focus upon the retina. But rays of light emanating from objects a few *inches* from the eye are strongly divergent, and would not, therefore, if the eye remained unchanged, be brought to a focus upon, but behind, the retina, and a blurred and indistinct image would be the necessary consequence. To surmount this difficulty, the eye is endowed with a faculty of accommodation.

By the term accommodation of the eye is understood the power which the eye possesses of adapting itself to see objects at different distances distinctly. In sitting for a photographic portrait the operator places the sitter at a variable distance from the instrument, and then arranges his glasses so that a sharp and well-defined image falls on the sensitive film of iodised silver. Nay, more; if the operator be an artist, he will place the hands of the sitter in a certain position, for he knows that if they are too far forward they will be out of focus, and that they will not only appear larger than natural, but ill-defined and blurred in outline: he knows, in fact, that the image of the face and of the hands will not be equally clearly defined unless they are nearly on the same plane, nearly at the same distance from the sensitised plate. He knows that he cannot obtain a good picture of fore, middle, and background simultaneously;

to obtain absolute clearness and definition of either one of these three, the other two must be sacrificed to a greater or less extent. If he wishes to make the foreground distinct he must draw the tube out a little and make it longer; if he wishes to emphasise the background and distant objects, then he must screw his instrument up a little and make the tube shorter. He must accommodate his instrument to the distance he wishes to make most distinct; and he is the best photographer by whom the imperfection of the instrument is distributed, so that images of objects in all places are tolerably clear, and none quite dim.

What the photographer does roughly and with his hands, the eye does for itself, by virtue of a power it possesses of increasing or diminishing the thickness of the lens contained in its interior; and this power is termed the faculty of accommodation. The possession of such a power by the eye can easily be made manifest. If a piece of rather coarse net be placed at a distance of eight inches from the eye whilst standing opposite an open window commanding a prospect of moderate extent, it will be found that if the attention be directed to the threads of the net they can be readily seen and counted; but if the observer look at a man, a church, a tree, or any other object at some distance from him, the fibres and interstices of the net will become indistinct, and if he wishes again to count them he must make a certain amount of effort. The process by which the near or the distant object is rendered clear is said to be by a change in the accommodation of his eye. In looking at a distant object he relaxes his accommodation, in looking at a near object he exerts his accommodation. The question then arises, By what means is this accommodation effected?

The accompanying diagram (Fig. 3) will aid in representing how accommodation is effected; and it will be seen that the figures 9, 10, 12, point to a white striated band, formerly named the ciliary ligament, but which recent researches have shown to be a muscle. This muscle runs round the fore-part of the eye, just beneath the junction of the cornea with the sclerotic, and at the outer border of the iris. Most of the fibres radiate as shown at 9—radiate outwards or backwards—but some, shown at 12, run in a circular direction. The muscle acts from a fixed point—its point of origin—marked 10, and when it contracts it pulls upon the choroid coat, 6, and brings this membrane forwards. The effect of this is to relax the suspensory ligament of the lens, 13. But the instant this is relaxed, the lens, being a highly elastic body, bulges forward, and instead of occupying the position which it does when the eye is at rest, shown on the upper half of the figure, it assumes that shown on the lower half. It becomes a thicker or a stronger lens, the amount of increased thickness depending on the degree of contraction of the ciliary muscle. The lens has thus become adapted for bringing more or less strongly divergent rays to the focus. If we look at a distant object, the muscle is not in action at all. The lens is compressed by the suspensory ligament, and it is adapted to bring the parallel or any very slightly diverging rays from the object we are regarding to a focus on the retina. If we look at an object ten feet distant the muscle is brought moderately, and almost unconsciously, into play; it somewhat relaxes the suspensory ligament, and the lens becomes a little

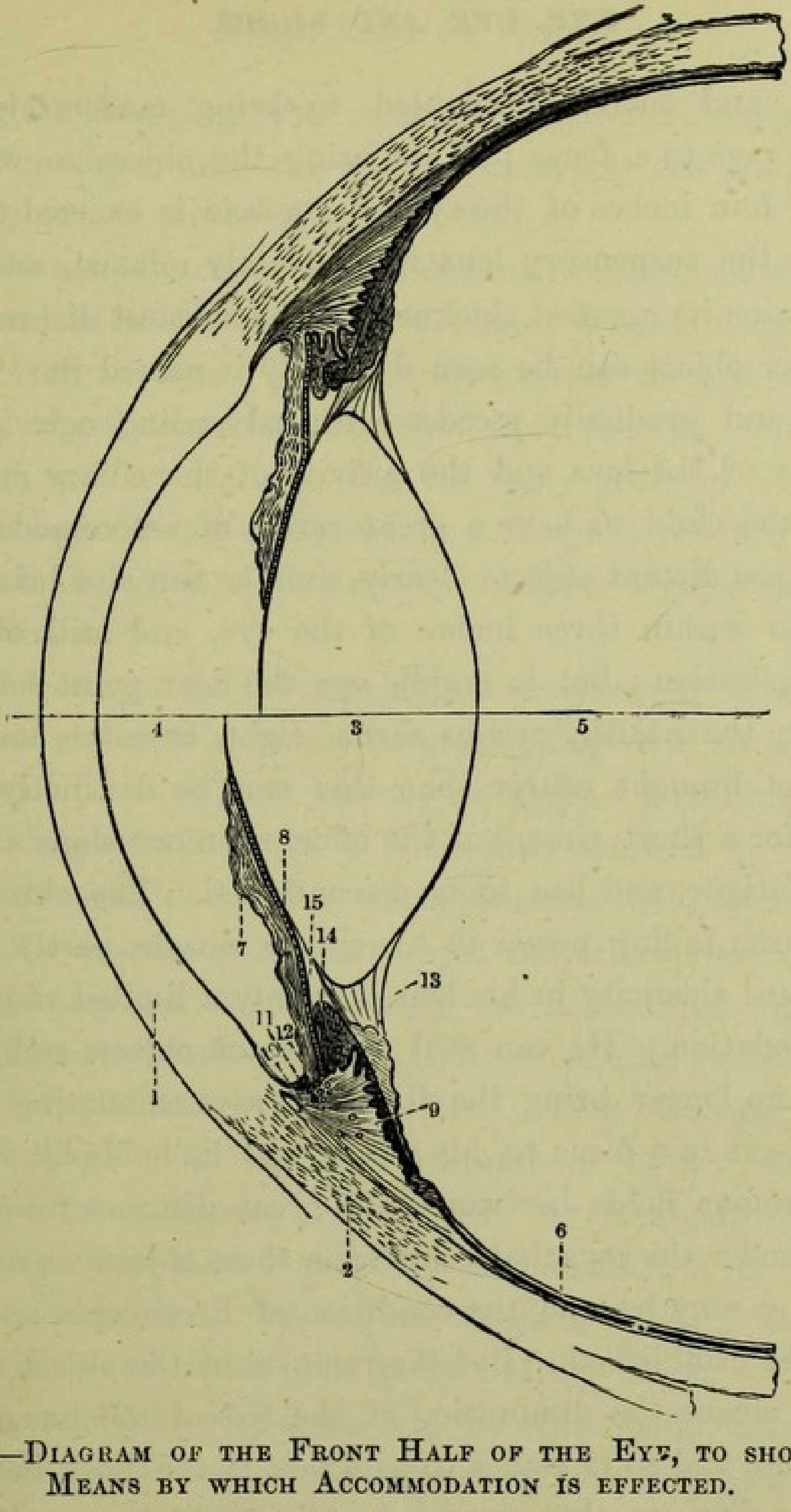


Fig. 3.—Diagram of the Front Half of the Eye, to show the Means by which Accommodation is effected.

1, Cornea; 2, Sclerotic; 3, Lens; 4, Aqueous humour; 5, Vitreous; 6, Black Choroid lying on the sclerotic, and covered by the retina; 7, Iris; 8, Black layer of pigment behind the iris, named the Uvea; 9, Ciliary Muscle meridional fibres; 10, Origin of ciliary muscle; 11, 12, Circular fibres of ciliary muscle seen in section; 13, Suspensory ligament of the lens; 14, Tip of ciliary process; 15, Posterior chamber of the eye.

thicker, and therefore adapted to bring moderately diverging rays to a focus ; if we bring the object to within three or four inches of the eye, the muscle is exerted to its utmost, the suspensory lens is completely relaxed, and the lens attains its greatest thickness. The shortest distance at which an object can be seen distinctly is named the "near point," and gradually recedes with advancing age. The elasticity of the lens and the activity of the ciliary muscle enable the child to have a great range of accommodation. He can see distant objects clearly, and he can also bring an object to within three inches of the eye, and still obtain sharp definition ; but in middle age the near point has receded in the healthy eye to seven, eight, or more, inches; an object brought nearer than this may be distinctly perceived for a short time, but the effort soon occasions a feeling of fatigue, and has to be discontinued. The old man, partly from failing power in his ciliary muscle, partly from diminished elasticity in his lens, has only a limited range of accommodation. He can still see distant objects well, but he can no longer bring the diverging rays emanating from near objects to a focus on his retina, and he holds his book, or the woman holds her work, at a great distance from the eye to render the rays that come from these objects as nearly parallel as may be, and the condition of Presbyopia is then said to be established. But the removal of the object from the eye means the diminution of the size of the image on the retina, and so it comes to pass that if the book be held at such a distance that clear and well-defined images of the letters are formed on the retina, these are so small that they can no longer be perceived. Hence, the size of the print must be increased, or glasses must be used, which will bring the diverging rays emanating from near objects to a focus on the retina, and which thus supply the place of the failing or lost power of accommodation.

The act of accommodation is usually associated with convergence of the eyes, and it produces a certain amount of tension of the eye. If it be only exerted for a short time, no injurious influence is exercised upon the eye ; but if prolonged, and especially during the early years of life, when the sclerotic is soft and yielding, it is apt to produce elongation of the globe, and thus to occasion Myopia or shortsightedness.

The sharpness of vision differs considerably in different persons, and may certainly be greatly improved by habits of attention; but that it has not undergone material change for at least 4,000 years is sufficiently attested by the fact that amongst the Arabs, whose pastoral habits, combined with the dryness and clearness of the atmosphere of their vast plains, led them to study the heavens at night, the small star Alcor was regarded as a test of good vision. They named it Saidak, or the "Tester." It is situated in the tail of the Great Bear, at a distance of 11′ 48″, or about one-fifth of a degree, from Mizar. It is about equal in brightness to a star of the fifth magnitude, but is to some extent overpowered by the brightness of Mizar. It is still just within the limits of ordinary healthy vision.

The satellites of Jupiter, on the other hand, may be regarded as just beyond the power of the ordinary eye to recognise; yet Humboldt informs us that a master-tailor in Berlin, named Schön, was able to determine correctly with his unaided eye, on clear moonless nights, the precise position of these satellites. He saw the third satellite best; he could also distinguish the first when at the greatest distance from Jupiter; but he was unable to see the second (which is the smallest) or the fourth. The distances of the several satellites from Jupiter are 1′ 51″, 2′ 57″, 4′ 42″, and 8′ 16″. The third, which is the largest, is yellowish, and is equal in brightness to a star of the sixth or seventh magnitude. To most people the stars appear as bright objects, with long bright lines, or streamers, radiating from them; but Schön saw them as points of light, showing that the dioptric apparatus of his eye was adapted to bring parallel rays of light exactly to a focus on his retina.

It is probable that all those races of mankind who live on extensive plains, or who dwell on the sea, possess very piercing vision. Humboldt has placed on record the remarkable acuteness of vision possessed by the Peruvians. He states that he was much impressed by a circumstance which occurred during his stay at a beautiful country-seat of the Marquis de Salvalegre, near Quito, from which the long ridge of the volcano of Pichincha was visible at a distance of 90,000 English feet, or about eighteen miles. His fellow-traveller, Bonpland, who was then engaged alone on an expedition to the volcano, was recognised by the Indians standing near "as a white point moving along the point of a black basaltic precipice," before Humboldt, who was looking for him with a telescope, could discover him. In a short time, however, having ascertained his position by this means, both Humboldt and his companion were able to discover the white moving figure with the naked eye. Bonpland was wrapped in a white cotton mantle, the *poncho* of the country. Allowing from three to five feet for the breadth of the shoulders, as the mantle sometimes clung close and sometimes seemed to fly loosely in the wind, and taking the known distance, we have from 7″ to 12″ as the angle under which the moving object was distinctly seen. White objects on a black ground, there can be no doubt, are visible at a greater distance than black objects on a white ground—a circumstance that is in part due to the phenomenon of irradiation.

Very recently it has been shown by Reich that the Georgians have exceptionally good vision for distant objects. Thus, in a company of Georgian infantry composed of 140 men, the vision was superior to the average in 83 per cent.; and there were no less than 32 per cent. whose vision was twice as good as the average European. They were almost all excellent shots, and their eyes were in all instances very dark. None of these men had been to school, and there was not a single myopic person amongst them; though it is known that in the State schools of Tiflis there are many myopes.

Again, the Nubians, eleven in number, who accompanied Reich's caravan in Breslau were carefully examined by Cohn. They were all young men and women, with one exception, and none of them could read or write, with the exception of this one, who was myopic, and who had worked at Arabic and read much. The sharpness of vision was in all the rest nearly double that of the average European, and in one case two-and-a-half times better.

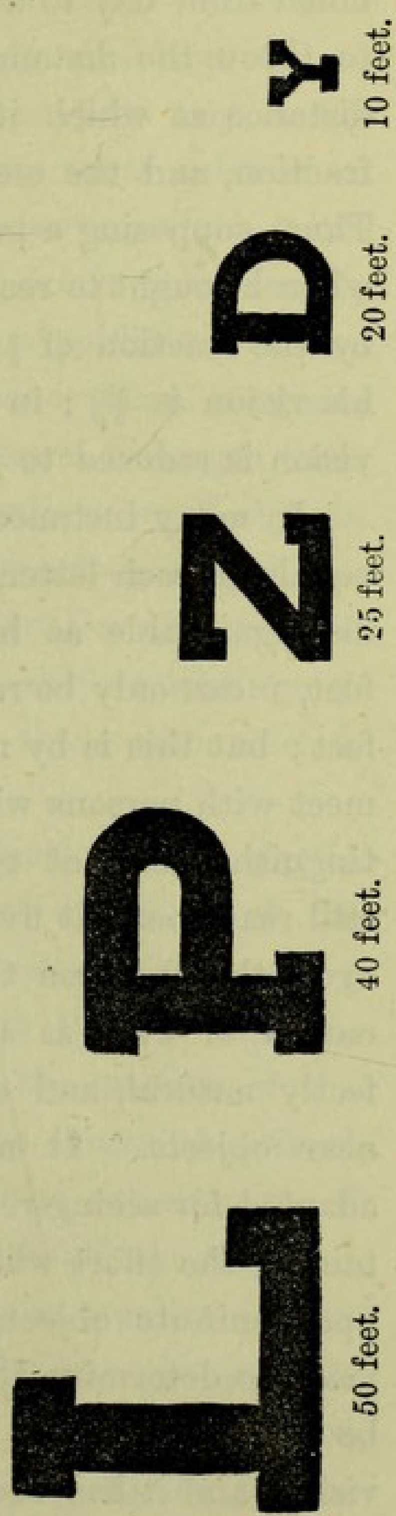
The limits of the field of vision were estimated as long ago as by Ptolemy, in the second century of our era; for Arago states that, according to Heliodorus of Larissa, Ptolemy announced that he had ascertained by experiment that the space which is visible, the eye remaining immovable, was limited by a rectangular cone : that is to say, by a cone having its apex at the pupil, and with the boundaries of the opposite sides parallel. Hence, in order that the horizon and the zenith should be seen simultaneously, the visual axis must, according to him, be elevated to a height of 45° ; whilst if the eye be kept motionless we can never see more than one-fourth of the surface of the sky.

The superior instruments and more precise observation of the present day have enabled the field of vision to be accurately determined ; and it is found, as might have been expected, that its extent and form vary slightly with the shape of the soft parts, and especially with the configuration of the nose, which, when prominent, limits the field of vision considerably on its inner side ; but it also depends in part upon the fact that the sensitiveness of the retina is greater on the inner than on the outer side ; and it is upon the inner side, of course, that the rays proceeding from objects situated at the outer part of the field of vision fall.

The model in which the field of vision is obtained is by the employment of a semicircular arc of iron which is capable of being rotated into a horizontal, vertical, or any intermediate position. To the semicircle of iron a traveller bearing a disc of white paper is attached, so that the disc may be brought from the extremity of the arc to its centre. The person to be examined is placed with his back to the light, and directed to look steadily at a small button in the centre of the arc, the two arms of which arch from side to side of his head. The disc is now slowly brought round from a point where it is invisible to him to a point where it is visible, and the number of degrees of this point from the centre is noted. The same proceeding is practised from the opposite side, and the number again noted. The arc is now rotated to the vertical position, one arm stretching over the head, the other under the chin, and the disc again brought forward, and the degree noted. By repeating this proceeding with a series of intermediate positions, a kind of map or plan can be obtained, which shows that our field of vision extends from side to side, the eye remaining immovable, about 140°, and that from above downwards it extends over 120°.

A considerable portion of the field of vision of one eye is, however, covered by the other, so that the area in view, when the two eyes are open simultaneously, is not much more than 180° in extent. By rolling the eyes outwards, the head remaining immovable, some 80° more may be added; and if the head itself be rotated, the whole circle may be completed. It is rather curious to find that, although the eyes of short-sighted persons are often large and prominent, their field of vision is considerably less than in long-sighted persons, in whom the eyes are usually small and less prominent.

Strictly speaking, we only appreciate degrees of light and colour with the eye; and although it is generally considered that with our eyes, and our eyes alone, we can, in addition, distinguish size, form, motion, and relative position of objects, this is only in a certain sense true, for a rigorous examination of the mode in which our conceptions of size and form and motion are formed demonstrates that the impressions made upon the retina are materially aided by those of other senses, and especially by those of touch. The blind man to whom sight is given by the removal of a cataract that has existed from birth sees the outer world as a flat picture, in which there is no relief of parts, and he finds that practice and experience are necessary to fuse together the impressions of the eye with those of touch. He is unable, for example, to distinguish whether an object is one foot or many feet distant from him—whether an object is a sphere or only a disc. In order to learn that the table is nearer to him than the wall, he must learn that a muscular effort has to be made, a certain space to be traversed to reach the one which is not requisite for the other. To learn that an orange is round, he must grasp it, and complete by touch and muscular action the conception of a sphere. It is only by experience that the double and different images of the stereoscope are fused into one, and give the impression of solidity. But, abstruse reasonings of this kind apart, it will be interesting to know what, in the adult man as ordinarily educated, the eye is capable of accomplishing, and what is to be regarded as healthy or average vision. The requirements in respect to vision are yearly becoming more exacting in the Services. The Army, and apparently also the Navy Boards, decline to fix any precise limit, on the ground that the condition of the vision is only one of the physical qualifications on which they determine the admission or rejection of candidates, and that it must be taken as a part of the whole. The limits of healthy vision will be here given; but it would be prudent for the parents or guardians of a boy commencing to work for the examinations required for the Public Services to have the eyes properly examined and tested. The defect may be slight, but the examinations for these services are now becoming very severe, requiring prolonged hours of study and hard work, and if the eyes should possess any defect of organisation, great injury may be done to them by nocturnal work, whilst the labour and anticipations of several years may be overthrown by sudden impairment of vision, due to over-exertion of an organ originally weak. Speaking roughly, the accompanying letters should be read at the distance in feet expressed by the numbers beneath them. Thus, the L should be distinguished at a distance of fifty feet, the P at a distance of forty feet, the Z at a distance of twenty-five feet, the D at a distance of twenty feet, and the Y at a distance of ten feet. Any person who is unable to read those letters at the distance named is suffering from some defect of vision; it may be short-sightedness, it may be haziness or cloudiness of the transparent media of the eye, or it may be some affection of the retina or brain, but whatsoever may be the cause, his vision is inferior to that of the average of mankind. Test letters of this kind, of a definite size, are very convenient, because they enable a comparison to be drawn between different persons having impaired vision, and constitute a means also by which, when



vision is known to be imperfect from the presence of disease, its progress towards recovery or its deterioration may be noted from day to day. It is only necessary in such cases to throw the distance at which each letter is read and the distance at which it ought to be read into the form of a fraction, and the means of comparison is at once before us. Thus, supposing a person can only read the L at forty feet when he ought to read it at fifty, his vision can be expressed by the fraction of $\frac{40}{50}$; if he can only read it at ten feet, his vision is $\frac{10}{50}$; in other words, it may be said that his vision is reduced to $\frac{4}{5}$ or to $\frac{1}{5}$ of its normal acuteness.

In many instances the degree of impairment of vision is equal for each letter, so that in the event of L being only distinguishable at half its proper distance, or twenty-five feet, D can only be read at half its proper distance, or ten feet; but this is by no means constant, and it is common to meet with persons who, whilst they are quite unable to distinguish the L at twenty-five, or even at twenty feet, can still read the Y at five feet. It by no means follows, moreover, that because the letters can be read at the distance named, or even at a greater distance, that the eye is perfectly natural, and capable of any amount of work upon near objects. It may be long-sighted, and whilst well adapted for seeing remote objects, yet be incapable of maintaining the effort which is required for work at close quarters upon minute objects. Careful measurements have been made to determine the size of the smallest object that can be perceived by an eye possessing average sharpness of vision, and it has been found to vary from $\frac{22}{10000}$ths of a millimeter to $\frac{68}{10000}$ths; but the size of one of the cones of the retina is about the same as the smallest of these two measurements, and hence it is concluded that if two objects were so small that when placed together their united area would not exceed $\frac{22}{100000}$ths of a millimeter—that is to say, would only stimulate one cone—they would be seen as a single object. Expressing the fact in another way, it has been found that to be visible an object must subtend an angle of about thirty seconds. Lines, however, which strike many retinal elements consecutively are much more readily seen than points. A telegraph wire or a spider's web can be distinguished at a much greater distance than it would be possible to recognise a segment of it equal in length to its diameter. The above remarks apply only to small objects, under ordinary daylight illumination, but a sparkling object, such as a piece of gold-leaf, of much smaller size, may be seen. Aubert found that he was only able to distinguish double stars when the interval between them amounted to as much as 3′ 30″.

Our appreciation of the size of an object depends partly on the actual number of the percipient elements of the retina that are stimulated by the luminous rays proceeding from the object, and partly on the effort that is made to converge the eyes upon it. The larger the surface of the retina that is covered by the image, the larger the visual angle under which it is seen, the greater is our estimate of the size of the body. But, on the other hand, the more we accommodate the eye for near vision, the smaller is our estimate of the size of the object regarded. As a rule, white objects on a black ground are seen at a greater distance than black on white, which is due to the phenomenon termed irradiation ; for the white ground spreads or widens out, and hence tends to cover the edges of a black square or circle, whilst a white circle advances in all directions on the surrounding black ground It is a mental, not a physical condition.

The duration of a stimulus capable of exciting the retina need only be very short, as is demonstrated by the visibility of an electric spark, which lasts only a minute fraction of a second; but the visual sense is much less capable than the sense of touch, or even of hearing, of recognising a succession of impulses or stimuli as separate and distinct impressions. In other words, there is a much greater disposition to fuse rapidly-succeeding impressions with the eye than with the other senses; or it might be yet again differently expressed, that impressions made on the eye last longer than in the case of the other senses. Thus, the more sensitive parts of the body, as the lips and tongue, can distinguish as interrupted the impulses of a tuning-fork vibrating 1,000 times in a second, and the ear can distinguish interruptions recurring 100 times in a second. But the eye retains the impression of a light for a second or more; hence the appearance of a circle of fire when a glowing ember is whirled round even by the hand. If coloured light is presented to the eye, and the eye is then suddenly closed, there is a short period during which the same colour is seen, termed the positive after-image; but this is soon replaced by a negative after-image, in which the image is seen of the opposite or complementary colour.

It is remarkable that in the oldest literary monuments of the world the sensations of colour should be only seldom and lightly referred to. Mr. Gladstone has pointed out, for example, that very few colours are mentioned by Homer, and of these few nearly all are misapplied. Geiger, again, states that neither in the Vedas of the Hindoos nor in the Zendavesta of the Parsees has he been able to find indications of a fully-developed sense of colour, no mention being made of blue, though the sky and light generally are specially described. Similarly, no mention of green occurs in the Rigveda Hymns, nor in the Zendavesta, though both often speak of the earth and its vegetation. Magnus, a recent writer on colour-sense, has arrived at the conclusion that mankind at first saw only white and black, that red was the first colour to be distinguished, and then the other colours in succession towards the violet end of the spectrum. He thinks that red and black and white were alone recognised at the time the Vedas were written, and that yellow was perceived in the Homeric period, green, blue, and violet being subsequently discriminated. He suggests that the colour-sense is still imperfect, and that the time may come when the ultra-violet rays will be distinguished by the human eye. Dr. Montague Lubbock holds a different opinion, and points to the ruins of Mycenæ, Assyria, and Egypt as affording evidence that man possessed a fairly-developed colour-sense at a very remote period. There seems reason for believing that the colour-sense can be improved by practice, for it has been noted that the number of colour-blind women is much less than that of colour-blind men, which is probably attributable to the attention women pay to dress. The proportion of colour-blind people varies in different nations, but is usually about 3 to 5 per cent.

All parts of the retina are not equally sensitive to colour, and this has been ascertained in the same way as the extent of the field of vision has been determined—namely, by slowly bringing coloured objects from behind the head, or other part where they cannot be seen, till they can be seen, and their colour can be correctly named. It is found that the presence of a blue, yellow, green, or scarlet object can be recognised for some time as an object before its colour can be correctly appreciated. The sensitiveness of the retina in those parts that are most distant from the entrance of the optic nerve, and upon which rays of light strike very obliquely through the pupil, is, however, lowered only, not abolished; for if some saturated colour—such, for example, as the blue or green of the solar spectrum—be concentrated on the eye, the colour can be perceived to the utmost limits of the retina; but if a piece of coloured paper of the size of a shilling, or a fragment of coloured worsted—the vividness of the colour of which is so much less than that of the spectral colours—be brought into the field of vision in the manner indicated, it will be found that blue can first be recognised, then red, then green: that is to say, it is only the more central part of the field of vision that is capable of distinguishing green, whilst nearly the whole of the retina can distinguish white or blue, the part that can recognise red occupying an area of intermediate size. The field of vision for each colour differs a little in the different meridians of the eye, the area for green being an oval placed horizontally, whilst the areas for red and blue are more nearly circular in outline. In some forms of disease affecting the nervous system of the eye the appreciation of colours is remarkably modified or impaired, and the affection sometimes called Daltonism, from the distinguished philosopher who suffered from it and described it, is due to inability to distinguish one or more of the colours. Red-blindness, from which Dalton suffered, is the most common; then green-blindness. The loss or absence of the power of appreciating blue is rare. The importance of the possession of an accurate knowledge of colour by all those engaged in operations by means of coloured signals is now becoming generally recognised; and as there is reason to fear that many fatal accidents, both by land and sea, have been occasioned by inability on the part of engine-drivers, guards, and helmsmen to distinguish green from red, it is now the practice to submit the men applying for such posts to tests for colour-blindness—a proceeding that will certainly prove of advantage to the public.

The Effects of Variations of Light and Temperature.

Having described the structure and functions of the eye, as fully as is necessary to enable the following observations to be understood, we may with advantage consider the action of great variations of light and of temperature to which all are liable, and which in conditions of disease undoubtedly exert a powerful influence.

It may be safely stated that some disease of the eyes or disorder of the general health is present if the ordinary and diffused light of day, and still more, if candle or lamp-light, is felt to be painful. Artificial light of every kind—candles, oil-lamps, gas, and even the electric light itself—is very feeble compared with sunlight; and yet sunlight is that form of light to which all living beings have been exposed from their first appearance on the earth, and to which, therefore, we must suppose that their eyes have, in the course of many generations, become structurally adapted.

Every one must have noticed the low penetrating powers of even the most powerful electric light in hazy conditions of the atmosphere, as compared with the sun. It has been estimated that the light emitted by the sun and falling on a page of such a book as this, is about 60,000 times greater than that of a good wax candle placed at a distance of one yard from it, and about as much greater than the light of the moon at the full.

But if the diffused light of day is well borne by every healthy eye, there can be no doubt that the direct light of the sun is injurious if allowed to fall upon the eye. The case of Sir Isaac Newton is well known. Impelled by curiosity, he ventured to look at the sun directly through a telescope; the effects were both serious and permanent. He was obliged to keep in a dark room for a considerable period, and the image of the sun had so far impressed itself upon his retina—burnt itself in, as it were—that years afterwards, when he had ceased to notice the spots, it was only requisite that he should direct his attention to the subject to cause him to see the spectra of the sun which had formerly distressed him. In this case, however, the light of the sun was concentrated by lenses, and the retina was therefore acted upon as by a burning-glass.

Still, the bad effects of long exposure to the bright rays of the sun, and especially of its reflection from the sands of the desert, from snow, from the sea, from arid plains and rocks of bright colour, are noticed by all travellers, and numerous expedients have been adopted to save the eyes. In a great part of India the sun is scorching for three months of the year. The thermometer often rises above 100° in the shade during part of the hottest days: it has been known to reach 120° Fahr.; even the wind is hot, the land is brown and parched, dust flies in whirlwinds, all brooks become dry, small rivers scarcely keep up a stream, and the largest are reduced to comparatively narrow channels in the midst of vast sandy beds. Is it surprising that a part of the body so delicately constructed as the eye should feel such a degree of heat, attended with such intense radiation of light and dryness? And, indeed, those who have had large experience of the ophthalmic diseases of this and other hot climates state that headaches are not uncommon from exposure to the direct rays of the sun, and that the end of the optic nerve may in such cases be observed to be reddened, and in an incipient condition of inflammation. Still, either the natives of India and other parts of the torrid zone must be extraordinarily careful in regard to such exposure, or the effects of bright light must have been somewhat exaggerated, since cases of inflammation of the retina do not appear to be much more frequent there than elsewhere. It is probable that the large amount of pigment which their eyes contain absorbs the light, and prevents to a certain extent those injurious consequences that would otherwise result.

Denham and Clapperton, in their travels through the country of Bornou, just south of the Great Sahara, where the intensity of the light during day is very great, found that blindness was a prevalent disease. Within the walls of the chief city there was a separate district, or village, for people afflicted with this infirmity, who had certain allowances from the governor, but who also begged in the streets and market-place. With the exception of the slaves, none but the blind were permitted to live here, unless on rare occasions a one-eyed man was received into their community.

There are certain effects of over-stimulation and exhaustion of the retina by the bright glare of white light which are well known to result from long exposure to snow. Dr. H. Cayley gives in the *Indian Medical Gazette* for 1868 an interesting account of his experience of snow-blindness in crossing the "Zoji La" Pass from Cashmir to Ladak. He states that on the day of crossing the pass his party were on the move for more than sixteen hours over fresh-fallen snow the whole way, and soon after midday he noticed some of the baggage servants and coolies stumbling along with their eyes covered, and protected as much as possible, and all complaining of intense burning and throbbing in the eyeballs, of headache, and of dimness of sight. Dr. Cayley recommended what he had heard was serviceable from natives, and had himself found to give great relief, viz., the application of a handful of snow on the eyes for a few minutes till the burning was removed, and the repetition of this proceeding at intervals. After the march was over and during the night, all those whose eyes were affected, consisting of nearly half the party, suffered most acutely from deep-seated pain in the eyes and orbits, with more or less complete loss of sight, and many of the coolies, who were all hill-men, and accustomed to the snow, were sitting out in the cold night air, groaning with pain, but finding their sufferings less than in the smoky huts. The next morning two of the servants and about twenty-five coolies were suffering in a greater or less degree from the following symptoms: almost complete loss of sight—they could just see their way about, but some even were quite blind—the most intense intolerance of light, severe deep-seated pain and burning in the eyeballs and orbits, and generally bad headache. The other symptoms were profuse lacrymation, injection of the conjunctiva, and swelling and puffiness of the lids and contracted and inactive pupils—acute ophthalmia, in fact, with the symptom of nervous irritation especially prominent. In some only one eye was affected, but generally both, though not always in the same degree. In some the affection commenced after the day's march and exposure were over, but this occurred chiefly amongst those who went into the huts, and who were consequently exposed to the irritating vapours arising from fires made of wood and animal dung. The treatment employed by Dr. Cayley, and which he states gave great relief, consisted of warm fomentations, and a lotion of equal parts of tincture of opium and water dropped into the eyes, and keeping the eyes covered with a wet bandage.

Nordenskiöld, in his account of the voyage of the *Vega*, remarks that the eyes of the Chuckches suffer terribly during the spring from the strong light of the sun upon the snow. Many wear a green shade in the shape of the peak of a cap. It is noticeable, however, that notwithstanding this frequently-repeated periodic strain upon their eyes, they have, as a rule, exceedingly good vision.

The Tartars are said to protect their eyes when travelling in winter from the injurious effects of snow by means of a contrivance made of horse-hair, similar to crape spectacles;

and the Eskimos, who are familiar with the injurious effects of snow, use guards composed of wood, with slits in them, through which a comparatively small quantity of light only can penetrate to the eye.

Gauze wire spectacles were suggested by Curtis, and have been commonly used.

A remarkable condition, known as night-blindness, often results from retinal exhaustion, due to protracted exposure to bright light; and many interesting cases have been placed on record. Amongst others, the following may be mentioned :—

Captain Smith, R.N., of H.M.S. *Merlin*, reports in the "Royal Naval Biography" (Vol. IV.) that in September, 1801, the *Merlin* captured a Spanish privateer, and having been sent with twenty men to cruise in her as a tender, he states that in a few days at least half the crew were affected with night-blindness. They were chased one calm morning by a large Xebec, carrying from eighty to one hundred men, and towards evening she was fast pulling up to them, his people having been fagging at their oars many hours without any relief. Knowing that night would deprive half of his crew of sight, it was proposed to try conclusions with the enemy whilst it was daylight; a proposition that was answered by three cheers. The oars were run across, and the enemy being by this time within gunshot, the action commenced. After a time, to their great relief, the Xebec sheered off and pulled away from them. They in their turn became the pursuers; but when night came on they took special care to lay their head from the Xebec, and saw no more of her. This circumstance led Captain Smith to devise some means of curing the people affected with night-blindness, and he could think of none better than that of excluding the rays of the sun from one eye during the day by placing a handkerchief over it, and he was pleased to find on the succeeding night that it completely answered the desired purpose, and that the patients could see perfectly well with the eye which had been covered during the day, so that in future each person so affected had one eye for day and the other for night. It was amusing enough, he remarks, to see Jack guarding with tender care his night eye from any exposure, however slight, to the sun's rays, and occasionally changing the bandage, that each eye in turn might take a spell of night-duty, it being found that guarding the eye from the action of light for one day was sufficient to restore the tone of the optic nerve.

Captain Smith concludes his interesting observations by remarking that this disease frequently attends scurvy in tropical climates, and is sometimes occasioned by derangement of the digestive organs and hepatic system.

This account fully agrees with what is now known in regard to the action of light upon the retina, to which reference has already been made. Men badly fed and exhausted by fatigue are not in a condition to reproduce the colouring matter of the retina, the small stock of which actually generated is soon exhausted by brilliant light, but the protection of the eye from light gives time for its renewal in sufficient quantity to fulfil its functions. The treatment adopted by Captain Smith, though of course he was unacquainted with its *rationale*, was extremely sensible, and, as the event proved, thoroughly effective.

THE CARE OF THE EYE IN INFANCY.

The infant is liable to few diseases of the eyes, but those from which it does suffer are dangerous, and often fatal to vision. One of the most common of them, as well as one of the most serious if neglected, is the affection known as purulent ophthalmia, or the purulent eye of new-born children. It usually makes its appearance on the third day after birth, and is attributable either to the entrance of some virus into the eye during birth or to some injudicious treatment by the nurse shortly after birth. Thus, it is a common practice with nurses to wash the new-born child with gin, and the entrance of a drop of this fluid into the eye would certainly set up acute inflammation. Exposure to cold draughts of air would be followed by the same result. But it is not with the mode of causation of the disease that we have here to deal; nor is it the object of this work to discuss the treatment of disease, which should be committed to the hands of those who are competent to undertake it; but purulent ophthalmia is one of those affections which a mother or nurse may be unexpectedly called upon to tend, and it may not be unwise to give a short account of the disease, and of the remedies that should be employed to prevent the destruction of the eye. This will seem the more necessary when it is stated that a very large proportion of the inmates of blind asylums owe their loss of sight to this particular form of inflammation, and when it is added that the treatment is simple, easily practised, and, as a rule, very successful. The symptoms, then, that are presented by this disease are that about the end of the second or the beginning of the third day after birth the nurse or mother observes a small accumulation of yellow matter at the inner corner of the eyes. The lids look a little puffy, and stick together when the infant wakes. The pain is trifling, for the child lies placid, and though it may show some signs of aversion to bright light, it sleeps and takes its food without difficulty. In the course of the next and following days, the yellow discharge increases in quantity, and, drying up, causes the lids to adhere during sleep; it then accumulates behind them, making them bulge considerably, and when they are opened, large yellow drops flow down the cheeks. It is difficult to see the eye at this period, but if the matter be cleared away, it appears somewhat red and inflamed, though less so than might be expected. The discharge reaches its maximum about the end of the second week, and after that period begins to decline, but too often only after irreparable mischief has been inflicted on the eye. It is during the second and third weeks that the greatest harm is wrought. Cases properly treated during the first week recover, in many instances, without mark of any kind. If, however, a case is neglected, and the discharge is profuse during the second week, irreparable damage is done to the cornea, which becomes hazy and ulcerated; but recovery may still take place—occasionally perfect, but more frequently with some opacity of the cornea, which may or may not permanently interfere with vision. If the case be still neglected, the third week witnesses the penetration of the cornea by the ulcer, or even the entire destruction of that membrane, allowing the escape of the humours, and the total collapse and loss of the eye. The progress of the disease is sometimes slower, the discharge being less abundant, and the child improves a little one day and becomes worse the next, such alternations extending over three or four weeks. In these cases, the risk of complete loss of the eye is much diminished. In some instances, again, the affection runs a violent and rapid course, unchecked by any remedies, and quickly destroys the eye. In these cases, the best directed and most skilfully applied treatment sometimes fails to save the eye, though it may leave it in a condition permitting relief from surgical treatment.

The interesting point in regard to purulent ophthalmia, from our present point of view, is that in a large proportion of cases it is a curable disease, and though the means employed are simple, yet they require to be practised with care and assiduity, and for a considerable period. The disease is an inflammation; the discharge chiefly comes from the surface of the lids, and if allowed to accumulate, probably becomes by its decomposition a source of irritation. The local treatment must be, then, as a mere matter of common sense, to clear away the discharge as much as possible, and to prevent its accumulation between the lids. If, in addition, there is any circumstance causing the general health of the infant to be disturbed, appropriate general treatment should be adopted.

How are these measures to be carried out? The nurse should be supplied with a glass syringe, capable of holding about two ounces of water, and at intervals of about three hours, and always before the child sleeps and after it wakes, the eyes should be syringed out. The water should be at a temperature of about 65° Fahr., or cool without being cold to the fingers. The same water should *not* be used twice.

It is well, therefore, to have two basins, and the infant should be held with the head somewhat depending; and if it happen that one eye only is affected, which now and then occurs, this eye should be held lowermost, whilst a little pad of cotton-wool may be placed over the sound eye, to prevent the entrance of any of the matter washed out by the syringe. The strength of the stream should be moderate; it should first play on the closed lids, then on the edges of the lids, so as to soften any dried secretion and cause no pain when they are opened, and finally, should be directed fairly on the surface of the eye itself. The syringing should be continued till all the yellow matter is washed away, which may generally be accomplished with four or five syringefuls of pure water. The head of the infant should be held firmly, and the nozzle of the syringe held at four inches from the eye, and directed obliquely towards the inner corner, so that there may be no chance of injuring it by an unlucky movement of the child, or from nervousness on the part of the nurse. The cries of the child must be disregarded; they merely indicate its dislike to the free movement of its head being restrained; the syringing produces no pain, and to some children the cool water clearly gives relief. Care should be taken that the clothes of the infant are not wetted. As soon as the cleansing of the eye is completed, a little vaseline or a drop of sweet oil may be swept along the margins of the lids with a camel-hair brush, and the operation is complete. No bandages or cloths are required, as these only serve to keep the eye hot, and promote the flow of the discharge. The adoption of these simple measures suffices in a large number of cases to cure a troublesome and dangerous disease; and though in some instances the affection may linger for some time, yet it is satisfactory to feel that it is under control, and that no serious damage to the cornea is to be apprehended. No discouragement need be felt on account of a slight relapse after apparent recovery. The syringing should be recommenced, and it may be expedient to drop into the eye a little weak alum lotion, made by dissolving a fragment of alum the size of a Barcelona nut in a tumblerful of water. The ventilation of the room should be attended to, and the bowels should not be allowed to be confined. A word of caution may be added in regard to the person who syringes. The matter proceeding from the infant's eye is highly contagious, and the introduction of some of the spray spirted back from the eye has been not unfrequently known to set up acute and serious purulent inflammation in the person using the syringe. There is little risk of this, however, if the stream be not too violently forced out. The total duration of the disease is often six weeks or two months.

That purulent ophthalmia is of a contagious nature has long been recognised, and it has even been thought that the material conveying the infection has been obtained. In a severe epidemic of it that occurred in the course of the year 1866 in the Hôpital des Enfants, in Paris, the physician in charge, M. Giraldés, desired a gentleman well versed in practical chemistry, M. O. Reveil, to examine, analyse, and report upon the air of the wards ; and the careful investigation to which this air was subjected showed that it contained globules of pus, together with scales of the skin, which were so dry and light as to float in it, or, at least, to be easily raised on the slightest disturbance of the dust on the floor, or on the admission of a current of air ; and there is good reason for believing that such globules contain germs which, though desiccated, are not entirely dead, but when allowed to enter the eye, and placed under favourable conditions for germination, may once more become active, and reproduce the disease of which they were themselves the origin. This view is remarkably supported by experiments that have been made at different times with a view of establishing its inoculability by direct application of the matter discharged from the inflamed eyes to healthy eyes; for although it has been found that a healthy system is sometimes capable of resisting a minute dose of the virus, yet if a large dose be introduced its poisonous properties are quickly manifested. It would appear also that the poison, when diluted with water, is much less effective than when pure; and it is certain that thorough washing of the eye with cool water and a syringe greatly restricts or altogether prevents its effects. There is good reason for believing that the frequent relapses to which the children of the poor are liable are due to the practice of placing over the eyes bits of dirty rag, or sponging them with foul sponges, which actually convey the infection they are intended to remove. A small ball of well-carded cotton-wool, dipped in pure water, forms the best sponge, and should be thrown away, or, still better, burnt after it has been used.

If the infant escape during the first few days from inflammation, it is usually so well cared for that it is free from disease for some time, or, at least, suffers only from slight colds and catarrhs. One disease may, however, be mentioned which requires instant attention. This disease is cancer of the eye. It is recognised by a remarkable golden reflection from the pupil when the child is placed looking towards a moderately strong light, whilst the observer has his or her back to the light. It makes its appearance, in the great majority of cases, during the first few months of life, and if recognised sufficiently early, while it is still wholly limited to the globe of the eye, and promptly treated, the life of the infant may be saved. But this involves the hard alternative of removal of the eye. If observed, however, no time should be lost in obtaining a skilled opinion upon the nature of the case, since the only chance of preserving life is that the disease should be extirpated from the system before the seeds are implanted in other organs.

It need hardly be said that the general principles of hygiene should be adopted in children as in adults, if the eyes are to be kept healthy. Moderate exposure even to cold air in a well-nourished and healthy infant can be borne without harm, but cold draughts, dust, and bright lights should be avoided. The room in which the infant lives should be well ventilated, and the food, if brought up by hand, moderate in quantity, wholesome in quality, and always given at the same temperature.

The period of teething is perhaps that at which the next troubles of childhood in respect to the eyes are apt to occur. In many children the teeth are cut without a sign to mark the remarkable physiological process that is taking place, whilst in others it is a stormy period, the irritation of the sensitive nerves of the jaws radiating to many other organs and tissues, and leading to local spasms, general convulsions, and even to death itself. The management of the child at this critical period of its life cannot, however, be considered here; and it need only be remarked that violent convulsions are a common cause of a peculiar kind of cataract, known as laminar cataract, which is sometimes stationary, at others gradually increases in opacity till, at the age of from ten to fifteen, reading becomes difficult or impossible, and operative measures have to be resorted to. Every care, therefore, should be taken to tide over the period of teething without accident, and by a judicious system of diet, by exposure to fresh air, with clothing appropriate to the season, and by general attention, to prevent the occurrence of convulsions. If, unfortunately, cataract has been thus produced, it may be observed that it is not expedient to perform any operation for its removal during the first year or two of life; it is better to wait till the strength of the child is thoroughly regained than to operate too early.

We may now proceed to the consideration of two kinds of visual defect, the effects of which are usually apparent in childhood, and which it is of great importance to recognise early and treat appropriately, since, if neglected, they become the source of infinite trouble throughout the whole of school life, and may seriously interfere with the most important occupations of after-years. We refer to long-sightedness and to short-sightedness, to which the technical names of hypermetropia and of myopia are applied; whilst there is still a third defect, termed astigmatism, to which no popular name has yet been given.

Each of these conditions is due to a defect in the form of the eye, in consequence of which the image of the outer world is not properly focussed on the retina, but either in front of or behind it; and as the path for the rays of light to reach the retina is otherwise clear, these cases are often termed cases of error of refraction. In the course of the last twenty years, the recognition of such errors of refraction, formerly greatly neglected, has become an important part of the work of an ophthalmic surgeon; and the application of glasses of various forms to remedy defects of vision arising from this cause occupies much of his time.

Long-Sightedness, or Hypermetropia, and the Prevention of Squint.

Many children appear to have good vision during their infancy, and nothing occurs to excite suspicion that the eyes are not perfectly healthy until their education commences. It is then observed that after a short period of application a disinclination is manifested for further work; complaint is made that the eyes ache, or that reading or spelling makes the head ache. At first this is regarded as a mere piece of idleness. It is considered that the child, having got over the novelty of lessons, is becoming lazy, and should be made to work, and notwithstanding his reiterated complaints that he is unable to see clearly, he is treated with more and more severity. Parents or tutors are sometimes intelligent enough to suspect that the eyes are at fault, but not seldom the complaints are passed by unheeded; the child continues to be thought dull, or stupid, or not inclined for books, or incorrigibly lazy, though he may exhibit intelligence enough in all other respects. If, however, his complaints are disregarded, it is observed that after an hour or two of reading or writing, not only is pain complained of, but the eyes become visibly red and inflamed. A little secretion is poured out in the course of the night, causing the lids to stick together in the morning. Some difficulty is experienced in separating them, a gummy, crumbling matter having to be first rubbed away, and this proceeding, repeated on many successive mornings, leads to soreness of the margins of the lids, and to the condition known as blear eyes. It is remarked that when the boy is at home from school, at which time he carefully abstains from taking up a book, but engages freely in any outdoor sports that may be open to him, he steadily improves, his eyes regain their natural aspect, and he goes back to school apparently well, but only to relapse into the same state as soon as work commences. This state of things—now better, now worse—may continue for years, in fact, till education is finished, the lad being incapable of protracted exertion, and usually taking but an indifferent position in the class. Observation has shown that the whole train of these symptoms proceeds from long-sightedness or hypermetropia, the nature of which we shall now proceed to explain.

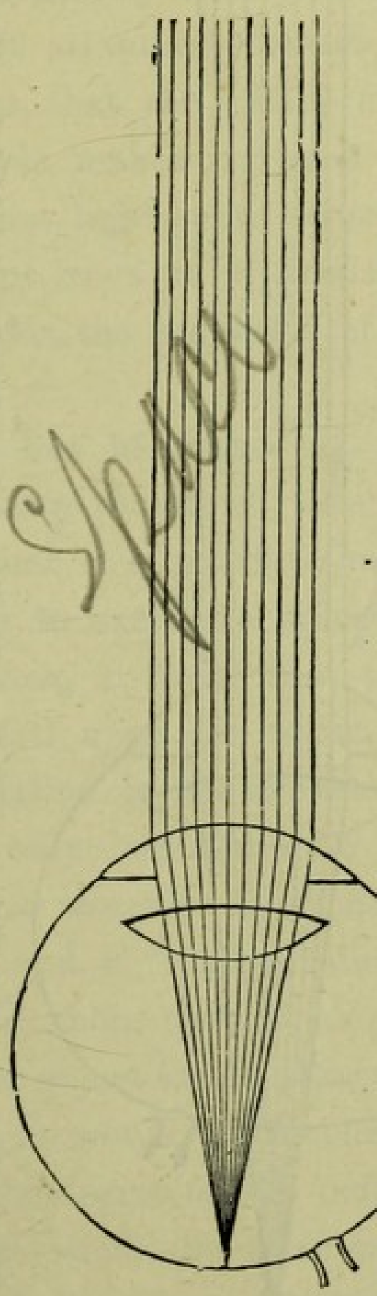


Fig. 4.—Healthy Eye.—Parallel rays brought to a focus on the retina when the eye is at rest.

We have seen that, as in Fig. 4, parallel rays of light falling on a healthily-formed eye are brought to a focus exactly upon the retina, when the eye is at rest: that is to say, when no effort at accommodation is made.

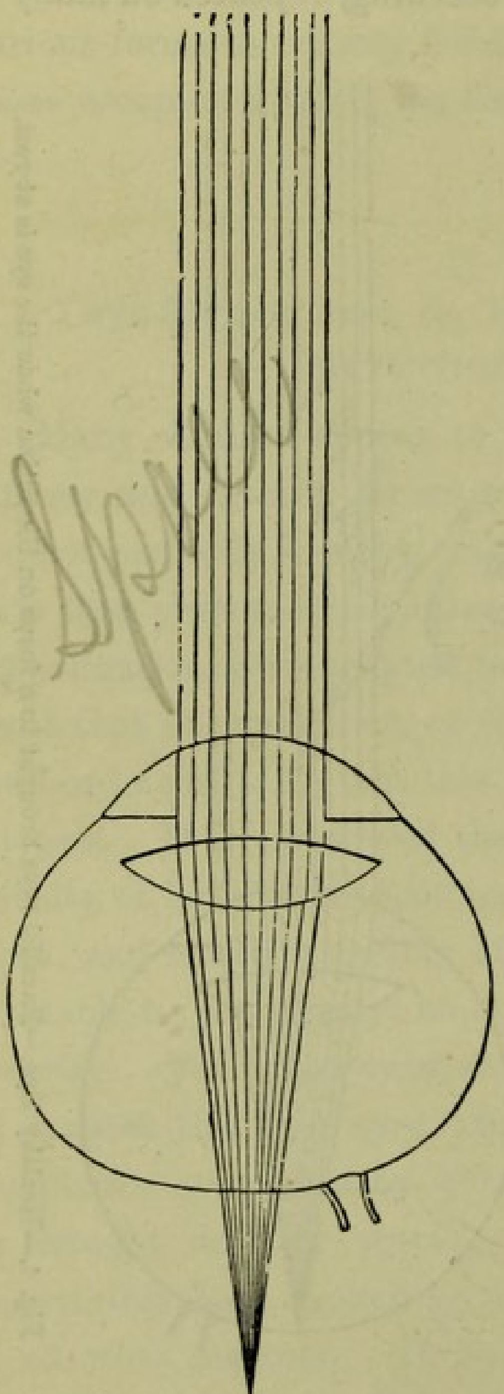


Fig. 5.—Long-sighted or Hypermetropic Eye.—Parallel rays brought to a focus behind the retina when the eye is at rest.

A long-sighted eye is one in which parallel rays of light, or those which proceed from an object at some distance, and are therefore approximately parallel, are not brought to a focus upon the retina, but behind it, as in Fig. 5. This condition may result from one of two causes: either the lens may be too weak, or the distance between the lens and the screen on which the focus is formed —that is to say, between the lens and the retina— may be too short.

The usual cause of long-sightedness is, as shown in Fig. 5, that although the lens preserves its usual thickness, the distance between it and the retina is too short. The eye is a flattened eye. This alteration in the form of the eye has some very important consequences.

We have seen that when a person with healthy eyes looks at a remote object, no effort is required to see it. The rays of light, being parallel, or nearly so, are brought to a focus on the retina without any muscular exertion. It is only when a near object is attentively considered, the rays from which are divergent, that the ciliary muscle is brought into play. That muscle makes the lens thicker, and causes it therefore to refract light more strongly, and consequently to bring divergent rays to a focus on the retina. But now let us consider the condition of a long-sighted person.

Every far-sighted person has to make an effort of accommodation when he looks at a remote object: in other words, when rays of light that are parallel, or nearly parallel, fall on his eye, he has to exert his ciliary muscle and to make his lens more convex, in order that the focus of such parallel rays should fall upon his retina. He is always exerting his accommodation, is always doing what the man with the healthy eye only does when he looks at some object close at hand. But muscular exertion implies a tax upon the nervous system, and, if long continued, more or less exhaustion. Supposing, then, that a long-sighted man were not to look at a near object at all, but to confine his attention to remote objects, he would at the close of the day be as tired, according to the degree of his defect, as a man with normally-formed eyes would be after reading a book at a moderate distance; if he is very long-sighted, as tired as a man would be with good eyes after reading many hours very small type, or as a woman would be who, with normally-constituted eyes, had been hemming or darning fine cambric or working cross-stitch.

But if an effort of accommodation be required for the parallel rays coming from a remote object, much more must he exert his accommodation when he has to turn his attention to a near object, and has to focus on his retina the divergent rays which proceed from the letters of a book, the notes of music, or the threads of a woven fabric. An immense effort is then required, for the lens has to be made strongly convex, and such an effort can only be maintained for a short space of time. Hence, although the child can see perfectly at a distance, he yet soon complains of headache and a sense of fatigue in the eyes if made to attend to minute objects; and hence it is also that he is unable to read for more than a few minutes at a time. If compelled to work, the violent effort required produces congestion and redness of the eyes, a larger flow of blood to them and to their appendages takes place, and hence watering of the eye and increased secretion of mucus. If work is still insisted on, dizziness and absolute inability to distinguish the letters of a book follow, and in some instances headache, a feeling of sickness, or even actual vomiting, may be induced.

A circumstance which is often mentioned, and which occasions surprise, is that the child is worse in the morning than in the evening—worse, as it would appear, after rest than when making exertion; but this is easily explained. The sense of weariness experienced in the eye is of precisely the same nature as that which is felt in the limbs after a long walk has been taken. The muscles of the limbs and of the body generally are in that case exhausted, they retain in their tissues the materials of their own disintegration and decay, the flow of blood through them is tardy and feeble, and the attempt to use them on rising in the morning gives rise to a sensation of pain and aching, which does not pass off till the circulation through them has been re-established by moderate exertion after the rest. Just so is it with the long-sighted eye. The child retires to bed with the muscle in a thoroughly exhausted state, especially if it has long evening lessons; during the night the muscle is at rest, but as soon as it begins to be exerted in efforts at accommodation on the following morning, it feels weary, and aches, and it is not till it has been fairly brought into play that it becomes supple and active.

Another symptom is often misunderstood; it is that when a book is given to a child to read, it begins to be remarked that it holds it nearer and nearer to the eye, and in many instances that it holds it to one side, or twists the head down to see the lines. The child is thought to be getting short-sighted, and, after due deliberation, is brought to the ophthalmic surgeon, who, after short inspection, pronounces it to be long and not short-sighted. Then why, it is asked, does it poke its head down close to the book? and the answer is simple. The effort which is required to make the long-sighted child see small objects at a moderate distance from the eye with distinctness is so great that when the attempt to read is made the muscle passes at once into a condition of spasm, contracting to its uttermost—to a greater extent even than is required to meet the conditions present. The luminous rays coming from the letters of the book are then brought to a focus in front of the retina, and in order to obtain a distinct image, the child brings the book closer and closer to the eye, to render these luminous rays more diverging; and this, again, leads to greater spasm of the muscle, so that the affection has a tendency to intensify itself; and it can easily be understood that this condition of spasm or cramp of the ciliary muscle is attended with pain. The disposition to look sideways at the book is probably best explained on the supposition that a difficulty is felt in bringing the muscles effecting convergence of both eyes into play, and, after a time, one alone is actively engaged in the effort of accommodation, and the book is naturally placed in front of that eye by which the clearest images are received.

But occasionally another symptom arises as soon as the child is made to apply himself to books. He begins to have a cast in the eye—that is, to squint. At first this is occasional; it is only observable now and again, when the attention is strongly excited, and it may be difficult to determine which eye has the cast; but soon it becomes persistent, and the most absurd ideas are often entertained in regard to the cause of this affection. The nurse, it is said, has arranged its hair so that a particular curl constantly attracts its attention, or it is thought to result from imitation of an older child who is also affected. The real cause in most instances is that the child is long-sighted, and it is not difficult to explain the mode in which squint arises from long sight.

A muscular effort has to be made in order that the eyes should converge upon any near object, and there is a very perfect harmony between the degree of accommodation and the amount of convergence, both being, as a rule, increased or diminished together; and, in accordance with this, the two recti muscles outside the globe, which rotate the globe of the eye inwards and effect convergence, and the internal or ciliary muscle which, by its action, renders the lens more convex and effects accommodation, are supplied by the same nerve—the third cerebral nerve. Hence, when a long-sighted person looks at a near object, impulses issue from the brain, which are directed to the ciliary muscle and to the internal straight muscle of the globe ; but the demand for accommodation in order that clear images should be obtained is excessive, and hence it appears probable that a stronger impulse than necessary is transmitted to the internal rectus, and, as a result, an inward squint is gradually developed. At first the squint is only slight and occasional, and often in one eye only, though alternation of the cast is also frequently observed ; but soon it becomes more and more confirmed. The best formed eye of the two—the one, that is to say, which is least hypermetropic—is systematically used, whilst the other is neglected, and the disused eye becomes permanently inverted ; sometimes the two eyes are alternately affected.

These considerations will afford an explanation of various symptoms that are familiar to all those who have a tendency to squint. It is observed most when the child is exhausted and debilitated ; and hence before meals, or after a fatiguing walk, or after a dance and late sitting up, after diarrhœa, and during convalescence from any infectious disease, such as measles or scarlet fever. At such times the whole nervous and muscular system of the body, and therefore the nervous and muscular apparatus of the eye, is enfeebled. A more than usually powerful impulse has to be sent down from the brain to effect accommodation, and the internal recti muscles are consequently inordinately excited to contract, and, in addition, their superior power enables them at such times to triumph more easily over their antagonists.

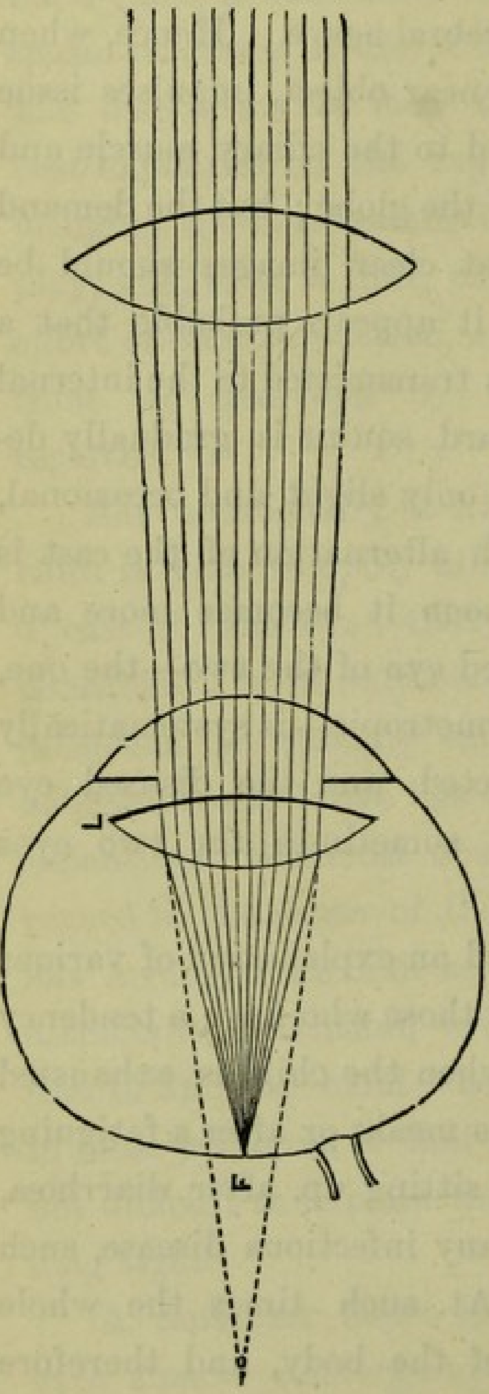


Fig. 6.—Hypermetropic Eye. Parallel rays, as indicated by dotted lines, come to a focus behind the retina. By the use of a convex glass, parallel rays, being made convergent, are focussed on the retina. F, focus; L, lens.

The question then arises, How are the two conditions of weariness and exhaustion of the eye, with the attendant symptoms and squint, to be prevented? The answer is, By the selection of appropriate glasses—of glasses just strong enough to enable the lens, without unnatural effort, to bring parallel rays to a focus on the retina (Fig. 6); and it is of great consequence that such glasses should be given, for many of the symptoms complained of by long-sighted children are at once and permanently removed. The ciliary muscle, no longer strained, ceases to give pain; reading or sewing can be continued for an hour or more without discomfort. No congestion of the eye follows even prolonged exertion, because the glasses have placed the eyes of the patient in the same condition as regards accommodation as those of a healthy person. As there is no congestion or increased flow of blood to the parts, the secretions of the eyes are lessened; there is no tendency to the adherence of the lids in the morning, no gummy secretion to be cleared away; and, which is a matter of far greater importance, both eyes are brought equally into play, and the disposition to squint is removed.

It cannot be too strongly stated that any tendency to squint that may be observed in a child of from four to seven years of age should receive immediate attention. Such tendency is, in a large majority of cases, simply due to some error of refraction, which is capable of being remedied by the selection of appropriate glasses; and not only do spectacles greatly relieve the work of the eye, but they may actually prevent the occurrence of squint, and effect the preservation of good vision in both eyes throughout life.

No fears need be entertained in respect of danger to the eyes from the breaking of the glasses. They are placed in such close proximity to the eye that the child instinctively shrinks from anything that would injure them, as he would from anything threatening the eye itself, and there is no record of any accident from this cause.

A nervous twitching is often seen in children. At first the eyes are closed more frequently than natural; then the winking becomes more energetic, the lids being tightly pressed together. Other muscles begin to participate in the contraction, and a spasm passes across the features, the corners of the eye being wrinkled, the eyebrows drawn down, and the mouth drawn up with a kind of grin, which disappears in a moment, to be repeated after a short interval. The attacks are more common after reading. These symptoms sometimes depend on brain disease, and then are serious; but far more frequently it is only a consequence of long sight. As has been explained, to see near objects distinctly an effort is required: a nervous impulse has to be sent down from the brain to the eye. And this impulse, or effort to make it, is very distinctly perceptible even in the healthy man, but the unusually powerful effort the long-sighted child has to make renders the nervous impulse apt to radiate or discharge itself through other channels: to affect, that is to say, other nerves outside the eye; and the result is seen in the spasmodic action, first of the muscle closing the eyes, then of the muscle raising the angle of the mouth, and sometimes of many other muscles. The twitching in this case closely resembles stammering, and, like that defect, occurs in feeble, ill-developed, and ill-fed children. In stammering, the nervous impulse intended for one muscle passes down other nerves, and brings other muscles into play. The adoption of appropriate glasses, if commenced at an early period, and before the habit has become fixed, will often cure this twitching affection, especially if due attention be paid to the general health and to the development of the bodily powers.

Nature and Causes of Myopia or Short-sightedness.

The uneducated man, in common with animals, uses his eyes for the perception and intelligent recognition of distant rather than of near objects. The shepherd tending his flocks on wide steppes or plains, the hunter pursuing the deer or the buffalo, the seaman in his canoe or bark—all have their attention fixed on distant objects, and for short periods only accommodate them for near objects; and even the occupations of women in illiterate nations, such as spinning and knitting, make little demand upon the muscular system of the eyes; but as civilisation develops, as a knowledge of letters becomes imperative, as manufactures become more numerous, and the products of art more delicate and refined, as hemming and stitching and fine tapestry-work take the place of the coarser kinds of work done by women, sedentary occupations become more numerous, and the eyes are more and more severely tried.

The conditions for the obtainment of food, that prime mover to all exertion, are reversed. The savage loses his dinner if his distant vision is bad; the artisan of the present day has little chance of obtaining his if his vision for near objects is impaired. But, in proportion as the eyes are exerted upon near objects, they tend to become specially adapted for that kind of work. Vision for distant objects becomes impaired, whilst vision for near objects is improved, and the condition termed near- or short-sightedness, the technical name of which is myopia, is developed.

Myopia may be defined as that condition of the eye in which parallel rays of light are brought to a focus in front of the retina, or, in other words, that condition in which, in order that an object should be distinctly seen, it must be brought within a certain measurable distance from the eye—to a distance, in fact, at which the luminous rays proceeding from it are so divergent that they exactly focus on the retina; and this point is called the far point. If the object be removed to a greater distance than the far point, the rays of light proceeding from it are focussed in front of the retina, and crossing, form a blurred and confused image upon it.

The greater or less distance of the far point from the eye constitutes the higher or lower degree of myopia, and a rough judgment of the degree of myopia present in any given case may be formed by noticing the position in which any person holds a paper with intent to read, or attempts to thread a needle. In extreme degrees of myopia the patient sometimes almost sweeps the page with the nose. Myopia is assisted by concave glasses, because concave glasses cause the rays of light that traverse them to diverge, and the depth of the glass that is required to give a clear image of a distant object furnishes the measure of the myopia present in any given case.

The accompanying diagrams will render the nature of the physical changes that are present in myopia intelligible. The healthy eye, as has been already explained, may be regarded as of nearly spherical form, and parallel rays, or those coming from very remote objects, are, as in Fig. 4, brought to a focus when the eye is at rest exactly upon the retina; but the typical form of the myopic eye is elongated, more or less egg-shaped, and as a necessary consequence, the structure of the other parts of the eye being unaltered, rays of light coming from very remote objects are, as in Fig. 7, brought to a focus in the vitreous humour, as at F, at a certain distance, varying with the degree of myopia, in front of the retina. The image thus formed is necessarily blurred and indistinct, for the rays of light, after uniting in the focus (F) to which they have converged, owing to the action of the lens upon their direction, cross one another, and form a circle of dispersion on the retina. A person with healthy eyes may acquire a good idea of the appearance which the world presents to a short-sighted person by looking through such an ordinary hand lens as that used for examining pictures, placed close to the eye. Under these circumstances, all objects in a room become ill-defined; the form of a picture-frame, the broad differences of light and shade, the colour of the dress worn by a lady, may be readily distinguished, but the details are invisible, and the degree of impairment of the clearness of the image is directly dependent upon the strength of the glass used, exactly as in myopia the indistinctness of vision is in direct

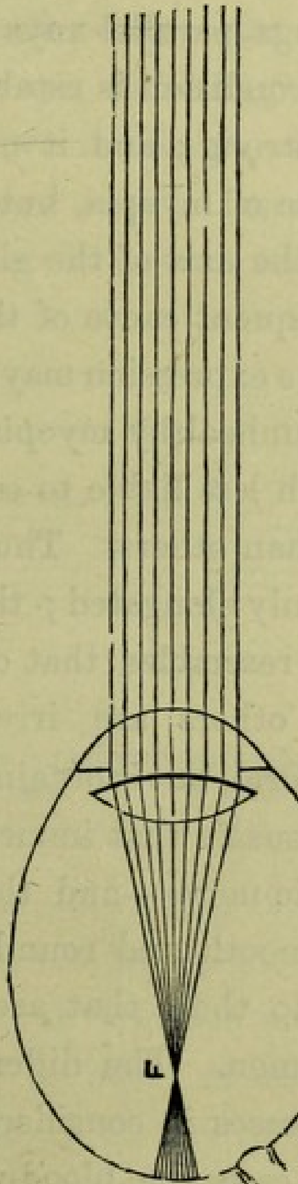


Fig. 7.—Short-sighted or Myopic Eye. Parallel rays falling upon it brought to a focus (F) in front of the retina.

ratio to the elongation of the globe of the eye: the longer the axis of the eye from before backwards the worse the vision.

It is obvious that just as the lens placed in front of the eye brings parallel rays of light to a focus too early, so a similar condition is established if the lens in the eye itself be too strong; and it may occasionally happen that this is the cause of myopia, but it is probably rare, and the elongation of the axis of the globe must be regarded as by far the most frequent cause of the defect.

If the expression may be allowed, there are cases of healthy and of unhealthy myopia; or rather, some cases of myopia are much less liable to complications which seriously impair vision than others. Thus, some myopic eyes are smoothly and evenly elongated; their outline is regular, and the back surface resembles that of an egg in the uniformity of its curve; others are irregular in form; the elongation is not uniform, but is obtained at the expense of some particular part—usually that immediately surrounding the entrance of the optic nerve—and the back part of the eye, instead of being smooth and rounded, presents bosses and projections similar to those that are often seen near the footstalk of a large lemon. The difference in the prospects of the two sets of cases is considerable, and is easily intelligible. In the one case, the blood-vessels of the retina and choroid, if somewhat stretched, are yet elongated evenly, and with no varying strain; whereas, in the other case they are tortuous and irregular, and as the disease advances, are irregularly strained, and are hence apt to give way or to become the seat of disease.

The mode of treatment adopted for the relief of myopic eyes is to place in front of the eye a concave glass. This form of the glass causes parallel rays of light falling upon it to diverge. Such divergent rays will not be brought to a focus so soon as parallel rays, and the object is to give glasses of just such strength as shall compensate for the increased length of the axis of the eye, and bring the rays to a focus on the retina. This is shown in Fig. 8, where the parallel rays, falling on the bi-concave lens in front of the eye, are rendered divergent, and therefore come to a focus

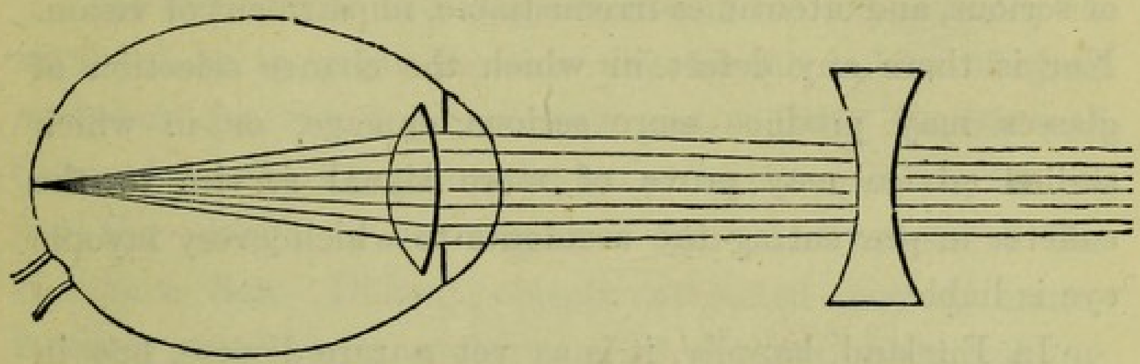


Fig. 8.—Myopic Eye, the vision of which is rendered perfect by the use of a concave lens.

on the retina, and not in front of it as in Fig. 7. It is important that the glass given should not be too strong, because if the rays of light are made to diverge too much the focus will fall behind the retina, and an effort of accommodation is required to bring the focus up to the retina—an effort that is always injurious to the eye. The myopic patient should, therefore, use the weakest glass with which he can see tolerably well. It is better to err on the side of insufficient strength of glass than to use those glasses that are too strong.

The prevention of the spread of myopia is a subject of national importance; ~~and since~~ it is an affliction that is apt to be developed in childhood, and can certainly, if originally present, be greatly intensified by the method in which education is conducted, it fairly falls within the scope of this work to explain the mode of its production, and the means that should be adopted to prevent its occurrence or to stay its progress.

Once formed, moreover, there is no condition of the eyes which demands more frequent attention, which is more likely, as the child advances to maturity, to interfere with its progress in life, or which is more frequently the precursor of serious, and oftentimes irremediable, impairment of vision. Nor is there any defect in which the chance selection of glasses may produce more serious damage, or in which skilled advice may prove of more signal service to the sufferer in preventing the accidents to which every myopic eye is liable.

In England, happily, it is as yet a rare disease, but in France it is common, whilst in Germany it has of late years been met with so frequently as to have attracted the attention not only of professional men but of the State authorities, and to lead to enactments which it is hoped may ultimately effect its extinction. Unfortunately, however, it is an hereditary disease, or at least there is a strong hereditary tendency to it; so that the children of myopic parents develop this affection under circumstances in which a healthy child, or one descended from healthy parents, would suffer no injury.

As a matter of fact, it appears that few children are born short-sighted, but they become so as soon as their attention is directed to minute objects: that is, as soon as their education begins; and the more minute the work, and the closer and the more protracted the attention that is given to it, the more rapidly does the malady progress. At the age of twenty or thereabouts in a large proportion of cases, partly through the increasing firmness of the tissues, and partly owing to the cessation of education, myopia becomes stationary, but when severe work is continued beyond that time, it still increases, and may continue to develop almost throughout life. Its course is, however, somewhat modified by the natural changes that take place in the eye with advancing age.

The freedom of the English race from myopia may be regarded as in great measure due to the habits of their ancestors for many generations past. Their Danish and Saxon forefathers lived on the sea or in the open air, following the plough or dancing over the blue waters of the Northern Sea. Distant objects attracted notice, manufactures were few in number, and of workmanship involving close examination there was little or none. The imperfection of the means of lighting at night, the absence of books, the ignorance of letters, both among the nobles who scorned them and amongst the poor who had not the means of acquiring them, led to drinking and the telling of stories, to the wassail bowl, and the song of Cædmon, but also to early rest, long sleep, and—not the least advantage—to a healthy form and construction of the eyes. And if outdoor occupations were followed by the men, the labours of the women were not of a kind to seriously tax the visual powers. Spinning and knitting, the weaving of coarse clothing, required but little attention, and are at the present day actually regarded as occupations well adapted for those whose vision is failing from age or infirmity.

It has been stated that myopia is hereditary, but it is also an affection that can be acquired, and this fact has an important bearing on the whole system of education, and upon almost every part of it. The age at which education should be commenced, the time during which it should be continued, the position of the child when learning, the books that should be put into his hands, and the general surroundings in regard to light and ventilation, are all points requiring and fully repaying careful consideration and research.

Attention was first directed to the remarkable development of myopia during school life by Jäger, in 1861, whose observations were, however, made upon comparatively few children. The subject was soon afterwards taken up by Cohn, of Breslau, who examined more than 10,000 scholars, and who was able to deduce some very remarkable conclusions from his observations; for he found, in the first place, that the children attending rural schools were almost free from short-sightedness, but that the affection increased in frequency in proportion to the demands made upon them, attaining its maximum in the gymnasia; secondly, that the number of myopic children, proceeding from the lower to the higher classes in all schools, was augmented in a regular and uniform manner; and lastly, that the degree of myopia increased from class to class, so that not only were there more myopic youths of both sexes in the higher classes, but the imperfection of vision consequent on the degree of myopia was much greater in the higher classes than in the lower.

Cohn's observations have been repeated in Germany, in America, in this country, and elsewhere, and in every instance with confirmatory results. As regards the actual numbers, Cohn found that in the rural schools of Germany one child in every hundred was myopic; in the elementary schools there were from five to eleven in every hundred; in girls' schools, ten to twenty-four; in the royal schools, twenty to forty; and in the gymnasia, thirty to thirty-five in every hundred. The proportion of myopes amongst the students in Breslau was found by Cohn to be 60 per cent., and amongst the medical students 56 per cent. in 1867 and 57 per cent. in 1881; and he has noticed that in the first year of study the proportion is 52 per cent., whilst in the last year it has risen to 64 per cent. He goes so far even as to suggest that a term for this special form of myopia should be instituted, and that it should be named the myopia of examination. At Tübingen, Gärtner found that amongst 600 students pursuing theological studies the number of myopes was 79 per cent.

The subjects taught in the gymnasia are classics, French, English, mathematics, natural science, history, geography; and the number of these schools is very large, being no less than 360, or about one to every 117,000 of the population. In the Realschülen no Greek is taught, though the curriculum is otherwise similar, and of these there are 129. In the Gewerbeschülen no languages are taught.

In the schools of all countries it has been found that, as at Breslau, the number of myopes increases in passing from the lower to the higher classes, till it reaches a frightful number during the last two years of study at the gymnasia, the average number oscillating between 35 and 60 per cent., whilst it still continues to increase if the lad goes up to one of the universities, rising to 64 at Breslau, 75 at Magdeburg, 80 at Erlangen, and Heidelberg heading the list in some classes with 100 per cent. Cohn, indeed, remarks that so prevalent is myopia amongst the Germans that in one of the International Medical Congresses he had no hesitation in hailing any member as a compatriot and addressing him in the German language if he wore strong myopic spectacles.

In like manner, Zehender, the learned professor of ophthalmology at Rostock, examined the scholars of the gymnasium at that place. The number of scholars was 314, and there were no less than 30·57 per cent. of myopes amongst them, which were distributed as follows amongst the different classes :—

In the lowest classes . . .	10·9 per cent.
5th class	16·0 ,,
4th B	31·03 ,,
4th A	35·45 ,,
3rd B	33·33 ,,
3rd A	40·0 ,,
Lower 2nd	47·82 ,,
Upper 2nd	33·33 ,,
1st	41·38 ,,

In addition, there were 36 whose eyes were weak.

The remarks here made must be regarded as referring to the past rather than to the present, since the Germans have themselves been the first to notice the alarming development of myopia, to experience the evils that it entails, and to study its nature and causes, and under the influence of numerous pamphlets, popular lectures, and scientific treatises, the public have become enlightened on the subject, and immense improvements have taken place in every detail of school life—improvements which, if they do not effect the complete removal of the disease, will yet exert a powerful influence in preventing its extension and limiting its degree.

The general standard of knowledge amongst the Germans is, of course—as a result of the work done in the schools—far higher than amongst other nations. Thus the proportion of illiterates, or people unable to read or to write, is only 1 per cent. of the whole population; whilst in England, as lately as 1865, 34 per cent. of the Marines could neither read nor write, 4 per cent. could only read, and 37 per cent. could only write imperfectly. Yet the Marines are a fine body of men, chiefly drawn from the rural population. In certain parts of Germany general education is still more widely spread, for it was found that in Würtemburg only one recruit in 6,000 was unable to read or write, whilst in England there would have been at the date referred to no less than 2,240 in 6,000 quite unable to do either.

The institution of our Board Schools has, no doubt, greatly diminished this proportion, and most of the children of the lower classes will in a few years be able to read and write with moderate facility; but whilst no intelligent ophthalmic surgeon will inveigh against the acquirement of the rudiments of literary knowledge by the poorer classes, since, if properly directed by a wholesome tone of the daily and weekly press, it is sure to produce good fruit, it must always be borne in mind that its tendency is to develop myopia, and through myopia many other affections of the eyes.

In France, in 1833, as we learn from the reports furnished by Lorraine and the first visitor of schools appointed by M. Guizot, the school charges depended on whether the pupil was taught reading alone or reading and writing; and many children left school incapable of writing even their own names, and of those who could read some could only read print, whilst others could decipher writing. It is even said that in some cantons of Brittany, of the Limousin, and of Cevennes, there are schools where no writing is taught until the children can read easily and know their Catechism. In many of our own schools *good* writing is almost ignored, and boys are allowed to send up almost anything they please. The habit of setting impositions in which 500 or 1,000 lines have to be written out for some trivial fault is to some extent responsible for this; and examiners and all who have a large correspondence know how much of the writing of the present day supplies evidence of bad teaching in the irregular inclination and imperfect formation of the letters, individual words being often quite illegible, unless the reader knows something of the subject, and can guess at them by the context, or that part of the context which he can make out.

It is certain that the number of myopes is much less in other nations than amongst the Germans. Thus observers in New York, amongst whom Derby, Loring, and Agnew may be mentioned, have not found more than from 4 to 27 per cent. of myopes between the ages of 6 and 21 in the schools of America, and in Russia it varies from 11 to 44 per cent. between the same ages; but Derby noticed a considerable increase in the number of myopes amongst medical students after only four years of study, and similar observations have been made by Reuss at Vienna and, as already stated, by Cohn at Breslau. The latter observer states that he examined all the students at the Frederick Gymnasium at two periods, with an interval of about two years, and found that in the course of that period no less than seventeen who had previously good vision had become myopic, whilst those who were previously myopic suffered an increase of their defect.

As in Germany short-sightedness is most common, and as sufficient evidence has now been advanced to show that this affection is most prone to develop during the period of education, it is natural to turn to that country with the view of investigating the mode in which education has been conducted, as compared with that of other countries, and of profiting by those infractions of the broad rules of hygiene that are applicable both to the body at large, and to the eye in particular, that may be ascertained to have been in operation in that country; for it is reasonable to suppose that similar errors are to a great or less extent practised in every other country where myopia is prevalent.

The causes at work in producing myopia—or, as they may be termed, the factors which have been fairly ascertained to exert a powerful influence in the development of the disease —are prolonged exertion of the eyes upon near objects, inadequate amount of light, bad form of type, indifferent paper and printing, and insufficient physical exercise and food.

Want of exercise and of food do not in themselves cause myopia, but must, nevertheless, be regarded as powerful predisposing causes; for, in the first place, vigorous exertion tends to strengthen the coats of the eye, in common with all other parts of the body, and thus prevents them from yielding to internal pressure, whilst it also prevents local congestions of blood, and fulness of the blood-vessels in the head in particular, by calling the blood to the limbs and muscles employed in the acts of progression or in gymnastic exercises; and secondly, those who are engaged in sedentary occupations necessarily employ the eyes on near objects, which it will be shown directly is one of the most potent causes of myopia.

Physical exercise is acknowledged by the best instructed Germans to be remarkably deficient amongst German boys. One writer in particular expresses in warm terms the astonishment he experienced in witnessing, on a visit to England, the large numbers of youths of all classes who may be seen in Battersea Park and other open spaces playing at cricket and other games, and the, to him, surprising interest taken in such games by the bystanders. He notices the crowds that assemble to see the Oxford and Cambridge boat-race, and observes that it is impossible to conceive that they would take the trouble to go so far for the momentary glimpse they obtain of the race, were it not that they felt an interest in it from personal knowledge of the art of rowing. "We laugh at their folly," he continues, "because we cannot emulate or practise it."

The amount of food given to German children, although simple and plain, is probably sufficient for all the purposes of nutrition, though it probably has the fault of being a little too monotonous or wanting in variety.

In Germany the school hours vary from four to six daily, and home tasks are given which require at least as much work: that is to say, the boy has to sit at his books and accommodate his eyes for near objects for a period varying from eight to twelve hours daily, almost without interruption.

In regard to illumination, the amount of light supplied in schools in Germany was probably, up to a recent time, insufficient. The Germans are a thrifty nation, live economically, and if the statements of such German boys as come to this country may be relied upon, no more than one candle was formerly allowed to every six, eight, or even ten boys.

Lastly, no one can inspect the German books of fifty years ago, whether school-books or the dictionaries intended for adults, without being struck with the singular roughness and inequality of the paper, and the difficulty of deciphering the old Gothic type, which was made still more illegible by the bad ink with which it was printed.

There can be little doubt that these causes have collectively conspired to render the Germans a nation of myopes, and it follows that the defects which have been pointed out should be carefully avoided; and we shall venture here to give some further details upon each of these points, with the view of maintaining the general standard of vision at present possessed by English children.

No observations need be made in regard to exercise, as physical exertion of every kind is encouraged to a sufficient extent in all public and in most private schools.

That the requirements of work at English schools both for boys and girls are gradually rising, that more and more is required of them, is well known, and the lists of subjects cannot be read over by any one familiar with children without feeling that either much of the work must be scamped (which is probably the case, or we should have more myopes amongst us) or that the scholars are worked at high pressure, and that the effects are likely to be injurious. At some boys' schools there are three half-holidays in the week, which is an excellent arrangement, and probably, even in those who work hard, saves many from visual defects, especially as the games are such as for the most part require distant vision.

Our arrangements for very young children are perhaps the worst. Half an hour, or three-quarters of an hour is as long as a child of six or seven can devote his mind to any object, and he should then be allowed a rest; and it would be well if in English schools more use were made of the black-board and chalk, as is customary in Kindergarten establishments.

Since, on the one hand, the employment of the eyes on minute objects for any length of time is injurious, and, on the other, education which renders such employment of the eyes compulsory must be pursued, it follows that the amount of work that any child is called upon to do must be of the nature of a compromise between the two; and perhaps the best compromise that can be made is that work should not be carried on unintermittingly, but that it should alternate with periods of rest—that mental exertion should be relieved by bodily exercise. Children should rise early, especially in summer, and may fairly be called upon to do an hour's work before breakfast, providing they have a cup of milk with half a slice of dry bread. It is not right to require any mental work from a child who has just awaked, and who has a perfectly empty stomach. Children, especially between the ages of ten and sixteen, when demands of this kind are often made upon them, are growing rapidly, and not only absorb, but use up in the constructive acts all the food ingested on the previous evening, and probably also much of that which is in reserve in the blood; and to compel mental work before any food is taken is to make a serious demand upon the vital powers.

And work should not be demanded from a growing child immediately after food. The acts of digestion require a large supply of blood, and so long as these acts are in progress the rest of the system, and the brain in particular, must be comparatively bloodless, or if it be brought into play, it diverts a certain quantity of the blood from its proper destination, and interferes with the due assimilation of the food. An interval of rest, then, is necessary after breakfast; but if this be taken at eight a.m., school work may well be commenced at nine, and vigorously prosecuted till twelve. At some schools, and upon sound physiological principles, a rest from lessons and a run for a quarter of an hour are allowed at eleven. The period between twelve and one should be spent in play. Dinner, consisting of plain roast or boiled meat and a farinaceous pudding, may occupy half an hour, and after a short interval for digestion school work may be resumed for two hours. The evening or home lessons should be light, and should not make a greater demand upon the child's time than three-quarters of an hour, and he should go to bed at nine. Children should be helped with their lessons, at all events when they first attend school, and they should be taught the immense saving of time that is obtained by close attention for a short period. All loitering and inattention should be discouraged. A child in whom habits of attention have been cultivated will learn more in half an hour, and learn it more accurately, than an inattentive child will do in treble the time, and all time so saved reduces the period during which active accommodation of the eye is required.

It may just be noticed also that many children will learn by oral instruction—a method far too much neglected in our schools—with great rapidity, and more intelligently than if set down to books and told to learn a lesson by heart. But few parents have the time to devote themselves systematically in the morning hours to their children, and tutors and governesses are apt to be discouraged if they find a child is stupid and inattentive at first, and they commonly take no pains to discover the method by which its interest may be excited. No doubt can be entertained, however, that if the relatives can devote themselves to the education of a child with a strong tendency to myopia, or are wealthy enough to procure the services of others who will take an interest in their work, it is better to conduct the education by means of oral instruction rather than by book work; and, in the case of a girl, fine sewing, and other kinds of feminine occupation entailing very close examination with the eyes, should not be insisted upon.

The *rationale* of the production of myopia under these circumstances is that the sclerotic coat of the eye in children is comparatively soft and yielding, and that the muscles effecting the convergence and accommodation of the eyes required for the clear vision of minute objects exert a kind of pressure on the globe, which causes its elongation; and it follows that the longer the hours of work, and the closer the application, the greater is the deformity of the eye that is induced.

As it is the exertion of the eyes on minute objects at short distances that really tries their powers, and in many instances leads to trouble, especially if they are not quite healthy, it is clear that the arts of reading, writing, sewing, and music, in the acquirement of which much of the accommodative work of early life is done, should be practised under those conditions which experience has shown to be most favourable, and that, as far as possible, the objects themselves should be well illuminated and defined. The quantity of light admitted into a schoolroom should be a point of the first consideration; for, although a moderate or small amount of window-surface may give sufficient light to enable children to read, write, or sew with ease and comfort in the middle of a bright summer day, it may be seriously defective in the darker days of winter, and especially in the afternoon, inducing the children to stoop over their lessons, and to strain their eyes by close inspection of their work.

It has been ascertained that in schools where lighting is defective, other things being equal, myopia is most prevalent; and the rule has been laid down that window-surface should be one-fourth or one-fifth of the floor surface. This proportion is ample in the case of a house standing apart, or for the upper stories of a town house; but it should be borne in mind that in towns much of the sky, which alone affords the requisite supply, is cut off by the opposite houses. Properly, the space between the schoolroom windows and the neighbouring houses should be twice the height of the adjoining buildings, though few streets in London and other large cities fulfil this requirement. The light admitted by a skylight is good, since it falls vertically on the paper and illuminates all parts alike, but it can only be obtained in exceptional circumstances, and rooms so lighted are dull and uninteresting, and give the impression of living in a well. It is generally admitted that light should enter from the left side. The advantage of this in writing is obvious, for the strokes made with the pen are at once seen; whereas, if the light enter from the right, they are to a certain extent concealed and in shade. Front light, especially if to the south, is dazzling, and in the event of a sloping desk being used, causes the writing or text to be in the shade; and light entering from behind is necessarily obstructed by the body and head; and neither of these, consequently, is so good as light entering from the left side.

During the long afternoons and evenings of winter some kind of artificial light must be used, and the choice in schools usually rests between gas and candles—gas being generally selected on the several grounds of safety, cleanliness, and economy. Gas, however, spoils the air to a much greater extent than other means of illumination, not only using up more oxygen, but yielding by its combustion a considerable volume of sulphurous acid and other gases, which are extremely deleterious, even in small quantities. The effects of these gases are quickly shown in conservatories by the drooping of plants, and make themselves apparent in our rooms by their action on the leather binding of books. The fish-tail light is apt to flicker, though with a Sugden's burner and shade it can be made sufficiently steady. If candles are used, there should be at least two to every four boys. For home work, a kerosene lamp will be found very serviceable. It should have a dark-green shade to protect the eyes, with white internal surface to reflect the light on the book. But, as already remarked, the lessons done at home and in the evenings should be short. A healthy child, from ten to fourteen years of age, who has risen at 7 a.m., and has pursued a proper system of education during the day, is not in a condition to begin serious study at seven at night, or at least to do more than an hour's work; and if the exigencies of modern examinations will allow of it, the evening is the time for relaxation and pleasure.

Again, although good illumination occupies the foremost place because it is essential for giving definition of external objects, yet it is of scarcely less importance that the objects themselves should be, as far as possible, clearly cut and well defined, and should give no unnecessary trouble to the eye and brain in acquiring a knowledge of them. It cannot, therefore, be regarded as a matter of small importance to consider what forms of printed books and what kinds of sewing should be presented to young children, and on these points much interesting information has been recently obtained.

It may be stated, as a general rule, that the books given to children to read, and especially those that are given to them to acquire a knowledge of the art of reading, should be of large, clear type, and should be printed on good paper. In this respect the Roman type of the present day is a manifest improvement upon the Gothic type, which, up to a recent period, was in common use throughout Germany.

The Gothic type was employed by the earliest German printers to make their books resemble the contemporary manuscripts; and it is believed by some that the Roman, or Latin, type, as we call it, but which is termed "antiqua" by German and other printers, was the creation of Italian humanism, and was adopted as representing at once a close approximation to the character of the antique classics and rebellion against the monks, from whose manuscript character the Gothic was derived. Javal has demonstrated that, in reading, the eye travels along a horizontal line just below the upper extremity of the letters which constitute the words, and this movement is made in accordance with our Western mode of printing and reading in horizontal lines from left to right, and to avoid useless and complicated movements of the eyes.

If the upper half of a line of print be covered with a sheet of opaque paper, we shall find that it is difficult to make out many of the words, and almost impossible to read fluently; whereas, if the lower half of the line be covered, and the upper extremities of the letters be alone seen, it is easy to read the line; and this may be attributed to the greater number of letters that are prolonged above the line as compared with those below. Thus, of the former we have b, d, f, h, k, l, t, and the dotted i, whilst amongst the latter we have only g, j, p, q, and y; and taking the relative frequency with which these letters are used, together with capitals, and in some languages, as the French, accents, we find that eighty-five marks are above the line, for fifteen below, in every hundred, and to this circumstance is due the fact that every reader runs his eye along the letters a little below their upper extremities.

In typical forms of type, the letters should be as distinct as possible from each other, so that no difficulty may exist in reading them. This is especially the case with the h and the b, the v and the n. But these are not the only points that demand attention. The thickness of the down-strokes and of the up-strokes, the spaces between the letters, the spaces between the words, the space between the lines, and the length of the lines themselves, are all points of interest, and have all received consideration at the hands of the printers.

The words in the margin represent well-known sizes of type :—

Brilliant. Pearl. Minion. Bourgeois. Small Pica. Pica. Great Primer. Double Pica.

The usual round, the common task, will furnish all we need to ask.

It may be said that no type smaller than Pica should be used to teach children to read; but when they have once acquired the art, the size may be considerably reduced. Cohn proposes that the type of ordinary journals should be 4 mm. in height, which is equivalent to $\frac{1}{6}$th of an inch; but M. Javal thinks that it may be allowed to diminish to 2 mm., or $\frac{1}{12}$th of an inch.

The list of conditions is not even yet exhausted, for as there are varieties of type, so also there are differences of printing, and although the ink is rarely at fault, yet the unpleasant effects of letterpress obtained from an old and worn-out fount, and resulting in imperfect impressions of the individual letters, are familiar to every one. In such cases the loops of the a and e, of the b, d, p, and g, are apt to become foul, and form a black spot—"monks and friars," as they are termed; the long letters become broken and the fine up-strokes imperceptible, and these imperfections are much increased by roughnesses and inequalities of the paper, which may also have the additional disadvantage of being porous.

Each of these conditions increases the difficulty of learning to read—an art that, from the smallness and the nearness of the objects looked at, is one requiring great attention on the part of a child. Reading is so universally taught amongst the upper classes, and is in such constant requisition, that many persons hardly recognise the difficulty that a child experiences in learning it, and how important it is that all difficulties should be lessened or avoided.

An adult practised in reading bounds from word to word, and probably sees only a letter here and there, his knowledge of the subject supplying the others and suggesting the meaning of the sentence, while some, as is recorded of Macaulay, appear to take in several lines at a glance; but a child plods laboriously from letter to letter, and to arrive at the end of a single word is a feat accomplished.

The books, then, that should be put into the hands of a young child should have these characteristics:—They should not be too large and heavy. The paper should be clean, white, and smooth. The letters should be large, well-formed, and well printed. The spaces between the letters and between the words and lines should be relatively wide, and the line should not be too long. The light should be good, and, as already stated, should enter from the left side; and, finally, the lessons should not be so long as to exhaust the power of attention. The habit of attention has, like other habits, to be learned; and a few minutes' strain at a time is as much as can be expected from a child of six or seven.

The introduction of good prints into story-books is of advantage, since it both excites the attention and relieves the eye. It would be well if children who have any hereditary tendency to myopia were taught by the long slips, with a picture at the head, sold by most of the large stationers. The child should be placed with his back to the light, and at a distance of four or six feet from the slip. The separate letters and words may be indicated by the teacher with a light wand.

The mode in which writing should be taught is hardly less important than reading. Children are apt to be very slovenly in this respect. They place the copy-book in all sorts of impossible positions—standing, kneeling, or lying; and those who have much to do with examinations know only too well that much of the handwriting of the present day is very irregular and indistinct, occasioning not only loss of time but of temper to decipher it. It is customary to insist that the copy-book should be straight before the child, but no rapid writer ever places his sheet in that position. He sits square to the table, rests the arm well upon it from the elbow downwards, though with a slight elevation of the wrist, the hand being supported on the little finger. The pen is held between the thumb and first and second fingers, pointing well away to the right, and the paper is almost always so placed that the diagonal from the right corner to the left is perpendicular to the edge of the table, and there is no objection to this position being taken up by the child.

The child should be taught to write early. The page should be at fourteen or fifteen inches from the eyes, and should be placed either opposite the right shoulder or diagonally in front. The body and head should be held fairly upright, or with but a moderate inclination forward. The copy-book should be placed on a slightly-inclined desk. The page should be well illuminated.

Some children are taught to write by means of a slate, or with lead pencil and paper, perhaps on the ground that these methods are more cleanly, and that there is less risk of injury to cuffs and collars; but the objections to both plans are that there is a particular reflex, and that the letters are indistinct unless the light falls in a certain direction.

Neither reading nor writing should be permitted in the dim light of evening; nor should a child ever be allowed to read stretched out on the hearthrug, endeavouring—

> "Whilst dying embers through the room
> Teach light to counterfeit a gloom"—

to spell out its lessons. The head is necessarily brought within a few inches of the book, and the strain on the eye, both for accommodation and on account of insufficient light, is very great. The same may be said of reading in bed, which is distinctly hurtful. If the child lies prone, the same objections hold as in lying before the fire; if supine, there is a great tendency to bring the book very close to the eyes, and make it rest on the chest for support. Considerable strain is also exerted on the inferior rectus muscle, or that one which rotates the eye downward ; and this is often complained of by those who read much whilst in the recumbent position.

Girls are taught the art of sewing, and this is certainly more trying to the eyes than any work that boys are called upon to do. In ordinary coarse calico there are about seventy threads to the inch ; and what is considered good work in stitching consists in taking up four threads, two in front of the cotton and two behind ; but in moderately fine linen—shirt-front, for example—there are about 120 threads to the inch, so that the child has to work to the sixtieth of an inch—a very much smaller distance than the smallest print.

The serious results of lace-work, in which the eyes are severely taxed, compelling nearly all who work at it to use magnifying glasses and leading to premature decay of the eyes and loss of vision, and the impairment of vision complained of by girls who work at night on articles of dress of a black colour, are sufficient evidence of the injurious effects of sewing if too fine or prolonged, or performed under unfavourable conditions of light. Hence the sewing required of children, whilst it should be neat and accurate, should not be too fine, nor should too much be exacted of them.

Many children complain that after working for a few minutes the stitches and threads grow dim and indistinct, and that if they still continue to exert the eyes, the stitches run into each other, and a peculiar feeling of dizziness and sometimes of headache, or tension about the brow, is experienced, which disappears as soon as work is given up. In many cases the distress of the child is apparent, for the eyes, after working for half an hour, become red, and stream with water. In some extreme cases vomiting is actually induced by any prolonged effort to work. In the large majority of these cases the child is long-sighted, and the explanation of the symptoms has already been given (*see* page 64 *et seq*).

Ulcer of the Cornea.

The only remaining affection of the eyes in childhood which needs mention here, as being capable of prevention by judicious treatment, is ulcer of the cornea. An ulcer of the cornea commences as a small speck situated on the cornea or glass of the eye, or upon the white. At first careful examination shows that it is slightly elevated; but in the course of a few days the top separates, the contents of the little pimple are discharged, and a pit or ulcer is left. Much discomfort, if not actual pain, is usually experienced. Light is disagreeable, and the lids are kept closed, or, if forcibly opened, a flood of tears escapes from them. The disease often attacks weak and strumous children, and these may often be seen clinging to their mother, with their heads buried in her lap, or sitting in a dark corner of a room with their hands before their eyes to exclude the light, for hours, almost motionless, during the day; though, when twilight comes, they will sometimes rise to play, and then a casual observer sees in the dim light scarcely anything to indicate that an important disease is in progress in the eye. When an ulcer has formed, medical advice should at once be obtained; and the disease is here only noticed in order to point out that it is often dependent upon injudicious diet.

The children of the poor are constantly brought to the out-patient rooms of hospitals eating unripe fruit or sucking sweets, whilst it is admitted that they have little appetite for wholesome articles of diet. We cannot here enter into questions involving the consideration of the food that is most appropriate in quantity and quality for children ; but if it could be impressed on the minds of the mothers of families, both rich and poor, that bread-and-milk or porridge for breakfast, meat and potatoes, followed by some farinaceous pudding, for dinner, and bread-and-milk again for tea, constitute a wholesome diet, and that it is as well to abstain from sweets, raw fruit, and pastry, many cases of ulcer of the cornea, which puzzle the medical attendant, irritate the child, and distress the parents, would be prevented or cured.

The Care of the Eyes in Middle Age.

The care of the eyes in middle age must depend in great measure upon the occupation that is followed and the means of livelihood. Those who live in a temperate climate, and are engaged in open-air avocations such as farming, or who pursue the ordinary life of an English gentleman, and have healthy eyes to begin with, and who are, withal, moderate in the gratification of their appetites, should be practically free from ophthalmic disease ; but there are numerous trades, the prosecution of which constitutes a strong predisposing cause to impairment of vision. Many, like those of the tailor, the compositor, and the sempstress, are harmful in consequence of the sustained exertion of the ciliary muscles in effecting the accommodation of the eye for near objects, which they require. Others, like that of the washerwoman, are injurious in consequence of the alternate exposure of the eyes to cold and damp heat. Others, like those of fitters, riveters, hammermen, and smiths of all kinds, owing to the liability to accident and the effects of bright fires. Others, like farm labourers, harvestmen, and reapers generally, are exposed to cold, and to the singularly dangerous results of a slight scratch of the surface of the eye with an awn of barley or a blade of grass—dangerous because they are usually disregarded, and the man continues to work under a hot sun, and drinks largely, whilst he perhaps takes little food. Loss of the eye often results in these cases from what might have been originally cured by the instillation of a drop of sweet oil, and the application of a wet pad and bandage, with rest of the eye for a few hours.

It is an interesting fact—showing that the employment of a glass to reveal minute details, even when used in one eye only, is quite harmless—that an examination of a considerable number of watchmakers has shown they have as good, if not somewhat better, average vision than men following other avocations.

There are two agents that in mid-life are largely used, and which deserve attention—tobacco and alcohol.

That tobacco exerts a powerful influence on the nervous system is well known. The first cigar produces a series of effects that are as unpleasant as they are distinctly referable to this action. The burning, bitter taste in the mouth; the augmented flow of saliva; the nausea and vomiting, followed by purging; the giddiness and faintness; the pallor of the face ; the outbreak of perspiration on the brow ; the feeble and frequent, or slow and feeble, action of the heart, and the utter prostration of the whole muscular system ; the depression of the temperature, and, as physiological experiments show, the diminished pressure of the blood in the vessels ; and, finally, as has actually occurred when an excessive quantity has been consumed, the fatal effects that may ensue—all betoken the extremely poisonous properties of the drug.

A single drop of nicotine applied to the eye of a cat will kill the animal in a few minutes. A small bird will die from the inhalation of a portion of nicotine vapour so small as to be inappreciable by a fine balance. Rabbits, cats, and dogs, die in from twenty to thirty seconds with less than a drop placed on the tongue, so rapidly is it absorbed, and so violent are its effects ; and man suffers severely with only the 25th of a grain.

No doubt the mode in which it is used—namely, in the form of vapour—materially reduces its poisonous effects ; for much of the nicotine is probably destroyed before it is inhaled by the action of the heat of the burning leaves, but some must clearly be absorbed by old sailors and others who chew tobacco.

Habit, however, overcomes this action ; the system becomes accommodated to it, and that which was at first detested is at length endured, then enjoyed, and ultimately almost indispensable. There are men who would prefer to be blind rather than give up smoking, and it cannot be doubted that it acts in some way or other advantageously in the general economy of the body. The rapid manner in which the habit spreads through a country when once introduced into it—the fact that tobacco-smoking is practised by a very large proportion of the males in the whole of Western Europe and in America, notwithstanding the great variety of race and habits of life—shows that it must possess some beneficial qualities. Its votaries generally extol its soothing and tranquillising effects, especially when the mind is exhausted and irritable, and state that it promotes digestion, and contributes to mental activity.

But even those who are habituated to it can generally perceive the effect of an overdose, or excess, which betrays itself by tremors, unsteadiness in the co-ordinated movements of the hand and eye in actions requiring delicate manipulation, and by wakefulness.

Those who have paid special attention to the process of training for the performance of great feats of physical exertion, such as racing or rowing, consider that good material can be rarely found amongst men who are seriously distressed at the sudden relinquishment of the habit.

It must not be forgotten, however, that the number of cases of impaired vision, which even those who are engaged in ophthalmic practice, and who, therefore, are likely to meet with them, can certainly refer to the action of tobacco, is surprisingly few. Thousands of men smoke many cigars or cigarettes, or pipes, and yet cases of tobacco blindness are so rare that some still doubt its existence. The truth seems to be that it seems to affect the nervous system of some men much more powerfully than that of others; here, as elsewhere, one man may take with impunity what is seriously injurious to another. As a rule, in what is termed tobacco amaurosis, the failure of vision is gradual.

Some intelligent surgeons hold that when tobacco exerts a prejudicial influence on the eyes it is due to some idiosyncrasy on the part of the individual, for it sometimes occurs at an early period of life, when, therefore, the poison has had less time to act injuriously; and it has been noticed that the relatives of such young persons have been liable to exhaustion or wasting of the nerves from other causes.

One of the reasons that render it difficult to mark and distinguish tobacco poisoning is that its excessive use is often associated with other causes of nerve depression, such as the abuse of alcohol, or excessive mental exertion.

The mode in which tobacco is consumed may reasonably be supposed to exert some influence. The active principle is the highly poisonous fluid and volatile alkaloid nicotine. It exists in the leaves in proportions varying from fourteen parts to seventy-nine parts in 1,000—the former quantity existing in the more delicately-flavoured and highly-prized tobaccos of Havannah, the latter in the coarser kinds grown in middle and southern Europe. The composition of nicotine is represented by the formula $N^{0}H^{14}O^{2}$.

Probably the worst method of using tobacco is that of chewing, for, even if the saliva be not swallowed, a large proportion of the juice must be absorbed. Amongst those who use cigars some inhale the smoke into the lungs, whilst others only allow it to enter the mouth, or mouth and nose.

It has been suggested that one reason why tobacco poisoning is rare, is that more or less alcohol is consumed with it, and that possibly the action of alcohol and tobacco may be antagonistic, so that the poison and the antidote are taken simultaneously.

It is possible that particular kinds of tobacco may exert a prejudicial influence on the nervous system, though it is more probable that the system becomes accustomed to, and can bear, a certain amount of nicotine, while if this be materially increased its ill effects are soon experienced. A remarkable case supporting the latter view has been placed on record by Cohn, in which a gentleman, seventy years of age, applied to him on account of rapidly-failing acuteness of vision. The patient was a hale man, the picture of good health, and had been accustomed to smoke from twelve to fifteen Havannah cigars daily from the age of fifteen without experiencing the slightest impairment of his otherwise excellent vision. A few months before applying to M. Cohn, however, he had taken to smoke a kind of Dutch cigar, still consuming from twelve to fifteen daily, and in the course of this period his vision had rapidly failed. In the right eye it was reduced to $\frac{1}{30}$th and in the left eye to $\frac{1}{40}$th of its normal amount. His perception of colours, especially of red and green, was lowered, both tints in small objects appearing yellowish. No changes could be discerned in the eye, after the most careful examination. M. Cohn determined to have the two kinds of cigars analysed, and accordingly forwarded them to Dr. Poleck, an experienced chemist. At first sight, it appeared that the Havannah cigars, which had been freely smoked for upwards of fifty years, contained a larger quantity of the poisonous agent nicotine than the others, for they contained 2·02 per cent. of nicotine, whilst the Dutch cigars, which he had just commenced to use, and to which he attributed his dimness of vision, contained only 1·8 per cent. of nicotine. The enigma was, however, solved by weighing the cigars; and it then appeared that whilst the harmless Havannah cigars weighed 72·5 grains each, the harmful Dutch cigars weighed 139 grains each; so that in smoking an equal number of each kind he inhaled in the case of the Dutch cigars nearly half as much again of nicotine—that is to say, in smoking twelve Havannah cigars he inhaled 216·5 grains of nicotine, whilst in smoking twelve Dutch cigars he inhaled 300 grains of nicotine. It may be added that, by reducing the allowance of cigars to a minimum and by the administration of appropriate medicines, the vision rapidly underwent improvement, though some dulness of vision, both for objects and colours, remained. Not only, therefore, the number and kind, but the actual weight of the cigars used should be considered.

The use of tobacco is commenced very early in some nations. In "The Voyage of the *Vega*," Captain Nordenskiold states that the Chukches of all ages are great smokers. He often saw little boys leave their mother's breast to take a whiff or two of their father's pipe, and then go back to their mother. The children of the Chukches, like those of the Eskimos, suckle unusually long, generally till they are three years old. The women do not smoke, but confine themselves to chewing tobacco, and this they begin with very early—in fact, before they can walk.

There is reason to believe that in certain sets of men especially of business men, a quantity of alcohol is consumed which, hard as their work may be, is greatly in excess of what is required, either for nutritive or social purposes. Men who have to undergo severe mental or bodily exertion can bear a large amount of stimulus with comparatively little harm, though it probably tells even in them. The writer was once crossing the broken country of the Western Highlands, when at a height of about 2,000 feet he was glad to ask for refreshment at a lonely shepherd's hut, the occupant of which, an old man of seventy, was just opening his door. He appeared in a few moments with a large tumbler half filled with whisky. It was declined, on the score that on an empty stomach it would produce intoxication, and that if milk were to be had it would be preferred. The opportunity was too tempting, and the man finished it himself. On inquiry, it appeared that he had already had his breakfast, which had consisted of a basin of porridge and such another glass, and that his breakfast for many years had included at least this quantity. Yet he was a robust, powerful man, with no other ache, he said, than an occasional attack of rheumatism, in winter—perhaps, after more than the usual dose. This man was accustomed to go down daily into the valley, besides, he said, walking about nearly all day tending sheep; and it is reasonable to suppose that the difficult air of the keen mountain-top burnt off the alcohol which he consumed. Health and excellent vision, it is clear, may under such circumstances be maintained.

But the case is different with the dwellers in towns. The quantity taken is at least equal, and the variety probably much greater. Whilst writing this very page, a hale, strong man, the model of an Englishman, thirty-eight years of age, from a large provincial town, called on the writer complaining of great impairment of his vision. He was told that it was of a serious nature—that it was the indication of living too fast, of eating and drinking more than was requisite, and of taking too little exercise. "Exercise!" was the reply. "I take exercise enough; I walk three hours a day hard, from shipper to shipper. I hunt on Saturday, and I take a long walk on Sunday; but I acknowledge I do take more than probably is good for me." He was asked to state what he had taken the day before, and this is the account he gave, word for word: "I made a good breakfast, though I had been up the night before till half-past two, playing cards. I went down to the City on business, and met two friends, and we had a bottle of champagne; as we finished it another friend joined us, and we had another bottle of champagne. I then had some sherry and bitters, and walked to Cheapside, where I had oysters and half a pint of stout. I then took some Kümmel liqueur. In the course of the afternoon I had two glasses of port wine. I dined at seven, and had a pint of claret. After dinner I had one glass of brandy-and-water. But then," he added, "yesterday was a very light day." Such instances of excess are, probably, not rare.

When it is considered how great are the changes in the economy that culminate in the casting off of a bud and the birth of a child; that the bearing of children is in all women a severe strain upon the constitution, as indicated by the debility and exhaustion that are experienced, and by the incapacity to take the usual amount of exercise; by the languor, sickness, and variable appetite; and by a variety of well-known symptoms—it is not to be wondered at that the eyes participate in the general disturbance of the constitution, and that complaint is *frequently* made of more or less impairment of vision. The most common complaint is, that difficulty is felt in reading for more than a few minutes at a time, when the letters begin to run together, and a feeling of giddiness is produced. This sensation is relieved when the book is put down, and when the eyes are closed and rubbed, or strongly pressed. Half a page or more can then again be read, but very soon the same symptoms reappear, and after a few ineffectual attempts the book is thrown down in despair, and fears are entertained that blindness is to be added to other troubles. In such cases black spots, or muscæ, are apt to appear in the field of vision, which produce considerable annoyance, for they constantly attract attention by their movements, which follow those of the eye, whilst they are apt to exactly cover and obscure any minute object that may happen to be looked at. The eyes after a short spell of work not only feel tired and ache, but look red and congested, and the eyelids are apt to adhere in the morning. Objects are not clearly seen, and on waking a distinct effort is required to see print of even large size. Towards evening, and after food, some improvement usually takes place.

These symptoms are often thought to indicate biliousness, and in some instances they, perhaps, really do so; but, as a rule, the patient may take heart of grace and be satisfied that they all are only temporary, and that with returning strength they will wholly pass away.

They are, in truth, only indications that the power of accommodation has somewhat failed, that the ciliary muscle is a little weakened, that it requires an unusual nervous impulse to cause the muscle to contract, and that consequently the patient is temporarily made presbyopic.

The affection, perhaps, attracts more notice because it is apt to occur, and is always most strongly marked, in those who are long-sighted, and who have, therefore, enjoyed, as they have thought, particularly clear and good vision, and a little consideration will show why this is so. The long-sighted person, as has been already explained, requires to make a certain exertion—has, that is to say, to accommodate the eyes for distant objects. A very great exertion has to be made to see near objects. Any cause that weakens the tone of the nervous system generally will therefore act much more strongly on the hypermetropic eye than on the normally-formed eye, and will make it difficult and fatiguing for the woman to read or do fine work in proportion to the degree of her long-sightedness. The black specks and flies complained of are in many instances small portions of pigment which are physically detached from the ciliary processes by rubbing the eyes, and after a time break down and disappear. In cases of this kind the patient will find that the use of a low power of convex glass will speedily remove all her discomfort. Symptoms of a character almost identical with those just described are often observed during nursing, and may generally be regarded as indicating that the strengh of the system has been overtaxed, and that the child should be weaned.

There are some other symptoms, however, which may happen at this period that should immediately lead to careful examination, and which can only be referred to here. Such are sudden loss of vision in one eye, the failure to see one-half of an object, and other forms of distorted vision. These are usually indicative of a blood-vessel giving way either in the globe of the eye or in the brain, and timely and good advice may avert more serious mischief, of which such symptoms are often the forerunners.

The Preservation of Sight in Old Age.

As age advances various circumstances conspire to impair the vision, and to render it less acute than in childhood and youth. The media of the eye, through which light has to pass before it reaches the retina, and which in young people are exquisitely pellucid, become hazy and dull, and objects are seen, as it were, through a smoky glass. The lens, in particular, loses its limpidity, and becomes, if not cloudy, at least brownish or discoloured; and many may, perhaps, remember the discussion which took place some years ago between Liebreich and Ruskin as to the peculiarities of Turner's painting during the latter years of his life, which were affirmed by Liebreich to be due to Turner's lenses having acquired a yellowish tint. Whether this was so or not in Turner's case, and whether, if present, it would account for the peculiarities of the paintings of his later years, is beside the question, but it is certain that the lens undergoes degenerative changes with advancing years. Moreover, the nutritive processes are less active. The plate of our photographic apparatus is less sensitive. The visual purple of the retina is less freely produced.

The eyes of elderly people, further, require more light to see distinctly than those of young persons, and this seems to be due to two circumstances. First; as we become older the vis inertiæ, or resistance to change of the nervous system, occasioning diminished sensibility, augments; and, secondly, the physical conditions of the eye are less adapted for the reception of images. Old people should read chiefly by day, or obtain good, steady, artificial light by night. The print they read should be clear and of fair size. Foot-notes should be avoided. As a rule, spectacles are required after the age of fifty. Hot rooms, late and heavy meals, are injurious.

The main characteristic of age, so far as the eyes are concerned—that condition which occurs in both sexes, and in all conditions of life—is the recedence of the near point of distinct vision. The printed page, the piece of work, is gradually held further and further away from the eye, or if brought near its close examination is felt to be a strain, and the exertion can only be made for a short time. Remote objects are as distinct as ever, but the outlines of all near objects are blurred and confused. Hence, the letters of a word run into one another, and reading and sewing become difficult or impossible. The eye of the needle becomes doubled or trebled, and workmen in all kinds of handicrafts find that the sharpness of their outlines, whether made with chisel or brush, is inferior to the work of their younger days. Persistent work at near objects is, under these circumstances, distinctly hurtful, and all who after the age of fifty begin to feel that reading at night is attended with difficulty, and is followed by redness and increased secretion of tears and mucus, causing the lids to adhere in the morning, should betake themselves to glasses, which, if appropriately chosen, will really act as preservers of the vision.

But that condition which is the best known, and one of the most frequent causes of impaired vision in old age, is cataract.

The Nature and Prevention of Cataract.

The term cataract is in common parlance often applied to all visible opacities and white spots about the eyes, but properly it is limited to an opacity occupying the area of the pupil, and resulting from a change in the structure and composition of the lens. The lens, so-named from its shape, is the most important of the transparent media of the eye, and is the agent by which the rays proceeding from luminous bodies are brought to a focus on the retina, and by means of which a picture of the outside world is formed on this membrane. Its structure is very remarkable. It is composed of a number of fibres, the edges of which are slightly toothed or serrated, and which interlock with each other in such a way as to form a continuous layer. There are many layers, so that the lens resembles an onion in miniature. In size it is about one-third of an inch in diameter and one-fifth of an inch thick, and it is perfectly transparent, reflecting no light. Hence, on looking into the eye of a child, the pupil seems absolutely black. As age advances, however, the lens becomes less transparent ; it reflects yellow rays of light, and one of the causes of the dim and dull aspect of the eyes of old people is that the pupil presents a greyish-yellow appearance, due to the change in character of the lens. Such change, however, is not a cataract; for a patient may still see well, and by a proper arrangement of light, the details of the back of the eye, that is, of parts behind the lens, may be made out with perfect distinctness, proving clearly that it is not opaque or even cloudy.

A cataract consists in the breaking down of the fibres of the lens; these first become finely dotted with fat drops of microscopic size, which, after a time, run together to form larger drops, strongly reflecting light. The fibres then swell in some parts, and in others become attenuated, and at length soften and rupture, so that they can no longer be traced under the microscope; and in their place are fat drops—crystals of a particular kind of fatty body, named cholesterine—and chalky particles. It is to these (if we may so call them) foreign substances, as well as to the altered disposition of the regular layers of the healthy lens, that the white aspect of the lens in cataract is due.

As a rule, cataracts form very slowly, though many instances have been recorded of their complete formation in the course of a few days. That form of cataract which results from injury—as from direct blows on the eye, the penetration of the eye by the point of a needle or knife, or of a pair of scissors, or a thorn—is rapid in its development. It is due to the admission of the aqueous humour to the substance of the lens, and to the swelling up of its tissue. Such cases require immediate and skilled medical and surgical treatment.

But the ordinary form of cataract, which occurs in elderly persons, and hence called senile, is slow in its progress. It usually commences in one eye, which may be so gradually affected as to be unnoticed by the patient until his attention is suddenly awakened to the defect of his vision when on closure of the healthy eye he attempts to look through a telescope with it, or by observing that he is unable to judge accurately of distances—a man often pouring wine over the edge of his glass, and a woman finding it difficult to hit the eye of her needle. The vision is often preserved when the cataract is far advanced and very evident even to unskilled observers, for the changes described above occur in bars and patches, leaving portions of the lens clear and transparent, and through these, as through lattice-work, the patients often see fairly well—quite well enough for all ordinary duties of life; and even on occasion, and with a good light, well enough to read or write. The development of cataract is unaccompanied by pain.

Now and again we meet with elderly people who, after wearing convex or magnifying glasses for many years, are able to give them up, and can even read small print. This phenomenon is generally due to the supervention of cataract, and to some slight swelling of the lens having taken place.

No means, except operation, are at present known by which a cataract, when once fairly formed, can be removed. Medicines, lotions, ointments, electricity, magnetism, are all weapons of quackery and charlatanry; and no experienced ophthalmic surgeon would for a moment encourage the hope in a patient who has well-developed, or even incipient, cataract, that it can be conjured away by such means. But inasmuch as it is a progressive disease, and capable of being hastened in its progress by circumstances unfavourable to the general health, so it may be delayed by general care and attention to those rules that may improve the constitution : good food, regular exercise, sound and uninterrupted sleep, a quiet mind, and the avoidance of all work that may strain the eye, would be the best means for delaying, or perhaps temporarily arresting, the progress of cataract. If, however, it still continues to advance, an operation is the only remedy, and this consists in the removal of the lens, or in its solution by the natural fluids of the eye, after the investing capsule has been divided by a needle. The latter method is usually adopted in children, the former in cases occurring at an advanced period of life. The operation itself, though requiring much skill and knowledge, as well as constant practice, on the part of the operator, is not in itself a severe one, and the high interest which attaches to it is dependent on the importance of the issue rather than on any difficulty or danger in its performance.

The Protective Apparatus of the Eye.

The eye, buried as it is in a deep cavity of the skull, and resting upon a soft cushion of fat, is remarkably protected from injury, and it is rare to find it seriously damaged by direct violence, but it is unavoidably exposed to the entrance or lodgment of dust and to the action of irritating vapours ; to the sting and bite of insects ; and to minor troubles which, though apparently slight, may, by exciting inflammation in the cornea and rendering it opaque, materially impair the visual powers. To prevent accidents of this nature the eye is protected by the eyelids, and by the lacrymal apparatus.

The lids are two processes of skin strengthened by dense tissue termed the tarsal cartilage, which project over the eye, and, by the contraction of a circular muscle, can be made to meet in front of it. Their inner surface, which is soft, moist, and velvety, is accurately adapted to the rounded surface of the globe, and plays over it with extremely slight friction. The upper lid is much the larger as well as the more movable of the two, and has attached to it a muscle, the elevator of the upper lid, by which it is raised. In sleep the muscle relaxes, and the upper lid falls over the eye, which is thus protected from light. An additional precautionary act takes place in sleep, causing the eyes to roll upwards and inwards, which prevents the entrance of light to the retina through the chink of the lids, and at the same time removes the cornea from the accidental sting of insects. The lids are fringed with a row of large, highly sensitive hairs, which are gently curved in opposite directions—those of the upper lid having their concavity looking upwards, and those of the lower lid downwards. The hairs have been noticed to live for about three months, when they drop out and are replaced by new ones.

Throughout our waking hours the eyelids are in frequent movement, the upper eyelid in particular rapidly descending, and as rapidly rising, whilst the lower advances a little way only, to meet it. This movement fulfils a double purpose: it serves to sweep away particles of dust which have alighted on the surface of the cornea, and at the same time to keep the surface moist and bright.

The lacrymal, or as, perhaps, it ought to be spelt, lacrimal apparatus, consists essentially of a gland *l* (Fig. 9) which occupies the upper and outer part of the orbit, lying between the globe of the eye and the bone. This gland, under the influence of the nervous system, secretes the tears which serve to wash away any foreign body that may have lodged between the lid and the eye. After moistening the surface of the eye the tears are carried away by two small canals, the openings of which, called the puncta lacrimalia, *a a*, may be seen on the edges of the lids, near the inner angle of the eye. These two little ducts unite, and discharge their contents into the lacrymal sac, *c*, from which they are conveyed by the nasal duct, *d*, into the nose.

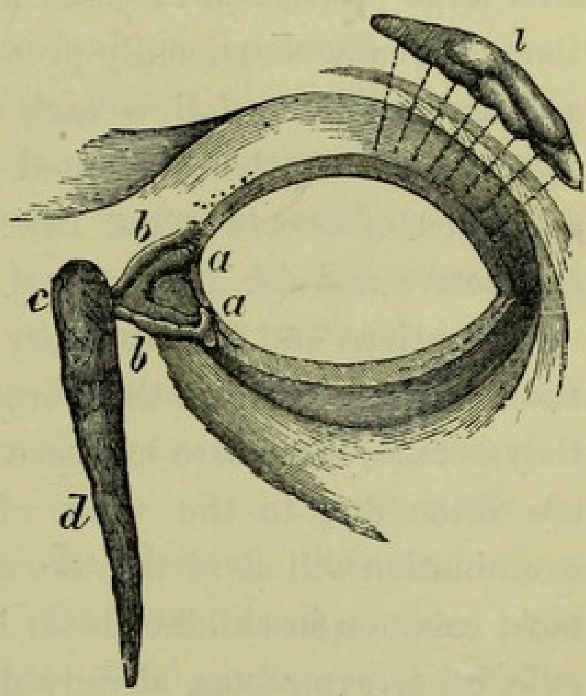


Fig. 9.—Lacrymal Apparatus.

l, lacrymal gland; *aa*, puncta; *bb*, canaliculi; *c*, lacrymal sac; *d*, nasal duct.

The commonest affections of the eyelids, and those only that need mention in treating of the general care and preservation of the eye, are stye, or stine; inflammation of the margins of the lids; twitching or quivering of the lids, and overflow of tears. More serious affections, such as cuts and burns, tumours, drooping of the lids, and eversion or inversion, render recourse to medical advice requisite. A stye on the eyelid is, for its size, one of the most troublesome and disagreeable affections of the body. It produces considerable swelling of the lid, accompanied by throbbing pain preventing sleep; is three or four days or even more in maturing, forms a head containing matter, and then bursts. In a large proportion of cases it is due to errors in diet, though it may occasionally proceed from cold. Sometimes a dozen or twenty follow each other in succession. Their occurrence may be prevented by attention to diet—the avoidance of sweets and of raw fruit and pastry—pure air and active exercise.

Eruptions and inflammatory affections of the margins of the lids also often owe their origin to errors in diet; but if they persist, after care has been taken in this respect, they are often due to the want of appropriate glasses; and examination will show that the child—for such affections are most common in childhood—is long-sighted. If this be the case, other symptoms, already described under the head of long-sightedness, will usually be complained of. Twitching and quivering of the lids are commonly referable to one of two causes—overwork and general exhaustion of the system at large, and long-sightedness. The former condition must be met by rest, better and more abundant food, and freer exercise; the latter by glasses.

In many persons a large tear collects from time to time at the inner corner of the eye, necessitating the use of a handkerchief, or, if this be neglected, rolling down the cheek and causing more or less redness and excoriation of the skin. This condition is due either to the closure, obstruction, or displacement of the puncta lacrimalia, or to some constriction in the lacrymal sac or nasal duct; and may be regarded as a condition of latent disease ready at any moment to burst into severe inflammation. The lacrymal sac is usually distended, forming a smooth, rounded swelling at the inner corner of the eye. This swelling is painless, and on gentle pressure may sometimes be made to disappear, the fluid it contains either running down into the nose or regurgitating through one or both of the small openings of the canaliculi over the surface of the eye. This condition may last for months or years without harm; but at length the distended sac is exposed to some exciting cause of inflammation—such as a slight blow, or the extension of inflammation from the eye or nose, as in ordinary catarrh—and a rather serious disease is quickly established; violent pain is experienced, the swelling increases in size, and becomes exquisitely tender; the eyelids appear puffy and swollen, and occasionally delirium occurs. It is then evident that an abscess has formed, which, in process of time, bursts by one or two small openings. The swelling then subsides; and generally, but not always, the troubles of the patient are over. Occasionally, however, the violence of the inflammation is such that the bone is killed, and much after-trouble results.

It is well, in all cases of watery eye, to attempt to restore the passage; but for this surgical interference is requisite. If acute inflammation has unfortunately set in, an early opening is advisable, in order that the matter may be allowed to escape before the bone becomes implicated.

The milder cases of overflow of tears that occur in old people are often the result of looseness of the skin of the lower lid, causing the openings of the lacrymal canals to be a little everted, or no longer in contact with the globe of the eye ; and relief may generally be obtained by astringent lotions and the adoption of such hygienic measures as may promote the circulation and general health of the body.

THE EAR AND HEARING.

How is it that we hear? This is a question which, I think, but few persons are able to answer. Whilst the majority of mankind can at least boast, with Bottom the weaver, of "a reasonable good ear in music," and many people not only know what it is to have the teeth set on edge by a grating note, but can detect even minute errors in tone and pitch, yet the structure of the wonderfully beautiful and complex mechanism by which hearing is rendered possible, and the sounds that enchant the ear or the reverse are conveyed to the brain, seems to have been almost by general consent ignored. I shall now, therefore, endeavour, as briefly as possible, to elucidate this mystery.

The auricle, pinna, or outer ear, is essentially a trumpet-shaped expansion of a strong but flexible material, cartilage, by means of which sound-waves are collected together, carried into the ear-passage, and caused to impinge upon the membrane of the tympanum, or drum, of the ear, the consequent vibrations of which, taken up by connecting structures, convey to the brain the impression of sound. A deaf man improves his hearing when he places his hand behind his ear, because he thereby adds to the power of the auricle to take up sound. This power does not, however, appear to be great, since some persons have lost the whole of the auricle without suffering any appreciable impairment of hearing;

so we may conclude that, probably, the main use of this outward and visible ear is to indicate the direction whence a sound proceeds.

Wax in the ear prevents the skin from chapping, and with or without the short thick hairs sometimes found at

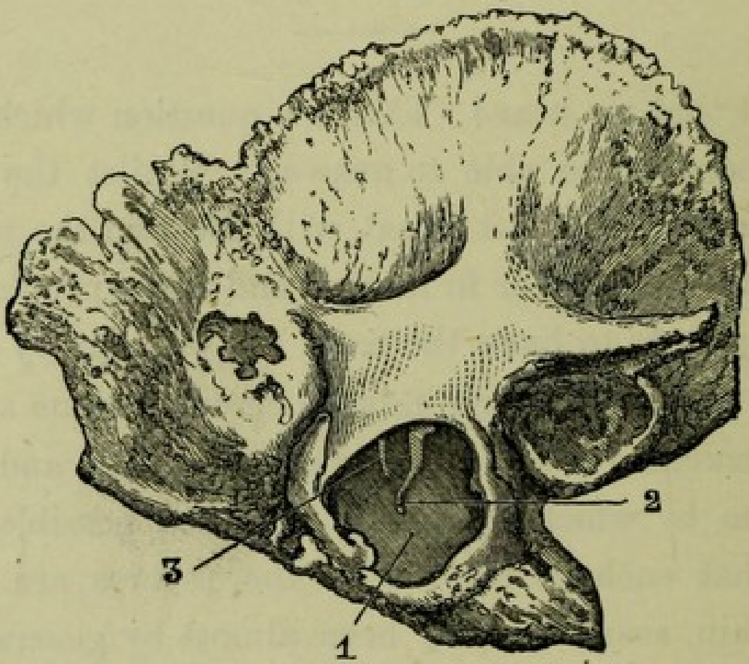


Fig. 1.—Right Temporal Bone. Outer View.

The outer side of the drum-head, with a portion of the ear-bones showing through it.

1. The Membrana tympani, or drum-membrane; 2, the handle of the *malleus*, or hammer-bone; 3, the long process of the *incus*, or anvil. Both bones are seen through the transparent membrane.

the entrance of its canal, serves to hinder the entrance of insects or dust.

The Outer Ear Passage, or external auditory canal, is about three-quarters of an inch in length, circular in outline, and hardly large enough to admit the little finger. As it narrows towards its middle, considerable difficulty may be experienced in extracting a pea, or other foreign body, lodged in the cul-de-sac formed by its further end.

The Drum-head, or tympanic membrane (Fig. 1), forms the end of the outer ear-passage, is concave inwards, and slants downwards and forwards. It is composed of three distinct layers, and is very tough and strong, considering its tenuity, which is about equal to that of thin note paper. Were this fact more generally known, people would be less prone to pour strong liquids into the ear, and to pick it with sharp instruments. The truth is, one might almost as well attempt to probe one's eyes with a pin as risk making holes in this very delicate paper-like membranous disc. The old adage, "You should never touch your eye but with your elbow," may well be applied in the case of the ear. The translucency of the drum-head is such that one can see shining through it, running downwards and backwards against its inner side, what is known as the handle of the malleus, or hammer-bone of the ear. The lower part of the smooth surface of the normal and healthy membrane reflects light brightly over a cone-shaped area, the apex of which is opposite the tip of the handle of the malleus.

Before proceeding further, we must say a few words about the shape of the external ear. Darwin considers the auricle to be rudimentary in man. Certainly the muscles that go to it must be so regarded, for very few persons can move it at will; also, we should add, it has been observed that the more nearly the ear in the brute creation resembles that of man, the less developed are these muscles. One may note in the human ear a small pointed projection from its turned-in margin, or *helix;* this, if enlarged, would form an apex to the ear like that met with in certain of the lower animals; and in some men it does project strangely outwards, requiring only a curl upwards and forwards to make it similar to what one sees in the ancient statues of fabulous sylvan deities. The auricles, especially when small and well set, have for ages been regarded as no mean adornment of the person; and disfigurement by their removal, in which apparently originated the epithet "crop-eared," was in times not far remote a favourite method of punishment. "Me vill cut his ears," says Dr. Caius of his rival; and Prince Henry, hearing Falstaff's slander of himself, cries, "Would not this nave of a wheel have his ears cut off?" Soame Jenyns, writing in 1746, described the politician who—

> "Kings, lords, and commons ventures to abuse,
> Yet dares to show those ears he ought to lose."

In the middle ages it was not an unusual thing to hang up delinquents by their ears—a practice less endurable but scarcely more deformative than the curious custom, still extant in both savage and civilised society, of loading the ear-lobes with weighty gew-gaws. Fox, in his *Acts and Monuments*,* mentions a singular use of the auricle, relating that the "Tartarians," after having vanquished the army of Henry, prince of Polonia and Silesia, "recounting their victory, by taking each man but one ear of every one of the Christians that were slain, found the slaughter so great, as that they filled nine great sacks full of ears." Lavater, the physiognomist, professed to judge the character by the nature of a man's ears; and another French author went so far as to say, "Montre moi ton oreille, je te dirai qui tu es, d'où tu viens, et où tu vas"—*i.e.*, "Do but show me your ear, and I will tell you who you are, whence you come, and whither you are going." Dr. Laycock held that the shape of the ear afforded a clue to the original development of the brain, and that its appearance was indicative of the condition

* Vol. 1., p. 385, 9th Ed., 1684.

of structures within the skull; but, as Mr. Jonathan Hutchinson points out, we can hardly follow him so far as to believe that a special state of the ear is associated with general paralysis, and that the adhesion of the lobule to the cheek from birth—which, indeed, might be purely hereditary in origin—bears upon the occurrence of that disease. We cannot, however, but accept the conclusion of the latter distinguished observer, that "the ear affords excellent facilities for observation as to the general state of nutrition and circulation," and that "the degree of perfection in its form is a tolerably safe guide as to the descent of the individual from a sound and well-bred stock."

The Middle Ear, drum, or tympanum (Fig. 2), is a small air-chamber, with hard bony surroundings, ventilated internally from the throat by an air-passage, called the Eustachian tube, and closed in externally by the drum-head, or tympanic membrane, just described, between which and the complicated structures of the internal ear it consequently lies. In front of this chamber, separated from it merely by thin bone, a highly important blood-vessel, the internal carotid artery, runs up towards the interior of the skull.

Lining the hollow of the drum, and forming the innermost layer of the drum-head, is a delicate mucous membrane, like that inside the mouth; it envelops the little chain of bones within the drum, and, passing forwards and inwards, coats the interior of the Eustachian tube.

About an inch and a half long, the Eustachian tube passes forwards and inwards from the anterior part of the drum cavity to the throat behind the nostrils. The atmospheric pressure required on the inner side of the drum-head to counterbalance that on its outer side is provided for by the communication of the Eustachian tube with the throat by its inner end in the acts of breathing and swallowing. If the tube is healthy, a little click may be heard as one

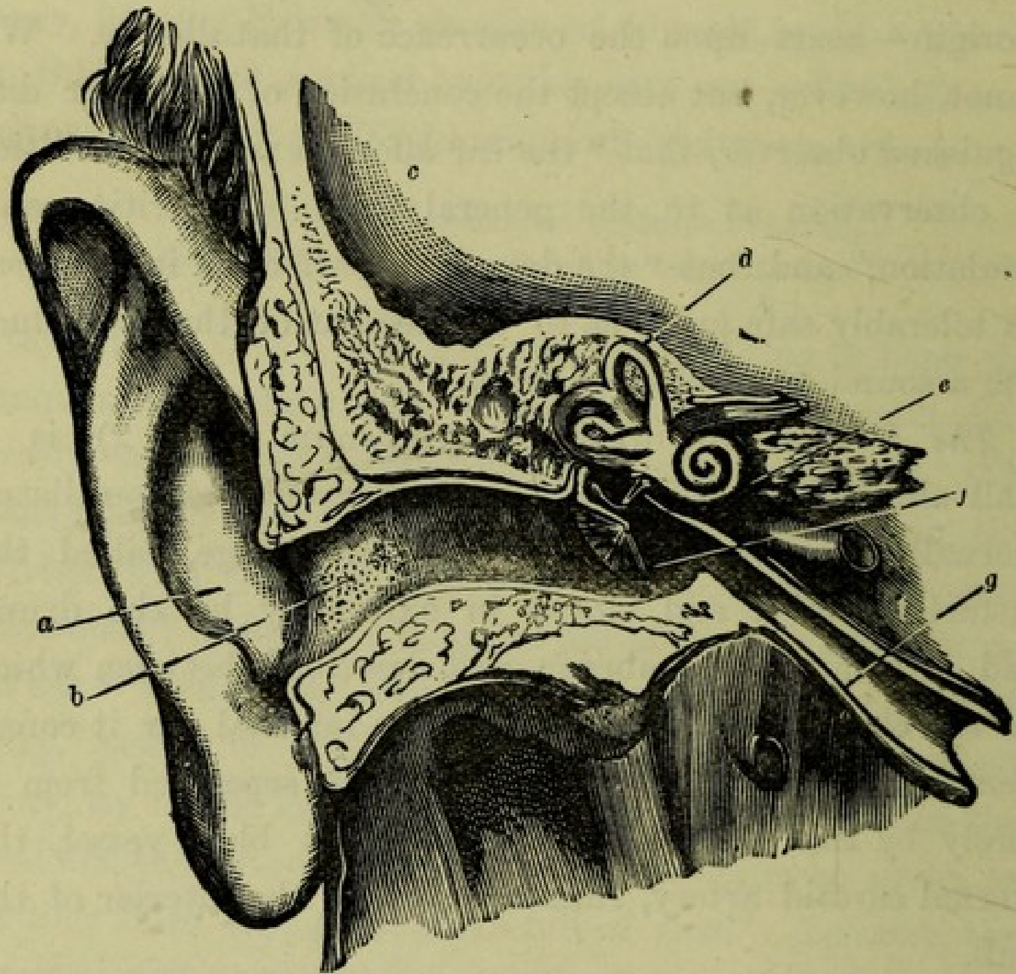


Fig. 2.—TRANSVERSE SECTION OF THE EAR. RIGHT SIDE.

a, External ear-passage; *b*, cerumen glands; *c*, brain; *d*, semi-circular canals; *e*, cochlea; *f*, drum, or tympanum; *g*, Eustachian tube

swallows, owing to the entry of air into the drum. When through a cold or disease, the tube remains closed, and the air in the drum becomes rarefied, the drum-head and the little chain of bones connected therewith are forced inwards, and, by causing excess of pressure on the structures of the internal ear, produce deafness. Loss of hearing is far more common from this than from any other cause, and can, as a rule, be quickly remedied. The tympanic ossicles, or ear-bones (Figs. 3, 4, 5), are named: (1) The malleus, or hammer; (2) the incus, or anvil; and (3) the stapes, or stirrup. The malleus and incus are suspended from the roof of the tympanum by delicate ligaments. The three bones form a chain, which is swung across the chamber of the drum. By their oscillations they transmit vibrations of sound, received by the parchment-like drum-head, to the fluid contained in the internal ear, a portion of the acoustic apparatus presently to be described.

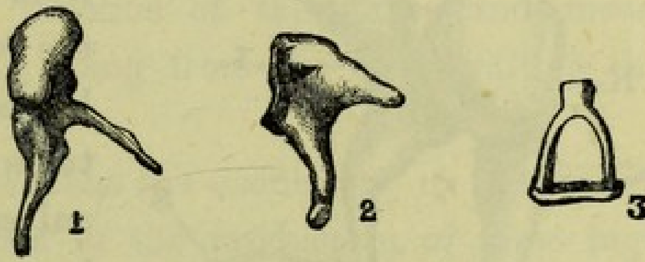


Fig. 3.—The Ossicles, or Ear-bones, Enlarged.

1, *Malleus*, or hammer; 2, *incus*, or anvil; 3, *stapes*, or stirrup.

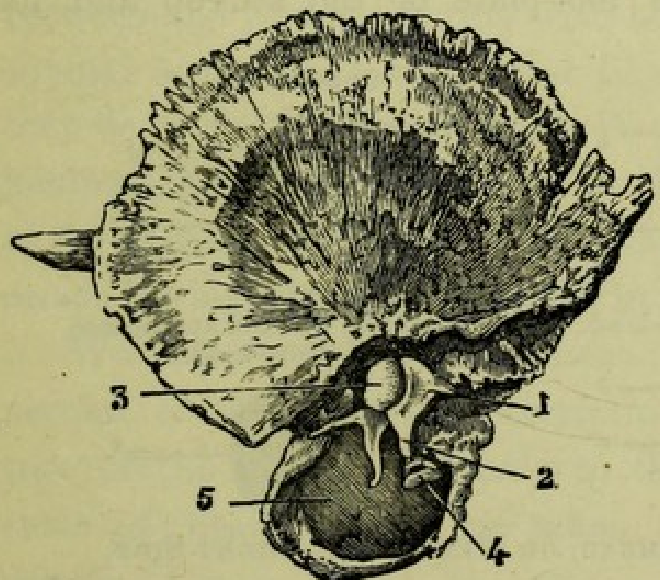


Fig. 4.—A Child's Right Temporal Bone, from within, showing the Inner Side of the Drum-head, with Ear-bones in Position.

1, The *incus*, or anvil; 2, the long arm of the anvil; 3, the *malleus*, or hammer; 4, the *stapes*, or stirrup; 5, the drum-head, or *membrana tympani*.

We have seen that the handle of the hammer at the one end of the chain of ossicles is attached to the drum-head. The foot-plate of the stirrup at the other end of the chain is similarly attached to a membrane (Fig. 6.)

This second membrane closes in a small oval opening or window (*fenestra ovalis*), in the inner wall of the drum, separating its cavity in part from another space, called the vestibule, in which are lodged fluid-containing structures belonging to the internal ear. When we observe how the hammer and the stirrup are connected together by the anvil, it becomes evident that oscillations to and fro of the first named, in consequence of vibrations of the drum-head, must cause similar motions of the foot-plate of the stirrup and its

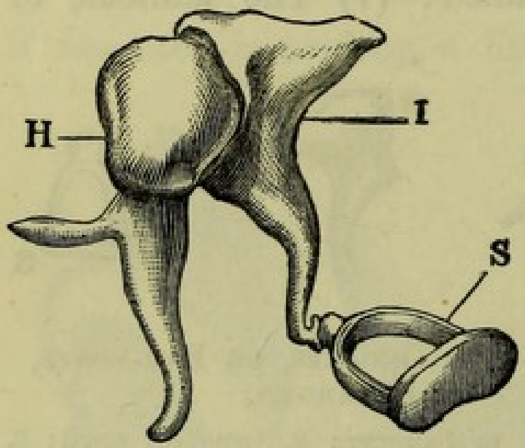


Fig. 5.—EAR-BONES, SEEN FROM THE FRONT.

H *Malleus*, or hammer; I, *incus*, or anvil; S, *stapes*, or stirrup. Enlarged four diameters.

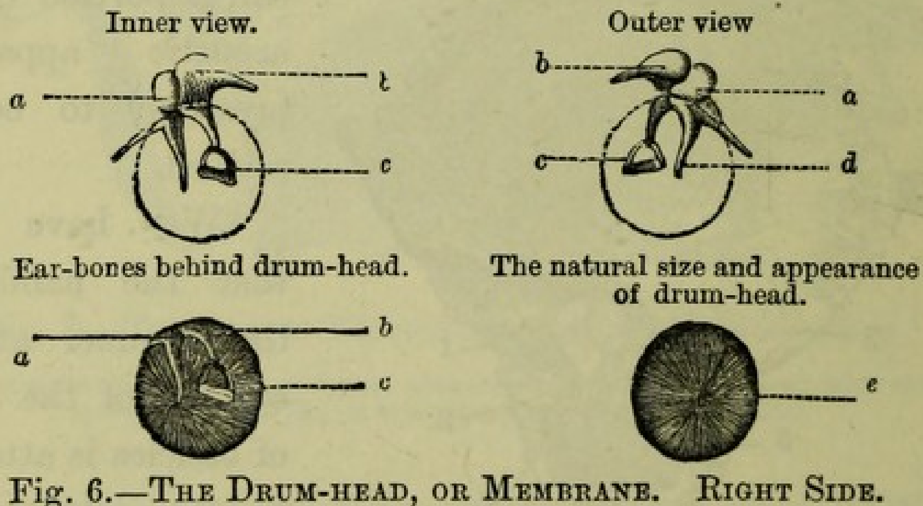


Fig. 6.—THE DRUM-HEAD, OR MEMBRANE. RIGHT SIDE.

a, Hammer; *b*, anvil; *c* stirrup, which is attached to fenestra ovalis; *d*, handle of hammer; *e*, handle of hammer, seen through membrane. In the two upper figures a dotted line indicates the position of the drum-head, or membrane. In the two lower ones, the drum-head is drawn with the portions of bones actually seen in the space covered by the membrane.

attached membrane; these affect the fluids and eventually the nerve-fibres of the internal ear, thus producing the sensation of hearing. The extent of the vibrations of the two membranes above mentioned is limited by two muscles —namely, the *stapedius,* going from the floor of the drum to the point of junction of the stapes and incus, and the *tensor tympani*, going from the drum-wall to the malleus.

It has been estimated that the oscillatory or piston-like movements of the stapes in the production of some high notes exceed 40,000 per second, and for some low notes are 16 per second.

We must now give some description of the internal ear. This consists essentially of membranous structures, containing and more or less surrounded by fluid, and lodged in and corresponding in name to three bony chambers—the *cochlea* in front, the *semicircular canals* behind, and the *vestibule* between and communicating with both of them. The semicircular canals are tubular, and like horse-shoes in shape; they lie at right angles to each other, just as do three adjoining sides of a box, and open at their ends into the back of the vestibule by five apertures, the superior and posterior canals having two ends conjoined in one.

We can venture to recommend a more than cursory perusal of the following description of the minute structure of the internal ear only to those who are sufficiently stout of heart not to be taken aback by complicated details.

The bony cochlea, so called because when freed from the less dense surrounding bone it is like a snail-shell, has its broad end against the bottom of the internal auditory canal. For a view of its relations to neighbouring bony structures, see Fig. 7.

The cavity of the cochlea, gradually diminishing, takes two and a half turns round a central tapering axis, called the *modiolus* (Fig. 8).

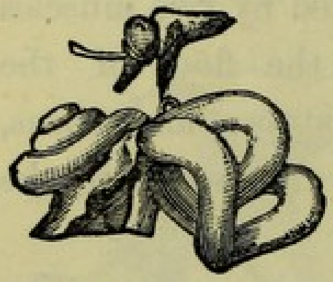


Fig. 7.—Right Osseous Vestibule, Semi-Circular Canals, Cochlea, and Ear-bones.

From the modiolus there extends into the cavity, growing narrower out of proportion to the size of the same as it ascends, a bony spiral lamina—the *lamina spiralis* (Fig. 9).

This is continued outwards into a membranous plate, the *basilar membrane*, which completes the division of the cavity into two chambers. The chamber which is uppermost when the cochlea is regarded with the base downwards is separated into two by another membranous plate, running obliquely from the wall to near the end of the spiral lamina, and known as the *membrane of Reissner.* The chamber below the basilar membrane, called the *scala tympani*, would, but for the thin diaphragm closing in the fenestra rotunda, communicate with the tympanum. The chamber above the membrane of Reissner, the *scala vestibuli*, has an opening into the lower and fore part of the vestibule. These two scalæ contain a watery fluid, the

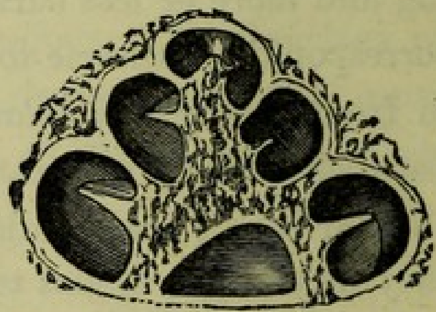


Fig. 8.—Cochlea in Section, showing Modiolus. Magnified.

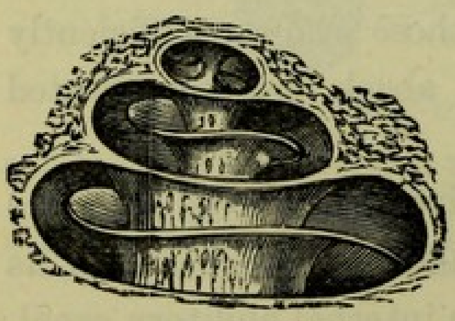


Fig. 9.—Cochlea laid open to show Lamina Spiralis. Magnified.

perilymph, and at the apex of the cochlea are united by a minute aperture, the *helicotrema*. The triangularly-shaped chamber comprised between them, called the *duct* or *canal of the cochlea*, or the *scala media*, contains a fluid, the *endolymph*, like that just mentioned, and by a small membranous canal (*canalis reuniens*) near its larger blind extremity opens almost at a right angle into the smaller of the two membranous sacs which are suspended in the perilymph of the bony vestibule, namely, the *saccule.*

Within the cavity of the cochlear duct, and bathed therefore by endolymph, several different structures have been observed, of which the most peculiar, and doubtless by far the most important, is that which we are about to describe—namely, *the organ of Corti.*

The individual cells of human beings, just as whole organs, evince a capacity for alteration in their structure to fit them for the performance of special functions.

The organ of Corti consists really of cells, peculiarly modified, belonging to the inner lining, or epithelium, of the basilar membrane.

Passing from without inwards we find, first, what are termed the *supporting cells of Hensen ;* these over-ride rows of cells which, their free ends being clothed with stiff cilia, are distinguished as the *outer hair-cells.*

Next, more internally, we come upon the *arch of Corti*, which is made up of two rows of pillar-like cells inclined towards each other, like cards placed face to face so as to support each other, and making an angle at the junction of their upper thickened portions, or heads.

The convex head of each outer pillar is received by a concave surface formed by the heads of two inner pillars. Over the space covered by the arch of Corti the substance of the feet of the pillars is interblended. The inner pillars support a row of large cells, the *inner hair-cells of Deiters;* and still further inwards is seen a single layer of columnar supporting cells. A very delicate structure, Kölliker's *lamina reticularis,* the limits of the outer and inner divisions of which are the two sets of supporting cells above mentioned, is pierced by small rimmed openings, like eyelet-holes, through which protrude the ciliated ends of the outer and inner hair-cells. The portions of the lamina reticularis lying between these holes, and resembling fingers in outline, are known as the *phalanges of Deiters.*

Minute nerve-fibres are distributed to the pointed ends of the inner hair-cells; and still finer filaments pass between the bodies of the pillars of Corti's arch to end in the outer hair-cells. The nervous network supplying the organ of Corti passes into a layer of ganglionic tissue, the *ganglion spirale Corti,* similar in its essential structure to those nodular highly complex masses, or ganglia, which are to be found in certain situations in the course of many nerves, and which serve, apparently, the purposes of a sort of agency offices for the reception, interpretation, and furthering of messages.

The ganglionic layer, again, is connected with branches of the cochlear nerve, which lie in canals in the modiolus.

A very small canal from the saccule, the less capacious of the vestibular membranous sacs, or vesicles, joins a similar canal from the other sac, the *utricle* (Fig, 11), so that the endolymph of the two is in communication.

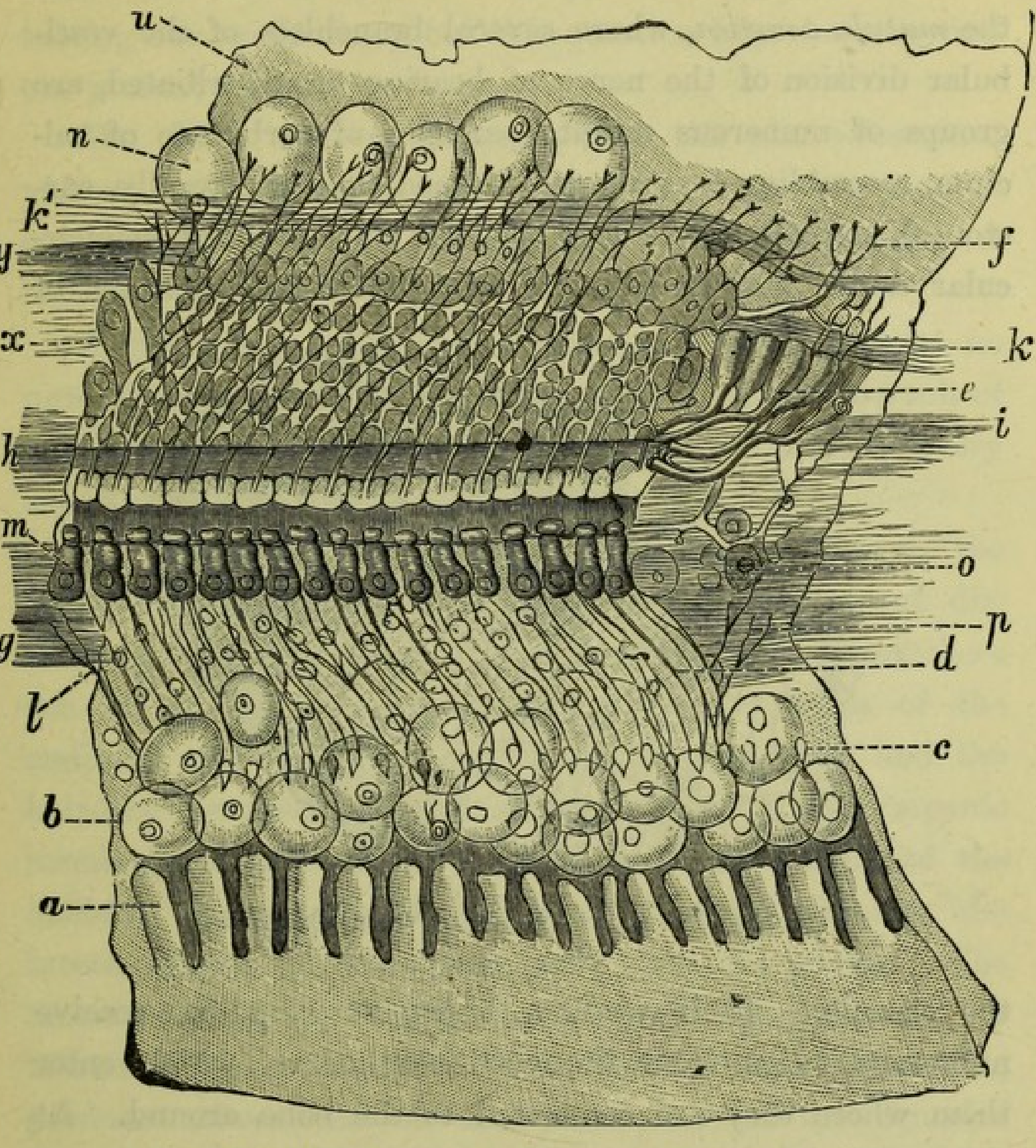


Fig. 10.—Terminal Auditory Apparatus.

The entire Membrana Basilaris, with all its parts lying exposed from above to show the proportion of nerves. Corti's organ from the side.

a, The auditory teeth; *b*, the cells lining the sulcus spiralis; *c*, the holes of the Labenula perforata for the passage of the nerve-fibres of the organ of Corti; *d*, the inner rods, or pillars, of Corti's arch; *e*, the outer pillars of Corti's arch; *g*, inner spiral nerve-fibres; *i*, *k*, and *k'*, outer spiral nerve-fibres; *l*, ascending nerve-fibres; *m*, the inner hair-cells; *n*, the cells of Claudius, lining the outer angle of the scala media; *u*, the external portion of the membrana basilaris; *x*, the cells of Corti: to the right of these, and covering them, is seen the lamina reticularis with its phalanges; the outer hair-cells are also indicated; *y*, the outer supporting cells of Hensen.

Attached over a portion of the inner wall of each sac, called the *macula acustica*, where several branchlets of the vestibular division of the nerve of hearing are distributed, are groups of numerous minute particles of carbonate of calcium, resembling crystals, and termed *otoliths* (literally, earstones), or *otoconia* (Fig. 11). The membranous semicircular canals may be regarded as tubular prolongations of

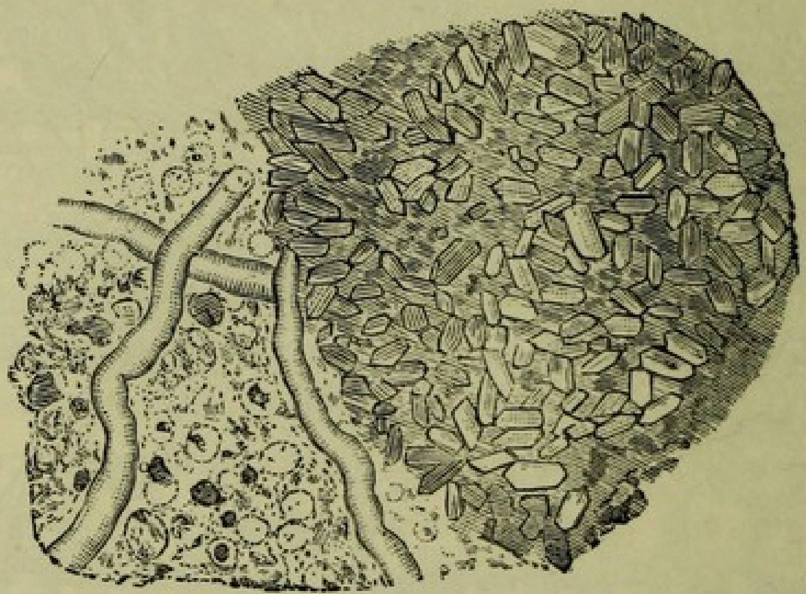


Fig. 11.—Wall of Utricle, with Otoliths.

the saccule. Their swollen bases, or ampullæ, receive numerous twigs from the vestibular nerve, which enter them where they are connected to the bone around. At this point there projects into the endolymph a small rounded protuberance, the *crista acustica*. This, like the macula acustica, has an epithelium consisting of superficial cylindrical or conical cells and deeper spindle-shaped cells. The outer end of each of the latter sends up among the superficial cells a process which terminates in the endolymph as a stiff rod or hair; the inner end is connected with a network of fine nerve-fibrils. It is said that the semicircular canals have the important function of maintaining our equilibrium, but this question is perhaps beyond our present scope.

We have now to consider how the above-described various parts of the sensory apparatus of the ear may be supposed to furnish their possessor with the capacity of hearing.

Happily for mankind, the tympanic membrane emits no note of its own when it vibrates; were it not so, the roll of the little ear-drum would mingle with and modify every sound that is heard.

As we have already had occasion to observe, the sense of hearing depends upon the occurrence of disturbances in the fluids of the internal ear; these, there can be no doubt, cause excitation of the fibres of the auditory nerve by their effect upon the otoliths and the hair-like processes of the auditory cells. The tympanic membrane forces to and fro the attached handle of the malleus, the rocking of the head of which, through the intermediation of the incus, acts upon the stapes. The movements of the membrane of the fenestra ovalis, by reason of the excursions of the foot-plate of the stapes, produce movements of the membrane of the fenestra rotunda corresponding in character, but reversed in direction. This results from the fact that the perilymph of the vestibule, which is directly agitated by every vibration of the membrane of the fenestra ovalis, is in immediate communication with that of the conjoined scala vestibuli and scala tympani of the cochlea, the latter of which is closed in at its larger end by the membrane of the fenestra rotunda.

It is interesting to note that oscillations in the perilymph of the scala vestibuli must travel through the whole length of that canal—that is, to the apex of the spire of the cochlea—before they can be directly transferred to the perilymph of the scala tympani, just as in a coal-mine—to compare great things with small—the descending current of air, in consequence of the careful blockage of all lateral ways of communication, must pass to the extremity of the workings before it can become the ascending or return current. The endolymph occupying the scala media, or duct of the cochlea, is thus very fully exposed to the influence of disturbances in the perilymph round about it.

From its close relation to the chambers of the internal ear, one perceives that the most important of the auditory ossicles must necessarily be the stapes. The sense of hearing has been known to persist when, in clumsy attempts to extract foreign bodies from the ear, the two other ossicles have been removed, or when they have been set free and carried away by the discharge of a tympanic abscess. One finds also that in cases where, in consequence of disease, the stapes has become fixed in position, or its dislodgment has allowed of the escape of the perilymph, the patients suffer from permanent deafness. In instances where the stapes has lost its mobility, but the fluids of the internal ear are retained, some degree of hearing may, however, still be possible, vibrations of sound being conveyed to the auditory nerve through the bones and other tissues of the head. As one often has cause to note in medical practice, auditory phenomena may be produced simply by the influence on the nerve of unhealthy conditions of the ear, either alone or in conjunction with disorders of other structures of the body.

The proper perception of sound seems to be effected by a division of labour among the various parts of the ear. In some of the lower animals, what represents the membranous vestibule in man is the sole organ of hearing; hence we may conclude that this is the most essential portion of the auditory apparatus. Its nerves are supposed to enable us to judge only as to the intensity or quantity of sound, and those of the semicircular canals as to its direction; whereas the special function of the organ of Corti is apparently to enable us to discriminate between sounds—*i.e.*, to judge of their quality. Hence, if these theories are correct, it is the semicircular canals that, when we desire to study, apprise us of the existence of a hurdy-gurdy immediately below our window; while the vestibule affords us the information that the sounds are overpoweringly noisy, and the organ of Corti keeps us constantly aware that the instrument is out of tune—

"Straining harsh discords, and unpleasing sharps."

It has been suggested that each of the little arches of the organ of Corti with its accompanying nerve filament is comparable to one of the keys of a piano with its corresponding wire, and that the two answer to their proper note just as an untouched harp-string responds in unisonant vibration to a voice singing the special note which it is itself capable of emitting when struck. According to this idea, the organ of Corti must far surpass in selective capacity the skilled lace-maker who, from two or three hundred bobbins, can select the one which she requires at any particular moment; for it has been estimated that the arches in a single scala media number some three thousand.

With respect to the arches of Corti, we must bear in mind that, since they are not elastic and vibratile structures, and since, moreover, birds—creatures apparently well able to distinguish diversities of tone—do not possess them, they may subserve but the single purpose of supporting the hair-cells. It has been thought that the hair-cells are affected by various sounds much as the hairs on the antennæ of a species of *Mysis*, a minute crustacean, which were observed by Hensen to vibrate some to one note and some to other notes of a keyed horn. It has been surmised that the appreciation of dissimilarities in the rate of vibration in the hair-cells may depend upon the degree with which different segments of the membrana basilaris are stretched.

But we must now leave a confessedly abstruse subject, and pass on to other considerations in regard to the reception of sound—that agent without which the internal ear, with all its wonderful mechanism, would in man and beast alike be no more than one of nature's articles of *vertu*.

The sensation of sound is dependent on a molecular disturbance or a kind of motion of certain special constituents, of the auditory nerve; consequently, it is not of necessity dependent upon influences external to the hearer; and, as we have seen, it is sometimes produced simply by abnormal bodily conditions. Usually, however, it is the result of a shock, or series of shocks, communicated through the medium of the atmosphere to the tympanic membrane. It would appear that in most if not in all cases where sound seems to be conveyed directly to the auditory nerve through the structures of the head, air serves for its transmission; for the vibrations of a tuning-fork placed on the head which have ceased to be heard by an open ear may still be perceived by one that is covered externally, so as to afford a closed cavity outside the tympanic membrane in which the vibrations may be amplified by reverberation.

The normal ear apparently best hears sounds that are produced by about 3,000 vibrations a second. Usually, high tones are more audible than low tones equal to them in intensity; hence, probably, it is that deaf people hear shrill better than grave notes, and the voices of women and children more easily than those of men. Helmholtz has pointed out that the vibrations of the membrana tympani are diminished in extent by $\frac{2}{3}$, and thus inversely strengthened, by virtue of their transmission by means of the auditory ossicles. A sound is not perceptible for more than a very short time after its cause has ceased to operate, because the excursions of the tympanic membrane are hampered by the handle of the malleus. When tense, the tympanic membrane responds best to sounds of high rates of vibration; when relaxed, to sounds of low rates. Dr. W. H. Wollaston found* that the ear became insensible to grave sounds when, by shutting the mouth and nose and making a forcible attempt to take a breath, so as to partially exhaust the air in the tympanum, the membrane was made tense. To be heard at all, it is evident that vibrations require to be of a certain amplitude and duration; and it has been proved

* "Philosophical Transactions," Vol. XC

that, to produce the impression of a continuous musical note, they must be at the rate of not less than thirty (some say sixteen), and not more than 35,000 (or, possibly, 38,000) per second. Vibrations slower than 30 per second are heard separately, and vibrations above 35,000 per second are not heard at all, these numbers being respectively the limits of what are known as tones of low and tones of high pitch. Ordinary musical tones range between 40 and 4,000 vibrations a second. Skilled musicians, it is said, may be able to perceive a difference between two notes of as little as 1-64th of a semitone. Sounds that are irregular in duration, strength, or time of emission, or that are inharmoniously blended, are heard as noise. The capacity of the ear to take cognizance of several distinct vibratory impulses at the same time constitutes one of the chief sources of enjoyment in the hearing of music, since it is the extra tones—or over-tones, as they are termed—whose vibrations are in the ratio of simple multiples of those of a fundamental note, that give to the latter its quality, richness, or timbre.

Although the majority of persons are capable of hearing about nine octaves of notes, there are some whose audition is restricted to far less. Wollaston discovered that the power of hearing ceased in a friend of his at a note four octaves above the middle E of the pianoforte, although his perception of musical pitch was as correct as that of ordinary ears. As Wollaston was, perhaps, the first to point out, the chirping of the cricket, the squeak of the bat, and the peeping of the common house-sparrow are of too high a pitch to be heard by some. "The suddenness of the transition," says he, "from perfect hearing to total want of perception occasions a degree of surprise, which renders an experiment on this subject with a series of small pipes among several persons rather amusing. It is curious to observe the change of feeling manifested by various individuals of the party in succession as the sounds approach and pass the limits of their hearing. Those who enjoy a temporary triumph are often compelled in their turn to acknowledge to how short a distance their little superiority extends." He further makes the interesting remark that "since there is nothing in the constitution of the atmosphere to prevent the existence of vibrations, incomparably more frequent than any of which we are conscious, we may imagine that animals like the grylli, whose powers appear to commence nearly where ours terminate, may have the faculty of hearing still sharper sounds, which at present we do not know to exist, and that there may be other insects hearing nothing in common with us, but endowed with a power of exciting, and a sense that perceives vibrations of the same nature indeed as those which constitute our ordinary sounds, but so remote that the animals who perceive them may be said to possess another sense, agreeing with our own solely in the medium by which they are excited, and possibly wholly unaffected by those slower vibrations of which we are sensible."

Many of us, it is to be feared, acknowledge to ourselves, even if we are loath openly to confess, that a deaf person is what is commonly called a bore. Of some worthy creature in whose company we have, perchance, had to pass an evening, our sole reminiscence is, to use the words of Chaucer, that—

> "She was som del defe, and that was scathe."

Certainly, the constant necessity of rehearsing in a loud voice what has been said in conversation, however trivial, in reply to the oft-repeated query, "What is it?" or "What did he say?" is not only apt to be wearisome, but may become positively trying to the temper, especially when, as is quite within the bounds of possibility, one's communication is not gratefully received, or is incomprehensible to the listener, because he has lost the pith of the story or the point of the joke to which one would refer. It assuredly is somewhat tedious—to mention no imaginary case—to hear the deaf son tamely repeat, at one end of a dinner table, the tale which he has failed to perceive that his father has just been telling at the other end. There is no denying that in a thousand ways, many of which must have already suggested themselves to my readers, deafness is, both to a man affected with it and to his friends, a dire calamity. The contentment and unaccountable vivacity of the blind have often been commented on, and have been contrasted, not unduly we must admit, with the very generally cheerless and melancholy demeanour of the deaf. One would, on first thoughts, imagine the everlasting absence of the pleasures of vision to be as great a misfortune as the loss of the singing of birds, the voice of friends, the strains of music, and other sounds delightful to the ear. When, however, we come to perceive how deafness, out of all proportion to blindness, shuts men off from intercourse with the world of living men around them, we are no longer at a loss to comprehend the dulness and dejection so frequently seen in those that suffer from it. Kitto goes so far as to say that "it is surely a social duty in the deaf to avoid company." The blind but hearing infant, having its intellectual capacity fostered by facility of interchange of thought, early begins to make progress in mental development; but the child that has either been born or has become deaf is, in ordinary circumstances, debarred from the influence of this potent educational stimulus, and all methods of instruction are shackled by the stupendous initial difficulties of adapting them to the perceptions of the sufferer.

Dean Swift but faintly depicted the destitution of many a deaf man when, sketching his own condition, he wrote the characteristic lines :—

"Deaf, giddy, helpless, left alone,
To all my friends a burden grown;
No more I hear my church's bell,
Than if it rang out for my knell:
At thunder now no more I start,
Than at the rumbling of a cart:
Nay, what's incredible, alack!
I hardly hear a woman's clack."

Let us attempt for a few moments to realise some of the annoyances and trials that must daily be endured by the deaf in ordinary life. If so be our deafness is complete or is severe, no friendly knock can awaken us in the morning; the breakfast-table is silent as the grave; and we walk out among men seemingly as among speechless mummers. When we cross the road, no warning voice can apprise us of danger; and if we enter a shop, the answers to our inquiries must be written down for us, or made comprehensible by signs. Churches and theatres are alike practically closed, music is no more, and the visits of friends are few and far between. He that is poor and, though not absolutely deaf has become hard of hearing may fail of obtaining fit employment, and increasing want and finally the workhouse are his assured heritage. Often have I asked in our Unions the reason for the presence there of some apparently able-bodied and comparatively young-looking person, and well-nigh invariably have I received the answer, "Oh! he is very deaf, and could never get anything to do." Such are the servants who for deafness have lost their places, and who can find none to help them, and also many an incurable hospital out-patient who struggles on, from day to day growing more shabby and cadaverous in appearance, hoping to avoid the poor-house, but "through weakness . . . . forced at last to yield himself unto the mighty ill."

Having now considered (1) how we hear, and (2) some of the disadvantages of impairment of hearing, let us proceed to discuss the best methods of preserving the powers of the ear, and then lay down some general rules for the guidance of those that are partially or wholly deaf.

The necessity of shunning the causes which tend to injure the mechanism of the ear and, more especially, to diminish the efficiency of the auditory nerve, is a matter which unfortunately those whose hearing has never been defective but seldom dwell on. Of these causes the chief is exposure to chills and to the shocks of loud sounds.

A most essential thing for the avoidance of deafness is to run no risk of catching cold in the head—perhaps its most common source. Although the variable climate of England has much to do with this complaint, still, in a great majority of instances, carelessness and lack of common sense are far more accountable for it. Thus, some persons go about either over or under clad: a lady in the middle of a mild winter's day, for example, hurries hither and thither oppressively warm in her thick sealskin jacket; but at night, when a frost has just set in, she attends a ball in a low muslin dress. What wonder that severe cold and sore throat result! Again, cold in the head, the precursor of ear-disease, is often due to reckless sitting or standing in draughts. A man, after heating himself in running to catch a train, elects to grow cool by travelling with his face towards the full current of air from an open window, and very soon, in consequence, his friends have to commiserate with him upon a stiff neck or earache. Other and similar sources of danger to the ear are exposure to wet, damp feet, neglect to change the clothes after excessive perspiration, and cutting the hair too short, or washing it at bed-time. The ear is much more liable to be affected by a succession of slight attacks of cold than by a single severe one. What are the several pathological processes involved in taking cold, it would be beside our purpose here to discuss in detail. Suffice it to say that the vessels supplying the mucous membrane from the nose to the mouth expand, and the blood within them flows slowly or stagnates—that is, the mucous membrane becomes congested. As a result, there is more or less swelling, with augmentation of the natural secretions. The congestion is apt to be continued into the mucous membrane of the Eustachian tube, and thence it may spread to that of the tympanum. By degrees, as one cold after another is caught, the mucous membrane becomes permanently thickened, and the functions of other structures, notably the little ear-bones, are interfered with. When, by the thickening of the walls of the Eustachian tube, the passage of the air through it to the drum is blocked, the tympanic membrane soon gets to be unduly pushed inwards by atmospheric pressure; and we have already seen how important it is for the integrity of the hearing that the membrane be free to vibrate naturally.

Some little space has above been devoted to the subject of cold-catching, firstly, because aural disease, particularly aural catarrh, due thereto, is very common, and, secondly, because although generally amenable to treatment when early attended to, yet, if neglected, it induces deafness of a usually most severe and intractable character. Aural catarrh is not necessarily preceded by affection of the throat or Eustachian tube, as it may begin primarily in the tympanum, and then deafness very rapidly comes on. As a rule, catarrhal deafness is a malady of slow production, especially during its earlier stages. The hearing-distance gradually diminishes, only an inch or so being lost in a twelvemonth. The sufferer's friends are for long scarcely conscious of the change going on; but at length they pronounce the verdict that he is becoming very inattentive and dull of apprehension, and if he happen to belong to that class of mortals whose brain-development is popularly imagined to be promoted by appeals to brute force—*i.e.*, children—his so-called absence of mind and stupidity may be avenged by frequent cuffs and blows, of which the ears are likely to receive a full share. Then, perhaps, some charitably-disposed person suggests that the supposed evidences of perversity or of defective mental power will soon disappear under the administration of tonics; yet still the evil continues.

Nearly every day of my life do I see patients who have become deaf—many shockingly so—merely from neglected aural catarrh ; and some have put off seeking advice until too late. Those cases are the most successful which have come early under treatment. Though, doubtless, what is known as a strumous diathesis has much to do with loss of hearing in a considerable number of children, still it is most requisite to eradicate from the minds of parents the fancy that their offspring will recover their hearing with improvement in their constitution. Whilst this vain hope is being indulged in, and treatment neglected, deafness from thickening of the tympanic membrane, and from the collection of thickened mucus in the tympanum hampering the movements of the little ear-bones, is constantly on the increase. As we have already seen, the friends of a deaf child have sometimes not the slightest notion that it is hard of hearing ; and, reflecting on the faults and corruption of their own nature in youthful days, they are apt to inform the little sufferer that it is careless or provokingly obstinate, and that "None is so deaf as he that won't hear." We read in Holmes's "System of Surgery" of a boy who, from early life, had been the subject of aural disease, and who actually died from abscess in the brain caused thereby, but whose father used to box his ears for what he termed "inattention." When of recent origin, aural catarrh yields readily enough to appropriate treatment. One may find that in some children the frequent opening of the Eustachian tube, and the consequent admission of fresh supplies of air into the tympanum is prevented by a habit of breathing solely through the mouth, which in some instances is due to clogging of the nostrils, swelling of the tonsils, and other hindrances to free respiration, but in others appears to be simply a trick. Many of the children whose deafness is occasioned by enlargement of the tonsils suffer from chronic colds; and, as they always keep the mouth open, they are unable to pronounce the consonants M, N, and NG, for the utterance of which the mouth-passage is variously closed, whilst the nose with its cavities performs the part of a resonator; they are erroneously said, in short, to "talk through the nose." Such children may generally be recognised by their weakly appearance, by their narrow jaws, crowded teeth, and small but always patent mouth-opening. Sometimes hearing is interfered with by an accumulation in the tympanum of fluid, chiefly mucus, in consequence of the closure of the Eustachian tubes through swelling caused by cold and damp. Air blown into the tympana through this fluid makes a rattling sound. When, in process of time, the fluid has been all expelled, the hearing is usually found restored in its integrity. From what has been said under the head of anatomy of the ear, it is evident that rarefaction of the air in the tympanum must occasion constant undue atmospheric pressure upon the drumhead; the results of this pressure may be damage to the ear both lasting and irremediable. Some deaf persons, by turning the head on one side, are able to open the Eustachian tube, and thus temporarily to improve their hearing.

Exposure to cold and damp and resultant soreness of the throat are potent in causing catarrhal inflammation of the middle ear, a chief sign of which is very severe pain. This disease is not uncommon in children, who, because it comes on with restlessness and loss of appetite, are treated with poultices to the stomach, doses of castor-oil and grey-powder, and lancing of the gums, while the anxious friends fail to note the important symptom—clearly pointing to the true nature of the malady—that the head cannot for pain be rested on the affected side. It must not be forgotten that affections of the ear may be secondary to the condition of the teeth and gums, which latter, moreover, may act prejudicially on the ear by rendering it peculiarly susceptible to the irritant influence of cold, and a variety of other baleful agencies. There are few persons unacquainted with the sensation of the teeth being "set on edge," and this, as Sir Astley Cooper long since pointed out, may be attributed to that part of the auditory nerve which lines the labyrinth of the ear, which through the medium of the portio dura, its anatomical associate, conveys to the nerves of the teeth the impression of acute and disagreeable sounds. We can similarly account for affection of the ear by the eruption or decay of teeth. Singularly enough, one may sometimes discover that a diseased or badly-stopped tooth which is not in itself at all painful is the cause of neuralgia in the external auditory canal. The ear may be severely injured by the access of cold water to the inner extremity of its external canal in bathing or diving. The drum-head may be ruptured by the act of taking a header into water, or by the impact of a wave, which latter, moreover, either directly or, by causing spasmodic expiratory efforts, indirectly may force water through the Eustachian tube into the drum, and so do mischief. The plugging of the ear with wool is a precaution which bathers are prone to neglect, even though they happen to be suffering from perforation of the membrana tympani, which, by allowing the direct ingress of water, or that which is still more irritating, brine, into the drum, may occasion fatal inflammation, as in the case of Lord Justice Thesiger and many others. It is a strange fact that, notwithstanding the known existence in many marine animals of special provisions for the prevention of the contact with the more delicate structures of the ear of the element in which they swim, the antiquated notion still popularly obtains that exposure to the influences of cold sea-water in bathing cannot possibly lead to any mischief.

A very severe form of deafness, due to chronic inflammation of the ultimate nerve-fibres of the cochlea or to concussion of the labyrinth, is to be met with among boiler-makers, artillerymen, and others frequently subjected to the shocks of loud and jarring sounds. It may be in great measure prevented by placing a plug of cotton-wool in the ears. Another precaution which should be adopted by those who fire heavy guns is to keep the mouth open, instead, as is usually taught, of closing it and pressing the teeth together. When an artilleryman does happen to suffer from sudden deafness—the result of rupture of the drum-head—this accident is most probably the indirect effect of decreased atmospheric pressure in the tympanum, owing to the closure of the Eustachian tube from catarrh or some other disease of the ear. That the shock of an artillery discharge does not produce sudden damage of the drum-head seems attributable to some preparatory action on the part of the internal muscles of the ear, more especially the stapedius.

It is much to be regretted that many persons, unaware that the hardness of hearing from which they suffer is the outcome of structural changes in the ear, allow themselves to be persuaded that by the use of "drops for the ear," and other quack nostrums, they will be sure to obtain relief:

the defect can be prevented from increasing and be remedied only by the adoption of such curative measures as are suited to its special cause, which must, of course, be carefully ascertained previous to treatment. Some excessively cleanly people are possessed of the notion that, in order to secure the well-being of the ear, and to clear it of wax and epidermic scales, its passage must daily be drenched with oil, glycerin, or other more potent detergents—a practice as promotive of their good intention as would be the employment of a coal-heaver to dust a drawing-room.

The cerumen, or wax, of the ear is a bitter, soapy substance, five-eighths soluble in alcohol, the remainder being albumen, oil, and salts of sodium and calcium. It is sometimes entirely absent in adults. In aged persons it becomes dry and brittle, and occasionally in children it is fluid and malodorous, and may cause serious damage to the ear if not removed. Deficiency and dryness of the cerumen may be associated with diseases of the internal ear. A mass of hard wax in the ear may do much mischief, by causing thickening, excessive concavity, or perforation of the drum-head, and dilatation of the osseous meatus. Attempts to remove wax and foreign bodies from the meatus and to relieve itching must never be made with ear-picks of any kind.

An objectionable instrument, called an aurilave, consisting of a fragment of sponge attached to the end of a piece of stick, has been invented for the cleansing of the ears, which it certainly does effect in a sense, but only by thrusting the cerumen deep down into the meatus, where it forms a plug difficult to remove. The same result is brought about by the habit, indulged in by some persons, of using the twisted corner of a handkerchief or towel to clear away cerumen and other matter. In some cases an accumulation of flakes of skin in the meatus, and in others an overgrowth of hairs may obstruct the passage of sound.

It must never be forgotten that instrumental interference with the ear for the extraction of foreign bodies is rarely necessary, and is often hazardous, especially when ventured upon by the inexperienced. Almost invariably do I find that the well-meant but misdirected endeavours of the friends of a patient to dislodge foreign bodies from his ear have been productive of mischief; and cases are known of total deafness, and even fatal inflammation of the brain, resulting from ill-considered meddling with the ear, sometimes when there has actually been nothing whatever to remove. The foreign bodies met with in the ear are commonly beads, small pebbles, cherry-stones, shells, portions of tobacco-pipe and slate-pencil, sealing-wax, grass, and hardened masses of cotton-wool. This last substance, if not used in a piece of sufficient size, may find its way through a perforation in the tympanic membrane, and, after traversing the tympanum, reach the Eustachian tube.

Boils in the auditory canal are not infrequent among middle-aged persons. They are considered by some careful observers to be largely due to irritation caused by parasitic organisms; and antiseptic preparations, which are destructive of these lower forms of life, are undoubtedly of great value in the treatment of boils. Vegetable fungi may occur in the ear: the growth of one of these, a species of *Aspergillus*, is especially favoured by a warm and impure atmosphere, such as is to be found in the houses of persons who, like the

Russians, endeavour to ward off the chills of severe winters by careful exclusion of the outer air.

Insects are occasional intruders into the meatus, and the presence of their larvæ therein has been known to cause severe pain. It is difficult sometimes to persuade country folk that an earwig is not the cause of their woes; and on one occasion I was guilty of deeply offending a patient by my scepticism as to the existence of a "black-beetle" in her ear. Old medical treatises contain many a strange remedy for "worms in the ear," by which designation almost every kind of aural disease appears to have been known. Bleeding from the ear takes place in various diseases, as purpura, yellow-fever, and malignant small-pox. Its usual cause is injury to the head, with fracture of the base of the skull. Very frequently it is due to rupture of the membrana tympani, either by direct injury, or by atmospheric strain upon it, as in the ascent of lofty mountains, or during a sudden descent in a diving-bell, or when, as in whooping-cough, asthma, and violent sneezing, air is driven up with great force through the Eustachian tube. The ear-passage sometimes becomes blocked up by one or more bony growths, which may be so hard as to require the employment of a dentist's drill for their removal. In cases where malformation of the auricle is met with, the ear-passage may be entirely wanting. Nature, as if to assert her right of way in the manufacture of mortals, has created some few persons with no auricles at all, whilst upon others she has bestowed more than the customary dole of two.

Upon the subject of blood-tumours of the auricle we need not here enter, except to say that where they are not caused by violence they are mostly the product of a diseased condition of the brain, and that they occur most frequently in the paralysed and epileptic insane. The auricle, like other organs of the body, may sometimes have to be removed by the surgeon, on account of malignant disease. In cold countries its exposed position renders it liable to frost-bite, in case of which the renewal of the circulation of blood in it must be promoted by bathing with only lukewarm water, or by gentle friction with ice or snow, and not by the sudden application of heat, which is apt to cause inflammation, and consequent destruction of tissue. Practisers of the art of piercing for ear-rings should be especially careful, after each operation, to cleanse the instrument employed, in order to obviate the possibility of poisoning by the introduction of impurities into the blood. Dr. Constantine Paul is of opinion that a scrofulous constitution is evidenced by the formation of a linear scar or slit-like opening where the lobule is pierced; but others have suggested that the weight of ear-rings may be sufficient to account for this peculiarity. In certain cases a ring in the ear appears to play the part of a seton, acting as a counter-irritant upon the progress of eye-complaints. Of the skin-diseases that attack the ear, eczema is the most common. Chronic and, less usually, acute erysipelas of the ear are far from rare.

Itching of the ear, generally met with among nervous females in the latter half of life, especially in those whose circulation is defective, is a troublesome ailment, for which examination of the ear reveals no sufficient cause. As we have already had occasion to remark, the dropping of supposed medicaments into the ear may do it serious damage. We know of one case where a mother thought fit to put tur pentine into her child's ear, with disastrous effects; and of another case where a country gentleman, acting under what he described as medical advice, swabbed his ear with a strong solution of lunar caustic, thus very thoroughly burning away his already far from efficient tympanic membrane.

It is unfortunate that in many sick persons there exists a tendency to distrust the practitioner who, called to their aid, will patiently set himself to further rather than at haphazard to seek to force the operations of nature in accomplishing the cure of their complaint. With them and their diseases they like daily to see that there has been "something attempted, something done;" and they fly to the officious charlatan, who will promise them, through the use of some vaunted panacea of his own, a sure and speedy passage to the heaven of restored health. And so, despite the fact that nearly all serious diseases of the ear arise on the inner side of the impervious drum-head, "drops for the ear" are bought by the poor and ignorant, and inserted with all solemnity into the outer ear-passage, and quacks continue to batten on the proceeds of shameless advertisements.

It would seem that there will always be people, even as in the dark ages, ready to accept the assertions of mountebanks with respect to the magical efficacy of their wares. It must be borne in mind that the irritation set up by fluids dropped into the ear is prone to eventuate in serious inflammation of the tympanic membrane, and consequently to cause decided impairments of its functions; indeed, certain recent experiments, independently made by Professors Brown-Sequard and Vulpian upon several small animals, tend to show that indulgence in the employment of medicinal drops for the ear in order to relieve earache and facial neuralgia is liable to produce even fatal results.

Some drugs, notably salicin and quinine, when used as internal remedies, are productive of singing in the ears and deafness. The latter in large doses induces marked congestion of the auditory apparatus, and thus, if long administered, may cause disease of the labyrinth and internal ear, and resultant incurable deafness.

The most common cause of ear-disease in children is scarlet-fever, and not a few cases are due to measles, whooping-cough, and mumps. When the disease is early treated, there is a fair prospect of completely overcoming it; but where allowed to take its own course it in almost every instance produces most lamentable results, among which may be mentioned aural polypus, thickening or perforation of the drum-head, destruction of the small ear-bones, the constant flow of a foul discharge, owing to chronic inflammation of the tympanic mucous membrane, and sometimes, from extension of that inflammation, abscess, or other injury of the brain, eventuating in paralysis, epilepsy, insanity, chronic vertigo, or death, or even fatal infection of the lungs by means of matter that has found its way into the internal jugular vein. It is the anatomical position of the structures of the ear that renders disease in them especially dangerous; for the upper wall of the bony tympanum has a portion of the brain immediately above it; the lower wall forms part of a fossa in which runs the internal jugular vein; the inner wall is tunnelled by the important nerve that governs the muscles of expression of the face; and the front wall abuts upon the internal carotid artery.

Otorrhœa, or running from the ear, is frequently the result of acute otitis—*i.e.*, sudden and severe inflammation of the ear—which may cause an accumulation of matter in the tympanum sufficiently great to occasion the rupture of the drum-head. The otitis may be brought on not only by fevers, but also by a blow on the head, or exposure to wet and cold in various ways. In scrofulous children otorrhœa comes on without any of the symptoms of acute otitis. In some cases of fever, deafness is an almost necessary result of the rapid disorganisation of the auditory apparatus by a discharge of sanguineous fluid into the tympanum; but in a very large proportion of cases it is traceable to the neglect of parents who, instead of seeking a cure for their child's otorrhœa, have calmly assumed that "the little thing will grow out of it." One would naturally imagine that the risks to health and hearing implied by a perpetual foul discharge from the ear would speedily impress themselves upon the public mind, yet so far is this from being the case that there are actually persons who hold the extraordinary notion that such a discharge is positively salutary; and it is one's repeated experience in hospital practice that not the malady, but simply the offence to the sense of smell occasioned thereby, is that which has at last induced a patient to seek one's aid.

When, in consequence of scarlet-fever or some other affection, otorrhœa first takes place, the discharge usually escapes through a slit-like opening in the drum-head (see Fig. 12); but, if allowed to persist, it gradually wears this opening into a round orifice (see Fig. 13), which is difficult of closure. When, therefore, the drum-head has become perforated, the surgeon's great endeavour is to restore it at once to a healthy condition, in which it can repair the narrow breach in its structures almost as quickly as it could a linear cut just made with a sharp knife.

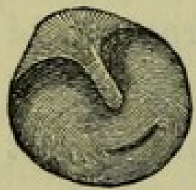


Fig. 12.—Slit-like perforation in the membrana tympani.

Fig. 13.—Perforation in the membrana tympani—a round orifice.

Perforation of the membrana tympani when insidiously effected by disease—scarlet-fever, *e.g.*—is very commonly left untreated for a long period; when, however, it is the direct result of a blow, it is usually attended to betimes. Snowballing accounts for a few cases of rupture of the membrana. Another cause is the brutal practice adopted by some tutors of boxing the ears of their pupils, to which were attributable eight out of five hundred (or 1·6 per cent.) consecutive hospital cases seen by the writer. The annexed figures (Figs. 14 and 15), which show the effect that a self-appointed instructor of his spouse produced in one of her membranæ by a blow from his fist on the side of her head, might afford to some pedagogues a hint of no mean value.

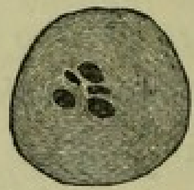


Fig. 14.—Exact appearance of the ruptured membrana tympani on the day after the injury.

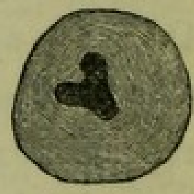


Fig. 15. — The appearance of the membrana on the third day.

The position, shape, and size of perforations in the drum-head, as well as their influence on the appreciation of sounds, vary very greatly. Hardness of hearing is usually the outcome of the happily rare formation of an opening through its uppermost part. The degree of audition may be very different in two patients whose membranæ present perforations which, from their history and condition, are seemingly identical in character. Many years ago, Mr. Cheselden, a surgeon, arranged that a condemned criminal should be pardoned on condition of his submitting to a direct experiment to ascertain what loss of power the ear would undergo on the making of an aperture in the drum-head; "but, a popular outcry being raised, it was thought proper to relinquish the idea." *

The aurist has sometimes to deal with cases in which the establishment of a perforation would undoubtedly be of lasting benefit to hearing. The late Sir Wm. Wilde held that a large is preferable to a small permanent aperture in the drum-head; and his opinion is supported by what Sir Astley Cooper relates of a medical student who consulted him. This person had lost the right membrane partially, while of the left not a trace was discernible, and yet he could hear better with the left than with the right ear; his deafness, moreover, was inconsiderable, and he was nicely susceptible of musical tones. One interesting discovery made with respect to this patient was that the external ear had acquired the power of distinctly moving upward and backward immediately anything was listened to that was not distinctly audible. (See "Phil. Trans.," Vol. XC., p. 152 *et seq.*) The presence and the condition of the little ear-bones determine, to a great extent, the degree of hearing compatible with perforation. When the incus is detached from the stapes, there is, as Hinton pointed out, an inability to hear anything except during the act of listening. Artificial pressure, such as that afforded by a moistened pellet of

* "Phil. Trans." Vol. XC.

cotton-wool, is the only means by which it is feasible to improve hearing impaired by interruption in the continuity of the chain of ear-bones. Disease of the internal ear is almost always secondary to some other affection, as, for example, effusion of blood or serum into the labyrinth, injury to its structures or to the brain, inflammation of the cerebral membranes, fevers, rheumatic joint-affections, and mumps. It may exist without any discoverable impairment of the condition of the membrana tympani.

In considering the functions of the organ of hearing, one must bear in mind that it is made up, first, of a sound-conducting portion—namely, the external and middle ear, together affording passage to sonorous vibrations as such; and, secondly, of a sound-perceiving portion, *i.e.*, the labyrinth with the auditory nerve, by which vibrations are accepted and assorted, and then translated into messages cognisable by the brain. When a deaf person having a tuning-fork placed on his forehead hears its vibrations louder in his more defective ear than in the other, the aurist knows that there is obstruction to sound-conveyance; when the reverse is the case, he diagnoses faultiness in sound-perception.

The effect of obstruction to the passage of sound may easily be experienced by any one with normal hearing, when, one ear being closed by the finger, a vibrating tuning-fork is applied to the forehead. Disease of the auditory nerve is manifested principally in absolute deafness, and it appears that when there is affection of the terminations of the nerve in the labyrinth, giddiness, singing in the ears, faintness, and vomiting may be present. In fevers, especially typhus, failure of hearing in proportion to nervous weakness is far from uncommon, and in some cases the defectiveness of audition is persistent after convalescence, thus resembling the lasting mental incompetency occasionally observed subsequent to serious and prolonged interference with the cerebral activities. Considerable loss of hearing has been known to come on without any clearly defined cause. It would seem that in certain instances severe nervous strain avenges itself, so to speak, upon the organ of hearing more especially, its precise mode of action being as difficult to trace as in those cases where its effect is to turn the hair white in the course of a few hours. Thus, one of the author's hospital patients became almost totally deaf immediately on the announcement of the death of a child, and another suffered similarly when his wife died.

Deafness is sometimes the concomitant of the constitutional conditions prevalent for a few months before parturition, and during the period of suckling. When it occurs in bilious attacks, it is probably due, as in gout and fevers, to an impoverished and poisoned condition of the blood.

A species of giddiness caused by disease of the internal ear is known as aural vertigo, and this, with other symptoms, is specially characteristic of what, from the name of its first describer, is designated as Ménière's disease, in which there is abnormal irritation of the nerve-fibres of the semicircular canals.

The main peculiarities of a typical case of this disease are that the patient first experiences the sensation of a rotatory movement in a vertical position, perhaps with that of swaying to and fro; then he feels as though he were revolving forwards and backwards on a transverse axis; his vertigo now increases, and he swoons, and may vomit. Usually there are with the movements sensations of sound. In long-established cases there is slight vertigo between the seizures, a sensation of falling backwards or forwards, or a fixed and unnatural position of the head. A great similarity exists between many of the symptoms of auditory vertigo and those of sea-sickness.

Loss of hearing due to disease of the auditory nerve, or "nervous deafness," is generally most efficaciously tested by means of the tuning-fork. It yields very poorly to remedial measures, but happily is rare in comparison with other and more manageable affections of the ear.

Singing in the ears, or *tinnitus aurium*, is sometimes the accompaniment of general disturbances of the constitution, sometimes the result of direct irritation. Kramer describes it as "a completely local affection of the ear, which may be produced, and is always proportionately increased, by sympathy with general derangement of the system."

It is in most aural diseases a frequent and more or less trying symptom. Roosa and Kramer tell of two cases of suicide on account of it; and Sauvage mentions an instance of a musician who, as in a case once under the care of the author, heard in addition to every note he played a second inharmonious sound, so that he was compelled to give up his occupation.

Patients affected with tinnitus aurium generally compare it to those sounds with which they are most familiar. Country folk having it for their companion must perforce, so far as sounds are concerned, from early morn to dewy eve—

> "all the pleasures prove
> That valleys, groves, or hills, or fields,
> Or woods and steepie mountains yeelds;"

but the townsman, *nolens volens*, has to bear with the rumbling of carriages, the clang of hammers, or the whirring of machinery; whilst the servant is throughout his waking hours perpetually pestered with the tingling of the bells whose summons he has been wont to obey. Most patients complain of what is termed the "tidal sound"—*i.e.*, a noise such as is heard when one holds a shell to the ear. Tinnitus aurium is usually overcome by the removal of its primary cause, whatever that may happen to be, and by the cure of the accompanying deafness.

The sound of one's own voice in the head, double hearing, or autophony (from αὐτός, one's self, and φωνή, voice) is a phenomenon by no means rare in sundry diseases of the ear. Sir Everard Home states that an eminent music-master once, after catching a cold, for a long time found that the pitch of one ear was half a note lower than that of the other, and that the perception of a simple sound did not occur in both ears at the same instant, but was rendered double, the second sound being the lower and weaker. Before dismissing the subject of the musical perception of the organ of hearing in different pathological conditions, we may mention another anecdote given by Home, to the effect that a lady who had been incapable of singing any tune, from the want of an ear for music, in the course of an attack of madness, to the astonishment of her friends, sang a tune with tolerable correctness.

Most of us can call to mind examples of the curious mental effects produced by various sounds heard during sleep or a drowsy condition. Shakespeare has told us how, when Queen Mab drums in his ear, the soldier "starts and wakes; and, being thus frighted, swears a prayer or two." The vibrations of a pair of tweezers close to his ear as he slept M. Maury found to occasion dreams of bells, the tocsin, and the events of June 1848; and a lover, we read, effected a change of sentiments in his obdurate fair one by whispering his name in her ear when she was slumbering, thus inducing a happy habit of dreaming about him.*

The census statistics of several European and American countries within the last half century reveal the somewhat startling fact that one person in about 1,650 is a deaf-mute—*i.e.*, is both deaf, and though not, as a rule, potentially, yet virtually dumb. Deaf-mutes are divisible into two groups—viz., the congenitally mute, whom deafness at birth has deprived of the infant's facilities for learning to speak, and those who are mute because deafness has come on sufficiently early in life to prevent either the acquisition or else the retention of speech. The relative proportion of these two groups in any given population, it is, from various circumstances, difficult with any certainty to determine; but it appears that at the British census for 1871 sixty-three per cent. of the inmates of twelve institutions for deaf-mutes were congenitally affected. Fevers and other inflammatory diseases, and falls and blows, are common causes of non-congenital deaf-mutism, especially in scrofulous subjects; and inherited tendency, and indubitably ill-assorted marriages,

* See James Sully, "Illusions," p. 140.

and the inebriety of parents, are potent in producing the congenital affliction. It is noteworthy that the congenitally deaf are rarely free from more or less well-marked constitutional defect of some sort; still it must not be supposed that the comparatively high mortality exhibited by deaf-mutes is altogether attributable to this fact, for diseases affecting the circulation and respiration, to which they are specially liable, are precisely what their usually sedentary habits and, in cases where articulation is not learnt, their mouth-breathing and deficient exercise of the lungs render one prone to contract. Observation and experience as an aural surgeon have constrained the author to accept the conclusion that where congenital deaf-mutism is not traceable to any kind of inherited taint or family defect, it is, generally speaking, due to the close relationship of the parents, they commonly being first-cousins. Dr. A. Hartmann has called attention to the following results of recent very exact statistics, which, as he truly observes, positively prove that consanguineous marriages are a cause of congenital deaf-mutism:—In Prussia, where the total number of consanguineous marriages yields a percentage of 0·8, there were among 1,210 congenital deaf-mutes 156, or 12·9 per cent., who were the offspring of consanguineous marriages; while among 1,551 individuals with acquired deafness there were only 47, or three per cent., who sprung from such marriages.

The systems that have been most generally adopted for the instruction of the deaf and dumb are known as the "French," or "old;" the "old English," or "combined," and the "German," or pure oral. Of these, the first aims simply at the expression of thought through the intervention of signs and gestures, or dumb-show, and of words spelt with a finger-alphabet. By this system, diligently learnt, the deaf-mute, as Kitto, who was himself deaf from the age of twelve, admits, may indeed become possessed of "the solid bones, the dry bread, the hard wood, the substantial fibre of life," but gets "little of the grace, the unction, the gilding, and the flowers, which are to be found precisely in those small things which are not worth reporting on the fingers."

The old English system embraces speech, together with natural and artificial signs of all sorts, and reading from the motions of the lips. The German system, rejecting all manner of signs and symbols, imparts, by means of sight and touch, an exact and practical knowledge of articulate speech, so that the deaf-mute, by dint of practice, may be able with readiness both to utter all its various combinations of sounds and to read them from the lips of others. The German is sometimes designated the "new" system, though, as Kinsey remarks, it was in vogue long before any method of signs was introduced. Its principles, we may surmise, were those upon which a certain Dr. Amman, at about the close of the 17th century, taught a girl of seventeen to speak very intelligibly, and to read Dutch and Latin. (See Charles Ellis, "Phil. Trans.," 1703, p. 1416). The slowness with which its advantages have come to be perceived in England is perhaps due in part to a popular persuasion that deaf-mutes are by nature dull of sight and apprehension, and could not, therefore, overcome its intrinsic difficulties. It is reported that but lately the usher of a British court of justice, asked why he was writing the questions for a deaf person in words some inches long, replied, without a moment's hesitation, "Because the witness is so deaf!"

Although the ear is undoubtedly in close organic connection with the voice-producing mechanism, the success of teachers of the pure oral system of instructing the deaf and dumb proves beyond all controversy the untenableness of the notion which some have held, that there is associated with deafness, and quite independent of it, a sort of physical inability, as well as a disinclination, to utter articulate sounds. So little was this system understood in England some few decades since, that writers on the education of the deaf and dumb were disposed to regard an imperfect mastery of it as a phenomenal achievement, and gravely expressed their thorough persuasion that "mouth-reading must be wholly inadequate to the purposes of real conversation, involving intercourse of the intellect or the imagination," and that "writing and signs are abundantly sufficient for all the intercourse to which a deaf-mute is equal." Now, however, it is very generally recognised, and can be abundantly proved, that signs, gestures, finger-alphabets, and even phonetic symbols are not only unnecessary for the requirements of those deaf-mutes to whom can be afforded the opportunity of learning oral speech and lip-reading, but actually serve as so many serious obstacles to their intellectual advancement. Even were the language of signs a codified system common to all institutions and countries, which it emphatically is not, it could but enable the deaf to communicate with the deaf. Unfortunately, it has been found, in proportion to its use, to prevent the acquisition of oral speech and lip-reading, by means of which alone can dumbness and its many sad accompaniments be practically abolished. It was some forty years since that Kitto, writing of deaf-mutes, said: "It is an idle dream to hope to restore such persons entirely to society;" still, thanks to the dissipation of prejudice, and to the spread of knowledge, this "dream," long ago realised on the Continent, has of late years in England also had its ample fulfilment in irrefragable facts.

Aids to Hearing.—Most instruments employed for the improvement of defective hearing are constructed with a view to the augmentation of resonance within the external ear, and the reflection into it of waves of sound. It is for these purposes that the deaf man places a hand behind his ear. The instrument called an otophone increases the receptive power of the auricle by causing it to project forwards. Hard and compact bodies—*e.g.*, metal, glass, and porcelain—are the most efficient reflectors of sound; but many such materials are practically inadmissible for the manufacture of ear-trumpets, on account of their weight or fragility, or their peculiar note when subjected to vibration.

A hollow cone forms a good sound-reflector, the efficacy of which may be enhanced by widening and obliquely truncating its base. The instrument is thus made not unlike the ears of some quadrupeds. Transverse vibrations of the air within it are found to be diminished by piercing the sides with several holes. Some deaf persons are greatly benefited by the use of small globular or conical metallic resonators. Double aural instruments are those generally found most efficacious. When the sound-collector is furnished with a tube, the free end of the latter must be of a size to fit accurately into the auditory meatus.

That an ear-trumpet may form a useful social weapon of defence, we perceive from the lines of Goldsmith on Sir Joshua Reynolds, telling us that—

"To coxcombs averse, yet most civilly steering,
When they judged without skill he was still hard of hearing;
When they talked of their Raphaels, Correggios, and stuff,
He shifted his trumpet, and only took snuff."

In foreign countries, however, the employment of an ear-trumpet might possibly lead to untoward and somewhat embarrassing results, as the following true story serves to indicate:—A deaf old lady in India was asked out to dinner, at which she seemed to be thoroughly enjoying herself, until, at length, one of the native servants asked her whether she would take some green peas. Not hearing the question, she raised an enormous silver trumpet to her ear, exclaiming, "What does the stupid man say?" Whereupon the servant, evidently regarding the trumpet as some new-fangled implement of European epicureanism, poured into it a good spoonful of the peas.

The different forms of resonator and sound-conductor that have been invented for the relief of deafness are exceedingly numerous. Experiment alone can prove which of these is likely to prove of most service to a patient; and the same may be said of the several kinds of artificial drum-heads.

Some deaf persons are acutely affected by vibratory impulses conveyed through the tissues of the body to the auditory nerve; thus, Kitto found that every movement or concussion in a wooden-floored uncarpeted room caused him a sensation amounting to torture.

The possibility of hearing through the teeth and other structures has been thought to be enhanced by a lax state of the membrana tympani. It has been rendered available for some cases of impaired audition by the invention of the audiphone, osteophone, tonomittor, and other forms of solid sound-conductors. Some few experiments that have been made with the audiphone tend to prove that it is unlikely to be of any use for the instruction of deaf-mutes.

THE

THROAT, VOICE, AND SPEECH.

WHETHER we regard them physiologically, or in their relations to disease, there are few, if any, more important and interesting parts of the body than those that are concerned in the production of the voice and speech. Placed immediately above the windpipe and gullet, and lying between these below and the mouth and nostrils above, they form a common antechamber to them, and the only channel by which air can be supplied to the lungs for the purposes of respiration, and food conveyed to the stomach for the purposes of nutrition. Hence these organs not only subserve the functions of voice and speech, which have a special relation with respiration ; but they are the organs of smell and taste, and those for the prehension, mastication, and swallowing of food.

It is wonderful, as we pass, step by step, from the lower forms of animal life to such as are highest in the scale, and thence to man, to observe how parts that are primarily devoted solely to the maintenance of life—at first to the selection, prehension, and preparation of food for digestion, and later to the respiratory function as well—become also adapted to the performance of higher duties which the growth of intellect depends on and demands ; and how the comparatively simple mechanism, which subserves these heterogeneous functions, not only remains perfect for its primary purposes, but proves itself at least as marvellous an instrument for its more complex, various, and delicate superadded duties.

The organs to which we have mainly to confine our attention in the present article are bounded above by the anterior part of the base of the skull, behind by the spinal column, and below by the upper outlet of the chest, the collar-bones, and the parts connected therewith; and they comprise the mouth and nose, with their appendages, the fauces, the larynx and upper part of the trachea, and the commencement of the œsophagus or gullet.

It would be difficult, however, if not impossible, to understand the duties they have to perform, and their mode of performing them, without some reference to subsidiary organs, not included in this district; and such a reference, therefore, will here and there be made in the course of the subsequent pages.

Structure.

The Cavity of the Nose (Fig. 1, *a*, and Fig. 2, *d*) occupies the central region of the face, lying between the base of the skull and the roof of the mouth, and bounded on either side by the orbits (or cavities containing the eyes) and the cheek-bones. Its anterior limits are the facial projection, which constitutes the nose proper; its posterior limits the posterior nares or nostrils, which, extending obliquely from the skull above to the palate below, allow of a very free communication between the cavity of the nose and the upper compartment of the pharynx. The cavity of the nose, however, is not nearly so simple as the above brief description might lead one to suppose. For, first, it is divided into two parallel vaulted compartments by a vertical septum (Fig. 2 *c*), which extends uninterruptedly throughout its whole antero-posterior extent; second, its outer wall on either side has connected with it

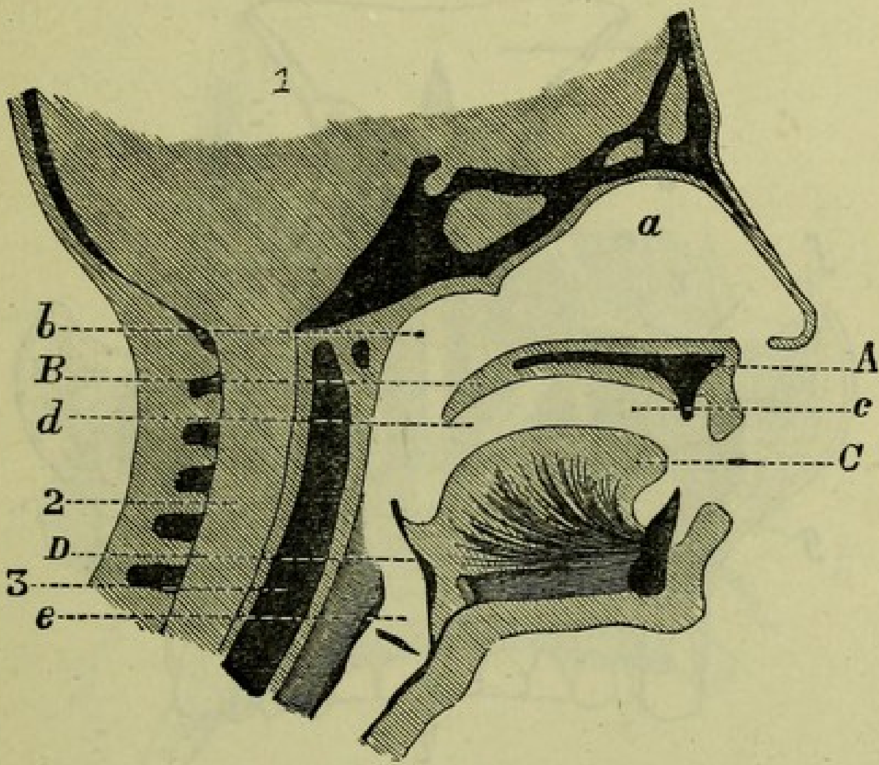


Fig. 1.—Vertical Section from Before to Behind of Nose, Mouth, Fauces, Larynx, and adjoining parts.

1, Cavity of skull; 2, Spinal canal; 3, Bodies of vertebræ; A, Hard palate; B, Soft palate and uvula; C, Tongue; D, Epiglottis; *a*, Cavity of nose; *b*, Pharynx; *c*, Cavity of mouth; *d*, Fauces; *e*, Larynx.

three projecting, twisted shell-like films of bone (Fig. 2 *e*, and Fig. 3 *a*, *b*, *c*), extending horizontally from back to front, and imperfectly dividing each lateral compartment into three galleries or meatus; and third, several diverticula, or caverns, open out of these compartments—one on either side (Fig. 2 *g*), into the upper jaw-bone, immediately under the eye; and one also (Fig. 3 *e*), on either side, into the frontal bone, where it helps to cause the prominence immediately above the bridge of the nose and inner extremity of the eyebrows ; and others into the ethmoid and sphenoid bones (Fig. 3 *d*). Further, a direct channel passes on either side from the puncta at the inner extremities of the eyelids

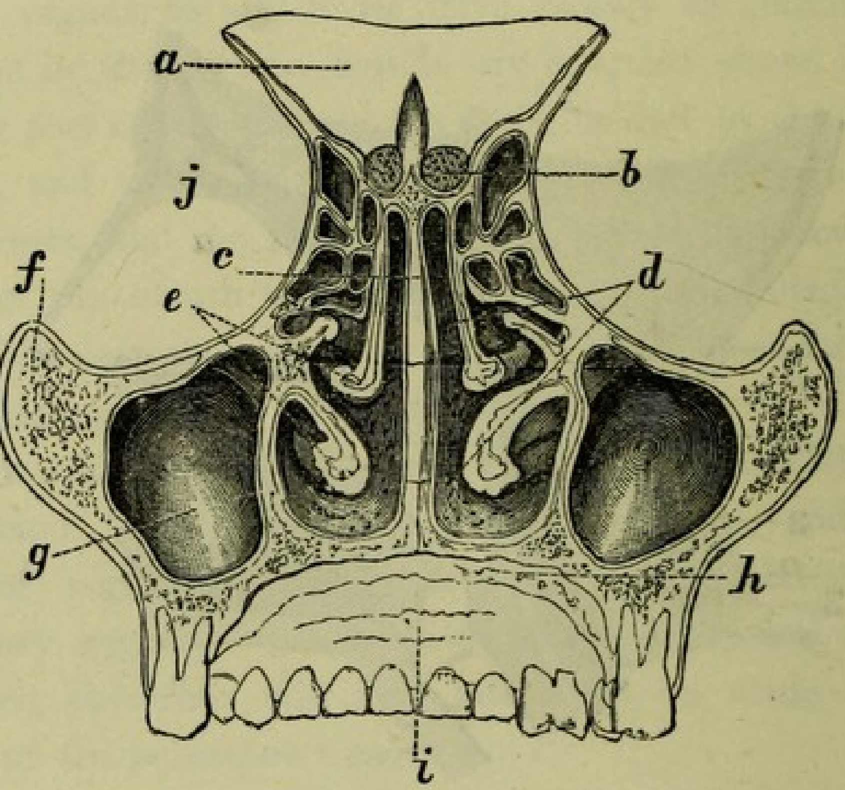


Fig. 2.—Transverse Vertical Section of Nose, seen from behind.

a, Frontal bone ; *b*, Olfactory nerve on base of skull ; *c*, Septum of nose ; *d*, Cavity of nose ; *e*, Turbinate bones ; *f*, Cheek bone ; *g*, Maxillary sinus ; *h*, Palate ; *i*, Cavity of mouth ; *j*, Cavity for eye, or orbit.

into the inferior meatus, along which tears travel from the surface of the eye to the interior of the nose.

The primary purposes of the nose are for smelling and for breathing. The greater part of its complex cavity is invested in a mucous membrane, which, being abundantly supplied with thin-walled veins, is eminently adapted to warm the air in its passage from without to the lungs, and must obviously be regarded physiologically as belonging to the respiratory tract. The upper part only is devoted to the sense of smell. It is supplied with a special form of mucous membrane, and has distributed over its surface the branches of the olfactory nerve (the nerve of smell) (Fig. 2 *b*),

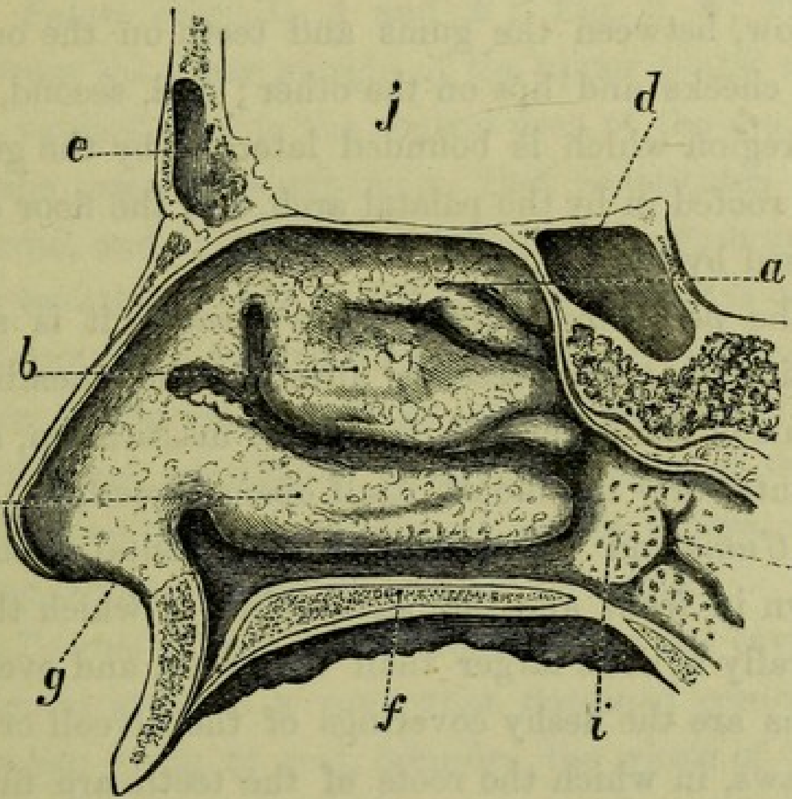


Fig. 3.—VERTICAL SECTION OF NOSE FROM BEFORE BACKWARDS, SHOWING RIGHT SIDE.

a, Superior turbinate bone; *b*, Middle ditto; *c*, Inferior ditto (the upper, middle, and lower meatuses, are below the corresponding bones); *d*, Sinus extending from nose into sphenoid bone; *e*, Sinus extending from nose into frontal bone; *f*, Palate; *g*, Nostril; *h*, Orifice of communication with ear; *i*, Posterior nostril; *j*, Cavity of skull.

derived directly from a special part of the brain which lies immediately upon the thin plate of bone separating the cavity of the skull from that of the nose.

The Mouth is a much larger, much more complicated, and much more important organ than the nose. It is bounded laterally by the cheeks, anteriorly by the oral orifice or mouth proper, behind by the arch of the fauces, above mainly by the palate, and below by the soft tissues included between the horizontal rami of the lower jaw, and from which the tongue springs. The cavity may be considered to be divided into two parts—first, that formed by the sulci, grooves or pouches, which intervene both above and below, between the gums and teeth on the one hand, and the cheeks and lips on the other; and, second, all that central region which is bounded laterally by the gums and teeth, is roofed in by the palatal arch, and the floor of which is occupied by the tongue.

Of the *peripheral part of the oral cavity* it is sufficient to mention that its presence, allowing the unembarrassed movement of the lower jaw, facilitates mastication, and that into it anteriorly the mouth itself opens directly.

The *Gums* and *Teeth* form two horizontal arches, with the crown in front and the base behind, of which the upper is naturally a little larger than the lower, and overlaps it. The gums are the fleshy coverings of the alveoli or sockets of the jaws, in which the roots of the teeth are firmly embedded. The teeth, as is well known, are of different kinds. The central four in either jaw, which are furnished with a cutting chisel-like edge, are the incisors. External to the incisors come the canine or tearing teeth, which are particularly strong and pointed, and which, in purely carnivorous animals, are always highly developed. These are four in number. Next to the canine are placed the bicuspid teeth, two on each side, both above and below; and beyond these again the large molars, or grinders, of which there are altogether twelve, and whose purpose is to grind or triturate the food submitted to them. The above brief description applies only to the second set. The first, or milk teeth, as they are called, are much smaller than their successors, and, immediately beyond the canines, consist of small molars only, which, collectively, are eight in number.

The *Palate* (Fig. 1, *A* and *B*; Fig. 2, *h*; Fig. 3, *f*), springs from the inner margin of the upper dental arch, and forms a vaulted roof to the central area of the mouth. Its basis is the same bony expansion that constitutes the floor of the nose, and it is covered by mucous membrane. The anterior two-thirds only of the palate are osseous and rigid. The posterior third, termed the soft palate, and prolonged from the other, is formed essentially of mucous membrane and muscular tissue, constitutes a movable flap, and terminates behind in two concave scallops, or arches, separated by the projecting conical process known as the uvula.

The *Tongue* (Fig. 1, *C*), situated within the cavity of the lower dental arch, is a somewhat flattened conical organ, which, when lying at rest, occupies the whole of the space bounded by the lower teeth, its point lying just behind the incisors, its lateral edges being pressed against the bicuspids and molars, its dorsum presenting a convexity facing the palate, its base (behind) being united to the movable hyoid bone (from which, also, the larynx and trachea are suspended), and to several other important parts which will by-and-bye be discussed; and its under aspect (which, in the greater part of its extent, is free) being attached to the floor of the mouth by a narrow longitudinal duplicature of mucous membrane, between the layers of which is contained a series of muscles which, springing partly from the hyoid bone and partly from the lower jaw, are largely instrumental in effecting the varied movements of the organ. The tongue is made up mainly of interlacing muscular fibres, which, in association with the muscles attached to it, enable it to execute the most varied movements with the utmost precision. It is covered, except on its under surface, with large papillæ, and not only is endowed with extreme sensitiveness to tactile impressions, but is the main seat of the sense of taste.

The Fauces (Fig. 1, *d*) constitute the posterior orifice of the oral cavity, as the mouth constitutes its anterior orifice; and here, as in the latter situation, the channel becomes constricted. They are formed by the arch of the soft palate above, the sides of which are continued into two slightly divergent descending columns, formed mainly by projecting bands of muscular tissue, and known as the pillars of the fauces. Of these the anterior one blends with the side of the base of the tongue, while the posterior one loses itself in the walls of the pharynx; and between them is situated the tonsil.

The Pharynx (Fig. 1, *b*) is the somewhat irregular cavity or bag, with muscular walls, into which the posterior nares and fauces open. It extends from the skull above to the level of the cricoid cartilage below, and is in contact behind with the anterior part of the spine, and the muscles and other parts attached thereto. It is narrow from before backwards, but comparatively wide in all that region of it which is directly related with the nose and mouth. Below it assumes a funnel-like shape, and blends with the narrow, cylindrical œsophagus. Besides the orifices already referred to as opening into it (namely, the nose, mouth, and œsophagus) there are yet three others, two of which (the Eustachian tubes leading from the ears) open, one on each side, above the level of the soft palate; while the third is the laryngeal orifice, which lies immediately behind the base of the tongue, and in front of the œsophagus.

The soft palate (Fig. 1, *B*), in its movements and its relation to the pharynx, is so constituted that when at rest it hangs down, partly closing the posterior orifice of the mouth, but leaving the communication of the nose, through the pharynx, with the larynx and œsophagus, free and uninterrupted; when in action, on the contrary, it assumes a nearly horizontal position, and forms a complete septum between the upper part of the pharynx, into which the nose and ears open, and the lower part, whose relations are directly with the mouth, larynx, and œsophagus.

Of the *Œsophagus* nothing more need be said than that it is a muscular tube, in the adult nine or ten inches long, which leads from the pharynx to the stomach, and whose special function it is to carry food from the mouth to the latter organ.

The Larynx and Trachea constitute the common channel along which air is transmitted to and from the bronchial tubes, and hence to and from the lung-tissue. The tube commences at about the level of the horse-shoe-shaped hyoid bone (Fig. 5, *a*) (from which it is suspended, and to which the base of the tongue is also attached), and runs down in the front of the neck parallel with the œsophagus, which is behind it, into the upper part of the chest, where it divides into two branches, one for each lung.

The *trachea* (Fig. 5, *f*) is the longer, narrower, and simpler part of the tube. It measures in the adult from three-quarters of an inch to an inch in diameter, and is formed partly of muscle, partly of connective tissue, partly of mucous membrane; and is furnished also with a series of cartilaginous rings (imperfect behind, and circumscribing the tube for three-quarters of its circumference), which from their firmness and elasticity impart strength and permanence of shape to the tube.

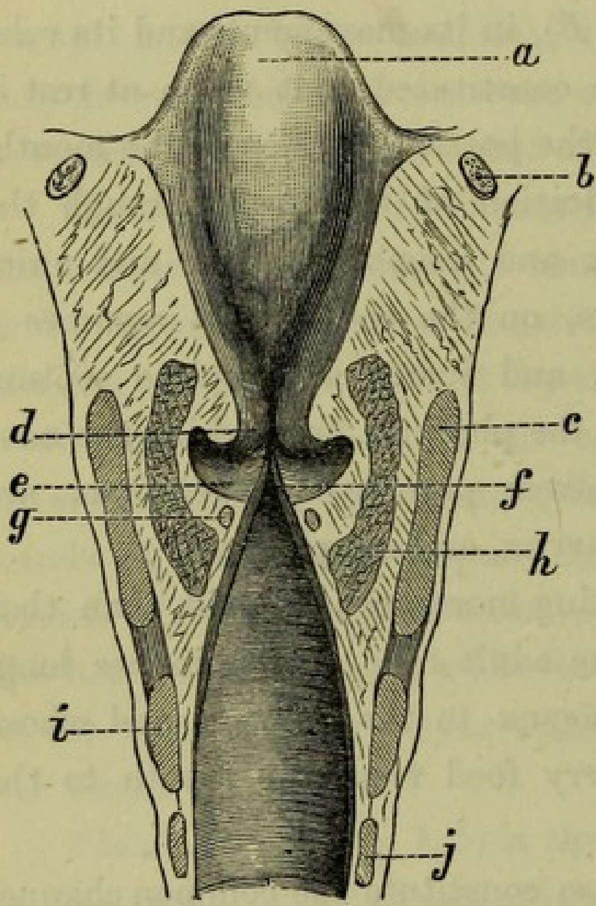


Fig. 4.—Vertical Transverse Section of the Larynx.

a, Epiglottis; *b*, Hyoid bone; *c*, Thyroid cartilage; *d*, False vocal cord; *e*, Sinus; *f*, Rima glottidis; *g*, True vocal cord; *h*, Thyro-arytenoid muscle; *i*, Cricoid cartilage; *j*, First ring of trachea.

The *larynx* (Fig. 1, *e;* Figs. 4 and 5) is much more irregular in form, much more complicated in structure, and much more difficult to describe than the trachea, or indeed than any of the parts which have hitherto claimed our attention.

If we look into it from above, in its natural state, we find it immediately below and behind the base of the tongue, to which it is united by direct continuity of tissue. Its upper orifice, which is bevelled off from before backwards, is irregularly oval but variable in shape: bounded in front by a vertical plate named the *epiglottis* (Fig. 1, *D;* Fig. 4, *a;* Fig. 5, *b;* Fig. 6, *a*); behind by the upper points of the two *arytenoid cartilages* (Fig. 5, *d;* Fig. 6, *b*); and laterally by folds of mucous membrane, passing downwards and backwards from the lateral edges of the epiglottis to the arytenoids.

At some little depth (an inch or an inch and a half) below the summit of the epiglottis, and perhaps one-half or one-third that distance below the tops of the arytenoids, we observe another and narrower orifice, which is called the *rima glottidis* (Fig. 4, *f;* Fig. 6, *e*). This occupies a horizontal position, and varies in form; being sometimes a linear chink, taking an antero-posterior direction, sometimes an isosceles triangle, with the apex pointing forwards. The margins of this orifice are formed by white elastic bands (the *vocal cords*) (Fig. 4, *g;* Fig. 6, *d*), enclosed in duplicatures of mucous membrane, derived from that which lines the walls of the larynx. Above, and a little further apart than these, are two other horizontal duplicatures of membrane—the false vocal cords—one on each side (Fig. 4, *d*; Fig. 6, *c*). Between each of these duplicatures and its

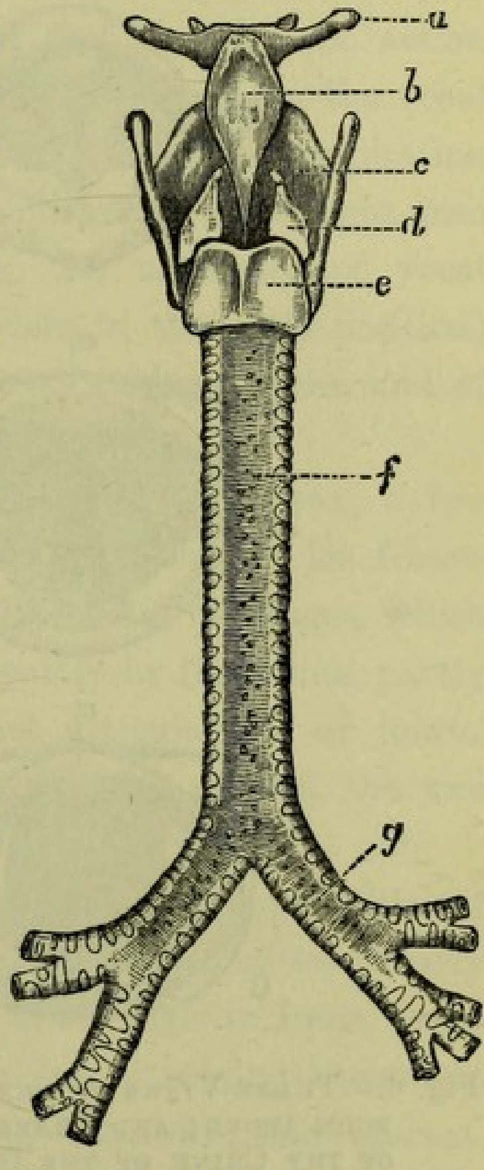


Fig. 5.—OUTLINE SHOWING GENERAL FORM OF LARYNX AND TRACHEA, AS SEEN FROM BEHIND.

a, Hyoid bone; *b*, Epiglottis; *c*, Thyroid cartilage; *d*, Arytenoid cartilage; *e*, Cricoid cartilage *f*, Trachea; *g*, Bronchus.

corresponding true cord is a chink leading to a small blind cavity termed the *sacculus laryngis* (Fig. 4, *e*).

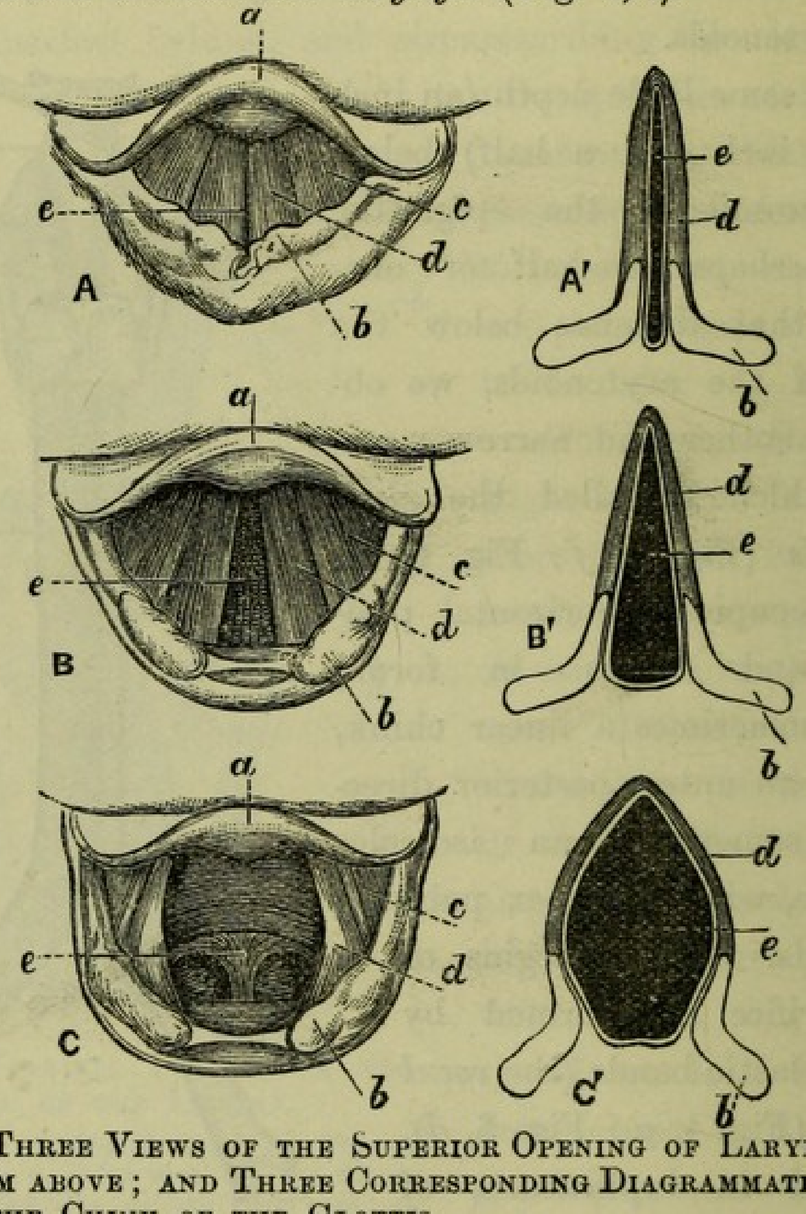


Fig. 6.—Three Views of the Superior Opening of Larynx, seen from above; and Three Corresponding Diagrammatic Views of the Chink of the Glottis.

AA', Glottis closed as during formation of a high note. BB', Glottis open, as in easy respiration. CC', Glottis wide open, as in drawing a deep breath. *a*, Epiglottis; *b*, Arytenoid cartilage; *c*, False vocal cord; *d*, True vocal cord; *e*, Chink of glottidis.

If we look into the larynx from beneath we shall see that its lower part almost exactly resembles the trachea in size and shape; except that it forms a kind of dome above, the summit of which is occupied by the chink of the *rima glottidis*.

The chief points concerning the movements of the larynx are :—1st, that, in the act of swallowing, the vertically placed epiglottis descends with the base of the tongue over the upper opening of the larynx, and so prevents the entrance of food into the air passages; and 2nd, that, by the action of the numerous small muscles which act on them, the vocal cords are capable of being separated during respiration (Fig. 6), and of being approximated and brought into contact with one another during the utterance of vocal sounds, and further (especially while in the latter position) of being stretched longitudinally and rendered tense, and of being shortened and relaxed.

Before dismissing the anatomy of the larynx, a few further facts concerning it may be pointed out. Its framework, like that of the trachea, is formed of cartilages, which are connected with one another partly by ligaments, partly by muscles, and partly by distinct articulations or joints. The chief cartilages are the *thyroid*, the *cricoid*, the two *arytenoids*, and the *epiglottis*.

The *thyroid* (Fig. 4, and Fig. 5, *c*) which has something of the shape of the spout of a pitcher, is formed of two nearly quadrilateral plates, which unite at an angle in front, forming in men the *pomum Adami*, but diverging somewhat behind, and remaining separated by a considerable interval. The posterior edges are prolonged above and below into somewhat elongated processes, of which the superior one on each side is attached by ligament to the corresponding extremity of the hyoid bone, while the inferior and shorter one articulates with the side of the cricoid cartilage.

The *cricoid* (Fig. 4, *i;* Fig. 5, *e*) *cartilage* forms a complete ring, which is narrow in front and deep behind, and so formed that, while the lower orifice is horizontal and circular, the upper one is oval, and faces upwards and forwards. Its anterior part lies immediately below the front of the thyroid, to which it is united by a ligament; while the posterior rises into the concavity of the thyroid, and its sides, as before stated, are articulated with the lower processes of that cartilage. On either side of the median line behind, the upper edge of the cricoid presents an articulating surface, to which one of the arytenoid cartilages is applied.

The *arytenoid cartilages* (Fig. 5, *d*) are three-sided cones, the apices of which are directed upwards, while the bases resting on the cricoid, on the articulating facets of which they move as on a pivot, are also triangular. Each base, therefore, presents three points: one directed forwards, to which the corresponding vocal cord is attached; one directed outwards, and giving insertion to certain muscles; and one (less prominent than the others) directed backwards and inwards, and closely related to the articulating facet.

The *epiglottis* (Fig. 4, *a*; Fig. 5, *b*; Fig. 6, *a*) is a leaf-like body, somewhat pear-shaped in outline, with the broader extremity above, and the narrower extremity (which springs from the thyroid in the angle formed by the junction of its quadrilateral plates) below.

The *vocal cords* (Fig. 4, *g*; Fig. 6, *d*) are united side by side in front to the thyroid cartilage, close to the attachment of the epiglottis, and behind, as before stated, to the anterior processes of the arytenoids. The false cords are attached to the same parts immediately above.

All the structures above described are united to one another by complex ligaments and muscles, and are covered in by a layer of mucous membrane.

It will probably not be difficult now to understand the mechanism by which the glottis opens and closes, and by which the cords become stretched and relaxed. The anterior extremities of the cords being united to the thyroid cartilage are practically immovable ; but the posterior (being attached to the long anterior processes of the arytenoids which are capable of revolving horizontally round the articulating facets situated behind) admit, according to the movements of these processes, of being brought into absolute contact, or of being widely separated. The tension of the vocal cords is determined by the separation or approximation of their points of attachment—namely, the posterior surface of the thyroid cartilage and the arytenoid cartilages. This function is performed by the rotation of the thyroid cartilage in the vertical direction on the joints by which it is attached to the cricoid. The cricoid remaining fixed, and consequently the articulations of the arytenoids remaining fixed, the upward movement of the thyroid causes the anterior attachments of the vocal cords to approach nearer to their posterior attachments, and the cords consequently to be shortened, and rendered less tense ; while the downward movement of this cartilage causes the anterior and posterior attachments to recede from one another, and the cords to be stretched.

Glands connected with Mouth and Throat.—To the above brief account of the anatomy and physiology of the parts concerned in speech and voice, mastication, deglutition, &c., it must be added : 1st, that the mucous membrane is everywhere thickly studded with small embedded mucus glands, the secretions of which keep the surfaces moist, and protect them ; 2nd, that six salivary glands, of which the two largest are situated behind the angles of the lower jaw, discharge their products into the mouth, in order mainly to assist in masticating, swallowing, and digesting food; and 3rd, that embracing the upper part of the trachea in front and laterally, there is a peculiar two-lobed gland, the thyroid body, the use of which is not understood, but which has remarkable relations to various forms of disease.

FUNCTION.

Having now briefly considered the anatomy, and touched on the physiology, of the organs to which our attention has to be specially devoted, we shall proceed to discuss in a little more detail the actions and uses of these organs.

And first let us consider them in connection with the digestive functions.

Digestive Functions.—There is no doubt that the mouth has special relations with the alimentary canal, and may be regarded as its commencement; and that the nose has special relations with the respiratory apparatus, and constitutes the proper channel for the entrance and discharge of the air in breathing. At the same time the nose, especially in the lower animals, is intimately concerned with the selection of suitable nourishment; and the mouth takes a leading part in the functions superadded to respiration—namely, speech and vocalisation.

Sensation.—The mucous membrane of the mouth and fauces is generally extremely sensitive, and parts of it are endowed with specific sensory properties. The lips and tongue are exquisitely delicate organs of touch. The tongue, mainly at its tip, edges, and root, and also the soft palate, and some of the neighbouring parts, are the special seats of the sense of taste. It is, besides, to the fauces that the sensation of thirst is particularly referred; and their irritation causes nausea and vomiting.

Mastication, etc.—When solid food is taken into the mouth, as in biting a slice of bread-and-butter, the detachment of the mouthful from the rest of the mass is effected by the incisor or cutting teeth. If a piece of tough crust be encountered, the incisors are probably found insufficient for the purpose, and the canine, or tearing teeth, are called into requisition. But when once received into the mouth, the mass is conveyed to one or other side, is kept between the grinders by the action of the tongue and cheek, and (partly by crushing, partly by grinding) is gradually reduced into a pulpy mass suitable for reception into the stomach. This preparation of the food is largely aided by the fluid secretions of the mouth, which flow especially abundantly during the process of chewing or mastication, and, mingling with the disintegrated food, convert it into a soft, plastic mass. The fluids here referred to are, partly, the mucus, which is yielded from all parts of the mucous membrane, but mainly the secretion of the salivary glands, which has a specific influence in converting starchy matters into substances of greater solubility, and more fitted for ready absorption into the system.

Deglutition or Swallowing.—The food thus prepared is then conveyed to the stomach. The process by which it is conveyed is really simple, but like many other simple processes difficult to describe. It has to find its way to the back of the mouth, thence through the faucial aperture, thence into the pharynx, thence along the œsophagus, and finally into the stomach. It has, moreover, while traversing the pharynx, to be prevented on the one hand from passing into the nose through the posterior nares, and on the other hand from slipping into the larynx, over the upper orifice of which it necessarily passes in its course.

The process is effected in the following manner. The bolus of masticated food is carried by voluntary effort to the back of the mouth, this conveyance being effected mainly by placing it first on the dorsum of the tongue, and then (beginning in front and proceeding gradually backwards) forcibly pressing the tongue against the palate. In this way the bolus is carried back into the fauces, where all voluntary control over it ceases. The fauces involuntarily close upon it, and, with the aid of the back part of the tongue, squeeze it onwards into the pharynx. Then the muscular walls of the pharynx act similarly, propelling it into the œsophagus; which tube, contracting with a powerful and rapid undulating movement, commencing above and travelling downwards, conveys it in a few seconds into the stomach. The intrusion of food into the upper compartment of the pharynx, and consequently into the nose (and, may-be, into the Eustachian tubes) is prevented by the closure of the communication between the lower and upper parts of the pharynx by means of the soft palate; and the larynx is protected, partly by the approximation of the vocal cords, and the consequent shutting of the *rima glottidis*, but mainly by the closure of the upper opening of the larynx by the backward pressure of the tongue, and the falling back of the epiglottis over it.

It may be added that, not only in certain paralytic conditions affecting the fauces, soft palate, and larynx, do these protective mechanisms fail to act, but that occasional failure may result from accidental circumstances, as when a cough, laugh, or sudden inspiration occurs at the moment of swallowing, and the food consequently is propelled in part into the nose, or "goes the wrong way."

The *swallowing of fluids* is effected in precisely the same way as the swallowing of solids, but is so far more difficult that any disarrangement of the mechanism is attended with more liability to choke in the former than in the latter case.

Sucking, as performed by babes, is determined by a piston-like movement of the tongue, by which a vacuum tends to be created between the tongue and palate, so that by atmospheric pressure the milk or other fluid is driven into the resulting cavity, whence it is conveyed to the back of the mouth and swallowed in the usual way.

Respiratory and Associated Functions.—The proper respiratory passages, so far as we have to do with them, are the nose, pharynx, larynx, and trachea. But in order to complete the enumeration of the true respiratory organs, we must add the bronchial tubes and lungs, which are contained in the cavity of the chest, and the thoracic parietes, by the alternate expansion and contraction of which air is alternately drawn into and expelled from the lungs.

The introduction of air into the lungs is for the purpose of conveying the oxygen of the atmosphere, primarily into the ultimate tissues of the lungs, and thence (through the agency of the blood) to the general organism; wherein it acts directly in oxidising or slowly burning the effete or waste products of the body, and so promoting their discharge from the system through the several excreting organs whose function it is to separate such products, and indirectly (through the heat generated in the process of burning) but not less importantly maintaining the bodily temperature. The act of expiration effects the double object of removing the deoxidised, and therefore no longer suitable, air from the lungs, in order to make room for a fresh and purer supply, and of discharging from the body carbonic acid gas, which is one of the important products of oxidation in the system, which imparts to the venous blood its relatively dark or venous hue, which in even moderate excess is a deadly poison, and for the separation or excretion of which no other organs than the lungs are available.

The alternate movements of inspiration and expiration, therefore, are essential for the preservation of life; they are constantly performed at the rate of about eighteen a minute, both sleeping and waking, and (in health) without sensible effort; they cannot be restrained for many seconds without a sense of distress, which rapidly augments while the period of suspension of respiration is maintained, and ere long becomes insupportable; and if they be arrested by mechanical or other means, which cannot be overcome, death, preceded by insensibility, ensues in the course of a minute or two.

We have already pointed out that, while the nose is doubtless the primary and special channel for the entrance and discharge of breath, the mouth is not only capable of performing the same function, but under certain conditions constitutes the chief or even sole agent in the performance of this duty. But we repeat that for the simple purpose of respiration the nose has special endowments. In its lower chambers (which are mainly concerned in this duty), the epithelial lining, like that of the larynx, trachea, and bronchial tubes, is endowed with peculiar vibratile fringes, termed "cilia," whose purpose is respiratory; while the mucous membrane is largely vascular, and the channels are narrow and tortuous, so that the air in its passage over and along them becomes delayed and warmed, and is thus rendered suitable for admission into the lungs. When, however, respiration is effected by the mouth, as happens when the nose is obstructed from any cause, and also occasionally during sleep, the evaporation of the moisture of the mouth which attends it always makes the mucous surface of this part clammy or dry and uncomfortable.

The functions which, so to speak, are engrafted on respiration, are smelling and speech.

The *sense of smell* may be regarded in some degree as a simple adjunct to the sense of taste (with which it has close physiological relations), and as a guide in the choice of food. It is also a guide to us in the detecting and avoiding of agencies likely to be deleterious when drawn into the lungs. But like our other senses, it constitutes, apart from its primary object, one of our important sources of pleasure. Gaseous fluids, in their ordinary tranquil journey from the anterior nostrils to the lungs, scarcely reach the olfactory region, and delicate or faint odours possessed by them may thus be scarcely or not at all appreciated. For the full development of the sense of smell, it is necessary that the air be drawn in through the nose with sustained force, or in a succession of pretty powerful sniffs.

Voice and Speech.—Of all the attributes of the group of organs now under consideration, those of voice and speech are the most complicated, have the closest relations with all that is intellectual in us, and are in every point of view the most interesting. We proceed, therefore, to discuss them in some detail.

Before they can be understood it is necessary to have a knowledge of so much of acoustics as concerns them. And as we are bound to assume that most of our readers are more or less ignorant of this subject, we proceed to make some remarks upon it.

All sounds are caused by waves of alternate expansion and contraction, which traversing air or water or solids (as the case may be) fall upon the drum of the ear, whence they are conveyed along the ossicles of the middle ear to the fluid contents of the internal ear, and thence to the specially arranged rootlets of the auditory nerves, which carry the acoustic impressions to the brain, where they become perceptions of sound. These waves are produced or determined by forces (for the most part acting with more or less suddenness or violence) exerted on the medium in which they originate; and they tend to travel more or less rapidly in widening circles in the same manner as the circling waves spread over the surface of water from the point at which it has been disturbed by a stone. Sounds are musical or unmusical.

Musical Sounds are the product of waves or undulations of uniform length, following one another at equal intervals, which are so short that the individual waves are undistinguishable by the ear as separate sounds, but blend acoustically into continuous notes. The varying characters of musical sounds depend on loudness or volume, pitch, and quality or timbre.

Loudness or volume has no relation to the length of the waves or to their form; but depends solely on their amplitude; that is, on their height if they be represented by the vibrations of a string; but on the intensity of the molecular movement if they be represented as waves of alternate condensation and expansion.

Pitch relates to the highness or lowness of the musical sounds, and depends wholly on the rapidity with which wave follows wave; or, in other words, on the length of waves in the same medium. Thus, the lowest audible note is composed of waves which follow one another at the rate of about sixteen in the second, and individually measure about sixty-four feet in length; whilst the highest audible note consists of waves following one another at the rate of about 38,000 in the second, of which each measures about one-third of an inch in length. Any note which is the octave above another consists of waves which are exactly twice as rapid and half as long as those of the latter; and of course, conversely, every note which is an octave below another is formed by waves of half the rapidity and twice the length of those due to the other note.

Quality of sound is determined by the form or complexity of the vibrations; but especially, perhaps, by the latter condition. Thus, in most musical sounds, the primary or fundamental waves, whose length and rate per second determine the notes, are overlaid, as it were, by a more or less complex series of subordinate waves, just as the larger waves on the surface of water are rippled over with groups of waves of smaller dimensions. But these subordinate waves (in the case of sound-waves), however numerous and various in amplitude they may be, are always aliquot parts of the larger waves; are always (for example) half, a quarter, one-eighth, one-sixteenth part of them, and so on, and thus blend harmoniously with them, mingling the higher notes due to themselves with the fundamental tones due to the primary vibrations. The secondary, or *harmonic* sounds, which mingle with the primary or *fundamental* notes, differ in number and individuality, and also in relative intensity in different cases. And it is due to differences in these superadded conditions that the same notes produced by different musical instruments, and by human voices, differ characteristically from one another.

Unmusical sounds or *noises* are either due to undulations, which are solitary, so that no musical quality can possibly attach to them; or produced by groups of vibrations which are of unequal length, and follow one another irregularly, or which possibly (while of equal length) are irregular in volume and intensity. Not infrequently sounds which are unmusical in themselves are followed or attended by comparatively feeble musical resonances. This is exemplified in the specific sounds of consonants, and also in the sound of the footfall in a vault or between high walls.

Let us now return to the consideration of the organs of speech. The sounds of speech are made up of two distinct, though associated, elements: namely, first, the *voice*, or sounds (for the most part musical), produced in the larynx, at the *rima glottidis;* and, second, *articulate sounds*, which are essentially the product of the parts above the larynx, and mainly of the mouth, and to a large extent are engrafted on the laryngeal sounds.

Voice.—The larynx is a musical instrument of great beauty, and (within its limits) of great perfection; but while it is capable of evolving a fairly wide range of musical notes, it is wholly incapable of moulding them into articulate sounds. The music of the voice depends upon it alone. What is the nature of the instrument, and how does it act?

Musical instruments are of various kinds; but there are three varieties, to each of which it has been supposed to have some kind of relation: namely, first, the organ; second, stringed instruments; and third, reed instruments.

The *organ* consists of a series of pipes of different lengths, the vibrations of the air within which cause musical notes, the pitch being determined solely by the length of the pipe in which vibration is taking place. The longer the tubes the deeper the notes, and conversely. In this instrument the air is put into vibration by means of a tongue or reed, over which air is made to pass with more or less violence. The resemblance of the larynx to an organ-pipe is due to the association with it of the pipes of the trachea and larger bronchial tubes; the vocal cords being the reed. But that it is really not an instrument of this nature is shown by the fact that, while an organ-pipe is capable of producing only one fundamental note—namely, that due to its length—

the organ of the voice is capable of uttering all the notes embraced within two or three octaves, even though the tube associated with it undergoes no material change of dimension. Moreover, the deeper notes of the voice would need for their production a much longer tube than that of the combined air-passages.

The relations of the larynx to a *stringed instrument* reside mainly in the fact that the voice is determined by the vibration of the vocal cords, which in the main obey the laws governing the vibrations of strings. We need not go fully into these laws. There are two, however, which concern us now. One is, that the vibrations of strings, equally stretched, equally thick, and of the same density, vary in number in a given time inversely as their lengths. Thus, if we have three such strings, of which one is four feet long, the second two feet, and the third one foot, and we assume the first to yield 100 vibrations in the second; the next will yield 200 vibrations, and the last 400. The other law is that, assuming the length, thickness, and density of a string to remain unaltered, the number of vibrations which it yields in a given time is proportional to the square roots of the numbers representing the weights or forces by which they are stretched. Hence, if three such strings be rendered tense by forces represented by one pound, four pounds, and nine pounds respectively, the second string will vibrate twice as rapidly, and the third thrice as rapidly, as the first. A further principle relating to strings is that, while by the rate, complication, and intensity of their vibrations they determine the pitch, and to a great extent the quality and power of musical notes, they effect this result not directly by their own vibrations (which in themselves are almost voiceless), but mainly by evoking similar concurrent vibrations in some sound-board to which they are attached. But, in the case of the larynx (although no doubt the vibrations of the vocal cords determine the pitch, and some of the other properties of the notes of the voice), this is due in a very small degree, if at all, to excited vibrations in the solid walls of the organ, but essentially to the rhythmical transmission of air through the chink which the vocal cords bound. The larynx is, therefore, not a *stringed* instrument in the usual sense of the term.

The third class of instruments to which the larynx has been likened consists of those known as reed instruments, in which a tongue, free to vibrate in a narrow chink, is made to vibrate rhythmically by directing a blast of air upon it; its vibrations determining the rhythmical transmission of air in puffs through the chink, by which rhythmical puffs, and not by the tongue itself directly, nor by the solid material to which the tongue is attached, the musical note is produced. The essential difference, it may be remarked, between these instruments and organ-pipes (which are also wakened into sound by reeds) is this :—in the organ-pipe the reed merely causes a flutter which evokes the fundamental note of the pipe; in the true reed instrument the reed determines the note. It is clear that the larynx, if not a true reed instrument, has at any rate very special relations thereto.

Let us consider now, with particular reference to the above remarks, how the larynx acts in the production of sound. Whenever we are about to sing or speak aloud, the vocal cords are made more or less tense, and brought into close apposition (Fig. 6, A, A^1); they touch one another in their whole length, and the space between them is obliterated. Then with more or less force, through the agency of the muscles of expiration, we drive the air accumulated in the lungs outwards along the bronchial tubes and trachea to the larynx, and through the *rima glottidis*, whence it passes onwards to the nose and mouth. The forcible transmission of air between the closely approximated and tense vocal cords throws them into synchronous vibration, and determines the passage of the air, not in a continuous stream, but in a series of jets or puffs, which correspond in frequency to their vibrations. These puffs are ample or the reverse, according as the vibrations of the cords are ample or the reverse; and have impressed upon them all those varieties of form due to the presence of secondary undulations or harmonics, which attend the vibrations of the cords themselves. So far it is clear we have a reed instrument to deal with; but it is a reed instrument in which, in place of a vibrating tongue placed within a narrow chink, we have two vibrating tongues or bands bounding such an orifice. The chief peculiarity of the laryngeal reed, however, is, that in the main it obeys the laws of strings, and determines the notes of the voice in accordance with these laws.

The principal cause of the varying notes of the voice is the varying tension of the cords in length, determined, as we have already shown, by the vertical rotation of the thyroid cartilage on the cricoid cartilage, and the consequent approximation or separation of the anterior and posterior attachments of the cords. When the cords are shortened and relaxed their vibrations are relatively few in number, and the notes are consequently deep; when they are elongated and tense their vibrations are relatively rapid, and the notes are consequently high. The law which mainly governs the vocal functions of the cords is the second of the laws previously quoted with respect to the vibrations of strings (namely, that in strings of the same thickness, density, and length, the numbers of vibrations yielded in a given time vary directly as the square roots of the stretching forces)—a law the exercise of which allows of the production of a wide range of sounds from strings of small dimensions. But the vibrations of the cords are not dependent wholly on the operation of this law, for the cords vary in length with the variations in the force which acts upon them, and at the same time become thicker or thinner, as the case may be. Hence, as they are relatively short when the force tending to elongate them is acting feebly; and as cords of low tension vibrate less rapidly than cords of high tension, while short cords (other things being equal) vibrate more rapidly than long cords, the tendency to slow vibration due to the former condition is modified by the tendency to rapid vibration due to the latter condition. And so, conversely, the cords become relatively long when they are forcibly pulled, so that the numbers of vibrations due to the increase of tension become diminished from the effects of their increased length. It is, nevertheless, certain that the various notes of the voice are determined essentially by variations in tension, and that the differences of length and of thickness modify the action of the law of tension only in a very slight degree.

The *Compass* of the voice—that is, the range of musical notes which it can evolve—varies, in different persons, from one to three octaves, and its collective total range is about four octaves. The voices of men extend about an octave lower in the scale than those of women. But, on the other hand, women's voices reach about an octave higher than men's. The difference between the sexes in this respect is due to the fact that in men the larynx is larger than in women, and the vocal cords are longer. There are two principal varieties of voice in men—namely, the bass and the tenor; and two principal varieties in women—namely, the contralto and the soprano. The *bass* is the lowest male voice, and its strength lies in the lowest notes. The *tenor* extends higher than the bass, but not so low. The *contralto* is the lowest female voice; the *soprano* the highest. It must be borne in mind, however, that these several voices may all be capable of uttering certain notes in common, and that even the higher voices may be able to produce notes low in the scale, and conversely. Essential distinctions between them are, that the strongest notes of each variety occupy a particular part of the scale, and that they present marked differences of quality or timbre.

Children's voices are higher than those of adults in consequence of the comparatively small size of their vocal organs; and even at this early period there is a marked difference in quality between the voices of males and females. Young boys' voices have a close resemblance to women's voices. In both sexes there is a change in the voice about the time of puberty; but, while in the girl this is slight and gradual, and occurs without any hitch, in the male the change of the child's voice into that of the man is attended with remarkable phenomena. In the latter case the conversion of the childish treble into the deep tones of the adult, which depends upon a rapid and characteristic development of the larynx, is marked by a transition period in which the voice becomes husky and uncertain, and apt to utter grave and high notes indiscriminately.

The remarks above made refer to the *natural* or *chest voice* alone. It is well known, however, that singers, and men in greater proportion and in greater degree than women, are capable of uttering two series of vocal sounds: one, the natural voice, which is produced with comparatively little effort; the other a higher and thinner voice (termed the *falsetto*), which is evolved with comparative difficulty and a sense of effort or constriction about the throat, some notes of which overlap the notes of the natural register, and which, as a general rule, does not amalgamate readily with the natural voice. Different explanations have been given by physiologists of the falsetto voice. There is reason, however, to believe, with Helmholtz, that through the agency of muscular fibres which are attached to the outer sides of the vocal cords, these may be rendered thinner at the extreme edges, and that the vibrations occurring in these edges produce notes of different quality from those due to the vibration of the cords in their entire thickness.

Another variety of voice is the *whispered voice.* In this there is no musical sound whatever, and indeed, if while whispering the *rima glottidis* be examined by means of the laryngoscope, it will be found partly open, and the conditions necessary for the production of musical sounds absent. The breath, in fact, in whispering, is made to escape with a kind of breezy sound through the partly open glottis. A somewhat similar sound is caused, in the same manner, during yawning or sighing, or whenever respiration is deep or rapid.

Articulate Sounds, which are the essential factors of speech, are effected mainly in the cavities above the *rima glottidis*, the mouth taking the principal share in their production. The proper sounds of the letters are elementary articulate sounds. And it is by the grouping of such sounds in various combinations that words are formed. Words are practically innumerable; but literal sounds are comparatively few. Let us consider their varieties and mode of production.

The *Letters of our Alphabet* are twenty-six in number, of which five are regarded as vowels, and the remaining twenty-one, with, perhaps, one or two exceptions, as consonants. Our alphabet, however, is imperfect in many respects. In the first place, many of the names applied to the letters are mere names, having little or no phonetic relation to the sounds they represent. In the second place, several letters are superfluous, standing (like *j*, *q*, *x*) for a combination of simple letters, or (like *c*) having two sounds, of which each is also represented by another letter. In the third place, many letters represent indifferently several distinct literal sounds. This is the case with all of the vowels, and with several of the consonants, such as *s*, *z*, *g*, and *y*. And lastly, there are several literal sounds for which we have no letter-characters, and which are indicated in practice by letters, or combinations of letters, which represent them conventionally only. Among the consonants unrepresented by proper characters are the *ng* in *tongue*, the *th* in *this*, the *th* in *thing*, the *sh* in *she*, the *z* in *azure*, and the German *ch* in *ich*, and as sounded also at the beginning of the word *Hugh*.

Vowels are sounds capable of continuous utterance without alteration of quality; they are the sounds which, with very few exceptions, are employed to give force to consonants, and to blend them into syllables, and they are the vocal sounds which in singing carry the music of the singer's voice. Their fundamental sound is the product of the larynx, and may be any note which the larynx is capable of uttering, or the mere breezy sound which characterises a whisper. In these respects the vowels are all alike and undistinguishable. Their mutually distinctive qualities are acquired in the throat and mouth, and (in the case of the French nasal vowels) in the nose, and are determined by differences of form which these cavities and their inlets and outlets are made to assume—differences of form which are special for each vowel-sound. It is an essential characteristic of vowels, however, that in their utterance there is a free channel for the continuous passage of air along the fauces and mouth, and between the lips.

The vowel-sounds in English are probably thirteen in number, and are represented in the vowel-sounds comprised in the following words: *far*, *fal*(low), *fell*, *fail*, *fill*, *feel*, *fur*(rier), *fur*, *fol*(ly), *fall*, *foal*, *full*, and *fool*. And they may be arranged in three groups determined by the positions which the organs of articulation assume in their enunciation.

The vowels of the first series are the first six in the above list. They seem related to one another, not only in sound, but because in their utterance the lips are separated from one another in their whole extent; and the differences between them appear to depend partly on the fact that in enunciating them in their order, from the first to the last, the orifice between the lips tends to become progressively narrower, but mainly on the fact that the tongue, which is much depressed and retracted in the utterance of *a* (in *far*), becomes progressively more and more elevated and projected forwards in the utterance of the others, until, in the pronunciation of *e*, the dorsum of the tongue leaves only a narrow channel between it and the palate, and the tip approaches within half an inch of the lower incisor teeth.

The vowels of the second series are *u* in *fur*(rier) and *u* in *fur*. In their articulation the mouth is kept slightly open, without effort, as it commonly is in ordinary quiet breathing, and the tongue, similarly at rest, lies on the floor of the mouth. These, in fact, are the easiest vowel-sounds to pronounce, and are the most common.

The last series comprises the remaining five enumerated vowels. There is a manifest relationship between them in sound, and in the fact that in pronouncing each of them the oral aperture assumes a rounded form. The size of this orifice becomes smaller and smaller as we proceed from the first to the last; and, as in the first series, the tongue, which is depressed and retracted in uttering the first, rises towards the palate and approaches the front teeth as the remainder of the series are in turn pronounced.

The above brief discussion merely shows that for the enunciation of each letter a particular arrangement of the organs of articulation has to be made; but it does not explain, or even hint, how it is that by such various arrangements we produce series of sounds which the ear distinguishes from one another with the utmost facility. The explanation of this phenomenon was suggested by Wheatstone many years ago, and has been put beyond dispute by Helmholtz. It is that the vowel-sounds differ from one another in the number, individuality, and intensity of the harmonics which cluster, as it were, around the sound emitted by the larynx, and that these are determined by the special resonating qualities which the oral and faucial canal presents, in the several varieties of capacity and form it assumes during the utterance of the several vowel-sounds.

Consonants are distinguished from vowels mainly by the facts that more complete barriers are opposed in the articulating organs to the passage of the breath than occurs when vowels are sounded, and that they are, in their mutually distinctive characters (which are given them above the larynx), clicks or noises which are distinctly unmusical.

Consonants admit of arrangement in several more or less natural groups. We shall not enter on this difficult subject at length or minutely, but shall endeavour to give such an account of them as may be generally intelligible. First, then, we have the consonants in pronouncing which the obstruction or barrier exists at the lips, or is formed by the lips and teeth: these are *b*, *p*, *m*, *v*, *f*, and *w*, and are termed *labials*. Next we have those in which the barrier is formed by the margin of the tongue and teeth: these, the *linguals*, are *d*, *t*, *n*, *th* in *this*, *th* in *thing*, *s*, *z* in *gaze*, *r*, *l*, *sh* in *she*, and *z* in *azure*. And, lastly, we have the *gutturals* in which the barrier is formed by the approximation of the soft palate and base of the tongue. The chief of these are hard *g* and *k*, *ng* in *tongue*, *y* in *youth*, and the German guttural *ch* in *ich*, or in the first sound of such words as *Hugh* and *Whewell*.

In the next place, we may divide the consonants into those which are *explosive* and those which are, like vowels, *continuous*. The former are only of momentary duration, and developed at the time either of closing a barrier or of opening it. They are *b*, *p*, *d*, *t*, hard *g*, and *k*. In forming the others the barriers are at all times imperfectly closed, and the specific sound is produced while the air is fluttering or streaming past the barrier. All the remaining consonants belong to this category. It is observable that these have all somewhat of the vowel character, that tunes may be hummed with such of them as are sonant, and that not unfrequently they take the place of vowels in the formation of syllables. The last syllable of "maiden" and "little" are examples, for the written *e* in either case is unsounded.

Again, consonants may be distinguished as *oral* and *nasal*. The latter are *m*, *n*, and *ng*, in pronouncing which the oral barrier is closed, but the communication between the fauces and nose remains open, so that the breath, during their utterance, escapes through the nostrils. In regard to all other consonants, the soft palate comes into relation with the posterior wall of the pharynx, and the nasal cavity is cut off from the parts below.

Lastly, consonants are divisible into *voiced* or *sonant*, and *voiceless* or *surd*. In the former series the consonantal sound is engrafted (as are the vowel-sounds) on vocal or laryngeal sound; in the pronunciation of the latter the *rima glottidis* is open, no laryngeal sound whatever occurs, and the consonantal sound is the simple, uncomplicated product of the mouth. The vocal consonants are *b*, *v*, *m*, *w*, *d*, *th* in *this*, *n*, *z* in *gaze*, *r*, *l*, *z* in *azure*, hard *g* and *y*. The unvocal consonants are *p*, *f*, *t*, *th* in *thing*, *s*, *sh* in *she*, *k*, and the German guttural *ch*. It may be observed that, in naming them, all consonants are associated with voiced or sonant vowels, and that, in determining whether consonants are voiced or not, they must be pronounced apart from vowel-sounds.

We have pointed out with, we hope, sufficient clearness, the scientific explanation of the acoustic differences between the vowels. What is the scientific explanation of the acoustic differences between the consonants? The explanation is of much the same kind in both cases; only, as respects the consonants, the fundamental sound, or that which determines the character of the consonant, is effected at that point in the mouth or throat at which the barrier or obstruction exists. Thus, the fundamental sound of *b* or *p* is produced at the lips at the moment of making or breaking contact, and the fundamental sound of *d* or *t* is produced in the same way, between the tip of the tongue and the anterior part of the palate, just above the front teeth. Now, in each of these cases the fundamental sound is a mere click or crack, something like the crack of a whip, momentary in duration, and wholly without musical character; and if the lips had not the cavity of the mouth behind them, or if the tip of the tongue had not a cavity in front and one also behind, the sound produced would be a mere click, and have no literal characteristic whatever. The clicks, in fact, derive their distinctive literal qualities from the fact that they are produced in relation with cavities wherein they evoke musical resonances which, blending with the fundamental sounds, convert them into letters. In *b* and *p* the resonance takes place in the general oral cavity, in *d* and *t* it takes place in the two differently sized portions into which the tongue divides this cavity. The differences between *m* and *b*, and *n* and *d* respectively, are (in addition to the continuous character of the nasal sounds) that in sounding *m* and *n*, the nose retaining its continuity with the fauces allows resonances also to take place in the nasal cavity, which blend with those occurring in the mouth. The above remarks have had reference chiefly to the explosive consonants. But the continuous oral consonants admit of a similar explanation. The essential sound in each case is produced by a kind of unmusical flutter developed during the passage of breath past or through the barrier, and the superadded oral resonances (determined as to quality by the various forms and sizes which the internal parts of the mouth assume for each case) give the consonants their distinctive characters.

A word or two may here be added with reference to the so-called consonant *h*, which is generally regarded as a simple unvocalised rush of air through the glottis opened widely. This, however, does not correctly convey its real character. It is, no doubt, an unvocalised sound; but the air which comes noiselessly from the larynx acquires sound in the mouth, through which it is forcibly driven. And a little examination will show that, in uttering it before any vowel or any consonant which admits of a preceding aspirate, the mouth assumes the form of the letter which it precedes; and that, in fact, in every case, it is the surd or voiceless equivalent of the sonant vowel or consonant in conjunction with which it is pronounced.

FUNCTIONAL DERANGEMENTS.

The effects of disease, apart from the local processes (such as inflammation, the growth of tumours, and degeneration or destruction of tissue) which accompany it and indicate its presence, are essentially exaltation of function, impairment of function, and perversion of function. Let us consider what are the functional disturbances which characterise affections of the organs now under consideration.

And first, as regards the mucous membrane. The duties which this has to perform are—to act as an organ of common sensation, to minister to the special senses of smell and taste, to secrete a protective mucus which lubricates the surface, and itself to protect the parts that lie beneath it.

Common sensation exists throughout the whole of the ori-nasal surface, and throughout that of the fauces, pharynx, and larynx. It depends on the abundant distribution to these parts of sensory nerves derived from the base of the brain. It varies, no doubt, in quality in different regions, and serves partly to protect the organs from injury, partly to guide them in their actions. The tactile sensibility of the nose readily recognises degrees of temperature ; it is through it that the nose resents the intrusion of irritant gases such as ammonia or sal volatile, and it is through muscular co-ordinations brought into play by irritation of this surface that sneezing is produced—a violent spasmodic expiratory action, in which the blast of the air from the air-passages is directed mainly through the nose for the purpose of expelling offending matters within it. The sensibility of the mouth, which is peculiarly developed in the lips and tip of the tongue, is of service partly in determining whether matters taken into the mouth are hurtful through their hardness, angularity, temperature, or chemical attributes, but mainly by guiding our lips, tongue, and cheeks, in the complicated movements connected with mastication. The sensibility of the fauces and pharynx is mainly instrumental in evoking the automatic phenomena of deglutition, or swallowing, actions over which the will has no direct control. It is this same kind of sense which compels the soft palate, in swallowing, to guard the posterior entrance to the nose, and the laryngeal muscles to close the glottis. The sensibility of the larynx and windpipe is protective against the entrance of offending matters, and, under the influence of irritation, causes the protective act of coughing.

In disease these sensory functions are sometimes exalted : influences which in health have little or no effect, now provoke unwonted sensory impressions, or evoke in an extreme degree spasmodic movements, such as sneezing, constriction of the pharynx, and closure of the glottis. Sometimes they are impaired or annulled. Sometimes they are perverted, and the patient suffers from neuralgia, or some other form of uneasy sensation.

Similar observations may be made as regards the special senses of taste and smell. These may be rendered oversensitive, and impressions that would have been agreeable or scarcely noticeable in the normal state now become disagreeable, painful, or unbearable. They may undergo diminution or be destroyed ; or they may become perverted ; and, moreover, the patient may suffer from what is equivalent to neuralgia in the nerves of common sensation—namely, subjective sensations of smell or taste; or, in other words, he may experience smells or tastes (for the most part disagreeable ones) which are not due to the action of sapid or odorous substances, but take their origin in some affection of the gustatory or olfactory nerves.

The several phenomena above enumerated may be due to various causes. They may be a consequence of morbid changes taking place in the mucous membrane itself, and in the nerves included in it; or they may be due to affections of the nerve-trunks which are the carriers of impressions to the brain; or they may be determined by morbid conditions of the substance of the brain itself. It may be observed that when the cause of the symptom is some affection of the mucous membrane, this generally manifests changes visible to the naked eye which are sufficient to explain them; that when it resides in a nerve-trunk the symptoms are limited to the area of distribution of the nerve, and are consequently unilateral, and stop short at the median plane of the body; and that when it is seated in the brain itself the symptoms are sometimes unilateral, but occasionally general, and often associated with phenomena due to similar affection of the nerves of other regions of the body.

The secretion of mucus in health is only sufficient to keep the surfaces moist. In disease the mucus may be augmented in quantity, it may undergo diminution, or its quality may be altered. All these phenomena are well exemplified in the course of an ordinary catarrh of the nose. In the first instance, the mucous membrane becomes swollen and dry; later the secretion becomes re-established, but it is now formed in excess; and, further, it is materially altered in character—being at one time thinner and more watery than true mucus should be, and irritating to the parts over which it flows, at another time thick, opaque, and ropy. But the moisture of the mouth is not wholly or even chiefly mucus, for three pairs of salivary glands are constantly pouring their specific secretions into the oral cavity, where they mingle with the mucus, and aid importantly in the mastication and reduction of the food. The saliva, again is, liable in disease to be modified in each of the three ways above indicated.

The acts of prehension, mastication, and swallowing, demand for their perfect performance the integrity of all the organs concerned in the process. For the division of solid food and its reduction to a pulp, not only must the teeth be in good condition, but the muscles which open and close the jaws, and those which make the lower jaw rotate horizontally on the upper jaw, must retain their inherent strength, and the nerves which convey the behests to them from above must also be in working order. Further, in order to retain the food within the mouth the lips must be capable of closure, and the muscles of the cheeks must be able to co-operate with the tongue in retaining the food between the teeth, and, finally, in placing the food on the dorsum of the tongue preparatory to its being swallowed. And again, in order that the act of swallowing may be effected easily and without hitch, the base of the tongue, the pillars of the fauces, and the other muscular walls which co-operate in the process, must be in condition to act in unison and with promptness. Lastly, it must be pointed out that the sensory attributes of the mucous surface constitute an essential factor in the performance of these duties. If the lips do not feel, they can scarcely act efficiently in retaining food within the mouth. If the tongue and cheeks be without sensation, the presence of food in the mouth cannot be recognised, and it is scarcely possible that it should be "manipulated" with dexterity. And if the fauces and pharynx be devoid of sensation, or rather, perhaps, be devoid of that sensibility which determines reflex action, the act of swallowing—which is a purely reflex phenomenon, and wholly independent of voluntary effort—would become impossible.

The circumstances which interfere with the due performance of the above functions are numerous, and their modes of operation are widely different. If the lips, or gums, or cheeks, or tongue, be inflamed or sore, or the seat of morbid growth, it is clear that the uneasiness or pain attending mastication will interfere more or less with its effectual performance. If the salivary and other secretions be scanty, and the mouth therefore dry, solid food will be difficult to deal with; it will crumble, will be incapable of being collected into a coherent mass, and will be difficult both to bring within the influence of the teeth and to form into a bolus suitable for swallowing. If the teeth be absent or defective, the due comminution of the food becomes a matter of difficulty, or even impossibility; and, again, the duties which should be effected within the mouth are inefficiently performed.

The most serious difficulties which interfere with the duties of the mouth, in relation to the digestive functions, are those which are referable to the nerves of sensation or motion, or to the nervous centres with which these nerves are in relation.

As before pointed out, when nerves alone are affected the resulting paralysis or spasm is, for the most part, unilateral or one-sided. The particular affections of this kind generally met with are paralysis of the nerve which supplies the muscles of expression; paralysis of the nerve which is the medium of common sensation for the face, nose, and mouth, but which also is the motor nerve of the proper muscles of mastication; and paralysis of the nerve governing the movements of the tongue.

The first of these nerves is the motor nerve of the muscles which move the lips, and also of that muscle which, extending in the form of a sheet from the upper to the lower jaw, constitutes an essential part of the cheek. The effects of paralysis of these special parts are, first, as regards the lips, that they are pulled towards the healthy side in consequence of the unopposed action of the muscles on that side, that the mouth is neither opened so widely nor closed so firmly on the affected side as on the other, and that food and saliva, and more especially fluids, are imperfectly retained; and, second, as regards the cheek, that this becomes flaccid, and having, consequently, no power to contract on the food which finds its way into the pouch between it and the teeth, permits of the passive accumulation of the food there until, probably, it has to be dislodged by the finger.

The second of the nerves above referred to supplies sensory fibres to the whole of the side of the face from above downwards, and also to the interior of the mouth and nose on the corresponding side. When this, therefore, is affected—to speak only of the mouth—one-half of the lips, one-half of the tongue, and one-half of the interior of the cheek and gums, up to the median plane of the body, are wholly devoid of feeling. The cup, when taken between the lips, feels broken at the point where sensation ceases, and neither touching, nor cutting, nor burning is perceived upon the affected side. Consequently, although the muscular strength may be fully retained, their inability to appreciate what is required of them renders the muscles as useless as if they were paralysed; so that, as in the former case, the food is apt to fall from the mouth, or to collect in the pouch between the teeth and cheek. If, at the same time, the special muscles of mastication be involved, the preponderating action of those on the other side causes lateral displacement of the lower jaw during mastication, and impairs the efficiency of the act of chewing.

Paralysis of one-half of the tongue is attended with less inconvenience than might be supposed. In protruding the organ its tip is made to incline to the sound side, owing to its active side overcoming its passive side in the process; and in drawing it back again, the converse phenomenon occurs. Mastication and deglutition, however, are but little interfered with.

In one-sided paralysis of the body (hemiplegia, as it is called) incomplete paralysis affects the voluntary muscles of one side of the face, tongue, and mouth. The lips, the tongue, the cheek, and the muscles of mastication, are equally affected. But it is an interesting fact that the muscles over which the will has no special control, and those which cannot by voluntary effort be dissevered in action from those of the opposite side, do not share (or share almost imperceptibly) in the paralysis. Hence the muscular walls of the fauces and those of the pharynx escape; so that, while there may be a little difficulty in prehension and mastication, there is none in swallowing.

But paralysis of cerebral origin is occasionally of irregular distribution, or affects both sides equally. One variety of this is exemplified in general paralysis of the insane. Another variety is that sometimes called bulbar paralysis, where the damage causing it is seated in that part of the base of the brain which is the immediate source of most of the motor and sensory nerves of the head and face. A third variety is that which so often follows on diphtheria, during the period of convalescence. In the first place the patient loses, for the most part in equal proportion, smell and taste, common sensation, and the power of motion, and has (as the consequence of the last condition) progressive loss of power of mastication and swallowing, and finally is likely to die choked. In the second case, the progress of the disease is, for the most part, unattended with any mental impairment. Taste and feeling are rarely lost. But as the disease develops, the lips become large, loose, and pendulous, incapable of complete closure, and requiring, perhaps, to be brought together by the hand when the upper one has been largely elevated in the act of laughing; the tongue becomes large and flabby and lies almost motionless on the floor of the mouth; the soft palate and fauces lose power; and, as a consequence of these conditions, saliva drips from the mouth and accumulates in the oral cavity, mastication becomes almost impracticable, and it is difficult or impossible to carry food from the mouth to the fauces, so as to start the act of swallowing. Moreover, when the food reaches this part (having either been pushed on by the finger or allowed to fall there by throwing the head back), it is swallowed with difficulty, and not infrequently finds its way into the nose or goes down the "wrong way." In diphtheria the paralysis is symmetrical, and, for the most part, evanescent, and sensation and motion are both liable to suffer. The paralysis is apt to be more or less widely distributed; but, so far as the organs under consideration are concerned, there may be loss of feeling in the lips or tip of the tongue, but the motor paralysis is usually limited to the throat, and is consequently indicated by difficulty of swallowing and the entrance of food into the nose and windpipe.

But besides paralytic affections we meet with the converse condition of spasm. Amongst the most interesting and important varieties of spasms may be enumerated those of chorea or St. Vitus's dance, those of tetanus, and those of hydrophobia. In the first case the lips and tongue generally share in the odd fidgety movements which characterise the disease, and the presence of these movements sometimes interferes seriously with mastication and deglutition. One of the most striking features of tetanus or lockjaw is the more or less persistent spasmodic closure of the jaws, liable, however, to frequent aggravation, attended with painful cramps in the muscles, and preventing in large degree the administration of food. In hydrophobia the spasm affects mainly the throat, and in the height of the disease is brought on not only by any attempt to swallow fluids, but even by the sight or sound of water, or by a breath of air.

Affections of Respiration.

By far the most interesting affections implicating the mouth and throat are those which involve respiration, voice, and speech; and these we now proceed to discuss.

The function of respiration suffers in a greater or less degree in a large number of affections, most of which are beyond the sphere of our present investigations. Respiratory troubles due to affections of the nose, mouth, and throat, are likely to be more severe as we pass from above downwards, and necessarily culminate in affections of the larynx itself.

The symptoms which indicate impediment to respiration vary in their intensity and in the rapidity with which they are developed. But essentially they are those of asphyxia, or symptoms depending on the poisonous effects of carbonic acid (which should be thrown off during respiration) retained in the blood.

The purposes of respiration are: first, the furnishing of the oxygen of the atmosphere to the blood, for the purpose of destroying effete matters by slow combustion, and maintaining the animal temperature; and, second, the elimination of carbonic acid, one of the chief products of this combustion, which accumulates in the venous blood, and is a virulent poison. Now, when respiration is impeded the due amount of oxygen does not enter the blood, and the due amount of carbonic acid does not escape from it; and consequently, the venous blood, remaining unpurified or imperfectly purified in the lungs, passes thence into the arteries still as venous or dark blood and, with the persistence of impediment, the blood generally becomes darker and darker.

The immediate effects of the poisoned blood are exerted mainly on the circulatory organs and nervous system. As regards the organs of circulation, we observe that very soon the altered blood finds its way with difficulty through the small vessels of the lungs, and that consequently, while the left side of the heart becomes starved (so to speak) of blood, the right becomes overloaded ; and, as a later consequence, that, while the arteries become empty, the veins and capillary vessels become distended ; and that, depending on these conditions, the pulse becomes feebler and feebler, the visible veins appear enlarged, the general surface grows more or less leaden-coloured, or livid (especially those parts of it which are generally rosy) and swollen, and the temperature tends to fall. As regards the nervous system, we observe that the patient complains of headache and noises in the ears, and that he tends gradually to ramble in his mind, and ultimately to become comatose or insensible. But, associated with the symptoms above detailed, we have other symptoms which are referable to the exaggeration of that instinctive sense and impulse on which the due performance of our respiratory actions in health depends. In the presence of any serious and persistent impediment, the sense of want of breath increases to agony ; and the acts of respiration become almost frantic in their violence. The patient opens his mouth widely ; the ordinary muscles which move the chest act with violence; and additionally other muscles, which have only an indirect influence over the movements of respiration, are called into play. The patient, moreover, has probably to sit up in bed or to rise to the standing position, and to clutch at things above his head, in order to give his powerfully-working muscles due leverage.

The symptoms of dyspnœa are the same essentially, whether the impediment be slight or severe, whether it be acute in its development, or of slow progress. If, however, it be slight, it may well be (in some cases, at any rate) that increased respiratory efforts succeed in ensuring the due supply of oxygen, and the due discharge of carbonic acid; and the symptoms of carbonic acid poisoning consequently do not arise. If it be of slow development, the respiratory actions may never be exceedingly violent; and the consequences of carbonic acid poisoning may be fully developed only after the lapse of some weeks or months. Under these circumstances phenomena which have not time to appear in rapid asphyxia gradually arise: these being mainly dilatation of the right side of the heart, permanent enlargement of the veins, general dropsy, and the results of long-continued congestion of certain internal organs. The tendency to loss of temperature, also, is more marked in these cases than in others.

In rapidly fatal asphyxia, as in drowning or strangling, or even as in acute inflammatory affections of the larynx, the phenomena of asphyxia arise rapidly, and the symptoms, which are terrible to witness and painful to suffer, speedily culminate in coma or insensibility and death.

In connection with the subject of dyspnœa we may draw attention to the process by which irritations or impediments seated in the strictly respiratory passages—namely, the larynx, trachea, and bronchial tubes—are removed or attempted to be removed for the most part automatically : we mean the act of *coughing*. This effects for the true respiratory passages what sneezing effects for the nose. Ordinarily the steps of the process of coughing are as follows :—1st, a deep breath is drawn ; 2nd, the laryngeal orifice is tightly occluded by the juxtaposition of the vocal cords ; and 3rd, the muscles of expiration, by a sudden violent and combined effort, discharge the accumulated air in the lungs along the air-passages and through the glottis, which itself spasmodically opposes the escape of air. The air is expelled with much violence, and carries with it such offending matters as are capable of dislodgment.

Coughs, however, vary in character. In some cases, as in the early stage of hooping-cough, they are incessant, hacking, and, for the most part, dry. In some, as in the later and characteristic stage of the same disease, they are spasmodic in a special sense : the patient is seized with a sudden propensity to cough, which is continued by a succession of more or less noisy expiratory shocks, without any intervening inspirations, until all the available air is expelled from the chest, and the patient is livid in the face, and possibly even becomes insensible ; when suddenly he draws a deep and prolonged inspiration through the still contracted glottis, with a prolonged sound (a whistle or whoop), which gives its name to the disease. Not infrequently prolonged coughs lead to irritation of the fauces and pharynx, and this induces (again, as in hooping-cough) vomiting.

The noise which attends the shocks of coughing will be readily understood from the above account. It is effected mainly, as are vocal sounds, by the forcible emission of air between the closed and tense vocal cords ; and the variations which it presents depend upon the presence of modifying causes. If the blast be strong, the sound produced (other things being equal) will be strong also. If it be feeble, we may expect the sound to be weak. It is generally loud and brassy when the vocal cords are modified in character by inflammatory changes ; and, on the other hand, it is apt to be voiceless and wheezy when inflammatory products or diphtheritic membranes invest the vocal organs and narrow the channel for the escape of air. Hysterical coughs, which are by no means rare, are often loud and barking.

Affections of the Voice.

The voice, apart from articulation, is (as we have shown) effected essentially at the *rima glottidis*. It is there alone that its pitch and loudness are determined ; and it is there, mainly, that it derives the timbre or quality by which we recognise the voice as being that of one person or another. Other harmonics, however, are added above the glottis, which, mingling with the voice as it is emitted from that part, tend, in a greater or less degree, to modify its quality as it escapes from the mouth.

Any affection of the throat which interferes with its normal condition influences the character of the voice. If the throat be inflamed, and stiff and swollen, and especially if the tonsils be enlarged, and the faucial passage consequently contracted, the voice acquires a peculiar character which is extremely difficult to describe, but which all persons probably have recognised in some one or other of their acquaintances. If the soft palate be paralysed or partly destroyed, or if a communication exist through the hard palate between the nose and mouth, the voice acquires a snuffling, nasal character, which again is well-marked and commonly appreciated.

Affections of the larynx itself are the most frequent causes of modification of the voice. Such affections are, mainly, inflammation; diseases attended with specific implication of the vocal cords (such as diphtheria, small-pox, and leprosy); morbid growths (such as cancer, tubercle, and lupus); and affections due to paralysis, or spasm.

In inflammation the vocal cords become thickened and softened, and are apt to be studded with adherent flakes of mucus. It is natural, therefore, that the voice should be rendered rough and hoarse, that its range should become contracted and the high notes especially fail, and that its utterances should be uncertain. It is often louder and harsher than natural in the early stages; but, later, tends to become weak and husky, and occasionally to be reduced to a mere whisper. In diphtheria and other cases in which the cords become invested in copious exudation, the voice naturally before long fails, and the patient becomes aphonic.

Similar phenomena occur in most of the other affections above enumerated; but the permanent mischief, which always results from such affections as cancer, tubercle, leprosy, lupus, and the like, necessarily leads before long to permanent impairment and ultimate loss of voice.

Paralytic Affections of Voice.—The most interesting modifications of the voice, however, are those which occur in connection with paralytic and other nervous disorders. Of these, many varieties are recognised and described by those who have paid special attention to the subject. There are two or three only to which we need refer.

The nerves which minister to the movements of the larynx are the pneumogastric nerves, derived from the medulla oblongata. Each of these gives off two branches to supply the corresponding half of the larynx. The upper branch is the nerve of sensation, and supplies motor fibres to one or two muscles only. The lower branch is the main motor nerve, and supplies nearly all the laryngeal muscles. Any disease destroying or obstructing one of the pneumogastric nerves causes complete sensory and motor paralysis of the half of the larynx on the the same side; and any similar affection of either of the special laryngeal nerves causes paralysis of the parts included in the area of its distribution. It is a curious fact, however, that that branch of the left pneumogastric which especially supplies the muscles is the nerve which, above all others, is liable to be involved in disease. This nerve takes a peculiar course: running down from the point at which it is given off from its trunk in the neck, it dips into the upper part of the chest, winds round the transverse arch of the aorta (the arterial trunk which comes direct from the heart), and, retracing its steps, ascends in the neck between the windpipe and the gullet, until it reaches the laryngeal muscles, to which it is distributed. In this long and tortuous course it is exposed to two main dangers. In the first place, if dilatation or aneurism of the transverse aortic arch takes place (and this is a frequent seat of aneurism), the nerve becomes stretched or compressed, and at length destroyed; and, in the second place, if the gullet be the seat of cancer (and this is a not uncommon disease), the morbid growth is apt to implicate the nerve. In both of these cases the left vocal cord becomes paralysed in its movements and stationary: a condition which reveals itself symptomatically by hoarseness or loss of voice, and can be recognised by inspection of the larynx by the laryngoscope. This paralysis is one of the most striking and important symptoms of these diseases, and is very often one of the earliest indications of the formation of an aneurism.

Diphtheria and hysteria are apt to cause paralysis of the vocal cords. But in these cases the paralysis involves both cords equally, is transient, or at any rate remediable, and is for the most part incomplete. In diphtheria it follows on affection of the throat, and is associated with the other characteristic paralyses of diphtheria. In hysteria, the loss of voice (which is often in the first instance induced by a cold, or by a mental shock) is usually associated with other more striking symptoms of hysteria. Moreover, the patient under excitement, or under the influence of a locally applied electric shock, may often be made (notwithstanding her paralysis), to call out at the top of her voice.

Another cause of nervous aphonia is chorea or St. Vitus's dance. In this disease there is often manifest difficulty of speech, the words coming out spasmodically. But occasionally complete aphonia, lasting for some time, may be observed. This is probably due rather to spasm than to paralysis.

The effects of age, of practice, and of abuse of the voice, are other subjects of interest, and in many respects of much practical importance.

We have already shown that the voice, in pitch, in quality, and in power, differs in the two sexes, and in the periods of life anterior to and succeeding puberty. The voice also undergoes changes with advancing life. This is particularly noticeable in the case of singers, who, sooner or later, suffer impairment not only of quality and power, but also (and very markedly) of compass. The extreme, and especially the higher, notes in the register are lost soonest. But what occurs in them occurs also, in a greater or less degree, in all persons. Further, in old age, the voice, from feebleness and uncertainty in the use of the respiratory organs, very often becomes tremulous.

By education, as is well known, not only may the voice be improved in strength and quality; but, within certain limits, the facility may be acquired of producing notes both higher and lower than those which the voice in its uneducated state could utter. Education also effects other improvements which are important not only for the singer, but for the speaker. Such are, economy in the use of breath in phonation, the art of managing inspiration, so as not only never to get out of breath when speaking or singing, but to draw the breath in at moments when it least interferes with utterance, and the art of allowing the freest escape of vocalised breath through the fauces and mouth. Untaught singers and speakers not only tend to constrict the throat, but often phonate with insufficiently separated teeth and lips: faults which impair the resonance and quality of the voice, and render it indistinct.

It need scarcely be said that the application of the voice to singing demands something more than simple perfection of the mechanism by which vocal sounds are produced. The due use of the voice for this purpose requires the presence of the mental faculty of appreciating the relations of musical sounds to one another, and those combinations of them which are beautiful and pleasure-giving. Without the possession of a so-called "ear," the most beautiful and flexible voice will fail to produce music. With its possession, the harshest and most unpromising may be educated to some degree of musical excellence. There are few persons, however, who are so devoid of musical instinct as to be utterly incapable of benefit from musical training.

It may be added, as tending to show that the larynx is a simple musical instrument, and that articulation is in a sense a function independent of that of phonation, that, in consequence of disease, the larynx has been excised by the surgeon, and its place supplied (for the purpose of speaking) by an artificial larynx, the glottis of which has been made by a metallic tongue, as in the accordion. The result has been that the patient has been enabled to speak perfectly intelligibly, articulation being (as might have been surmised) perfect, but the basis of his spoken voice being loud, metallic, and incapable of modulation.

Affections of Speech.

The subject now to be considered is one of wide extent and of great interest. It includes not merely defects in the utterance of elementary sounds, but blundering utterance, stammering or stuttering, and defects of speech dependent on affection of the supreme nervous centres. Further, it may be remarked that just as the utterance of the laryngeal sounds depends on the due performance of the function of respiration, so the utterance of articulate sounds and words demands the associated action of the purely respiratory organs, and of the organ of voice. Hence, in discussing this subject, we shall have to make frequent reference to the co-ordinate action of these several parts.

The first point to be considered is that relating to defective enunciation of literal sounds. It seems a curious fact, when one considers that the vowels differ from one another only in the presence or absence and the relative intensity of the harmonics which accompany the fundamental note (in other words, in quality or timbre), and that the differences between many of the consonants are mainly of the same kind, that the recognition of the different sounds, and the acquisition of facility in uttering them, have no apparent relation to the presence or absence of musical education or musical talent. Indeed, persons with utter incapacity for music, for the most part, discriminate and evolve articulate sounds with the utmost nicety. And it not infrequently happens that persons with marked musical talent and of musical skill display striking defects of utterance, even when the failure is altogether unconnected with defective conformation of the organs of speech. The faculty of articulate speech, indeed, is clearly independent of the faculty of music.

Defects of articulation are dependent occasionally on structural defects of the organ of articulation, but still more often on paralytic affections of the same parts. They are more commonly due, however, to defective education and the acquisition of bad habits. Sometimes they seem to be hereditary.

Loss of front teeth is a common cause of lisping. Congenital or acquired perforation of the hard palate, or destruction of the soft palate, causes the conversion of b into m, d into n, and hard g into ng, and gives more or less of a nasal quality to all the sounds. A too-high palate, tongue-tie, &c., each tends to cause its own special articulatory defect. It is a curious fact, however, that the removal of the tongue by operation has been shown over and over again to be attended with less impairment of articulatory power than could *à priori* have been expected. The fact, however, is that not all the articulate sounds need the use of the tongue; that the stump of the tongue which is left behind accommodates itself in some degree to the requirements of speech; and, further, that speech is generally intelligible, even when many of the letters are imperfectly uttered, provided these are associated in utterance with others that are well pronounced.

Defects of speech due to paralytic conditions of the organs concerned in speech present many varieties. We have already referred to the fact that one-sided paralysis does not materially interfere with the due enunciation of articulate sounds. In facial paralysis, where one cheek and one side of the mouth only are involved; in hemiplegic paralysis, where with paralysis of the same parts there is paralysis of the same side of the tongue; and in paralysis of one side of the tongue alone, due to affection of one of the motor nerves of the tongue; we rarely observe anything more than a little thickness or apparent slovenliness of utterance, and very often there is no noticeable defect whatever.

It is very different when the paralysis is bilateral, or involves similar parts on both sides. Occasionally, as a consequence of cold or of injury (such as a fall on the head), both facial nerves become more or less completely paralysed. In the latter case the results are remarkable. The sufferer (though still able to roll his eyeballs, and to open and shut his jaws, by the muscles which work these parts) has lost all power over his muscles of expression. His eyes remain wide open, he can neither open nor close his lips (which always remain partly open), he can express no emotion, the natural creases are smoothed away, his face is utterly blank and expressionless, and looks like a mask. In these cases the disappearance of the true labial sounds from the patient's vocabulary is quite remarkable. B, p, m, v, f, w, are no longer pronounced, and he either drops them out of his speech, or (as is more probable) he replaces them, for the most part, by the corresponding linguals d, t, n, and th.

If the soft palate be the seat of symmetrical paralysis, as we often observe after attacks of diphtheria, the failure to close it in speech imparts that nasal quality to the voice which has already been referred to as one of the incidents of absence, or loss of power, of the palate. The explosive consonants especially are replaced by their corresponding nasal continuants.

We proceed to remark on those forms of faulty articulation which depend on defective education or the persistence of bad habits. All who have had the opportunity of observing the progress of children in learning to speak know that the earliest imitative efforts result in the production of combinations of sounds which have a greater or less resemblance collectively to the words which they are intended to reproduce, but which have often so little resemblance actually that only the parent or the nurse is capable of interpreting them. If we analyse them we find that they are composed largely of the literal sounds which babies, as yet inarticulate, are in the habit of uttering in their playful or noisy moods; among which may specially be named b, p, m, and hard g. Gradually, however, and partly, no doubt, by accidental arrangements of the oral canal and aperture, other sounds are added to the *répertoire*, and these, being made to replace in words the letters which had hitherto done service for them, tend to the progressive perfection of the art of speech. The times at which children begin to speak, and those at which the capability of speaking accurately is attained, vary very largely in different cases: in part, no doubt, in accordance with the amount of imitative faculty present, in part dependent on the child's intelligence, and in part possibly determined by the ear for music which it possesses. It is important, however, to note that while idiotic children are, as a rule, late in attempting to speak, highly intelligent children are sometimes late also; and that while many children with no idea of music learn quickly, musical children are not infrequently slow to speak correctly.

On the whole, the art of speaking is acquired by children with very little apparent effort; though, no doubt, correctness of enunciation is the result of that constant practice with the organs of speech which is natural to childhood. It is wonderful, indeed, to observe not only how accurately children learn to utter letters and combinations of letters to which they are accustomed, but how accurately also they imitate the tones and peculiarities of pronunciation and accent of those with whom they associate and who teach them. It is wonderful, also, to observe how great is the difficulty of disembarrassing oneself of the lessons thus learnt in infancy; and how hard, sometimes how impossible, it is in later life to acquire facility in the utterance of articulate sounds which had not been learnt in infancy, or even to learn how to utter them. The organs of articulation lose, as life advances, the plastic quality which belonged to them in infancy. It is hardly surprising, however, that children occasionally fail to acquire the method of articulating certain sounds; it is less surprising that having thus failed they fail to repair that error in future life.

Among the sounds which children are specially apt to fail to acquire in infancy may be enumerated *s* (which they mispronounce as sh or th), *th* (which they are apt to pronounce as z or s), *l*, and, more commonly than any, *r* (which is sounded as w with the lips, or in the throat). Now there is no structural or mechanical reason whatever why each one of these sounds should not be accurately effected; and, therefore, so far as one can see, no reason why the faults of pronunciation in respect of them should not be rectified. As we have already explained, the production of the literal sounds is a simple mechanical question. If the lips and tongue and soft palate be placed in certain definite positions, and breath emitted from the larynx, definite letter-sounds will necessarily result, a specific sound being the consequence of each such specific arrangement. A person has, therefore, only to arrange his organs in a certain definite manner to produce any literal sound he may require to utter. If he arranges them in the position to sound s, s and no other letter is produced; and similarly of all the others.

There is little or no mystery with regard to these arrangements. An unskilled person might no doubt fail to work them out for himself. But there are many persons who have studied them, who know exactly what they are, and who are capable of explaining them clearly to those who require such explanation. Then why is it that persons continue such mispronunciations to the end of their lives? Mainly it is that they never take the pains to be taught or to learn; partly, it is that, even when they have learnt how they should be developed, their no-longer youthful and no-longer plastic organs fail to acquire that readiness of action in regard to them which is necessary for rapid and easy speech. We have ourselves on more than one occasion instructed such imperfect speakers how to pronounce their faulty letters, and have heard even those who habitually say w for r pronounce the r correctly. We do not know, however, that we have ever had the good fortune to cure a patient of his bad habit.

Many mispronunciations which are acquired and perpetuated are provincialisms or vulgarisms, and depend less (or it may be not at all) on actual inability to pronounce the correct sounds than on an acquired failure to appreciate and discriminate sounds the correct use of which has not been learnt by example.

The most striking case of this defect is the abuse of the letter h. All persons who have been educated to its appropriate use in infancy, and whose education has not been subsequently neglected, sound it with perfect ease and fluency in all places in which its use is required, and, on the other hand, omit it unerringly wherever its employment is inappropriate. Those, however, whose education in this respect has been imperfect, fail not so much to pronounce the letter at all, as to use it with uniformity and discrimination. The ear seems unattuned to it. They do not seem to recognise when they sound it and when they do not. As a general rule they omit it from all words in ordinary quiet conversation, but add it incontinently whenever they are excited or wish to be emphatic. Now, here again, there is no mechanical difficulty as to the utterance of the letter. In pronouncing it before any vowel, all that one has to do is to place the organs of articulation in the position which that vowel requires for its utterance, and to precede the utterance of the vowel by the emission of breath, which must be continued into that on which the vowel is sounded. Nor is it difficult to teach how to aspirate. There is, however, very great difficulty indeed in overcoming the early defect; and the greater number of persons who make the attempt fail to a greater or less extent in acquiring that facility which early training would have given them. They are apt still occasionally to drop the h when it is needed, to sound it in error when they are emphatic, and habitually (even when they sound it correctly) to pronounce it with a manifest effort and undue harshness.

Other letters which are thus apt to be misused, or interchanged, are v and w. It will be recollected how Sam Weller, when asked his name in court, pronounced it Veller, and how his father called out, "Spell it with a we, Sammy." A further example of the same kind is the omission of the sound of *y* from such words as *duke* and *tune*, and their pronunciation as *dooke* and *toone.*

It may, perhaps, be here pointed out that not infrequently the peculiar "twangs" which characterise the typical Cockney, and certain provincials, depend simply on the combination in diphthongal forms of vowels different from those which are used for the same purpose by persons of superior education. One of the commonest of these mispronunciations in London is the use of the long i for long a. Thus, one gutter-child will say to another, "come and pli with me," instead of "come and play with me;" or, "take care of the biby," instead of, "take care of the baby." Here the sound of the long i (which is a diphthong, composed of a in calf and i in hit) is put in the place of long a, a letter which in other words he pronounces without difficulty.

Other defects of articulation due to bad habits or bad training are, the tendency presented by many persons to speak with the lips, or especially the teeth, insufficiently separated; and, what is even more common, of slurring letters in combination, and so uttering them indistinctly, and may be of dropping some of them altogether.

Another common defect is that of interpolating letter-sounds between others, and mostly between vowels, at the end and the beginning of words. An example of every-day occurrence is the interpolation of the letter r in such combinations as idea-r-of, and Sarah-r-Ann.

The way to remedy each of the above defects is sufficiently simple. It is, first, to call the attention of those who are in fault to the character of their faults; and then after they have been recognised fully, to show how, by careful and deliberate utterance, they may be rectified. The correction of none of them presents any inherent difficulty.

Stammering.—It may seem needless to describe stammering, seeing how common it is, and how easy it is to recognise and imitate. It often happens, however, that what is supposed to be understood is really not understood. And as we are writing for the public, we shall assume this to be the case now.

Stammering depends neither on structural defects of the mouth nor on imperfect education or bad habits, nor on paralysis of the organs concerned in speech. Nor, again, is it the result of mental defect. It is a peculiar affection of speech in which, in the course of utterance, a sudden spasm occurs, which either checks the flow of sound altogether for a short space, or in which the arrest of speech is attended with a series of rapidly repeated sounds, which are usually those literal sounds at which the check took place.

The spasm may occur in connection with any literal sound; but the consonants suffer in this respect more than the vowels; and the explosive consonants b, p, d, t, hard g, and k, more frequently than any of the others. Further, it is more apt to arise at the commencement of words or syllables than in syllables where vowels and consonants are blending with one another.

In considering this subject, we must not forget that the art of speaking is extremely complicated: that for the utterance of every articulate sound three distinct mechanisms have to act in unison and in due relation to each other. The mechanisms here referred to are, the respiratory apparatus, or parts specially concerned in respiration; the larynx, or the organ of music; and the mouth and structures connected with it, which collectively constitute the organs of articulation. To articulate, it is not sufficient to put our mouth and tongue and fauces into particular postures; we must also, at the very time at which such postures are assumed, transmit vocalised or breezy air from the laryngeal orifice through the mouth; otherwise the articulate utterances remain latent, and nothing is heard. Again, to produce laryngeal sound, air, with regulated force and in regulated quantity, must be discharged from the lungs by the action of the complicated muscles of expiration; for, without that, either laryngeal sound would be wholly absent, or it would be evolved irregularly, and in a manner unsuitable for the due development of laryngeal sounds and those of articulation. In the utterance of speech, therefore, it is obvious: that the expiratory organs must be made to regulate the transmission of air through the larynx and mouth in exact accordance with the requirements of phonation and articulation; that the larynx must vary its arrangements at the same time (first in respect of tension, for the production of higher or lower notes; and, second, in respect of modifying the laryngeal aperture from complete closure, as occurs in the production of vocalised vowel sounds and sonant consonants, to partial closure, as occurs in uttering the same letters in a whisper, and thence to complete patency, as happens during the pronunciation of the voiceless or surd consonants, such as f, s, t, p, k, and h); and, lastly, that the organs of articulation must assume many varieties of position, in order to produce the many various articulate sounds of which they are capable.

It will be gathered from the above statement that, for the pronunciation of each separate letter, a complicated co-ordination or co-operation of different mechanisms must take place. But when it is recollected that words are combinations of several letters, each one of which requires its particular group of co-ordinations, and that during speech such groups of co-ordinations are succeeding one another with great rapidity, are passing like dissolving views into one another, and are associated together in almost endless variety, it will be acknowledged that the mere mechanism of speech, simple and easy as it appears to those who have acquired due command over it, is full of complicated details, disarrangement of any one of which would naturally and readily disturb the smoothness and perfection of its action.

Of the three groups of associated movements, that of the organs of respiration is the least complex and most instinctive; while that of the organs of articulation is by far the most various and complicated, the most artificial, and that which is last and most laboriously acquired. The movements of the larynx occupy an intermediate position in these respects.

Now it is found that it is mainly in those musculo-nervous mechanisms (facility in the employment of which is acquired only by long-continued practice) that disarrangements or hitches are liable to occur which interfere more or less permanently with their perfect action. Thus the skilful pianist occasionally becomes liable to recurring spasms of the muscles of the hand or arm, which mar his performance; and writers are subject to a similar condition, which is apt, sooner or later, to render writing impossible.

Speech is a typical art of this kind; and, on the principles here indicated, we might naturally suppose that such impediment to its due performance might arise in any one of the mechanisms concerned, or in all of them, but especially in the mechanism immediately concerned in articulation. And so it is.

To return to the description of stammering. When the check occurs at the lips, the evolution of the labial sounds is arrested by a sudden spasmodic closure of the mouth ; when at the point of the tongue, this gets fixed in the position belonging to the utterance of lingual sounds ; when in the throat, the base of the tongue becomes spasmodically approximated to the palate. In some instances, and especially when the vowel sounds are implicated, the spasm takes place at the glottis. And not infrequently the stammering, whether occurring in connection with vowels or consonants, is due to a sudden inspiration. But whatever part the spasm may affect primarily, the arrest may consist either in a sudden, simple, more or less prolonged spasm, or in a series of such spasms in rapid sequence, during which the implicated literal sound undergoes more or less frequent repetition. And, further, there is generally a tendency, especially if the spasm be prolonged, for a greater or less number of other groups of muscles to be involved. So that if, for example, the spasm commences at the base of the tongue, we may find successively the mouth opening widely and remaining open, the muscles of expression working convulsively, the glottis contracting, respiration checked, and finally spasmodic movements of remote parts becoming also excited.

The causes of stammering are various. It usually comes on in early childhood, and often at that time without any obvious cause. It may, however, arise in later life, for the most part as the consequence of some sudden impression, either on the general system or on the nervous organisation. It may follow a serious accident, sudden fright, or acute illness. It is not an uncommon incident of general paralysis of the insane, and occasionally comes on in the course of hysteria. In the last case, and some others, it is merely a temporary phenomenon. Generally it is more or less permanent. It is important to observe, however, that it is rarely constantly present even in the worst stammerers. There are times when their utterance is perfectly natural and continuous; and it generally happens that their infirmity becomes aggravated during bodily illness, and under the influence of any kind of excitement. It is curious that males stammer in much larger proportion than females. It is further curious that stammerers seldom stammer when they whisper, or when they sing or intone.

Can stammering be remedied or cured? This is, of course, a very important question. The facts that certain varieties of stammering are simply accidental, and of short duration; that stammering coming on in childhood occasionally gets well spontaneously; that even the worst stammerers are at times ready of speech; and that stammerers, as a rule, do not stammer when they whisper or sing, may be regarded as proofs that stammering is, to some extent at any rate, remediable. Nevertheless, it must be admitted that persons who become stammerers in early life rarely lose their infirmity. Some, indeed, who aim at becoming public speakers, get over the difficulty by intoning their speech. It was thus that a well-known clergyman, now dead, who was a confirmed stammerer, learnt to deliver his sermons.

But the practice is, to say the least, disagreeable to those who have to listen. Moreover, it cannot be adopted in ordinary conversation. The fact of stammering being often worse when patients are out of health shows that the maintenance of good health is an important element in their treatment. And on this account tonics, and perhaps especially the so-called "nervine" tonics, are often useful. The treatment, however, on which chief reliance must be placed is educational, and its success will depend largely on the patient's own perseverance. He should learn to speak slowly and deliberately ; and, however excited he may feel, should make a point of not giving way to excitement, or of attempting volubility. He should learn so to regulate his respiration in the course of speaking that he should never be in want of breath for the purposes of utterance. He should especially avoid making persevering efforts to overcome the impediment when it arises, for this only increases the difficulty. The proper method is for a second or two to cease making any attempt, and then to begin at the word or letter at which he stumbled. We know of several stammerers who have practically cured themselves in this way, and in whom the only trace of its previous existence is the occasional momentary pause they find it necessary or convenient to make. Lastly, stammerers should make a constant practice of reading or reciting aloud for an hour or two or more a day, slowly, deliberately, and with marked or even exaggerated articulatory action ; and should further practise systematically those letters and combinations of letters at which they are specially apt to stumble.

Blundering Enunciation.—Another defect in speech to which persons are prone is that of stumbling or misplacing letters or syllables. "Thumbers and fing," "tags and ratters," are examples of the kind of stumbling which is of the most frequent occurrence. And the well-known alliterative discourse about "Peter Piper," and others of the same kind, have of course been invented for the purpose of exposing this tendency, and causing amusement at those who display it. But blundering includes the occasional use of wrong words, and even an occasional hesitation or stammer in persons who are not habitually stammerers. Defects of this kind are much more common in some persons than in others, and are largely due to, or at any rate much increased by, carelessness, inattention, and hurry in utterance, and by nervousness. The fact of being out of health, too, being dyspeptic, having a headache, and even temporary local discomforts, such as a sore throat, a pimple on the tongue, a broken tooth which frets the tongue or cheek, and even mere febrile dryness of mouth, are all liable to increase the ever-present tendency.

The remedies for the above state of things are in the sufferers' own hands, and are sufficiently indicated in the above account.

Forgetfulness of Names.—One of the most interesting defects of speech to the physician is that to which the name of aphasia is generally applied. It presents many varieties, both in kind and in degree. In one form, which is comparatively rare, the patient loses absolutely the power of uttering any articulate sound, though probably apparently well in every other respect. He hears and understands all that is said to him; he sees and comprehends all that he reads; he can communicate his ideas by writing as well as ever he did; he can open and shut his mouth, can move his tongue freely, can masticate and swallow without impediment; he can, in fact, use his muscles of articulation for every other purpose than articulation with perfect ease and facility—yet, if he be asked to speak, if he be asked to read, he is as much at a loss to utter even a single articulate sound as a man who had never seen or heard of a telegraph apparatus would be to send messages by means of it.

This latter simile probably suggests the real explanation of the phenomenon. The loss of power of speech is doubtless due to some local affection of the brain which interrupts the passage of those telegraphic messages which, emanating from the supreme centre for speech in the surface of the brain, should, in order to effect speech, act upon the subordinate motor centres, or agents, by means of which the complex arrangements for speech are co-ordinated. Such patients sometimes recover the faculty of speech spontaneously, and even suddenly. And occasionally, where the condition becomes persistent or chronic, they admit of being taught again how to speak. It will be recollected that we have shown speech to be a mere mechanical art; and that if only the organs of speech be arranged in certain positions, and breath be emitted, letters due to these positions must be developed. Now, considering that these patients for the most part retain their intellectual power, and have perfect control over all strictly voluntary movements of the tongue, the possibility of successful education becomes apparent.

The more common form of aphasia is that in which the patient forgets words and misapplies words. To a certain extent this is a condition to which most persons are more or less prone. There are but few persons who are not, when speaking or writing, liable to forget the word which they specially want to use, and are especially apt to forget the names of things. And, indeed, unless the name arises automatically, or without thought (as it were), the difficulty of recalling it is sometimes extreme. One of the most curious examples of this kind of forgetfulness which we can call to our mind is that of a lady of our acquaintance, who, being driven in her carriage to a shop where she was unknown, and having made her purchases, forgot her own name when she was about to direct the shopman where to send them; and being then asked to give her address could not recollect that either; and had to go to the door and ask her own coachman what her name and address really were.

In this form of aphasia, however, due to disease, the symptoms are much more pronounced and much more persistent. The forgetfulness is not the mere occasional forgetfulness of a word. But such forgetfulness pervades the patient's conversation, writing, and reading.

In a typical case he forgets the names of the commonest things, and even his own name and age, and where he lives; and often, moreover, has a tendency to repeat one word as the designation of everything that is shown him. If asked to name the finger, he may either fail to reply, or call it a spoon; and if told that it is a finger, he may apply the word finger to the next object he is asked to name. At the same time, probably, he recognises the proper names when they are mentioned before him, although he does not recollect them the next moment. In reading, the same defects show themselves: most of the words and most of the letters he is quite unable to specify; but, probably, here and there he recognises a word or letter, just as one beginning to acquire a foreign language here and there recognises a word amongst the many of which he has no knowledge. In writing also his defect becomes equally apparent; if asked to write his own name he often commences fairly well with its first letter, but soon begins to repeat it more or less imperfectly, and presently lapses into the formation only of meaningless up and down strokes.

In an extreme case the patient's response to questions may be only "yes" or "no," applied without relation to their actual meaning, or some such phrase as "can't afford it," or an oath, which slips out incontinently, and at times apparently against his will and to his annoyance. Here, probably, the patient is wholly unable to read or write. In slight cases there is, perhaps, only the persistent oblivion of certain names, or a tendency to omit or to interpolate certain letters; peculiarities which reveal themselves also in his writing.

Curious facts, noticeable in some of these cases, are, first (and this is the more common) that, though they cannot think of words, they repeat them readily to dictation; and, secondly, that in cases where the patient not only forgets words, but is incapable of reading or writing, either spontaneously or to dictation, he will translate with perfect facility and accuracy a printed paragraph placed before him into its equivalent in written characters, without understanding in the least the words which he has thus transcribed.

This form of aphasia has been shown to be due either to disease implicating a definite small region on the surface of the left side of the brain, which region is regarded as the cerebral centre for speech, or to some damage which interrupts or destroys the nervous connection between this and other parts of the brain. The determination of this region is regarded as one of the main foundations of the modern views with respect to the localisation of the cerebral functions. Similar disease on the right side of the brain very seldom indeed exercises any like influence over the function of speech, excepting in the case of left-handed persons, in whom there is reason to believe that the left-handedness is associated with a similar transposition of cerebral preponderance.

Persons who suffer from this affection are usually paralysed on one side of the body, and (since the influence of the brain over the body is crossed) almost always on the right side. Further, although some recover more or less completely from this aphasic condition, the majority remain more or less defective of speech. It is curious, however, that many of these persons appear to be in all other respects clear of mind and intelligent, and competent to perform the ordinary duties of life.

In cases of this kind, the attempt to teach the patient is practically useless. Now and then with much labour one or two fresh words may be impressed upon him for a time, but no real improvement is effected by such means. His recovery, when it takes place, is due to the dispersion of the lesion causing it, or to the restoration of the parts to health.

Hints as to Public Speaking and Singing.

Before we conclude our observations with respect to articulation and phonation, it may be well to make a few remarks concerning public speaking and singing, which represent these arts, or should represent them, in their highest phases of development.

Speaking.—Very few persons, unfortunately, with whom public speaking becomes a profession, or whose position in life compels them to speak frequently in public, take any trouble to learn how to speak effectively and agreeably, or to overcome those natural defects or acquired bad habits which mar their performance. One reason no doubt is, that boys are rarely taught to read intelligently or instructed in elocution, so that by the time adult age is reached their faults have become stereotyped and difficult or impossible to cure. It is obvious, however, that the greater this early neglect, the more imperative do study and practice later in life become. And it is really inexcusable that our pulpits and lecture halls should be occupied, as they too often are, by speakers who have obviously never taken the slightest pains to qualify themselves for the duties they undertake to perform. We do not profess to teach persons how to become public speakers. Yet there are certain hints in regard to this subject which naturally arise out of the discussion in which we have been engaged.

In the first place, a speaker should give the greatest pains to the accurate and complete articulation of his words. He should take care that every letter that ought to be sounded be sounded fully, and that his words be begun and ended crisply and cleanly. To this end it is especially necessary that all natural slovenliness of atriculation, all tendency to slur or to drop letters, all such defects as lisping and the like (which are capable of cure), should be subdued.

In the second place, the musical element of the voice, that part of it which is produced at the larynx, requires the nicest management. Upon this the strength and volume of the voice depend. The loudness of the voice should always be regulated by the distance to which it has to be carried, or the space it has to fill; and, hence, it is usually advisable for the speaker to assume that he is addressing those who form the fringe of his audience. If it be possible it is well to test his voice beforehand in the place in which he is about to make a speech; always, however, bearing in mind that it is necessary to speak louder in a room filled with people than in an empty room. Again, although no doubt a public speaker will need, while speaking, to modulate his voice according to a variety of conditions which we do not propose to consider now, it is still necessary, in order to be well heard, and to make the best of his voice, to regulate its general pitch according to the requirements of the occasion. Thus it is generally undesirable to speak in a relatively low key; and if a large area has to be filled, it is specially important, for acoustic reasons, to pitch the voice high. Further, the voice should always be sustained. The tendency, we might almost say the natural tendency, amongst uneducated speakers is to drop the voice often at the end of polysyllabic words, but especially to drop it at the end of sentences, and thus to become almost inaudible. The voice, we repeat, should be sustained not only throughout words, but throughout sentences, and to the very end.

In the third place, and this relates both to articulation and to phonation, the speaker, in order to emit his words clearly and accurately, should take care to give free play to his organs of speech, and therefore to open his lips and teeth and throat as widely as the correct enunciation of his literal sounds will allow. Especially he should not speak with closed teeth or constricted throat. To the same end, the speaker should always hold his head up, and direct his speech to his auditors.

In the fourth place, he should be careful not to be too rapid, for rapidity leads to, or perpetuates, many of the faults above referred to, largely promotes inelegancy and inappropriateness of diction, and renders even good speaking difficult to follow, and unimpressive; and he should acquire skill in so arranging his inspirations that he may never be out of breath, or appear to be making an effort.

In the fifth place, he should look out for and suppress all bad habits which take from the effect of speaking; he should avoid all sing-song and monotonous, stilted, and flippant modes of delivery; he should learn to put the emphasis on those words which need emphasis; he should avoid the use of all those inarticulate sounds which so many speakers interpolate between their words, more particularly when they hesitate; and, further, he should weed from his discourse all such expressions as, "You know," "Don't you know?" and many others which have no relation to the subject-matter, and no meaning.

And, lastly, it may be added, while only few men possess the special gifts which combine to make the orator, there are few who with practice cannot acquire more or less facility in speaking fluently, and pleasantly, and clearly, provided they overcome original bashfulness, take the trouble before speaking to understand the subjects on which they are going to speak, and to arrange their matter and their argument, and while speaking stick to their text.

Singing.—Some of the remarks just made apply equally to singing. We shall not presume to enter at any length into this subject. But we may point out that accuracy and clearness of articulation, the free opening of the mouth and throat, so far as the due enunciation of articulate sounds permits, the addressing of oneself to one's audience, and the adaptation of one's voice to the space it has to fill, are as essential in singing as in speaking.

A common fault among singers is indistinctness of articulation, whereby the hearers are not permitted to understand the words that are supposed to be uttered, and so lose half the pleasure of listening. Another fault, connected with articulation, which uninstructed singers fall into, is in the management of the vowel-sounds, and especially of those which are diphthongal, that is, in which two vowel-sounds are combined in immediate sequence. On certain of the short vowels, such as *u* in *hut*, it is impossible to sustain prolonged notes; and, if it be attempted, the vowel alters in character. And in regard to diphthongal sounds, such as long *i* (which is made up of *a* as in *art* and *i* as in *hit*, which latter when prolonged becomes *e* as in *meet*), the common uninstructed tendency is for the first part, *a*, to be uttered shortly, and thus for the latter when prolonged to develop into the utterly different sound of long *e*. The proper method is to dwell on the first of the combined vowels, and to utter the second shortly at the end of the note.

In reference to both of these subjects, we may observe that, whilst careful training and constant practice are needed for the full development of the performer's vocal powers, and for their due preservation, injudicious training and injudicious practice are apt to be injurious or ruinous. One of the most perilous practices both for the speaker and for the singer is that of straining the voice, and especially of persistently straining the voice when the throat, and consequently the vocal cords, are congested, inflamed, or "relaxed." Under the influence of such affections the cords are apt to get impaired in their elasticity, and to become more or less weak and yielding; and the tension and violence to which they are exposed during persistent vocalisation are thus apt to damage them seriously, and perhaps permanently. Further, the constant irritation of the inflamed soft parts about the vocal cords is apt to be followed by permanent thickening and other changes. It is owing to such a combination of circumstances that professional speakers become the subjects of that impairment of voice, with irritability of the throat, which, when it affects clergymen, is known as the "clergyman's throat;" and that professional singers are not infrequently compelled to give up their means of livelihood. We know at the present time an excellent public speaker who some years ago ruined a naturally fine voice in this way, and who has ever since spoken in hoarse and uncertain tones. We may well admit the plea of a sore throat, which the public is apt to think is too often made by public singers, as a valid excuse for their declining to fulfil engagements. Their voices are their stock in trade, and we have no right to require them to damage them for our pleasure.

The foregoing remarks are to a large extent applicable to the excessive use of the voice in children before the organs of voice are fully developed, and especially to their excessive use about the time of puberty, when the voice is undergoing momentous developmental changes.

Catarrh.

This name is given to the affection, ordinarily termed a cold, which is usually induced by exposure to cold or wet, or both. It is sometimes contagious. It is an inflammatory condition, affecting mainly the tracts of mucous membrane which have been under consideration, and having a tendency to spread both in surface and in depth. It begins, sometimes in the nose, with irritation, dryness, stuffiness, and tendency to sneeze, followed first by the discharge of thin, irritating mucus, and later by a thick secretion; sometimes in the soft palate, with soreness, itching, and dryness; sometimes in the larynx, with sore throat, hoarseness of voice, and tendency to cough; and sometimes in the chest, with the ordinary symptoms of bronchitis. Or it may involve all these parts at once. Further, such inflammation often spreads along the nasal ducts to the surface of the eyes, inducing ophthalmia; along the Eustachian tubes into the ear, causing earache and deafness; into the frontal sinuses, inducing frontal headache; and sometimes to the deeper tissues, in which case periosteal inflammation, neuralgia, and toothache result.

Catarrhal inflammation may be slight or severe; and, in the latter case (where the larynx becomes involved), we have the formidable disease to which the term laryngitis is applied, a disease in which the affection of the throat rapidly induces difficulty of breathing, and not infrequently death from asphyxia.

The liability of persons to catch cold varies remarkably. The preventive rules applicable to one person, therefore, may often be safely disregarded by others. There are certain conditions, however, which are specially liable to be followed by catarrh. These are: long exposure to cold, especially if at the same time one's clothes are wet; and draughts playing on the surface, particularly about the head and neck. Cold and wet, however, rarely cause catarrh if the person exposed to them is keeping the surface warm by active exercise. But if he be fatigued, or the exercise he is taking be insufficient to maintain surface-temperature, or if, after exposure to great heat, he stands or sits in the cold air, and becomes chilly, catarrh is specially likely to supervene. These are conditions, therefore, which those liable to colds should be careful to avoid. It is often recommended for such persons that they should habitually take a cold bath in the morning. As a general rule, no doubt, this recommendation is a judicious one; but there are some who always feel chilly after a cold bath, and in whom such a bath frequently causes headache, roughness of throat, and running at the nose. It need scarcely be said that in these cases a cold bath is contra-indicated. A tepid bath, however, and a good rub down with a rough towel afterwards, is always beneficial. Persons liable to colds should always be very careful to be warmly clad, especially in changeable weather.

Accidents to Œsophagus, Larynx, etc.

An accident which occasionally happens to the œsophagus and windpipe is the lodgment of solid bodies in them. Sometimes a fish-bone, sometimes a pin, sometimes a set of false teeth, find their way into the former tube. If they pass on to the stomach, little or nothing can be done, except to wait for the result, which is almost always favourable. If they be arrested in the œsophagus, they often become dislodged, sooner or later, during the swallowing of solid food; or they may be removed by surgical interference. Sometimes large angular bodies, such as false teeth attached to a plate, become impacted, and remain in the gullet in spite of all measures that may be adopted to remove them. In one case with which we are acquainted, such a body remained fixed for many months, interfering seriously with the taking of nourishment, and leading to extreme emaciation and debility. It caused ulceration, however, where it lay, and at length fortunately was vomited up.

The lodgment of foreign bodies in the larynx or other air-passages is a matter of much greater seriousness. Every now and then we hear of persons who, while eating, are attacked with sudden complete obstruction of the windpipe, and who, after frantic efforts to breathe, die of asphyxia in the course of a minute or two. This is often due to the accidental swallowing of a large mass of unchewed meat, and its sudden impaction at the top of the larynx, a condition which might have been relieved (by any one who suspected what was the matter) by passing the fingers into the throat and dislodging the mass. But often smaller bodies are suddenly sucked, with more or less sense of choking in the transit, into the larynx, and thence find their way into one of the bronchi. Pins, small coins, and fruit-stones, are some of the commonest of these intruders. It is difficult to recommend what to do when such accidents occur, beyond consulting a medical man, for it is always a serious question whether anything should be done, and if any course be determined upon, it needs to be conducted with skill and care. It may be well, however, to point out that, in order to prevent such accidents as far as possible, persons should never hold pins and other such things between the teeth, should never catch small bodies in the mouth, and should avoid laughing or suddenly inspiring when eating or drinking.

Other accidents, often fraught with extreme danger, are the swallowing of corrosive fluids, and (especially in young children) the drinking of boiling water from the spout of a kettle. These matters naturally find their way to the stomach, wherein they do more or less damage; but they are also extremely apt to cause severe inflammation and swelling of the throat and larynx, over which they pass, and thus to induce intense laryngeal symptoms, which often prove fatal.

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