There have been a few cases reported in which the joint lesions persisted for several weeks. The urticaria and erythema which at times accompany the rise in temperature are in certain cases very distressing, and in a person already prostrated might not be wholly without danger to the patient.

I have seen, in watching over fifteen hundred cases, no serious effects upon the heart, kidney, or nervous system which I attribute to antitoxin, with the possible exception of two cases of scarlatina complicated with diphtheria. In these two there was an almost complete suppression of the urine. This was probably due to the scarlet fever and diphtheria, and not to the antitoxin.

Dosage of Antitoxin.—From my observation of cases in both hospital and private practice, I have been led to adopt the following dosage:

	Units.
Very mild cases	1,000-1,500 for the first dose.
Moderately severe cases	2,000-3,000 " " "
Very severe cases	4,000-5,000 " " "
Laryngeal cases, according to their severity	2,000-5,000

For children under one year I should give about one-third less than for older children and adults. I believe the condition of the throat as to swelling, extent and nature of the membrane, etc., to be a better guide to antitoxin dosage than the general condition of the patient. The duration of the disease, rather than the dosage, influences the curative power of the antitoxin.

If, at the end of twelve hours after the injection, the inflammation is advancing, or if at the end of eighteen hours the inflammation has not clearly begun to subside, as shown by lessened congestion and swelling, I believe a second dose of antitoxin should be injected. In a very few cases a third dose is required at the end of from twenty-four to thirty six hours. For the broncho-pneumonia and sepsis complicating some of the worst cases antitoxin is generally of no avail. Although I cannot agree with Dr. McCollom in regard to the necessity of from 40,000 to 60,000 units in the very bad cases, nevertheless his results certainly encourage us to give all the antitoxin that we think indicated. It is better to give too much rather than too little. I think I am correct in saying that it is the opinion of the visiting physicians at the hospital that moderate doses accomplish as good results as very large ones. *William H. Park.*

DIPLOPIA (from διπλόος, double, and ὄψ, eye) is the double vision resulting from the formation of two images of the same object upon non corresponding parts of the retinæ of the two eyes. Strictly speaking, in every act of binocular vision this condition obtains in the case of all objects which are either nearer or more distant than the point of intersection of the visual axes, although, in these cases, the incongruity of the two images is ordinariily recognized as the expression of a difference in distance (stereoscopic vision) rather than as double vision. In viewing near objects against a distant background, the details of the background, as seen by either eye singly, are in a measure effaced as a result of the exercise of the accommodation required for distinct vision at the shorter distance; and, in binocular vision, the incongruity of the two retinal images of the background operates still further to prevent their special recognition. Again, in looking at distant objects, as at the details of a landscape, through a window screen of gauze, we may be almost or even quite unconscious of the presence of the screen, although, by a voluntary exercise of the accommodation and the convergence, we may see its meshes distinctly, and may then become conscious of the fact that the finer details of the landscape, as seen through it, have become indistinct, and that some of its more conspicuous features appear doubled. In fact, we unconsciously concentrate the attention upon objects at about the distance for which the two eyes are accommodated and for which their axes are converged, and so come to disregard the less perfectly defined and incongruous images of nearer or of more distant objects.

The fact of the formation of incongruous retinal images of objects either nearer or more distant than the point of intersection of the visual axes, may be demonstrated by holding a small object, such as a pencil, in a vertical position at a distance of a foot or two from the face and at about the same distance from a vertical bar of the window sash; if we look with the two eyes at the pencil, it will be seen single between two images of the sash bar; if we look with the two eyes at the sash bar, it will be seen single between two images of the pencil. That this seeing of one or the other of the objects doubled is

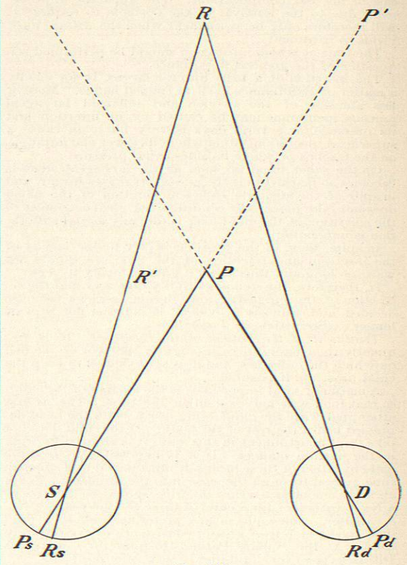

FIG. 1597.

a result of simultaneous vision with the two eyes is shown by the fact that one of the images disappears on covering either eye.

If, directing the eyes upon the nearer object (the pencil), so that the more distant object (the sash bar) is seen doubled, we cover the right eye, we find that we shut off the right-hand image of the more distant object; similarly, covering the left eye, we shut off the left-hand image. The double vision (diplopia) is then, in this case, *homonymous—i.e.*, the image to the right is seen by the right eye, and the image to the left by the left eye. If now, directing the eyes upon the more distant object (the sash bar), so that the nearer object (the pencil) is seen doubled, we cover the right eye, we shut off the left-hand image of the pencil, and, covering the left eye, we shut off the right-hand image; the diplopia is, in this case, *heteronymous*, or *crossed*.

Let *D* and *S* (Fig. 1597) represent the right and the left eye, respectively, and suppose that the two eyes are directed to converge upon a small near object at *P*; the two retinal images, *Pd* and *Ps*, will then be formed each

at the fovea centralis of its own eye, and the object *P* will be seen single with the two eyes. If we suppose now a second and more distant object at *R*, two images of *R* will be formed, at *Rd* and *Rs* respectively, each to the inner or nasal side of the fovea. The more distant object *R* will then be seen by the right eye in the direction *Rd R*, to the right of *Pd P*, and by the left eye in the direction *Rs R*, to the left of *Ps P*; therefore doubled, and the doubling (diplopia) will be *homonymous*.

If we suppose the two eyes to be directed to converge upon the more distant object at *R*, the two retinal images, *Rd* and *Rs*, will be formed each at the fovea centralis of its own eye, and *R* will be seen single with the two eyes; but the two images of *P* will be formed, at *Pd* and *Ps* respectively, each to the outer or temporal side of the fovea. The nearer object *P* will then be seen by the right eye in the direction *Pd P*, to the left of *Rd R*, and by the left eye in the direction *Ps P*, to the right of *Rs R*; therefore doubled, and the doubling (diplopia) will be *crossed*.

The apparent direction of any visible object from the observer is ordinarily determined by the direction in which the two eyes are turned in order to see it single. When, however, only one of the eyes is directed accurately upon the object, its apparent direction is determined by that of the accurately directed eye, and the image formed on the retina of the misdirected eye is projected eccentrically, on the visual field, in a direction opposite to that in which this eye is turned. Thus in the case of an eye which deviates inward, the retinal image of the object upon which the other eye is directed is formed to the inner side of the fovea, and is projected, on the visual field, to the outer side of the object as seen by the accurately directed eye. A diplopia which is the result of *crossing* of the eyes is therefore *homonymous*. Again, when one of the eyes deviates outward, the retinal image is formed to the outer side of the fovea, and is projected to the inner side of the object as seen by the accurately directed eye. A diplopia which is the result of *divergence* of the eyes is therefore *crossed*. In the case of a vertical diplopia, the higher position of the false image indicates that the misdirected eye is turned downward, and *vice versa*. So, too, in the case of a diplopia in which a line drawn through the two images is intermediate between the horizontal and the vertical, the displacement of the false image on this oblique line is in the direction opposite to that in which the misdirected eye is turned.

Referring again to Fig. 1597, suppose the eye *D* to be directed upon an object at *R*, and the eye *S* to be turned toward a second object at *P'*, on the line *Ps P* produced. Two different retinal images, *Rd* and *Ps*, will then be formed, each at the fovea of its own eye, from which it might be expected that the two objects, *R* and *P'*, would be seen simultaneously as a composite picture. This is, however, not ordinarily the case. Either the attention is concentrated upon the object *R*, which is then seen centrally and distinctly with the eye *D* and also eccentrically and less distinctly with the eye *S*, or upon the object *P'* which is then seen centrally and distinctly with the eye *S*, and also eccentrically and less distinctly with the eye *D*. In the one case the object *R* is seen homonymously doubled, and the two images of *P'* are disregarded; in the other case the object *P'* is seen homonymously doubled, and the two images of *R* are disregarded.

Again, suppose the eye *D* to be directed upon an object at *P*, and the eye *S* to be turned toward *R'*, in the direction of *R*. In this case two different retinal images, *Pd* and *Rs*, are formed, each at the fovea of its own eye, but the attention is concentrated either upon the object *P* or upon the object *R'*, one of which is seen heteronymously doubled (crossed diplopia), and the two images of the other object are disregarded.

Diplopia may be evoked experimentally by slightly changing the direction of one of the eyes by making moderate pressure upon the eyeball through the eyelid; the second image then appearing to the side of the object opposite to that toward which the axis of the eye has been turned. Diplopia may also be evoked by artificially altering the direction in which the rays of light from any object enter one of the eyes, as in looking through a thin prism held in front of one eye. If, while looking at any small object with the two eyes, we interpose a thin prism in front of either eye, so as to cover about half of the pupil, the object will be seen single with the two eyes through the uncovered half of the pupil, and doubled through the half of the pupil covered by the prism; or, by slightly varying the direction of the two eyes, so as to look either past the prism or through it, the object may be seen single or doubled, at will. When the prism is turned with its refracting edge either toward the nose or toward the temple, the resultant horizontal diplopia, whether crossed or homonymous, may be observed to drift almost immediately into single vision with the two eyes, through an unconscious change in the convergence; in other positions of the prism the diplopia persists. The apparent displacement of the object, as seen through the prism, is in the direction of the edge of the prism.

Diplopia, as an anomaly of vision, may result from any deviation from the normal relative direction of the axes of the two eyes. Such deviation may be the effect of a purely mechanical cause, as when the range of movement of one of the eyes, in some particular direction, is limited by a cicatrix of the conjunctiva, by a symblepharon, etc.; or it may be dependent on a displacement of one of the eyeballs from an orbital hemorrhage or tumor; or upon a fracture of the bony wall of the orbit impairing the lateral support of the globe, or perhaps injuring one or more of the muscles of the eye. Diplopia from such causes may be either transient or permanent; and it may be present, often in varying degree, in all positions of the eyes, or, in cases in which certain movements of the affected eye are restricted only in their extreme range, it may appear only on looking in some particular direction, and may then be prevented by avoiding such movements of the eyes by substituting for them a movement of the entire head.

Diplopia is sometimes a predominating symptom in cases of slight preponderance of either the recti interni or the recti externi muscles over their antagonists, and is then either homonymous or crossed. As the normal range of convergence of the optic axes is somewhat increased when the eyes are directed downward, and diminished when they are directed upward, a person suffering from slight insufficiency of the interni will sometimes correct the tendency to crossed diplopia by habitually carrying the head tipped a little backward; and, similarly, in the case of slight insufficiency of the externi, he may correct the tendency to homonymous diplopia by habitually bowing the head. In such cases the wearing of prismatic spectacles, with the bases of the prisms turned inward or outward according as the interni or the externi are in need of assistance, may afford perfect relief, and enable the patient to carry his head in the normal position. So, also, a slight deviation of one of the optic axes upward or downward may give rise to a vertical diplopia which may be corrected by wearing spectacles of which one of the glasses is a prism set with its base downward or upward, as may be indicated; or a pair of prisms may be given, with their bases in opposite directions, so as to divide the correction between the two eyes.

As in normal binocular vision, both eyes are directed upon the object, with the result that the two nearly identical images, falling centrally upon the two retinæ, are mentally combined in a single composite impression, so in diplopia dependent on a faulty direction of the axes of the two eyes, one to the other, the object is always fixed by one eye, the image falling centrally upon its retina and eccentrically upon the retina of the deviated eye. Of these two images, the central image, in the fixing eye, is recognized as the "true" image and is utilized in seeing the object and in estimating its direction; at the same time, the eccentric image, in the deviated eye, is recognized as a "false" image, obtruding itself more or less persistently on the vision to the confusion

of the general impression. Simultaneous vision with the two eyes becomes then a hindrance rather than a help, and the sufferer learns to suppress the confusing second image, at first by covering or closing the deviated eye and later, in many cases, by ceasing to take cognizance of the confusing visual impression. Confused vision with the two eyes then gives place to single vision with the fixing eye, the deviated eye no longer contributing anything to the psychical impression, and this wholly independently of the actual acuteness of vision in either eye.

Instances of this psychical suppression of one of the two retinal images occur in different types of strabismus. Thus in strabismus, whether convergent or divergent, the patient sees, as a rule, exclusively with the straight eye, although on covering this eye he may see perfectly with the fellow eye, the previously straight eye then assuming the position of deviation. In the alternating type of strabismus, the patient is able to fix the object and see it distinctly with either eye, but receives no simultaneous impression through the other eye. In periodic strabismus there is ordinarily good binocular vision so long as the two eyes are properly directed upon the object, but this gives place to vision with a single eye whenever the second eye wanders from the true direction.

In true (concomitant) strabismus the angle of deviation of the misdirected eye is approximately constant, whatever may be the direction in which the fixing eye is turned. The position of the false image, as regards its direction and distance from the true image, remains, therefore, practically unchanged in all movements of the eyes. To suppress the false image, it would then appear to be necessary to disregard only such part of the retinal picture in the deviated eye as is formed on a definite and rather small eccentric area of the retina. That this is what actually occurs, in many cases of strabismus, is shown by the fact that the suppressed diplopia may often be made manifest by changing the relative position of the two images by looking through a prism or prisms placed before one eye or both eyes. So, also, a previously suppressed diplopia not infrequently reasserts itself as the result of the change in the position of the false image following an incomplete correction of strabismus by an operation.

The suppression of simultaneous recognition of the two images in strabismus, although complete under ordinary conditions, may, nevertheless, often be shown to be incomplete by artificially varying the conditions under which the object is viewed. Thus, in looking at the flame of a lamp, at a distance of say ten to twenty feet, the flame will ordinarily be seen single with the fixing eye; but on placing a colored glass before one of the eyes, so as to change the apparent color and brightness of the flame as seen by this eye, two differently colored images of the flame may appear.

By the use of the "glass-rod" test of Maddox, which consists in looking transversely through a cylindrical glass rod of 4 mm. or 5 mm. diameter held in front of one eye, the flame of a lamp, as seen with this eye, is drawn out into a very long bright streak at right angles to the axis of the rod. This linear streak, which is wholly unlike the image of the flame as seen by the other eye, and which also extends across an area of the retina many times larger than that occupied by the untransformed image, is often perceived simultaneously with the flame in cases in which prisms or colored glasses, whether used alone or in combination, give only a negative result. As improved by its inventor, by the substitution of several somewhat smaller parallel rods (which may be of colored glass) for the single rod, or replacing the system of rods by a disc of plain or colored glass crossed by parallel flutings, this test affords the most effective known means for bringing to light a diplopia which has become latent through the suppression of one of the two retinal images, as well as for investigating the relation of the two images, one to the other.

In paralysis or paresis of one or more of the external muscles of the eyeball, from suspended or impaired function of one of the motor nerves (third, fourth, or sixth), diplopia is from the beginning a prominent and generally a persistent symptom. In uncomplicated paralysis (or paresis) of a single muscle, deviation of the axis of the affected eye occurs only in looking in the particular direction in which the muscle is unable fully to perform its proper work, while in looking in other directions the normal relative direction of the axes of the two eyes is preserved. Binocular vision is, therefore, only occasionally disturbed by the perception of double images, and the diplopia evoked by an unsuccessful attempt to turn the eye in the direction of the paralyzed muscle may be corrected by turning the head in the same direction, and so fusing again the momentarily separated images. Furthermore, the distance by which the two images are seen separated from each other is dependent wholly upon the direction in which the eyes are turned, and is, therefore, a varying quantity; so that the false image, which is projected at different times upon different portions of the retina of the deviated eye, is constantly reasserting itself in a new position, and is, therefore, less easily disregarded than in the case (as in strabismus) in which the relation of the two images to each other is practically constant. In a later stage of the affection, however, the unopposed antagonist of the paralyzed muscle usually becomes shortened, so that some degree of doubling appears even in the most favorable positions of the eyes; but even then the diplopia remains variable in degree, and is apt to persist as an ever-recurring source of visual disturbance.

In diplopia, whether dependent on an impediment to the free mobility of one of the eyes, or upon perverted action of one of the ocular muscles, it is ordinarily the affected eye which deviates; exceptional cases occur, however, in which this eye is so much the better eye, as regards acuteness of vision, that it continues to be used, and is consequently accurately directed upon the object, while the deviation is transferred to the eye whose motility remains unimpaired. Hence, it is sometimes possible to fall into the error of attributing a defect in motility to the wrong eye, as, for instance, in a case of vertical diplopia, in which it may be difficult to decide whether one of the eyes is turned a little upward or the other a little downward, or in a case of homonymous or crossed diplopia, where we may be in doubt whether the excessive or insufficient convergence has its seat in one or the other of the eyes, or in both eyes. From a practical standpoint, however, these nicer points of diagnosis are ordinarily of minor importance, for the reason that, if the deviation is of such a nature and degree as to bring it within the power of prisms to correct it, the prisms must usually be applied to both eyes in order to obtain a sufficient refractive effect with the least disturbance from dispersion; and, similarly, in a large proportion of cases of deviation for which tenotomy may be the appropriate remedy, the requisite correction is often best attained by operating upon both eyes.

We have thus far considered diplopia as simply a doubling of the visual impression; but, in fact, the axis of the deviated eye is often not only misdirected, but also more or less rotated or twisted. Of the six muscles which move the eyeball in different directions, only two, the rectus internus and the rectus externus, effect a simple change in its direction. The other four muscles, viz., the rectus superior, the rectus inferior, the obliquus superior, and the obliquus inferior, when they act singly, cause also some degree of rotation of the axis of the eyeball, and thus give rise not only to a displacement, but also to a notable rotation of the image. Under normal conditions, the tendency to rotation from the action of the superior rectus is neutralized by an equal tendency to rotation in an opposite direction through the action of the inferior oblique; and, similarly, the rotating effect of the inferior rectus is neutralized by an opposite rotating action of the superior oblique. But when any one of these muscles is paralyzed, this correcting power is lost, and the correlated muscle is left free to exert its function of rotation. This rotation of the false image is

best studied by directing the patient to look at a foot-rule held vertically or horizontally at a distance of from one foot to three or four feet from the face; the relation of the two images, one to the other, may then be noted for different positions of the rule. The false image will be seen turned in a direction oblique to that in which the rule is held and in which it is seen by the non-deviated eye. Diplopia with marked rotation of the false image is often a source of especially annoying and persistent visual disturbances; the rotation cannot be overcome by wearing prisms; an operation on the weakened muscle (advancement of its insertion) proves, at the best, only palliative in most cases; and the division of the tendon of the muscle which is the active cause of the combined deviation and rotation, when the eyes are turned in certain directions, will often only aggravate the trouble by giving rise to new and disturbing limitations of the movements of the eyeball in looking in other directions. The special consideration of the different positions and rotations which the false image may assume, in connection with paralysis of a particular muscle or of particular muscles, belongs properly to the subject of the disorders of the motor apparatus of the eyes.

An anomalous type of diplopia has been occasionally observed in which a false image, evoked by colored glasses or by the Maddox test, is seen at the side of the object opposite to that at which it should appear in accordance with the law of optical projection. The few instances of this anomaly which have come under the observation of the writer have been in cases of convergent strabismus which had been approximately corrected by operation, but in which some residual crossing was still to be detected by inspection of the eyes and by their change of direction in alternate distant fixation. With perfect central fixation and visual acuity scarcely below the normal, in either eye, it was impossible to elicit any evidence of simultaneous central vision with the two eyes; but on bringing a colored glass before one eye or differently colored glasses before the two eyes, or applying the Maddox test, a crossed diplopia, equivalent in degree to that which is ordinarily associated with notable ocular divergence, became manifest. In a case of convergent strabismus in a young man twenty-three years of age, with convergence in distant vision of about 6°, persisting after division of both recti interni about seven years ago, a crossed diplopia of about 15° can still be demonstrated by colored glasses and by the Maddox test. This reference of a retinal impression, made actually at the nasal side of the fovea, to a different position, at the temporal side of the fovea, has been conjecturally explained on the assumption of a possible anomaly of distribution, in the retina, of special nerve fibres directly concerned with the function of binocular vision.

Diplopia Monophthalmica, or double vision with a single eye, is a result of the formation of two images of the same object on different parts of the same retina. If we look at a candle flame through two pinholes, about 3 mm. apart, pricked in a card, the images formed by the refracting media of the eye in the two uncovered small areas will fall together on the retina only under the condition of the accurate adjustment of the eye for the distance of the object. In all other cases the two images will fall on different parts of the retina, and the object will be seen doubled. Similarly, in the somewhat rare cases of a supernumerary pupil resulting from traumatism, or perhaps from an imperfectly executed surgical operation involving the iris, the rays traversing the two pupils may either fall together, to form a single retinal image, when the eye is accurately adjusted for the distance of the object, or separately, on different parts of the retina, to form two images, when the eye is not so adjusted. The correction of the eye by an appropriate lens suffices to effect the fusion of the two images in a single image.

Double vision in a single eye may occur as a particular case of polyopia monophthalmica, in which a bright point appears broken up into a star of small bright spots, as an effect of incongruous refraction through different sectors of the crystalline lens (see Fig. 376, vol. i., p. 596). In the early stages of cataract this refractive incongruity is often both notably increased and accompanied by some degree of ametropia, so that the disc of the moon may appear as a cluster of overlapping moons. In astigmatism, the more or less completely separated images of a bright object may appear compressed into a row of images corresponding in direction to the ocular meridian of greatest ametropia; or a row of lights corresponding in direction to the ocular meridian of least ametropia may be seen as two or more parallel rows of lights. In myopic astigmatism, when the meridian of greatest refraction is vertical, the moon is often described as appearing like two overlapping moons, one above the other, and a telegraph wire or a clothes line may appear not only blurred but doubled at the two margins of the diffuse image.

A local deformation of the cornea may give rise to a second image separated more or less widely from that formed by refraction at the general corneal surface. When a diplopia from this cause is very troublesome, a considerable measure of relief may sometimes be afforded by tattooing the disturbing area of the cornea with India ink.

John Green.

DIPPEL'S ANIMAL OIL.—(*Animal Oil; Ethereal Animal Oil.*) By the dry distillation of bone, horn, and animal substances generally, an oily liquid is produced, which was formerly used in medicine under the common name of *Dippel's oil* or *Dippel's animal oil*. The oil, when purified, is a thin, colorless, or yellowish fluid, of a pungent, ethereal, and smoky flavor. It is a very composite body, containing among other things quite a number of organic bases. Physiologically it is neurotic and irritant, and has proved fatally poisonous in doses of a tablespoonful. It was formerly prescribed internally in doses of a few drops, or used externally as an irritant embrocation, clear or as an ingredient of composite liniments.

Edward Curtis.

DIPTHERYX. See *Tonka*.

DIRECTION, JUDGMENT OF.—It is proposed to consider here the judgment of direction of such objects only as are outside the body and not in contact with it.

Heat and Cold.—The direction of an object capable of producing either of these sensations can be roughly estimated by inference from the part of the skin affected, but the judgments thus made are of little importance in normal persons. In the blind, however, these sensations are much used, forming an important portion of those involved in "facial perception."

Sound.—Sound waves also offer some data for judging direction. The following account of the phenomena is taken from Wundt. The concha acts as a condenser, specially collecting those waves which come from in front. The same sound is therefore heard more intensely when coming from that direction. This fact is brought out by an experiment where the conchas are bound down and some apparatus representing them is attached to the sides of the head, with the concavity directed backward. By this device the natural conditions are reversed, and sounds coming from behind are thus heard more distinctly and are then wrongly judged to come from in front. It has been suggested that the tactile sensibility of the concha, re-enforced by the hairs on it, may, in the case of loud sounds, be a means of indicating the direction. But this explanation is not sufficient, for in the case of faint sounds discriminations between "right" and "left" can be more easily made than between "in front" and "behind," while with sounds coming from in front it is possible, to a certain extent, to determine the angle formed by the line of the sound waves with the median vertical plane of the body. Since the closing of one ear destroys this localization of direction, the latter must be considered as a function of binaural audition. When certain partial tones are intensified by the resonance in the external meatus, then the relative intensity of the sensation in the two ears has an influence. It is proba-

bly due to the latter cause that noises in which, as a rule, high resonating overtones exist, are more exactly localized than simple notes. In the studies on the monaural localization of sound made by Angell and Fite, it was found that the judgment of direction was very accurate in persons depending on one ear only, and depended largely on the quality of the sound coming from different directions. It is possible that certain muscular and tactile sensations should also be here included. Ed. Weber conjectured that the tympanum felt its own vibrations. It better accords with the results of other experiments, however, to consider that the action of the tensor tympani muscle, by its involuntary accommodation to sounds of different intensities, thus accompanies auditory impressions with muscle sensations of varying strengths. In cases of auditory hyperæsthesia, affecting one ear alone, errors of judgment may arise, owing to the fact that a sound coming from the side *opposite* to the hyperæsthesia may nevertheless cause a so much stronger sensation that the patient completely misjudges its direction.

LIGHT.—Sight is the sense through which the chief judgments of direction are made. In all cases the direction of an object is represented by a line joining the body with the object, and objects on that line or its continuation are considered to have identical directions. The phenomena are first to be considered for one eye alone, the field of vision being stationary. When the image falls on a part of the retina other than the fovea, the eye must be turned in order to bring the image on that point, and for this purpose it must be moved by its muscles. In performing such a muscular movement there are at least two sensations which may be recognized: the innervation feeling and the tension of the muscles. When the eyeball is pulled to one side by the hand, objects in the field of vision appear to move, and the eye to remain quiet; at the same time, pulling the eye changes the tension of the muscles; nevertheless, neither the movement of the eye by a means other than the contraction of its own muscles, nor the tension of the muscles due to the same cause is recognized as a motion of the eye, and so objects appear to move in a direction opposite to that in which the eye is pulled.

In patients having the musculi recti paralyzed, an attempt to contract a rectus is followed by an apparent motion of objects in a direction opposite to that in which it is willed to move the eye. In this case there is present neither the contraction of the muscle nor any result of the exertion, but merely the innervation feeling; yet, from this arises a subjective sensation of motion. Since the innervation feeling can produce this result, it is argued that our judgment of the direction of an object seen is based on the remembrance of the innervation feeling necessary to bring the eye into such a position that the image shall fall on the fovea.

The only result of the innervation impulse which we plainly recognize in the eye is the altered position of objects in the field of vision. This alteration, bringing with it a variation in the position of the image, can be shown to act as a control on innervation efforts.

If a prism be put before the eye so as to cause the rays from a given object to fall on a new part of the retina—the object, for example, having thus been apparently moved to the left—and then, the eyes being closed, if the hand is stretched in the supposed direction, it will fail to touch the object, passing by it to the left. On touching the object, however, with the eyes open, and associating thus the new position of the image with fresh tactile sensations, a new combination is developed by which it can be inferred from the position of the retinal image where the hand must be placed to touch the object.

When two eyes are used the conditions are somewhat complicated, for one eye influences the judgments derived from the other. Helmholtz gives the following illustration: When one eye is closed, both axes being kept parallel, and first a distant then a very near object is fixated, both having identical directions, no change occurs in their apparent position in the field so long as the eye is simply focussed from one to the other. If, however, the near object be fixated and the closed eye be now converged so as to occupy the position necessary to fixate it if it were open, a marked apparent motion takes place in the distant object in such a way that, if we consider the left eye as the one open during the experiment, the distant object moves from right to left. On again making the axes parallel, it resumes its former position. The sense of direction, as derived from one eye, must accordingly be considered modifiable by the other eye, even though the latter remains closed. In an analogous way the judgment of horizontal and vertical lines is found to be influenced by the motions of the closed eye. For instance, with the axes parallel, one eye being closed, a thread forming the diameter of a short circular tube, when judged to be vertical or horizontal, is found to be really so, though by putting the head in different positions during the experiment the retinal horizon of the observing eye may, in certain of these positions, make an angle of even ten degrees with the true horizon. When, however, the previously parallel axes are converged, and the individual fixates a point on the thread, the line which was previously horizontal is now seen to undergo apparent rotation of such a nature that it corresponds with the rotation of the retinal horizon of the closed eye. Suppose in this case the right eye to be open, then on converging the left (closed) eye the right end of the thread apparently sinks while the left rises. The position of the eyeballs is found to be in part under the reflex control of impulses from the semicircular canals, and for this reason all judgments modified by the position of the eyeballs tend to be also modified by changes in the position of the head.

In the section on judgment of direction Helmholtz treats of a number of cases in which the objects viewed are in motion, for example, falling water. One who has watched a waterfall for a time notices, on looking at the bank, that objects there appear to move in a direction opposite to that of the water. The explanation offered by Helmholtz is that the eye, in order to view the falling water, continued to follow it downward for a time, then twitched up only again to follow it down, and so on. On now directing the gaze to the bank, the objects there apparently move in the opposite direction because the observer is unconsciously still continuing the same movements of the eyes as when gazing at the waterfall, and because this motion is unconscious the objects on the bank are consequently judged to move. The objection to this explanation of these illusions of motion is that they can be obtained in the after-image with the eyes closed, and, further, that two opposite motions can be simultaneously produced in the same retina. These facts, which with others were brought out by Bowditch and Hall, conclusively show that the explanation of Helmholtz will not apply in these cases. No other explanation of the phenomena is, however, at present formulated.

In considering the centre to which these lines of direction are referred, E. Hering drew attention to the fact that we perceive the direction of objects seen as if both eyes were fused into one, and that one was located in the median plane of the head. This cyclopean eye is considered as so constructed that the retinal images are projected outward in the line of vision of that eye.

The habit of thus attending only to the mean direction of the lines of sight is considered by Helmholtz to depend on the fact that the median vertical plane of the body is the one to which all objects are referred, so that an object neither right nor left lies in that plane, which also passes midway between the two eyes. Further, an object may lie to the right or left of this plane and bear the reverse relation to the vertical plane (parallel to the median vertical plane) of the homonymous eye. In practice, we thus fuse the directions of both the optic axes and refer the lines of sight to a point in the head midway between the two eyes. That this process results from habit is indicated by the fact that variations occur in the location of the cyclopean eye, and that fixation of the attention on the impressions from one eye alone serves to

make that for the time being the reference point. Other observations indicate the same conclusion.

The above statements are mainly from Helmholtz's "Physiologische Optik," where they are elaborated.

Henry Herbert Donaldson.

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DISEASE, FATALITY OF.—(Ratio of Deaths to Cases.) The question is often asked, Out of a given number of cases, how many die? The answer to this question is derived from the observations of physicians in active practice, both in hospitals and in private practice. The fatality in hospitals, as a general rule, is usually greater than that of private practice, since the milder cases are not usually sent to hospital for treatment.

The enactment of laws requiring the notification of infectious diseases has enabled the health officers of cities to contribute a considerable amount of information upon this subject, so far as the fatality of the principal infectious diseases is concerned.

The following figures are the results of observations collected from six States (Connecticut, Massachusetts, Michigan, Indiana, Rhode Island, and Vermont), and from nineteen of the principal cities in the United States, during the five years, 1894–98.

In these States and cities there were reported to the sanitary authorities 619,765 cases of smallpox, typhoid fever, scarlet fever, diphtheria, and measles in the period mentioned, and there were in the same States and cities 75,715 registered deaths from the same causes during the same time.

These cases and deaths were distributed as follows:

Diseases.	Reported cases.	Registered deaths.	Fatality, per cent.
Smallpox	9,222	2,385	25.8
Typhoid fever	69,758	13,284	19.0
Diphtheria and croup	195,783	44,411	22.7
Scarlet fever	197,847	9,211	7.2
Measles	217,755	6,424	2.8

In the compilation of these figures it was found necessary to reject the returns of several entire States and cities, in consequence of manifest deficiency in the number of reported cases.

The use of antitoxin for the treatment of diphtheria became general in the early months of 1895 throughout the country. If, therefore, the returns for the year 1894 be treated separately it appears that there were 25,844 reported cases, and 7,654 deaths in that year, the fatality being 29.6 per cent., while the fatality of the remaining years was only 21.6 per cent.

Treating the year 1898 in the same manner, the fatality was only 20.5 per cent., or the ratio of 31,494 cases to 6,471 deaths. In two States and seven cities combined, having a total population of 4,250,000, the fatality from diphtheria in 1894 was 29.7, and in the same places in 1898 it was only 14.6, confirming the statement that the diphtheria fatality has been cut in twain since the general introduction of antitoxin treatment. It is also quite noteworthy that in several large cities, situated a thousand miles apart, the diphtheria fatality before 1895 was quite uniformly from 29 to 30 per cent.*

The following figures are the result of observation in England during the eight years, 1891–98, under the operation of the English Notification Act. The diseases quoted are smallpox, scarlet fever, diphtheria and croup (considered together), typhus fever, typhoid fever, and erysipelas. The number of reported cases of these was 974,907, and the deaths from the same causes were 89,864:

* "Public Hygiene and State Medicine in the United States," a monograph contributed to the Paris Exposition of 1900, p. 22.

FATALITY OF CERTAIN DISEASES IN ENGLAND (1891–1898).*

Diseases.	Reported cases.	Registered deaths.	Fatality, per cent.
Smallpox	27,613	2,639	9.6
Scarlet fever	538,828	23,034	4.3
Diphtheria and croup	167,452	37,304	22.3
Typhus fever	2,441	522	21.4
Typhoid fever	126,967	22,208	17.5
Erysipelas	111,606	4,157	3.7

* Compiled from the reports of the Local Government Board of England for the years 1891–1898 inclusive.

The fatality in different years varied for the different diseases as follows (1891 being excepted, as notification was at that time comparatively incomplete): Smallpox, a maximum of 17.2 per cent. in 1896, and a minimum of 6.8 per cent. in 1895; scarlet fever, a maximum of 4.8 per cent. in 1894, and a minimum of 3.7 per cent. in 1898; diphtheria and croup, a maximum of 25.1 per cent. in 1894, and a minimum of 18.6 per cent. in 1898; typhus fever, a maximum of 26.9 per cent. in 1893, and a minimum of 19.5 per cent. in 1895; typhoid fever, a maximum of 17.8 per cent. in 1892, and a minimum of 16.8 per cent. in 1898; erysipelas, a maximum of 4.7 per cent. in 1892, and a minimum of 3.1 per cent. in 1898.

The fatality of smallpox showed a wide variation in different years, the variation being undoubtedly dependent upon the relative protection afforded by vaccination in the community attacked. In some parts of England vaccination has been neglected to a much greater degree than in others. (For the comparative fatality of smallpox in the vaccinated and unvaccinated, see *Vaccination* in a later volume.)

The fatality of diphtheria in recent years appears to have undergone decided modification under the use of antitoxin, as already shown.

If the figures for the four years, 1891–94, previous to the introduction of antitoxin in England, are compared with those of the four years, 1895–98, succeeding the introduction, a marked decrease is shown, the fatality of the previous period having been 24.3 per cent., while those of the latter period were 20.8 per cent. The fatality in the last year of record, 1899, had fallen to 17.3 per cent.

In Massachusetts where free distribution of antitoxin has been made throughout the entire State since March, 1895, the fatality for diphtheria had fallen from 28.3 per cent. in the four years (1891–94) to 14.9 per cent. in the succeeding six years (1895–1900) and to 10.2 per cent. for 1900.

Observations in the same State also show that the fatality among those who were treated with antitoxin was 11.2 per cent., or 657 deaths out of 5,888 cases. The number treated was much larger than this, but this number 5,888 represents those in relation to whom returns were made to the State Board of Health by attending physicians. This includes cases in private practice and in hospitals.*

The probability that any one will die when attacked with a given disease differs very much in degree with the character of the disease. For example, compare the fatality of chickenpox with that of smallpox, or that of hydrophobia or of tetanus with that of measles or mumps.

Fatality differs also with age and to some degree with sex. It also is modified by artificial conditions introduced for the purpose of limiting its severity, such as vaccination and the use of antitoxin.

The general degree of resistance to the fatal result from all causes is greatest at about eleven or twelve years of age.

Samuel W. Abbott.

DISINFECTANTS.—Littré, in his "Dictionary of the French Language," defines disinfectants as follows: "*Désinfectants*, substances qui détruisent chimiquement les mauvaises odeurs." This is the popular sense in which

* "Thirty-first Annual Report of State Board of Health of Massachusetts," 1899, p. 667.