parts of the pharynx and tonsils before even the local lesions are manifest. Lying thus in the crypts and recesses of the parts, they cannot all be reached and killed by such antiseptic fluids as we attempt to apply to them. It is also true that only in the mildest cases are the lesions wholly accessible to local treatment.

Some years ago a series of experiments were carried out under my supervision by Drs. White and Somerset, the resident physicians of the New York Hospital for Contagious Diseases, to test the comparative value of irrigating the nose and throat with simple cleansing solutions and with disinfectants (1 to 4,000 bichloride of mercury and five- to ten-volume solutions of peroxide of hydrogen). After a fairly thorough trial it was very difficult to see more than a trifling advantage in the use of antiseptic solutions.

If we attempt to kill the bacteria in the accessible lesions by caustics or the actual cautery, we are apt to injure the tissues without killing all of the bacteria, thus doing probably more harm than good. I believe, therefore, that we should not use any treatment which will irritate or lacerate the mucous membrane. I believe that no swab should be used in making applications to the mucous membrane unless it is done by the physician or by a trained nurse, and only then with the greatest care. Personally I prefer to trust to irrigation. For the nostrils I prefer a solution of one teaspoonful of salt to one pint of tepid water. This is best applied by means of a fountain syringe, but a small glass syringe with a rubber tip answers quite well. If the nostrils are so firmly plugged that great pressure is needed, then an ordinary hard-rubber syringe can be used. To its point is attached a short rubber tube, ending in a bulb to fit the nostrils. The force needed may be great, but the shock is of less harm than the continued total occlusion of the nostrils with the accompanying absorption of toxin and the probable production of sepsis.

When the local lesions of diphtheria are limited to the tonsils, irrigation of the nostrils is unnecessary, but when the posterior nares are involved, the nostrils should be irrigated from three to twelve times a day. Even weak solutions of peroxide of hydrogen are often very irritating to the nasal mucous membrane. For the irrigation of the mouth and pharynx either a normal salt solution or a 1 to 10,000 bichloride of mercury or a neutral five-volume peroxide of hydrogen solution may be employed. In older children and adults gargles may be used when the tonsils only are attacked. The solutions are simply held in the throat as far back as possible and then ejected. It is impossible for most persons through gargles to reach more than the tissues anterior to the faucial pillars.

Local treatment may be combined with general medication; thus the giving internally of the diluted tincture of the chloride of iron or of the bichloride of mercury in small frequent doses has considerable local effect upon the mucous membranes of the throat and pharynx. Lime water and solutions of boric acid may also be given frequently in small amounts by the mouth for their local effect.

The irrigation of the nostrils with salt water or one-per-cent. boric-acid solution has not appeared to cause ear trouble.

General Treatment.—The air in the patient's room should be pure and kept if possible at a temperature of 70°–72° F.

The drugs suggested for the treatment of diphtheria have been numberless, but few of them have proved themselves as of use generally. With the exception of the antitoxin none of them are specific. At the New York Hospital for Contagious Diseases mild cases are given an abundance of light diet, milk, broth, eggs, etc., and a dose of 1,000 to 2,000 units of antitoxin. This and the local treatment are all they receive. More severe cases are given brandy, from half an ounce to twelve ounces, in the twenty-four hours, according to the severity of the disease and the amount of prostration and the weakness of the heart action. In these severe cases and in any in which paralysis threatens, strychnine is given three times a day in doses of gr. $\frac{1}{100}$ to $\frac{1}{30}$. Where necessary, cardiac tonics such as caffeine and digitalis are employed. As the patients begin to convalesce they are given some preparation of iron as a tonic if they show much anæmia.

The antipyretics are to be avoided, because of their depressant effect, and also because the temperature is, as a rule, not seriously high in diphtheria.

The tincture of the chloride of iron in moderate and frequent doses is thought by many to be of great benefit, both locally and for its tonic effect, though if it causes nausea or vomiting it should be stopped. Jacobi advises up to ℥ i. each day for an infant, and for a child three years old twice that amount. Large doses do not appear to have any more beneficial effect than small, and are more apt to cause irritation of the stomach. The internal administration of bichloride of mercury, gr. $\frac{1}{15}$ to $\frac{1}{12}$ daily, in divided doses, has not seemed to me to be of any other than local value, though thought highly of by some. Good observers advocate small to moderate doses of quinine. I myself have had but little experience with its use.

Whenever paralysis of the muscles of deglutition has become sufficiently marked to prevent the swallowing of food, it is necessary to feed through a soft-rubber tube passed through the nose into the pharynx and œsophagus. All having serious disease should remain as absolutely quiet as possible and should take their food and evacuate their bowels in a recumbent position. Bronchitis, pneumonia, otitis, nephritis, and other diseases complicating diphtheria are treated as if they were primary diseases.

Treatment of Laryngeal Diphtheria.—For the relief of obstruction in laryngeal diphtheria there are the inhalation of the fumes of subliming calomel, the inhalation of warm steam with or without lime or other additions, the application of warmth or cold over the larynx, and the use of medicines internally, especially those causing nausea or vomiting.

The first two are the most important means of combating the beginning laryngeal obstruction.

Calomel Fumigation. This was first advocated by Corbin in 1881, and has since been extensively used. The inhalation of subliming calomel does not, as some claim, destroy the diphtheria bacilli, but it does often greatly relieve the obstruction with its accompanying symptoms. This so often follows each employment of it that there seems to be no doubt of its action. It does not, however, afford relief in all cases, even when used very early.

The method of using calomel fumigation varies with the apparatus at hand. The child should be put in an improvised tent so as to confine the fumes sufficiently to fill the tent with a rather dense white smoke. From ten to twenty grains can be thrown on a few live coals placed on a shovel and held under the tent while it sublimes, or a lump of live coal may be put in an iron or earthenware vessel and over it a strip of iron or an iron spoon upon which the calomel is placed. In the larger cities a suitable apparatus can be bought ready for use, which is, of course, more convenient.

Steam. The inhalation of warm steam is certainly at times of great benefit. To the water may be added equal parts of lime water, or to each pint one or two teaspoonfuls of compound tincture of benzoin. The warm, damp vapor is the chief thing. The steam should be inhaled as warm as possible, and the patient should be protected from the dampness by a covering of oil-muslin, or a thin blanket.

If in a strong child the laryngeal symptoms increase so that it seems as if intubation will soon become necessary, the effect of vomiting may be tried. For this purpose a dose of fl. ʒ ss.–i. of syrup of ipecac should be given every ten minutes until effective. Instead of ipecac, tartar emetic or the yellow subsulphate of mercury, gr. ij.–v. to a child of two years, and repeated, may be given. If an attack of vomiting does not give appreciable relief, it is not well to repeat it, as it exhausts the child and offers but slight hope of benefit. If a child is much prostrated, it is unwise to resort to emetics at all.

Intubation and Tracheotomy. If in spite of treatment the laryngeal stenosis advances so far that actual obstruction to breathing is marked and increasing, we must resort to intubation or tracheotomy.

By one or the other of the means we overcome the obstruction to the entrance of air through the larynx, and thus prevent suffocation, unless the membrane is too extensive below the end of the tube. We also aid the expulsion of mucus and portions of membrane through the opening formed by the tube. The insertion of the tube does not, of course, limit the extension of the disease or prevent complications. The apparent improvement due to the removal of the obstacle to respiration will therefore only be permanent when the disease itself yields to treatment.

The time at which intubation should be performed is a question of the greatest importance.

The insertion of a tube into the larynx is not wholly a matter of indifference even in trained hands. More or less abrasion of the swollen and inflamed laryngeal mucous membrane may be caused by its insertion, and its presence for several days is very likely to cause a superficial ulceration, either where its lower end impinges on the trachea or where its sides cause pressure.

On the other hand, so soon as the laryngeal stenosis becomes so marked that the person struggles for air, and in spite of the struggle sufficient aeration of the blood does not take place, that condition is a great detriment to the condition of the child long before any actual suffocation is impending.

In spite, then, of the possible injury to the larynx of the insertion and retention of the tube, we should not wait too long and thus allow a greater injury to occur.

If, therefore, the stenosis steadily increases and the retraction of the epigastric and jugular regions becomes decided, and cyanosis is evident, it is better not to wait longer. (See article on *Intubation.*)

Treatment of the Patient while Intubated. It is frequently the custom to raise slightly the foot of the bed on which the child lies, and it is always well to keep the child prostrate if possible.

A matter of vital importance is the feeding of the child, so that food will not pass down the tube. This is first attempted with the child lying down, with the head depressed below the rest of the body. If the child does not take fluid nourishment in this way, it is allowed to drink in the natural manner. If it is impossible to feed the child by either of these means, it must be fed by a stomach tube passed through the nose into the stomach. For a child of one or two years the tube should be the size of a No. 6 catheter; for a child of three to four years, a No. 8 catheter. Some physicians prefer, instead of a fluid diet, food which is of greater consistence or even entirely solid. At the Willard Parker Hospital for Contagious Diseases, however, fluid diet is, as a rule, preferred.

Extraction of the Tube. At any time after the insertion of the tube it may be coughed up, or it may become obstructed by membrane either blocking the tube or filling up the trachea below. Whenever the tube becomes obstructed it must be instantly removed. In those cases, however, in which the tube is neither coughed up nor obstructed it is found best to leave it in for such a period that five to seven days have elapsed from the time of the beginning stenosis. If the tube is removed earlier, it will usually have to be replaced, with the danger always of creating slight abrasions or injuries of the larynx.

Serum Therapy. The use of diphtheria antitoxin has passed the experimental stage and its use is now as firmly established as is that of vaccine as a preventive of smallpox. Its action seems to be to neutralize the diphtheria poison produced by the diphtheria bacillus and thus to render it inert and powerless to do injury. Whether this is the entire explanation of its action or not, it is most important to realize that both in animals purposely infected with diphtheria and in human beings ill with the disease the beneficial effects of antitoxin are most evident when it is given very early in the disease, before marked tissue degeneration has occurred.

Statistics gathered from all over the world are in accord, that the cases injected on the first day show the least, those on the second somewhat more, and those on the later days the greatest mortality. The chemical nature of antitoxin has already been considered under *Antitoxins* in Vol. I. As the results obtained with the antitoxin treatment have been so much in evidence in the journals, I will give here only a few figures from Krönlein (Zurich), quoted from the article on diphtheria by Jacobi in the "Twentieth Century Practice of Medicine." These are in accord with my personal observations in private practice, but rather more favorable than in hospital practice.

		Mortality, per cent.
Preantitoxin period, total cases	1,333	39.3
Operative cases	662	66.1
Antitoxin period, total cases	457	12.5
Operative cases	17	36.0

When antitoxin is given in sufficient amount shortly after the onset of the first symptoms the mortality is less than four per cent. It is rare for an uncomplicated case of diphtheria thus treated to die.

The immediate results which follow an injection of antitoxin in a case of diphtheria differ according to the period of the disease at which it was given and the characteristics of the case. This is due to the fact that while injection of sufficient antitoxin prevents any further effect of the diphtheria toxin, it will not lessen the toxic effects of the poisons produced by the other bacteria nor will it stop the progressive degeneration of cells already so injured that recuperation is impossible.

When antitoxin is administered early in pharyngeal, tonsillar, and nasal diphtheria the results are usually striking; improvement sets in quickly, the temperature drops within from three to twelve hours, the local inflammation abates, and the membranes and exudate soon loosen. The local disease does not spread to adjacent or distant portions of the mucous membranes. Except for slight prostration and anæmia the patient is frequently well in from two to three days.

When antitoxin is administered after the full development of the diphtheria the results are much less striking, so that we often are in doubt as to whether any actual results have been obtained. Undoubtedly many of these cases run a milder course than without antitoxin.

In laryngeal diphtheria it is difficult to be certain of the immediate effects in individual cases. When we examine a case we cannot as a rule tell the amount of larynx, trachea, and lung involved, and so are ignorant of the real severity and extent of the disease.

More cases of those receiving antitoxin early recover without having needed intubation than formerly, and those needing intubation are on the average able to have the tube removed earlier than before. Upon the bronchitis and broncho-pneumonia which develop in some, antitoxin has little or no effect.

Ill Effects of Antitoxin Serum.—A small percentage of the cases have a slight rise of temperature immediately after an injection. In a very few cases abscesses develop at the seat of the injection. This is a preventable accident.

Rashes.—These are peculiar to the serum injections. They are undoubtedly partly due to the horse serum, not altogether to the antitoxin. They occur in from five to twenty per cent. of the cases, according to the characteristics of the serum. The eruption may be limited to the point of injection, or may more or less completely cover the whole body. It most often appears as an urticaria, but may very closely resemble scarlet fever or more rarely measles. It usually develops between the seventh and fifteenth days, but may occur as early as on the second day. In some cases all the forms may be united in one person. Following the eruption, desquamation may occur. In about one-fifth of the cases there is a rise in temperature of 2°–4° F. This lasts for from one to three days. In a small percentage of cases there is accompanying the rash tenderness over the joints of the extremities. These pains last, as a rule, for from one to four days.

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

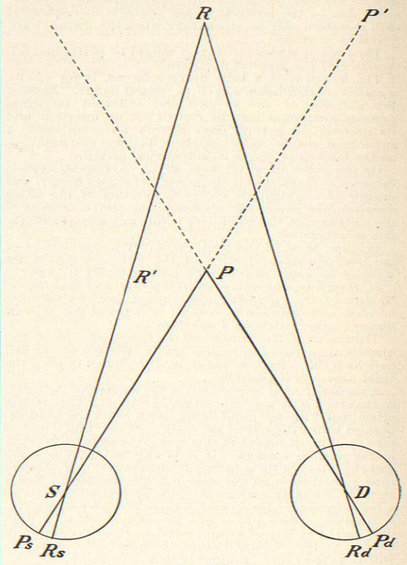

FIG. 1597.

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