the same number having a white count below 10,000 per cubic millimeter, only fifteen (30.61 per cent) produced a positive complement fixation test.

**COMMENT**

The complement binding factor of serum from influenza pneumonia patients is probably a very weak one. At first, when two units of complement were used, many more negative results were obtained than when one unit was finally resorted to. Two units probably produced a marked excess of complement for that factor of the serum that causes complement fixation.

The results suggest strongly that the influenza bacillus forms specific antibodies that will fix complement when this organism is used as an antigen.

It is difficult to conclude definitely from these experiments alone whether only one or many strains of the influenza bacillus were active during the epidemic; but this can be stated: Polyvalent antigens did not give more positive results than a monovalent one. If many strains of this organism were present, then one could have expected more positive reactions in these experiments than were obtained from the use of an antigen made from one strain.

Serums that gave positive tests were also found more suitable for the serotherapy of influenza pneumonia patients. It seems possible that persons who have not had influenzal pneumonia, but whose serum gives a positive reaction, might be useful as donors.

Since some of the reactions were inconstant, it must be concluded that the complement fixation test in influenza pneumonia cannot yet be accepted as a diagnostic test; but it may be of some value together with other diagnostic methods in confirming the condition as having been present, at least in more than 50 per cent. of the cases.

This presence of complement fixation would indicate that the influenza bacillus plays an important part in the complicating pneumonia of influenza; but the results furnish no conclusive evidence of a primary etiologic rôle of the influenza bacillus.

**SUMMARY**

Experiments were made for the purpose of determining whether specific antibodies existed in the serum of patients who were convalescent from influenzal pneumonia.

The influenza bacillus was found in more than 80 per cent. of the necropsies at this laboratory was used as an antigen.

The presence of antibodies was demonstrated by the complement fixation test, for it was found that out of the 300 control sera 9.6 per cent. gave a positive reaction, while of the 295 sera from convalescent influenzal pneumonia patients, 54.5 per cent. had antibodies that fixed complement.

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**THE TRANSMISSION OF INFECTION THROUGH THE EYE**

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Captain M. C., U. S. Army

FORT SILL, OKLA.

Recently the eye has received little or no attention as a factor in the transmission of acute respiratory infections. It has been disregarded in planning measures for the prevention of the spread of contagious diseases. This was especially true in the recent epidemic of influenza. No provision has been made in the ward routine of contagious hospitals for the protection of the eye of healthy persons in attendance on the unmasked sick. A brief consideration of the anatomic relations and physiologic facts of the lacrimal-nasal mechanism, together with certain simple experiments illustrating its modus operandi, will convince one of the reality and importance of this portal of entry for pathogenic micro-organisms.

It has long been known that large numbers of various organisms, including the pneumococcus, streptococcus, influenza bacillus, and many others, may be recovered from the conjunctival sac, especially if there is obstruction to the overflow of tears. The conjunctival sac is never sterile. The source of contamination has been attributed largely to the impingement on the conjunctiva of the eyeball and the cornea of dust particles bearing micro-organisms. It is evident that droplets sprayed from the mouths of other persons during the act of talking, laughing, coughing, sneezing, etc., must be another frequent source.

It is now generally accepted that many contagious diseases are transmitted from one person to another through this direct droplet spray. Experimentally it has been shown by Doust and Lyon1 that a person infected with a micro-organism (B. prodigiosus) may project this organism from his mouth during ordinary conversation or loud speech to a distance of 4 feet, and that during coughing, infected material from the mouth might be projected at least 10 feet. These observers, together with Haller and Colwell,2 proved that this promiscuous spraying of the environment by an infected person could be entirely prevented by the wearing of a properly constructed gauze face mask. There is no experimental proof, however, that the reverse relation holds true, that is, that the noninfected healthy person is entirely protected from droplet spray by the wearing of such a mask. Droplets may not enter the nose or mouth when a face mask is worn, but the conjunctiva remains openly exposed.


importance of this portal of entry will become more evident if the conditions under which infection occurs are closely examined.

THEORETICAL CONSIDERATIONS

Infections are most likely to be transmitted during the waking hours when a person has his widest range of activity and is coming into intimate association with numbers of other human beings. This is especially true in crowds, in which the range for droplet spray is short. Under these conditions the mouth is closed a large part of the time, in particular when another (perhaps infected) person is talking to (spraying) the non-infected healthy person who assumes the attitude of a listener. With the mouth closed, only the lips may receive the droplets; the bacteria dry there and perish, or perhaps they are swept into the mouth by movements of the tongue. Furthermore, when a healthy person is talking, air currents are created that are adverse to the entrance of droplets from the infected. The mouth surface exposed to droplet spray may consequently be represented as averaging about 100 sq. mm.

The nares at such times may not be directly exposed, owing to the protected anatomic position when the head is slightly inclined forward. With every expiration, adverse air currents are created. Hence, although a cross-section of the nares gives an area of about 200 sq. mm., this is available for direct droplet spray less than half of the time.

Contrasted to these areas, some 600 sq. mm. of eye surface area is constantly exposed to droplet spray during the waking hours, except for the very brief intervals during the act of winking, an act which is in itself of significance for the mechanism, as will be seen later. Certainly the chances of infecting the eye are fully as good as those of infecting the nose and mouth, if not better. These relations are brought out graphically in Figure 1.

THE LACRIMATORY-NASAL MECHANISM

The disposition of organisms reaching the conjunctival sac through droplet spray or dust particles may be easily demonstrated by the use of some harmless saprophyte, preferably a pigment producer, such as Bacillus prodigiosus. This will be made clear by the subjoined experiments and Figure 2.

By the winking movement of the lids, the surface of the eye is swept at regular intervals, and the lacrimal secretion, which has no bactericidal action, together with the contained micro-organisms, is carried into the nose through the lacrimal duct (Fig. 2, 1).

EXPERIMENTS

EXPERIMENT 1.—To show the appearance of organisms in the nose after introduction into the conjunctival sac.

With a capillary pipet, 1 drop of suspension* was instilled into the eye near the inner canthus in each of five subjects. Just previous to the instillation, a straight swab was introduced into the nostril on the same side and smeared on the first quarter of an agar plate to demonstrate the absence of B. prodigiosus from the nasal fossa at the beginning of the experiment. In a similar manner a swab was introduced on the same side at five, ten and fifteen minute intervals after the instillation, and then smeared on agar plates. The plates were examined at twenty-four and forty-eight hours for colonies with characteristic pigmentation. The result of such an experiment is shown in Table 1.

It is evident from this experiment that B. prodigiosus instilled into the conjunctival sac is quickly carried into the nose, and that the organisms may there be recovered on a nasal swab within five minutes of the instillation. From the opening of the lacrimal duct (Fig. 2, 1) two courses are open. They may pass out through the anterior nares. This occurs when there is excessive secretion, or when the nose is "blown." Secondly, they may be carried backward into the nasopharynx (Fig. 2, 3). The topography of the nose favors the latter disposition, and this normally occurs in the absence of the factors mentioned above.

EXPERIMENT 2.—To show appearance of organisms in the nasopharynx after introduction into the conjunctival sac.

The details of the technic are the same as in Experiment 1. In addition, at the end of thirty minutes a long wire swab, slightly bent at the end, was introduced into the nasopharynx through the mouth and smeared on the agar plates. The result is shown in Table 2.

EXPERIMENT 3.—To show appearance of organisms in the nasopharynx after introduction of diminishing doses into the conjunctival sac.

The details of the technic are the same as in Experiment 2. In addition, the standard suspension used on the first subject was diluted 1:100 in the second, 1:1,000 in the third, and 1:10,000 in the fourth. A single drop from a capillary pipet was the dose instilled in each instance. The result is shown in Table 3.

Experiments 2 and 3 demonstrate that even very small doses of B. prodigiosus instilled into the conjunctival sac may be recovered from the nasopharynx from fifteen to thirty minutes later.

The disposition of organisms from this point (Fig. 2, 3) may follow one of three courses: 1. They may

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* The standard suspension of B. prodigiosus used in these experiments was prepared by growing a 2 inch streak on an agar slant for from eighteen to twenty-four hours at incubator temperature, and washing the organisms off the surface with 2 c.c. of salt solution.
pass outward through the mouth with the sputum. 2. They may be carried into the larynx and reach the lower respiratory tract. 3. They may be carried downward into the esophagus with the swallowing movements, and persist in the intestinal canal or be excreted with the feces. The latter is probably the most frequent course.

**TABLE 1.—INSTILLATION OF B. PRODIGIOSUS INTO CONJUNCTIVAL SAC; RECOVERY FROM THE NOSE**

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Result of Nasal Swabs</th>
<th>Result of Nasal Swabs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M. K. F.</td>
<td>0 0 0 0 + + + + + + +</td>
<td>0 0 0 0 + + + + + + +</td>
</tr>
<tr>
<td>2</td>
<td>F. B.</td>
<td>0 0 0 0 + + + + + + +</td>
<td>0 0 0 0 + + + + + + +</td>
</tr>
<tr>
<td>3</td>
<td>E. A.</td>
<td>0 0 0 0 + + + + + + +</td>
<td>0 0 0 0 + + + + + + +</td>
</tr>
<tr>
<td>4</td>
<td>J. W.</td>
<td>0 0 0 0 + + + + + + +</td>
<td>0 0 0 0 + + + + + + +</td>
</tr>
<tr>
<td>5</td>
<td>P. L.</td>
<td>0 0 0 0 + + + + + + +</td>
<td>0 0 0 0 + + + + + + +</td>
</tr>
</tbody>
</table>

Specimens of the stool were obtained from Subjects 7, 9 and 10, about twenty-four hours after they had submitted to Experiment 2. In one of the three (Subject 7), a viable *B. prodigiosus* was recovered. Success might have attended the other attempts had cultures been taken of successive passages.

The disposition outlined above holds true for the bulk of organisms introduced into the conjunctival sac. Larger or smaller numbers are left along the course, particularly on the nasal mucous membrane and in the adenoid tissue of the nasopharynx. If the biology of the organism is unsuited to the environment, its growth is inhibited or it is perhaps destroyed by neutralizing substances in the nose. If the biology of the organism is such that the environment is suitable for reproduction, growth ensues with resulting stimulation of protective mechanisms and manifestations of infection of the respiratory tract.

**LIMITATIONS OF THE GAUZE FACE MASK**

From the foregoing it is clear that the eyes present a relatively large surface for the reception of droplet spray, and that organisms introduced into the conjunctival sac quickly reach the nose and throat. It follows that the gauze face mask fails completely to close this portal of entry. This fact may be demonstrated experimentally:

**EXPERIMENT 4.—To demonstrate infection of the upper respiratory tract by droplet spray while a gauze face mask is being worn.**

The standard suspension of organisms was diluted 1:20 with salt solution so that it was slightly but definitely turbid. The suspension was placed in an atomizer connected with a compressed air tank. After a swab had been taken to show the absence of *B. prodigiosus* from the nose of the subject at the beginning of the experiment, the nose and mouth were covered with a gauze mask. All subjects, except 20 and 21, used a mask consisting of eight thicknesses of gauze, of 28 by 24 mesh. Subjects 20 and 21 used a three layer butter-cloth mask constructed according to the specifications of Doust and Lyon. Besides wearing the mask, the first five subjects were instructed to hold their hands over their mouths, closing off the nostrils and holding the breath during exposure. The atomizer was directed toward the faces of the subjects from a distance of from 3 to 4 feet, and the spray applied twice—each application lasting about a second—imitating a couple of coughs. With the last four subjects, particular care was taken to exclude the possibility of organisms gaining entrance through inhalation. The swabbing was done in one room, and the exposure to spray in another. The subjects, having previously been masked, were brought into a room where they were exposed, and then immediately withdrew to the room where the swabs were taken. The mask was worn during the whole twenty minutes of observation except when the swabs were being taken.

The result is shown in Table 4.

The result is unequivocal. It may be repeated by any one for his own satisfaction. The possibility of infecting the upper respiratory tract through the eye by direct droplet spray, even when a properly constructed mask is worn, is an easily demonstrated fact.

**TABLE 2.—INSTILLATION OF B. PRODIGIOSUS INTO CONJUNCTIVAL SAC; DECREASING DILUTION; RECOVERY FROM NOSE AND NASOPHARYNX**

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Recovery from Nose</th>
<th>Recovery from Nasopharynx</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>C.</td>
<td>0 + + + + + + + +</td>
<td>0 + + + + + + + +</td>
</tr>
<tr>
<td>12</td>
<td>N.</td>
<td>0 + + + + + + + +</td>
<td>0 + + + + + + + +</td>
</tr>
<tr>
<td>13</td>
<td>W.</td>
<td>0 + + + + + + + +</td>
<td>0 + + + + + + + +</td>
</tr>
<tr>
<td>14</td>
<td>H.</td>
<td>0 + + + + + + + +</td>
<td>0 + + + + + + + +</td>
</tr>
</tbody>
</table>

**COMMENT**

The frequency with which respiratory infections—for example, acute coryza, measles and influenza—begin with a conjunctivitis suggests that this entrance for the causative organism may not be uncommon. It is realized that the conjunctivitis in certain cases is simply a suffusion and part of the general mucous membrane response. In other cases the priority and prominence of this symptom indicates rather a primary relationship with the disease. Certainly the evidence is sufficient to warrant serious consideration of this portal of entry in planning measures for the prevention of the spread of contagion. The obvious means of protection is the wearing of a large lens or pair of goggles in addition to the gauze mask by those who are within range of droplet spray from heavily infected individuals. In this connection it is interesting to note that during the great epidemics of plague that have from time to time swept over the Old World, masking of the whole face, eyes included, has been wonderfully effective.

The gauze mask is efficient in preventing the infected person from spraying his environment, and should be used for this purpose when possible. It is impracticable.
cable to mask very sick patients, especially those with respiratory difficulty. These patients are prolific distributions of droplet spray. Physicians and attendants, even though properly masked, cannot come within close range of such persons without the danger of infection through the eye. Public health administrators should bear in mind the limitations to the protective value of the gauze mask when worn by the noninfected. The pathologist at the necropsy table should remember that infectious material splashed into the eyes is just as potent as if it had been directly implanted on the mucous membrane of the nasopharynx.

CONCLUSIONS
1. The eyes offer a relatively large surface area for the reception of droplets sprayed from the mouths of other persons.
2. An organism introduced into the conjunctival sac may be recovered from the nose in five minutes, from the throat in fifteen minutes, and from the stool in twenty-four hours.
3. The upper respiratory tract of a person wearing a properly constructed mask may be infected by exposing the eye briefly to direct droplet spray.
4. This portal of entry is of importance in the transmission of acute respiratory infections.

HYSTERICAL APHONIA ASSOCIATED WITH LATENT SYPHILIS

REPORT OF CASE

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TAKOMA PARK, D. C.

A well developed man, aged 36, 5 feet 11 inches in height, whose habits were good, who drank beer occasionally, smoked moderately and was a telegrapher, enlisted in the Army, Jan. 10, 1918, at Fort Thomas, Ky. While on a furlough at home, he developed a cold and an eruption which a civilian physician diagnosed as measles. Hoarseness accompanied by a cough first appeared at this time and progressively increased until January 16, when the patient completely lost his voice. He was sent to Fort Wood, N. Y., for treatment. The post surgeon there referred him to the Manhattan Ear and Throat Hospital, where he received active treatment from February 20 to March 30. His condition apparently remained the same; several Wassermann tests had been negative, and no definite diagnosis could be made. The soldier was then transferred to the Canal Zone in the belief that a climatic change might affect the aphonia, and reported there for duty, April 15, where he was shortly afterward admitted to the Ancon Hospital.

July 6, a blood test gave a ++ Wassermann reaction for the first time; July 11, the spinal fluid gave a negative Wassermann reaction; July 12, a blood test was again ++. With a history of a sore on the penis in 1906 and the presence of a scar there, together with a ++ Wassermann reaction, it was decided to institute specific treatment. He therefore received five arsphenamin injections intravenously, six mercuric salicylate injections intramuscularly, and potassium iodid by mouth between July 23 and August 19. August 8 and 19, the Wassermann tests were reported negative with no improvement in the aphonia.

September 30, the patient was transferred to the Walter Reed General Hospital for final disposition. Two Wassermann tests were taken, one, October 2, and the other, October 7; the former was negative, the latter +. A neurologic examination revealed slightly exaggerated knee jerks, a marked Romberg sign, but no Babinski reflex or ankle clonus. The laryngologic examination revealed no pathologic condition of the vocal cords; the tonsils were in a state of chronic hypertrophy; otherwise the patient was normal. In view of the foregoing symptoms, a lumbar puncture was performed, October 17; the spinal fluid was clear and under normal pressure. All the tests, namely, the Wassermann, globulin, colloidal gold and cell count, were negative. Although the biologic tests were normal, still we felt justified in administering further specific treatment in the expectation that the therapeutic test would throw further light in clearing up the diagnosis.

Accordingly the patient received four intravenous injections of arsphenamin, 0.5 gm. each, four injections of mercuric salicylate intramuscularly at weekly intervals, and potassium iodid by mouth, from October 22 to November 12. The Wassermann test, November 4, was still ± with no change in the patient's aphonia and the Romberg sign.

After much deliberation, it was decided to examine the larynx under ether anesthesia. December 12, the patient was anesthetized and the larynx examined by the direct method. Nothing abnormal was found to account for the aphonia; only a slight congestion of the false cords was noted. When reacting from the anesthetic, the patient began to speak in normal pitch and his voice remained so until December 31, when it was decided to return him to duty. The Romberg sign was still present, which we believe to be purely functional. Before the administration of the anesthetic the patient was told that an operation would be performed in his throat, after which his voice would be restored. After the patient reacted, he complained of some soreness which he thought was due to the operation. The passage of the laryngoscope probably set up enough irritation to account for the complaint.

DIFFERENTIAL DIAGNOSIS

From the standpoint of differential diagnosis, the following conditions had to be considered:
1. Acute and Chronic Laryngitis.—This condition, with the symptoms starting as an acute laryngitis and going into a chronic condition, was thought not probable, as no improvement followed local treatment.

2. Tuberculosis of the Larynx.—This condition following an attack of measles had to be considered. The symptoms appeared suddenly, there was no pain, and there was an absence of laryngeal and pulmonary signs, all of which eliminated this diagnosis.

3. New Growths.—There was no local or constitutional evidence of these.

4. Interstitial Neuritis of the Recurrent Laryngeal Nerve Caused by Syphilis.—Such a condition causing paresis or paralysis would have responded quickly under specific treatment; there was no improvement in this case.

5. Final Diagnosis of Hysterical Aphonia.—This was made because of restorative voice after the administration of an anesthetic to an individual who probably had latent syphilis.

Cost of Preventable Illness.—The cost of sickness in the state of Illinois for the year ended July 1, 1918, reached the total of $184,881,685, according to a statement issued, January 16, by Dr. C. St. Clair Drake, director of the state department of public health. In the order of their annual cost to the state through sickness and death the several diseases embraced in the study rank as follows: tuberculosis, $114,905,500; pneumonia, $30,999,360; typhoid fever, $3,006,900; malaria, $2,660,800; diphtheria, $1,156,625; whooping cough, $745,620; smallpox, $675,600; infantile paralysis, $461,600; measles, $456,020; epidemic spinal meningitis, $425,000; scarlet fever, $388,300.