contain vacuoles, detritus of myelin, and an occasional pair or short chain of diplococci. There was no evidence of acute leptomeningitis or of ependymal changes.

REMARKS.

The acute non-purulent encephalitis of the adult was first brought prominently to the knowledge of the medical profession by Strümpell¹ in 1890, although in 1884² he had described and discussed the acute non-purulent encephalitis of children. This disease was then considered as closely allied to the superior polio-encephalitis of Wernicke, and as differing from it pathologically, chiefly in the location of the lesions. The clinical symptoms, however, in the two affections were dissimilar.

Strümpell¹ describes this form of acute encephalitis in adults as an affection of very acute onset, with severe cerebral symptoms and rapidly fatal termination. Almost without prodrome a condition of dulness or apathy occurs, soon increasing to the deepest coma. This is usually accompanied by high fever, and hemiplegia appears as the loss of consciousness deepens.

Shortly after the publication of Strümpell's article other observers began to report more or less similar cases. Schmidt,³ in 1892, related a case in a girl of nineteen, with involvement chiefly of the basal ganglia, and Fürbringer⁴ and Königsdorf⁵ published cases. Goldscheider⁶ described a case of polio-encephalitis superior, with involvement of the optic thalamus, posterior commissure, internal capsule, and to a slight extent of the centrum semiovale. Büchler's⁷ article in the *Archiv für Psychiatrie*, describing Leichtenstern's cases, was the fullest and most complete up to this time (1891).

From the accounts of these writers it appeared that many cases of this affection were more or less closely connected with influenza, occurring either after an attack of that disease or during an influenza epidemic. In spite, however, of many attempts, the influenza bacillus could not be detected.

In 1895 Oppenheim⁸ published six cases of this affection which recovered, and showed that the disease was not necessarily, or even generally, fatal. It was now recognized that the symptoms as described by Strümpell¹ must be modified, as in many cases these were prodromata, and the general course of the disease might be much less rapid than in his cases. Brie⁹ in 1897 gives a good description of the symptoms.

The most important article which has appeared on this subject is, however, that of Oppenheim,¹⁰ in which he gives a full description of this encephalitis, with a summary of all the knowledge acquired in regard to it up to the time of writing. He states that it may come on suddenly, or it may be preceded by headache, vertigo, nausea and vomiting, general weakness, apathy and insomnia. A rigor may occur. As the disease progresses the apathy becomes more marked, somnolence appears, which is apt to increase to total loss of consciousness, from which the pa-

tient cannot be aroused, or can be aroused only momentarily. This is usually accompanied by restlessness and delirium. General convulsions may occur, and in one case there was status epilepticus. Stiffness of the neck muscles and trismus have been recorded. The temperature is raised; the pulse may be slow or rapid; respiration may be rapid. The chief local phenomena are the paralysis, hemiplegia, monoplegia, aphasia; unilateral convulsions may occur. Anomalies of sensation are not marked. The deep reflexes vary. This is now the accepted symptomatology.

The first case which I have been able to find in which diplococci were detected is that of Hochhalt¹¹ in 1897. Fischl,¹² in 1899, in writing of the various forms of encephalitis in children, states that no bacteria have been found in them except such as might accompany septicemia.

Since 1897 little has been added to our knowledge of this disease. Friedmann's¹³ article in 1899 is largely devoted to pathologic considerations, and Nonne,¹⁴ in 1900, wrote a somewhat lengthy article on the same subject.

Meningitis, accompanied by and presumably due to pneumococci, has been known for some years. Boulez and Courtois-Suffit (1890), Hutinel (1892), Woods (1894), Ferrand (1896), Gailard (1898), Graham (1899), may be consulted on this subject.

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- ¹ Strümpell: Ueber primäre acute Encephalitis, *Deutsch. Arch. f. klin. Med.*, 1890, xlvii, 53.
- ² Strümpell: Ueber d. acute Encephalitis d. Kinder, *Deutsch. med. Woch.*, 1884, p. 714.
- ³ Schmidt: *Deutsch. med. Woch.*, 1892, xviii, 703.
- ⁴ Fürbringer: *Deutsch. med. Woch.*, 1892, no. 3, p. 45.
- ⁵ Königsdorf: *Deutsch. med. Woch.*, 1892, no. 9, p. 182.
- ⁶ Goldscheider: *Charité Annalen.*, 1892, xvii, 139.
- ⁷ Büchler: *Arch. f. Psych.*, 1892, xxiv, 730.
- ⁸ Oppenheim: *Deutsch. med. Woch.*, 1895, xxi, 85.
- ⁹ Brie: *Allg. Ztschrift. f. Psych.*, 1896, liii, 604; *Neurol. Centralbl.*, 1897, xvi, 2.
- ¹⁰ Oppenheim in Nothnagel: *Spec. Path. in Therapie*, ix, 1 th., 3 Abth. 1.
- ¹¹ Hochhalt: *Pest. med. Chir. Presse*, 1897, xxxiii, 796.
- ¹² Fischl: *Jahrb. f. Kinder.*, 1899, xlix, 58.
- ¹³ Friedmann: *Arch. f. Psych.*, 1898, 1899, xxi, 846.
- ¹⁴ Nonne: *Festschrift Wilhelm Erb.*, etc., 1900, 1.

FLIES AND TUBERCULOSIS.*

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PREVIOUS OBSERVATIONS.

SPILLMAN and Haushalter¹ found tubercle bacilli both in the intestinal contents and the excreta of flies in a hospital ward.

Hofmann² demonstrated tubercle bacilli in the intestinal contents in four of six flies caught in the room of a recently fatal case of phthisis; fly specks scraped from different parts of the room also showed tubercle bacilli. Flies were fed on tubercular sputum and the presence of tubercle bacilli observed in their excreta. Of three guinea pigs inoculated with the intestines of these flies only one developed tuberculosis. Inoculation of specks which had dried for six to eight weeks gave a negative result.

* From the Pathological Laboratory of the Massachusetts General Hospital. J. H. Wright, Director.

Read before the clinical meeting of the Medical Board, Dec. 2, 1904.

¹ Spillman and Haushalter: *Dissemination du bacille de la tuberculose par les mouches.* *Comp. rend. 1887*, t. cv, no. 7, pp. 352, 353.

² Hofmann: *Die Gefahr der Weiterverbreitung der Tuberculose durch unsere Hausfliegen.* *Jahrb. d. Gesellsch. f. Nat. u. Heil.* in *Dresd.* 1887-8, pp. 145-147.

Celli³ states without details that Alessi, under his direction, fed flies on tubercular sputum. Two rabbits developed tuberculosis after inoculation into the anterior chamber of the eye with the dejecta of these flies.

Hayward⁴ has recently confirmed the presence of virulent tubercle bacilli in the excreta of flies fed on tubercular sputum.

Thus far, therefore, it may be considered established that tubercle bacilli may appear in the stools of flies which have recently ingested tubercular sputum. Celli and Hayward obtained tuberculosis of experimental animals by inoculation of fresh dejecta, while Hofmann succeeded in one of three injections with the intestines and failed with specks which had dried for six to eight weeks.

PERSONAL OBSERVATIONS.

I. *Flies and Tubercular Sputum under Artificial Conditions.*

In August, 1904, my interest was aroused in the possible dissemination of tubercle bacilli through flies by their feeding on sputum under examination.

A. *Feeding experiment: apparatus.* — Three glass jars were inverted over a piece of window glass. They were raised three quarters of an inch above the glass plate and the intervening space closed with fine wire netting.

FIG. 1. — Glass jar for confining flies.

Flies and tubercular sputum. — Thirty House flies were confined in one of the glass jars (Fig. 1). Many clean cover glasses and a small glass dish containing sputum with about ten tubercle bacilli to each microscopic field were placed on the bottom of the cage. The flies were allowed to feed on this sputum between Aug. 10 and 13, 1904.

Death of the flies. — Within three days, twenty-six of the flies were dead. The four remaining flies were very inactive.

Control I: Six flies were confined in a second similar jar and fed on non-tubercular sputum. They were all found dead on the bottom of the cage within two days.

Control II: Six flies were confined in a third similar jar and fed on water, sugar and meat. Two of these

³ Celli: Transmissibilità dei germi patogeni mediante le deiezioni delle mosche. Bull. d. Soc. Lancisiana d. Osped. di Roma. 1888, Fasc. 1, p. 1 (quoted from Nuttall. The Johns Hopkins Hosp. Rep., vol. viii, 1900).

⁴ Hayward: The fly as a carrier of tuberculous infection. N. Y. Med. Journal and Phila. Med. Journal, Oct. 1, 1904.

died within two days. The remaining four were still alive after one week, when the experiment was discontinued.

The short duration of the life of the flies fed on tubercular sputum is not due, therefore, to tubercle bacilli, but to some other constituent of the sputum.

Tubercle bacilli in the fly. — Paraffin sections were made from many of the flies fed on tubercular sputum. Tubercle bacilli were found in the intestinal contents of all. No invasion of other parts of the body could be determined.

Tubercle bacilli in the specks: time of appearance. — Examination of the cover glasses placed on the bottom of the cage showed that the bacilli appear in the stools within at least eighteen hours after the ingestion of the tubercular sputum.

Number of tubercle bacilli disseminated. — Examination of many specks on the cover glasses showed that the number of bacilli in each microscopic field had increased from about 10 in the original sputum to 150 in the specks. Each speck contained from 3,000 to 5,000 bacilli. About 2,000 specks had been deposited by the 30 flies within three days, thus from 6,000,000 to 10,000,000 tubercle bacilli had been transferred from the sputum to the inner sides of the cage during this period.

Morphology of the bacilli in the specks. — When the bacilli in the specks were compared with those in the original sputum, it was seen that they were much larger, both in length and diameter and showed some evidence of apparent branching.

Virulence of the tubercle bacilli in the specks. — At the completion of the feeding experiments, the glass jar containing the specks was placed on a table in the middle of an unused room of the laboratory. This room (floor, 18 x 18; height, 20 feet) is lighted by two windows with a northern exposure. The direct rays of the sun do not reach it at any season of the year. A board

FIG. 2. — The relation of the specks to the lighting of room. Drying experiment.

three feet high was placed between the glass jar and the windows (Fig. 2) to protect the jar from strong diffuse daylight.

Guinea pigs were each inoculated with one hundred fly specks scraped from the cage at intervals of

one, eight, fifteen, twenty-eight and fifty-five days. The first inoculation was made subcutaneously, the others into the peritoneal cavity. The animals were killed after five to seven weeks. Tuberculosis was produced by the inoculated material in the first three animals, showing that virulent tubercle bacilli were present in the specks for at least fifteen days. The pigs were negative after this interval.

The pig inoculated with the specks which had dried for only one day showed generalized tuberculosis. A gradual diminution in the extent of the process was observed. The pig killed after fifteen days presented large isolated tubercular lesions of the spleen and of two lymph glands: one in the gastro-hepatic omentum, the other in the anterior mediastinum. Tubercle bacilli were demonstrated in the lesions.

The above experiment is thought to show that fly specks contaminated by tubercle bacilli may be a source of danger by direct transfer to the human subject, as in the ingestion of infected food, for at least fifteen days after their deposit, if exposed only to diffuse daylight in the interior of a room. Previous observers have shown that tuberculosis can be produced in animals by feeding them on infected material. As this has been already established (see below) it was not thought necessary to feed the infected fly specks to animals, but merely to determine their virulence and its duration.

The far greater frequency of tuberculosis of the lungs in the human subject and a mass of experimental data (Cornet⁵) indicate that the usual contagion of tuberculosis is not by the ingestion of infected food, but by the drying and distribution as dust of infected material through the air.

It was next of interest, therefore, to try to determine whether infected fly specks play any part in this indirect and more common infection by contamination of the surrounding air.

B. Inhalation experiment: apparatus.—A glass cylinder (18 x 2 inches) was closed at either end by wire netting, tacked to a rim of cork. One end of this tube was closely fitted to a hole in the side of a wooden box. The inner opening of this hole into the box was also closed by wire netting, leaving a space of one-half inch between this and the netting closing the end of the glass cylinder. The box (8½ x 9 x 12 inches) was closely fitted with a glass cover and its sides sealed by pasting paper about it. A stiff rubber tube connected with a water vacuum apparatus⁶ (Eimer and Amend) was led through the side of the box opposite the entrance of the glass cylinder (Fig. 3). The air in the box was exhausted by this means so that a constant slow current passed through the cylinder into the box and out the rubber tube at the other side. The direction of the air current was readily shown by blowing smoke toward the free end of the glass cylinder. An attempt was made merely to keep a gentle flow of air through the cylinder into the box.

⁵ Cornet: Spec. path. u. Ther. Nothnagel. xiv Bd. 2. II Abth.

⁶ Suggested by J. H. Wright.

Twenty-three flies were confined in the glass cylinder, with tubercular sputum. They deposited, between Aug. 17 and 19, a large number of specks on the inner surface of the tube. Dur-

Fig. 3.—Inhalation experiment. Pig confined in box for eight days.

ing these two days all but four of the flies had died. These survived only twenty-four hours longer.

On Aug. 19, a young and healthy guinea pig was placed in the box and a slow current of air drawn through the glass cylinder into the box by means of the vacuum apparatus. The pig was confined here for eight days. The apparatus was kept in the same room and under the same conditions as in the feeding experiment. (Experiment A.)

Twelve weeks were allowed to elapse before this animal was killed. At the autopsy, not a trace of tuberculosis could be found in any part of the body. Microscopic examination of sections from different parts of the lungs revealed no lesions.

Cornet⁷ has shown that guinea pigs can readily be infected by dust from tubercular material. Of forty-eight guinea pigs exposed in a room to dust shaken from a contaminated carpet, tuberculosis was produced in forty-seven.

From the above experiment (Experiment B) there is no evidence of the spontaneous liberation of tubercle bacilli from the fly specks, even when swept by a gentle current of air. It is probable, however, that when mechanically disturbed infection of the air would occur as in Cornet's carpet experiment.

II. Flies and Tubercular Material under Natural Conditions.

I have frequently observed the eagerness with which flies feed on sputum even when other food is accessible. Their dejecta frequently soil the walls and cloud the windows of unscreened rooms. During the fly season, I have counted many thousand fly specks on windows which are frequently washed. In their migration from one kind of food to another, they must deposit great numbers of specks on food. If they eat

Cornet: l. c. p. 61.

of tubercular material and later alight on food stuffs intended for human ingestion, they may deposit on them great numbers of tubercle bacilli. If these infected specks are unexposed to sunlight or strong diffuse daylight, they may maintain their virulence, as the above experiment (Experiment A) has shown, for at least fifteen days. If the specks are exposed to the direct rays of the sun they probably lose their virulence much more quickly. Mitchell and Crouch,⁸ for example found that tubercular sputum, placed in direct sunlight failed to infect guinea pigs after thirty-five hours. If preserved in the dark, they may remain infective for a much longer period than fifteen days.

Tuberculosis may readily be produced in animals, experimentally, by feeding them on food infected with tubercle bacilli (Baumgarten,⁹ Fischer,¹⁰ Dobroklonski¹¹). In these animals, the tubercular lesions are in the cervical lymph glands, the intestines, the mesenteric glands, the liver and more rarely the lungs (Baumgarten¹²). By analogy, primary tuberculosis of the intestines or the mesenteric lymph glands in man may be regarded as due to the ingestion of infected food. Many such cases have been reported among others by Demme,¹³ Ollivier,¹⁴ and Wyss.¹⁵ In such infections I have no doubt that flies play a part.

Cornet readily produced tuberculosis of the lungs and bronchial glands in guinea pigs by dust from his infected carpet. If undisturbed, spontaneous liberation of tubercle bacilli from fly specks is unlikely, even when they are exposed to a current of air. (Experiment B.) If mechanically agitated, however, aerial infection probably occurs, as with dried tubercular sputum.

CONCLUSIONS.

1. Flies may ingest tubercular sputum and excrete tubercle bacilli the virulence of which may last for at least fifteen days.

2. The danger of human infection from tubercular fly specks is by the ingestion of the specks on food. Spontaneous liberation of tubercle bacilli from fly specks is unlikely. (Experiment B.) If mechanically disturbed, infection of the surrounding air may occur.

As a corollary to these conclusions, it is suggested that

3. Tubercular material (sputum, pus from discharging sinuses, fecal matter from patients with intestinal tuberculosis, etc.) should be carefully protected from flies lest they act as disseminators of the tubercle bacilli.

4. During the fly season, greater attention should be paid to the screening of rooms and hospital wards containing patients with tuberculosis and laboratories where tubercular material is examined.

5. As these precautions would not eliminate fly infection by patients at large, food stuffs should be protected from flies who may already have ingested tubercular material.

INNOCENT CASES REPORTED AS DIPHTHERIA.

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THAT true cases of diphtheria occur, not seen by a physician, or being seen, escaping correct diagnosis, or being recognized, failing to be reported as diphtheria, is unquestionably true, although the actual number or percentage of cases thus escaping registration cannot be determined. Conversely, many cases diagnosed as diphtheria are undoubtedly really innocent, and even of those reported as diphtheria, a very appreciable percentage are not diphtheria.

This latter percentage can be determined, under bacteriological control, in two ways. The following figures give the results of applying these methods to the bacterial results obtained by the Boston Board of Health laboratory.

First method. — The physician's diagnosis at the time of taking the first culture for diagnosis was "diphtheria" in 1251 cases (1898–1900). Of these, the bacteriological report was positive in 785 cases, an average of 62% of positive clinical diagnoses confirmed, or about 38% in error.

Second method. — When cases bacteriologically positive for diagnosis come to be examined later on for release (soon after the disappearance of the membrane, usually), from 40% to 50% of the cases (469 cases out of 1,010 [1901–1902]), yield positive cultures for release. On the other hand, there were 1,020 cases (1901–1902) reported as diphtheria without any culture positive for diagnosis. When these cases came to be released by culture, 473 should have shown positive cultures on the above stated grounds, had the whole number been originally true diphtheria. As a matter of fact, only 298 cases proved positive for release, corresponding, therefore, with about 636 originally positive cases, and leaving about 384 which were probably negative throughout, or about 38%. The physician would, therefore, appear to be right, by either method of calculation, in only about 62% of those cases which he calls diphtheria without cultural aid. (This second method of calculation was suggested by J. F. Broderick, clerk in this laboratory.)

It is because of such considerations that the New York City Board of Health will not accept a report of diphtheria unless accompanied by a positive culture; if the physician does not take a culture, a medical inspector is sent to take one. Similarly, the Boston South Department refuses to accept a clinical diagnosis of diphtheria for admission, except in cases very obviously developed to the hospital standard. Dr. McCollom believes that cultures should be taken more freely in all such cases than at present, notwithstanding that the profession in Boston are amongst the foremost in this country in the use of bacteriological methods in diagnosis.

⁸ Mitchell and Crouch: *Journ. of Path. and Bact.* vi, p. 14.

⁹ Baumgarten: *Cent. f. kl. med.* 1884, no. 2.

¹⁰ Fischer: *Archiv. f. exp. Path. u. Pharm.* Bd. xx.

¹¹ Dobroklonski: *Archiv. f. m. exp.* 1890, p. 253.

¹² Baumgarten: *l. c.*

¹³ Demme: quoted from Cornet, *l. c.*, p. 100.

¹⁴ Ollivier: quoted from Cornet, *l. c.*, p. 100.

¹⁵ Wyss: quoted from Cornet, *l. c.*, p. 100.