Epidemic cerebro-spinal meningitis and its relation to other forms of meningitis : A report of the State Board of Health of Massachusetts.

EPIDEMIC CEREBRO-SPINAL MENINGITIS

AND ITS RELATION TO

OTHER FORMS OF MENINGITIS.

A REPORT

OF THE

STATE BOARD OF HEALTH

OF MASSACHUSETTS.

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INTRODUCTORY.

The prevalence of epidemic cerebro-spinal meningitis in Massachusetts has been marked with much irregularity. An epidemic of unusual severity in 1873 gave rise to an investigation and report by Dr. J. B. Upham, which appeared in the report of the State Board of Health for that year. A summary of 517 cases reported by different physicians throughout the State was given in that report. Dr. Upham was particularly well qualified for this investigation by his previous acquaintance with the disease in Newbern, North Carolina, during the civil war. In considering the causes of the disease he paid particular attention to the influence of insanitary conditions as an active or predisposing cause. With regard to this he says: —

> The relation of insanitary conditions in and around the abode of the patient to its origin or supposed cause demands the most careful consideration. In weighing the evidence contained in the returns, I find the scale to be pretty evenly balanced in this particular. The cases are distributed among all classes and grades of society, — the high and low, the rich and the poor, locations unexceptionable for situation, open to abundant light and air, and the pent-up hovels of the lowly and wretched, have all contributed to the material of the epidemic. We believe, therefore, that the primal origin of the disease is atmospheric, and, for the present, beyond our ken.

Since Dr. Upham's report, great discoveries in regard to the ætiology of many of the infectious diseases have been made. The bacterium which can now be regarded as the

essential cause of epidemic cerebro-spinal meningitis was discovered in 1887, but the first important confirmation of that discovery was not made until 1895. There has always been a great deal of obscurity in the relations between cerebro-spinal meningitis which appeared in an epidemic form and sporadic cases which sometimes appeared alone or in connection with other diseases, and which were very similar in their clinical manifestations and pathological lesions to the epidemic form. With the view of clearing up this and some other obscure points in the general ætiology and pathology of the disease, the present investigation has been undertaken by the State Board of Health. The present epidemic is the only one of considerable importance which has been seen since the advance in bacteriology and pathology has made such an investigation possible. In this investigation only the cases which were seen in the principal hospitals and in which the diagnosis of the disease could be regarded as certain have been considered at any length.

The accuracy of the statistics relating to this disease must necessarily be questioned, as presenting a history of its actual prevalence, for the following reason : —

The confusion of medical terms by physicians, together with the fact that all returns made to the State authorities are copies of certificates, and not originals, and that these copies are in the majority of instances made by men who have little or no knowledge of the significance of medical terms, give to the information obtained in regard to this disease a great measure of uncertainty. This is peculiarly true of epidemic cerebro-spinal meningitis, — a disease which is liable to be confounded with several other forms of brain disease, in consequence of the similarity in nomenclature of the terms employed to define such diseases. In addition to this, the disease is not a common one, and the clinical

manifestations of it are liable to be confounded either with other cerebral diseases or with forms of diseases in which cerebral symptoms predominate.

The whole number of deaths reported in the State as due to cerebro-spinal meningitis during the period of nearly twenty years, ending with Oct. 1, 1897 (nineteen years and nine months), was 2,909, or nearly 150 per year. In this summary the deaths from this cause in the fraction of the year 1897 are those which were reported directly to the State Board of Health by local authorities. The numbers for the years 1878 to 1896, inclusive, were fairly uniform, the maximum being 171 in 1888 and the minimum 78 in 1878. But in the first nine months of 1897 the number reported to the State Board of Health was 405, those in Boston alone being 184.

That these numbers are probably much too large is shown by a classification of the deaths by ages. For this purpose the deaths occurring in the nine years, 1887–95, are selected, since the finer distinction of separating the deaths in each of the first five years of life was first introduced into the State Registration Report in 1887. The deaths recorded in those years by ages were as follows: —

Deaths from Cerebro-Spinal Meningitis, Massachusetts, 1887–95.

AGE PERIODS.	Deaths.	Males.	Females.
0–1 year,	316	180	136
1–2 years,	146	74	72
2–3 years,	99	51	48
3–4 years,	77	41	36
4–5 years,	38	19	19
5–10 years,	132	59	73
10–15 years,	81	47	34
15–20 years,	61	36	25
20–60 years,	186	89	97
All over 60 years,	43	12	31
Totals,	1,179	608	571

By the foregoing table it appears that 316 deaths from this disease, or 26+ per cent. of the whole number, were reported as having occurred among children under one year. This fact necessarily vitiates the accuracy of the returns to a considerable degree, since the disease is extremely rare among infants as well as among those of advanced years.

The reported deaths from this cause occurred mainly in the large cities and towns, the whole number reported from towns of less than 5,000 inhabitants being only 136, or less than 5 per cent. of the whole number.

The map of Boston which faces the title page of this monograph presents the locality of those cases only which were treated at certain hospitals of Boston during the spring of 1897. A similar map could not have been prepared with accuracy for the State, for the reason, as already stated, that very many cases reported in towns and cities elsewhere and not under hospital supervision were not genuine cases of this disease.

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PREFACE.

We shall endeavor in this paper to describe the epidemic of cerebro-spinal meningitis which has prevailed in this community during the past winter and spring, and also to consider other forms of meningitis allied to the epidemic form. The disease has a peculiar interest here, from the fact that in the United States it was first recognized as an independent disease in Medfield, Mass., a year after the appearance of the disease in Geneva, by Danielson and Mann,[15]* whose observations were made independently of those of Vieusseaux[118] in Geneva. In the epidemic at the beginning of the century the disease was more prevalent in the New England States than elsewhere in this country, and in subsequent epidemics there have been many cases in these States.

The literature of the disease has been enriched by the careful studies of these epidemics in New England. The clear objective description of the character of the disease by Danielson and Mann, with the records of autopsies, served, as much as the somewhat earlier description of Vieusseaux, to establish the disease as an entity. The most complete of the earlier descriptions is contained in the report of a committee of the Massachusetts Medical Society, appointed in 1809 to investigate the disease. The secretary of the committee and the author of the report was James Jackson.[125] The committee carefully investigated the symptoms and course of the disease, its relation to other diseases, its pathology and most approved mode of

* The small numbers refer to the bibliography.

treatment. The report contains the records of eight post-mortem examinations, made by J. C. Warren,[125] one of the members of the committee. Another report on the disease, which is one of the classics in medicine, is that of Elisha North[75] of Goshen, Conn., in 1811. In a small book, now very rare, he gives the result of his own observations, together with reports from others, both physicians and laymen, which appeared in the various newspapers of the day. A committee appointed by the Massachusetts Medical Society made a report on the epidemic which appeared in this State in 1864 and 1865.[126] In reference to the same epidemic a Boylston prize essay by Dr. S. G. Webber[127] gives the best account which has ever appeared of the history of the disease and its relation to other epidemics. In this paper Dr. Webber takes the ground that the disease is probably identical with some of the earlier and imperfectly described epidemics of Europe. It is to be regretted that this paper of Dr. Webber's, which appeared in the form of a long serial in the "Boston Medical and Surgical Journal," should have so generally escaped the notice of subsequent writers. There is further a careful study of the epidemic of 1874 by Upham,[116] who had previously become acquainted with the disease in Newbern, N. C., during the civil war. We should have some hesitation in adding to the voluminous literature of the disease, were it not for the fact that the recent advances in the technique of investigation, and the possibility, which the discovery of the organism of the disease has given us, of studying the lesions and symptoms in relation with the ætiological factor, have enabled us to fill out some points only touched upon by the earlier investigators.

We wish to express our deep indebtedness to the physicians of the City Hospital, the Massachusetts General Hospital and the Children's Hospital, who have generously placed their clinical observations and cases at our disposal. Our work has been further materially assisted by the zeal and enthusiasm of the assistants in the laboratories of the City and Massachusetts General hospitals.

We are indebted to Dr. Wentworth for his notes on spinal puncture, with descriptions of the character of the fluid withdrawn. Dr. Edwin Jack has allowed us to publish his observations on the character of the eye complications of the disease which he observed at the Children's Hospital.

The plates which accompany the article with one exception are from water-color paintings made by Miss Byrnes. They were drawn by the camera lucida, with little or no assistance from the authors, and represent actual conditions.

Under the term meningitis is understood inflammation of the pia-arachnoid, the membrane which forms the immediate investment of the brain and spinal cord. The separation of this membrane into the pia and arachnoid is artificial, although there is more justification for such a separation in the spinal cord than in the brain. Considered as a single membrane, it consists of a serous surface (arachnoid) in contact with the dura, forming one side of the sub-dural space, and beneath this a loose connective tissue (pia mater) containing numerous and large lymph spaces and carrying the blood vessels for the brain and cord. In the spinal cord there is a single large space between the upper serous surface and the tissue which closely invests the cord, crossed by numerous fibrous trabeculæ. The lymph spaces in the membrane communicate with the lymph sheaths around the vessels of the brain and cord, and by means of the lymphatics accompanying the nerves, with the general lymphatic system of the body. The membrane in the form of the choroid plexus passes into the ventricles of the brain.

The surface forming part of the sub-dural space is covered with a single layer of endothelial cells; beneath this there is a more or less definite layer of connective tissue, which passes into the loose connective tissue of the pia with its numerous lymph spaces and blood vessels. This tissue contains the single connective tissue cells of the fibrous tissue, the cells of the blood vessels and lymphatics, and a variable number of lymphoid cells which are found in the lymphatics and in the lymph spaces around the vessels.

There are various means by which infectious agents can gain access to this tissue. They may enter into it by means of the blood or by the extension of infectious processes from adjacent

regions. The extension may be direct, or by means of lymphatics which communicate directly or indirectly with those of the membrane.

All inflammatory processes in the pia-arachnoid, however produced, agree more or less in their anatomical features; and in so far as the symptoms depend upon the purely local lesions, there is considerable uniformity in the symptoms produced. There are, however, certain minor differences in the anatomical lesions which are sufficient to differentiate certain forms of meningitis from others. These differences depend in general upon the extent and character of the exudation, upon the varying degree in which the blood vessels and nerves are involved, and upon the direct extension of the process in the meninges into the adjacent tissues of the brain and cord. In some cases the lesions are limited to the membranes; in others there is a tendency for the process to extend into the adjacent nervous tissue and along the nerves. There is little doubt that all cases of meningitis are cerebro-spinal, the meninges of the cord being affected as well as those of the brain. The cord lesions are, however, so much more marked in certain cases that these have been especially distinguished by the name cerebro-spinal meningitis.

In epidemic cerebro-spinal meningitis there are sufficient differences in the character of the exudation, in the greater degree of involvement of the meninges of the cord, in the extension of the inflammation along the nerves, and in the participation of the tissue of the brain and cord in the process, to enable us to distinguish anatomically most cases of this from other forms of meningitis. There is a further difference between the epidemic cerebro-spinal meningitis and all other forms of meningitis, in the general absence of inflammatory lesions in the intima of the arteries in the epidemic variety, while it is common in all the other forms.

The peculiarity of all lesions produced by the tubercle bacillus enables us to distinguish tuberculous meningitis from the other forms. There are few differences between the inflammations produced by the streptococcus, the staphylococcus aureus and the diplococcus lanceolatus. There are certain peculiarities in the

anatomical processes in all forms of meningitis which are dependent upon the character of the tissue affected. Inflammations of the meninges due to the action of certain organisms differ somewhat from the lesions produced by the same organisms elsewhere in the body. Tuberculosis of the membrane appears both in the form of tubercle formation along the vessels, and as a diffuse inflammation due to a fibrino-purulent exudation; the latter may be present to such an extent that the tubercles may be overlooked. In all forms of meningitis the inflammatory exudation is more marked on the base than over the convexity of the brain, and along the posterior than the anterior surface of the cord.

EPIDEMIC CEREBRO-SPINAL MENINGITIS.

It is usually considered that epidemic cerebro-spinal meningitis first appeared in 1805 in Geneva. Vieusseaux[118] described an uncommon disease which appeared in Geneva in the winter and spring of 1805. The disease commenced suddenly with loss of strength, vomiting, violent pains in head and along spine, and, in infants, with convulsions. The course of the disease was rapid in fatal cases, lasting from twelve hours to five days. In the greater number of patients who died in twenty-four hours the body was covered with violet spots.

Mathey[118] gives an account of a post-mortem examination made of one of the fatal cases. He describes a gelatinous exudation covering the convex surface of the brain, and a yellow puriform matter upon its posterior aspect, upon the optic commissure, and the inferior surface of the cerebellum and the medulla oblongata. The description of Vieusseaux combined with the post-mortem examination described by Mathey can leave no doubt as to the character of the disease.

Although this is generally regarded as the beginning of epidemic cerebro-spinal meningitis, there can be little doubt that the disease existed previously. Among the early accounts of epidemics similar to cerebro-spinal meningitis, Bascome,[129] in his history of "Epidemic Pestilences," speaks of a local epidemic at Roettinggen in Franconia in the autumn of 1802, in which the young and

strong were suddenly seized with pain and anguish at the heart and pain in the nape of the neck. In the fatal cases the patient fainted, the limbs became rigid, and death sometimes took place twenty-four hours from the commencement of the attack. It is interesting, as showing the probably greater distribution of the disease, to note that in the same volume of the "Medical and Agricultural Register" which contains the description of Danielson and Mann there is a letter from Indiana, describing a severe epidemic which appeared there in Vincennes. The disease especially affected young females, and some of the symptoms would point to meningitis. The editor of the magazine very pertinently asks if this be not the same disease described by Danielson and Mann. In the histories of the great epidemics of Europe, from the thirteenth century on, symptoms are described which almost certainly point to this disease. A very interesting account of these early epidemics and their affinity to or identity with cerebro-spinal meningitis is given by Webber in his admirable account of the history of the disease. The descriptions of these epidemics are exceedingly obscure, and, in the general absence of the records of post-mortem examinations, it is impossible to say exactly what disease they represent. The descriptions of the clinical symptoms could apply equally to typhus, typhoid or cerebro-spinal meningitis. Webber attaches considerable importance to the description of the skin lesions, but these are not sufficiently constant or sufficiently characteristic to serve as a means of diagnosis.

In his work on the diseases of the army, published in 1752, Sir John Pringall[130] gives an account of a jail or hospital fever, which in many respects was similar to cerebro-spinal meningitis. On post-mortem examination suppuration of the brain was found.

The classification of a disease should always be made from an ætiological point of view; the recognition of a definite infectious agent establishes the identity of a disease. In the absence of this, a definite class of symptoms, based on certain anatomical lesions, is our only method of classification. The insufficiency of this method of classification is shown by the fact

that before the recognition of the infectious agent causing epidemic cerebro-spinal meningitis there was no way of separating sporadic cases and small epidemics of this disease from meningitis caused by other infectious agents.

After the epidemic at Geneva the disease next appeared in Medfield, Mass., and was described by Danielson and Mann in 1806. The publication of Danielson and Mann was made independently of the work of Vieusseaux, with which they were not familiar. They described carefully the symptoms of the disease, and gave the results of five post-mortem examinations. They speak particularly of the uniformity of the symptoms and the mode of attack. The disease soon became rapidly diffused in the New England States. It extended to nearly all the towns in Massachusetts, and was particularly severe in Worcester; then it appeared in New Hampshire, Connecticut, New York, New Jersey, Vermont and Maine, and kept up continuously in one place or another in New England until 1816.

There are two classical descriptions of the epidemic of this period. One is by Elisha North[75] and the other by a committee appointed by the Massachusetts Medical Society[125] to investigate the new disease. The committee was composed of Drs. James Jackson, J. C. Warren and Thos. Welch, and the report was written by James Jackson, the secretary. The committee sent letters to various physicians all over the State, and analyzed their replies. The disease was described as beginning suddenly with great prostration, intense pain in the head and along the spine, and vomiting. Many of the cases died suddenly in ten to twelve hours; others in twenty-four to forty-eight hours after the first symptoms. Almost all the fatal cases died before the third day. The disease affected especially young persons of both sexes, but not generally very young infants or aged persons. The committee reported in all eight autopsies, most of which were made by J. C. Warren.

Jackson thinks that the description of malignant fever by Sennert[131] agrees in many respects with this disease. He thinks the seat of the disease is not in the skin lesions but in the membranes of the brain, the skin lesions being secondary and symp-

tomatic. Notwithstanding the infrequency of the skin lesions and their varying character, the disease continued to be named petechial or spotted fever.

North describes the disease from his personal experience with it, and appends to this various other accounts which have been given by contemporaneous authors. North divided the disease into two types depending on the more or less rapid course of the disease and the intensity of the symptoms.

Dr. Samuel Woodward,[75] in a newspaper printed in Hartford, describes an epidemic in Litchfield County in 1807. In the same paper, Dr. Bestor, after giving an excellent account of the clinical course of the disease, says that, though it has been attributed to various causes, he is convinced that the "immediate cause of the disease is the increase in the sensorial power of sensation with the decrease of the sensorial power of irritation." The book of North also contains a description of the disease by Dr. Fiske, "Sketch of Spotted Fever" ("Massachusetts Spy," April 9, 1810), "Observations on Anomalous and Irregular Diseases," by Dr. Williamson (Baltimore, 1808; letter to Philadelphia Medical Museum), and a collective report from Drs. Haskel, Spooner and Holmes, who were a committee appointed at Farmington, Conn., to investigate the disease.

Hirsch[39] divides the history of the disease into four periods. The first, from 1805 to 1830, shows the disease in isolated epidemics in various places in Europe, but more generally in the United States. In the second period, from 1837 to 1850, the disease became prevalent in wide-spread epidemics in France, Italy, Algiers, the United States and Denmark. During the third period, from 1854 to 1875, it reached its widest diffusion throughout most of Europe, the adjoining countries of Asia, the United States and some parts of Africa and South America. The fourth period, from 1876 to the present day, shows a return in slight epidemics of more or less considerable groups of cases in various countries, but particularly in the United States, Germany and Italy. In this last period there has been very little of the disease in France. In the first period it was seen in Canada in 1807; in Virginia, Kentucky and Ohio, in 1808; in New York and Pennsylvania, the year after.

The year 1816 forms the close of these series of epidemics, with the exception of one at Middletown, Conn., in 1823, and one at Trumbull, O., in 1828. The United States was free from epidemic cerebro-spinal meningitis until the year 1842. In Europe in the first period there was an epidemic in Paris in 1814,[132] in 1815 at Metz,[133] and in subsequent years in two or more villages in the province of Geneva, and in a few places in Germany.

Lichtenstern[61] gives Sibergundi[134] the credit for the first description of the disease in Westphalia, Germany. In the second period, from 1837 to 1850, the disease first broke out in two localities in the south of France, in Bayonne and the department of the Landers on one hand, and the districts of Foix and Narbonne on the other. It extended all over France, most of the cases being among the garrisons, and next to France its greatest ravages were in southern Italy. The only other country in Europe in which meningitis was prevalent to any extent during this period was Denmark, and from here it was probably carried to Iceland. In Germany there are references to a few slight epidemics of encephalitis and acute hydrocephalus, which in all probability were cerebro-spinal meningitis. In the United States in this period the disease appeared principally in small epidemics in the western and southern States. The most extensive epidemic was seen at New Orleans, in a regiment of recruits which had come there from Mississippi. In 1848 it was seen in the towns of Millbury and Sutton, in Worcester County, Mass., and described by Sargent.[135]

The second period was characterized chiefly by the prevalence of the disease among the troops. The epidemic was most prevalent in France, and in nearly all cases it appeared first in the military, and from there in some cases, notably in Metz, extended to the civil population.

The descriptions of the disease by French authorities during this time are of great value. They devoted their attention chiefly to the description of the course of the disease, the rare symptoms, the manifold complications, the ordinary and the rarer pathological lesions. The most prominent of the French treatises are those of Rollet,[136] Tourdes,[137] Forget[138] and Broussais.[139]

In the third period the disease began in Sweden, a country hitherto free from it, and prevailed there in extensive epidemics for ten years (Hirsch). Another one of its principal seats was Germany, where it reached its height in 1864 and 1865. Here it first appeared in Silesia, and broke out almost simultaneously at a number of points in east and west Prussia, gradually extending throughout south Germany.

In this period the best descriptions are those of Wunderlich[140] of the disease in Leipzig, and of Ziemsen and Hess[141] of the epidemic in Erlangen. The disease appeared in Berlin in 1864, and the pathological lesions were carefully described by Klebs,[54] who reported the results of twenty-six autopsies. Kotsonopulos[142] described an epidemic of the disease in Nauplia, Greece, in 1869, and in 1873 he gave a further account, showing that the epidemic of 1869 continued with a number of single cases and small epidemics until 1873.

The United States was free from the disease from 1850 to 1857, when it again appeared in two such widely separated areas as North Carolina[143] and the western part of New York.[144] During the civil war, from 1861 to 1864, the disease became widely spread. In the winter of 1861 and 1862 it appeared in the Army of the Potomac and in camp near Washington,[145] and was especially severe among the negroes sent by the Confederates to Memphis.

Upham[116] gives an account of the disease as it appeared in the winter and spring of 1862 and 1863 in the camps in and around Newbern, N. C. He compares the symptoms observed in this epidemic with those of the Massachusetts epidemic in 1810, and concludes that both diseases were the same. He made a number of post-mortem examinations, and gives a careful description of the anatomical lesions.

The disease appeared again in Massachusetts in 1864 and 1865, and a report was made on it in 1865 by a committee appointed by the Massachusetts Medical Society. The report of this committee, unlike that of 1810, did not make any material addition to our knowledge of the disease. The disease was also described at this time by Webber, whose article is

chiefly valuable for his study of the history of the disease and the relations of early epidemics to it.

From 1865 there was a period of quiescence in Massachusetts until 1872 and 1873, when there was another severe epidemic in Boston, which was reported by Upham.[116] In Philadelphia and other parts of Pennsylvania there was a severe epidemic in 1863, which was described by Stille.[115]

The disease took the character of a very wide-spread epidemic in Ireland in the first half of the year 1866, appearing in Dublin and the surrounding country. It was spoken of by the people as the "black death." It appeared first among the troops, and extended from these to the civic population, being most prominent among the troops in 1866 and among the population in 1867.

From 1860 to 1874 epidemics of the disease were seen in almost all parts of the United States. The epidemics usually appeared in the winter and reached the greatest extension in the spring. Hirsch thinks that in the last period, beginning in 1876, the disease is retreating into narrower limits, so that it nowhere retains a character of a prevalent disease of the people. A review of the literature since 1884, the date of the publication of his work, shows numerous, for the most part small, epidemics, in widely different localities. In this period also reports of a great many sporadic cases of the disease have been published. The reports of so many sporadic cases are probably due in part to the closer observation and better recognition of the disease, and the greater interest which the development of our knowledge of bacteria has brought about. In 1876 there was a small epidemic at Birmingham, reported by Forster[146] and at Galston near Glasgow, reported by Frew.[22]

Strümpel,[111] in an article on "Pathology of Cerebro-spinal Meningitis," says that the disease has continued in Leipzig since 1864, a few cases being seen every year. In the first half of the year 1879, at the same time with the extensive epidemic of recurrent fever, the disease became more common and prevailed to a slight extent up to the summer of 1880. In 1881 he saw four cases. Frölik[26] reports a small epidemic in the garrison in Leipzig. The disease began to appear in 1877, and up to

October, 1879, sixteen cases were taken to the hospital, of which five died and eleven recovered. Leyden[62] says there has been in recent years slight epidemics of the disease in Berlin, especially in the year 1885 and the spring of 1886. Blümm[8] reports a small epidemic in Sulzbach, and says that at the same time single cases or small epidemics were observed in the surrounding towns. In Ziemssen's clinic in Munich in 1890 there were seventeen cases and three deaths, and in the clinic of Bauer in the same city there were twenty-four cases and eight deaths.

Leichtenstern[61] gives an account of cerebro-spinal meningitis on the Rhine from 1885 to 1893. The disease appeared in Cologne in 1885, and reached an epidemic extension. One hundred and eleven cases occurred, with thirty-seven deaths. There were thirty-four cases in 1886, twenty-six in 1888, and in other years a varying small number of cases.

In 1890 the disease extended from Cologne to the neighboring village of Düsseldorf, where there was a small epidemic of twenty cases with six deaths. Panienski[85] reports a small epidemic in Karlsruhe in the winter of 1892 and 1893, in which there were sixteen cases and seven deaths. A small epidemic of thirty cases appeared in Copenhagen in 1891, which was described by Friis.[25] Austria has generally been more or less free from the disease.

Karg[147] reports a small epidemic in the Orphanage of Vienna in 1863. Warschauer[119] reports an epidemic in Cracow, which prevailed principally among the Jews, whom he considers more susceptible to the disease than the Slavonic population. In 1867 Baxa[2] describes an extensive epidemic which prevailed in Pola in Bohemia. One hundred and twenty-nine cases occurred, with a mortality of sixty-six per cent. In 1868 a similar epidemic prevailed at the same place. At various other places in the Austrian monarchy there are reports of small scattered epidemics, none of them reaching any considerable extent. In the United States since 1876 sporadic cases and small epidemics have been seen in various places. The most extensive epidemics during this period have been those of New York[3] in 1893, that in

Lanaconing, Md., in the same year, and the recent epidemic in Boston, 1896 and 1897. Many of the epidemics have not embraced more than four to six cases, and most of the accounts concern only sporadic cases.

The Character of the Epidemic.

Considered as an epidemic, cerebro-spinal meningitis has many features which distinguish it from epidemics of the other infectious diseases. As a rule, none of the epidemics has shown a continuous extension, this being noticeably the case with the first recognized epidemics. After the disease had appeared in Geneva in 1805 its next appearance was in Medfield, Mass., and shortly after this it appeared in other towns in New England, Illinois, New York, New Jersey and Maryland. In some cases, as in the French epidemics from 1840 to 1845, it appeared to extend with the movements of the troops. It was undoubtedly carried into Algiers in this period by the French troops. In almost all cases it appeared first among the troops, and from these it extended to the civic population. Hirsch, in his study of the disease, has found only one instance in which an epidemic has followed a regular course. In the diffusion of the disease through central Franconia it travelled somewhat regularly from north-east to south-west. As a rule, the outbreaks of the disease have been seen as perfectly isolated epidemics in places which had been hitherto free from it.

Almost all of the epidemics have appeared in the winter and spring. Vieusseaux pointed out that the disease in Geneva disappeared on the approach of mild spring weather. All of the early epidemics in Massachusetts were seen in the winter and spring. Woodward speaks of the disease in Litchfield County appearing in April, when the frost was dissolving and the ground breaking up, and says the disease seemed to be more common in rainy weather.

Love[149] has pointed out that the epidemic in New Orleans in the winter of 1847 was confined to one regiment newly arrived from Mississippi, who were quartered in bad barracks, on damp ground, and exposed in their wet clothes to the cold. Other troops quartered near them, which were seasoned to the weather

and supplied with woollen clothing, remained absolutely free from the disease.

Baxa[2] shows that the epidemic in Pola commenced in January and lasted until the end of May. There were no cases in the summer, and in 1868 the disease broke out again. Although the disease frequently begins in the winter, it usually reaches its height in the spring months, April and May.

In the epidemic in New York, both in 1892 and 1893 the greatest number of cases was found in May. In the epidemic of Cologne, in 1885, the greatest number of cases was seen in April, although there were but slight differences in May and June. In the Strassburg epidemic among the soldiers in 1841 the greatest number of cases was seen in March, there being in that one month sixty-five out of a total of one hundred and ninety-eight cases.

Hirsch reports a few exceptions to this general rule. At Bordeaux, 1839, Toulouse, 1842, Dublin, 1850, and Chrzanow, 1874, the disease first appeared in the summer. The weather in itself probably has little to do with the disease, because the number of cases has frequently increased with the approach of warm spring weather and an increase in the temperature.

This supposed relation between the period of the year and the appearance of the epidemic led people to suppose that cold in itself could be an exciting cause. Löwy[64] says cold and heat, rain and sunshine have nothing to do with the appearance and extension of the epidemics.

TABLE I.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1896, . .	-	-	-	-	-	1	-	-	1	-	-	3
1897, . .	1	10	23	29	21	14	7	0	3	-	-	-

The preceding table gives the date of the appearance of the disease in the cases observed in the hospitals of Boston in the present epidemic. From this it will be seen that the greatest number of cases was in the spring months. The first case seen

was in June, but the epidemic character of the disease was not recognized until the following February.

Age.

In general the disease has been most prevalent in children and young adults. The cases occurring in the military epidemics were mostly young soldiers, from the age of eighteen to twenty-four years. Leichtenstern found, in the epidemic in Cologne in 1885, out of one hundred and eleven cases, only twenty-three which occurred after the thirtieth year. More than half of his cases occurred before twenty-one. The following table, taken from Leichtenstern, gives the ages of cases seen in the epidemic in 1885, and in the small epidemics which followed this.

Table II.

	Ages.															
	1-5.	6-10.	11-15.	15-20.	21-25.	26-30.	31-35.	36-40.	41-45.	66-50.	51-55.	55-60.	61-65.	66-70.	70.	Totals.
1885, . . .	17	14	10	19	18	10	6	6	4	1	1	4	-	1	-	111
1886, . . .	-	3	3	11	7	2	1	2	1	2	1	1	-	-	-	34
1887, . . .	-	2	1	-	-	-	-	-	1	-	-	-	-	-	-	4
1888, . . .	2	2	1	7	9	3	-	2	-	-	-	-	-	-	-	26
1889, . . .	-	-	1	1	1	-	-	1	-	-	-	-	1	-	-	5
1890, . . .	-	-	1	-	-	1	-	-	-	-	-	-	1	-	1	4
1891, . . .	1	-	-	1	1	1	-	-	-	-	-	-	-	-	-	4
1892, . . .	2	-	-	3	1	-	-	-	-	-	-	-	-	-	-	6
Totals, . .	22	21	17	42	37	17	7	11	6	3	2	5	2	1	1	194

Of twenty-eight cases reported by Rollet,[136] sixteen were from eighteen to twenty-two years, eleven from twenty-three to twenty-seven years, and only a single case of thirty years. The cases seen by him extended from January to August.

Strümpel[111] observed thirty-two cases, twenty-four of which were between ten and thirty years. The youngest case was in a child four and one-half months; the two oldest cases were fifty-two and sixty-six years.

The epidemics in the early part of the century were particularly prevalent in children. At more advanced periods of life meningitis is very rare.

The following table gives the ages of the cases seen in the present epidemic. Only those cases which were seen in the hospitals are considered. A separate tabulation of those under five years of age shows but five cases under three years and one under one year. Nothing shows the inaccuracy of mortality tables of cerebro-spinal meningitis more than the analysis of ages in the cases in which diagnosis is certain. Epidemic cerebro-spinal meningitis is exceedingly rare under one year of age. All other forms of meningitis, though rare at this age, are more common than the epidemic. In mortality statistics of the disease a large percentage of cases is put down as under one year. In the present epidemic no cases were seen in the infant hospital.

TABLE III.

0-5.	6-10.	11-15.	16-20.	21-25.	26-30.	31-35.	36-40.	41-45.	46-50.	51-55.	56-60.	60 5.
18	12	6	11	16	20	13	8	1	3	1	2	0

There is a general agreement among writers on the disease as to contagion. Vieusseaux[118] says the extension of the disease shows that it is not contagious. In Geneva it began among the poor population, living generally under bad hygenic conditions, and did not extend from case to case. The attendants on the sick and the neighbors remained free from it. Even when there were two sick in the same house, the disease usually appeared at the same time, and they did not acquire it from one another.

North[75] says, in speaking of the epidemic character of the disease: "I have known more than one instance in which persons coming from a part of the country where the epidemic has never prevailed, and resting a short time in a town where the disorder has been epidemic, have had the disease at a season when the inhabitants of the said town had been free from it. I have also

known persons who resided in sections of the country where this epidemic appeared, after having been on a journey to places where it had never been, attacked with it soon after returning home, and at a season when it did not attack those in different circumstances."

Stevenson and Smith[107] reported a small epidemic in Davonport in 1885. The first cases were seen on some ships moored there, and then the troops in the barracks became infected without there having been any communication between the ships and the troops.

Berg,[3] in the epidemic in New York in 1893, could not find a single case in which two or more members of the same family were affected. The outbreaks occurred in widely separated parts of the city, and no relation could be traced between the various outbreaks.

Panienski[85] reports an epidemic in Carlsruhe. The disease began among the soldiers, and after a number of cases had occurred a portion of the garrison which had not been affected were sent to Rastatt. One of the men in the garrison there was affected the next day, and then after a pause of four weeks there were three other cases, all of which recovered. In the town of Carlsruhe there were sixteen cases. Coleman[150] gives the following observations on contagiousness: —

No. 1. Man, aged sixty-one years, typical case of the disease. In the same house several weeks later the eighteen-year-old son became affected, and one week later the daughter.

No. 2. Fourteen-year-old boy died with typical disease. His mother became attacked with croupous pneumonia, which was followed two days afterwards by meningitis..

No. 3. Girl, seventeen years, died with typical disease. Body remained in the house four days. Clothes from the house were lent to other people, among whom several cases of the disease appeared.

Herman and Kober[36] in reporting the epidemic of cerebro-spinal meningitis in upper Sicilia, in Beuthen, say that the epidemic was not limited to a definite place, but broke out in a number of places, most cases coming from crowded and filthy parts of the city. Several cases appeared in the same house or room. No infections were observed in the hospitals.

Singer[106] reported in the epidemic in Tirgul Frumor that eight members of the same family died of the disease. Baxa[2] found in one house four deaths, in another three, in three others two.

Friis,[25] in the epidemic in Copenhagen, 1891, found that the disease generally occurred in small family or house epidemics of from two to five cases.

Peterson[87] studied the epidemic which prevailed in Berlin in 1895 and 1896, and thinks that infection takes place by personal contact or by visiting infected localities. The disease may be given to children by intermediate conveyors who remain healthy.

Gahlberg,[27] in the epidemic in Mailberg, found there were numerous cases from the same house, and the disease was especially virulent in certain streets.

Nowlin[151] found in the small epidemic of five cases of Shelbyville, Tenn., that two cases arose in the same house.

Leichtenstern[61] has collected the cases bearing on contagion in the epidemic studied by him. In this epidemic there was a small house-epidemic in the hospital, in which four nurses on the medical side of the house, four employees of the house who in no way came in contact with the sick, and one patient who was carefully isolated in the syphilitic division, became affected. In one hundred and eighty cases in which the dwelling could be ascertained, one hundred and fifty came each from one house.

In the Strassburg epidemic, in 1840, the disease appeared among the soldiers in October. The first case in the civic population appeared in January, 1841. Hirsch[39] gives the following interesting observations: —

> On the 8th of February, "K," twenty years old, in Sczakan, became infected with meningitis, and was cared for by a woman from Sullencyen. After the death of "K," "W," who had cared for him, returned to Sullencyen and died there of meningitis on the 26th of February. A family, "K," accompanied by the boy "D" and the four-year-old daughter of a teacher, "O," came to the funeral of this girl. Shortly after the return to Podgass a small child of the family "K," the boy "D" and the daughter "O" all died of the disease.

Herman[36] gives a case of house infection in the epidemic in Breslau in 1887. A family in which there had been meningitis

moved from a house and another family moved into it. In this family there were several cases. He thinks that the epidemic in 1887 was a continuation of the one in 1879, there being sporadic cases between the two epidemics.

In the epidemic in Beuthen, reported by Richter,[91] there were fifty-six cases and twenty-four deaths. Seventeen of the cases came from tap rooms, and he thinks that in such localities there may be foci of infection.

Richter[91] thinks that the disease may be contagious. He often found cases in the same family, and the disease spread most in places where people congregated. He gives one case which speaks strongly for contagion. A woman visited at a house where two children had been sick with the disease; she stayed in the house one day, and then visited an uncle. She had meningitis on the fourth day. In the last days of her disease, on November 6, she was visited by a young man; on the 10th he had a light case; after five days he returned to his business, and on the 19th an apprentice in the same shop was affected. The period of incubation he thought was about five days.

In a question of the probability of transmission of an infectious disease we should consider the location of the disease and the ways in which the organism causing it can pass from the lesions of the disease to the outside; further, the viability of the organisms and their possibility of leading a saprophytic existence. The lesions of meningitis are chiefly in the meninges of the brain and cord, and confined to these organs in most cases. While located in the meninges, there is little or no opportunity for the organism to infect the outside. In a certain number of cases there are lesions in the lungs, ears and nose, in which large numbers of organisms are present, and from which an infection of neighboring objects or persons could easily take place. The organism, as far as we have been able to tell from its behavior in culture media and in the tissues, has a feeble vitality, and would not be capable of leading a saprophytic existence. In the report on the bacteriology of the disease will be found some observations bearing on the vitality of the organism producing it, when subjected in pure culture to

various external conditions. Still, it must be remembered that we cannot reproduce artificially all the conditions which organisms might find in nature. It is certain that the disease is an infectious disease, and is produced by a definite micro-organism. This organism increases in the body of the affected individual, and in a certain number of cases may infect his surroundings, and may in a manner which we do not know be conveyed to the tissues of a susceptible individual and there produce the disease. Why this takes place in some cases and not in others, and the conditions under which it takes place, we do not know. The evidence, on the whole, is not conclusive that the disease is incapable of being transmitted from one individual to another. In the present epidemic there were but few cases in which several individuals in the same house were affected. In one case a mother was attacked two days after the death of her child from the fulminating form. In two other cases there were cases in the same family, and in one case it was said that children in the same neighborhood had died of brain fever.

We have been able to find but little in the literature bearing on the subject of immunity in this disease. North,[75] in his description of individual cases, gives one undoubted case in which there was an attack twenty-five months previously. Another case had the disease in August, 1808, and was again attacked in May, 1810. Herman and Kober[35] report that a girl who had the disease in May, 1886, died in the second epidemic the following year. Löwy[64] reports a second attack three weeks after apparent recovery. Warshauer[119] reports a case in a woman who had the disease in an epidemic five years previously. From the fact that second attacks are so rarely mentioned, it would appear that a relatively high degree of immunity must be conferred by a single attack. In the present epidemic there was no history of a previous attack.

Hygienic conditions do not appear to play much part in influencing the epidemics. Randolph found, in the epidemic in Lanaconing, that virulent types of the disease appeared in such widely different localities and under such different hygienic conditions that he thinks that hygienic conditions can have but little to do

with the extension of the disease. Claverie,[11] in the epidemic observed in Rocheford, found that the disease was not more prevalent in the crowded parts of the city. In Barden the disease seemed to shun the most crowded streets and only appeared in the best streets. He quotes Laveran as saying that the disease once appeared in the barracks when very few troops were in them, and disappeared when they filled up again. The reports of most epidemics show that the disease is more prevalent in the poorer and more crowded parts of the cities. The map at the end shows the distribution of the cases in this city which came to the hospitals. It is seen from this that with the exception of a small area along the water front, the cases were pretty equally distributed over the city.

Rollet[136] gives the mortality in all the epidemics in France up to 1844. At Nancy, where Rollet observed his cases, the mortality was 28 per cent.; Le Mans, 33⅓ per cent.; Ancenis, 33⅓ per cent.; Montbrison, 34 per cent.; Caen, 40 per cent.; Poitiers, 40 per cent.; Versailles, 48 per cent.; Metz, 55 per cent.; Perpignan, 56 per cent.; Strassburg Military Hospital, 58 per cent.; Strassburg, inhabitants, 60 per cent.; Laval, 63 per cent.; Colmar, 71 per cent.; Bayonne, 75 per cent.; Aigues-Mortes, 75 per cent. General average of all cases, 51 per cent. The mortality varies greatly in different epidemics. Hirsch[39] gives it as from 20 to 75 per cent. In this epidemic one hundred and eleven cases were seen in the three hospitals. Of these, seventy-six died and thirty-five recovered, a mortality of 68½ per cent.

With the view of ascertaining the prevalence of the disease in the State, the following circular letter was sent to three hundred and fifty physicians: —

COMMONWEALTH OF MASSACHUSETTS.

STATE BOARD OF HEALTH,
STATE HOUSE, BOSTON, MASS., Sept. 1, 1897.

DEAR DOCTOR: — During the past year an epidemic of cerebro-spinal meningitis has prevailed in Massachusetts, a large number of cases having been seen in the hospitals of Boston. With the view of ascertaining the extent of the epidemic and the prevalence of the disease in private practice, the following circular letter has been addressed to a number of physicians: —

1. Have you seen any cases of epidemic cerebro-spinal meningitis in your practice in 1896 or 1897? (If the cases were seen in Boston, give their residence, street and number.)
2. Under what form of the disease did these cases come?
3. Among what class of the population did such cases arise?
4. Were you led to believe that the disease is communicable?
5. What was the mortality?
6. Were autopies made, and result?

Remarks: —

One hundred and fifty replies were received from physicians in all of the large cities and a number of the towns. Positive reports, in most cases giving short and adequate clinical histories, were received from twenty-one physicians. Cases of the disease were reported in Springfield, Gardner, Marlborough, Framingham, Lowell, Lexington, Weston, Tewksbury, Waltham, Newton, Melrose, Somerville, Gloucester, Rockland, Cambridge and Quincy. With the exception of Springfield, where one case was reported, and Gardner, where two cases were reported, all of the reports come from towns within a radius of thirty miles of Boston. With the exception of Rockland and Quincy, all are to the west of or north of the city. Of course a number of cases reported in the practice of single physicians represent but a small fraction of the total number of cases which may have occurred. It is seen from this that the epidemic was not confined to Boston, but that cases occurred in other parts of the State.

Sporadic Cases.

The accounts given of epidemics of cerebro-spinal meningitis show that they are not of short duration. In the table given by Leichtenstern[61] (Table II.) he shows the number of cases which were observed in Cologne from 1885–92. It will be seen from this that in 1887, 1889, 1890, 1891 and 1892 there was a small number of cases each year, and in 1888 a larger number. The epidemics appear in many cases to have been preceded and followed by a number of sporadic cases.

Strümpel,[111] in 1882, says that, since the appearance of the disease in Leipzig in 1863 and 1864, single cases have been seen almost every year, but they never rose to an epidemic extension

until the first half of the year 1879. At that time and with the epidemic of recurrent fever the disease became more frequent, and in the months from April to June thirteen cases were taken into the hospital. Then the epidemic extended in small numbers until the summer of the following year, during which time fifteen more cases were taken in; finally, after a still longer pause in February and March of 1881, four cases were received. Leyden,[62] in 1887, says that sporadic cases have still remained after the great epidemic in 1864 and 1865. In recent years there have been slighter epidemics in Berlin, embracing a considerable number of cases. This was especially in the year 1885 and in the spring of 1886, when there were several cases. Mason[68] reports five cases of cerebro-spinal meningitis occurring from 1881 to 1883 in Boston, and says there has been a steady decline in the number of cases of this disease since 1874, but a small number are seen in every part of the State except on Cape Cod. Herman and Kober[35] say that sporadic cases have been observed in the years preceding the epidemic extension.

These reports as to the sporadic cases, coming from observers who are well acquainted with the epidemic form, are interesting. Omerod[82] reports ten cases of sporadic meningitis, with autopsies. Four of these cases occurred between March and June, 1890, and in the summer of the same year there was an epidemic of the disease in the eastern counties of England. He thinks that the sporadic cases do not differ from the epidemic cases. In all of Omerod's cases the cord was examined and spinal meningitis found. They all had the same clinical history, and the same conditions were found at autopsy, as in the epidemic cases. Both the clinical and the gross anatomical descriptions of Omerod are excellent, and it is greatly to be regretted that they were not completed by bacteriological cultures. Osler[84] reports a case of sporadic meningitis of a chronic form, which was followed by total blindness which was gradually recovered from. Rotch,[97] in an article on meningitis, in his text-book gives an admirable picture of a chronic case of sporadic meningitis, with recovery, which would seem almost certainly to have been the epidemic form. Senator[103] reports a case of sporadic meningitis in which

the clinical history conforms exactly to the type of the chronic epidemic disease. The disease lasted from May 13 to August 8, and was characterized by great emaciation.

Sinclair also reports a case of sporadic meningitis in the Dundee Royal Infirmary. Both from the clinical history and the autopsy this seems to have been of the epidemic form, and there were no other cases of meningitis in the vicinity at that time.

May, Schmidt and Kastner[69] reported twenty-four cases of sporadic cerebro-spinal meningitis from the clinic of Professor Bauer between 1885 and 1889. There was acute swelling of the spleen in eight cases. It is probable that many of these cases represent sporadic cases of the epidemic form, but in the absence of bacteriological examinations it must remain uncertain. The same may be said of the seventeen cases reported from Ziemmsen's clinic in the same period.[8] The comparatively small mortality would show that the cases were of the epidemic form. In Bauer's cases there were eight deaths out of twenty-four, and in Ziemmsen's three out of seventeen. Senator[103] reports several sporadic cases in Berlin in 1886, with two autopsies. Reichmann[152] gives a number of sporadic cases in which the symptoms were in all respects similar to the epidemic form. One case lasted from the 5th of June to the 14th of August. Laboulene[60] says that most of the epidemics have left in their trail sporadic cases analogous to Asiatic cholera. There is but one report of a case of sporadic meningitis in which the diplococcus intracellularis was found; this is by Stoeltzner, who found these organisms in a typical sporadic case.

In going over the literature of the disease we find a great many reports of sporadic cases, some of them of single, others of multiple cases. Of course it is very difficult to say whether these cases were of the epidemic form or some one of the other forms. Neither the clinical history nor the autopsy without cultures are absolutely conclusive. In going over the clinical histories of large numbers of cases one receives an impression of the epidemic form which differs somewhat from that of the pneumococcus form and the streptococcus form, but the clinical history

alone is not conclusive. Autopsy accounts would be more conclusive had they been accompanied with cultures or even with careful histological investigations. The importance of combined clinical and pathological investigation is very evident in going over these reports. There are careful clinical histories given with imperfect accounts of autopsies and without bacteriological investigation, and in those cases in which the latter were carried out the clinical histories were either absent altogether or very meagre. In the reports of these sporadic cases it may be generally assumed that the recoveries were of the epidemic form. So far we have not been able to find a case which certainly could be regarded, from the accompanying pneumonia or endocarditis, as pneumococcus meningitis, which has recovered. Of course there is a certain number of cases of pneumococcus meningitis in which the affection of the meninges is primary, and it is impossible to say with regard to these cases whether there are any recoveries among them. In the same way there are no recoveries noted from cases of meningitis secondary to thrombosis of the lateral sinuses or disease of the middle ear. Those sporadic cases which have been followed by eye and ear lesions are probably the epidemic form and due to the diplococcus intracellularis.

In going over the cases of meningitis which have occurred in the City Hospital in the five years previous to the appearance of the epidemic, and in which bacteriological examinations were made at the post-mortem examination, no cases due to the diplococcus intracellularis were found.

This matter of the relation of sporadic cases to the epidemic form is one of the greatest importance, and can only be determined by a careful bacteriological examination of the organs of the cases which die, and bacteriological examination of the fluid obtained from the spinal puncture in all cases. This is one gap in our knowledge of the disease which remains to be filled up. It seems probable that there must be a large number of sporadic cases of epidemic meningitis constantly occurring, which, under certain conditions, the nature of which we are not aware of, may so increase in number as to form an epidemic. Nothing can be

learned with regard to these cases from an examination of the mortality tables. One gets the impression from such tables that the disease is very frequently not recognized when it occurs, and that many cases are reported as meningitis which are not so. The large percentage of cases under one year in such tables shows how unreliable they are.

CLINICAL CASES.

The description of individual cases is taken from the records in the three hospitals in which the cases occurred. They are not reported in full, but the most important of the phenomena noted in the records are described. These records have been made by a number of physicians, and they represent the routine hospital examinations of patients. There is a certain advantage in having the observations of a number of men, because a single individual would almost certainly have his attention directed to single clinical phenomena which seemed to him of special importance and interest. The cases reported by Dr. Williams[153] are included in this report. A number of charts, which are illustrative of the pulse and temperature of the disease, is given with the individual cases.

In estimating the duration of disease, the time of onset as given in the history of the patient before entry into the hospital is taken. Many of the patients were brought into the hospital in an unconscious condition, and were without relatives or friends from whom their previous history could be obtained. Many of them were foreigners, and many belonged to a class in which there would be but little attention paid to the early symptoms of the disease. The charts which are given were taken after the patients had entered the hospital, and after the disease had existed a variable length of time. It is greatly to be regretted that we could obtain no chart which represented the entire duration of the disease, nor could we find any such in the literature.

CASE 1. Female, age fifty years. Entered hospital June 21, 1896. Present illness began three days before admission. At that time frontal

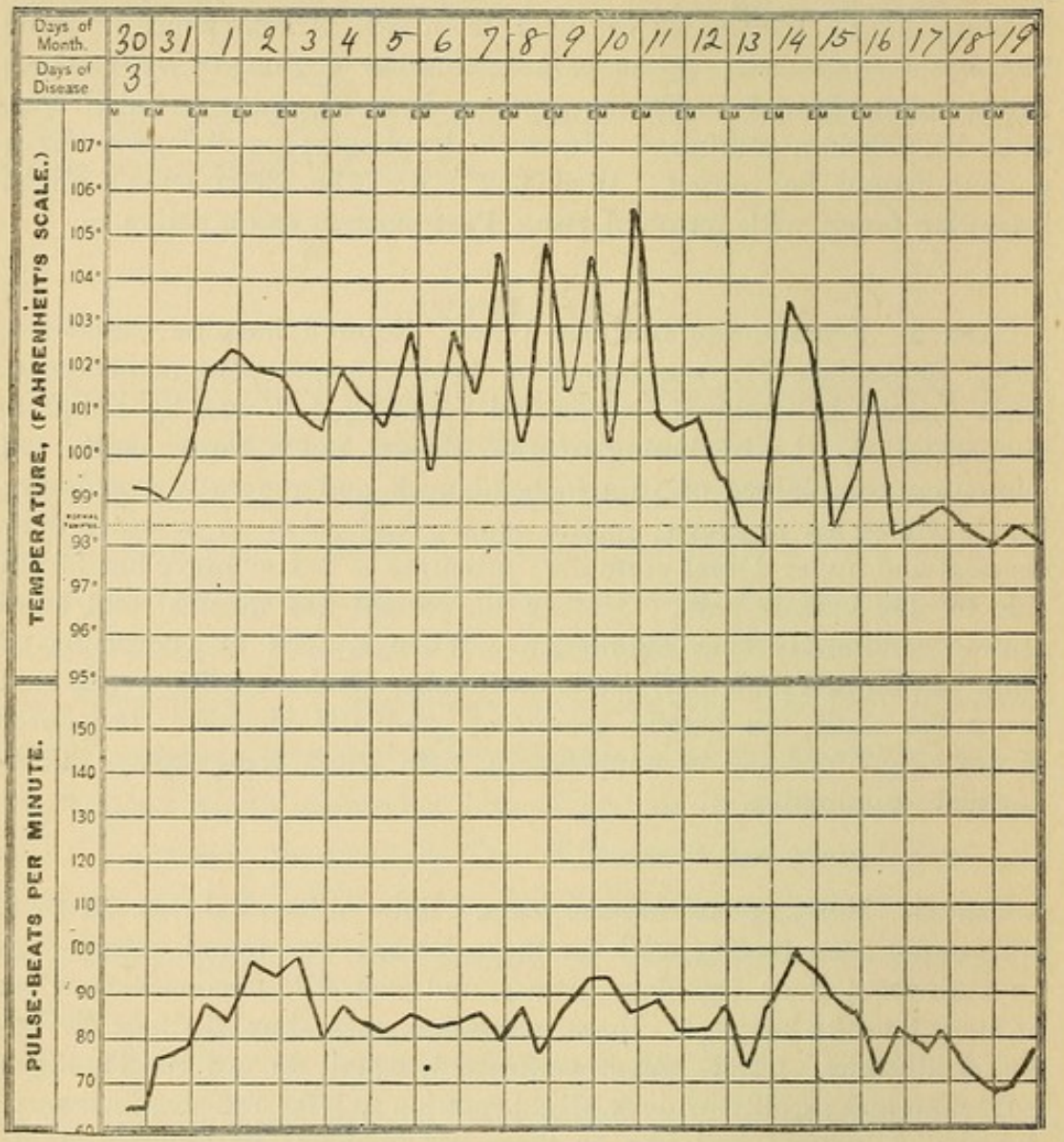
headache, constant vomiting, pain in small of back and both calves. On admission, pupils regular; some general tenderness in muscles of calves and thighs; great rigidity of neck; whole body can be raised without bending neck; movement of head from side to side painful. June 22, pupils contracted; great pain in lumber region; very restless. Blood count showed 15,000 leucocytes. June 23, noisy and delirious. June 24, delirium continued. June 25, dysphagia; pupils react alike; patient cannot be roused. Died 4.52 P.M The chart shows slight irregular fever, with terminal rise. Post-mortem examination.

CASE 2. Female, age fourteen years. Entered hospital October 6, 1896. September 21, complained of headache and pain in abdomen. After one week, continual nausea and vomiting, followed by complete annorexia. At the beginning of the illness, had a severe chill. On admission, complained of pain in head, neck, and generally over body; said it pained her to move; pupils equal; tenderness on pressure over cervical and upper dorsal vertebræ; attempts to flex or move head from side to side causes pain. October 10, patient has moaned and cried almost continually since admission. When spoken to, complains of pain. From this time until death, on October 17, the condition remained about the same, the patient becoming gradually weaker. The chart shows slight increase in temperature, with great irregularity. Post-mortem examination.

CASE 3. Male, age twenty-six years. Entered hospital Dec. 31, 1896. He had not been feeling well for three weeks; was found unconscious on bath-room floor (no date given), and was still unconscious when brought into the hospital. Upon admission, eyes showed slight divergent strabismus; pupils much contracted, equal, do not react; slight retraction and rigidity of neck, slight rotation to left; reflexes increased. January 2, patient had two or three convulsions; extremities rigid; still unconscious; very restless; retraction of neck increased. January 3, condition worse; still unconscious. January 4, has had convulsions nearly all day, with short intermissions; twitching of hands and face. January 4, died.

CASE 4. Male, age twenty-three years. Entered hospital Dec. 30, 1896. Three days before, had a chill, went to bed, and soon began to have severe headache and vomiting. Two days previous, had been taking care of a child which died of "inflammation of the brain." Upon admission, very restless, complained of severe pain in head and neck; eyes normal. December 31, blood count showed 16,500 whites. January 6, temperature higher; epistaxis; delirious for past two days. January 11, much improved. January 15, improving slowly. January 23, temperature normal. January 26, discharged well. The appended chart shows the highest temperature found in any case in the

series, with the exception of some terminal temperatures. The comparison of the pulse with the temperature is interesting.



Case 5.* Male, age forty years. Entered hospital January 2. Dec. 27, 1896, went to work as usual, when severe headache came on; next day delirious, and knew no one. On admission, he was in a semi-comatose condition, and remained so until death, January 5. Post-mortem examination.

Case 6. Female, age seven years. Entered hospital February 11. Three weeks before admission, violent headache and vomiting Four days after this, became deaf, and had pain in both ears. No discharge from ears; has had marked opisthotonos. On admission, head retracted and drawn to right side; eyes bulging; perfectly deaf; complains much of pain. February 13, examination of ear shows otitis media on right side; left ear shows an old otitis media. Child sent to surgical wards

* The following cases in the series are in 1897.

for operation. Re-entered April 3, after mastoid operation, wound healed. Child very much emaciated; abdomen retracted; no retraction of head; understands very little; seems to have no perception of light; hears but little, if any. On May 20, can recognize light and shade. May 30, much stronger. June 6, can stand alone. Can see contour and light and shade. June 10, hearing somewhat improved; sees somewhat better. June 20, discharged. This case is evidently one of the very chronic forms of cerebro-spinal meningitis. Three lumbar punctures were made, the turbidity of the fluid withdrawn diminishing in the successive punctures. No organisms obtained; first spinal puncture made four weeks after onset.

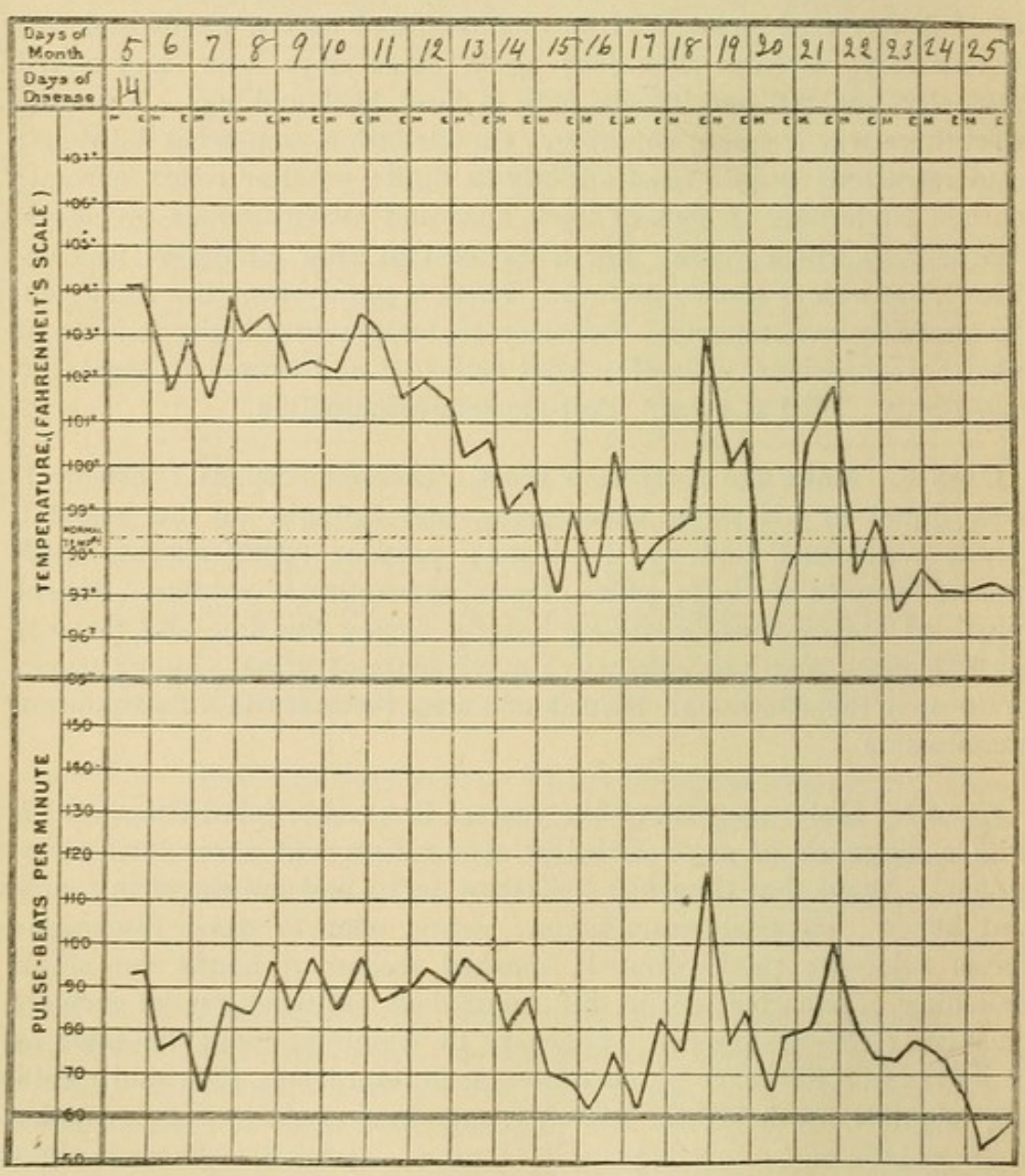
Case 7. Male, age forty years. Entered hospital February 10. For a week before entrance, intense nausea, severe pain in back and legs. A day after onset, was unconscious, and moved hands and feet convulsively. Became conscious again three days later, and talked rationally, but still had intense pain in head, back and legs. From the onset there was frequent vomiting. On admission, somewhat delirious; head retracted; pupils react slightly to light; patellar reflex normal; marked tenderness of back of neck, head and along spinous processes. February 15, much worse. For a day or two after admission was delirious, but now is semi-conscious. There is paralysis of the right side. Passes urine involuntarily. February 17, temperature high; œdema of lungs; unconscious, cyanotic: head retracted and turned to right; no strabismus. Died at 4 P.M. Post-mortem examination.

Case 8. Male, age forty-nine years. Entered hospital February 7. Was found in his room unconscious, and brought to the hospital. Pupils contracted, and do not react; patellar reflex absent; stiffness of muscles of neck; pulse of good strength and volume. Patient remained unconscious, breathing heavily during the day, and towards night moaned and had convulsive movements of arms. Lungs began to fill up in the afternoon. Died at 1.30 A.M., February 11. Post-mortem examination.

Case 9. Male, age twenty-five years. Entered hospital February 12, with a diagnosis of acute articular rheumatism and unresolved pneumonia. About that time had headache, pains and swellings in hands and knees. Physical examination; septic odor to nasal discharge; throat injected; pupils dilated; marked tremor of hands and slight twitching of muscles; seems dull, somnolent, but when roused answers questions; reflexes present. February 16, condition about the same as at entrance. February 20, condition much improved. Pain and swelling in joints much better. March 1, examination shows flatness under right scapula and a few sub-crepitant rales. March 6, dullness in right back not so marked. March 16, condition same as at last note. Blood count shows 20,000 whites. March 21, growing gradually weaker; dyspnœa came on in evening, for which no cause could be found. Died at 12.45 A.M.

CASE 10. Male, age ten years. Entered hospital February 23. Four days before admission, headache, pain in stomach, restlessness, vomiting, and constipation. On admission, delirious and unmanageable; head retracted; muscles of neck tense and contracted; quite deaf since entrance. There was very little increase of temperature throughout the disease; eyes normal. Lumbar puncture, March 22, thirty-one days after admission and thirty-five days from beginning of disease, showed slightly clouded fluid; no organisms found. There was great emaciation. Child discharged relieved, though perfectly deaf, April 4.

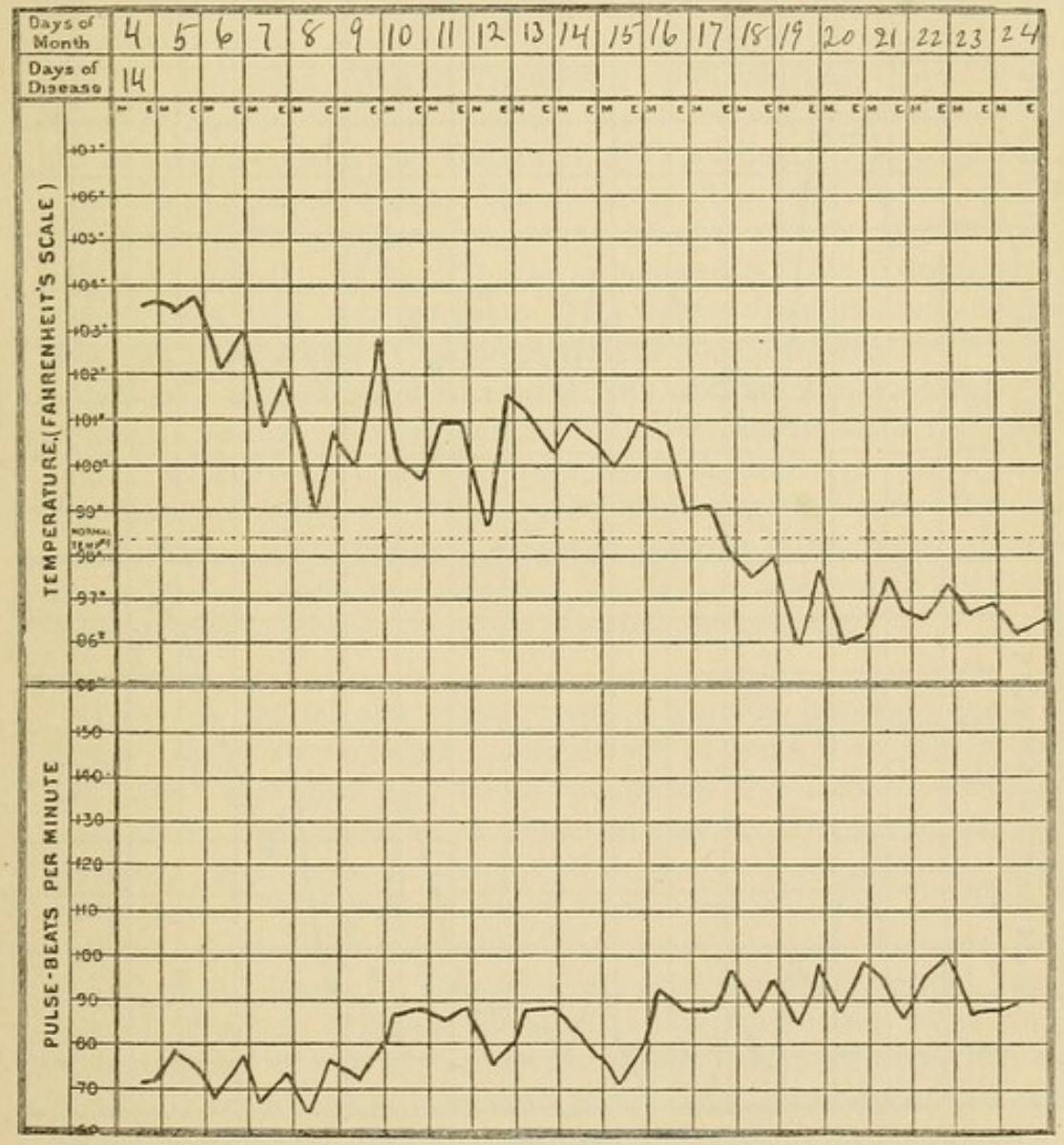
CASE 11. Male, age thirty-one years. Entered hospital March 5. Has been having severe chills for two weeks. One week before entrance, went to bed complaining of pains in back and neck and



headache. Upon admission, slight ptosis of right lid; right pupil larger than left, both react; tenderness behind mastoids; pain upon movement of head; lumbar muscles tender. March 7, blood count

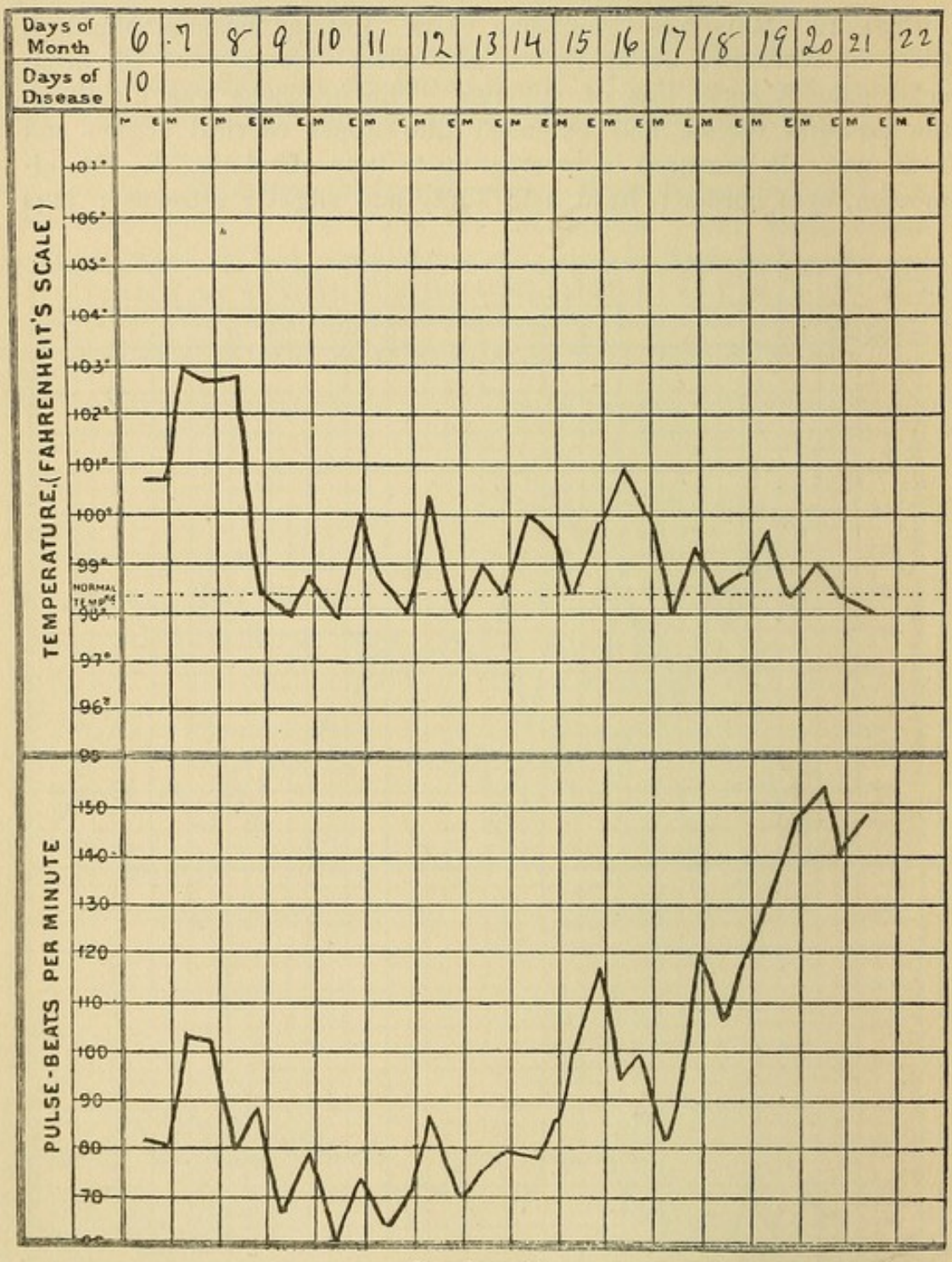
shows 19,000 whites. March 9, has severe headache and pain in back of neck. March 12, pain not so severe; lumbar puncture negative. March 15, nervous, but better. March 27, patient up and doing well. April 10, discharged well.

CASE 12. Male, age twenty-one years. Entered hospital March 4. Gave up work two weeks before admission. Complained of headache, pain in neck, loss of appetite. The headache was mainly in the occipital region, and extended into upper cervical region and both eyes. It increased in severity up to time of admission. On admission, eyes normal; head held stiffly and slightly retracted; legs



weak; pulse dicrotic. March 8, noisy delirium. Movement of head more free. Ophthalmoscopic examination showed slight optic neuritis. March 10, lumbar puncture, patient slept quietly after it. Stiffness of neck and back very marked. March 19, rigidity still marked; patient occasionally cries out. March 19, still delirious, but more rational than before. March 23, apparently has less pain; answers

questions intelligently. On the 27th, decidedly better, no pain, head moved freely. From this time the patient steadily improved, and was discharged April 10. The fluid from spinal puncture made March 10 showed no organisms on microscopic examination. In the cultures



See Case 14.

apparently no growth after twenty-four hours, but after this there was an abundant growth of typical diplococci just above the water of condensation. The appended chart shows a rather high and irregular temperature, with drop to sub-normal at the last. The pulse is low throughout.

CASE 13. Female, age three years. Entered hospital April 19. On February 22, acute attack; convulsions, vomiting, high fever; right eye swollen, but afterwards became sunken. On admission, retraction of head. Choroiditis found on examination. Lumbar puncture, April 22, gave practically clear fluid; no organisms found. Child discharged unrelieved April 29.

CASE 14. Male, age seventeen years. Entered hospital March 6. Ten days before admission, pain in back of neck, followed by a chill and extension of pain to head and back. Three days before admission, diplopia and deafness in left ear. Eight days before, vomiting and vertigo. Had been in bed since onset. Was more or less delirious during first seven days. On admission, muscles of neck tense; pupils equal and reacted; ptosis of left eye, and photophobia. March 10, less pain in the head. March 12, double optic neuritis. Blood count, March 11, showed 16,000 leucocytes. March 12, left ear congested over the whole extent of drum March 14, mild delirium. March 15, blood count showed 22,000 whites. March 18, condition much worse; patient in stupor, which continued to increase until March 21. Death at 1.10 P.M. Spinal puncture, March 15, showed 8 cubic centimeters of clear, watery fluid. No sediment Microscopic examination showed no cells. Cultures sterile. March 18, lumbar puncture gave 6 cubic centimeters of a slight opalescent watery fluid, with trace of albumen. No cellular elements No organisms. Cultures sterile after forty-eight hours. In this case spinal punctures, made nineteen days, twenty days, and twenty-two days after acute onset, were negative, both for organisms and pus cells. The temperature in this case is interesting, showing a rapid fall to normal on third day of entrance, after which there were slight, irregular rises. The pulse is equally irregular.

CASE 15. Male, age fifteen years. Entered hospital March 19. Three weeks before admission, complained of continuous pain in head and back. For three days before admission was semi-conscious, but responded when spoken to. Vomited frequently. On admission, semi-conscious; convergent strabismus of right eye; some diplopia; pupils unequal, and did not react alike; tâche cérébrale well marked; all reflexes absent; no tenderness along spine; at times marked retraction of head. March 21, purpuric spots observed on knees and flexure side of forearm; complete unconsciousness; urine and fæces passed involuntarily. March 22, patient steadily failed, and died at 1.30 P.M. Lumbar puncture made March 20 gave 6 cubic centimeters of an opalescent watery fluid, which deposited slight sediment. Microscopic examination showed pus cells and diplococci. Cultures positive.

CASE 16. Male, age 30 years. Entered hospital March 18. Twenty days before admission, general malaise and headache, which increased in severity, and neck became stiff and rigid. A few days before entrance, became delirious. On entrance, noisy and delirious. At times

violent rigidity of muscles of neck; head retracted; tenderness along cervical and dorsal region; pupils equal and reacted alike; eyeballs rolled up; rigidity of muscles of extremities. March 22, continuous delirium and coma a few hours before death. Death, 4 P.M. Lumbar puncture on March 22, shortly after death, gave 5 cubic centimeters of clear straw-colored fluid, with slight flocculent sediment. On microscopic examination, numerous lymphoid cells; no pus cells; no organisms; cultures sterile. In this case the lumbar puncture was made twenty-four days after acute onset.

CASE 17. Female, age twelve years. Entered hospital March 8. One week before entrance, headache; burning feeling in head; pain about eyes; vomiting; rather stupid three days before entrance; stiffness of neck. On admission, marked retraction of head, with stiffness; slight convergent strabismus; could answer questions intelligently. Blood count showed 9,800 whites. Herpes of lips; large patches of herpes on left arm; few hæmorrhagic spots on abdomen. March 11, brighter; no tenderness along spine. Lumbar puncture negative Blood count gave 19,000 whites. Eye examination showed atrophy of optic nerve on left side. Another blood count gave 22,000 whites. On March 23, blood count gave 26,000 whites. Condition changed constantly; one minute would complain of headache, and then of no pain. April 1, vomited. April 2, no vomiting. No change. April 5, blood count gave 20,000 whites. April 8, vomited during night. April 9, vomiting continued. April 11, headache most of the day. April 13, more comfortable. April 16, severe headache; retraction of head diminished. April 23, culture from nasal mucous membrane negative. April 26, temperature practically normal. May 6, still complained of headache; vomiting. May 20, much better. May 22, pain in legs. Blood count showed 14,000 whites. Patient discharged well June 12. Some tendency to walk on heels.

CASE 18. Male, age eight years. Entered hospital March 5. Three days before entrance, headache, pain in stomach, vomiting. On admission, tenderness over entire body, chiefly in neck; head retracted. For next three days retraction continued; muscles tense. Lumbar puncture on March 9, eight days after acute attack, gave cloudy fluid. April 3, macular eruption noted over legs and trunk. Continued to gain gradually. Discharged well on May 10, 1897. In this case lumbar puncture was performed three times at different periods of the disease. There was constant diminution in the turbidity of the fluid: 1st, very turbid, with thick purulent sediment; 2d, less marked; 3d, slightly cloudy; some fibrin formed in the fluid, but there was no purulent sediment. Diplococci uncertain.

CASE 19. Male, age twenty-two years. Entered hospital March 5. Day before admission, pain, slight cough, vomiting, headache, chill in evening. Tried to work morning of admission, but became drowsy

and vomited several times. On admission, conjunctivæ injected; skin hyperæmic; reflexes normal. In evening, several convulsive attacks; eyes varied; part of time left pupil dilated, at other times equal; right eye turned in at times. March 6, worse; head somewhat retracted. Died at 8.45 P.M. Post-mortem examination.

CASE 20. Male, age five years. Entered hospital March 11. One week before entry, vomited and had chilly sensation; pain in stomach and headache. Herpes on admission; red spots on abdomen; held head stiffly; no retraction; pupils equal; slight tenderness in back of neck, none along lower part of spine or mastoids; irritable; patellar reflexes diminished. Blood showed 36,000 whites. Eye examination showed indistinct discs, more marked in right eye. Face congested. March 15, optic discs more distinct than at first examination. March 16, neck not so stiff. March 18, blood count showed 24,000 whites. March 22, neck painful; stiffness of neck, but no retraction. Blood count showed 22,000 whites. Discharged well April 1. Last blood count, March 30, showed 8,100 whites.

CASE 21. Male, age twenty-three years. Entered hospital March 10. Five days before, complained of pain in head, neck, back and limbs; on the same day became delirious. Upon admission, eyes normal; physical examination negative; mental condition seemed dull; he talked strangely. March 14, delirium less; resisted treatment. Lumbar puncture, milky fluid withdrawn. March 18, patient got out of bed and wandered about; seemed brighter. March 26, patient remained in a condition of semi-stupor. March 31, vomited yesterday, and seemed weaker. April 4, abdomen "scaphoidal." Died April 6.

CASE 22. Male, age twenty-five. Entered hospital March 9. Twenty-four hours before admission he complained of headache, and during the evening was found unconscious on the floor of his room. On admission into hospital, unconscious; muscles of back and neck stiff and rigid; head retracted; pupils dilated; patellar reflex increased. March 10, condition the same. A blood count showed 19,800 leucocytes. On March 12, patient still unconscious; became comatose, and died at 11.15 A.M. on March 13. The temperature was 100° at time of admission, and showed a gradual increase, reaching 104° on the last day. Post-mortem examination.

CASE 23. Male, age 23 years. Entered hospital March 11. Three days before admission, complained of pain in back, headache and nervousness; on night before admission, became delirious and vomited a great deal. On admission, was very restless; no retraction of head; pupils equal, and reacted alike; patellar reflex absent; legs held rigidly. Patient resisted examination. March 12, patient very stupid; lay on left side; no apparent tenderness over mastoid region. March 13, dark-red eruption over trunk and extremities; patient rational; tongue protruded

slightly to the left. March 15, general condition better. Mental condition improved; slight convergent strabismus of right eye. All the symptoms continued to improve, and he was discharged well April 13. Spinal puncture, made March 20, gave 8 cubic centimeters of clear watery fluid, with very slight floculent sediment. Microscopic examination showed a few lymphoid cells, but no polynuclears. No organisms found microscopically. On cultures after several days there developed very small colonies of diplococci, which varied considerably in size, but which showed the characteristic staining.

Case 24. Female, age five years. Entered hospital March 18. Ten days before admission, poor appetite on returning from school; next day, dull, cried much; kept eyes closed most of the time; screamed once or twice, as if in severe pain; herpes of lips. Retraction of head and inequality of pupils noticed on day of entry. The mother said that another child in her neighborhood had similar symptoms, and died in eight days. On admission, head retracted; eyes closed; pupils large and equal, and changed from time to time; reacted sluggishly to light; slight convergent strabismus; no tenderness of mastoids or along spine; purulent secretion on conjunctiva. Blood count showed 18,000 whites. March 21, no change in condition; spoke occasionally to nurse; eyes closed most of the time. March 26, evidence of broncho-pneumonia. March 30, blood count showed 16,000 whites. April 2, no particular change; left chest still dull; retraction of head the same. April 5, blood count showed 21,000 whites. April 8, left lung cleared up. April 13, fretful; retraction continued. April 14, discharge from right ear. April 16, both ears discharging. April 19, discharge from ears much less. April 21, retraction of head extreme; eye symptoms the same. April 28, ear discharge slight. April 30, ear discharge profuse. May 9, severe cough, with rapid respiration. May 10, collapse during morning; continued to grow weaker, and died at 10.30 A.M. of the 12th. April 23, cover-slips from nose and from ear discharge showed diplococci decolorized by Gram in the leucocytes. No diplococci found in the sputum examined May 9. The temperature chart of the case is interesting, as showing a continuous high temperature, running above 103°.

Case 25. Female, age seventeen years. Entered hospital March 11. March 9, had chill, headache, pain all over body, pain in eyes, and throbbing in ears which interfered with hearing; vomited several times. On admission, slight nystagmus; pupils equal and reacted alike; reflexes normal; tâche cérébrale well marked. March 12, intense pain in back and neck. March 13, vomited several times; slight delirium; diplopia, convergent strabismus and slight ptosis; tenderness on pressure along spine. Blood count showed 31,000 white corpuscles on March 14. Delirium continued; could be roused to answer questions. March 16, patient much duller, and died at 3.30 P.M. Spinal puncture, March 14, gave 8½ cubic centimeters of cloudy fluid, with slight sediment. On microscopic

examination, abundant pus cells were found containing numbers of diplococci. Cultures showed abundant pure growth of diplococci. The chart shows a rise to 105⅘° the second day after entering hospital, then a fall to normal, followed by a rise to 102° at death.

Case 26. Female, age 25 years. Entered hospital March 17. Sick four days before entrance; complained of headache and of indefinite pain all over body; this was followed by delirium and vomiting. On admission, pupils regular and reacted; reflexes normal. March 20, slight nystagmus and diplopia; marked tenderness in back of neck. March 25, sixth nerve paralyzed on right and partially on left side; constant variable nystagmus; answered questions slowly; was lethargic. March 26, paresis of third nerve; optic nerves showed slight swelling and congestion. March 30, vomiting; patient much weaker; stupor appearing. April 2, stupor increased, and patient died at 5.55 A. M., April 3. Lumbar puncture, April 3, shortly after death, gave a small amount of turbid fluid. No microscopic examination made of the fluid. It was sterile in cultures.

Case 27. Female, age two and one-half years. Entered hospital April 8. Sickness began twenty-five days before entry into hospital with headache, loss of vision and vomiting. On admission, emaciated; head not retracted, but some resistance to flexion. April 11, lumbar puncture gave turbid fluid with slight deposit of pus at bottom of tube; diplococci in pus cells. Chart shows irregular sharp rise in temperature up to 106° before death.

Case 28. Male, age thirty-seven years. Entered hospital March 20. One week before admission, headache, pain and stiffness in neck; three days before admission, was delirious. On admission, head rigid, patient cried out with pain on attempting to move it; delirium; head retracted; pupils contracted, but reacted alike; patellar reflex absent. March 24, continued delirium; back and neck painful to touch. Blood count gave 14,000 whites. On March 28, quieter and more rational. April 1, less tenderness and rigidity; no special change of mental condition; no optic neuritis. April 5, still delirious and restless. April 9, some improvement; the mind clear at times. April 13, continuous improvement. April 17, mental condition better, but at times delirious. The patient continued to gain in strength, and on May 17 was discharged, to go into country. At the time of discharge, irritable and childish. Lumbar puncture, March 24, was negative for organisms both on microscopic examination and cultures. There were abundant pus cells in the fluid.

Case 29. Female, age four and one-half years. Entered hospital March 20. Attack began three days before entrance; vomiting; after that great pain in head and neck; opisthotonos. Lumbar puncture made March 20. Optic neuritis of both sides on May 15. Child con-

tinued to improve, and was discharged well June 6. Temperature of the case is interesting, as showing a very low temperature, rising only once to 101°. Fluid from lumbar puncture, March 20, was cloudy but not very turbid; only slight deposit.

CASE 30. Female, age three years. Entered hospital March 24. Four days before admission, tenderness of neck muscles; hyperesthesia of entire body, Lumbar puncture positive. Herpes of lips. Condition improved rapidly, temperature falling to normal on March 28. Discharged well April 12.

CASE 31. Female, age eight years. Entered hospital March 23. Three days before admission, vomiting, pain in back, headache and constipation. Strabismus two days before admission. On admission, strabismus of both eyes; hyperesthesia of entire body, chiefly back of neck; patellar reflexes normal. Lumbar puncture, March 26, negative. At this time, temperature was gradually going down. Lumbar puncture, April 3, positive. Discharged well July 5. The spinal puncture was made during an exacerbation of fever.

CASE 32. Female, age seventeen years. Entered hospital March 25. March 21, came home from work complaining of pain in head, chilliness and vomiting. On the following morning, rigidity of arms and legs, with slow movements; was in stupor and unconscious for most of the day. On third and fourth days, delirious, and complained of pain in head and neck. On admission, muttering delirium; marked retraction of head; pupils equal and reacted to light; convergent strabismus. Patient died suddenly at 6.30 A.M., March 26. Temperature on admission, 100°; pulse, 120. Post-mortem examination.

CASE 33. Male, age twenty-five years. Entered hospital March 30. Eight days before admission, feeling of malaise, with headache. Two days before entrance, delirious; in the evening was nauseated. On admission, semi-conscious; fever and headache, pain in neck; herpes on lips and nose; pupils equal, occasionally strabismus of left eye; knee jerk not obtained. April 2, patient unconscious. Blood count showed 21,600 whites. Became gradually weaker, and died at 10 P.M. Spinal puncture, made April 2, gave temporary relief. Puncture showed considerable cloudy fluid. Smears showed abundant pus and diplococci.

CASE 34. Female, age seven years, two months. Entered hospital March 26. Two days before admission, face flushed, complained of headache, vomiting. There were convergent strabismus and opisthotonos. On admission, child crying, with eyes partly closed and hands to head. Easily roused; answered questions. Pain in forehead; pupils reacted alike; convergent strabismus; tenderness of neck; tâche cérébrale well marked; patellar reflexes unequal. Blood count showed 25,000

whites. March 27, restless; tenderness of right wrist, which was swollen and red; moderate retraction of head; internal strabismus; stupor; complained of tenderness of right ankle. March 28, vomiting ceased; stupor increased. March 29, large patch of herpes just below and anterior to lobe of left ear. Culture from fluid from herpetic vesicles negative. April 15, much better. Discharged well May 4. Temperature was high until April 2, then gradually declined.

Case 35. Male, age five years. Entered hospital April 3. Nine days before admission, headache; irritable. Two days before, went to Eye and Ear Infirmary and was sent to hospital. On entrance, right pupil slightly larger than left; no herpes; no ecchymosis; slight stiffness of neck. April 4, much pain in head and neck; at 6 P.M., delirious; quieter afterwards. April 5, less delirious. April 7, left pupil larger than right; strabismus; slight stiffness of neck; backward and forward movement caused pain. April 8, did not recognize relatives; seemed more stupid; no strabismus. Discharged against advice.

Case 36. Male, age nineteen years. Entered hospital March 30. Five days before admission, pain in side, severe headache; vomiting, with delirium and retraction of head. On admission, delirious and deaf; herpes labialis; pupils equal and reacted alike; patellar reflex slightly increased. Blood count showed 9,350 whites. April 3, retraction less marked; had grown more deaf. April 6, head moved without pain. April 12, better. Ophthalmoscopic examination, April 16, showed slight optic neuritis. April 19, discharged.

Case 37. Male, age twelve years. Entered hospital April 1. Vomiting and headache three days before entrance. On entrance, photophobia; hyperæthesia of skin, no eruption; delirious, unconscious. Herpes developed, general condition became much worse. Died April 7. No post-mortem examination. Purulent discharge from eyes. Temperature irregular, with sharp terminal rise. Lumbar puncture, immediately after death, gave thick purulent fluid with diplococci in pus cells

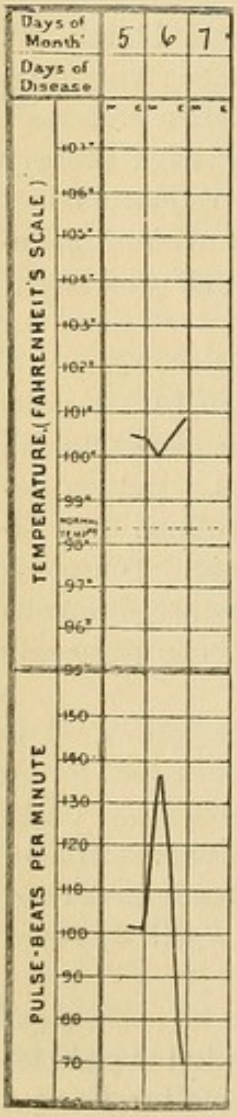
Case 38. Male, age thirty-three years. Entered hospital April 1. Three days before admission, began to vomit, and continued to do so since; pain in back of head. On admission, pupils equal, slight convergent strabismus of left eye; patellar reflex absent; stiffness of neck; pain limiting motion in all directions; no tenderness; no retraction. April 4, very delirious, tearing his bed. April 5, rapid failure; death in coma, 3 P.M.

Case 39. Male, age thirteen months. Entered hospital April 13. Two weeks before admission grew feverish; loss of appetite; cried a great deal. Four days before admission, slight convulsion. Head retracted five days before admission. Eyes reacted alike; tâche cérébrale on admission; skin clear. Grew gradually worse; died May 18.

CASE 40. Male, age three and one-half years. Four days before admission, fever and chills; vomiting day before admission; head retracted; slight discharge from both ears. Lumbar puncture, April 8; fluid very turbid, with thick pus at the bottom of test tube; diplococci. Died June 14. Post-mortem examination.

CASE 41. Female, age fifteen years. Entered hospital April 3. On April 2 she was irritable, had intense headache and vomiting. On day of admission, was delirious and had marked muscular spasm. No retraction of head, although flexion was resisted, and there was considerable pain and tenderness in back of neck. At times divergent strabismus and slight nystagmus. Pupils dilated, of equal size and reacted alike. April 4, the same condition; frequent vomiting and complained of headache. Died suddenly. Post-mortem examination.

CASE 42 Male, age nineteen years. Entered hospital April 3. Well up to night before admission. Sickness began with chill, followed by nausea and vomiting. He became stupid and somewhat delirious. On admission, pupils somewhat dilated, reacted to light; jaws closed; no retraction of head; knee jerks normal. April 4, delirious; in semi-lucid intervals complained of head; tenderness of muscles in back of neck. April 5, breathing somewhat labored. Blood count showed 18,000 whites. Died at 3 P.M. Post-mortem examination.



CASE 43. Male, age thirty-five years. Entered hospital April 5. Two days before admission complained of headache and intense pain through head; pain also in back and limbs. The day before admission, became delirious and later unconscious. On admission, unconscious, pulse full; neck retracted; pupils slightly contracted, reacted alike; extremities rigid; pain on pressure along back of neck and spine. April 6, very cyanotic. The removal of exudation by lumbar puncture was followed by relief, but the patient soon grew worse, and died at 6.20 P.M. About 5 cubic centimeters of distinctly cloudy, purulent fluid was obtained from lumbar puncture. Smears showed pure pus, many of the pus cells very large and filled with flattened diplococci.

CASE 44. Male, age fifty years. Entered hospital April 4. No previous history could be obtained. On admission, the head was drawn down to the right posteriorly, rotation to the left caused intense pain; marked tenderness on pressure below mastoids; pupils equal and reacted alike; nystagmus present; patellar reflex absent. Patient failed rapidly, and died April 9. Post-mortem examination.

Case 45. Female, age four and one-half years. Entered hospital April 9. Sudden attack day before entrance, with headache, etc., then became unconscious, delirious and stupid. Marked hyperæsthesia; tonic spasms of arms and legs Lumbar puncture, April 22, showed cloudy fluid, with pus cells and diplococci. Child continued to grow worse. Died May 24.

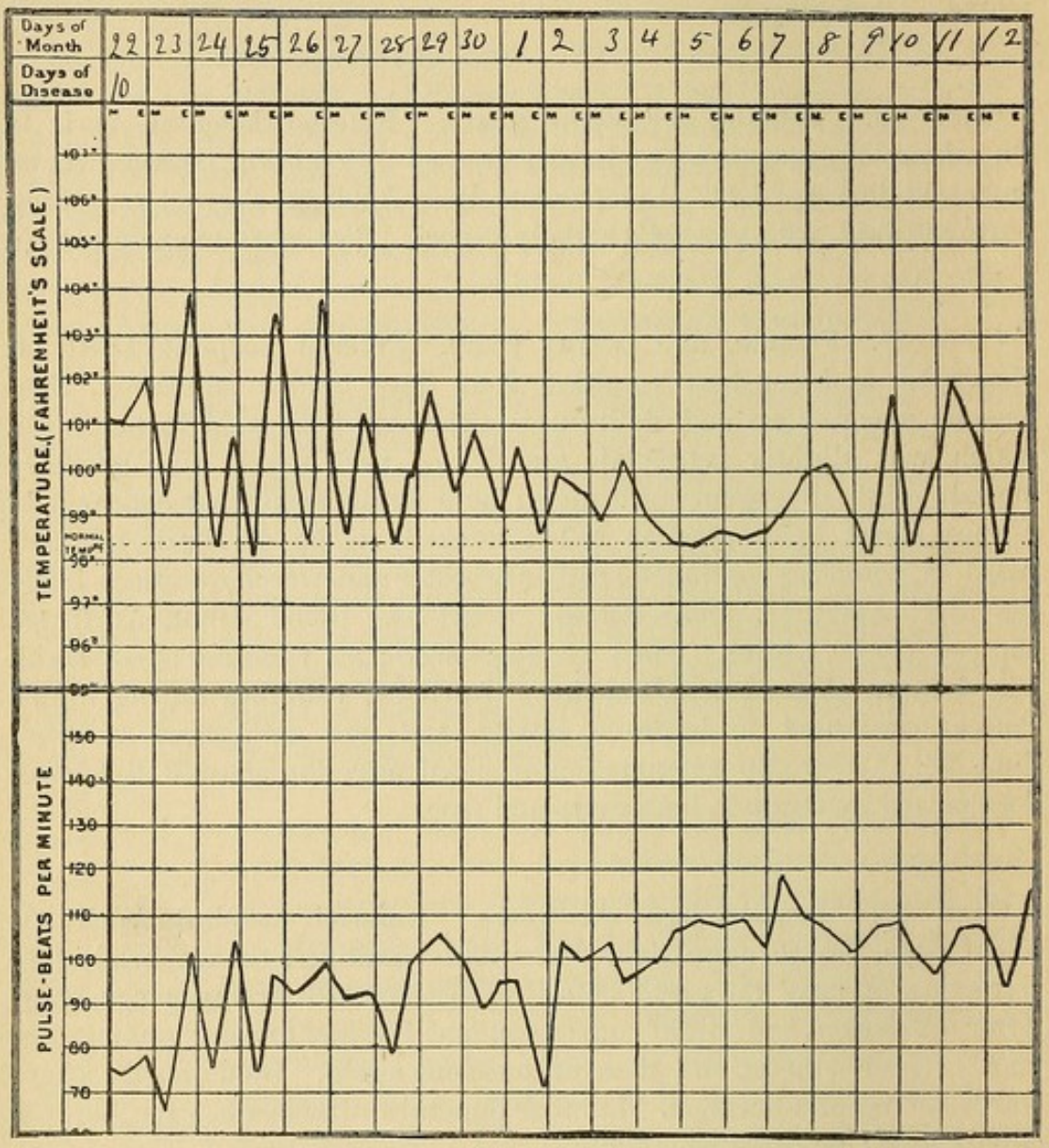
Case 46. Female, age eight years. Entered hospital April 9. On admission, unconscious; head retracted. Condition became worse, and child died April 11. Lumbar puncture, April 11, showed very thick purulent fluid, with pus cells and diplococci. Post-mortem examination.

Case 47. Female, age twenty years. Entered hospital April 14. Headache and constant vomiting four days before admission, then became unconscious and delirious. Cried out with pain in her head, which was slightly retracted; muscles of neck tense; eyes partially closed; slight divergent strabismus; both pupils somewhat contracted; herpes about lips; patellar reflex normal; tâche cérébrale marked. April 15, vomiting continued; rather brighter; answered questions intelligently. April 17, more stupid; delirious. Blood count, April 18, showed 13,000 whites. April 21, slept well; no vomiting; less rigid. Blood count showed 20,000 whites. April 23, vomiting during night. Patient continued to improve slowly, and was discharged relieved June 23. Cover-slip examination of nasal secretion showed diplococci decolorized by Gram in leucocytes and free.

Case 48. Female, age six years. Entered hospital April 19. Eight days before admission, fever and vomiting; severe headache; retraction of head the night before admission, with frequent vomiting. After admission, had slight convulsion and became unconscious; afterwards hyperæsthetic, and then unconscious again. Died shortly afterwards, on day of admission. Lumbar puncture, after death, gave slightly cloudy fluid; no organisms found.

Case 49. Male, age thirty-five years. Entered hospital April 22. Ten days before admission, complained of headache and vomiting; vomiting persisted for several days. On admission, patient in stupor; answered no questions; muscles of back of neck not tense except when head was bent forward; abdomen retracted. Blood count showed 14,000 whites. April 23, rigidity of back of neck quite marked. April 25, bed sore developed. Died April 26. Fluid from spinal puncture, made April 24, was slightly cloudy. Direct examination for bacteria negative. Polynuclear leucocytes present in moderate numbers. Cultures on two tubes sterile; in one, colonies of staphylococcus albus, evidently skin contamination. The temperature shows a rapid terminal rise to 107°.

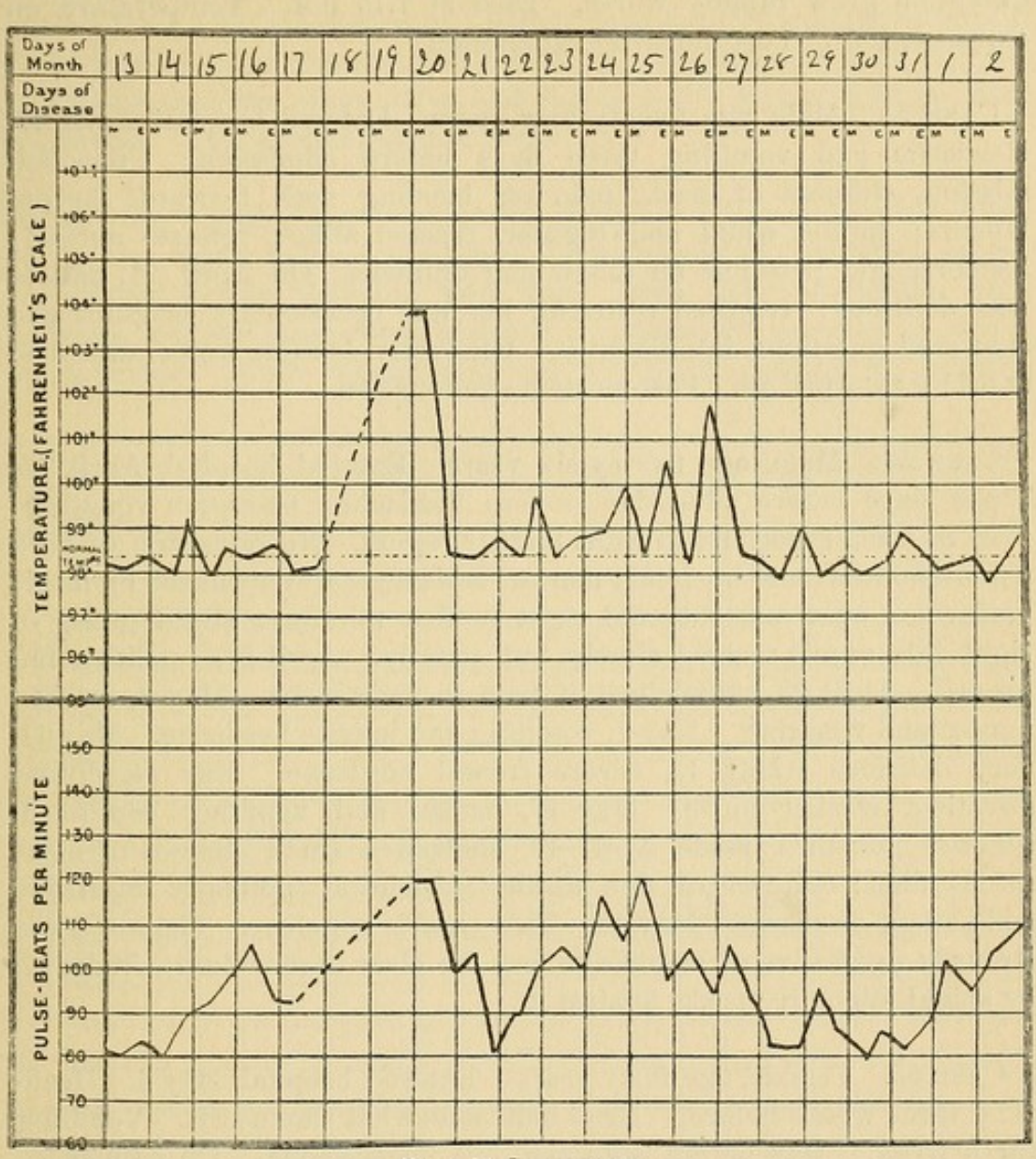
CASE 50. Female, age thirty-six years. Entered hospital April 22. On April 12, had chill; headache and pain running down the back into the extremities. Vomited up to four days before admission; was delirious the day before admission. On admission, herpes labialis; pupils equal and reacted; reflexes normal; stiffness of neck; motion



CASE 50.

limited by pain. April 24, slight delirium; no eye symptoms, no retraction of head, no vomiting; still complained of pain in neck. April 28, ptosis of both eyes; pain in back had increased. Blood count showed 24,500 leucocytes. May 2, ptosis had disappeared; pain diminished. May 6, patient restless, at times noisy. May 19, patient was up and about ward, but still complained of pain in head. May 26, vomited and was very restless. June 3, still complained of headache. June 5, discharged well. Lumbar puncture, April 22, gave 20 cubic centimeters of slightly cloudy fluid. Microscopic examination showed very few pus cells or other cellular elements; no organisms found. Cultures gave pure growth of the diplococcus. The cultures were made by pouring 1 cubic centimeter of the fluid over slanting test tubes of serum. One colony

developed on one tube, three on a second and none on four others The appended chart shows two complete intermissions, one lasting eight days.



CASE 50 CONCLUDED.

CASE 51. Male, age fifty years. Entered hospital April 13. Patient found in a vacant building. On admission, unable to talk; pupils small and equal; slight fibrillar twitchings of muscles; partial anæsthesia. April 14, patient fairly rational. April 16, optic neuritis, with convergent strabismus. April 20, delirious; herpes on face; some petechiæ on buttocks; no vomiting, no headache. Steadily failed, and died 9.25 P.M. Lumbar puncture, April 15, gave 15 cubic centimeters of slightly cloudy, watery fluid, with slight sediment. Microscopic examination showed pus cells, with occasional diplococci. Cultures showed very feeble growth of typical diplococci.

CASE 52. Male, age twenty-seven years. Entered hospital April 14. On day before admission, had a chill; delirious; face cyanotic; tongue dry; left pupil smaller than right, both reacted alike; no en-

largement of spleen; legs covered with reddish hyperæmic blotches; similar condition on arms, but less marked; patellar reflex normal. Condition grew rapidly worse. Died at 7.15 P.M. Temperature on entrance, 105°. Post-mortem examination.

CASE 53. Male, age twenty-four years. Entered hospital April 17. Headache and vomiting three days before admission. Upon admission, stiffness of neck, pain on bending neck forward; herpes labialis; pupils equal and regular, reacted alike; reflexes normal; hæmorrhagic petechiæ on elbow and buttocks. On April 21, patient was delirious; required restraint, but was occasionally brighter and answered questions intelligently. Gradually became worse, and died at 3.45 P.M., April 23. Post-mortem examination.

CASE 54. Male, age twenty-six years. Entered hospital April 15. Three days before admission, severe headache; excessive vomiting; pain in back, especially in right lumbar region. No retraction of neck when admitted into hospital; marked resistance to movement of head; tenderness over mastoids and right lumbar muscles; slight ptosis of right lid; pupils reacted slowly, but equally. April 20, condition improved. April 23, complained of pain in right wrist. May 3, marked nausea and vomiting. May 7, vomiting and intense headache. May 11, very delirious. May 13, severe frontal headache. May 14, diffuse sweating, weaker pulse. May 17, nausea and vomiting continued. Lumbar puncture, made April 19, showed a small amount of clear serous fluid: cultures of this sterile. Condition gradually improved, and patient discharged May 15. This case is not clear. The history is strongly suggestive of meningitis, but the clear serous fluid withdrawn by spinal puncture speaks against it.

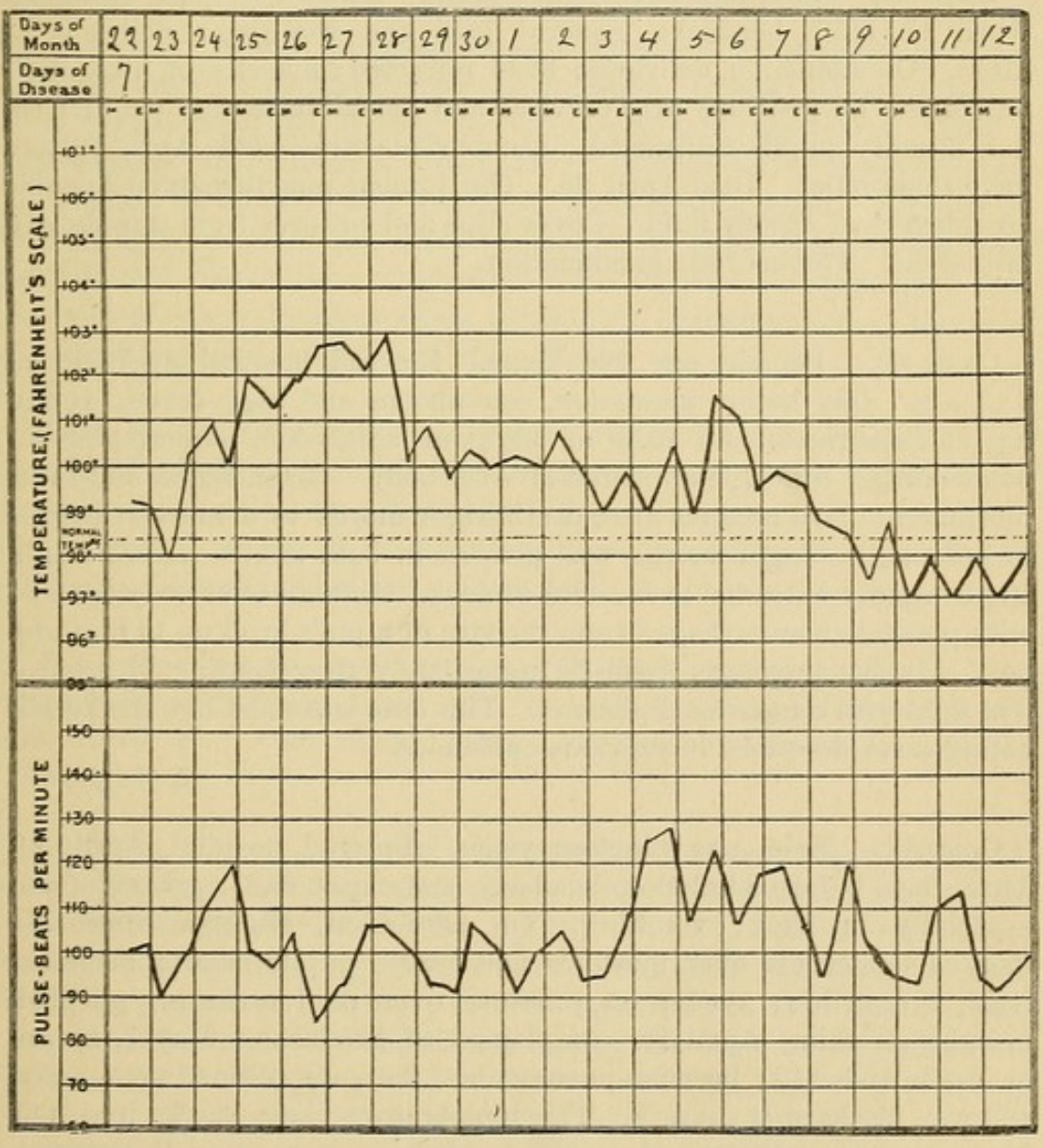
CASE 55. Female, age forty years. Entered hospital May 6. Headache three weeks before. Head held somewhat backwards. Vomiting for a week. Day before entrance, fell unconscious. On admission, pupils reacted; tenderness of back of neck; very slight rigidity; knee jerks diminished. White corpuscles, 19,000. Continued more or less unconscious. Died May 8.

CASE 56. Female, age three and one-half years. Entered hospital April 19. Illness began four days before admission, with incessant vomiting. Three days before admission, stiffness of neck, with great pain on motion. No strabismus. On entry, cyanotic; dulness at base of both lungs; no retraction of head; no especial tenderness along spine. One hour after admission, pupils contracted; cyanosis worse. Gradual improvement up to 6 P.M., when the respiration became difficult; unconsciousness developed. Died on morning of 20th. Post-mortem examination.

CASE 57. Male, age twenty-four years. Entered hospital April 17. Perfectly well up to day before admission, when he awoke with intense

headache, vomited several times, was very restless. On admission, almost complete unconsciousness, turning from side to side, burying his head in the pillow. No retraction of head and no tenderness at back of neck. The pupils were normal. Patient continued very restless, turning from side to side: restraint was necessary. He suddenly showed signs of failure, cyanosis, weak pulse, and died at 4 15 P.M., three hours after admission. Post-mortem examination.

CASE 58. Male, age twenty-eight years. Entered hospital April 23. One week before admission, complained of headache, which was followed by delirium two days later. On admission, high delirium, patient struggling violently; rigidity of muscles of neck; opisthotonos; pupils dilated and did not react. April 26, delirium



and opisthotonos. Patient became less noisy after spinal puncture. April 28, blood count showed 11,400 leucocytes. April 30, patient seemed better; a third puncture was made. May 4, slight change; patient dull, could not answer questions. Patient continued to improve, and was dis-

charged on May 22. At the time of discharge he was rational, but his mind was evidently impaired. Lumbar puncture was made on April 23, on the 26th, and on April 30. On the 23d two test tubes were filled with a bloody, serous fluid containing large clots. There was a great deal of blood and abundant pus cells. No organisms found on microscopic examination or in cultures. On April 26, 15 cubic centimeters of cloudy, yellow, serous fluid removed. Microscopically, showed abundant pus and epithelioid cells; diplococci contained in pus cells and in cultures. This puncture made during an exacerbation of temperature. The puncture on April 30 was negative. The chart shows rise after entering hospital, with decline to sub-normal, marked by exacerbations.

Case 59. Male, age twenty-nine years. Entered hospital April 21. April 17, chill, headache, general pain and vomiting; delirious at night. On admission, delirious; head retracted; muscles of neck stiff; tenderness on pressure over cervical and dorsal vertebræ; patellar reflex absent; pupils contracted. Lumbar puncture made April 22, and gave some relief. Died April 23. The lumbar puncture gave 20 cubic centimeters of bloody fluid. Cover-slips and cultures from this showed diplococci. Post-mortem examination.

Case 60. Female, age five years. Entered hospital April 18, at 3.15 A.M. Day before admission, convulsions and high fever; vomiting and diarrhœa. At 10.30 of night of admission, numerous small hæmorrhages into skin appeared all over body. On entrance, child was moribund. Two minutes after death, rigor mortis to a marked degree in both legs. Rigor mortis was present in both ankles before death. Rigor rapidly extended to muscles of neck. Skin all over body covered with punctate hæmorrhages from the size of a pin's head up to that of a pea. Lumbar puncture, April 18, immediately after death, gave a purulent fluid with numerous diplococci. This case was most like the fulminating cases described in previous epidemics.

Case 61. Male, age nineteen years. Entered hospital April 21. Three days before admission, headache and slight chill; general pain, especially in back; vomiting. On admission, slightly irrational; marked tenderness over mastoids and back; pupils small; abdomen rigid, tympanitic; tender on pressure over recti muscles; purplish maculæ on skin. April 29, complained of headache. May 7, severe headache and chill; broncho-pneumonia. Patient continued to improve, and was discharged June 8. The temperature chart shows irregular fever, not over 101°, then sharp rise to 102°, corresponding to broncho-pneumonia. Lumbar puncture, April 23, gave 35 cubic centimeters of turbid, slightly yellowish fluid. Microscopic examination showed abundant pus cells and large epithelioid cells. Diplococci found in pus cells in considerable numbers and sometimes free. Cultures showed abundant typical development of diplococci.

Case 62. Female, age four and one-half years. Entered hospital April 20. One day before admission, attack began; no vomiting; malaise; anorexia; coryza. On admission, restless, delirious and at times unconscious; head retracted. Died April 22. Lumbar puncture, post-mortem, gave cloudy fluid, and cultures showed pure growth of diplococci.

Case 63. Male, age twenty-seven years. Entered hospital April 30. Nine days before admission, complained of severe headache and pain in neck, with vomiting. Headache had not been constant since, but there had been stiffness of muscles and retraction of head. April 29, became delirious. On admission, unconscious, marked retraction of head with rigidity of neck; conjunctivæ injected; pupils equal, moderately dilated, did not react; patellar reflex normal. May 1, retraction of head less marked; mental condition improved; slight nystagmus; no strabismus. May 2, condition more unfavorable. Spinal puncture May 2. May 5, sane mentally, hiccoughs; Cheyne-Stokes respiration. May 8, temperature fell to normal. Died May 8. Spinal puncture gave 6 cubic centimeters of cloudy fluid, containing considerable blood Microscopically, single pus cells and many mononuclear cells. None of the large cells found. On culture, most of the tubes sterile. One tube gave four colonies of staphylococcus albus, probably a contamination of the skin. Puncture negative twelve days after attack.

Case 64. Female, age three years. Entered hospital April 21. A cousin of this child died four days before this with "brain fever" in the same house in which the patient was living. On admission, unconscious; head strongly retracted; could not be flexed; convergent strabismus of both eyes. Continued to fail. Died April 22.

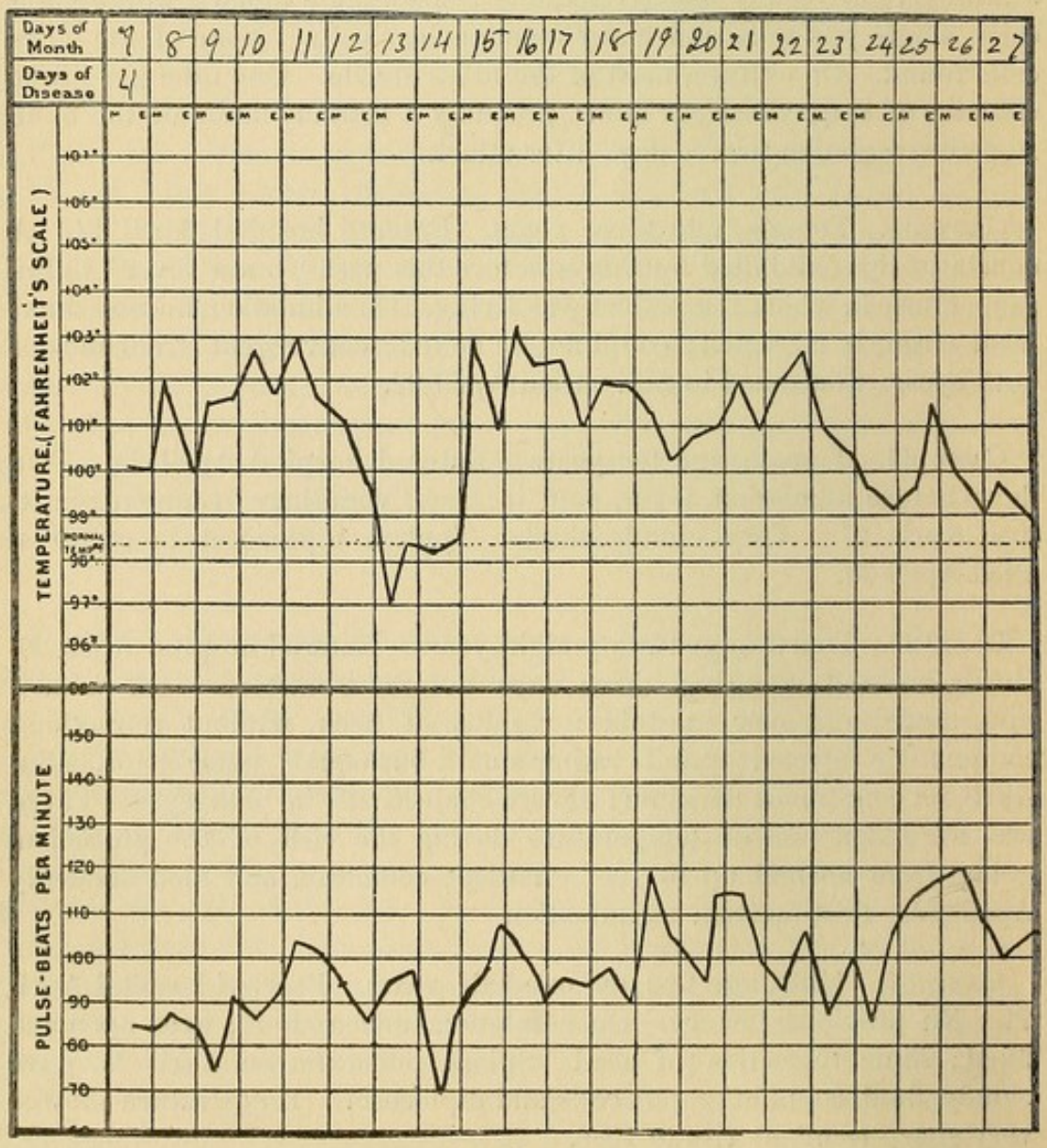
Case 65. Female, age ten years. Entered hospital April 25. Two days before admission, fever, pain in back, vomiting. Lumbar puncture April 27. Very cloudy fluid. Typical diplococci in cultures. Died April 29.

Case 66. Female, age twenty-eight years. Entered hospital April 26. Headache and vomiting three days before admission. On admission, tenderness over mastoids; rigidity of neck, without retraction; conjunctivæ injected; pupils rather small, but equal; petechiæ of skin. April 20, continuous delirium; severe conjectivitis in both eyes. There was a sudden rise of temperature during the visit of the physician, going from normal up to 105°. Patient comatose, and died suddenly April 29. Post-mortem examination.

Case 67. Male, age two and one-half years. Entered hospital April 24. No previous history. On admission, unconscious; eyes open and fixed; some retraction of head. Spinal puncture, on April 26, gave cloudy fluid, containing pus cells and diplococci. Temperature showed very sharp terminal rise to 108°.

CASE 68. Male, age ten years. Entered hospital May 5. Present illness began six days ago, with pain in right leg, followed by headache; vomiting; delirium; three days after this, herpes developed. On entry, herpes about lips; muscles at back of neck tender and rigid; no tenderness along spine. Blood count showed 15,000 whites. May 7, seemed better. May 9, rigidity of neck less; less pain. Blood count on the 15th showed 14,000 whites; a count on the 17th showed 17,000 whites. Discharged well May 18. Temperature came down on day after admission, and remained normal.

CASE 69. Male, age thirty-five years. Entered hospital May 5. Five days before admission, complained of pain in back and headache; had one chill the first day and one on day of admission; vomited on three days before admission. On admission, pain in eyes, throbbing pain in back and occasional pain in ears; pupils equal, regular and reacted alike; reflexes normal; stiffness of neck and whole back; slight herpes and petechiæ on nose. May 15, for some days had no pain for several hours each day. May 19, marked improvement. Discharged well May 22. Lumbar puncture made May 7, no fluid obtained.



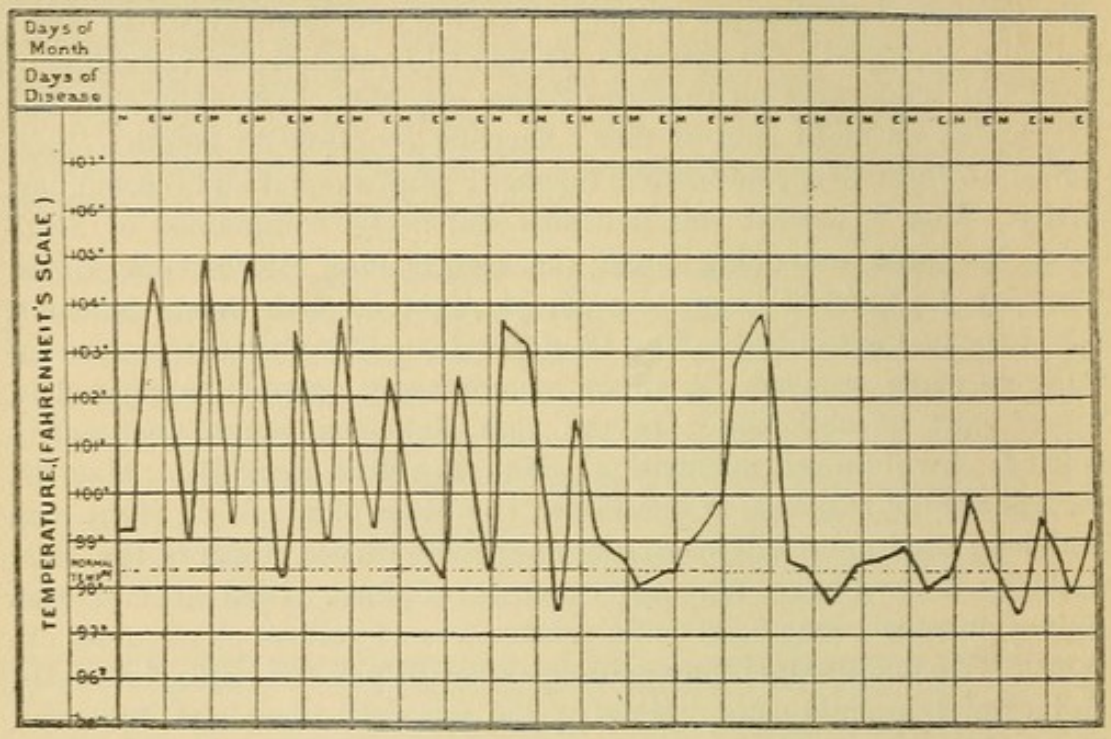
SEE CASE 70.

Case 70. Male, age twenty-seven years. Entered hospital May 7. Four days before admission, began to have pain in arms and legs; the next day, vomited, had headache and pains in back; on day following this, epistaxis; tenderness in parotid region and lower down in neck; delirium appeared. On entrance, stupid and irrational; no retraction of head, but tenderness on pressure below mastoids; lack of motion and expression on right side of face; herpetic eruption on mouth; slight ptosis of right eye, conjunctivæ injected; pupils equal and reacted normally. May 9, patient was delirious and noisy, complained of headache, the pain extending down the back; nose bled several times. On May 12, marked improvement; at night of 12th, more delirious, could not be kept in bed. May 17, general condition better; patient intelligent when aroused. A slight hæmorrhagic eruption appeared on upper part of abdomen. On the 20th, delirious, stupid, not easily roused; involuntary micturition. May 24, clear mentally. May 27, patient did not respond to questions; complete paralysis of right arm and leg; occasional slight nystagmus; eyes turned towards the left; inability to swallow. May 29, cyanosis of face. Died at 2.32 P.M. Spinal puncture, May 9, 60 cubic centimeters of yellow, cloudy fluid obtained. On microscopic examination, abundant pus and epithelioid cells, and a few lymphoid cells. Many of the pus cells contained diplococci in considerable numbers. Fifteen tubes were inoculated with large amounts of the fluid; three of these showed a growth. On two of these tubes two, and on one ten, colonies of typical diplococci. The chart shows complete intermission of fever for two days, coincident with marked improvement of the patient.

Case 71. Male, age two years. Entered hospital May 7. May 5, suddenly attacked with headache, pain in abdomen and vomiting. May 6, became drowsy, stupid and finally unconscious. On admission, persistent retraction of head and irregular temperature, varying from normal to 105°. Lumbar puncture May 7. Fluid cloudy, cultures showed diplococci in pus cells. The child's condition gradually improved. Emaciation was marked. On May 30, an enlarged cervical gland was noticed; examination of throat showed membrane on both tonsils. Bacteriological examination showed K.L. bacilli. Entered south department of Boston City Hospital June 1. Condition gradually grew worse; death on June 3, in convulsions. No urine passed while in south department hospital, and none found in bladder by catheterization. Post-mortem examination.

Case 72. Female, age six years. Entered hospital May 12. Illness began seven days before admission with abdominal pain, fever and vomiting; two days before admission there was headache, slight retraction of head and delirium. On admission, slight strabismus; tâche cérébrale well marked; legs flexed; pain on attempting to straighten them. Lumbar puncture, May 15, gave cloudy fluid with pure culture of diplococci. Discharged well June 21. The temperature chart is interesting, in showing a very sharp evening rise, somewhat resembling

the typhoid chart; then gradual decline, with a few sharp rises in between.



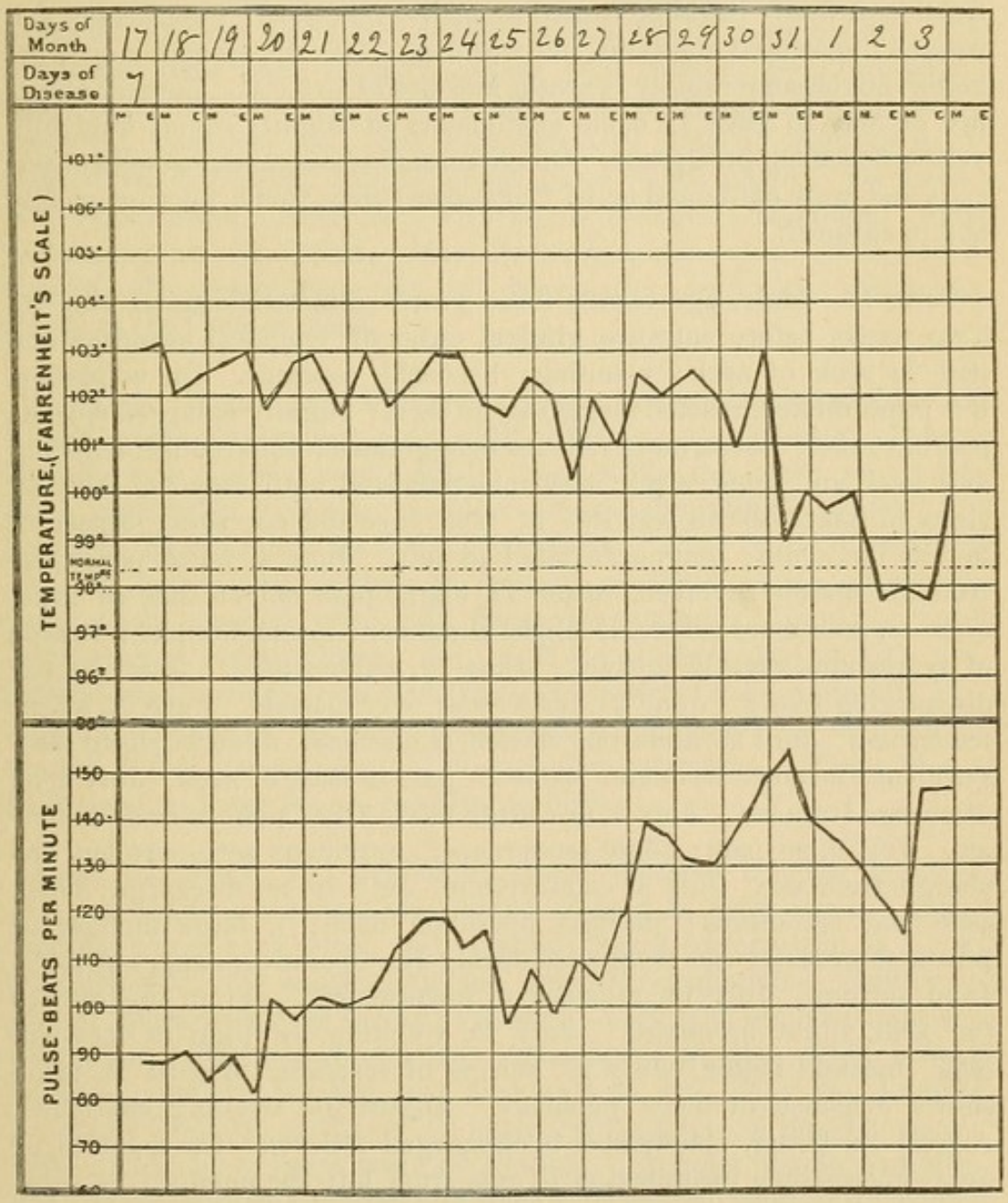
Case 73. Male, age twenty-six years. Entered hospital May 21. Fourteen days before, began to have pain in the back and head, which was continued with varying severity; movements of head painful; constant vomiting from the first. On admission, dull and slightly delirious; herpes on lips and around nose; pupils equal, and reacted; marked conjunctivitis; head held stiffly; motion limited by pain; no tenderness on pressure over vertebræ. May 24, active delirium; rigidity of head and back more marked. May 28, less delirious; no vomiting; head could not be touched without pain; no eye symptoms. June 1, mild delirium continued. June 5, occasional delirium; rigidity of neck had in large measure passed away. On June 9, head could be moved without pain. Patient continued to improve, and on June 21 was discharged well.

Case 74. Female, age ten years. Entered hospital May 9. Illness began night before admission, with chills and vomiting. On entrance, high fever; erythematous blotches on legs. Child rapidly grew worse, and died May 13. Lumbar puncture, May 12, gave cloudy fluid. Cultures of this showed typical diplococci.

Case 75. Male, age forty years. Entered hospital May 12. Three days before admission, complained of headache and sore throat; became deaf the following day; there was retching, but no vomiting. On night before admission, delirious. On admission, pupils small, equal, responded slightly to light; slight nystagmus and divergent strabismus of right eye; deafness; head stiff; pain on motion; no retraction; slight tenderness along vertebræ; reflexes absent. May 15, herpes on

lips increased; delirious. May 18, eyes again normal; involuntary micturition. Patient slowly failed, and died at 7.30 P M., May 19.

CASE 76. Male, age thirty years. Entered hospital May 17. Patient was in bed one week before entrance, with severe headache and pain in neck, with limited and painful motion of head; pain in back extending into legs; vomiting daily before admission into hospital. On admission, head held fixedly; flexion limited by pain; eyes normal; patellar reflex normal; abdomen tender. May 20, no vomiting since entrance;



headache continued; patient dull and quiet. May 23, slight delirium. May 27, lay in apparent stupor. May 28, delirious again; rigidity of head and back. May 31, stupor continued June 3, patient steadily continued to fail, and died at 5.30 P M. Lumbar puncture, May 19, showed 15 cubic centimeters of a slightly cloudy fluid, which after some hours

deposited a yellowish clot. The sediment contained many pus cells, with a few lymphoid and large cells. A few diplococci found. They were occasionally free, usually in pus cells, several pairs of them grouped about the nucleus. Cultures on every tube showed abundant growth of typical colonies. The chart shows a fever of medium degree, with slight variation, then fall to normal, with slight terminal rise.

Case 77. Female, age nineteen years. Entered hospital May 14. For three days before admission, pain in head and neck and stiffness in neck and back; slightly stupid. On admission, evident pain, some retraction of head; could be roused to answer questions; pupils equal and reacted; answered questions, but was dull. May 15, seemed somewhat better, but became rapidly cyanotic, and died at 2.40 P.M. Lumbar puncture on May 15 gave 12 cubic centimeters of slightly cloudy fluid with yellow flocculent precipitate. On microscopic examination abundant pus cells and large epitheloid cells. Diplococci were found microscopically and in cultures.

Case 78. Male, age twenty-three years. Entered hospital May 25. Two weeks before entrance, gradual onset of temporal headache and pain in back of neck; vomiting; headache constant. On admission, left pupil dilated, reacted sluggishly to light; slightly enlarged spleen; patellar reflex absent, other reflexes exaggerated; faint reddish mottling over back and upper arms; headache persisted until May 30. May 31, signs of paralysis on left side of face; eye did not shut; corner of mouth immobile; tongue deviated to left. June 4, facial paralysis; frontalis muscle involved. June 17, slight pain on left side of head. June 18, pain more severe, localized about ear; mastoid tender; vessels of tympanum slightly injected. June 19, paracentesis. June 20, ear discharging freely. June 21, tenderness over mastoid. June 24, slight tenderness. June 25, almost no mastoid tenderness. June 26, slight sero-purulent discharge from ear. June 27, pain in back of neck. July 2, no discharge from ear. July 3, discharge fairly free; pain in neck moderate. July 6, no pain; slight tenderness; continuous sero-purulent discharge from ear. July 8, comfortable. July 10, no discharge; much pain and tenderness; mastoid operation done; a large amount of purulent material ran from nose during the operation, supposed to be from antrum. July 16, returned to medical side. From the 16th to the 19th, slight bronchitis. July 20, vomiting, swelling of feet and legs; mastoid better. July 28, œdema of scrotum. August 12, urine shows evidence of acute nephritis. August 16, swelling continued. August 18, better. September 3, discharged relieved. On the 19th of June, microscopic examination of pus from left ear obtained by paracentesis showed leucocytes and diplococci. June 15, microscopic examination of the purulent nasal secretion showed a few intracellular diplococci and few leucocytes. The diplococci did not grow on culture.

Case 79. Male, age fifty-eight years. Entered hospital May 13. The previous history of the patient could not be obtained, as he could

speak no English. On admission, was semi-conscious and at times delirious; ptosis of left eye, left pupil smaller than right; neither reacted to light; pulse regular, of good strength and volume; patellar reflex diminished on left side; superficial reflexes diminished. May 16, still delirious; incontinence of urine and fæces; condition much the same as at entrance. May 19, patient much weaker; stupor deepened, and patient died at 6 A.M., May 19. The temperature was sub-normal while in hospital. Post-mortem examination.

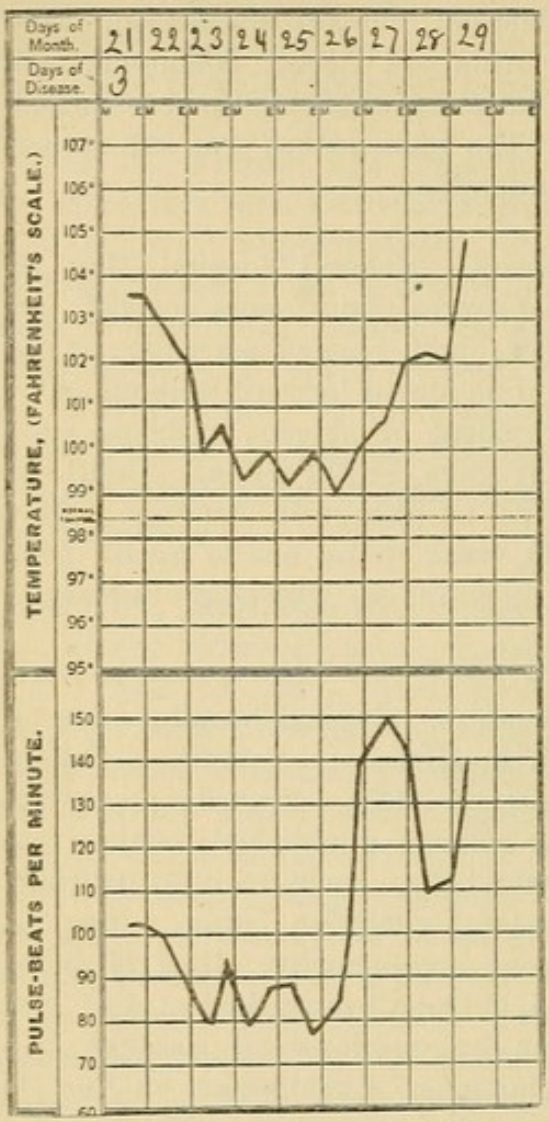
CASE 80. Female, age thirty years. Entered hospital May 21. Seven days before, headache; vomited several times; neck not stiff. On admission, right pupil slightly larger; both reacted normally; slight strabismus; head retracted, but could be forced forward without pain; cried out, groaned, etc.; no enlargement of spleen; reflexes more marked on right side. Blood count gave 14,800 whites. Delirious. May 22, delirious; headache. May 23, no change in condition. May 24, picking at bed clothes. May 25, weak, pulse not so good. Died May 25. The temperature was 102° on entrance; with slight remissions it rose to 105° before death.

CASE 81. Female, age twenty-six years. Entered hospital June 14. Illness began four weeks ago, with headache; no vomiting. Patient stupid; eyes closed; pupils small; head stiffly retracted; no tenderness; respiration irregular; patellar reflexes diminished; conjunctivæ injected. Blood count showed 10,000 whites. June 15, mild delirium. June 19, pulse weak. June 21, mental condition better. June 22, more stupid; passed urine and fæces involuntarily. June 24, blood count showed 14,000 whites. July 4, failed all day; died at 4.45 P.M. Several examinations were made from the superior nasal passages. No diplococci found on the early examinations. Examination on June 15 showed a few leucocytes; no intracellular organisms. There was a high terminal temperature, reaching to 106°.

CASE 82. Male, age fifty-eight years. Entered hospital May 17. The day before admission, complained of pain in right leg and chilly sensation; was very weak, and vomited; found unconscious at 1 P.M. On admission, was unconscious and cyanotic; conjunctivæ slightly injected; tenderness over cervical vertebræ; neck stiff, but no retraction; pupils equal; did not react alike; limbs rigid; patellar reflex absent. Became gradually weaker, and died at 4.50 P.M., May 18. Lumbar puncture, May 18, produced 14 cubic centimeters of bloody, cloudy fluid, containing a large trace of albumin. On microscopic examination, pus cells with diplococci. Cultures from fluid showed diplococci. Post-mortem examination.

CASE 83. Male, age sixteen years. Entered hospital May 21. Three days before admission, sudden severe headache in frontal region, extending down middle of neck to middle of shoulders; retraction of head, with pain on motion. On admission, conscious; tenderness over sterno-

mastoid and lumbar muscles; herpes labialis; eyes and reflexes normal. May 24, marked delirium; retraction of head less marked. May 26, delirium increased; frequent vomiting. May 27, somewhat better. May 29, patient became worse, and died at 12.45.



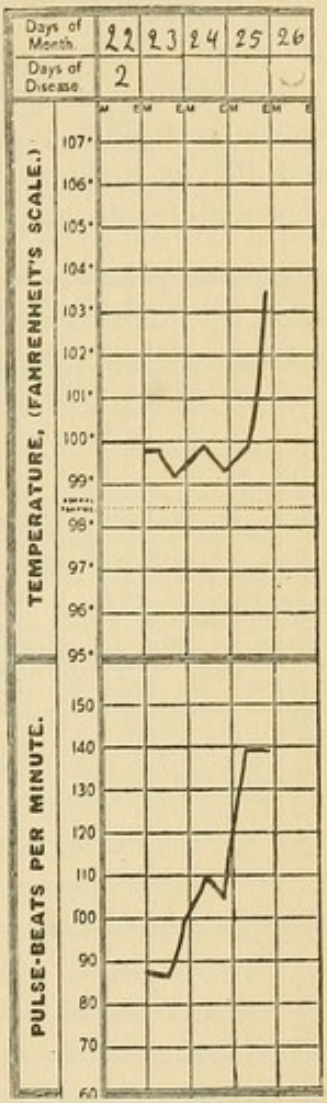
Case 84. Female, age thirty-one years. Entered hospital May 22. Three days before entrance, pain in head and back of neck, and vomiting; became unconscious. On admission, pupils equal; convergent strabismus on right side; head partially retracted; no tenderness over cervical vertebræ; spleen not enlarged; diminished patellar reflex. Blood count showed 18,000 whites. May 23, still unconscious; quiet most of the time, groaned if moved; retraction of head more marked than at entry. Died May 24. Temperature chart shows steady rise from time of admission to death. Post-mortem examination.

Case 85. Male, age twenty-five years. Entered hospital May 22. Two days before admission, felt tired, remained in bed, complained of general tenderness of scalp and soreness of head. On May 21, complained of numbness, and became delirious in the evening. On entrance, semi-conscious, dull and restless; pupils of equal size, and reacted alike; patellar reflex normal; no rigidity of extremities; some stiffness of neck, which was not tender on pressure. On the 26th, convergent strabismus of both eyes Lumbar puncture, May 24, gave about 60 cubic centimeters of clear, serous fluid, which deposited a yellow viscid sediment. It contained many pus cells and a few large mononuclear cells with vesicular nuclei. There were few large, flat diplococci in the pus cells, and cultures gave abundant growth of typical diplococcus colonies In this case there was extensive diplococcus pneumonia. The chart shows a terminal rise of temperature. Post-mortem examination.

Case 86. Female, age thirteen years. Entered hospital May 24. Two days before admission, vomited; this was followed by pain in neck, with retraction. Night before admission, unconscious; lay on right side, with her face buried in pillows. Slight retraction of head, with tenderness in back of head and neck; herpes labialis; slight bulging

of left eye; slight nystagmus; pupils normal. May 25, small purplish spots in right axila. May 26, quieter; not easily aroused; pulse rapid and feeble; unconsciousness continued. Death at 12.45 P.M.

CASE 87. Male, age thirty-five years. Entered hospital May 30. Six days before admission, complained of pain all over body; four days before had chill; headache and pain in neck and back had been constant and severe; vomited every day; several times had nose-bleed. On admission, pupils and reflexes normal. June 23, headache; pain and rigidity in neck and back. June 2, spinal puncture. June 7, patient not so well; seemed dull. June 11, patient had evidently failed; he was dull, unresponsive, and had been delirious for one or two nights; neck held rigidly. June 15 to June 23, the condition continued. On the 26th, chill; temperature and pulse rose, and death occurred at 11.45 P.M. Spinal puncture made June 2. About 20 cubic centimeters of cloudy serous fluid removed. Examination showed abundant pus and large epithelioid cells. A few diplococci were found in the pus cells. Cultures gave abundant typical growth. There is complete intermission in temperature on June 11, 12 and 13, coincident with evident failure of patient.

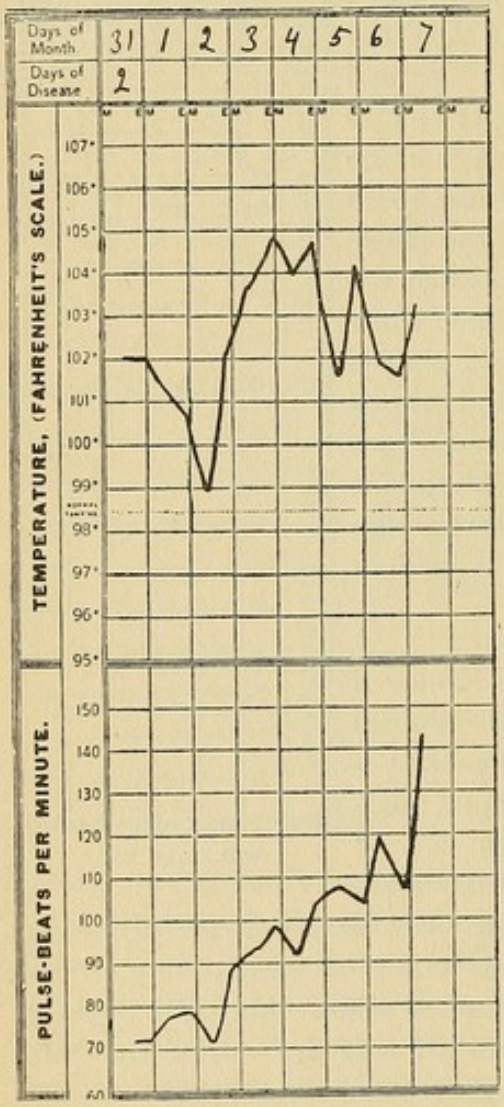


SEE CASE 85.

CASE 88. Male, age seventeen years. Entered hospital May 30. Had had weakness and general malaise four days before admission On day before admission, complained of obstruction of nose, and frontal headache and vomiting; on day of admission, became unconscious. On admission, complained of intense pain in back and neck and across forehead; stiffness of muscles of neck, slight retraction of head; tenderness over mastoid region; pupils equal and reacted alike. May 31, slightly conscious; marked convergent strabismus of left eye. Died at 9.40. Lumbar puncture, made just after death, gave 20 cubic centimeters of a rather thick, bloody fluid, in which a thick clot formed after six hours. Microscopic examination showed abundant pus cells and many large epithelioid cells with vesicular nuclei, occasionally containing enclosed pus cells. A few flattened diplococci were found within the pus cells grouped about the nuclei. Cultures gave an abundant pure growth of diplococci.

CASE 89. Male, age thirty-seven years Entered hospital May 31. On May 27, complained of pain in small of back and legs; there was severe headache for three days, and for two days he was unconscious for a short time; a great deal of vomiting. On admission, dull and

stupid, but answered questions fairly well; complained of pain across forehead and back of neck; stiffness of neck; head held rigidly, pain upon rotation; not retracted; pupils equal; slightly contracted and reacted slowly; patellar reflex normal. On June 4, patient's general condition improved; no delirium. On this day had a chill, and pneumonia appeared. Cultures taken from the nose showed no diplococci. June 5, well-developed pneumonia; patient delirious, noisy, violent and required restraint. June 7, patient weaker and cyanotic; failed rapidly, and died at 10.30 A.M. The appended chart shows a sharp rise, coincident with the development of the pneumonia. Post-mortem examination.



CASE 90. Male, age thirty-three years. Entered hospital July 5. Illness began five weeks before admission, with severe pain in forehead. On night before admission, intense pain on left side of forehead. While at drug store, where he went to consult a doctor, had an attack of dizziness and vomiting. On admission, face flushed; eyes injected; walked with difficulty; severe pain; marked rigidity; slight divergent strabismus; no stiffness of neck, no tenderness; arms rigid; abdomen retracted; patellar reflex active. Blood count showed 22,000 whites. July 6, temperature continued to rise; unconscious. Examination of nasal secretion from upper sinuses showed pus cells enclosing diplococci. July 7, still unconscious; conjunctivæ more injected. Died July 7. The temperature in this case is remarkable, showing a gradual increase from time of entry into hospital, reaching 109° six hours before death. Post-mortem examination.

CASE 91. Male, age twenty-seven years. Entered hospital June 10. One week before entry, chill, followed by headache, nausea and vomiting. On admission, stiffness of head; herpes; soreness in all the limbs; pain on pressure over mastoids; eyes normal; patellar reflex absent; knee joints sore and stiff. June 21, blood count showed 15,800 leucocytes. June 26, condition improved. Blood count, 9,800 leucocytes. July 2, intense headache, neck stiff, but more comfortable. July 9, pain in head, mild delirium. July 30, patient was delirious; knee very painful and swollen; much exudation present. August 9, patient up and about; knee better. Discharged August 11.

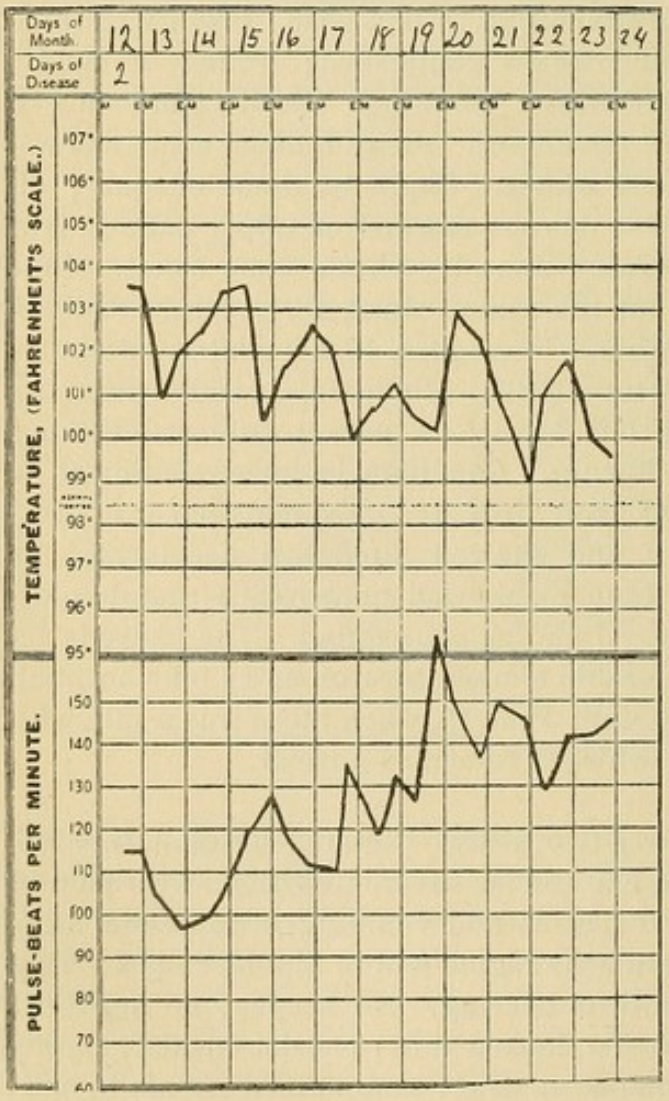
CASE 92. Male, age twenty-nine years. Entered hospital June 8. Four days before admission, complained of pain in head and abdomen; three days before, screamed and threw himself about; day before admission, became suddenly deaf. On admission, eyes normal; stiffness of neck and pain on motion; apparent total deafness; mental condition dull and confused; apparently in much pain, but could not definitely locate it. June 10, marked herpes labialis. June 14, still deaf, but heard better than at entry, June 16, chill. June 18, held head stiffly, and complained of pain in head and neck. June 22, delirious for two nights. June 26, bloody, purulent discharge from left ear. June 30, was losing strength and becoming more stupid. Died July 4. Lumbar puncture, June 9, gave 12 cubic centimeters of a cloudy, serous fluid with thick, yellow, tenacious sediment, much fibrin, many pus cells, few endothelial cells; very few pairs of flattened diplococci in pus cells. Cultures gave typical diplococci.

CASE 93. Male, age twenty-four years. Entered hospital June 6. Two days before admission, chill, with headache and vomiting; great prostration. On examination, head not retracted; pupils dilated and reacted; nystagmus; pain on attempting to flex head; rigidity of muscles at back of neck; patellar reflexes diminished; tremor of hands; legs not rigid; more or less restless; vomiting. Blood count showed 10,000 whites. June 8, herpes developed. June 9, blood count showed 15,000 whites. June 10, 16,000 whites. Pupils at times unequal; divergent strabismus of left eye; herpes marked on upper part of jaw. June 11, condition about the same. June 13, whites same count. June 17, quieter; slept. Blood count the same. June 18, general condition not so good. June 19, diminished leucocytes, 12,000 whites. June 20, condition the same; leucocytes 13,000. June 23, 16,000. June 25, 10,000. July 7, stiffness of left knee; no pain. July 8, left knee swollen, fluctuating, patella floating. Condition in knee continued to improve. Patient discharged well July 14. Examination of nasal secretion was made June 10, and showed diplococci decolorized by Gram inside of leucocytes. June 15, showed numerous Gram decolorizing diplococci in leucocytes. June 26, none found. The chart is interesting, as showing a considerable temperature on entry into hospital. The temperature remained up until June 19, when there was a fall, with another rise on the 22d, after which it remained normal.

CASE 94. Female, age thirty-two years. Entered hospital June 16. Eleven days before admission, had sudden severe headache, with pain in occipital region; more or less nausea and vomiting began soon after headache; afterwards pain in lumbar region and in hip developed. Day before admission, became hard of hearing. No herpes; no appetite; never unconscious. On admission, looked dull; cheeks flushed; pupils irregular, reacted equally; somewhat deaf; complained of pain in occipital region when head was flexed; no tenderness in back of head; no rigidity. Blood count showed 12,000 whites. June 18, had ringing and drumming in ears; patient continued worse; somewhat delirious.

June 20, right pupil contracted; did not react. Died June 20. Examination of nasal secretion on June 18 and 19 showed diplococci decolorized by Gram, within leucocytes.

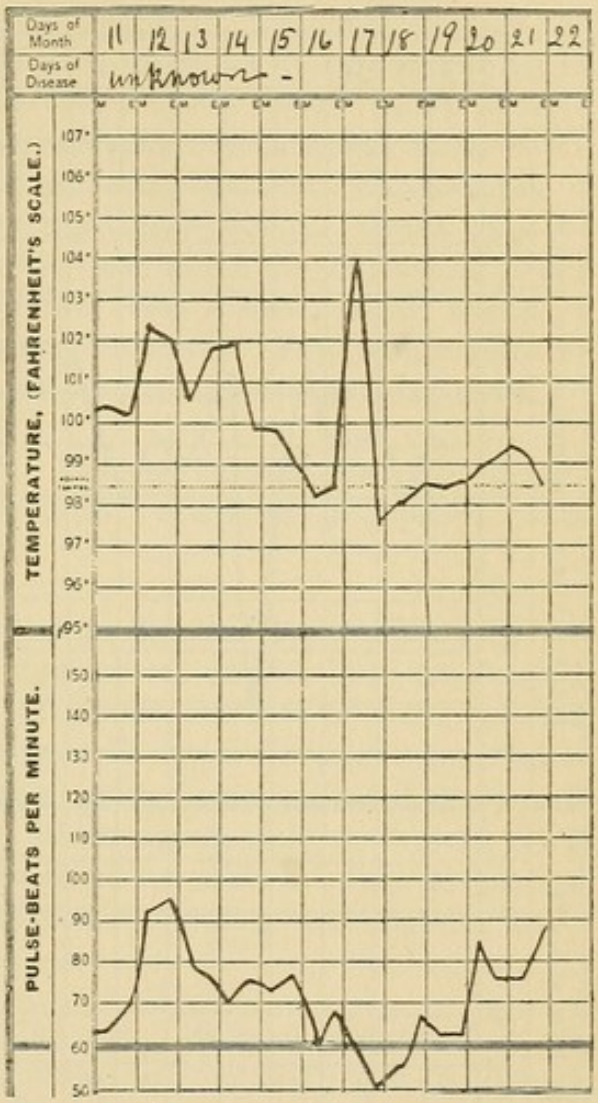
Case 95. Male, age thirty-one years. Entered hospital June 12. Three days before admission, pain all over body; face flushed; frontal headache; pain in legs; vomiting; on entry, eyes normal; herpes of lower lip and right nostril; spleen enlarged. June 13, less headache. June 14, delirious. June 15, quieter. June 16, irrational. June 21, increase of temperature, and pain back of neck June 24, severe pain in back and neck, not relieved by morphia by mouth, which continued unabated until July 4. July 4, area of splenic dulness increased. July 5, mild delirium; tremor of hands; slight headache. July 7, no morphia for several days. July 8, did not recognize wife; did not respond quickly to questions; tremor of hands more marked. July 9, died suddenly. Examination of nasal secretion, July 8, showed leucocytes and diplococci. Temperature extremely irregular, never very high. No terminal rise.



Case 96. Female, age sixteen years. Entered hospital June 12. Two days before admission, headache, vomiting, and pain in head and back. On admission, slight delirium; retraction of head; tenderness over back of neck; herpes labialis; eyes normal; patellar reflex diminished. June 15, paralysis of left side of face developed; herpes on both ears and sides of neck; no delirium; patellar reflex absent; left knee swollen and painful. June 19, eyes injected; no complaint of pain; general condition much worse. Died suddenly June 24. The chart shows an exceedingly irregular curve, with a general downward tendency. The pulse. equally irregular, gradually ascends.

Case 97. Female, age thirty years. Entered hospital June 11. No history could be obtained, as patient was semi-conscious on admission,

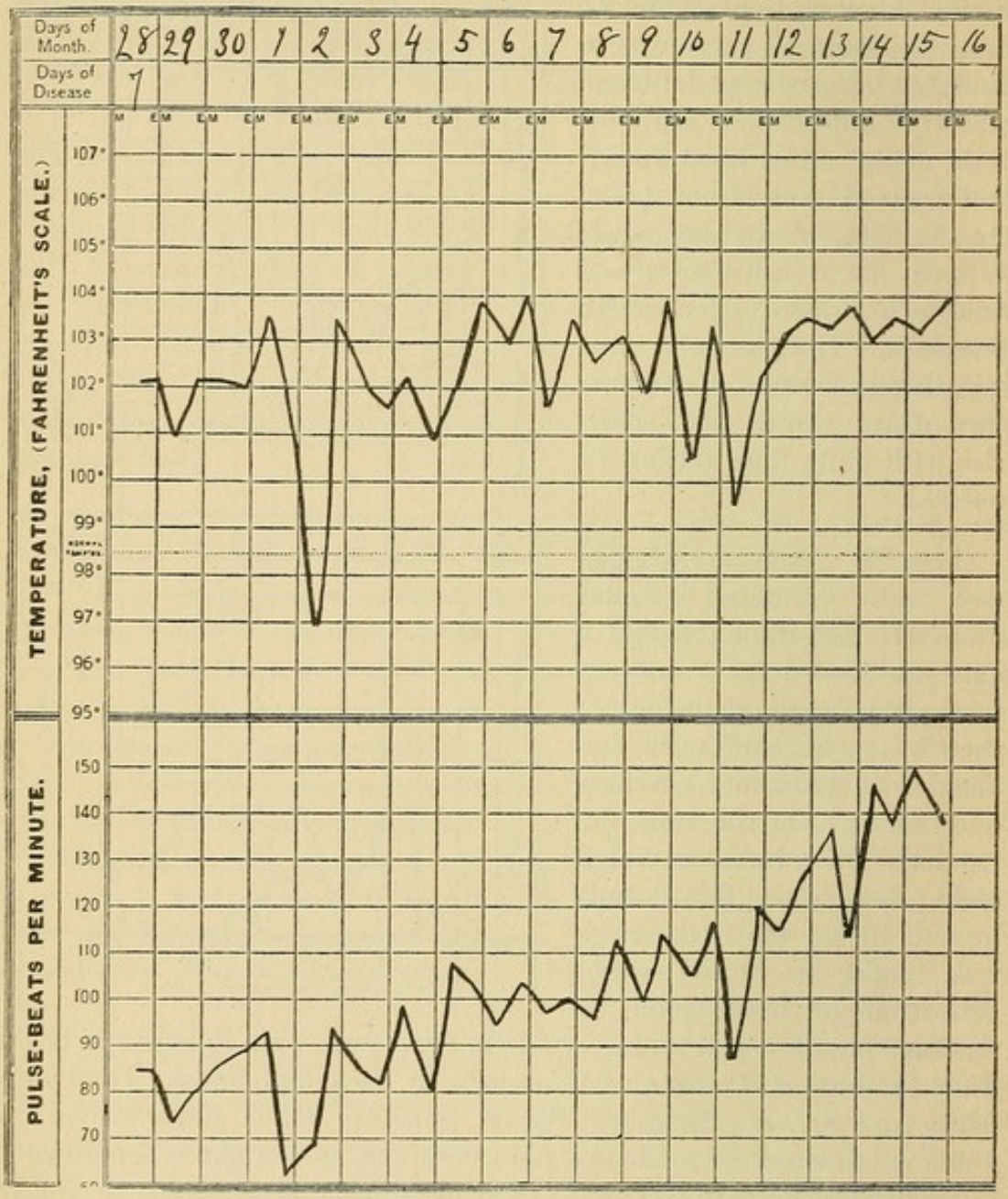
and had no friends. Patient resisted examination. Pupils regular and small, and did not react; held head stiffly, turned toward the left; no marked pain on movement of head; no tenderness along spine; no herpes or petechiæ. June 15, still delirious, requiring restraint; complained of pain in neck and back. June 12, lumbar puncture. On June 17 there was a chill, but otherwise patient had steadily improved. On the 20th, could move head freely and seemed free from pain. On the 24th, discharged well. Fifteen cubic centimeters of fluid withdrawn by lumbar puncture. The pus cells contained diplococci. Temperature chart shows the sharp rise with chill, then falling to normal.



Case 98. Male, age twenty-five years. Entered hospital June 17. On June 14, had a chill, succeeded by vomiting, which lasted through the night; then headache, stiff neck and back, with pain and soreness over limbs. On the 16th, delirious. On admission, mind clear; complained that it hurt him to lie on the back; neck was tender to touch; slight retraction of head, pain on flexion; pupils equal and reacted slowly; some pain in legs and back. June 18, mind still clear; extreme pain in back and limbs. Died suddenly at 8.30 A.M., June 19. Spinal puncture made post-mortem; 5 cubic centimeters of a bloody fluid obtained, which showed abundant pus with diplococci in pus cells. The organisms were usually in single pairs, two pairs being found in only two cases. The organisms did not grow on culture.

Case 99. Male, age twenty-four years. Entered hospital June 28. Seven days before admission, chill and vomiting; since then, two more chills. Complained of severe headache in back of head, pain extended down spinal column. On admission, stiffness and limited motion of head; tenderness on pressure in cervical and lumbar region. Blood count, June 29, showed 11,200 leucocytes; July 3, 12,400; July 9, 14,200. July 2, patient in mild delirium, but seemed to be free from pain. July 10, head turned toward the left; general condition more

stupid. Stupor continued until death, on July 15. Temperature chart shows an irregular, generally high, temperature, with one marked intermission. There is a gradual increase in the pulse, which shows no relation to temperature.



Case 100. Male, age twenty-six years. Entered hospital June 29. Week before entry, headache, vomiting, no chill; pains in back of neck; became stupid two days before entry. On entry, expression dull, stupid; right pupil larger; both reacted alike; divergent strabismus more marked on right side. July 1, stupid; muttering delirium; herpes on forehead; nystagmus; reflexes more active on right than left. Steady decline; died at 6.20 P.M. The temperature shows a continual rise until death, reaching 108½°. Examination of nasal secretion, July 1, showed some diplococci decolorized by Gram, in leucocytes. Post-mortem examination.

Case 101. Female, age nine months. Entered hospital July 4. Illness began twelve days before admission, with diarrhœa and fever. Child held head backwards. Discharge from eyes developed. On admission, sero-purulent secretion from eyes; pupils contracted; convergent strabismus; child lay with head retracted; rigid; no herpes. July 7, hyperæmic spots, with hæmorrhages on right side of face and temple; convulsive movements more marked, as well as retraction of head; almost opisthotonos; no herpes; condition not much altered. July 22, blood count showed 17,800 whites. Petechiæ had disappeared. July 23, vomiting; purulent discharge from right ear. Examination of pus from ear showed diplococci decolorizing by Gram. Death, July 23. July 6, examination of nasal secretion showed a few diplococci in pus cells. On examination on July 8, they were absent. Examination of conjunctival pus, July 8, showed no diplococci. The temperature of this case is exceedingly irregular, running a high course throughout.

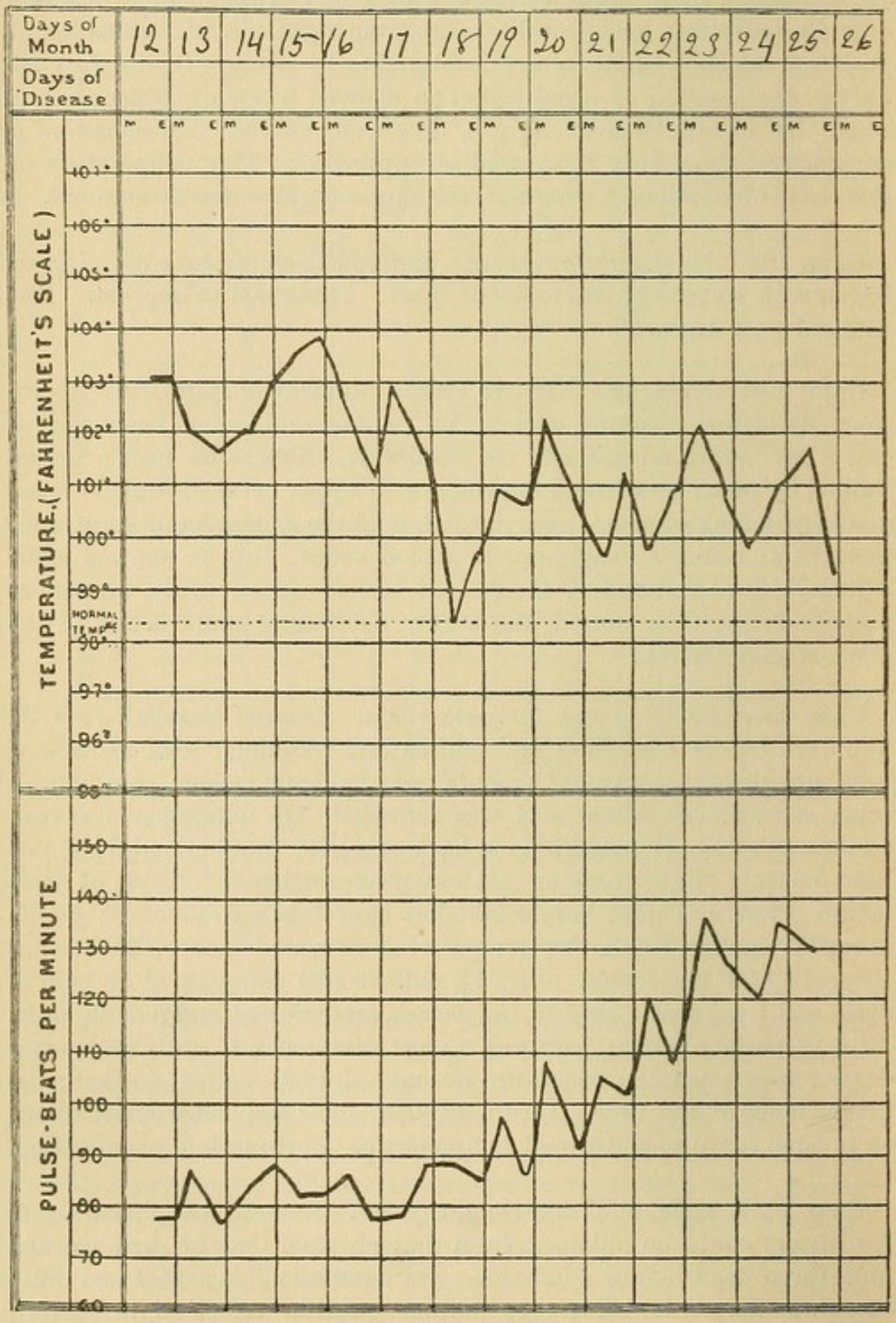
Case 102. Male, age six years. Entered hospital June 30. Illness began with vomiting; retraction of head. Continued to improve. Discharged well August 3.

Case 103. Male, age fifty-two years. Entered hospital July 7. No previous history obtained, except that patient said he had been sick for one week before admission. On admission, stiffness of neck; motion limited by pain; tenderness to pressure in upper cervical region; spasmodic twitching of arms; eyes normal, with the exception of slight conjunctivitis; reflexes exaggerated. Blood count, July 8, showed 8,000 whites. Blood count, July 11, showed 18,400 whites. July 14, patient became noisy, then stupid, the stupor continuing until death. Post-mortem examination.

Case 104. Female, age forty-six years. Entered hospital July 12. Ten days before admission, had nausea and vomiting; pain in back of neck and general weakness; complained of double vision; pain in neck somewhat relieved when head was retracted. On admission, was conscious and rational; tenderness in back of neck; rotation and flexion of head painful; slight drooping and loss of expression on left side of face; mouth drawn to right; herpes labialis; convergent strabismus; pupils normal; patellar reflex absent; petechiæ over abdomen. Blood count showed 19,600 leucocytes. July 14, patient still complained of pain in neck, and weakness. July 15, the paresis less marked, and less diplopia. July 18, patient better; paralysis almost disappeared. July 20, mental derangement; patellar reflex still absent. July 24, patient weaker; delirious most of the time. Death, July 25. The appended chart shows an inverse curve of pulse and temperature. Post-mortem examination.

Case 105. Male, age thirty-eight years. Entered hospital July 5. No history could be obtained from patient, save that he had worked until three days before admission. On admission, his aspect was dull; there was herpes labialis; eyes normal; patellar reflex slight on left,

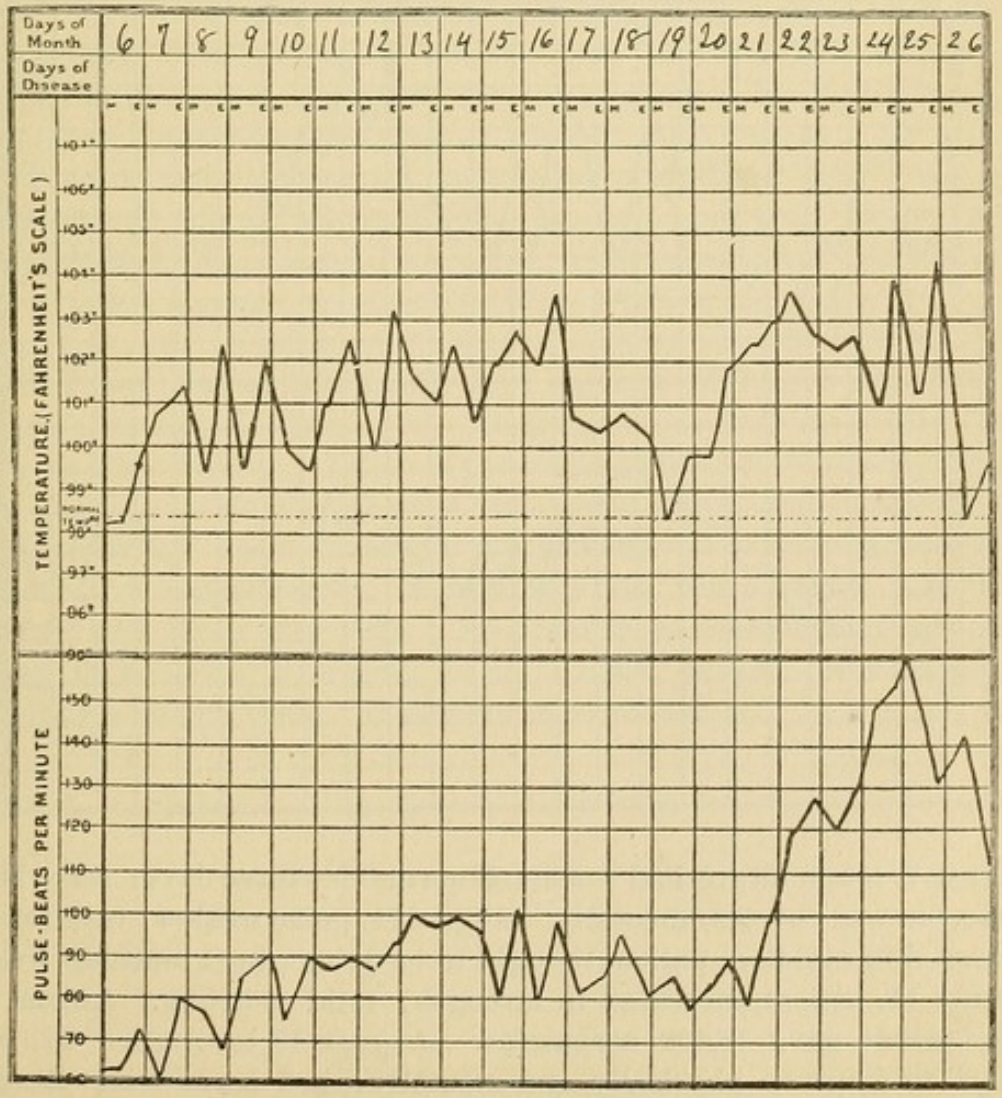
absent on right side. July 8, blood count showed 15,600 leucocytes. July 16, by spinal puncture a small amount of cloudy fluid obtained, containing pus cells and diplococci. July 21, patient in mild delirium since July 16. At times he was quite rational; at others stupid. July 25, patellar reflex absent. July 30, no change from last note; patient still continued stupid. The condition became somewhat better, pulse and temperature became normal, and patient left hospital August 31 with marked mental impairment.



See Case 104.

CASE 106. Female, age twenty-seven years. Entered hospital July 6. On July 3, patient's child died of cerebro-spinal meningitis, child being ill for twelve hours. After this she appeared dazed and at times delirious. In the evening she complained of pain in the back of neck; began to vomit, which continued for twenty-four hours. On admission, patient unconscious; joints of wrists and ankles swollen, red and painful; head painful on motion; pain on pressure on calves and thighs. July 7, marked divergent strabismus. Blood count showed 29,400 whites. July 9, blood count showed 14,000 whites. Patient much better; neck less stiff; no strabismus. July, 19, blood count showed 19,400 whites. Patient discharged well August 11. Lumbar puncture, July 7, gave small amount of cloudy fluid which contained pus cells and diplococci.

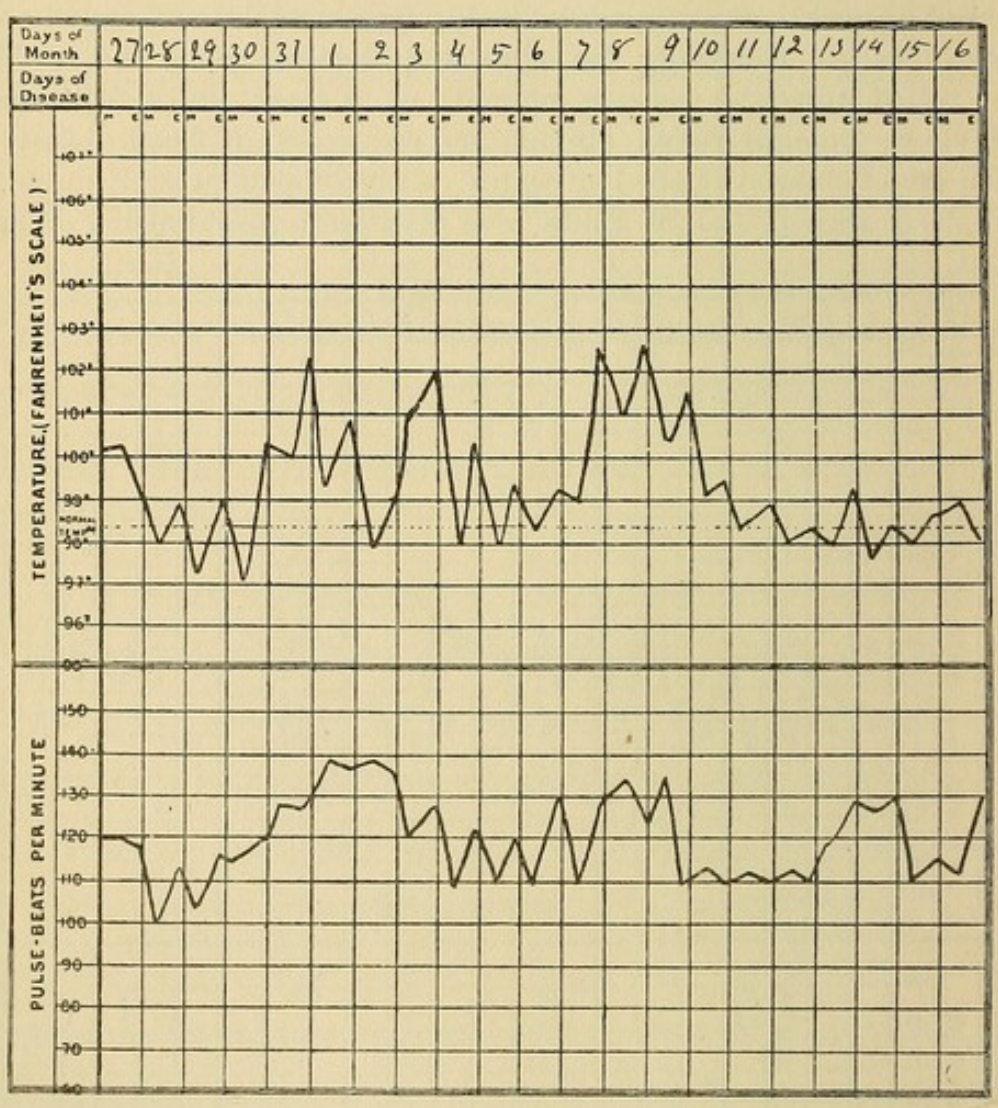
CASE 107. Male, aged thirty-two years. Entered hospital July 26. On July 4, began to have severe headaches; no pain or stiffness in back of head or neck; general pain in body; weakness, loss of appetite and drowsiness; no vomiting. On admission, semi-conscious and restless; eyes rolled upwards; reflexes normal; no herpes; pulse full, strong and slow; patellar reflex absent; no retraction of head. July 27, blood count showed 11,500 leucocytes. July 30, patient sank gradually into deep stupor, and at times was delirious; incontinence of urine



SEE CASE 108.

and fæces; retraction of head appeared, and at times amounted to opisthotonos; weakness increased; death occurred at 4.15 P.M. Post-mortem examination, which showed a mixed infection with tuberculous meningitis.

CASE 108. Male, age twenty-six years. Entered hospital July 6. Two days before admission began to vomit, and complained of head-ache. On admission, unconscious; eyes, normal; head held rigidly, with slight retraction at times; pain on motion. Blood count, July 7, showed 16,400 whites. July 14, slight irregularity of pupils. July 18, stupor more marked. July 22, profound stupor; head retracted; eyes and mouth partly open; corneal reflex gone. July 26, stupor deepened, until the morning of the 26th, when temperature dropped and he seemed better. July 28, marked improvement, which lasted until August 1.



August 7, temperature had remained normal for three days; recognized nurse, but was not clear mentally. August 11, pulse weaker; respirations increased in rapidity; patient thought to be dying; next morning, better. August 15, patient increased in strength; mild delirium. August 17, blood count gave 13,400 corpuscles. August 19 to August 22, continued to improve physically and mentally; bed sores over sacrum.

The improvement continued, and at this time, September 26, the patient is still in the ward, but his general condition is good. The appended temperature and pulse curve shows the extreme irregularity which may be seen in a chronic case.

Case 109. Female, age thirty-two years. Entered hospital July 21. On the 22d, began to vomit, and complained of severe headache; vomiting continued until the morning of admission. The headache was severe, with darting pains in back of neck; was unconscious part of the time; eyes normal; reflexes normal; tenderness over spinous processes of cervical and dorsal vertebræ. Blood count, July 25, showed 13,800 whites. July 28, herpes labialis developed. Had been in great pain since entry, but was somewhat better. Blood count, July 29, 7,400 whites. Patient became gradually better, and was discharged well August 14.

Case 110. Male, age three and a half years. Entered hospital September 12. Unconscious on day of admission. Died September 15. Retraction of head. This case is interesting, as showing a well-marked terminal rise of temperature, which reached 109.7° just before death. Post-mortem examination.

Case 111. Male, age thirty-five years. Entered hospital September 18. Two days before admission, complained of headache, vomiting and diarrhœa. On admission, unconscious; face flushed; expression anxious; head turned slightly to the left; mouth drawn to left; respiration labored and noisy; turning of head to right resisted; no retraction of head; no evidence of tenderness to pressure over vertebræ; pupils reacted alike; slight dulness posteriorly in both lungs, more marked on right side; respiration noisy; loud rales heard everywhere; patellar reflex normal; considerable loss of power both of arm and of leg on right side. September 19, area of dulness of right base greater; bronchial respiration and moist rales; right pupil larger than left; a divergent strabismus developed. Remained unconscious until death, which occurred on 19th. Lumbar puncture made on 19th, shortly before death, gave a considerable amount of slightly cloudy fluid, which in the course of twelve hours developed a slight amount of whitish yellowish sediment and a considerable amount of fibrin, which formed a definite layer through the entire tube. Microscopic examination of the fluid showed the sediment composed of polynuclear pus cells, with numbers of diplococci within them. Post-mortem examination.

BACTERIOLOGY.

The ætiology of the disease has been involved in obscurity until quite recently. Notwithstanding the numerous investigations made with the view of ascertaining the particular micro-organism which could be regarded as a causative agent, it is only recently that such an organism has been discovered and its causal relation to the disease been proven.

The first description of an organism which might be considered as the diplococcus intracellularis was given by Leichtenstern[61] in his first paper on meningitis in which he describes the first cases seen in the epidemic in Cologne. He found in the exudation in the meninges a few cocci, sometimes single, sometimes in groups similar in arrangement to gonococci, enclosed in white corpuscles. Schwabach found, in pus from a case of otitis media secondary to meningitis, diplococci in the pus cells. It is probable that in this case also the organism was the diplococcus intracellularis. In 1887 Weichselbaum[120] described a peculiar form of micrococcus, resembling the gonococcus, which he found in six cases of acute cerebro-spinal meningitis. When these cases appeared the disease was not prevailing in Vienna in epidemic form, although there was at the time an epidemic in Mailberg,[27] in lower Austria.* The organism described by Weichselbaum was a diplococcus occurring almost solely within the cells. It grew best on agar-agar. In pure culture it formed a grayish-white, rather viscid growth, and the single colonies often appeared to be formed of small confluent masses. It would not grow at room temperature, and died quickly, so that new cultures had to be made every two days. In cultures the organisms occurred singly, in pairs and in tetrads. Both in cultures and in the tissue they were decolorized by the Gram stain. They were not easily demonstrated in sections of the meninges, and in most cases but few organisms were found. Weichselbaum inoculated mice, guinea-pigs,

* Widerhofer[122] reported seven cases of cerebro-spinal meningitis in children in Vienna in 1885, just before the cases seen by Weichselbaum[120]. The histories of the cases given by Widerhofer and Weichselbaum coincide with the epidemic form.

rabbits and dogs with pure cultures of the organism. Subcutaneous inoculations were without result, but inoculation in the pleural or peritoneal cavities proved fatal to guinea-pigs and rabbits in from one to four days. In these serous membranes, inflammation with sero-fibrinous exudation was produced. He produced meningitis and encephalitis in dogs by inoculating them directly in the meninges. He found the organism not only in the meninges in all six of his cases, but also, in one case, in foci of broncho-pneumonia in the lungs. The plate which accompanies the article of Weichselbaum gives a very correct representation of the organism, showing the irregular and swollen forms which are sometimes found. He called the organism the diplococcus intracellularis meningitidis. Goldschmidt[154] found the diplococcus in a case of acute meningitis in a child of four months. His description of the morphology and cultural peculiarities of the organism agrees essentially with that given by Weichselbaum. Netter[74] investigated twenty-five cases of meningitis, with reference to the bacteria present, and found the diplococcus intracellularis in two of these cases.

There is no other mention made of this organism until 1895, when the most important confirmation of Weichselbaum's investigation appeared. Jäger[155] described the diplococcus in twelve cases of epidemic cerebro-spinal meningitis occurring in the garrison in Stuttgart. His description of it agrees essentially with that of Weichselbaum, with the exception that he says a capsule was sometimes found around the organisms, and that cover-slips made from the cultures could be stained with Gram. In cultures there was some tendency for the organism to grow in streptococcus form, and a fine line running longitudinally could be made out along the chain. He calls attention to the very slight amount of exudation which he found in most of the cases. The number of organisms varied with the amount of exudation, being most numerous where the exudation was most abundant. In only two cases was there a microscopic examination made of the meninges and in these the organisms were found in small numbers.

Heubner[156] found the diplococcus in nine typical cases of cerebro-spinal meningitis in the fluid obtained by lumbar puncture. He produced acute meningitis in goats by injecting pure cultures of the organism into the spinal canal. His experiments on other animals were negative. There were other cases of meningitis in Berlin at the time when Heubner made his report. In six of Heubner's cases the diagnosis made by spinal puncture was confirmed by post-mortem examination.

Holdheim[42] gives the result of spinal puncture in four cases of meningitis. In all of these cases the organisms were obtained. Two of the cases died, and the organisms were found on post-mortem examination. He confirms Jäger's description of the streptococcus form and the longitudinal line found in this.

Peterson[87] investigated an epidemic of the disease in Berlin in 1895 and 1896. In twelve post-mortem examinations he found the diplococcus in the exudation in the spinal canal. Furbringer[157] found the diplococcus intracellularis in the meningeal exudation of an individual who had acute gonorrhœa at the same time. The two organisms were so similar in appearance that he thought they might be the same, but cultures showed the difference. Kischensky[52] reports a case of cerebro-spinal meningitis in which he found the diplococcus in the meninges and in hæmorrhagic foci in the lungs. This article is valuable for the histological description of the lesions. Kister[158] obtained the organisms in two cases from fluid removed by spinal puncture. He found some difficulty in growing the organisms on agar-agar, and obtained the best growth on blood-serum agar. Subcutaneous inoculation was without result, but animals inoculated in the pleura or peritoneum died in from four to six days. Stoeltzner[108] found the diplococcus in the fluid obtained by lumbar puncture in a sporadic case of meningitis in a child two and one-half years old. The fluid was cloudy, and contained the diplococci enclosed in pus cells. The child recovered.

Finkelstein[19] found the organism on post-mortem examination of one case which died and in the fluid withdrawn by lumbar puncture in a case which recovered. The diplococci were found within the cells. Scherer[176] investigated an epidemic of meningitis

in an army corp in Stuttgart. He found the organisms in the meninges in two cases which died, and in the nasal secretion in eighteen cases. He thinks that infection of the nose is always present, and that the presence of the diplococci can establish the diagnosis.

In thirty-five of our cases on which post-mortem examinations were made, diplococci were found in cultures or on microscopic examination of the exudation or in sections in all but four cases. In most of the cases they were found in all three methods of examination. In one case in which they were not found they had previously been found in the fluid withdrawn by spinal puncture. Two of the other cases were chronic, and no acute lesions were found. The fourth case was a chronic case with a mixed infection with tuberculosis. The diagnosis of the mixed infection in this case was made from the character of the lesions in the meningitis, and from the extension of the inflammatory exudation along the nerves without any evidence of tubercular lesions, although old tubercles were found in the meninges. There was marked infiltration of the Gasserian ganglia.

In a certain number of cases cultures failed to give the organisms, although they were abundantly present both on cover-slip examination and in sections. As showing the difficulty in growing the organisms in cultures made from the meninges at the post-mortem examination, ten cultures were made in one case from the exudation on the brain and six from the cord, cover-slip examinations showing abundant organisms in the cells. Only two of the cultures from the brain and one from the cord showed a growth, a single colony being found on each tube. In ten cultures from the brain and nine from the cord in another case, but two tubes, one from the brain and one from the cord, showed a growth. As a rule, the organisms were more easily obtained in cultures made on the acute cases than on the chronic. In a few of the cases the tubes showed a very abundant growth of the organisms, so abundant that on casual inspection of the tube it might have been taken for a growth of the pneumococcus.

The diplococcus intracellularis of Weichselbaum has the following characteristics when grown in pure culture. It is a

micrococcus of about the same size as the ordinary pathogenic micrococci, and appears in diplococcus form as two hemispheres separated by an unstained interval. It stains with any of the ordinary stains for bacteria, and is decolorized by the Gram method of staining. There is considerable irregularity in staining, some organisms being brightly stained, others more faintly. Sometimes this difference in staining is seen in a single pair of organisms, one being more brightly stained than the other. There may also be considerable variation in size, and the larger organisms stain imperfectly. In the swollen organisms there is often a brightly stained point in the centre, while the remainder of the cell is scarcely colored. It may have been this condition which was mistaken by Jäger for a capsule. These variations in size and in staining appear to be due to degeneration, and are more common in old than in fresh cultures.

The two organisms are usually sharply separated, but in some there seems to be a small amount of material uniting them. Division takes place usually in one plane giving rise to diplococci; tetrads are occasionally seen. There is little or no tendency to growth in the streptococcus form, although short chains of four to six organisms may be found. We have never seen the streptococcus formation described by Jäger, and in the short chains the longitudinal line on which he lays much stress was not seen.

In cultures the organism does not give a profuse growth on any medium. We have found the blood-serum mixture of Loeffler prepared in the method given by Mallory the best adapted for its growth. From its feeble growth on agar we are sure that had this been generally used for the first cultures the organism in many instances would not have been found. This is particularly the case when other organisms are present. In all cases a large number of organisms appear to be dead, or at least they do not grow. In no case was it possible to obtain a continuous growth over the surface. Even when a large quantity of an exudation which on microscopic examination contained large numbers of the organisms was smeared over the surface, only single colonies would develop. The

same was true in transplanting colonies; in the place of a streak, single colonies would develop in the line of the needle. To be sure of obtaining growth it was necessary to make a number of cultures, using large amounts of the material investigated. To keep pure cultures going, transfers were made daily and four or five tubes inoculated. On some of them the growth would usually fail.

On the Loeffler serum mixture the growth forms round whitish, shining, viscid-looking colonies, with smooth, sharply defined outlines, and may attain a diameter of 1 to 1½ mm. in twenty-four hours (Plate I., Fig. 1). The colonies tend to become confluent, and do not liquefy the blood serum. In acute cases, when large numbers of the organisms are present, there is in some cases an abundant growth of minute, round, transparent colonies, bearing much resemblance to the pneumococcus lanceolatus (Plate I., Fig. 2). There is a better growth when the serum is freshly prepared.

The growth is feeble on plain agar, but better on glycerine agar, though not so good as on blood serum. On glycerine agar the organism forms round, pearly, translucent, flat, shining, viscid-looking colonies, with smooth, sharply defined outlines. On examination with low power they are homogeneous, semi-transparent and faintly brownish, with transparent, sharply defined, smooth margins. They rapidly become confluent. On agar it is often impossible to obtain a second growth.

In bouillon the growth is feeble and the medium becomes only slightly cloudy. At the bottom of the test tube there is a scanty grayish-white sediment, which rises up as a viscid string when the tube is shaken. On potato it has no visible growth, and it produces no change in litmus milk.

In the tissues the diplococcus is almost strictly confined to the interior of the polynuclear leucocytes (Plate III., Figs. 1 and 2). It was never found in the bodies of other cells. In the cell it has no definite position, and is never found in the nucleus. When smears of an exudation are made, appearances suggestive of this may be found, but they result from the distortion of the cells in making the preparation. In paraffine

sections, in which the cells are better shown, nothing similar is seen. The numbers found in the cells varied from a single pair in a cell to cells so packed with them that the nucleus was obscured. The greatest numbers were found in the leucocytes in the lungs in cases of diplococcus pneumonia (Plate III., Fig. 2). There is no difficulty in demonstrating their presence in the tissues when the method of hardening and staining recommended is used. In the cells the same irregularity in size and in staining was found which has been described in the pure cultures.

In no case were the diplococci found except in connection with the lesions of the disease. So far as could be learned from cultures of blood, liver, spleen and kidneys which were made at each post-mortem examination, it never produces septicæmia. It is possible that it may occasionally have been present and not grown on the cultures.

Mixed infections with other organisms were not uncommon. The pneumococcus was found seven times, once in connection with Friedländer's bacillus. Terminal infections with staphylococci and streptococci were occasionally found.

The results of inoculation show that the organism has but feeble pathogenic powers for rabbits and guinea-pigs. The results of our inoculations would seem to show a still more feeble pathogenesis than has been obtained by previous investigators. All of the inoculations made in the subcutaneous tissues were negative. More successful results were obtained from inoculations into the peritoneum and pleural cavities. The material used for inoculation was in part pure twenty-four-hour cultures of the organism, in part the fluid containing the organisms obtained from lumbar puncture, and in part portions of the meningeal exudation containing the organisms. Inoculations made into the spinal canal in rabbits, guinea-pigs and cats in all cases gave negative results. Out of a large number of inoculations made into the peritoneal and pleural cavities, only six guinea-pigs died. All of the fatal cases were inoculated with 1 cubic centimeter of a strong bouillon suspension of a pure culture on blood serum twenty-four hours old. Death took place in from twenty-four

to forty-eight hours. In two negative cases there was marked emaciation of the animals, but there were no lesions found on killing them.

In the successful inoculations in the pleural and peritoneal cavities, inflammation with slight fibrino-purulent exudation was found. The entire peritoneum was injected, there was a small amount of fluid present in the cavity and a slight fibrinous exudation over the surface of the liver. Microscopic examination of the exudation showed pus cells which contained enormous quantities of the organisms. In some cases a cell was so filled with these that the nucleus could not be made out. Among the organisms in the pus cells there was a large number of swollen and degenerated forms. The organisms were obtained from cultures from the peritoneal cavity, but there was no invasion of the tissues. The same condition was found in the pleural cavity.

The only successful inoculation resulting in the production of a typical meningitis was made on a goat. This animal was inoculated in the spinal canal with 1 cubic centimeter of a bouillon suspension of a pure culture of the diplococcus from an acute case at the Massachusetts General Hospital. The inoculation was made in the afternoon, and the animal was found dead the next morning at ten o'clock, having evidently been dead for several hours.

Macroscopically nothing could be made out beyond intense injection of the meninges of both brain and cord, with slight cloudiness in the meninges of the brain along some of the vessels and a slight increase in the meningeal fluid. Microscopically in the brain there was deep injection of the blood vessels and in the meninges an exudation composed principally of pus cells. There was very little fibrin and only small numbers of diplococci in the pus cells. The purulent infiltration extended from the meninges into the brain, following along the vessels, and in the outer layer of the cortex there were scattered pus cells at a distance from the vessels (Plate III., Fig. 3). The tissue of the meninges was swollen, the fibres softened and separated, the cells were swollen, and there seemed to be beginning proliferation, although no nuclear figures were found. No change could be made out in the neuroglia. In the cord the purulent infiltration

of the meninges was not so marked as in the brain, and here only pus cells were found. A section of one of the ganglia of the cord showed that the purulent exudation had extended up to this, and a few pus cells were found among the ganglion cells. The sections stained to show degeneration showed a very slight but perfectly obvious degeneration in both the anterior and posterior nerve roots. In the tissues of the cord a few degenerated and swollen fibres were found.

The diplococcus was obtained in pure culture both from the brain and cord. The other organs were sterile, and showed no change microscopically beyond slight cloudy swelling of the kidneys.

This case is interesting not only in being a positive inoculation, but as showing how extensive a pathological condition can be produced in so short a time. An inoculation made at the same time in the spinal canal of a sheep with the same amount of the same culture was negative.

The following observations were made on the viability of the organism: —

Oct. 1, 1897. Cultures (7) made from a fluid which had been obtained by lumbar puncture and had been kept at room temperature for eight days, were sterile. (This fluid had shown an abundance of organisms, and good cultures had been readily obtained from it previously.)

Sept. 30, 1897. Cultures on blood serum, twenty-four hours' growth, were dried on sterile paper in sterile Petri dishes and placed (1) in direct sun-light, (2) in thermostat at 37.5°, and (3) dark drawer, room temperature, for twenty-four hours respectively. Plants then were made on blood serum with negative result in Nos. 1 and 2, but positive in 3.

Dried preparations in dark after forty-eight hours and sixty hours produced growth when planted on blood serum; after seventy-two and ninety-six hours, they were sterile.

1. Action of formaldehyde gas, on smears of organisms on paper in bell jar, exposed for four to seven hours.

Dilutions of 1-7500, 1-15000, 1-30000, 1-60000, 1-20000, 1-225000 destroy vitality. Plants on bouillon and blood serum sterile.

Smears of organisms on paper exposed to continuous action of formaldehyde for eighteen hours, in rooms of 1,200 and 9,000 cubic feet respectively, show no growth when planted on blood serum.

2. Bouillon containing carbolic acid in proportion of 1-100, 1-300, 1-500, 1-600, 1-700 and 1-800 prevents development of organisms.

LUMBAR PUNCTURE.

Lumbar puncture was performed in fifty-five cases, and in some of these several punctures were made. Diplococci were found either on microscopic examination or in cultures in thirty-eight cases. In seventeen of the cases they were absent. The average duration of time from the onset of disease before spinal puncture was made was seven days in the positive cases, and seventeen days in the negative cases. The longest time after onset in which the puncture was positive was twenty-nine days. The negative cases were most numerous in the early part of the epidemic, before we had realized how difficult it was to obtain cultures of the diplococci in all cases. When but few organisms were present they could easily be missed on microscopic examination, and even when present in large numbers cultures made in the usual way, by spreading a loop full of the exudation on the surface of the medium, frequently showed no growth. How difficult it was in some cases to obtain cultures is seen from the notes. In case 49, in which cultures were made by pouring 1 cubic centimeter of the fluid obtained over the slanting surface of the culture media, on one tube one colony developed, three on a second and none on four others. In case 68, fifteen tubes were used. On two of the tubes there were two, and on one ten colonies of the organisms. In this case microscopic examination of the fluid showed considerable numbers of diplococci and pus cells. Toward the last of the epidemic there were no negative results when the spinal puncture was made early and the tubes inoculated with a large amount of material. The character of the fluid obtained varied greatly. In some cases, even when diplococci were found in it, it was almost clear, showing only a slight turbidity when held before a dark background. In most of the cases where the puncture was made early in the disease the fluid was turbid, in some almost like pus, and in twenty-four hours a large sediment formed in the bottom of the tube. When the fluid was most turbid there was little or no formation of fibrin; in some cases the fluid became gelatinous on standing, from the abundant for-

mation of fibrin. We have not considered those cases in which no fluid was found, and those in which pure blood was obtained.

Interesting results were obtained in those cases in which several spinal punctures were made during the course of the disease. In these cases there was found a diminution in turbidity, often accompanied by absence of organisms in fluids withdrawn last. In one chronic case three punctures were made, one before, one after and one during an exacerbation. In the fluid obtained before and after the exacerbation no diplococci were found. The fluid obtained by the puncture during the exacerbation was more cloudy, and contained diplococci. Microscopic examination of the fluid agreed perfectly with the character of the lesions in the meninges. In the fluid obtained in early punctures two to three days after the onset almost the only cellular elements were polynuclear leucocytes. Later the large epithelioid cells of the meninges were found among the pus cells, often enclosing them. A small number of lymphoid cells were found in many cases, and were numerous in the chronic cases. The number of diplococci found on microscopic examination varied greatly. In some cases they were so numerous that in every field several cells containing them were found; in other cases they were found only after prolonged search for them. They were occasionally found in the fluid, their presence here being probably due to the rupture of pus cells containing them in making the preparation. They were only found in the polynuclear leucocytes. We have taken the following description of the technique of the operation from Wentworth's description in Mallory and Wright's "Pathological Technique": —

The operation and the subsequent examination of the fluid should be as carefully performed as any other bacteriological investigation, in order to obtain accurate results. The back of the patient and the operator's hands should be made sterile. The needle should be boiled for ten minutes. The patient should lie on the right side, with the knees drawn up, and with the uppermost shoulder so depressed as to present the spinal column to the operator. This position permits the operator to thrust the needle directly forward rather than from side to side. An antitoxin

needle, 4 cm. in length, with a diameter of 1 mm., is well adapted for infants and young children. A longer needle is necessary for adults and children over ten years of age.

Aspiration of the fluid is not necessary, but some operators prefer to attach a hypodermic syringe to the needle, to afford a better grasp for the hand. In this case the syringe would have to be detached to allow the fluid to flow. The additional manipulation, and possibly the defective sterilization of the syringe, might impair the subsequent bacteriological examination.

The puncture is generally made between the third and the fourth lumbar vertebræ, sometimes between the second and third. The thumb of the left hand is pressed between the spinous processes, and the point of the needle is entered about 1 cm. to the right of the median line, and on a level with the thumb nail, and directed slightly upward and inward toward the median line. Care must be exercised to prevent the point of the needle from passing to the left of the median line and striking the bone. At a depth of 3 or 4 cm. in children and 7 or 8 cm. in adults the needle enters the subarachnoid space, and the fluid flows usually by drops. If the point of the needle meets with a bony obstruction, it is advisable to withdraw the needle somewhat, and to thrust again, directing the point of the needle toward the median line, rather than to make lateral movements, with the danger of breaking the needle or causing a hæmorrhage. The smallest quantity of blood obscures the macroscopic appearance of the fluid by rendering it cloudy. The fluid is allowed to drop into an absolutely clean test-tube which previously has been sterilized by dry heat to 150° C. and stoppered with cotton. The fluid should be allowed to drop into the tube without running down the sides. From 5 to 15 cubic centimeters of fluid is a sufficient quantity for examination."

No ill effects were seen from spinal punctures. Dr. Williams believes that the withdrawal of the exudation may be of positive benefit to the patient. A note in one case says the patient became very much quieter and slept after the operation. Too much cannot be said of the importance of the procedure in making the diagnosis of the disease. There should always be a

microscopical and bacteriological examination of the fluid obtained, in order to determine what organism is present. If the puncture be made early enough, there need be no difficulty in distinguishing the organisms and the character of the meningitis. Acute meningitis may be due to a variety of organisms and it is important to know which is present for this has an influence in making the prognosis, and in the future it may be of importance in influencing the treatment. By this means the character of the meningitis in sporadic cases can be established, for there is a great lack of definite information about these cases.

PATHOLOGICAL ANATOMY.

In the literature of cerebro-spinal meningitis there are numerous accounts of post-mortem examinations, often with the details of the microscopic examination. These examinations have been made both in acute and chronic cases, and there is considerable uniformity in the descriptions of the lesions. In many cases special features in the pathological anatomy have been most studied and a general application of the results of the study of the pathological lesions to the explanation of symptoms has been attempted. The descriptions of the pathological changes in the text-books on medicine and pathology, and those contained in the special treatises on the disease do not seem in general to have been founded on personal observation, but to have been compiled from various sources. Most of these articles, even those recently published, give erroneous ideas of the pathological anatomy, and the diplococcus of Weichselbaum is rarely mentioned in connection with the pathogenesis. Since the discovery of this organism there has not been any study of the lesions of the disease in their connection with the organisms. Certain of the lesions, especially those connected with the ear, have been carefully studied. The study of the eye lesions in the disease have not been so good.

We shall make no attempt to give the entire literature of the pathology of the disease, only citing the most important. Mathey[118] describes a yellow gelatinous exudation in the mem-

branes of the brain, in a post-mortem examination made on one of the cases of Vieusseaux. Danielson and Mann made post-mortem examinations on five cases. In the first case, in which the symptoms of the disease were of twenty-two hours' duration, they found only hyperæmia of the meninges. In another post-mortem examination, on a girl in the same family, the disease was of longer duration, and they found a fluid resembling pus between the pia and dura, together with intense injection of the vessels.

The committee appointed by the Massachusetts Medical Society in 1809[125] give the results of eight post-mortem examinations in their report. The lesions they found differed according to the duration of the disease. In those cases dying within twelve hours there was intense congestion of the membranes of the brain; in the cases of longer duration there was a greenish yellow, purulent exudation. The ventricles were distended and the choroid plexus infiltrated. In one case there was acute pericarditis and pleurisy.

The lesions were more carefully studied in the French epidemics from 1840 to 1845. Rollet[136] thinks that both from a clinical and pathological point of view the disease can be divided into two categories. In one of these, which he calls cerebro-spinal meningitis, the lesions are confined to the meninges. In the other, which he calls encephalo-meningitis, there is an extension into the substance of the brain and cord. These lesions of the tissue of the brain and cord seem to have especially engaged the attention of the French authors at this time. They were recognized by Faure Villar,[160] who describes both general and localized softening, and thinks the brain is affected in all cases in which there are symptoms affecting motion. Chauffard[161] says he has recognized alterations of the cord consisting of foci of softening containing a purulent substance, in his study of the disease in Avignon. He was so impressed with the frequency of these lesions in the cord that he called the epidemic in Avignon "cerebro-spinite."

Böhmer,[9] who investigated an epidemic in Cologne in 1865, gives a very good description of the pathological anatomy. He

describes the exudation as occurring in the sub-arachnoid space, and most abundant over the base of the brain. The ventricles were only slightly dilated, their walls were soft and the fluid in them increased in amount. He was the first to describe the large cells in the exudation, and thinks these are the mother cells for the pus cells which he often found filling them. He found the same large cells in other forms of meningitis than the epidemic, but they were then filled with fat instead of with young cells. In some cases there was considerable fibrin in the exudation. In the substance of the brain and cord there was serous transudation and an increased number of cells in the perivascular lymph spaces, as well as small collections of cells in the brain itself. He never found enlargement of the spleen or any change in the intestinal follicles.

Klebs[54] investigated the pathological lesions in the epidemic in Berlin in 1865. He found no exudation between the dura and arachnoid. He attributed the large amount of exudation found at the base of the brain to the effect of gravity. He found softening and purulent infiltration in the tissue of the brain and cord and in some cases small blood extravasations in the white matter. Reichman[162] thinks there is a difference in the pathological lesions between epidemic meningitis and the other forms, the most marked difference being the extensive participation of the meninges of the cord in the process in the epidemic form.

Probably the best general description of the lesions of the disease is that given by Strümpel[111]. He found purulent exudation in the meninges in cases which macroscopically showed no abnormal condition. He calls special attention to the participation of the tissues of the brain and cord in the process. In the brain a small zone immediately beneath the meninges is infiltrated with round cells, and these foci seem to be independent of the vessels. The largest of the areas of cellular infiltration within the brain are around the vessels. There is marked hyperæmia of the vessels in the interior of the brain, and hæmorrhages may be found. There are histological changes in the nerves of both brain and cord, consisting

in hypertrophy of the axis cylinders. He thinks that brain abscesses may arise in the course of meningitis, and may be the result of a meningitis which was not recognized. He gives the history of three cases of apparently idiopathic brain abscess which had been preceded by meningitis.

Reichman gives an account of the lesions in a chronic case of meningitis which lasted from the 5th of June to the 14th of August. The pia arachnoid was cloudy, and over the base of the brain it was infiltrated with a firm, yellowish material. The same infiltration extended through the foramen magnum and surrounded the cord as far as the exit of the third cervical nerve. The convolutions of the convexity of the brain were flattened, the ventricles dilated. The brain substance was somewhat œdematous and of peculiar elastic consistency. The pia in places adhered strongly to the surface of the hemispheres, portions of the cortex being torn off in removing it. There was thickening and exudation around all of the cervical nerves. A small portion of the cervical cord appeared to be softened.

Meschede[70] found, in a post-mortem examination on a chronic case of meningitis, characterized by marked remissions in the course of the disease, partly cicatricial thickening and partly exudation in the meninges with transitions between these.

Clozel[12] reports the examination of two chronic cases of meningitis, one lasting two and the other three months. No inflammatory exudation was found, but there was considerable thickening of the meninges with dilatation of the lateral ventricles.

In the six cases of meningitis reported by Weichselbaum, in which he found the diplococcus intracellularis, there was an acute exudation in the meninges of the brain and cord.

Hagelstamm[163] investigated the histological changes in the spinal cord in eleven cases of epidemic cerebro-spinal meningitis in Helsingford. He found the changes most common at the edge of the cord about the blood vessels coming from the pia. In this part of the cord there was small cell infiltration and various degrees of degeneration of the nerves. In the central part of the cord there was degeneration in the nerve fibres, though of slighter degree.

TABLE OF POST-MORTEM EXAMINATIONS.

	Number of Case.	Sex and Age.	Duration of Sickness.	Condition of Body.	Brain.	Cord.
1	**1**	F. 50	7 days, .	Well nourished, abundant adipose, muscles pale.	Weight, 1,095 grams. Over entire surface of pia, over both lateral convexities, thin purulent exudation and cloudiness.	Slight exudation, most marked on posterior surface.
2	**2**	F. 14	26 days, .	Skin pale, abdomen sunken, muscles thin and pale.	Brain bulging, convolutions flattened. Over base and cerebellum, extending up over convexities, a dense fibrino-purulent exudation. This extended downwards, filling the foramen magnum. Lateral ventricals dilated. The ependyma softened. Exudation in fourth ventrical.	Abundant exudation of same character as in brain, particularly marked on posterior surface of dorsal cord.
3	**5**	M. 40	7 days, .	Good muscular development. Over abdomen small hyperæmic areas. Decubitus over sacrum.	Thick fibrino-purulent exudation over base; on upper surface extends over frontal lobes.	Exudation of same character on posterior surface.
4	**7**	M. 40	14 days, .	Good nutrition, pale.	Softening in left side of brain involving fissure of Rolando. Over the base, extensive exudation, involving cranial nerves.	Exudation along entire posterior surface.
5	**8**	M. 49	Unknown, found unconscious.	Slight icterus, .	Over convexity and base thick fibrino-purulent exudation.	Could not be examined.
6	**19**	M. 22	2 days, .	Good nutrition, rigor mortis.	Very slight exudation over convexity occurring as faint yellowish streaks and cloudiness. At base and in ventricals slight amount of cloudy fluid.	Could not be examined.
7	**22**	M. 25	5 days, .	Post-mortem decomposition over abdomen.	Tough fibrino-purulent exudation over base extending up over both lateral convexities.	Could not be examined.
8	**32**	F. 17	5 days, .	Well nourished, marked rigor mortis.	Convexities of brain showed yellowish exudation along the course of vessels. Slight exudation at base, foci of softening and hemorrhage in white matter.	Exudation abundant on posterior surface, extending around nerves of cauda equina.
9	**41**	F. 15	3 days, .	Well nourished,	Along fissure of Sylvius on both sides a slight yellowish infiltration along the vessels; at the base the exudation only about optic commissure.	Slight exudation along posterior surface of lumbar cord.

TABLE OF POST-MORTEM EXAMINATIONS.

Heart.	Lungs.	Liver.	Spleen.	Kidneys.	Cultures and Remarks.	
Myocardium rather soft, slight arterio sclerosis.	Slight congestion and œdema.	Tissue opaque.	Weight, 250 grams; on section homogeneous. Malpighian bodies not visible.	Weight, 360 grams; capsule easily stripped, opaque cortex, pale.	Liver, spleen and heart sterile. Kidney colon. Brain cocci, arranged as diplococci. Single organisms flattened.	1
Small, normal.	Intense congestion posteriorly in both.	Congested, .	Normal in size and appearance; weight, 75 grams.	Congested, .	All organs sterile; a few diplococci found in sections.	2
Normal, .	Lower lobe of right hyperæmic, with areas of broncho-pneumonia, some of which coalesce.	Pale, . .	Rather soft; weight, 307 grams.	Pale, . .	Lungs, multiple organisms, chiefly staphylococci. Brain sterile, diplococci found on sections.	3
Normal, .	Foci of broncho-pneumonia in lower lobes of both.	Pale, . .	Slightly enlarged; weight, 170 grams.	Normal, .	Pneumococci in lungs, spleen, kidney and heart; in brain diplococci.	4
Weight, 500 grams. Fatty degeneration of myocardium. Slight arterio-sclerosis.	Beginning red pneumonic consolidation upper lobe of left, lower of right.	Soft, pale, .	Soft, large, adherent; weight, 300 grams.	Pale, . .	Pneumococci in lungs. Heart, liver, sterile. Brain, diplococci.	5
Slight acute pericarditis, ecchymoses in pericardium.	Congestion, .	Pale, . .	Enlarged, soft; weight, 302 grams.	Enlarged; hyperæmic ecchymoses in cortex; markings obscure.	In brain diplococci; other organs sterile.	6
Myocardium soft.	Broncho pneumonia of both. Lax pneumonia lower lobe of right.	Pale, cloudy,	Slightly enlarged and soft; weight, 135 grams.	Pale; opaque,	Lungs, abundant staphylococci, few streptococci. Liver, streptococci; brain, diplococci.	7
Normal, .	Muco-pus in bronchi.	Rather opaque with some injection in centres of lobules.	Somewhat enlarged; paler follicles distinct; weight, 195 grams.	Normal, .	Liver, spleen and kidneys sterile. Brain and cord, profuse growth of diplococcus. Colonies of streptococci also found. Only diplococci found in sections.	8
Normal, .	Congestion and œdema in lower lobes.	Moderately congested.	Enlarged; weight, 215; follicles numerous.	Injected; cloudy.	Heart, liver, kidney and brain sterile. Abundant diplococci found in sections.	9

Table of Post-mortem Examinations — Continued.

	Number of Case.	Sex and Age.	Duration of Sickness.	Condition of Body.	Brain.	Cord.
1	42	M. 19	3 days, .	Well nourished, rigor mortis.	Vessels of meninges deeply injected. Faint yellowish streaks along vessels and yellowish cloudy fluid in meshes. In white substance of both frontal lobes ill-defined, grayish, softened areas. Ecchymoses in white matter generally.	Similar exudation in cord.
2	44	M. 50	5 days, .	Well nourished, good muscular development.	Abundant gelatinous fibrino-purulent exudation, more abundant on right side and over base. All the cranial nerves involved in the exudation.	Similar exudation in cord, involving all the nerves of the cauda equina.
3	52	M. 27	2 days, .	Well nourished, rigor.	Pia over convexity and base infiltrated with yellowish exudation. In ventricals slight exudation with fibrinous flocculi.	Exudation well marked along posterior surface of cord.
4	53	M. 24	9 days, .	Well nourished. Herpes about mouth and chin.	Over convexity faint yellowish exudation along blood vessels. Over the base an abundant fibrino-purulent exudation; ventricals dilated, contain exudation. Exudation along cranial nerves.	Abundant exudation along cord.
5	56	F. 3½	5 days, .	Well nourished,	Extensive exudation over base, less over cortex. Small ecchymosis in corpus striatum and optic thalamus. In white substance ecchymoses.	Abundant exudation along cord.
6	57	M. 24	2 days, .	Well nourished, slight rigor.	A slight, grayish-yellow exudation over the convexities, along blood vessels and in the sulci. Slight over base; more cloudiness than visible exudation.	Very slight exudation along cord posteriorly and general cloudiness.
7	79	M. 58	30 days, .	Good muscular development, spare.	Thickening of pia over convexity, with small, opaque yellowish foci in the meshes. Fibrinous and in part organized exudation over base and in ventricals, induration of brain.	Thickening of meninges of cord.
8	59	M. 29	6 days, .	Well nourished,	Could not be examined, . .	Abundant exudation along cord, greatest amount in lumbar region.
9	66	F. 28	6 days, .	Well nourished; over various parts of the body hemorrhages, some with whitish centres.	Great amount of exudation over entire surface of brain, particularly over base. Injection of vessels, exudation in ventricals, softening of ependyma. Exudation around cranial nerves.	Exudation along entire cord, particularly posterior surface.
10	71	M. 2	29 days, .	Great emaciation.	Pia thickened, cloudy; yellow foci in meshes; thick exudation at base and over cerebellum. Optic commissure covered by thick exudation.	Thickening of meninges; accumulations of thick, yellowish masses posteriorly.

Table of Post-mortem Examinations — Continued.

Heart.	Lungs.	Liver.	Spleen.	Kidneys.	Cultures and Remarks.	
Normal, .	In lower lobe of right lung ill-defined areas of consolidation, size of pea to that of bean. Diplococcus pneumonia.	Cloudy, .	Normal; weight, 120 grams.	Cloudy; pale,	Cultures from lung and brain diplococci. Diplococci on sections of lung and brain.	1
Normal, .	Ecchymoses over pleura. Congestion posteriorly. Broncho pneumonia. Bronchiectatic cavities.	Normal, .	Soft; weight, 75 grams.	Cortex; cloudy.	Heart, spleen, liver and kidneys sterile. Diplococci in cultures from cord.	2
Normal, .	Hyperæmic, .	Pale, . .	Normal; weight, 120 grams.	Normal, .	All cultures from brain show pure diplococci. Mixture of other organisms in cord. All the other organs sterile.	3
Very slight fibrinous exudation over pericardium.	Fibrous thickening at apices.	Small centres of lobules injected.	Weight, 150 grams. On section, soft and flabby; follicles visible.	Injected, .	Cultures from brain gave colon and other contaminating organisms. Cord gave on four tubes pure cultures of diplococcus.	4
Normal, .	Foci of consolidation. Diplococcus pneumonia.	Pale, . .	Weight, 29 grams; normal.	Normal, .	In brain and cord pure cultures of the diplococcus. Diplococci in lungs. Cultures from upper nasal cavity showed diplococci.	5
Normal, .	Old tuberculous nodule. Injection.	Slightly enlarged.	Enlarged; firm on pressure; weight, 210 grams.	Injected, .	Heart, liver, spleen and kidney all sterile. In brain and cord a few colonies of diplococcus.	6
Normal, .	Œdematous, .	Cloudy, lobules indistinct.	Weight, 145 grams; follicles visible.	Normal, .	All cultures negative save a few streptococci in liver and kidneys. Brain and cord sterile. Evidently old case, — older than history given.	7
Normal, .	Foci of consolidation with necrosis and breaking down.	Normal, .	Weight, 85 grams; firm, follicles visible.	Normal, .	Cultures from cord show diplococci. Lungs abundant pneumococci and other organisms. Other organs sterile.	8
Normal, .	Injected œdematous.	Large injected lobules, very distinct cellular infiltration in portal spaces.	Enlarged; weight, 410 grams; follicles distinct.	Rather large, vessels injected; normal markings.	Lung staphylococcus, aureus and pneumococcus. Liver, spleen, kidney and heart sterile. Brain and cord diplococcus.	9
Normal, .	Congestion and broncho pneumonia.	Firm and congested.	Small, smooth, firm; weight, 25 grams.	Large; pale; cortex swollen; contain ecchymoses.	In this case, spinal puncture at Children's Hospital gave diplococci. Child acquired diphtheria with acute glomenlo nephritis. Cultures at autopsy showed diphtheria bacilli.	10

Table of Post-mortem Examinations — Continued.

	Number of Case.	Sex and Age.	Duration of Sickness.	Condition of Body.	Brain.	Cord.
1	**74**	F. 10	5 days, .	Well nourished,	Abundant exudation, yellowish soft sero-purulent in places; serous over lateral convexities and base. Cranial nerves involved in exudation.	Posterior surface of cord hidden by the abundant, thick, yellowish exudation.
2	**82**	M. 58	2 days, .	Muscular; well nourished; rigor mortis.	General serous exudation beneath pia with lines of deep, thick yellow exudation along vessels at base; abundant exudation around nerves.	Vessels of meninges deeply injected, with only slight exudation posteriorly.
3	**85**	M. 25	5 days, .	Fairly well nourished.	Abundant exudation over base and cerebellum, extending over cortex; exudation along nerves; exudation in ventricals.	Abundant exudation.
4	**89**	M. 37	10 days, .	Well nourished,	Not examined, ...	Abundant exudation on posterior surface of lower dorsal and lumbar.
5	**90**	M. 33	37 days, .	Emaciated, .	Pia thickened; frontal lobes adherent; red thrombus in basilar artery with softening of pons.	Thickening of meninges, with slight exudation.
6	**95**	M. 31	30 days, .	Emaciated, .	Pia thickened; small amount of exudation along vessels.	Cloudy fluid in canal; slight exudation, thickening.
7	**100**	M. 26	9 days, .	Well nourished,	Yellowish purulent streaks along vessels over lateral convexities; exudation at base not abundant.	Thick exudation posteriorly.
8	**103**	M. 52	14 days, .	Well nourished; marked rigor.	Abundant purulent exudation extending along cranial nerves at base; exudation in ventricals.	Thick exudation, most abundant in dorsal and lumbar.
9	**104**	F. 26	23 days, .	Well nourished; marked rigor.	Pia œdematous, thickened; small amount of exudation, except here and there in masses; most abundant in base.	Thick exudation over posterior surface of cervical and dorsal.

Table of Post-mortem Examinations — Continued.

Heart.	Lungs.	Liver.	Spleen.	Kidneys.	Cultures and Remarks.	
Normal, .	Old fibrous adhesions.	Normal, .	Normal; weight, 55 grams.	Vessels injected; cortex opaque.	Pure cultures from brain and cord of diplococcus.	1
Normal, .	In lower lobe of left lung a large area of consolidation with purulent infiltration and partial breaking down. Diplococcus pneumonia.	Large, . .	Capsule wrinkled; follicles visible; weight, 175 grams.	Firm; normal markings.	Cultures of brain sterile. Diplococci found on cover slips and sections of brain and lungs.	2
Normal, .	In both lungs foci of consolidation from 1 mm. to 3 cm. in diameter, reddish-gray in color, surrounded by yellowish zone. Diplococcus pneumonia.	Normal, .	Small; weight, 95 grams.	Cortex more opaque; markings normal.	Cultures from brain and cord pure diplococci. Diplococci found in lung with other organisms. Other organs sterile.	3
Normal, $\frac{5}{6}$.	Complete reddish-gray consolidation of lower lobe; acute pleurisy; partial consolidation of upper lobe.	Congested, .	Small; weight, 80 grams.	Opaque; pale; markings normal.	Cultures from lung show pneumococci; no cultures from cord. Microscope shows diplococci in cord and in abscess in seminal vesicles, in latter with pneumococci.	4
Normal, .	Congested, .	Normal, .	Small; weight, 105 grams.	Normal, .	No diplococci found in cultures, nor on microscopic examination. Condition one of chronic meningitis with abscess following.	5
Normal, .	Œdema, . .	Normal, .	Small; weight, 90 grams.	Normal, .	Cultures from brain, few diplococci.	6
Normal, .	Congested, .	Normal, .	Small; weight, 102 grams.	Normal, .	Autopsy 3 days after death. Cultures overgrown with contaminating organisms. Diplococci found in sections of the cord.	7
Normal, .	Foci of consolidation; yellowish centres with hyperæmic periphery up to 3 cm. in diamter. Diplococcus pneumonia.	Normal, .	Slightly enlarged; firm; weight, 170 grams.	Congested, .	Brain, 10 cultures, 2 show each 1 colony of diplococcus. Cord, 6 cultures, 1 shows 1 colony of diplococcus. Lung, diplococcus, streptococcus, pneumococcus and staphylococcus; sections only diplococcus.	8
Normal, .	Intense injection with foci of consolidation. Diplococcus pneumonia.	Normal, .	Soft; follicles visible; weight, 85 grams.	Normal, .	Brain, 10 cultures, 1 tube shows 2 colonies of diplococci. Cord, 9 cultures, 1 tube shows 1 colony of diplococcus. Heart, liver, spleen and kidneys sterile. Lung, pneumococci and Friedländer's bacillus.	9

Table of Post-mortem Examinations — Concluded.

	Number of Case.	Sex and Age.	Duration of Sickness.	Condition of Body.	Brain.	Cord.
1	**110**	F. 3½	3 days, .	Well nourished,	Over both lateral convexities foci of yellowish purulent exudation along vessels; abundant exudation at base.	Cervical cord free; abundant exudation over lower dorsal and lumbar.
2	**111**	M. 35	3 days, .	Good muscular development.	Exudation abundant; intense hyperæmia of brain; foci of hemorrhage in white matter; abundant exudation at base along nerves.	Along posterior cord; best marked in lumbar and dorsal; ganglia swollen.
3	**40**	M. 3½	74 days, .	Greatly emaciated.	Firm, organized exudation at base; thickening of meninges; small opaque foci in meninges.	Thickening of meninges, with opaque foci.
4	**27**	F. 2½	35 days, .	Emaciated, .	Entire pia cloudy and thickened; over base firm yellowish exudation with more opaque foci.	Firm exudation along posterior surface.
5	**X**	M. 43	Unknown, estimated at 7 to 10 days.	Slight muscular development; spare.	Over entire anterior surface of brain, extending down over lateral surfaces and over occipital lobe on left side, abundant yellowish, gelatinous exudation; large amount over base and cerebellum.	Not examined, .
6	**107**	M. 32	26 days, .	Emaciated, .	There are tubercles along vessels in Sylvian fissure and elsewhere; tubercles old and caseous. Fibrino-purulent exudation over base with few tubercles; purulent exudation along cranial nerves, extending to gasserian ganglion, which was infiltrated with pus and granulation tissue.	Pia of cord cloudy and œdematous; slight exudation; no tubercles.
7	**9**	M. 25	-	Slight muscular development; poor nutrition.	Firm, yellowish exudation along vessels of convexity, best marked laterally; abundant exudation at base.	Not examined, .

Table of Post-mortem Examinations — Concluded.

Heart.	Lungs.	Liver.	Spleen.	Kidneys.	Cultures and Remarks.	
Normal, .	Congestion and œdema.	Normal, .	Small; weight, 50 grams.	Normal, .	Cultures from brain and cord show abundant pure cultures of diplococci.	1
Normal, .	Large area of consolidation; œdema and hemorrhage at periphery, with confluent areas of purulent infiltration. Diplococcus pneumonia.	Normal, .	Slightly enlarged; firm; weight, 200 grams.	Pale, . .	Five cultures from lung all show abundant growth of diplococcus. Diplococci in cultures from brain and cord.	2
Normal, .	Foci of consolidation with softened centres. Diplococcus pneumonia.	Firm, lobules prominent; increase of connective tissue and foci of infiltration around portal spaces.	Normal; weight, 60 grams.	Congestion of pyramids.	No cultures made. Spinal puncture April 8 gave diplococci. Large numbers of diplococci found in sections of lungs; none found in sections of brain and cord.	3
Normal, .	Congestion and broncho-pneumonia.	Normal, .	Normal; weight, 70 grams.	Normal, .	Diplococci found in cultures and in sections of brain and cord.	4
Normal, .	Congestion and œdema.	Normal, .	Firm; slightly enlarged; weight, 130 grams.	Normal, .	Cultures and cover slips from brain showed pure diplococci. Other organs not examined. Diplococci found in sections.	5
Normal, .	Conglomerate tubercles and tuberculous broncho-pneumonia.	Few tubercles present.	Small; weight, 65 grams.	Congested, .	From lungs pneumococcus; cultures of brain sterile. This case was considered one of mixed infection of meningitis with tuberculosis. In considering it epidemic meningitis, the main points were the character of the exudation and the infiltration extending along the nerves.	6
Normal, .	Congested, .	Congested, .	Normal; weight, 85 grams.	Congested, .	The body had been kept 5 days before autopsy. Cultures were unsatisfactory, being overgrown with various organisms. Diplococci found in pus cells in the ventricals.	7

Flexner and Barker, in two cases investigated by them in the epidemic in Lanaconing, Md., described the large cells in the meninges and small foci of cellular-infiltration in the brain and cord.

When we review these brief extracts, we find that in the most acute cases there is found intense hyperæmic of the meninges, with purulent infiltration visible only on microscopic examination. In cases of longer duration fibrino-purulent exudation is present most abundantly over the base. In chronic cases fibrous thickening of the meninges is found with or without exudation. The exudation contains pus cells, fibrin and large cells of unknown origin. Changes in the tissue of the brain and cord, consisting of cellular infiltration, of abscesses or foci, of softening, have been described.

The preceding table (pp. 86–93) gives the results of thirty-five post-mortem examinations. In most cases the examinations were made a short while after death. When the period was longer most of the bodies had been kept preceding the examination in a room cooled by a freezing process to 32° to 35° F. We have made post-mortem examinations on bodies which have been kept at this temperature four days and found the tissues almost perfectly preserved; the nuclear figures showed nearly as well as in fresh tissues. In a few of the bodies which were kept at ordinary temperatures the tissues were not so good and the cultures unsatisfactory. At every autopsy where it was possible cultures were made from the brain, cord, heart, lungs, liver, kidneys and spleen. For general histological purposes portions of the brain, cord and other organs were hardened both in Zenker's fluid and in alcohol. For the study of degenerated nerve fibres small pieces of nervous tissues were hardened in Müller's fluid or in formaldehyde followed by Müller's fluid, before staining in Marchi's solution. For the fixation of ganglion cells strong alcohol was employed.

For the study of the distribution of the diplococcus and of the histological changes in the tissues eosin followed by Unna's alkaline methylene blue solution was found to be by all odds the most satisfactory stain. The advantage of Unna's solution, which is considerably more alkaline than Loeffler's, is that it stains bacteria

and nuclei in tissues hardened in Zenker's fluid, which gives a much more perfect fixation of tissue elements than alcohol. Imbedding in paraffin was used almost exclusively. The corrosive crystals were removed from the sections after cutting, not from the blocks of tissue, so as to avoid prolonged treatment with iodine, which acts injuriously.

The steps in staining are as follows: —

1. Stain paraffin sections in a five per cent. to saturated aqueous solution of eosin, twenty minutes to one hour.
2. Wash off in water.
3. Stain in Unna's alkaline methylent blue solution (methylene blue, 1; carbonate of potassium, 1; water, 100), one part, diluted with nine parts of water, for one to two hours.
4. Wash in water.
5. Decolorize in ninety-six per cent alcohol followed by absolute alcohol, until the tissue is well differentiated.
6. Xylol.
7. Balsam.

Bacteria and organisms stain a sharp, clear blue; red blood globules, protoplasm, fibrin and intercellular substance stain of varying shades of pink and lilac.

A little practice is required before good results can always be obtained. It is important not to carry the decolorization with the alcohol too far.

Nissl's stain for ganglion cells and Marchi's stain for fatty, degenerated nerve fibres require no special mention.

In the cases on which post-mortem examinations were made the duration of illness varied from two days up to seventy-four days. The average duration, leaving out of consideration the very chronic case of seventy-four days, was eleven and one-third days, this being taken, not from the stay of the patient in the hospital, but from the initial symptoms of the disease. The duration is really much less than this for the average number of cases, being greatly increased by seven cases, which were twenty-three, thirty-two, twenty-three, thirty-seven, twenty-nine, thirty and twenty-six days respectively. Leaving out these, and the seventy-four-day case, the average duration is six and one-half days. This can be taken as the average of the acute

cases, while twenty-eight and one-half days can be considered as the average of the chronic cases, here again leaving out the exceptional case of seventy-four days.

The condition of the body varied in the acute and chronic cases. In the acute cases the body was generally well nourished, and in some there was an abundant development of adipose tissue. The chronic cases presented an almost characteristic appearance; the body was greatly emaciated, the skin was pale, the abdomen sunken, the muscles thin and pale. In one case of unknown duration there was slight icterus. The presence or absence of rigor mortis was not always noted. When it was noted it was generally very well marked in the acute cases and in most of the chronic. In one case, which was of but six days' duration, there was a decubitus over sacrum. Evidence of herpes and other skin lesions were not as apparent at post-mortem examinations as they were during life. In one case there was a perfectly characteristic hæmorrhagic eruption over various parts of the body. There are few observations with regard to the condition of the muscles. They were generally pale and cloudy.

Lesions of the Nervous System.

Macroscopic lesions.

The lesions produced by the disease may be divided into those affecting the meninges, those affecting the tissues of the brain and cord, and those affecting the nerves. The lesions of the meninges vary in their extent and character, this depending mainly upon the differences in the intensity and acuteness of the process. The pathological process consists in inflammation, with purulent, sero-purulent and fibrino-purulent exudation. The most marked lesions are found at the base of the brain, extending from the optic commissure backwards over the crura, the pons, and medulla. The meninges of the entire brain are rarely affected; the exudation on the convexity is usually most intense on the lateral surfaces, extending for some distance on either side of the fissure of Rolando. In some cases it is more marked in other parts of the brain, and

the principal exudation may be found over the parietal or even the occipital lobes. There is usually little or no exudation in the meninges along the longitudinal fissure. The meninges of the cerebellum are always involved; the exudation extends over the under, but especially over the upper, surfaces of this. Along the upper rim of the cerebellum masses of it from two to six mm. in thickness may be found. Small masses of it may also be found along the vessels of the choroid plexus. The exudation is chiefly found in the sulci along the vessels. Rarely a wide-spread exudation is found covering large areas of the brain.

In the most acute cases, those dying in a few days after the onset, the changes are not so marked as in the more advanced cases. We have not had any post-mortem examinations on foudroyant cases dying within ten to twenty-four hours after the onset. In the most acute cases there is very little exudation. The blood vessels of the pia-arachnoid are intensely injected; not only do the large blood vessels appear as red lines, but the entire surface of the brain has a pinkish hue, due to the injection of the smaller vessels. The exudation appears in yellowish lines in the sulci along the vessels, and in some cases there is little more than cloudiness. There is more or less œdema of the entire meninges, in addition to the purulent exudation; they strip off easily from the surface, and a considerable amount of fluid runs out. In these more acute cases there seems to be but a small amount of fibrin, and the exudation may easily be removed with a needle from the meshes of the meninges. In the loose tissue of the meninges of the base of the brain there is more exudation, and it often has a distinctly purulent character, appearing either diffusely spread over the surface or as larger or smaller yellowish masses.

In the more advanced cases, those dying from five to twelve days after the onset, the amount of exudation is much greater and it contains more fibrin. It has a tough, more gelatinous character, and cannot be removed from the meshes of the meninges with a needle. There may be a great amount of

it at the base of the brain and the medulla may be embedded in it. The injection is marked, but not so intense as in the more acute cases (Plate II., Fig. 1).

In the chronic cases in which death has taken place in from fifteen to thirty days from the acute onset, the appearance of the meninges differs widely from that in the acute (Plate II., Fig. 3). In these the most marked condition is the œdema and general thickening of the meninges. The change is most marked in those places where the acute process is most evident. Along the vessels the meninges are thickened and whitish; there is little evident exudation, yellowish circumscribed foci scattered here and there in the sulci marking the remains of it. The meninges at the base are opaque, enormously thickened, and there are bands of organized tissue extending from point to point. In one of the most chronic cases, in which the duration of the disease could not be ascertained with any accuracy, owing to the mental condition of the patient when he was brought into the hospital, the appearance simulated that of general paralysis. There was marked thickening of the meninges over the entire frontal and parietal lobes and over the base and medulla. The only evidence of exudation was in the ventricles, in which masses of partly organized fibrin were found adherent to the walls. In one case, the duration of which, from the imperfect history, was apparently over thirty days, in addition to the thickening of the meninges the entire medulla was so embedded in a dense mass of connective tissue that it was difficult to remove it.

The inflammation is confined to the pia-arachnoid. The adjoining surface of the dura is smooth and there is little injection of the vessels. The amount of fluid in the subdural space is increased in amount, and it is more cloudy than normal.

The process in the meninges of the cord is very similar to that in the brain. The cord is always affected to a greater or less extent, and in some cases the lesions in the cord were more marked than those in the brain. In the acute cases the injection of the inner meninges is not so marked as in the brain,

but there is intense injection of the dura. The amount of fluid in the sub-arachnoid space is greatly increased, and a large amount escapes on opening this. The fluid is cloudy, and may contain floculi of fibrin and pus. The exudation is always most marked along the posterior surface of the cord, and may be found here in large amount, while the anterior surface may show only cloudiness and injection. All parts of the cord are not affected to the same degree; there is usually more exudation along the dorsal and lumbar cord than along the cervical, though the reverse of this was often found (Plate II., Fig. 2).

In the chronic cases the same conditions were found as in the brain. There was general thickening of the meninges, and in the place of a general and diffuse exudation, there were scattered yellowish patches marking the remains of the exudation.

There were few lesions of the tissue of the brain and cord apparent to the naked eye, and without careful microscopic examination lesions which must be regarded as among the most important in the disease would have been over-looked. All these lesions of the brain and cord were less marked in the most acute cases. The ventricles in the acute cases were slightly dilated and the fluid increased and cloudy. The vessels of the ependyma and choroid plexus were dilated. In the posterior cornua of the lateral ventricles there was usually a small amount either of pure pus or of pus and fibrin. In more advanced cases the surface of the ventricles had lost its glistening appearance; it was softer; sometimes almost mushy to the touch, and small losses of substance or a more or less ragged or uneven condition of the surface were found. In the chronic cases the dilatation was more marked, the surface of the ependyma uneven and covered with granulations. Section of the brain tissue beneath the ependyma showed this to be looser in texture, somewhat more transparent and œdematous. In one chronic case there was a mass of connective tissue and organized fibrin which completely closed the foramen of Magendie.

In the acute cases the meninges stripped off easily from the surface. In one chronic case they were adherent, and small bits of the surface of the brain were removed on stripping them off.

The general consistency of the brain is little altered; it may be somewhat softer to the touch, owing to the dilatation of the ventricles, and there may be œdema. The vessels both of the gray and white matter are injected. The gray matter on section may have a pinkish tinge, and blood flows from the sections of the dilated vessels. The surface may be softer, and punctiform hæmorrhages may be found in it. In one case, which was unfortunately not examined microscopically, there was distinct softening over a considerable area of the lateral surface. In eight cases there were definite macroscopic lesions in the tissue. These consisted for the most part in hæmorrhages, in the white matter, either single or in aggregations. In one case there was an area of distinct softening in the pons adjoining a thrombus in the basilar artery. In two cases there was hæmorrhage with softening of the cortex of the cerebellum. In one case there were foci of induration in the basal ganglia. In no case was there definite abscess formation. The only macroscopic lesions noted in the cord were increased injection, and a softer consistency.

The cranial nerves were affected to a greater or less degree in all cases. The nerves most affected were the second, the fifth and the seventh and the eighth. The nerves were embedded in the exudation which extended along them. On section they were swollen and reddened. The Gasserian ganglia were removed in a number of cases, and in all they were found swollen and softened. The olfactory bulbs were in some cases slightly swollen. The exudation could often be followed along the seventh and eighth nerves into their foramina. The spinal nerves were also affected. The nerve roots were embedded in the exudation, and the spinal ganglia red and swollen. The exudation around the nerves was often particularly prominent around the nerves of the cauda equina.

In two cases the exudation from the meninges extended into the sella tursica and the periphery of the pituitary body was infiltrated and softened.

Microscopic Lesions.

The results of the microscopic examination of the tissues differ according to the acuteness of the process. In the most acute cases in which there was but little change on macroscopic examination, the lesions consist in purulent infiltration in the meninges. Even in the advanced cases examination of the meninges at the periphery of the more marked lesions shows purulent infiltration as the main change. The blood vessels are injected and many of the smaller veins contain numbers of leucocytes both within the vessels and infiltrating the walls. The leucocytes in the exudations are contained in the tissue in larger and smaller masses, the largest masses being in the sulci. In the meninges over the surface of the convolutions there is infiltration of the tissue. The denser tissue on the surface (arachnoid) is infiltrated, but there are no masses of cells in this. In places the leucocytes are closely packed together; in others they are found scattered in a finely granular mass, which is evidently the coagulated albuminous exudation. There is little fibrin among the cells. The leucocytes are exclusively the polynuclear variety, the nuclei stain intensely and there is no evidence of degeneration. The methods used brought out very distinctly the character of the granulations in the leucocytes, and the absence of eosinophilic cells was remarkable. In most cases not a single eosinophile cell was found. In these acute cases there is little or no change in the fixed cells of the tissue. Some of the cells of the walls of the vessels are swollen, but there is no evidence of proliferation.

In more advanced cases the number of cells is much greater. They appear in large masses in the meshes of the tissue. A part of the mesh-work evidently represents the dilated lymph spaces of the tissue, and a part, in which the meshes are much smaller, represents the dilated cell spaces of the more compact tissue of the surface. In some cases but little can be seen of the connective tissue, the whole tissue being infiltrated with cells. Here also the cells are principally polynuclear leucocytes; in most of them the nuclei stain brightly, but there

may be masses of them in the middle of the membrane which are swollen, more granular, and whose nuclei either stain imperfectly or not at all. In most cases there are no red corpuscles in the exudation, in others scattered ones may be found among the leucocytes, and in one case areas were found where the exudation had an almost hæmorrhagic character. There is more fibrin than in the most acute cases. It appears in masses by itself or as a delicate net-work among the pus cells. In one case there was a considerable amount of it, and in places it had undergone hyaline metamorphosis. It is never present to the same extent as it is in other forms of meningitis, particularly that produced by the pneumococcus. In addition to the pus cells and the scattered red corpuscles other cells appear in the exudation, and often form a large part of it. These are large cells, from two to eight times the diameter of a leucocyte. They are present to some extent in all cases, but very few are found in the most acute cases. The nuclei of these cells are large and vesicular, the protoplasm stains very faintly and is finely granular. It is difficult to make out the protoplasm of the largest of these cells, for they are filled with other cells which they have taken up (Plate VI., Fig. 2). Polynuclear leucocytes, often in considerable numbers, are found in these cells. In one as many as fifteen were counted. The enclosed leucocytes show various changes. Most often they are contained in a vacuole of the large cell, and a clear space can be seen around the periphery of the enclosed cell. Rarely lymphoid cells may be found in them. The protoplasm becomes pale and gradually disappears, while the nucleus may be but little changed. Finally the nucleus breaks up into irregular masses of chromatin, and some cells are found which are filled with irregular chromatin fragments. The large vesicular nucleus of the cell may be made out lying close to the periphery. In most cases the large cells were well preserved, in others they were among masses of degenerating leucocytes, and seemed to undergo the same degeneration. They were most numerous around the periphery of the cell masses of the exudation.

These large cells have excited the interest of all who have

studied the process, but their origin has been obscure. Owing to the freshness and variety of the material and the use of improved methods of technique, it has been possible to follow the various stages of their formation. In the place of the few scattered cells, with thin, spindle-shaped nuclei, seen in the connective tissue of the normal meninges, the nuclei become large and vesicular, and the protoplasm of the cells is increased in amount and granular. These cells are greatly increased in number, there are masses of them around the blood vessels and in the connective tissue. The spaces in the tissue enclosing the pus cells may be lined with them. Nuclear figures in considerable numbers and in great variety and beauty are often seen in cells which are still in connection with the tissues, and in those lying free among the cells in the exudation. By taking different cases, and sometimes even in the same case, the various steps in the formation of these large cells from the cells of the connective tissue and from the cells lining the lymph spaces in the tissue could be followed. The connective tissue fibres become less evident, and, as the cells multiply, they become swollen or disappear.

The vessels are dilated and in some of them thrombi are found. Masses of leucocytes with a few lymphoid cells among them are often found in the centre of the vessels among the red corpuscles. Occasionally a few lymphoid and plasma cells are found around the vessels. The proliferative changes found in the intima of the arteries, which are so common in tuberculosis and pneumococcus meningitis, are but rarely found here. This change consists in the loosening of the endothelial layer of the intima, and the formation between this and the elastica of numbers of large epithelioid cells, which appear to form a lining to the vessel. In one specimen the intima of a small artery was elevated and back of this was a clear space filled with polynuclear leucocytes, which also to some extent infiltrated the muscular coat. Some degree of purulent infiltration is seen in wall of an artery (Plate III., Fig. 2) which is from a case of experimental meningitis in a goat.

In the chronic cases the lesions are much less striking. The exudation is confined to the small, yellowish masses mentioned

in the macroscopic description. These are composed for the most part of masses of degenerated pus cells and nuclear detritis. At the periphery of the masses occasional leucocytes are seen whose nuclei are clearly stained. The meninges are converted into thick, dense masses of tissue, resembling cicatricial tissue, which contain few cells. Here and there in the tissue, especially close to the brain, there are groups of cells. In these there are but few of the large cells which form such a conspicuous feature in the acute cases. In the place of these we find in the cell groups and around the vessels numbers of lymphoid and plasma cells. We understand, under the term plasma cells, cells which are similar to those described under this term by Unna. They have a nucleus similar in its general character to that of the lymphoid cell, and a variable amount of granular protoplasm which stains blue with Unna's alkaline methylene blue solution. In the cell groups there are cells which seem to show transitions between the lymphoid and plasma cells. It is only by means of fine sections and the use of high powers that the character of the cells forming the closely packed masses around the vessels can be made out.

The changes in the meninges of the cord are of the same general character as those of the meninges of the brain. The large cells, though present, are not so numerous as in the latter. The blood vessels are injected. The greatest mass of the exudation is invariably in the meninges on the posterior surface of the cord. The pus cells lie in larger masses and the reticulum is not so evident, and there is always a smaller amount of fibrin than in the meninges of the brain. In cases where the macroscopic examination showed only hyperæmia with slight cloudiness of the meninges, as on the anterior surface of the cord and in places over the entire surface, microscopic examination showed well-marked purulent infiltration. In the more chronic cases, just as in the meninges of the brain, the purulent exudation is confined to small areas of degenerated pus cells, and there is thickening of the meninges with cellular accumulations around the vessels.

Lesions of the Tissue of the Brain and Cord.

These lesions are interesting on account of their frequency, their general bearing on pathological processes and from being most marked in the particular form of meningitis which is produced by the diplococcus intracellularis. In only a few cases were these lesions absent. The lesions are most evident in those cases in which from five to ten days elapsed from the onset of the disease until death. The blood vessels of the convexity are injected, the cortex in most cases wider, and the tissue more loose and reticular, as though œdematous. The lymph spaces around the blood vessels are dilated. In some places there is a circumscribed infiltration of the tissue with pus cells which extend downward from the infiltration in the meninges. The spaces around the dilated vessels are often filled with pus cells which extend from here into the surrounding brain tissue. The infiltration was usually most marked in the outermost layer of the cortex above the ganglion cells, but in some cases it was found deeper down among the ganglion cells, and even in the white matter. In addition to this infiltration around the vessels single pus cells are often found in the brain tissue, apparently remote from the areas of infiltration. There were but few hæmorrhages found in the cortex of the cerebrum. In two cases there was extensive softening, with purulent infiltration and hæmorrhage in the cortex of the cerebellum. In these places, which partly extended into the granular layer, the cortex was represented by scattered granular masses, among the pus cells and hæmorrhage, and the cells of Purkinje had disappeared, or only granular fragments of them were found. The areas in the white matter which showed macroscopically as hæmorrhages generally appeared as foci, composed of numerous fine hœmorrhages, with but little infiltration with pus cells. Around these foci there were changes in the neuroglia which will be presently described. In one case there was an acute focus of softening with infiltration with pus cells in the pons just over a thrombus in the basilar artery. In this area the tissue was distinctly

broken down, necrotic and infiltrated with pus cells. In the most chronic case there was a firm mass resembling a gumma on the upper surface of the cerebellum which completely closed the foramen of Magendie. On microscopic examination, the centre of this was composed of totally necrotic pus cells and fibrin, with fine remains of nuclear detritis. This was surrounded by a dense mass of connective tissue with infiltration of plasma cells and lymphoid cells, and it extended downwards through the granular layer. It seemed to have resulted from the necrosis of a large purulent exudation in the meninges, combined with superficial necrosis of the tissue of the cerebellum immediately beneath. In several of the chronic cases, in which there was marked thickening with cellular infiltration of the meninges, the same cellular infiltration was found around the vessels extending into the tissue. In one acute case, in which almost complete paralysis of one side appeared twenty-four hours before death, the exudation was most marked on the side of the brain opposite the paralyzed side. In this place the œdema and cellular infiltration of the cortex was most marked. Macroscopically the cortex was much swollen and softer. Pus cells were found not only in large numbers around the vessels but had generally infiltrated the brain tissue. At various places in the white matter and in the internal capsule there were small foci of hæmorrhage.

In no case in which the ventricles were examined were they found free from alteration. The ependymal lining was in some cases preserved, in others it was lost over greater or smaller areas. The tissue beneath the ependyma was loose, reticular and œdematous. The blood vessels were injected and there was more or less infiltration with pus cells both immediately around the vessels and at a distance. In many of the chronic cases the surfaces of both the lateral and fourth ventricles were covered with granulations.

The tissue of the cord was always less affected than that of the brain. Only in one case did we find a purulent infiltration of the cortex extending from the meninges with foci of infiltration in the tissue.

The most interesting changes concern the neuroglia. These were found both in the cortex and beneath the ventricles, and in the neighborhood of the foci of softening. With a low power there is a distinct increase in the cells of the cortex outside of the ganglion cells, which is both general and more marked in certain places. With high power the cells of the neuroglia are swollen, their nuclei are large, clear, vesicular, and contain larger and smaller masses of chromatin. Around these large nuclei there is a faintly stained, very much branched, irregular mass of granular protoplasm. This presents some similarity to a branched connective tissue corpuscle, but can be distinguished from it by the more faintly stained and more granular character of the protoplasm. The shape of the cells varied; some were branched in all directions, while others were more spindle-shaped, with short secondary protoplasmic prolongations from the main branches. Many of the cells contained two nuclei, and in places there were groups of four or more nuclei closely clustered together with a considerable amount of protoplasm around them (Plate VII., Fig. 4). In all these places, in favorable tissues, varying numbers of nuclear figures were found (Plate VI., Figs. 2 and 3). They presented the same forms as other multiplying nuclei, and in some cases the spindles and centresomes were distinct. Apparently for the recognition of these nuclear figures much depends either upon the condition of the tissue or the period of the disease. They were numerous in one specimen, while in others, in which there was evident proliferation, they could be found only after prolonged search. In some of the places where the proliferation was most marked there was some infiltration of the tissue with pus cells; in others the nuclear figures were found at a distance from such infiltration and in apparently normal tissues. The same change in the neuroglia was found deeper down in the cortex among the ganglion cells. The number of nuclei around the ganglion cells was increased, and in several instances nuclear figures were found in these places. The greatest increase in the neuroglia was found around the foci of hæmorrhage and

cellular infiltration in the white matter. The hæmorrhagic area was often surrounded by an area made up of proliferating neuroglia cells, and areas composed of them were often found apart from such hæmorrhages; but these seemed probably to be the peripheries of hæmorrhages which did not appear in the section. In all of these places there were numerous nuclear figures. The same proliferation in the neuroglia with the presence of nuclear figures was also found in the acute areas of softening in the cerebellum and in the neuroglia of the optic and olfactory nerves.

In every case proliferative changes in the neuroglia were found in the tissue of the ventricles. Where the ependymal lining was preserved the cells were closely packed together, the nuclei were large and proliferation had evidently taken place, but no definite nuclear figures were found. Beneath this the tissue was loose and reticular, and contained large numbers of single cells and cell groups. The first nuclear figures were found in the neuroglia cells here, but they were not as numerous as in the cortex and in the white matter. In the more chronic cases the changes in the neuroglia of the cortex were not so marked as in the acute. There was some increase in the cells, most of which assumed a normal appearance, the tissue was denser and the fibres more evident. These more chronic changes in the neuroglia were best studied in the ventricles. In these there was a dense lining of neuroglia with rather coarse fibres, and with a greatly increased number of cells immediately beneath the ependyma and extending into the tissue. In those cases in which there were granulations on the surface they were composed of neuroglia alone.

Marked changes in the neuroglia of the cord were found in but one case. In this the central canal was dilated and around it were cell aggregations. The blood vessels were dilated, and their sheath and the tissue around them infiltrated with pus cells. This was most marked in the gray matter. The neuroglia cells were greatly increased in number in the gray matter of the cord, and to a less extent in the white, and there were numerous nuclear figures within them. In some of the chronic

cases there was thickening of the neuroglia around the periphery of the cord.

These neuroglia changes were accompanied by changes in the connective tissue. The cells of the blood vessels were swollen, increased in number and nuclear figures found in them. In the same field nuclear figures were often found in the neuroglia cells and in the blood vessels. In the smaller hæmorrhagic foci the walls of the vessels were often found infiltrated with large epithelioid cells, together with lymphoid and plasma cells. This cellular infiltration was most marked around the blood vessels beneath the surface of the ependyma. A definite formation of connective tissue proceeding from this vascular proliferation was not found save in the chronic case referred to, and in this the process had advanced so far that the steps in the formation of the connective tissue could not be followed. In this same case sections through the indurated areas in the optic thalamus showed masses of fibrin in the tissue with dense cellular aggregations. These cell masses were almost entirely composed of plasma cells, with a few lymphoid cells between them.

The examination of the ganglion cells for degenerative lesions was the least satisfactory part of the work. The tissue was examined in all the usual methods after hardening in alcohol and formaline. In many of the cases the tissues undoubtedly remained too long in the hardening fluid before examination. Changes were undoubtedly present, especially in the most chronic cases. The changes found consisted in an alteration in the cell granules, combined with irregularity in shape and often atrophy of the body of the cell. The granules in some cases were absent, in others in place of the large angular granules there was an indistinct fine granulation. In some of the sections which were hardened in Flemming's solution and in some hardened in Müller's fluid and subsequently treated by Marchi's method for degeneration, fatty degeneration was found in the cell protoplasm. These fat granules resulting from degeneration could be distinguished from the pigment granules of the cells, which also stain with osmic acid, by their greater intensity in staining, their irregular size and irregular distribution in the cells.

In addition to the nerves, portions of both brain and cord were treated by Marchi's method for degeneration in the nerve fibres. Degeneration to some degree was present in all the cases examined. In sections of the cortex embracing the white matter it was present to some degree but was not marked. Here and there in the white matter small areas of degeneration could be seen. In those sections of the brain which embrace the internal capsule the degeneration was more conspicuous. The degeneration was much more marked in the cord. In this, it was most conspicuous in the posterior column of the cord. Under a low power these columns were often almost black from the extent of the degeneration. A certain amount was evident in the pyramidal tracts of the cord and in the antero-lateral tract. The stain for degeneration was of importance in another way, — in bringing out a degeneration of the swollen cells of the vessels, which was often of high degree.

Diplococci were found in variable numbers in the meninges and in the brain (Plate III., Fig. 1). They were always most numerous in the acute cases, where the exudation was composed almost wholly of pus cells. Variable numbers were found in the single cells, but the cells wholly filled with them which were so common in the alveoli of the lungs were rarely found. In the chronic cases prolonged search was often necessary to find them; in the acute cases numbers of cells containing them were often found in a single field. In the meninges of the cord they seemed to be less numerous than in the brain. In the brain they seemed more numerous close to the inner surface. They were also found in the tissue of the brain in those acute cases in which there was considerable purulent infiltration of the tissue. Here they were found not only in the pus cells around the vessels, but in the single cells in the interior of the tissue.

Lesions in the Nerves and Ganglia.

The importance of the study of the nerve lesions was only appreciated in the latter part of the epidemic, so that in the earlier cases the nerves were not examined. In six cases the cranial nerves, including the Gasserian ganglia, were examined,

and in two cases the spinal ganglia. In one case, in addition to the cranial nerves a number of peripheral nerves were examined for degeneration. The nerve roots of the spinal nerves were examined in the sections of the cord in every case. Lesions of greater or less degree were found in every case examined, and seem sufficiently constant to justify the conclusion that they are present certainly in all the severe cases.

The most marked lesions were found in the second, the fifth and eighth nerves. The lesions in the optic nerves represent an extension of the inflammatory process from the meninges. The nerve was examined in cross and longitudinal sections from the brain to its entrance into the eye. The dural covering of the nerve in the orbit showed little change save dilatation of vessels. The sub-dural space was dilated, but usually contained no cellular exudation. Just as in the brain, the purulent exudation was found in the pia-arachnoid of the nerve. The connective tissue of this was infiltrated with pus, and there were masses of pus cells in the membrane and in spaces chiefly around the retinal artery after this had entered into the sheath (Plate IV., Fig. 1). The blood vessels of the nerve itself were dilated, the space between the bundles of fibres increased, and around the periphery were lines of cellular infiltration which extended from the outside between the bundles of fibres. In a longitudinal section of the nerve, involving a part of the retina, the infiltration could be followed from the meninges of the nerve into the eye. Another longitudinal section of the nerve in one case showed a small mass of pus cells lying in the sub-dural space and the dura immediately over this was infiltrated with cells. In the acute cases the cells in the meninges of the nerve extending between the nerve bundles were polynuclear leucocytes. The degree of the infiltration varied. In one case considerable numbers of leucocytes were found extending almost to the centre of the nerve. In more chronic cases along with the pus cells there were numerous large epithelioid cells similar to those found in the meninges of the brain. Around the vessels there were very few lymphoid and plasma cells. Changes similar to those in the optic nerve were found in the olfactory nerve and the bulb, but the cellular infiltration between

the nerve bundles was not so marked. It was very interesting to find in both the optic and olfactory nerve proliferative changes in the neuroglia cells similar to those described in the brain. In one case of five days' duration nuclear figures in great variety and beauty, showing centresomes and spindles, were found in the neuroglia cells (Plate VII., Figs. 2 and 3). Two such figures were sometimes seen in the same field. Cells with granular protoplasm and two or more nuclei were also seen.

Sections of the eighth nerve (Plate V., Fig. 1) in acute cases showed the nerve embedded in a mass of pus, the nerve sheath softened, broken up and in places entirely lost. The nerve itself was infiltrated with enormous numbers of pus cells, partly in the form of lines running through it, partly as a more diffuse infiltration. In some sections the nerve was broken up, greatly swollen and the single bundles of fibres separated by large accumulations of cells. Here also in acute cases only pus cells were found around the invading nerve, and in the more chronic cases there were fewer pus cells, and in the place of them lines of epithelioid and plasma cells. The seventh nerve frequently showed as great degree of infiltration as the eighth. Some infiltration was also found along the third and sixth nerves, but it was not so marked. In one case longitudinal sections of the fourth nerve were made, and showed no infiltration.

Longitudinal sections of the fifth nerve, involving the ganglion and some of the peripheral branches, showed an intense neuritis on the cerebral side of the ganglia. The single bundles of fibres were widely separated from one another, and between them there was considerable exudation, in which there were numbers of pus cells and epithelioid cells. The cellular infiltration did not seem to extend so diffusely into the nerve bundles as it did in the case of the eighth nerve. These exudative changes were accompanied in the fifth nerve, as in the spinal nerve, by a considerable degree of cellular proliferation.

Sections of the nerve roots (Plate IV., Fig. 2) of the spinal cord showed that these were affected in every case, but there was a great deal of difference in the extent of the lesions. As a rule, the greatest degree of affection of the nerve roots was found in that

part of the cord where the cellular infiltration was greatest, although in some cases a considerable degree of involvement of the nerve roots was found, with very little infiltration of the meninges. In most of the acute cases the lesions in the nerve roots, as shown on cross and oblique sections, were of the same character as those seen in the cranial nerves. There was a marked degree of dilatation of the blood vessels, the peri-neurium was infiltrated with pus cells, the nerve was swollen, the separate bundles of fibres separated from one another by spaces in which there was considerable cellular infiltration. Even in the most acute cases these changes were accompanied by proliferative changes in the peri- and endo- neurium. The cells of the blood vessels were swollen, increased in number, and around the blood vessels along with the pus cells there were numbers of large epithelioid and plasma cells. The lymphoid cells were comparatively few in number. Nuclear figures were often found in the epithelioid and plasma cells. Not only were these changes found in the peri-neurium and in the small bundles of connective tissue separating the larger bands of nerve fibres, but small collections of plasma and lymphoid cells were occasionally found within the nerve bundles and between the fibres (Plate VII., Fig. 1). All of these changes were more marked in the posterior than in the anterior roots.

In some of the more chronic cases lesions in the spinal nerve roots were more marked than in the acute. Around all of the blood vessels, even the smallest, there was an intense proliferation of cells, which so extended between the single nerve fibres that in places these seemed to be entirely destroyed. The cells belonged principally to the type of plasma cells. The greatest amount of nerve degeneration, as shown by the Marchi method, was found in the optic nerve in one case (Plate VII., Fig. 2), and in the eighth nerve in another. Sections of the optic nerve under the low power were very dark from the masses of fatty degenerated myelin stained black with osmic acid. With a high power in some of the bundles a large number of the single nerve fibres were found to be affected. The degeneration was almost as marked in the seventh nerve. In a longitudinal section of

the nerve, in which the degeneration of the single fibres could easily be followed, a count showed in one place three-fourths of the fibres to be affected. In most of the nerves in which the myelin was swollen and broken up the axis cylinder was swollen, transparent or entirely absent.

Longitudinal section of the optic nerve from the same case did not show so great degree of involvement. In every case degeneration was found in the spinal nerve roots, and was more marked in the posterior than in the anterior roots (Plate VIII., Fig. 1). Only in one case was there an extensive examination of the peripheral nerves for degeneration. A minor degree of degeneration was found in the nerves of the cauda equina and in the popliteal nerves. A considerable degree was found in the same case in the seventh nerve. The fifth nerve was only examined in one case, in which there had been great involvement of the ganglia, and in this extensive degeneration was found.

In one of the cases a section treated for degeneration was taken through all the nerves and muscles of the orbit. All of the nerves showed more or less marked degenerative changes, but the optic nerve, and next to this the branches of the sixth, seemed to be most affected. The muscles of the section showed advanced fatty degeneration. Sections of the spinal cord stained by Weigert's method show equally the destruction of the nerve roots. In one chronic case comparatively few intact nerve fibres were found.

In five cases sections were made of the Gasserian ganglia, and in two of the spinal ganglia. The Gasserian ganglia in the acute cases were infiltrated with pus, and masses of ganglion cells were often separated from their connection (Plate V., Fig. 2). Even single ganglion cells were often found lying free in the exudation. Along with the purulent exudation there was more or less hæmorrhage. Many of the ganglion cells, especially those most distant from the exudation, seemed to be normal. Others were small, their outline exceedingly irregular, the nucleus pale or in some cases absent altogether. Small irregular masses, representing completely necrotic ganglion cells, were often found. In the most marked cases the granulation

of all of the cells was indistinct. The cells also often contained large vacuolar spaces. The diplococci were found in the pus cells infiltrating the optic nerve and in the infiltration of the pia-arachnoid around it. In several cases they were found in the sections of the Gasserian ganglia, but were not found in the sections of the spinal ganglia. In one case they were found in the olfactory nerve and in the auditory in one. They were not found in the other nerves or in the nerve roots of the spinal cord. No leucocytes were found in the necrotic ganglion cells. In the more chronic cases the amount of leucocytic infiltration was less, and throughout the ganglia there were large numbers of cells which came from proliferation of the connective tissue. In one case the ganglion appeared to be œdematous. The tissue was loose and the single cells widely separated from one another both by cellular infiltration and by the œdema. Immense numbers of newly formed cells were found around the ganglion cells. The cellular investment of the single cells was in most cases much thicker, and the cells were swollen and many took on an epithelioid character. Nuclear figures were found in the surrounding cells. The cells lying in the tissue between these ganglion cells often had the character of plasma cells. There were also considerable numbers of lymphoid cells. The same condition of atrophy of the cells, often going into complete necrosis, was found here as in the acute cases. The spinal ganglia were not equally affected. This was apparent on macroscopic examination. All seemed to be somewhat swollen and œdematous, but in some this condition was much more marked than in others. On microscopic examination much the same changes were found in these as in the Gasserian ganglia. The blood vessels were injected and the ganglion infiltrated with pus. There was proliferation of the cells about the blood vessels and of the cells about the ganglion cells. The ganglion cells were often separated from their connection and lying in the exudation. These were irregular in shape and the nucleus stained imperfectly or not at all. Others showed the same degenerative lesions as have been described in the Gasserian ganglion (Plate VI., Fig. 1). Sections of the gan-

glion, including longitudinal section of the nerve roots in connection with it, showed these infiltrated with pus. The rapidity with which these changes can take place was shown in a section of the ganglia in the goat which died not later than twelve hours after inoculation in the spinal canal with a pure culture of the diplococcus. In one of the ganglia there was beginning purulent infiltration. There seems little doubt that in both the spinal and Gasserian ganglia the condition is due to direct extension along the nerves. There were no lesions in a small sympathetic ganglion found in one of the sections through the orbit. In one case, in which sections of the Gasserian ganglion and the nerves showed a very extensive neuritis, sections were made through the olfactory bulb. This was swollen and in places intensely infiltrated with cells among which were many pus cells, but the cells seemed to come principally from proliferation. The tissue was œdematous and the large triangular nerve cells often appeared atrophied. Sections passing through the olfactory nerve from the same case showed a considerable degree of degeneration.

Sections of the eye were examined in two cases, in one of which choroiditis, cloudiness of cornea and conjunctivitis were ascertained during life. The sections embraced in this case the fundus of the eye through the entrance of the optic nerve, the ciliary region and the cornea. The sections through the optic nerve and fundus showed a marked infiltration of the nerve sheath up to its entrance into the eye. Where the nerve sheath was lost in the eye there was a considerable accumulation of pus cells, with proliferation of the adjoining tissue cells. From this point an infiltration with leucocytes extended directly into the eye. The optic nerve was swollen, the spaces between the fibres increased, and in these spaces an occasional pus cell and cells of new formation were found. All of the vessels of the choroid were intensely injected, but there were few hæmorrhages and no infiltration with pus cells in this. The retina on either side of the entrance of the optic nerve was broken up and infiltrated with pus. Further up the retina was in places very well preserved, but generally nothing could be seen of the

layer of rods and cones. The tissue was infiltrated with pus cells and hæmorrhage, and in places the entire retina, with the exception of the granular layer immediately beneath the rods and cones, was destroyed. All the blood vessels of the retina were intensely injected, and in places there was a considerable amount of fibrin around them. Notwithstanding the enormous congestion of the blood vessels of the choroid, no diapedesis seemed to take place from them and in none of them was there an accumulation of leucocytes. Only in a few places scattered leucocytes were found in the tissue of the choroid. The tissue appeared to be looser than normal, and in the loose meshes of the tissue epithelioid cells with nuclear figures were found. The vitreus was filled with a large amount of pus made up entirely of polynuclear leucocytes, none of them containing eosinophile granules. The largest mass of this pus was adherent to the retina and to the iris. The anterior chamber contained a large amount of pus. The tissue of the iris was œdematous and infiltrated with pus cells. The blood vessels were injected. The pigment cells were broken up, the pigment scattered in the tissue, and the pus cells in the iris and in the anterior chamber were loaded with pigment derived from this destruction of cells. A considerable amount of reticular fibrin and numbers of red blood corpuscles were found among the pus cells in the anterior chamber. No evidences of proliferation were seen in any of the pigment cells of the iris or ciliary region. In the ciliary region the blood vessels were injected, the tissue was swollen, œdematous and infiltrated both with pus cells and with cells arising from proliferation. The sclera was normal, except at the corneal attachment. There all of the blood vessels were injected, and it contained large numbers of pus cells and epithelioid cells. The cells of the vessels were swollen, and nuclear figures were found in them. The section passing through the cornea showed the fibres of this separated, and the tissue contained a great many pus cells lying in the corneal spaces. At its commencement the cornea was almost homogeneously infiltrated, further along toward the middle a few pus cells were found in the posterior portion of the cornea and they seemed most abundant

in the middle. The epithelium was almost entirely lost over the posterior surface of the cornea, and over the anterior surface it was for the most part reduced to single cells. In this case the duration of the disease was seven days. In the other eye examined, coming from a case of three days' duration, the lesions were not so marked. The vessels of the choroid were intensely injected, and here and there a slight amount of hæmorrhage and cellular infiltration was found. The retina was separated, the vessels were intensely injected, and a few slight hæmorrhages were found. The different layers of the retina were usually made out, and appeared to be but little changed.

In the eye first described a portion of the conjunctiva was cut at the same time with the eye. All of the blood vessels in this were intensely injected and there was a great deal of hæmorrhage in the tissue which seemingly came from the small vessels. The tissue was infiltrated with pus cells which extended up into the epithelium. The spaces in the tissue beneath were increased, and it was evidently œdematous. About the vessels in the spaces in the tissue there were large numbers of plasma cells and occasional groups of epithelioid cells. Nuclear figures were found in both in small numbers. Diplococci were found in considerable numbers in the pus cells in the vitreous and in the anterior chamber. In one section a few were found in the retina. None were found in the cornea or in the iris. In the acute case it was easy to trace the organisms from the brain along the optic sheaths to the eye.

Pituitary Body.

In two cases the pituitary body was examined. Sections passing through the pedicle showed a purulent infiltration extending around this and down into the gland. At the periphery of the gland in one place the exudation extended down into the tissue and there was necrosis and atrophy of the glandular elements.

Nose.

In three cases sections of the mucous membrane of the upper air passages were examined. Two were normal and in one there

was a purulent infiltration of the mucous membrane and of the sub-mucous tissue with intense hyperæmia of the blood vessels. A few single pairs of diplococci were found in the pus cells. In this case microscopic examinations of the nasal secretion from the nose during life were positive, showing diplococci in the pus cells.

Lungs.

The condition of the lungs is interesting, on account of the relation which has very generally been supposed to exist between acute epidemic cerebro-spinal meningitis and pneumonia. In thirteen cases there was merely congestion, with more or less œdema. In a few of the cases the œdema was well marked. In seven cases there was broncho-pneumonia, most marked in the lower posterior portions of the lung, with more or less bronchitis. In two cases there was characteristic croupous pneumonia, one in the stage of red hepitazation bordering on gray. There was a fibrinous pleurisy over the consolidated lung. Pneumococci were found in cultures and on microscopic examination. In eight cases a pneumonia due to the diplococcus was found. Nearly all of these cases come from the last part of the epidemic. It is very possible that in some of the earlier cases in which the lesions were described simply as broncho-pneumonia, they were really due to the diplococcus. The lung lesions in cases which are described as broncho-pneumonia with bronchi-ectatic cavities, and foci of consolidation with necrosis and breaking down, may also have been due to the diplococcus. The lesions macroscopically consisted of areas of consolidation in various parts of the lung, more particularly in the lower lobe and they were most numerous beneath the pleural surface. The foci varied in size from a pin's head up to that of a bean, and on section some of them resembled small hæmorrhages in the tissue. In other cases the periphery of the area was distinctly hæmorrhagic and the centre opaque and yellowish. The number of these areas varied. In some of the cases but few were found, in others they were numerous. In one case the consolidation in the lung was so extensive that it might easily have been regarded as croupous pneumonia, particularly as the pleura over it was covered with a definite fibrinous

exudation. On section the large area was composed of a number of irregular grayish foci with softened centres and with hæmorrhagic and œdematous tissue between them.

The lung tissue in the yellowish centres was frequently broken down, and pus oozed from this. The bronchi in these places contained more or less muco-purulent material, but there did not seem to be that relation between the bronchi and the areas of consolidation which is found in broncho-pneumonia.

On microscopic examination the central areas showed in most cases a purulent infiltration of the tissue, breaking down and beginning abscess formation. In the centres there were large numbers of pus cells in the alveoli. The walls of the alveoli were thin, infiltrated with pus and in places entirely broken down. Surrounding this the purulent infiltration was not so intense and around the outside there was often œdema with a slight amount of hæmorrhage. Some of the foci were distinctly hæmorrhagic, with areas here and there of purulent infiltration. The exudation in the alveoli in the centres contained nothing but pus cells. Further out mixed with the pus cells there were numbers of large cells similar to those in the brain, and they often enclosed the pus cells. These large cells were also found in the more œdematous portions. In addition to the exudation, at the periphery there was some cellular proliferation of the tissue of the lung. There were plasma and epithelioid cells about the blood vessels, and the cells lining the walls of the alveoli were swollen. In one case nuclear figures in small numbers were found in these cells. The exudation in the lung, as in the brain, was characterized by the absence of eosinophile cells. On microscopic examination the foci of consolidation did not appear to be bronchial in origin. The bronchi in the vicinity often contained pus cells, but their walls were not infiltrated. The duration of the disease in the cases in which diplococcus pneumonia was found was: in two cases, three days; in one case, two days; in one, five days; in one, nine days; in one, twenty-three, one seventy-four and one five days. The average duration was fifteen and one-half days. It will be seen from these figures that the lung complications due to the diplococcus can take place in almost any period of the

disease. In the case of seventy-four days' duration the lesions in the brain and cord could be regarded as almost completely healed, and the lesions in the lung were acute. In one case, in which the apparent history of the disease was only of two days' duration, the lung lesions were so advanced that they seemed possibly to antedate those of the brain, providing the history as given by the patient's relatives was accurate.

Immense numbers of diplococci were found in the pus cells in these places (Plate III., Fig. 2). They were most numerous in the cells in the centres of the foci, where the softening of the tissues was taking place. Sometimes in an alveolus every pus cell was almost filled with them. With low power the places containing them in greatest abundance could be easily recognized by the dark color which their presence gave to the cells. They were found exclusively in the cells. Although most numerous in these places, they were also found in the pus cells in considerable numbers around the periphery of the central area and in the scattered pus cells of the œdematous portion. None were found in any of the large cells, but occasionally a few swollen and imperfectly stained forms were found in the pus cells enclosed in these. In the centre of one of the foci a small branch of the pulmonary artery occluded by a thrombus formed of pus cells enclosing large numbers of diplococci was found. It seemed probable that this thrombus may have come as an embolus from the meninges and may have produced the infection of the surrounding tissue. The organisms were also found in the pus cells in some of the bronchi within the consolidated areas, but they were not found in the bronchi at a distance. The perivascular lymphatics were dilated and contained coagulated material, pus and fibrin.

Spleen.

There is a great variation in the size of the spleen. In general it is not much enlarged, and is probably smaller than in most of the acute infectious diseases. In only three cases was it found considerably enlarged; in one of these it weighed four hundred and ten gms., in one three hundred and seven

and in one three hundred and two gms. The average weight of the adult cases was one hundred and sixty-three gms. It is rather remarkable that in the two acute cases complicated with croupous pneumonia the spleen should have weighed in one eighty gms. and in the other eighty-five gms. The small spleen was normal on histological examination. In the largest spleen, which was macroscopically rather soft, there was no enlargement, but rather a diminution in the size of the malpighian bodies, with considerable diminution in the lymphoid cells. Increased size of the spleen was due chiefly to acute hyperæmia. At the beginning of our study of the disease we were of the opinion that the smallness of the spleen could serve clinically as a differential mark in distinguishing this form of meningitis from the pneumococcus form, but a small size is not sufficiently constant to be of service clinically. In some of the more chronic cases the capsule of the spleen was wrinkled, showing that the spleen had been larger. The average duration of disease in the three cases of enlarged spleen was five days.

Lymphatic Glands.

The lymphatic glands in the uncomplicated cases were never found enlarged. Microscopically the blood vessels were injected, but there was no alteration in the histological structure of the gland and no dilatation of the lymph spaces.

Liver.

The liver presented but little abnormal. It was generally rather pale and cloudy on section. In three cases microscopically there was slight increase in the fibrous tissue, with cellular infiltration. In one case, where it was enlarged, the cells were swollen, granular and fatty, and there were numbers of leucocytes in the capillaries. In one case there were foci of purulent infiltration in the enlarged portal spaces. There were no foci of necrosis such as are sometimes found in some of the infectious diseases.

Kidneys.

In two cases acute lesions were found in the kidney. In one of these the kidney lesion had nothing to do with the meningitis, the

boy having become infected with diphtheria, of which he died, after having practically recovered from the meningitis. The kidneys in this case were swollen, the glomeruli enlarged and opaque, showing as yellowish points. Under a low power the glomeruli were prominent. About most of them there was a darkly stained mass, composed of fibrin and blood. The interstitial tissue was dilated. With high power the convoluted tubules were everywhere swollen, in some places entirely filling up the lumen, and the cells in some places were filled with hyaline granules. In a large number of tubules there was hæmorrhage, and in places they were filled with masses of definite fibrin. In a few places in the intermediate zone of the kidney there were found both in the vessels and in the interstitial tissue the large cells characteristic of acute interstitial nephritis. Around most of the glomeruli there was a mass of fibrin, partly reticular, partly converted into hyaline masses. In places in the glomeruli groups of vessels were necrotic and here and there were hæmorrhage and leucocytes with broken-down nuclei in the tissue. Some of the glomeruli were completely necrotic. The hæmorrhage and fibrinous material in the capsules of the glomeruli extended into the tubules leading off from them. The kidney lesions in this case should be attributed not to the meningitis but to the diphtheria, although such glomeruli lesions are extremely uncommon in diphtheria. In this case there was complete anuria for two days before death.

In one other case there was acute hæmorrhagic nephritis. In this case there was an accompanying acute pericarditis, the organisms causing which could not be ascertained. In two cases there was a minor degree of chronic interstitial nephritis. The only lesions found in the kidneys which could be properly attributed to the meningitis were acute degenerative lesions, which were always present. In one case there was an abcess in the seminal vesicles. The case was accompanied by croupous pneumonia, and on both cover-slip examination of the contents, and in the cultures only pneumococci were found. On microscopic examination, in addition to the numerous pneumococci a small number of swollen and degenerated diplococci were found in the pus cells.

Intestinal Canal.

The intestinal canal was found normal in every case save in the case accompanied by diphtheria, and in this the usual swelling of the follicles was found. This is interesting in view of the fact that swelling of the follicles and even ulceration have been described in the disease.

In one case an abscess of the tonsil was found, in which characteristic diplococci were found on cover-slip examination and cultures. No sections of this were examined.

Heart.

The heart was not examined microscopically as a matter of routine. In several cases in which sections were made of it it was found normal. In two cases there was an acute pericarditis, combined in one case with foci of necrosis and purulent infiltration in the myocardium. No diplococci were found in connection with these lesions.

Skin Lesions.

Lesions of the skin were found in but one of the cases which came to autopsy. In this case over upper and lower extremities, chest and abdomen there were numerous small, dark purplish spots in the skin, varying in size from a pin's head up to that of a pea. The smaller ones were not elevated above the surface. In many of the larger ones the centres were more opaque and slightly elevated. They could not be made to disappear on pressure, but remained more sharply marked, the blood being pressed from the surrounding hyperæmic vessels. On microscopic examination of these areas there was intense congestion and dilatation of the blood vessels of the skin in the area and in the surrounding skin. Immediately beneath the epithelium there were small and diffuse hæmorrhages. In the deeper tissue about the sweat glands and extending down into the fat the hæmorrhages were more diffuse and more extensive. The largest hæmorrhages were found in the subcutaneous fat. The deep vessels of the skin and the vessels

of the fat were intensely congested. There was some proliferation around the superficial blood vessels throughout the entire area. In the centre corresponding to the area of hæmorrhagic infiltration beneath the epithelium there was some infiltration with pus cells. In the larger areas with a yellowish centre the epithelium was infiltrated with pus, and one of the specimens showed the upper layers of the epithelium slightly elevated by the accumulation of pus cells beneath. No diplococci were found in the pus cells in these areas. In one case the herpetic vesicles on the lip were examined. In them there was an intense infiltration with pus cells in the tissue around the vessels with proliferation of the fixed cells of the tissue. Here also no diplococci were found in the pus cells.

CLASSIFICATION OF THE DISEASE.

Hirsch[39] divides the disease into the following form: —

1. Meningitis cerebro-spinalis epidemica siderans.
2. Meningitis cerebro-spinalis epidemica abortiva.
3. Meningitis cerebro-spinalis epidemica intermittens.
4. Meningitis cerebro-spinalis epidemica typhoides.

Strümpel,[111] while in the main adopting the classification of Hirsch, thinks that the so-called abortive form should include the mild cases which begin with the phenomena of the disease in an intense form and which rapidly recover.

While recognizing the futility of attempts to classify a disease, it would probably be well for practical purposes to recognize certain types, the differences between which depend on the intensity and duration of the disease. There were no cases seen of what might be regarded as the abortive form of the disease. Cases of this have been reported in early epidemics in which patients would be suddenly attacked with the phenomena of the disease in an intense form, and in a short while, often in twenty-four hours, all the symptoms would disappear.* These cases were most frequently seen in children, and occurred

* Such cases would be seen more likely in private practice than in hospitals.

in the course of severe epidemics. It is very possible that in many cases these sudden symptoms may have had some other origin, and only the presence of an epidemic caused them to be referred to meningitis. Until the diagnosis in these cases shall be confirmed by spinal puncture they must always remain in doubt.

We can distinguish an acute type which will include the fulminating type. In the acute should be reckoned those cases in which the active symptoms last not more than fifteen days. In these acute cases the term of the patient in the hospital is much longer, but he is then recovering from the conditions which the disease has left. In the fulminating type those cases should be included which are fatal within forty-eight hours from the onset. The chronic form includes those cases in which the symptoms from the beginning are not so active, and in which during the course of the disease there are remissions and exacerbations.

The intermittent form is founded mainly on the character of the temperature. In this there may be complete intermissions of the temperature with or without abatement of the other phenomena. It would seem probable, from some results which have been obtained from spinal puncture, that the exacerbations in this type correspond to multiplication and fresh invasions of the organisms causing the disease, they having previously been quiescent.

Acute Type, including Fulminating Cases.

The very acute type of the disease appears to have been more common in the early epidemics than in the late. In Jackson's report to the Massachusetts Medical Society[125] he says many of the cases died suddenly in ten to twelve hours, others in twenty-four, thirty-six, or forty-eight hours after the first symptoms. Some physicians who had much experience with the disease considered the patients safe if they passed the first twenty-four hours without mortal symptoms. North[75] says that patients may die in the first twelve to twenty-four hours. Woodward[76] says death often ap-

peared in ten to twelve hours after the first attack. Löwy,[64] in the epidemic in Papa, had one case in which death took place in twelve hours; in another, in three days.

Frew[22] gives the following history of a fulminating case. Girl, aged eight and a half years, in good health up to the evening of February 28, when she went to bed complaining of headache. She afterwards arose and stood by the fire for some time, and was found in the morning at 4 A.M., almost comatose. She complained of thirst, and asked for water. She drank greedily, but vomited it immediately afterwards, mixed with greenish matter. Previously she had vomited in bed. At 6 A.M. she got out of bed, partially unconscious, and walked across the room to procure more water, which she immediately vomited. She seemed to be shaking all over, and died at 9 A.M.

Giulini[30] reports such a case in a child five and a half years old. At 5 P.M. she was suddenly attacked with pain in head, weakness, pain in bones and chill; at 6 P.M. vomiting and diarrhœa came on, which continued during the night, together with great restlessness, fever and thirst. In the morning at 6 o'clock general convulsions occurred, varying with spasmodic cramps of both upper and lower extremities. These convulsive movements appeared whenever the skin was touched. At 9.30 consciousness was lost. Urine and fæces were passed unconsciously. Temperature of skin increased, pulse hardly perceptible; abdomen retracted; death took place shortly afterwards.

Haüser[33] reports a case in which death took place five hours after the initial symptoms. Many of Richter's[91] cases were fulminating, death taking place in twelve to fourteen hours. In Klarner's[53] cases death took place in one in ten and another in twelve hours.

Bauer[164] thinks that in the beginning of epidemics these very acute cases are more common than towards the end. There have been very few post-mortem examinations on these fulminating cases reported, and there are no reports of microscopic examinations. In the post-mortem examinations which have been made, no exudation was apparent to the naked eye. There was

intense hyperæmia, with cloudiness of the meninges. In an autopsy by Haüser on his first case, which died in six hours, there was no pus, but simply cloudiness of the meninges.

That extensive lesions both in the meninges and brain can be produced in a short time is seen in the case of experimental meningitis in a goat. The duration of the disease in this case could not have been more than twelve hours.

Eight of our cases were extremely acute. In five of these the time from onset to death was three days, in one two days and in two about thirty-six hours. Certainly in one of these cases the history seemed to have been at fault, for at the autopsy there was extensive diplococcus pneumonia.

Chronic Type.

The chronic form has been seen in all of the epidemics. Woodward[76] says that some patients survive the acute symptoms and afterwards die, seeming to sink away under the load of the disease. They become cold and die comatose, with all the marks of general mortification. Clozel[12] gives a peculiar case of the chronic form. A soldier was carried in a delirious condition into the hospital on the 21st of May. On the 29th all the symptoms of excitation had disappeared. The patient fell into a coma and remained in this condition for two months. He speaks of another case, which lasted from the 16th of February until the 6th of May. Daga[14] gives a typical history of a chronic case which lasted from the 19th of March until the 27th of May, and which eventually recovered.

Osler[84] reported a case of blindness following chronic meningitis in which there was gradual restoration of sight. The child had a typical acute attack five months previously. This may have been the remittent form, for the report says she recovered and was sitting up in bed, then had a second attack with high fever and stiffness of the extremities.

Martin and Levall (Daga[14]) give an admirable account of this chronic form. They say that there is as much danger at the end as at the beginning of the disease. Recovery takes place with difficulty, and it is impossible to say when it begins. There may

be weakness of the limbs, paralysis of various muscles, and after the paralysis disappears the limbs may remain feeble.

Long-continued diseased conditions which may be due to faulty enervation are not uncommon. The wretched patients may be reduced to skeletons. The skin is dry, the face without expression, they lie on their beds heavily covered, silent, indifferent to what is taking place around them. They answer with difficulty questions addressed to them. They have no appetite for food, and the stomach often rejects the food which is taken. The temperature is diminished (in one case Daga saw it descend to 34½° C.), the marasmus continues, and they eventually die.

Leyden[62] says that if the first attack does not kill there may be a return of the process, and the patients may eventually die in the long convalescence.

The cases reported by Hart[40] in Birmingham seem nearly all to have been of the chronic form. The shortest case lasted three weeks, the longest fourteen weeks. In the long-standing cases there was great emaciation. In thirteen of the fatal cases in this epidemic the average duration of the disease was forty-three days. In one case, in which a post-mortem examination was made, the duration was seventy-four days, and in another the time given was thirty days, and may have been much longer. In two of the cases which recovered, and in which the disease ran a typical chronic course, with numerous complications, remissions and exacerbations, the duration was five months. The cases described by Hirsch[39] as the typhoid form come under the chronic type.

The symptoms in these chronic cases may be due to the persistence of conditions left by the acute attack. The exudation may not be absorbed completely and a slow form of inflammation may be developed. It is probable also that an extensive and general neuritis may follow.

The Intermittent and Remittent Types.

These types are common. The disease is characterized by decided remissions, or in some cases actual intermissions, in which not only the fever but all of the other symptoms of the

disease abate. The remissions may be followed by exacerbation of all the symptoms. These cases are probably due either to the successive involvement of parts of the meninges which have been hitherto free from inflammation or to a fresh growth of the organisms. A case seen at the Children's Hospital would point to this. In this case two spinal punctures made at periods of remission showed an almost clear fluid, with absence of organisms microscopically or in culture. A spinal puncture made during one of the exacerbations gave a cloudy fluid, containing numerous pus cells and diplococci. In the present epidemic there have been numerous cases of this form. Cases 11, 50, 70, 72 and 108, with temperature charts, show the characteristics of this form. Leyden[62] gives a case which was marked by complete intermission of all symptoms. Child aged sixteen years was taken ill on the 19th of April with headache, pain in the neck and vomiting. On the 24th of April she returned to school, and remained well until May 1. She was again taken with vomiting and intense pain in the head. From the 7th to the 11th of May she was again in school. On the 11th there was a chill, headache, intense pain in the neck, piercing pain in the eyes, continued vomiting and delirium. Throughout this attack vomiting was seen to be one of the most dangerous symptoms, as it prevented the patient from taking any nourishment. There was slow recovery by June 19. Löwy saw one case in which there was a relapse three weeks after the disease was apparently recovered from. The second attack began with vomiting, intense headache, etc., just as the first attack did. Meschede[70] reports a case which showed an intermittent type during the fourteen weeks of the disease. It began with chills, vomiting, painful stiffness of the neck and neuralgic pains. Henoch[34] speaks of the frequent intermittent course of the disease. Most of his cases were in children. The disease began with the usual acute symptoms, then the fever diminished and the symptoms disappeared. After a short interval of twenty-four hours or several days all of the symptoms again appeared and the general condition became worse. In these cases there was a general absence of the phenomena which point to the involvement of the spinal cord.

SYMPTOMS.

Wunderlich[140] divides the symptoms of the disease into two groups: in the first group, he includes those which depend upon the local disturbances of the cerebro-spinal organs; and in the second, those which must be regarded as evidence of a general disturbance of the organism. Among the constitutional symptoms he speaks of the enlargement of the spleen, the eruption of the skin, hæmorrhages, and secondary inflammations, especially of the lungs. In the most severe and rapidly fatal cases the symptoms of both groups seemed to be united. In the least severe cases the nervous symptoms are more predominant and are more important for diagnosis.

Berg[3] divides the symptoms into three classes: —

1. Those produced by the poison of the disease, chills, convulsions, fever, vomiting, nasal catarrh, constipation, skin eruptions, emaciation and affections of the joints.

2. Symptoms produced by inflammation of the cord, stiffness of the neck, opisthotonos, pain along spine, hemiplegia, difficulty in micturition, incontinence of fæces and urine.

3. Symptoms produced by inflammation of the brain, headache, slow pulse, hydrocephalic cry, vertigo, convulsions, delirium, stupor, coma or coma vigil, Cheyne-Stokes respiration, eye symptoms, ptosis, strabismus, internal inflammation of the eye, conjunctivitis, corneitis, paralysis, hemiplegia and paraplegia.

We have not made any attempt at such a classification of the symptoms nor is it possible with our present knowledge to do so.

Vomiting.

Leyden[62] regards vomiting as one of the most common symptoms of the disease. It may become a complication which seriously interferes with recovery. In one of the cases reported by Leyden there was constant vomiting, which prevented the patient from taking food, and which constituted one of the most dangerous symptoms of the case. In our one hundred and eleven cases vomiting was absent in but forty-one, and in nearly all of these stupor and unconsciousness or delirium was marked from the

beginning. Vomiting may appear among the initial symptoms, or later in the course of the disease. It is generally regarded as cerebral in origin, and due to direct or reflex stimulation of the vomiting centre.[20]

Delirium.

In all of the accounts of epidemics which we have gone over delirium is mentioned as among the most common symptoms. North says that violent mania may come on in a few hours after the onset, especially in sanguine young men. It was present in sixty of the cases reported by us. The character of the delirium varied greatly, sometimes being so violent that the patient had to be forcibly restrained; in other patients it was of the low muttering variety. In many cases it developed very early, and in others at a late period of the disease. It was not more frequently present in the cases which died than in those which recovered. Some patients were delirious from the time they entered the hospital until death; in others there were periods of delirium, alternating with periods of consciousness. The attacks of delirium were not always coincident with increase of temperature and aggravation of the other symptoms.

Pain.

Pain, sometimes limited to the head, sometimes extending all over the body is also a common symptom of the disease. North says that in the acute forms of the disease the pain is often agonizing; in the more common form the pain in the head and limbs is less severe. Fiske[75] gives the following graphic description of the character of the pain: "In some cases a pain resembling the sensation felt from the sting of a bee extends from the extremities of the fingers or toes, it darts from the foot or hand to some other part of the limbs. After traversing the extremities, generally on one side only, it seizes the head and flies with the rapidity and sensation of electricity over the whole body, occasioning blindness, fainting, nausea, with indescribable distress about the precordia."

Almost all the patients in the epidemic reported by Gahlberg[27] complained of severe pain in the head. The pain was so severe

that the patients often tore the hair or struck the head against the wall. The pain often showed an intermittent character, coming on from day to day at the same time.

Levy[65] says that hyperæsthesia of the skin was constant in his cases, and could be made out even in a comatose condition of the patients. It might extend over the entire body, or it might affect only certain portions. The patients begged not to be touched. There was often spasm of the muscles of the skin. Almost without exception pain was a constant phenomenon in the cases observed in this epidemic. The headache was often agonizing, and was felt either generally or to a greater degree in certain portions of the head. Patients often complained of headache in the occipital region, extending down the back; in other cases the headache was frontal, and often assumed the character of an intense neuralgia. In a few cases, mostly in children, the first symptoms of the disease were colicky pains in the abdomen, and in some cases pains in the extremities. Patients often buried the head in the pillow to shut out light and sound. In the course of the disease the pain varied in character and intensity. There were periods in which the patient was free from pain, alternating with periods in which the pain would become more intense. These severe attacks of pain were often followed by periods of unconsciousness. Pain was more constant in the head than in any other part. The pain suffered can easily be accounted for. The general pain in the head is due to the inflammation of the meninges. The neuralgic character of the pain may in some instances be referred to the extension of the process from the meninges to the Gasserian Ganglia; the pain in the cervical region and back may be referred to pressure exerted by the exudation on or inflammation of the posterior nerve roots.

Neck Symptoms.

Symptoms referred to the neck were found in all but twenty-eight cases. In many cases there was pain in the neck, with or without pressure. In many there was simple stiffness in the muscles, without contraction or retraction of the head. In all

these cases any attempts to move the head or neck increased the pain. The muscle contractions were sometimes limited to the neck; in some cases the muscles of the back were also affected, producing opisthotonos. In one case in which the neck symptoms were absent the post-mortem examination showed that the cervical cord was very slightly affected. It is obvious that all these symptoms can be referred to the effect of pressure on or inflammation of the spinal nerve roots.

Coma, etc.

Various disturbances of consciousness, which varied from stupor and drowsiness to deep coma, were noted. In some cases coma came on in the beginning, and the patients remained in a comatose condition until death; in other cases it was among the later symptoms. Strümpel[111] finds the same variations in the cerebral symptoms a in the temperature. Variations may appear not only from day to day but from hour to hour. Insensibility will suddenly give place to consciousness, intense pain in the head may cease, and a marked opisthotonos may suddenly relax.

Paralysis.

Paralysis is not uncommonly observed. It may develop during the disease and disappear shortly, or it may persist for some time. We have not found any cases recorded in which the paralysis was permanent.

Gahlberg[27] reports paralysis of the bladder in one case; in another, paralysis of the right side of the face and of the right upper and lower extremity. In one case there was paresis of the tongue, which disappeared in eight weeks after recovery. Mosler[73] reports, in one case which recovered, paresis of the lower extremities. Baxa[2] found that the disease was often accompanied and sometimes followed by paralysis. In three out of twenty-nine cases reported by Leichtenstern[61] there was complete hemiplegia, including the facial nerve, and in one case paralysis of all the extremities, including the rectum and bladder. In one of Ziemmsen's cases, reported by Sittman, there

were left hemiplegia and facial paralysis which passed off in a few days after recovery. Strümpel observed in one case unilateral facial paralysis; in another, well-marked paralysis of the lower extremities, and in this case the cerebral symptoms were not so marked as the spinal. In our cases paralysis was rare. In two cases there was unilateral facial paralysis; in one, bilateral; in one paralysis of the right leg; and in two, complete hemiplegia. In one of the cases of hemiplegia in which a post-mortem examination was made the exudation in the meninges was much more abundant on the side opposite the paralyzed side, and there was marked purulent infiltration of the cortex. Minute foci of hæmorrhage with surrounding purulent infiltration were found in the internal capsule.

SKIN.

Lesions of the skin seem to have played a greater part in the descriptions of the early epidemics than in the more recent. In the early epidemics these lesions gave the commonly accepted name of spotted fever to the disease. Jackson says the skin lesions may occur in any stage of the disease. A rash or miliary eruption may appear. This may itch and the skin be torn by scratching, resulting in the formation of ulcers. He describes particularly the appearance of large blisters, often from two to five inches in length, which seem to have been more common in the reports of the disease from Worcester than elsewhere (Woodward[76]). It is more than probable that these large blisters were due rather to the treatment than to the disease. Sweating was induced by placing billets of wood, which had been immersed in boiling water, in bed with the patient. Such a billet of wood in bed with an unconscious patient is capable of producing such blisters very easily. Every one is acquainted with similar conditions which have been produced by hot water bottles.

The frequency of the skin affections in the first epidemics varied much, according to the different observers. One found that in eighty cases only four had any affection of the skin. Another estimates them as appearing in one-half of all his cases.

Jackson did not regard these lesions of the skin as the seat of the disease, but as being merely symptomatic.

Vieusseaux does not mention these lesions of the skin. North gives a very good description of the eruption. He says "they take the form of blind hæmorrhages, where the blood flowing from the vessels of the skin is detained beneath the cuticle, forming petechial spots. So frequent was this species of hæmorrhage in the early part of the epidemic that it was considered one of the most striking characteristics, and gave rise to the name petechial or spotted fever, which has been very generally but inaccurately given to the disease. These spots appear commonly on the face, neck and extremities, frequently over the whole body. They were generally observed in the early stages of the disease; in size the head of a pin, and a six-cent piece would mark the two extremes. They were evidently formed of extraversated blood. They do not arise above the surface and do not recede upon pressure. In color they vary from a common to a very dark purple, and the darker the shade the more fatal the prognosis. These spots, which in 1806–1807 marked almost every case, in 1808–1809 were rarely observed."

Woodward[76] says there was soreness of the flesh, and spots appeared on the skin the size of half a common duck shot, resembling blood blisters.

North, in a letter to the Philadelphia Medical Museum, says further that some of the patients have in the true skin spots which resemble flea bites. One patient was covered all over with such spots for a number of days, but more commonly there were a few scattered ones on different parts of the body. They are of different grades of color, from red to dark, some resembling bruises. Fiske says an eruption of the skin is not a constant attendant on the disease. It generally comes on in some form or other, according to the violence of the disorder; sometimes appearing as a miliary eruption over the entire body. It may appear in patches in the bend of the arm or the breast or neck, without any discoloration at first. These skin eruptions seem to have been especially abundant in the epidemics in Ireland in 1866 and 1867.

Gordon[165] observed in one case an eruption something like measles, but the patches were irregular in size and shape. They were dark colored, rough looking on the surface and thickly interspersed with petechiæ. In another place he describes a definite eruption, which comes out with great rapidity and is found on all parts of the body, but chiefly on the lower extremities. It is of a very dark color, sometimes deep brown or purple, or even black. In some cases it is studded with black spots, appearing on the nose or face of the patient as though a quantity of black ink were scattered over his face.

Marston found in very few cases an intense eruption of petechiæ, which was followed by rapid coma and collapse. The rapidity with which this very dark eruption appeared, its great extension and the deep collapse which accompanied it gave to the cases a frightful appearance, and caused the people to describe it as the black death.

In all of the investigations on this epidemic in Ireland it was seen that the nervous symptoms preceded the affection of the skin even in the most rapid cases.

In Upham's cases, in Newbern, petechiæ often identical with those of true typhus were seen in all parts of the body except the face.

In the epidemic reported by Hermann and Kober[35] petechiæ on the skin or conjunctiva were frequently seen. Many of the cases reported by Richter[91] had petechiæ and ecchymoses. Gahlberg says that the skin eruptions may vary, and he has seen one case in which it was very similar to measles. In the report by Tipton[114] purpuric spots occurred in some cases, but they were generally absent.

Herpes is far more common than any other form of eruption. It is more common on the lips and nose, but may appear on other parts of the face and even elsewhere on the body.

Klemperer[55] speaks of the frequency of herpes in meningitis, and says it is more common in the epidemic than in any other form.

Leichtenstern found herpes in twenty-six out of twenty-nine cases examined.

Frey[23] describes herpes as very common in the epidemic reported by him.

Hallenstein says that herpes is the most common of the skin affections of the disease. It is most common on the nose and mouth, then on the cheek, forehead, eyes and ears. More rarely there is an eruption of the vesicles on the neck and extremities. Rollet[136] did not find herpes common in the cases examined by him, although he says it was present in Strassburg in nearly all the cases. Friis in the epidemic in Copenhagen found herpes of the lips in seventeen cases. Decloux[16] found herpes and other skin eruptions in all of the cases which recovered.

In this series of one hundred and eleven cases herpes was mentioned as occurring in thirty-five cases. It is possible that its presence was not always noted. The amount of it varied from an eruption of a few fine vesicles to an abundant eruption of large vesicles. Cultures were not made from the contents of the vesicles.

Petechiæ or larger hæmorrhagic foci in the skin were found in eleven cases. They were most abundant in two fatal cases, the duration in one case being two days, in the other seven days. In the two-day case, that of a child, there was present all over the body an abundant eruption, which developed with great rapidity. The spots were more commonly found over the elbows and knees. Circumscribed areas of hyperæmia which disappeared on pressure were mentioned in a few cases. Hæmorrhages in the skin were found in but one of the cases in which a post-mortem examination was made. In the centres of some of these there was a beginning formation of pustules.

PNEUMONIA.

The relation between pneumonia and the epidemic meningitis has been complicated by confusing other forms of meningitis with this. Meningitis is sometimes seen in connection with acute croupous pneumonia, and is due to a metastasis from the lungs. And from this it has become a common belief that pneumonia is a frequent complication even of epidemic meningitis. In most

cases the character of the pneumonia is not defined, but it is apparent that croupous pneumonia is referred to.

It has been frequently stated that epidemics of pneumonia have occurred at the same time with epidemics of cerebro-spinal meningitis, and this statement has been used by those who sought in the pneumococcus the cause of epidemic meningitis. We have not been able to find the authority for such a statement. It is very possible that the opinion of the relation between the two may be due to the fact that both diseases are more common at the same time, — that is, in the late winter and spring. Practically all of these accounts of the relation between the two diseases come from clinical sources.

Levy[65] remarks on the frequency with which congestion of the lungs is found as a complication. He thinks this condition is rather a consequence than a complication of the disease, and is due to the hebitude of the patient and the dorsal decubitus.

Jaffe[167], who reported the epidemic in Hamburg, found but one case of typical fibrinous pneumonia with meningitis, and the clinical history of this case would rather show that the meningitis followed the pneumonia and was probably due to the pneumococcus.

Immerman and Heller[45] speak of the frequency of complications of croupous pneumonia with purulent meningitis at the close of the epidemic in Erlangen in 1866. They say that after a pause of several months, from August, 1866, up to January, 1868, thirty cases of pneumonia were seen, nine of which were complicated with meningitis. This appeared at the end of the epidemic, and they think there is no relation between the two, but that the epidemic meningitis paves the way for the pneumonia.

Leichtenstern, in his admirable account of the epidemic in Cologne, takes up the question, and does not believe that there is any relation between the two.

Croupous pneumonia was found at the post-mortem examinations of two of our cases. In these the pneumonia was the result of infection with the pneumococcus which was found in the lungs, while the diplococcus intracellularis was found in the lesions in the

brain. In several of our cases there were small foci of broncho-pneumonia and small areas of congestion in the lungs from which the pneumococcus along with other organisms was obtained.

It is very possible that many of the cases of pneumonia which have been reported in connection with epidemic meningitis were not cases of genuine croupous pneumonia, but cases of diplococcus pneumonia. This was found in eight cases and in one the amount of lung involved was so extensive that it could have been mistaken both clinically and anatomically for a case of croupous pneumonia. Leichtenstern found no cases of croupous pneumonia in the epidemic reported by him, and opposes the prevalent view that the pneumococcus is the cause of epidemic meningitis. He says "pneumonia is a disease spread over the entire earth, and appears at all times, there being no land immune from it. Epidemic meningitis is very rare, and in many countries is still unknown. Croupous pneumonia attacks every age, the disposition increasing somewhat with increasing age. Epidemic meningitis is a disease which affects children and young people; beyond thirty-five there is slight disposition towards it. Croupous pneumonia has a typical course and a crisis; epidemic meningitis has no crisis. The complications of the two diseases are different. Epidemic meningitis frequently shows multiple synovitis as a complication; this is extraordinarily rare in croupous pneumonia. The affections of the eye, etc., which are seen in meningitis, are extremely rare in pneumonia. The character of the exudation in the two diseases is different, being more fibrinous in croupous pneumonia. It is often difficult to make a differential diagnosis between meningitis and severe pneumonia with predominant brain symptoms."

In these cases, according to Leichtenstern, at the time of the crisis, the brain symptoms drop just as the other symptoms. He thinks it is also possible to distinguish clinically between meningitis arising as a complication of pneumonia and epidemic meningitis. In meningitis following pneumonia contraction of the muscles of the neck is often absent, while in epidemic meningitis it is almost invariably present. Pneumonia-meningitis soon leads to delirium and coma, while in the epidemic form the sensorium

may be normal throughout the entire course. Pneumonia-meningitis, moreover, is rapidly fatal, while the epidemic form is frequently recovered from. The remissions and exacerbations, the varying course and relapses, the following hydrocephalus, the uncertain gait, the eye and ear affections,—are all exclusive attributes of the epidemic form.

Runeberg[98] reports a case of pneumonia with following meningitis which recovered, but in this case the symptoms of meningitis were not definite. In one of Weichselbaum's cases there was lobar pneumonia in connection with the meningitis. He found the pneumococcus in the lobar pneumonia and the diplococcus in the meninges.

Strümpel does not mention croupous pneumonia as a complication in his cases.

THE EYES.

Symptoms relating to the eyes have a prominent place in the descriptions of epidemics of meningitis. North describes dilatation and in some cases contraction of the pupils, redness and suffusion of the conjunctiva, double or triple vision, and in a few cases there was total blindness. Woodward says that the eyes are red and watery. The pupils are dilated in some cases, in others they are small, like those of dying persons. Bestor[78] says the eyes are often red and suffused, and the pupils are enlarged. There may be double or triple vision, and in some cases there was partial or total blindness after the first twenty-four hours. Baxa[2] says blindness is often seen in cases which recover. Friis[25] examined the eyes in thirteen out of thirty cases, and in three of these cases he found congestion of the optic papilla. Tourdes[137] found ophthalmia in six of his cases; in three cases it occurred during convalescence, and was not severe. Daga,[14] in the epidemic in Metz, found purulent ophthalmia in a number of cases, but he considers this to be an accidental complication which is not usually dangerous. Wilson[123] says the eyelids may be enormously swollen, and present the appearance of purulent ophthalmia or suppurative inflammation of the eye-ball. He thinks this may result from lack of sensa-

tion and exposure of the eye. The anterior chamber often contains pus and the choroid and iris are often affected. Blindness may occur either as the result of clouding of the lens, with adhesions and infiltration of the iris, or of atrophy of the optic nerves. Knapp[56] found eye symptoms in four or five per cent. in all cases of meningitis. They appeared ordinarily during the second or third week of the disease. The eye symptoms often took the form of more or less intense choroido-iritis, which could lead to blindness in three or four days. This condition was often accompanied by injection of the conjunctivæ and infiltration of the cornea, with adhesions and discoloration. There was complete blindness in ten of the cases observed by him. He does not think that the eye lesions can be regarded as an extension of the inflammation from the meninges along the optic nerves, but regards it as an acute idiopathic iritis. Collins[168] observed, relatively frequently, serious affections of the eyes, among which he especially speaks of irido-choroiditis with separation of the retina, purulent infiltration of the eye and atrophy. Hirsch describes conjunctivitis as an almost constant symptom.

In the epidemic reported by Frey[23] there was injection of the conjunctiva, strabismus, turgescence of the eyeball and more or less serious disturbances of sight.

In the epidemic described by Blümm[8] both subjective and objective eye symptoms were prominent. The patients complained of light. In one case there was destruction of the cornea. He thinks that softening of the cornea may be due to trophoneurosis.

Hallenstein[169] says the most frequent lesion of the eye is paralysis of the oculo-motor nerves, producing dilatation of the pupil, divergent strabismus and ptosis. Next to this comes paralysis of the abducens with convergent strabismus. The conjunctiva at the height of the disease is injected, reddened and swollen. There are also affections of the cornea, appearing as clouding and ulceration, paralysis and spasms of the eye muscles, abnormal narrowness or dilatation of the pupils, and even complete blindness. The blindness may result either from a purulent

inflammation of the eye with separation of the retina and destruction of the bulb, or from an optic neuritis.

Niemeyer[170] thinks that the affections of the eye arise from imperfect nutrition of the tissue, due to inflammation of the trigeminus. He founds his views on the fact that in meningitis the same conditions of the eye are seen which come from the destruction of the Gasserian ganglion.

Rudnew concludes that inflammation of the eyes is not secondary to the meningitis, and does not arise by an extension of the process from the membranes of the brain to the eye. It comes simultaneously with the affection of the meninges, and is due to the same cause. Disturbances of innervation of the eye were seen in almost all of Strümpel's cases. He says the ophthalmoscopic investigation of the eye may show changes without the sick person being aware of any disturbance of sight.

Randolph[90], in the epidemic in Lanaconing, examined the eyes in thirty-five cases, twenty of which were fatal. He reports the different cases in detail, and from this some idea of the character and frequency of the lesions may be gained. In the thirty-five cases examined the fundus was normal in but seven. Of these seven cases one had divergent strabismus and dilated pupils. The right eye was more often affected than the left. Every case of strabismus was of the divergent variety. He found congestion of the optic disc in many cases, and thinks this marks the beginning of optic neuritis. There was atrophy of the optic nerves in one case which recovered. Osler[84] has reported a case similar to the one described by Jack (page 144), in which there was total blindness following a case of meningitis with gradual recovery of sight after months. Omerod[82] found in one case internal strabismus of the right eye, but the fundus of each was normal. In one case there were purpuric spots on the conjunctiva. One of the cases reported by Mills and Cahall[71] was blind and deaf three weeks before death. In the cases reported by us no systematic examination of the eyes was made in all cases.

Various abnormal conditions of the eyes were noted in sixty-seven cases. Strabismus, usually affecting both eyes, was noted in twenty-eight cases. It was convergent in thirteen, divergent

in eight, and in the remainder its character was not noted. Conjunctivitis was not commonly present; it was noted in but ten cases, and in these the condition varied from injection of the conjunctiva up to a purulent discharge. In one case the purulent secretion of the conjunctiva was examined for bacteria, but no diplococci were found. In many cases irregularity in the pupils was noted. In one case there was slight bulging of the eyes. No post-mortem examination of this case was made, so that it cannot be known whether this condition was due to purulent infiltration of the orbit. Nystagmus was seen in but ten cases. In none of the cases which recovered was there complete blindness.

We are indebted to Dr. Edwin E. Jack for the following description of the eye lesions observed by him in the cases seen at the Children's Hospital: —

The conditions found were conjunctivitis, dessicating keratitis, strabismus, contraction and dilatation of the pupil with little or no reflex action, inequality of pupils, neuritis of various grades, from reddening of the disc to violent inflammation of the choked-disc variety, post-neuritic atrophy and purulent choroiditis. No cases of loss of vision without ophthalmoscopic appearances such as might occur from trouble at the convexity were observed, though one case in which no ophthalmoscopic examination was made must remain in doubt. Visual acuteness and fields of vision could naturally not be taken. There was no implication of the orbital tissue in any case and no œdema of the conjunctiva. Conjunctivitis was frequent. The dessicating keratitis seen was due to the imperfect closure of the lids and secondary necrosis of the cornea. Strabismus caused by paralysis or irritation of the ocular nerves by exudation at the base was present in many instances, and in those personally observed was always convergent. It is doubtful if there was any paralysis of the third nerve except so far as the pupillary branch was concerned. Strabismus seemed to have no connection with the severity, length or outcome of the disease. Of all the children still alive who had this symptom I have found but one in whom the squint persists, though diplopia is not apparent. No instances of conjugate deviation were noted.

Neuritis, present or past, as shown by atrophy of post-neuritic character, was present in at least six cases, and probably in more; for, in addition to the cases not seen, no case was recorded as having neuritis without having definite signs in the way of cloudiness of the disc or distended or tortuous vessels. It was suspected in others from the appearances, so that the number is probably larger than stated. It is often hard, even under the most favorable circumstances, to decide whether a disc is

abnormal or not; but in these children, the struggles and movements of the eyes making only a fleeting glance possible, mucus on the cornea and in some instances an uneven surface, made the task still more difficult. Neuritis was apparently no more common in the fatal cases than in those who recovered, and was most marked in two children who still live. One of these had violent neuritis with hæmorrhages, which had not then gone on to atrophy, and the sight was apparently perfectly good. I have recently seen this child. The vision is as good as ever, the discs are normal, showing no traces whatever of the previous inflammation. The other is a remarkable instance of restored vision after weeks of blindness. The child was ill a very long time, was extremely emaciated and had decidedly atrophic discs. Much to my surprise, two weeks ago I found a vision which enabled the child to go about readily; the disc was more pink in color and the vessels were actually larger. Her mother stated, perhaps with exaggeration, that the child could recognize her at a distance from the yard to the second or third story window In this case there was total deafness, which has persisted.

There were two cases of purulent choroiditis. This condition closely resembles glioma of the retina. One of the children died, the other lived, and is to-day perfectly well, with the exception of a useless right eye. The fatal case was a very marked one, with a history of some weeks' illness before entrance. It was said by the parents that the right eye, meaning probably the lids, was swollen one week before, and that after that the eye began to look small. When seen, the eye was much smaller than the other, soft, had considerable ciliary injection, pupils moderately dilated (atropin had been used), iris discolored, its pupillary edges frayed and uneven, and from behind the lens was seen a yellow reflex tinged with red, the whole making a typical picture of what is known as metastatic choroiditis. This child was very ill, and in marked contrast with the other one, who came into the hospital looking perfectly well, and indeed nothing out of the way could be found. The day previous he had had vomiting and slight fever. On the second day the eyes were looked at and the fundus was normal. On the third day there was vomiting, pallor, coldness, weak pulse and the child seemed partially unconscious, but was better in the evening. Strabismus was apparent. Next day it was noticed that the right eye was red. In two or three days the child was all right again, the strabismus had disappeared, and from that time he seemed well. At the first appearance of the inflammation in the eye, on account of great difficulty in examination, the child screaming loudly even when approached, nothing was made out except iritis and a deposit of lymph in the pupil. Later the typical yellow reflex was visible, making the diagnosis certain, the general appearance resembling that already described in the first case, though the eye was not so shrunken at that time.

This case is interesting for several reasons: first, the coincidence in point of time of the only cerebral symptoms, and the beginning of the process in the eye; second, the fact that the lumbar puncture was negative. With reference to this, on account of the possible doubt it might throw on the diagnosis, it should be stated that the patient's sister died

at this same time, after less than a week's illness, of undoubted cerebro-spinal meningitis. In her case lumbar puncture was positive and optic neuritis was present. Third, it shows that this complication is not limited to severe or fatal cases.

Notwithstanding the frequency of the eye complications in cerebro-spinal meningitis, there have been but few anatomical investigations of the eyes after death. Rudnew and Burzew examined the eye in one case. Pus was found in the ciliary region and in the vitreous. They regarded the lesions in the eye as probably embolic.

Hoffman[41] reports an interesting condition of the eye following meningitis. There was complete blindness in one eye in a case which recovered, with ptosis, dilated pupils, immobility of the eye-balls and swelling of the lids. This condition remained for some time. He then operated, and found the sheath of the optic nerves dilated into an ampular form and evacuated considerable pus.

Saltini[99] investigated the eye in two cases of meningitis. One eye was removed three and one-half minutes and the other four or five minutes after death. He found total separation of the retina and extensive inflammatory destruction especially of the anterior equatorial parts of the uvea and retina. There was also atrophy of the optic nerve, with cellular infiltration of the sheath and of the septum.

Leichtenstern reports that at one autopsy all the cranial nerves were bathed in the exudation, and the oculomotor nerve was rosy red. There were no cases seen of involvement of the optic nerve, and no cases of pan-ophthalmitis.

Confusion has also arisen, in that this form of meningitis has not been distinguished from the pneumococcus and other forms. Axenfeld[1] reports four cases of metastatic inflammation of the eye, due to the pneumococcus, and two of these were from meningitis. One of his meningitis cases was secondary to an acute endocarditis. He found no continuity between the organisms in the sheath of the optic nerve and those in the interior of the eye. There were fresh capillary emboli in the retina, which he regarded as the source of the eye lesions. He

does not think that it has been shown in a single undoubted case that there is a continuity between the inflammation in the eye and that in the meninges. In one of the autopsies reported by Klebs[54] there was purulent infiltration of the tissues of the orbit.

When we review the eye lesions of this disease, it can easily be seen that they are due to three causes. In the first place, there may be neuritis or degeneration of the nerves of the eye, due to their involvement in the exudation at the base of the brain without any extension of the inflammatory process to either the orbit or the eye. This condition seems to affect the oculomotor more than the other motor nerves. The optic nerves may also be involved in this exudation. Secondly, the inflammation from the meninges may extend directly from the brain into the eye, the route most frequently chosen being the pia arachnoid of this nerve. All of the cases of purulent choroido-iritis, and the very rare cases of suppuration in the orbit, are probably due to such an extension. Most of the ophthalmologists seem to have a deeply rooted belief that these conditions are due to metastasis, but it is plainly not a metastasis but a direct extension. Undoubtedly there are cases of metastatic choroido-iritis seen in connection with other forms of meningitis, but in these cases both the meningitis and the eye lesions are due to metastasis. Such are the cases of meningitis accompanying acute endocarditis, croupous pneumonia and certain other infectious inflammations. The lesions of the cornea may be due to an extension of the inflammation to this from the iris and ciliary region, which was undoubtedly true in one case examined. The third cause of the eye lesions, and that to which most of the cases of keratitis in meningitis are due, is neuritis of the fifth nerve, with destruction of the Gasserian ganglion and loss of sensation. There are no lesions due to tropho-neurosis. Purulent conjunctivitis, which is frequently found, may also be due to this lack of sensation. We have but one record of the examination of the pus from the conjunctiva, and in this case no diplococci were found in the pus.

EAR COMPLICATIONS IN MENINGITIS.

The symptoms relating to the ears play an important part in all the descriptions of meningitis. That there should be disorders of hearing is apparent from the study of the lesions. In all the post-mortem examinations made by us in which the auditory nerves were examined there was a greater or less degree of involvement. The nerve was generally swollen and surrounded by exudation. Microscopic examination showed in some cases purulent exudation along the nerve sheath, with more or less complete destruction and infiltration of the nerve. The studies of nerve degeneration showed extensive degeneration of the nerve fibres in all cases examined, the degeneration being most marked in the more chronic cases. The bony ear was saved for examination in a number of cases, but it has not been possible to complete the microscopic examination. This has been done by others, however, in a number of cases, and the anatomical foundation of the ear symptoms has been established.

The first investigation on the condition of the internal ear in epidemic cerebro-spinal meningitis comes from Heller,[172] who examined the ears in two cases in the epidemic in Erlangen in 1865. In both he found acute purulent inflammation of the labyrinth, which he thought was due to the extension of the inflammation from the brain along the nerve. Schwabach[101] gives a more detailed account of the examination of the ears in a case of otitis, which developed in the course of an attack of meningitis. The symptoms of ear trouble developed seven days after the beginning of the attack, and consisted in throbbing, drumming, difficulty of hearing and unbearable pain. Death took place five weeks after the beginning of the disease. He found great hyperæmia of the vessels in the course of the acoustic nerves and in all parts of the labyrinth, purulent inflammation of the sheath of the acoustic and ecchymoses between the fibres. There was abundant formation of granulation tissue in some of the branches of the nerves and in the ganglia, combined with suppuration and hæmorrhage. Pus was found in the peri-lymphatic spaces of the scala and other parts.

There was slight purulent infiltration of the sheath of the facial nerve on the right side. In the pus taken from the middle ear by puncture of the drum he found enclosed in the cells diplococci which he says resembled the pneumococci. (It is most probable that this was the diplococcus intracellularis.) Lucae[173] examined the ears in a case of cerebro-spinal meningitis which was fatal in twenty-four hours. At the post-mortem examination he found a purulent infiltration of the meninges which extended along the facial and acoustic nerves. The exudation extended along the acoustic to the cochlea and vestibule, and into the semi-circular canal. There was no alteration of the middle ear or of the drum membrane.

An interesting case is that reported by Schultze,[100] who examined the ears of a deaf-mute, five years after an attack of meningitis, to which the condition was due. There was atrophy of both auditory nerves and formation of granulation tissue in the labyrinth. Nothing remained of the organ of Corti. The cavity of the cochlea was filled with osteoid tissue and round cells.

Kochner says in the disease of the ear which follows meningitis there may be ecchymoses with thickening and softening of the membranous part of the labyrinth. Moos[72] says the inflammation extends along the perivascular and perineural lymphatics from the brain to the ear. From the perineurium of the acoustic nerve the disease extends to the labyrinth. Merkel has found destruction of the semi-circular canals in one ear.

In all these investigations it has generally been seen that the disease of the ear was secondary to the meningitis, and due to extension of the inflammation from the brain to the ear along the nerves; or, as Mosler[73] has suggested, to an involvement of the striæ acousticæ in the fourth ventricle. There was nothing found in our cases which spoke in favor of this view of Mosler.

Some confusion has existed in the minds of writers as to the relation between otitis and meningitis, some regarding the ear affections as primary, others as secondary to the meningitis. There are forms of meningitis which are secondary to ear disease, and result from the extension of the inflammation in the

ear to the brain. The infection in these cases, according to Körner,[174] may take place by contact with the diseased bone or by extension of the suppuration. In all the cases which we have seen of this, the infectious organism was either the pneumococcus or the streptococcus. The ear lesions of epidemic cerebro-spinal meningitis are always secondary.

Voltoline[175] described as an independent disease inflammation of the labyrinth, beginning with intense pain in the head, vomiting, high fever and convulsions. It lasts for some days, and usually ends in recovery. It often leaves deafness and uncertain, trembling gait. One of the chief points which makes Voltoline regard this as an independent disease, and not as a complication of meningitis, is that it only affects children, and in a short time tends to recovery. He finds that herpes of the lips, so common in meningitis, is rare in the labyrinth disease. In the ear disease vomiting is constant and may be absent in meningitis. This view has been shown to be erroneous by Moos and by Leichtenstern. Leichtenstern says there are slight abortive cases of epidemic cerebro-spinal meningitis which lead to deafness in consequence of a simultaneous affection of the labyrinth, so that the affection of the labyrinth may seem to be the most important or primary.

These ear lesions are the most common of the complications of meningitis. Schwabach[101] found that one-half the cases of deaf-mutism were the result of disease of the central nervous system. Moos[72] found that of sixty-four cases of meningitis which recovered fifty-nine per cent. were deaf, thirty-one per cent. had normal hearing and in seven the hearing was impaired. Out of forty-three cases deafness appeared in two on the first day, in six on the second, in three on the third, in seventeen between the fourth and tenth and in fifteen between the fourteenth day and the fourth month. He thinks that it is possible that the abortive form of epidemic cerebro-spinal meningitis is the cause of many cases of early acquired deafness. Erhardt observed twenty-seven cases of deafness after cerebro-spinal meningitis, and comes to the conclusion that the severity of the disease stands in no relation to the deafness. The deaf-

ness appears suddenly, without pain, and, as a rule, in the beginning of the disease. Jackson[125] found purulent discharge from the ears in a number of cases, and in a few there was deafness on recovery. Friis[25] found seven cases of ear disease in thirty cases investigated by him. Of those that recovered, two had otitis media, one otitis interna and one was partially deaf without discoverable cause. Knapp[56] reports a case of unilateral deafness. The character of the disorders of hearing has been investigated. Kochner found, in the cases studied by him in Wurzburg, many variations in the character of sound perception. There were transitions from more or less difficult hearing to absolute deafness. When deaf to ordinary sounds, patients could often distinctly hear scratching noises. Blümm[8] describes buzzing and hammering in the ears and hallucinations of hearing. Mosler[73] gives the history of a case with slow recovery. At first there was total deafness, after a time loud sounds could be distinguished; there was ringing in the ears during the entire time. The walk was at first trembling and uncertain, but gradually became better. Gahlberg[27] reports the case of a child three years old which recovered, having a tottering, swaying motion and a tendency to turn in a circle. The disease of the internal ear may or may not extend to the middle ear.

In the notes on our cases pathological conditions relating to the ears are mentioned sixteen times. The conditions found varied from pain and mastoid tenderness to deafness with or without otitis media. One case was operated on for mastoiditis, and pus was found in the sinuses. Otitis media developed in five cases, and in three of these the pus was examined for diplococci. The organisms were found enclosed in pus cells in all three of the cases examined. These cases of secondary otitis media with diplococci in the pus cells are important, from the possibility of further infection which they offer. They also furnish proof of the extension of the infection from the brain.

NOSE AND THROAT.

Acute Coryza.

There is but little mention of acute coryza as a complication. Richter reports that in all his cases there was coryza in the beginning, and nasal catarrh was sometimes seen among the prodromata. Strümpel says that in a number of his cases meningitis was preceded by nasal catarrh, and in one case there was marked disturbance of smell. This matter is of interest, in view of the opinion which was first advanced by Weigert, that in meningitis the nose forms the portal of entry for the infectious organisms. In our cases acute coryza is mentioned but once. There were three cases of epistaxis, and in one this was among the first symptoms noted.

Scherrer examined the noses in eighteen cases, and in the secretion of all found pus cells with diplococci. He believes that this examination of the nose is one of the most important points in the diagnosis of the disease.

The nasal secretion of nineteen of our cases was examined by means of cover-glass preparations. The preparations were stained first by Gram's method and afterwards with a solution of Bismarck brown, as in the method for the examination of urethral pus for gonococci.

The material for examination was obtained in most instances from the higher portions of the nasal cavities, with the aid of the platinum "loop."

Of the fifteen cases, ten showed the presence in the nasal secretion of diplococci, decolorizing by Gram's method, and identical in morphology with the diplococcus intracellularis meningitidis. They occurred as a rule in small numbers, and were very frequently observed inside of polynuclear leucocytes.

Similar Gram decolorizing diplococci were also found within leucocytes in the nasal secretions of two cases of convalescent meningitis. Attempts were made to isolate this diplococcus by cultures in ten cases in which the microscopical examination showed it to be present, but without success. This was probably

due to the large number of colonies of other bacteria which developed and to the relatively small number of the diplococci.

With reference to the occurrence of this organism in the nasal secretions of patients not affected with meningitis, twelve hospital patients, chosen at random, were examined. In the nasal secretions of two among these twelve diplococci like the preceding were found by cover-glass examination. They were not cultivated.

From the results of these examinations it would seem either that the diplococcus intracellularis may be met with in the nasal secretion of patients who have not meningitis, or that other species of diplococci identical with this morphologically and in staining peculiarities may be found there. It is greatly to be regretted that it was not possible to obtain cultures of the organisms from this locality, for only by that method combined with inoculations can the identity be established. At any rate, it is impossible to regard the presence of diplococci decolorized by the Gram stain in the nose as of much diagnostic value, as has been claimed by Scherrer.

The mucous membrane was examined microscopically four times, and in one case pus cells and small numbers of diplococci were found. In three other cases in which the membrane was examined at autopsy no inflammatory condition was found. The relation of acute coryza to meningitis is of great importance, and it is one point which must be cleared up in the future investigation of the disease. Even assuming that the organisms found in the nose were certainly the diplococcus intracellularis meningitidis it would seem that the presence of an acute coryza with organisms in the pus cells is not a conclusive proof that the nose forms the portal of entry for the organisms. The acute coryza can be just as well a secondary complication, and due to the entry of the organism into the nose from the brain.

Inflammation of the throat is frequently mentioned in the earlier accounts of the epidemics, but not in the latter. Jackson says that patients often complain of sore throat, and the fauces were often found red and inflamed. North says that aphthous patches were often seen in the throat. In one of Daga's cases there were

small abcesses in the tonsils. Lavaran says that the tonsils are frequently the seat of small abcesses. Faure-Villar [160] mentions a case in which there was gangrenous pharyngitis complicating the disease. In one case reported by Senator [103] there were drops of pus in the tonsils. Swelling and abscess of the tonsil were found in one of our cases at autopsy, and a culture from the abscess material showed the presence of diplococci. The tissue was not examined microscopically.

JOINTS.

Acute inflammation of the joints is frequent in meningitis. Jackson says in some cases the joints and limbs were swollen, and resembled gout. North describes swelling of the joints, resembling acute rheumatism. Lavaran says that acute articular rheumatism was very common at the same time with the epidemic of meningitis, and was found as a complication in one of the cases of meningitis. In three of the cases reported by Richter [91] there was acute inflammation of the joints. In one it appeared on the sixth day. Kotsonopulos,[109] in the epidemic observed by him at Nauplia, Greece, found acute inflammation of the joints in a large proportion of his cases. He gives no anatomical description of the lesions. Strümpel found multiple swelling of the joints in several cases. In one of the cases reported by Friis there was an inflammatory exudation in the knee joint, but no organisms were found in the synovia examined. Berg says that in the epidemic in New York, in 1895, affections of the joints were present in most of the cases which he saw. The knees were most commonly affected; and the condition varied from pain to swelling, redness, and conditions simulating acute articular rheumatism. Levy found pus in the joints twice. In one case there was phlegmonous pus in almost all the joints, extending into the sheaths of the tendons. There are no records of any microscopic examination of these joints, and the only record of an examination of the pus for organisms is that given by Friis. In six of our cases acute inflammation of the joints was found. Five of these cases recovered. At all of the post-mortem examinations the articulations were examined with great

care, but no lesions were found in them. It is greatly to be regretted that the opportunity was not given for careful bacteriological and histological examination of this interesting condition, to ascertain its cause and its relation with the other lesions of the disease.

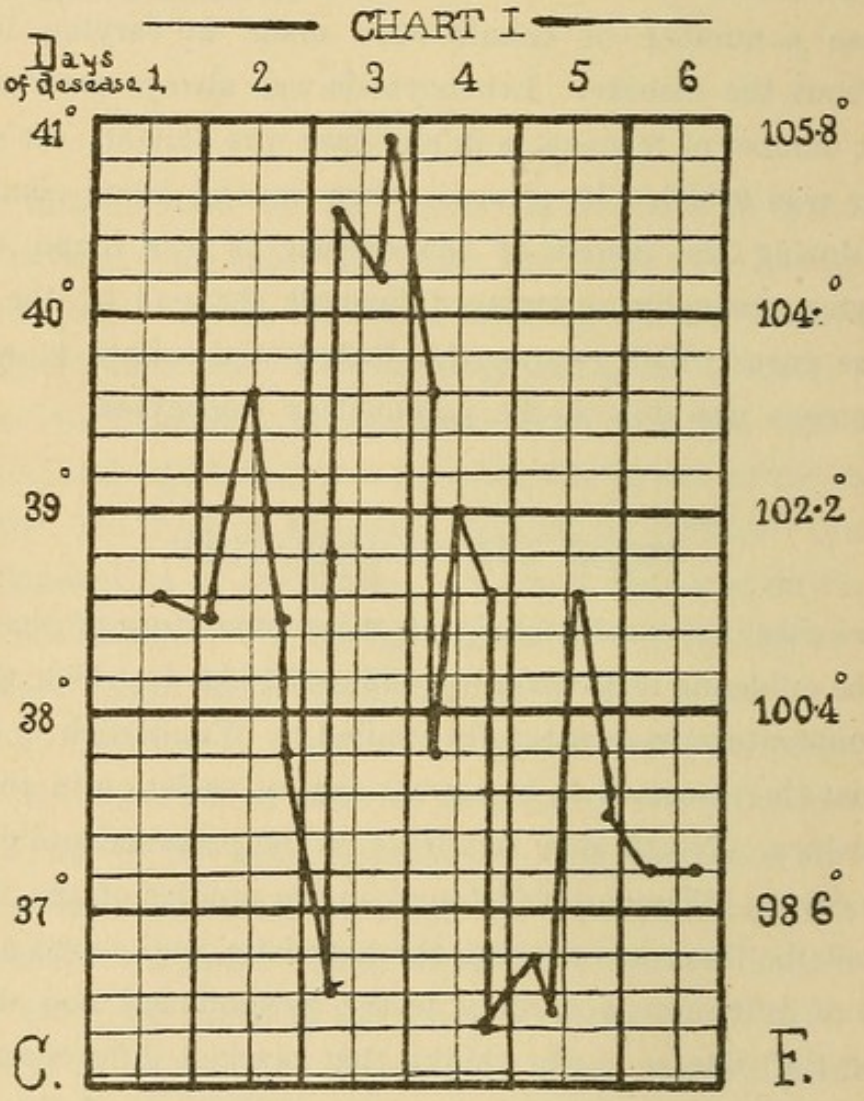
BLOOD.

Blood counts were made in thirty-three cases. In many of these a number of counts were made at varying intervals throughout the disease. Leucocytosis was always present. The highest number of leucocytes in any case was 31,000; the smallest number was 9,350. In general, when several blood counts were made during the course of the disease it was found that the leucocytes gradually diminished towards the end of the disease in those cases which recovered. Differential counts showed that the increase was due to the polynuclear leucocytes.

PULSE AND TEMPERATURE.

There was no careful study of the temperature of the disease until the epidemic in Leipzig in 1863 and 1864, in which the pulse and temperature were carefully studied by Wunderlich. Jackson says that there seemed to be a great deal of variation in the bodily temperature. North says but little on the presence and character of the fever. Wunderlich[140] found in his studies of the temperature that the fever has nothing characteristic, and shows a marked degree of difference, according to the development and the duration of the disease. He thinks that marked differences in the course of the fever may be due to complications of the disease. Exacerbations of the nervous symptoms are not always coincident with a rise of temperature. The fever can have the course and the exacerbations and may attain the height of a typhoid temperature, but the curve varies materially from this. It is more similar to the fever in tuberculosis, and in no place shows the regularity of the typhoid curve. The most marked characteristic of the disease is the inequality between the pulse and temperature. The fever is of short duration, and, while the temperature may reach

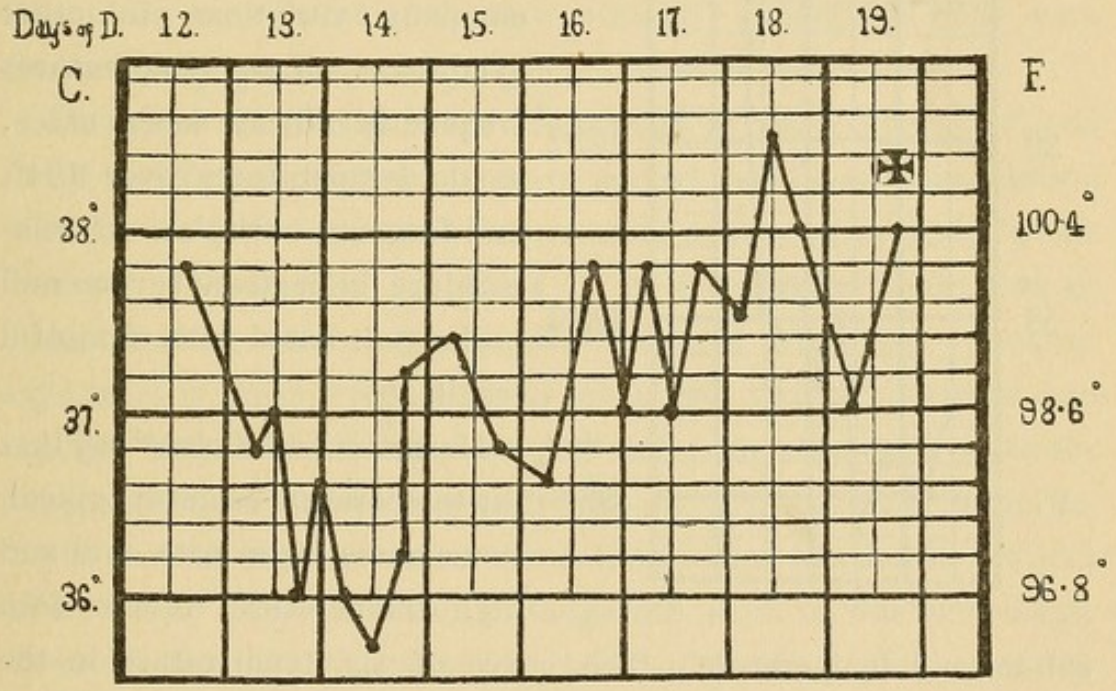
a considerable height, the pulse often remains normal. In the article by Strümpel there is also an interesting study of temperatures. He finds no relation between the height of the fever and the severity of the other symptoms. He gives a temperature chart, in what he speaks of as the abortive type, in which there is a temperature up to 105⅘° on the third day, and on the sixth, normal temperature.



He says, on the one hand, that severe cases may have a rapid course with but little fever; and, on the other hand, very mild cases may have high fever. In a number of cases there was no relation between the degree of fever and the other symptoms. The accompanying curve, which is taken from Strümpel, gives an example of a very severe case, ending fatally with but slight fever. It is possible for the most severe cases to run their course without any or very slight increase of tem-

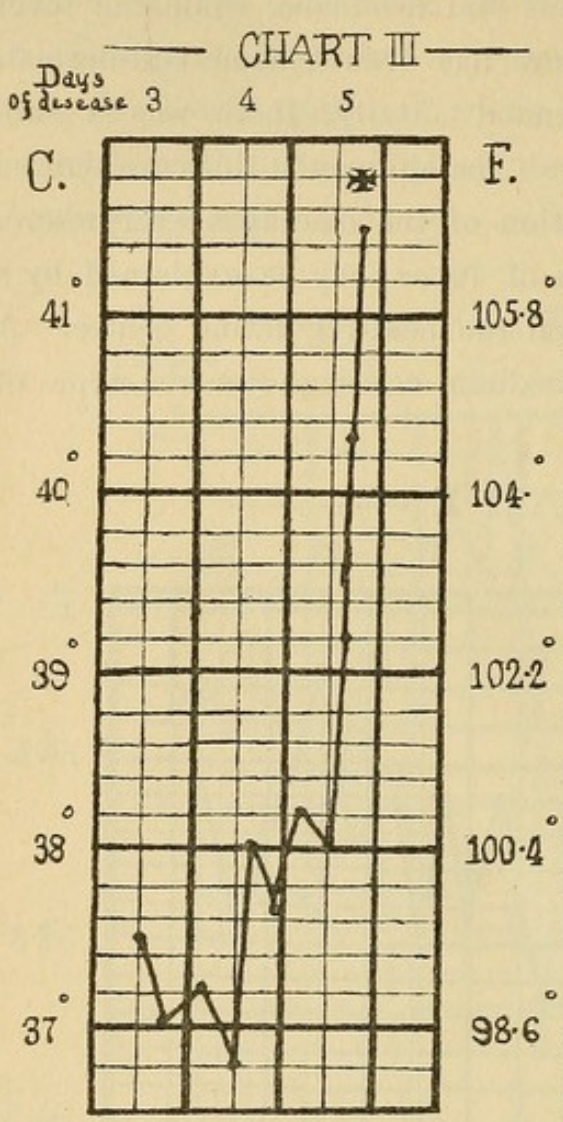
perature. The fever may suddenly drop, but the symptoms do not abate; for weeks there may be severe disturbances of consciousness, delirium, opisthotonos and headache, while the fever has long ceased or the temperature has even become sub-normal. In one of his cases which ended fatally, there was a sub-normal temperature throughout. The autopsy in this case showed a very marked purulent infiltration of the meninges everywhere, and he thinks that the absence of fever may be explained by a direct influence of the lesions on the heat-regulating centre. A large number of severe and medium cases shows the type of

CHART II



remittent fever. The temperature rarely reaches the height of 104° and varies between 102.2° and 100.4°. Sometimes this course is interrupted by deep remissions. In these cases the curve has a certain similarity with the curve in mild cases of typhoid. The fever ceases gradually, and the fall is interrupted by irregular rises and falls. Strümpel has seen cases of typical intermittent character, and the intermissions took place in the morning and forenoon. He gives two cases showing typical intermissions. Both recovered. A terminal rise of temperature was seen in a number of his cases, and he gives the curve of one case in which there was a rise to $107\frac{3}{5}°$. (Chart III.)

Grimshaw,[32] in his study of the temperature in the disease, concludes that there is no typical temperature chart. In mild cases the fever seldom exceeds 100°. In some rapidly fatal cases 103° was found, and in none was there a temperature of over 104°. The degree of the temperature and the rapidity of the pulse have not that accord usually found in acute diseases. Variations in temperature seldom precede but usually accompany variations in other symptoms. Low temperatures frequently indicate severe cases, as do temperatures over 104°, and frequent variations of temperature indicate a severe and prolonged case with doubtful result.



Hermann and Kober[35] say that the temperature is never typical. Some cases begin with chill and high temperature, others with sub-normal temperature. The curve of the temperature in the course of the disease is always irregular. There are remissions and exacerbations, sometimes continuous sub-normal temperatures, and at others the curve shows the type of continued fever, with a temperature of 102.2° to 104°. Levy[65] says the disease frequently begins with chill; the temperature in general is not high and the pulse is slow.

Gahlberg, in the epidemic of Mailburg, found the temperature low, usually not exceeding 102.2°. Hermann[36] reports one case in which the temperature was very high, reaching 113°. In the cases reported by Berg[3] in New York, in 1893, he found in some rapid rise and fall of temperature. As a rule the temperature was not high, but cases dying in a comatose condition as a

rule have high temperatures, up to 106° or over. Most of Berg's observations were made on children.

Bungeroth says many cases begin with chill and sudden increase of temperature, while in others the temperature is scarcely raised above normal, and it gradually increases, sometimes to a considerable degree. In the first report by Leichtenstern of the cases in Cologne he says that the fever is exceedingly irregular and atypical, and not always proportionate to the severity of the case. Severe and fatal cases may show for some time a sub-normal temperature, which increases rapidly at the end. In some of his cases there was agonal and post-mortem elevations of temperature. Sub-febrile temperatures were often interrupted by a rapid rise, which could take place at any time of the day or night. Sometimes there were marked daily variations at irregular intervals.

The pulse shows the same irregularity as the temperature, and in all the epidemics observers have agreed that there is no relation between the pulse and temperature, such as is seen in acute febrile diseases. North says the pulse is often soft and weak, slow or slower than in health, often intermittent and fluttering. Jackson says there is great irregularity in the pulse, and its character and rapidity vary at short intervals. Wunderlich says that, while the temperature may reach a considerable height, the pulse often remains normal or even under normal, and this relation is not met with in any other disease. Bungeroth says it was constantly observed that the pulse was soft and small in the beginning of the disease. In severe cases it was thread-like and could scarcely be felt. In fatal cases the pulse generally becomes rapid and intermittent, or it changes suddenly from very slow to very rapid, so that in a minute it varied from 70 to 130.

Mankopf observed in a series of cases that the rate of the pulse in the beginning of the disease was diminished, so that even in high temperatures at the beginning of the disease the pulse scarcely reached normal, and might be below it. In almost all of the fatal cases the rate of the pulse went up to over 120, while at the same time the temperature fell. Leichtenstern found that the pulse varied enormously. Changes from 80 to 100 in the following minute were seen. Absolute slowness of the pulse was

not common. Relative slowness in relation to the temperature was found often, especially in children. In two cases reported by Presse[38] there was strong pulsating movement of the entire head, and in a child seen by Danielson and Mann there was such strong pulsation that the fontanells bulged.

The slight variations in these descriptions of the pulse and temperature are probably due to the small number of cases seen by some observers. In going over the histories of the cases we have carefully studied the attached charts, and the extraordinary irregularity of the temperature is most striking. Single charts might be selected which for a week or more show a curve very similar to that of typical cases of typhoid fever. We have appended a number of charts of pulse and temperature to the description of the individual cases, which will give a fair idea of the great variability of both pulse and temperature. These record the morning and evening temperatures, and the four-hour charts show the same irregularity. In one case there was a rise of 5° during the visit of the attending physician. None of these curves shows the temperature for the whole period of the disease. A variable length of time, from one day to several weeks, elapsed from the onset of the disease until the patient entered the hospital. It would be very important to have a few observations of temperature from the onset. All the observations on temperature which have been recorded were made on hospital patients in all of whom the beginning of the fever would be lost. These variations in temperature do not seem to have been dependent upon complications of the disease. In one case the onset of acute croupous pneumonia was marked by a sudden rise in the temperature. While we believe that it would not be possible from a single temperature to diagnose the character of the disease, the observation of a number of charts in an epidemic would enable us to be certain of its character.

MENTAL CONDITION ON RECOVERY.

The influence of epidemic meningitis in producing a permanent impairment of the mind has not received the attention it should

have. It is certain that pathological alterations may be produced in the brain which are not easily recovered from. Baxa found that the disease was sometimes followed by idiocy. According to Blümm, the influence of the disease on the intelligence may be marked. In our cases there are four notes on abnormal mental conditions of patients at the time of discharge from the hospital. Marked mental impairment was noted in two cases, a third was irrational and childish and a fourth was stupid and did not recognize his relatives. None of these cases could be followed up, to see whether the mental disturbance was permanent.

DIAGNOSIS.

The diagnosis of typical cases of epidemic meningitis is easy, and other diseases should not be confounded with it. Krannhals[58] says there may be symptoms exactly resembling those of meningitis, without the anatomical lesions. He gives the clinical history of seven such cases, with six deaths. It is difficult to say on what grounds the diagnosis of meningitis was made in the cases which died. Suddenness of attack, vomiting, pain and stiffness of neck, inequality of the pupils, irregularity of the pulse and temperature were all lacking. There was headache, partial coma, delirium, clonic convulsions, clonic stiffness of the muscles. In every case the spleen was enlarged, and in one case very much so. In the case which recovered the symptoms very much resembled those of cerebro-spinal meningitis. He says that during the epidemic of influenza in Riga, in 1889 and 1890, there were six cases diagnosed as meningitis. One of these cases proved to be endocarditis, one pneumonia and the four others true cases of meningitis.

Koht[59] speaks of a case of influenza in which there were typical symptoms of meningitis, but the autopsy showed only hyperæmia.

Strümpel says there may be a clinical picture of a primary acute cerebral disease without appreciable cause, so that a diagnosis of acute meningitis is apparently justified, and the autopsy may be entirely negative with the exception of hyperæmia or œdema or some such slight alteration.

Hermann thinks that the diagnosis is easy in general, but in children may be confounded with tubercular meningitis; and some of the cases with abundant skin eruption may be confounded with typhoid.

It is difficult to make an absolute diagnosis of any disease from the symptoms alone. The surest method of diagnosis, and one which should always be carried out when possible, is by lumbar puncture. The method is easy, and experience has shown it to be devoid of danger. If properly carried out in the early stages of the disease, which is the time when there is most difficulty in diagnosis, it is almost conclusive. It certainly deserves to be ranked as a method of diagnosis with the examination of the sputum. If the patient has meningitis, a more or less cloudy fluid will be withdrawn. If it is the epidemic form, diplococci will be found in it either on microscopic examination or in cultures. It is of the greatest importance, in the study of the epidemics that this method of diagnosis should be carried out especially in the sporadic cases. In some of the chronic cases if seen late there may be a question of diagnosis between meningitis and typhoid fever.

SUMMARY.

Epidemic cerebro-spinal meningitis is an acute infectious disease, which is produced by a micrococcus characterized by its growth in pairs and by certain cultural and staining properties. The organism, so far as we can tell by laboratory experiments, is one of feeble vitality, but it must be remembered that we cannot produce in the laboratory exactly the same conditions that the organism might find in nature. The essential seat of the disease is in the meninges of the brain and cord. How the organism gains access to the meninges is not actually known. It is possible that the nose forms the portal of entry, the organism passing from the nose to the meninges by means of the lymphatics connecting this with the subdural spaces. In a number of cases organisms identical with it on microscopical examination, have been found in the nose together with evidences of slight acute inflammation. These or-

ganisms have not been cultivated and have been found in other diseases. The lesions in the meninges are confined to the pia-arachnoid, in which an acute purulent inflammation is produced. From the meninges the process extends into the brain substance. Lesions are found not only in the cortex but in the depth of the tissue and in the ventricles. These lesions consist in part of purulent infiltration of the tissue both around the vessels and elsewhere, together with proliferative changes in the neuroglia and degenerative changes in the ganglion cells and nerve fibres. The cord is always affected, and to a greater extent than in any of the other forms of meningitis. The organisms are found in considerable numbers in the most acute cases. In the more chronic cases they may be missed. Probably the surest method of diagnosis in the disease is that by spinal puncture. If the puncture be made in an early stage of the disease, a fluid more or less clouded by the presence of pus cells will be found, and in these pus cells there are variable numbers of the organisms. In many cases the growth of the organism is so feeble that great care must be exercised in making the cultures, and large amounts of the fluid used. If the spinal puncture be made late in the disease, the results may be negative. The disease, especially in its chronic form, is characterized by remissions and exacerbations. Spinal puncture may be negative if made during a remission, and positive in the exacerbation.

A marked feature in the pathological lesions of the disease is the tendency for the infection to extend along the nerves, particularly along the optic, auditory and fifth nerves. By its extension along the optic nerve it may produce a purulent inflammation of the orbit or a purulent inflammation of the eye. In its extension along the fifth nerve it produces an acute inflammation of the Gasserian ganglion, with destruction and degeneration of the nerve cells composing it. By its extension along the auditory nerve it may lead to destruction of the internal auditory apparatus, with or without acute inflammation of the middle ear. In the acute inflammation of the middle ear, which appears not infrequently as a complication of the disease, diplococci are found in the pus cells. It is possible that the presence of the organisms in the nose is to be referred to such an extension, and not to a primary invasion.

The organism does not produce a general septicæmia. There is no general invasion of the other tissues of the body.

The organism is capable of entering the lung and producing a focal pneumonia characterized by especial anatomical features. In the periphery of the foci there is a hæmorrhagic œdema of the tissue. The foci vary in size from a pea or a bean to an involvement of the lung comparable to an acute croupous pneumonia. In the large areas of consolidation several centres are usually found. This form of pneumonia was found in eight of our cases. It may appear either in the very acute or in the more chronic cases. It seems probable from the microscopic study of the lesions that the organism enters the lung by means of the blood vessels rather than by the bronchi. The possibilities of bronchial infection are given by the presence of the organism in the nose from which it could easily extend into the bronchi, and by the disease of the middle ear, the organisms from here entering the throat by means of the eustachian tube.

The symptoms of the disease are those which might be expected from the anatomical lesions. There are no prodromata, and the usual history is that of sudden onset, with vomiting and pain in the head. In most cases there is pain, stiffness and muscular contraction of the neck, which may extend to the muscles of the back and the lumbar region. There is usually delirium, and in many cases unconsciousness passing into complete coma. There are numerous complications in the disease. Those of the eye and ear are easily understood. The joint complications which are seen with greater or less frequency in some epidemics (and they have been very frequent) cannot be explained. No opportunity was given in the study of the epidemic for the microscopic and bacteriological examination of these joints.

Degenerative lesions of the nerves have been found to a greater or less extent in all the cases in which these were looked for.

The cases reported were seen in the Boston City Hospital, the Children's Hospital and the Massachusetts General Hospital. Few cases seem to have been seen in private practice. The disease was most prevalent among the poor, and the cases were very generally distributed over the city.

Reports as to the contagiousness of the disease vary, but the general opinion is that the disease is not propagated by contagion. In this epidemic there were seen several instances in which two cases came from the same house and family. There were one hundred and eleven cases seen in the epidemic, and of these seventy-six died and thirty-five recovered, making a mortality of sixty-eight per cent.

There is some ground for the assumption that many of the cases of sporadic meningitis are of the epidemic form. The disease may be present in a community and only show itself in scattered sporadic cases. Then under favorable conditions, the nature of which we do not understand, the number of cases may increase to an epidemic. The epidemics of the disease usually last more than a year and slowly decrease, but the disease does not disappear. The mortality is high and varies much in different epidemics, ranging from twenty to seventy-five per cent. So far as we have been able to learn from a review of the literature methods of treatment have but little influence on the mortality. The disease is most apt to appear in the young, cases being rare in persons over thirty-five years of age.

Meningitis Due to Various Infectious Organisms.

With a view of ascertaining the frequency, together with the clinical and anatomical features of cerebro-spinal meningitis due to other organisms than the diplococcus intracellularis, we have collected a number of cases from the reports of the laboratory for the past five years. Most of those cases come from the Boston City Hospital, but a number of them are from private autopsies, and the bacteriological and histological examinations in these cases were made at the Sears Pathological Laboratory of the Harvard Medical School.

In the literature of meningitis there are a number of cases reported of infection with various organisms, but there is seldom a complete description from both a clinical and anatomical point of view. When the clinical history is good, the bacteriological and anatomical investigation has usually been imperfectly carried out, and *vice versa*. We have found the infection of

the meninges to be most commonly caused by the tubercle bacillus, the pneumococcus and the streptococcus. In one case, the entire history of which is very imperfect, there was a mixed infection with the bacillus pyocyaneous and the staphylococcus aureus, and in another case the infection was due to the anthrax bacillus.

In most of these cases the meningitis is secondary to infection elsewhere, which fact complicates the clinical history relating to the meningeal symptoms.

Meningitis Due to the Pneumococcus.

Judging from the literature, the pneumococcus appears to be the organism most commonly associated with meningitis. Not only has it been found in most of the sporadic cases, but extensive epidemics are reported as having been caused by this organism. The fact that the pneumococcus organism was the first organism that was described in connection with acute meningitis, and that the first cases in which it was found were cases of meningitis secondary to pneumonia and acute endocarditis, has led to this organism being generally regarded as the cause even of epidemic meningitis. We have found in our reports ten cases in which the pneumococcus was found, and so associated with the lesions of the disease that it can certainly be regarded as the cause. In eight of these cases the meningitis was secondary. In two there was fracture of the base of the skull, extending across the temporal bone, the organism evidently gaining entrance into the meninges from the middle ear. In one there was otitis media with necrosis of the bone, and the pneumococci were found both in the pus from the ear and in the meninges. In three the meningitis was secondary to acute croupous pneumonia, and in one case to acute fibrinous pericarditis. In one case there was broncho-pneumonia and thrombosis of the longitudinal sinus. In two the affection of the meninges was primary, no other lesions due to the organism having been found in the body. We regret to say that in none of these cases was the histological examination carried out so thoroughly as in the epidemic meningitis. Only portions of the brain cut from

various places with the meninges attached were examined as a matter of routine, to confirm the anatomical and bacteriological investigation. A thorough and systematic examination of the nerves was not made. In two cases, one of them primary and the other secondary to croupous pneumonia, the sections and portions of tissue were preserved, and from these more detailed examinations have been made.

The records of the autopsies show some difference in the description of the amount and distribution of the exudation in the meninges. In one case secondary to acute croupous pneumonia there was only a slight fibrino-purulent exudation over the base of the brain extending a short distance over the lateral convexity on each side. In another case there was extensive exudation over the base and over almost the entire surface of the brain. In but one case is it especially mentioned that the exudation extended in lines along the vessels in the sulci, a condition which was so common in the epidemic meningitis. The exudation was usually confined to the meshes of the pia arachnoid, but in one case it is said to have been both in the membranes and on the surface. The microscopic examination showed considerable differences in the lesions here as compared with the epidemic form. Fibrin was present in the exudation in much greater amount. It was found both forming a mesh-work within which pus cells lay, and in separate masses. The fibrin was generally in coarser filaments than in the exudation in the lung alveoli, and in places had undergone hyaline transformation. Some of the smaller veins were thrombosed and surrounded by a reticulum of hyaline fibrin, a condition similar to that often found in the vicinity of diphtheritic membrane. In the specimens examined the exudation was confined to the meshes of the pia-arachnoid, the surface of the arachnoid being smooth and free from change. The cells in the exudation were chiefly polynuclear leucocytes. These were most abundant in the meshes of the fibrin, and were to some extent seen in large masses without any fibrin between them. Close to the surface of the brain and beneath the surface of the arachnoid, in addition to the polynuclear leucocytes, there were large numbers of cells somewhat larger than these, with round vesicular nuclei.

None of these contained pus cells in its protoplasm. While it seems probable that these cells came from a proliferation of the connective tissue cells of the meninges, it was not possible to prove this. The large cells enclosing large numbers of leucocytes which were so prominent in the exudation in epidemic meningitis were generally absent. In one of the cases a few were found on the borders of the masses of pus cells. The most marked feature in the process in both the pneumococcus and the streptococcus meningitis was the acute endarteritis. This condition is similar in kind to the vascular lesions which have been described in tuberculosis of the meninges. The condition of the circulation in these vessels could not be ascertained. In many of them there seemed no other change than the acute inflammation of the wall. In some the lumen was filled with cells, chiefly leucocytes, and in others there was a mass of fibrin and red corpuscles. The inflammatory change consisted essentially in an accumulation of cells between the endothelium, which was generally elevated in festoons, and the elastic lamina. In some cases the cell accumulations were so great as to occlude the lumen of the vessels, the endothelial coat lying as an irregular mass in the centre. In others the changes were so slight that they might escape notice. The endothelium in some places was broken through and rolled up, the cells then filling the vessel. The cells were principally polynuclear leucocytes, and among them some larger cells of an epithelioid character. It was not possible to ascertain the probable origin of the larger cells in the specimens we have. The muscularis in most cases was unchanged; in others it was partially invaded by leucocytes. In one case extensive lesions were found in the muscularis. The vessel was greatly dilated, the muscularis in places apparently broken through or destroyed, and in these places the tissue was filled with leucocytes. Outside of the muscularis there was often considerable exudation. In the sections of the meninges of the cord which were examined, the exudation was of the same character as that in the brain, but more limited in amount. There were but slight changes in the tissues of the brain. In one case there seemed to be no involvement of the cortex, and in the other there was œdema and slight

softening of the outer layer of the cortex, with some infiltration with pus cells. No lesions were found in the neuroglia.

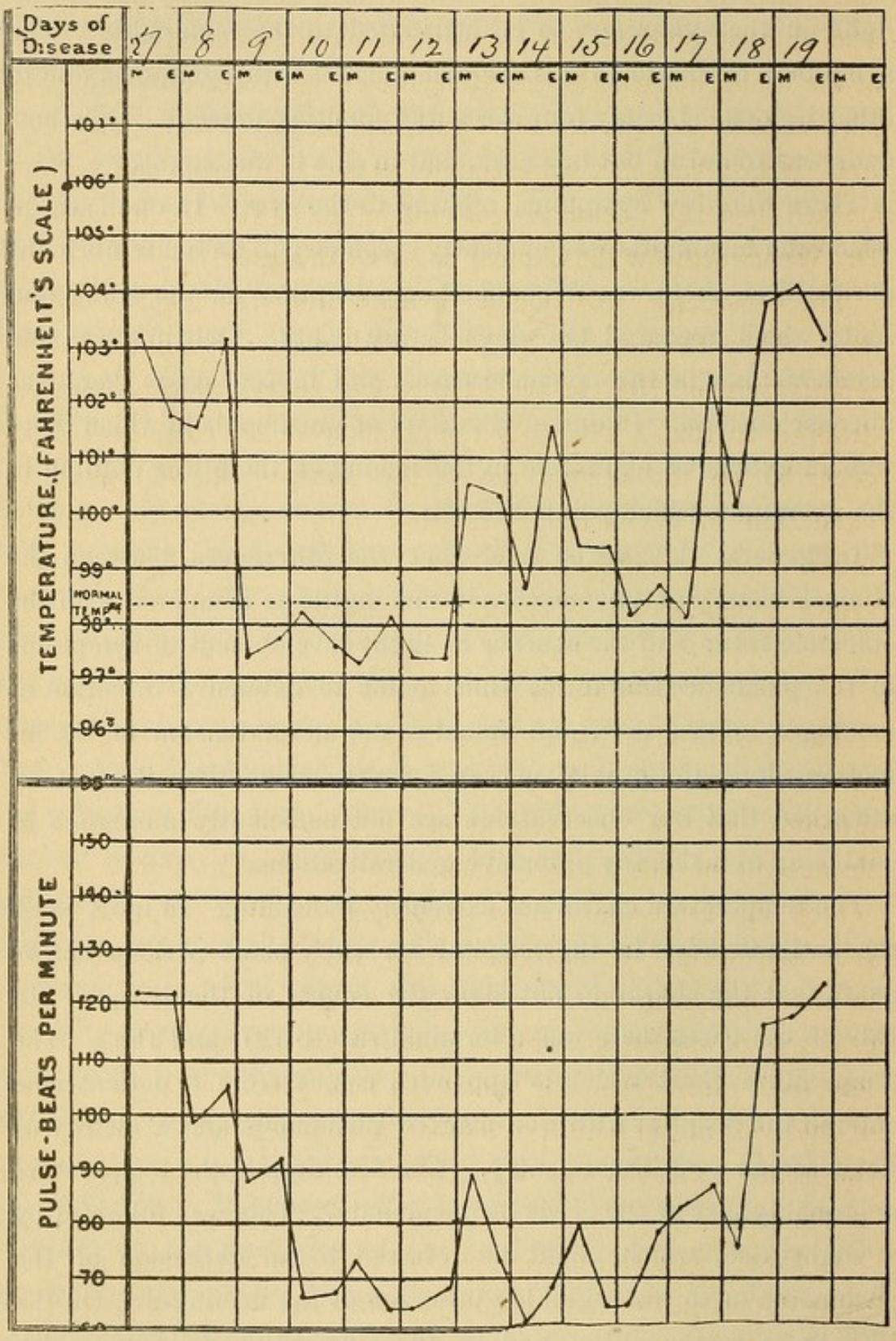
The clinical histories in the eight cases in which the meningitis was secondary to other conditions do not throw a great deal of light on the symptoms to be attributed to the meningitis. The symptoms referable to this are complicated with symptoms due to other lesions. In only four cases was vomiting present. Opisthotonos was found in but one case, and in this it was slight.

There were few symptoms relating to the eyes. In one case, in which the meningitis was evidently secondary to an acute fibrinous pericarditis, there was a hæmorrhagic eruption on the trunk and limbs which appeared two days before death. Delirium was less common than in the epidemic cases, and in four cases there was unconsciousness. In one of the cases of pneumonia in which there was an extensive exudation in the meninges there was nothing in the symptoms which pointed to this.

In general it may be said that the differences between the clinical history of pneumococcus meningitis as compared with the epidemic form is in the absence or slight development of symptoms in the pneumococcus form, which point to extensive infection of meninges, of the cord and spinal roots, and extension of the infection along the cranial nerves. At the same time it must be remarked that our observations are not sufficiently numerous to enable us to make any extensive generalizations.

The temperature charts are extremely indefinite. In most cases the patients were in the hospital for such short periods before death that the charts do not show the course of the disease. In two of the cases there was a terminal rise to 107° and 108°. The temperature chart which is appended comes from a patient who entered the hospital with well-marked pneumonia and a history of sickness one week before entry. The first drop in the temperature is probably that of the crisis of pneumonia. This was followed by a slight rise, which might be referred to an extension of the pneumonia or to the beginning infection of the meninges. On the 16th there was vomiting, and on the 17th active delirium, which continued until unconsciousness came on a few hours before death. At the autopsy there was gray hepatization in the lower lobe of

right lung, red hepatization in the lower lobe of left lung, and fibrino-purulent meningitis. All of the eight cases were in adults, and the average age was thirty-four years.



Greater interest is attached to the two cases in which the meningitis was primary. In one case, a well-nourished and

well-built child of ten months, there was a history of slight gastro-intestinal disturbances two weeks before onset. The disease began with restlessness, high fever (105° F.) and vomiting, the temperature continuing high until death, three days after onset. The autopsy showed fibrino-purulent exudation in the meninges of the brain, apparently extending down the cord, only the upper portion of which was removed with the brain. Pneumococci with well-marked capsules were found in the meninges, and cultures showed general pneumococcus infection. (We are indebted to Dr. Wentworth for the clinical notes on this case.)

The other case was that of a child who was taken when six days old with general clonic convulsions, accompanied by a temperature of 104° in the first twelve hours, which afterwards dropped to 102°. The only symptoms were convulsions. Death occurred on the second day. The autopsy showed extensive exudation in the meninges of the brain (cord not examined). Microscopic examination of the exudation showed numbers of typical pneumococci. (Rotch, "Pediatrics," p. 695.)

Meningitis Due to Streptococcus.

There were eight cases of this, and in all the meningitis was secondary to infection elsewhere. In four cases the primary infection was in the ear, and in two of these there was thrombosis of the lateral sinus. In one the meningitis represented an extension to the meninges of an erysipelas of the face and scalp. In one case there was acute endocarditis, and in one the meningitis was secondary to an alveolar abscess. One case was of special interest, in showing an infection which doubtless took place from the nose. In this case there was fracture of the base of the skull, extending across the cribiform plate of the ethmoid bone. Pus and abundant streptococci were found in the nose.

In these cases the lesions in the meninges were very similar to those found in the pneumococcus infection. The exudation was purulent, with a variable amount of fibrin, usually not so much as in the pneumococcus cases. The acute endarteritis was well marked, and there was no extension of the process into the brain.

The organisms were found in large numbers in the exudation. The clinical histories of all these cases do not show anything of especial importance. Opisthotonos was found in but one case, and was not well marked. Pain and stiffness of the neck were found in two cases. Symptoms referable to the eyes were noted in three cases.

Tubercular Meningitis.

Twelve cases of tuberculous meningitis were found. Tuberculosis of the meninges in general presents a different anatomical picture from tuberculosis elsewhere in the body, in the extent of the acute inflammatory lesions with fibrino-purulent exudation, which accompanies the formation of tubercles and tuberculous tissue. This, though present to some extent in tuberculous lesions elsewhere, never reaches the same extent as in the brain.

We shall not enter into a more detailed description of the clinical and anatomical features of this form of meningitis, which is perhaps the best known of all.

Anthrax Meningitis.

The case is that of a man about forty years of age, a teamster, engaged in handling hides. He had a carbuncle in the neck, which was removed by operation. Infection of the alimentary canal probably took place through the instrumentality of his fingers, which he was constantly putting into his mouth to feel an inflamed tooth. At the autopsy there were thirteen carbuncles in various places in the intestinal canal, and an acute hæmorrhagic meningitis with focal hæmorrhages throughout the brain. The exudation in the meninges was distinctly hæmorrhagic, and numerous anthrax bacilli were found in the tissues.

There is no doubt that acute meningitis may be produced by the entrance into the meninges of a number of infectious organisms. These forms are rarely primary. The organisms enter the meninges either by the formation of a communication between the meninges and some cavity where they may be accidentally present (as in the middle ear or nose), or by the ex-

tension to the meninges of an infectious process in the vicinity (mastoiditis, erysipelas), or they are brought to the meninges by the blood from some other focus in the body (pneumonia, endocarditis). In tuberculous meningitis we have never found a single case in which the lesions in the meninges could be regarded as primary. The only two cases of apparently primary infection were in the two pneumococcus noted, and in one of these the infection may have come from the intestinal canal. We believe that all infections of the meninges other than the diplococcus intracellularis are fatal, but this can only be determined by microscopic and bacteriological examination of the exudation obtained during life by spinal puncture. If tubercle bacilli, pneumococci or streptococci are found with the evidences of meningitis in a case which recovers, it would settle the point; clinical evidence, without lumbar puncture, will not.

DESCRIPTION OF PLATES.

Plate 1:—

FIG. 1. Forty-eight-hour culture of diplococcus intracellularis on Loeffler's blood-serum mixture.

FIG. 2. Abundant growth in twenty-four-hour culture on fresh blood-serum. The colonies are minute, very numerous, and somewhat resemble similar cultures of the pneumococcus.

Plate 2:—

FIG. 1. Portion of the surface of the brain from case of five days duration.

FIG. 2. Posterior surface of lumbar cord from the same case.

FIG. 3. Portion of surface of brain from a case of seventy-four days' duration.

Plate 3:—

FIG. 1. Pus cells containing diplococci from the meninges. A few diplococci are in the exudate outside of the pus cells. Between the pus cells there are delicate fibrillæ of fibrin. The drawing is an accurate representation of a group of cells in the field of the microscope.

FIG. 2. Pus cells from an alveolus of the lung in a case of diplococcus pneumonia. The cells are swollen, and contain immense numbers of diplococci.

FIG. 3. Section passing through a sulcus in brain of goat which died of experimental meningitis. The exudation extends into the cortex, and there are pus cells both around the vessels and infiltrating the tissue.

Plate 4:—

FIG. 1. Cross-section of optic nerve close to eye, showing the purulent infiltration of the inner sheath of the nerve in places extending between the nerve bundles.

FIG. 2. Cross-section of the posterior root of lower dorsal cord from an acute case, showing hyperæmia and purulent infiltration of nerve.

Plate 5:—

FIG. 1. Longitudinal section of auditory nerve in acute case, showing purulent infiltration in and around the nerve.

FIG. 2. Section of edge of Gasserian ganglion from acute case, showing purulent infiltration of nerve and ganglion.

Plate 6:—

FIG. 1. Section of posterior root ganglion of cervical cord, showing purulent infiltration with degeneration of ganglion cells.

FIG. 2. Portion of meninges in acute case, showing the formation of large epithelioid cells. The cells lying free enclose polynuclear leucocytes. Immersion.

Plate 7:—

FIG. 1. Section of posterior root from chronic case, showing perivascular infiltration. The plasma and lymphoid cells are the most numerous. The cells with deep-blue protoplasm are plasma cells. Immersion.

FIGS. 2, 3, 4. Sections showing neuroglia proliferation: Fig. 2, neuroglia cell from olfactory nerve, showing nuclear figure; Fig. 3, same from optic nerve from acute case; Fig. 4, large neuroglia cells, some with numerous nuclei from beneath lateral ventricle in case of fourteen days' duration. Immersion.

Plate 8:—

FIG. 1. Section of posterior nerve root, showing degeneration. (On the right the nerve has been slightly crushed in cutting.) Marchi method.

FIG. 2. Section of optic nerve from same case as Plate 4, Fig. 1, showing degeneration. Marchi method.

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Fig. 1.

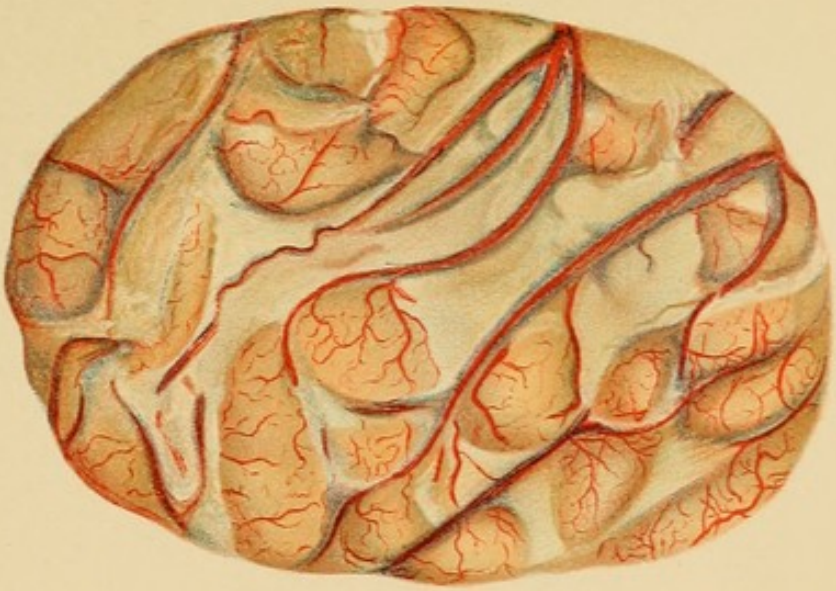
Fig. 2.

F. Byrnes, del.

HELIOTYPE PTG. CO. BOSTON

CEREBRO SPINAL MENINGITIS.

[Councilman.]



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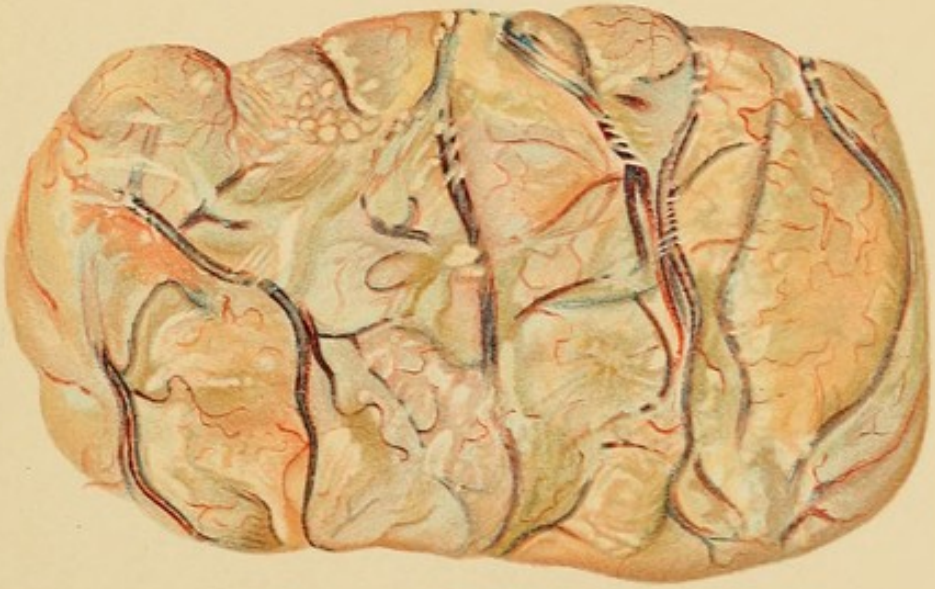

Fig. 3.

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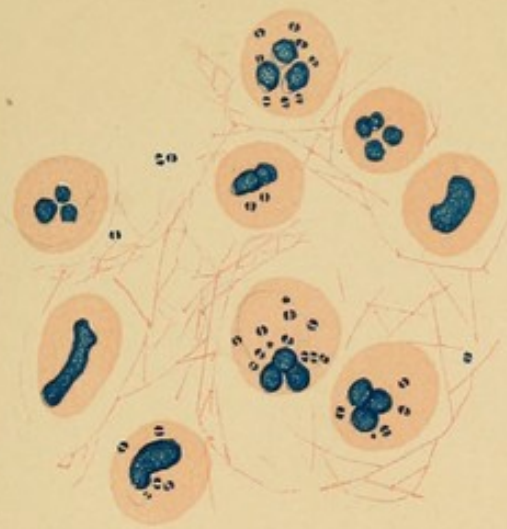

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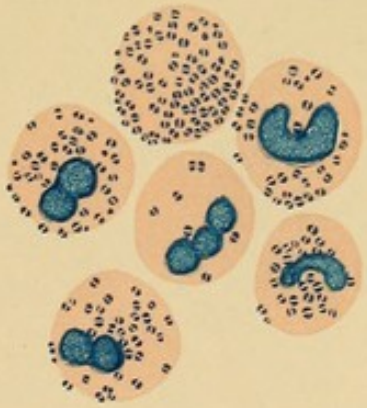

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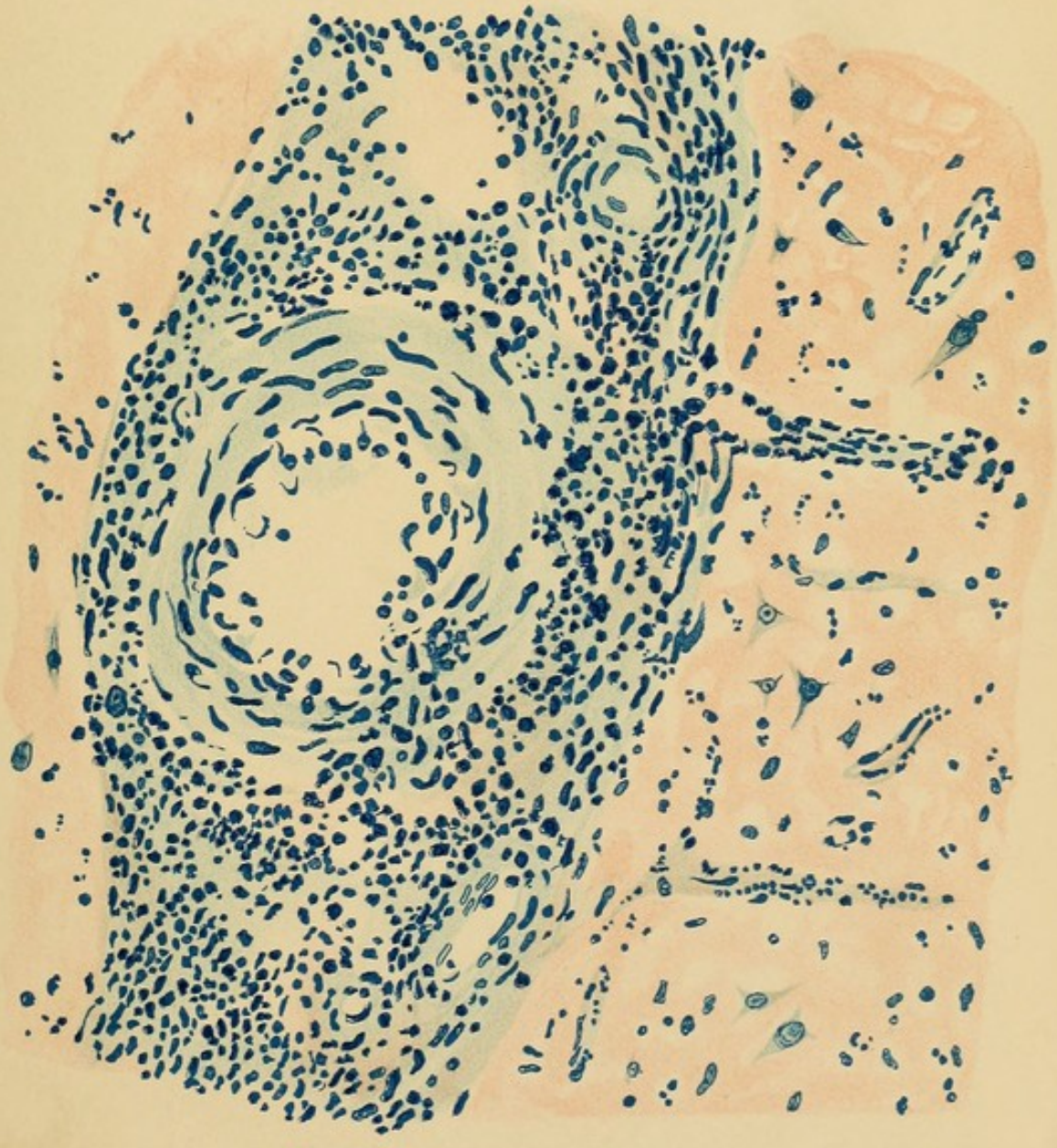

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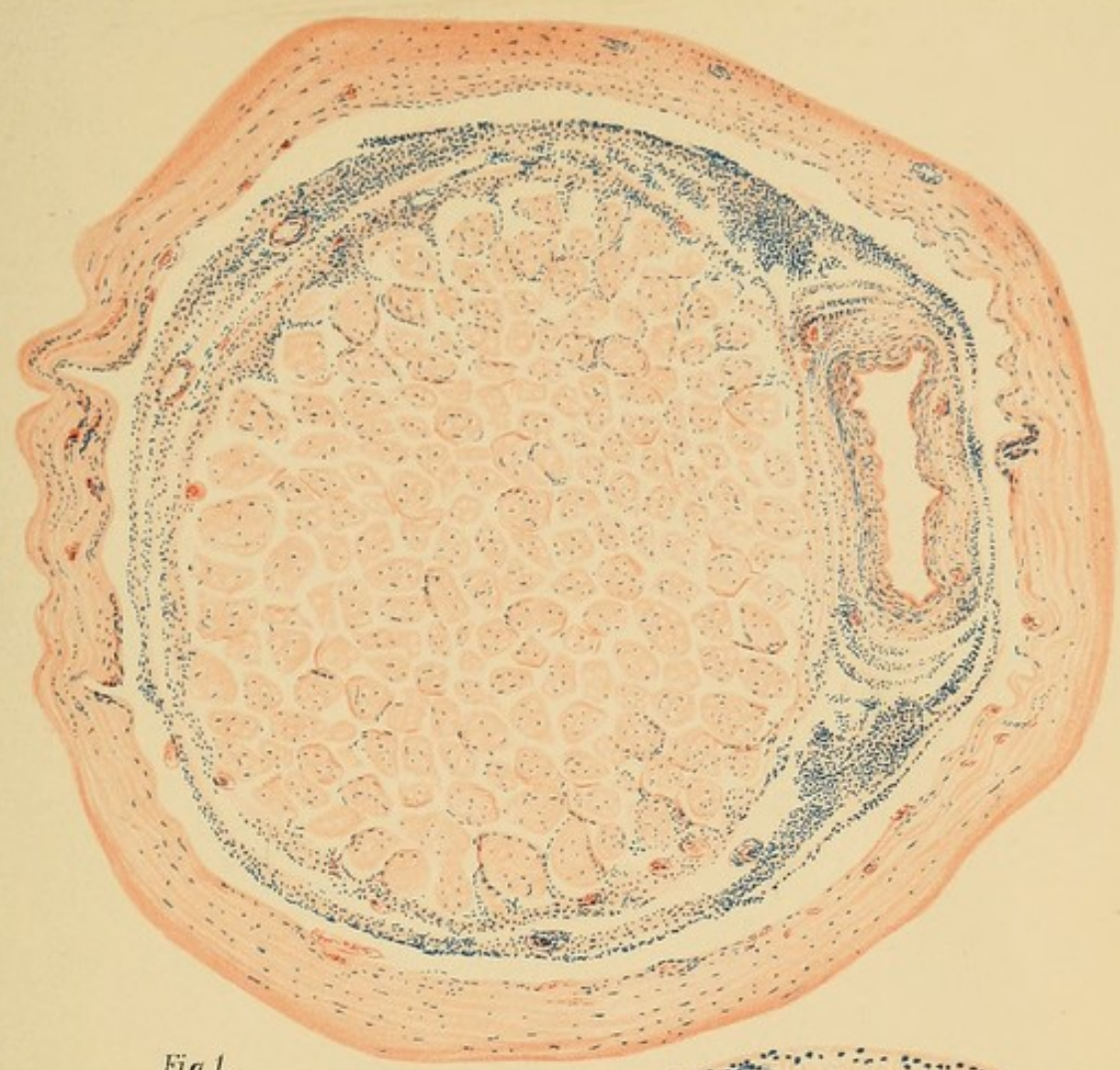

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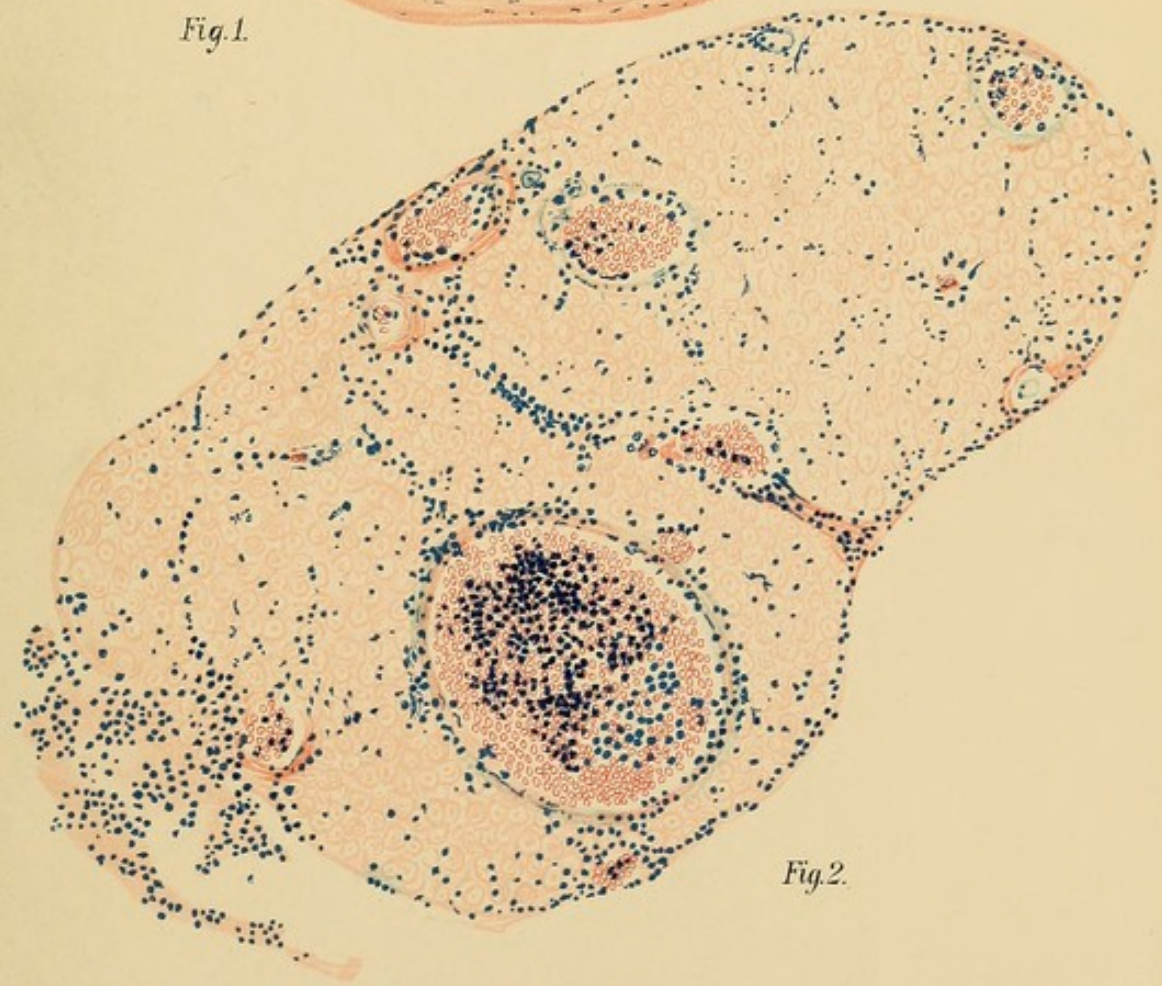

Fig. 2.

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HELIOTYPE PTG. CO. BOSTON

CEREBRO SPINAL MENINGITIS.

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Fig. 1.

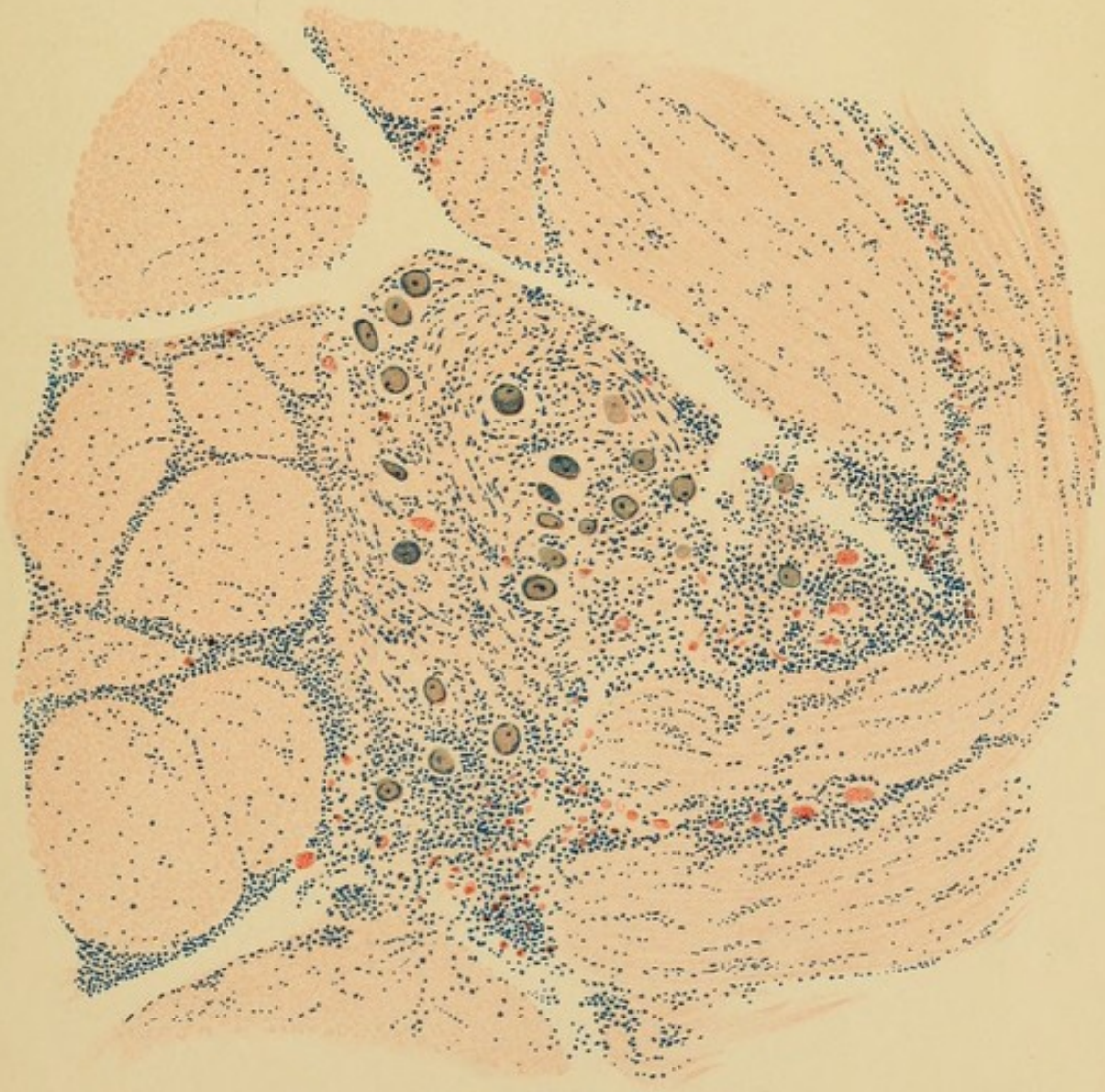

Fig. 2.

F. Byrnes, del.

HELIOTYPE PTG. CO. BOSTON

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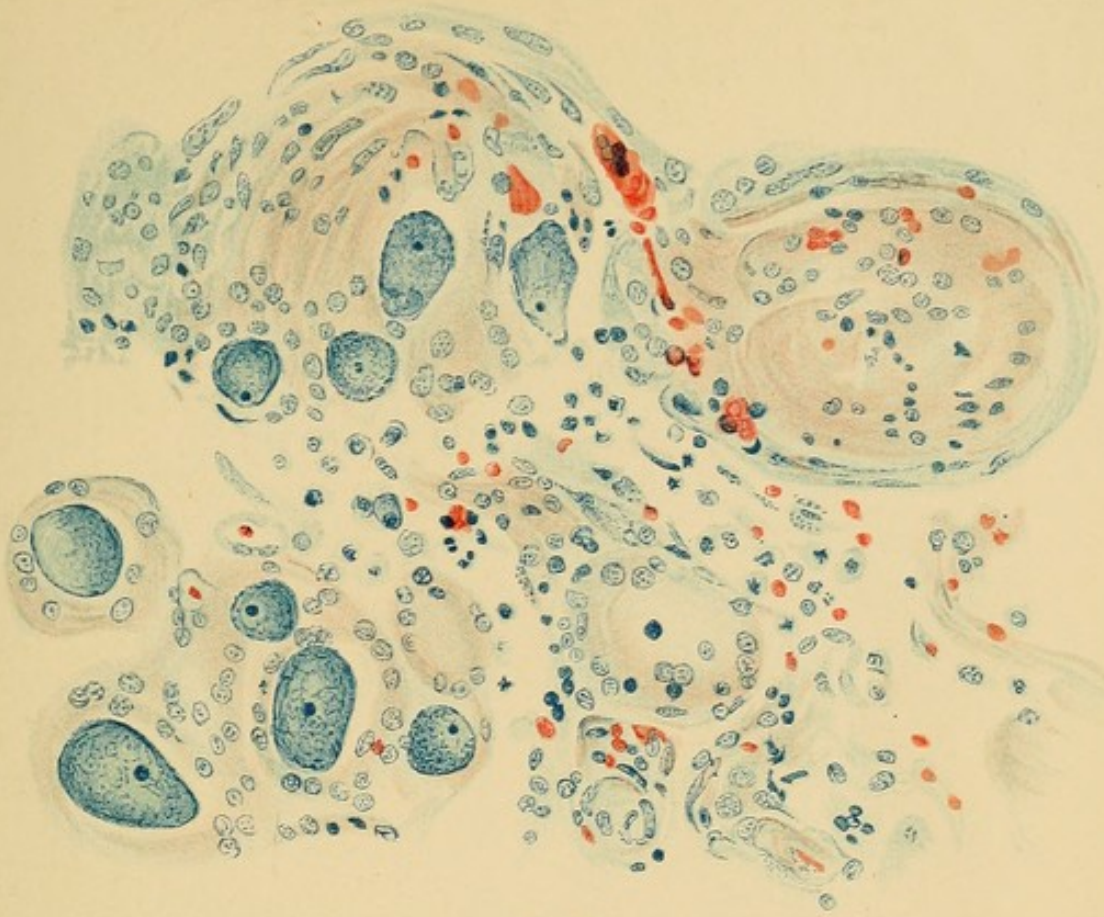

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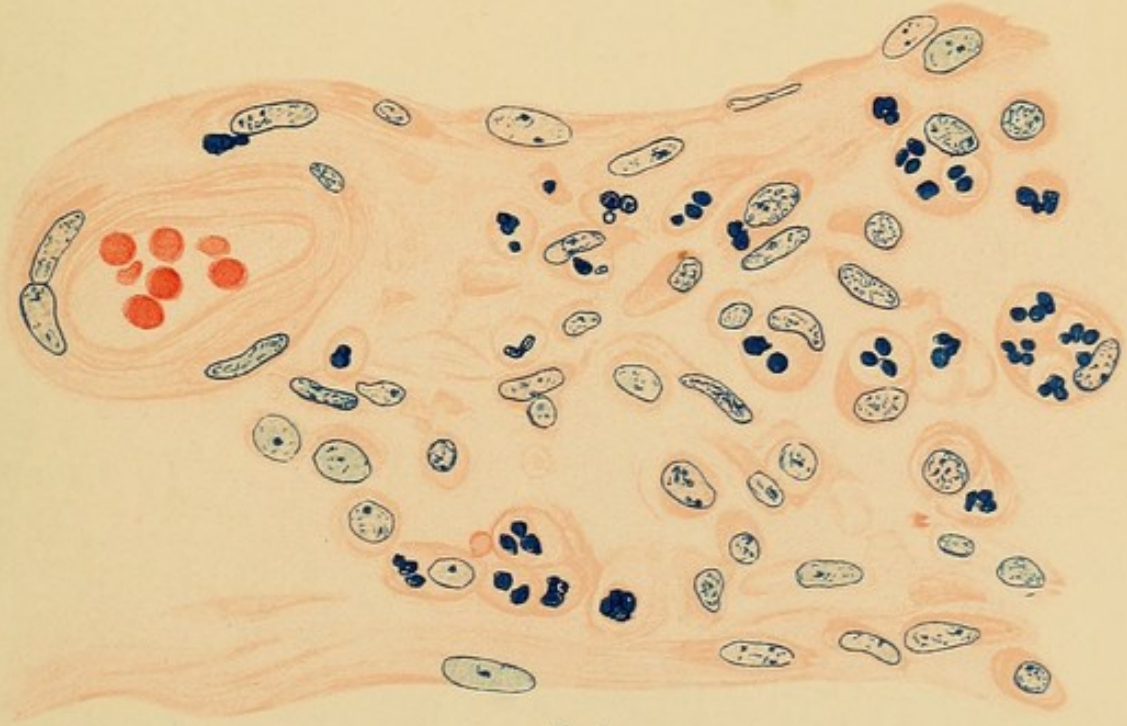

Fig. 2.

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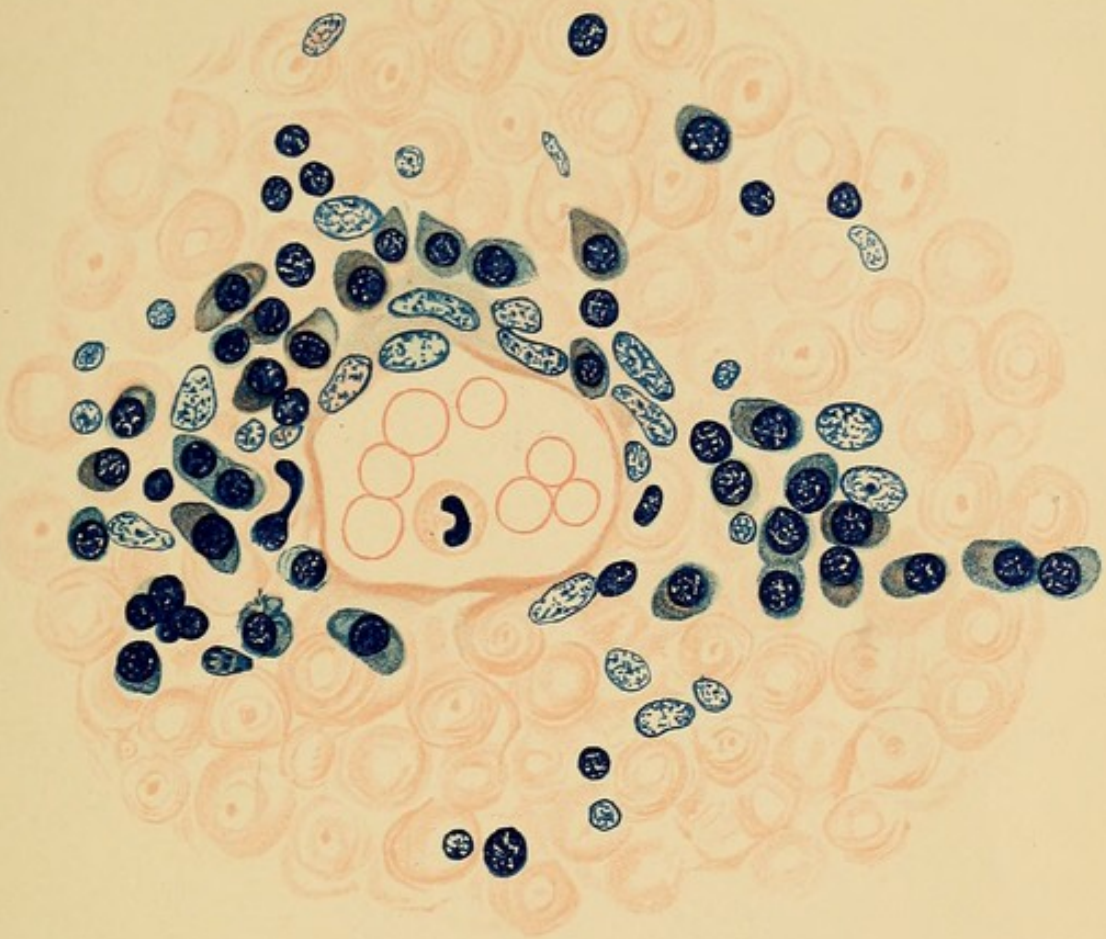

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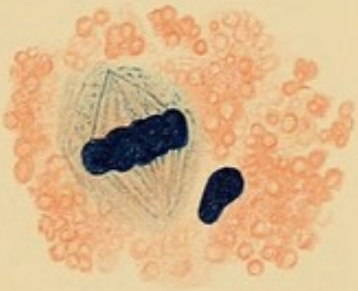

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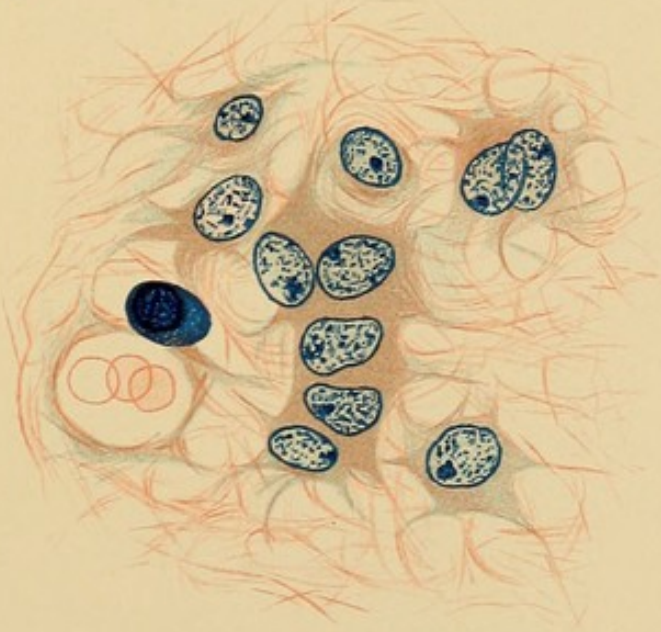

Fig.4.

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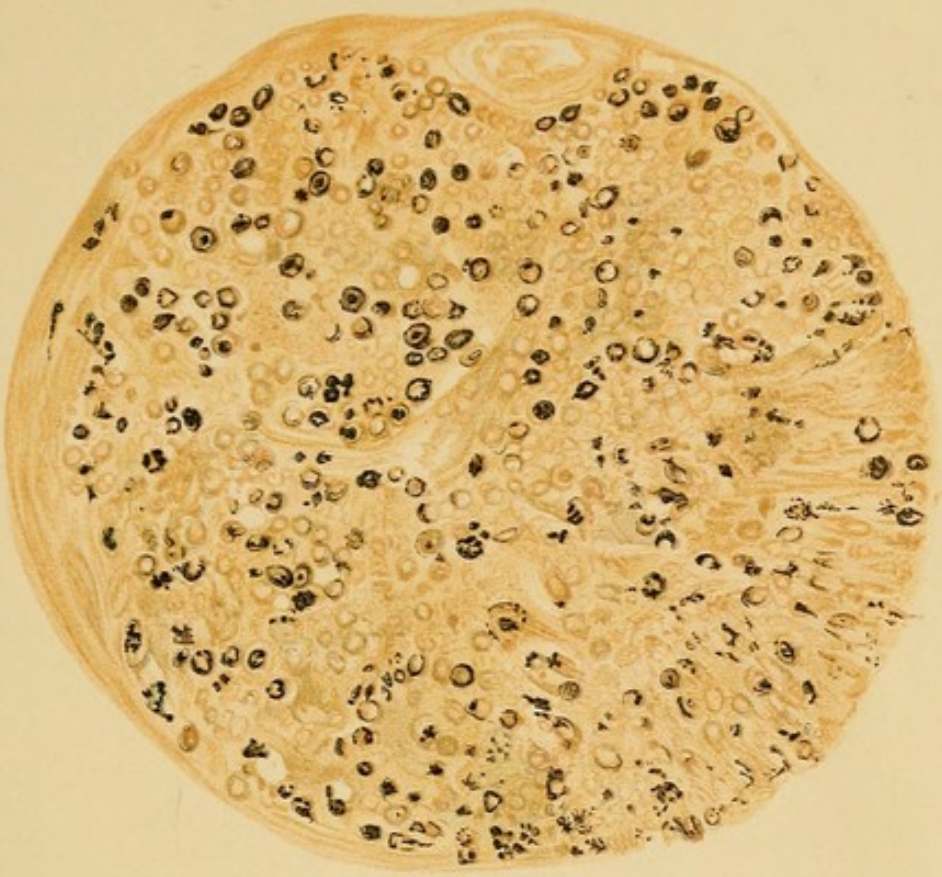

Fig. 1.

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HELIOTYPE PTG. CO. BOSTON

CEREBRO SPINAL MENINGITIS.

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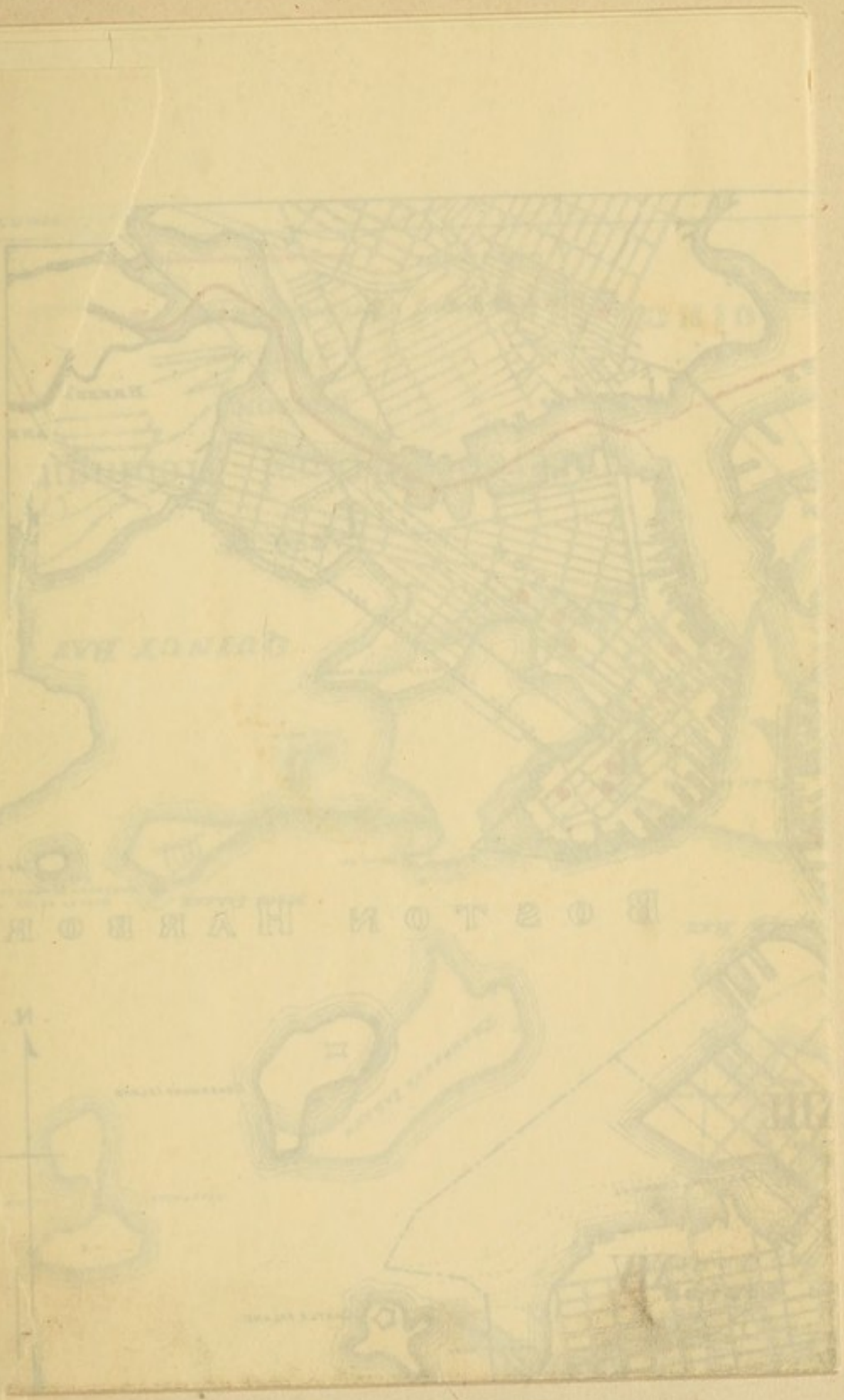

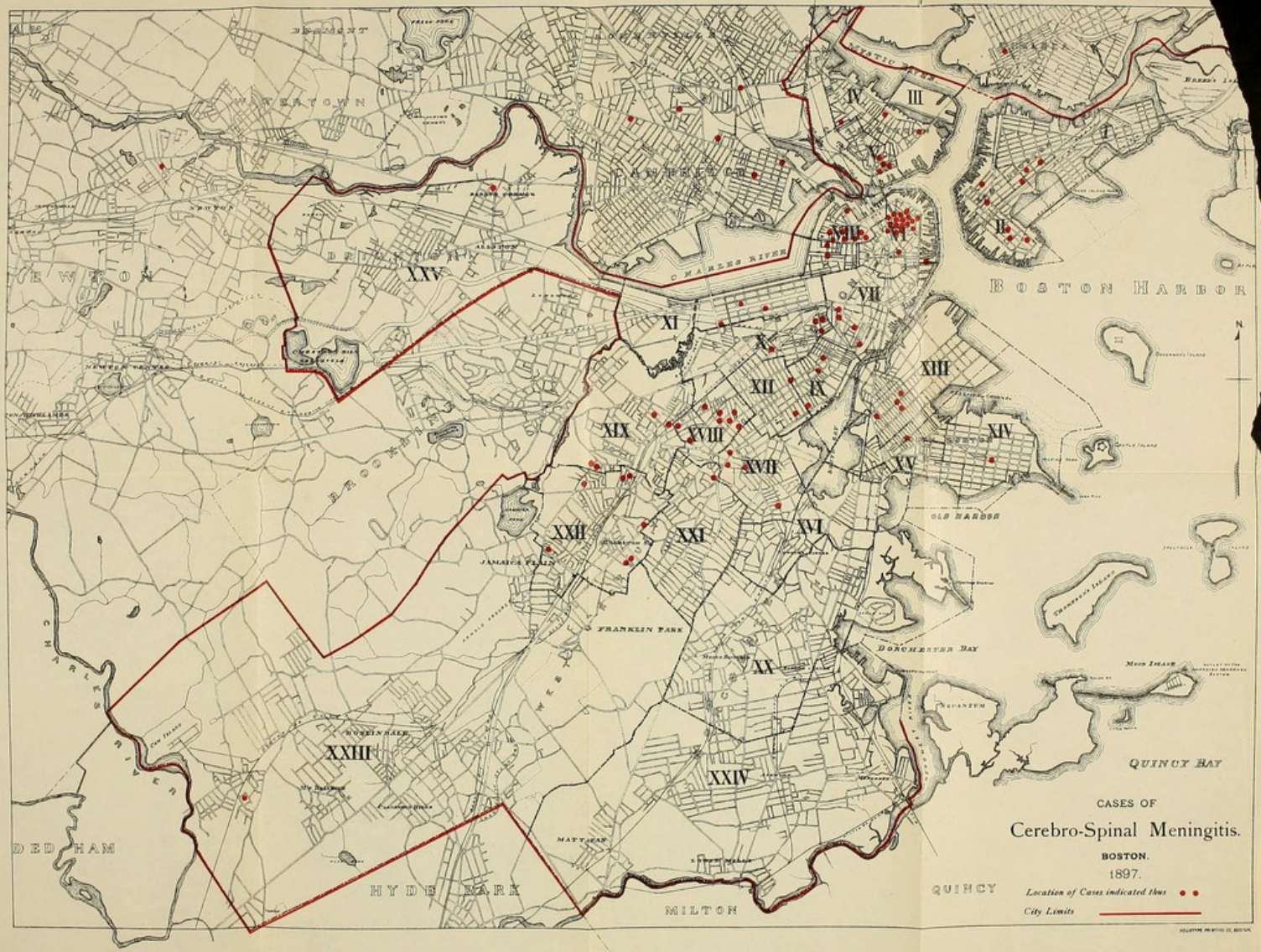
CASES OF
Cerebro-Spinal Meningitis.
BOSTON.
1897.
Location of Cases indicated thus
City Limits
BOSTON HARBOR
QUINCY BAY
DORCHESTER BAY
OLD HARBOR
CHARLES RIVER
BROOKLINE
NEWTON
WATERTOWN
CAMBRIDGE
DEDHAM
HYDE PARK
MILTON
QUINCY
FRANKLIN PARK
JAMAICA PLAIN
MATTAPAN
I
II
III
IV
V
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VII
XI
XII
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