Marine

Public Works (1898) Department.

G.O., No. 619 Mar

DATED 18th July, 98

[Despatch Abstract.]

Reports of the Plague Research Committee.

Forwarded by Govt. Depte. - Distribution of Copies of the Reports, Bombay, recorded.

JP

[P. W. 23. 1,000—2-5-98]

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Marine

~~Local & Munl.~~ (1898) Department.

CURRENT No. 903

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No. 311 of 1897.

From

THE PRESIDENT,
The Plague Research Committee;

To

THE SECRETARY TO THE SURGEON-GENERAL
WITH THE GOVERNMENT OF BOMBAY.

PETIT LABORATORY,
SIR JAMSETJI JIJIBHOY HOSPITAL:
Bombay, 20th November 1897.

SIR,

I have the honour to forward herewith the reports of the undermentioned members of the Plague Research Committee.

2. My own report and Surgeon-Captain Childe's are sent in full. Of Mr. Hankin's report a summary is sent, the details having already been furnished by him from time to time as his investigation proceeded. Dr. Haffkine has not, up to the present time, been able to arrange the materials he has collected, on account of the pressing nature of the laboratory work in which he is engaged. He will furnish his report to you in detail hereafter.

Dr. Surveyor has been prevented through illness from pursuing his observations and writing a report.

I have, &c.,
R. W. S. LYONS, Surgeon-Major,
President.

B 1751—6

I.—Report by Surgeon-Major Lyons, I. M. S., President of the Plague Research Committee.

The Plague Research Committee was originally formed, under Government Resolution, General Department, No. 4533, dated 13th October 1896, to inquire into the nature and history of the disease, stated to be bubonic plague, of which a number of cases had occurred in Bombay City.

Surg.-Major R. Manser, *President.*
Surg.-Capt. L. F. Childe.
Dr. Nusservanji Fakirji Surveyor.
Dr. W. M. Haffkine.
Mr. E. H. Hankin.

The Committee was composed as per margin, and the members decided to distribute the work among them as follows:—

Surg.-Major Manser:—The clinical aspect of the disease; its treatment by drugs; the source of the Bombay outbreak; the history of its introduction and spread; and the evidence relating to its incubation period.

Surg.-Capt. Childe:—The macroscopic and microscopic pathology of the disease.

Mr. Hankin:—Its origin in the outside world; search for the microbe in food, clothing, bedding, drains and sea-water; and whether the microbes survived longer in rotten than in sound grain.

Dr. Surveyor:—The nature of the disease in rats and fowls; bacteriological proof that rats are suffering from the disease; the effects of antiseptics on the microbe, and the relative value of different antiseptics practically.

Dr. Haffkine:—The study of the microbe and its relation to the patient and to the animal body; the question of its communicability by infection or contagion between man and man, and between man and animals, inoculations, etc.; diagnostic methods; the period during which the patient continues infectious; immunity; and antitoxine and other treatment.

Surg.-Major Manser contracted plague from which he died on 6th January 1897, and his place on the Committee was taken by me on the 25th January 1897.

Dr. Surveyor has been unable, owing to illness, to pursue his line of investigation or to write a report.

The reports of the other members, with the exception of that of Dr. Haffkine, are submitted herewith in full detail. Owing to the pressure of laboratory work, in which he is still engaged, Dr. Haffkine has not yet been able to arrange the material he has collected in the form of a report. Such suggestions as have been submitted by the Committee will be found in the General Appendix.

The members of the Committee have in addition examined and reported on a very large number of specimens from suspected plague cases sent from every part of India; experimented with numerous antiseptics sent for report; and answered an immense number of inquiries addressed to them; involving tedious laboratory work and a considerable amount of correspondence.

The difficulties of laboratory research were very great, owing to want of apparatus and of trained and intelligent assistants to carry out the ordinary routine work.

The portions of the programme which devolved on Surgeon-Captain Childe and myself had to be carried out at such times as we could spare from our other duties, which, owing to the presence of the epidemic, were unusually heavy.

In the present outbreak of plague the infection was no doubt imported from some locality in which the disease existed, but the most searching inquiry, instituted at the time it was first noticed, failed to discover evidence of plague cases (or indeed of any severe form of sickness except twelve cases of cholera) on board vessels which entered Bombay Harbour after 1st June 1896.

Inquiry was also instituted among ship-owners regarding any noticeable mortality among rats on ships trading with China and ports where plague was known to have existed, but in this case also with negative results. As the outbreak commenced near the Docks, it appears most probable that the infection was introduced by sea and carried in their clothes or goods by traders* who were themselves insusceptible. It is also possible that it may have been introduced in this way by traders from Northern India, as plague is believed to be endemic on the southern slopes of the Himalayas.

The disease probably commenced to spread in Bombay about the beginning of August 1896, as the mortality of the city began to increase in the second week of that month (*vide* Table VII). This increase in mortality was attributed at the time to remittent fever and lung affections, but as rats were dying in great numbers in Mandvi Ward, where the death-rate among the population was unusually high and where the prevalence of the epidemic was first discovered, there can be little doubt that the excessive mortality was due to plague. The epidemic spread slowly, and the total mortality continued to increase until by the second week in February the whole city had become infected. After that time the mortality began to decrease, and by the end of May it had fallen to the normal and deaths from plague ceased to occur.

The official returns of deaths from plague are for various reasons not very accurate. A fairly correct estimate of the mortality can be obtained, however, by taking as plague mortality the difference between the weekly mortality and the mean of the corresponding weeks during the preceding five years (*vide* Table VII), as there was no other unusual cause of sickness present.

It must be remembered that the average weekly mortality during the preceding five years is taken on a population of 800,000, and that, owing to the exodus which occurred after the outbreak of the epidemic, the population was reduced by from a fourth to a third of that number. The true incidence of the disease was consequently considerably heavier during the later weeks than shown in the table, and this error is a gradually increasing one growing with the decrease of the population.

It has been stated that in other places outbreaks were often preceded by the appearance of cases of painless buboes unaccompanied by vomiting, fever, headache or other symptoms of plague, but this was not observed in Bombay.

It may here be noted that the great difficulty which arises in tracing the mode of infection and the course of plague as compared with the other more common infectious diseases is due to two facts—*viz.*, that animals such as rats readily contract and afterwards spread the disease, and that the microbe is capable of thriving and multiplying outside the animal body, as is seen, for example, when it is cultivated in broth or on *ghee*. It is evident that infection may be carried by rats to persons who have never been brought into contact with plague patients, nor with persons visiting plague patients, and whose food and clothing could not have been contaminated in any other way. On the other hand, the germs may be conveyed by persons who are themselves insusceptible to plague, and, having grown and multiplied on suitable media and under favourable conditions, may infect large numbers of people who have never come into contact with plague patients, their attendants or plague-stricken rats.

The development of plague in an epidemic form was believed by many persons to be due to rotten grain which had been buried underground, and it was thought by some, infected with plague germs. Had rotten or diseased grain been sold as food (and there was no evidence that this took place), it would in all probability have given rise to digestive disorders, and in so far have predisposed to plague; but if the grain had been infected with plague bacilli, the disease would have appeared in several localties simultaneously, wherever the infected grain had been eaten. It is impossible to believe, too, that large stores of infected grain could have been sold without giving rise to an outbreak of disease

* Dr. Jan Mahomed's first cases occurred towards the end of September among Mooltanis who trade with China, and who lived near the docks.

among grain-sellers throughout Bombay. It is well known that this spreading of the disease far and wide among grain-dealers did not occur, and the 54 grain and flour sellers, millers and grain-parchers who died from plague between the months of September 1896 and January 1897, died principally in infected localities in the neighbourhood of the Docks where the disease first appeared, but did not themselves form centres from which the disease spread in unaffected districts.

The epidemic was observed to increase notably during the cold season and to decline during the hot weather (*vide* Table VII.). This increase during the cold months was probably due, to a great extent, to the sick and healthy occupying the same rooms during the day and sleeping together at night, and also to the depressing effects of cold. During the warm months the poor live under much more sanitary conditions than in the cold season.

The influence of animals in spreading the disease was, with the exception of rats, probably inappreciable. A searching inquiry at Damaun, where there were great numbers of pigs at large in the streets, elicited no evidence of a single death, or even of an appearance of sickness among pigs, although an exceptionally severe epidemic of plague had visited the town. Sheep, goats, horses and cows were unaffected. There was evidence (*post-mortem*) of a dog having been affected, but none that cats contracted the disease. Birds were not at all affected.

In the epidemic at present going on at Hardwar, monkeys are infected and dying in considerable numbers. The grey monkey is very susceptible to plague and rarely recovers, the brown monkey is much less severely affected.

The influence of ants and bugs in spreading the disease is considered by Mr. Hankin (*vide* his report) to be unimportant.

An alluvial soil, situated at a low level, copiously watered, associated with a high degree of atmospheric moisture and a temperature of 80° F. (conditions which are fulfilled by seaports like Bombay), are generally looked upon as those most favourable for the development of plague to epidemic proportions. But as far as can be judged, the Bombay outbreak, where these conditions obtained, was certainly no more severe than that which has since occurred at Kirkee. In the latter place the soil is of laterite and well drained, and the cantonment has a high situation, a small rainfall and a dry atmosphere.

All observers up to the present time have connected the occurrence and diffusion of the disease with want and filth, and there seems to be no doubt that these factors do favour it, in so far as they lower the general health and diminish natural immunity. But it will be seen that filth *per se* has but little influence, from the fact that there occurred in the House of Correction, Byculla, where cleanliness is brought as nearly to perfection as is attainable, an outbreak which exceeded in severity that in any of the filthy chawls and tenements around. There were 345 prisoners confined in this jail when plague broke out there on the 23rd January 1897, the outbreak lasted for 15 days, and in that time 33 prisoners were attacked, 17 of whom died. It is a significant fact, too, in this connection that out of 1,579 patients treated at the Arthur Road and Parel Hospitals there were only 16 sweepers, and that the halacores who remove the night-soil from the houses, and who form probably the dirtiest portion of the population, were notably free from plague. It is true they are a strong well-nourished class, of whom only the fittest have survived, and they are highly paid and live well.

The predisposing causes were mainly those leading to a lower state of vitality, and which consequently lessened the natural resistance of the individual to infection. In this way, as abovementioned, the long-continued and exceptionally hot season of 1896, the unusually heavy rainfall which followed and which confined the poor constantly in their overcrowded and insanitary dwellings, and the great heat which succeeded the rains, were powerful factors in lowering vitality. Then came scarcity due to dearness of food. During the cold season the unhealthy condition of chawls (native flats) and houses in the city was rendered worse by overcrowding, the inmates being unable to sleep and work in the open, as large numbers of them are accustomed to do during the warmer months. Indeed, the effect of cold alone on the feeble and on those who are insufficiently clothed, as already mentioned, is a powerful factor in lessening resistance to infection.

The largest number of admissions into hospital occurred between the ages of 20 and 30 years. At the Arthur Road Hospital, Bombay, out of 1,275 admissions, 445 or 34·9% occurred between the ages of 20 and 30 years; 291 or 22·8% between 10 and 20 years; and 255 or 20% between 30 and 40 years.

In the Poona Plague Hospital out of 1,130 admissions, 263 or 23·27% occurred between the ages of 20 and 30; 137 or 20·97% between the ages of 10 and 20 years, and 197 or 17·43% between the ages of 30 and 40.

A constant source of error in these statistics is that the ages of those admitted are seldom or never exactly known, consequently those given are only approximate. Another source of error is that in young children death from plague frequently occurs before the nature of the disease is recognised, so they are not admitted into the plague hospitals. In the case of children, however, the very small number of admissions (*vide* Tables I. and II) is no doubt partly due to the smaller number exposed to infection, as the exodus which took place on the outbreak of the epidemic was very largely confined to women and children. The withdrawal of the women gave rise to a marked decrease (*vide* Table VII.) in the birth-rate of the city, which during the ten months under review fell below the mean of the preceding five years for the same period by 3,685.

That young adults should give the highest number of admissions is not surprising, as they form the largest proportion of the population, and they travel about more, and so are brought more frequently into contact with the disease. The greatest number of admissions into hospital occurred among domestic (cooks, hamals, massalchis,) and personal servants, (*vide* Table V.) who formed 20·88%; mill-hands came next forming 11·53%; coolies 8·8%. The comparatively large number of dhobies (native washermen), dirzis (tailors), gowlies (milkmen) and hajams (barbers) deserves notice, as from their occupation they are likely to spread the disease. The large percentage of admissions among domestic servants is doubtless due to the disease being detected early, and to their masters seeing that they were taken to hospital.*

It is impossible to estimate the influence of race and caste on susceptibility to plague, owing to Europeans living under very different sanitary conditions from natives, and to the effect of social position in altering the conditions obtaining among natives themselves; besides, correct statistics cannot be obtained as to the native population present during the epidemic and the numbers attacked by plague.

That more males than females were attacked (*vide* Table IV.) is probably entirely owing to the former having been present in larger number.

The *exciting cause* of plague is the plague bacillus of Kitasato, which is believed to gain admission to the body, usually through an abrasion of the skin, or more rarely of a mucous surface. In a number of instances in the present epidemic points of inoculation were found on the extremities of plague patients, from which plague cultures were obtained, and in these cases buboes were found above the point of inoculation. In the majority of instances however no local indication could be found marking the point at which the microbe was implanted. Less frequently infection is believed to have occurred in the respiratory organs or in the digestive tract. When the disease appears in the form of primary plague pneumonia, it may be caused by the inhalation of bacilli disseminated in the air by patients as they cough, or it may be carried by the blood vessels, or lymphatic vessels to the lungs, where it developes.

When a monkey is inoculated by pricking its hand with a needle dipped in plague culture, the slight wound made disappears in a couple of days, and leaves no indication of the point at which inoculation was performed. After 4 or 5 days a bubo appears in the axilla or at the bend of the elbow, and the symptoms of plague develop. The lymph from the bubo in these cases contains plague bacilli in great numbers, from which cultures can be made. In the case of man also, as already mentioned, the point at which inoculation occurred was but rarely discovered. Plague bacilli could however be obtained in immense numbers, and cultures made, from lymph taken from buboes. In septicæmic cases they could

* For the purpose of comparison, it was intended to have also given a statement showing the number of deaths from plague in Bombay City according to occupation (Table VI), but information could only be obtained up to 31st December 1896.

be obtained from the blood as well as from lymph from enlarged glands; and in pneumonic cases they were obtainable from the sputa and from enlarged glands when present. Bacilli were probably also present as a rule in the sputa, vomit, urine and fœces of plague patients, but they were hardly ever found in the blood taken from the finger in cases where a bubo was present from the first.

The slow spread of plague and the immunity observed among hospital servants, nurses and medical men who were in constant contact with the disease, handling the sick, and making *post-mortem* examinations, indicates that the germs produced in the bodies of the sick are but little infectious to healthy persons under ordinary circumstances. The conditions under which they become virulent will only be known when the life history of the microbe outside the body has been traced. Infection occurred most frequently among those living in the same rooms with, and in constant attendance on, the sick, and there can be little doubt but that among the poor and ignorant it was often due to the common custom which exists of friends receiving the sputa of the sick in their hands,* and using their hands and clothing to wipe away discharges from the patient's mouth. It is easy to understand also that want of personal cleanliness among the friends of those affected, and the neglect of precautions as to the disinfection of clothing soiled by the discharges and excreta of the sick were fruitful sources of infection.

Plague in its epidemic form, as seen in Bombay, is a malignant infectious disease characterized, in the majority of cases, by enlarged and painful lymphatic glands, high fever and great prostration; and is due to the presence in the system of the plague bacillus.

In the Bombay epidemic the period of *incubation* varied in duration from 36 hours, the shortest,† to ten days, the longest‡ recorded, while in the majority of cases the period of incubation appeared to be from four to six days.

No definite history of *premonitory symptoms* could be obtained, the invasion being, as a rule, sudden and marked by severe rigors or by chills. In infants and young children convulsions frequently ushered in the attack. In a small proportion of cases, however, no marked onset was noticed, the patients stating that the disease began with fever, heat of the skin and pains in the limbs. These cases usually ran a mild course ending in recovery.

The symptoms in a typically severe case generally commenced with a well marked rigor, which was followed by fever, accompanied by vomiting, headache and intolerance of light, pain in the epigastrium and frequently also in the back and limbs. Thirst was unusually much complained of. The *temperature* rapidly rose to 104° F. or more, reaching its maximum, often 105° F. or 106° F. on the evening of the second or, more rarely, on the first day; occasionally a remission of 1° F, or sometimes more, occurred during the day, but with no regularity as to time. A well marked fall in temperature of 2° F. to 3° F. or more was frequently noticed on the second or third day, after which the temperature rose again, but seldom to its former height (*vide* Charts III, IV, VII, X, XV, XVII, XVIII, XIX, XX, XXII); a further fall to normal, or subnormal, occurred between the fifth and seventh days (*vide* Charts I, II, III, VIII, XXII). In uncomplicated cases a fall to normal sometimes occurred on the second or third day (*vide* Charts XX, XXVI), and was often attributed to a particular line of treatment

* It seems not improbable that plague cultures grow in the ghee always present under the nails of natives who eat curry with their hands, and that they often infect themselves from the cultures when scratching skin eruptions, &c.

† The case of Chinwal Khan reported by Surgeon-Major MacCartie, Health Officer of the Port of Bombay, on the 11th January 1897.

Chinwal Khan was a fireman on the S. S. *Hydaspes* which arrived from Shanghai (an uninfected port) on Thursday, 7th January, and entered dock the same evening. He did not complain of illness during the voyage to Bombay, and was on regular duty up to the evening of the 7th. Probably on that evening, and certainly on Friday morning the 8th he visited the city. On Saturday morning the 9th he complained of fever and pain in the groin, and on examination was found to be suffering from plague. The incubation period in this case was at most 1½ days and may have been only one day.

Nurse Joyce went to attend on Surgeon-Major Manser on the 4th January at his house. She was in good health and had not been near plague cases up to that day. She nursed him from 4th to the morning of the 6th. She was attacked by plague on the evening of the 7th, and died on the 9th January 1897.

‡ This period cannot be accepted as finally settled, as the person attacked, a native of Bombay, may have carried the infection with him and infected himself in Poona, where he was attacked ten days after arriving from Bombay and before plague had broken out in Poona.

when it was really the usual course of the temperature unaffected by the treatment. The occurrence of complications, *e. g.*, the appearance of fresh buboes, secondary pneumonia, &c., gave rise to great irregularity in the course of the temperature (*vide* Charts II, XIV, XX, XXIII, XXVIII).

Nausea and vomiting were met with at the onset in almost every case, and frequently continued for the first day or two. Splitting frontal or general headache was present from the first and continued while the temperature remained high, subsiding with the fall which occurred on the second or third day. Occasionally epistaxis occurred about this time. The countenance was pale; the eyes red and injected with bands of deeper colour at the outer and inner canthi owing to the eyelids remaining constantly unclosed. Sleeplessness was a distressing symptom, and there was often delirium at night. The pulse frequent, 100 or more, and full at the beginning, soon became soft, compressible, and dicrotic, and eventually running, so that it was difficult or impossible to count. The tongue was as a rule very characteristic. At first it was tooth-indented, somewhat swollen, and evenly covered with a thin white fur, except at the tip and edges, where it was clean. Later, it became dry, thickly covered with a yellowish white or brownish-white fur, the tip and edges remaining red and irritable. The bowels were almost always constipated at first, but sometimes diarrhœa was present.

Buboes were met with in over three-fourths of the cases, and in about half the number of cases in which buboes were found, the glands of the vertical set in the groin were involved. They were as a rule noticed at the onset of the disease, giving rise to lancinating pain, but in a number of cases were not found until the second or third day. Generally one gland was markedly affected, and two or more adjacent ones less so. The affected glands varied in size from that of a filbert to a walnut, and they were very tender from the first, although often but little swollen. When in the groin the patient kept the thigh well flexed on the abdomen in order to relieve tension. In about two-thirds of the remaining cases the axillary glands were found to be affected, the patient usually lying on his back with the arm held away from the side and kept perfectly still. In the remaining third the glands below the angle of the jaw or of the superficial cervical set were enlarged.

As a rule a bubo appeared only in one region, but sometimes they were found in more than one region, or on both sides of the body. As the disease progressed the glands of the same chain, situated above those first affected, often became enlarged; so that in cases of a femoral bubo the glands lying along the course of the external iliac and common iliac vessel were also found to be enlarged and tender on pressure. A rise in temperature occurred with each fresh gland or group of glands involved.

In cases which proved fatal early the buboes continued hard and very tender to the last; while in more prolonged cases effusion, frequently large in amount, occurred around them giving rise to a doughy or brawny swelling, and often causing œdema of the limb below from pressure on the vessels and nerves.

With the appearance of effusion the buboes usually became less painful. In a few cases where the patient lived long enough, the swelling subsided by resolution, but in the majority of instances suppuration occurred after the seventh or eighth day, the skin over the infiltrated area becoming inflamed. On opening the bubo thin yellowish or sanious pus was evacuated; the skin frequently sloughed eventually, however, leaving an indolent unhealthy ulcer, with ragged, overhanging edges and a greyish sloughing base, on which one or more necrosed lymphatic glands might be seen. Such ulcers usually took weeks to heal and gave rise to large thickened cicatrices. In cases where suppuration did not take place the glands remained hard and indurated long after convalescence was established.

The nervous system was markedly affected in almost every case from the beginning of the fever. The patient complained of extreme feebleness and prostration; in many cases he could only walk with the greatest difficulty, and was sometimes unable even to leave his bed. There was some loss of sensibility

to touch, and often the general cutaneous sensibility to pain also seemed impaired, but in a few cases there was marked hyperæthesia.

Intelligence was generally unaffected at first, but sometimes the patient appeared to be dazed and stupid and totally indifferent to his surroundings. Memory was defective, or he was unequal to making an effort of memory when asked, for example, to give the date of attack, or to state what his symptoms had been. In a number of cases, owing to inco-ordination of the lingual muscles, there was thickness of speech like that caused by alcoholic poisoning, and this symptom was so characteristic that the attendants in hospital came to look upon it as a certain sign of plague in cases where enlarged glands had not already appeared. Later in the disease dumbness not infrequently occurred from paralysis of the laryngeal muscles. In addition to loss of muscular power in the upper and lower limbs there was tremor and twitching of the muscles of the hands, and in many cases marked loss of co-ordination also, causing clumsiness of movement in the hands, and giving rise to a staggering gait on attempting to walk. As a rule there was loss of expression, owing to relaxation of the facial muscles, giving the patient an apathetic or a stupid look, and masking the approach of death. Occasionally at the beginning of the illness the expression was anxious. In a number of cases cerebral symptoms were present from the commencement of the disease and continued day and night throughout the attack, taking sometimes the form of delirium and at others that of coma. The delirium was of the busy type, like that of delirium tremens, and was often accompanied by illusions terrifying in character, from which the patient tried to escape; among children convulsions frequently took the place of delirium. In cases marked by stupor the mental faculties appeared to be paralysed, the patient lying in a comatose condition, from which he could only be roused with difficulty, if at all. Such cases generally died within the first two days, but sometimes even within 24 hours.

The respiratory symptoms were hurried breathing and a sense of oppression and tightness across the chest. In most cases congestion of the bases of the lungs occurred early, and was rapidly followed in many instances, particularly during the cold months, by bronchitis, by œdema of the lungs, or by secondary pneumonia. In these cases of secondary pneumonia the expectoration was bronchitic in character, and after a short time became profuse and watery, often showing a considerable colouring of blood. These blood-stained serous sputa, owing to the patient's clothing becoming reddened by them, sometimes gave rise to the impression that hæmoptysis had occurred. Primary plague pneumonia was also met with, but this form of plague (which was first recognized and described by Surgeon-Captain Childe) during the present epidemic is so important as to require a detailed description.

In connection with the digestive system, the occurrence of vomiting at the onset of the disease, in some instances accompanied by diarrhœa, has been referred to above. In some cases nausea, vomiting and diarrhœa appeared at the onset and persisted throughout the whole course of the attack. The vomited matter was at first bilious in character; afterwards it contained only water and such liquid nourishment as had been taken. Diarrhœa when it occurred was also bilious in character, the motions numbering five or six in twenty-four hours, the stools being always very offensive and sometimes tinged with blood. In a certain proportion of cases there was pain and tenderness in the epigastric region, pain in the back, and abdominal distension, accompanied by enlargement of the liver and spleen. Surgeon-Captain Hojel has recorded a number of cases of this sort in which low nervous symptoms occurred like those met with in enteric fever, and in some of these cases petechiæ were seen on the abdomen and lower part of the thorax somewhat resembling the rash of enteric. After death the lesions found were those of plague; Peyer's patches were found to be slightly raised, œdematous and congested, the solitary follicles were as large as hempseed, but enlargement of the mesenteric glands was absent.

In the circulatory system there was throbbing of the carotids, and the apex beat of the heart could generally be seen at the beginning of the attack. The impulse at the apex was found to be more diffuse than normal, and sometimes a thrill could be felt in the præcordial region. The sounds soon became

feeble, the first sound being very much shortened, and the second sound so weak that it frequently could not be heard at the apex. In one case only, out of a very large number examined, was a murmur present, although in many cases the heart appeared to be dilated. On examining the blood drawn from the finger it was found to coagulate slowly, and the red corpuscles did not tend to run into rouleaux quickly. In cases where the disease had lasted for a few days the number of white corpuscles present was greatly in excess of the normal. In most cases after the first day, and in all cases after two or three days a marked fall in blood pressure occurred; this fall in blood pressure and the great frequency of the heart's action were the most marked circulatory changes observed.

In the urinary system pain was sometimes present in the region of the kidneys. The urine secreted was diminished in quantity, of high specific gravity, and intensely acid in reaction. In colour it was generally brownish yellow, but sometimes it was smoky or red from the presence of blood. Albumen was present in about three-fourths of the cases, urea and uric acid were deficient, and chlorides markedly deficient; casts were generally present. The attached table (Table IX) gives a quantitative urine analysis made by Surg.-Capt. Hojel. It shows the results obtained in fifty plague cases treated at St. George's Hospital. With the exception of No. 19, all the analyses were made between the third and sixth day; all were examined as soon after admission as possible, and the majority for several days in succession. Micturition was frequent in many cases, but no symptoms of scalding were as a rule complained of. In cases which terminated fatally the urine was often retained towards the end.

Where pregnancy was present, the patient, as a rule, aborted on the first or second day after the onset of the disease, but this was not invariably the case. Out of three pregnant cases treated at St. George's Hospital only two aborted, and both recovered; the third (*vide* Chart XXII), two months pregnant, went on to full term. When premature labour occurred, both mother and child usually died. In one case, however, a native woman was attacked by plague five days before full term; she was confined the same day and died, but the child was born alive; it exhibited no symptoms of plague, and is still living.

The skin was hot and burning to the touch from the first, and continued dry and harsh until the temperature began to decline on the third or fourth day, after which it became moist. On the temperature falling to normal or subnormal, sweating almost invariably occurred and continued for a few days, being usually worse at night,

Occasionally before death petechiæ were observed over buboes or on the abdomen; but no characteristic skin eruptions were seen. In some instances small patches of skin (unconnected with lymphatic glands) two or three inches or more in diameter became inflamed, and eventually sloughed, leaving indolent ulcers with steep overhanging edges. These patches were noticed in some cases at the sides of the abdomen, and over the loins, where they were in no way due to pressure or irritation; but more frequently they occurred on the extremities, being situated on the dorsum of the foot or hand, on the leg, the thigh or forearm. Sometimes extensive sloughing occurred, laying bare the muscles over considerable areas and giving rise to severe hæmorrhage. Rarely boils were seen which became black, owing apparently to capillary hæmorrhage; but no true carbuncles were observed.

Amongst natives the progress of the disease was towards death in about 70% of the cases admitted into the Arthur Road and Parel Hospitals; among Europeans and Eurasians treated in St. George's Hospital the mortality was less, viz., 32·35% and 42·62% respectively. As death approached, respiration became more and more shallow and feeble, the eyes became sunken, and the patient passed from a state of muttering delirium into coma, and died, as a rule, quite quietly from heart failure.

Sometimes the temperature ran up to 107° F. or more before death, and continued to rise after death; but more frequently death appeared to occur from collapse, the temperature falling and the pulse increasing in frequency to such an extent that it could not be counted. In cases that recovered the temperature

generally fell by lysis on the fifth, sixth and seventh days. But not infrequently a fall by crisis occurred on one of these days (*vide* Charts II. VIII. XXII.) and the patient remained in a more or less collapsed condition with subnormal temperature, profuse perspiration and an exceedingly feeble pulse for days. In this condition the slightest effort sometimes gave rise to fatal syncope. In the Parel Hospital 22 convalescents, out of 304 cases treated there by Surgeon-Captain Thompson, dropped dead through attempting to get out of bed or to sit up.

When the patient was recovering, it was occasionally found that he was suffering from dumbness or from partial laryngeal paralysis; or that hemiplegia, paraplegia involving the legs or the legs and arms, monoplegia of a limb or a portion of a limb was present. In some cases facial paralysis was observed, or paralysis of one or more ocular muscles. More rarely the inco-ordination of the tongue, hands, arms or legs, noticed at the beginning of the attack, remained present during convalescence, and the speech continued slow, thick, and indistinct (*vide* the case of Kallian Vishram given below).

Occasionally an attack of plague ran a very mild course, the patient (frequently a boy of 10 or 12 years) not being confined to bed by it. In these cases enlargement and tenderness of a lymphatic gland was noticed, followed by fever (*vide* Chart XXVI), headache, a characteristic tongue and sometimes nausea and vomiting; the temperature rarely exceeded 103° F. or 104° F., and generally fell to normal or subnormal on second or third day. Prostration and cerebral symptoms were not well marked, and the bubo subsided as a rule without suppurating. The duration of the attack seldom exceeded three or four days, and convalescence was established in a week or ten days.

There remain to be described two forms of the disease in which the general features of plague in its most acute form were present, but in which there was no particular enlargement of lymphatic glands (buboes) during life, and in which, after death, only very slight general enlargement and congestion of the glands were found.

In one of these forms of plague the microbe grows in the blood, hence it has been called *septicæmic plague*; in the other it grows in the lungs giving rise to *primary plague pneumonia*.

In *septicæmic plague* the invasion was usually marked by a prolonged and severe rigor, or repeated rigors; and vomiting, headache and high fever were constantly present. The most distinctive features of this form of the disease were the great nervous prostration and muscular weakness present from the beginning, and the rapidity with which cerebral symptoms supervened. Delirium often set in during the first day, and was quickly followed by picking at the bed clothes, stupor and coma, in which the patient died generally on the second or third day, but sometimes within 24 hours of the onset. In some cases death did not occur for several days. The pulse early became soft and very frequent, 120 to 140 or more, the temperature (*vide* Chart XXV.) rapidly rose to 104° F. 105° F. 106° F. ran an irregular course and often reached 107° F. or more before death; respiration was hurried and panting; gastro-intestinal catarrh and tympanitis were frequently present; the urine was often retained. Epistaxis and sub-conjunctival hæmorrhage sometimes occurred; blood was occasionally seen in the stools and urine; and, if the patient lived long enough, secondary pneumonia sometimes set in. These cases were very fatal.

In a considerable number of cases *primary plague pneumonia* was observed, the development of the disease being due to the growth of plague bacilli in the lung tissue. Lobular pneumonia was the form usually met with in these cases. Its onset was marked by rigors, or, in some instances, by chills, followed by a sense of constriction across the chest, difficult and hurried breathing, cough and expectoration. As the disease progressed, respiration became very frequent (40 to 60 in the minute) and difficult, and duskiness of the face appeared. Pain was present, but never appeared to be severe or stitch-like in character, and was rarely much complained of. The expectoration, bronchitic at the beginning, very soon became watery and profuse; it often contained little

whitish specks floating in it, and on examination was found to contain plague bacilli in great numbers. Frequently this serous expectoration was tinged of a pink or reddish colour from the presence of blood; but rusty sputa, as in ordinary croupous pneumonia, were rarely seen. There was great prostration from the first; the pulse soon became feeble and very frequent, so that the alteration in the pulse-respiration ratio ordinarily met with in pneumonia was not observed; the temperature was high and ran an irregular course (*vide* Charts XI, XII, XVII, XIX, XXIX, XXX, XXXI,); the tongue was coated white, except at the tip and edges, and the bowels were confined. The physical signs present were those of broncho-pneumonia, patches of consolidation being found in one or both lungs, the right generally being the one most affected. Very soon marked œdema occurred, the lungs becoming loaded with fluid. Buboes were not met with in these cases, but slight enlargement of the lymphatic glands was sometimes found before death. Death generally ensued in three or four days, and was preceded by incessant cough and by blueness of the skin due to deficient æration of blood, caused mainly by the amount of fluid in the air vesicles.

The complications met with in plague were — in the nervous system delusions, in one case ending in insanity; motor paralysis, local or general; impaired sense of touch; sometimes diminished sensibility to pain, sometimes hyperæsthesia; deafness; ulceration of the cornea, conjunctivitis, and sub-conjunctival hæmorrhage. In the circulatory system, softening of the muscular tissue of the heart with enfeebled cardiac action and dilation of the heart. In the respiratory system, bronchitis; hypostatic congestion and œdema of the lungs, secondary pneumonia; pleurisy; and rarely pulmonary hæmorrhage. In the digestive system, gastro-enteric catarrh; diarrhœa; and in a few cases hæmorrhage from the bowels. In the urinary system, albuminuria; renal congestion, and renal hæmorrhage, in one case causing death. In the reproductive system, menorrhagia at the menstrual period; and abortion in many cases of pregnancy. In the cutaneous system, sloughing of the skin, and boils.

The sequelæ most frequently met with were deafness in one or both ears; impairment of vision due to degeneration of the choroid and retina; dumbness due to the loss of memory of words, or to laryngeal paralysis; paralysis of the muscles of the eyes or face; paresis or paralysis of the muscles of the extremities either hemiplegic or paraplegic; inco-ordination of the muscles of the face, tongue and extremities (*vide* case given below); impairment of cutaneous sensibility to pain.

The duration of the disease in 902 fatal cases admitted into hospital was 19 hours in one case, one day in 5, two in 43, three in 99, four in 143, five in 129, six in 85, seven in 76, eight in 56, nine in 42, and ten in 24 cases. It must be remembered that probably very few of the cases dying during the first 24 hours were brought to hospital, and that many of the cases dying on the second and third day were also not detected and sent to hospital. The average duration of the disease from attack to death in 17 fatal cases among native prisoners in the House of Correction, Byculla, was $5\frac{1}{2}$ days.

Second attacks from plague occurred in two cases which have been recorded. In the first case the patient who had suffered from plague at Hong kong in June 1894 was attacked in Bombay on the 6th December 1896, had rigors, vomiting, high fever (105° F.), severe headache, and a bubo in the right groin. The fever and other symptoms subsided within a week and she recovered. The second case was that of a cooly admitted into the Arthur Road Hospital in November 1896 for plague. He was discharged cured in December and continued to work until February 1897, when he was readmitted for plague and died.

The diagnosis of plague in its most typical form is easy. The sudden onset, rapid rise in temperature, vomiting, headache, sleeplessness, the stupid expression, injection of the eyes, thick speech and great prostration point to plague; and later, the condition of the tongue, the frequent and very feeble pulse, the enlarged and painful lymphatic glands, the course of the temperature (showing a marked fall on the second or third day followed by a further fall to

normal or subnormal between the fifth and seventh days) and the rapidly fatal course of the disease in the majority of cases, render the diagnosis unmistakeable.

When however the disease takes the form of *primary plague pneumonia*, it becomes exceedingly difficult to diagnose, whilst at the same time, owing to the danger of infection from the sputa which contain plague bacilli in great numbers, it is most important to recognise it early. In primary plague pneumonia the absence of acute or subacute bronchitis before the attack; the rapidity with which high fever, severe headache and marked prostration occur after the onset; the character of the expectoration, less viscid from the first and early becoming profuse and watery, and generally tinged with blood or reddish from admixture of blood; the rapidity with which signs of œdema of the lungs appear; the quality of the pulse, which is never full and bounding, and soon becomes very soft and frequent, serve to distinguish it from ordinary broncho-pneumonia or lobar pneumonia in the majority of cases; and the presence in all cases of immense numbers of plague bacilli in the sputa, from which cultures can be obtained, renders the diagnosis certain.

Severe cases of *malarial fever* may be distinguished from plague by the nature of the onset, the cold stage being more prolonged, the features pale and shrunken, and the nails blue. In the hot stage the face becomes flushed and the pulse full and bounding, but is not so frequent as in plague. In malarial cases, too, the temperature generally shews marked periodicity; there is no prostration, patients possessing as a rule their muscular strength and mental energy; and buboes are very rarely met with.

Relapsing fever, like plague, occurs in times of scarcity. In both the onset is sudden, and rapidly followed by high fever, accompanied by severe headache, frequent pulse, and a hot and burning skin; the tongue is furred white, the temperature reaches its maximum on the first or second day, and a remission accompanied by sweating often occurs on the second or third day, the temperature falling to normal between the fifth and seventh days (*vide* Chart XXI.). But in relapsing fever there is giddiness; prostration is slight; jaundice not infrequently occurs on the third or fourth day; the face is flushed, and the expression is not stupid nor confused; buboes are not met with; and spirilla are found in the blood during the height of the fever.

Plague in its onset and early symptoms somewhat resembles *Typhus fever*. But the duskiness and flushing of the face present at the beginning of typhus fever, and the occurrence of an eruption on the body and limbs between the fifth and seventh days, as well as the different course of the temperature (*vide* Chart IX.) and the absence of buboes would serve to distinguish between them.

Owing to the feebleness, thick utterance and staggering gait, frequently seen in plague cases, the disease is sometimes mistaken for *alcoholic poisoning*. The following is a typical case. Govind Jeeva was taken by his friends for treatment to a qualified medical practitioner. They stated that he had had a fall, and the following note of his case was made: "Pupils slightly dilated, breath smells very faintly of alcohol, has a slight contused wound over but not exposing malar bone," and an emetic was prescribed. Fortunately this was not given. Next day a note was made as follows: "Bowels not opened for two days, is not quite recovered from the effects of drink," and on the following day: "Speech indistinct, temperature 102° F., bowels not opened." On the fourth day he died. In this case enquiry showed that the patient had been two days ill with fever, and was given a little alcohol after having fallen down in a faint. He was seen by another medical man shortly after the emetic was prescribed, and found to have a very frequent and feeble pulse, fever, and a typically coated tongue. The diagnosis of plague was made and afterwards verified by *post mortem* examination. Had the case been one of alcoholic poisoning, there would have been a full and bounding pulse, a normal or subnormal temperature, and considerable mental excitement; or in a later stage drowsiness, or coma with stertorous breathing, a slow and compressible pulse, and a subnormal temperature.

In plague cases where *abdominal symptoms* are marked and a typhoid condition has supervened, the diagnostic features given by Surgeon-Captain Hojel

are :—The onset is sudden, usually ushered in by a well marked rigor; the temperature shows a high initial rise in most cases, followed by a marked remission to normal (or a little above or below it) on the second, third or fourth day (*vide* Chart XXIV); the pulse large and full at first, becomes peculiarly soft and is characterized by a great want of sharpness in stroke; it is very compressible at an early stage and dicrotic, but the dicrotism is not very easily recognized by the finger; the aspect is dull, heavy and apathetic, and the patient has a peculiar stricken look; the eyes are dull and muddy looking, the conjunctivæ are suffused, but the pupils in most cases are normal; there is generally flushing of the face; diarrhœa when present is simple, but very offensive; delirium and other cerebral disturbance occur early, and there is great prostration from the first; abdominal distension occurs early, on the third, fourth or fifth day; the eruption is not readily effaced and is of a "deep red colour (petechial)"; there is severe pain lumbar in many cases.

During the present epidemic no cases of *glandular fever* among children or young adults were met with; nor did an outbreak characterized by the appearance of buboes, and accompanied by a little or no constitutional disturbance, precede or accompany the outbreak of plague in Bombay. Until bacteriological diagnosis has settled that the microbe in these cases is the plague bacillus, it is premature to speak of them as cases of benign plague. In Calcutta a number of cases of this sort occurred over twelve months ago, but up to the present no outbreak of plague has followed.

The bacteriological diagnosis of plague has been purposely omitted, as it will be given in full detail in M. Haffkine's report. Besides, it cannot be carried out in practice by medical men who have no special bacteriological training nor access to a laboratory, and as they are the first persons who come in contact with the disease, it is of especial importance that they should be able to recognise plague cases by their ordinary clinical features.

The *prognosis* of plague is always exceedingly grave, as it is the most fatal of all known epidemic diseases. Dr. Viegas, who practises on the Port Trust Estate and was the first to notice the presence of plague in Bombay about the third week in September 1896, states that the mortality during the first four weeks after the outbreak was discovered lay between 95 and 99%, and between the end of October and the end of November between 85 and 90%.

The mortality in 1,579 cases treated in the Arthur Road and Parel Hospitals was 69·54%. In the Poona Plague Hospital, out of 1,130 patients admitted, 757 died, giving a mortality of 67%.

In the House of Correction, Byculla, however, where the entire number of those attacked were admitted into hospital at once, only 17 persons died out of 33 attacked, or 51·52%. These prisoners were all adults between 20 and 50 years of age, in good bodily health, and carefully attended to from the time they fell ill.

In Damaun, out of 110 persons living in the same families, 54 were attacked by plague, of whom 37 or 68·52% died.

Under ordinary conditions therefore the mortality among those attacked during the present outbreak was probably between 65 and 70%.

Looking at the mortality, according to race and caste, among the patients admitted into Arthur Road and Parel Hospitals (Table II), the highest mortality, 71·25%, occurred amongst Hindoos; then follow Jews with 65·67%, Native Christians with 65·45%, Brahmins with 65·21%, Parsees with 64·29%, and Mahomedans with 64·24%: the number of Jews (9), Brahmins (23) and Parsees (14), however, were too small to give reliable results.

Among Europeans and Eurasians a much lower death-rate, 38·95%, occurred, owing most probably to their possessing more stamina, and being treated earlier and more carefully nursed during the attack. Out of 34 Europeans admitted into St. George's Hospital 23 recovered and 11 died, the percentage of deaths to attacks being 32·35%, while out of 61 Eurasians under treatment 58 recovered and 37 died, or 42·62% of deaths to attacks. Table I.

shows the recoveries and deaths among Europeans and Eurasians at the different periods of life, but the numbers are too small to attach much value to their analysis. It will be noticed however (Table III.) that while among natives the lowest percentage of deaths to attacks occurred between the ages of 1 and 20 years, in Europeans and Eurasians it lay between the ages of 20 and 40 years; also that between 20 and 40 years the percentage of deaths to attacks was twice as high among natives (69·75%) as among Europeans and Eurasians (34·21%).

It is impossible to give any definite prognosis with regard to individual plague cases, as sometimes those that appear to be quite hopeless recover, while others apparently much less severe die. The conditions regarded as most unfavourable are the occurrence of the disease in its septicæmic form, or as primary plague-pneumonia. Among cases in which buboes are found, those where the buboes are situated in the cervical region appear to be more unfavourable than those with buboes in the axilla or groin; and cases with multiple buboes are more unfavourable than those with single buboes. The symptoms which are generally looked upon as unfavourable are the persistence of severe and continuous vomiting, and the early appearance of diarrhœa, the early onset and continuance of violent delirium, or the setting in of coma. The appearance of petechiæ is generally believed to precede death, and hæmorrhages from the kidneys and bowels are considered very unfavourable.

Attacks occurring late in the epidemic, although often no less severe in their onset (Chart XXVI.), run a milder course than those occurring at the beginning of the outbreak.

Treatment.—No specific remedy has up to the present been discovered for the treatment of plague cases.

During the present epidemic two lines of treatment have been tried, the one, *hygienic and symptomatic*, with the object of tiding the patient over a certain period when, as in the case of the other specific fevers, experience has shown that there is a natural tendency to recovery; the other, *the antitoxic treatment*, with the object of neutralizing by means of antitoxic serum the virus produced by the microbe, and of preventing the growth of the bacillus itself.

The hygienic and symptomatic treatment consists in economising, as far as possible, the nervous and muscular energy of the patient by placing him under the most favourable conditions and treating symptoms. With this object a plague patient is put to bed at the onset of the disease, kept in the recumbent posture (on account of the tendency which there is to fatal syncope) until convalescence is established, and supplied with suitable nourishment at short intervals.

The symptoms which require special attention are those connected with the nervous system and with the circulation. In the nervous system they are mainly due to congestion of the nervous centres at the commencement of the attack, followed by œdema towards its close, the former giving rise to fever, headache, vomiting, insomnia and delirium, the latter to stupor and coma. These symptoms are treated on general lines, *i.e.* the avoidance of light, the application of ice or cold water to the head and surface of the body if the temperature continues high, and the use of hypnotics and sedatives for sleeplessness and delirium.

In connection with the circulation the symptoms to be combatted are vasomotor paralysis and heart failure, the latter probably due partly to the direct action of the toxic poison on the cardiac ganglia and partly to softening and degeneration of the muscular wall of the heart. For these symptoms the use of alcohol in some form is generally required after the first day; in most cases also the administration of drugs which act as cardiac tonics and vascular stimulants such as ammonia, digitalis, strychnine, quinine, is found necessary. All drugs which depress the heart and circulation should, as far as possible, be avoided.

The treatment of pneumonia, primary or secondary, calls for the free administration of stimulants and of stimulating expectorants for the relief of cough and dyspnœa, due to the accumulation of fluid in the bronchial tubes.

Gastro-intestinal symptoms, buboes and such other complications as arise are managed on general principles.

In *treatment by antitoxine* the correct principle of removing the cause of the disease is aimed at, but up to the present time, so far as information is obtainable of M. Yersin's results, and those of other doctors, French and Russian, who have tried it, it has failed to influence favourably the mortality among those attacked.

Surg.-Captain Thomson, the Medical Officer in charge of Parel Plague Hospital, has kindly supplied me with a tabular statement (*vide* Table VIII.) showing the details of 27 cases under his care treated by M. Yersin's antitoxic serum. From these 27 cases he excludes 4 (2 of which died and 2 recovered), *viz.*, one suffering from meningitis and an osseous tumour pressing on the medulla (case 4), one treated prophylactically (case 11), and two which were not plague cases (cases 24 and 27). Of the remaining 23 plague cases, 14 or 60·83 per cent. died.

The detail of the cases treated by M. Haffkine with the antitoxic serum prepared by him in Bombay will be found in his report.

The *prophylatic measures* which demand attention on the occurrence of a case of plague in a family are the removal, when practicable, of the unaffected members from the house, to allow of its being thoroughly cleaned, and of the patient to a hospital, where he can receive proper care and attention, unless suitable provision can be made for his treatment at home. All those who have been living with him should undergo inoculation against plague, as this is found to diminish the risk of infection by 70 to 80 per cent., and to increase the prospect of recovery in those attacked after inoculation by 60 to 70 per cent. (*vide* report on inoculation). The patient's sputa and excreta and all discharges from buboes and sores should be received in vessels containing suitable disinfectants, and on the termination of the illness everything which was used by him, or had been rendered liable to contamination, should be thoroughly cleansed and disinfected, or, if practicable, burnt (*vide* Mr. Hankin's report).

Nurses and attendants who are in close and constant attendance on plague patients should undergo inoculation. All wounds and abrasions on the hands, etc., should be protected from the risk of infection, and the hands should be thoroughly washed and disinfected after dressing sores or otherwise becoming soiled. Their natural immunity should be increased as much as possible by regular meals, sufficient exercise and rest to ensure their keeping in good health.

CASES ILLUSTRATING THE COURSE OF PLAGUE IN THE INOCULATED.

Kondabai, a female, aged 11 years, came from a compound in which four other servants were attacked by plague, three of whom had died. Kondabai and the other servant who recovered were inoculated with M. Haffkine's prophylactic lymph nine days before she was attacked.

When first seen on the 21st February 1897, at the Arthur Road Hospital, she was delirious, her expression was frightened, the eyes were not red nor injected. The pulse was frequent, 126 per minute and rather wiry, respiration 35 per minute, temperature 103° F. Her tongue was moist and somewhat swollen and thickly coated white except at the tip and edges; the bowels were confined. Her father stated that she had had slight fever after inoculation, and that previous to the onset of plague symptoms she had been in good health. She was attacked on the previous night by shivering, vomiting and headache, and at the same time a very painful bubo appeared in the cervical region at the angle of the lower jaw on the right side. There was a good deal of infiltration into the cellular tissue around the gland, giving rise to a painful swelling which prevented her opening her mouth freely. She had slight cough with tough and scanty expectoration. On examining the lungs the bases were slightly congested, particularly the right. The heart sounds were normal. The liver and spleen did not appear to be enlarged, but it was very difficult to examine her, as she was delirious and could hardly be kept in bed. Vomiting had ceased. The urine was passed involuntarily, and was not examined. There was no skin eruption. On the evening of the 21st her temperature had run up to 106° F. (*vide* Chart VIII),* pulse was frequent and fair in volume, there was a doughy swelling filling up the interval between the lower jaw and the neck and extending for a short distance downwards; the corresponding cervical gland on the left side was also inflamed and tender. She was very delirious, the cough continued, but no examination of her lungs was possible. On the morning of the 22nd she was still delirious, but became conscious towards the evening, her temperature falling to 102·4° F. Next morning a painful gland appeared in the right axilla. All these glands eventually suppurated; otherwise the course of the disease presented no features of special interest.

Noronha, a clerk in the office of the B. B. and C. I. Railway, left his house in Girgaum and went to live in the Fort on the 1st April 1897. He had been inoculated with M. Haffkine's prophylactic against plague on the 1st, and on the 3rd March, having been given 3 c. c. on the 1st and 3½ c. c. on the 2nd occasion. He was attacked by plague on the 9th April. The disease set in with a chill, followed by fever, severe headache and acute pain in the left groin. He stated that on the 1st April a mouse was found dead under his cot, and on the 2nd April a dead rat was discovered in the house. On the 12th April the fever and headache diminished considerably. On the 13th February he was seen by Dr. Bhalchandra Krishna, who found he had a temperature of 100° F. and a left femoral bubo, and diagnosed the disease plague. On the 14th he had no fever and afterwards attended Dr. Bhalchundra's dispensary for medicine, and made an uninterrupted recovery.

A CASE OF MARKED GENERAL INCO-ORDINATION AND PARESIS AFTER PLAGUE.

Kallian Vishram, aged 19, a Hindu, by occupation a clerk, was admitted into the Jamsetji Jijibhoy Hospital on the 27th September 1897 for inability to walk.

Towards the middle of April 1897 he was attacked with plague at Musjid Bunder (Mandvi) and removed to the Jain Hospital. His wife had died from plague. On the day after admission he became unconscious, and on recovering

* Chart XVI shows the course of the temperature, pulse and respiration in an attack of plague occurring three days after inoculation with M. Haffkine's prophylactic.

consciousness was unable to feed himself, and his legs were feeble and unmanageable as at present. He was discharged from the Jain Hospital towards the end of May; the bubo, which was in the right groin, having cicatrized. He never had syphilis, but had a mild attack of small-pox four years ago.

He was brought on a stretcher to the ward: nutrition is good; the facial expression is vacant and stolid, all the muscles are quite toneless; he lies on his back and finds great difficulty in turning from side to side or sitting up; he is unable to perform any movements with steadiness and precision. When sitting up, movements of the arms and legs are made with sudden jerkiness and with wider range than normal. The pulse is regular, 52 per minute, of fair volume and tension; respiration 20 per minute, jerky and irregular in rhythm.

The muscles are fairly nourished, but relaxed. Electrical reactions are normal; the feet are rather flat; and the hands are held as seen in drop-wrist. Superficial reflexes are present; the planter reflex elicits a sudden and forcible movement. There is marked inco-ordination of the muscles in general. The head falls forwards and is moved from side to side, instead of being turned to look at objects. On attempting to get out of bed the legs are extended with suddenness, and then thrown outwards with a forcible jerk; he sits holding on to the edge of the bed to maintain his balance; stands with the feet widely apart and leans forwards so as to see their position. The muscles are tremulous, and movements markedly exaggerated, the legs crossing one another, when a step is taken, and thrown forward with a sudden jerk, the toes being brought to the ground forcibly, and the body swaying like that of a drunken man. The movements of the hand are exaggerated and unsteady, the right being worse than the left. When the hands are at rest, the fingers tremble irregularly. Simple movements of the hand are accomplished by spasmodic jerks, and fine movements are most clumsily attempted and imperfectly finished, as is seen on carrying a spoon to the mouth or tying a string. He is unable to maintain his balance in any position.

The acts of swallowing, defœcation and urination are properly performed but delayed.

There are no lightning pains, nor formication of the extremities. He does not complain of giddiness, or of gastric or rectal crisis. He has not suffered from vomiting or girdle sensation. Sensibility to touch is delayed but not actually diminished, and the patient is unable to recognise how often he has been touched or by how may fingers. His sense of feeling amounts to something being brought in contact with his body, but he is unable to recognise what it actually is. Sensibility to pain is somewhat diminished, a forcible pinch giving him pain after a little time. Sensation to heat or cold is not affected. A hot tube passed along the course of the spine gives a burning sensation at the 1st, 2nd, 3rd and 4th dorsal vertebræ. No spinal nor cranial percussion tenderness is present. Cerebral, mental, vaso-motor and nutritive functions are not in any way altered. There have been no trophic changes.

Articulation is slow and deliberate; individual syllables are pronounced separately and forcibly, laying great stress on the final part of the word. The answer to any question put to him takes time, and the act is deliberate. He is intelligent and understands all that is said to him.

Taste is normal; hearing is somewhat diminished in the right ear, but he does appreciate after a time the character of the sound: smell normal.

There is no nystagmus. The left eyeball does not move outwards to the same degree as the right; besides this deviation in the axis, there is nothing peculiar. Pupils are moderately dilated and the Argyll Robertson phenomenon is not present; pupils react to light and accommodation. In both eyes there is a well defined area of old choroiditis between the optic disc and yellow spot. This is quite symmetrical in both eyes.

All other systems were examined and found normal. The patient has been under observation for some time and has as yet shown no improvement. The symptoms present exactly resemble those seen in many severe cases of plague after the second day.

TABLE I.

A table showing the admissions among Europeans and Eurasians into St. George's Hospital, Bombay, at different periods of life, and giving the results.

		1 year and under.	Years 2 to 5	Years 6 to 10.	Years 11 to 20.	Years 21 to 30	Years 31 to 40.	Years 41 to 50.	Years 51 to 70.	Total.	Percentage of deaths to attacks.
Europeans	R	1	0	6	4	6	6	0	0	23	32·35
	D	0	1	3	0	3	2	1	1	11	
Eurasians	R	0	0	4	13	10	3	3	2	35	42·62
	D	0	0	2	12	6	2	2	2	26	
Total ...	R	1	0	10	17	16	9	3	2	58	
	D	0	1	5	12	9	4	3	3	37	
Percentage of deaths to admissions		0	100	33·3	41·38	36	30·76	50	60	38·95	

R = Recovered. D = Died.

TABLE II.

A table showing the admissions among Native Christians, Jews, Parsees, Mohamedans, Brahmins and other Hindus into the Arthur Road and Parel Hospitals, and giving the results: for the Arthur Road Hospital the admissions at the different ages are shown.

		1 year and under.	Years 2 to 5.	Years 6 to 10.	Years 11 to 20.	Years 21 to 30.	Years 31 to 40.	Years 41 to 50.	Years 51 to 70.	Total.	Treated in Parel Hospital.	Total	Percentage of deaths to attacks.
Native Christians ...	R	0	1	4	19	14	7	9	0	54	22	76	65·45
	D	0	2	3	23	30	16	24	1	99	45	144	
Jews	R	0	0	1	0	0	0	1	0	2	1	3	66·67
	D	0	0	1	2	0	0	0	0	3	3	6	
Parsees	R	0	0	0	2	0	1	0	0	3	2	5	64·29
	D	0	0	0	1	1	1	2	0	5	4	9	
Mahomedans	R	0	0	0	16	19	9	7	0	51	8	59	64·24
	D	0	0	4	21	24	25	24	0	98	8	106	
Brahmins	R	0	0	0	2	2	1	0	0	5	3	8	65·21
	D	0	0	0	0	3	3	0	0	6	9	15	
Other Hindus ...	R	5	2	19	66	106	42	17	1	258	72	330	71·25
	D	0	6	32	139	246	150	112	6	691	127	818	
Total ...	R	5	3	24	105	141	60	34	1	373	108	481	69·54
	D	0	8	40	186	304	195	162	7	902	196	1,098	
Percentage of deaths to admissions		0	72·73	62·5	63·92	68·31	76·47	82·65	87·5	70·74	64·47	69·54	

Table III.

A table showing the comparative case mortality per cent. among (a) Europeans and Eurasians and (b) Natives, in youth, adult life and old age.

	Years 1 to 21.	Years 21 to 40.	Years 41 to 70.
Europeans and Eurasians ...	28/18 or 39·137 per cent.	25/13 or 34·21	5/6 or 54·55
Natives	177/293 or 62·34	255/588 or 69·75	49/216 or 81·51

Table IV.

*A statement showing the number of deaths from Plague in Bombay according to age and sex from August to December 1896.**

Months.		1 Year and under.	Years 2 to 10.	Years 11 to 20.	Years 21 to 30.	Years 31 to 40.	Years 41 to 50.	Years 51 to 60.	Years 61 and over.	Total.
August ...	Males ...	...	...	...	...	...	...	...	...	...
	Females .	...	...	...	...	...	...	...	...	...
September ...	Males ...	...	4	15	18	14	5	4	3	63
	Females .	...	1	3	6	2	3	1	...	16
October ...	Males ...	1	11	58	81	36	23	10	4	224
	Females .	...	15	23	23	10	12	5	1	89
November ...	Males ...	1	15	51	64	32	18	7	5	193
	Females .	...	23	25	22	8	8	2	2	80
December ...	Males ...	1	56	208	291	183	91	42	18	890
	Females .	2	49	109	95	50	45	14	17	381
Total ...	Males ...	3	86	332	454	265	137	63	30	1,370
	Females .	2	78	160	146	70	68	22	20	566
Percentage ...		·26	8·47	25·41	30·99	17·30	10·59	4·39	2·58	...

* Details up to 31st May have not yet been received from the Health Department.

Table V.

Admissions into the Arthur Road Hospital according to Occupation.

Occupation.	Arthur Road.	Total.
Domestic Servants*	266	266
Mill-hands	147	147
Coolies	110	110
Syces	49	49
Beggars	41	41
Sepoys (including Native Soldiers and Police)	21	21
Dhobies, Labourers (each)	19	38
Dirzies	18	18
Gowlies, Metalworkers, Peons (each)	15	45
Cart-drivers	13	13
Malies	12	12
School children, Carpenters (each)	11	22
Barbers	10	10

* Including personal servants, cooks, hamals and masalchies.

Occupation.	Arthur Road.	Total.
Shopkeepers	9	9
Clerks and Butchers (each)	8	16
Printers	7	7
Masons	6	6
Shoemakers, Painters, Sweepers (each)	5	15
Ward-boys and Lascars (each)	4	8
Priests, Sailors, Firemen, Wool-cleaners, Bakers, Carpenters, Compounders, Fishermen (each)	3	24
Unclassified	.....	398
		1,275

Table VI.

*A statement showing the number of deaths from Plague in Bombay City according to Occupation from September to December 1896.**

No.	Occupation.†	Number of Deaths in				Total.
		Sept.	Oct.	Nov.	Dec.	
1	Municipal and Local Bodies (including Police)	...	...	2	19	21
2	Devotees, Bhikshuks, Fakirs, &c.	...	2	4	11	17
3	Indoor servants	2	3	5	26	36
4	Dhobies (Washermen)	...	...	2	17	19
5	Servants not otherwise described	5	8	6	27	46
6	General Merchants	...	6	1	4	11
7	Bankers	...	1	2	9	12
8	Commercial Agents, Brokers, &c.	6	9	2	7	24
9	Commercial Clerks, &c....	1	11	8	36	56
10	Drivers of public vehicles	...	1	...	5	6
11	Cart-owners and drivers	...	3	4	15	22
12	Seamen (not Government)	...	...	...	5	5
13	Messengers, Porters, &c. (not Government) ...	...	3	1	6	10
14	Jockey Grooms	...	4	4	10	18
15	Fishermen, &c.	...	2	...	5	7
16	Printers by steam, compositors	...	...	...	8	8
17	Figure casters (Otarva)	...	...	...	5	5
18	Engine makers (Fitters, &c.)	...	2	...	9	11
19	Carpenters, Joiners, Sawyers	...	3	4	18	25
20	Masons and Bricklayers	...	1	1	12	14
21	Cotton Dyers	...	...	...	5	5
22	Spinners, Weavers and Factory workers ...	...	1	...	16	17
23	Cotton goods sellers, drapers	1	1	...	3	5
24	Tailors	1	6	4	11	22
25	Shoe and Boot Makers	...	1	5	14	20
26	Workers and sellers of Jute	...	5	1	...	6
27	Cow-keepers and Milk-sellers	...	2	1	4	7
28	Grain, Pulse and Flour Dealers	9	15	9	18	51
29	Sweetmeat makers and sellers of pastry, cooks.	...	1	1	10	12
30	Fruit and vegetable dealers	...	1	2	10	13
31	Grocers, Spice-dealers	...	...	1	4	5
32	Stone-cutte	1	...	...	4	5
33	Gold and Silver Smiths	1	...	1	9	11
34	Black-smiths	...	...	1	5	6
35	General labourers and coolies	18	66	50	185	319
36	Factory labourers (unspecified)	...	7	14	92	113
37	Shopmen, &c. (unspecified)	...	9	3	19	31
38	Mendicants	...	...	2	20	22
39	Males following no occupation	2	6	4	32	44
40	Females do. do.	12	50	34	171	267
41	Children, males	16	41	49	188	294
42	Children, females	2	28	29	131	190
	Total ...	77	299	257	1,205	1,838

* The details up to 31st May 1897 have not yet been received from the Health Department.
† Occupations have been excluded in which less than 5 deaths occurred during the 4 months.

Table VII.

Staement showing the probable mortality from Plague in Bombay City from the commencement of the outbreak to the end of May 1897, and also showing the fall in the birth-rate.

For Week ending	Total Deaths including Still-born.		Probable Plague mortality in 1896-97.	Total Births excluding Still-born.	
	1896 and 1897.	Mean of corresponding weeks in preceding 5 years.		1896 and 1897.	Mean of corresponding weeks in preceding 5 years.
August 4th	564				
„ 11th	598	564	...	287	313
„ 18th	650	534	64	311	307
„ 25th	669	538	12	263	307
Sept. 1st	667	581	88	298	301
„ 8th	593	540	127	345	
„ 15th	618	531	62	346	291
„ 22nd	647	492	126	321	312
„ 29th	720	506	141	304	273
Oct. 6th	791	527	193	339	271
„ 13th	634	491	300	279	338
„ 20th	606	498	136	320	329
„ 27th	698	477	129	284	336
Nov. 3rd	668	470	228	283	278
„ 10th	623	443	225	295	291
„ 17th	704	449	174	247	303
„ 24th	760	462	242	238	346
Dec. 1st	772	446	314	296	286
„ 8th	1,051	457	315	356	301
„ 15th	1,310	460	591	370	331
„ 22nd	1,416	470	840	321	355
„ 29th	1,853	470	946	299	333
Jan. 5th	1,711	469	1,384	282	305
„ 12th	1,638	494	1,217	232	317
„ 19th	1,758	484	1,154	206	320
„ 26th	1,721	501	1,257	138	341
Feb. 2nd	1,645	518	1,203	132	257
„ 9th	1,911	526	1,119	85	323
„ 16th	1,728	540	1,371	98	313
„ 25th	1,650	569	1,159	71	294
March 2nd	1,484	542	1,108	49	284
„ 9th	1,326	546	938	57	271
„ 16th	1,258	544	782	109	292
„ 23rd	1,139	534	724	97	284
„ 30th	1,141	539	600	37	253
April 6th	1,007	544	597	89	270
„ 13th	970	559	448	92	240
„ 20th	836	572	398	60	281
„ 27th	671	614	222	81	248
May 4th	638	625	46	117	261
„ 11th	558	606	32	133	263
„ 18th	547	599	...	156	295
„ 25th	541	602	...	173	291
		581	...	159	269
					276

Table VIII.

The details of 27 Patients treated at Parel Plague Hospital with M. Yersin's Anti-toxic Serum.

No.	Initials.	Sex.	Age.	Caste.	Occupation.	Duration of Disease.	Serum in C. C.	Total C. C.	Result.	Remarks.
						Days.				
1	C. D. N.	M	51	N. C.	Medical Practitioner.	4—5	30+20	50	D	Double pneumonia.
2	D. P.	F	40	H.	Cooly ...	2	30+20	50	D	
3	D. N.	F	1½	N. C.	.....	2	10+10+10	30	R	
*4	R. T. N.	F	18	N. C.	.....	3	20+20	40	D	Meningitis and tumour (osseous) pressing on medulla in P. M.
5	S. B.	M	24	H.	Clerk ...	3—4	20+10+10+20	60	D	
6	S. B. K.	M	18	H.	Mill-hand ...	3—5	20+10	30	D	
7	P. D.	F	60	H.	.....	2	30+30+40	100	D	
8	R. M.	M	25	H.	Mill-hand ...	2	30	30	D	
9	J. D. D. S.	M	13	N. C.	School-boy...	36 hours.	40+40	80	D	Developed pneumonia double.
10	P. R.	M	7	H.	Do. ...	2	30+30	60	R	
*11	R. F.	F	25	N. C.	.....	.....	20	20	...	
12	M. D.	M	30	H.	Hamál ...	2	40	40	D	
13	R. M.	M	9	N. C.	School-boy...	1	40+40+40+40+30	190	R	
14	S. J.	M	9	H.	Sweeper ...	2	40+40+30	110	R	
15	B. J.	M	25	H.	Do. ...	2	30+40+40	110	R	
16	R. G. S.	M	28	H.	Clerk ...	36 hours.	40+50	90	D	
17	T. M.	M	18	H.	Mill-hand ...	2	50+50+50+50+30	230	R	
18	M. S.	M	30	H.	Mali ...	26 hours.	40	40	D	
19	K. H.	M	22	H.	Massál ...	4—5	40	40	R	
20	L. R.	F	12	N. C.	.....	3—9 hours.	40	40	D	
21	A. K. T.	M	60	N. C.	Merchant ...	9 hours.	40+50+50	140	R	
22	M. E.	M	45	Parsee.	Cook ...	3	60	60	R	
23	D. E.	F	11	Parsee.	.....	27 hours.	50	50	D	
*24	H. B.	F	32	Hindu Jain.	.....	7 „	50	50	R	I heard came from Charni Road Hospital.
25	C. M.	F	32	N. C.	.....	24 „	50+50	100	D	
26	K. B. S.	F	4	H.	.....	42 „	40	40	D	
*27	G. R.	M	52	H.	Clerk ...	3—5	20	20	D	Hepatitis and R. Ferri injected at his own urgent request.

* These were not cases of plague.

Case No. 4 died of meningitis and should be excluded and mortality = 60·8 per cent.

2 cases developed sub-acute synovitis.

2 cases developed erythematous rashes on the skin. In one of these the rash persisted 2½ weeks.

TABLE IX.

Showing the results of the quantitative urine analyses obtained by Surgeon-Captain Hojel in fifty plague cases at the St. George's Hospital, Bombay.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
No.	Race.	Age.	Sex.	Day.	Quantity.	Colour.	Reaction.	Sp. Gr.	Urea.	Chlorides.	Sulphates.	Phosphates.	Solids, Gms. per diem.	Albumin.	Globulins.	Peptones.	Albumoses.	Bile.	Sugar.	Indican.	Leucin, Tyrosin.	Acetone, Diacetic Acid.	Diazo Reaction.	Sediment.
1	E. ...	34	F	4	700·C.C.	Muddy Yellow.	Faintly acid ..	1,015	2%	Trace.	P	D	25·46	Trace.	*Nil*	*Nil*	*Nil*	Trace.	*Nil*	Trace.	*Nil*	*Nil*	Port wine colour.	Amorphous urates; no casts.
2	Eurasian .	36	M	3	760·C.C.	Reddish Brown.	Sharply acid ..	1,025	1·85%	Do.	P	D	44·27	Do.	,,	,,	,,	Do.	,,	Do.	,,	,,	Do. ..	No casts.
3	D. E. ...	18	M	3	800 C.C.	Light Yellow...	Do. ...	1,018	1·75%	Absent.	P	D	35·55	Do.	,,	,,	,,	*Nil*	,,	Marked.	,,	,,	Do. ..	Do.
4	Eurasian .	22	M	5	630 C.C.	Brown Red ...	Do. ...	1,020	1·75%	Trace.	P	D	29·35	Do.	,,	,,	,,	,,	,,	M	,,	,,	Do. ...	Hyaline and uratic casts; uric acid crystals abundant.
5	Do. ...	21	M	4	760·C.C.	Pale Yellow ...	Do. ...	1,024	1·85%	Absent.	Trace.	Faint.	42·49	*Nil*.	,,	,,	,,	Trace.	,,	M	,,	,,	Do. ...	No sediment; mucous clouds.
6	E. ...	32	M	3	900·C.C.	Red Yellow ...	Do. ...	1,015	2·5%	Present.	P	D	31·45	,,	,,	,,	,,	*Nil*	,,	M	,,	,,	Do. ...	Cloudy; no sediment.
7	R. J. ...	36	M	4	800·C.C.	Do. ...	Intensely acid .	1,026	1·85%	Trace.	P	D	48·46	Trace.	,,	,,	,,	,,	,,	M	,,	,,	Do. ...	Cloudy.
8	D. E. ...	9	M	4	900·C.C.	Yellow Red ...	Alke ...	1,022	1·85%	Do.	P	D	46·13	Do.	,,	,,	,,	,,	,,	M	,,	,,	Do. ...	Amorphous and triple phosphates.
9	E. J. ...	29	M	3	800·C.C.	Red Yellow ...	Sharply acid...	1,015	2·0%	Absent.	Trace.	Abundant.	27·96	*Nil*.	,,	,,	,,	,,	,,	M	,,	,,	Do. ...	Amorphous urates; uratic casts.
10	E. J. ...	31	M	4	760·C.C.	Do. ...	Neutral ...	1,018	1·85%	Trace.	Marked.	D	31·87	Trace.	,,	,,	,,	,,	,,	M	,,	,,	Do. ...	Urate of ammonium.
11	N. C. ...	18	M	4	800·C.C.	Light Yellow...	Sharply acid...	1,025	0·85%	Absent.	P	D	46·60	½	Trace.	,,	Present.	,,	,,	Trace.	,,	,,	Do. ..	Granular casts, large and small urate of ammonium.
12	Eurasian .	45	M	3	850·C.C.	Red Yellow ...	Do. ...	1,025	1·80%	Do.	P	D	49·51	6	Do.	,,	P	,,	,,	M	,,	,,	Do. ...	A few granular casts.
13	Do. .	22	M	5	1,000·C.C.	Dark Red ...	Do. ...	1,028	1·75%	Trace.	P	D	63·04	Trace.	*Nil*	,,	*Nil*	Trace.	,,	Fair.	,,	,,	Light Port wine colour.	Do. do.
14	Do. .	23	M	4	850·C.C.	Yellow Red ..	Do. ...	1,018	1·25%	Do.	P	Present.	35·64	*Nil*	,,	,,	,,	Do.	,,	M	,,	,,	Port wine colour.	*Nil*.
15	Do. .	15	F	4	800·C.C.	Red ...	Do. ...	1,015	2·5%	Do.	P	D	27·96	½	Trace.	,,	P	*Nil*	,,	M	,,	,,	Do. ..	R. B. corpuscles; hæmoglobin crystals.
16	G. ...	34	M	3	760·C.C.	Deep Red ...	Do. ...	1,024	1·85%	Absent.	P	D	42·49	¼	Do.	P	P	,,	,,	M	,,	,,	Do. ..	Do. do.
17	Eurasian .	26	M	3	600·C.C.	Red Yellow ...	Do. ...	1,025	1·75%	P. Trace.	Trace.	D	34·95	¼	Do.	*Nil*	P	,,	,,	Trace.	,,	,,	Do. ...	R. B. corpuscles; amorphous urates.
18	D. E. ...	38	M	9	700·C.C.	Red ...	Do. ...	1,025	1·90%	Absent.	P	Trace.	40·77	½	*Nil*	,,	P	Trace.	,,	Marked.	P	Acetone	Do. ...	Granular casts.
19	Eurasian .	13	M	4	400·C.C.	Muddy Yellow Red.	Faintly acid ...	1,020	2·0%	Trace.	P	D	18·64	Trace.	,,	,,	*Nil*	*Nil*	,,	Trace.	*Nil*	*Nil*	Do. ..	Epithelial casts.
20	Do. .	29	M	4	650·C.C.	Do. ...	Sharply acid ..	1,018	1·5%	Absent.	P	D	27·26	Do.	,,	,,	,,	,,	,,	Marked.	,,	,,	Do. ...	*Nil*.
21	Do. .	9	M	5	1,000·C.C.	Light Yellow...	Do. ...	1,015	2·5%	P.	P	D	34·95	*Nil*	,,	,,	,,	,,	,,	Fair.	,,	,,	Do. ..	,,
22	G. ...	44	M	3	700·C.C.	Do. ...	Do. ...	1,020	1·85%	Trace.	P	D	32·62	,,	,,	,,	,,	,,	,,	M	,,	,,	Light P. W.	,,
23	G. ...	14	M	3	500·C.C.	Yellow Red ..	Do. ...	1,024	2·0%	Do.	P	D	27·26	Trace.	Trace.	,,	,,	,,	,,	M	,,	,,	P. W.	,,
24	D. E. ...	18	M	4	950·C.C.	Red Yellow ...	Do. ...	1,014	2·5%	Do.	Slight.	D	30·08	*Nil*	*Nil*	,,	,,	,,	,,	Trace.	,,	,,	Do. ...	,,
25	G. ...	16	M	5	1,000·C.C.	Yellow Red ...	Do. ...	1,018	1·85%	Do.	P	D	41·94	,,	,,	,,	,,	Trace	,,	M	,,	,,	Do. ...	,,
26	Eurasian .	15	M	6	800·C.C.	Do. ...	Do. ...	1,010	1·0%	Do.	P	D	18·64	,,	,,	,,	,,	*Nil*.	,,	Trace.	,,	,,	Do. ...	Urate of soda.
27	G. ...	26	M	4	800·C.C.	Red Yellow ...	Do. ...	1,012	1·85%	Do.	P	D	20·26	,,	,,	,,	,,	Trace.	,,	Marked.	,,	,,	Do. ...	Amorphous urates.
28	D. E. ...	31	F	3	850 C.C.	Do. ...	Do. ...	1,016	1·90%	Do.	P	D	31·68	Trace.	,,	Trace.	,,	*Nil*	,,	Trace.	,,	,,	Do. ...	*Nil*.
29	D. E. ...	7	M	4	630·C.C.	Do. ...	Do. ...	1,015	2·25%	P.	P	D	22·01	*Nil*	,,	*Nil*.	,,	,,	,,	M	,,	,,	Do. ..	Vaginal epithelum; no casts.
30	D. E. ...	8	F	4	900·C.C.	Yellow Red ...	Do. ...	1,018	2·0%	Trace.	P	D	39·84	Trace.	,,	,,	,,	Trace.	,,	M	,,	,,	Do. ...	Amorphous urates.
31	Eurasian .	30	M	3	800·C.C.	Light Yellow...	Do. ...	1,025	1·85%	Do.	P	D	46·60	Do.	,,	,,	,,	*Nil*	,,	M	,,	,,	Do. ...	Vaginal epithelium; urates.
32	D. E. ...	22	F	4	900·C.C.	Yellow Red ...	Do. ...	1,024	2·5%	P.	P	D	50·32	*Nil*	,,	,,	,,	Trace.	,,	M	,,	,,	Do. ...	Urate of ammonium.
33	Eurasian .	21	M	4	1,000·C.C.	Light Yellow...	Faintly acid ...	1,010	1·75%	Trace.	P	Trace.	23·30	Trace.	,,	,,	,,	*Nil*	,,	M	,,	,,	Do. ..	Granular and epithelial casts.
34	Do. ...	55	M	5	1,500·C.C.	Red Yellow ...	Sharply acid ...	1,025	1·75%	P.	P	D	87·37	¼	,,	,,	,,	Trace.	,,	M	,,	,,	Do. ...	Uric acid.
35	G. ...	22	M	3	760·C.C.	Brown Red ...	Intensely acid .	1,026	2·75%	Absent.	P	D	46·04	¼	Trace.	,,	Trace.	*Nil*	,,	M	,,	,,	Do. ...	Hyalin casts.
36	Eurasian .	32	M	5	1,400·C.C.	Yellow ...	Sharply acid ...	1,022	1·50%	Do.	P	D	71·76	½	*Nil*	Trace.	Do.	,,	,,	M	,,	,,	Do. ...	*Nil*.
37	Do. ...	19	F	5	1,000·C.C.	Do. ...	Do. ..	1,025	2·0%	Trace.	P	D	58·25	½	,,	*Nil*	Do.	,,	,,	M	,,	,,	Do. ...	Amorphous urates.
38	J. ...	20	M	5	1,500·C.C.	Brown Red ...	Do. ...	1,024	2·0%	Absent.	P	D	82·88	½	,,	,,	Do.	,,	,,	M	,,	,,	Do. ...	Epithelial casts.
39	Eurasian .	18	F	3	500·C.C.	Do. ..	Do. ...	1,025	2·5%	Trace.	P	Trace.	23·12	Trace.	,,	,,	*Nil*	,,	,,	Trace.	,,	,,	Do. ...	*Nil*.
40	Do. ...	33	M	4	1,260·C.C.	Light Yellow...	Do. ...	1,030	2·5%	Do.	P	P.	88·07	Do.	,,	,,	,,	Trace.	,,	M	,,	,,	Do. ...	Uric acid; oxalate of lime.
41	Do. ...	17	M	4	900·C.C.	Do. ...	Intensely acid .	1,024	1·25%	Do.	P	Slight.	50·32	Do.	,,	,,	,,	*Nil*	,,	M	,,	,,	Do. ...	Amorphous urates.
42	G. ...	44	M	5	950·C.C.	Red Yellow ...	Sharply acid ...	1,026	1·75%	TraceSalmon Pink	P	D	57·45	Do.	,,	,,	,,	Trace.	,,	M	,,	,,	Do. ...	Granular and uratic casts.
43	J. ...	40	M	4	950·C.C.	Do. ...	Do. ...	1,035	1·25%	Trace.	P	D	77·48	½	Trace.	Trace.	Trace.	*Nil*	,,	Trace.	,,	,,	Do. ...	Vesical and vaginal epithelium.
44	European .	17	F	3	800·C.C.	Light Yellow...	Do. ...	1,025	1·50%	Fair.	P	D	46·60	Do.	*Nil*	,,	*Nil*	P	,,	Do.	,,	,,	Do. ...	*Nil*.
45	R. J. ...	26	F	4	900·C.C.	Red Yellow ...	Do. ...	1,032	2·25%	Trace.	P	Slight.	67·10	Do.	,,	,,	,,	Trace.	,,	M	,,	,,	Do. ...	Granular casts.
46	J. ...	16	M	4	1,000·C.C.	Red Brown ...	Do. ...	1,025	2·0%	Do.	P	Do.	58·25	*Nil*	,,	,,	,,	*Nil*	,,	M	,,	,,	Do. ...	Triple phosphates.
47	Eurasian .	12	M	5	1,200·C.C.	Light Yellow...	Neutral ...	1,018	2·5%	P.	P	Abundant.	5	½	,,	,,	P	,,	,,	M	,,	,,	Do. ...	*Nil*.
48	Do. ...	28	M	5	1,600·C.C.	Red Yellow ...	Do. ...	1,018	3·2%	D.	P	D.	67·10	*Nil*	,,	,,	*Nil*	Trace.	,,	M	,,	,,	Do. ...	,,
49	D. E. ...	13	M	4	760·C.C.	Do. ...	Sharply acid ...	1,028	2·5%	Normal.	P	Slight	49·35	¼	,,	,,	Trace.	*Nil*	,,	Trace.	,,	,,	Do. ...	Uratic casts.
50	Eurasian .	42	F	4	700·C.C.	Do. ...	Do. ...	1,020	2·5%	Trace.	P	De.	32·62											

Abbreviations.—E. = European. D. E. = Domiciled European. E. J. = European Jew. J. = Jew. R. J. = Russian. G = Goanese. N C = Native Christian. P = Present. D = Diminished. M = Marked.

GENERAL APPENDIX.

The following recommendations were made by the Committee :—

From

THE PRESIDENT,

PLAGUE RESEARCH COMMITTEE;

To

THE SECRETARY TO THE SURGEON-GENERAL

WITH THE GOVERNMENT OF BOMBAY.

Petit Laboratory, J. J. Hospital,
Bombay, 9th December 1896.

SIR,

The undersigned members of the Plague Research Committee strongly urge the adoption of the following measures for dealing with the existing epidemic.

2. Seeing that it is known that each plague patient contains in himself the source of infection, and seeing that there is a possibility of this passing either directly or indirectly from the sick to the healthy, it is absolutely necessary that the most rigid isolation of the sick should be practised. For the attainment of this end it is not necessary in all cases that the sick person or persons should be removed from the house in which the attack commenced. Suitable rooms might be available in the house in which the case could be efficiently isolated. In selecting such room, the points to be especially kept in mind should be the free supply of sunlight and air and the minimising of the chances of communication with other persons in the house. Often, in place of a room, the flat roof of a house or other such open space in connection with a house could be utilised for isolation, a temporary erection sufficing to keep off the direct rays of the sun. Whichever method be adopted, the door, passage of communication with the house should be guarded by hanging over it a cloth kept constantly saturated with carbolic solution (1 pint to 2 gallons).

3. All articles of clothing, etc., used by the patient, and all secretions should either be disinfected before removal from the room, or destroyed by fire. Not more than one attendant, or at the most two at a time, should be allowed in the room.

4. If no suitable accommodation is available in the house, the patient must be removed to a suitable place, which should, if possible, be a special hospital.

5. After the removal recovery or death of the patient, the infected room should first be hermetically closed and thoroughly fumigated with sulphur fumes. The walls and floor should then be scraped, and they, together with all the articles in the room capable of being so treated, should be washed with solution of carbolic acid ($\frac{1}{2}$ pint to 2 gallons). Finally, the walls should be washed with fresh quicklime and water, or preferably with a solution of chlorinated lime. Clothing, bedding, etc., should be treated in a steam steriliser. For the purpose of transporting them to the steriliser, it is advisable that they should be wrapped in a sheet soaked in carbolic acid solution. The room should be then vacated for a period of at least six weeks. About a week before it is re-occupied, the floor and walls should again be treated with chlorinated lime. On the occurrence of a second case in the same house within 15 days of the occurrence of the first case, the whole house should be vacated, the sick person being removed to a suitable hospital. If the removal of the sick cannot be effected without giving rise to an objectionable amount of prejudice, they should be treated in the house. The whole house, when vacated, should be subjected to the same process as detailed for the infected room, with the proviso that any godown or place of business, provided with a separate entrance and not used as a residence, need not necessarily be vacated, but should be treated on its merits as to how far it should come under the operation of the measures applicable to the rest of the house.

6. To meet prejudices against promiscuous segregation, communities in the various districts objecting to the ordinary isolation hospitals should be permitted to open as many selected and approved hospitals as may be necessary for the purpose. Vacant houses, huts, tents or ships in the harbour may be used for the purpose.

7. To meet the difficulty of housing the evicted healthy persons temporary accommodation might be required, and could be erected on any available open land, but much might be done by utilising houses already more or less deserted. Houses that have been vacated for six weeks, owing to the occurrence of plague cases, might be found suitable.

8. To meet the serious difficulty of the concealment of cases, all householders should be made responsible that all serious cases of illness should immediately be reported to the Health Department of the Municipality. On receipt of such a report the Municipal Medical Officer should visit the case, and if it should prove to be one of plague, the person reporting might be suitably rewarded. In the case of chawls, it might be necessary, not only to make the landlord responsible, but also to compel him to keep a representative constantly on the premises to report cases of sickness in the same manner as a householder. The concealment of cases of severe sickness should be made a penal offence. To ensure the efficient reporting of cases of plague, house to house visitations by Municipal Medical Officers should be carried out daily in all infected localities.

9. Meanwhile the present measures for opening up and cleansing of drains, gullies &c., disinfecting of roads, burning of dead rats &c., should be continued; but we consider that the practice of burning sulphur in open spaces and in open houses is useless and had better be discontinued.

10. We consider that an extensive mortality among rats in any locality may be taken as an indication that there is a risk of the appearance of plague among human beings there residing, and that on the occurrence of this phenomenon, all rat-holes should be dug up and thoroughly disinfected, either by fire or by means of a strong solution of chlorinated lime. Rat-holes should also be carefully disinfected wherever found in an infected house.

11. A set of simple rules for the guidance of the people should be drawn up in the various vernaculars and circulated both by printed notices and by criers. Such rules should direct attention to the necessity for free and efficient ventilation, the prevention of overcrowding and the necessity of cleanliness both of the person and of the dwelling. The whole contents of dwelling rooms should be well aired and exposed to sunlight once a fortnight; bedding and clothing should be so treated every day. Special care should be enjoined in keeping clean all injuries or skin abrasions even of the slightest description. They should be washed with disinfectants obtained from the Municipality and protected by plaster, or clean bandages, or otherwise. Householders and landlords should be compelled to wash and limewash all houses and rooms which on inspection are found to be dirty. Such limewashing will obviously give an opportunity for exposing the contents of a room to sunlight and air. Persons coming in contact with the sick, especially if contaminated with secretions, should be instructed to carefully wash all exposed skin surfaces with carbolic lotion of 1 in 20 strength.

12. In order to increase the accuracy of the death returns and to obtain a better check on the progress of the disease, a Medical Officer should be stationed at each of the places for the disposal of the dead, and should be empowered to examine bodies in all suspicious cases. As a general rule, this examination need only be external.

13. With regard to general measures, it may be noted that overcrowding, deficient ventilation of houses and rooms, accumulated dirt in rooms and passages, are frequently present and obviously require to be dealt with, where necessary, by compulsion. The opening up of crowded localities for the free perflation of air is urgently needed. The crowded and insanitary burial grounds present in the midst of thickly populated districts should be closed on

the earliest possible occasion. We also point out the need for a steam steriliser in each district of the city.

14. The committee is well aware that the carrying out of much of the above measures will be attended with hardship and inconvenience to the inhabitants, but we consider that nothing less than the above desiderata will suffice to eradicate the disease. While every effort should be made to prevent the regulations bearing harshly on the people, these regulations should be firmly and unflinchingly applied in view of the enormous interests at stake. Although interference with trade and even panic may ensue on enforcing the above measures, it should be borne in mind that greater interference with trade and greater panic is likely to be produced by the disease itself if allowed an untrammelled course in the succeeding months of the cold weather.

15. While leaving the carrying out of the above rules to the Municipal authorities, the Committee advocates the employment of a Commissioned Medical officer in each of the infected districts to inspect and supervise the methods of combating the disease. It might be feasible to ask the Army Medical Staff and the Royal Navy to contribute their quota of such officers, if any difficulty is found in providing them from the Indian Medical Service. Such aid is requisite, as it is feared that in some cases the present measures of disinfection are not efficiently carried out, and more responsible aid is required in supervising the sanitary needs of the infected areas. At present it is feared that the Medical officers employed by the Municipality have most of their time employed in inspecting and treating the sick. These Municipal officers should direct the whole of their time to inspecting their districts and to seeing that the above suggestions are carried out efficiently. The Commissioned Medical officers, if employed, should be independent of the Municipality and should report to the Sanitary Commissioner with the Government of Bombay.

16. We also consider that steps should be taken for obtaining further supplies of M. Yersin's antitoxin for treatment of the sick.

17. In conclusion we wish to point out that until scientific researches have shown us the exact sources and modes of infection in this disease, the utility of any special mode of disinfection must remain a matter of theory, and the safest way of avoiding the disease must be to run away from it. In other words, although it is probable that the suggested measures of disinfection will be of some use, we consider that there is reason for placing more reliance on the evacuation of infected houses as a means of combating the disease.

We have the honour to be,
Sir,
Your most obedient servants,

(Signed) R. MANSER, M.D.,
Surgeon-Major, I. M. S., *President.*

(Signed) E. H. HANKIN.

(Signed) L. F. CHILDE,
Surgeon-Captain, I. M. S.

(Signed) N. F. SURVEYOR.

A minority report by Professor Haffkine is appended.

Petit Laboratory, 10th December 1896.

DEAR DR. MANSER,

I regret to be unable to sign the paper which you have read us during our sittings yesterday and on the day before yesterday, even after its having been altered by the Committee.

Kindly forward to the Surgeon-General the following statement which represents the views I hold personally on the situation.

The sanitary precautions now being taken against the plague are in conformity with the general sanitary principles adopted at present.

Any new suggestions can be made only after a patient study for which we have not yet had sufficient time and which ought to be uninterruptedly pursued.

No immaterial alterations or additions in the present measures are in the least likely to affect the course of the epidemic, and it is not advisable to interfere with the sanitary system at present at work in the city, for which there is no reason to substitute any other.

The preparation of an antitoxin serum, similar to that which is being experimented upon by Dr. Yersin, is a correct attempt, and in my programme of work submitted to the Government of India previous to my coming to Bombay, this was the first problem to be taken up after having ascertained the identity of the disease. Since several weeks horses, cows, goats and sheep are being immunised at the Government Lazaretto at Siwri. Dr. Yersin has also been asked for a supply of serum, just at the commencement of the outbreak, through the Consul General in Calcutta, and he answered that he had only a small amount of serum, of which he could send only two doses, since then received in Calcutta. At my request to have the sample here for a trial, I had first a telegram from the Health Officer of Calcutta, saying that it was being despatched to me, but later on he informed me that he could not spare the specimen. I am repeating the request to-day.

As there is the possibility of Dr. Yersin having since prepared another supply of serum, or of his being now ready to submit it to trial, it is advisable to repeat the inquiry, and I concur with the rest of the Committee in the clause which has been inserted in your paper to that effect.

Yours faithfully,
(Signed) W. M. HAFFKINE.

MEASURES RECOMMENDED TO BE ADOPTED FOR LIMITING THE SPREAD OF PLAGUE IN THE MOFUSSIL.*

1. On the appearance of plague in a district or when the disease is prevalent in the neighbourhood, Collectors should take measures to prevent the admission into villages of persons from infected areas and the movement of villagers between neighbouring villages.

2. Sanitary measures such as will improve the water supply and drainage, the provision of food where scarcity prevails, and the supervision of the quality of the grain sold in the bazaar—in short, all sanitary measures calculated to improve the general health—should be carried out without delay, as improvement of the general health of a population increases its resistance to epidemic disease.

3. The death-rate should be closely watched and the cause of any unusual mortality enquired into, so that the disease may be detected before it has spread throughout the village.

4. When the presence of plague has been ascertained, a temporary hospital should be erected, if possible, with wards for male and female patients, and shelter provided near the hospital for such of the patients' friends as will act as nurses. When a temporary hospital cannot be provided—*e. g.* in the monsoon—as suitable a house as possible should be obtained.

* For translation into vernacular for the use of village officers.

5. A hospital establishment, medicines, instruments &c. will be necessary in proportion to the size of the village and extent of the outbreak. A dooly or the patient's cot may be used for conveying the sick to hospital.

6. In the fair season and when the disease is limited to a few families, segregation of the infected families should be carried out. For this purpose sheds or other accommodation will generally be necessary. Occasionally the whole population of a village will turn out into the fields of their own accord on the appearance of plague. This appears to act excellently in checking the outbreak and should be encouraged. They should not return until cases of plague have ceased to occur among them, and in the interval their houses should be thoroughly cleaned. During the rains the most that can be done, as a rule, is to warn the uninfected not to expose themselves unnecessarily by going into infected houses.

7. The dead should be buried at a safe distance from banks of nálas and from wells. Where burning is employed, the body should be entirely consumed.

8. Schools should be closed, and gatherings at fairs &c. discouraged or prohibited.

9. In cleaning houses the woodwork should be well washed, and articles of furniture washed and exposed to the sun and air for some days. The walls and floors should be swept as clean as possible, and the house thrown open to the light and air; where there are mud floors, these should be renewed.

10. The clothing of infected persons should be disinfected by boiling or steeping for some hours in perchloride of mercury solution (1 in 1000).

11. Villagers should co-operate with the village officers in carrying out these measures as thoroughly as possible, as they are intended for the good of the whole community.

Professor Haffkine objects to paras. 6, 10 and 11. He thinks they should run as follows :—

6. While the disease is still limited to a few families, the Pátel should explain to the people the danger of residing in the infected houses, and try to induce them to go to some other unoccupied dwellings. As far as practicable, they should be assisted by providing them with accommodation at the public expense. When the village is small and there is the possibility of the whole population vacating it for a time, this ought to be encouraged, the people remaining outside the village till the cessation of the epidemic amongst them. The practicability of this measure is limited in the rainy season.

10. The clothes of infected persons should not be used before being thoroughly washed and dried in the sun.

11. The head of the village is enjoined to watch over the carrying out of the above measures, as they are for the good of the community under him.

R. W. S. LYONS, M. D.,
Surgeon-Major, I. M. S.,
President, Plague Research Committee.

Bombay, 2nd August 1897.

From

SURGEON-CAPTAIN L. F. CHILDE.

To

THE PRESIDENT,
Plague Research Committee.

Bombay, 20th October 1897.

SIR,

I have the honour to forward herewith my report on plague. It is mainly confined to the pathology of the disease and the mode of entry of the plague-bacillus into the body, with its exit therefrom, as this was the portion of the enquiry assigned to me at a meeting of the Committee held in October 1896. A clinical account of plague-pneumonia has been added, as well as some notes on cases of unusual interest.

I regret that this report is not more complete, as I could have made more *post-mortem* examinations had time permitted, and it is possible that there may be some other varieties of plague which have escaped me; but as I have had to perform all my ordinary duties during the whole of this enquiry, and those of the First Physician, Sir Jamsetji Jijibhoy Hospital, in addition, during a part of it, I have been unable to devote as much time to this research as I could have wished.

I have the honour to be,
Sir,
Your most obedient Servant,
L. F. CHILDE, Surg.-Capt., I. M. S.,
Member, Plague Research Committee.

II.—Report by Surgeon-Captain Childe, I. M. S.

I.—ON THE POST-MORTEM APPEARANCES OF PLAGUE.

The bodies examined were for the most part those of well-nourished adults of the servant and labouring classes. Usually the skin was found intact, except that there were cracks and abrasions about the hands and feet, resulting from occupation, and also in many cases marks of the common parasitic skin diseases, especially ringworm and itch; and although clinically various skin-lesions were met with, such as sloughing at the site of the bubo, boils and ulcers, yet in these cases recovery generally took place, and I had no opportunity of observing such conditions in the *post-mortem* room.

The following varieties of plague were met with :—

The Bubonic Form.

The Septicæmic Form or Plague-Septicæmia.

The Pneumonic Form or Plague-Pneumonia.

A.—The Bubonic Form.

The bubo was usually situated in the groin of either side, less commonly in the axilla, rarely in the neck, and most rarely in the supra-trochlear or popliteal region; the limb corresponding to the bubo was swollen and œdematous and petechiæ were usually seen upon it, but they were always in greatest number over the site of the bubo itself; and though there might be some over the body generally, still these were but few. In the case of an axillary bubo the whole axilla looked full and smooth, and the swelling extended down the side nearly to the margin of the ribs, down the inner part of the arm to the elbow, and over the anterior and posterior axillary folds. On dissection there was an enormous mass of dark coagulated blood and serum which occupied the whole axilla and included the glands, so that the whole mass had to be removed together; and on incision this was found to consist of the connective tissue of the part gorged with blood and of coagula due to hæmorrhages, whilst within were seen the glands. In recent cases, of 4 or 5 days' duration, there were some of a deep red and some of a lighter red colour, but all intensely engorged and solid, not breaking down but a little soft from the amount of blood in them; whilst in older cases, of 7 or 8 days, the glands were softer, more pink in colour and almost diffluent, suggesting in fact the appearance of a rather soft spleen. The glands were rounded or oval in shape, and varied in size from a walnut to a pea. As a rule too, the smallest glands were the deepest in colour and most solid, whilst the largest were of a lighter red colour and softer consistence. The axillary vessels were pressed upon and surrounded by the enlarged glands and extravasated blood, so that in fact they became incorporated in the bubo, and it was mainly by this pressure on the axillary vein that the œdematous condition of the arm, as referred to above, was produced. The hæmorrhage and coagula extended beyond the axilla and were found in the areolar tissue, as well as amongst the muscles, but more between them than in their substance; this condition also extended down the arm and could be seen in the areolar tissue as far as the elbow. There was also much clear œdema fluid which assisted in forming the swelling, and it was found in the axilla as well as beyond its borders. The bubo thus was found to consist, not of a single enlarged gland, but of a chain of glands of various sizes, surrounded by a mass of engorged areolar tissue coagulated blood and œdema fluid.

In the case of a bubo in the groin there was a similar diffuse swelling in Scarpa's Triangle extending to the neighbouring parts; whilst when the bubo was in the cervical region this swelling was enormous, and pressed upon and embarrassed the larynx and trachea (hence the dyspnœa in these cases). With regard to the remaining lymphatic glands of the body in a bubonic case, there is but little to be said. Thus in the case of a left axillary bubo the following condition was found. The left supra-trochlear gland was intensely engorged and the size of a large bean, rather firm and full of dark blood; the right supra-trochlear, right axillary, cervical of both sides and bronchial looked normal or just *slightly* engorged. The mesenteric, iliac, lumbar and popliteal were in the

same condition; whilst the inguinal were some as large as beans, pinkish and slightly engorged, others of about the normal size and appearance. It may be mentioned here that the lymphatic vessels presented no abnormality as a rule, except that in some cases those near the bubo seemed to be slightly swollen; the thoracic duct too was either normal or possibly slightly swollen.

Condition of the other Organs.—Hæmorrhages were frequently found beneath the conjunctivæ, in the connective tissue under the scalp, and under the periosteum on the surface of the cranial bones, also extravasations sometimes of large size were occasionally found amongst the muscles, especially in those of the abdominal wall. The occurrence of petechiæ in the skin has been already mentioned.

Nervous System.—The dura mater and pia mater were much engorged, and the appearance of lymph was seen along the course of the larger vessels in the latter membrane; the puncta cruenta in the brain were well marked, but the brain substance itself looked normal, as did the fluid in the ventricles. The spinal cord presented a similar engorged appearance but showed no other abnormality, and the nerve-trunks appeared to be normal.

Alimentary System.—The tonsils were either normal or enlarged to the size of almonds, of a dusky purple colour, soft and engorged; and similarly the pharyngeal tonsils were either normal or engorged. The parotid and sub-maxillary salivary glands were either normal or engorged to some extent the mucous membrane of the pharynx and œsophagus was usually dusky from engorgement. The stomach showed constantly a distinctly engorged appearance with hæmorrhages into the mucous membrane which were usually petechial but sometimes of a larger size. Similar engorgement and petechiæ were frequent in the large intestine and rectum, but were less generally found in the small intestine. (This applies especially to petechiæ.) In some cases Peyer's patches and the solitary follicles looked distinct, prominent and slightly swollen; but usually they were either somewhat distinct or of the normal appearance.

The *Liver* was always distinctly enlarged and full of blood, but the substance itself was usually rather pale and soft from parenchymatous degeneration, there was bile in the gall bladder either of the usual appearance or thin and watery. Hæmorrhages into the mucous membrane of the gall bladder were rarely seen. In one instance small necrotic patches were scattered through the liver. This case will be described hereafter.

The *Pancreas* was either normal or engorged.

The *Spleen* was always enlarged, sometimes to two or three times the ordinary size, the capsule was normal, the spleen-pulp of a brick-red or purple colour and always markedly engorged. It was either fairly firm or rather soft and the Malpighian bodies plainly seen as if each were engorged, so as to give the section sometimes almost a granular appearance.

Urinary System.—The kidneys were always enlarged and much engorged, the capsule stripped easily and petechial hæmorrhages were constantly found beneath it; the kidney substance itself was pale and soft from parenchymatous degeneration. There was distinct engorgement of the pelvis of the kidney with petechial hæmorrhages and sometimes a large clot distending the pelvis and calices. The whole ureter was frequently engorged, and distinct hæmorrhages could be seen under its inner coat. The bladder was usually distended with urine, which was either of the normal or a slightly blood-stained colour; small hæmorrhages were frequently seen in the mucous membrane of the bladder.

The Genital System showed nothing abnormal beyond some engorgement. The supra-renal capsule and thyroid body were engorged but otherwise normal.

The Peritoneum showed considerable engorgement, and hæmorrhages into the retro-peritoneal tissue were frequently found; thus, they were seen on the under surface of the diaphragm, on the upper surface of the liver, especially close to the ligaments, and in one instance there was a hæmorrhage completely enclosing the gall-bladder, so that there was a casing of coagulated blood

between the peritoneum and gall-bladder. Similar hæmorrhages behind the peritoneum were found on the surface of the spleen, kidneys and intestines, and sometimes large coagula in the retro-peritoneal tissue of the lumbar region.

Circulatory System.—The pericardial cavity usually contained a few ounces of blood-stained or clear fluid, and petechial hæmorrhages were constantly seen beneath the visceral and parietal pericardium. The heart-muscle was either normal or in some cases rather soft and friable; considerable dilatation of the right side, with *post-mortem* clots in the cavities, was often present. There was not much engorgement of the walls of arteries, but the vena cava and other large veins showed this condition very markedly. On opening the veins distinct petechial and larger hæmorrhages were seen under the inner coat, giving it a mottled appearance. Where a large vein, *e. g.* axillary or femoral, was included in the bubo, this hæmorrhage into its walls was constantly seen so that the extravasated blood in the gland itself, in the areolar tissue outside it and in the walls of the vein was all directly continuous. I think that the blood itself was rather more fluid and showed less tendency to clot than is usually seen after death.

The Respiratory System.—There was some engorgement of the larynx and trachea, and the mucous membrane of the bronchial tubes was usually swollen and engorged, sometimes greatly so. There was much general engorgement of the lungs with œdema, and small hæmorrhages into the lung tissue were seen rather frequently. Frothy sero-mucous fluid which was sometimes blood-tinged was found in the bronchi. The pleura showed marked engorgement, and its cavity often contained some blood-stained or clear fluid; sub-pleural hæmorrhages, sometimes of large extent, were commonly found on the upper surface of the diaphragm, on the chest-wall and on the surface of the lungs, especially between the lobes. In cases of cervical bubo the engorgement and œdema extended to the larynx, and œdema of the glottis was present.

Note.—A variety of the bubonic form of plague must be mentioned here; for, instead of finding one large bubo, such as has been described above, the following condition was observed. A chain of enlarged glands was found in the inguinal region and it extended into the pelvis right along the iliac artery as far as the lumbar glands. These glands were dark-red, soft and friable and intensely engorged and looked like soft spleen tissue; there was great engorgement, extravasation and œdema around them, and they surrounded the iliac artery and vein, so that in dissecting out the gland mass these vessels came away enclosed in it. The glands were as large as almonds or smaller and were so incorporated in the coagulated blood that it was scarcely possible to dissect them out. The remaining glands and other organs in the body were in the condition described above.

B.—The Septicæmic Form or Plague-Septicæmia.

In the bubonic form of plague, one set of glands with extravasated blood around them forms the bubo, and there is practically no alteration in the remaining glands of the body; but in the septicæmic form there is no such bubo, yet there is a general involvement of nearly all the lymphatic glands. Yet though so many glands show evidence of disease, one gland or several glands of one set show characteristic changes which are pathognomonic of this type of plague. These appearances are:—The gland is enlarged to the size of an almond or less, is rounded, firm and pink in colour; on section it shews some but not much engorgement and some œdema, its substance is rather soft and can be easily scraped off with a knife, and sometimes small softening areas were present. There was no hœmorrhage in the areolar tissue around this gland and at most only a little œdema and trifling engorgement of the vessels. Commonly there were one or several such glands in one inguinal region, and usually the lowest gland of the chain was most markedly affected; whilst those higher up varied in size from a bean to an almond, and had the same firm pink appearance, though there were at times some which looked nearly normal in size and shape. The iliac glands of the same side were similarly affected, as large as almonds and either pink and firm or softer and of a dark red colour. The inguinal glands of the opposite side showed similar changes, but sometimes to a less extent, and

the iliac sometimes showed slighter changes or some of them looked normal. The lumbar usually showed slight enlargement and were either pale and soft or somewhat pink and firm. The cervical and axillary varied in size from hazel-nuts to peas and usually shewed merely engorgement, being full of dark blood; but sometimes some of them showed the pink firm appearance described above. The mesenteric were enlarged to the size of peas and beans and were either slightly or considerably engorged. The supra-trochlear and popliteal were normal or engorged. There was no hæmorrhage or œdema around any of the above-mentioned glands, and no enlargement of the lymphatic vessels was observed. The condition of the remaining organs was such as has already been described under the bubonic form.

Note.—In several cases of plague-septicæmia where death had occurred shortly after attack, the glands were found slightly enlarged of a dark red colour and contained much blood and œdema fluid. This appeared to be an earlier form of the characteristic pink plague glands described above. The difference between the bubonic and septicæmic form of plague appears to be this:—In the bubonic form the plague bacillus after entering the body is arrested at the nearest group of glands, grows here vigorously, and as a result of its growth the bubo is formed. Here the bacillus forms the toxins which are discharged into the system and cause the symptoms of plague, but the glands of the bubo form a barrier which prevents the bacilli from passing on and growing generally throughout the body; and it is only shortly before death, in fatal cases, that this resistance is overcome and the bacilli are able to pass on into the system generally. But in the septicæmic form the bacillus, after entering the body, meets with feeble resistance at the nearest glands; it speedily overcomes all opposition and passes on to infect other glands and organs where it grows abundantly. These points will be illustrated later in the detailed account of autopsies.

It may be mentioned here that no bubo of the mesenteric glands was ever found; these glands were always examined, and though changes might be found in them, they were always less marked and less distinct than plague glands found in other parts of the body. In short, there was no autopsy which went to show that the plague bacillus had reached the stomach or intestines, *e. g.* in food, and thence infected the mesenteric glands.

C.—The Pneumonic Form or Plague-Pneumonia.

In this form of plague the only marked evidences of disease are found in the lungs, whereas the lymphatic glands and other organs are scarcely affected at all. The lungs were in the following condition:—There was general engorgement with considerable œdema, a reddened condition of the mucous membrane of the bronchi, but no marked evidences of bronchitis, and frothy watery fluid, sometimes blood-stained, could be squeezed from the bronchi. (Pus in the bronchial tubes was only found on one occasion.) A number of pneumonic patches were found scattered through the lungs, varying in size from a pea to an egg. They were light pink or red grey in colour, solid, airless and sank in water; they were rounded in shape and usually separated by a distinct ring of engorgement from the crepitant lung around. Some, instead of being pink, were of a deep blood colour throughout and less solid, and some of these had a small greyish more solid centre. Those of the patches which were situated on the surface of the lung were prominent and projected distinctly from the surface; whilst the pleura over them was roughened and shewed signs of early inflammation. These patches had in fact the appearance of the first and second stages of lobular pneumonia, but no patches were found which had passed on to the third stage of softening and breaking down. In a few cases larger masses of pneumonic lung than these were found, and once about half the lower tube was found in this condition. Petechial hæmorrhages were usually found on the surface of the lung; the bronchial glands were either enlarged, swollen, œdematous, soft and distinctly engorged, or else they were small and of the usual appearance, perhaps a little engorged. The remaining lymphatic glands throughout the body showed none of the appearances of either the bubonic or septicæmic form of plague; most of them looked absolutely normal, and the only noticeable change was that the axillary, and sometimes the cervical chains were a little engorged.

The description of the remaining internal organs already given applies equally to this form of plague, except that the large hæmorrhages were absent, but petechiæ on the surface of the heart, in the pelvis of the kidney, bladder, stomach and intestines were commonly present. Petechiæ in the skin were not observed in this form of plague.

Reference must be made here to a variety of this form of plague which may be shortly described as a combination of Plague-Pneumonia with Plague-Septicæmia. In this condition the lungs were found in the state which has just been described, pneumonic patches being scattered through them; and in addition the lymphatic glands of the body presented the appearances seen in cases of Plague-Septicæmia. Thus in these cases the plague-bacilli had specially infected both the lymphatic glands and lungs, whereas in the varieties of plague treated of above, only one or other of these tissues was the special focus of disease.

Allusion must also be made at this place to one case of Plague-Septicæmia, in which the lungs contained a patch of ordinary pneumonia which was not due to plague. This case will be described in detail later on.

II.—MICROSCOPIC PATHOLOGY OF PLAGUE.

A.—The Bubonic Form.

The areolar tissue around the glands of the bubo is intensely engorged, free hæmorrhage is seen in the areolar tissue and fat, and all the vessels visible are full of blood, and their walls deeply engorged. The glands are uniformly full of extravasated blood throughout, with more intense hæmorrhages here and there, and the gland tissue is so overlaid with blood as to be scarcely visible; in some, probably earlier, glands the blood-cells are distinct; in others, probably older, they are not so distinct, and the gland is stained with blood-colouring matter, softer, showing granular debris, and beginning to break down in parts. Still there is no distinct appearance of pus, and it seems to be a necrotic softening. In some of the smaller glands the exact early appearance is seen; the whole gland is infiltrated with blood, the blood corpuscles being distinct, and at parts there is a large deeply-stained hæmorrhage occupying half or more of the gland. So intense is the hæmorrhage that in most glands there is no distinction between cortex and medulla, nor can the gland tissue or blood and lymph-vessels be easily made out, but the walls of such vessels as are seen are deeply engorged both in the gland as well as at the hilus. Such lymph-vessels, as can be seen particularly at the hilus, are full of lymph corpuscles, and there is some engorgement of their walls, and sections of the lymph-vessels, seen outside the gland, shew the same appearance. Specimens were cut to shew the glands of the bubo lying against and around the axillary artery and vein; here there is intense engorgement of the walls of these vessels with hæmorrhage into them, but much more of the vein than of the artery; in the vein the extravasated blood comes in most parts right through its wall into the inner coat and as far as the lumen; so that at these parts the inner coat cannot be properly seen at all. Hence one sees the plague gland lying right against the vein, with extravasated blood in the gland in the little connective tissue outside it, and then in the vein-wall as far as the lumen; and thus there is a direct path for the passage of the plague bacillus from the gland to the lumen of the vein and so into the general circulation. A similar condition of affairs was observed in those cases in which, instead of a bubo, there was a chain of enlarged plague glands, *e. g.*, along the iliac artery and vein. The remaining glands of the body in a bubonic case showed either a normal appearance or a little engorgement of vessels.

Lung.—A section of the lung shows blood-cells in all the vessels as well as in the alveolar capillaries; the vessels under the pleura always contain blood, and large hæmorrhages are sometimes present here; scattered about, areas are seen where blood-cells are present in the alveoli themselves, and similarly blood-cells may be seen in the smaller bronchial tubes. The vessels of the walls of the bronchi, like those of the rest of the lung, are distended with blood; the bronchial mucous membrane shows no special change. Specimens of lung stain well.

Liver.—All vessels are engorged and the specimen has the appearance of early nutmeg disease. The central veins are wide, as are the capillaries round

them, and the portal veins are also distended with blood-cells; around the distended central and portal veins there is fine granular pigmentation of the liver cells. Engorged vessels are usually seen well just beneath the capsule of the liver, and there may be hæmorrhages here. The nuclei of the liver-cells stain badly and the cells have a cloudy indistinct appearance as of parenchymatous degeneration.

Spleen.—The vessels generally, both large and capillary, are distended with blood-cells, and this is more marked in certain distinct areas; here a dilated vessel is seen full of blood and round it an area of engorged capillaries, with hæmorrhage into the spleen tissue, blood-cells being seen amongst the spleen-cells. Engorged vessels are also seen in some glorimeruli, and a vessel distended with blood leading to the glomeruli; further distended vessels with hæmorrhages around them are usually well marked under the capsule of the spleen. Section of spleen stain well and the cells are distinct.

Kidney.—The vessels, both large and capillary, are distended with blood-cells at places, vessels have ruptured and hæmorrhage is seen into the kidney substance. This condition is marked immediately beneath the capsule. Blood-cells are seen in many of the tubules, but more so in the straight than in the convuluted tubes, and some of the glomeruli are likewise engorged. The epithelium of the tubules is swollen and in a condition of parenchymatous degeneration and the nuclei of the cells stain badly; but this condition is more plainly seen in the convuluted than in the straight tubes. Some specimens show engorged vessels with hæmorrhage at the pelvis of the kidney.

Ureter.—The vessels of the walls of the ureter are distended with blood, and hæmorrhage has occurred into the walls, blood-cells being seen in the mucous membrane even as far as the lumen; the condition is similar to that found in the walls of veins.

Stomach and Intestines.—The vessels are distended with blood, this condition being best seen in the sub-mucosa; at places small hæmorrhages have occurred. The epithelium does not stain well. Nothing abnormal was seen in Peyer's patches.

Brain and Spinal Cord.—The large vessels and capillaries of the pia mater are distended with blood, but no special changes have been seen in the substance of the brain or spinal cord.

Muscle.—In specimens of voluntary muscle some fibres are seen well-stained and distinctly striated, but mixed with them are others which are badly stained, with striation faint or absent, and the muscle-substance is swollen, broken up into irregular lumps and of a shiny homogeneous appearance. Specimens of the *heart-muscle* showed this condition also.

Note.—This degeneration of heart-muscle is associated with the dilatation of the heart and nutmeg condition of the liver found *post-mortem*; and also with the fact that plague-patients are liable to die suddenly of heart-failure.

Blood-vessels.—In the outer coat of large arteries the blood-vessels are found full of blood, and the capillaries of the middle coat may also be seen distended; but the inner coat is always perfect, distinct and intact, and its elastic tissue plainly visible. The walls of large veins, however, show much more engorgement, and, in these, large collections of blood may be seen immediately beneath the inner coat, extending as far as the lumen, and at parts the inner coat is either extremely thin or cannot be traced over the hæmorrhage. This condition is best seen in vessels incorporated in a bubo, but is also to be found in the vena cava, iliac veins, &c.

The following organs were also examined, but nothing was observed under the microscope except some engorgement. The tonsils, salivary glands, thyroid body, breast, male and female generative organs, cartilage, nerve and thoracic duct. Sections of the skin were also made and showed engorged capillaries with small hæmorrhages where petechiæ were visible on the surface.

B.—The Septicæmic Form.

Lymphatic Glands.—The areolar tissue around the plague-glands (*i. e.*, the characteristic glands already described) shows none of the intense engorgement seen in the bubonic form. The plague-glands themselves are well stained and

all their anatomical features are distinct. All the blood-vessels in the gland are distended with blood-corpuscles, and at parts hæmorrhage has occurred into the gland-substance, which is most frequently seen beneath the capsule, but may also be at other parts. The lymphatic vessels and lymph channels in the gland are wide and distended with lymph-corpuscles. The distension of the blood and lymph vessels is always most marked at the hilus, and there may be hæmorrhages into the areolar tissue here. In some glands small areas may be seen, where softening and breaking down is taking place, granular debris and broken-down cells being seen here. The glands shew these changes in varying degree; in some there is merely slight engorgement with some distension of lymph-vessels, in others there is wide distension of both kinds of vessels, with some amount of hæmorrhage into the gland tissue; whilst in others again there are many hæmorrhagic areas which may occupy half or more of the gland, and it is in these glands that breaking down is usually seen. In a septicæmic case the glands, which have not the characteristic plague appearance, shew under the microscope either slight engorgement or normal features.

With regard to the remaining organs the appearances described under the bubonic form apply also to the septicæmic form of plague.

C.—The Pneumonic Form.

A section of lung-tissue, apart from a pneumonic area, shows great engorgement of all large blood-vessels, and of the alveolar capillaries as well, and patches of hæmorrhage into the alveoli around these engorged vessels are seen scattered about. In a pneumonic area three zones can be made out. At the circumference there is intense engorgement of all vessels including alveolar capillaries, the alveoli are full of blood, and the hæmorrhage is so intense that many of the alveolar septa are broken down, entirely absent, or represented by mere shreds. Within the circumference is seen a zone in which the alveoli are intact and are completely filled with well-stained cells, so that there is no interval between the alveolar walls and their contents; and at the centre is one universal mass of similar cells, and the cellular infiltration is so extreme that the walls of the alveoli are scarcely visible. Such is the general arrangement of the pneumonic patch, although there many be alveolar hæmorrhage in parts of either the middle or central zone.

Under a higher power the alveoli of the circumference are seen to be completely filled with blood-corpuscles, and there is scarcely any appearance of fibrin, or none at all; in the middle zone the alveolar contents consist for the most part of catarrhal epithelium with some white and a few red blood-corpuscles, and a little fibrin or none at all, whilst the dense central mass of cells consist of catarrhal epithelium and leucoceptes with some granular debris. Thus the pneumonic area has the appearance of very extreme lobular or catarrhal pneumonic.

The walls of the bronchial tubes, as well as of the large veins, show great engorgement, and there are hæmorrhages into the vein-walls. Blood and catarrhal cells may be seen in the finer bronchi, but the bronchial mucous membrane is scarcely altered, there being at most a little cellular proliferation. There are the appearances of acute pleurisy over those pneumonic areas which project upon the surface of the lung, with hæmorrhages beneath the pleura.

The bronchial glands show engorgement of blood-vessels, some hæmorrhage into the gland tissue and distended lymphatic vessels; but in some cases these conditions are only slightly marked and the glands looked nearly normal. The remaining lymphatic glands in the body looked either normal, or presented the characters described above to a slight extent.

With regard to the other organs, the description given under the bubonic form of plague applies here also, except that generally engorgement and hæmorrhage are less marked.

D.—The Plague Bacillus in Situ.

Sections of the various organs and lymphatic glands were prepared to show the plague bacillus *in situ*; they showed best when stained with Löffler's methylene blue or carbol-fuchsin, but they could not be demonstrated with Gram's method.

In the glands of the bubo the bacilli could be seen in enormous numbers, both amongst the cells of the gland-tissue and also in the lymphatic vessels; they were also seen amongst the blood-corpuscles extravasated into the gland, as well as in the hæmorrhage outside the gland. In cases of plague septicæmia they were similarly present in the enlarged characteristic glands. In the kidney the bacilli could also be seen especially among the blood-cells of the tubules into which hæmorrhage had occurred; in the spleen they were also present, sometimes in large numbers amongst the cells of the spleen-tissue and in the hæmorrhagic areas; similarly they were found in the liver, especially in those cases where engorgement and extravasation were marked.

In cases of plague-pneumonia, the bacilli were seen in abundance in the pneumonic areas; they could be found in profusion amongst the catarrhal epithelial cells and leucocytes which filled the alveoli and terminal bronchioles, as well as among the blood-corpuscles of the alveoli into which hæmorrhage had occurred. Similarly in the lungs of non-pneumonic cases they could be seen, but in far less numbers, and mostly where small hæmorrhages had occurred into the alveoli.

Note.—These specimens were only prepared from cases where the *post-mortem* was made immediately after death, and in which the presence of the plague-bacillus had been proved to be present by the method of cultures, so as to avoid the fallacy of diagnosing plague bacilli from their microscopic appearance alone.

III.—CASES TO ILLUSTRATE THE VARIOUS FORMS OF PLAGUE.

A.—The Bubonic Form.

Bubo in the Left Axilla.—R. N., male, Hindu, aged 40 years, admitted 1st March 1897, says he got suddenly ill four days ago with fever and severe rigors; temperature on admission 104·8 F., pulse 110, has pain in left axilla. March 2nd.—Temperature 103·2, pulse 110, still pain in left axilla, and swollen glands are felt. During the day a large, doughy, diffuse swelling arose in the axilla, and there was much more pain. March 3rd.—Temperature 100, the swelling filled out the whole axilla and was very painful. Patient died at 9-30 A.M.

Post-mortem examination one hour after death.—Œdema and petechiæ of left arm; old abrasions on hands and feet; large swelling in left axilla, with small petechiæ on the skin over it. The whole of the left axilla was occupied by a mass of coagulated blood and serum, and within the mass the axillary glands were found; they varied in size from almonds to peas, and were all intensely engorged, deep or lighter red and a little soft; the axillary vessels were included in the bubo thus formed of coagula and swollen glands. The hæmorrhage and œdema extended beyond the borders of the axilla in all directions.

Left supra-trochlear gland intensely engorged and the size of a large bean.

Right supra-trochlear, right axillary, and cervical chains on both sides were a little engorged but of normal shape; the popliteal were normal; the inguinal were some as large as beans, and some smaller or of normal size; they were all slightly engorged, on the right side rather more than on the left. The iliac and lumbar were a little engorged, and the mesenteric slightly so, the bronchial glands looked normal. There was no hæmorrhage or œdema round any of these glands.

Heart.—Some sero-sanguineous fluid in pericardial cavity and small sub-pericardial petechiæ; dark blood in cavities of heart, mostly on right side. Hæmorrhages into walls of vena cava seen well under inner coat.

Lungs.—A little blood-stained fluid in pleural cavities, many sub-pleural hæmorrhages of petechial and larger size. Intense engorgement, with some hæmorrhages into lung tissue and some œdema of lungs.

Liver.—Large, and all vessels, both hepatic and portal, gorged with blood; liver-substance rather soft; large sub-peritoneal hæmorrhages on the surface of the liver, specially along the ligaments.

Tonsils.—Swollen and engorged; mucous membrane of stomach and intestines engorged, and small hæmorrhages in stomach and large intestine. Hæmorrhages under serous coat of intestines.

Spleen.—Large, brick-red and somewhat soft, and many small hæmorrhages under its serous coat.

Kidneys.—Large, and all vessels engorged, the kidney-substance itself rather pale and soft. Many small hæmorrhages under the kidney-capsule and coagula distending the pelvis of each kidney. Hæmorrhages into walls of ureters and bladder distended with urine.

Distribution of the Plague Bacillus.—In this case the plague bacillus was found in the various organs as follows:—It was present in enormous numbers in the glands of the bubo, and in immense but diminished numbers in the blood, as well as the œdema fluid from the left axilla. The right axillary glands, the supra-trochlear and cervical of both sides showed a considerable number of plague bacilli, but far less than the bubo. The lumbar also showed them in considerable numbers, but they were rather less in the iliac and inguinal chains of both sides. A few were seen in the mesenteric glands. A specimen of blood taken from the left ventricle of the heart and from various large veins in the body showed many plague bacilli, but far less than in the blood taken from the bubo. Immense numbers were found in the spleen and liver, almost as many as in the glands of the bubo; and some, but far less, in the lung and kidney.

In point of fact it appeared from these specimens that the bacillus had grown most abundantly in the glands and blood of the bubo, and next in the spleen and liver; whereas in the remaining lymphatic glands and other organs it was present in about the same numbers as in the blood of the general circulation, and the bacilli seen in these specimens were probably those contained in the blood of the respective organs. Possibly it might have grown to some extent in some of the lymphatic glands, as indicated by the above specimens.

Note.—In a case of this nature, where there is extravasated blood around the glands of the bubo, which extends through all the coats of the large vein (the axillary in this instance), and where there are enormous numbers of plague bacilli in this extravasated blood, there appears to be a direct path for the passage of the plague bacilli into the lumen of the vein and so into the blood of the general circulation.

B.—Case of a Bubo extending along the Iliac Vessels.

M. R., Hindu, male, aged 27 years, admitted January 26th, 1897, says he has been ill two days. The left inguinal glands are large, painful and tender and the left leg is swollen, is much exhausted, and died one hour after admission.

Post-mortem examination made three hours after death. Body well-nourished, rigor-mortis present.

The Left Inguinal glands were as large as almonds, rather soft, red and distinctly engorged; the lower ones showed this condition markedly, but some of the higher to a less extent. There was no hæmorrhage around these glands.

The Left Iliac were all dark red, soft, friable and intensely engorged and looked like soft spleen tissue; there was great engorgement, extravasation, and œdema around the glands, and they surrounded the iliac artery and vein, so that the whole mass of coagula, glands and vessels had to be removed together. There was no rounded bubo as in the former case, but a chain of swollen glands with hæmorrhage around them extending along the vessels.

Lumbar Glands.—The lower ones were rather large, soft and engorged, but much less than the iliac, and there was but little extravasated blood around them. The upper ones showed even fewer changes, and some looked normal.

The Right Femoral and Right Iliac were normal. The remaining glands looked normal, except that the right axillary were engorged, two of them being as large as almonds, and the right supra-trochlear was likewise engorged to the size of a large pea.

With regard to the remaining organs, the heart showed some dilatation of the right side, and the lungs a great deal of engorgement and œdema; there were petechiæ under the pleura and pericardium. The liver and spleen were both

large, dark and full of blood, and the kidneys large, soft and engorged. There were some petechiæ in the stomach, and the brain and its membranes were engorged.

Distribution of the Plague Bacillus.—The enlarged left inguinal glands contained well-stained plague bacilli in considerable numbers; specimens of the left iliac glands showed them in immense numbers, as did those from the lower lumbar glands, but the higher lumbar showed less. The right inguinal and iliac, the axillary and cervical of both sides and the bronchial glands showed only a few plague bacilli, but of this series the right axillary specimens showed rather more than the others. The lung, liver, spleen and kidneys similarly contained a few, as did the specimen of blood taken from the heart; in fact, apart from the bubo the remaining lymphatic glands and organs merely showed about as many plague bacilli as the blood.

C.—The Septicæmic Form.

P. S., Hindu, male, 30 years old, was admitted on the 19th February 1897. His friends said he had been ill with fever for about four days and had been delirious for one day. He died immediately after admission. The *post-mortem* examination was made one hour after death. No petechiæ on surface of body.

Lymphatic Glands: Right Inguinal.—The lowest was the largest, of the size of a small almond, and of the others some were nearly as large and some smaller; they were rather firm and pink and of the characteristic plague appearance.

Left Inguinal.—The lowest was like a small almond, those above quite small and the highest as large as beans; all were slightly firm and pink, but in an earlier stage than on the right.

Right Iliac.—The three lowest were like large almonds, pink and firm, but the upper were smaller.

Left Iliac.—The lowest was like a small almond, but red and full of blood and rather soft, the upper ones were like small beans and less engorged. The *Lumbar* were like small peas and beans, all rather red and firm. The *Mesenteric* were enlarged to the sizes of small almonds, beans and peas, and were all dark red, engorged and soft. *The Right and Left Axillary* were light red in colour, and rather firm, some being as large as hazelnuts and some smaller. The *Cervical* chains showed a similar appearance, whilst the *Supra-trochlear* and *Popliteal* glands were small and pale.

There was no inflammation of lymphatic vessels and no hæmorrhage or œdema round the glands in this case, so that there was no appearance like the bubo described in former cases. The condition of the remaining organs was such as has been already described, and it only remains to notice that there were many small hæmorrhages in the lungs.

Distribution of the Plague-Bacillus.—Specimens taken from the inguinal, iliac and axillary glands of both sides showed enormous numbers of distinct well-stained plague-bacilli; specimens of the lumbar and mesenteric glands showed the same appearance. The cervical glands showed them also, but in less numbers, and the bronchial, supra-trochlear and popliteal glands still less. A large number of specimens to show the bacilli were made from the glands of each region, and, as a general rule, those glands which were largest and most distinctly altered showed the greatest number of plague bacilli. Specimens of the spleen contained many of the bacilli, but less in number than the plague glands. The liver and kidneys showed plenty, but fewer than the spleen, and the lungs still fewer. The blood contained a fair number, about as many as in the lung.

Note.—In this case the mesenteric glands showed distinct changes and contained many plague bacilli, but in some other cases of this type these glands were only slightly altered and presented a few plague-bacilli: and, as a general rule, the peripheral glands were most obviously altered and contained the bacilli in the greatest numbers, whereas the visceral were more normal-looking and showed the bacilli only in small numbers.

D.—The Pneumonic Form.

R. F., Hindu, male, 23 years old, admitted on January 31st, 1897, complaining of fever and cough of four days' duration. He looked very ill, temperature 102, and he had dyspnœa and cough. There were physical signs of pneumonic patches in the lungs. He complained of no pain whatever, nor was any enlargement of lymphatic glands made out. He remained very well and died on February 2nd. *Post-mortem* examination seven hours after death. No petechiæ on surface of body, body well-nourished and plenty of subcutaneous fat.

Heart.—Muscle rather soft and flabby and dilatation of the right side with slightly coagulated blood in the cavities.

Lungs.—Much general engorgement and œdema of lung-substance, some congestion of bronchial mucous membrane, with frothy sero-mucous fluid in trachea and bronchi. Distinct rounded nodules in the early second stage of pneumonia were distributed in the lungs as follows:—There were five such nodules in the right upper lobe, varying in size from a hazelnut to an egg, and a few in the rest of this lung, with one mass quite at the base; also the left lung contained a few similar pneumonic patches. Those on the surface projected and there was early pleurisy over them, also petechiæ under the parietal pleura generally. The nodules were surrounded by a ring of engorged lung in the first stage of pneumonia. The liver, spleen and kidneys were large and engorged, and the bladder full of urine; the intestines rather engorged with some petechiæ in the stomach, the brain and its membranes engorged.

Condition of Lymphatic Glands.—Bronchial, enlarged and a little swollen and engorged.

Cervical, normal; *Axillary*, a little swollen, mostly on the right side.

Supra-trochlear and *Popliteal*, normal.

Inguinal, slightly enlarged.

Iliac, Lumbar and *Mesenteric*, normal.

Distribution of the Plague-Bacillus.—The pneumonic lung in the second stage shows immense numbers of early well-stained bacilli, and some of them are collected into large masses or groups; the pneumonic lung in the first stage shows the same appearance, but not so many of the masses. The general lung-tissue shows many of the bacilli, but far less than the pneumonic patches. The fluid obtained from the trachea and bronchi also shows the bacilli in large numbers. The bronchial glands contained plague bacilli in considerable numbers. The spleen showed a few, the liver rather more and the kidneys still more, but nothing like the numbers in the lungs. The blood of the general circulation showed extremely few, just one here and there.

The axillary and cervical chains, the lumbar, iliac, mesenteric and inguinal glands showed extremely few, only one here and there as was seen in the blood. Thus the plague-bacilli were present in enormous numbers in the lungs and only to a very slight extent in the lymphatic glands and remaining organs.

Note.—In some other cases of the pneumonic form of plague, fewer of the bacilli were seen in the bronchial glands and kidneys than in this instance.

E.—Plague-Pneumonia with Plague-Septicæmia.

K. B., Hindu, 31 years of age, was admitted on February 23rd, 1897, for fever and cough, said to be of five days' duration. He was extremely ill and there were physical signs of pneumonic patches in the lungs; also enlarged glands could be felt in the groins and axillæ. His temperature varied between 103 and 105, delirium set in, and he died on February 26th. *Post-mortem* on February 27th, twelve hours after death; there were no petechiæ on the skin.

Heart.—Right side dilated, muscle rather soft.

Lungs.—Much blood-stained, watery fluid in trachea and bronchi, much general engorgement and œdema of lungs. There were many distinct, solid pneumonic patches, each surrounded by a well-marked ring of engorgement;

six such patches in the right lung and five in the left. The patches on the surface had early pleurisy over them, and there were sub-pleural petechiæ. There were also five or six areas of mere engorgement, not consolidated but full of blood and of intense purple-red colour; they were patches in the first stage of pneumonia.

Bronchial glands, rather engorged and soft.

Liver, Spleen and Kidneys, large and engorged.

Stomach and Intestines engorged and some petechiæ.

Lymphatic glands: *Right Popliteal*, two the size of beans rather red and firm, the left one normal.

Inguinal on both sides. The lowest were the largest, like walnuts partly red, partly cream-colour, all rather firm; the upper were all smaller, like beans, some being red and some pale.

Iliac.—The lowest on each side was like a large almond, the others like beans; all were of a cream colour and rather soft.

Lumbar.—Pink, soft and as large as beans, some of them almost diffluent.

Mesenteric.—Some normal, some like beans and slightly red.

Supra-trochlear.—Right, like a large bean, purple-red, engorged and firm. The left was normal.

Cervical.—The highest on each side was like an almond, swollen, firm and deep-red; of the lower ones some looked normal and some engorged.

Axillary, as large as hazelnuts, beans and peas, the larger ones being much engorged and the smaller less so.

There was no hæmorrhage, engorgement or œdema of the areolar tissue around these sets of glands respectively.

Distribution of the Plague-Bacillus. Lung.—Second stage of pneumonia; enormous numbers of plague bacilli; firt stage of pneumonia, plenty, but not so many as above; and general lung tissue far less.

Fluid in Trachea and Bronchi.—Enormous numbers of plague bacilli.

The Bronchial Glands showed only a few.

Liver and *Kidney* a few; *Spleen* rather more.

Blood, present, but not in large numbers.

Lymphatic Glands. Right Inguinal showed enormous numbers and so did the left, and generally the larger glands showed more of them than the smaller.

The Right and Left Iliac showed immense numbers.

The *Lumbar* showed large numbers, but not so many as the above.

The large upper *Cervical* glands on each side showed huge numbers, and the lower glands less.

The large *Axillary* glands of both sides showed large numbers, and the smaller glands a few.

Right Supra-trochlear gland contained immense numbers, and the left extremely few.

Right Popliteal contained a few, and the left scarcely any.

The *Mesenteric* contained very many, presenting almost the appearance of the large inguinal glands.

Thus in this case the plague-bacillus was found in enormous numbers in the pneumonic patches of the lungs, as well as in nearly all the lymphatic glands of the body; whereas the remaining organs showed it to an inconsiderable extent.

It will be convenient here to give an account of two further cases which were of considerable interest.

F.—Case of Plague-Septicæmia. With secondary deposits in the Liver, and pneumonia which was not due to plague.

S. D., Hindu, female, aged 60, was admitted on 9th March 1897. She was delirious, was in a very weak condition and had some cough; the inguinal glands were felt to be enlarged, but were not painful; temperature 102·8. She remained delirious and very ill, and died on March 12th. The duration of illness was unknown. *Post-mortem* examination made two hours after death.

Heart.—Some dilatation of right side.

Lungs.—Old thickened pleurâ with firm adhesions over both lungs, with some engorgement and hæmorrhage in the adhesions. Considerable engorgement and œdema of both lungs generally were present. There was one patch of pneumonia in the early second stage, the size of an egg, behind and below the right apex; it was irregularly oval in shape, of a dusky red colour and not distinctly round and marked off from the lung-tissue, as in the cases of plague-pneumonia described above.

The *Liver* was most peculiar; it was slightly enlarged and congested as in the early nutmeg condition, and was stuffed throughout with small yellow rounded masses in size from pin's heads to peas. They were rather soft and friable but not fluid, and there was no area of engorgement around them. They were found both on the surface and throughout the whole substance of the liver. They looked like necrotic foci.

Spleen, rather large and a little engorged.

Kidneys, senile degenerative changes and a little engorgement.

Intestines, some general engorgement of the stomach and intestines, and distinct petechiæ in the mucous membrane of stomach and large intestine. There were no deposits in any of these organs such as were found in the liver.

Condition of Lymphatic Glands. Right Inguinal, the lowest was the largest like a walnut, light red and firm; the higher ones were smaller and paler and one of them contained a small softening area.

Left Inguinal, the lowest was like that on the right side and the upper ones slightly enlarged and red.

Right and Left Iliac, the lowest was like an almond, light red and rather firm, and the upper ones much smaller and paler.

Lumbar, small and nearly normal.

Bronchial, rather large and engorged.

Supra-trochlear, right, small and normal-looking; left, slightly large, soft and pink.

Axillary on both sides, were all red and engorged, and varied in size from a pea to a hazelnut.

Cervical, like the axillary.

Mesenteric, some looked a little enlarged, soft and pink, and some looked normal.

Distribution of the Plague-Bacillus. Glands, Right Inguinal—A considerable number of well-stained plague-bacilli.

Left Inguinal—Enormous numbers; on both sides, fewer seen in the smaller glands.

Right Iliac, a fair number, and *Left Iliac* many more; seen best in the large glands.

The *Axillary* and *Cervical* glands showed a few plague-bacilli; the *Right Supra-trochlear* very few and the *Left Supra-trochlear* an enormous number, just like the large Left Inguinal glands.

Liver—In the yellow masses described above an enormous number of distinct plague-bacilli were seen, whereas the liver generally showed only a few, about as many as in an ordinary case, and far less than in the yellow patches.

Sections of the liver were also examined and presented the following appearance:—The liver was in the early nutmeg condition, the central veins dilated, with some blood-corpuscles extravasated around them, the portal vessels also

congested and fat globules in the adjoining liver-cells. The liver-substance was stained badly and, scattered through it, the above-mentioned masses were seen, all better-stained than the liver-cells and looking finely granular; some were large, some small, and some seen under the microscope which were not visible to the naked eye. The small ones were granular and stained well throughout, but the large were breaking down in parts and irregularly stained. The small ones were distinctly rounded and no liver-tissue was seen in them, but some of the large were less regular in shape and contained some distinct remains of liver-cells: these were probably two or three adjoining masses which had coalesced. Speaking generally, the small masses were mostly situated near the portal spaces, but this could not be said of the larger, as some were as big as two or three lobules. Under higher power the masses were seen to consist of leucocytes, pus-cells, granular debris and remains of liver cells, and there appeared to be an excess of leucocytes in the surrounding capillaries; in fact the structure of the masses resembled that of small early abscesses.

Specimens of the liver were also prepared to show the plague-bacilli *in situ* in the sections; enormous numbers of them could be seen in the masses and only a few in the general liver-tissue.

Cultures also were made from the masses, and typical colonies of the plague-bacillus grew in abundance. Thus these small necrotic masses resulted from the growth of the plague-bacillus in innumerable definite areas throughout the whole liver, and are comparable with the pneumonic patches found in cases of plague-pneumonia due to the same cause. This condition of the liver was extremely rare and was only observed in two other cases during the Bombay epidemic, once by the Austrian and once by the Russian Plague Commission. No similar condition was ever found in the spleen or kidneys to the best of my belief.

Lung.—Cultures made from the pneumonic patch showed the appearance not of plague but of Fraenkel's Pneumococcus; and specimens taken from the patch showed the same pneumococcus under the microscope. Cultures made from the inguinal and axillary glands, from the spleen and from the heart's blood all showed the typical growth of plague. These cultures were made by Professor Bitter, who has kindly permitted me to make use of his results.

Note.—This was the only case amongst the autopsies on plague made by myself in which secondary pneumonia was found, not due to plague.

G.—Case of Plague in a pregnant woman. Survival of the Fœtus: death of the Mother.

D. R., Hindu woman, 25 years old, was admitted to hospital for child-birth on 15th April 1897 at 11 P.M. She stated that she was five days short of her full term of gestation, that for the past several days she had had fever preceded by rigors, and that a few hours before admission she felt some pains in the abdomen of a bearing-down character and thought she was about to be confined.

On admission she was examined and found not to be in labour, and the pains were thought to be false. She was quite conscious and able to walk; temperature 102. She stated that she had two children and that her previous confinements were normal.

On 16th morning, temperature 102, no pain in abdomen, slight pain and tenderness over right inguinal region, and some glands could be felt a little enlarged. Patient had a peculiar drowsy expression of features, with injection of conjunctivæ, and looked very ill. The temperature remained high and at 4 P.M. was 104. At this hour labour pains commenced. She now complained of some pain in both sides of the neck, and the cervical glands were tender and slightly enlarged; also the pain in the right inguinal glands persisted. At 10 P.M. the patient was very restless; temperature 105; labour was progressing normally. At 10-50 P.M. labour was completed normally. There was no unusual hæmorrhage, merely the average loss of blood. Patient was much exhausted, temperature 102, pulse 140, respiration 72 per minute, with considerable dyspnœa. The temperature gradually rose to 104, and there was much prostration, dyspnœa and cardiac failure.

17th, patient died at 7-55 A.M. The child was 18 inches in length and weighed 4 lbs., and although small, it was fully developed. It remained perfectly well, throve, and after 20 days was sent to a foundling home. When last heard of on June 1st, it was still in good health. It never showed the slightest sign of plague or of any illness whatever.

Post-mortem examination of the mother was made three hours after death. Body well nourished, no petechiæ on skin, hæmorrhages under conjunctivæ, rigor mortis present.

Heart.—Petechiæ under visceral and parietal pericardium; heart-muscle looked firm; there were *post-mortem* clots in the cavities and in the aorta.

Vena Cava.—Great engorgement of its coats and many hæmorrhages under the inner coat, giving it a mottled appearance; these were seen in the abdominal vena cava as well.

Lungs.—Intense engorgement and œdema; there was one small round patch of early pneumonia at the back of the left lung, it was light red and fairly solid, with recent pleurisy over it. There were small hæmorrhages under both pleuræ. Bronchial mucous membrane much engorged, purple and swollen; the tubes contained frothy watery fluid, but no pus.

Liver.—A little large, its substance rather pale and soft and much engorgement of vessels.

Spleen.—Rather large and soft, of purple colour and engorged; the Malpighian bodies were prominent and appeared to be engorged.

Kidney.—Hæmorrhages under capsule, engorgement of vessels, the kidney substance pale and soft. There were hæmorrhages in the pelvis and calices and the whole ureter was purple red with distinct hæmorrhages under its inner coat. The bladder contained urine, and there were hæmorrhages into its mucous coat.

Uterus.—Large, as of a woman recently delivered. There was much recent clot in its cavity of the normal appearance, and a well-marked corpus luteum in the left ovary. All the generative organs looked normal.

Peritoneum.—Considerable engorgement and large hæmorrhages in the retro-peritoneal tissue, mostly in the lumbar regions.

Brain.—Hæmorrhages under scalp and beneath periosteum on surface of cranium; cerebral membranes engorged, with puncta cruenta in brain distinct; no excess of fluid in ventricles; brain-substance looked normal.

Lymphatic Glands. Inguinal, on both sides, some as large as beans, and some smaller, engorged, light red in colour and œdematous, but some of the upper ones were flatter and more normal-looking.

Iliac right side, the lowest was like an almond, deeply engorged and rather soft, the upper ones were smaller and paler. Left side, lowest like a large bean, and the others smaller.

Lumbar, rather large and a little engorged.

Mesenteric, slightly swollen and engorged.

Bronchial, of normal size, slightly engorged.

Axillary, in size from hazel-nuts to peas, dusky red, œdematous and much engorged.

Cervical, as large as hazel-nuts, deeply engorged and œdematous, and some with a little hæmorrhage into the surrounding connective tissue.

Supra-trochlear, as large as peas and engorged.

Alimentary System.—Tonsils small, slightly engorged, œsophagus rather engorged but no hæmorrhages in its walls; there were distinct petechiæ in the stomach, a few in the small intestine, and more in the colon and rectum; all these parts being likewise engorged. The sub-maxillary and parotid salivary glands and the pancreas were slightly engorged.

The *Breast* looked normal and contained good secretion of normal-looking milk, and its vessels were rather full of blood.

Under the microscope plague-bacilli in large numbers were seen in the inguinal, cervical and axillary glands: they were also present in the blood to a considerable extent.

This account of the pathology of plague is based upon fifty complete autopsies, of which twelve were examples of the pneumonic type. Sections for the microscope of the various lymphatic glands and organs were made in twenty-three of the cases, and from these the minute anatomy has been described. Further, in all the cases, many specimens were prepared to show the distribution of the plague-bacillus in the various parts of the body, and cultures were made as well in nearly every instance. As the results obtained from cultures have not been stated above in the *post-mortem* descriptions, it will be convenient to group them together here. By the method of cultivation the plague-bacillus has been isolated from the following organs and secretions;—from the bubo, and, in septicæmic cases from plague glands in the various regions (*e. g.* in one case from the inguinal, iliac, axillary and cervical glands); from the lung, liver, spleen and kidney; from the blood and urine. In one instance the plague-bacillus was proved by Dr. Bitter to be present in the mucus obtained from the large intestine. In cases of plague-pneumonia the bacillus could be isolated from the sputum during life, from the fluid contained in the trachea and bronchi after death, from the pneumonic patches and in several instances from the bronchial glands.

IV.—MODE OF EXIT OF THE PLAGUE-BACILLUS FROM THE BODY.

From consideration of the *post-mortem* appearances it is seen that engorgement and hæmorrhage are marked features of plague, and further that hæmorrhage is constantly found on the surface of mucous membranes; consequently, as soon as the bacillus has entered the blood of the general circulation, it is possible for it to escape from the body in the hæmorrhages on mucous surfaces. Thus in the urinary system blood may be found in the urine during life, and after death in the tubules and pelvis of the kidney; and, besides, there may be extravasations on the surface of the ureter and bladder; hence by the urine there is a direct route for the bacillus to leave the body.

Again in the alimentary system, petechiæ are nearly always present in the stomach, and as vomiting is a very constant symptom of plague, the bacillus may escape in the vomit; similarly petechiæ are generally found in the colon and rectum, and hence the bacillus may escape in the fœces. As for the respiratory system, blood may be found in the alveoli of the lungs in ordinary cases of plague, whilst in cases of the pneumonic type it is invariably present; besides in these latter cases the bacillus is present in enormous numbers in the pneumonic patches and in the sputum, and it is extremely probable that plague-pneumonia for this reason plays an important part in spreading the disease. (In the preceding section the secretions have been named from which the plague-bacillus was isolated by the method of cultures.) With regard to the bubo itself, in certain cases it suppurates, and it would seem possible for the bacillus to escape in the pus; but this was not found to be the case, for in several instances where cultures were made from the pus, no growth of the plague-bacillus was obtained. It remains to make a remark about the presence of the bacillus in the blood. In a number of *early* plague cases which will be detailed hereafter, cultures were made from the finger-blood, but the bacillus could not be isolated from them, in fact they all remained sterile: whereas in fatal cases the bacillus could always be grown from the blood after death, even when the *post-mortem* was made one hour after death, and in one instance it was grown from the finger-blood twenty-four hours before death. Hence one may say that at least in fatal cases, which form the large majority in this disease, the bacillus is present in the blood for a certain time before death, and is able to leave the body in the various secretions which contain blood.

V.—MODE OF ENTRANCE OF THE PLAGUE-BACILLUS INTO THE BODY.

Having regard to the fact that the initial bubo in plague is usually situated in the glands of the extremities, especially the inguinal and axilliary chains, it appears probable that the bacillus may enter the body through a lesion of the skin—preferably of the extremities—and thence travel upwards to the nearest

group of lymphatic glands and thus form the bubo. In order to test this theory a large number of plague cases were examined to see if any primary lesion in the skin could be discovered through which the bacillus had entered; and as the patients mostly belonged to the lower classes, who commonly go bare-footed and bare-legged, it was usual to find cracks and abrasions about the feet, and also about the hands, the latter resulting from occupation. Further, as various parasitic skin diseases, such as ringworm and itch, are very common among these people, it will be seen that there are many opportunities for the bacillus to enter the body through the skin.

Bearing in mind the analogy of anthrax and syphilis, the skin was examined to see if any characteristic lesion was similarly present in plague. No such definite lesion was found, but in certain cases the bacillus was proved to be present in a particular lesion on the skin and as in each instance the bubo was situated in the glands corresponding to the lesion, this place was believed to be the point of entrance of the bacillus. There was nothing characteristic about the lesion. It was usually a small ordinary-looking papule on a slightly inflamed base, with a little serum at its apex and partly covered by a scab. In some cases a hair was found growing through its centre, and it seemed to be merely an inflamed hair-follicle which had been scratched. These cases will now be given in detail.

B., Hindu man, aged 40, came to hospital on 5th October 1896. Three days ago he was seized with fever and shortly afterwards found pain and swelling in the left axilla. On admission he looked very ill, temperature 103, and there was a large bubo in the left axilla. On the outer side of the left fore-arm near the wrist there was a small papule the size of a pea, with a hair growing through it; it was slightly red at the base, contained a little serum at the apex and was partly covered by a scab. It was not painful, and the patient knew nothing about it; there were no inflamed lymphatics leading from it. Cultivations were made from the serum squeezed from the papule, and a typical growth of plague was obtained. Part of the culture was injected into a rat, and the rat died of plague after 60 hours. On the same date, 5th October, cultures were made from the finger blood, but all remained sterile. This man died on 8th October.

N. S., Hindu man, aged 28, came to hospital December 1st, 1896. There was a large bubo in the vertical set of the right-inguinal glands. He said he had been ill three days. There were many old cracks and fissures about the feet and toes, the skin being thick and horny, and some scratch marks on both legs. On the outer surface of the right calf there was a slightly raised œdematous portion of skin about one inch long, and on it there was a small bleb, the size of a large pin's head. From the bleb some thin serum was squeezed out. Cultures were made from the fluid in the bleb and from the finger blood. A pure growth of the plague-bacillus was ultimately obtained from the bleb, whereas the cultures of the blood remained sterile. In this case too, the patient could give no history of the œdematous patch on the leg, and there was no pain in it.

N., Hindu man, aged 30 years, was admitted on March 3rd, 1897, with a bubo at the back part of the right axilla. He had been ill two days. On the back, near the angle of the right scapula, there was a papule, the size of a pea, on a slightly-reddened base and partly scabbed over; it looked like a pimple which had been scratched. Cultures were made from the serum squeezed from this papule and from the finger-blood; a pure growth of the plague-bacillus was ultimately obtained from the papule, but the cultures of the finger-blood remained sterile.

P., Hindu boy, aged 16, admitted on October 26th, 1896. On either side several of the oblique inguinal glands were enlarged to the size of walnuts, and painful. There was a small unopened papule on the glands penis exactly in the dorsal middle line; its apex contained a little pus and serum. It did not look at all like a chancre, and the boy said he knew nothing about it. Cultures were made from the papule and from the finger-blood. From the former a pure growth of plague was ultimately obtained. This was injected into a rat, and the rat died of plague. Cultures of the finger-blood remained sterile. This patient recovered.

As confirmatory of the above observations, I may quote as follows from "A report on the Epidemic of Bubonic Plague at Hong-Kong in the year 1896" by Staff Surgeon Wilm of the Imperial German Navy:—"As regards infection through the skin, two incontestible cases were observed in the epidemic of 1894. Two Japanese physicians were infected, while making *post-mortem* examinations, and were attacked a few days later by plague. They had axillary buboes and lymphangitis of the arm, which spread upwards from the small inflamed wounds of the fingers.

The above are the four cases in which the plague-bacillus was found in a certain definite situation on the skin, and this place was believed to be the seat of inoculation of the disease; moreover, in each instance the corresponding proximal glands formed the bubo, and there was nothing characteristic about the skin lesion. It looked like an ordinary pimple which had been rubbed or scratched, and no local reaction had occurred in it, due to the presence of the bacillus; also it was not painful and the patient was unaware of its existence. It may be stated here that in a large number of other patients small papules or abrasions were similarly examined, but the plague-bacillus was not proved to be present. Thus, in one instance a man had acne extensively on the face and a bubo in the left cervical region; in another, three small scabbed wounds on the right foot with a bubo in the vertical right inguinal glands; in a third, a number of papules on the left arm with a left axillary bubo, and other cases could be quoted. Some of the papules were examined in these cases, but with a negative result. A point remains to be noticed; it may be objected that if the bacillus were already in the blood, it could pass with the serum into a papule wherever situated, and its presence there would be the result, and not the cause, of the disease. But against this view there are the facts, 1st, that in the above four cases, which were all early, the bacillus could not be isolated from the blood on the same day that it was found in the papule; and 2nd, that in a number of other early cases pimples situated in various parts of the body were examined, not only on the limb corresponding to the bubo, but the bacillus was not found in them. Also in three early cases of inguinal bubo, a small blister was raised upon the chest, but the plague-bacillus could not be isolated from the contained serum.

The conclusion drawn is, that the bacillus of plague can enter the body through a trifling lesion in the skin, that it produces no local reaction at the seat of inoculation, and that the bubo is formed at the nearest proximal glands.

With regard to infection by food, no evidence was found *post-mortem* that the bacillus had entered through the stomach or intestines; but cases of cervical bubo might have resulted from infection through abrasions on the lips, tongue or tonsils.

As for the cases of primary plague-pneumonia, no evidence of the path of infection was found, but the bacillus was thought to have entered by the respiratory tract, as its growth had mainly occurred in the lungs.

Appendix A.

On the clinical aspect of Plague-Pneumonia.

When plague appeared in Bombay, and as the disease developed, one was struck by the following facts:—First, in all published accounts of the disease, although the ordinary phase of the malady, *viz.* plague with buboes, is principally described, still mention is always made of another and more fatal form without buboes; whereas here in Bombay it seemed as if the bubonic form were alone appearing, for at the beginning one saw no examples of the other form. Then one observed that coincidently with the increased death-rate due to plague, there was a large and unexplained increase assigned to remittent fever and respiratory diseases. Week by week as the plague mortality increased, so did that under these two headings, and though it was possible that all these were cases of known but concealed plague, still one could not help suspecting that some of them might be due to plague which was not diagnosed because of the absence of buboes. So I resolved to examine the bodies of all hospital patients

who had died of fever, pneumonia or any acute illness, to see if there were evidence that any of them had really died of plague. And at the end of December I met with a case which had been diagnosed as broncho-pneumonia, but which turned out to be one of plague affecting the lungs, without causing any marked enlargement of the lymphatic glands—a case, in fact, of plague-pneumonia; and as this *post-mortem* is exactly like many others that I have since made, and is typical of the disease, I will give a few notes of it.

B. L., Hindu, male, 25 years old, admitted for fever and cough, December 26th, 1896, under Dr. S. He said he had been ill for about seven days. He had symptoms in the chest which led to the diagnosis of broncho-pneumonia being made. No lymphatic glands were found to be enlarged or painful, and a specimen of blood taken by Dr. S. shewed no plague-bacilli under the microscope. He coughed up about two ounces of blood-stained fluid on the night of the 27th, and died at 3 A.M. on December 28th.

Post-mortem on December 28th, seven hours after death.

Lungs.—Much general engorgement and œdema, with sero-sanguineous frothy fluid in the bronchi, but no pus; and the usual appearances of acute bronchitis were absent. There was one small pneumonic patch, the size of a walnut, in the early second stage, situated a little below the apex on the front of the right lung, and two similar but smaller patches at about the same part of the left lung. These patches stood out a little from the surface and were light grey in colour, airless, friable and sank in water; and each was surrounded by a dark ring of engorged lung in the first stage of pneumonia, which merged into healthy lung; there was some recent pleurisy over the pneumonic areas. All the other organs were examined and showed considerable engorgement, but no special lesion was observed.

Condition of the Lymphatic Glands.—The bronchial were quite small and of normal appearance; the cervical were slightly enlarged, but pale and not engorged; the axillary were pink and slightly enlarged; the left iliac were somewhat large, red and soft; the lumbar were swollen but pale; and all the other glands looked absolutely normal.

Cultures were made on agar-agar from the pneumonic lung and spleen, and ultimately a pure growth of the plague-bacillus was obtained from each.

Microscope.—The pneumonic patches in both stages showed an immense number of plague-bacilli, and the rest of the lung showed a large number; the left supra-trochlear and the left femoral glands shewed a fair number, and all the other glands extremely few; the spleen and blood also showed a few.

So this was a case of plague, in which during life all the symptoms pointed to disease of the lungs, and in which there were no evidences of glandular enlargement, whilst after death there was clear proof of enormous growth of plague-bacilli in the lungs, and of only very slight growth in the lymphatic glands.

I have made up to the present twelve *post-mortems* on such cases, all presenting appearances similar to the above; and I may add that all the patients were brought to hospital by their friends, supposed to be suffering from cough and fever, and, as far as I know, they were quite unaware of the nature of the disease. I have also to say that in nearly all the other cases the fluid from the trachea or bronchical tubes has also been examined; it shows an immense number of plague-bacilli, and cultures of plague can always be obtained from it. With regard to the clinical symptoms of these cases, it fell to me to attend on the late Dr. Manser, and as he died of this form of plague, I will mention a few facts about his case. He was in his usual health on January 2nd, and had a sudden rigor in the morning and felt fever coming on. During the day a bad headache developed, he felt nausea and vomited several times, and he had pains and a tired feeling in his limbs; his tongue remained clean and moist, and his skin was slightly moist. At 2 P.M., temperature 103·4, pulse 116, respiration 25, and there were but slight variations during the day. On January 3rd, had passed a bad night and felt worse, and all the symptoms persisted, except the aching in the limbs, and he felt very ill. The temperature remained between 103·5 and 104·5, pulse about 110, and respirations about 23 throughout the day. During

the afternoon he felt some pain at the lower part of the left axilla just under the anterior fold, but there was no glandular enlargement or pain in the glands anywhere. On January 4th, had passed a bad night and felt very ill, temperature 104·6, pulse 113, respiration 25, tongue still moist, with a little fur behind, and no sordes about the lips or teeth; the other symptoms as before. During the night he began to cough and brought up some watery sero-mucous fluid, slightly blood-tinged, and the pain remained in the same place, only more diffused now, being felt over an area of a square inch. At this part some moist sounds could be heard like those of early pneumonia, and they could also be heard just below the left clavicle; the rest of the lungs and other organs appeared to be normal, as did the lymphatic glands. Patient considered that he had pneumonia, but the symptoms were not like ordinary pneumonia.

For the onset was different, the condition of the tongue and mouth different, there was no dyspnœa or pneumonic disproportion of pulse and respiration, and the sputum was not at all like rusty sputum; for it was loose and free, coming up with the slightest cough, it was watery, looking more like serum than mucus, and it was slightly pink, not rusty yellow at all. Also there was the striking fact that the patient's general condition was far worse than could be explained by the small amount of lung-disease present. So I examined the sputum under the miscroscope, and found it full of bacilli looking like those of plague, and cultures were made from which a pure growth of the plague-bacillus was obtained. During 4th and 5th, patient became steadily worse, his temperature remained about 104, and his expectoration became most profuse; the moist sounds were heard over a larger area, as well as slightly at the bases; the respirations increased to 35, and then to 45, and the pulse to 120 and 135; and he ultimately died early on January 6th.

There is also the case of the nurse who attended him, who unfortunately died of a similar form of plague. In brief she became ill on the evening of January 7th, and showed symptoms of pneumonia on January 8th. She rapidly became worse and died on the 10th, but her sputum was not nearly so profuse as in the former case, and symptoms of exhaustion came on much earlier. She also had no glandular pain or enlargement whatever, and bacteriologically her sputum was exactly as described above. Other cases were met with in which, besides plague-pneumonia, there was also general enlargement of the glands,—plague-septicæmia; and clinically it was found that either the pneumonia was primary, and the glandular enlargement secondary, or that the disease first shewed itself in the glands and later on in the lungs; and whilst some of the latter recovered, the former were usually rapidly fatal. Also the sputum was not always as has been described above, for in some cases the presence of blood in it was a marked feature, and it was either moderate or abundant in quantity. These pneumonic forms of plague are highly infectious and probably take a large share in the spread of the disease; for in these cases the patient's sputum is practically a virulent pure culture of the plague-bacillus, and as there is reason to believe that many of the cases are not recognised as plague at all, precautions are not taken by the patients' friends, and the dangerous nature of the disease is not appreciated. I have no means of knowing how frequent this variety of plague has been in the present epidemic, but there is some evidence to show that a considerable number of cases have occurred. Moreover, it seems likely that a ship's passenger suffering from this form of plague might escape detection by sanitary officers, and might be permitted to land at his destination as though he were the subject of simple pneumonia; and so a centre of infection for the spread of plague would be established. With regard to the literature on this subject, I have not been able to find a published description of this variety of plague; but an allusion to it is made in the accounts of the Pali epidemic of 1836, and it is stated that the Astrakhan outbreak of 1877 was first regarded as croupous pneumonia or as typhus complicated by pneumonia; from the reports on the Hongkong epidemic it appears that plague-pneumonia did not occur there. There is just this to add: the usual definition of plague in works on medicine is—"A specific fever attended by bubo of the inguinal or other glands," but it is clear that such a form of words does not include all varieties of the disease. (This paper was read before a meeting of the Bombay Medical and Physical Society on April 2nd, 1897.)

Appendix B.

On the occurrence of involution forms of the Plague Bacillus in the human body.

In January last Mons. Haffkine shewed me involution forms of the bacillus which he had found in a rabbit dead of plague, and he suggested that I should examine human bodies to see if similar forms could be found. Accordingly in many instances a large number of lymphatic glands and other organs were examined and involution forms were frequently present. The forms seen were mostly of the rounded or swollen oval shape, and always stained more faintly than the young early bacilli. This investigation was made for the following reason. In cultures of plague, as the culture becomes old, involution forms begin to appear, and the older the culture, within limits, the more distinct are the involution forms. So it was thought possible that a similar condition of affairs might be found in the human body, and that most involution forms would be present in that part where the bacilli had been longest situated, that is, where they had first begun to grow: thus, in a case of plague-septicæmia, for example, if most involutions were found in some particular gland, one might infer that the bacilli had first infected and grown in this gland. The enquiry, however, did not bear out this theory, for it was found that the involution forms had a direct reference to the period after death at which the autopsy was made, and in fact they appeared to be a *post-mortem* change. Thus, in autopsies made between one and five hours after death, the plague-bacili always shewed a distinct well-stained normal form; in those made between five and ten hours after death early involution forms were seen, rounded in shape and less distinctly stained; whereas in the few *post-mortems* made more than ten hours after death involution forms were plainly seen of rounded and oval shapes and still more faintly stained. It may also be noted that in cases of plague-septicæmia some glands shewed more involution forms than others, but the variations followed no rule, and no conclusions could be deduced from them.

Appendix C.

Case of Plague with a Carbuncle.

R. B., Hindu, aged 30, admitted on 24th December 1896, looking very ill. There is a large mass looking like a carbuncle situated over the hepatic region and towards the right axilla; it is round, four inches in diameter and half an inch above the skin level. It has a red ulcerated surface with beads of reddish serum exuding from it at various points, and there is no skin remaining on it. There is a large mass of glands in the right axilla with effusion around them, the whole filling out the axilla and having the usual appearance of a plague-bubo; glands can also be felt in the left axilla and both groins, but they are only a little enlarged and are not buboes. Patient states that the ulcerated mass began fifteen days ago as a small boil or pimple; some native ointment was applied to it, and then it increased and reached its present size. Four days before admission he felt a painful swelling in the right axilla, which has since increased to its present condition, and during this time he says he has had high fever.

Cultures were made from the bubo in the right axilla, and a pure growth of plague was obtained from them.

This patient was very ill and there was no means of ascertaining the truth of the history he gave. But if it was true that the first symptoms of plague had shown themselves in the formation of the right axillary bubo four days before admission, it seemed likely that infection had occurred through the carbuncle.

I have to express my thanks to Professor Bitter, Director of the Institute of Hygiene, Cairo, to Mons. Haffkine, C.I.E., and to Mr. Hankin for assistance in this research; and also to Dr. A. C. Viegas for showing me cases of plague immediately after he had discovered the existence of the disease in Bombay in September 1896.

L. F. CHILDE, Surgeon-Captain, I. M. S.

20th October 1897.

III.—SUMMARY OF WORK CARRIED ON BY Mr. HANKIN.

Mr. Hankin has carried out a long series of researches on the action of disinfectants on the microbe of bubonic plague. He finds that it is somewhat resistant to the action of carbolic acid. Both phenyle, lysol and izal appear to have a more energetic action. Phenyle and lysol, however, were found not to exert a marked bactericidal action on a cowdung floor. Naphthaline was found to have no action on the plague microbe. The plague microbe was found to be comparatively resistant to the action of alkalies, and especially sensitive to the action of acids. Even weak organic acids appear to destroy it readily. It is however usually able to exist for some hours in acid urine. Milk, so soon as it has acquired an acid reaction, appears to have acquired the power of destroying the microbe. Inorganic acids are naturally still more active, and Mr. Hankin thinks that sulphuric acid might be used as a cheap disinfectant against the plague infection. The microbe was found to be resistant to the action of reducing agents, and sensitive to the action of oxidising agents, such as permanganate of potash or chloride of lime. A solution of one part of permanganate of potash in 50,000 parts of water appears to be capable of destroying the plague microbe in five minutes under the conditions of Mr. Hankin's experiments, but this substance is not recommended as a disinfectant except in cases in which there may be reason for thinking that water has been infected by the washing of infected clothes, &c. It was shown that the activity of potassium permanganate in destroying microbes may be greatly increased by the addition of a small quantity of sulphuric acid, but the mixture is not recommended except under special conditions. Mr. Hankin discusses the bearing of his observation of the sensitiveness of the microbe to oxidising agents on the generally advocated plan of combating the infection by means of ventilation, which, he shows, is probably a means of producing oxidation under the influence of air and light. A series of observations was made in houses undergoing disinfection. Results were obtained throwing doubt on the utility of sulphur fumigation and whitewashing as a means of destroying the microbe. Mr. Hankin comes to the conclusion that the only substance capable of satisfactorily disinfecting a cowdung floor is sublimate in an acid solution. Sublimate in a neutral solution was found to be without action on the microbes present. As an after-treatment and as a means of treating courtyards, passages and drains, Mr. Hankin recommends sulphuric acid in a strength of 1 in 250, which solution he shows to be far cheaper than that of other disinfectants in common use. It is likely that this will make the treated places for some time unfitted to act as a nidus for the microbe, for the latter is shown to be destroyed within 5 minutes by a solution of the strength of 1 in 1429. Another method of disinfecting floors investigated by Mr. Hankin is by covering them with a layer of combustible material at least two inches thick, which is then set on fire. It was shown that this treatment is far more efficacious than the use of ordinary disinfectants. Though it is pointed out the risk of fire may prevent the wide application of the method in towns, it may find application in the treatment of public latrines that may be supposed to be infected, and which are commonly built of incombustible materials.

Mr. Hankin has also carried out a series of experiments on the asserted possibility of finding the bubonic microbe in the earth of infected houses. He has examined large numbers of specimens brought from places in which many people had recently succumbed to the infection without finding the microbe in any case, with one probable exception. The search has been carried out by several methods, including one communicated to him by Professor Calmette, which method appears to have been the one employed by Professor Yersin in Hong Kong, and which led him to positive results. In Mr. Hankin's hands no such results were obtained, thus throwing doubt on the statement that the microbe can be readily found in the soil of infected houses, at any rate by existing methods.

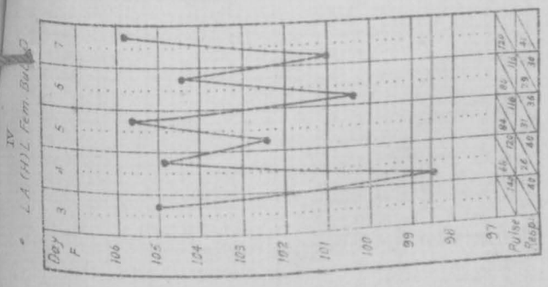
The only case in which a microbe probably identical with that of plague was met with was in some salt water in a field near Siwri, at the time that the epidemic was present in the place. Some of this water was injected into a mouse. On its death a microbe was isolated from its organs, which resembled that of

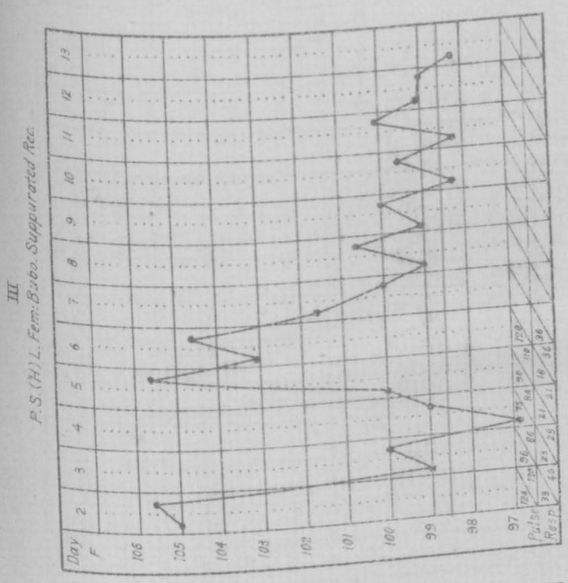
plague in most respects, but which differed from it in the rapidity with which it formed involution forms on agaragar. Mr. Hankin found that the plague microbe could be changed into a microbe having these aberrant characters by cultivation on agaragar containing three or four per cent. of salt, and that further the microbe from Siwri was pathogenic to a rabbit that had not been protected by Haffkine's plague vaccin, but had no effect on a rabbit that had been so protected. Consequently it was supposed that this microbe was the plague microbe altered by its sojourn in salt water. This observation has led to the discovery of a rapid method of identifying the plague microbe by its cultivation on agaragar containing a certain percentage of salt. It has been further worked out by Surgeon-Captains James and Thomson under Mr. Hankin's supervision.

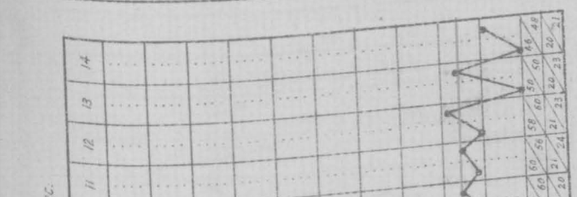
Mr. Hankin has investigated the relation of insects to the dissemination of the disease. He has found the microbe in bugs from the infectious Diseases Hospital. He has also found it in ants that had recently been eating rats dead of plague. A long series of experiments showed that ants do not retain the plague infection long, and further that no trace of infection is present in ants from localities in which rats have not been dying recently. Hence these insects cannot be regarded as important agents for the spread of the disease.

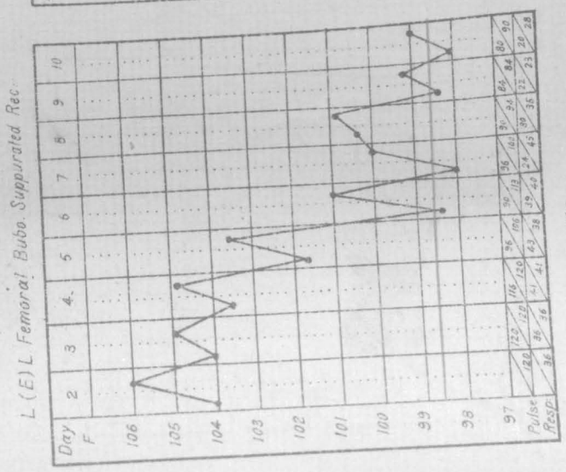
Experiments were carried out on different kinds of grain and other articles of export. They were infected with plague microbes under many different conditions. At stated intervals extracts of specimens of the infected grain were prepared and injected into mice. By this means it was found that the infection usually died out within 4 to 6 days. The possibility was indicated that it might in exceptional cases survive for so long as 13 days, but of this no definite proof was obtained. Mr. Hankin points out that grain, when it becomes rotten, usually acquires a well marked acid reaction, owing to the production of various fatty acids from the decomposition of carbohydrates. He has found that such fatty acids act as disinfectants for the bubonic microbe. Hence it is difficult to believe that the microbe can exist in rotten grain, as has been frequently assumed. The matter was put to an experimental test by Dr. Srinivasa Rao while working in Dr. Hankin's laboratory. It was found that the microbe always dies out in rotten grain within 2 to 24 hours.

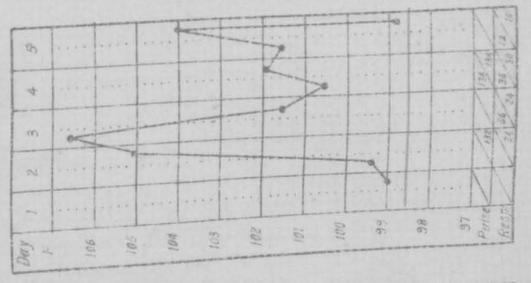
The microbe, though usually dying out, when placed in sterilised water, within three days, appears to be able to survive in sterilised cowdung for several days. The observation appears to have some bearing on the question of the persistence of the infection in houses having cowdung and mud floors. Through lack of time these experiments could not be continued sufficiently for any conclusion to be arrived at as to whether any particular kind of filth is more suitable than another to sustain the life of the microbe. But the general trend of Mr. Hankin's observations is to indicate that the chief source of infection is not likely to be in a saprophytic form of the microbe in the outside world, but more probably in the recently passed excreta of men or animals suffering from the disease.

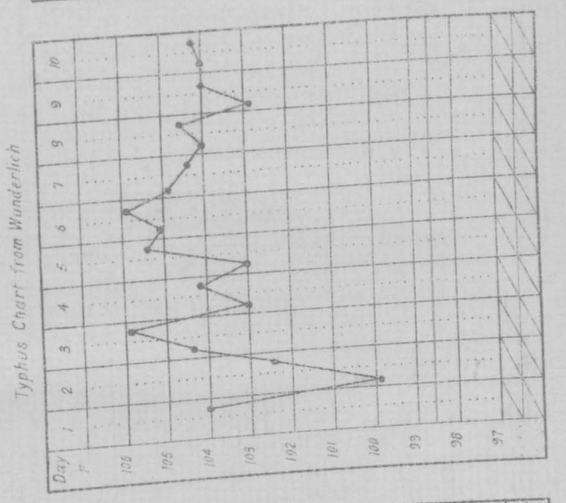


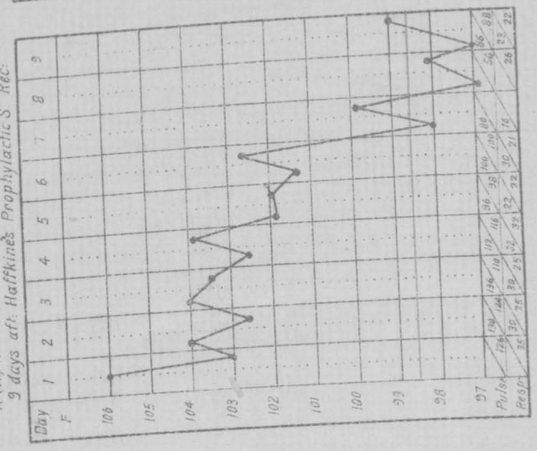


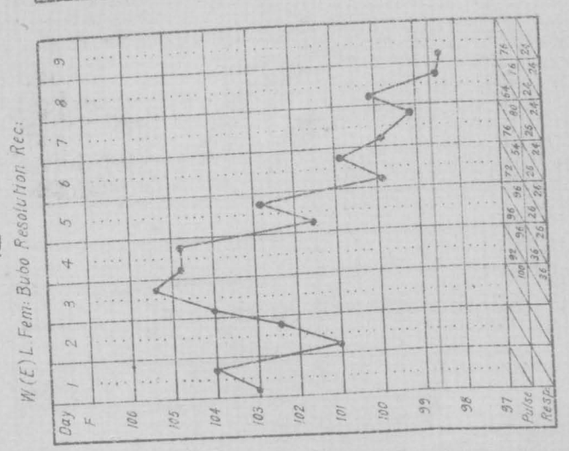


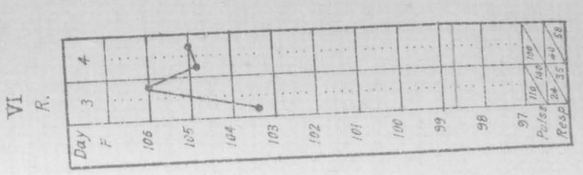


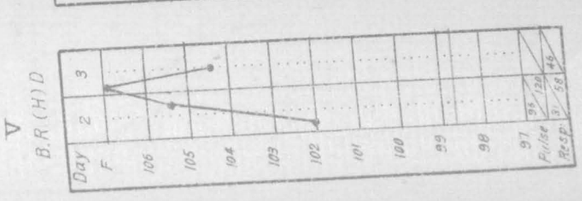










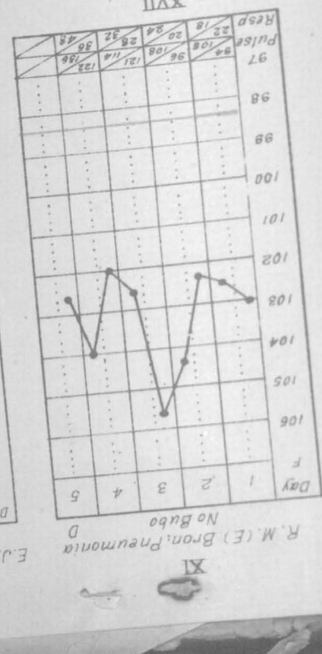


(E) = European. (N.Ch.) = Native Christian. (H) = Hindu. L = Left. Rt = Right. Rec = Recovered. D = Died. Letters at left corner = Patient's initials.

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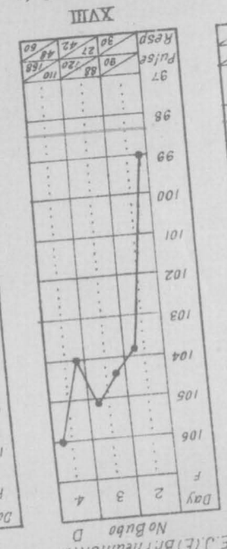
XI

R.M.(E) Bron. Pneumonia D
No Bubo



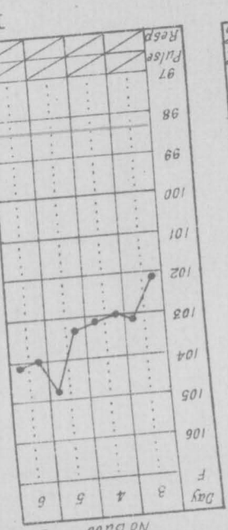
XII

E.J.(E) Br. Pneumonia D
No Bubo



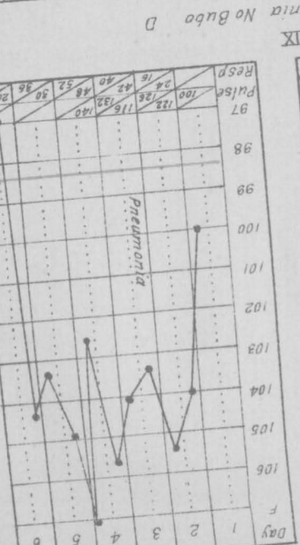
XIII

K.B.(H) Br. Pneumonia D
No Bubo



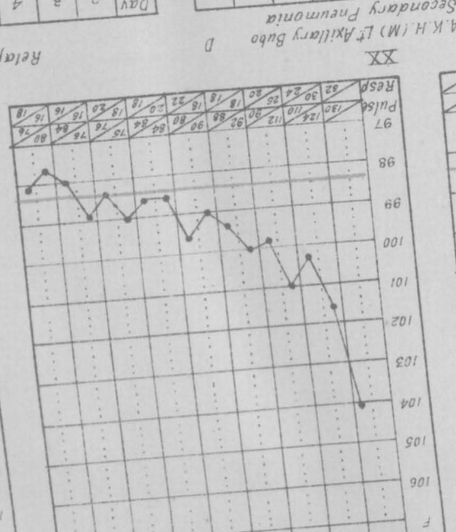
XIV

R.G.(H) R. Axil. (Second Pneumonia. D



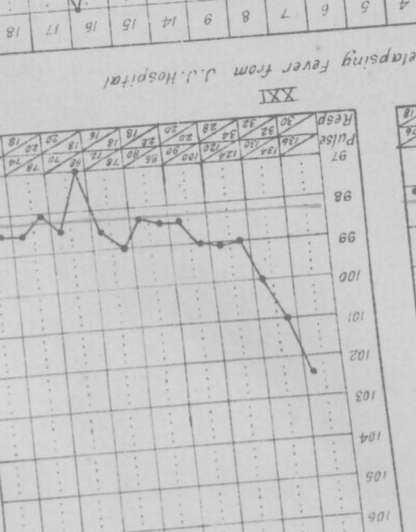
XV

K.L.(H) Rt L† Fem. Bubo Diarrhœa R.



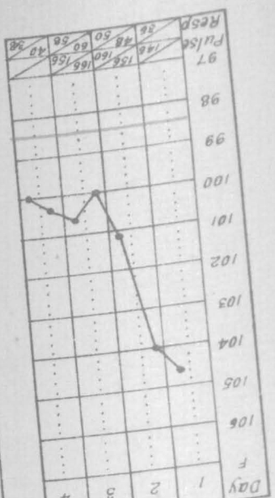
XVI

G.B.(H) Rt Axil Bubo
3 days artl. Hæmorrhages Proph. Serum R.



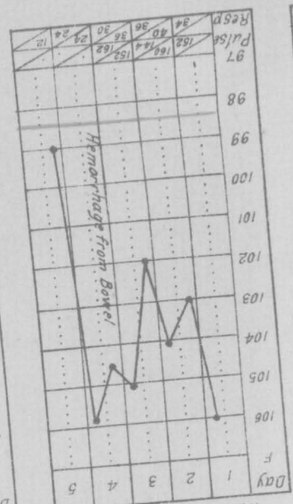
XVII

B.M.(H) Br. Pneumonia
No Bubo D



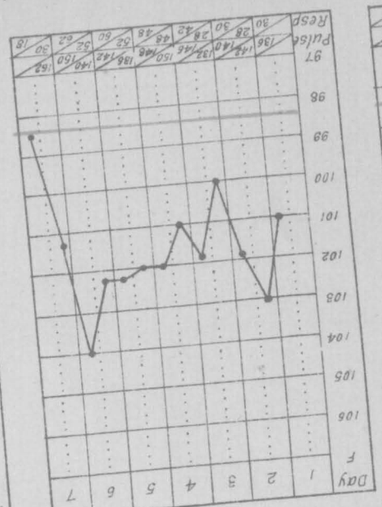
XVIII

W.Ch.(M) Rt fem. Bubo D
Hemorrhage fr. Bowel



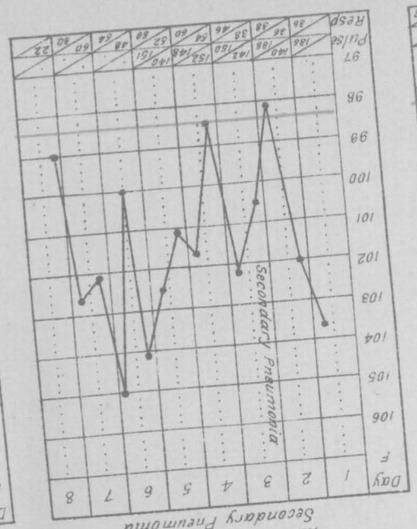
XIX

V.J.(H) Br. Pneumonia No Bubo D



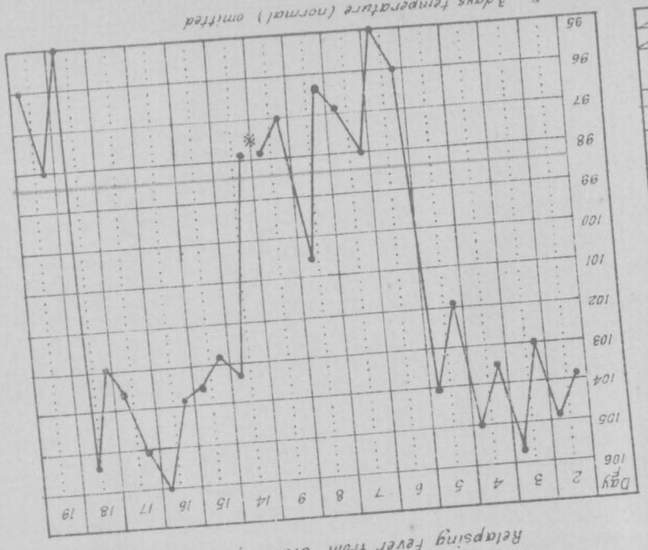
XX

A.K.H.(M) Lt Axillary Bubo D
Secondary Pneumonia



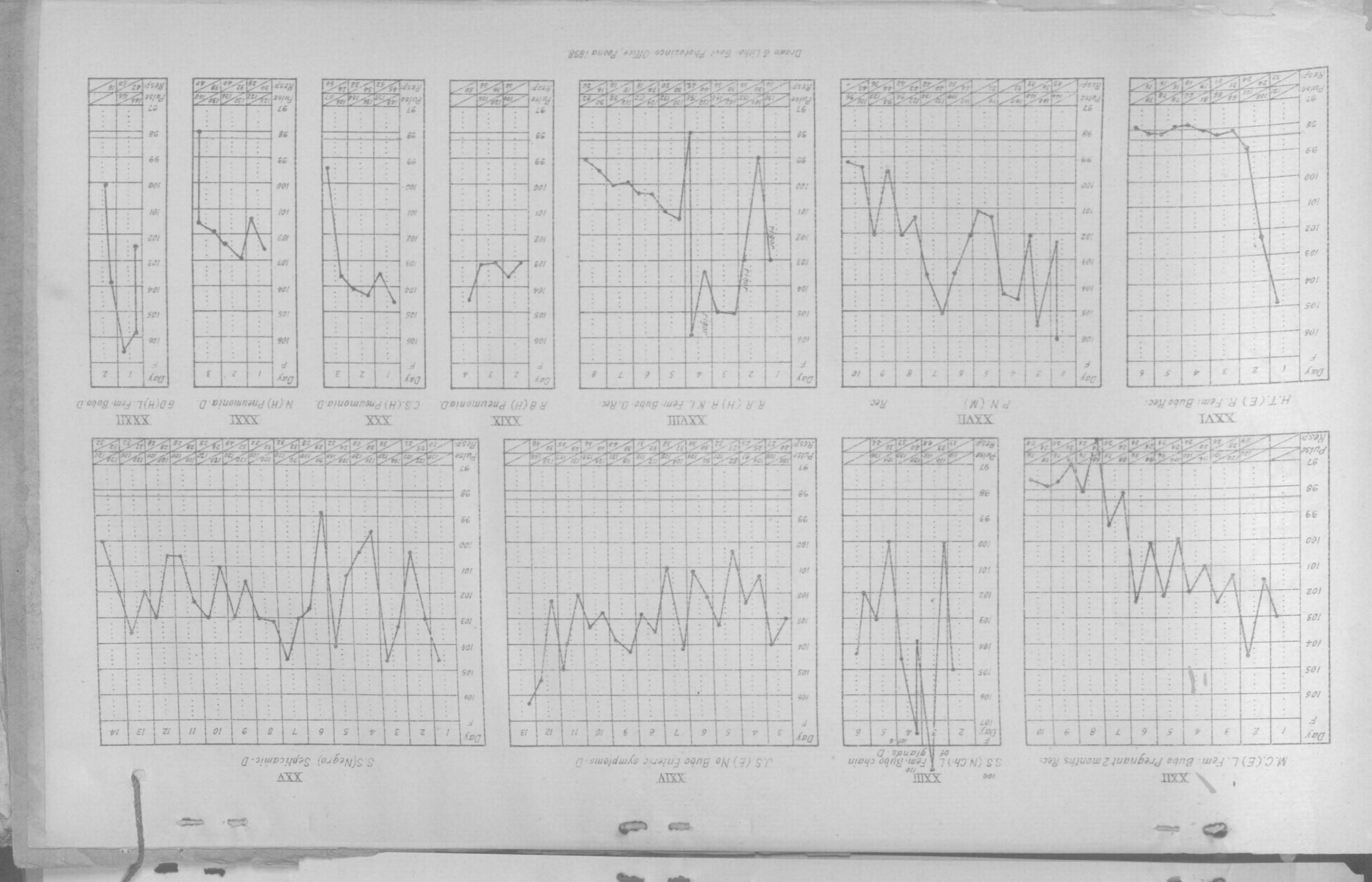
XXI

Relapsing Fever from J.J. Hospital



* 3 days temperature (normal) omitted

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XXVI
H.T.(E) R. Fem. Bubo Rec.

XXVII
P.N.(M) Rec

XXVIII
R.R.(H) R.K.L. Fem. Bubo D. Rec.

XXIX
R.B.(H) Pneumonia D.

XXX
C.S.(H) Pneumonia. D.

XXXI
N.(H) Pneumonia. D.

XXXII
G.D(H)L. Fem. Bubo. D

XXII
M.C.(E) L. Fem. Bubo Pregnant 2 months Rec.

XXIII
S.S (N.Ch.) L. Fem. Bubo chain of glands. D

XXIV
J.S (E) No Bubo Enteric symptoms. D

XXV
S.S(Negro) Septicamic. D

Drawn & Litho. Surv. Photolitho. Office. Poona 1858.

PROCEEDINGS OF THE MADRAS GOVERNMENT.

Read the following paper :—

From the Secretary to Government, General Department, Bombay, dated 18th June 1898 No.3867 P forwarding 10 copies of the report by Surgeon Major Lyons I.M.S.President of the Plague Research Committee.

Order No. 643 P. Mis., dated 5th July 1898.

x x x

2. The report will be distributed as follows :-

Surgeon General	1	copy
Sanitary Commissioner	1	,,
Marine Department	1	,,
Library	1	,,
Local & Municipal Deptt.	6	copies
	10	

(True Extract)

A Edgmiston

for Secretary to Government

To

The Surgeon General

,, Sanitary Commissioner

,, Marine Department

,, Library

Med Genl
903/98