Plague : how to recognise, prevent, and treat plague.

PLAGUE

HOW TO RECOGNISE, PREVENT AND TREAT PLAGUE

BY

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INTRODUCTION.

THE modern literature of plague is so scattered, and occurs in so many languages, that a concentration of the information at our command seems desirable.

The appearance of plague in Glasgow, in August, 1900, has brought the subject home to the people in this country, so keenly, that it behoves every medical man to know something of a disease which develops so insidiously and encroaches so stealthily that it may escape recognition, until a serious hold on the community may be obtained before its presence is recognised. It is to enable medical men to diagnose an unfamiliar disease that this short account of plague is written. The author has pleasure in acknowledging the valuable assistance he has received from Mr. David Rees, M.R.C.S., L.R.C.P., Superintendent, London School of Tropical Medicine, in revising the proof sheets.

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PLAGUE.

Definition.—The term plague is, at the present day, employed to designate a specific, contagious disease, appearing usually in an epidemic form and with a tendency to linger and recur once it has attacked a community. A febrile state, an inflammatory enlargement (buboes) of the superficial and deep lymphatic glands, parenchymatous changes in the lungs, kidneys, and other organs, inflammatory changes in the cerebral membranes, and a toxic condition, characterise the disease. A specific bacillus is met with in the glands, the blood, excretions, and viscera of persons suffering from, or who have died of, the disease.

Nomenclature.—To the French plague is known as *la peste*, to the Germans as *die Peste*, to the Italians as *la plaga*, and various descriptive titles, such as bubonic plague, the black death, Oriental typhus, Levantine plague, Pali and Mahamari (Northern India), Yunnan plague (China), have been applied to it.

Besides these, several names serving to indicate the resemblance which seems to exist between plague and such diseases as malaria, typhus, pneumonia, etc., have been introduced. In Tripoli, in 1856, plague was designated "typhus with glandular swellings." In Mesopotamia "adynamic typhoid fever" (1856), and "intermittent fever with glandular swellings" (1885). In Persia, in 1868, plague was known as "hæmorrhagic fever." In Russia, when plague prevailed along the Volga in 1877-79, it was severally termed "intermittent fever with buboes," "croupous pneumonia with buboes," "typhus with glandular swellings," and "a peculiar form of mumps." Attempts were made by the writer to introduce the term "polyadenitis" or "malignant adenitis." Since the discovery of the pneumonic form of plague by Childe in India, however, in which no glandular enlargement is found, it is evident that polyadenitis is not sufficiently comprehensive to include every variety of plague.

THE HISTORY OF PLAGUE.

In early times any epidemic disease attended by a high mortality seems to have been termed plague. There is no

doubt, however, true plague did occur even in Biblical times, and the term "emerod" mentioned in the Bible is no doubt synonymous with "bubo." Arabic, Greek, and Latin writers gave accounts of epidemics of plague, but it was not until the sixth century that bubonic plague was described as occurring in Europe.

Little definite, however, is known of plague pandemics during the centuries from the sixth to the thirteenth; but in the fourteenth century the disease known as the "Black Death"—true bubonic plague—spread over Europe. During the fifteenth and sixteenth centuries almost every part of Europe was visited by epidemics of plagué; during the latter century also typhus fever appeared for the first time, and there was considerable confusion in the diagnosis between plague and typhus. In the second half of the seventeenth century plague again visited Europe in pandemic form, and it was during this period that the "Great Plague" outbreak took place. In connection with the "Great Plague" in London much has been written about the beneficial effects on the "stamping-out" of the disease by the "Great Fire" which occurred during the wane of the epidemic. The burning of a portion of the city was, and is still, believed by many to have completely stayed the progress of the disease. This is not the case, however, for plague continued to recrudesce for many years after the occurrence of the fire. The effect of this story, however, remains, and accounts in great measure, no doubt, for the belief that the destruction of infected areas by fire will eradicate the disease.

During the eighteenth century plague was mostly confined to Eastern Europe, but severe visitations occurred in several cities in the south of France. It was during the dread of infection from France at this time that quarantine was first imposed in England against shipping coming from plague-infected districts.

In the nineteenth century until the year 1899 plague did not visit Western Europe, but it occurred occasionally in Eastern Europe and in some of the islands of the Mediterranean.

In 1877–79 a limited epidemic of plague occurred in a few Russian towns on the Volga, but, with that exception, up to 1899, plague had not visited any part of Europe during the latter half of the century.

THE MODERN PANDEMIC.

In 1894 Southern China was visited by an epidemic of plague, and it was when, in that year, the disease appeared in Hong Kong, that for the first time plague was scientifically studied. In 1896 plague appeared in Bombay, and from 1896 to the present moment the disease has prevailed in many parts of India, and India has now become the chief centre of the disease. A brief statement of the countries in which plague has prevailed since 1894 is interesting historically and from a public health point of view.

In Asia.—Southern China, including the British Crown Colony of Hong Kong and the Portuguese possession of Macau, has suffered severely, and for over five years has been the seat of several epidemics. In Northern China, the treaty port of Niuchwang, in the province of Liau-tong, has been the only place where the disease obtained a hold. Corea has been fairly free of the disease. Japan has had several visitations, and in Formosa plague seems to be now endemic. Annam, in the northern part adjacent to the Chinese frontier, has had several outbreaks. In India plague may be said to have been pandemic since 1896. It appeared first in Bombay; but in the Bengal, Bombay, and Madras Presidencies, and in most of the native states, plague has appeared in many instances in severe epidemics, but in others in a much more limited form. From Bombay the plague epidemic extended over sea to Kurachi, to Bushire in the Persian Gulf, to Aden and to the Arabian port of Jeddah. The other parts of Asia where plague has been recorded are in the neighbourhood of Lake Baikal, in Siberia, and in the village of Anzob, near Samarcand.

In the islands of the Indian Ocean.—Plague has occurred in Mauritius, in the town of Tamatave in Madagascar, in Réunion, and a few cases have been reported from Penang.

In the islands of the Pacific.—Plague has prevailed in the Philippines, New Caledonia, and Honolulu during the present pandemic. Japan, Formosa, etc., have been mentioned under the heading of "Asia."

In Africa.—Plague appeared in Egypt, at Alexandria and at Suez, in 1899 and 1900 respectively; but both outbreaks were limited in extent and virulence. Koch demonstrated the presence of plague in an unsuspected quarter, namely, in

Uganda; but the disease seems to be endemic there, and has probably nothing to do with the present pandemic. French observers have also reported cases of plague in the hinterland of the French West African possessions. At Laurenço Marques, in Portuguese East Africa, a few cases have been recorded.

In Europe.—From June, 1899, to January, 1900, plague was prevalent at Oporto, Portugal. In August, 1900, a limited outbreak of plague occurred in the city of Glasgow. In the autumn of 1899 (two cases), and again in the summer of 1900 (four cases), six cases in all, were brought to the London Docks and treated in the Seamen's Hospital Society Hospitals, where four of the six died of the disease. A case of plague was brought to Hamburg in a ship bound from Cardiff to Hamburg; and a sailor died in Cardiff of plague (1900).

The cases of plague that occurred in Vienna in 1899 seem to have been due to infection from laboratory cultures.

In America.—In North America, San Francisco is the only city where plague has prevailed. During the summer of 1900 plague was endemic amongst the Chinese in the "Chinatown" district of San Francisco, and although the number of cases detected by the sanitary authorities were some fourteen only, there is every reason to believe that many more cases and deaths from the disease have occurred there. In South America limited outbreaks of plague have occurred at the cities of Rosario and Ascuncion in Paraguay, in Buenos Ayres, and in Santos in Brazil.

In Australia.—Plague appeared in several cities of the Australian continent in 1900. Sydney has had the most serious outbreak, 300 cases in all, but from Adelaide, Melbourne, and Brisbane cases of plague have been reported.

The term pandemic may with reason be applied to the modern incursion of plague, for though, except in Asia, the epidemics have not been severe, the disease has affected a wider area than it ever did before. Until the present outbreak, plague had never appeared south of the equator, and the western hemisphere had never been visited by the disease. The freer communication of the countries south of the equator with those lying to the north, in recent years, no doubt accounts for the southern countries being affected, adding proof, if such were needed, that plague extends along the trade routes.

ENDEMIC CENTRES OF PLAGUE.

The inhabitants of Kumaon and Ghurwal, two hill states in the North-West District of India, lying on the southern slopes of the Himalayas between Nepaul to the east and the Punjaub to the west, have long been known to suffer from an endemic disease apparently identical with plague, but termed locally Mahamari. Plague is also believed to be endemic in parts of Yunnan and Sze-chuen, two provinces of China, adjacent to Burmah and Thibet. It is also probable that in Mongolia, in Siberia, and in the hinterland of German East Africa, endemic centres exist. But although in these localities plague may have existed for many decades, we have several cities and districts, such as Canton, Bombay, etc., which must now be placed in the category of endemic centres.

Etiology.—A specific disease has a specific cause, and the toxic agent is now known to be the bacillus pestis discovered by Kitasato during the Hong Kong epidemic of 1894. The bacillus is met with in the fluids which surround a bubo, in the gland itself, and in the pus from a recently opened bubo. In the saliva, the expectoration, the fæces, and in the urine the bacillus is met with in greater or less quantity, varying according to the type of plague which prevails. *Post mortem* the bacillus is found in the spleen, lungs, liver, kidneys, and in the walls of the stomach and intestines. In the blood the bacillus may occasionally be met with during life, especially in the later stages of the disease, but seldom, except in the septicæmic variety, in greater numbers than one or two bacilli in a microscopic field; *post mortem* their numbers in the blood run higher. Except in the sweat, the bacillus has been found in well-nigh every fluid and organ of the body, even penetrating the corpuscles themselves. In pus flowing from suppurating buboes of some days' standing the bacillus may be, in fact usually is, absent.

Microscopical appearances.—In stained cover-glass preparations obtained from the animal body, the bacillus pestis appears for the most part as a short rod, 1·5 μ to 2·0 μ in length and 0·7 μ in breadth (Hewlett). The measurements of the bacilli are, however, so variable that, instead of being rod-shaped, many appear coccoid or oval in form. Towards either end the bacillus stains more deeply than in the

centre, and a clear film or capsule is sometimes demonstrable around the whole area. The bacilli appear singly or in pairs. Flagella have been demonstrated by Gordon, Muir, and others; they are terminal in position, spiral in shape, and number one, two, or three. The motility of the bacillus is still a question of discussion, but the general consensus of opinion is that the micro-organism is non-motile. In preparations made from buboes streptococci and staphylococci are frequently associated with the plague bacillus. Laboratory cultures of the plague bacillus exhibit several microscopic departures from the type which prevails in specimens obtained direct from man or lower animals. Although the short rod form prevails, many of the micro-organisms attain greater length, and some again appear even shorter and narrower. The medium on which they grow seems to affect their anatomy and development; thus, in broth cultures the bacilli form chains of very short elements resembling streptococci; in dry media involution forms occur, when the bacilli may assume an ovoid, pear-shaped, or spindle-shaped form (Hewlett); in media containing 2 or 3 per cent. of salt involution forms, according to Hankin, are very pronounced. Bipolar staining is less definite in culture preparations than in those obtained direct from the body. Spores have not been found.

Staining the bacillus is a matter of easy accomplishment by any of the ordinary dyes. The staining may be accomplished readily by any one of the following fluids:—

1.—Loeffler's alkaline methylene blue:

Concentrated alcoholic solution of Methylene blue	30 c.c.
Solution of potassium hydrate (1 : 10,000)	100 c.c.

2.—Carbol-fuchsin stain:

Fuchsin	1 gr.
Absolute alcohol	10 c.c.
5 per cent. watery carbolic acid solution	100 c.c.

3.—Aniline-gentian violet stain:

Concentrated alcoholic solution of gentian violet	11 c.c.
Absolute alcohol	10 c.c.
Anilin water	100 c.c.

A small quantity of any of these staining fluids added to three or four times its quantity of water in a watch glass will suffice; the length of time of exposure to the stain depends on the strength of the solution employed; two or three minutes is long enough, especially if the watch glass is held over the flame of a spirit lamp for a moment.

Should the medical practitioner desire to establish the diagnosis of a case being plague, he is to proceed as follows:— 1. Wash the skin over the bubo with soap and water, wipe it freely with alcohol; into the periglandular tissue, or substance of the affected gland, thrust the needle of an antitoxin syringe, and draw off a small quantity of fluid. A number of cover glasses are then freely smeared with the fluid from the syringe, and the stains dried by passing three times rapidly through a spirit lamp, or Bunsen, flame. 2. When the practitioner has no time or opportunity for making microscopical examinations, the smeared cover glasses should be carefully packed and sent to a bacteriologist for examination and report; and even when he proposes to further investigate the matter himself, it is imperative that some of the cover-glass preparations, stained or unstained, be submitted to an authority on the subject as soon as possible. 3. To stain and mount the preparation for provisional diagnosis, the dry smeared surface of the cover glass is allowed to float on the diluted methylene blue fluid, or other stain, in the watch glass (warmed over a spirit lamp) for a few minutes. The cover glass is then lifted carefully off, washed by a gentle stream of water, when the cover glass is tilted on its edge and allowed to dry. The preparation, when thoroughly dry, is mounted in xylol canada balsam, and the preparation examined by a one-twelfth-of-an-inch oil immersion lens. The bacillus pestis cannot be stained by Gram's method. When in a specimen so prepared bacilli exhibiting bipolar staining, and which are decolourised by Gram's method, are found, plague infection must be suspected; but it is only by laboratory cultures and by inoculations of animals that the diagnosis can be considered final. Microscopical examination, as a means of diagnosis, may suffice when once plague is prevalent in a town or district, but for diagnosis of initial cases experimental investigations are necessary. Should the micro-organism not be found by microscopical examinations, it must not be

concluded that the case is not one of plague. There are numerous causes for its absence; thus in the blood it is seldom found until late in the disease: in pus from bubonic sores of some standing the bacilli are usually absent, so that extreme caution has to be exercised in pronouncing that any given case is not one of plague should microscopical examination give negative results. Should micro-organisms (staphylococci, streptococci) other than plague bacilli be present in stained specimens, they will be stained by Gram's method.

Cultures.—The plague bacillus grows well on most of the common media employed in the laboratory. In artificial nutritive media at the temperature of the blood the bacillus grows readily, the most favourable temperature being 36° C. to 39° C. The medium used may be blood serum, agar-agar, glycerine agar, bouillon, gelatine (in temperate climates), etc. According to Wilm, "the most favourable culture medium for the bacillus is a 2 per cent. alkaline solution of peptone containing 1 per cent. of gelatine." On blood serum, at the end of the first or during the second day after inoculation, a yellowish-grey, abundant growth occurs. On agar-agar the colonies are greyish-white in colour, of the size of a pin's head at the end of twenty-four hours; discrete at first, they afterwards coalesce and form a thin semi-transparent film. On bouillon the growth of the bacillus resembles that of "streptococcus pyogenes."

Haffkine's researches; Haffkine's stalactites absolutely diagnostic of plague.—No diagnosis of plague is reliable unless, in addition to the microscopic evidence, culture experiments substantiate the evidence. M. Haffkine worked out the bacteriology of plague in India in a masterly fashion, and it is to his work we are indebted for an absolutely reliable bacteriological diagnosis of plague. The culture medium employed by Haffkine is a faintly alkaline, or neutral peptone bouillon, to which a few drops of oil (olive, cocoanut, or linseed) or fat (ghi = clarified butter) are added. Fresh cultures of the plague bacillus or recent animal cultures are sown upon the bouillon contained in a flask, and at the ordinary temperature of the room. The flask must be kept absolutely at rest. In from ten to twelve hours a diffuse cloudiness is observed through the whole liquid. The cloudiness

disappears, and colonies are seen hanging from under the surface in stalactite form ("Haffkine's stalactites"). The

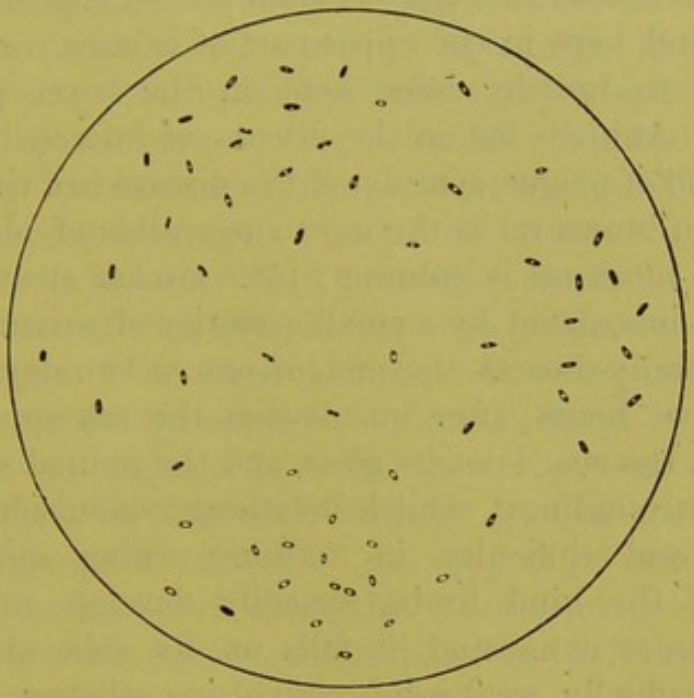

Fig. 1.—Plague bacilli examined by $\frac{1}{12}$-inch oil immersion lens.

colonies increase in size and number so as to form a thick jungle of stalactites, an appearance peculiar to bouillon growths

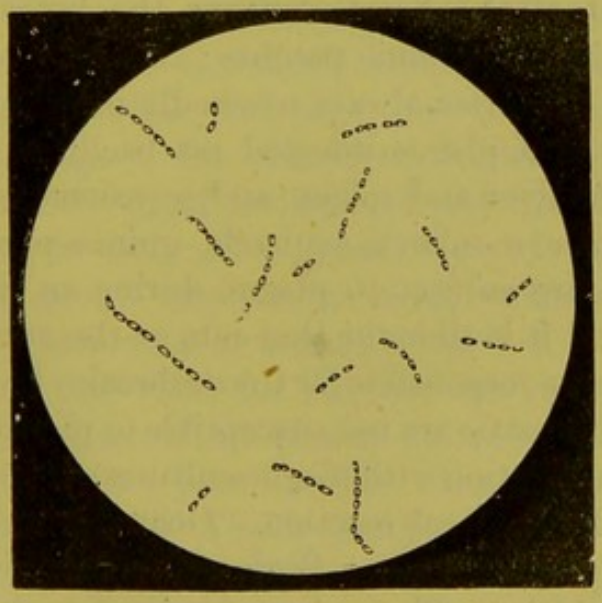

Fig. 2.—Bacillus of plague in chains showing polar staining. From a young culture in bouillon. (× 1000.) (*Muir and Ritchie.*)

of the plague bacillus, and therefore absolutely diagnostic. If the flask containing the stalactite formation is gently moved,

the growths precipitate like snowflakes during a fall of snow, the supernatant fluid becoming again clear.

Experiments on animals.—Yersin proved that mice infected by plague and kept in the upper part of a cage communicated the disease to healthy mice kept in the lower part of the same cage. Animals fed on the viscera of human beings, or of animals, dead of plague, contracted the disease in a virulent form. The common brown rat is the most susceptible of all animals to plague; the musk rat is immune; mice are less susceptible than rats. A rat inoculated by a small quantity of a virulent plague culture generally dies at the end of one or two days. In some ten or twelve hours after inoculation the rat appears ill; it refuses food, the coat loses its gloss, and the animal seems heedless of its surroundings. Quick breathing, convulsions, muscular twitchings, and difficulty in walking, owing apparently to paralysis of the hind limbs, speedily develop, until, as the animal becomes exhausted, it falls on its side, and during a series of gradually weakening convulsive seizures it dies. A *post-mortem* examination of a rat thus killed shows at the seat of inoculation some hæmorrhage or œdema; in the groin, axilla, and neck a hæmorrhagic œdema may also be found, but not necessarily any swelling of the glands in these regions. There is engorgement of the heart cavities; the lungs are collapsed and studded with pneumonic patches; the liver and spleen are congested, and the latter always markedly increased in size. In the dead body of a plague-infected rat bacilli can be found in the blood, in the liver and spleen, and occasionally in the urine. Besides rats, mice, monkeys, squirrels, guinea-pigs, and rabbits in confinement, are subject to plague during an epidemic which attacks man, and it is thought that rats or the vermin which inhabit them may be responsible for the outbreak. Dogs, cats, sheep, swine, horses and cattle are not susceptible to plague, but all, after experimental inoculation with plague cultures, suffer from a febrile reaction and exhibit a local reaction. Goats are more susceptible than other domestic animals. Birds are apparently immune.

Communicability.—Plague is transmitted to the healthy—by persons suffering from the disease; possibly by plague-infected animals, especially rats; by insects and body parasites; and perhaps by articles of clothing, goods, grain, etc., which have been contaminated by the plague bacillus.

1. *Air as a vehicle.*—Plague is not readily infectious. In plague hospitals, doctors, nurses, and even native attendants, although of the same nationality as the sick, are but seldom attacked by the disease. Amongst the staff of inspectors and workmen employed in inspecting and in disinfecting plague houses, or in transporting patients to the hospitals, or dead bodies to the mortuary or cemetery, the same holds good, attacks of plague occurring amongst persons so employed being exceptional. It is possible that prolonged exposure to a close atmosphere, loaded with effluvia from the patients and saturated with emanations from their excreta, as occurs in the houses of the poor, especially amongst Orientals, may be sufficiently concentrated to infect; but in the well-ventilated wards of a hospital, or in fair-sized sanitary houses, the danger of infection by the air is not great. In support of this statement, it must be remembered that the bacillus does not outlive desiccation, and therefore cannot exist as a living entity in the dust of the air.

2. *Food and water as vehicles of infection.*—Many consider that the plague bacillus finds entrance by way of the alimentary canal. In favour of this assumption, there are several well-founded contentions. Fæces are commonly found to be impregnated with plague bacilli, in some cases to a great extent; in almost all cases the intestinal follicles and the glands of the mesentery are swollen and, according to those who believe in infection by way of the alimentary canal, are the first to be affected. Further proof is also adduced in this direction by the fact that it is only after some days of illness that the buboes in the groin, arm-pit, or neck usually make their appearance. Experiments on animals further help towards a substantiation of this view, for animals fed on the organs of bodies dead of plague, or on plague cultures, readily contract the disease, and exhibit, *post mortem*, changes chiefly confined to the alimentary tract. The hydrochloric acid of the gastric juice is not in sufficient quantity to kill the bacillus, as it has been shown experimentally that in a $\frac{1}{2}$ per cent. solution of hydrochloric acid the plague bacillus will live for a day or two. In plague-infected houses, also, cultures of the bacillus pestis have been found to thrive on most meats and on many fruits. When the cervical glands are those primarily affected,

the tonsil is suggested as the channel of infection, and as the tonsil is frequently found inflamed there is some justification for the belief. Wilm asserts that in fresh, distilled, and sea water the plague bacillus will live for sixteen, twenty, and six days respectively; but the more recent investigations by Gaffky show that in distilled water at any rate the plague bacillus became non-virulent after three days, and could not be found after twenty-four hours of the water being contaminated.

In wells into which surface water finds its way from plague-infected dwellings, the water has been found to contain plague bacilli; and as many natives of Asia wash their bodies and clothing in the wells from which water is drawn for household purposes, the possibility of the well-water becoming contaminated and a vehicle of plague is apparent. Streams also may become impregnated in like manner, and if the water from a contaminated stream is utilised on boats or for ship storage, their potency in spreading plague is readily understood.

Although there is much presumptive evidence of infection by food, the conclusions arrived at by Childe in India do not bear this out. Childe's statement is—"With regard to infection by food, no evidence was found *post mortem* that the bacillus had entered through the stomach or intestine; but cases of cervical bubo might have resulted from infection through abrasions on the lips, tongue, or tonsils."

3. *Infection by the skin.*—Infection by way of the unbroken skin is not believed probable; but as the skin is exposed to injury and to the bites and stings of insects, there is a danger of infection by way of such wounds. The insect may or may not be itself infected by plague; the bite of the insect, or the mere scratching its presence induces, may serve to erode the surface sufficiently to allow the bacillus to gain entrance to the lymphatic or vascular systems from other sources; or, on the other hand, the insect may itself inject the poison whilst biting, and so cause inoculation. It has been suggested that the frequency with which the femoral glands are swollen in plague serves to indicate that the poison may enter by the skin of the foot, especially in natives who go barefooted, and in whom a surface abrasion must be a frequent occurrence. Against this argument, however, it must be stated that Europeans, or natives who wear shoes and stockings, have their

femoral and groin glands becoming bubonic more frequently than other groups of glands; and that, were entrance by the skin general, it would be the axillary glands that would be most likely to be affected, seeing that the hands are much more exposed to injury than the feet, and also that workers in hospitals or in plague-infected houses have their hands constantly in contact with plague-infected articles. Two Japanese doctors, whilst performing a *post-mortem* in a case of plague in Hong Kong in 1894, contracted the disease by wounding their fingers. The fact, of course, that they were living in a plague-infected environment rather detracts from the value of the evidence that they were directly infected by the wounds, but lymphangitis and adenitis succeeded in each case, and they were the only doctors that contracted plague in Hong Kong amongst the British, French, German, Japanese, or Chinese.

In India the Plague Research Committee gave particular attention to infection by the skin, and their conclusions were, that no definite skin lesion specifically indicative of infection by this channel was demonstrable; but in certain cases the bacillus was present in the skin lesion, 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. The supposed point of entrance when examined showed nothing definite or peculiar; "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 many plague patients similar skin lesions were found, but the plague bacillus was not proved to be present in them. It may be asserted that were the plague bacilli in the blood, their distribution is so general, that in any skin scab, scar, or papule they might be met with; but plague bacilli have been found in the skin lesions when they could not be demonstrated in the blood, and in many cases it was only in the skin lesions of the affected limb where the bacilli were found. The evident conclusion, therefore, is that the plague bacilli may enter by way of a skin wound or abrasion; and although no local inflammation or specific change is set up in the wound, it is significant that the resulting bubo occurs at the nearest gland to the seat of possible infection.

4. *The spread of plague by animals.*—Many animals are

susceptible to plague; amongst others, rats, mice, monkeys, guinea-pigs, and rabbits are susceptible to plague pretty much in the order given. Pigs, sheep, horned cattle, dogs, horses, and cats are but feebly susceptible. Of birds, the pigeon is the one that has been mostly experimented upon, but there is no proof that birds can contract the disease; this is fortunate, for were it possible to spread plague by the medium of birds, the consequences would be too terrible. One observer in India lately caused considerable alarm by announcing that he had found birds to be susceptible to plague. Fortunately the observation was inaccurate. The old story of a plague-infected raven falling dead whilst flying over Rome, and infecting all the children who plucked its feathers, is a tale which does not bear the light of scientific investigation. The *rat* is the most susceptible of all animals to plague. Whether the rat is primarily infected and originates plague in man, or whether the rat is infected from persons suffering from the disease, is a point not yet settled. In almost all outbreaks of plague, however, the rats have been early infected; they have been seen to leave their runs and holes and comport themselves in a peculiar dazed way. They seem to be, and no doubt are, intoxicated by the poison they have absorbed, and they die in large numbers. Coincidently with the appearance of rats dead of plague in a house, some of the inmates develop plague almost invariably, but which is cause and which is effect is not yet determined. The outbreak in Glasgow has not been traced to rat infection, and even after the disease had prevailed for weeks, no dead rats up to the present (November, 1900) have been found infected by the plague. That the rats may become infected by human beings is most probable, and, given a focus of house infection, it is possible rats may spread the disease rapidly. Simond has lately investigated the probability of the rat proving contagious by the vermin which inhabits its body (see *Insects*). The exact method by which the rat infects man, unless by the vermin on its body, is not determined; but, on the other hand, some observers contend that the parasites in the rat's coat will not bite man. It may be that the excrement of plague-infected rats gains access to the food; and articles of consumption, such as bread, fruit, vegetables, butter, and all sweetmeats which rats largely affect, may become so contaminated. In a similar manner, the excrement of man gaining

access to the sewers, ash-pits, etc., may infect the rats which have their abode therein.

The spread of plague by rats is readily understood when their habits are considered. In the first place, they inhabit sewers and gather from them and from household refuse material which, during a plague epidemic, may be infected. Secondly, the rat is a cannibal, in common with mice and guinea-pigs, and experimental investigations prove that the healthy rat readily catches plague by eating the viscera of men or the bodies of animals dead of the disease. Thirdly, the rat is a migratory animal at all times, now overrunning, now abandoning, a neighbourhood. The cause of these normal migrations may be the question of food or it may be disease, and in plague epidemics Clemow mentions that these migrations are especially frequent, probably due to self-protecting instincts.

Insects.—In 1894 Yersin found the flies in his laboratory in Hong Kong infected with plague bacilli, and a bouillon extract of the powdered flies when injected into a guinea-pig proved fatal. Since then many insects—ants, bugs, fleas, etc.—have been proved to harbour the bacillus. Simond has worked out the influence the vermin inhabiting the coat of the rat have on the spread of the disease in a most careful manner. He contends that by handling rats dead of plague the danger is not from the rat's body itself, but from the fleas and other insects which leave the dead rat and bite, or otherwise infect, the bodies of men. His investigatio s are most thorough and convincing, and there seems little doubt that his theory is correct. Healthy rats are not infested with vermin to any marked extent, but when the rat becomes ill from the disease he neglects his toilet, and the parasites increase in number. From three to four hours after death, when the rat's body cools, the insects leave and seek other homes, and Simond makes out a practical point in connection with this fact of considerable importance. He finds that rats dead for more than four hours may be handled with impunity, but that rats just dead—that is, before the fleas, etc., leave them—are dangerous to those handling them. To sanitarians and to rat-catchers this is a lesson in practical hygiene they should lay to heart and act upon. Clemow finds that in the neighbourhood of Lake Baikal, in Siberia, plague outbreaks are associated with the occurrence of the disease in

the tarbagan (*arctomys bobax*), a species of marmot. It is interesting to note that this animal is hunted by the natives for its fur, and it is probable that to the vermin inhabiting its body is to be attributed the infection of men who handle the animals.

In the light of fleas, bugs, and other parasites being the carriers of the plague bacillus, some interpretation is afforded of the part of the body of human beings most liable to be attacked. On the upper part of the body these insects are not so likely to settle as they are about the lower extremities, whether bare or clothed. They are less likely to be disturbed there, and hence the poison they bring will most probably find entrance by way of the lymphatics and glands of the lower limbs. This is in accordance with clinical experience, for it is well known that the groin glands are swollen in plague more often than any of the other groups.

Clothing.—That the contagion of plague can be carried by articles of clothing that have come in contact with persons suffering, or dead, from the disease is generally believed. Plague cultures have frequently been obtained from portions of personal clothing, from sheets, surgical dressings, blankets and bedding that have been soiled by the excretions of plague patients. Some attribute the infectivity of clothing, bedding, etc., to the vermin they contain; but although this is quite possible, the fact that sterilised pieces of clothing, after being soaked in a bouillon culture of the plague bacillus (Wilm), and subsequently protected from extraneous infection, gave cultures of the bacillus after four weeks, would seem to point to the fact that plague-soiled clothing can harbour the micro-organism independently of insects. How clothing infects is yet to be ascertained, for the mere wearing of the clothing of persons dead of the disease is not in itself sufficient, as proved by a French physician in Egypt long ago. It is possible that from the bacilli on the infected clothing the body parasites become infected, and they in turn infect the wearer.

A well-authenticated case of possible infection by clothing is here mentioned for the first time. The account was sent to the writer by Dr. F. Edwards, of Durban, Natal.

"A family of six persons came from a plague-stricken district in Mauritius to Natal in March, 1900. In May, two months after arrival, one of the sons, aged 16, opened a deal case

which contained soiled linen which the family had brought with them, but which had not been previously opened. Two days afterwards the boy was seized by an illness which was diagnosed as bubonic plague, and died in two days. The autopsy confirmed the diagnosis, and the cocco-bacillus was found in quantity in the glands and viscera by Dr. Leuman, the plague expert attached to the troops in Natal. It may be mentioned, also, that the patient had been inoculated with Haffkine's serum in July, 1899. No other case of plague occurred in consequence of this."

Two points are suggested by this interesting case. First, that soiled clothing may harbour the plague bacillus for over two months, and that Haffkine's prophylactic inoculations do not afford protection after an interval of nine months.

Grain and other food-stuffs.—Hankin devoted considerable attention to this subject during the Bombay epidemics of 1896–97. It is of especial importance to arrive at a distinct understanding on this point, as the prohibition of the import or export of grain in some parts of the world might have wide and important significance. In grain infected with plague cultures the bacilli soon die out. How soon they disappear is not quite known, but, after four to six days, extracts from the plague-smeared grain are not infective. In rice, sugar, etc., the same law holds good, so that food-stuffs of themselves are not pre-eminently dangerous. But all these articles may harbour rats, mice, etc., and are therefore liable to be foci of infection. It should be laid down as a rule, therefore, that when rats are found in any article of commerce, shipped at a plague-infected port, the goods must be viewed with suspicion.

It is frequently asserted that it is not fresh grain but "rotten" grain which harbours plague. This point Hankin also investigated, with the result that "rotten" grain is less likely to favour the growth of plague than is fresh grain. The acid reaction set up in decomposing grain is fatal to the bacillus, and in all probability the microbe can live in such a medium for a few hours only, and certainly not longer than twenty-four hours (Ras).

Insanitary environment.—Although a filth disease, yet plague cannot arise *de novo* or because of dirt.

The specific bacillus must be imported, and it is only when this takes place that an insanitary state serves to propagate

the disease. In the history of every recent outbreak, it is invariably the uncleanly poor that suffer. Inmates of good sanitary houses escape plague in a marked manner, even when they dwell in a locality where the disease is rife, and Europeans in the tropics possess no immunity except by reason of their cleanliness. The improved sanitation of European cities and dwellings generally would seem to prove an obstacle to the spread of plague. The outbreak of the disease, even in a city with so slight pretensions to sanitation as Oporto, proved abortive, and the same it is to be hoped will (no doubt) prove to be the case in Glasgow. It is well to remember, however, that there are "slums" in our cities of Western Europe as foul as any in Calcutta or Canton. We are apt to pride ourselves on the superiority of our dwellings, but we have only to visit some parts of London, Glasgow, or Dublin to gather how unjustified such an assumption is. Our public sanitation may be superior; a pure and plentiful water supply and perfect sewage arrangements may all help to keep plague at a distance, but if our neighbours have plague, and our domestic and personal conditions are uncleanly, we have no guarantee that in our large cities plague may not gain a firm footing. Hong Kong is as well provided with pure water as Glasgow, and its drainage as good as that of London, yet because of the proximity of plague in Canton, Hong Kong suffered severely.

Infection of the soil.—Were the earth to harbour or grow the bacillus, the explanation of infection by way of the skin of the lower extremities, in persons who go barefooted more especially, would seem a simple explanation of a difficult point. In 1894 Yersin believed he found the bacillus of plague in the mud floors of dwellings infected by plague, and also in adjacent plots of ground. This observation has not been verified by any other observers. The bacillus has been found "on" the mud floor and in the dust of infected house, but the spot may have been recently contaminated by sputa or by excretions.

The results of Hankin's observations, in short, are "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."

The *meteorological*, *geological*, and *climatological* influences

on the power of the infectivity of plague seem to be almost *nil.* Plague may occur in the hottest or in the coldest climates, and develop amongst hill residents and dwellers by the sea. Neither *sex* nor *age* seems to avail. *Race* would appear to exercise a certain influence, but it is doubtful if to "race" *per se* is to be attributed the difference between the prevalence of the disease amongst the Europeans and the natives in Asia. The Malay race, curiously enough, seem wonderfully exempt from the disease. In Java, Sumatra, and the Malay Peninsula plague has not obtained a hold. This may be ascribable not to *race,* but to the fact that the equatorial belt has never been known to be deeply, if at all, affected by plague, and the nearer this belt is approached, so the virulence of plague seems to diminish. Plague was styled by Murchison "the typhus of the tropics"; but although it has crossed the "line," it does not seem that the disease finds a favourable soil in the immediate neighbourhood of the equator.

VARIETIES OF TYPE.

The term "bubonic" is frequently used to designate true plague, but buboes are by no means an essential sign of plague. In many outbreaks but few cases of a bubonic nature have been met with; so few, in fact, that enlargement of the glands proves the exception rather than the rule. Again, a succession of outbreaks in the same city seldom preserves the same type; pneumonic symptoms prevailing in one, buboes in another, and yet again, a toxic or septicæmic form in the third accession of the disease. So numerous are these divergent forms that the varieties of plague are grouped by several writers as follows:—

(1) *Bubonic plague.*—Three-fourths of all plague cases belong to this type. As our experience increases, however, and closer attention is paid to "collateral" plague ailments, it will be found that many forms of complaint, in addition to the partially recognised pneumonic and septic types, will prove to be plague. A mere enlargement of a gland does not constitute a bubo. Enlarged glands are met with in the septic and septic-pneumonic types. It is the adenitis and the inflammation in the periglandular tissues that combine to form a bubo. The bubonic form is generally stated to be the primary type of the attack, and that in subsequent recurrences a pneumonic type is more commonly met with. The truth of this assertion must be

doubted; rather is it that the "collateral" ailments are not recognised as due to plague by a community unfamiliar with the disease. In the bubonic type the chief characteristic is the presence of a mass of inflamed and enlarged glands in one (seldom more) region of the body, attended by œdema and by an extensive exudation of inflammatory products, or by an extravasation of blood around the glands. Bubonic plague is regarded as less fatal than either the pneumonic or septic varieties.

(2) *Pneumonic plague.*—As the name implies, lung symptoms assume the principal *rôle* in the illness. The fact that pneumonia could be caused primarily by plague was discovered by Childe in Bombay. As the plague mortality increased Childe observed that deaths from pneumonia advanced correspondingly. He directed his attention to the subject, and found that, in the sputum of patients suffering from what appeared an ordinary pneumonia, plague bacilli swarmed. This interesting observation was, however, only a re-discovery, for, in the beginning of the century, White stated that the pneumonia occurring during plague epidemics was characterised by peculiar features, and no doubt was an indication of the disease.

Pneumonic plague usually commences with a rigor, headache, nausea, vomiting, body and limb pains, and a temperature ranging from 102°–105° F.; cough, dyspnœa, a quantity of watery sputum tinged with blood and becoming profuse as the illness progresses. The sputum is coughed up with but little effort. Prostration is extreme and out of all proportion to the evidence of local lung lesions in the early stage of the illness. Moist sounds are to be heard over the base of the lung and over the more dull pneumonic patches. The pulse is from the first soft and compressible, and evidence of cardiac failure occurs within a day or two of the commencement of the illness. Delirium of a marked type prevails, which before death usually ends in coma. The pneumonic variety is not only the most highly infectious, but is also the most certainly fatal form of plague.

Infection is conveyed by the sputum, which swarms with bacilli. Cases are recorded where the sputum falling on a nurse's conjunctiva infection has resulted, and as the sputum may be received in handkerchiefs, and on clothing, bedding, or on the floor, each and all of these are rendered highly infectious,

the bacilli in the sputum consisting of almost a pure culture of the organism.

(3) *Septicæmic plague.*—The sudden onset and the virulence of this form of plague are such that the patient seems struck down as if by the effects of an acute and active poison. The glands, although *post-mortem* evidence shows that they are universally affected, are seldom to be felt during life, and there is no bubo. In the septic type of the disease the bacilli invade the blood at an early period of the illness in such numbers that the system is profoundly and suddenly affected. The intensity of the poisoning is such that the prostration is extreme from the first, and the patient has no strength to resist the depressing influence of the attack. Hæmorrhages from the nose, bowel, and kidney are more frequently present in the septic variety than in any other type of the disease. The temperature may not rise above 100° F., but in other instances it becomes hyperpyrexic. Muscular twitching, delirium, stupor, and coma mark the illness, which usually ends in death during the first, second, or third days of the disease. Several other types of plague are mentioned by authors, such as:—

(4) *The intestinal type,* in which an intestinal flux occurs with blood, mucus and epithelium in the evacuation.

(5) *The nervous type,* in which cerebral symptoms are so pronounced as to mask all other features. The most interesting and important class of cases under this heading are those of convulsions in children, where not only does a seizure usher in the disease, but tonic or clonic spasms continue through the illness, which generally ends in death. Deafness, dumbness, muscular twitchings, tremors, mania, or insanity may prevail as the prominent symptom and relegate to a secondary place all other evidences of the disease.

(6) *The puerperal type.*—In this class are grouped all cases in which miscarriage, abortion, uterine hæmorrhage, etc., constituted the chief and most declared feature of the illness.

(7) *The typhus type.*—Plague in some instances closely resembles typhus. The presence of petechiæ or a septic rash, and the general febrile state which is met with occasionally, may defy all clinical acumen to diagnose, and the microscope has usually to settle the matter.

(8) *Pestis fulminans or siderans* are the names suggested

to describe a type of plague in which the disease proves fatal in from twelve to twenty-four hours. It is merely a virulent variety of the septic type.

(9) *Pestis ambulans*, termed *larval* or *abortive* plague, indicates a mild form of the disease in which the patient is but little inconvenienced. A gland or glands may be enlarged for a day or two and subside, or a gland may suppurate and quickly heal. The patient has few or no constitutional symptoms, and in many instances is never confined to the house. Unless suspicion is aroused and the bacillus sought for, there is but little chance of such ambulatory cases being diagnosed.

(10) *Pestis Minor.*—In Hong Kong, in Calcutta, and in Russia cases of "chronic buboes" of non-venereal origin have been recorded, previous to outbreaks of true plague. The writer brought forward an account of twenty-one cases of this kind before the Medical Society of Hong Kong in 1893; that is, twelve months before the epidemic of true plague occurred. Medical men in Singapore and elsewhere met with cases of a similar nature about the same time, and Surgeon Godding, R.N., recorded several instances of the disease that occurred amongst seamen in the Royal Navy. In Calcutta, Drs. Simpson and Cobb investigated this ailment bacteriologically, and came to the definite conclusion that it was plague. The illness lasts about three weeks. The patient comes complaining of feeling ill and weak, and shows a commencing enlargement of glands in the groin. The feverish symptoms continue, general malaise causes the patient to leave off work and seek his bed, the gland continues to enlarge, and at the end of ten days suppurates, and discharges a watery pus from two or three fistulous openings. Unless the gland is removed sinuses form, and the skin overlying the gland gives way. When the gland is cut down upon it is found detached from its surroundings either completely or except at one point, a neighbouring gland or two are affected, and may require removal likewise. When cut into the substance of the gland shows two, three, or more purulent points, and the tissue of the gland is soft and easily broken down. It is in such glands as these that Drs. Simpson and Cobb found the plague bacillus. Their contention was disbelieved, and attempted to be disproved, but subsequent

investigations have confirmed their statement and conclusions. It is further interesting to note that all the cases occurred in Europeans, and that it was on the men of the Shropshire Regiment in Calcutta that Drs. Simpson and Cobb made their investigations. The regiment had come to Calcutta from Hong Kong, where the men had been employed "on plague duty."

In Russia, in 1878, on the Volga, pestis minor prevailed in one city near the mouth of the Volga for several months before true plague occurred in another town situated some distance further up the river.

Pestis minor has been observed to occur before, during, and after an outbreak of true bubonic plague.

The late Sir R. Thorne, in the Supplement to the Twenty-eighth Annual Report of the Local Government Board, wrote as follows:—

"*Fever, with glandular swellings*, prevailed in Bombay before it was recognised that plague had reached that city; and it is impossible to read the medical history of this disease in almost every part of the world without being impressed with the frequency with which recognised plague has been preceded by ailments of such *slight severity, involving some bubonic enlargement of glands*, and *some rise in body temperature* so as to mask the real nature of the malady. In this respect plague would appear at times, if not commonly, to resemble other specific epidemic diseases in their pre-epidemic behaviour; and just as seemingly simple sore throats or slight diarrhœal attacks, both of them so trivial in their nature as to allow the subjects of them to move about freely amongst their fellow subjects, turn out ultimately to have been the means of sowing broadcast the infections of diphtheria and typhoid fever respectively, so does the *ambulatory plague patient, who feels somewhat out of sorts, and has some commencing enlargement in his groin or armpit*, often constitute a grave danger to public health. Indeed, if plague differs from the diseases referred to in this sense, it would be by the frequency with which indolent buboes form a solitary outward indication of mischief, and by the facility with which these otherwise ominous symptoms evade detection."

The same authority further adds:—

"I have no hesitation in venturing to assert that the individual who suffers from pestis minor or pestis ambulans, and whose movements no one has found cause to control, is an infinitely greater danger as a vehicle of infection than even infected clothing."

THE CLINICAL FEATURES OF BUBONIC PLAGUE.

Exposure.—The exact period of exposure to plague infection is seldom readily ascertainable. When, however, a healthy

person from an uninfected locality develops plague after a single temporary visit to a locality or dwelling where persons are suffering from the disease, it may be safely inferred that the visit and the infection stand to each other in the relation of cause and effect. Such seemingly exact processes of infection as *post-mortem* wounds followed by an attack of plague are not necessarily the correct interpretation of how the disease was acquired, for persons so wounded may have acquired the disease immediately previous, or subsequent, to their presence at the *post-mortem*. A doctor dwelling in a plague-stricken locality may develop the disease after a single visit to a plague hospital, yet the visit may not be the cause of the infection. A nurse receiving the sputum of a patient suffering from pneumonic plague on the conjunctiva may not have become infected thereby, although, no doubt, this is possible; the nurse may have become infected before or after the occurrence. Rat-catchers may ascribe infection to handling dead rats, stretcher-bearers to carrying a dead body, sanitary inspectors and workers to cleansing premises; yet each and all, if they reside in a town or locality in which plague is prevalent, may have contracted the disease from other sources. Should a plague-infected ship reach a healthy port, and should amongst the shore hands unloading the cargo plague develop in a few days, it may be safely assumed that the period of exposure dates from that time. Were the disease not to appear until, say, ten days subsequent to having finished handling the cargo of the plague-infected ship, then the source of the disease, in all probability, is not due directly to the cargo, but to the rats which have found their way on shore. To prevent falling into error on these points great caution is necessary, and the most careful and patient investigation is requisite.

Incubation.—Three to five days is the usual period which intervenes between the period of exposure to plague and the development of symptoms of illness; as many as ten days, however, have been known to intervene, and this may be taken as the maximum incubative period. It is important to remember that *ten* days does not mean the *tenth* day, a mistake which is frequently made in estimating the limits of the incubation for this and other infectious diseases, and frequently with dire results. During the incubation period no definite indications

that infection has taken place are in evidence. A *post-mortem* wound received during the examination in a case of plague will, as in *post-mortem* wounds received from bodies dead of other diseases, in all probability give signs of local trouble at the end of twenty-four hours; but one must not assume that the symptoms are due to specific plague infection, although septicæmia may rapidly ensue.

There are no well-founded proofs that the period of incubation ever exceeds ten days' duration. When such periods as fifteen days are mentioned, the probability is that the source of infection has been mistaken.

Invasion.—Plague may be said to commence in one of three ways:—

1. A sudden rigor or chill may usher in the disease, accompanied or followed by high fever, headache, giddiness, thirst, vomiting, epigastric pain, extreme prostration, and aching in the back and limbs. The mental state of the patient may be one of apathy or of delirium.

2. In a certain number of cases no rigor occurs, but fever, headache, loss of appetite, and pains in the limbs obtain, with but little mental disturbance.

3. In children convulsions frequently usher in the attack, and may be the first indication that the child is ill.

Buboes may be present from the first, or their appearance may be delayed for a day or two; but, on the other hand, it must be remembered that none of the superficial groups of glands may be felt to be swollen during any period of the illness.

INVASION, SIGNS, AND SYMPTOMS.

The early symptoms of a case of plague, at the period the patient is usually seen by the medical practitioner, are as follow:—

The patient may be found in a state of excitement, delirium, or partial apathy, and unable to answer questions put to him; the features are pain-drawn and haggard, or they may appear expressionless, as if the patient were intoxicated. The eyes look sunken, the conjunctival vessels are injected, the face pale, and a dusky congestion prevails round the eyes, extending to the forehead and cheeks. The pulse will be found to beat at the

rate of 100 or more, and to be full and not readily compressed. The breathing is hastened from the beginning of the illness, and not infrequently hiccough or a short, dry cough is noticeable. The temperature of the body in the majority of cases will during the first day of illness be found to be between 101° and 103°, but it may suddenly rise to 104° or 107° within a few hours of invasion. In some cases, even in the early stages of the disease, the temperature will be found normal or subnormal, but in such apyretic cases no doubt a temporary initial rise has preceded.

The tongue appears swollen, and the dorsum is coated with a general white fur, leaving the sides and tip red and uncovered; sore throat may be complained of; one or both tonsils may be enlarged; and vomiting and nausea are often distressing, any food or drink swallowed being immediately ejected with considerable force. The abdomen is frequently tender and tense, and, if the patient is sensible, epigastric tenderness is complained of or elicited on pressure. Constipation is the rule at first, but diarrhœa is not uncommon; the urine is unaltered during the onset, except that it is scanty in amount. The patient may be found lying flat on the back, or if a bubo pains, he may be sitting up in bed with the knees almost at the chin, or may lie on one side with the lower limb on which the buboes exist in the position of flexion. The glands in the groin, the axilla, or the neck may be found swollen and tender, or tenderness alone may exist, elicited only when deep pressure is made in the region of the glands.

Such are the signs and symptoms usually presented to the doctor when first he is brought to see a case of plague. It will be seen there is nothing specific in their character, nor anything to point to the illness being of a peculiar nature, unless buboes are present. Buboes are, however, seldom an initial sign, and in their absence there is nothing to suggest a specific ailment. The further history of a case of plague will be best considered by an analysis of the different organs and functions as they are severally affected.

The temperature in plague varies with every type of the disease, and it is seldom that two cases in any one of the types follow a precisely similar course. In the more *favourable cases of bubonic plague* the temperature, which, during the first and

second days of the illness, is high, drops on the third and fourth days to near, or even below, the normal. A high temperature is again to be expected on the fifth and sixth days, followed by fever of moderate amount, which gradually subsides during convalescence. The initial rise may be gradual or it may reach 103°–104° or 105° F. within a few hours of the commencement of

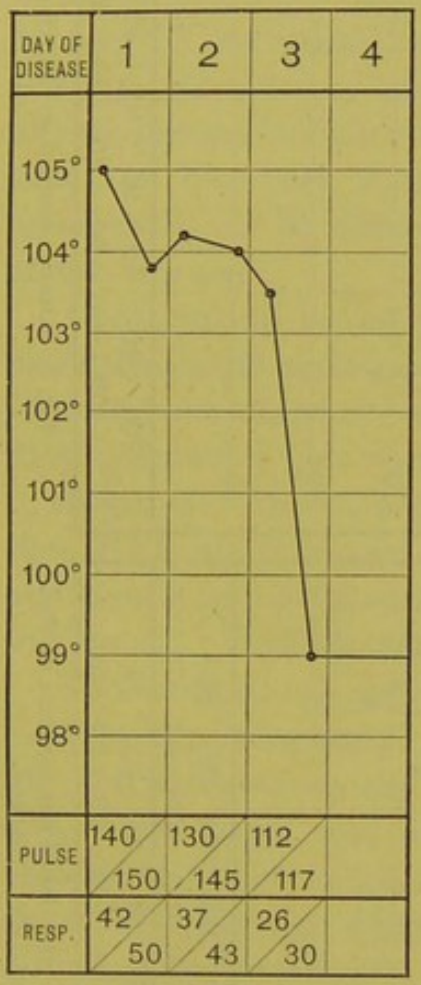

Fig. 3.—A rapidly fatal case of bubonic plague.

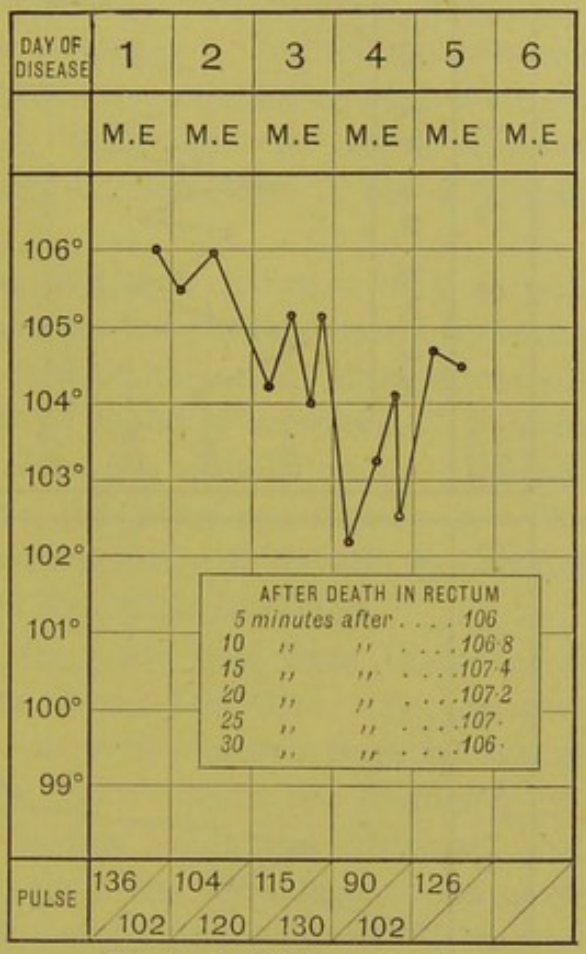

Fig. 4.—Initial hyperpyrexia.

the invasion. The initial temperature registers give no indication of the subsequent course of the disease, unless a hyperpyrexia obtains.

When after the second rise of temperature in bubonic plague fever recurs, it generally indicates a septicæmic or pyæmic condition and a fatal issue. In *septicæmic* plague the temperature usually rises to a considerable height, 104° or 105° F. at the very commencement, and may rise even higher during the second day. The high fever is usually maintained to the end. In the most virulent form of plague, the so-called fulminant plague, the temperature may scarcely, if at all, rise above the normal. This

apyrexia would seem to indicate that the toxic power of the disease is so virulent that reaction is impossible, and the patient is rendered prostrate as if by shock.

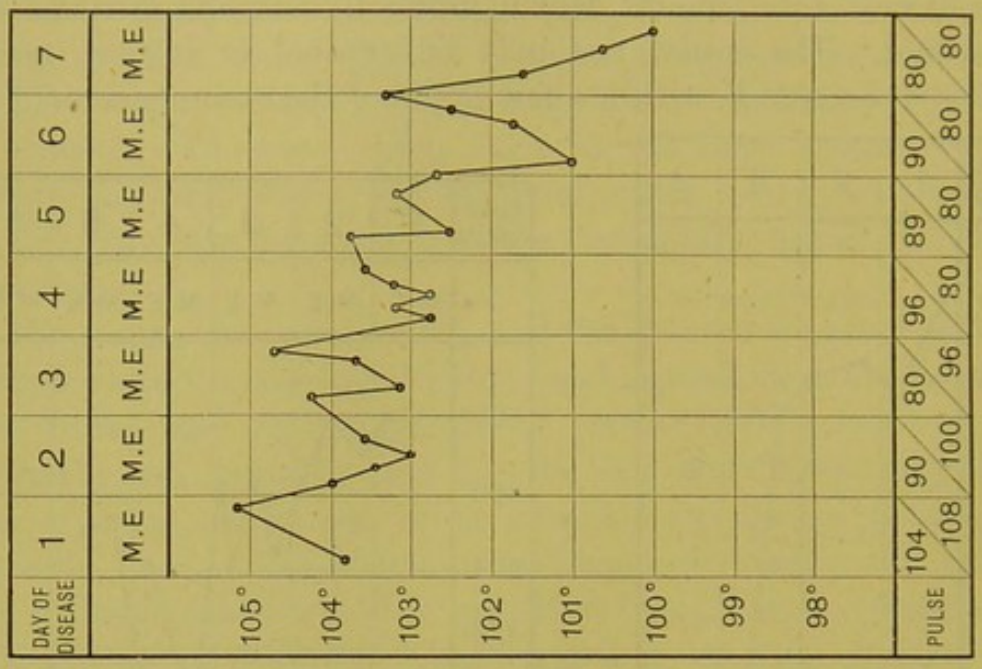

Fig. 5.—Death occurred on 7th day.

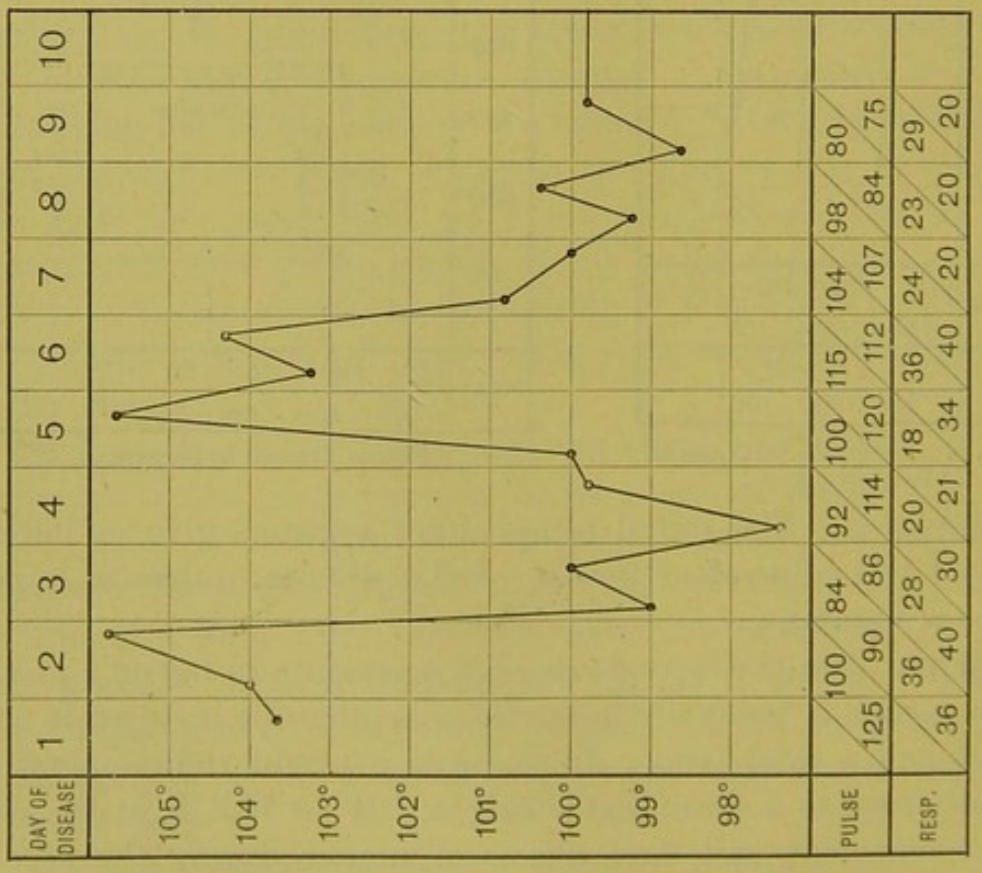

Fig. 6.—A case which recovered; the rise of temperature on 2nd and again on 5th day is well marked.

In *pneumonic* plague the initial rise is usually pronounced, and the temperature may continue high to the end or may fall suddenly just before the patient dies.

The alimentary canal.—The lips, as the disease progresses, become dry and shrivelled; sordes collect on the teeth; the tongue, which at first is plentifully coated with a dirty white fur, after a day or two shrinks and cracks, and the white coat is first tinged yellow, then assumes a mahogany colour, and finally becomes brown or almost black, looking like the tongue in typhus. Vomiting and nausea, present from the onset, frequently continue for a day or two, or even longer. Vomited matters are at first bilious, but afterwards watery, or containing such nourishment as has been swallowed. Although the vomit appears occasionally to be coffee ground, hæmatemesis is not a feature of the disease.

Constipation is the rule at first, but diarrhœa may accompany the initial sickness and nausea; it is more usual, however, for a bilious diarrhœa to succeed constipation, when the stools may number a half-dozen daily: blood is occasionally present in the stool. The liver and spleen are usually tender to palpation, both are increased in size, the latter remarkably so. The abdomen may be distended independently of the enlargement of the viscera; in some cases it is somewhat retracted.

The circulatory system.—The pulse beat from the onset is increased in frequency, seldom being less than 100. At first full and fairly tense, the pulse in a day or two flags, becoming soft, compressible, and dicrotic; before death the frequency increases to 140 or more, and becomes feeble and irregular. An examination of the heart will show the apex beat to be more diffuse than normal, and occasionally a præcordial thrill may be felt. Dilatation of the right side of the heart, a shortened first, and a feeble, scarcely audible second, sound, and occasionally a systolic murmur, are, with the exception of the last, common features in the disease. Pulsation of the carotids is usually in evidence. The number of white corpuscles, in cases of two or three days' standing, is increased, and it has been observed that the red corpuscles show but little tendency to form rouleaux.

The respiratory system.—In several recorded epidemics lung lesions have been stated to be almost altogether absent, and in others to supervene, if at all, rather late in the disease; in others the lung was the primary seat of inflammation. This discrepancy may be accounted for, in some measure, by the fact that attention was at first not directed to cases of death from pneumonia

which occurred concurrently with the prevalence of plague. The deaths from pneumonia were not associated with plague until, in 1896, in Bombay, Childe observed that pneumonia and so-called remittent fever seemed to increase *pari passu* with the spread of plague. On attention being directed to the subject, it was found that plague bacilli existed in swarms in the sputa of many patients suffering from pneumonia, and from that time dates our exact knowledge of lung lesions and pneumonic plague. Excluding, however, the pneumonic type of the disease, affections of the respiratory tract are rare. From the commencement the rate of breathing is accelerated in proportion to the height of the fever and the rapidity of the pulse. Bronchial catarrh may occur on the fourth or fifth day of the illness, and occasionally the expectoration is stained with blood. A sense of oppression and tightness across the chest is complained of in cases in which no lung affection can be diagnosed. Patchy and evanescent congestion of the lung may be noticed, and occasionally some bronchitis and œdema of the lung. Even pulmonary abscess and purulent pleurisy (Wilm) have been recorded.

The urinary system.—At the commencement of the illness the excretion of urine is frequently diminished in quantity, the specific gravity is high, and the reaction intensely acid. Suppression of urine with lumbar pains is not uncommon; it may exist from the onset, but is more common towards the end in fatal cases. Albumen, in the first epidemic in Hong Kong in 1894, was rarely found in the urine, but during the second recrudescence, and in all the Indian epidemics, a trace of albumen was rarely absent from the urine. Granular urinary casts are frequently detected, and when they are present it is not uncommon to find blood corpuscles also. Urea, uric acid, and chlorides are deficient. The urine is frequently retained.

The cutaneous system.—No characteristic skin rash occurs in plague; but a few cases during every epidemic present a rash closely resembling the rash in typhus. Petechiæ occasionally occur, just before death, over the abdomen or over the seat of bubonic enlargements. Small patches of skin may slough, leaving a foul, suppurating surface and indolent ulcers with undermined edges. These ulcerative changes are independent of pressure or the presence of glands, and may develop

anywhere on the trunk or extremities. Boils are rare, and carbuncles still more exceptional. Subcutaneous hæmorrhages, generally spreading from an inflamed gland, are more common in some epidemics than in others; the effused blood may be absorbed, or an extensive slough may result, followed by severe hæmorrhage.

The nervous system.—Every degree of mental aberration may be met with in plague, from the fatuous or apathetic to one of active delirium or mania. As a rule, the patient's expression is placid, and there is a seeming apathy. The unconcerned appearance of the patient is apt to lead one to the conclusion that the attack is of a mild type, a conclusion which is but too frequently dispelled by the speedy and sudden death of the patient. The intellect may be said to be always affected to some extent, although by the patient answering ordinary questions it would seem to be unclouded. In most cases the answers are found to be wrong when their truth is inquired into; and, apart from replies as to the physical state, the patient's memory is defective. Early in the disease weakness and prostration supervene; so early, in fact, that on being first seized with illness the patient may be unable to get up or walk. Tremor, especially of the muscles of the upper extremities, develops early. Loss of co-ordination is witnessed in the staggering gait of the patient and in the inability to button or unbutton the clothing. Deafness would appear to be fairly common, but in many—in fact, in most—cases deafness is apparent only, and its semblance is to be ascribed to the patient's apathetic state and clouded intellect, rendering him indifferent to, or incapable of taking heed of, interrogations. A furious delirium is by no means uncommon from the first; the patient may rush to the window or to the verandah with seemingly suicidal intentions, and may struggle violently with anyone interfering with his progress. When left alone, however, or gently restrained, it is usually seen that his movements are purposeless. Not infrequently patients run out of doors, and may be found wandering about aimlessly; or they may even take passage by train without any coherence or sense in their intentions or movements. Terrifying dreams, picking at the bed clothes, busy delirium, muscular twitchings, and convulsive seizures have all been met with in plague. A

comatose state from which the patient can only be roused with difficulty, if at all, generally indicates imminent death.

More remote nervous affections are:—Dumbness, owing to paralysis of the laryngeal muscles. Thickness of speech, due to loss of co-ordination of the lingual muscles, causing the patient's utterance, even in the early part of the illness, to betoken intoxication by alcohol, is a diagnostic sign of some value. An impaired sense of touch, or, on the other hand, hyperæsthesia, may prevail. Various irregular forms of motor paralysis, local or general, may appear during convalescence. The patient may become permanently insane. Perhaps the most distressing symptom is sleeplessness, and one of the chief aims in treatment is to produce sleep. A number of drugs have been tried, but nothing short of a hypodermic of morphia seems to be effectual.

The lymphatic system.—The formation of buboes is the principal clinical diagnostic evidence we possess that the patient is suffering from plague. Three-fourths of plague patients suffer from buboes. In some epidemics the number of patients showing buboes may amount to from 60 to 70 per cent. only, but in others 90 per cent. may be attacked by glandular swellings. Some contend—and there is pathological evidence for the contention—that some of the glands of the body are always swollen. The fact that none of the more superficial groups of glands shows enlargement does not refute the argument, for it may be the prævertebral or mesenteric glands that are affected, and the knowledge that they are so affected may become apparent only at *post-mortem* examinations. A bubo may be apparent in the groin, in the armpit, or in the neck from the very commencement of the illness; or a mere tenderness over a particular gland may be all that can be found, its presence being only elicited by careful examination of these regions. When buboes are present, before the patient becomes indifferent to suffering, they cause pain of a sharp lancinating character. In the majority of cases the buboes appear during the first thirty-six hours, but it may be the third day or even later before their presence is evident. Of patients suffering from buboes, 50 per cent. are affected in the groin (femoral), 30 per cent. in the axilla, and 15 per cent. in the neck; occasionally the popliteal and elbow glands are swollen. Unilateral adenitis is the rule, but, although

there are many exceptions, simultaneous enlargement of glands in different parts of the body is not a common occurrence. The size of the gland varies, but its actual dimensions are usually obscured by œdema due to perivascular effusion, or by hæmorrhage, or by sero-sanguinolent extravasation, extending for a considerable distance around. The whole swelling may appear suddenly of the size of a hen's egg, or it may resemble a thick bun in outline and dimensions. A much more moderate swelling, however, is not unusual, the glands attaining the size of a bean or walnut only. In searching for enlarged glands in plague, attention should first be directed to the vertical set of inguinal glands, *i.e.* the glands just below Poupart's ligament. In this region it is the glands some two or three inches below the groin fold and deeply placed beneath the fascia lata that are most frequently first enlarged; the superficial glands in Scarpa's triangle being generally secondary to the swelling of the deep set. Whilst examining the groin, deep pressure should also be made in the iliac fossæ, for it is not uncommon to find the primary mass of swollen glands there. As a rule, one gland of a group is markedly affected, the others enlarging only to a small extent. As adenitis proceeds the tissues around the glands become matted together by fluid exudation, which may be at first clear, but speedily becomes sero-sanguinolent. Œdema spreads to the thigh, the gluteal region, and the lower part of the abdominal wall. Hæmorrhage may occur in this wide area, the skin becoming rapidly discoloured. The tissues over the gland feel elastic and tense, but in no long time the skin reddens, then sloughs, and a large cavity is left which discharges pus freely. When the axillary group of glands is affected, the inflammatory effusion may extend to the sternum in front and to the shoulder-blade behind, and as far as the loin below. In the neck it is usually the glands at the angle of the jaw that are first attacked; but, on the other hand, it may be the deep-seated glands beneath the sterno-mastoid, just above the middle of the neck, that enlarge. The swelling in this region may extend around or press upon the larynx or trachea, causing some dyspnœa.

The pain attending the adenitis may be excruciating, but, as the patient's mental state becomes affected, evidence of the gland being painful can only be elicited by pressure over it. On the

other hand, the fact that any inconvenience is felt by the patient can only be judged by the attitude assumed. When the groin glands are swollen, the patient usually lies on the back or on the side with the limb of the affected side flexed and well drawn up, no doubt in order to relieve the tension of the inflamed part; when the axillary glands are affected, the patient usually lies with the arm well away from the body, and either maintains the dorsal position or he may lie with the trunk slightly inclined towards the affected side.

The glands in plague do not, however, always suppurate. Suppuration seldom takes place before the seventh or eighth day, and the most fatal period of the disease is the fifth day. But the glands may resolve even in what seem the most unpromising cases, and may be felt as hard, indurated nodules long after the active symptoms of the disease have subsided.

The plague bacillus does not by itself cause suppuration; when it occurs it is due to the presence of other micro-organisms. The bacillus can, however, cause necrosis of tissues.

Pregnant women, as a rule, abort during the first or second day of the illness, and usually both mother and child die. Cases of a mother recovering whilst pregnant and giving birth to a healthy child, and of a mother giving birth to a healthy child and dying immediately after, are, however, recorded.

CONVALESCENCE.

Not until two or three months after the acute symptoms have subsided is the patient's strength sufficiently restored to allow him to follow his usual vocations. But the period may be prolonged by fresh inflammation of glands, by the formation of abscesses or carbuncles, and by renal or pneumonic complications.

It is the exception for a person who has once had plague to contract it again during a recurrence of the epidemic.

Sequelæ of plague.—Several of the after-effects of an attack of plague have been already indicated. Of these, deafness in one or both ears; loss of the power of speech, due either to loss of memory or to laryngeal paralysis; loss of co-ordination of the muscles of the extremities, of the tongue, of the face, or of the eyes, have all been observed. In a few cases anæsthesia persists, and in still fewer the sight becomes affected by intra-ocular

changes, probably located in the choroid. The ulcers left by sloughs or by suppurating glands take a long time, frequently several months, to heal. The general health remains impaired for an indefinite time, and mental work or physical exertion may be impossible for six months or more, even in those who make a fairly rapid recovery.

PATHOLOGICAL ANATOMY.

A body dead from plague seldom shows any marked emaciation, nor is there any special peculiarity in the rigor mortis when the patient succumbs to the bubonic type of the disease. An inspection of the body reveals the site of the buboes, and the limb of the affected side is frequently found swollen and œdematous. Petechiæ are usually confined to the region of the limb on which the bubo exists; but occasionally petechiæ may occur elsewhere. Boils, abscesses, and "carbuncular swellings" are sometimes met with. An incision into a "carbuncle" shows the cutis to be thickened and the presence of a subcutaneous hæmorrhage. Bites of insects, scabs due to itch, ringworm, etc., are often apparent, more especially in persons of the poorer classes.

Examination of a bubo proves it to consist of a chain of glands of various sizes, incorporated in a mass of connective tissue matted together and infiltrated by serum, pus, or coagulated blood. The glands vary from quite minute dimensions to the size of a walnut. Intense engorgement characterises all the glands, but whilst the smaller present on section a dark colour and almost a normal consistence, the larger glands are of a light red, almost pink, colour, and more soft and diffluent to the touch. As a rule, every gland in the body is somewhat swollen, even the mesenteric, lumbar, and mediastinal glands showing evidence of congestion. Neither the general lymphatic tracts nor the thoracic duct have been found to be affected by the disease.

The respiratory system.—Engorgement of the pleuræ, subpleural hæmorrhages—both parietal and visceral—and a moderate effusion of clear or blood-stained fluid into the pleural cavities, sum up the pathological changes occasionally met with on opening the chest. The lungs are œdematous, deeply congested, and occasionally show minute hæmorrhages into their tissues; in the bronchi a frothy mucus, frequently tinged with

blood, is seen, and their mucous lining is sometimes swollen, red or dusky red in appearance. The laryngeal and tracheal mucous surfaces may be somewhat engorged. Wilm, in one autopsy, found an abscess in the left lung.

The circulatory system.—Beneath the visceral and the parietal pericardium petechiæ are fairly constant, and an effusion of some two or three ounces of fluid, clear or blood-stained, into the pericardial cavity occasionally occurs. The right side of the heart may show dilatation and blood-clots, and the heart muscle, if at all altered, becomes cloudy, soft, and friable. The large veins near the heart are engorged with blood, and petechiæ and small hæmorrhages occur beneath their subendothelial coat. Veins, traversing a mass of infiltrated tissues containing buboes and extravasated blood, show the hæmorrhages in their walls to be continuous with the perivascular coagula.

The peritoneum and abdominal viscera.—Subperitoneal hæmorrhages are common. They may occur beneath the parietal lining of the abdominal wall or the diaphragm, or upon almost any one of the viscera. Retro-peritoneal extravasation of blood, when associated with swollen lumbar glands, is at times extensive. In the omentum and mesentery extravasations of blood are not uncommon. The stomach, the large and small intestines, present on their mucous surfaces petechiæ, or sometimes large hæmorrhages; the whole membrane is engorged; and the solitary glands and Peyer's patches are usually more prominent and defined than normal. Peyer's patches are sometimes the seat of hæmorrhages, and are not infrequently ulcerated. The *liver* is increased in size and full of blood. Its colour varies, being at times pale and in other cases brownish red. The consistence may be unchanged, but in cases of some duration the parenchyma may be softened. The gall bladder is usually found full of bile, and its walls may be œdematous or show hæmorrhages into its substance.

The *spleen* is always enlarged, attaining as a rule three or four times its normal bulk; its consistence varies; hyperæmia is usual, and the organ may assume a brick-red or a purplish tint. The capsule is normal; but beneath it, and extending some way into the splenic pulp, extravasated blood is frequently seen.

The *pancreas* may be normal or hyperæmic.

The *kidneys* are enlarged, congested, and, according to the

amount of distension, the tissue appears pale or purple on section. The capsule peels off readily, the stellate veins are pronounced, and small hæmorrhages are frequently found on the surface beneath the capsule. A thickened cortex and a cloudy swelling of the parenchyma of the renal tissue is almost invariably present. It is in the peri-renal tissues that the most extensive hæmorrhages occur in cases of plague; the blood may not only extend upwards towards the diaphragm, but may reach as far as the iliac fossa and the cavity of the pelvis. The blood would seem condensed by pressure, assuming a thick, tarry-like consistence and a blackish colour. Petechial hæmorrhages and congestion affect the renal pelvis and the ureter, and clots of blood are met with in their lumen.

The bladder may be full of urine, which is occasionally blood stained, and the mucous lining shows petechiæ at times. The bladder may, however, be contracted and the wall and contents normal.

The uterus and Fallopian tubes not infrequently present points of hæmorrhage in their mucous membranes.

The nervous system.—Congestion of the meninges, engorgement of the sinuses, œdema and vascular puncta in the cerebral substance are constant, and, with an occasional ecchymosis in the pia mater, sum up the pathological changes within the brain cavity. The substance of the cerebral tissue, of the spinal cord, and of the nerve trunks presents a normal appearance.

In the genital organs, the suprarenal bodies, the thyroid body, and the salivary glands no changes are recorded, except simple hyperæmia or venous engorgement.

The post-mortem appearances in septicæmic plague.—With the exception of the condition of the glands, there are but few points of divergence between the *post-mortem* appearances met with in bubonic and septicæmic plague. The glands, however, in septicæmic plague never develop buboes; but practically every gland in the body is enlarged somewhat, and on section presents a pink colour and a firm consistence. It would appear, however, that there is always to be found a gland of a group, or a whole group of glands, which attain a larger size and present more evidence of adenitis than the others; the tissue is softer, and softening areas are to be recognised. Perivascular effusion and hæmorrhages are, however, not met with.

The bodies of persons who have died of *pneumonic* plague show many of the changes described under the bubonic type, but the glands are, as a rule, normal in appearance, and the pathological changes are confined to the lungs. The *post-mortem* appearances in the lungs are: Œdema, with general engorgement; pneumonic patches in the lungs, irregularly distributed and varying in size from minute points to the dimensions of a hen's egg, or they may be as large as the fist. The patches are airless, pink, reddish grey, or claret coloured, and surrounded by a ring of crepitant, engorged lung tissue. The bronchial lining is reddened, and occupied by a frothy fluid, occasionally blood stained. Subpleural petechial hæmorrhages are frequent. The bronchial glands are occasionally swollen and soft, but, usually, beyond a slight engorgement no further change is apparent.

Several instances of a combination of pneumonic and septicæmic plague are recorded by Childe in which the lung changes and glandular enlargement were combined.

Duration of the disease.—Plague usually proves fatal on the fifth or sixth day, but cases have succumbed in twenty-four hours. It is but seldom these rapidly fatal cases are brought to hospital, and in private practice the patient is frequently moribund before the doctor arrives. Until the tenth or twelfth day has passed, however, death is probable; but after that period recovery may be expected. Although the patient may be possibly out of danger, the illness may continue more or less acute for a month or more. Wounds left by suppurating buboes heal very slowly, and convalescence may be prolonged indefinitely.

Diagnosis.—The plague appearing in a locality where contamination is unlooked for is a disease difficult of recognition. In such places as Oporto and Glasgow, in both of which plague developed without warning, the recognition of initial cases is not to be expected. Two or three persons may die of pneumonia running a rapid course within a few days of each other, yet plague need not be "dragged into" the argument to account for the calamity. A woman in the pregnant state may abort and die, a child may be suddenly convulsed, glandular fever may occur amongst children, a patient may develop abdominal symptoms of a typhoid or typhus type, without plague occurring to one's mind as the cause. It is only when a number of

sudden deaths, arising from some undetermined cause, occur that alarm is raised; and at the present day, seeing that plague is pandemic, the idea that the plague is the cause should suggest itself to everyone. When plague exists in a locality the diagnosis of a typical case is easy. The sudden incidence of the disease, the headache, vomiting, hot dry skin, rise in temperature, giddiness, congested conjunctivæ, thickness of speech, intoxicated appearance, and the extreme prostration, all point to infection by plague. Assistance in coming to a conclusion is afforded later by the appearance of the tongue, the glandular enlargements, hæmorrhages, mental aberration, sleeplessness, and the course of the temperature. The pneumonic type of the disease is still more difficult to diagnose, if plague is not present to one's mind as a cause. Assistance in suspecting plague as a cause is afforded by a study of the rapid onset of the lung lesion without any previous bronchial symptoms, by the sudden attack of prostration, fever, and general symptoms, and inspection of the sputum, when it will be found watery and profuse, and tinged by or mixed with blood. It is only, however, by microscopical examination of the sputum that the presence of the disease can be actually diagnosed.

In tropical countries the medical practitioner has to eliminate malarial fever, filarial fever, and relapsing fever from the list of possibilities in coming to a conclusion. The writer once sent a patient suffering from filarial fever to the plague hospital. The man, a Parsee, was dwelling in a house in which a case of plague had occurred. He had high fever, severe lumbar pain, vomiting, restlessness, a full bounding pulse, and a mass of enlarged and tender glands in the left groin. Yet he had not plague, for he passed within a few hours after being sent to hospital chylous urine, and the filaria nocturna was found in his blood.

The diagnosis of plague from the signs and symptoms can be safely made in the majority of cases when once the cause is suspected; but in many cases—in fact, in every case—the diagnosis can only be positively made when the bacillus pestis is proved to exist in the fluid drawn off from a gland or periglandular swelling, in the sputum, fæces, urine, or the blood.

Prognosis and mortality.—In the Hong Kong epidemic of 1894 the death rate in the Chinese hospital amounted to over

95 per cent. of those attacked by plague—a truly appalling figure. In subsequent epidemics, and in cases (Chinese) treated in European hospitals, the mortality was some 10 per cent. less. In India the death rate amongst natives from plague has amounted to between 60 and 70 per cent. Europeans recover with much more frequency than do natives. In India the proportion of deaths to cases among Europeans varies between 30 and 40 per cent.; and the same held good in Sydney, where of 303 Europeans attacked only 103 died. This mortality is not taking into account any of the prophylactic or curative treatments by inoculation.

In regard to individual cases, prognosis is well-nigh impossible. In many apparently hopeless cases recoveries result, and in many seemingly mild cases the patients die. Unfavourable signs and symptoms are sleeplessness, delirium, coma, persistent vomiting and hiccough, renal and intestinal hæmorrhage, early diarrhœa, multiple buboes, and extensive hæmorrhages or petechiæ. The septicæmic and pneumonic forms of the disease are much more fatal than the bubonic type. Cervical buboes are more to be dreaded than either inguinal or axillary. When the patient survives the first febrile stage, or is fairly well on the fifth or sixth day, a hope of recovery may be entertained. When the tenth day is reached, and the bubo has suppurated, or the glandular swellings have disappeared and the intellect is clear, the chances of the patient's recovery are fair. Should fever reappear after the tenth day, as it very occasionally does, pyæmia is probably the cause, and a fatal issue is probable. The suppuration of the bubo is not in itself a sign of certainty of recovery; it only indicates, or occurs synchronously with, the end of the first febrile stage.

Prophylaxis and public sanitation.—When plague is first reported in a city the impulse of every citizen seems to be to repudiate the idea and to maintain that the doctors have made a mistake in diagnosis. The name of the medical man who first discovered plague to be in their midst is not mentioned with general respect, and the bacteriologist and all his ways are looked at askance. Then an alarm occurs, and the medical officer of health and the sanitary department are called upon to exert themselves; they must "stamp out" the disease at once, because the commercial interests of the place will suffer.

For the most part the sanitary department has been viewed by the citizens as one of the useless fads of a science-ridden age, but now they see a practical use for its existence inasmuch as it will "stamp out" the disease. This phrase, "stamping out" a disease, is an unfortunate one; it implies in some indefinite way the arrest of a disease by legislation and strict sanitary measures, and every citizen calls aloud that it be carried out. When, however, the regulations and restrictions for "stamping out" are imposed, remonstrances are the rule and virulent public protests are to be heard. The disease is maintained to be "mild," and that much too much fuss has been made of the affair, and that were the press and the doctors to keep quiet there would be no trouble. It may seem unnecessary to mention these idiosyncrasies and public clamour, but they are as much part and parcel of a plague outbreak as a bubo in the groin or a bacillus in the blood. The "stamping out" process is a misnomer. No doubt, when applied to foot-and-mouth disease amongst cattle or to "fever" amongst pigs, the term has some signification. Cattle or pigs that are either "suspects" or "contacts" may be slaughtered, but the use of the word is inapplicable in the case of human beings. Plague or any other epidemic disease may be arrested, limited, or narrowed in its ravages, but that it can be suddenly "stamped out" or suppressed by any known act of legislative sanitation is impossible.

Plague warnings.—When plague exists in any town or locality the medical men in practice should keep a careful watch on the "behaviour" of their patients' illnesses. It is, perhaps, not going too far to say that when any town in the *nation* is infected with plague it behoves medical men in every town and hospital of that nation, and all sanitary authorities, to bear the fact in mind that plague may stealthily creep into their midst, and that patients may die of the disease without the cause of the fatal issue being diagnosed or even suspected. A pneumonia which carries off two or three persons in a house, typhoid or typhus fever to which a query is attachable, convulsions in children of undetermined origin and with a rapidly fatal issue, glandular fever in children, and many other conditions and symptoms, ought to suggest to the doctor's mind, if plague is in the country, that this untoward infection may play a part in the disease roll. In seaport towns with a large foreign

trade this is evidently necessary, but even in inland towns the danger is by no means so remote as many would seem to think. Railway communication is more dangerous from an intra-national point of view than is carriage by sea. The greatest danger to Britain, owing to Glasgow being infected, is by way of express trains, and to any of our remote inland villages the disease may be carried by passengers coming from an infected source.

A plague expert.—The appointment of a medical man who is clinically familiar with plague is one of the first requisite steps in dealing with a threatened outbreak of plague. He ought to be available for consultation in all cases to which any doubt in diagnosis is attached. He no doubt will be sometimes called, during the incipient or threatening stage of the disease, unnecessarily, but from the preventive point of view it may be well that this should be so. Without bacteriological confirmation a diagnosis by clinical evidence is of only partial avail. The medical expert chosen for plague work should be capable of himself testing the clinical suggestions by microscopic appearances at once, and should be capable, or have associated with him in his work a bacteriologist of repute who is capable, of applying laboratory experiments for further proof of the presence of the plague bacillus.

A sanitary executive staff.—The medical officer of health must have ample powers conferred upon him to deal with the disease or with its prevention. Given men, money and authority, the medical officer could, as has occurred in several known instances, check plague from spreading. The whole question is, *when* the measures are taken in hand. When the disease has got hold of a community it is too late. Everything must be in readiness beforehand to deal with an outbreak, and to this end such questions as diagnosis, segregation, isolation, quarantine, cleansing of insanitary localities, transportation of sick, plague hospitals, nursing, inoculation, disposal of the dead, disinfection of houses must have all been arranged beforehand. All this can be done if only sufficient authority is bestowed upon the plague sanitary staff. The question of diagnosis has been already dealt with.

Quarantine.—The length of the period of quarantine considered necessary for plague is determined by the maximum duration of the period of incubation. This is fixed at ten

days, so that eleven days' quarantine is usually considered sufficient. That is to say, the passengers on a ship on board which no case of plague has occurred for ten days should be free to proceed to their destinations. This period, which at first sight would appear sufficient, may not be so. If plague had occurred amongst the crew or passengers of a ship during a voyage, and all the plague patients died and were buried at sea, then, after eleven days from the last death, passengers may be justly considered as non-infective, or as unlikely to develop the disease; but when a case or cases of plague have recovered, eleven days is insufficient in their case, for it is known that the excretions, especially the fæces, may be infected with plague bacilli for a month.

In regard to the infection of the ship itself, the matter again is not so simple, for the rats on board a ship may be infected by plague, even when no cases of plague have occurred, and after the disease has completely disappeared from amongst the passengers and crew.

Quarantine by land is open to the same objections, and the imposition of quarantine, be it as strict as it may by either land or sea, is not in itself a guarantee that it will check the spread of the disease.

Quarantine has been practically given up by the British, other means having taken its place. This is not so, however, in most other countries; quarantine is still insisted upon, with all its absurd restrictions, inconveniences, incongruities, and errors.

Cordons around cities, if capable of being strictly enforced, have something to recommend them. It may be a double or a single cordon; the latter is, perhaps, the more commendable. But the cordon must be strict. It should be composed of soldiers, and if we are to follow the thoroughness with which a Russian cordon is carried out, the soldiers must be armed with power to shoot any living thing, man or beast, that attempts to break through from the infected area. Nothing but "buckshot" will prevent some persons breaking the cordon regulations, but it is a system of enforcement which scarcely recommends itself to the less thorough believers in the efficacy of cordons in general. As plague can be carried by animals and by insects, the cordon, even when armed, is likely to prove a failure.

Segregation, *isolation*, and *disinfection* are the means adopted by sanitary authorities in every part of the world when plague breaks out in a community. The moment a case of plague occurs in any dwelling the patient should be removed from the house to a specially constructed hospital. It is advisable that this hospital should be built of "temporary" materials merely, so that it can be burnt when the epidemic is over or when it has become foul from long use. The hospital should be just outside the town in some isolated piece of ground, but if the city is large, it is unwise to have the hospital too far removed from the infected area, otherwise patients may suffer ill effects by having to be conveyed a long distance. Persons who have been in actual contact with the patient, and not only these but all persons in the dwelling and also in the houses immediately adjacent, should be removed, and the houses disinfected. The "contacts," as the exposed persons are termed, are to be quartered in "camps" specially laid out for their accommodation. Here they are medically examined once or twice a day, and detained for at least seven days. Should any of the contacts in the isolation camp develop plague, the building or tent must be evacuated, disinfected, or destroyed, according to the material of which it is built. A further observation period is then necessary before those remaining can be released. Should, however, the contacts consent to vaccination by Haffkine's prophylactic, the example set by the Indian Government may be wisely and safely followed—namely, granting inoculation certificates entitling the holder to exemption from plague rules for a period of six months.

SEA-INSPECTION.

(1) *Outward inspection of ship's crew and passengers.*—When a seaport town is the seat of an epidemic of plague, it is necessary to conduct a careful inspection of the crews and passengers of ships before they proceed to sea, so as to prevent plague being carried to the port of destination or to the ports the ships may touch at on their voyage. The Venice Sanitary Convention ruled that the inspection should be carried out on shore before embarkation. In large seaports this is frequently a work of great magnitude, and it implies an ample staff of medical men if the investigation is to be thorough and exact.

Every individual of the crew and passengers must be examined. A cursory glance at the tongue and a few general questions as to the general state of health will not suffice. The temperature of each person must be taken, and if the temperature is above the normal a further inspection for buboes must be insisted upon. When women passengers are being dealt with, it is advisable that a lady doctor be included in the medical staff. Those found suffering from plague are to be sent to the plague hospital. In cases in which doubt exists, the suspects should be detained in a camp or otherwise segregated or observed until the diagnosis is decided upon.

(2) *Inward inspection of ship's crew and passengers.*—When a healthy seaport is in direct communication by sea with an infected port or locality, all the passengers and the crew, and the ship itself, should be subjected to inspection by a staff of medical men (and women). The crew and passengers may be examined on board ship or in a carefully guarded area on shore. Temperatures must be taken, and buboes sought for if there is any sign of fever or illness. Those suffering from plague are to be sent to hospital; the suspects are to be carefully guarded in a special camp or house, and the healthy persons, if they can give a reliable address, allowed to proceed, each bearing a pass, a copy of which is sent to the medical officer of the district to which they are proceeding. If a reliable address is not obtainable, the contacts must be detained at the port until eleven days have passed, *i.e.* until the maximum period of incubation is over. The ship must be then made to leave the dock and proceed some little distance from the shore, where it is cleaned, disinfected, and the rats caught and destroyed.

In every case the contacts should be asked to submit to inoculation by Haffkine's prophylactic before proceeding on shore, and, if they do so, a free pass should be given them forthwith. The healthy persons are to be passed on board ship under a police escort, so that there be no possibility of suspects or sick persons subsequently mixing with the healthy. The ship itself must also be inspected, foul quarters must be cleansed, soiled clothing or rags must be disinfected or destroyed, and if the ship has been lying some time in the harbour the cargo must be inspected and dead rats sought for. If the rats on board ship are found to be suffering from plague,

or the grain or other cargo is infected, the ship should be condemned, and the voyage disallowed until such time as, by disinfection and cleansing, it is found safe.

Ships arriving at a plague-free port with cases of plague on board should not be allowed to land passengers or goods until satisfactory accommodation for the sick and the healthy is available on shore. If there is no adequate means for dealing with the disease at one port, the vessel ought to be sent to another port where accommodation is provided; or, better still, some specially selected landing-place, away from a town, should be chosen, to which plague-stricken ships should be sent. At the landing-place a hospital for the sick, an isolation camp for the "contacts," and a supply of Haffkine's prophylactic should be at hand. The ship and cargo must also be dealt with. Metal goods may be landed, if they have been previously wiped with a disinfectant solution or left exposed to wind or weather for say a week before being taken from the shore. Rat-infested grain should be destroyed. It is better to throw it overboard than to take it ashore and burn it. The rats in the grain will be landed with it if the grain is taken ashore, and their escape may mean infection of the rats in the neighbourhood. Wood from a plague-infected ship should be allowed to float in the sea for a week or two before being landed. A cargo of rat-infested sugar ought to be thrown overboard. Cotton, silks, and wool may be landed in specially isolated sheds; every box or bale should be previously carefully examined for rats, and any goods in which the trace of a rat can be found should be immediately destroyed. The sound cotton, silk, or woollen goods should be opened out, exposed to free ventilation or to the sun, and frequently turned over during at least ten days. When the ship is emptied she must be thoroughly disinfected, the bilge water pumped out, and the rats exterminated before being allowed to take a fresh crew.

RAILWAY INSPECTION.

Outward and inward inspections must be conducted for railway traffic on much the same lines as those given for sea inspections. At certain stations on the various lines converging upon a city, and at some few miles outside, the inspections ought to take place. Here a staff of medical inspectors are required, also a plague hospital and a segregation

or detention camp or house for suspects and contacts. The railway ticket will generally serve as a guide to indicate whether the passenger has come from a plague-infected area or no ; but the ticket is not altogether a safe guide, as there may be attempts at deception by taking out a fresh ticket at intermediate stations. Infected clothing must be disinfected by steam where that process is possible, or by boiling, or it may be burnt when of little value.

The destruction of vermin.—The rat is so intimately connected with plague in man that its destruction as a prophylactic measure is a necessity. It is not only necessary to destroy the plague-infected rats, but when human beings are the primary sufferers from plague, it is quite as necessary to destroy the rats in the area of infection, as they may become infected from human beings, and thereafter spread the disease. It may be asserted that an outbreak of plague will become widely spread through a town or city, or remain limited in its extent, in direct proportion as the rats are or are not infected.

When the destruction of rats is decided upon, the methods by which they are to be got rid of require consideration. If fumigation of their runs or of the public drains is attempted, the rats will speedily decamp and seek other homes ; and if they are infected they will cause a widened area of infection. If some of the rats are killed by poison the others may take fright and scatter, carrying infection far and wide. Trapping the rats seems the only proper method, and here again a danger arises to those who handle them immediately after death, as the vermin from their coats may infect whoever picks them up. To avoid this contingency the dead rats ought to be picked up by tongs or some other contrivance. If the ratcatcher is paid by the number of rats he kills, it is necessary that the animals be kept for counting. Burning their bodies is therefore out of the question, and a pail with a strong disinfectant should be at hand to plunge the rats into. When rats on a ship are to be destroyed it is necessary to take the ship away from the wharf or shore, otherwise when fumigation or other means of destruction is employed the rats leaving the ship will gain the shore.

The destruction of fleas, bugs, etc., is brought about during the disinfection of beds and their belongings.

Disinfection and disinfectants.—The action of disinfectants upon the plague bacillus varies considerably.

(1) Drying and direct exposure to sunlight kills the microbe readily. When a smear of living cultures is spread on a piece of glass or porcelain and exposed to sunlight for one hour the bacilli are killed; if the layer is thicker, their death may be delayed for two or three hours, but never more than four. Laboratory cultures on agar-agar are killed after a day's exposure to bright sunlight.

(2) Heating plague cultures, or clothing, etc., smeared with excreta of plague patients, will destroy the vitality of the microbe when a temperature of 65° C. is reached. In addition to these agencies, therefore, it would seem that disinfectants were not necessary; but the sun's rays and the means of applying heat are not always available or applicable, therefore artificial disinfectants are necessary.

(3) Ventilation as a means of destroying the plague bacillus is merely the introduction of light and air, and is thereby, from what we know of the life history of the microbe, an efficient means of disinfection.

(4) *Disinfectants.*—The plague microbe is intolerant of the action of acids, but offers considerable resistance to alkalies. Even the acid formed during milk going sour has the power of destroying the microbe, and weak organic acids act slowly in the same way. The inorganic acids are, however, much more potent destroyers of the plague bacillus. Of these, sulphuric acid, in the strength of 1 in 250 (Hankin), is a convenient and cheap form of disinfection; and even at the strength of 1–1,429 sulphuric acid is a reliable antisepticide, killing the microbe in five minutes. To carbolic acid the plague bacillus is somewhat resistant; phenyle, lysol, and izal are potent disinfectants, but naphthaline is powerless. Of oxidising agents, permanganate of potash, even in the strength of 1 in 50,000 of water, is efficacious, destroying the plague bacillus in five minutes; chloride of lime is a reliable disinfectant. Corrosive sublimate, 1 in 5,000, is the most reliable of all disinfectants, killing the bacillus in five minutes. At the strength of 1 in 1,000, corrosive sublimate destroys plague cultures instantaneously. It is necessary to employ an acid solution of the sublimate, as a neutral solution is not destructive to the microbes.

In regard to the disinfection of houses, considerable doubt has been thrown upon the efficacy of fumigating premises by sulphur and applying whitewash.

The question of *disinfection of the soil*, as in the case of mud floors in houses, turns upon the presence or absence of the bacillus of plague in the soil. Yersin enunciated the belief that the plague bacillus could live in the soil, but no subsequent observer has confirmed his statement. It is customary to dig up the mud floors of infected dwellings to a depth of 2 in., and to mix the loosened earth with quicklime or to burn it.

The steam disinfector is a necessity at every plague hospital, and where it is not available the clothing, etc., should be boiled for at least fifteen minutes.

Exposure to saturated steam for fifteen minutes, at a pressure of 10 lb. to the square inch, gives a temperature of 230° F. By this heat the most resistant microbes are destroyed.

The plan adopted in Glasgow, and the disinfectants employed in dealing with houses, clothing, etc., and which has proved so efficacious, is a model to go by, and reflects the greatest credit upon Dr. Chalmers, the medical officer of health for Glasgow, who drew it up.

(1) Within the plague-infected district special cleansing operations are conducted in the following detail :—
   (*a*) Ashpits are
      (1) emptied three times a week, and
      (2) washed once weekly with chloride of lime whitewash (1 lb. chloride of lime added to 12 gallons of freshly slaked lime solution of the consistency of milk).
   (*b*) Back courts in dirty condition are hosed every night with chloride of lime solution, 1 in 100 (1 lb. chloride of lime to 10 gallons water). For this solution chloros was afterwards substituted, owing to a mechanical difficulty in the distribution of the mixture having arisen.

(2) A special inspection of the district is held for the detection of dirty houses, closes, etc., and for overcrowding of houses.

(3) Infected tenements, and, if necessary, those where "contacts" reside, are dealt with as in (8).

(4) Medical inspection of the district is carried out; the occupants of the infected tenements, and all "contacts," are offered inoculation with Yersin's serum, and others in the neighbourhood with Haffkine's prophylactic. Suspected cases are being seen with the medical attendants.

(5) Plague has been added to the Infectious Diseases (Notification) Act, 1889.

(6) Handbills are distributed offering the services of the medical staff at any time, on application to the nearest police office.

(7) Efforts are made, through co-operation with the surgeons of the shipping companies, to arrange for medical inspection of Lascars and other crews of ships from infected countries.

(8) The detailed arrangements for the removal of cases and disinfection of infected tenements are under the personal supervision of one of the medical staff, and may be detailed as follows :—

(*a*) Removal of patient to hospital.

(*b*) Removal of "contacts" to reception house, and kept under medical observation for 14 days.

(*c*) Fumigation of infected house by liquefied sulphur dioxide from 12 to 24 hours, the disinfectant being used in proportion to the cubic space dealt with.

(*d*) After the fumigation the house is entered ; all articles of clothing, etc., to be removed are first of all thoroughly wetted with 2 per cent. solution of formalin (1 gallon 40 per cent. solution formaldehyde to 50 gallons water), then wrapped up in sheets soaked in the same fluid and removed to the sanitary wash-house. There all articles which cannot be boiled or steamed, or treated with formaldehyde, are burned.

(*e*) The walls, ceiling, flooring, woodwork, etc., and furniture of the infected house are also sprayed with the formalin solution (1 gallon to 50 gallons water).

(*f*) All houses in the infected tenement are cleansed by the department ; the lobbies, stairs, and closes being dealt with by formaldehyde or chloride of lime solution.

(*g*) Courts of such tenements are watered with chloride of lime solution.

(*h*) Ash-pits have contents watered with same, and then removed and burned.

(9) Rat-catchers are at work in the district.

Haffkine's prophylactic fluid.—Under the heading of Cultures, at page 12, a description was given of Haffkine's method of demonstrating an absolutely conclusive proof that the micro-organism he submitted to examination was the bacillus pestis. In the flasks containing the neutral peptonised bouillon in which a few drops of an oleaginous material floated, Haffkine obtained a characteristic growth when plague cultures were sown on its surface. The colonies of bacilli hung down in a stalactite-like shape into the medium. It was from these cultures that Haffkine prepared his prophylactic fluid.

When the bouillon in the flask is filled with a rich jungle of stalactites the flask is shaken so that the growths fall from the under surface of the drops of oil or ghi, and subside to the bottom of the liquid. Growths again develop on the oil-drops, are again shaken off, and fall to the bottom. This process is repeated until in the course of a month half a dozen successive crops are obtained. The microbes in this fluid are then exposed

to a temperature of 70° C., maintained for an hour, by which process they are killed. Two different substances are thus obtained—one a thick white sediment, and the other a perfectly limpid fluid. Injected subcutaneously into animals the *sediment* produces a local inflammation and a nodule at the seat of inoculation, accompanied by little fever or general constitutional effect. The *fluid* when similarly injected causes a considerable rise in temperature and a general feeling of malaise, but no noticeable local effects.

With this culture M. Haffkine inoculated animals, and, after testing the strength of the culture upon them, inoculated himself. The injection was made in the flanks with 10 cubic centimetres of a culture in which the microbes had been killed by heating to 70° C. The symptoms produced were pain at the seat of inoculation and a rise in temperature. The highest temperature reached was 102° F.; this occurred in eight and a half hours after inoculation, and the temperature fell to the normal in twenty-four hours. The pain extended for some distance around the seat of puncture, but was never severe, and noticed most on getting out of bed in the morning following the operation. The small nodule which formed at the seat of puncture was rapidly absorbed. Having proved the harmlessness of the fluid, Haffkine proceeded to treat any member of the community who wished to be inoculated, and the process has been extensively employed up to the present day. Many returns and statistics have been recorded showing the beneficial effects of Haffkine's fluid. On an extensive scale the treatment was first employed in the Bombay House of Correction at Byculla. The results of this, the first experiment, were that of 172 uninoculated persons twelve caught plague, and six died; whereas, of 147 inoculated persons, two only caught the disease, and both got well. In the town of Damaun, the treatment by Haffkine's prophylactic fluid was practised, with the result that "if the inoculated had suffered in the same proportion as the uninoculated, they should have had 188 deaths, instead of 27—a difference of 85 per cent." In many other instances where the treatment was employed even a better result is recorded, and in every place where it has been tried benefit has ensued. The conclusions arrived at by the Plague Commission in India were—

(1) "That inoculation is harmless."

(2) "That when given in the incubation stage, *i.e.* before the signs of plague are apparent, it has in many cases the power of aborting the disease."

(3) "That inoculation affords to all those inoculated a strong protection against attack by plague."

(4) "That in the few cases when inoculated people are attacked a very large proportion recover."

The length of time the person inoculated is rendered immune has not yet been ascertained, but it is almost certain that the effect lasts from four to seven months. As an epidemic in a large city generally lasts for seven months, the inoculation is at any rate effective during the period the particular epidemic is raging. Objections to Haffkine's treatment have been made in several quarters. It is objected (1) that the immunity lasts but a short time, some say one month only; (2) that the dose is indefinite; (3) that Haffkine's fluid contains the dead bodies of the bacteria; (4) that the employment of heat to kill the microbes is apt to, or actually does, destroy the delicate proteic substances to which the immunising power is due; (5) that there is great difficulty in preventing the fluid becoming contaminated. Several bacteriologists have introduced immunising fluids intended to obviate several of these defects.

Lustig and Galeotti, of Florence, introduced a plague prophylactic which consists of a nucleo-proteid in a dry state. They describe their method of preparation as follows:—

"We cultivate the plague bacilli in large glass dishes containing a stratum of common agar-agar. After some days' development we scrape off with a bone spatula the colonies which have formed, and dissolve the mass in a 1 per cent. solution of caustic potash. We then add a very dilute solution of either hydrochloric or acetic acid until a slight acid reaction is introduced, and we collect in a filter the precipitate formed. After careful washing the precipitate itself is dried *in vacuo*, and in the presence of sulphuric acid, or else immediately redissolved in a 0·5 per cent. solution of carbonate of soda. The dried substance, which has lost none of its chemical and biological properties, is easily redissolved in a solution of carbonate of soda when required. The solution of this substance may also be passed through a Chamberland filter for greater guarantee of sterility. The precipitate is composed solely of a nucleo-proteid in a state of relative purity. It possesses all the general reactions of nucleo-proteids, is soluble in alkalies, insoluble in dilute acids, gives on digestion an insoluble product and a peptone, and on dissociation by sulphuric acid gives nucleinic bases. It is extremely toxic for several animals, and is able to produce intravascular coagulation of the blood."

The quantity of the nucleo-proteid used is 3 milligrammes dissolved in a solution of carbonate of soda. After the injection the patient begins in a few hours to shiver and to feel uncomfortable: the temperature may rise, in some sixteen hours, to 101·3° F., but in twenty-four hours all symptoms pass off, except that at the seat of puncture some disturbance remains for two or three days.

The advantages claimed by Lustig and Galeotti are:

(1) That as the immunising substance is in the dry state, it is more easily preserved, distributed, and sold.

(2) That the dosage is exactly known.

(3) That no other toxic substances are introduced with the immunising substance.

TREATMENT.

At first sight it would seem as though the treatment of plague was a subject which it is useless to discuss, as it is repeatedly stated that we have no cure for plague. We have no "cure" for many, nay, most, of our diseases; yet experience has shown that although no specific treatment is known, still, with care, judicious nursing and medical supervision, ailments, such as typhoid, cholera, and zymotic diseases generally, can be, and are, conducted to a successful termination. Much, therefore, as it is desirable to know what will "cure" the disease, it is not consistent with our behaviour in other illnesses to stand by and wait until it is discovered what form of attenuated virus may be tried as a specific remedy.

Once for all let it be understood that in no disease does one get such immediate results from careful and prompt medical treatment, and as a direct outcome of watchful nursing, as in plague; and perhaps one ought to add to that, "in the case of Europeans." Natives, whether of India or China, succumb more readily to plague than Europeans. There are one or two reasons for this: (1) a native seldom comes to a doctor (a European doctor most of all) until the disease is well advanced; (2) in point of stamina the poorer natives are a long way below northern Europeans; (3) the inherited dislike of the natives for all forms of stimulants, be they medicinal or alcoholic, during illness; (4) the belief of the natives in the old adage that "to starve a fever" is correct. The difference between Europeans and natives was well illustrated during the 1894 epidemic in

Hong Kong, by the fact that out of 11 British patients, 9 recovered—a mortality of only 18·2 per cent.—whilst the Chinese died at the rate of something like 95 per cent. This favourable result, however, cannot be ascribed altogether to racial influence; it was rather due to the effect that medical treatment and good nursing had upon the course of the disease. The British patients were seen early in the disease. They could take and stand stimulants, medicinal and alcoholic, well, and the result was the satisfactory number of recoveries that took place. Even with such Asiatics as would submit to similar treatment, most markedly in the case of the Japanese doctors, were the satisfactory results of treatment during plague manifest.

The attendance of the doctor must be prompt, and his treatment must be decisive. In fact, during the first five days of illness in plague the doctor must be within a few minutes' call. To each ward of a hospital a doctor should be assigned, or, if a valuable life is at stake in a private house, medical aid must be obtainable in a few seconds. The changes are so rapid in plague, the features of the disease so fulminant, that without immediate treatment being possible, success is hopeless.

Nursing.—In a hospital ward, during the first five days of illness, practically two patients require an attendant to themselves if the utmost good possible is to be done. A nurse must never let a patient out of sight for a moment, be the patient asleep or awake. She cannot leave the ward or room, without posting a deputy, for any purpose whatever. No nurse should be on duty for more than eight hours at a time; still better is it to follow the "four" hours "watches" kept at sea.

The number of nurses required may seem outrageous, but we have in many illnesses a day and night nurse for private patients, and no more is demanded in this, the most fatal illness known. Plague comes in epidemics, and the required number of nurses may be unobtainable; but we must not lose sight of what is necessary in considering what is expedient. Shortly, it may be put that a liberal supply of doctors and nurses is essential if the lives of the plague-stricken, be they Asiatics or Europeans, are to be saved.

Enough has been said as to the rapidity of the onset, the development, and the fatality of plague to make the importance

of early treatment in the disease, and of the requisite promptness in its administration, understood. The symptoms and signs change so rapidly, and in such varying succession, that no stereotyped line of treatment can be followed. Now vomiting may supervene; or an unexpected heart failure, or a collapse, totally without warning, may carry off the patient before any help is obtainable. The much despised legend, "treat symptoms as they arise," is the maxim in plague, and if the word "promptly" were added, the summary of plague treatment is before us. The disease is caused by a bacillus, the toxic effects of which upon the blood give rise to functional derangements of possibly all organs, but most markedly of the nervous system, central and peripheral. The poison is so acute that, with the exception of the glandular inflammation, little structural change is met with in the more vital organs. The cardiac trouble which is so marked an accompaniment of the disease is evidently a functional one, and the result of derangement of the nervous supply of the heart. This has constantly to be borne in mind when the subject of drugs is dealt with.

GENERAL TREATMENT.

The essentials are free ventilation, a cool room (60° to 70° F., where such is possible), a plentiful supply of hot and cold water, ice, a sufficiency of servants, and, of course, all the appliances of a modern hospital. Deaths are so frequent and so sudden that when the hospital is large it is necessary to have men employed whose sole duty it is to remove, to disinfect, and to dispose of the dead.

Nothing should be allowed to leave the ward but to be disinfected. Crockery and glass shou be scalded. Fæces should be sprinkled with quicklime; bed and bedding, if not burnt, are to be disinfected by heat; the steam disinfector is well-nigh essential. Scrupulous cleanliness of the floor and bedsteads, obtained by washing with a disinfectant solution, are of primary importance, and all doorways should be curtained by a sheet wet with carbolic acid, Jeyes', or other reliable antiseptic.

The patient should not be allowed to get out of bed for any purpose, and the use of the bed pan and urine bottle should be

insisted upon. So many times has it occurred that the patient has tumbled over dead whilst getting up to stool, etc., that this is an imperative measure to insist upon.

MEDICAL TREATMENT.

Purgation.—When the patient is first seen, the foul state of the tongue, the foul breath, the jaundiced tinge of the conjunctivæ, and a generally bilious aspect, suggest a purge. For this purpose, calomel, in 5-grain to 10-grain doses, recommends itself. This is to be followed by a saline in some five hours' time. Against this treatment it may be argued that the drain upon the system and the lowering action of calomel are deleterious, but if given quite early in the disease and not when the pulse is flagging, it undoubtedly seems to do good. It frequently stops vomiting which is often present, it clears away the jaundiced aspect, it restores the power of taking nourishment, and it seems to diminish mental aberration and cardiac distress. If a full gall bladder justifies the exhibition of calomel, *post-mortem* evidence of that condition is not wanting. So far as is known, bacilli of plague escape from the body in greatest numbers by the bowels. In the breath (except in the pneumonic variety) or urine bacilli are but sparsely met with, but in the fæces a rich supply is found. This points to the necessity of ample disinfection as being requisite for all latrines, bed-pans, closets, etc., but it also proclaims as justifiable and rational the attempt to assist Nature in expelling the poison of plague by a free action of the bowels.

Stimulation.—From the very first onset, or certainly after twenty-four or forty-eight hours, it will be found necessary to stimulate the plague patient by food, by alcohol, or by medicine.

Food.—Unless the patient is actually delirious, there is not usually much difficulty in feeding plague patients. In fact, in comparison with allied ailments, appetite is wonderfully good. One encourages this in a general way, but the occurrence of sudden death supervening after the ingestion of a full bowl of rice, for example, and its accompaniments, in the case of Chinese patients on several occasions, leads one to the belief that a full meal is not without its danger. The heart is in such a condition that it takes but little to disconcert its rhythm, and the pressure consequent upon a full stomach is calculated to do this. Food

should be in small quantities frequently repeated and of a kind which is easily digested. Ox-tail soup, mutton broth, beef and chicken tea should be constantly at hand to suit the varying palate of the patient. Several of the prepared foods now on the market are very useful to have at hand. The various "Maggi" preparations are efficacious and handy; in the gastric irritation so prevalent in plague, Plasmon is theoretically, and will no doubt practically prove to be, a perfect food; Brand's Essence is especially to be commended; and such substances as Bovril, Liebig's Extract, etc., are convenient forms, inasmuch as they are speedily prepared.

Drink.—Thirst is at times a marked symptom, and its relief should be attended to by allowing the patient anything in reason. Ice to suck, if not kept up too long; water, or lemon and water (not lemonade) to drink, if not in such quantity as to distend the stomach, are grateful beverages; beer and stout iced, especially for Europeans, are "at once stimulant, soporific, nutritious, and thirst-quenching" (Lowson). Brandy and whisky diluted (not aërated waters) should be freely supplied. When the pulse shows signs of failing, or collapse or faintness supervenes, then, of course, alcohol is doubly beneficial, and brandy is preferable to whisky as a cardiac stimulant. Conjee water—that is, the water in which rice is boiled—is useful as a drink, and serves as nourishment. Milk with ice (sipped slowly) and ice cream (Lowson) are particularly grateful.

Delirium.—When active, the delirium of plague is best combated by cold to the head. Leiter's coil would be perhaps the readiest method provided the patient could be kept still, but an ice bag or constantly wetted cloth is efficient. These applications, combined with tepid sponging of the body at frequent intervals, seem grateful to the patient, and seem the safest and readiest method of quieting active delirium.

Hyoscine.—In many cases hyoscine administered hypodermically in doses of $\frac{1}{100}$ gr. is an efficient and safe hypnotic. It may serve to calm the nervous system and induce sleep when everything else fails. Hyoscine should be one of the first drugs in the armamentarium of a plague hospital.

Morphine.—At times nothing but morphine administered hypodermically in doses of $\frac{1}{8}$ to $\frac{1}{4}$ gr. is of any avail. *A priori*, one would not select it as a hypnotic or anodyne, but experience

has proved it to be reliable, and not so unsafe as to exclude its use. It is almost certain that when painful adenitis complicates the cerebral intoxication, morphine effects its purpose.

The safest method of administration is in combination with atropine.

Bromide of potassium.—An occasional dose of bromide of potassium during delirium is useful and without danger, but its prolonged use is not permissible.

Diarrhœa.—An intestinal flux need not be stopped, unless it continues over 24 hours, and the patient seems exhausted thereby. It is but seldom obstinate, and yields to salol in 10-grain doses, or to an enema of starch and opium, or to a suppository of morphine and cocaine, $\frac{1}{4}$ and $\frac{1}{2}$ gr. respectively, more especially when continued straining persists.

Vomiting frequently ushers in an attack of plague, and may persist throughout the illness. When the latter condition obtains, it is an unfavourable sign, as loss of strength ensues owing to rejection of food and medicines.

A mustard plaster to the epigastrium, ice to suck, and an effervescing draught of a few drops of hydrocyanic acid and liquor morphinæ, are generally sufficient to check this untoward symptom.

Pyrexia no doubt accounts for some of the delirium, the restlessness, the headache, and subsequent collapse: hyperpyrexia is exceptional. The usual chemical antipyretics, antipyrin and phenacetin, are such severe depressants that they should not, as a rule, be used; should hyperpyrexia necessitate their use, one hypodermic of antipyrin is no doubt justifiable, but only as a last resource. Frequent sponging with tepid water, ice to the head and nape of the neck, iced drinks, and a short application of the wet pack, with the administration of brandy by the mouth or by the rectum, are useful when promptly and rationally used.

Stimulants (a) externally.—Flying blisters of mustard to the limbs, abdomen, and over the heart are useful. Smelling salts and strong ammonia applied to the nostrils often succeed in restoring the pulse, rousing the patient in collapse, and not infrequently cause him to rally from what seems a moribund state (Lowson). Nor is this kind of stimulation of mere passing effect, for in several instances, when death seemed inevitable

and at hand, patients have revived and actually recovered permanently.

(*b*) *Internally* the form of drug most useful is either a general stimulant, such as ammonia, or a cardiac tonic or specific. Most practitioners who have treated many cases of plague rely upon prescriptions containing carbonate of ammonia and the tincture or decoction of cinchona, and with this mixture, now given, now withheld, should be exhibited digitalis, nux vomica, or camphor. More good is ascribable to ammonia in some form than to any other known and more specific drug.

Stimulation by *hypodermic* injection of ether is a treatment that gives grateful response, and must be used freely and frequently. The collapse from plague does not take place at that period of the disease when organic structures are played out, but it occurs early in the disease, in two or three days, and is therefore more of a functional and toxic than of an organic nature; consequently, the use of stimulants, in whatever form, is more likely to be attended by remedial results and not by a mere temporary flickering response.

Digitalis in infusion, tincture, or in leaf, the latter perhaps the best, seems the one drug called for when the pulse becomes dicrotic and the nervous stimulation of the heart flags. In practice, however, it is unsatisfactory, and seldom can any good results be traced to its administration. No doubt the slowness of its action is against it; but, what is still more positive, clinical evidence is against its being considered a reliable drug in an acute illness like plague.

Strophanthus is in the same category with digitalis.

Camphor in its double action as a direct cardiac stimulant and a stomachic carminative is useful as an alternative drug. Undoubtedly the best form is in pill, in doses of gr. ij. Camphor may advantageously be used hypodermically dissolved in sterilised oil. *Caffeine* is also worthy of a trial.

Musk, in the few cases in which it was tried by the writer, seems to justify its administration, and it is a form of circulatory stimulant which one welcomes as an addition to one's resources. The musk, as fresh as can be obtained, may be given in 5-grain doses every six hours.

Strychnine, administered by the mouth or hypodermically, is of the greatest use. Granted that a functional abeyance of

the nervous influence, more especially of the heart, is the essence of the toxic effect of the plague bacillus, strychnine ought to be a drug of importance in the treatment. This expectation was borne out in practice, and Dr. Lowson in his report, and all who have reported on the treatment of plague, regard strychnine as a most reliable agent in the form of stimulation required in plague. Liquor strychninæ in 5 to 10-minim doses, given every four hours, is the most convenient form; but when vomiting is present, a hypodermic solution of gr. $\frac{1}{48}$ of the sulphate of strychnine in 10 minims of distilled water is advisable.

Other drugs may be mentioned, but, though useful as a change and a stand-bye on occasions, they do not justify more than a passing notice. Among the more important are *quinine* when chronic malaria complicates the disease; *aconite* in the early stages when high fever and a full pulse are present. *Chloride of ammonium* as an alterative is occasionally useful.

The inhalation of oxygen (Lowson) is not to be neglected, and the gas ought to be always at hand and ready for immediate use.

The result of experience gained by local radical or tentative *treatment of the glands* does not lead one to expect much benefit therefrom. That abscesses should be opened when they point or when fluctuation is perceptible is, of course, natural; but that local remedial steps should be early taken for the purpose of affecting the course of the disease by acting on the gland is, from what we know of the pathology of the disease, scarcely rational. Injection of a swollen gland when it is accessible, as in the groin, with such substances as carbolic acid, perchloride of mercury, or a solution of the perchloride of mercury and iodide of potassium, has, perhaps, a theoretical basis of justification, but practically little good can be claimed. The latter-mentioned solution may have a higher claim, as in several cases in which it has been administered temperature falls and the patient seems easier. It may be, however, that the mere pricking of the tense capsule of the gland, even by needle punctures, may serve to relieve tension and thereby pain. This leads one to the belief that subcutaneous incision of the gland may be attended with beneficial results, and it is a method of surgical procedure not without precedent. Early free incision of the gland is not

to be recommended, nor can excision be in any way justified. The disease is a polyadenitis, and of so extensive a nature that eradication of infected glands is an impossibility. The skin over a gland, when red and painful, may be smeared with glycerine and belladonna or poulticed to relieve pain, and when fluctuation is perceptible the abscess should be opened; but further procedure is useless. When pus is evacuated, dusting the wound with iodoform and ensuring thorough drainage are the means by which the best results are obtainable.

Retention of urine, a frequent concomitant during the delirium of plague, renders the use of the catheter imperative.

Anti-plague serum.—The Yersin-Calmette serum. In 1895 Yersin produced a serum for which he claimed both prophylactic and curative powers. His efforts in this direction consisted in first inoculating animals with plague cultures until they were rendered immune, and then utilising the serum obtained from the animal's blood to inoculate man. The serum of the horse was employed for the purpose, the animal having become immune by repeated intravenous injections of living plague cultures.

Gelatine was the medium on which Yersin grew his cultures: the gelatine cultures were mixed with bouillon and killed by heating to 58° C. The toxins in the medium are not affected by the heat, and cause, when the fluid is injected into animals, a pronounced reaction. Rabbits injected three or four times, with fifteen-day intervals, are rendered immune; and the serum of this animal injected into another rabbit within twelve hours after it has been infected with plague cuts short the disease and preserves the rabbit's life.

Clinical experience has not sustained the high opinion formed of this serum in either China or India. Calmette claims to have improved the therapeutic value of the serum, and he employed the Yersin-Calmette serum in Oporto, where he claims to have proved its value, maintaining that by its use the plague mortality can be reduced to *nil*.

Disposal of the dead.—The body of a person dead of plague should be prepared for burial as soon as possible. The body should be stripped of clothing, washed, and mopped over with a solution of 1 in 1,000 corrosive sublimate in acid solution. The coffin ought to be of lead; but if it consists of wood it must

be freely sprinkled with quicklime or with a mixture of quick lime and wood charcoal.

The grave ought to be at least 6 ft. deep, the bottom of the grave covered with quicklime, which should also be thrown over the coffin when it is lowered. The earth over the grave should not be reopened to receive further burials for several years. Two or more coffins can be laid in the grave at a time, provided the upper coffin is 6 ft. beneath the surface. A separate special burial-place for persons dead of plague is not necessary, nor is it advisable. Such a measure only tends to more widely infect the district. Cremation is the best method of disposal of the bodies of persons dead of plague; but the means of cremation are not usually available. Europeans, and almost all races except Hindoos, have religious scruples against its adoption.

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