Title: Plague

Author: Thomas Wright Jackson
Contributor: Otto Schöbl

Release date: October 12, 2013 [EBook #43942]

Language: English

Credits: Produced by Chris Curnow, Sandra Eder and the Online
Distributed Proofreading Team at http://www.pgdp.net (This
file was produced from images generously made available
by The Internet Archive)

Transcriber's note:

Illustrations were moved to paragraph breaks, therefore the page reference in the List of Illustrations might differ from the actual placement. The index is sorted by page numbers within the alphabetical groups. This has been retained. Footnotes were moved to the end of the corresponding paragraph.

A list of corrections made can be found at the end of the book.

PLAGUE

PLAGUE

ITS CAUSE AND THE MANNER OF ITS EXTENSION—ITS MENACE—ITS CONTROL AND SUPPRESSION—ITS DIAGNOSIS AND TREATMENT

BY

THOMAS WRIGHT JACKSON, M.D.

MEMBER AMERICAN RED CROSS SANITARY COMMISSION TO SERBIA, 1915; LATELY CAPTAIN AND ASSISTANT SURGEON, U. S. VOLUNTEERS; LATELY LECTURER ON TROPICAL DISEASES, JEFFERSON MEDICAL COLLEGE; MEMBER OF MANILA MEDICAL SOCIETY AND PHILIPPINE ISLANDS MEDICAL ASSOCIATION; AUTHOR OF A TEXT BOOK ON TROPICAL MEDICINE; DIRECTOR, DEPARTMENT OF SANITATION AND EPIDEMIOLOGY FOR H. K. MULFORD COMPANY

WITH BACTERIOLOGIC OBSERVATIONS

BY

DR. OTTO SCHÖBL

BUREAU OF SCIENCE, MANILA

ILLUSTRATED

PRESS OF

J. B. LIPPINCOTT COMPANY

THIS BOOK IS DEDICATED BY THE AUTHOR TO

DR. ALDO CASTELLANI

REGIUS PROFESSOR OF TROPICAL DISEASES, UNIVERSITY OF NAPLES. EMINENT IN MEDICAL RESEARCH, MY FRIEND, COLLEAGUE AND COMRADE DURING STRENUOUS DAYS IN SERBIA.

CONTENTS

ILLUSTRATIONS

PLAGUE

ITS CAUSE AND THE MANNER OF ITS EXTENSION—ITS MENACE—ITS CONTROL AND SUPPRESSION—ITS DIAGNOSIS AND TREATMENT

INTRODUCTION

THE question of the need for new books upon medical topics must ever remain undecided, by general agreement, in the medical profession.

There is no such thing in medical literature as an insistent demand from the profession for new volumes upon old topics.

Authors need not hope, therefore, to create the impression that they are meeting long-felt though unexpressed wants of medical readers in launching new books.

On the other hand, the creator of a new volume upon an old subject should seek justification for literary paternity in the progressive changes in the status of our knowledge of disease, its causes, prevention, and cure. Such changes are admittedly going on with a certain degree of constancy and at such a rate of frequency that new presentations of old themes, are both justified and desirable from time to time.

With this idea in mind and with the desire to present, in useful and practical form, a work which shall contain at least some unhackneyed material and which shall represent modern studies and a record of actual control work done in this justly-dreaded disease, the following pages are submitted to the medical profession and to sanitarians generally.

With a profound respect for the laboratory worker and his work and with a profound conviction that to him belongs the greater measure of credit for real accomplishment in connection with plague up to the present time, I desire to insist that the true utility of knowledge gained within laboratory walls lies in its intelligent application in the outer world and that ofttimes this application must be made by men who are themselves without extended laboratory training. An appreciation of principles—with an intelligent ability to accept, to appropriate, to apply and, most of all, to refrain from entering without due preparation the domain of the laboratory worker—is an indispensable requisite in the equipment of the practical sanitarian, upon whom must fall the responsibilities of success or failure in combating the disease we are now to consider.

During the past fourteen years it has been my privilege to observe two epidemics of plague in the Philippine Islands. Some of these observations were made in the capacity of a military medical officer, but my later observations, upon which this report and study are chiefly based, were made from the view-point of a civil health officer. At different times I have been called upon to deal with the disease both as sanitary officer and clinician, and from October, 1912, to July, 1914, I had charge of all plague suppressive measures in Manila. In 1914 I was also in charge, as acting chief, of the San Lazaro Hospitals Division of the Bureau of Health, Manila, where all cases of plague are brought, either for treatment or autopsy.

As some of the material which I have collected for text-book articles during the past eight years bears directly upon the present discussion and presentation, I have ventured to quote from it, sometimes without rephrasing, such parts as are accurate at the present time. I am also quoting freely from the records and from the experiences of my predecessors and colleagues in the work in Manila.

It should be understood that the pathology of the disease has been practically omitted from consideration as out of place in an epidemiologic investigation and report. The pathologic side of the work during the Manila epidemic of 1912–1914 was covered in a masterly manner by Dr. B. C. Crowell and his associates at the Medical School of the University of the Philippines, and I have no doubt that the record of the work done and studies made will appear in appropriate form in due time and will hereafter be referred to as among the most valuable pathologic studies ever made during a plague epidemic, on account of their accuracy and completeness.

I have included, as of great value and directly related to the epidemiologic phase of this study, reports of some of the bacteriologic work done in connection with this epidemic at the Bureau of Science, Manila, by Dr. Otto Schöbl. I am sure that the value of his studies as reported in part here, with his permission, will be apparent to every careful reader. I am greatly indebted to him for his permission to make use of this portion of his studies. Having been in daily touch with Dr. Schöbl during the year and a half of the continuance of this epidemic, I can appreciate to the fullest extent the painstaking and accurate character of his work and findings, of which the part here presented is by no means the greatest.

I am quite aware of the fact that there are those who view with some question the practicability of controlling plague by the measures applied in Manila, as recited here; but American plague workers are likely to meet this unbelief by pointing to the accomplished fact, in San Francisco, in Honolulu, in Porto Rico, as well as in Manila; and before long, as we confidently expect, in New Orleans.

These exponents of the school which contends that plague epidemics are little affected by rat-excluding, rat-destroying and rat-proofing efforts, believe that the waning and disappearance of epidemic plague in a given place depend in chief part upon the exhaustion of susceptible material among the rodent population. However appealing this argument may be, it is impossible for its exponents to duplicate American results with equal results in the cities of China, India, Java and elsewhere, where governmental control and adequate financial ability to carry out campaigns have been lacking, from one cause or another. Wherever our methods have been followed, at home and in the insular possessions of the United States, we have terminated human epidemics of plague and have apparently put an end to rat plague in comparatively short campaigns. So long as this discrepancy in results continues we shall favor the American plan. When we review the work and results of Blue and his fellows of the United States Health Service and the officers of the Bureau of Health of the Philippine Islands, we find little reason for us to favor a change to the expectant plan of waiting for an epidemic to run its course.

While speaking of the Philippine Islands, the admirable work of Strong in Manila, covering years of study of the immunity problem, and his dangerous and highly valuable work as a member of the Commission which studied the Manchurian epidemic of pneumonic plague in 1911, must be mentioned.

Some years ago I called attention to the fact that few, if any, American cities were prepared to meet an outbreak of plague with an adequate supply of antipest serum and that the preparation of antiplague serum was a neglected or overlooked branch of serum manufacture in the United States. Since that time, in the midst of a plague epidemic in Manila, where, for a time, the supply of locally prepared (Bureau of Science) serum threatened to become exhausted, I looked into the possibilities of getting a supply elsewhere and found that, to do so, in anything like a reasonable length of time, was impossible. Fortunately the threatened serum famine did not occur, the local supply in Manila proving adequate, although for a few weeks we were obliged to make use of a stock of Japanese serum which had been on hand for several years. Since the warning of some years ago, at which time the plague danger was an anticipated one, bubonic plague has actually appeared in the United States (New Orleans), the cases being sufficiently numerous to cause grave concern and to call forth the utmost repressive efforts of the authorities. The possibility of plague appearance in the coast cities of the United States, at any time, cannot be disregarded and provision for the treatment of human cases, as well as repressive (antirat) measures, is imperative. Antiplague serum is not producible upon a few hours' notice, nor is it manufactured in the United States. In view of present war conditions the difficulty of securing serum from overseas sources is greatly increased, so that we are well-nigh compelled to depend upon home-produced serum. In view of the uselessness of drug treatment it is plainly the duty of national, state and municipal authorities to keep on hand a reasonable supply of antipest serum to meet any outbreak. Manufacturers of biological products realize that the preparations for producing, storing and marketing antiplague serum are expensive and that the maintenance of immunized animals and the employment of expert serologists call for expenditures which are unlikely to be recovered from any demand for serum and that, moreover, the government is doing and will do all that lies within its power to make the serum unnecessary, by excluding plague. These are not encouraging conditions to lead American serum producers to add antiplague serum to the list of their products. If, under these adverse conditions, any producer of biologic products shall undertake to produce and maintain an adequate supply of antiplague serum, he will merit credit for a truly philanthropic service and will deserve the support of governments, national, state and municipal, as well as that of the medical profession.

CHAPTER I
ITS HISTORY AND ITS EXTENSION

In plague there exists the most intimate relationship between cause and prevention. We will therefore set forth here, as briefly and concisely as their importance will permit, the principal facts related to the causation of the disease. Without an understanding of this relationship there can be no rational preventive treatment.

These facts constitute one of the interesting stories of modern medicine: the story of the arrangement and interpretation of certain apparently unrelated facts, some of them long known to men, in the clear light of modern method; the story of the application of analysis, synthesis, logic and experiment, all leading to the creation of an understanding which permits us to battle successfully with *pestis bubonica*, one of the most ancient of human plagues.

History.—This disease has an historic interest, most engaging and fascinating, which one finds it difficult to pass over with mere mention.

I venture to recall, therefore, that plague almost certainly dates back to the pre-Christian era, the earlier record naturally being lacking in sufficient accuracy of description to enable us to identify the recorded epidemics, definitely and positively, with true bubonic plague.

An epidemic of the second century B.C., as described, seems to have been one of true plague, while the pandemic which began in Egypt in the sixth century A.D., thence extending to Constantinople, Europe and the British Isles, was certainly the disease known in modern times as the plague. This pandemic, beginning as the plague of Justinian, was probably followed by the continuous presence of the disease in Europe, marked by many local outbreaks and periods of quiescence and extending down through the centuries to the period of the Crusades. In the eleventh and twelfth centuries the returning Crusaders spread the plague widely through Europe, which country it ravished from the eleventh to the fourteenth centuries, reaching its climax of intensity in the "Black Death" of Europe of the Middle Ages. The disease thereafter continued to devastate Europe, the great population centres, Paris and London, suffering especially from its visitations and its more or less constant presence. The Great Plague of London, the last important epidemic of the disease in that metropolis, began in 1664 and lasted five years. With less than half a million of inhabitants it is estimated that London gave one of every six or seven of her citizens to the Black Death during the first year of the epidemic. Then followed a remarkable disappearance of the disease from Western Europe. The eighteenth century was marked by few epidemic appearances of plague.

At the end of the first half of the nineteenth century it had practically disappeared from Egypt and from European and Asiatic Turkey, formerly its favorite haunts. In interior Asia it has probably existed for centuries, the non-emigrating character of the people limiting and confining its devastations.

To these centres and to the commercial invasion of China, we must probably trace the beginning of the present pandemic of plague, which exists to-day, a menace to the civilized and uncivilized world. In the days of the Crusades a religious invasion of the infected centres caused the disease to spread throughout Christendom, while in the present day a commercial invasion has caused it to spread completely around the world.

That this is a truth and not a fanciful statement is shown by the appearance of plague in the following countries since 1894, when it spread from interior China. In every case it has followed those sanitary lines of least resistance, the paths of commerce.

Extension.—To the eastward, from China, it spread to Japan, the Philippines, Australia, the Hawaiian Islands, Alaska, California, Mexico, Peru and the western coast of South America. To the westward, it invaded India, Mauritius, Egypt, Suez ports, Eastern, Central and South Africa, Mediterranean ports, Great Britain (Scotland), the West Indies and Brazil. In the last twenty years plague has caused millions of deaths, and, during a single week in April, 1907, it destroyed more than 75,000 lives in India, a number about equal to the deaths of a year in London during the Great Plague of 1665. In contrast with India the rest of the world has suffered little during the present world-epidemic, but this loss, while relatively small, is enormous when translated into lives and dollars. The figures for India are simply huge.

Mortality.—The official lists of *deaths* in India for the last twenty years include some in which the number of *reported* deaths per year exceeded one million, and it has been estimated that the actual number of persons dead from the plague during this period approximates 8,000,000.

It is gratifying to note a marked decrease in the total mortality in the reports of the last few years, but so long as the annual death list, year after year, was measured by hundreds of thousands, rather than thousands, the situation could not be considered as anything but grave.

Widespread Dissemination in Recent Years.—Without going into statistics deeply we may consider also the list of countries, states and islands from which plague cases have been reported officially during the last few years.

My purpose is to invite attention to the continued existence of various plague foci, any one of which might serve to extend the infection further, were governmental quarantine and public health supervision relaxed.

During August, September, October, November and December, 1909, plague cases occurred in India, Mauritius, China, Japan, Egypt, Turkey, Russia, British East Africa, the Azores, Venezuela, Ecuador, Peru, Chili, California (two cases), and the Hawaiian Islands.

During the first half of 1910 no very marked variation in the distribution of plague occurred, cases being reported from practically all of the foreign countries just named.

A year later the situation, so far as the distribution of plague cases is concerned, was not greatly changed, as may be seen from the following tabulation, which I have abstracted from the *British Medical Journal* of September 16, 1911.

India.—Deaths from plague in India during the first six months, 604,634. Most prevalent (1) United Provinces, 281,317; (2) Punjab, 171,084; (3) Bengal, 58,515; (4) Bombay Presidency, 28,109. Deaths in July, not included above, 8990.

Hong Kong.—April 24 to August 21, 255 cases, 194 deaths.

China.—January 1, 1911, plague was reported in varying intensity in (provinces and towns) Manchuria, Peking, Tien-tsin, Chefo, Shantung, Shanghai, Amoy, Foochow, Swatow, Canton, Pakhoi and Laichow.

Indo-China.—At Saigon, in March and April, 1911, many cases reported. April 17 to May 7, 56 cases; 17 deaths. May 22 to May 28, 37 cases; 12 deaths.

Siam.—In Bangkok plague was more severe during 1911 than in any previous year. March 15 to April 15, 33 cases and 29 deaths.

Java and Sumatra.—In Java, May 25 to June 3, 105 cases and 62 deaths (one province). In Sumatra plague was present, no statistics.

Straits Settlements.—A few cases, mostly imported, reported in 1911.

Japan.—A few cases at Kobe in 1911. In Formosa, from April 2 to April 15, 31 cases; 24 deaths.

Egypt.—Plague reported from Port Said, Suakin (on board ship), Cairo and Alexandria; also from 11 provinces. The province of Kena had a severe outbreak, May 5 to May 31, 51 cases and 49 deaths.

Persia.—Several cases reported from ports on the Persian Gulf.

Turkey in Asia.—A few cases at Muscat, Basra and at Port of Jeddah.

British East Africa.—Kismayu and Port Florence reported a few cases in April, 1911.

Mauritius.—January 1 to April 11, 110 cases and 70 deaths.

Portuguese East Africa.—Plague was reported present at Nahoria in May, 1911.

Russia.—In the Kirgis Steppe in the Astrakan Government in January, 50 cases; 30 deaths.

South America.—Plague prevailed during 1911 in Peru, Ecuador, Brazil, Chile and Venezuela. No severe outbreak except in Peru, where from February to May many cases occurred and died. At Libertad, in March, were reported 60 cases and 23 deaths.

Appearance of Plague in Porto Rico, New Orleans and Manila.—The developments of 1912, which most concern us, were the appearance of human plague and the discovery of plague-infected rats in Porto Rico, Cuba, and the Philippines, and the discovery of infected rats in New Orleans. Thus the Atlantic cities of the United States were for the first time seriously threatened, and the menace of the pestilence at home loomed up on our horizon with sufficient prominence to excite public concern. Our protectors and guardians of the United States Public Health Service, to whose watchfulness we must credit our prolonged escape from the plague, are carrying out all the protective measures at their command with the utmost

activity.

At the present time we find Porto Rico freed from the disease. New Orleans has undergone and is still undergoing treatment which may be expected, most confidently, to clear it of both human and animal plague.

Of Manila and the work there, much will be found in the following pages, but as both rat plague and human plague have been absent for more than a year we may fairly look upon the epidemic as ended. After so long an interval as this any reappearance of plague may fairly be viewed as a new epidemic, although it is not humanly possible to say that rat plague has entirely and permanently disappeared from the city of Manila, as yet.

CHAPTER II
THE CAUSE AND THE MENACE OF PLAGUE

The foregoing facts are quite sufficient to make us realize both the possibility and the danger of a world-epidemic; a danger which has existed for some years and which recently has been especially menacing to the United States.

Causation of the Disease.—Plague is an acute infectious epizoötic disease, caused solely by *Bacillus pestis*, a bacterial organism. The disease is common to man and to a number of the lower animals and fowls.

Prominent among the animals susceptible to the disease is the rat, and from this animal, through the intermediation of the flea, by far the most cases of human plague arise. In California the ground squirrel (*Citellus beecheyi*), a rodent closely related to the marmots of Asia, plays a similar rôle. Of the Asian marmots, the tarbagan, a large rodent, also commonly suffers from subacute chronic plague, which is transmissible to man as an acute disease by the fleas which the animal harbors.

Its Conveyance.—Although conveyance of plague through rats by contact alone—that is to say without the medium of the flea—is denied by modern experimenters, it is perhaps wiser and safer to consider the disease infectious, inoculable and contagious in the common medical meaning of these terms. While it is usually conveyed to man by the flea, it may be acquired by the inhalation of plague bacilli and, according to some authorities, by ingesting or swallowing the bacilli.

When infection takes place through the digestive tract, or in other words, by the ingestion of bacilli, either the flesh of plague-infected animals or fowls, or food superficially contaminated with plague bacilli by rats, cockroaches or other carriers, serves as the medium.

Speaking practically, the possibility of infection through ingestion is nearly negligible. Indeed, the conclusion of Simpson in regard to this possibility has been disputed and denied. However, the recent occurrence of plague in a cat in Manila, in my own experience, observed with me and carefully worked out by Dr. Otto Schöbl, points strongly to the possibility of ingestion plague, the cat in this case apparently having acquired plague from eating rats dead from plague.

A full account of this case appears in the bacteriologic observations of Dr. Schöbl and in my recital of the history of the Manila epidemic.

Types of Plague.—Plague in man may be of several types and these are designated by names descriptive of the symptoms or of the regions of the body most affected. Thus we have bubonic, septicæmic and pneumonic types. As both mild and virulent cases occur, we also use terms descriptive of the severity and course of the cases. Thus we describe certain cases as ambulant, abortive, larval and fulminant. In the rat the evidences of plague are less striking in life than they are at the post-mortem table. Indeed plague-stricken rats, either naturally or artificially (experimentally) infected, often show very slight evidences of disease before death. Chronic plague in rats and a relative immunity to inoculation in certain wild rats are fairly well recognized phenomena.

Flea Conveyance of Plague Bacilli.—Both male and female fleas convey plague, but the exact method of carrying the plague bacilli from diseased rats to man, while fairly well determined, is of such recent decision as to leave room for further experimentation. At present it is believed that the flea deposits plague bacilli, at the time of biting, upon the skin, by ejecting the contents of its rectum and by regurgitation of its stomach contents. At least the flea is known to perform these acts at the time of biting, and the rubbing or scratching of the flea bite with the hand may easily introduce the bacilli into the skin at this spot.[1]

[1] Acknowledgment is hereby made to the Contributors to "The Rat and Its Relation to Public Health" by various authors, prepared by direction of the Surgeon-General, P. H. and M. H. S., for numerous facts utilized in the preparation of this article. The particular contributors whose valuable chapters have been drawn upon for information are D. E. Lantz, C. W. McCoy, D. H. Currie, Carrol Fox, Rupert Blue, W. C. Rucker, R. H. Creel, M. J. Rosenau, V. C. Heiser, W. C. Hobdy, and J. W. Kerr.

The possibility that the flea introduces the plague bacilli upon his mandibles, or the skin-piercing armament with which he is provided, is also to be considered. However, the following facts support the first proposition. It has been experimentally shown that the average capacity of a flea's stomach is about one-half of a cubic millimetre and that thousands of plague bacilli may be ingested by the flea during the biting of a plague-diseased rat; that the plague bacilli multiply enormously and for many days in the flea's stomach and that the bacilli are found only in the insect's digestive tract; that plague bacilli are regurgitated from the stomach and are voided from the rectum with the digested blood.

It has also been proved that almost all varieties of rat fleas, under favorable circumstances, will bite man and that the most common human flea (*Pulex irritans*) is frequently found upon rats, the flea, generally speaking, being much less particular in his choice of hosts and in his permanence of residence than most insects and ectoparasites in general.

Of the rat fleas, *Pulex pallidus* (*Lœmopsylla cheopis*) is common under various names in India, the Philippines, Australia, Italy, Brazil and in tropical countries generally. It bites both rat and man. *Ceratophyllus fasciatus*, the common rat flea of Great Britain and the United States, also bites both rat and man. In North America and elsewhere certain other fleas of the genus *Ceratophyllus* have been found upon ground squirrels, cats, rats, sparrows and in chicken yards.

Dog fleas and cat fleas (genus *Ctenocephalus*) also infest rats, and fleas of other genera are found upon mice, rats and ground squirrels rather indiscriminately.

The significance of these facts in connection with prevention of plague is apparent and it is plain that our warfare against fleas must be made upon *all* fleas and not upon a single variety. In this connection the possibilities of the conveyance of plague bacilli by other suctorial parasites and by insects which are not parasites, must be borne in mind.

Thus the bed-bug, the louse, the tick and the mosquito must be suspected as possible intermediaries and the fly and the cockroach as possible food contaminators. Indeed, laboratory experiments have already incriminated bed-bugs, flies and lice as potential vectors of plague bacilli.

Experiment and observation have demonstrated, however, that above all other parasites and insects, the flea is most likely to convey the plague germ from rat to man, by reason of his frequent excursions from rat-host to human-host, his taste for blood from either host, his enormous activity and his ability to jump. After a searching inquiry into the plague question the Indian Plague Commission came to the conclusion that contagion plays a very minor part in the spread of the disease, less than three per cent of human cases being so acquired.

This commission also decided that infection is conveyed from rat to rat and from rat to man solely through the agency of fleas. While these conclusions are probably true—and therefore of the utmost importance from the standpoint of practical prevention—I should question whether the other possibilities, however remote, are entirely negligible.

Seasonal conditions may affect the course of an epidemic in various ways. (a) By effect upon flea prevalence, cold weather greatly lessening the number of insects. (b) By effect upon rats, cold weather and rains either driving them from overground to underground, or vice versa, or from their principal avenues of travel in cities (the sewers), into houses and buildings. (c) By effect upon the plague germ, *Bacillus pestis*. The resistance of this organism is very variable, sunlight and drying being its greatest enemies, while darkness and dampness are its chief allies. So far as temperature is concerned, the plague bacillus is not likely to be seriously affected by natural temperatures, as it is not destroyed by heat below 150 degrees Fahrenheit, nor by cold measured by zero Fahrenheit, which means that it survives freezing, generally speaking.

It is probable that the periods of greatest seasonal prevalence of plague will be found to correspond generally with increased prevalence of rat fleas. During the periods when rat fleas are absent or least prevalent, the disease is perpetuated in the form of chronic (subacute) rat plague in a small number of the rodents. The India Plague Commission made and verified this observation.

Cholera epidemics often abate spontaneously and this is believed to be due in part to attenuations of virulence and changes in the cholera organism which may be demonstrated in the laboratory. We can hardly hope for such spontaneous abatements in plague epidemics, as it has been found difficult to attenuate or to intensify cultures of plague bacilli permanently in laboratory experiments with animals. If it is true that plague epidemics are often marked by a preponderance of mild cases in the early days and a gradual subsidence of intensity of the cases as the epidemics wane, we probably will have to look to the susceptibility of our patients for our explanation of this phenomenon, rather than to variations in the virulence of the plague bacilli. If plague bacilli continue to be distributed to susceptible people the disease should continue with a general stability of virulence.

Stability of Virulence of *B. Pestis*.—According to Strong, stability of virulence is a marked characteristic of *B. pestis*, it having been shown by him

that it is difficult to increase the virulence of a very virulent strain or to intensify an attenuated one in laboratory animals, working with monkeys, rats and guinea-pigs.[2] If his observations are correct (and they seem to correspond with the findings of other observers), the oft-recorded occurrence of a preponderance of mild cases of plague in the early days of an epidemic and the gradual subsidence in intensity of the disease as the epidemic approaches its close will have to be explained upon other grounds than those of variability of virulence by attenuation of virulent strains alone. While he admits that *B. pestis* may become attenuated under certain conditions many times during the course of an epidemic, it may also regain its virulence, he contends, under other conditions.

[2] "Studies in Plague Immunity," R. P. Strong, Philippines Journal of Science, June 1907, No. 3. Frequent reference has been made to these studies in the preparation of this article, for which acknowledgment is hereby made.

With these facts concerning the cause and the manner of extension of plague and its menace before us, we are in position to approach the problem of prevention intelligently, and in the case of plague prevention is preëminently preferable to cure, as well as decidedly more practicable.

I think we may be permitted here to sum up the problem of plague prevention thus: Without fleas, without rats, or without human plague cases, there can be no extension of plague, practically speaking.

Therefore the destruction of both rats and fleas, the isolation of human plague cases, and the exclusion from them of all suctorial parasites and insects, will provide practical security for mankind generally.

A word concerning pneumonic plague may be permissible. This form of plague occasionally occurs in epidemics of great fatality, as, for example, the epidemic in Manchuria, North China, a few years ago.

The mystery of this outbreak was largely dispelled by the work of the Americans, Strong, Teague and Barber, of the Bureau of Science of Manila.

The occurrence of secondary pneumonia in bubonic or septicæmic plague is rather common and it is likely that such secondary plague pneumonias are the starting points of epidemics of pneumonic plague, *i.e.*, of cases of primary plague pneumonia, the point of infection being in the respiratory organs and the infection being acquired through the inspiration of plague bacilli.

The principal prerequisites seem to be an extremely moist atmosphere under confined conditions and a low temperature; conditions most unfavorable to evaporation and ventilation. Under these conditions the pneumonic patient sprays plague bacilli into the air while coughing and droplet infection follows.

It is therefore apparent that epidemic pneumonic plague is controllable by sanitary and hygienic measures and, furthermore, that in the absence of original cases of bubonic and septicæmic plague, with secondary plague pneumonias which give rise to primary plague pneumonia in the manner explained, respiratory plague in epidemic form will not occur.

There is no evidence pointing to the conveyance of respiratory plague by insects or other carriers.

CHAPTER III
ITS CONTROL AND SUPPRESSION

Plague Prevention.—At present the most promising and the most rationally based phase of plague control is that of prevention. The reason for this is plainly apparent. If the facts in the case are as stated and if the conclusions of the Plague Commissioners and students of epidemiology the world over are correct, to eradicate plague we need only to control its carriers.

To exterminate the rat (and perhaps the marmot and ground squirrel), to prevent the transportation of rats or of infected rat fleas in ships, trains, clothing, merchandise and upon the bodies of men and animals from the numerous foci or plague centres of the world to non-infected localities, is a beautiful plan indeed.

Restricted to single communities, even where the intelligence, patriotism, effort and wealth of the whole people are enlisted, the undertaking is formidable, with obstacles to its execution, and discouragement must often be expected. Extended in its application to the whole plague-infected world it becomes an undertaking seemingly impossible of accomplishment.

Yet we are encouraged to face the situation by a glance at what has been accomplished. The United States, perhaps, presents the highest examples of achievement in the cases of San Francisco and Manila. The work in San Francisco is too recent and has been too well published to require detailed review here. A successful campaign against rats in 1907 practically terminated an epidemic of considerable proportions well within a year. Behind this movement, however, were the powerful machinery of the Federal Government, money in generous amount and a considerably aroused public, resentful of the mismanagement of the 1903 epidemic, whereby, through pure fear of financial loss to commercial interests and by a disgraceful suppression of the truth, California was made, permanently perhaps, one of the world's plague centres.

It has been estimated that the rat population of the world is equal to the human population, and this estimate does not appear to be unreasonable when one considers as indices the destruction of the rodents in cities by the hundreds of thousands, upon single farms by the thousand, and the wonderful procreative powers of the rat.

Economic Importance of Rat Destruction.—It is certain that the economic importance of rat destruction upon grounds other than those purely sanitary must be impressed upon the public wherever a rat campaign is to be carried on.

The absolute inutility of the rat, its enormous destructiveness to crops, to merchandise in warehouses and in transit, to poultry, eggs, fruits and vegetables, to buildings and furniture, and its incendiary habits causing annual fire losses of considerable magnitude, must be emphasized in season and out of season. Such items as the value of the grain consumed by a single rat per year, as estimated by the experts of the Agricultural Department, are convincing arguments in the case. At a daily consumption of two ounces, the ration for a full-grown rat, this grain value varies from sixty cents per year, for wheat, to two dollars per year, for oatmeal, for each rat subsisted. Similar data in great variety, relating to direct and indirect losses, are available for the purpose of making impressive the economic need for rat destruction.

Accumulated experience from various countries and cities shows plainly that there is no single method of rat destruction to be depended upon to the exclusion of all others and it also shows that without governmental direction and supervision, backed by ample authority and the ability and willingness to expend considerable money, neither single nor combined methods will be successful. Moreover in the countries where special effort is most needed there is often distrust on the part of the natives, religious prejudice against the destruction of animal life and frequently open opposition to the authorities in their efforts to destroy rats. The same superstitions and religious beliefs which prevent the killing of venomous snakes in India, at the annual cost of thousands of human lives, operate against most measures of rat destruction proposed by the Government.

Extermination Methods.—The plans and weapons of warfare against rats include the use of poisons; traps; starvation; rat-proof construction of buildings, wharves, bakeries, stables, granaries, etc.; the introduction of diseases among the rat population by bacterial viruses and the conservation of the natural enemies of the rat, such as the cat, the dog, the ferret, the mongoose, and certain wild animals and birds of the woods and fields.

Among the most widely used and most effective poisons is arsenous acid boiled with rice, or mixed with cheese or cornmeal in the form of a paste, or placed upon sweets and fruits.

Crude phosphorus is chiefly used in similar pastes. When mixed with glucose its inflammable properties are said to be lost. Its inflammability is, of course, a serious obstacle to its general use.

Strychnine, owing to its bitter taste, is of little value in poisoning rats, and when used is best combined with glucose and one per cent. of cyanide of potassium. Soaked wheat, bread or similar food is then treated with this mixture and placed where rats may eat it. It is said to be eaten readily by ground squirrels with fatal effect. It is, however, expensive and apt to be taken by domestic fowls. Most rat poisons have the disadvantage of being dangerous to human life and must be used with caution wherever children and ignorant native persons are about.

Trapping.—Trapping has been found to be a very effective means of rat destruction in cities. (See later pages for relative efficiency of traps.) Rat traps are of several varieties and are constructed upon various principles. It is sometimes desirable to catch the rats alive and uninjured, and for this purpose barrel traps, wire cage traps and similar devices are placed in the rat highways. These highways are readily discovered in the cities. Considerable care must be taken to overcome the natural caution of the rat, and this includes judgment in the use of attractive bait, the concealing and smoking of traps after handling and perhaps the use of some scent, such as the oil of anise, of which rats seem to be fond. As a general rule bait should differ from the food naturally supplied by the locality. For example, about granaries and stables fresh animal food should be used for bait, while about slaughter houses, meat-markets, fish-markets and similar places, where animal offal is abundant, the rat should be tempted with vegetable bait.

Where the circumstances will permit, and this is apt to be so for ground-squirrel destruction, the burrows may be filled with some asphyxiating or poisonous gas. In this manner whole families of rodents, and their fleas as well, are destroyed.

The system is not often applicable in houses, but aboard ships it is found most effective, the holds of ships being flooded with sulphur dioxide, developed by burning sulphur in a special furnace provided with a pumping and piping system for delivering the gas at distant parts of the ship. In empty ships' holds and elsewhere the simple burning of sulphur in open vessels effects the same results, provided sufficient sulphur and a sufficient number of vessels be used and further provided that the generation and confining of gas be sufficiently prolonged. In San Francisco harbor, where for more than a year nine vessels were disinfected per day, this method was adopted as more effective, speedy and economical than any other system. It has the disadvantage, in the case of laden ships, of affording some danger of fire.

Carbon bisulphide has been extensively used in California in the burrows of ground squirrels. Its fumes, being heavier than air, penetrate the burrows and promptly poison or asphyxiate all living animals and fleas. Absorbent material of some kind is saturated with the liquid and placed in the entrance of the burrow, which is then quickly sealed to confine the gas.

It will be seen that, in common with other methods of rat destruction, fumigation has a limited application and a number of serious objections. It is particularly useful aboard ships.

The method should never be employed by unskilled persons or those unacquainted with the dangers to human life from noxious or asphyxiating gases.

Starving Rats.—The subjects of the starvation of rats and rat-proof construction may be considered together.

Just as the pig in the Philippine Islands and elsewhere in the Orient must give place as a scavenger of human excreta to modern and decent methods of waste disposal, so must the rat, a garbage scavenger the world over, give place to systematic garbage collection and removal, with temporary storage of garbage in covered metal cans (rat proof).

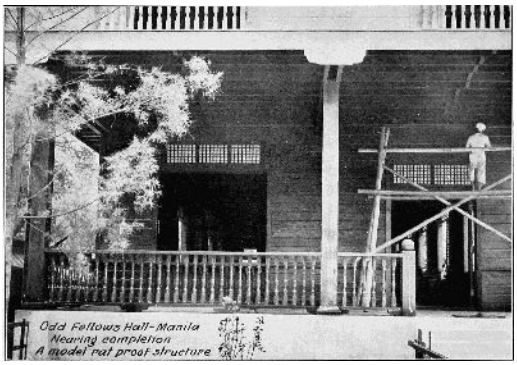
Incidentally it may be mentioned that the effect of such measures upon the prevalence of flies and the transmission of disease by these insects will be very great and very beneficial to the public health.

Food must be kept from rats and rats must be kept from the food. Perhaps the greatest resorts of rats are the places where cattle are fed, where grain is stored and where animals are killed. Slaughter houses, markets, grocery stores, restaurants, bakeries, wharves and warehouses must be regulated by ordinances duly enforced. Much can be done with screens of heavy iron wire with a mesh of less than one inch.

When concrete and metal have displaced wood and plaster as construction materials; when plank sidewalks and refuse piles are no more and

when the catch basins of sewers have been made rat-proof the subsistence problem for the rat will be greatly increased in difficulty, and starvation should then begin to lessen the rat population, at least in the cities.

Rat-proofing.—Municipal authorities should take up the matter of rat-proof construction for new buildings and the rat-proofing of old ones by approved alterations. In Manila, Hong Kong and elsewhere these methods are receiving attention and encouraging reports are recorded, more particularly with regard to the disappearance of plague in districts so treated than in the disappearance of rats. This is most important, for if the rat and his fleas are excluded from houses and therefore from intimate association with man (an apparently feasible matter through the rat-proof construction of buildings), protection against human plague is in great measure accomplished.



RAT PROOF STRUCTURE WITH SOLID CEMENT BASE, SOLID CONCRETE POSTS, AND UNBOARDED CEILING

In Manila the disappearance and continued absence of human plague in previously infected localities goes hand in hand with the introduction of systematic rat-proofing in sections where cases of human plague occur.

These measures were first instituted in 1906 and plague disappeared from Manila in the same year and did not reappear until 1912.

From 1900 to 1905, $15,000 was paid in rat bounties and $325,000 was paid for salaries, wages and expenses in rat catching, with little appreciable effect upon the number of rats and without causing the plague to entirely disappear. It must be admitted, however, that practical control of the disease was attained during this period.

Rat-proofing of dwelling houses is less expensive than perpetual wholesale rat destruction and is a perfectly effective measure against human plague. In the suppression of the San Francisco epidemic in 1907 rat-proofing was also extensively resorted to.

The expense of rat-proofing has been generally considered as prohibitive, but if the work be confined at first to the vicinity of infected centres and if it be carried on subsequent to rat-destruction in corresponding areas the expense need not always be prohibitive—at least in American governed cities. The Manila plan of plotting the city into "plague-infected" areas corresponding with the capture of plague-diseased rats and systematically working within geographic boundaries in which rat plague exists or is likely to spread, as determined by rat captures and examinations of the rats for signs of plague, has proved to be a good plan.

To prevent the transportation of rats in ships, trains and merchandise is an undertaking of difficulty as well as of importance. In the case of vessels it involves an understanding of the manner by which rats gain ingress to the ship and the ways of preventing them from entering. Few facts are better known, perhaps, than the fact that all ships harbor rats, but, except to the initiated, the extent to which some ships are infested is by no means understood. I have made voyages upon steamships, which upon alternate trips carried forage for animals in the holds, when the conditions were, to say the least, uncomfortable. To have one's state-room taken possession of by rats, his clothing carried away, or to awake with a rat in his berth are unpleasant, but not uncommon, experiences. I personally know of a woman, prostrated with sea-sickness, who was obliged to remain in her berth and see four large rats disport themselves about her room, and in another case, on the same ship, a rat jumped from the washstand into the berth of a sleeping woman, running across her exposed face and arm.

In travelling upon small dirty steamers in the Orient I have often slept on deck, quite as much to avoid the rats and vermin in the state-rooms as for better ventilation. In a certain ship in which I travelled some of the ship's officers amused themselves by shooting rats with an air-rifle in the lower decks, quietly hiding themselves in dimly-lighted places and shooting the rats as they crossed the lighter spaces.

In many ships the rat population far exceeds the human population. In San Francisco 310 rats were destroyed by a single fumigation on a vessel of only 260 tons burden. In Bombay 1300 rats were destroyed at one time upon a single ship and in London 1700 were secured at one fumigation.

The ease with which rats adapt themselves to new environment is shown by the fact that they live, when permitted to do so, in cold storage and refrigerating rooms where they grow heavy coats of fur for protection against the cold.

They gain ingress to ships in three principal ways: (1) By coming overside upon gang-planks, wharf stringers, etc. (2) By passing along the lines by which the ship is made fast to the dock, through hawse holes, the rat being an expert rope walker. (3) By coming aboard in the cargo.

By the latter method rats are often brought aboard by whole families, their fleas included. Many styles of packages such as barrels, bales, crated goods, grain in sacks and matting in rolls present the rat with abundant opportunity to take passage and it is probably thus, as stowaways, that rats go to sea in the largest number. Plainly, then, the placing of rat-funnels upon all lines from ship to wharf, the use of special fenders, the raising of gang-planks and even anchorage in the stream will not prevent rats from getting aboard ships unless cargo disinfection be practised before loading the vessel. The ship itself should be fumigated every three months if possible.

Rats are doubtless carried in considerable numbers upon railway cars, both freight and passenger.

While riding in a street car in Manila in 1908 I saw a rat run along the window ledge, to the mingled fright and amusement of the passengers.

The same principles which apply in the case of ships apply to cars and trains as well. Grain cars in particular should receive especial attention.

Rat Destruction by the Spread of Rat Diseases.—The proposal to destroy rats by wholesale, by spreading epizoötic diseases among them, through feeding them bacterial virus, has received much attention in the last ten years. In 1900 Danysz isolated a bacillus from field mice suffering an epidemic disease communicable to rats, and great hopes were entertained that by means of this method decided reductions in the rat population would result. Indeed the results in Cape Town, South Africa, in 1901, and in Odessa, Russia, in 1902, seemed to justify the hope to some extent and certain observers still believe the method to be effective. Experience with the Danysz and other organisms has shown, however, that introduced epidemic diseases do not destroy rats in sufficient number to do much good and that nearly all the viruses experimented with are more or less unreliable.

Most of the organisms are apparently related to the colon, typhoid or hog-cholera groups. The mouse-typhoid bacillus (*B. typhi murium*) was originally isolated by Loeffler in 1899. The paratyphoid bacillus and Gärtner's *B. enteritidis* correspond closely with the Danysz organism and can scarcely be separated culturally. In rodents they produce enteritis, sometimes hemorrhagic in character, and they are by no means to be regarded as harmless for man, as originally supposed. In Japan, in particular, serious and fatal cases of diarrhœal disease have followed the accidental eating by man of food treated by these bacterial poisons.

On account of the natural resistance of rats to diseases of bacterial causation (plague being the most notable exception to this rule), and the clinical fact that no sufficient death rate among rodents is produced by feeding them upon bacterial viruses, as well as on account of the dangers to man just mentioned, this method of rat destruction is not in favor at present.

Poisoning rats and ground squirrels by chemical poisons seems to be a preferable method, at least equally effective and without most of the disadvantages of uncertainty and danger which attach to the bacterial viruses.

Rat Destruction by Domestic Animals.—Concerning the utility of such domestic animals as are natural enemies of the rat, in the warfare against the offending rodents, there is considerable difference of opinion, based upon varying experiences. I leave out of consideration all but the cat and dog.

It will be found that wherever cats and dogs are well housed (indoors) and well fed they are apt to be fat, lazy and inefficient. House cats of this class will catch mice but will often leave rats alone, but half-wild cats, obliged to forage for their own subsistence, are often excellent rat-catchers.

Small, active dogs, particularly of the terrier breeds, will often keep houses practically free from rats and upon farms they are especially valuable, particularly if the construction of buildings is such as to permit them to get beneath the floors. The employment of these animals will necessarily be confined to individuals for the freeing of individual premises from rats.

A fact to be borne in mind is one already cited, viz.: that cats and dogs sometimes harbor the same fleas as the rat. Infected rat-fleas often leave dead rats for other animals and, all things considered, there are many other objections to the intimate house dog and house cat which find comfortable resting places impartially upon the beds of adults or the cribs of babies and children.

Furthermore, my personal observations have been such as to cause me to place small reliance in the value of the ordinary dogs and cats found about habitations wherein the construction is favorable to rat-harboring.

Summary of Prevention for the Community.—Before passing to the consideration of other matters I would sum up the measures of preventive treatment for the community. There must be (1) Active warfare against rats and other plague-affected rodents and their fleas; (2) Modified quarantine—detention or disinfection applied to persons, goods and animals; (3) Disinfection of cargoes shipped from infected ports; (4) Isolation of the sick and proper disposal of the dead; (5) International notification between governments of the occurrence of plague within their respective territories; (6) Lastly,—but we might say first in importance,—the early recognition of the presence of plague and the *rapid diagnosis* in individual cases, both of which are dependent upon laboratory workers.

All of these measures must be fostered, directed and aided in every possible way by competent authority (national if possible), whose officers must be men of great moral courage and of unselfish purpose. Behind all of this must be generous financial support.

I can best emphasize the importance of the observance of the principles I have laid down by introducing personal experiences in the conduct of the antiplague campaign in Manila during 1912, 1913 and 1914.

I therefore present here the following account of the epidemic, the campaign of suppression and the various lessons learned.

It should not be difficult for the reader to make applications of the principles already set forth and to confirm by the reported facts the assertion that methods based upon these principles are effective.

If repetitions of any of the foregoing principles occur it is hoped that, when taken in connection with concrete applications cited, they will not appear as redundant.

The Manila Epidemic of 1912 to 1914.—The chronologic facts concerning the development and extension of plague in Manila in 1912, 1913 and 1914 are as follows:

The disease made its reappearance in Manila, after an absence of six years for the human disease and five years for rodent plague, two verified human cases having been recorded in June, 1912.

Preceding the appearance of the first Manila cases there occurred upon incoming ships a number of cases of plague during the Spring of 1912, detected at quarantine. Although there is no conclusive evidence which connects these imported cases, originating in Hong Kong, China, with the epidemic which broke out in Manila a few months later, the fact of their occurrence and recognition is interesting enough for us to consider before taking up the study of the Manila epidemic. Concerning these imported cases Dr. Victor G. Heiser, then Director of Health for the Philippines, wrote as follows in the *Philippine Journal of Science*, in February, 1914.

> Unusual Character of Plague at Quarantine.—It is perhaps worthy of note that, prior to the appearance of plague in Manila a number of cases of the disease were found on incoming steamers. For instance, on April 6, 1912, a death was reported on the steamship *Zafiro*, which had arrived the day previous from Hongkong and had been in the harbor for twenty-four hours at the time of the death. At the medical inspection of the vessel, which was made the day previous, no illness was detected. An investigation showed that the victim had been on deck on the night of April 5, 1912, in apparently good health. The next morning, at 6 o'clock, he was found dead in his bunk. The necropsy and subsequent biological findings reported by Dr. R. P. Strong of the Bureau of Science showed that death was due to pneumonic plague.
>
> On April 7, 1912, the steamer *Loongsang* arrived in Manila from Hongkong, and the captain reported that a death had occurred the day previous in a Chinese member of the crew. Upon investigation of this case, the captain stated that the man was apparently in good health, but that while hauling on a rope he fell over in an apparent faint and was placed in a chair and in the course of a few hours expired. The necropsy and animal inoculations showed that he had died of plague and probably of the pneumonic variety.
>
> Beginning April 7, 1912, the temperature of all members of the crew and of the passengers that arrived in vessels from foreign ports was taken with a view to detecting any possible cases of plague.
>
> On the arrival of the steamship *Taisang* from Amoy at the Mariveles Quarantine Station at about 6.30 A.M. on April 30, 1912, the entire personnel was carefully examined and found free from sickness of a suspicious nature and from elevations of temperature. Seventy-three persons were detained to serve a quarantine detention of seven days. On the evening of April 30, a Chinese passenger, aged fifty-one years, was found to have a temperature of 39° C. with a pulse of 100. He was placed in the hospital, but protested vehemently that he was not sick. He was carefully watched from the first; there was a slight cough; physical examination of the chest revealed a few râles; smears made of the sputum and stained for plague bacilli were negative. On the fifth day, the fever still persisted, but the patient stated that he did not feel ill and demanded to be released from the hospital. On this day, the expectoration was blood-stained, but no suspicious organisms could be found in the smears nor could any physical signs of pneumonia be detected. Furthermore, there were no palpable glands. On the morning of the seventh day, the temperature and pulse dropped and the general condition was distinctly worse. The patient now admitted that he felt ill. Several hours later, he flinched when pressure was made in the right axilla. Lymphatic enlargement was now made out, and by the evening of the seventh day the bubo in the axilla had increased markedly in size, the swelling approximating 3 by 7 centimetres. Glands now became palpable in other portions of the body, particularly in the cervical region, and a few hours later there were inguinal and femoral buboes. The patient became rapidly worse, and died at 7 o'clock on the morning of the eighth day of his illness. At the necropsy, the glands of the right axilla and those of the right side of the neck were found enlarged; the other lymphatic glands were also enlarged, but to a lesser degree. There was consolidation of the lower lobe of the right lung, and the spleen was about twice its normal size. In brief, the necropsy findings of a typical case of septicæmic plague were present. Smears from the spleen and the right axillary gland showed immense numbers of bipolar-staining organisms. Cultures made from fresh pieces of tissues and later inoculated into animals gave positive results for plague.

Beginning of the Manila Epidemic.—Proceeding with the Manila epidemic inaugurated with the two cases referred to as recorded in June, 1912, we find that the total number of cases recorded from the time of the outbreak in 1912 until the last case in 1914 was 90. (This includes none of the imported cases from China which developed en route to Manila from Chinese ports.)

Of these 90 human cases, 76 were fatal and autopsies were performed in all instances. Fourteen persons recovered. The number of cases of animal plague up to July, 1914, was 53. This refers only to laboratory-proven cases of rat plague. As a matter of fact, hundreds of dead rats, almost certainly plague rats, were found in the course of rat-proofing operations.

Although the period covered by this epidemic approximates two years, it must not be supposed that the progress and extension of the epidemic was an uninterrupted or unobstructed one.

On the contrary, such extension as occurred was made in spite of the most active suppressive effort, and it is believed that this effort brought about a creditable result, as indicated by the accompanying record.

When one considers the favorable conditions for the natural spread of plague, both in Manila and throughout the Philippine Islands, and realizes the interposed difficulties and obstructions, natural and unnatural, geographic, human and domestic, which confront us at every turn of the path to correction, removal and reformation, our success in checking the spread of plague appears as a real achievement, especially when contrasted with the results of effort during the same period in a British city of similar size but a few days' sail from Manila, where the cases were numbered by thousands and where the infection still persists.

First Manila Cases.—The first case of plague (June 12, 1912) occurred in a resident of Tondo, 920 Calle Antonio Rivera, and in the light of subsequent developments it may perhaps be grouped with the October cases traced to the Manila Railway Company's freight station and yard, as 920 Calle Antonio Rivera is but a stone's throw from the Manila Railway property. The connection, however, is not clear, and, on the other hand, it is not wholly inconceivable that the rat epidemic and human plague cases at the railway station in October may have been secondary to this June case. Such speculation is fruitless, however, so far as establishing facts is concerned.

The second case of human plague occurred 13 days later, June 25, in a resident of a district somewhat removed from the first case, but in the same general section of the city.

Then came a lull of more than a month, until August 4, during which time no case of plague occurred; or at least none was reported.

August brought forth five cases on the fourth, eighth, fifteenth, and twenty-first days of the month, in residents of the Quiapo and Binondo districts.

These cases were unrelated to the preceding ones so far as could be ascertained.

Another lull of a month, until September 24, now occurred without a reported case of human plague. During this time, however, the first cases of rat plague were discovered, one on August 30 and two on September 6, all of them in the Quiapo district.

From this time (September 24) on, however, human cases occurred at intervals of a few days until Christmas Day, 1912, the longest plague-free period being one week; the number of cases by calendar months being distributed as follows: September, 3 cases; October, 22 cases; November, 12 cases; and December, 6 cases.

Geographic Grouping.—Not until October 21 was there any apparent geographic grouping of cases indicating a well localized infected centre. Upon this date there began the outbreak of plague among the employees of the Manila Railway Company, laborers at the freight station and yard of the company. This freight station and yard is located between Calle Azcarraga, Calle Dagupan and Calle Antonio Rivera. The outbreak totalled 17 human cases, all fatal, and extended into November. Indeed, the last case traced to this focus occurred on December 7, 1912.

During the present epidemic of plague in Manila this focus was the only one to which a larger number of cases than five could be traced, and in all the other instances where multiple cases were traced to an infected centre, the foci were all single buildings.

The locations giving rise to multiple infections and the number of cases of plague developing at each address, with months of incidence, are as follows: Calle San Fernando (804–814), November, 1912, 4 cases; Calle Teodoro Alonzo (518), November and December, 1912, 2 cases; Calle Cabildo (Intramuros), November and December, 1912, 2 cases; Calle Comercio (1028), February, 1913, 2 cases; Calle Sande (1364), April, 1913, 5 cases; Calle Juan Luna (1226), May, 1913, 2 cases.

Returning to the Manila Railway outbreak, it is necessary to state that a well-defined epidemic among rats preceded this outbreak, resulting in the death of a large number of rodents (undoubtedly from rat plague). This epidemic was not reported by the railroad company until the outbreak of human plague had begun. It was then too late to identify plague in the dead and mummified rats found under floors, platforms and elsewhere, but the fact that large numbers of rats had recently died here was established by the unanimous testimony of the employees at the freight station and the finding of rat cadavers.

As stated, the human outbreak here occurred upon October 21, and fifteen cases developed within 3 days.

This indicates an extensive desertion of fleas from plague rat cadavers and an attack upon human beings, after a fasting period, on the part of the fleas, of several days. The human outbreak at the station and the death of a large number of rats at the same place, just previous, correspond to a nicety and establish to a moral certainty the connection necessary to explain the epidemic.

After the railway epidemic of human plague, cases continued to occur through November and December, without apparent relation to each other, except in the following instances, which have already been mentioned:

Four cases under one roof on Calle San Fernando (November 12, 13, 16 and 22); 2 cases in one house on Calle Teodoro Alonzo (November 26 and December 2); and 2 cases in the same house on Calle Cabildo (Intramuros), November 23 and December 11.

These multiple cases will be referred to elsewhere.

The other cases during October, November and December were apparently sporadic and unrelated, either to the other human cases or to the few scattering cases of rat plague discovered from time to time. Without doubt, however, all were actually related to preceding cases of rat plague, *i.e.*, to undiscovered rat cadavers, dead from plague and deserted by infected fleas.

In the following plague houses (see list of cases) dead rats were actually found, although the advanced degree of desiccation and mummification defeated the biologic determination of the cause of death: 518 Calle Teodoro Alonzo; 973 Calle Azcarraga; 282 Estero de Binondo.

In other plague houses the recent finding of dead rats was alleged by the occupants, but rather too indefinitely to record positively.

A study of the maps and lists showing the localities in which cases of rat plague had been found up to this time (December 26, 1912), in connection with the location of plague houses, was much less suggestive than a similar study of the lists and maps covering the cases of 1913.

However, the existence of concurrent rat plague and human plague, in corresponding sections of Manila, had been well established already by bacteriologic studies of captured rats, made at the Bureau of Science.

Of nearly equal weight was the observation concerning the two epidemics, rat and human, at the Railway Station, which I have already described.

The year 1912 closed, then, with a recorded total of 50 human cases and 7 verified cases of rat plague.

January, 1913, saw but a single case of human plague. This occurred on January 24, just a month from the last previous case, that of Christmas Day. During this month no case of rat plague was reported.

In February, 3 human cases occurred and in March, 4 cases were recorded.

Early in March, 1913, cases of rat plague began to occur in the Tondo district in a section lying between Manila Bay and the Estero de la Reina and extending northward from Calle Moriones. This was a new district for rat plague and as the cases increased in number we were able to foresee and predict the appearance of human plague in the same district, which in point of congestion of population, poverty of its residents and in the matter of dilapidation of its light material houses and shacks, is about the worst locality in Manila.

From March 22 to September 20, 1913, all the cases of human plague, 11 in number, occurred in the midst of this district. During the same period 25 cases of rat plague were reported from the same section, and a glance at a map of this part of Tondo instantly shows the relationship existing here between rat plague and human plague.

This relationship is additionally emphasized by referring to the memoranda concerning certain overcrowded houses, in the midst of the rat plague district, where multiple human cases occurred. (See memoranda in re 1226 Calle Juan Luna and 1364 Calle Sande.)

CLEANING AND RAT PROOFING IN BASEMENT OF 1226 CALLE JUAN LUNA IN WHICH TWO CASES OF PLAGUE OCCURRED. RAT CADAVERS FOUND UNDER BROKEN FLOORS (MANILA PLAGUE CAMPAIGN)

The human cases in April were 5 in number, all originating in the same house, and the May cases numbered 4, two of which occurred in the same house.

It may be explained, in passing, that two cases of human plague, discovered in Malolos, 25 miles from Manila, on March 23 and March 26, respectively, were definitely traced to the same house in Manila, number 12 Calle Aguila, Tondo, both patients having lived in the basement of this house until within 48 hours of the development of the disease. These persons were unrelated and were two of a large number of people who lived in a tenement at this address. Both patients were detected, while still alive, in Malolos, where they were living in different and widely separated houses. One of the patients died in Malolos but the other one was brought to Manila by train and died at San Lazaro Hospital. Fortunately no infection was transferred to Malolos by these two persons. In this connection it is interesting to note that no other cases have been reported from outside of Manila, except the small outbreak in Iloilo in the southern islands, where the antiplague work was successfully directed by Dr. Carroll Fox. Concerning this outbreak, Dr. Heiser, then Director of Health for the Philippines, writes as follows (*Philippine Journal of Science*, February, 1914):

Plague in Iloilo.—In Iloilo, a case suspicious of plague was reported on July 5, 1912, and this diagnosis was subsequently confirmed by the laboratory. It

occurred in the person of a Chinaman who was reported to have come from Bais, Oriental Negros, but later investigation showed that he had been a resident of Iloilo at least since February, 1912. The next case was reported August 18, and the last case, September 17, 1912. There was a total of 9 cases. All of the cases were confined to two houses. During July, August, September, and October, 1146 rats were caught in the vicinity of the houses in which the human cases had occurred, along the water front, and in the places which were regarded as suspicious, but in not a single instance was an infected rat found.

Directed to Take Charge of Plague Suppressive Measures.—Upon my arrival in Manila from the United States, on October 23, 1912, I received orders from the Director of Health to take charge of all plague suppressive measures in Manila and I remained in charge of this work continuously until July 11, 1914.

Plague Fighting Organization.—The plague fighting organization was composed of three American Sanitary Inspectors and from ten to fifteen native Assistant Sanitary Inspectors of the Bureau of Health, rat catchers and laborers of the Bureau and laborers of the City of Manila supplied by the Department of Sanitation and Transportation. The combined force varied in numerical strength from 100 to 150 men and was usually divided into three parties, distributed in various parts of the city according to the local indications and needs from time to time.

After the invasion of Tondo by rat plague we made special effort to rat-proof the light material houses of that section, in the course of our cleaning operations, by the closure of the open ends of bamboo timbers with cement and with tin cans, in the manner shown in photographs herewith. In addition to this, special attention was given to the repair of broken cement work, and hundreds of Bureau of Health orders, verbal and written, were issued to owners, at my request, in the rat plague districts.

The number of houses in which bamboo timbers were closed by cement or tin exceeded a thousand.

In addition to these means, the very important matter of depopulating the insanitary basements of the light material houses in squares where plague has occurred was given attention, with the result that hundreds of families were moved from these insanitary and dangerous ground-floor rooms to quarters well above ground and measurably removed from the rats, which roam over the ground from house to house, foraging for food under kitchens and in ground-floor storerooms, tiendas and eating places. The fish packing factories afford them abundant food and a number of cases of plague have occurred adjacent to these fish-drying establishments.

Rat-proofing and Rat Destruction.—While it is frankly admitted that rats may not be completely exterminated by poisoning and trapping, the statement, so frequently repeated of late, that destructive measures really increase their number, is unwarranted and unsustained by facts, at least in Manila. It seems to be the common practice for disbelievers in trapping and poisoning to array the methods of rat-proofing and rat destruction as alternative policies, whereas everyone practically familiar with the work in such cities as Manila—or even in the United States—knows that there is often no choice permitted. Rat-proofing is highly desirable, permanent in its results, and in every respect the "method of election." On the other hand, it is entirely inapplicable at certain times and in certain localities where poverty, lack of interest of property owners, and ofttimes lack of interest and of money on the part of municipalities, absolutely preclude its immediate application. It is therefore unfortunate that the statement, that rat poisoning and trapping are ineffective, either in controlling plague or in reducing the numbers of rats, is circulated. It may be shown easily, by the daily records, that within a few weeks after extensive rat poisoning and trapping (with the breaking up of nests) is pursued in a given locality, the rat catch drops in the most decided manner.

Individual premises may be practically cleared of rats by continued intelligent rat catching and poisoning, and while the normal rat birth-rate may keep pace with the normal rat death-rate it will not keep pace with the normal death-rate plus the poisoning and trapping death-rate in any given locality, provided that the poisoning and trapping, with the destruction of nests, be intelligently and continuously carried out.

Rat-proofing and rat destruction, then, should not be contrasted as alternative procedures or policies. Both are valuable and each has a proper place. In communities non-infected with plague and unexposed to infection it will probably be found that rat-proofing, carried out in connection with the repairs of old buildings and the erection of new ones, will meet the requirements. On the other hand, in cities exposed to plague infection or already infected, rat destruction is bound to be necessary for years to come.

In emergency, the removal of people from intimate relationship with rats (so far as is possible), as practised recently in Tondo district, Manila, will often have to take the place of rat-proofing; and rat destruction and expulsion will be found, in the last analysis, to be the methods upon which success or failure in fighting plague during epidemic time will depend.

In this connection I quote correspondence which passed between the Director of Health and myself in 1913.

Upon March 22, 1913, I directed the following letter to the Director of Health:

Sir: I have the honor to state that Estaban Masibac, aged twenty-two, laborer, who died at 140 Perla of bubonic plague, slept upon the ground floor of this house upon a bamboo bed. All these basement dwellers in this district now infected with rat plague are in considerable danger.

The roving rats which wander over these ground surfaces from house to house come into pretty close contact with these basement dwellers, and it would appear that they visit the upper stories of the houses rather infrequently, unless food is stored there. Upon the ground they forage upon the food dropped there by the residents of the houses.

I would like to have authority to order the vacation of these basement rooms which are almost invariably unfit for human habitations.

I look upon this measure as an important one at this threatening time and believe it should be enforced in every square or block where plague rats have recently been found. If this authority is granted it will be used judiciously.

Very respectfully,
[Signed] T. W. Jackson,
Medical Inspector in Charge of Plague Suppression.

Upon March 24 I received the following letter of authorization:

Sir: Confirming my verbal instructions of yesterday I have to request that, in accordance with the recommendation contained in your letter of March 22, that on account of the danger of the spread of plague in the district in which plague has appeared extensively, the basement dwellers in blocks, or squares, in which plague has been found, should be ordered to vacate.

Very respectfully,
[Signed] Victor G. Heiser,
Director of Health.

Upon November 26, 1912, five dead rats were reported from the U. S. Army Commissary Warehouses on the Pasig River near the Malecon. They were found dead by workmen there and were thrown into the river by the finders and thus, unfortunately, examination for plague was prevented.

Upon November 27, a cat, known to have caught and eaten rats recently at the same place, was reported to be sick. I took the cat to the Bureau of Science where she was observed until she died, three days later.

At autopsy, typical bubonic plague (cervical) was disclosed, and several guinea-pigs inoculated from the spleen and bubo died from the same disease. A guinea-pig, inoculated from a swab introduced into the cat's rectum, also died from plague (see report of Dr. Schöbl).

Four kittens, recently born of this plague cat, were observed for two weeks but showed no sign of the disease.

Subsequently about 80 rats were caught at these warehouses and in the vicinity, but none of them showed post-mortem signs of plague. The Medical Department, U. S. Army, then took up the matter of rat catching on all military reservations in Manila and in all buildings thereon, but no more cases of animal plague were discovered.

Fleas and Their Habits.—In "Observations Upon the Bionomics of Fleas Bearing Upon the Epidemiology of Plague in Eastern Java," by N. H. Swellengrebel, Ph.D., published by the government at Batavia, Dutch India, in 1913, some interesting facts, developed by study and experimentation, are presented. Some of these facts have a bearing on the plague problem in the Philippines, for it should be borne in mind that certain climatic similarities and racial similarities pertain commonly to the Javanese and Filipinos and their respective countries.

While we are not prepared at present to make general application of the Javanese findings to the Philippine Islands, for lack of parallel or confirmatory studies in the Philippines, we may state some of the conclusions of the Java workers with propriety, and we may also point out similarities in the construction of certain Filipino and Javanese habitations in their relation to rat harboring.

Swellengrebel, in Java, noted the number of fleas per rat, dealing with *Xenopsylla cheopis* (the commonest rat flea in Java) almost exclusively. This flea, it will be remembered, is also the common rat flea of India, the Philippines, Australia, Italy, Brazil and tropical countries generally, being variously known as *Lœmopsylla cheopis*, *Pulex pallidus*, *P. brasiliensis*, *P. philippinensis*, and (in Italy) *P. murinus*.

It would not be unreasonable, therefore, to expect to find at least some of his observations applicable to the Philippine Islands.

Swellengrebel failed to find *Ctenocephalus canis* (dog flea), *C. felis* (cat flea) and *Ceratophyllus fasciatas* (the common rat flea of the United States and Europe) upon Javanese rats. In attempting to determine the normal flea census he found that field rats, and field rats caught indoors,

as well, generally carry fewer fleas than house rats and that the number of fleas per house rat varies in different districts from .02 per rat to 2.3 or 4 per rat and that this variation is not invariably constant with the presence or absence of rat plague. Concerning the question whether or not a high flea census may indicate rat plague, Swellengrebel offers the reasonable opinion that there is little doubt that plague in rats increases the number of fleas per rat above normal and that, consequently, a sudden or marked increase in the number of fleas per rat, without a known normal cause, indicates increased rat mortality and probably rat plague.

As to the influence of temperature and humidity on the hatching of larvæ, he concludes from experimentation that the duration of development of the egg varies under various hygrometric conditions, the general rule being, "the lower the humidity the longer the development period."

As to the influences of temperature and humidity upon the transition of larva to imago he finds that if humidity diminishes, a smaller number of larvæ reach the adult stage; and also that a saturated humidity (in artificial cultures), causing condensation of water in the substratum, is very fatal to larvæ. He offers the thought that this, perhaps, explains why only small numbers of fleas are found on field rats which live in holes in rice fields which are necessarily damp, especially in the rainy season.

His experiments to determine the duration of life of fasting fleas were made with laboratory-bred fleas which had never fed on blood and with fleas which had already sucked blood.

The duration of life was variable, but of those fleas already fed with blood three-quarters (¾) perished within 10 days and the remainder lived from ten to twenty days, only one-tenth, however, surviving for 13 days, if moist conditions were maintained. High temperature was determined to be an unfavorable condition.

If from these findings one should attempt to predicate or predict the extension of plague in house rats—based on flea prevalence—and this with relation to climatic conditions, we should be led to the conclusion that the rainy season, with its greater humidity, would be quite the most favorable time of year for rat plague extension in Manila and, upon the contrary, that the hot dry season through its unfavorable influence upon flea breeding would be the least favorable season for rat plague in Manila.

The hot months of 1913 did not bear out this reasoning, however, for during these months rat plague was at its height.

That increased prevalence of human plague has not gone hand in hand with increased prevalence of rat plague in Manila, may be explained, I feel sure, by the activity of our efforts to destroy rats and to remove the people from close relationship with them.

Another factor of possible explanation of the greatest prevalence of human plague in Manila during the late rainy season of 1912 (October), is the fact that rats are certainly driven above ground into houses and therefore into closer relationship with man by heavy rainfall and the consequent flooding of their subterranean homes.

It appears, therefore, that the seasonal explanation of greater plague prevalence, rat or human, is susceptible of several interpretations and I feel sure that in countries like the Philippines seasonal variations in heat do not suffice to rid the rats of fleas during any months of the year. If, then, conditions of rainfall serve to drive the rats above ground and indoors during certain months, it would be reasonable to expect more human plague from closer relationship of rat and man,—provided that no special measures were carried out.

Such, however, is not invariably the rule, if statistical studies are to be taken as evidence, and so we are reminded that generalizations for countries of different climates and seasons are not wholly reliable.

Rat breeding, as well as flea breeding, is influenced by climate, but as the reproductive activity of the rat is most retarded by cold weather—an unknown condition in the Philippines—and as the climate of Manila is fairly equable so far as heat and cold are concerned, the only factor which needs to be considered is that of rainfall. As already mentioned, rainfall doubtless serves to drive rats above ground and so, to a certain extent, away from their nests in burrows and underground.

Their well-known adaptability to changing conditions, however, permits them to house themselves comfortably above ground when driven out of these burrows and holes.

Javan Observations.—The following conclusions were reached by Dr. J. J. van Loghem in a report upon "Some Epidemiological Facts Concerning the Plague in Java" (published by Civil Medical Service in Netherlands India-Batavia, 1912):

1. In plague-infected villages, as distinguished from plague-free villages, there exists a considerable mortality among house rats.
2. Rats in plague houses and plague quarters have repeatedly died from plague. Fresh plague rats appear more often in the houses adjoining plague houses than in the houses themselves.
3. The house rat exists even in the immediate vicinity of man.
4. The ordinary parasite of the house rat is *Xenopsylla cheopis*, which experimentally is known to choose man as a host when starving.
5. Fresh plague rats have repeatedly been found to harbor a great number of fleas.
6. Virulent plague bacilli have been demonstrated in the stomachs of such fleas.

Concerning the prevention of plague by improving the native dwellings, the same observer says: "Obviously an increase in the distance between man and rat becomes an important factor as a means of preventing the disease."

Conditions of Manila Habitations Favorable to Rats and Plague.—As shown by our own experiences in Manila, this end, the separation of rats and men, is not obtainable by destruction of rats by poison, traps and rat catchers. Rats dying of plague in their nests furnish the greatest danger to man. The plague problem, therefore, where rats are already infected, from the stand-point of direct prophylaxis, is the problem of dwellings. It was from this stand-point that we attacked the problem in the Tondo (Manila) campaign in 1913.

Manila Verification of Javan Observations.—Having in mind the experiences of the plague investigators in Java during the recent epidemics there (1911–1912), we sought, from the time the Manila outbreak occurred, to verify some of the findings of the Java investigators, at least with special reference to the nesting of rats in close proximity to human beings and the consequent exposure of these persons to the infected fleas which desert the rats dying from plague in these nests.

Not until rat plague invaded the special district of Tondo, in Manila, in March, 1913, did the opportunity present itself. Theretofore the Manila cases had generally appeared in houses of the so-called "hard material districts," where house construction is entirely unlike that with which the Java workers dealt. With the invasion of Tondo, however, the Java and Manila conditions became similar. I quote the descriptions of Javanese house construction from the report of Dr. J. J. Van Loghem, "Some epidemiological facts concerning the plague in Java," Batavia, 1912.

The Javan Village House.—In substance, he says that the Java village house, as a general type, is a one-storied structure with its roof sloping to the front and back, *i.e.*, with its ridge parallel with the front and back aspects of the building. It is not elevated above the ground by supports or palisades and has no separate floor, the earth serving as the floor.

The outer frame is of strong bamboo poles and the inner frame is also constructed of bamboo. These bamboo timbers are perforated at various points to permit of framing with other pieces of bamboo and for the entrance of pegs, etc.

The roofs of these houses are often made of tiles, but at times the familiar thatched roof is seen. In both cases the supports or rafters are bamboo poles. The principal piece of furniture is the "bale bale," or bedstead, usually made of bamboo, except in the houses of the well-to-do. Small storerooms are often located in the houses, and stables are sometimes built against them. In many cases the family provisions are kept in the house and the cattle are housed here as well.

Manila Light Material Houses.—If, now, we turn our attention to the average Tondo (Manila) light material house it will be apparent that the description given for the Java village house fairly describes the Tondo house, except that the Philippine house is commonly elevated 2 metres or more above the ground upon bamboo supports (see photographs). The basement is usually enclosed in a manner similar to the principal room of the Java house and the basement room may fairly be compared, structurally and in the matter of its floor, with the one-story Java house. In the Manila house, however, the floor of the upper room takes the place of the roof of the Java house and like it is supported by bamboo timbers.

Here, then, in our enclosed basement story, we have a practical replica of the one-storied Java house.

Here, also, the principal piece of furniture is often a bamboo bed, practically identical with the Java "bale bale," if we may judge from photographs.

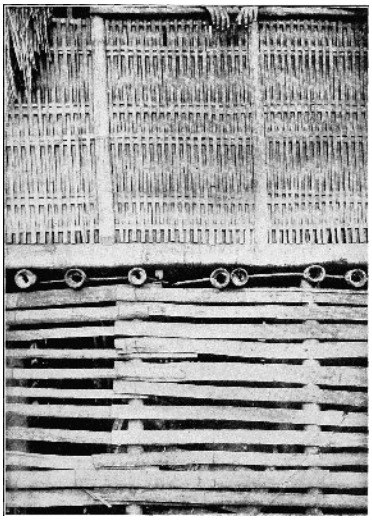
In the Java houses the favorite nesting places for rats were found to be the interiors of horizontal bamboo pieces of the roof, house frame and bedstead.

The rat usually gains entrance by gnawing through the natural partitions between the bamboo sections near the outer end of the pole. Our Manila photographs show both the natural open ends of such timbers and the rat-gnawed perforations in the partitions.

In Java, rats also nest in the thatched roofs, as they occasionally do in the Philippines.

Nest Materials.—The materials utilized for nests by rats in Manila and Java seem to be identical also. Straw, dry leaves and pieces of cotton are

mentioned in the Java reports. The same materials and additional ones will be found mentioned in our reports upon nests.



BAMBOO HOUSE SUPPORTS NOT SEALED WITH CEMENT. NOTE HOLES GNAWED IN BAMBOO ENDS. RATS FREQUENTLY MAKE NESTS IN THESE HOLLOW BAMBOO RAFTERS.

The presence of food was also noted in the bamboo nests in Java and we often find articles of food in our Manila nests.

Dr. Korn, P. H. Service, and the writer (T. W. J.) investigated a good many of these bamboo house-timbers and we not only found such evidences of rats as food, rat fæces and nest materials, but in one case a rat was actually driven out of a bamboo nest by introducing a long thin strip of wood. The evidence of similar conditions then is complete.

We also duplicated the experiences of the Java workers in finding dead rats inside of the bamboo house timbers in close proximity to patients sick (or dead) with plague (see memoranda in the case of Esteban Masabik, of 140 Calle Perla, March 22, 1913).

Very extensive rat destruction and cleaning operations, covering a large portion of the city of Manila and including all sections where cases of rat plague or human plague developed, were undertaken and this work was carried on without interruption for about two (2) years. City laborers to the number of 60 to 150 were used and the work was supervised by Sanitary Inspectors Brantigan and Searcy, of the Bureau of Health. During a part of the time a flying column of 50 men, under Sanitary Inspector Hunniecutt, was detached from the main party and employed at placing rat poison.

The total amount of accumulated dirt removed from houses and yards approximated 5250 tons (for 17 months ending November 1, 1913).

Without doubt this general cleaning campaign and the removal of this enormous accumulation of dirt and rubbish was of great value as an antiplague measure.

The rat catch will always be found to depend upon several factors, viz.: the number of persons employed; the number of traps and portions of poison placed; the location of the operations and the length of time a given locality is trapped, poisoned and cleaned. The variety of baits and poisons will also affect the results.

In addition to these factors certain others are found to operate in reducing the rat catch, as, for example, weather conditions and the occurrence of Sundays, holidays and the days just preceding and following holidays.

Upon rainy days and the days just mentioned the rat catch almost invariably falls off.

From statistics collected by me in connection with this work, Dr. V. G. Heiser, then Director of Health for the Philippine Islands, published the following memorandum in 1914. As it is a correct transcript of my records I introduce it here in its entirety.

Comparative Statistics in Rat-catching Methods.[3]—With a view to ascertaining which type of rat trap was most effective and also the average number of rats that are caught by a given number of poisoned baits that are set out, statistics were kept during the antirat campaign in Manila. The ratio maintained in catching rats with two types of traps is indicated in the following table, a perusal of which will show that for the three months ended June 30, 1913, there were 120,565 spring or snap traps set and that for every 100 of this type of trap set there were caught 6.9 rats. During the same period there were 47,075 wire cage traps set; the total number of rats caught was 339; which gives 0.72 rat caught for each hundred traps set. For the quarter ended September 30, 130,627 spring or snap traps were set and 9,753 rats were caught, which gives 7.47 for each 100 traps set. During this period 40,621 wire cage traps were set and 395 rats were caught, which gives 0.97 rat caught for each 100 wire cage traps set.

[3] Reprint from the Public Health Reports, Vol. 29, No. 6, February 6, 1914.

Kind of trap or poison	Quarter ended June 30			Quarter ended Sept. 30		
	Number set	Number of rats caught or poisoned	Per cent.	Number set	Number of rats caught or poisoned	Per cent.
Spring or snap traps	120,565	8,377	6.9	130,627	7,753	7.47
Wire cage traps	47,075	339	.72	40,621	395	.97
Poison bacon, rice, or coconuts	166,237	1,216	.731	177,309	216	.12

	Quarter ended—	
	June 30	Sept. 30
Number of rats:		
Caught by dogs	160	5
Killed with clubs and other weapons	2,889	3,818
Found dead from other causes	316	297

No accurate record was kept of the number of each kind of rat bait set. Only the total of all was recorded. Bacon or coconut with strychnine and rice with arsenic were used. For instance, for the quarter ended June 30, 1913, there were 166,237 poison baits set in new territory and the rats found poisoned average for each 100 baits 0.72. During the next quarter there were 177,309 baits set in territory that had been worked over, and only 216 rats, or 0.12 rat per 100 baits, were killed. From the foregoing it appears that the rat poison ranks lowest in efficiency but perhaps highest in economy. In view of the fact that the original cost of the cage trap is many times more than that of the spring trap, and the cost of maintenance is very high, it will be apparent that the spring trap is by far the more economical as well as more effective of the two.

Generally speaking, however, the number of rat catchers engaged and the location of their operations has the largest influence upon the total catch of rats. For the fiscal year July 1, 1912, to June 30, 1913, inclusive, the total catch was 55,101 rats (Manila only); to December 1, 1913, 79,676.

The most natural explanation of the general correspondence between the highest rat catch and the highest incidence of human plague would be

upon grounds of greater activity in rat catching effort at times of greatest plague prevalence, but from the inauguration of general systematic rat catching there was no cessation of effort, even during the abatement of plague, and in consequence this explanation does not apply strictly.

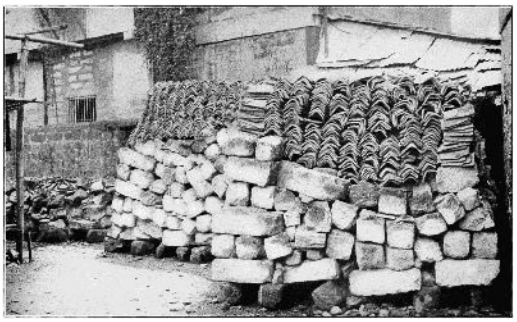
It is true, however, that whenever plague occurred in districts theretofore free from the disease, rat catching was pushed vigorously in the surrounding localities.

Making due allowance for all the factors mentioned I am impressed with the probability, amounting almost to certainty, that the catch of more than 79,676 rats definitely affected and checked the spread of plague in Manila in 1913; and I am of the opinion that systematic and wholesale rat catching, carried out in the most economical manner possible, should be persisted in indefinitely, at least until plague disappears, wherever the disease occurs.

Efforts to prevent the spread of plague to the provinces of Luzon, by way of the railways, were successful and the present measures employed, freight inspection, the fumigation of packages suspected or likely to contain rats, and the similar treatment of freight cars showing signs of rats, should be continued. In a few cases these measures have driven rats out of both packages and cars and the animals have been killed by the sanitarians on duty at the station.

The matter of water transportation was entirely within the control of the authorities in charge of inter-island quarantine affairs.

Rat catching in Manila was systematically performed and all rats captured were turned over to the Bureau of Science for examination for plague.



MATERIALS MUST BE MOVED ABOUT IN THE SEARCH FOR RATS (MANILA PLAGUE CAMPAIGN)

When plague foci were discovered the localities were trapped and poisoned both circumferentially and centrally, with a view to preventing the diffusion of infected rats throughout the city.

Rat-proofing.—The theoretic desirability and superiority of "out building" the rat, over all other methods of rat suppression, is admitted. The apparent impracticability of actually rat-proofing Manila at the present time and our inability to starve the animals out, justify the other and less permanent measure, viz.: rat catching. However, I heartily favor and urge the most complete and thorough-going rat-proofing of buildings actually infected with human or animal plague, in all cases. The building ordinances of Manila already provide for rat-proof construction in all new buildings erected.

With a view to cutting off the food supply of the rat, more than 1100 orders upon householders, to provide covered garbage cans, were served in the district of Tondo alone.

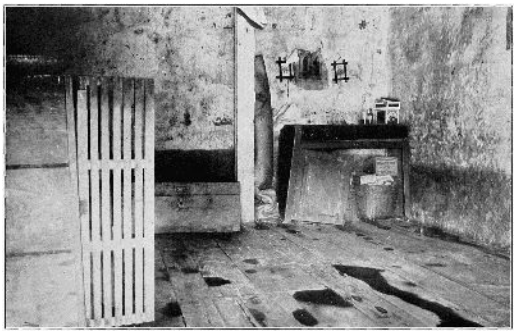
The open ends of bamboo timbers in more than 2300 houses were closed, either by cement or tin cans, during 1913.

Theatre Disinfection.—All the cinematographs and theatres in the city were disinfected upon repeated occasions by spraying with petroleum and cresols, with a view to destroying fleas and preventing plague infection.

Attempts at deception and concealment of plague patients, upon the part of members of their families, were numerous, but with the close scrutiny of death certificates and dead bodies exercised at all health stations it is believed that all cases were recognized.

One case of extremely careless diagnosis occurred. A death certificate was furnished by a local native doctor who certified the cause of death to be "uterine hemorrhage." Suspicion arising, an autopsy was ordered and a pronounced case of bubonic plague was disclosed postmortem. No evidence of uterine hemorrhage, except slight menstrual signs, was found.

The destruction of infected fleas in plague houses is of course the primary object of the disinfection by spraying, which is thoroughly carried out in every house where a case of human plague or rat plague appears. The method is a simple one and consists in spraying a mixture of cresols (2 per cent.) and kerosene (98 per cent.) over all surfaces of the house, floors, walls, underlying ground, furniture and the spaces above ceilings, etc., using the mixture liberally and securing a general surface distribution. There is no doubt of the toxicity of this mixture to all fleas and bed-bugs which it reaches, and it is undoubtedly an effective measure in rendering an infected house safe. All of the instances of multiple house infections, where the cases recurred after disinfection, in Manila, have been in houses where, for one reason or another, the recommended structural rat-proofing has been postponed or where it has not been done. Thus, on Calle San Fernando the sequence of the four cases (their progress by days and in consecutive houses) is explained by the travel of rats through efficient rat runs present in the walls and ceilings, rather than by the passage of fleas through partition walls, from uncommunicating house to house.



A RAT INFESTED PLAGUE INTERIOR

So also at Calle Cabildo, where the superstructure of the house was a veritable sieve, there was a series of communicating double walls.

At the house on Calle T. Alonso a similar condition existed, but here the two cases which occurred may have been synchronously infected, or nearly so, previous to disinfection of the premises.

At Calle Comercio, where six days elapsed between two cases, the rooms and building were piled full of merchandise, defeating immediate disinfection, that is, efficient disinfection, until all the merchandise was moved and the rooms were emptied.

At 1364 Calle Sande, Tondo, where 5 cases originated, the infections were undoubtedly almost synchronous and no infection occurred after disinfection of the house, while at 1226 Calle Juan Luna, Tondo, the two cases were plainly infected at about the same time and this previous to disinfecting the premises.

Guinea-pigs as Indicators of Infected Houses.—The following experiment shows strikingly the necessity for disinfecting houses where human or animal plague cases have occurred.

Upon December 17, 1912, Dr. O. Schöbl, of the Bureau of Science, and myself, placed two healthy guinea-pigs, free from fleas, in a wire trap cage in the house at No. 4 Calle Barraca, a few hours before the house was disinfected, a patient with plague from this house having died within the preceding twelve hours. The cage containing the guinea-pigs was placed exactly where the patient had slept upon the floor, as indicated by the other tenants of the house. Disinfection was delayed for a few hours and the guinea-pigs were left in the house for one day. Upon December 21 one of the guinea-pigs died from typical bubonic plague—anatomically and bacteriologically positive—other inoculated experimental animals also developing the disease.

Other guinea-pigs placed in plague houses on Calle Cabildo and Calle San Fernando, after disinfection of the premises, failed to acquire plague.

Natural Enemies of the Flea.—It was observed during the studies in Java that certain natural enemies of fleas exist and operate against their laboratory cultivation and their natural reproduction.

Ants of several varieties, large and small red ants and small black ones, were found to be very antagonistic to fleas, both in the larval and adult states, destroying them actively.

Fleas in the laboratory were found to be affected with mites, with a resultant high mortality among the insects. The same parasites were not found upon wild fleas. On account of the prevalence of mites upon the laboratory fleas certain experiments concerning the transmission of plague were vitiated.

The activity of ants in attacking and disposing of rat cadavers found in our antiplague work in Manila was frequently brought to my attention. We invariably included an attack upon ants in treatment of houses known to harbor, or suspected of harboring, plague rats. The combination of kerosene and cresols, elsewhere referred to, was found to be perfectly satisfactory in the destruction of ants; assuming, of course, that the necessary procedure of exposing the ants, by the moving of merchandise, boards or other protecting materials, was performed, so that contact, by spraying the insecticide mixture, was secured.

Activity of Fleas.—It was also observed during the Java studies that the rat flea, while rather lazy, may and does cover distances of five metres and that he sometimes covers eighteen centimetres at a single leap.

In addition to this, of course, there must be considered the possibility of his falling considerable distances.

Zoölogic Classification of Rats.—The matter of accurately, systematically and scientifically cataloguing and classifying rats is one of great difficulty and is not to be undertaken by anyone but a trained naturalist. However, some of the notes we have at our disposal, gathered from many sources, may be set before the reader. It is extremely difficult to find exact correspondence of statement in the various classifications offered by writers upon plague and rats.

Dr. Lantz gives the following brief classification in his section of the publication, "The Rat and Its Relation to Public Health."

Order: *Rodentia.*
Family: *Muridæ.*
Genus: *Mus.*
Species are many, but only three or four are cosmopolitan.
Cosmopolitan species: *Mus rattus*—black, brown, and roof (*Alexandrine*) rat; *Mus decumanus*—gray, barn, wharf, sewer, and Norway rat.

Mus rattus has many varieties known throughout the world and these are named according to color and habitat.

In addition to the names given in Lantz's classification, we constantly see reference to the black house rat, the brownish-gray rat (*Mus Alexandrinus*), the ordinary ship rat, the field rat, etc.; terms descriptive of habitat and appearance being very loosely applied. Little account is taken, by many, of the well-known variations in the coloration of rats due to climate and season and of the well recognized aptitude of the rat for living in-door or out-door according to circumstances of food supply, weather, etc. The "sawah" rat of Dutch India, implicated in the prevalence of plague there, was formerly considered a variety of *Mus decumanus*, but is now described as a field variety of *Mus rattus*. So too, varieties of *Mus decumanus* are frequently named according to alleged geographic origin, habitat, color and habits, viz.: sewer rat, brown rat, Norway rat and migratory rat.

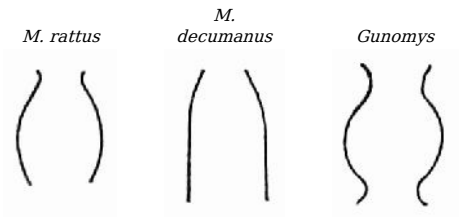
The inevitable confusion bound to arise from such loose classification is obvious.

Another genus, *Gunomys* (*Nesokia*), implicated in plague, is represented in India by two species and by at least one (an undetermined one) in Java, some confusion existing in the matter as yet. Members of this genus are described as large, rough-coated rats which live both as house rats and field rats. In India the Plague Commission reported specimens of this genus as particularly susceptible to plague.

In the Philippine Islands no specimens of *Gunomys* have been observed, but *M. rattus* and *M. decumanus* are both present and numerous and both are subject to plague, as shown by the presence of the disease in specimens examined.

In view of the unreliability of the points of difference in rats usually given as identifying data, such as the number and location of the mammæ, the variations in color and the peculiarities of the footpads, the Javan observers depend upon the conformation of the skulls for the determination of genera, the skull of *M. rattus* being oval and arched, that of *M. decumanus* more closely approaching the square and rectangular conformation, and that of *Gunomys* being broader, higher and longer than either.

In *M. rattus* the prominent borders which separate the parietal from the frontal surfaces of the skull are oval; in *M. decumanus* they are parallel or slightly divergent; in *Gunomys* they are lyre-shaped.



To determine these differences the heads of the rats are cut off, the tissues desiccated by antiformin, or by boiling and stripping.

From experiences in Porto Rico, Creel, of the U. S. Public Health Service, concludes that *M. norvegicus* (*decumanus*), while essentially a burrowing animal and not addicted to climbing or swimming, is nevertheless quite capable of doing either. He was found to burrow in the hardest earth to a depth of two and one-half feet and to pass through all kinds of wood, soft brick and lime mortar, probably by gnawing.

The black rat and Alexandrine rat (*M. rattus*) in Porto Rico, according to the same observer, do not burrow at all, but can climb and jump in expert manner, and are the species found in the rural districts, remote from houses. He found that all varieties of rats may swim, from ships to the shore, distances of from one-fourth to one-half mile, but that they lack the sense of direction and probably do not land from ships naturally in this manner (*Public Health Reports*, No. 9, February 28, 1913).

The female *decumanus* is a prolific breeder and brings forth larger litters than the *Mus rattus* female.

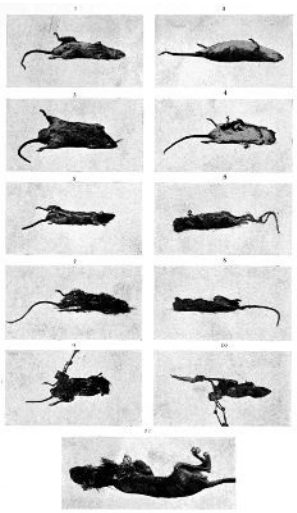
Mus decumanus is generally conceded to be larger and more ferocious than *Mus rattus*. For this reason he drives the smaller rats to the upper floors, the *decumanus* species generally living near the ground. He is a burrower and is rarely found in the upper stories of buildings. *Decumanus* is known as a wharf rat, but is rarely trapped on ships on the Pacific Coast, according to the observations of Surgeon Simpson of the U. S. Public Health Service (*Public Health Reports*, April 11, 1913). According to the same observer, *Mus rattus* is the commonest ship-borne rat. He also states that the black rat and the roof rat (*Alexandrinus*), both varieties of *M. rattus*, differ chiefly in color. They live in upper floors, between ceilings, in walls and roofs and are remarkable climbers as well as being expert rope-walkers and wire-walkers. On account of their natural wariness and caution it is not always easy to induce them to enter or approach traps.

The photographs introduced were taken under my direction in Manila in 1912, 1913 and 1914. Some of them show the character of the house construction in Tondo District, Manila, where plague flourished in 1913. Others illustrate methods of rat-proofing bamboo timbers in houses of light material. These end openings were either closed by introducing cement or by placing tight-fitting tin cans over the ends of the bamboo rafters.

There are many interesting memoranda, gathered and made in connection with our antiplague work in Manila, especially concerning the location and construction of rat nests found by our laborers; the materials used and the fabrication of the nests. Memoranda giving details of rat catching and rat-proofing are also presented and notes showing the location of dead rats found in relation to dead human bodies of plague victims.

Notes concerning cases of multiple house infection are also presented as being of possible interest.

The Javan studies in 1911 and 1912 establish the fact that it is possible to form a fair judgment as to the length of time a rat has been dead, up to ten or twelve days, from the condition and appearance of the rat cadaver, both as to decomposition and drying. A series of 50 rats was studied. It is to be understood that the conditions under which these observations were made were tropical conditions. They would be fairly comparable with summer conditions in America, but should not be followed too closely at other seasons of the year. In my own experience I have observed that ants are likely to attack the cadaver early and to obscure the deductions by their destruction of the body.



PROGRESSIVE POST-MORTEM CHANGES IN RAT CADAVERS. THE NUMBERS INDICATE THE NUMBER OF DAYS AFTER DEATH

Days after death	Appearance
First to third day	Distention of the abdomen, increasing.
Second to third day	Loosening of hair by gentle pulling.
Third to fourth day	Loosening of the epidermis by gentle pulling.
Third to fifth day	Perforation of abdominal wall with collapse and disappearance of distention. This perforation may result from bursting of abdominal wall, or through anus, vulva or thorax.
Fourth to sixth day	Moist shrinking of the body. Swarming of maggots. Spontaneous shedding of tufts of hair.
Fifth to eighth day	Drying of body.
Eighth to twelfth day	Complete dryness and rigidity.

Photograph (after *Publications of the Civil Medical Service in Netherlands, India*) shows the progressive postmortem changes in rat cadavers, the numbers indicating the number of days after death.

A Collection of Notes Concerning Rat Runs, Rat Nests, Their Location and Other Data.—Attention is invited to the following collection of notes concerning rat runs, rat nests and their locations and other data collected by the various working parties under the direction of Sanitary Inspectors Brantigan, Renner and Kennard, of Manila.

Special attention has been given to the finding and destroying of rat nests, and in this connection please note that during the month of May, 1913, one party of workmen (20 men) under Inspector Brantigan, killed by hand 511 rats out of a total of 1319. This means that many nests were broken up and that much breeding was interfered with. In June, 1913, two parties (40 men) killed 772 rats by hand out of a total of 3019.

This work occurred in Tondo District in connection with extensive cleaning and moving operations.

At 1279 C. Sandejas[4] 7 rats were found in a nest at the foot of a cluster of bamboo trees, between the trunks. Nest was made of leaves.

[4] C. is abbreviation for Calle, the Spanish term for street.

At 728 C. Velasquez, Tondo, 12 rats were driven from a burrow underneath a thick cement floor by formaldehyde gas delivered in the burrow through a rubber hose. This burrow was in sand and the rats came out about ten minutes after the flow of gas began. All were killed or captured and two or three died from the effects of the gas.

On October 27, 1912, two of the rat terriers belonging to the Bureau of Health caught 192 rats in one storeroom at the Manila Railway Station, in 38 minutes. At various times they have killed from 10 to 25 rats at a single location, in connection with the cleaning and moving work done by the laborers. The dogs caught about 600 rats in all.

On March 11, 1913, 27 rats were caught by laborers at 202 Calle Concha. They were nesting in straw covers which had been removed from bottles.

On March 11, 1913, 13 rats were found beneath a pile of loose tiles at 203 C. Sardinas. The nest was made of fibres from coconut shells and straw.

On March 13, 1913, 12 rats were found among stones scattered in a shallow pile on the ground at C. Conservador (interior). Nest was made of rice chaff and small pieces of cloth.

On March 15, 1913, 9 rats were caught at 1353 C. Anloague on the ground floor beneath a pile of boards. Nest was made of coconut fibre and shavings.

On March 16, 1913, 24 rats were caught at 934 (interior) Velasquez beneath a wood pile. Nest was made of coconut-shell fibre and pieces of cloth.

On March 17, 1913, 14 rats were caught under a pile of hay and straw at 173 Velasquez. Nest was made from straw, chaff and hay.

The following articles of food were found in the above-mentioned nests: chicken bones, rice, coconut, fish and bread.

MEISIC DISTRICT

At 822 Sacristia 6 dead rats found in holes.

At 540 T. Alonso a family of 8 rats was smoked out and all were killed.

At 514 same street 6 rats were smoked out and killed.

At 538, interior, same street, 4 rats were smoked out and killed.

At 546 same street 4 rats were smoked out and killed.

At 715 San Bernardo dead rat found in a hole. Nest made of banana leaves and rags.

At 627, interior, Zacateros, 9 rats were smoked out and killed.

At 669 Benavides 6 rats were smoked out of four runs and were caught.

At 631 Zacateros 2 rats were smoked out and killed.

At 417, interior, Misericordia, 4 rats were secured in two holes under a tile floor. Many rats were caught at this number (interior) in traps.

At 221 Espelita 7 rats were found in a nest made of palm leaves and excelsior; location of run way and nest beneath tile floor.

At 124 Tetuan, in a nest of straw and lint, 5 rats were caught by hand, alive.

At 415 T. Alonso one live rat and 3 dead ones were dug out from beneath a tile floor.

SAMPOLOC DISTRICT

At 1001 Bilibid Viejo there were 5 rat runs, in a Chinese store. Eight rats were secured in a nest under the cement floor. Nest made of straw and paper.

At 928 San Sebastian there were 8 rat runs. In one of them there were caught 8 rats. The nest was made of straw.

At the same address, later, 3 rats were caught in another run and 8 young rats, with eyes still unopened, were found in a nest of straw. A supply of bread was on hand in this nest.

At 629 Tanduay 20 rats and nests of straw and paper were found.

At the same address upon another day another rat run was found and one large rat and 16 small ones were taken from a nest made of rags, straw, and fibres.

PACO DISTRICT

At 1115 San Andres in a Chinese tienda (food store), a long rat run and a nest of rags, straw, and paper, and 30 small rats were found.

One nest in a bamboo tree 30 feet above ground was found. Rats had been observed going up the tree and one was caught at the foot of the tree in a trap.

SAMPOLOC DISTRICT

At 629 Tanduay 14 young rats and a nest of straw, paper and rags were found in a stable.

Same address, later, one rat run and nest of straw and rags with one large rat and 16 small ones were found.

TONDO DISTRICT

March 27, 1913, one rat was caught alive inside of a bamboo timber in house at 51, interior, Pesqueria.

At 631 Azcarraga 4 young rats were found in a nest of paper, leaves, and hay. Chicken bones, crab shells, and rice were present in the nest.

A young python was caught in a lumber yard in the Santa Cruz District in June, 1913. In his stomach was found a half-grown rat. Another snake was caught in a rat trap at the same address about the same time.

Plan for Household Rat Destruction.—The following plan for household rat destruction was proposed by me to the Director of Health. It is considered worthy of trial if rat plague appears in new districts.

> Proposal for periodic household rat poisoning in Manila.
>
> Proposed that, upon a certain day of each week, rat poison be issued free to all applicants (householders) in Manila who agree to place same about their premises, permitting the poison to remain in place for 48 hours.
>
> Instructions and poison placards to be issued with the poison. Issues to be made from Station Health Offices and records of issue to be kept.
>
> Collections of dead rats to be made at the end of 24 hours and 48 hours by Bureau of Health employees. Poison portions to be collected and turned in at the Station Health Offices at the end of 48 hours, that is, at the time of the last rat collection. Rats to be tagged and examined for plague in the usual manner.
>
> Due newspaper notice of the plan and of the gratuitous issue of poison to be given to the people and their coöperation requested.
>
> Plan to be tested for at least two months.

MULTIPLE HOUSE INFECTION

Memorandum concerning 1364 Calle Sande:

Within 72 hours (April 25-27) five fatal cases of plague, all in Filipinos, occurred in Manila. The five deceased persons lived at 334 C. P. Rada (Meisic), 1419, interior, C. Dagupan, 1364 C. Sande (Tondo), 642 C. Ylala (Meisic), and 1492, interior, C. Dagupan (Tondo).

The following relationships were established by inquiry and investigation and the circumstances point strongly to a common source of infection and to a single geographic focus of plague infection in connection with all of the cases, viz.: at 1364 C. Sande (Tondo).

> José Raymundo, boy, aged fifteen, lived at 334 C. P. Rada and worked daily until taken sick on Tuesday, April 22, at 1364 Sande, in the shop of Simplicio Enriques, a silversmith, who lived part of the time at the same address.
>
> José Raymundo died of bubonic plague at San Lazaro Hospital on Friday, April 25, 1913.
>
> Norberta Mendoza, woman, aged fifty-six, lived at 1418, interior, C. Dagupan. She was the mother-in-law of Simplicio Enriques, the silversmith at 1364 Sande, and visited her son-in-law there frequently and within a few days of her last illness. She was taken sick April 22 and died at 1419, interior, C. Dagupan, on the morning of April 26. At autopsy at San Lazaro morgue, the same day, bubonic plague was found to be present and the cause of her death.
>
> Trinidad Galves, a young woman, aged sixteen, lived at 1364 Sande and was taken sick there on April 25. She was removed to San Lazaro Hospital and died there April 26, extensive plague lesions being found at autopsy.
>
> Pablo Banzon, man, aged twenty-six, living at 646 C. Ylaya, was taken sick on Friday, April 25. He was removed to San Lazaro Hospital Saturday afternoon and died there Sunday evening, April 27. He was shown to have plague by bacteriologic examination made at the Bureau of Science. He worked at 1364 Sande as a silversmith, with José Raymundo and was employed by Simplicio Enriques.
>
> Simplicio Enriques, aged twenty-seven, a silversmith, conducting his business at 1364 C. Sande and employing José Raymundo and Pablo Banzon, was taken sick about April 23. He moved to two different houses in the interval between the onset of his sickness and his transfer to San Lazaro Hospital on April 27, first to 1419 C. Dagupan, interior, where he remained until the death of his mother at this house; then to 1492 Dagupan, interior, from which place he was transferred to San Lazaro Hospital, where he died with bubonic plague a few days later. Diagnosis was confirmed at autopsy.

The two women were patients of Dr. Hernando of Calle Ylaya. He recognized the case of the elder woman as a probable case of plague, after death, and reported the matter to the Bureau of Health.

The house at 1364 C. Sande is of the type in which cases of rat plague and human plague have recently been found. In our operations to put the house in a safe condition we found one dead rat, mummified, in the basement. Unfortunately, the workmen who swept it out did not note the exact location at which it was found. The house is in the midst of the district where rat plague has raged since early in March, 1913. The basement contained unauthorized and illegal sleeping rooms until a few days before this outbreak when they were removed in the course of our antiplague operations. The building is constructed of bamboo with a nipa thatch roof.

The front part of the basement was paved, but the pavement was undermined and broken. Being convinced that dead plague rats were present in the vicinity of this house and probably within it, I directed that the cement floor under the silversmith shop and the barber shop, located upon the ground floor at this address, be torn up. Accordingly, this was done (April 28) and three dead rats and one live one were found beneath the cement. As the bodies were mummified and unfit for bacteriologic examination they were burned. The living rat was examined at the Bureau of Science but was found to be healthy. The cement floor was broken and permitted fleas from the dead rats to enter the basement room of the house

which was occupied by the silversmith shop. The rats doubtless died from plague and the hungry fleas in due time attacked the nearest persons at hand, the unfortunate occupants of the silversmith shop and the two women who frequented the room also.

These facts account for the epidemic at 1364 Sande very completely.

The premises at 1364 Calle Sande were quarantined by the following order:

MANILA, April 27, 1913.

The premises 1364 Sande are hereby declared in Quarantine for Bubonic Plague by order of the Director of Health.

The inmates will be permitted to leave the building and find quarters elsewhere, provided they leave their addresses with the policeman in charge, so that they may be readily found. They must remain in the District of Tondo. If they remain in the house they will be obliged to stay in the upper story of the house and will have to arrange for meals to be sent in.

The barber shop and "platero" shop are hereby ordered closed until further orders.

By order of the Director of Health.

[Signed] T. W. JACKSON,
Medical Inspector, in Charge of Plague Suppression.

Memorandum reporting circumstance surrounding 2 cases of plague at 1226 C. Juan Luna (May 17, 1913):

Valeriano Lausin, aged fourteen, Filipino male, Carmelo maker by trade but out of work at time he was taken sick, recently removed to this house from 917 C. Jaboneros where he had been employed. The patient fixes the date at about a week previous to his sickness, but the proprietors of 917 Jaboneros are positive in their statement that he left the place where he lived and worked, at least two weeks before. This boy recovered.

The circumstances and especially the occurrence of a second case at 1226 C. Juan Luna, indicate that infection was incurred here.

Moreover, this house is in the midst of a rat-plague infected district.

PLAGUE HOUSE, 1226 CALLE JUAN LUNA

The house is of bamboo and nipa construction and contained illegal basement rooms until a week ago. About 60 persons lived in this house which was once licensed as a tenement but which is unsanitary in a multitude of ways. Bamboo construction, overcrowding, dirty condition and absence of proper drainage, water-closet, proper kitchens and paved ground floors, together with bad ventilation, made it a dangerous habitation and the added condition of plague infection made it necessary to vacate and quarantine the building.

On May 15, at the daily inspection of contacts in the house 1226 C. Juan Luna, Filomena Suñga, aged nineteen, and a relative of the owner of the building, was found to be sick. Her only symptom was fever, but she was transferred to San Lazaro upon suspicion and promptly developed symptoms of plague. She died in a few days and the diagnosis of plague was verified at autopsy. The following order was issued:

STATION "C," TONDO, BUREAU OF HEALTH
MANILA, P. I., May 15, 1913.

By order of the Director of Health, the house No. 1226 C. Juan Luna is declared infected and is quarantined this date, for Bubonic Plague. The house will be vacated and a policeman will register the names of all residents and the addresses to which they remove.

The residents may remove their personal effects but will not be permitted to return while the quarantine is in effect.

[Signed] T. W. JACKSON,
Medical Inspector, Station "C," Tondo.

Memorandum: Human body (dead from plague) and dead rats found in the same basement room. Upon March 21, 1913, a Filipino laborer living at 140 Calle Perla, Tondo, was found dead from bubonic plague.

Upon careful investigation and search of the premises the following findings were disclosed:

One rat, large, mummified and dry and therefore dead for at least one week, was found clinging to a bamboo wall just back of the cot upon which the dead human body was found.

In a section of bamboo, in a timber constituting the ceiling of the basement and also the upper part of the door frame, a rat, dead and dried up, was found. This section was the end section of the timber which was partly covered with nipa thatch, with which the sides of the house were covered. The ends of a number of the outside rafters (bamboo) were found to be gnawed through.

BAMBOO HOUSE SUPPORTS SEALED
WITH CEMENT TO PREVENT ENTRANCE
OF RATS (MANILA PLAGUE CAMPAIGN)

Similar conditions were found in adjoining houses and in one case a live rat was driven out of a nest in the bamboo.

SAMPLE OF DETAILED ORDERS ISSUED.—Sample of detailed orders issued by Medical Inspector in Charge of Plague Suppression. Similar orders were issued whenever new districts were entered or new work undertaken.

Memorandum Order. Effective March 25, 1913:

Beginning to-day, 13 men under Assistant Inspector Parás, will commence cleaning operations at C. Ostra, extending from the Bay to C. Sande and will clean towards C. Moriones. They will be provided with a disinfecting pump and will disinfect the ground surfaces wherever disturbed, outdoors and indoors. Cleaning is to be done in the most thorough manner possible, searching meanwhile for rat nests and rat harbors; re-piling wood, tiles, stones and merchandise; moving all movable goods out of doors in their search for rats and rat-holes or nests. All goods are to be piled above ground at an elevation of at least one foot. All bamboo beds and bamboo rafters and parts of the house (in the basements) made of bamboo or of double walls are to be thoroughly investigated for rats. All foodstuff attractive for rats is to be placed in covered boxes or galvanized iron cans, tin cans or barrels, with tight-fitting covers. Special attention is to be paid to straw, hay, shavings, grain, rat-holes, and food.

Two men will be detailed to cement up ends of bamboo and rat-holes, but will not do general repairing. They will carry materials for mixing cement as needed and will not be wasteful of materials.

If this force proves to be insufficient in numbers, additional men may be detailed from the other working parties.

[Signed] T. W. JACKSON,
Medical Inspector in Charge of Plague Suppression.

Specimen order issued to Sanitary Inspector assisting in Plague Suppression by Medical Inspector in charge.

Sanitary Inspector, Bureau of Health:

Please place the gang of workmen under your charge in the square bounded by Calles Velasquez, Moriones, Concha and Manila Bay which is infected with rat plague. Treat the houses and properties there in the same manner in which other plague-infected districts have been treated, viz.: by policing the houses and yards, vacating all basements of light-material houses in which human habitations are illegally present; removing (with the consent of the occupants) all unauthorized basement sleeping places, beds, platforms, etc., and other illegal structures, closing up the open ends of bamboo rafters or timbers of the house with tin or cement.

Where the occupants resist this action sanitary orders should be issued in the usual manner and interference should be stopped until the order is served and complied with. There are a number of most insanitary and unsuitable shelters of bamboo, tin, etc., used for houses by a number of families in this square and it is desirable to tear down these huts if permission can be secured. If permission is refused orders should be issued on the usual form.

[Signed] T. W. JACKSON,
In Charge of Plague Suppression.

VIEW OF HOUSE AT 447 CALLE CONSERVADOR, TONDO, WHERE INFECTED RATS WERE FOUND (MANILA PLAGUE CAMPAIGN)

Specimen order issued by the Medical Inspector in charge of Plague Suppression.

STATION "C," TONDO, May 21, 1913.

Redistribution of rat catchers and laborers engaged in antiplague work. Effective May 2, 1913.

Sanitary Inspector Kennard and 20 rat catchers will move into Tondo District and trap and poison rats in the district bounded on the west by Manila Bay and on the east by Estero Reina. The work will be begun at the extreme north water boundary of this district and will proceed toward the south.

Sanitary Inspector Brantigan with a similar number of rat catchers (20) will work within the same east and west boundaries and will begin trapping and poisoning at Calle Moriones, proceeding north. The poisoning and trapping is to be done in the most thorough manner possible, as this is a dangerously infected district and rat-plague must be controlled and terminated here.

The laborers, 60 men, divided into 4 parties of 15 men each under Assistant Sanitary Inspectors Jesús, De la Rosa, Laxamana and Parás, will continue the cleaning operations now under way on both sides of C. Juan Luna south of C. Moriones (plague localities in the same neighborhood), and thoroughly disinfect.

One party of 15 men will work in the vicinity of C. Perla, vacate basements as habitations, search for dead rats in yards, houses, bamboos, under broken concrete, etc., and will close up openings in structural bamboo by means of tin and cement. Emphasis is placed upon the necessity for permanently vacating basements and men will be sent back over the ground daily to see that the persons moved out do not return. Reports are desired so that prosecutions for violations of the law may be instituted if necessary.

[Signed] T. W. JACKSON,
Medical Inspector in Charge of Plague Suppression.

Specimen order issued to Assistants.

May 4, 1913. STATION "C," BUREAU OF HEALTH:

Please place work parties in (interior) 1627–1629 Sande and 525 C. Azcarraga, to clean, disinfect and thoroughly investigate these premises and the houses, stables and other buildings in the vicinity. Search for rats, living and dead, rat nests and rats in bamboos and wood piles, stone piles, stables, under planks and elsewhere. Cement the openings in bamboos in houses or close with tin. Make notes on needed structural work. Do the work as thoroughly as possible.

[Signed] T. W. JACKSON,
Medical Inspector in Charge of Plague Suppression.

METHOD OF PROCEDURE IN COLLECTING AND FORWARDING RATS SUSPECTED OF PLAGUE INFECTION TO THE LABORATORY IN MANILA, P. I.—Rat catching,—trapping and poisoning,—is conducted in accordance with instructions contained in the Sanitary Inspector's Handbook (pp. 36, 37, 38) issued by the Bureau of Health.

Rats are collected in Manila and forwarded to the Bureau of Science for autopsy and for biologic examination for the presence of plague bacilli in the following manner:

The various groups of rat catchers are provided with receptacles (iron pails) and a supply of a mixture of kerosene, cresol and water (kerosene 10 parts, cresol 2 parts; water 88 parts).

In these vessels, filled with the pulicidal mixture, the rats are immersed, with a minimum amount of handling, as soon as they are found (whether in traps or dead from poison).

If captured alive they are killed and then promptly immersed. The mixture must be well shaken or stirred when used, as it separates upon standing. The immersion is, of course, for the purpose of destroying any fleas which may be present upon the captured rat.

A paper tag showing the date and the exact location of the place of capture, with the name or group number of the rat catcher, is next affixed to a foot or to the tail of the rat and firmly tied upon the same, where it remains until the rat cadaver is finally disposed of. This tag is a card of strong Manila paper and the record upon it is made with an ordinary lead-pencil, as both ink and indelible pencil marks are apt to become illegible from wetting, whereas lead-pencil marks are little affected thereby.

If desired, the disinfected tag in any given case of rat plague may be returned to the Bureau of Health, for identification, where an accurate record of every rat captured is kept.

After dipping and tagging, the rats are taken to a central point, again dipped, and placed in large, tightly-covered, galvanized iron cans, in which containers they are delivered to the laboratory by cart, once or twice daily.

The Case of Mr. C.—The following are the facts concerning the case of Mr. W. C., a prominent American resident of Manila who suffered and died from plague in 1914.

Mr. C., an editor, was taken ill with plague on the night of September 18, sought medical advice and entered St. Paul's Hospital September 19, and was transferred to San Lazaro Hospital, September 20, with an established clinical and bacteriologic diagnosis of bubonic plague. He survived till September 22.

Upon September 21, in the course of disinfecting the business office of Mr. C., located in a district which had furnished a number of cases of both rat and human plague, a dead rat, mummified, was found in the right hand drawer of his desk and fleas were seen to hop from the drawer upon opening it.

A flea killed by the disinfecting mixture at this desk was identified at the Bureau of Science as a rat flea (*Xenopsylla cheopis*).

The rat cadaver was sent to the Bureau of Science and the following facts were reported from there some days later:

The mummified rat and skeleton were pulverized in a sterile mortar and an emulsion was made and injected into guinea-pigs. The animals died from plague in a few days and plague bacilli were recovered from the tissues, as well as from the rat cadaver, by culture.

A second rat cadaver, found at the same time in the same building, during cleaning operations, was similarly treated with identical results.

There could scarcely be a stronger chain of convincing evidence against the rat and the flea, nor a more complete and convincing explanation of Mr. C.'s death than that afforded by these established facts and official documents. So far as I know there is no more striking case on record in the modern history of plague.

Letter of Warning and Appeal.—The following letter of warning and appeal for coöperation was suggested and framed by me February 10, 1914, at the time that extensive rat plague was discovered in the heart of the business district of Manila. I presented it to the Director of Health with a strong recommendation for approval and publication and after consideration he approved and authorized publication upon February 10. No change was made in the wording of the proclamation, but it was issued over the signature of the Director of Health to give added force and authority to the appeal. The results were, as I had hoped they might be, highly beneficial. The taking of the public into the confidence of the health authorities brought about a coöperation, without which our efforts in this difficult situation would have been sadly handicapped. It is my belief that this method should often be used by health authorities, particularly where an intelligent community is threatened.

To Whom It May Concern:

You are hereby informed that the district bounded by Calles Rosario, Juan Luna, Dasmariñas and Plaza Calderon (and possibly the neighborhood bordering upon this congested district) is a dangerous one for all persons living or conducting business therein, on account of the presence there of extensive rat plague. Six human cases (with five deaths) have recently developed there and many dead rats have been found. All human cases have been directly traced to rats dead from plague.

The Bureau of Health is now doing everything within its power to make this district safe, but the attention of all citizens, property owners and tenants is called to the fact that they are required by law to keep their premises free from rats and to abolish all structural conditions of the buildings which favor the harboring of rats. This means rat-proofing, and owners are earnestly urged to perform this necessary work now, under the direction of the Bureau of Health.

As a temporary expedient and safeguard all interiors, walls, floors and ceilings should be sprayed with kerosene daily, or at intervals of two days, to kill the fleas which carry plague from rats to human beings. All dark insanitary places used for living rooms should be vacated at once; all merchandise should be piled upon trusses at least a foot above the floor; all straw, shavings and other material attractive to rats for nesting, should be removed and burned and all food materials upon which rats may feed and live should be placed in covered boxes, bins or cans.

All rat-holes should be permanently closed and all broken cement or masonry should be repaired.

Observance of these instructions may save the lives of yourselves, your families and your tenants. It is your duty to do your part in this matter, a part which neither the Bureau of Health nor the Government can do for you.

Through very great effort the Bureau of Health has controlled plague in Manila and the Philippine Islands during the last two years.

Residents must now do their part, and owners of property must permanently make their buildings safe for tenants, both for business and residential purposes.

Bacteriologic Observations Made by Dr. Otto Schöbl.—The following observations upon the bacteriologic aspect of the Manila epidemic which we are considering were made by Dr. Otto Schöbl of the Biological Laboratory of the Bureau of Science, Manila, and pertain to the cases of the first year of the epidemic. They were printed in the December number of the *Philippine Journal of Science* in 1913, but as they belong so definitely to the epidemic I am describing and as Dr. Schöbl has expressed his willingness for me to quote them in full, I gladly accept his permission. Dr. Schöbl advanced the possibilities of blood-culture diagnosis to such a point of reliability that it became practically possible for us to expect positive culture in nearly every case of true plague and the whole matter of bacteriologic diagnosis was perfected to a high degree of efficiency under his administration of the laboratory work.

He relates his observations as follows:

During the recent outbreak of plague in Manila, I had the opportunity to make certain observations which are of interest. These observations were made in the examination of: (1) Specimens taken from patients and from dead bodies at autopsies, (2) samples of blood-sucking insects collected in houses where plague patients had lived, (3) rodents caught by trap or poisoned in the parts of the city where plague cases occurred from time to time, and (4) domestic animals suspected of plague infection.

I. Bacteriological Examination of Plague Patients

In order to secure as early diagnosis as possible, the following procedure of investigation was adopted:

1. The bubo was aspirated by means of a sterile hypodermic syringe. The material thus obtained was placed in the water of condensation of an agar-slant culture tube.
2. At least 7 centimetres of blood were withdrawn from the *cubital* vein by means of another sterile syringe, and 5 centimetres of it were placed in an Erlenmeyer's flask, containing 200 centimetres of neutral meat broth. The rest of the blood was emptied into a sterile tube, and used for agglutination tests.

Cultures obtained by this method were examined microscopically, and the growths on various culture media were studied. Gram stain, Löffler's methylene blue, and hanging-drop method were used. Polar-staining and chain formation in liquid media and the characteristic type of colony on the surface of agar were looked for. Animal inoculation was performed in every case, and the culture isolated from each case was identified by agglutination test, rabbit's immune serum being used.

The results of the bacteriological examination of a series of 24 patients are tabulated in the two following tables. Table I includes the fatal cases and Table II those cases which recovered.

The diagnosis of plague could be safely made from the microscopical examination of the liquid aspirated from the bubo in the majority of the cases. However, in certain instances the amount of the aspirated fluid being small and the bacilli very few, it was impossible to diagnose the case, especially when the cultures from the bubo were negative. Repeated examination of the patient was necessary under those conditions, but it happened in cases 22 and 23 that the patients died of plague before a second examination could be made. The smears and cultures from case 22 remained sterile, while the smears and cultures

TABLE I.—EXAMINATION OF FATAL CASES OF PLAGUE

Patient	Race	Sex	Age	Date of examination	Duration of illness	Hours before death	Bubo			Blood		Skin			Sputum		
							Smear	Culture	Animal inoculation	Culture	Agglutination	Smear	Culture	Animal inoculation	Smear	Culture	Animal inoculation
			Years	1912	*Days*												
1. Sing Nu	Chinese	Male	(?)	July 11	5	48	+	+	+	0	0	+	+	+	-	-	-
3. Aluncion Raymundo	Filipino	Male	15	Sept. 29	3		+	+	+	0	0	0	0	0	0	0	0
4. Filo Almalas	Filipino	Male	39	Oct. 10	4	22	+	+	+	+	-	+	+	+	0	0	0
6. Polycarpio Guzman	Filipino	Male	34	Oct. 22	2		+	+	+	0	0	0	0	0	0	0	0
7. José Sarmiento	Filipino	Male	37	Oct. 22	3		+	+	+	0	0	0	0	0	0	0	0
8. Julian Gonzales	Filipino	Male	41	Oct. 22	3	23½	0	0	0	+	-	0	0	0	+	+	+
9. Valeriano Buencamino	Filipino	Male	31	Oct. 22	3	10	+	+	+	+	-	0	0	0	0	0	0
10. Pedro Nicomedes	Filipino	Male	30	Oct. 22	2	5¾	+	+	+	+	-	0	0	0	0	0	0
12. Regino Gulano	Filipino	Male	34	{Oct. 22	2	106	0	0	0	+	-	0	0	0	0	0	0
				{Oct. 24	4	82	0	0	0	0	0	0	0	0	+	+	+
13. Martin Dimalanta	Filipino	Male	35	Oct. 23	3	25½	+	+	+	+	-	0	0	0	0	0	0
14. Roberto Obiso	Filipino	Male	25	Oct. 23	1	53	+	+	+	+	-	0	0	0	0	0	0
15. Juan Barceta	Filipino	Male	23	Oct. 24	3	37	+	+	+	+	-	0	0	0	0	0	0
16. Yu Tum	Chinese	Male	14	Oct. 24	2		+	+	+	0	0	0	0	0	0	0	0
17. Augustin Monterey	Filipino	Male	29	Nov. 1	1	27	+	+	+	+	-	0	0	0	0	0	0
18. Demetrio Pabraw	Filipino	Male	27	Nov. 23	4	15	0	0	0	+	-	+	+	+	0	0	0
21. Ambrosio Sobremonte	Filipino	Male	20	Dec. 7	6	1	+	+	+	+	-	0	0	0	0	0	0
22. Mateo Marcelo	Filipino	Male	8	Aug. 20	(?)		-	-	-	0	0	0	0	0	0	0	0
23. Alejandro Gita	Filipino	Male	[A]17	Nov. 24	3		-	-	-	0	0	0	0	0	0	0	0

[A] Months.

TABLE II.—EXAMINATION OF PLAGUE PATIENTS WHO RECOVERED

Patient	Race	Sex	Age	Date of examination	Duration of disease	Bubo			Blood	
						Smear	Culture	Animal inoculation	Culture	Agglutination
			Years	1912	*Days*					
				{Sept. 29	2	-	-	-	0	0
				{Oct. 2	5	+	+	+	0	0
2. Dionisio Capate	Filipino	Male	18	{Oct. 3	6	0	0	0	-	+1:16
				{Oct. 7	10	-	-	-	0	0
				{Oct. 15	18	-	-	-	-	+1:64
5. Alejandra Fisher	European	Female	6	Oct. 20	7	+	+	+	0	0
				{Oct. 22	2	+	+	+	+	-
				{Oct. 24	4	+	+	+	0	0
11. Gabriel Sevilla	Filipino	Male	21	{Oct. 26	6	0	0	0	-	+1:16
				{Nov. 8	18	-	-	-	0	0
				{Nov. 15	25	-	-	-	-	+1:64
				{Nov. 26	3	+	+	+	+	-
				{Dec. 6	13	0	0	0	-	+1:32
19. Esteban Roa	Filipino	Male	15	{Dec. 16	23	-	-	-	-	+1:60
				1913						
				{Jan. 11	48	-	-	-	-	+1:120
				{Dec. 2	(?)	+	+	+	0	0
20. Sia Su	Chinese	Male	35	{Dec. 5	-	0	0	0	+	-
				{Dec. 16	-	-	-	-	-	+1:80
				{Dec. 11	3	+	+	+	0	0
24. Purificacion del Val	Filipino	Female	19	{Feb. 11	33	-	-	-	0	0

NOTE.—The bubo in Nos. 2, 5, and 24 never opened spontaneously. The pus was aspirated at the time of the second, eventually third, examination. Nos. 11 and 19 opened spontaneously. A fistula formed along the canal which was caused by the puncture, and healed up in several weeks. Hard inguinal buboes of secondary order persisted in patient 19 at the time of second examination. No plague bacilli were found either in the bubo of the first or second order. Patient 20 had a considerable amount of pus in the inguinal primary bubo, but it was not opened until after the last examination. made from the swelling on the neck of patient 23 revealed the presence of pneumococci. Both patients died of plague, as was ascertained by examination of the organs after death.

Two of the patients, cases 8 and 12, had numerous plague bacilli in the sputum at the time when the expectoration showed the presence of blood (twenty-three and one-half and eighty-two hours, respectively, before death). In 3 cases I was able to prove the presence of *Bacillus pestis* in the skin lesions, *intra vitam*, fifteen, twenty-two, and forty-eight hours, respectively, before death. In case 18 there was no doubt that the skin lesions, which covered the whole body and the face, were of secondary nature, as the patient died shortly afterward. It was undoubtedly a case similar to those reported by Gotschlich and Zabolotny.[5] In the other two patients there was only 1 maculopapulous efflorescence on the foot in case 1 (with a corresponding femoral bubo) and 2 lesions of the same type on the arm and forearm in case 4 (with a corresponding axillary bubo). It is possible that these lesions were the original port of entry of infection. Numerous plague bacilli were found in the skin lesions of these cases, both microscopically and in culture.

[5] Kolle und Wassermann: Handbuch der pathogenen Mikroorganismen. Gustav Fischer, Jena (1903), **2**, 521.

The plague patients tabulated in Table II recovered. They were all treated with antiplague serum. While cases 5, 11, 19, and 24 appeared clinically to be rather severe, cases 2 and 20 were mild.

It can be seen from the table that the plague bacilli may not be detected in the enlarged gland at first (case 2) and that their presence may be revealed only after repeated examination of the bubo. It is also evident from the results of repeated examinations that the plague bacilli disappear from the infected gland in a comparatively short time, as a rule at the time when pus starts to form. Contrary to the findings in patients who died, distinct phagocytosis was noticed in the smears made from the aspirated liquid in those patients who recovered and who had been treated with serum soon after the onset of the disease. It is undoubtedly this process that clears the gland of the infectious agents.

The general opinion in regard to the presence of *Bacillus pestis* in the circulating blood seems to have been, as Thompson remarks, that "the bacillus is rarely to be found in the peripheral blood stream before the agonal stage."[6]

[6] Journ. Hyg., Cambridge (1906), **6**, 558.

The Austrian Commission, using few drops of blood, found positive blood culture in 40 per cent; Calvert in Manila in 100 per cent when examined twenty-four hours before death; Choksy, Berestneff, and Mayr in 45 per cent; and Greig in 60 per cent. The Indian Commission examined 28 patients, and obtained positive blood cultures in 16 out of 23 fatal cases. Not a single positive blood culture was obtained from the patients who survived. The time of blood examination in positive cases was three and one-half to seventy-five and one-half hours before death. The amount of blood used was 1 cubic centimetre. Only 6 out of the 30 samples, which gave positive blood culture, were found positive by microscopical examination of blood smears. The following conclusions are based on these observations in regard to the septicæmic stage of bubonic plague: (1) "A severe septicæmia may be present at a comparatively early stage of the disease and for a considerable number of hours before death, and (2) the septicæmia may be of an irregular and fluctuating type."[7]

[7] *Ibid.* (1907), **7**, 395.

From the tables it will be seen that out of 15 patients examined by me, 14 gave positive blood culture; and of these 3 recovered. One blood culture revealed the presence of streptococcus in addition to *Bacillus pestis*. The results of the examinations tabulated in Tables I and II show, in agreement with the findings of the Indian Commission, the occasional early occurrence of plague bacilli in the blood stream, as the time of examination in the positive cases varied from one hour to one hundred six hours before death. In consideration of the ephemeral character of the septicæmic stage of plague, as evidenced by repeated blood cultures in the three patients who recovered, one can hardly avoid the impression that there is a certain degree of septicæmia in every case of plague. The possibility of detecting the bacillus in the circulating blood increases in proportion with the quantity of blood used for culture. The best chance to recover plague bacilli from the circulating blood seems to be in the stage of high fever and general prostration.

The phenomenon of agglutination of plague bacilli by the serum of patients was first observed by Wissokowitsch and Zabolotny in 1897[8] and later confirmed by the German Plague Commission. Vagedes, Klein, and others[8] pointed out the defects of the reaction as a diagnostic means. Aside from the technical difficulties, the reaction was found inconstant, and its occurrence was not noticed until the second week of the disease and even then only in low dilutions of the serum.

[8] Referred to in Kolle und Wassermann: Handbuch der pathogenen Mikroorganismen (1903), **2**, 524.

Although the recent work of Strong[9] and of Strong and Teague[10] has reduced the technical difficulties, the fact remains that positive agglutination of plague bacilli by the patient's serum cannot be obtained in the first week of the disease, and, therefore, the isolation of plague bacilli from the body of the patient is still

the only quick and safe method of plague diagnosis.

[9] The Philippine Journal of Science, Sec. B. (1907), **2**, 155.

[10] *Ibid.* (1912), **7**, 194–201.

Having utilized the technic devised by Teague, I have had no difficulty in performing the agglutination test in plague. The emulsion of plague bacilli, to be used for the test, was prepared by suspending young cultures of virulent plague bacilli, grown at 30° C., in salt solution and filtering the suspension through filter paper. No antiseptic was added nor heat applied. Serial dilutions of unheated patient's serum were mixed with equal amounts of bacterial suspension in small test tubes. Incubation at 35° C. followed. Controls, consisting of serial dilutions of normal human serum as well as bacterial suspensions without serum, excluded any possible error which might have been caused by spontaneous sedimentation of the bacterial suspension; while a parallel test with highly agglutinant serum facilitated the reading of positive results.

Altogether, 22 tests were performed on 15 patients, 11 of whom were fatal cases and 4 of whom recovered. In the negative reactions, the duration of the disease at the time of examination ranges from two to six days. The non-fatal cases showed slight agglutination from the sixth day on. From that day, the agglutination titer of the serum was found to rise, and the agglutinins persisted in the blood of convalescents up to the seventh week of the disease.[11]

[11] It is hoped that it will be possible to examine some of the survivors for agglutination from time to time.

It must be borne in mind that the patients, who showed positive agglutination, had been vigorously treated with antiplague serum. Nevertheless, in consideration of the low titer of the curative serum (dilution 1:32, agglutination positive; dilution 1:64, agglutination negative), the rise of the agglutinant power of the patient's serum in dilutions higher than 1:16 cannot be explained as wholly due to passive immunity, but rather to active immunity arrived at on the principle of simultaneous immunization.

From the preceding observations the following conclusions are drawn:

1. The importance of blood cultures as a diagnostic means is evident from the fact that positive blood culture was obtained in practically every case that was examined in the febrile stage of the disease, even when buboes or signs of pulmonary involvement had not been detected clinically.
2. It is also evident that *Bacillus pestis* may be found in the circulating blood of the patients even in cases which subsequently recover.
3. The period of time during which *Bacillus pestis* circulates in the blood is evidently short and irregular.
4. Mixed infection may be encountered in plague septicæmia (*Streptococcus*, *Pneumococcus*).
5. The agglutination test is of no value for the diagnosis of plague, as it was found positive only in convalescents.
6. Phagocytosis of plague bacilli in the bubo was noticed only in patients who recovered after being vigorously treated with curative serum.
7. The presence of numerous plague bacilli in comparatively insignificant skin lesions during the life of the patient points to the possibility of direct transmission, while the fact that a patient without any apparent bubo, who is not so sick as to be detained from his daily occupation, may expectorate large numbers of plague bacilli, are facts of great importance with regard to the communication of the disease. It is obvious that the last-mentioned condition might, and very likely does, give rise to an epidemic of pneumonic plague if the atmospheric and sanitary conditions are favorable.

TABLE III.—INSECTS FOUND TO CONTAIN BACILLUS PESTIS

Author	Insect	Source of infection	Experimental transmission
Yersin	Flies	Laboratory infection	
Nuttal	Flies	Experimental infection	
Nuttal	Bedbugs	Experimental infection	Negative by bite.
Nuttal	Flea	Experimental infection	Negative.
Hankin	Ant's fæces	Fed on plague material	
Hankin	Bedbugs	Plague hospital	
Ogata	Flea	Plague rats	
Simond	Flea	Plague rats, experimental	Positive.
Tindswell, 1900	Flea	Plague rats	Negative.
Tindswell, 1903	Flea	Plague rats	Negative.
Kolle	Flea	Experimental infection	Negative.
Gauthier and Raybaud	Flea	Experimental infection	Positive.
Liston	Flea	Epidemic among pigs; harbored fleas; dead rats found	Positive.
Zirolia	Flea	Retained *Bacillus pestis*, 7–8 days	
British Commission	Flea	Repeated experiments	Positive.
Verbijtski	Flea and bedbug	Experimental infection	Positive.
La Bonadière and Xanthopulides	Fly		
Herzog	*Pediculus capitis*	Dead body of a plague case	

II. OBSERVATIONS ON THE TRANSMISSION OF PLAGUE BY BLOOD-SUCKING INSECTS

Judging from the data which have been collected from the literature[12] on the transmission of plague (Table III), Simond seems to have been the first to call attention to the important part which blood-sucking insects, particularly fleas, play in the transmission of plague. Although many investigators have been successful in demonstrating the presence of *Bacillus pestis* in the digestive system of blood-sucking insects, it was not until the experiments of Gauthier and Raybaud that the actual transmission of plague infection by fleas was convincingly proved. Ever since the exhaustive and conclusive experiments, which were carried out both under natural and artificial conditions by the British Plague Commission, and the work of Verbijtski, which antedates the British Commission, were presented, there has been no doubt that the transmission of plague by blood-sucking insects, particularly by the fleas, is one, although not the only, mode of spreading this disease. It is obvious, as Herzog correctly remarks, that the factors which are responsible for the spreading of plague must be considered individually in each epidemic and in various parts of the world as well. There is no doubt that the importance of any insect in the transmission of plague depends on its habits as well as on those of the host, be it either animal or man.

[12] Centralbl. f. Backt., 1 Abt. (1897), **22**, 87, 437. Report of Indian Plague Commission (1898–99). Zeitschr. f. Hyg. u. Infectionskrankh. (1901), **36**, 89. Kolle und Wassermann: Handbuch der pathogenen Mikroorganismen (1903), **2**, 538. Zeitschr. f. Hyg. u. Infectionskrankh. (1905), **51**, 268. Journ. Hyg., Cambridge (1907–10), plague numbers. *Ibid.* (1908), **8**, 162, 260.

During the recent outbreak of plague in Manila, several samples of bed-bugs from the beds of the plague patients and dog fleas from a plague-infected house were collected and examined, but with negative result.

In spite of the fact that it adds nothing new to the question of whether or not plague can be transmitted by fleas, since the question has been conclusively answered by the work of the Indian Commission, nevertheless the following observations of a small outbreak of plague among animals, the spreading of which was due solely to fleas, are of interest.

One wild rat was inoculated with strain Iloilo 3 of *Bacillus pestis*. The skin adjoining the root of the right ear was scarified, and a loopful of the culture was smeared on the scarified skin. The rat was found dead three days after the inoculation.

The cage containing the dead rat was immersed in kreolin solution. At autopsy the cervical glands were found slightly swollen, somewhat reddened, but no hæmorrhagic œdema of the surrounding tissue was noticeable. There was slight necrosis at the place of inoculation, showing superficial, purulent discharge. Clear effusion in both pleural cavities and one hemorrhage in the pleura were found. The lungs were hyperæmic, but otherwise normal. The spleen was of somewhat darker color, but otherwise normal in size and appearance. The liver showed a slight degree of parenchymatous degeneration, the congestion making prominent the structure of the organ. The typical, although not constant, changes of the organ, which are characteristic of natural plague infection in rats, were absent. The kidneys were without macroscopic change. The lymph glands, with exception of the cervical nodes, were normal.

Examination of the rat's fur revealed ectoparasites on the neck, under the chin, and back of the ears; these at the time of the examination apparently were dead. About 6 common rat fleas were found and identified as *Lœmopsylla cheopis* Rothsch. The parasites were immersed in sterile salt solution for three hours. When removed in a dry test tube, they began to move about sluggishly. The intestinal tract of these fleas contained blood.

Five of the fleas were crushed by means of sterile forceps, and inserted in a pocket under the shaved skin of a guinea-pig. The animal died of plague within three days, showing considerable hemorrhagic œdema around the place of inoculation, typical bilateral inguinal buboes, and characteristic changes in the spleen. Smears and cultures made from the bubo and spleen were positive for *Bacillus pestis*.

Another wild rat, which was in a separate cage in the same room where rat 1 had been kept, died twenty-four hours after rat 1. The two cages were at least 10 centimetres apart. Rat 2 harbored fleas of the same species as were found on rat 1.

Numerous severe bites were detected back of the ears and on the neck of the dead animal. The post-mortem findings were identical with those described in rat 1; that is, cervical buboes, pleural effusion, and slightly enlarged spleen.

It is well to remark that both rats had been kept in the same room for about six months. Fleas had never been noticed on our guinea-pigs. During the time the rats had been kept in the plague house no irregular results were noticed in plague-inoculated animals. At the time the first rat was inoculated no other plague-infected animals were in the plague house, and since that time another building has been used for plague-infected animals.

Two days after the death of rat 2 three guinea-pigs, which were kept in separate cages in the same room, were found dead of plague (smears and cultures were both positive). Several fleas (*Lœmopsylla cheopis*) were found on the necks of these animals. They were collected and inoculated in the same way as the fleas from the first rat. The experimental animal, which was inoculated with the fleas, was killed and found to be infected with plague. The findings were local reaction, inguinal buboes, and typical spleen. Smears and cultures were positive for *Bacillus pestis*.

Although numerous healthy guinea-pigs were examined in the same plague house, no fleas could be found at that time, only the 2 rats and the first 3 guinea-pigs are positively known to have harbored fleas, the latter after the death of the rats and not before.

The gross lesions in these naturally infected guinea-pigs were somewhat unlike those found in guinea-pigs infected either by vaccination or by intraperitoneal or subcutaneous inoculation. All except one showed primary buboes on the neck with more or less extensive hemorrhagic œdema extending in some cases over the thorax. There was little pleural effusion present; the spleen always showed typical changes of necrotic foci varying in size and number. In one instance similar foci were found also in the liver, large enough to be visible macroscopically. This was in a case where like changes were found in the lungs.

Only one of the guinea-pigs showed an exception, in that the primary buboes were located in the inguinal region, with pelvic and axillary glands secondarily involved. These are the findings usually met within guinea-pigs artificially infected with plague by the vaccination method, if the lower part of the abdomen be chosen for inoculation. The reason for such a deviation from the findings in the rest of the guinea-pigs may lie in the fact that this animal was almost completely deprived of hair by a skin disease.

It is of importance to mention the skin lesions which were found on the necks of the guinea-pigs, particularly under the chin. Besides small red spots which appeared to be fresh flea bites, small, elevated, and fairly deep infiltrations partly covered with moist scab were found in the skin under the chin. Other animals showed changes usually found in the scarified skin of guinea-pigs after artificial inoculation with plague material. The base of each cutaneous efflorescence was hemorrhagic and œdematous.

A histological study of the tissues of these guinea-pigs known to be naturally infected by plague fleas showed the following changes:

THE CERVICAL BUBO.—The enlarged lymphatic gland was surrounded with a thickened capsule. Necrosis existed in the subcapsular part of the gland, where it formed an almost continuous circular zone, leaving the central part less changed. Smaller irregular necrotic foci were scattered throughout the section. Polymorphonuclears in various stages of disintegration were found throughout the section.

The Lungs.—Very few blood extravasations were present in the alveoli; otherwise normal.

The Spleen.—The capsule was thin. There were subcapsular hemorrhages. The Malpighian bodies were somewhat enlarged, but of normal structure. Throughout the parenchyma irregular multiple necrotic foci were found, leaving but little of spleen tissue intact. Numerous polymorphonuclears which were present showed varying degrees of karyorrhexis.

The Kidneys.—The outline of the cells was indefinite; a few miliary hemorrhages existed in the cortical part of the organ.

The Liver.—There was excessive congestion, fatty degeneration, and pigmentation of the cells. The capsule was slightly thickened.

The Skin.—The epithelium was missing in one place in the section, and cellular infiltration extended from that place into the subepithelial layer of the surrounding skin. The same kind of infiltration reached deep into the skin, stripes of cellular infiltration penetrating into the tissue along the muscle fibres.

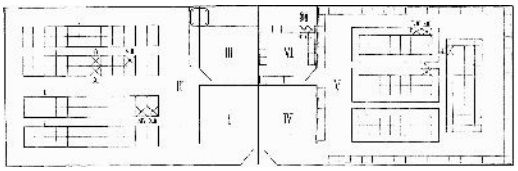
There was no direct connection between the cellular infiltration and the follicles of the hair.

It may be well to describe in detail the time of death from plague among these and the other animals in this outbreak, as well as the time when the plague house was disinfected.

The first animal (rat 1) having been inoculated on August 27, in the afternoon, died of plague within three days (August 30). The second animal (rat 2) died twenty-four hours later. Guinea-pigs 3, 4, and 5 (see plan) were found dead on the morning of September 2; that is, two days after the death of rat 2 and three days after the death of rat 1.

The same day that the three guinea-pigs were found dead of plague, rooms I, III, IV, and VI were thoroughly disinfected. The floor, the ceiling, and the walls were sprayed with kerosene and lysol solution. The remaining animals in room VI were destroyed, and the cages disinfected. No animals were kept in rooms I, III, and IV at that time.

Three days after the death of animal 5, guinea-pigs 6 and 7 were found dead of plague, while the next day guinea-pigs 8 and 9 died. No death occurred on September 7, but the next two days each recorded two plague guinea-pigs (10, 11, 12, and 13). On September 11, the last guinea-pig died of plague in this outbreak. The whole building was then thoroughly disinfected. No plague-inoculated animals were kept in the rooms after the first sign of the epidemic. After September 11, no more cases of spontaneous plague infection were observed.



ANIMAL HOUSE

It will be noticed that the epidemic lasted eleven days after the first animal died and fourteen days after animal 1 was inoculated. Altogether, 14 animals out of at least 200 animals exposed died of plague.

No death occurred among rabbits, although these animals were distributed among the guinea-pigs. In fact, 2 rabbits were surrounded by plague guinea-pigs 8, 9, and 10, but did not contract plague.

From the epidemiological standpoint it is interesting to know the dimensions and location of the cages in which the animals were kept.

Aside from the 2 rats which were confined in ordinary traps that stood on a table 80 centimetres high, the rest of the animals were kept in regular metal animal cages. The dimensions of the cages are: Fifty centimetres long, 36 centimetres broad, and 30 centimetres high. The cage stands on four legs each 10 centimetres long; the centre of the bottom of the cage holds a drain opening 8 centimetres above the floor.

The majority of the cages in room II were located on the floor; some on the second shelf of a wooden rack. This last-mentioned arrangement, judging from the construction of the wooden frame, allowed a continuous passageway for the fleas to the second shelf of the racks. On the other hand, the deaths among the guinea-pigs in room V were restricted to the cages standing on the floor, the majority of cages in that room being placed on tables 80 centimetres high.

Only a theoretical explanation can be given of the short duration and sudden cessation of the outbreak. One can assume with great probability that the first partial disinfection drove the fleas away from the primary source of infection, and that they traveled as far as possible. They finally settled in those guinea-pig cages which had not been molested by the first disinfection. Having no new supply of plague blood (all of the plague-infected guinea-pigs having been removed, most of them before death), the fleas soon cleared themselves of plague bacilli. The peculiar feature of the outbreak, namely, the failure to find fleas on the animals in rooms II and V, finds its explanation in the observation of the Indian Commission who found that the fleas "died or disappeared very rapidly."

The following conclusions can be drawn from these observations:

1. The common rat flea (*Lœmopsylla cheopis*) prefers the rat to the guinea-pig.
2. In the absence of rats it will attack guinea-pigs rather than rabbits.
3. The fleas which have sucked blood from rats or guinea-pigs afflicted with plague septicæmia were found to harbor virulent plague bacilli inside of their bodies.
4. The transmission of plague infection by direct or indirect contact being excluded in our case, the fact that fleas of the same species and harboring plague bacilli were found on the rat and on the guinea-pigs, the presence of flea bites on the rats and on the guinea-pigs with positive findings of skin lesions on that part of the body where the fleas and flea bites were located, together with the anatomical picture of the findings in the guinea-pigs, lead to but one explanation; namely, that the plague infection was transmitted by fleas.

III. Observations on Animals Suspected of Plague

Out of the several tens of thousands of rodents examined during the antirat campaign, we have found only two plague rats which showed the typical picture of natural plague infection in rat; that is, cervical buboes with surrounding œdema, subcutaneous injection, pleural effusion, enlarged spleen, and such changes of the liver as are characteristic of natural plague infection in rats. Microscopically, large numbers of plague bacilli were found in these cases, and pure cultures of *Bacillus pestis* were recovered from the spleen. Histological examination of internal organs, particularly that of the liver, confirmed the bacteriological findings. The remainder of the plague rats exhibited only two of the signs of plague infection, namely, bubo and œdema of the surrounding tissue, and eventually hemorrhages.

Besides plague infection, a great number of rats showed purulent conditions from causes other than plague. Abscesses of the lungs were frequently met with, and cervical or axillary buboes are not uncommon in Manila rats. Various pyogenic bacteria were found in the pus of such abscesses. Of the less common was *Bacillus pyocyaneus* and the pneumobacillus of Friedländer. Chronic plague was excluded in these cases since the animal inoculation failed to produce plague infection.

More than half of the rats examined harbored parasites in their organs. *Echinococcus taeniæformis* was found in the liver of practically every gray rat, while a small *Ascaris* and *Tænia diminuta* were not uncommon in the intestines. Two rats were found to have sarcosporidiosis, 2.6 per cent. showed rat leprosy, and 7.4 per cent. trypanosomiasis. One tumor of the mammary gland and one tumor in the axillary region were encountered, while one tumor of the large curvature of the stomach proved to be a chronic inflammatory tumor due to parasites. One peritoneal tumor in a rat (*Mus decumanus*) gave the impression of a malignant tumor on account of the miliary dissemination of the peritoneum. It was found to consist of muscle and spindle-cell sarcomatous tissue. Ectoparasites were very seldom noticed, on account of the method of collecting the rats. When present, they were mites and fleas.

In the naturally infected plague rats the rigidity of the fresh cadaver was pronounced. The primary bubo was in every case cervical. Cervical glands were enlarged and hemorrhagic with slight œdema of the surrounding tissue. The subcutaneous injection extended over the neck and chest. The inguinal glands were small and pigmented. The lungs were collapsed, and showed hemorrhagic foci. The spleen was slightly enlarged, firm, and dark red. The liver was rather large, firm, pale red, with shade of yellow, which was caused by minute yellowish foci thickly scattered throughout the tissue and visible through the capsule. The kidneys were hyperæmic. The intestines were without change. The serous membranes were pale with no hemorrhages.

Histological examination of the tissue of naturally infected plague rats showed the following changes:

Liver.—The structure of the organ was well marked; the veins dilated, trabeculæ slightly compressed, nuclei well stained, and few of the liver cells showed vacuoles. Small foci, most numerous under Glisson's capsule, were scattered throughout the organ; they varied in size, but were not larger than a miliary tubercle. The small necrotic foci were found to consist of few necrotic liver cells. The centre of the larger foci was formed by degenerated and necrotic liver tissue, surrounded by round-cell infiltration. Polymorphonuclears were also found in the zone of cellular infiltration. There was a slight degree of hemorrhage in each focus. Epithelioid cells and large vesicular cells with several nuclei were to be found. The foci, mentioned above, were sharply demarcated from the surrounding liver tissue, which appeared to be intact.

Spleen.—The structure was well preserved, the capsule thin. The Malpighian bodies were normal as to the elements of which they consist. Cells with pycnotic nuclei were scattered throughout the organ, and vesicular cells with small, deeply stained, excentrically located nuclei were present. Polymorphonuclears were found in the tissue in considerable numbers. No localized necrotic foci could be found in sections through the spleen.

Cervical Glands.—The blood-vessels were considerably distended. A few hemorrhages and polymorphonuclears were present. Œdema of the capsules and surrounding tissue existed. Part of the gland was necrotic.

Lungs.—The blood-vessels were distended. The alveoli contained homogeneous masses and blood. There were numerous subpleural hemorrhages. The bronchi were collapsed, and contained mucus.

Kidneys.—The cortical part showed subdued structure; the epithelial cells had an indefinite outline and occasionally showed vacuolization. The medullar part was better preserved. There were miliary subcapsular hemorrhages. A few small foci were scattered throughout both medullar and cortical parts. They consisted of round-cell infiltration.

Natural Plague Infection in a Cat

The experiments of the German Plague Commission proved that cats showed considerable resistance to plague infection as cutaneous and subcutaneous inoculations failed to infect them. According to the Austrian Commission, cats develop submaxillary buboes if fed on plague material. They are said by Albrecht

and Gohn[13] sometimes to recover. Out of four cats fed on plague material two died of plague, one showing submaxillary, the other mesenterial buboes. Virulent plague bacilli were found in the discharge from the nose and also in the fæces of cats which apparently did not become infected after having been fed on plague material.

[13] Über die Beulenpest in Bombay im Jahre 1897 (1897), II B, II C.

One case of spontaneous plague infection of a cat was recorded by Thompson[14] in Sydney.

[14] Report of an outbreak in Sydney, 1900. Referred to in Kolle and Wassermann (1903), **2**, 510.

W. Hunter,[15] in Hongkong made observations on cats suffering from plague infection. The author also undertook a few experiments, and arrived at the following conclusions:

1. Cats suffer from plague.
2. The disease may be acute or chronic.
3. The type of the disease is septicæmic.
4. The animals may occasionally play a part in the dissemination of plague.
5. In plague-infected areas cats probably become infected through rats, which they devour as food.
6. In plague-infected districts possible plague infection in cats is of great importance from a domestic point of view.

[15] Lancet (1905), **I**, 1064.

On November 27, 1912, a sick cat was brought to the laboratory for examination. It was reported that the animal was found in a warehouse in which dead rats had been found some time previously. The rats were not examined. In the morning of the 30th, the cat was found dead in the cage where it had been kept under observation. The following are the post-mortem findings:

The animal was a fairly well-nourished female.[16] The subcutaneous tissue, pericardium, mediastinum, and mesenterium contained considerable amounts of fat.

[16] The cat was the mother of 4 kittens which were about 3 weeks old at the time the cat was delivered for examination. They were kept under observation for several weeks, but showed no signs of plague infection.

The subcutaneous tissue of the neck showed œdema and small hemorrhages. The submaxillary tissues were swollen on both sides. When the fasciæ and superficial muscles of the neck were removed, enlarged glands were found on both sides. These were closely attached to the submaxillary salivary glands. The surrounding tissue was œdematous, but no hemorrhages were noticed in the vicinity of the enlarged glands. Upon section the glands were found to be necrotic, and upon pressure a thin purulent liquid escaped. There were no hemorrhages within the glands. Several enlarged lymph-nodes, smaller in size, could be followed down the neck on the left side. The lymph-nodes in the axillæ as well as in the groins and peribronchial nodes were normal. The mesenteric glands were slightly enlarged and reddened.

The lungs were slightly collapsed. A clear, sanguineous, slightly coagulated effusion was observed in both pleural cavities. The tissue of the lungs showed considerable œdema and hypostasis. The bronchi and pharynx showed no changes, the mucous membrane being pale and thin.

The heart was normal.

The spleen was enlarged, of light red color, with follicles slightly prominent.

The stomach contents was blackish in color; there were no hemorrhages or ulcers in the mucosa.

The liver was somewhat enlarged. The organ showed prominent structure, the centres of the acini being red, the periphery lighter in color.

The kidneys were slightly enlarged and pale. The capsule peeled off easily, the venæ stellatæ were prominent, the surface smooth; there were no hemorrhages. The cortex was increased in breadth and was of the same color as the surface; the pyramids were darker in color. The organ was of fragile consistence.

Suprarenals were normal, as were also intestine and bladder.

The histological findings were as follows:

Bubo.—The capsule of the gland was œdematous. The whole gland as seen in cross section had undergone necrosis, except a few foci which still showed cellular structure.

Lungs.—The alveoli were filled with homogeneous masses, containing but few degenerated epithelial cells and leucocytes. The blood-vessels were dilated, particularly in the subpleural part of the organ. In some places capillary mycotic emboli with subsequent hemorrhage were encountered. The large blood-vessels and bronchi were normal.

Salivary Glands.—Those glands attached to the primary bubo showed the normal structure of a combined mucous and serous gland.

Liver.—There was considerable congestion. The centres of the acini showed parenchymatous and fatty degeneration. The cells on the periphery of the acini exhibited typical fatty infiltration. The large blood-vessels and small ducts were without change.

Kidney.—The cells of the kidney showed various degrees of degeneration, ranging from parenchymatous to fatty infiltration. There were a few capillary hemorrhages and hyaline casts present.

Suprarenals.—These showed slight degeneration.

Spleen.—This organ showed congestion, a few hemorrhages, and bacterial emboli; otherwise normal.

The bacteriological examination of the material from this cat gave the following results:

1. *Smears:*
   a. From the buboes showed degenerated leucocytes, many lymphocytes, and numerous bacteria, some of which resembled *Bacillus pestis* in their polar staining.
   b. From the spleen showed numerous plague-like, polar-stained bacilli. Round involution forms were present.
2. *Cultures:*
   a. From the buboes were badly contaminated with *Bacillus coli* and *Bacillus pyocyaneus* colonies.
   b. From the spleen: A few scattered colonies of *Bacillus pyocyaneus* developed on the surface of the agar. Between the large colonies a scanty growth of dewy appearance was noticed. Smears made from this growth revealed plague-like bacilli of the cultural type, showing a few club-shaped involution forms. Subcultures were made in order to secure pure culture. They showed a pure growth of *Bacillus pestis* as indicated by the morphology of bacilli and shape of the colonies. Agglutination with plague-immune serum was positive.
3. *Inoculation experiments (vaccination method):*
   a. One guinea-pig was inoculated with the material from the left bubo, another one with material from the right bubo. They died of plague on the third and fifth days, respectively.
   b. One guinea-pig was inoculated with the material from the spleen. It died of plague on the third day.
   c. One guinea-pig was inoculated with material from the nostrils obtained by swab. The animal survived, showing no indication of plague.
   d. One guinea-pig was inoculated with material from the rectum obtained by swab. It died of plague on the fifth day.

Although plague infection among cats is apparently a rare occurrence, the fact that cats may contract the disease in spite of the high degree of resistance to plague infection has to be considered from the hygienic standpoint.

To appreciate the important rôle which cats may play in the spreading of the disease one need only consider the close contact of these animals with rats on one side and human beings on the other. It is also a well-established fact that not only plague-infected cats, but also those which have devoured plague-infected material and remained apparently normal, may excrete plague bacilli which have retained their full virulence.

NOTES ON PLAGUE IN HONG KONG BY DR. ROBERG.—During the Hong Kong epidemic of plague which preceded and was coincident with that of Manila, I visited that city twice (December, 1913, and July, 1914), but I did not closely investigate the methods adopted and carried out by the authorities there, for the reason that the Manila plan was so much more productive of results, as shown by the apparent inability of the Hong Kong officials to gain control of the disease. However, I received from Dr. David Roberg, of the Oregon State Board of Health, a copy of a report made by him to the Secretary of his State Board of Health, following an investigation of the Hong Kong epidemic and the methods there followed. I have Dr. Roberg's permission to use his report and it is herewith presented. It is dated Manila, April 16, 1914, and is as follows:

I have the following notes to present on the epidemic of bubonic plague in Hongkong.

On April 5th when I arrived in Hongkong the epidemic was rapidly approaching its height. With its onset in January there were 47 cases, in February 42, and in March 223. During the week previous to April 5th, there were 91 cases; during the six days I was in Hongkong they averaged 15 a day.

Judging from previous epidemics the present one will be exceptionally severe. The season for the occurrence of human plague is from the months of February to July. The onset is gradual; in May it reaches its maximum and then declines. In the epidemic of 1912, for the city of Victoria the monthly rate showed the following, January 9, February 22, March 61, April 265, May 513, June 346, July 105, August 11, and September 1. Comparing these rates with those of the present year it will be seen that the number for March far exceeds that of two years previous.

Illustrating the season for human plague, with its onset, maximum and decline, are the monthly rates for the city of Kowloon during 1912, when the following cases occurred: February 2, March 12, April 52, May 246, June 152, July 39, August 8, and September 3.

The season for human cases is determined by the condition of the rats. At the close of the season in July the rats die off from plague in great numbers as it is then the hottest time of the year. During the months from September to February the rats increase in number and in susceptibility to the extent of being sufficient to again infect human beings. Moreover every other year shows a marked severity in the epidemics of human bubonic plague. This is explained by the fact that it requires two years' time for the rat population to become of sufficient greatness and susceptibility to cause a severe human outbreak. This is shown by the yearly number of cases since the year 1911. During the years 1911, 1912 and 1913 respectively, there were 253, 1847, and 408 cases. During the present year the monthly rate is exceeding that of the heavy year of 1912.

The severe epidemic in 1912 was a result of the influx of 50,000 Chinese refugees into Hongkong during the revolution in 1911. The number of rats in the native district depends upon the available food supply, and as a result of this human overcrowding the amount of waste food so increased in the houses, yards and streets, that the over accumulation of garbage could not be kept pace with. This influx also brought in great numbers of susceptible rats.

The number of rats killed off during the epidemic in 1912 were so great that in 1913 they had not recovered sufficiently to cause a severe outbreak during that year, and as a result of the lightness of epidemic in 1913, they are so increased in number and susceptibility now that they are causing a very severe epidemic in human beings.

Of rats in Hongkong they have the *Mus decumanus* or drain rat and the *Mus rattus* or house rat. It is noteworthy that the drain rat is found plague-infected throughout the year, while the house rat is found infected only during the period in which the human epidemics occur, namely from February to July. The number of infected rats a year run parallel to the number of monthly cases.

The bulk of human infection is due to the spread of house rats. Man also becomes infected by the drain rat when the drains are flooded by rain storms and the rats are driven into the houses.

What has made plague permanent in Hongkong is the overcrowding of the native districts. Besides there is a floating population entering and leaving the native quarters, numbering about 4000 a day. The native houses have been built with double floors and walls which harbor the rats. Where the construction is of wood it is possible to remove the rat spaces. It has been found since the introduction of plague into Hongkong in 1894, that those districts containing the greatest number of soft brick houses with hollow walls, have shown the greatest incidence of plague. This can not be remedied as it would involve the destruction of buildings on too large a scale.

The Work of the Sanitary Board

The area under the control of the Board comprises the Island of Hongkong containing 32 square miles, with a sea frontage of 13 miles in length. Included also is the old city of Kowloon which is situated one mile and a third across the harbor and contains two and three-fourths square miles. The city of Victoria on the northern shore of the Island of Hongkong has a sea frontage of 5 miles, contains about ten thousand domestic buildings, of which about one thousand are non-Chinese.

The population of Hongkong is difficult to estimate, as the floating population is so great. In the 1912 census there were 446,614 Chinese and 21,163 non-Chinese.

The city of Victoria is divided into 10 Urban Health Districts and old Kowloon into 2. There is an inspector in charge of each. These districts are built over an area averaging from 31 to 140 acres. The houses in these districts average one thousand and the population from 8000 to 33,000. There are four inspectors in charge of the scavenging work, one for the disinfection stations in Victoria and old Kowloon, one for the cemeteries and two for general duty.

The measures employed by the Sanitary Board are summarized as follows:

1. The exclusion of rats from all dwellings by means of concreted ground surfaces, the protection of all drain openings and ventilating openings by iron gratings, and the prohibition of ceilings and of hollow walls in new buildings and in those existing buildings from which they have been removed by order.
2. The collection and bacteriological examination of all dead rats. Facilities for the collection of rats in the quarters are provided in the shape of small covered bins attached to lamp posts, telephone posts, electric light poles, etc. These bins contain a carbolic acid disinfectant, and the inhabitants are invited to at once put into them all rats found or killed by them. There are 650 of these bins distributed throughout the city and its suburbs, and each of them is visited twice daily by rat collectors who take all rats found by them to the City Bacteriologist. Each rat is at once labelled with the number of the bin from which it is taken, and if subsequently found to be plague infected, a special survey is immediately made of the block of houses in that vicinity. All rat-holes and rat runs are filled up with broken glass and cement, defective gratings and drains dealt with, and rat poison distributed free to the occupants. If several plague-infected rats are found in one locality, a special house-to-house survey and cleansing of that district is made.
3. The destruction of rats by poison, traps and birdlime boards; special efforts in this direction being made just before the onset of the regular plague season which is in the months of from March to July.
4. The encouraging of the community to keep cats.
5. The systematic cleaning and washing out of all native dwellings at least once in three months with a flea killing mixture made by emulsifying kerosene in water.
6. An efficient daily scavenging of all streets and lanes and the daily removal of refuse from the houses, coupled with the provision of covered metal dust-bins, to reduce as far as possible the amount of food available for rats.
7. The disinfection of plague-infected premises by stripping them and washing them out thoroughly with a kerosene emulsion. The bedding, clothing, carpets, rugs, etc., are conveyed in a huge covered basket to the disinfecting plant and sterilized with superheated steam. No objection is made to the treatment of plague cases in native hospitals, and no restrictions are imposed in regard to the burial of those dead with plague except the provision of a substantial coffin.
8. Every effort is made by means of lectures, addresses and explanations to induce the native population to participate in the above preventive measures.

Upon my last visit to Hong Kong, in July last, plague was abating. *The South China Morning Post* of July 15, 1914, contained the following statement:

> Plague is gradually disappearing from Hongkong. Last week's return shows that there were 26 cases, of which 19 were fatal. All were Chinese. The total number of cases for the current year to date is 2093, with 1939 deaths resulting.

I regret that circumstances do not permit me to relate in detail the work done and the observations made during the closing six months of the Manila epidemic.

Up to the day of my departure from the Philippines, in July, 1914, I remained in charge of plague suppression, but the added duties of administration at San Lazaro Hospital and the coincident occurrence of a cholera epidemic prevented me from keeping a detailed record in such form as to permit reproduction here. It will therefore suffice to say that the first six months of 1914 witnessed the passing of the most threatening situation that has confronted the city of Manila in years. The record of plague rats found does not convey an accurate idea of the prevalence of rat plague by any means, for the simple reason that, when found, the rat cadavers were in such condition as to forbid bacteriologic examination; and inasmuch as the bacteriologic test of plague had been used exclusively in determining rat plague up to this time, it seemed desirable to adhere to the original method.

In February we found in one of the districts, in which we undertook systematic work in consequence of a few cases of human plague, a very large number of dead rats, in and adjacent to houses which furnished human plague cases. In one building alone more than 150 rat cadavers were found during our cleaning and rat-proofing operations. It is this district concerning which the letter to the public (already quoted) was written.

The methods followed in treating this new and dangerous focus of infection did not differ from those practised during the previous year, except in the matter of intensity. Forces of the cleaning and rat-catching gangs were increased and the utmost thoroughness of treatment was insisted upon. The results fully justified our policy and demonstrated again how feasible it is to fight plague successfully if adequate authority be given.

During the last year of the epidemic in Manila it became the rule for us to expect our plague workers to locate and find the identical rat cadaver from which the infected fleas bore the disease to the human victim, provided the spot upon the floor where the patient's sleeping mat had been placed was known. In the better class of houses the rat (sometimes more than one) was found dead beneath the floor, behind some post casing, or in other space caused by double construction. Time and again I have directed the removal of some panel of woodwork, some post casing, or a board of the floor with the full expectation (seldom unrealized) of finding a dead rat or a rat nest. These experiences were positively uncanny at times. In the houses of the poorer class, usually of bamboo and thatch construction, the finding of the rat was less easy and more uncertain, although the nest was repeatedly found, and as related elsewhere the dead rat itself might be found in a hollow bamboo timber, or in the thatch construction of the wall. In a house on Calle Echague, from which a Filipino and his wife were removed, dead, within a few hours of each other, several dead rats were found in the floor (the only piece of double construction in the whole house) within four feet from the spot where the sleeping mats were placed. A rat hole led to the nest and through this hole the fleas from the dead rats found their way to the human victims sleeping on the floor above the encased nest.

These instances could be multiplied many times, but there is no longer any special reason to do so, as the rat and the rat-flea are so completely incriminated as to render these repetitions quite unnecessary, however interesting they may be to the plague worker. The danger of pursuing these investigations, to the persons so engaged, must not be lost sight of, and exposure of such nests and rat cadavers should invariably be preceded by thorough spraying of the place, and particularly of the spot where tearing out of double construction is to be done. I know of no more dangerous employment than this, both for laborer and bystander.

CHAPTER IV
ITS DIAGNOSIS AND TREATMENT

It was not my original intention to include the subjects of diagnosis and treatment in this presentation, except in so far as I have already referred to them in the relation of my Manila experiences in the preceding pages. I have decided, however, to add a chapter upon Diagnosis and Treatment, for the sake of completeness. No attempt will be made to present these subjects in the orthodox way.

Rather, my remarks will be confined to such matter as I believe to be thoroughly practical and relevant.

In my opinion, the day has arrived when we may properly exclude from such handbooks as this one (intended for practical guidance), all such methods of diagnosis and treatment as have failed to meet the test of actual experience through a reasonable length of time. Twice in recent years,[17] I have described the diagnosis and treatment of plague, attempting in each case to present a reasonably full account of the methods employed and advocated by authorities, for theoretic reasons and from the recorded personal experiences of medical men throughout the world. There comes a time, however, when wheat and chaff must be separated and when methods which have failed, in application, to justify preformed expectations must be relegated to the department of historical medicine.

[17] Tropical Medicine (1907) and Hare's Modern Treatment (1911), vol. 1.

Judging from recent medical text books it is evident that medical writers are generally accepting this view as the proper one. At any rate, my experiences and those of my medical friends during the Manila epidemic of 1912–1914, have led me to discard as impracticable, unproven, disproven or unpromising, certain plans of treatment formerly deemed worthy of trial. I do not refer to these methods individually but will content myself, instead, with reciting briefly the methods which I believe, from personal experience and the collected experience of others, to be worthy of continuance and of further trial.

Diagnosis.—The rapid diagnosis of plague is always of the utmost importance, both from the view-point of prognosis and treatment, in the individual case, and from the community view-point of the recognition of the presence of a dangerous communicable disease, with the resultant obligation falling upon the health authorities.

The Biologic Diagnosis.—Let us understand, first and finally, that but one diagnosis is absolutely and irrefutably dependable, viz.: the biologic diagnosis. Herein I would include not only the recovery of the pest bacillus from the patient, but the recovery and identification of the organism from inoculated animals, infected from blood, tissues, secretions or cultivated plague bacilli derived from the human patient or cadaver.

This entire process involves a lapse of time of several days, and, while it is indispensable in the earliest cases of an epidemic, and highly desirable for the proper study of all cases of plague, it is impracticable and unnecessary, in communities where plague is known to exist, to carry out more than the first steps of the biologic diagnosis, viz.: the recovery of *B. pestis* (morphologic identification) from the patient.

Necessity for Trained Bacteriologist.—It is evident that the services of a trained bacteriologist are indispensable in the accurate diagnosis of plague, unless (as rarely is the case) the observer himself is both clinician and bacteriologist. Even in this case it is far better for two persons, clinician and bacteriologist, to work together. I will not discuss the technic of the procedures of biologic diagnosis, which is described by Dr. Schöbl in the preceding pages. Except under circumstances of necessity, the clinician should always turn this work over to the bacteriologist.

Serum reactions, when present, occur too late to be of service in practical diagnosis.

The necessary procedures of the biologic diagnosis include blood-culture, smear examination (microscopic) of aspirated material from the œdematous tissues surrounding gland masses and from glands themselves; examination of sputum smears and of thick-blood smears.

All should be practised but, according to our Manila experiences, smear examinations of aspirated material and blood cultures are the most reliable methods, in the hands of a competent bacteriologist. Attention is invited to the reports of Dr. Otto Schöbl, already quoted.

Bacteriologic Procedure.—Dr. Schöbl was able to secure positive blood cultures, within 24 hours, from all of a long series of cases of plague, both bubonic and septicæmic. As much blood as it was possible to secure was aspirated from superficial veins and introduced into the culture media at the bedside, ten c.c. being secured whenever it was possible.

The smear preparations for staining and culture inoculations upon slants were also made at the bedside from aspirated matter obtained from œdematous periglandular tissues or from gland puncture, an aspirating syringe being used. The drop or two of fluid which can be expelled from the hollow needle is usually sufficient for smears and tube inoculations.

Non-biologic Diagnosis.—I do not contend that other diagnostic means than biologic ones should not be used in plague.

On the contrary, it will inevitably happen at times that resort must be had to methods of diagnosis which are purely clinical. When this is the case, treatment, along lines to be detailed presently, should be instituted upon the establishment of a presumptive diagnosis. This presumptive diagnosis may be reached after due consideration of physical signs and symptoms. A carefully taken history of the onset and course of the disease will be valuable but unfortunately such histories can rarely be secured. It is far safer to mistakenly pronounce a case "plague" and to institute appropriate treatment, than it is to hesitate in the absence of a perfect clinical picture and to permit the golden moment for treatment to pass.

It must be remembered that septicæmic, bubonic and pneumonic plague are all manifestations of systemic infection with *B. pestis*; that they are all expressions of the same disease; that they call for the same treatment and that when the distinctive signs of bubo or pneumonia appear the disease is dangerously advanced.

It should also be realized that every case is, almost from its onset, a septicæmic case, either mildly or overwhelmingly so. Accordingly the treatment should invariably be the treatment of septicæmic plague.

The attitude of the diagnostician should be one of suspicion and he should have the courage to carry out antiplague treatment, practically upon suspicion. In this way only can the mortality of plague be greatly reduced. It is true of plague, just as it is true of cholera, that many of the fatal cases develop and become hopeless before the disease is suspected or diagnosticated. It is also true that many fatal cases of plague, in times of epidemic, completely escape recognition during life, the diagnosis being made in the autopsy room.

Therefore, I lay great stress upon the necessity for an attitude of suspicion on the part of practitioners, wherever even a single case of plague (human or rodent) is known to have occurred.

When it becomes necessary to establish a presumptive diagnosis, *i.e.*, without resort to the microscope, the following symptoms and physical signs will be found to be most significant.

Symptomatology.—Acuteness of onset; rapidity of fever development; rapidity of the development of mental dulness or cloudiness, impairment of speech, delirium, stupor or restlessness; early and extreme prostration (perhaps more pronounced than in any other acute disease); extreme tenderness over involved gland masses, in the bubonic type of plague; cough, with considerable frothy sputum, soon becoming blood-discolored, in the pneumonic type of plague; and early cardiac asthenia in all clinical types of plague, septicæmic, pneumonic and bubonic.

The following diseases may be confounded with plague, if symptoms alone are considered: typhus (*exanthematicus*), influenza pneumonia, broncho-pneumonia, severe malaria, septicæmia, acute toxic typhoid, venereal bubo, mumps and tonsillitis.

I call attention again to the fact that mild cases of plague, septicæmic and bubonic, occur at times, clinical pictures in such cases being incomplete.

The statement that the prognosis in all cases of septicæmic plague is hopeless is not confirmed by my experience.

It should also be remembered that primary pneumonic plague and secondary pneumonia developing in the course of systemic plague are quite different in their significance and mortality, primary pneumonic plague being well nigh invariably fatal.

Pathologic Considerations.—Only the student of plague pathology, who has seen a large number of complete autopsies, can understand how universal is the involvement of organs, glands and tissues in systemic plague and how widespread is the distribution of *B. pestis* throughout the body, and he will best understand how treatment, to be in the least effective, must be given in the very earliest hours of the disease.

Plague is an exquisitely septicæmic disease and this fact must never be lost sight of by the therapeutist, who must realize that from the earliest moment of infection all plague is septicæmic plague.

Treatment, Conditions and Prognosis.—Passing to the subject of treatment let us, first of all, admit that even under the most favorable and approved conditions of treatment the mortality is extremely high. On account of the delay which usually occurs in the recognition of plague,—a delay which in the natural order of things is and must be the rule rather than the exception, because of the rapidity of onset of the disease and the fact that it occurs much more frequently in the lower social classes than elsewhere,—no brilliant results are to be expected from any plan of treatment.

The matter of plague treatment is far from being in the same satisfactory state as the matter of preventive control. I do feel, however, that biologic treatment from the earliest possible moment, with serum, is of the greatest promise, however discouraging the general prognosis may be in plague.

Serum Treatment.—Recent writers agree that there is no treatment with curative value except that with antipest serum. To this belief I subscribe assent, as I find it entirely in accord with my experience and that of my colleagues in Manila during 1912–1914.

Holding this view, I can see no reason for repeating here the details of purely symptomatic treatment. Symptomatic treatment has for its object the securing of comfort and of relief from suffering for the patient and is highly proper in its place, remembering always that it is not curative and that if employed alone it is worse than inadequate.

Symptomatic Treatment.—Opiates (morphine by needle) for pain, delirium and excitement; application of ice bags and cold or tepid sponge bathing for high temperature; stimulants for heart weakness, are all indicated and are required in nearly every case of plague.

As a rule surgery is not called for nor appropriate, except in cases which develop secondary surgical conditions, which conditions we need not consider at this time.

Statistical Studies in Mortality.—The statistical study of plague mortality from the point of view of treatment is misleading and unsatisfactory for reasons already given in our discussion of treatment, viz.: failure to secure early recognition and early serum treatment, and the greater incidence of plague in the lower social classes.

Few statistical compilations divide the cases studied into moribund and non-moribund, and indeed such division, being a matter of judgment, largely involves the personal equation of the observer.

The ease with which statistics may be moulded to support theories, or to break them down, all with perfect honesty of purpose, is proverbial.

To me, the spectacle of a single case of plague, apparently ill unto death, recovering under the administration of antiplague serum, is more impressive than the contemplation of statistics; and I have seen more than one such case respond to serum treatment and recover.

So far as it goes, however, the study of statistics supports the view that treatment with antiplague serum is effective.

I have not at hand the records of the last 20 or more cases, but of the first 68 cases of plague in the recent Manila epidemic, 32 were either found dead or died upon the same day that they were found.

If we exclude these cases from consideration there remain 36 cases. All of these patients received serum treatment and ten of them recovered.

It is at once apparent that this percentage of recoveries (27 per cent. plus) is far more favorable than the actual percentage of recovery in the series in which cases found dead and moribund are considered, the recovery percentage here being a little more than 14 per cent. It is also quite fair, it seems to me, to make this separation of cases, or even a more liberal one, if we are to consider the effects of serum treatment statistically.

Dosage and Technique of Serum Administration.—The amount of antiplague serum to be given will vary somewhat with the age and weight of the patient and with the apparent severity of the case.

In general terms it may be said that adults should be given from 300 c.c. to 500 c.c. of serum by injection, 100 c.c. being given every four hours. The injection may be either intramuscular or intravenous.

In view of the improvements in technic of intravenous administrations and its comparative simplicity, and especially in view of the uncertainties and delays of absorption from the tissues, the intravenous route should be given the preference. The serum may be delivered intravenously from a large glass syringe, the introduction being very slowly made, or through a gravity apparatus, as in the administration of salvarsan. The serum should not be diluted.

The use of antiplague serum for protective (immunizing) purposes is also recommended—especially when exposure to infection has occurred—in the same way in which diphtheria antitoxin is used. Its protective properties are conceded to be somewhat superior to those of plague vaccines as the protection conferred is immediate, whereas plague vaccines do not protect until sometime after their administration. The dose is from 30 c.c. to 50 c.c.

Prophylactic Serum and Anaphylaxis.—On one occasion in Manila in 1913, when some 30 persons were given prophylactic doses of serum, intramuscularly, following a particularly dangerous exposure to fleas from rats dead from plague, there occurred a number of cases of "serum sickness" (anaphylaxis). These persons suffered from severe urticarial, arthralgic and nervous symptoms, lasting for several days and a few were obliged to enter a hospital. In one case the symptoms did not entirely abate for a week. It has been stated that newly-prepared serum is particularly apt to produce serum sickness when used for immunizing purposes. This form of protection is brief (1 to 2 weeks) and is best suited for use where there has been special exposure.

Plague Vaccines.—Haffkine originally proposed prophylactic immunization, using killed broth cultures of *B. pestis* (carbolized to ½ per cent.), giving two injections at intervals of 10 days. Statistically it seems to be shown that this prophylactic immunization with dead bacteria reduces the incidence and mortality one-fourth or one-half (approximately). Experimentally, also, it appears that antibodies (agglutinins) are produced by the vaccine (and modifications thereof). Instead of broth cultures, normal salt solution suspensions of killed pest bacilli are usually used in vaccines at present.

Castellani[18] has prepared a combined cholera and plague vaccine for use in countries where both diseases coincidentally prevail. It is a mixed vaccine, so prepared that 1 c.c. of the emulsion contains 1000 millions of plague bacilli and 2000 millions of cholera vibrios. The cultures are grown on agar, killed by phenol and suspended in normal salt solution.

[18] A. Castellani: Journal of Ceylon Branch of British Medical Association, June, 1914.

He finds (1) that inoculation of the vaccine in the lower animals induces a production of protective substances for the plague bacillus and the cholera vibrio; (2) that the inoculation of human beings is harmless (producing less reaction than the Haffkine inoculation); (3) that a small amount of agglutinins, both for plague and cholera, appear in the blood of most inoculated persons (similar to amounts produced by Haffkine's vaccine), a rough index only of the amount of immunity produced.

INDEX

Transcriber's note:

The following corrections have been made:

Title page: Period added after J in "J B. Lippincott Company"
Dedication: Period added after "DAYS IN SERBIA"
Table of Contents: "Epidemic, By Dr. Otto Schöbl" By changed to by
p. 21: "christendom" changed to Christendom
p. 32: Removed italic type from the word genus in "genus Ctenocephalus"
p. 62: "secondary to this July case" July changed to June
p. 78: "known as Loemopsylla cheopsis" Loemopsylla changed to Lœmopsylla
p. 132: "While cases 5, 2, 19 and 24" 2 changed to 11
p. 139: "fleas from a plagueinfected house" plagueinfected changed to plague-infected
p. 142: "usually met with in" with in changed to within
p. 147: "Echinococcus teniæformis was found in the liver" teniæformis changed to taeniæformis
Index: "Swellengreble" changed to Swellengrebel
Footnote 5: "Jena (1903) 2" added comma after closing bracket

Everything else retained as printed, including inconsistencies in hyphenation.
The index entry for Simpson, Dr. W. J. is missing its page reference.

use of the work and the Project Gutenberg™ trademark as set forth in paragraphs 1.E.8 or 1.E.9.

1.E.3. If an individual Project Gutenberg™ electronic work is posted with the permission of the copyright holder, your use and distribution must comply with both paragraphs 1.E.1 through 1.E.7 and any additional terms imposed by the copyright holder. Additional terms will be linked to the Project Gutenberg™ License for all works posted with the permission of the copyright holder found at the beginning of this work.

1.E.4. Do not unlink or detach or remove the full Project Gutenberg™ License terms from this work, or any files containing a part of this work or any other work associated with Project Gutenberg™.

1.E.5. Do not copy, display, perform, distribute or redistribute this electronic work, or any part of this electronic work, without prominently displaying the sentence set forth in paragraph 1.E.1 with active links or immediate access to the full terms of the Project Gutenberg™ License.

1.E.6. You may convert to and distribute this work in any binary, compressed, marked up, nonproprietary or proprietary form, including any word processing or hypertext form. However, if you provide access to or distribute copies of a Project Gutenberg™ work in a format other than “Plain Vanilla ASCII” or other format used in the official version posted on the official Project Gutenberg™ website (www.gutenberg.org), you must, at no additional cost, fee or expense to the user, provide a copy, a means of exporting a copy, or a means of obtaining a copy upon request, of the work in its original “Plain Vanilla ASCII” or other form. Any alternate format must include the full Project Gutenberg™ License as specified in paragraph 1.E.1.

1.E.7. Do not charge a fee for access to, viewing, displaying, performing, copying or distributing any Project Gutenberg™ works unless you comply with paragraph 1.E.8 or 1.E.9.

1.E.8. You may charge a reasonable fee for copies of or providing access to or distributing Project Gutenberg™ electronic works provided that:

- You pay a royalty fee of 20% of the gross profits you derive from the use of Project Gutenberg™ works calculated using the method you already use to calculate your applicable taxes. The fee is owed to the owner of the Project Gutenberg™ trademark, but he has agreed to donate royalties under this paragraph to the Project Gutenberg Literary Archive Foundation. Royalty payments must be paid within 60 days following each date on which you prepare (or are legally required to prepare) your periodic tax returns. Royalty payments should be clearly marked as such and sent to the Project Gutenberg Literary Archive Foundation at the address specified in Section 4, “Information about donations to the Project Gutenberg Literary Archive Foundation.”

- You provide a full refund of any money paid by a user who notifies you in writing (or by e-mail) within 30 days of receipt that s/he does not agree to the terms of the full Project Gutenberg™ License. You must require such a user to return or destroy all copies of the works possessed in a physical medium and discontinue all use of and all access to other copies of Project Gutenberg™ works.

- You provide, in accordance with paragraph 1.F.3, a full refund of any money paid for a work or a replacement copy, if a defect in the electronic work is discovered and reported to you within 90 days of receipt of the work.

- You comply with all other terms of this agreement for free distribution of Project Gutenberg™ works.

1.E.9. If you wish to charge a fee or distribute a Project Gutenberg™ electronic work or group of works on different terms than are set forth in this agreement, you must obtain permission in writing from the Project Gutenberg Literary Archive Foundation, the manager of the Project Gutenberg™ trademark. Contact the Foundation as set forth in Section 3 below.

1.F.

1.F.1. Project Gutenberg volunteers and employees expend considerable effort to identify, do copyright research on, transcribe and proofread works not protected by U.S. copyright law in creating the Project Gutenberg™ collection. Despite these efforts, Project Gutenberg™ electronic works, and the medium on which they may be stored, may contain “Defects,” such as, but not limited to, incomplete, inaccurate or corrupt data, transcription errors, a copyright or other intellectual property infringement, a defective or damaged disk or other medium, a computer virus, or computer codes that damage or cannot be read by your equipment.

1.F.2. LIMITED WARRANTY, DISCLAIMER OF DAMAGES - Except for the “Right of Replacement or Refund” described in paragraph 1.F.3, the Project Gutenberg Literary Archive Foundation, the owner of the Project Gutenberg™ trademark, and any other party distributing a Project Gutenberg™ electronic work under this agreement, disclaim all liability to you for damages, costs and expenses, including legal fees. YOU AGREE THAT YOU HAVE NO REMEDIES FOR NEGLIGENCE, STRICT LIABILITY, BREACH OF WARRANTY OR BREACH OF CONTRACT EXCEPT THOSE PROVIDED IN PARAGRAPH 1.F.3. YOU AGREE THAT THE FOUNDATION, THE TRADEMARK OWNER, AND ANY DISTRIBUTOR UNDER THIS AGREEMENT WILL NOT BE LIABLE TO YOU FOR ACTUAL, DIRECT, INDIRECT, CONSEQUENTIAL, PUNITIVE OR INCIDENTAL DAMAGES EVEN IF YOU GIVE NOTICE OF THE POSSIBILITY OF SUCH DAMAGE.

1.F.3. LIMITED RIGHT OF REPLACEMENT OR REFUND - If you discover a defect in this electronic work within 90 days of receiving it, you can receive a refund of the money (if any) you paid for it by sending a written explanation to the person you received the work from. If you received the work on a physical medium, you must return the medium with your written explanation. The person or entity that provided you with the defective work may elect to provide a replacement copy in lieu of a refund. If you received the work electronically, the person or entity providing it to you may choose to give you a second opportunity to receive the work electronically in lieu of a refund. If the second copy is also defective, you may demand a refund in writing without further opportunities to fix the problem.

1.F.4. Except for the limited right of replacement or refund set forth in paragraph 1.F.3, this work is provided to you ‘AS-IS’, WITH NO OTHER WARRANTIES OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PURPOSE.

1.F.5. Some states do not allow disclaimers of certain implied warranties or the exclusion or limitation of certain types of damages. If any disclaimer or limitation set forth in this agreement violates the law of the state applicable to this agreement, the agreement shall be interpreted to make the maximum disclaimer or limitation permitted by the applicable state law. The invalidity or unenforceability of any provision of this agreement shall not void the remaining provisions.

1.F.6. INDEMNITY - You agree to indemnify and hold the Foundation, the trademark owner, any agent or employee of the Foundation, anyone providing copies of Project Gutenberg™ electronic works in accordance with this agreement, and any volunteers associated with the production, promotion and distribution of Project Gutenberg™ electronic works, harmless from all liability, costs and expenses, including legal fees, that arise directly or indirectly from any of the following which you do or cause to occur: (a) distribution of this or any Project Gutenberg™ work, (b) alteration, modification, or additions or deletions to any Project Gutenberg™ work, and (c) any Defect you cause.

Section 2. Information about the Mission of Project Gutenberg™

Project Gutenberg™ is synonymous with the free distribution of electronic works in formats readable by the widest variety of computers including obsolete, old, middle-aged and new computers. It exists because of the efforts of hundreds of volunteers and donations from people in all walks of life.

Volunteers and financial support to provide volunteers with the assistance they need are critical to reaching Project Gutenberg™’s goals and ensuring that the Project Gutenberg™ collection will remain freely available for generations to come. In 2001, the Project Gutenberg Literary Archive Foundation was created to provide a secure and permanent future for Project Gutenberg™ and future generations. To learn more about the Project Gutenberg Literary Archive Foundation and how your efforts and donations can help, see Sections 3 and 4 and the Foundation information page at www.gutenberg.org.

Section 3. Information about the Project Gutenberg Literary Archive Foundation

The Project Gutenberg Literary Archive Foundation is a non-profit 501(c)(3) educational corporation organized under the laws of the state of Mississippi and granted tax exempt status by the Internal Revenue Service. The Foundation's EIN or federal tax identification number is 64-6221541. Contributions to the Project Gutenberg Literary Archive Foundation are tax deductible to the full extent permitted by U.S. federal laws and your state's laws.

The Foundation's business office is located at 809 North 1500 West, Salt Lake City, UT 84116, (801) 596-1887. Email contact links and up to date contact information can be found at the Foundation's website and official page at www.gutenberg.org/contact

Section 4. Information about Donations to the Project Gutenberg Literary Archive Foundation

Project Gutenberg™ depends upon and cannot survive without widespread public support and donations to carry out its mission of increasing the number of public domain and licensed works that can be freely distributed in machine-readable form accessible by the widest array of equipment including outdated equipment. Many small donations ($1 to $5,000) are particularly important to maintaining tax exempt status with the IRS.

The Foundation is committed to complying with the laws regulating charities and charitable donations in all 50 states of the United States. Compliance requirements are not uniform and it takes a considerable effort, much paperwork and many fees to meet and keep up with these requirements. We do not solicit donations in locations where we have not received written confirmation of compliance. To SEND DONATIONS or determine the status of compliance for any particular state visit www.gutenberg.org/donate.

While we cannot and do not solicit contributions from states where we have not met the solicitation requirements, we know of no prohibition against accepting unsolicited donations from donors in such states who approach us with offers to donate.

International donations are gratefully accepted, but we cannot make any statements concerning tax treatment of donations received from outside the United States. U.S. laws alone swamp our small staff.

Please check the Project Gutenberg web pages for current donation methods and addresses. Donations are accepted in a number of other ways including checks, online payments and credit card donations. To donate, please visit: www.gutenberg.org/donate

Section 5. General Information About Project Gutenberg™ electronic works

Professor Michael S. Hart was the originator of the Project Gutenberg™ concept of a library of electronic works that could be freely shared with anyone. For forty years, he produced and distributed Project Gutenberg™ eBooks with only a loose network of volunteer support.

Project Gutenberg™ eBooks are often created from several printed editions, all of which are confirmed as not protected by copyright in the U.S. unless a copyright notice is included. Thus, we do not necessarily keep eBooks in compliance with any particular paper edition.

Most people start at our website which has the main PG search facility: www.gutenberg.org.

This website includes information about Project Gutenberg™, including how to make donations to the Project Gutenberg Literary Archive Foundation, how to help produce our new eBooks, and how to subscribe to our email newsletter to hear about new eBooks.