TEXT-BOOK

OF

HYGIENE

A Comprehensive Treatise on the Principles and Practice of Preventive Medicine from an American Standpoint

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With Many Illustrations and Valuable Tables

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PREFACE TO THE FOURTH EDITION.

THE advances made in hygiene and sanitary science, more especially in the field of causation and prevention of infectious diseases, made it necessary to subject this well-known and popular text-book to a thorough revision. Several of the chapters treating of subjects in which the discoveries were more recent were entirely rewritten, while others were brought up-to-date by including such matter as appeared essential in the light of recent advances.

The aim of the editor has been to preserve in the book the qualities which made it one of the most popular text-books on hygiene in the English language.

As no one man can be a specialist in all branches of hygiene and sanitation, it was necessary to secure the assistance of other men. This had been done by the author in the former editions of this book, and the plan has been followed by the editor in the present edition, with this exception, however: in the present edition credit to the several eminent contributors is given here in the preface.

Dr. Walter Wyman, Supervising Surgeon-General, U. S. Public Health and Marine-Hospital Service, has revised the chapter on "Quarantine." The chapters on "School Hygiene," "Exercise and Training," "Baths and Bathing," and "Clothing," grouped together with one chapter heading "Personal Hygiene," were prepared by Dr. Francis W. Upshur, lecturer on pathology, hygiene, public health and dietetics in the University College of Medicine, Richmond, Virginia. The chapter on "Military and Camp Hygiene" was entirely rewritten throughout by Walter D. McCaw, Surgeon-Major, Medical Department, Surgeon-General's Office, Washington, D. C. The chapter on "Naval Hygiene" also was entirely rewritten by Henry G. Beyer, Major Surgeon United States Navy and professor of hygiene, etc., in the United States Army and Navy Medical School, Washington, D. C.

The other chapters were revised and supplemented by the editor. It is hoped that this edition will be favored with the same cordial reception accorded to former editions by students and teachers throughout the country.

A. ROBIN.

WILMINGTON, DEL.

PREFACE TO THE THIRD EDITION.

In this edition every chapter has been subjected to a careful revision, and the advances in sanitary science and practice have been incorporated.

Recent legislation in the United States and Canada has almost revolutionized quarantine practice. Surgeon-General Walter Wyman, and Dr. H. D. Geddings, of the United States Marine-Hospital Service, have, at the request of the author, entirely rewritten the chapter upon "Quarantine," and it will be found to represent fully the modern principles and practice of maritime sanitation.

Medical Director Albert L. Gihon, United States Navy, has again thoroughly revised the chapter on "Marine Hygiene."

With the view of making the book still more useful to teachers, students, and sanitary officers than heretofore, an analytical set of questions has been appended to each chapter, and a separate section has been added on methods of examination of air, water, and food. For these additions the author is indebted to Professor Seneca Egbert, of Philadelphia. Dr. Egbert has also carefully revised the chapter on "Vital Statistics."

The author desires to thank all who have assisted him in the work, and especially the sanitarians throughout the country who have been helpful in the way of criticism and suggestion. He hopes that the new edition will merit, as well as receive, the approval of all students of preventive medicine.

G. H. R.

Baltimore, Md.

PREFACE TO THE FIRST EDITION.

THE aim of the author in writing this book has been to place in the hands of the American student, practitioner, and sanitary officer, a trustworthy guide to the principles and practice of preventive medicine.

He has endeavored to gather within its covers the essential facts upon which the art of preserving health is based, and to present these to the reader in clear and easily understood language.

The author cannot flatter himself that much in the volume is new. He hopes nothing in it is untrue.

G. H. R.

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CHAPTER I.

AIR.

EXACT investigation into the influence of the atmosphere upon health is yet in its infancy. Enough has been learned, however, to show that changes in the composition of the air, in its density, its temperature, its humidity, its rate and direction of motion, and possibly its electrical or magnetic conditions, influence in various ways the health of the individual. It is only very recently that any scientific attempts have been made to trace the bearing of atmospheric changes upon health. The observations already recorded indicate that a thorough study of meteorological phenomena in connection with the origin and progress of certain diseases is a promising field of labor for the educated sanitarian. The meteorological observations which have been gathered by the United States Signal Service, together with elaborate studies made by the meteorologists and climatologists of other countries, already form such a large and tolerably complete and well-arranged body of facts, that reasonably accurate deductions can even now be made. Heretofore, in studying the sanitary relations of the atmosphere, both in this country and abroad, the attention of observers has been riveted almost exclusively upon the changes in its composition occurring within certain limited areas. It is, perhaps, equally important to study this universally diffused and necessary condition of vital activity in its broader and more general relations. It will be shown, in the course of the present work, that the meteorological features of countries, or of seasons, or even the daily atmospheric changes, exercise an important influence upon life and health. In order to fully appreciate these relations it will be necessary to first give a brief summary of the facts and laws of meteorology.

THE COMPOSITION AND PHYSICAL CONDITIONS OF THE ATMOSPHERE.

Atmospheric air has the following composition:—

Oxygen	20.91 per cent.
Nitrogen	77.95 "
Argon	1.00 "
Carbonic acid	0.04 "
Aqueous vapor	variable.

Traces of organic matter, ozone, mineral salts, ammonia, nitric acid, krypton, neon, metargon, carburetted hydrogen.

These proportions are maintained, with but very little change, at different heights. At first thought, it would seem that carbon dioxide, being much heavier than the other constituents of air, would accumulate in the lower regions of the atmosphere, and there cause an excess of this poisonous constituent; but in obedience to the law of diffusion the intermingling of the component gases is perfect, and the proportion of carbon dioxide in the atmosphere is quite as great on mountain-tops as in the deepest valleys. This diffusion of gases, however, is modified by the wind and, in cities, by high buildings.

The proportion of nitrogen in atmospheric air is generally uniform, while that of oxygen varies, depending to a great extent upon the amount of carbon dioxide present. Hence, an increase in the amount of the latter constituent is usually accompanied by a diminution of oxygen, inasmuch as the formation of carbon dioxide can only take place at the expense of oxygen. The reciprocal activities of animal and vegetable life are beautifully illustrated by these relations between the oxygen and carbon dioxide in the air. In the processes of combustion and oxidation, oxygen is withdrawn from the atmosphere, and combines with carbon, forming carbon dioxide. During vegetable growth, on the other hand, carbon dioxide is withdrawn from the air by the leaves of plants, and decomposed into its elements, carbon and oxygen. The carbon is used in building up the plant, while the liberated oxygen is restored to the atmosphere. The animal consumes oxygen, and gives out carbon dioxide; the plant resolves this compound into its constituent elements, and gives back the oxygen to the air. However, at night, or in the absence of sunlight, plants evolve carbon dioxide instead of oxygen, and for this reason it is injurious to keep plants in bedrooms over night.

The atmosphere extends upward from the surface of the earth to an indefinite distance. The limit has been variously placed at from 75 kilometres to 40,000 kilometres. For all sanitary purposes the former may be taken as the upward limit of the atmosphere. In obedience to the law of gravity, this mass of air presses everywhere directly downward—toward the earth's centre—with a force equal to its weight. If a column of this air be balanced by a column or mass of any other matter—the columns being of the same diameter—we have a relative measure of the weight of the atmosphere. The instrument with which the weight or downward pressure of the air is measured is called a barometer. The atmosphere, at the sea-level, presses downward with a force equal to the pressure of a column of mercury 760 millimetres high. Hence, the barometric pressure at sea-level is said to be 760 millimetres, or 30 inches. If the barometer be carried to the summit of a mountain 1000 metres above the level of the sea, or be taken to the same altitude in a balloon, the mercury in the barometer-tube will fall about 90 millimetres. These 90 millimetres of the mercurial column represent the weight of 1000 metres of air now below the barometer, and consequently not measured or balanced by it.[1]

Upon ascending from the sea-level, it is found also that the air, being less pressed upon by that which is still above it, becomes more rarefied and lighter; its tension, as it is termed, is less. Hence, for the second 1000 metres of ascent above the sea, the mercury will fall a less distance in the tube, the weight removed not being so great as in the first 1000 metres.

The following table shows the diminution in atmospheric pressure for every 1000 metres above sea-level:—

TABLE I.

Sea-level	760.0	millimetres.
1,000 metres	670.4	"
2,000 "	591.5	"
3,000 "	521.0	"
4,000 "	460.3	"
5,000 "	406.0	"
6,000 "	358.2	"
7,000 "	316.0	"
8,000 "	278.8	"
9,000 "	245.9	"
10,000 "	216.9	"
11,000 "	191.1	"
12,000 "	168.8	"
15,000 "	115.9	"
20,000 "	61.9	"

[1] The figures here given are not absolute, but merely approximate. The limits of this work do not allow a full discussion of the meteorological elements modifying the pressure of the atmosphere at sea-level.

Variations in temperature and humidity of the air influence the tension of the atmosphere in a marked degree, and affect the height of the barometric column. In fact, most of the changes of atmospheric pressure at the surface of the earth are directly due to changes in temperature and humidity. Increase of temperature diminishes the density of the air. Hence, when the temperature rises the pressure decreases.

The proportion of moisture (aqueous vapor), if increased, likewise causes a diminution in pressure. It is found, for example, that when the amount of aqueous vapor in the air increases, the barometer falls. This is due to the fact that the specific gravity of aqueous vapor is less than that of dry air, being in the proportion of .623 to 1.000. Hence, as aqueous vapor is diffused through the air, the latter becomes lighter,—or, in other words, the barometric pressure diminishes.

The warmth of the air is primarily derived from the sun. On a clear day about one-fourth of the heat of the sun's rays is given off directly to the air during the passage of the heat-rays to the earth. Of the remaining three-fourths, part is reflected from the earth, while the larger portion is first absorbed by the earth and then given off by radiation and convection to the superincumbent air.

The air is always warmer near the earth's surface on a clear, sun-shiny day; for, as soon as the earth gets warmer than the air immediately above it, the excess of heat is given off to the latter by convection and radiation. On ascending from the surface of the earth the temperature decreases, and on the summit of a high mountain the air is always colder than at its base. The decrease of temperature with the ascent equals 1° F. to every 300 feet.

Professor Tyndall has shown that dry air absorbs less heat than air which is charged with vapor. For this reason the sun's rays strike the earth with much greater intensity on a very dry than on a moist day, while on the latter a larger proportion of the heat-rays is intercepted before they reach the earth.

Recent experiments seem to show, however, that the difference in diathermancy between dry and humid air is not so great as supposed by Tyndall. The depth of the air-stratum, through which the sun's rays pass, is of greater influence than the humidity.

Air, at different temperatures, is capable of absorbing different amounts of aqueous vapor. Thus, air at a temperature of 4° will require a much smaller amount of vapor to produce saturation than air at a temperature of 30°. For this reason air which appears "damp" at the former temperature, both to the bodily sensations and to appropriate instruments, would be considered as "dry" at the latter temperature, although the actual amount of vapor present, or absolute humidity, is the same in both cases.[2] In meteorological observations for sanitary purposes, the relative humidity is the condition deserving especially careful study.

It must be borne in mind that the mere statement of the percentage of relative humidity, without taking into account the temperature of the air, is of little significance. A like remark is justified with regard to statements of absolute humidity, when used to illustrate the apparent effects of atmospheric moisture upon life and health.

The following table shows the absolute humidity corresponding to the same relative humidity at different temperatures. It also includes the total possible absolute humidity and the difference between the actual and possible humidity (deficiency of saturation) at the temperatures given:—

TABLE II.

Temperature °C.	Relative Humidity (per cent.).	Absolute Humidity (grammes per cubic metre).	Greatest Possible Absolute Humidity.	Deficiency of Saturation.
—20	60	0.638	1.064	0.426
—10	60	1.380	2.300	0.920
0	60	2.924	4.874	1.950
+10	60	5.623	9.372	3.749
20	60	10.298	17.164	6.866
30	60	18.083	30.139	12.056

In forests the relative humidity is usually higher than over unwooded districts, although the absolute humidity may be the same, or, perhaps, even less. The evaporation is usually much greater in the open air than in forests. In closed apartments the evaporation may be greater or less than in the open air, depending upon the local conditions present.

[2] By "absolute humidity" is meant the total amount of vapor present in a certain mass of air. By the term "relative humidity" meteorologists designate the proportion of vapor present at certain temperatures, compared with full saturation of the air with vapor, which is reckoned 100. Thus, air which is saturated, or whose relative humidity is 100 at 4°, would have a relative humidity of only 24, if the temperature were raised to 27°, because in the latter case the capacity of the air for aqueous vapor is increased. Relative humidity is always designated in percentages; absolute humidity in grammes per cubic metre or grains per cubic foot.

The motion of the air—wind—is caused by differences in pressure; the latter being due to differences in temperature and humidity. A mass of air traversing a large body of water absorbs vapor, unless already saturated, and becomes moist; if it pass over a wide tract of dry land it loses moisture and becomes dry. Therefore in the eastern portion of the American continent, an easterly or southerly wind, which comes from over large bodies of water, and which is usually warm, and thus capable of holding a large quantity of water in a state of vapor, is always moist. On the other hand, a northerly or westerly wind, coming over a large extent of dry land, and from a colder region, is nearly always a dry wind. On the Pacific coast these conditions are reversed; there a westerly wind is a moist wind, while an easterly wind is dry. The dreaded easterly wind of England is likewise a dry wind. It is probable that the direction and rate of motion of air-currents have considerable influence upon the origin or intensification of certain diseases.

The electrical and magnetic conditions of the atmosphere have been as yet studied to little advantage. It is only known that atmospheric electricity is, in most cases, positive, and that its intensity increases with condensation of vapor. There seems to be no doubt that the varying states of atmospheric electricity are closely connected with evaporation and condensation. There is reason to believe that a fuller knowledge on these topics will yield most important results to the student of hygiene.

Ozone, which is oxygen in an allotropic and highly active condition (O_3), is generally absent from town air; and when it does appear, as after a summer storm, it is in such insignificant amount as to have no influence on health.

BACTERIA IN THE AIR.

In localities which are free from human or animal habitation, as in open plains, high moutains, midocean, etc., the air is free from bacteria; on the other hand, bacteria will be present wherever man or animal abides. The number of bacteria will be in direct proportion to the density of the population, the larger number being found in cities, and, again, in the overcrowded portions of the large centres of population. Defective sanitation will increase the number of bacteria. In addition to bacteria, the air contains yeasts and the spores of moulds and of the lower fungi. The moulds are provided with fine spore-bearing filaments, which become detached and float in a free condition. The bacteria, on the other hand, do not float, but are carried by particles of dust or moisture. The epoch-making experiments of Pasteur and Tyndall have demonstrated the axiomatic proposition that without dust there are no bacteria. Consequently, any disturbance which raises dust will also increase the number of bacteria in the air, and, conversely, any agent which allays dust also purifies the air. It is for this reason that the use of a damp cloth is preferable to dusting, and a carpet-sweeper is more sanitary than a broom. The bacteria present in the air may be of three kinds: (1) Harmless bacteria; (2) bacteria which produce putrefaction; and (3) bacteria which cause disease. The latter are the most important and are derived from sick persons. The actions of coughing, sneezing, speaking, and even of deep breathing distribute minute droplets of secretions from the respiratory passages and thus infect the atmosphere. Diphtheria, influenza, pneumonia, whooping cough, tuberculosis, and other infections of the respiratory organs may be and are communicated in this way. The fine particles of the bacteria-laden secretions may be directly inhaled by the person standing in front of the mouth of the patient, or else they fall to the ground, dry out, and dry bacteria are carried by the dust into the air. It is in this way that the sputum from consumptives becomes a serious and constant source of infection. In eruptive fevers, like measles, scarlet fever, small-pox, etc., the causative agent, still unknown, is eliminated through the skin and carried into the air by the fine particles of dry epithelium. The bacilli of typhoid fever and cholera may also find their way into the air through the drying of infected sewage or water, or the excreta from the patient may become mixed with dust, and, when dry, be carried into the air and subsequently deposited in water, milk, or other food. That infection by this method is not more frequent is due to the fact that many pathogenic bacteria are destroyed by drying and sun-light.

INFLUENCE OF CHANGES OF ATMOSPHERIC PRESSURE ON HEALTH.

The effects of a considerable diminution of pressure are familiar to every one in the "mountain sickness" which attacks most persons on ascending high mountains. M. Bert has shown experimentally that similar effects can be produced in an air-tight chamber by diminishing the pressure. The symptoms produced under a pressure equivalent to an altitude of from 4000 metres to 5000 metres were a feeling of heaviness, nausea, ocular fatigue, rapidity of pulse, convulsive trembling on slight exertion, and a sensation of languor and general indifference to the surroundings of the individual.

M. Lortet, who has left on record his experiences in the higher Alps, says that the symptoms noticed on ascending to high altitudes are: Labored respiration, increased rapidity of pulse, depression of temperature (as much as 4° to 7° C.). The normal temperature was restored, however, after a brief rest. Still more severe symptoms have been noticed on ascending high mountains in South America and Asia. Aëronauts have lost consciousness, and in several instances life, on rapidly ascending to great altitudes.[3] According to the observations of the brothers Schlagintweit, distinguished explorers of the highlands of Asia, the effects of diminished pressure upon the human organism are: "Headache, difficulty of respiration, and affections of the lungs,—the latter even proceeding so far as to occasion blood-spitting,—want of appetite, and even nausea, muscular weakness, and a general depression and lowness of spirits. All these symptoms, however, disappear in a healthy man almost simultaneously with his return to lower regions." A singular observation was made by these travelers on the effect of motion of the air upon the symptoms described. They say: "The effects here mentioned were not sensibly increased by cold, but the wind had a most decided influence for the worse upon the feelings. . . . When occupied with observations, we took very little, if any, bodily exercise, sometimes for thirty-six hours; it would frequently occur nevertheless, even in heights not reaching 17,000 feet (about 5150 metres), that an afternoon or evening wind would make us all so sick as to take away every inclination for food. No dinner was cooked; the next morning, when the wind had subsided, the appetite was better.

"The effects of diminished pressure are considerably aggravated by fatigue. It is surprising to what degree it is possible for exhaustion to supervene; even the act of speaking is felt to be a labor, and one gets as careless of comfort as of danger. Many a time our people—those who ought to have served us as guides—would throw themselves down upon the snow, declaring they would rather die upon the spot than proceed a step farther."[4]

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[3] MM. Sivel and Crocé-Spinelli, two aëronauts, lost their lives in this manner during an ascent from Paris, in April, 1875.

[4] Results of a Scientific Mission to India and High Asia. By Hermann, Adolphe, and Robert De Schlagintweit, vol. ii, pp. 484, 485.

These symptoms disappear when persons are exposed to these conditions for a prolonged time. Thus, in the Andes there are places 4000 metres above sea-level which are permanently inhabited; and in the Himalayas there are villages at a height of over 5000 metres constantly occupied. In this country, Pike's Peak, 4350 metres above the sea, has been occupied since 1873 by observers of the signal service. The men seem to become acclimated, as it were, and suffer little or no inconvenience from the diminished pressure after a time.

The minor disturbances of healthy function produced by diminished pressure (within the limits of 4000 metres altitude, or 460 millimetres barometric pressure) are an increase in the pulse and respiration rate. This is probably due to the struggle of the organism to take up the required quantity of oxygen, which is reduced in proportion by the rarefaction of the air. For example, the proportion of oxygen at a pressure of 460 millimetres would be equivalent to 12.6 per cent. at sea-level, instead of the normal 20.9 per cent.

Paul Bert has shown by personal experiments in the pneumatic chamber that the increase in pulse and respiration rate is not due to the merely mechanical diminution of pressure, but to the deficiency of oxygen. Hence the physiological effects of high altitudes upon circulation and respiration are not purely physical, due to diminished pressure, but vital, and depend upon the change in the chemical composition of the atmosphere. The simple diminution of oxygen without reduction of pressure will produce similar though not identical effects upon the organism.

Above the height of 4000 metres above sea-level (below 460 millimetres pressure) the profounder disturbances of function characterized as "mountain sickness" come on. Different individuals react in different degree to the morbific influences of greatly diminished atmospheric pressure (and coincident reduction of oxygen). Thus Glaisher reached an elevation of 11,000 metres (191.1 millimetres pressure) and returned to the earth alive, while Crocé-Spinelli and Sivel perished at the considerably lower elevation of 8000 metres, equivalent to a pressure of 260 millimetres (7.2 per cent. of oxygen).

The sanitarian is most concerned about the effects of pressure of the atmosphere from 760 millimetres down to 460 millimetres (or up to an altitude of 4000 metres above sea-level). The climatotherapy of various diseases requires that the effects of variations of pressure between these limits should be carefully studied. The observations of Mermod and Jourdanet[5] have illustrated the common physiological effects of these circumscribed changes, while the experiences of therapeutists have established the fact very clearly that many cases of phthisis improve markedly in a rarefied atmosphere, provided, however, they are not subject to hemorrhages, in which case high altitude increases the liability to hemoptysis. Other observers have also shown that the effects of diminished pressure are not always beneficial, and Dr. Loomis has warned against the sending of patients with heart disease to high altitudes. Whether the lethal effects that have been recorded in such cases are due to the increased activity of the heart and heightened blood-pressure from deficient oxygen, or as suggested by Dr. F. Donaldson, Jr., to dilatation of the heart-walls from diminution of external pressure, is as yet unsettled.[6]

It is probable that the diurnal or accidental[7] oscillations of barometric pressure at sea-level have no appreciable influence upon the organism. The statement is occasionally met that patients subjected to grave surgical operations often do badly during low atmospheric pressure, and some surgeons never operate when the barometer is low or falling if they can avoid it. An inquiry undertaken by the writer in 1876, in which the excellent records of the Massachusetts General Hospital and the observations of the Boston station of the United States Signal Service for five years were used as the basis of comparison, resulted negatively. The deaths following operations done on days when the barometer was high or rising were exactly equal in number to those following operations when the barometer was low or falling. Unfortunately, the investigation was never pursued to the extent of including other meteorological elements, such as humidity, cloudiness, precipitation, etc. The numerous studies of the relations of variations of pressure to the progress of infectious diseases have also failed to yield any fruits of value. Whether the nerve-pains so frequently complained of, especially by elderly patients, during the progress of areas of low barometer, are due to the diminished pressure, or to the influence of some other meteorological factor, such as humidity or electrical condition, cannot yet be decided.

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[5] Jourdanet states that while the French and Belgian soldiers in Mexico had an accelerated pulse, the natives had a normal pulse. In Mermod's observations the average frequency of the pulse at St. Croix (1106 metres above sea-level) was nearly four beats greater than at Strassburgh (142 metres). The condition of the natives at the high settlements of the Andes and Himalayas has not yet been investigated with exactitude.

[6] American Climatological Association, 1887.

[7] Meaning the oscillation produced by storm waves.

Increased atmospheric pressure, as noticed in caissons, tunnels, and mines, produces increase in frequency and depth of respiration, diminution in the number of beats and volume of the pulse, pallor of the skin, increase of perspiration (although Smith states that this is only apparent and due to lack of evaporation from the surface), increased appetite, and more abundant excretion from the kidneys.

Among the distinctly pathological effects of increased atmospheric pressure are rupture of the drum of the ear, pain in the frontal and maxillary sinuses, neuralgic pains, nausea, sometimes vomiting, and local paralyses. Dr. A. H. Smith[8] defines this collection of symptoms as "The Caisson Disease," and gives the following summary of its characteristic features:—

"A disease depending upon increased atmospheric pressure, but always developed after the pressure is removed. It is characterized by extreme pain in one or more of the extremities, and sometimes in the trunk, and which may or may not be associated with epigastric pain and vomiting. In some cases the pain is accompanied by paralysis more or less complete, which may be general or local, but is most frequently confined to the lower half of the body. Cerebral symptoms, such as headache and vertigo, are sometimes present. The above symptoms are connected, at least in the fatal cases, with congestion of the brain and spinal cord, often resulting in serous or sanguineous effusion, and with congestion of most of the abdominal viscera."

The measures to be adopted in preventing "Caisson Disease" are: (1) Working during short shifts, from 2 to 4 hours; (2) abundant supply of fresh air; (3) the use of electric light, so as to save the oxygen; (4) slow decompression, at the rate of one minute for every three pounds of pressure. The disregard of the last rule has recently caused several deaths among laborers working in the tunnels under the Hudson River.

INFLUENCE OF CHANGES OF TEMPERATURE ON HEALTH.

Many of the derangements of health ascribed to high temperature are to a considerable degree due to other factors, prominent among which are high humidity, intemperance, overwork, and overcrowding. There can be little doubt, however, that the importance

[8] The Physiological, Pathological, and Therapeutical Effects of Compressed Air, p. 47, Detroit, 1886.

of the high temperature itself can hardly be overrated. It has been generally accepted heretofore that a high temperature, together with a high relative humidity, is most likely to be followed by sun-stroke. A careful comparison in a series of deaths from sun-stroke in the city of Cincinnati in the summer of 1881 shows, however, conclusively that a very high mean temperature with a low relative humidity is more liable to be followed by sun-stroke than the high temperature when accompanied by a high humidity. The same series of observations also shows that the number of deaths was greater on clear days than on cloudy or partly cloudy days.[9] A corroboration of this result is found in the fact that sun-strokes very rarely occur on shipboard, at sea, where the relative humidity is always high.

The direct influence of the sun's rays upon the skin produces at times an erythematous affection which may run into a dermatitis if the insolation is prolonged. Artificial heat may produce similar effects.

The prevention of sun-stroke should include the wearing of light and loosely-girded clothing, so as to favor the rapid evaporation of perspiration; the use of cool, but not ice-cold water; total abstinence from alcoholic beverages; and the maintenance of the functions of the alimentary canal in a healthy condition. Constipation should be particularly guarded against. Severe muscular exertion should be avoided during the hottest part of the day.

Diarrheal diseases, both of adults and children, are much more frequent during hot than cold weather (and in hot than in cold climates), but it is probable that other factors, as the more ready putrefaction of food, aid in the production of these diseases besides the high temperature.

Certain epidemic diseases are likewise more frequent in, or exclusively confined to, hot climates. These are cholera, yellow fever, and epidemic dysentery. Elephantiasis, malarial fevers, and certain skin diseases seem also to have some connection with a constantly high external temperature. The intimate relation between cause and effect is not clearly understood, although the belief is current that the origin and spread of such diseases depend upon the development of various parasitic organisms.

Regarding the morbific effects of continued high temperatures, it is probable that an appropriate mode of life, proper diet, and suitable clothing would avert many of the bad consequences. Neverthe-

[9] The Sun-stroke Epidemic of Cincinnati, O., during the Summer of 1881. A. J. Miles, Public Health, vol. vii, pp. 293-304.

less, the fact remains that certain tropical or hot-weather diseases must be considered as primarily dependent upon high temperature, although the pathological effects may be due to an intermediate factor. It is not improbable that micro-organisms will be found to explain the occurrence of yellow fever, cholera infantum, and other diseases incident to hot weather.

Extreme low temperature, as observed in the arctic regions, seems to produce a progressive deterioration of the blood (anemia), in consequence of which most natives of temperate regions who are compelled to remain in the far north longer than two winters succumb to various hemic diseases, scurvy being the most prominent. It is not improbable, however, that the dietary furnished is responsible for a large share of the evil effects ascribed to cold. The absence of sun-light for a considerable part of the winter season may also have much to do with the bad influences for which the low temperature is held responsible.

Among the acute effects of great cold, frost-bite is the most frequent as well as the most serious. Loss of portions of the nose, or ears, or even of entire members are not infrequent results of frost-bite.

In the arctic regions one of the most annoying affections which the traveler has to contend against is snow-blindness, a severe ophthalmia produced by the glare of the snow. Neutral-tinted glass goggles should be worn as a preventive.[10]

Dr. Henry B. Baker[11] has placed upon record a large mass of observations which appear to indicate that most of the acute diseases of the respiratory organs are caused by a low temperature in conjunction with a low absolute humidity. Dr. Baker furnishes numerous diagrams, which seem to demonstrate that the curves for influenza, tonsillitis, croup, bronchitis, and pneumonia are in general outlines all practically the same, and that they follow the curve for atmospheric temperature with surprising closeness, rising after the temperature falls and falling after the temperature rises. He claims that this sameness indicates that the controlling cause is one and the same for all of these diseases, and that, directly or indirectly, the atmospheric temperature is that cause. They are diseases of the air-passages, and may be supposed to be influenced or controlled by the

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[10] See Prayer's Narrative of the Austrian Arctic Voyage of 1872-74, pp. 250-3 and 317, for an account of the effects of cold on the organism, and on the best prophylactic measures to be adopted. The Report of the Surgeon-General of the U. S. Navy for 1880 also contains (pp. 350-8) a valuable memorandum by Ex-Surgeon-General Philip S. Wales, on Arctic Hygiene.

[11] Trans. Ninth International Med. Congress, vol. v.

atmosphere which passes through them. Although the curves are all similar, yet their differences still further support his view, because the order of succession of the several diseases is such as would be expected if caused in the manner which he supposes. Thus, croup and influenza precede in time bronchitis and pneumonia; the curve for bronchitis shows that disease to respond quicker than does pneumonia to the rise and fall of the temperature. He suggests that the explanation of the causation of these diseases has not been grasped before because one of the principal facts has not been apprehended, namely, the fact that cold air is always dry air; on the contrary, it has been generally stated that when these diseases occur the air is cold and damp. He explains that while the cold air is damp relatively it is always dry absolutely, and he thinks that its bad effects on the air-passages are mainly through its drying effects, which can best be appreciated by reflecting that each cubic foot of air inhaled at the temperature of zero, F. [— 17.8° C.], can contain only ½ grain of vapor [1.33 grammes per cubic metre], while when exhaled it is nearly saturated at a temperature of about 98° F. [36.5° C.], and therefore contains about 18½ grains of vapor [about 43 grammes per cubic metre], about 18 grains of which have been abstracted from the air-passages. Thus cold air falling upon susceptible surfaces tends to produce an abnormal dryness which may be followed by irritation and suppuration. He claims that coryza is sometimes so caused. Under some conditions the nasal surfaces are not susceptible to drying, the fluids being supplied in increased quantity to meet the increased demand made by the inhalation of cold air. In that case an unusual evaporation of the fluid leaves behind an unusual quantity of non-volatile salts of the blood, such as sodium chloride, and an unusual irritation results; he thinks influenza is the name commonly given to this condition. The effects which the inhalation of cold air has on the bronchial surfaces depend greatly upon how the upper air-passages have responded to the increased demand for fluids; because, if they do not supply the moisture, it must be supplied by the bronchial surfaces, in which case bronchitis results. Finally, if the demands for moisture made by cold air are not met until the air-cells are reached pneumonia is produced.

These claims are partly supported and partly opposed by an elaborate paper by Dr. J. W. Moore.[12] According to the statistics furnished by this writer, bronchitis and pneumonia show a remarkable

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[12] The Seasonal Prevalence of Pneumonic Fever, Trans. Ninth Internat. Congress, vol. v.

contrast as to seasonable prevalence. The statistics of London and Dublin agree very closely upon this point. Bronchitis falls to a very low ebb in the third or summer quarter of the year (July to September, inclusive), when only 12 per cent. of the deaths annually caused by this disease take place in Dublin and only 11 per cent. in London. In the last or fourth quarter (October to December inclusive) the percentage of deaths from bronchitis rises to 27 in Dublin and 30 in London. The maximal mortality occurs in the first quarter (January to March, inclusive), when it is 38 per cent. in both London and Dublin. In the second or spring quarter (April to June, inclusive) the bronchitic deaths decline to 23 per cent. in Dublin and 21 per cent. in London.

The mortality from pneumonic fever is differently distributed throughout the year. In the summer quarter more than 14 per cent. of the annual deaths referable to the disease are recorded in Dublin and more than 15 per cent. in London. In the first quarter the figures are—London, 31 per cent.; Dublin, 31 per cent. In the second quarter they are—London, 26 per cent.; Dublin, 30 per cent. In the fourth quarter they are—London, 27 per cent.; Dublin, 24 per cent.

It therefore appears that the prevalence and fatality of pneumonic fever from season to season do not correspond with the seasonal prevalence and fatality of bronchitis. The latter disease increases and kills in direct relation to the setting in of cold weather; it subsides in prevalence and fatality with the advance of spring and the advent of summer. Pneumonic fever, on the other hand, increases less quickly in winter and remains more prevalent in spring than bronchitis; its maximal incidence coincides with the dry, harsh winds and hot sunshine of spring, when the diurnal range of temperature also is extreme.

Dr. Moore believes that acute bronchitis is produced directly by the influence of low temperature, while pneumonia requires an additional cause, which he supposes to be a specific micro-organism.

Since Dr. Moore's observations the specific causes of pneumonia (the pneumococcus) and influenza (the influenza bacillus) have been firmly established, and it is quite likely that acute bronchitis, coryza, and other acute affections of the respiratory passages are caused by micro-organisms, the cold acting merely as a predisposing factor.

HUMIDITY OF THE ATMOSPHERE AS CONNECTED WITH CHANGES IN HEALTH.

The propagation of certain acute infectious diseases is believed to be due to a high relative humidity. There can be no longer any doubt that a very humid soil and air, especially if connected with a variable temperature, are almost constant factors in the predisposition to pulmonary phthisis. Recent experience in this country and abroad has shown that the high plateaus and mountains, far inland, where the soil is dry and the relative humidity of the air low, are the best resorts for consumptives, although excellent results in the treatment of tuberculosis have been achieved in sanatoriums located under the most adverse climatic conditions.

Of the effects of excessively dry air on health little definite is known. It seems probable, however, that catarrhal affections of the respiratory mucous membrane are more frequent in a dry than in a humid climate.[13]

THE SANITARY RELATIONS OF AIR-CURRENTS.

Primarily, winds or air-currents may be considered as favorable to health. By the agitation of the air ventilation is secured, foul air removed from insanitary places, and diluted by admixture of purer air. But air-currents may also be regarded as either directly or indirectly unfavorably influencing health.

Full credit is given by the public to cold winds and draughts in producing catarrhs and rheumatic pains. The progression of certain infectious diseases, especially malaria, is believed with good reason to stand in a definite relation with the direction of the wind, which, if the latest theory of the causation of malaria be accepted, carries the infected mosquitoes.

Certain local winds are known to have a deleterious effect upon living beings, especially when the latter are in bad health. Among these winds is the *mistral,* a cold, dry, parching northwest wind which blows along the Gulf of Lyons. It brings on rheumatism and muscular pains, and is said to excite pleurisy and pneumonia and to act unfavorably upon consumptives.

The *bora* is a cold, dry wind coming down from the Alps and continuing across the Adriatic.

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[13] See *ante.*

The Texan *northers* are well known in the southwestern part of the United States. They are extremely dry, and are often accompanied by a sudden fall of temperature. Changes of 28° C. (50° F.) within twelve hours are not infrequent in Western and Central Texas. Both man and beast suffer intensely from the cold, parching character of the wind.

The *sirocco* of Northern Africa, Sicily, and Southern Italy has a world-wide notoriety for its depressing effect upon human energy. The *harmattan* is equally noted on the west coast of Africa. It is hot and dry, while in Southern Europe the sirocco is hot and moist.

The *simoon* is a hot, scorching wind of India, and is said to be deadly in its effects upon vegetation and extremely deleterious to men and animals who are encountered by it. In Australia and South Africa hot winds are said to occur which completely destroy vegetable life in their track, and are often unwholesome in their effects upon animal life.

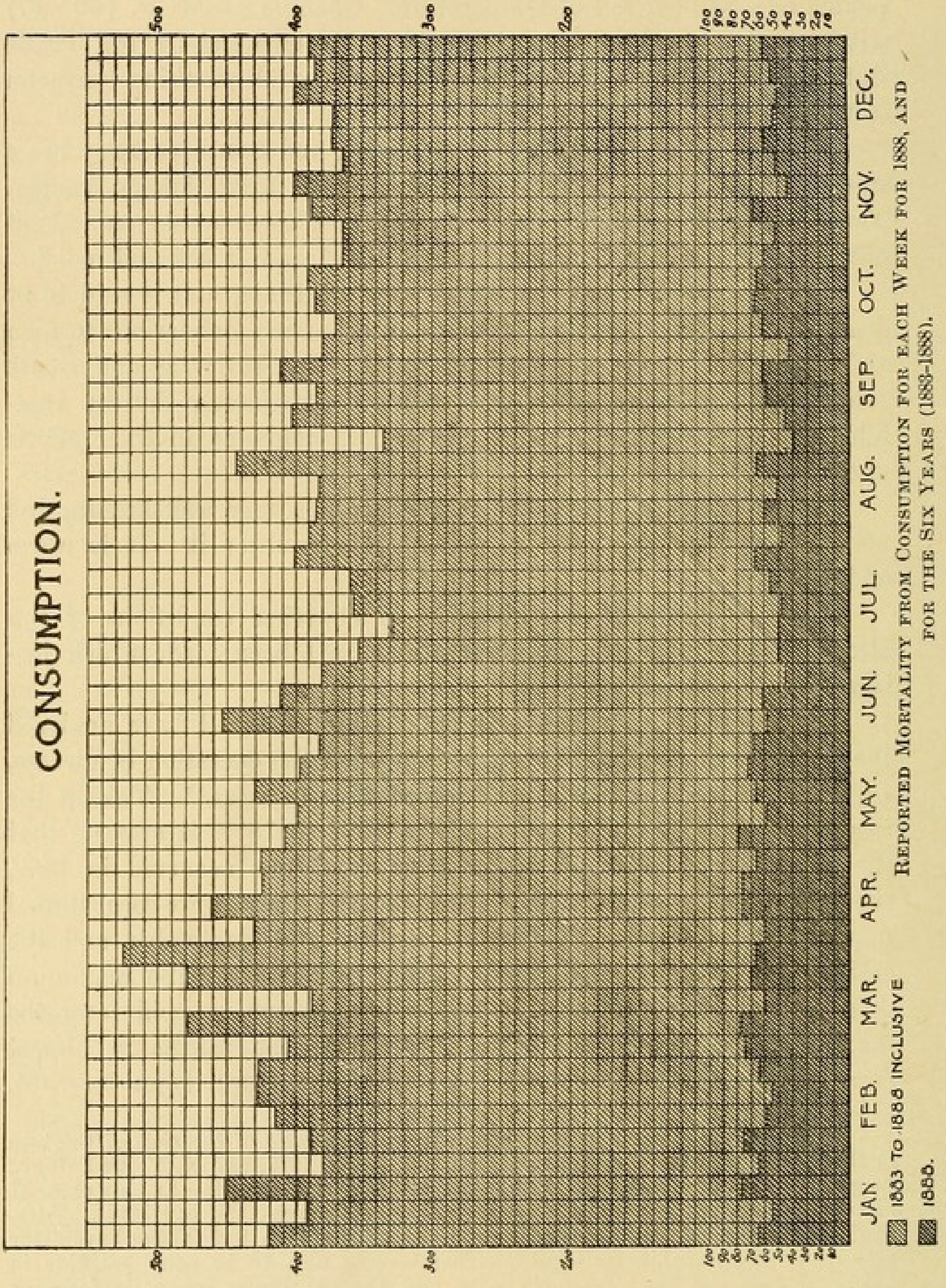
The evil reputation of the Alpine *föhn* is very well known, and neither native nor traveler is anxious to encounter it. It is warm and dry.

With reference to the influence of electrical conditions of the atmosphere upon health, no observations have been made which justify definite conclusions.[14]

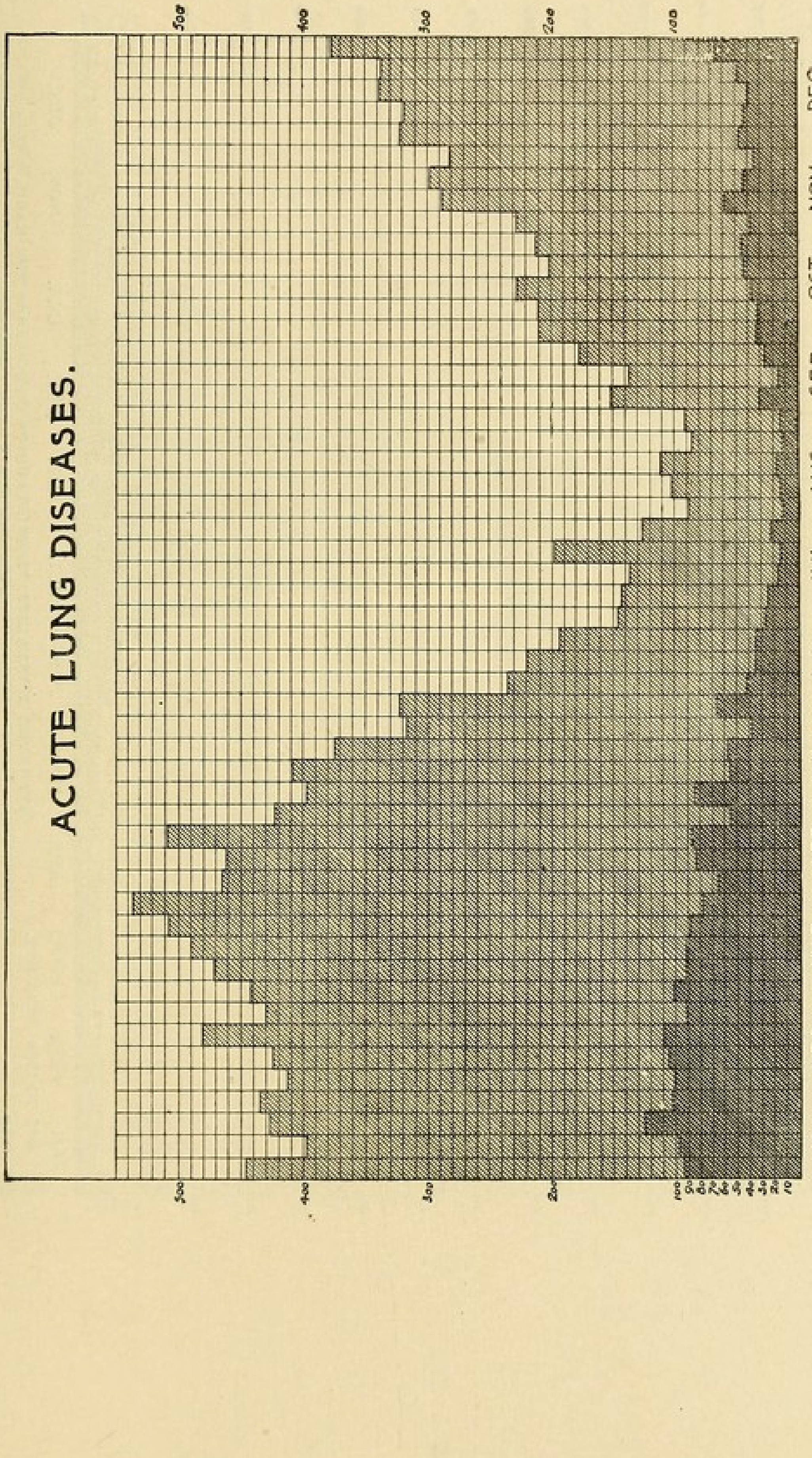
Mr. Alexander Buchan and Dr. Arthur Mitchell have analyzed the influence of the weather and season upon the causation of disease, or, rather, upon the mortality from various diseases.[15] Taking the records of the city of New York from 1871 to 1877, it appears that the maximum number of deaths from small-pox occurred in May, the minimum in September. From measles there were two annual maxima and minima, the greater in July and September and the smaller in February and April. From scarlet fever the maximum was in April, the minimum in September. From typhoid fever the maximum was from August to November, the minimum almost equally distributed throughout the rest of the year; from diarrhea,

[14] Dr. S. Weir Mitchell has shown, from the record of the case of Captain Catlin, U. S. A. (American Journal Med. Sci., April, 1877, and N. Y. Med. Jour., August 25 and September 1, 1883), that attacks of neuralgia—in this case, at all events—accompanied the progress of storms across the continent. Also, that the periods of maximum pain occurred with a high but falling barometer and increasing absolute humidity. There seems also to be some relation in this case between the maximum pain and the maximum magnetic force as shown by the declinometer. Dr. Mitchell's papers are among the most valuable positive contribution to hygienic meteorology, and deserve careful study.

[15] Journal Scottish Meteorological Society, 1875-78. (Abstract in Richardson's Preventive Medicine, p. 533 *et seq.* Philadelphia, 1884.)

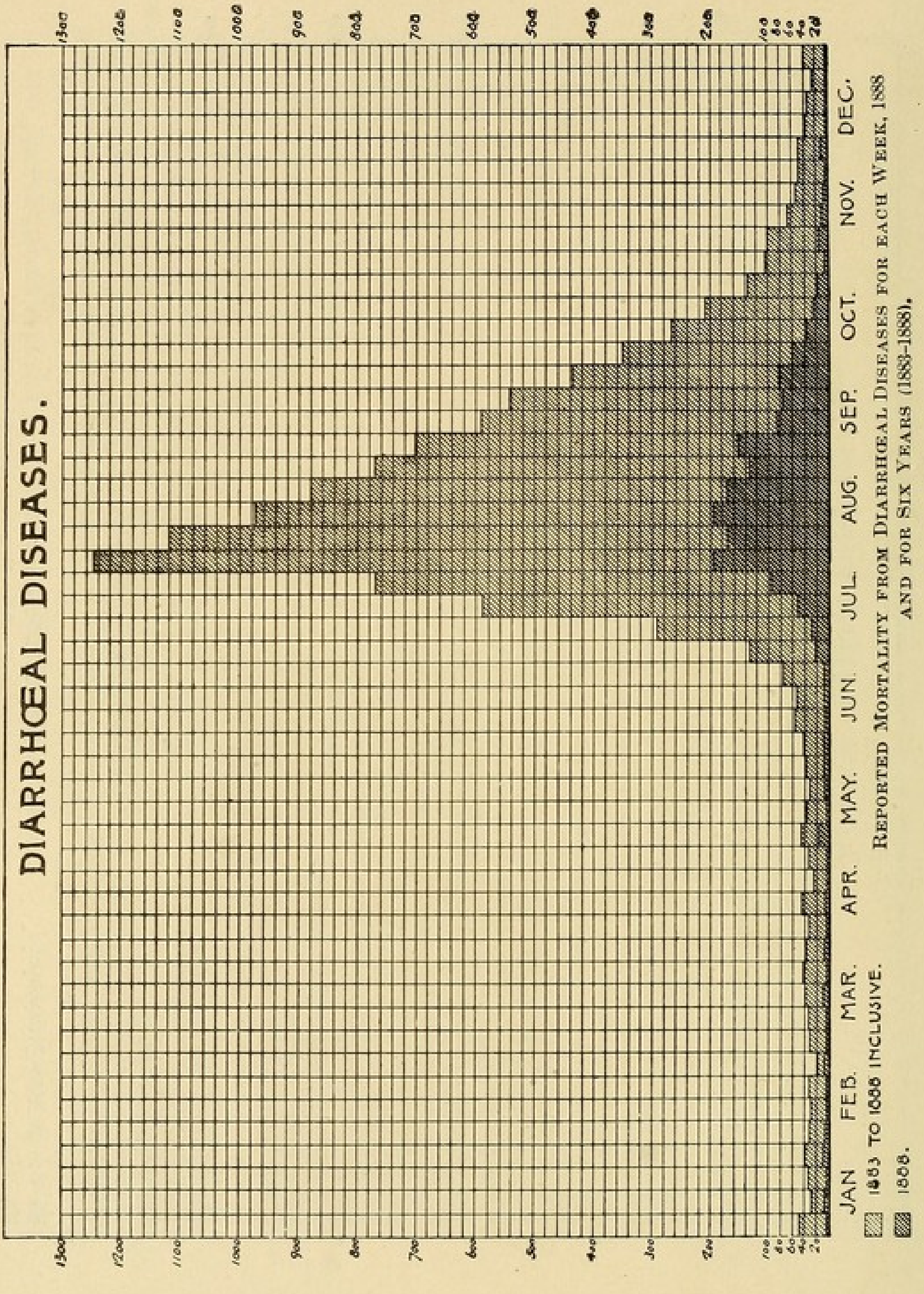


REPORTED MORTALITY FROM CONSUMPTION FOR EACH WEEK FOR 1888, AND FOR THE SIX YEARS (1883-1888).

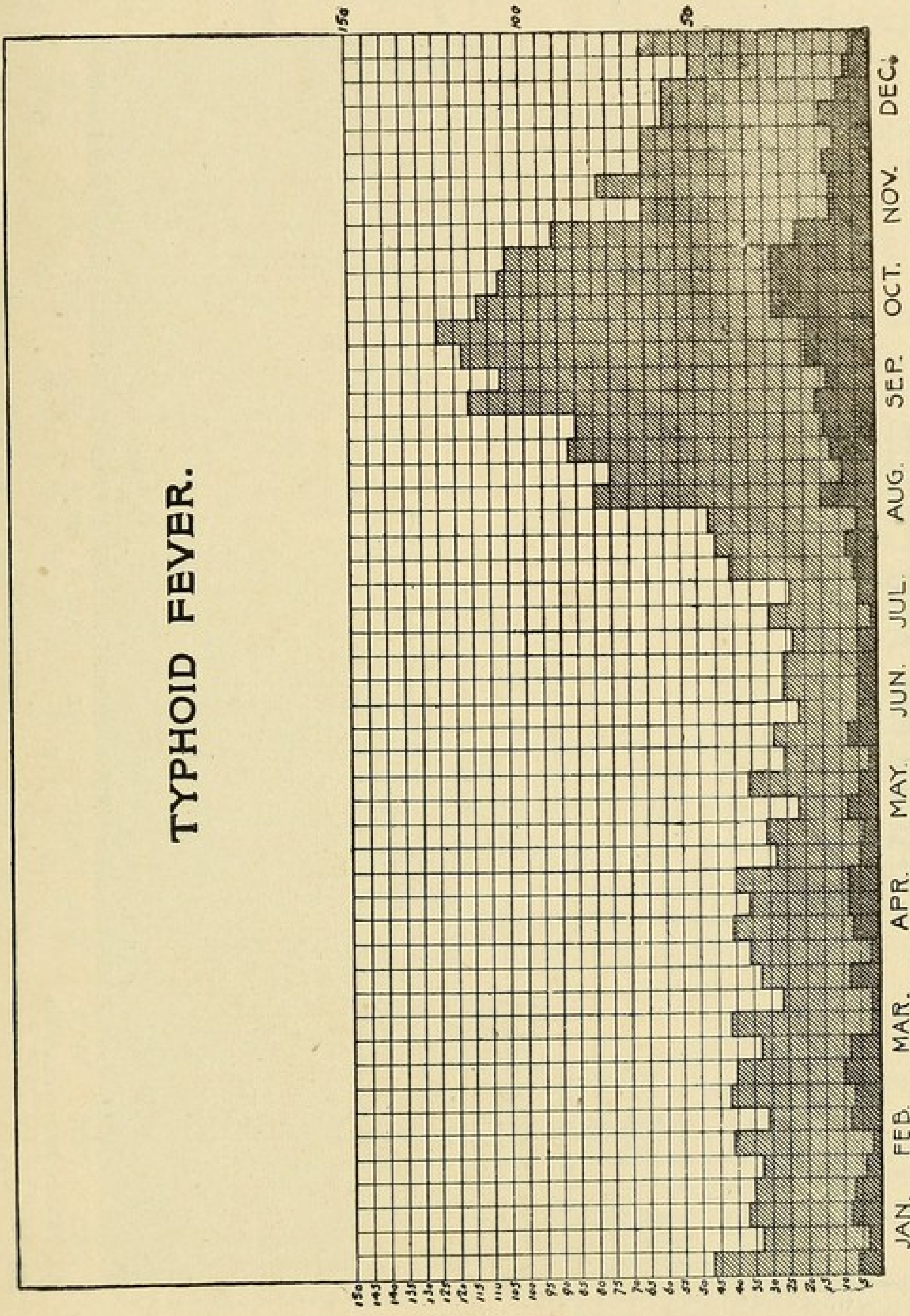


1883 TO 1888 INCLUSIVE.
1888.

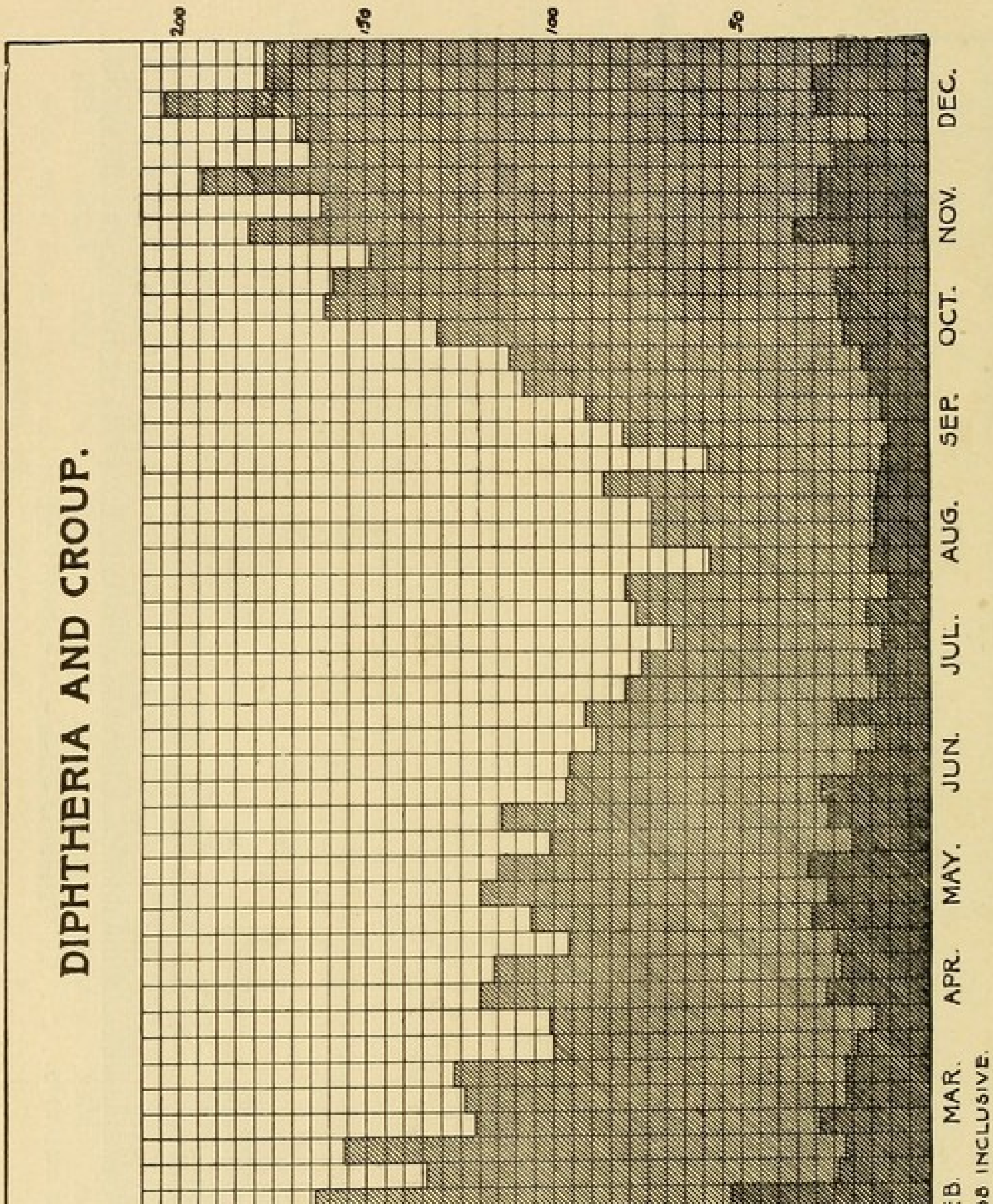
Reported Mortality from Acute Lung Diseases for each Week, 1888, and for Six Years (1883-1888).



REPORTED MORTALITY FROM DIARRHŒAL DISEASES FOR EACH WEEK, 1888 AND FOR SIX YEARS (1883-1888).



Reported Mortality from Typhoid Fever for each Week, 1888, and for Six Years (1883-1888).


DIPHTHERIA AND CROUP.
JAN. FEB. MAR. APR. MAY. JUN. JUL. AUG. SEP. OCT. NOV. DEC.
200
150
100
50
1883 TO 1888 INCLUSIVE.
1888.

the maximum in July and August, the minimum from December to March; from diphtheria, the maximum in December, the minimum in August;[16] from whooping-cough, maximum in September and February, minimum in November and June; for croup the curves agree pretty closely with the diphtheria curves; from phthisis, the maximum in March, minimum in June.

The foregoing charts, reproduced by permission of the Massachusetts State Board of Health from the report of that body for 1888, show an almost identical movement of the mortality from different diseases throughout the year. They exhibit the reported mortality for 1888 and also for the six years from 1883 to 1888.

From suicide, curiously, the greater number of deaths occurs in May, the smallest in February. This is contrary to the usual supposition that gloomy weather predisposes to suicide. The six summer months—from April to September—show a much larger number of self-murders than the remaining half-year. In eleven years, ending 1880, there were 1521 cases of self-destruction in New York. Of these 341 occurred during January, February, and March; 417 during April, May, and June; 412 during July, August, and September; and 351 during the last three months of the year. In Philadelphia, the results of examination of the statistics of suicide for ten years are almost exactly similar. Out of 636 cases of suicide, 78 occurred in May, 71 in August, 57 in December, 54 each in October, July, and April, 52 in June, 49 in November, 44 each in December and Februrary, 43 in March, and 36 in January.[17] Dr. Lee is led to believe that "a low barometric pressure, accompanied by a high thermometric registry, with sudden fluctuations from a low to a high temperature, together with much moisture and prevailing southwest winds, might somewhat account for the frequency of self-murder in the spring and summer months."

THE SANITARY RELATIONS OF CHANGES IN COMPOSITION AND OF IMPURITIES IN THE AIR.

The average proportion of carbon dioxide in the atmosphere is from 3 to 4 parts in 10,000. Pettenkofer[18] places the maximum limit

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[16] See paper on the Relation of Weather to Mortality from Diphtheria in Baltimore, by Richard Henry Thomas, in Trans. Med. and Chir. Faculty of Maryland, 1883.

[17] Suicide in the City and County of Philadelphia during a Decade, 1872 to 1881, inclusive, by John G. Lee, Trans. Am. Med. Asso., vol. xxxiii, p. 425.

[18] Quoted in Buck's Hygiene and Public Health, vol. i, p. 615.

of carbon dioxide allowable in the air of dwellings at 7 parts in 10,000. It is probable that this limit is very frequently exceeded without serious consequences to health, if the air is not at the same time polluted by organic impurities, the products of respiration. Professor William Ripley Nichols found the air in a school-room in Boston to contain eight times the normal proportion of carbon dioxide, while Pettenkofer found, also in a school-room, after the same had been occupied two hours, eighteen times the normal proportion, or 72 parts in 10,000.[19] While such an excess of this poisonous gas must unquestionably have an unfavorable influence upon health, it is probable that the most serious effects are due to the coincident diminution of oxygen and the pollution of the air by the products of respiration which necessarily take place during respiration. Carbon dioxide alone may be present in the air to a much greater extent than above mentioned without causing any appreciable inconvenience. In the air of soda-water manufactories there is frequently as large a proportion as 2 per cent. of this gas present without producing any ill effects upon those breathing such an atmosphere.

The amount of carbon dioxide in the atmosphere is greatest at night. It is also greater very near the ground than at a distance of several feet above it. As carbon dioxide is absorbed by the leaves of plants during the day-time, but given off at night, the difference may partly be thus accounted for. According to Fodor,[20] the source of a large proportion of the carbon dioxide in the air is the decomposition going on in the soil. This accounts for the larger percentage of carbon dioxide near the ground. This would also explain the variation of the proportion of carbon dioxide in the air under different meteorological conditions. For example, it is found that during rainy weather the carbon dioxide in the air is diminished. This is accounted for partly by the absorption of the carbon dioxide by the saturated ground, while at the same time the porosity of the soil is diminished and the escape of the ground-air prevented.

Mr. R. Angus Smith made a number of experiments upon himself to determine the effects of an atmosphere gradually becoming charged with the products of respiration and perspiration. His experiments were conducted in a leaden chamber holding 5 cubic metres of air. This air was not changed during the experiment. After remaining for an hour in this chamber, an unpleasant odor of organic

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[19] See table in Buck's Hygiene and Public Health, vol. i, p. 612.

[20] Hygienische Untersuchungen ueber Luft, Boden und Wasser, Braumschweig. 1882 2te Abth.

matter was perceptible on moving about. The air, when agitated, felt soft, owing, doubtless, to the excess of moisture contained in it. The air soon became very foul, and, although not producing any discomfort, the experimenter states that escape from it produced a feeling of extreme pleasure, like "that which one has when walking home on a fine evening after leaving a room which has been crowded."[21]

Hammond[22] confined a mouse in a large jar in which were suspended several large sponges saturated with baryta water, to remove the carbon dioxide as rapidly as formed. Fresh air was supplied as fast as required. The aqueous vapor exhaled was absorbed by calcium chloride. The mouse died in forty-five minutes, evidently from the effect of the organic matter in the air of the jar. The presence of this organic matter was demonstrated by passing the air through a solution of potassium permanganate.

The horrible story of the "black hole" of Calcutta is familiar to every one. Of 146 prisoners confined in a dark cell at night, 23 were found alive in the morning. Among the survivors a fatal form of typhus fever broke out, which carried off nearly all of them. After the battle of Austerlitz 300 prisoners were crowded in a prison; 260 died in a short time from inhaling the poisoned air. Numerous other similar examples of the effects of polluted air are recorded.

Usually the effects of foul air are not so sudden and striking. In most instances, especially where the pollution has not reached a high degree, there simply results a general deficiency of nutrition, which manifests itself in anemia, loss of vigor of body and mind, and a gradual diminution of resistance to disease.

It seems to be beyond question that persons who are constantly compelled to inhale impure air, especially if combined with an improper position of the body or lack of sufficient or appropriate food, furnish a very large percentage of chronic pulmonary affections. Phthisical patients, in the overwhelming majority of cases, are drawn from the classes whose occupations keep them confined in close rooms. Want of exercise and of good food doubtless aid in the development of the lung disease. Formerly, when less attention was paid to the proper construction and ventilation of barracks and prisons, the mortality from phthisis among soldiers and criminals was much greater than it is now. In animals kept closely confined the same disease claims a large share in the mortality.

[21] Air and Rain, p. 138.

[22] A Treatise on Hygiene, with Special Reference to the Military Service, by William A. Hammond, M.D., Surgeon-General U. S. Army, p. 170. Philadelphia, 1863.

Near the end of the last century over one-third of the infants born in the old Dublin Lying-in Hospital died of epidemic diseases. After the adoption of an improved system of ventilation the mortality fell to about one-tenth of what it had previously been. To illustrate the effect of similar conditions upon the health of domestic animals, the following instance is cited: Upward of thirty years ago a severe epidemic of influenza in horses appeared in Boston. At the instigation of Dr. H. I. Bowditch, every stable in the city was inspected, and classified as "excellent," "imperfect," or "wholly unfit," in respect to warmth, dryness, light, ventilation, and cleanliness. It was found that in the first class fewer horses were attacked and the disease was milder, while in the third class every horse was attacked and the more severe and fatal cases occurred.

Carbon monoxide is a very dangerous impurity often present in the air of living-rooms. Being an ingredient of illuminating gas, as well as the so-called coal-gas which so frequently escapes from stoves and furnaces, its dangerous character becomes apparent. Many persons die every year in this country from the inhalation of illuminating gas. People unacquainted with the mechanism of gas-fixtures frequently blow out the light instead of cutting off the supply of gas by turning the stop-cock. It is also a prevailing custom to keep the light burning "low" during the night. Any considerable variation of pressure in the pipes, or sudden draught, may put out the light and permit the gas to escape into the room, with fatal effect. Leaks in pipes or fixtures may have the same results. Chronic poisoning with minute quantities of illuminating gas is very common, especially in large cities, and many cases of obscure anemia and ill-health are due to this cause.

Coal-, coke-, or charcoal- fires may produce serious or fatal poisoning if the gas, which contains a large proportion of carbon monoxide, is permitted to escape into the room.[23] In certain parts of Europe, notably in France, the inhalation of the fumes of a charcoal fire is a favorite method of committing suicide.

The gas which sometimes escapes from the stove when coal is burning has the following composition:—

Carbon dioxide	6.75	per cent.
Carbon monoxide	1.34	"
Oxygen	13.19	"
Nitrogen	78.72	"

[23] See paper by Dr. John Graham in Transactions of Philadelphia College of Physicians for 1885.

Sulphuretted and carburetted hydrogen, are not infrequently present in the air, especially about cess-pools and in mines and certain manufacturing establishments. Sulphuretted hydrogen is generally considered to be a violent poison, but there is no evidence that it is so unless oxygen is excluded.

Carburetted hydrogen is the so-called "fire-damp" of mines, which is so often the cause of fatal explosions. Its inhalation does not seem to be especially noxious. It will be more fully referred to in a succeeding chapter.

Variations in the proportion of ammonia present in the air are frequent. Its presence is an indication of organic decomposition in the vicinity, but nothing is known of the influence of the gas itself upon health, in the proportion in which it is ever found in the atmosphere.

SEWER-AIR.

Sewer-air, or sewer-gas, as it is often improperly called, is a variable mixture of a number of gases, vapors, atmospheric air, and solid particles, and is derived from the decomposition of the animal and vegetable contents of sewers. A number of analyses by different chemists have shown that the composition of sewer-air is extremely variable. The most important components, in addition to the constituents of atmospheric air, are: Carbon dioxide, ammonia, sulphuretted hydrogen, and a number of volatile organic compounds, which give to sewage its peculiar odor, but which are present in such small quantity as to prevent accurate determination by chemical means. Sewer-air may also contain particulate bodies, bacteria, and other microscopic organisms, which may be the active causes of infectious diseases. Some recent researches by Carnelly and Haldane have shown that sewer-air usually contains a less number of micro-organisms than the external air of cities. The proportion of carbon dioxide found was also much less than was expected. When the contents of sewers remain in these receptacles or conduits long enough to undergo decomposition, sewer-air is always present.

The continual breathing of air polluted by emanations from sewers often produces more or less serious derangements of health. Diarrhea and other intestinal affections and mild cases of continued fever have been frequently noted in connection with defective sewerage, and the escape of sewer-air into inhabited rooms.

The effluvia from cemeteries, knackeries, and other places where the bodies of animals are undergoing decomposition, are popularly regarded as deleterious in their effects upon health. The evidence in favor of this view is, however, very indefinite.

Professor Tyndall has shown[24] that even the apparently clearest air is, when in motion, constantly filled with innumerable particles of dust, which are the carriers of various micro-organisms. The presence of these particles can be easily demonstrated by means of the electric light. Every one has observed these minute particles in a bright ray of sun-light. Under ordinary conditions these particles of dust would, of course, give rise to no trouble, but if intermingled with these dust-specks there were disease germs, then manifestly the inhalation of such "dust" would be dangerous.[25]

The quantity of dust found in the air of cities is much greater than in the country. Tissandier found that in Paris the percentage of dust was eight to twelve times greater than in the open country. One-fourth to nearly one-half of this atmospheric dust is organic, either animal or vegetable. Very recent observations have shown that in Paris the air contains nine or ten times as many bacteria in a given volume as the air at the observatory of Montsouris, just without the city. The relative proportions of organic and inorganic particles vary as 25 to 75 in Paris, 45 to 55 in Dublin, and 25 to 75 in the open country. The organic particles are either particles of dead organic matter, or minute organisms. The proportion of the latter varies in different seasons, being the least in winter and spring, and greatest in summer and autumn. These organisms are not necessarily pathogenic, but the conditions which favor the proliferation of non-pathogenic bacteria are likely to promote the development of disease-producing ones likewise.

Among the pathogenic micro-organisms which may be found in the atmosphere are spores of achorion Schœnleinii, streptococci, staphyloccoci, the bacilli of tuberculosis, cholera, and typhoid fever, and other micro-organisms which produce disease.

It is advisable in all cases to exhaust the stagnant air in old wells and privy-vaults before permitting any one to descend. Perhaps the readiest method of exhausting the vitiated air in such places would be to lower heated stones, masses of hot iron or pails of hot water, to near the bottom, which produce a rarefaction of the air and cause it to ascend. Its place will then be occupied by purer air from without. The rarefaction produced by the explosion of gun-powder

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[24] Essays on Floating Matter of the Air. New York, 1882.

[25] See Chapter IX, on Industrial Hygiene, for effects of inhalation of dust in various industries.

has also been made use of with success; but this has some objections, because the combustion of powder itself produces gases which are noxious if breathed in large quantity. An animal, such as a cat or dog, should be first lowered into the suspected well for fifteen or twenty minutes, in order to determine whether the air at the bottom is capable of sustaining life, before permitting the workmen to descend. Similar precautions should be used in old, long-unused mines to prevent fatal effects from the so-called "choke-damp," which is largely composed of carbon dioxide.

THE EXAMINATION OF AIR.

Occasions often arise wherein physicians or others desire information concerning the atmosphere of apartments or confined spaces. They have neither time, apparatus, nor, possibly, the skill necessary to obtain the accurate results of the expert chemist or bacteriologist; nor do they require that the information which they seek should be so extremely exact.

In the preparation of this chapter, therefore, such methods of procedure will be detailed as will serve to determine, with reasonable accuracy and with moderate requirements of time, expense, or technical skill, the hygienic condition of the substances examined. The apparatus and reagents will also be found, for the most part, to be cheap and easily obtainable, and they may often be improvised or prepared from material already at hand. Moreover, a little thought will show how a number of these methods may be developed along the line of greater accuracy, should this be desired, and the principles involved will indicate how similar examinations may be made of other phases of the respective subjects not herein discussed.

The substances in the atmosphere whose proportions or characteristics it may be important to determine are: the aqueous vapor; ozone; suspended particles, both organic and inorganic; living micro-organisms; volatile organic matters, and the various gases given off as products of respiration, combustion, etc., or in the course of certain manufacturing processes.

The proportion of aqueous vapor is to be determined by some form of hygrometer, such as Lambrecht's polymeter, or from the readings of wet- and dry- bulb thermometers, which readings, when applied to Glaisher's tables, furnish a means of determining the relative and the absolute humidity, the dew-point, the weight of water to a given volume of air, etc.

The presence of ozone in the atmosphere may be demonstrated by exposing to the air strips of white blotting- or filter- paper which have been saturated with a solution of potassium iodide and starch and dried. The ozone, decomposing the potash salt, liberates the iodine and colors the starch blue. During the test the paper should not be exposed to dust, rain, wind, or the direct rays of the sun. Another test (Houzeau's), perhaps even more delicate, is to dampen a strip of faintly-red litmus-paper with a solution of the iodide and dry. The action of ozone upon this is to liberate the alkaline potash and change the litmus to blue. As ammonia is the only other gas likely to produce the same coloration, if another strip of the litmus-paper, not moistened with the salt, be exposed at the same time, whatever difference in shade there may be in the papers is due to the ozone. An idea of the quantity of ozone present may also be gained by comparing the shade of blue given by either test with that produced in similar strips of the starch- or litmus- paper, respectively, which have been exposed to certain definite amounts of ozone, a series of such papers forming a standard of comparison.

It may be suggested, for still another test, that a definite quantity of the air to be examined be drawn through a faintly-acid solution of the potassium iodide, phenolphthaleine being used as an indicator. As soon as sufficient alkali is liberated to neutralize the acidity, the pink color of the phenolphthaleine will be developed and will deepen as the proportion of free alkali increases. Here, also, a control-test to eliminate the influence of ammonia should be made by drawing a similar quantity of air through the same amount of the solution *minus* the potassium iodide. As before, the difference in color-shading will be proportional to the amount of ozone in the air.

Numerous methods have been suggested for the collection of the solid impurities of the atmosphere, varying according to the kind or extent of examination to which they are to be subjected. If they are simply to be studied microscopically, glass slides coated with glycerin and exposed to the air will be sufficiently covered after several hours, or they may be collected more rapidly by aspirating large quantities of the air against such slides or through tubes coated interiorly with glycerin, as by means of Pouchet's aëroscope or by the apparatus devised by Dr. S. G. Dixon. This latter is especially advantageous where it is desired to collect samples of dust in the air of a number of localities within a short time, and consists essentially of a double cylinder of metal, within which is a rack carrying a number of glycerin- or gelatin- smeared cover-glasses. By an ingenious arrangement the air can be aspirated by means of a hand-bulb over each of these glasses in turn, the dust particles being deposited on the sticky surface, and thus the samples may be taken from as many localities as there are cover-glasses. Moreover, the specimens may be mounted and examined as they are, may be stained, or, if the glasses be coated with gelatin and the whole apparatus be sterilized before the collection, colonies of the bacteria, etc., in the dust may be allowed to develop on the glasses and be studied *in loco* under the microscope.

Another satisfactory method of collecting suspended particles is to draw a considerable volume of air very slowly through a small quantity of distilled water contained in one or two wash-bottles. The solid particles may then be allowed to settle, and subsequently be removed for microscopical examination by means of a pipette, or the whole may be filtered and the weight of the dust in the aspirated air thus obtained. It might also be well, in the latter case, to evaporate the filtrate to dryness and to determine what proportion of the residue is organic matter, and what are its nature and effects when administered to animals. Lastly, the air may be slowly drawn through a small tube packed with pure sugar, the sugar afterward being dissolved in distilled water, whence the solid particles taken from the air may be removed by means of a pipette or by filtration.

The physical nature of the particles of dust thus collected is to be determined by means of the microscope, it being presumed that the examiner is sufficiently familiar with the instrument to recognize at sight the more common materials that are apt to pervade the air of occupied apartments, such as bits of cotton, wool, hair, epithelium, etc. Charring on ignition will indicate that the residue is, at least, partly organic, and the odor of burnt feathers that it is nitrogenous and probably of animal origin. Suitable chemical tests will also determine the presence or absence of suspected substances. Thus, an examination of the dust by Marsh's or Reinsch's test may reveal the presence of arsenic, and lead to an investigation as to its source.

However, since Cornet and others have demonstrated that the micro-organisms in the air are, in general, closely adherent to the dust-particles, a bacteriological examination of the latter will, except in special cases, be of more importance than a physical or chemical one.

To make a qualitative bacteriological examination it is only necessary to coat the glass plates or tubes, already described, with nutrient gelatin instead of glycerin, and to sterilize them before use. They are then exposed to the air as before, covered, and set aside in

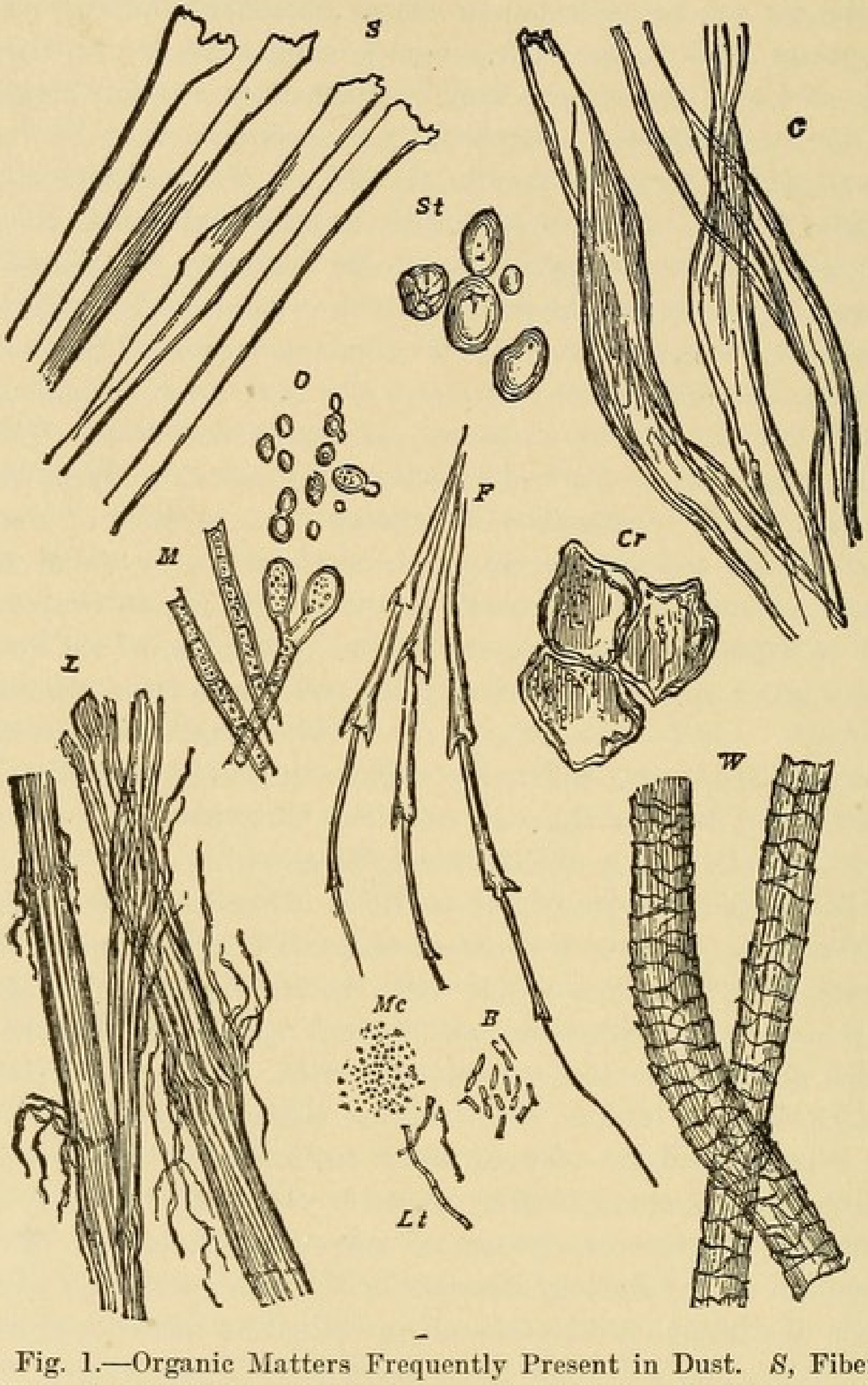

Fig. 1.—Organic Matters Frequently Present in Dust. *S*, Fibers of Silk; *C*, of Cotton; *L*, of Linen; *W*, of Wool. *F*, Feather. *St*, Starch-granules. *Cr*, Cork. *O*, Torulæ. *M*, Mycelia, or Threads, of Mildew. *Mc*, Micrococci. *B*, Bacteria. *Lt*, Leptothricial Filaments. (After Heitzmann.) × 500.

a place of proper temperature to allow the colonies to develop from the various micro-organisms which have adhered to the sticky surfaces; or Dr. Dixon's apparatus, with gelatin-coated glasses, may be used in the manner described.

A quantitative bacteriological examination is almost as readily made by drawing a given quantity of air through a sugar-filter, as stated. The tube should not be too large in diameter nor in length, should be filled with pure granulated sugar and the ends temporarily plugged with cotton, and should, of course, be sterilized before making the test. After the air has been drawn through it the sugar is carefully emptied into tubes or flasks of nutrient gelatin, which have been heated just enough to melt the gelatin, but not sufficiently high to kill the bacteria, etc., which have been caught in the sugar. The latter rapidly dissolves and leaves the micro-organisms free to develop in the gelatin, which may be poured out before cooling upon sterilized glass plates or into shallow (Petri) dishes. So-called colonies rapidly develop from the individual bacteria, and the total number of these colonies may be assumed to represent the number of micro-organisms in the quantity of air aspirated through the filter. Moreover, from these colonies pure cultures may be made, and the nature, etc., of the respective microbes determined. To determine the quantity of organic matter in the air the most feasible method is to slowly draw a certain volume of air through a given quantity of twice-distilled ammonia-free water, which retains not only all the volatile and suspended organic matters, but also the gases originating therefrom. The water is then to be tested by the Wanklyn process for "free" and "albuminoid" ammonia, and, if desired, by the Tidy-Forchammer process for oxidizable organic matter, though it should be noted that in the latter process other gases present in the air, such as sulphuretted hydrogen, may help to decolorize the permanganate solution, and must therefore be excluded or estimated separately.

However, as these processes are, perhaps, too complex for the purpose of this chapter, and as it has been shown by de Chaumont and others that the organic matter with which we are usually most concerned—namely, that given off from human bodies as a product of respiration and like processes—is produced in quantities proportional to the amount of carbon dioxide eliminated in the same processes, it generally suffices for our purpose to determine the proportion of this gas in the atmosphere, especially as this determination is much more readily made than the foregoing one.

The methods devised by Wolpert and Angus Smith for rapidly estimating the percentage of carbon dioxide have been materially simplified by Professor Boom.

Professor Boom has suggested that, instead of the special and somewhat expensive apparatus of Professor Wolpert, a mark be made on any test-tube,—say, one inch from the bottom. Fix the bulb of any atomizer to a small glass tube—a capillary one, if possible—sufficiently long to reach the bottom of the test-tube, and in such a manner that a definite volume of air is driven *from* the atomizer-bulb through the tube at each compression of the former. In using, fill the test-tube exactly to the mark with a clear, saturated solution of lime-water, and find how many compressions are needed in the out-door air—forcing the air through the lime-water each time and taking care not to draw any fluid up into the bulb—to make the fluid just turbid enough to obscure a pencil-mark or print on white paper placed beneath the test-tube and viewed from above. Clean the test-tube thoroughly, and repeat the process in the apartment of which the air is to be examined. Assuming that the out-door air contains the normal proportion of carbon dioxide,—viz., 0.04 per cent.,—the percentage in the air of the room is determined as follows:

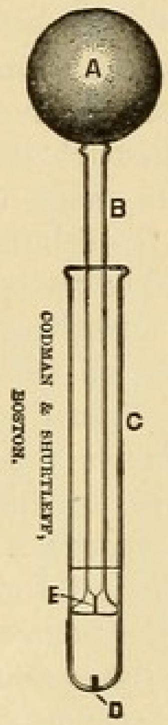

Fig. 2.—Air-tester.

The number of compressions of the bulb in the out-door air : the number of compressions in the room :: x : 0.04 per cent., x representing the percentage of carbon dioxide in the air of the room.

As a modification of the Angus Smith method, the author would suggest the following as being, perhaps, more accurate, and as certainly not requiring so much apparatus, etc. :—

To a wide-mouthed bottle, holding about a quart or litre, fit a doubly-perforated rubber stopper, one perforation being just large enough to receive the tip of a 1 c. c. pipette, the other carrying a *small* test-tube, its mouth opening into the jar and close to the inner surface of the stopper. Fill the bottle and test-tube with the air of the room by filling them with water and emptying; fit in the stopper, and introduce, by means of a 1 c. c. pipette, a cubic centimetre at a time of a standardized alkaline solution, slightly colored with a few drops of a neutral alcoholic solution of phenolphthaleine. Close the pipette perforation in the stopper with a bit of glass rod and shake the bottle well each time after adding the alkaline solution. Continue in this way until the color is no longer discharged by the acid carbon dioxide of the air. By having the test-tube fitted in the stopper as above and inverting the bottle, the same thickness of fluid is observed each time, and there is more accuracy than if the bottle is used without the test-tube. In either case the fluid should be examined by looking through it against a white light or surface.

Now, since the quantity of the alkaline fluid used indicates a correspondingly definite amount of carbon dioxide,—

$$\frac{\textit{the number of c. c. of solution used} \times \textit{the volume of } CO_2 \textit{ each c. c. represents} \times 100}{\textit{the capacity of the bottle and test-tube in c. c.} - \textit{the number of c. c. of solution used}}$$

= the percentage of carbon dioxide in the air examined.

A suitable alkaline solution may be prepared by dissolving exactly 4.766 grammes (73.549 grains) of pure anhydrous sodium carbonate in 1 litre (35.238 fluidounces) of distilled water. Each cubic centimetre of this solution is equivalent to a like volume of carbon dioxide. To 10 cubic centimetres of this solution add a few drops of a neutral alcoholic solution of phenolphthaleine and dilute with distilled water to 100 c. c. Each cubic centimetre of the dilute solution will now be neutralized by 0.1 of carbon dioxide, and, if used as suggested, should give close results. The phenolphthaleine is used as an indicator, as it loses its color as soon as the alkalinity of the soda solution is destroyed by the carbonic acid. Example: If 11 c. c. of the foregoing dilute solution be used, and the capacity of the bottle and test-tube is 1153 c. c., then

$$\frac{11 \times 0.1 \times 100}{1153 - 11} = \frac{110}{1142} = 0.0963,\text{—}$$

the percentage of carbon dioxide in the air of the apartment. The first (stock) solution must be kept in well-filled and tightly-stoppered bottles, and the dilute solution made up as needed.

Pettenkofer's method for determining the percentage of carbon dioxide in the air, which is usually considered the best, is as follows: Into a large, clean bottle or jar, filled with the air of the room as on page 34, introduce 50 c.c. of a clear, saturated solution of lime (calcium hydrate), stopper the bottle, and shake it well, so that the air may be well washed by the lime-water. This shaking should be repeated at intervals for several hours, from eight to ten hours being required for the lime-water to absorb all the carbon dioxide in the air in the jar. (However, if baryta—barium hydrate—water be used instead of the lime-water, the absorption will be completed in an hour.)

The strength of the lime- (or baryta-) water being unknown and variable, it is determined by means of an oxalic-acid solution of such strength that 1 c. c. corresponds in acidity to 0.5 c. c. of carbon dioxide. Such a solution is made by dissolving exactly 2.84 grammes (43.827 grains) of pure crystallized oxalic acid in 1 litre of freshly-distilled water. This acid solution is run into 25 c. c. of the lime-water in a beaker from a graduated burette, or pipette, until the alkalinity of the lime is just neutralized, the neutral point being indicated either by means of a few drops of a neutral phenolphthaleine solution in the beaker or by turmeric paper, the latter being colored brown, and the phenolphthaleine retaining its color as long as the solution is alkaline. When the lime is exactly neutralized the amount of the acid solution used from the burette is noted. Then 25 c. c. of the lime-water from the testing-bottle is measured into a beaker, and its acidity determined in the same manner by means of the oxalic-acid solution. Now, since part of the lime in the solution in the testing-bottle has already been neutralized by the carbonic acid of the air therein, it will require less of the acid solution to neutralize the lime-water from the bottle than it did to neutralize the same quantity from the stock solution, and the difference will indicate the exact amount of carbon dioxide in the air in the testing-bottle. For, though each cubic centimetre of acid solution is equivalent to only one-half cubic centimetre of carbon dioxide, the loss of alkalinity of only *half* the lime-water in the bottle has been determined, and the total loss would be expressed by twice the difference found. The number of cubic centimetres of carbon dioxide in the air in the bottle having been thus determined, and the capacity of the bottle found by measuring the quantity of water it will hold, the percentage of carbon dioxide in the air is readily determined. For example: 25 c. c. of stock lime-water requires 30 c. c. acid solution, and 25 c. c. of lime-water from testing-bottle requires 27 c. c. acid solution; therefore, $30 - 27 = 3$ c. c.,—the amount of carbonic acid in the bottle, which contains, say, 2250 c. c. Then—

$$\frac{3 \times 100}{2550 - 50} = \frac{300}{2500} = 0.12,$$

the percentage of carbon dioxide in the room at the current temperature and pressure. It should be noted that the accuracy of all these tests is somewhat vitiated by other acid gases, if present in the air, and due allowance should be made wherever they are suspected.

As has been intimated, baryta-water may be used in place of the lime-water, being more rapid in action, but considerably more expensive, than the latter. The solution should be made of the strength of about 7 grammes of crystallized barium hydrate to the litre of distilled water; it must not be forgotten, also, that it is poisonous when taken internally. A good indicator, in addition to the phenolphthaleine and turmeric, is methyl-orange, which is yellow in alkaline and of a reddish tint in acid solutions.

The quantity of ammonia in the atmosphere may be determined by drawing a certain volume of air through ammonia-free water and then "Nesslerizing" the latter, as in the Wanklyn process of water analysis. So, also, the presence and percentage of other gases, such as nitric, hydrochloric, sulphurous, and sulphuric acid, sulphuretted hydrogen, ammonium sulphide, etc., are obtained by drawing the air through distilled water and subsequently making the proper chemical tests. For instance, the sulphur gas will darken a solution of lead acetate and ammonium sulphide will change the blue color of nitroprusside of sodium to violet; consequently, the air may be drawn through standard solutions of these reagents and the resulting coloration compared with that produced by known quantities of the respective gases.

The presence of carbon monoxide is shown by the darkening of a solution of palladium chloride or sodio-chloride, but a more delicate test is that of Vogel by means of the spectroscope, which will show the presence of as little as 0.03 per cent. of the gas. In this test a drop of fresh blood is mixed with a little pure water and the mixture well shaken with a sample of the air in a jar. Then a few drops of ammonium sulphide are added and the fluid examined spectroscopically. If carbon monoxide is present the spectrum of oxyhemoglobin will be seen, it not having been reduced by the ammonium sulphide; but if the carbon monoxide is not present, we shall have the spectrum of reduced hemoglobin.

As even very small quantities of carbon monoxide in the air are harmful, it will not often be necessary to make a quantitative test for it; but should this be desired, it can be done by passing a given volume of air several times through a solution of subchloride of copper, which absorbs the carbon gas, and then determining the loss of volume the air has suffered by means of the eudiometer.

PRINCIPLES OF VENTILATION.

During ordinary respiration an adult human being adds 900 grammes = 455,500 cubic centimetres (14 cubic feet) of carbon dioxide to, and abstracts 744 grammes = 516,500 cubic centimetres (16 cubic feet) of oxygen from the atmosphere in twenty-four hours. Hence, if the individual were confined in an apartment where the inclosed air could not be intermingled by diffusion with the atmosphere without, the proportion of carbon dioxide would soon become so great that the processes of life could not be sustained, and the individual would die. This result would be reached even sooner than the point here mentioned, for the organic matter exhaled from the lungs and the surface of the body would increase the poisonous condition of the air even more than the carbon dioxide given off. It is easily seen, therefore, how important the study of the principles and practice of ventilation becomes in hygiene. In this chapter only the principles underlying this subject can be definitely stated. Practical details will be more fully given in the chapters devoted to dwellings, schools, hospitals, etc.

It is generally accepted among sanitarians that the presence of .07 per cent (7 parts in 10,000) of carbon dioxide in the air indicates the greatest amount of organic impurity (from respiration or combustion) consistent with the preservation of health. As each individual gives off from his lungs, in the process of respiration, 316 cubic centimetres of carbon dioxide per minute, the diffusion in the air surrounding him must be sufficiently rapid to keep the air to be breathed at the standard of .07 per cent. above mentioned.

Adopting this as the standard of maximum impurity allowable, 90 cubic metres of fresh air per hour will be needed for each individual to keep him supplied with pure air. This is for a person in a state of health; in cases of disease a more rapid change of air will be necessary to keep that surrounding the patient in a state of purity.

Ventilation is defined by Worcester as "the replacement of noxious or impure air in an apartment, mine, or inclosed space by pure, fresh air from without." By Dr. Parkes the term is restricted to "the removal or dilution, by a supply of pure air, of the pulmonary and cutaneous exhalations of men and the products of combustion of lights in ordinary dwellings, to which must be added, in hospitals, the additional effluvia which proceed from the persons and discharges of the sick. All other causes of impurity of air ought to be excluded by cleanliness, proper removal of solid and liquid excreta, and attention to the conditions surrounding dwellings."[26]

A proper system of ventilation must take into consideration the cubic space of the apartment or building to be ventilated, the number of persons ordinarily inhabiting this space, whether constantly or only temporarily occupied, and certain other collateral elements, such as the character of the building to be ventilated, its exposure, necessity for artificial heating, etc.

The amount of cubic space that must be allowed to each individual is determined by the rapidity with which fresh air must be supplied in order to keep that surrounding the individual at the standard of less than .07 per cent. of carbon dioxide. For example, in a space of 3 cubic metres, the air must be changed thirty times in an hour in order to prevent the carbon dioxide exceeding the above proportion; that is to say, to allow 90 cubic metres of air to pass through that space in the time mentioned. This would create an uncomfortable, if not injurious, draught. If the space contained 30 cubic metres, the air would need renewal only three times an hour.

A space of 15 cubic metres could be kept supplied with pure air without perceptible movement if all the mechanical arrangements for changing the air were perfect; but such perfection is rarely attainable, and hence there would be either draughts or insufficient ventilation in such a small "initial air-space," as it is termed. The initial air-space should, therefore, be not less than 30, or, better, 40 cubic metres. The air of this space could be changed sufficiently often to keep it at its standard of purity without creating unnecessary draught. For sick persons this should be doubled. In hospitals, therefore, the cubic air-space allowed to each bed should be not less than 60 to 80 cubic metres.

As stated, the purposes for which the building or apartment to be ventilated is employed require differences in the cubic space and in the volume of fresh air supplied. In Table III (page 40) Morin gives the cubic space for various purposes.

These figures are not excessive from a sanitary standpoint, although few buildings meet the requirements here set down.

The source of the air supplied must, of course, be capable of yielding pure air. It should not be drawn from damp cellars or basements, or from the immediate vicinity of sewers or drains. Air taken

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[26] Manual of Practical Hygiene, 6th ed., New York, vol. i, p. 157.

TABLE III

Hospital wards for ordinary cases		60-70 cubic metres.
Hospital wards for surgical and obstetrical cases		100 " "
Hospital wards for contagious diseases		150 " "
Prisons		50 " "
Workshops	ordinary occupations	60 " "
	unhealthy occupations	100 " "
Barracks	during the day	30 " "
	during the night	40-50 " "
Theatres		40-50 " "
Assembly rooms for long receptions		60 " "
Assembly rooms for brief receptions		30 " "
Primary schools		12-15 " "
Higher schools		25-30 " "
Stables		180-200 " "

from such places is little better for respiration than that which it replaces in the apartments to be ventilated.

Ventilation may be accomplished either with or without artificial aids. In buildings or rooms, used as habitations, natural ventilation (with, perhaps, the simplest mechanical aids) is made use of almost entirely. In large buildings, such as churches, theatres, schools, or in ships and mines, one of the artificial systems must be adopted if efficient ventilation is desired.

Natural ventilation takes place by diffusion, by perflation, and in consequence of inequality of atmospheric pressure. By diffusion is meant the slow and equable entrance of air from without and exit from within a room through the walls or ill-made joints without the influence of wind-currents. In an occupied room this is, however, insufficient to keep the air pure, because many of the organic impurities of respired air are molecular, and, therefore, incapable of making their way out of the rooms through the walls.

Perflation means, literally, "blowing through," and, if the direction and force of air-currents could be regulated, this would, with simple mechanical arrangements, be an efficient means of ventilation. However, the uncertainty of the force and direction of the wind makes this method of ventilation untrustworthy except in warm weather.

Unequal pressure between the air in a room and that without is, within certain limits, an efficient means of ventilation, and is usually relied upon in ordinary apartments. When the air in a room is heated above the temperature of the external air, either by a fire, lights, or by the presence of a number of persons in the room, it expands, and part of it finds its way out through numerous crevices and bad joints found in all buildings. The air which remains being less dense than the external air, the latter enters the room by various openings, until the equality of pressure is re-established. But as the heating of the enclosed air continues, the process is momentarily repeated and becomes continuous.

Although the impurities of respired air (carbon dioxide, organic matter) are heavier than the air itself at the same temperature, it is a familiar fact that the most impure air in an occupied room is always found near the ceiling, the impurities being carried upward with the heated air, and that the pure air from without, being colder, fills the lower part of the room.

If the cold, outside air were to be admitted at the bottom of the room, and means allowed for the escape of the hot air at the top, the conditions of the old health-maxim, to "keep the feet warm and the head cool," would be reversed. This would be no less uncomfortable than unwholesome. In all plans for natural ventilation, therefore, provision must be made to secure a gradual diffusion of the cold, outside air from above, or to have it warmed before it enters the room. With a large chimney as an aspirating shaft,[27] with flues at the top and bottom of the room, and openings in the walls of the room near the ceiling to admit fresh air, sufficient ventilation can be usually secured in cold weather, in a room not overcrowded.

When a room is heated by a furnace, the fresh air is warmed before it is introduced, and the foul air escapes either through a ventilating shaft, a ventilator in the window or wall, or through the numerous fissures and other orifices which defective carpentering always leaves for the benefit of the health of the occupants.

The following rules for the arrangement of a system of natural ventilation are modified and condensed from Parkes[28]:—

The apertures of entrance and of exit for the air should be placed far enough apart to permit thorough diffusion of the fresh air.

When the air is brought into a room through slits or tubes in the walls near the ceiling the current should always be deflected upward by an inclined plane, in order to prevent a mass of cold air from descending over the shoulders of the occupants and chilling them.

The air must be taken from a pure source.

[27] Of course there is really no such thing as a real aspiration, or "sucking out" of the air through the chimney or so-called "aspirating shaft." The upward movement of the air in the shaft is due to its displacement by the colder or denser air entering the room.

[28] Manual of Practical Hygiene, 6th ed., New York, vol. i, p. 177.

The inlet-tubes should be short, and so made as to be easily cleansed, otherwise dirt lodges and the air becomes impure.

Inlets should be numerous and small, to allow a proper distribution of the entering air.

Externally, the inlets should be partially protected from the wind, to prevent strong draughts; they should also be provided with valves to regulate the supply of air.

If the air cannot be warmed, the inlets must be near the ceiling; if it can be heated, it may enter near the floor.

The air may be warmed by passing it through boxes containing hot water or steam coils, by passing it through chambers around grates or stoves, or heating it in a furnace.

In towns or manufacturing districts the air should be filtered before allowing it to enter the room. Thin flannel or muslin spread over the openings answers very well as filtering material.

Outlets should be placed at the highest point of the room and should be protected from the weather. An opening into the chimney near the ceiling will answer well in many cases.

In one-story buildings, ridge-ventilators make the best outlets. The entrance of snow and rain must be prevented by suitable arrangements.

A small space or slit between the horizontal bars of the upper and lower window-sash will admit sufficient air in a proper direction in small rooms, even when the window is shut.

In all rooms, howsoever ventilated, doors and windows should be often opened to permit a thorough *flushing* of the interior with fresh air.

For large buildings, hospitals, schools, theatres, ships, and mines, two systems of artificial ventilation are in use. One operates by extracting the foul air by means of fans, the other by forcing in fresh air, allowing the impure air to find its way out as best it may.

Rotating cowls on the tops of chimneys may be used to increase the aspirating power of the air; in this way the natural force of the wind may be utilized for ventilation of rooms or buildings of moderate size.

Further details upon the practical application of these principles will be given in succeeding chapters of this work.

QUESTIONS TO CHAPTER I.

AIR.

What is the composition of the atmospheric air? Is the mixture a chemical or mechanical one? What constituent is the most constant in proportion, and what ones most variable? What are the causes and limits of variation in the composition of the air? Has this variation any effect upon health?

How is the general uniformity of composition maintained? What is the relation of the oxygen and carbon dioxide to plant and animal life and to one another?

What is the depth of the atmosphere? What is its weight, and how is this measured? How may you determine the altitude of any place above the sea-level?

What effect has temperature on barometric pressure? What effect has moisture and why? Whence does the air derive its warmth? Where is the atmosphere warmest?

What is the relation between the temperature and humidity of the air? What is meant by "absolute" and "relative" humidity? How is each always designated? What is meant by "saturation"?

What causes motion in air or wind? What conditions of the atmosphere probably have relation to, or influence upon, disease? Why should a sanitarian be a practical meteorologist?

What are the physiological effects of diminution of atmospheric pressure? What may aggravate these effects? To what are they due? Can the human body become accustomed to them? What name is given to this physiological disturbance? What diseases will probably improve in a rarefied atmosphere, and what ones will not?

What are the effects of increased atmospheric pressure upon the organism? Is there any danger of fatal results? Have the diurnal variations of pressure any effect upon the body in health or in disease?

What effect has high temperature upon health? What diseases are more frequent in hot weather and in hot climates?

What peculiar affection seems to be caused or favored by long-continued exposure to cold? What are some of the acute effects of cold? What effect has the relative humidity in the production of these diseases? Indicate and explain a possible relationship of causation between coryza or influenza, bronchitis and pneumonia. Is this altogether substantiated by statistics? Is low temperature the only cause of pneumonia?

What part has the relative humidity in the production of certain diseases?

What is the general rule as to the effect of winds or air-currents upon health? Name some apparent exceptions to this rule. Has the season any thing to do with the morbidity and mortality from different diseases? Give examples.

What is the average proportion of carbon dioxide in the atmosphere? What should be the maximum limit permissible in dwellings? Is this limit often exceeded? When exceeded, to what are the evil effects upon health probably due? How much carbon dioxide alone may be present in the atmosphere without producing any apparent ill effects?

When and where in the out-door atmosphere is the proportion of carbon dioxide greatest? In what way may this be explained?

What are the products of respiration and perspiration, and which of these is most harmful to health? What evidence have we to that effect? Have we any evidence that the respiratory carbon dioxide alone is harmful to health? Where there is a moderate degree of respiratory pollution, what are some of the symptoms usually produced thereby? In the production of what especial disease has impure air a decidedly causative influence?

Which is the more dangerous to health, carbon monoxide or carbon dioxide? Of what gases is the former an ingredient? How does it produce its harmful effects?

Have sulphuretted and carburetted hydrogen any effect upon health? If so, in what proportions must they be in the atmosphere? Has ammonia, in the proportion in which it is usually found in the atmosphere, any bad effect upon health?

What is sewer-air or sewer-gas, and what are some of its constituents? In what way may it be the cause of infectious disease? Will the continued breathing of air polluted with sewer-gas affect health, and, if so, what symptoms may be caused thereby?

Is there any positive evidence that the emanations from cemeteries, bone-yards, etc., are harmful to health?

What diseases may be produced by the inhalation of pathogenic micro-organisms carried by the air?

How may the presence of ozone in the air be demonstrated? Upon what does the test depend? How might an approximate quantitative test of ozone be made?

How may the suspended impurities in the atmosphere be collected for examination? Which method requires the least apparatus, etc.? How may the character and nature of the suspended particles be determined? How may a quantitative bacteriological examination be made? What are some of the advantages of Dr. Dixon's apparatus? Of the sugar-filter method? How may pure cultures of micro-organisms in the air be obtained?

How may the quantity of organic matter in the air be determined? Why do we determine the proportion of carbon dioxide in the air? What is Wolpert's method for finding the percentage of this gas, and how may this method be simplified? Upon what does this test depend? What precautions must be observed in making the test? What is the Angus Smith method for determining the proportion of carbon dioxide? How may it be improved? What is the use of the phenolphthaleine in the solution? How is the percentage of carbon dioxide calculated? How is the alkaline solution to be prepared?

Upon what does Pettenkofer's method depend? What apparatus and reagents are required? Why must the lime-water be standardized each time?

What is the value of the oxalic-acid solution? What are some good indicators to use in this test? Why is just twice the volume of lime-water introduced into the bottle that is afterward taken from it and tested? What are some of the advantages and disadvantages of baryta-water in comparison with lime-water?

How may the quantity of ammonia in the atmosphere be determined? How may the presence of other gases be shown? What is the usual test for carbon monoxide? Upon what is Vogel's test based? Is it a delicate one? Why is it usually not necessary to make a quantitative examination of the carbon monoxide?

Ventilation.—How much oxygen does an adult human being at rest ordinarily take from the air, and how much carbon dioxide does he add to it in twenty-four hours? What percentage of carbon dioxide in the air indicates the greatest amount of organic impurity from respiration, etc., consistent with health? How much fresh air per hour is, therefore, needed by each individual to maintain this state of purity? Will sick persons need more fresh air than the well? Why?

What is meant by ventilation? What should be excluded from the term?

What matters must a proper system of ventilation consider? What governs the amount of cubic space that can be allotted to each individual? What should be the minimum air-space for the well, and what for the sick? What should be the floor-space for each person, and why? From what kind of a source must the air for a ventilation supply be taken?

What is the difference between natural and artificial ventilation? What are the forces acting to produce natural ventilation? What is meant by diffusion? Why is it insufficient for ventilating an occupied room? What is meant by perflation? Why cannot it be used alone for ventilation? Upon what does the inequality of atmospheric pressure depend? Why is it the most valuable of the forces of natural ventilation?

In what part of an occupied room is the most impure air found, and why?

What precautions must be observed in all plans for natural ventilation? What makes the air from a room pass up a chimney? When a room is heated by a hot-air furnace, how does the foul or used air escape? What rules may be laid down for the arrangement of a system of natural ventilation?

Where should the fresh-air inlets of a room be located? How may the air be warmed before bringing it into the room? How should the inlet-tubes be arranged? Where should the outlets of a room be located?

What systems of artificial ventilation may be employed for large buildings or rooms? By what appliances may we make use of winds for ventilating purposes?

CHAPTER II.

WATER.

PHYSIOLOGISTS teach that nearly two-thirds of the tissues of the animal body consist of water. Inasmuch as this water is constantly being lost by evaporation from the skin, exhalation by the lungs, and excretion through various organs, it is evident that the loss must be constantly supplied if the functions of life shall be properly performed.

It appears probable that certain diseases are at times spread through the agency of insufficient or impure drinking-water. It is therefore a matter of very great importance to have a definite knowledge of what constitutes a pure and sufficient supply of water, and how best to secure it, to be able to detect its conditions of purity and impurity, and to know how to maintain the former and avoid the latter. It will be necessary to consider in detail, therefore, the quantity of water required by each individual for the maintenance of health, the sources whence water is obtained, how it should be collected and stored to the best advantage, the impurities likely to be contained in it, and the methods of keeping it pure, or of purifying it when it has become polluted or vitiated in any manner.

THE QUANTITY OF WATER REQUIRED BY HUMAN BEINGS.

Dr. Parkes, after a number of experiments, concluded that a man of the English middle class, "who may be taken as a fair type of a cleanly man belonging to a fairly cleanly household," uses about twelve gallons of water per day. This covers all the water needed, including a daily sponge bath. Dr. DeChaumont estimates[1] that 16 gallons should be the daily allowance. By order of the British War Department, 15 gallons of water are allowed to each soldier daily. In very many instances this quantity cannot be furnished, but in such cases there necessarily results some deficiency in cleanliness. It is probable that among the poorer classes, especially where a large supply of water is not convenient, the quantity used is not over one-fourth of the above estimate.

[1] Parkes' Hygiene, 6th ed., New York, vol. i, p. 5.

Parkes and Kenwood[2] give the average daily quantities per head:—

TABLE IV.

Household	Fluids as drink	0.33
	Cooking	0.75
	Personal ablution	5.00 to 10.00
	Utensils and house washing	3.00
	Clothes washing (laundry)	3.00
	Water closets	5.00
Trade and manufacturing		5.00
Municipal	Cleansing streets	5.00
	Public baths and fountains	5.00
	Flushing and cleansing sewers	5.00
	Extinguishing fires	5.00
		27.08 to 32.08

In American cities the daily consumption is much greater, as seen from the following table:—

TABLE V.

Showing Consumption of Water in 105 American Cities.

City and State	Population	Daily Consumption Gallons	Per Capita[3] Gallons
Akron, Ohio ....p	46,733 ('03)	7,500,000	137
Altoona, Pa. ....m	52,000 ('03)	4,500,000	90
Anderson, Ind. ....m	20,178 ('00)	2,000,000	66
Atlantic City, N. J. ....m	32,272 ('03)	5,250,000	138
Augusta, Georgia ....m	41,283 ('03)	5,500,000	110
Atlanta, Georgia ....m	96,550 ('03)	7,500,000	60
Battle Creek, Mich. ....m	18,563 ('00)	1,133,000	60
Boston, Mass. ....m	594,618 ('03)	83,000,000	145
Buffalo, N. Y. ....m	381,403 ('03)	125,000,000	320
Burlington, Iowa ....p	23,201 ('00)	2,000,000	80
Binghamton, N. Y. ....m	39,647 ('00)	....	.....
Brocton, Mass. ....m	50,000 ('05)	2,000,000	36
Camden, N. J. ....m	79,811 ('00)	12,000,000	160
Cambridge, Mass. ....m	98,444 ('03)	8,775,000	89
Cincinnati, Ohio ....m	340,000 ('03)	48,536,000	137
Chicago, Ill. ....m	1,873,880 ('03)	175,000,000	200
Cleveland, Ohio ....m	444,600 ('05)	61,572,000	138
Charleston, S. C. ....m	55,807 ('00)	3,070,000	55
Council Bluffs, Iowa ....p	25,802 ('00)	2,500,000	85
Denver, Colo. ....p	147,111 ('03)	32,000,000	200
Detroit, Mich. ....m	369,805 ('05)	60,212,539	168
Danville, Ill. ....p	16,354 ('00)	2,500,000	157
Davenport, Iowa ....p	37,768 ('03)	4,000,000	100
Dayton, Ohio ....m	92,716 ('03)	7,000,000	66
Duluth, Minn. ....m	57,397 ('03)	5,000,000	85
Danbury, Conn. ....m	16,537 ('00)	2,000,000	125
Easton, Pa. ....p	23,238 ('00)	2,000,000	87

[2] Hygiene and Public Health, 1902.

[3] The per capita is based on the number of consumers.

TABLE V.—(*Continued.*)

Showing Consumption of Water in 105 American Cities.

City and State	Population	Daily Consumption Gallons	Per Capita Gallons
Elmira, N. Y. ....p	37,106 ('03)	5,000,000	125
Erie, Pa. ....m	56,363 ('03)	10,000,000	168
Evansville, Ind. ....m	61,482 ('03)	9,000,000	145
Fort Smith, Ark. ....p	11,587 ('00)	2,225,000	125
Fall River, Mass. ....m	114,004 ('03)	4,000,000	36
Fond du Lac, Wis. ....p	20,000 ('05)	1,250,000	63
Fort Wayne, Ind. ....m	48,031 ('03)	4,000,000	84
Fitchburg, Mass. ....m	34,378 ('03)	3,000,000	90
Grand Rapids, Mich. ....m	93,679 ('03)	14,000,000	139
Harrisburg, Pa. ....m	52,951 ('03)	8,750,000	135
Hartford, Conn. ....m	100,000 ('05)	6,150,000	67
Haverhill, Mass. ....m	38,987 ('03)	4,100,000	111
Henderson, Ky. ....m	10,272 ('00)	....	.....
Houston, Texas ....p	75,000 ('03)	10,000,000	134
Holyoke, Mass. ....m	50,831 ('05)	5,000,000	100
Indianapolis, Ind. ....p	197,555 ('03)	18,750,000	94
Johnstown, Pa. ....p	39,980 ('03)	8,000,000	200
Jamestown, N. Y. ....p	22,892 ('00)	2,250,000	100
Kansas City, Mo. ....m	250,000 ('05)	19,200,000	77
Kingston, N. Y. ....m	25,516 ('03)	3,500,000	200
Lowell, Mass. ....m	100,150 ('03)	5,500,000	52
Los Angeles, Cal. ....m	116,420 ('03)	....	165
Lynn, Mass. ....m	72,350 ('03)	5,500,000	64
Louisville, Ky. ....m	215,722 ('03)	18,000,000	72
Lincoln, Neb. ....m	44,158 ('03)	18,000,000	36
Manchester, N. Y. ....m	60,845 ('03)	3,500,000	50
McKeesport, Pa. ....m	38,274 ('03)	4,200,000	90
Minneapolis, Minn. ....m	214,112 ('03)	18,500,000	79
Milwaukee, Wis. ....m	313,025 ('03)	27,000,000	80
Memphis, Tenn. ....p	113,669 ('03)	12,000,000	100
Muskegon, Mich. ....m	20,818 ('00)	2,900,000	132
Norfolk, Va. ....m	55,318 ('03)	6,300,000	110
New Bedford, Mass. ....m	66,000 ('05)	7,000,000	95
New Orleans, La. ....p	300,625 ('03)	14,000,000	47
New Albany, Ind. ....p	20,628 ('00)	2,000,000	66
Nashville, Tenn. ....m	83,275 ('03)	13,500,006	135
New Haven, Conn. ....p	114,627 ('00)	20,000,000	150
Oshkosh, Wis. ....p	29,919 ('03)	2,500,000	85
Paterson, N. J. ....p	113,217 ('03)	10,500,000	100
Peoria, Ill. ....m	62,348 ('03)	4,500,000	72
Pittsburg, Kans. ....p	10,112 ('00)	1,000,000	75½
Portland, Me. ....p	52,656 ('03)	6,000,000	110
Portland, Ore. ....m	98,655 ('03)	20,000,000	200
Quincy, Mass. ....m	26,053 ('03)	2,600,000	103
Quincy, Ill. ....p	37,680 ('03)	1,435,000	38
Reading, Pa. ....m	85,051 ('03)	11,000,000	124
Rochester, N. Y. ....m	170,798 ('03)	15,238,000	87
Roanoke, Va. ....p	21,495 ('00)	3,000,000	94
Rock Island, Ill. ....m	19,493 ('00)	3,400,000	17
Rushville, Ind. ....m	4,541 ('00)	800,000	160
Richmond, Va. ....m	86,148 ('03)	13,000,000	129
Salem, Mass. ....m	23,504 ('03)	3,300,000	89
Saginaw, Mich. ....m	45,543 ('04)	10,000,000	200

TABLE V.—(*Continued.*)

Showing Consumption of Water in 105 American Cities.

City and State	Population	Daily Consumption Gallons	Per Capita Gallons
Sioux City, Iowa.................m	33,111 ('00)	1,290,000	39
Salt Lake City, Utah ....m	57,138 ('03)	15,000,000	200
South Bend, Ind. ....m	40,327 ('03)	4,000,000	81
St. Joseph, Mo.......................p	110,479 ('03)	6,000,000	55
Somerville, Mass. ....m	68,090 ('03)	6,000,000	89
Springfield, Mass. ....m	74,916 ('05)	9,700,000	128
St. Paul, Minn. ....m	172,038 ('03)	9,000,000	52
St. Louis, Mo.......................m	612,279 ('03)	75,000,000	125
Springfield, Ill. ....m	36,211 ('03)	4,470,000	108
Syracuse, N. Y. ....m	114,443 ('03)	12,000,000	105
San Antonio, Texas................p	58,016 ('03)	10,000,000	170
Taunton, Mass. ....m	32,713 ('03)	1,750,000	64
Terre Haute, Ind...................p	54,008 ('05)	4,200,000	77
Toledo, Ohio ....m	145,901 ('03)	11,000,000	69
Utica, N. Y..........................p	60,097 ('03)	4,000,000	33
Waterbury, Conn. ....m	56,521 ('05)	6,000,000	130
Vincennes, Ind. ....p	10,249 ('00)	....	.....
Watertown, N. Y...................m	21,696 ('00)	4,000,000	188
Worcester, Mass. ....m	130,207 ('05)	10,000,000	75
Wilmington, N. C..................p	20,976 ('00)	700,000	50
Waltham, Mass. ....m	23,481 ('00)	2,000,000	80
Washington, D. C..................m	300,000 ('05)	65,000,000	217
Wilmington, Del. ....m	84,000 ('05)	8,000,000	95
York, Pa. ....p	36,438 ('03)	2,850,000	70
Yonkers, N. Y. ....m	62,000 ('05)	6,500,000	92

"m"—Municipal. "p"—Private Company.

This excessive consumption is brought about not so much by legitimate use of the water as by waste: negligence and imperfections in the supply apparatus, allowing the water to run in the winter to prevent freezing of pipes, etc. When it is taken into consideration that the cost of pumping water averages from four to five dollars per million gallons, and in cities which purify their water-supply the cost is from two to three dollars more, the question of waste assumes a very important economic phase. In several of the larger American cities this problem has been satisfactorily solved by the introduction of metres, by means of which the water consumed in each household or factory is measured and charges regulated according to the amount of water consumed. In Wilmington, Del., the introduction of metres has eliminated waste and reduced the consumption to an average of 100 gallons per capita. This, however, includes the consumption of water by manufactories. In one of the strictly residential portions of the city the per capita consumption averages 30 to 35 gallons daily, the latter being the average amount of water required by a middle-class American household. One of the objections to metres is that the very class of persons whom it is desired to induce to use a plentiful supply of water would, from motives of economy, use less than is necessary for cleanliness and health. This objection, however, is purely hypothetical. Water is the cheapest commodity, and by the elimination of waste the cost could be still further reduced. As a matter of fact, it is not abundance of water that encourages cleanliness. "You can lead a horse to the water, but you can't make him drink it." Habits of cleanliness should be inculcated in ways other than by allowing a wanton waste of water.

SOURCES OF DRINKING-WATER.

All water, from whatever direct source obtained, comes originally, by precipitation, from the atmosphere. In many places the rain- or snow- water is the only source of supply. This is usually collected as it falls upon the roofs of buildings and conveyed by gutters and pipes to cisterns, where it is stored until needed.

In Venice, the rain falling upon the streets and courtyards is also collected in cisterns after filtering through sand. The cisterns used for the storage of water in New Orleans and other Southern cities in the United States, where the temperature rarely falls below the freezing-point, are generally constructed of wood and placed above-ground. Farther north, where it is necessary to protect them against the action of frost, they are placed under-ground. These under-ground cisterns are usually built of brick. The water from cisterns above-ground becomes very much heated in summer, and necessitates the use of large quantities of ice to make it palatable. The water from the under-ground cisterns is pleasantly cool in summer, and is also guarded against freezing in winter. There are, however, very serious objections to storing drinking-water in under-ground cisterns. These reservoirs are usually placed within a few feet of privies and cess-pools, and, as neither the retaining walls of the cisterns nor those of the privies are water-tight, it often happens that the drinking-water becomes strongly impregnated with the soluble portions of the excrement, or the products of its decomposition, which have drained into the cistern. Personal observations in Memphis in 1879, as well as the careful chemical analyses made afterward by Dr. Chas. Smart, U. S. A.,[4] have convinced the author that the objections to all under-ground cisterns built of brick, stone, or cement are insuperable from a sanitary point of view. Dr. Smart

[4] Report National Board of Health, 1880, pp. 437-441.

found over one-half of the under-ground cisterns examined by him in Memphis and other cities and towns to be leaky and presenting evidence of organic pollution. The water from 31 out of 80 cisterns analyzed showed decided contamination by sewage. It would seem advisable to prohibit all under-ground cisterns for the storage of drinking-water unless they are constructed of iron, which should be protected against oxidation by a thorough coating of coal-tar. Where any other system of collection and storage is available, however, the under-ground cistern should be unreservedly condemned.

Rain-water collected in the country, away from manufacturing districts, is usually quite pure and wholesome. Its taste is, however, flat and insipid, owing to absence of carbon dioxide and mineral constituents. In cities rain-water frequently contains such a large amount of organic matter and other impurities, which have been washed out of the air by the rain, that it may be unfit for drinking. On account of its softness, rain-water is very desirable for washing and other domestic purposes. If the statement made in the last chapter, concerning the presence of organisms in the atmosphere, is remembered, then it will be evident on a moment's thought that such organisms, when contained in rain-water, may be the source of disease. The putrefaction which so readily takes place in rain-water upon standing a few days is caused by certain of the organisms carried down out of the lower strata of the air by the descending rain or snow.

Precipitation is an exceedingly untrustworthy source of water, and should never be depended upon when other sources of supply are available. Water famines are frequent wherever people are compelled to rely upon such an uncertain source of supply as rain or snow.

Rivers and smaller streams probably supply the larger number of cities and towns in this country with drinking-water. When care is taken to prevent the pollution of the stream above the point whence the water is taken, this is usually of fair quality for domestic purposes. When the river can be tapped near its source, or before a large number of manufacturing establishments can empty their waste products into its current, or before it receives the sewage of a considerable number of inhabitants living on its banks, the water can generally be regarded as safe. It is very difficult, however, except in the less settled portions of the country, to find these favorable conditions.

Among the minor objections to the use of river-water for domestic purposes are the liability of most streams to become turbid in times of freshet, and the discoloration of the water from dissolved coloring-matters if the stream flows through a marshy or peaty region. These objections are, however, not serious, as filtration will readily remove the suspended matters. The coloring-matter is probably harmless. The organic matter contained in the water of some streams, even when pollution by sewage and manufacturing refuse is absolutely excluded, may, however, be the cause of disease. Dr. Smart has shown[5] that the water from streams in Nebraska, Wyoming, and Utah contained organic matter varying in amount from .16 to .28 parts per million.[6] He thinks the so-called "mountain fever" of the Rocky Mountain region is a malarial fever caused by the large amount of organic matter in the drinking-water.

Dr. G. M. Kober, U. S. A., states that he has frequently drunk water from mountain streams which had a perceptible taste of cattle-manure, and suggests that as the origin of the ammonia found by Dr. Smart in the water of mountain streams. Dr. Kober also regards the "mountain fever" as a typhoid fever with malarial complications.[7]

The most serious objection to the use of river-water for domestic purposes is the employment of streams as carriers of refuse from manufacturing establishments, or of the sewage of cities and towns. In Great Britain and some parts of the continent of Europe, owing to the density of population and the variety and extent of manufacturing industries, many of the streams are in an extremely filthy condition. In this country, too, especially in the more thickly settled manufacturing districts, the pollution of rivers has increased to a degree to seriously jeopardize the health of the people who are compelled to draw their water-supply from such streams. That the presence of such excessive contamination renders the water unsuitable for domestic purposes must appear evident. It is probable, however, that the most dangerous of the polluting matters are the excreta of human beings, especially those of patients suffering from certain specific diseases, such as typhoid fever or cholera.

Only a few years ago it was a generally-accepted theory that running water, though polluted by sewage, "purifies itself" after flowing a distance of twelve miles, and the comforting and reassuring doctrine is still held by many. Recent observations point to the conclusion, however, that "no river is long enough to purify itself." A certain proportion of the sewage, it is true, undergoes oxidation in the presence of light and air and minute organisms,[8] and so becomes

[5] American Journal Med. Sciences, January, 1878, p. 28 *et seq.*

[6] The source of this organic matter seems to be the melted snow which makes up a large portion of the streams.

[7] Report of California State Board of Health for 1886, pp. 48 and 177.

[8] Desinfection, in Eulenburg's Realencyclopædia d. ges. Heilkunde, vol. iv, p. 68.

changed into other, possibly innocuous, compounds. But at present it is not known what proportion or what kind of organic matter does undergo this change. Another portion of the impurities is deposited upon the bottom and sides of the stream, having been only held in suspension, and not dissolved in the water. A portion probably forms chemical combinations with other suspended or dissolved matters, and is changed into compounds which may be volatile and pass off into the air or form insoluble precipitates.

The remainder is rendered less perceptible or imperceptible by dilution. Every stream has sources of inflowing water—feeders—which increase its volume, and thus dilute any foreign admixture.

In view of these facts, the theory of the self-purification of streams, as formerly held, can no longer be regarded as true. But it is unquestionably true that running water does regain comparative purity if the inflow of sewage and other refuse is not excessive. It cannot be stated with confidence, however, when a stream, once polluted, becomes fit to use again.

The water from fresh-water lakes and ponds is generally to be preferred to river-water for domestic use. It is less liable to become turbid from time to time, and, except in the case of small ponds, the inflow of sewage is not likely to cause fouling of the water to any serious extent. When the supply can be drawn from large lakes, as is done in Chicago and other cities on the great lakes of the United States, no purer or better source can be desired. In these cases the point whence the water is taken should be far enough from shore to avoid the possibility of sewage contamination. When the water-supply is taken from small ponds, all sewage and waste products from houses and factories must be rigidly excluded; otherwise, diseases attributable to the polluted water are likely to arise among those using the same.

The water in small lakes and storage reservoirs sometimes becomes offensive in taste and odor. The water-supplies of several of the large Eastern cities have at times had a peculiar odor and taste somewhat resembling cucumbers. The cause of this odor and taste was found to be a minute fresh-water sponge, the *Spongilla fluviatilis*. A still more offensive odor, tersely described as the "pig-pen odor," is given to the water by the decay of certain species of nostoc and other algæ. It is not known that either these vegetable or animal micro-organisms, if present, render the water prejudicial to health.

Ponds are often used as sources of ice-supply. It was formerly supposed that in the process of freezing, solid matters in the water were not included in the block of ice when congealation occurred. Recent observations have shown the falsity of this assumption. In 1875, an outbreak of acute intestinal disease at Rye Beach, New Hampshire, led to an inquiry by Dr. A. H. Nichols, which disclosed the fact that the ice used contained a large percentage of organic matter.[9] The use of ice from a different source was followed by an almost immediate disappearance of the disease. Upon further investigation it was discovered that the impure ice had been gathered from a small, stagnant pond into which a small brook carried large quantities of saw-dust from several saw-mills. The water of the pond was loaded with organic matter, and in summer the gases of decay arising from it were very offensive. Chemical examination showed that the ice from this pond contained nearly 6 quarts of organic matter in 100,000, while in pure ice the organic matter amounted to only .3 part in 100,000. A similar investigation into the character of the ice furnished to the residents of Newport, R. I., was made under the auspices of the Sanitary Protection Association of that city. The ice, which was cut from ponds in the immediate neighborhood of the city, was found to contain an excessive proportion of organic matter. Large quantities of sewage and other impurities were discharged into these ponds.

Experiments made at various times show that the purification of water by freezing is in no sense absolute. A considerable number of the bacteria, infusoria, and other organisms remain in the ice and retain their vitality, so that when thawed they rapidly multiply. In the ordinary process of freezing the upper portion is the purest, but if snow or rain fall upon the ice and freeze, this upper layer will be found much more impure than the lower. Rational conclusions from these experiments are, that ice should not be gathered from an impure source, and that an early harvest of the ice should be encouraged.

Prudden has shown that typhoid bacilli contained in water are not entirely destroyed by freezing, even after remaining in this condition for 103 days.

Springs and wells supply the water for most persons not aggregated in large communities, as cities and towns. Even in the latter no inconsiderable quantity of the water used for drinking and domestic purposes is derived from wells. Spring-water usually comes from a source at a considerable depth below the surface; that is to say, the

[9] Report Massachusetts State Board of Health, 1876, p. 467.

water has percolated through thick strata of soil before re-appearing at the surface. In its passage through the soil it has lost most of its organic matter, and perhaps taken up mineral and gaseous constituents in larger quantities. It may be so strongly impregnated with the latter as to vitiate it for ordinary use and to render it valuable as a medicine. Ordinarily, however, spring-water is clear, cool, and sparkling, with a refreshing taste and uniform temperature, and is in all respects an agreeable and wholesome beverage.

Springs vary greatly in character. They may be cold, hot, or thermal, and boiling or geysers; they may be either superficial or deep, and the water may be either pure or polluted, depending on

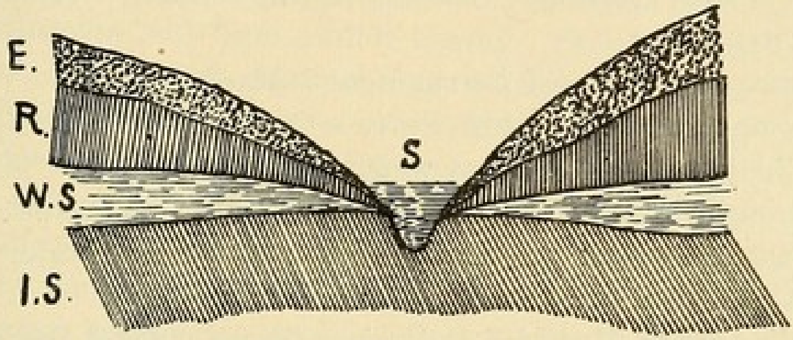

Fig. 3.—Showing Formation of Spring. *E*, Earth. *R*, Rock. *WS*, Water-bearing Stratum. *IS*, Impervious Stratum. *S*, Spring.

source or location. The chemical constituents of spring-waters in this country vary from waters containing but a few grains of mineral substances to the gallon to waters so saturated with mineral matter as to be classed as medicinal.

The various mineral waters in this country are classified by Haywood and Smith[10] as follows:—

TABLE VI.

Group.	Class.	Subclass		
	I. Alkaline	Carbonated or bicarbonated	Sodic	
			Lithic	
		Borated	Potassic	
		Silicated	Calcic	Nongaseous
	II. Alkaline-saline	Sulphated	Magnesic	Carbondioxated
Thermal		Muriated	Ferruginous	Sulphuretted
Nonthermal		Nitrated	Alumnic	Azotized
	III. Saline	Sulphated	Arsenic	Carburetted
		Muriated	Bromic	Oxygenated
		Nitrated	Iodic	
	IV. Acid	Sulphated	Silicous	
		Muriated	Boric	

[10] Bureau of Chemistry, Bul., 91.

Under this classification the mineral waters on the market may be arranged as follows:—

Alkaline Bicarbonated Sodic.—Augusta White lithia water. Geyser Jeffress lithia water. Manitou water. Powhatan water. Thompson's bromin and arsenic water.

Alkaline Bicarbonated Magnesic.—Osceola water.

Alkaline Bicarbonated Calcic.—Allouez water. Augusta White lithia water. Bear lithia water. Crocket arsenic lithia water. Golindo lithia water. Great Bear water. Jeffress lithia water. Londonderry lithia water. Manitou water. Mardela water. Massanetta water. Missisquoi. Osceola water. Otterburn water. Poland water. Powhatan water. Rubino Healing Springs water. Sublett lithia water. Vitan water.

Alkaline Bicarbonated Ferruginous.—Mardela water.

Alkaline-saline Muriated Sodic.—Carlsbad water. Champion water. Chief water. Congress water. Hathorn water. High Rock water. Lincoln water. Magnetic water. Peerless water. Gitche Crystal Spring water. Seltzer water. Sheboygan water. Vichy water. White Rock lithia water.

Alkaline-saline Muriated Potassic.—Gitche Crystal Spring water.

Alkaline-saline Muriated Calcic.—Carlsbad water. Champion water. Chief water. High Rock water. Lincoln water. Magnetic water. Peerless water. Seltzer water. White Rock lithia water. Sheboygan water.

Saline Sulphated Sodic.—Pluto concentrated water.

Saline Sulphated Magnesic.—Veronica water.

Saline Sulphated Calcic.—Berry Hill dyspepsia water. Bedford mineral water. Buffalo lithia water. Geneva lithia water. Tate epsom water.

Saline Muriated Sodic.—Arondack water. Blue Lick water. Cherrydale water. Deep Rock water. Mount Clemens water. Star water. Victoria water. Webster Springs salt sulphur water.

Saline Muriated Calcic.—Cherrydale water.

Acid Sulphated Aluminic.—Rockbridge alum water. Wallawhatoola water.

Regarding the effect of mineral waters on the human organism both in health and disease, Haywood and Smith[11] present the following summary:—

Carbonated or Bicarbonated Alkaline Waters.—Stimulate the secretions of the digestive tract, neutralize hyperacidity of the stomach,

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[11] *Loc cit.*

increase metabolism, dissolve uric acid and uric acid deposits, increase the flow of urine, and correct acidity of the latter. They are, therefore, of value in catarrhal conditions of the mucous membranes, rheumatism, gout, diabetes, etc.

Sodic Carbonated and Bicarbonated Alkaline Waters.—Increase metabolism, dissolve uric acid, and allay irritation of the mucous membrane of the urinary tract. They are useful in acid dyspepsia, rheumatism, gout, and diabetes.

Potassic Carbonated and Bicarbonated Alkaline Waters.—Have very much the same action as the sodic carbonated. Their chief use is in the treatment of calculi.

Lithic Carbonated and Bicarbonated Alkaline Waters.—These are active diuretics and form soluble urates. They are used in the treatment of rheumatism, rheumatic tendencies, and gout. In cases of gravel and calculi they are also valuable disintegrating agents.

Magnesic Carbonated and Bicarbonated Alkaline Waters.—Act as mild laxatives, and are perhaps the best of all the alkaline waters in correcting an acid condition of the stomach and curing sick headache caused by constipation. They favor the solution of uric acid, are valuable agents in breaking up deposits in the bladder, and are much used in catarrhal conditions of the mucous membrane or the urinary organs.

Calcic Carbonated and Bicarbonated Alkaline Waters.—This class of waters produces constipation and decreases the secretions. Very obstinate cases of chronic diarrhea have been cured by a sojourn at a spring rich in calcium bicarbonate. Uric acid gravel and calculi are also disintegrated and eliminated by the free use of these waters.

Ferruginous Bicarbonated Alkaline Waters.—Increase the amount of hemoglobin and in connection therewith increase the temperature, pulse, and weight. They also increase the appetite and reduce intestinal activity. They give excellent results as a tonic, and find their principal application in anemia and general debility. Prolonged use results in constipation and derangement of the digestion.

Borated Alkaline Waters.—They act as antacids. They promote the menstrual flow and may be used in catamenial irregularities.

Muriated Alkaline-saline Waters.—They increase the flow of urine and the excretion of uric acid. Are especially valuable in the treatment of catarrhal conditions of the mucous membrane of the stomach, intestines, biliary passages, and urinary tract.

Sulphated Alkaline-saline Waters.—They act as diuretics. In large quantities they act as purgatives by increasing the peristaltic movement and liquefying the intestinal contents. Valuable in the treatment of catarrhal conditions of the mucous membrane and in obesity.

Muriated Saline Waters.—Stimulate the secretion of the stomach, increase digestion, favor a better absorption of foods, and act as diuretics.

Sodic Muriated Saline Waters.—Increase the flow of gastric juice, improve the appetite, increase the flow of urine and excretion of urea. Also prevent putrefactive changes in the intestines.

Potassic Muriated Saline Waters.—Action very much like that of sodium salt.

Lithic Muriated Saline Waters.—Same as above, with an intensified diuretic action due to the lithium.

Calcic Muriated Saline Waters.—Act as a tonic, increase the flow of urine, sweat and bile, and are used in scrofula and eczema.

Sulphated Saline Waters.—These waters are laxative or purgative, according to the amount taken. Are indicated where long-continued intestinal stimulation is desired without stimulation of the vascular system.

Sodic and Magnesic Sulphated Saline Waters.—Act as laxatives in small, and purgatives in large, doses. Increase flow of intestinal fluids and urine, also excretion of urea. Are of great service in eliminating syphilitic, scrofulous, and malarial poisons from the system, in throwing off mercury and other poisons. Useful in the treatment of obesity, derangement of the liver, and Bright's disease.

Potassic Sulphated Saline Waters.—Same effect as above.

Calcic Sulphated Saline Waters.—Have no well-known action.

Ferruginous Sulphated Saline Waters and Aluminic Sulphated Saline Waters.—Iron and aluminum usually occur together when either is present as a predominating constituent in sulphated saline waters. These are practically always acid and their action is best considered under the sulphated acid group.

Nitrated Saline Waters.—Only one spring of this kind found. Action has not been determined.

Acid Waters.—Principally composed of the ferruginous-aluminic sulphated classes, although there are a few acid springs which contain comparatively little iron and aluminum, but quite large amounts of calcium, sodium, or magnesium. These waters are used in relaxed conditions of the mucous membranes, especially in diarrhea and dysentery. They are also used in the treatment of exhausting night-sweats and impoverished condition of the body brought about by intemperance or specific diseases. Locally, they are used in the treatment of inflamed or relaxed conditions of the mucous membrane such as are found in conjunctivitis, chronic vaginitis, etc. Have the usual effect of all iron waters, but when desired as a tonic it is best to give the ferruginous carbonated water, as the latter is more readily absorbed and assimilated.

Iodic and Bromic Waters.—Act as alteratives. Stimulate the lymphatic system to greater activity and promote absorption in all tissues. Indicated in the treatment of scrofula, syphilis, goitre, chronic exudations, etc. Also favor the elimination of mercury and other metallic poisons. The bromic waters also act as sedatives.

Arsenic Waters.—Act as alteratives, increase the appetite and digestion, and improve the general nutrition of the body by increasing the secretions of the gastro-intestinal mucous membrane and at the same time checking katabolism. Especially valuable in the treatment of anemia and a number of skin diseases. Also indicated in chronic malaria, neuralgia of anemic origin, scrofula, etc.

Silicious Waters.—Precise action unknown. Have been said to be useful in cancer and to have caused the disappearance of albumin and sugar from the urine.

Azotized and Oxygenated Waters.—On account of slight solubility neither nitrogen nor oxygen occurs in waters in very large quantities. They possess no medicinal value.

Carbondioxated Waters.—Increase the flow of saliva and intestinal fluids, also increase the peristaltic movement of the stomach and thereby improve digestion. Also tend to increase the flow of urine. Obstinate cases of nausea are often relieved by these waters.

Carburetted Waters.—Sometimes occur in coal and natural gas regions. Are not known to have any medicinal value, but are usually considered unfit for drinking purposes.

Sulphuretted Waters.—Increase the action of the skin, intestines, and kidneys. Also possess a decided alterative effect. Have been used in the treatment of syphilis, chronic metallic poisoning, rheumatism, and gout. They have also given excellent results in many skin diseases, hyperhemia of the liver, and in catarrhal conditions of the pharynx, larynx, and bronchi.

The great demand for spring-waters, especially mineral waters, has called forth a supply of all kinds of spring-waters, good, bad, and indifferent. In many cases the claims made by the promotors are so extravagant as to class the water among the rankest of patent medicines. The United States Bureau of Chemistry, therefore, has done a most valuable service to the people and the medical profession by analyzing the more popular mineral waters. The following table shows the results of some of these analyses, compiled from Bulletin No. 91:—

Table VII.

Showing Analyses of Some of the More Popular Mineral Waters.

	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Oxygen Required.	Ammonium Chloride.	Lithium Chloride.	Potassium Chloride.	Sodium Chloride.	Potassium Iodide.	Sodium Sulphate.	Magnesium Sulphate.
	Parts per Million.											
Poland Water (Calcic Bicarb. Alkaline)	.008	.051	1.33	.001	.45	0.24	(a)	4.6	4 6	...	5.3	......
Veronica Water (Magnesic Sulphated Sal.)	.08	3.05	392.8	0	.25	.24	....	169.5	3,170	(a)	802.7	14,151.4
Bedford Mineral Water (Calcic Sulphated Saline)	.014	.008	.05	Tr.	.85	.045	Tr.	9.3	9.2	....	29 0	686.1
Geneva Lithia Water (Calcic Sulphated Saline)	.015	.015	.10	Tr.	.55	.048	.6	7.6	330.4	Tr.	2.8	575 3
Buffalo Lithia Water (Calcic Sulphated Saline)	.035	0	.50	Tr.	.60	.114	Tr.	7 6	12	...	77.7	31.7
Vitau Table Water (Cal ic Bicarb. Alk.)	0	.05	.20	0	.45	...	(a)	10 5	....	Tr.	14.9	......
Great Bear Water (Calcic Bicarb. Alk.)	.01	.04	2 0	Tr.	.30	.03	Tr.	3 2	17 5	....	....	11 0
Londonderry Lithia Water (Calcic Bicarb. Alk.)	.015	.075	.66	Tr.	.90	.048	Tr.	5.5	.5	....	11.2	......
White Rock Lithia Water	.04	.09	1 0	.005	.50	.125	76.4	5.7	573.6	...	49.6	......
Bear Lithia Water (Calcic Bicarb. Alk.)	.02	.04	.2	Tr.	.25	.063	Tr.	3 1	1 2	Tr.	4.3	......
Massanetta Water (Calcic Bicarb. Alk.)	.175	.054	.5	.001	.45	.549	(a)	2.9	. .	0	...	......
Otterburn Lithia Water (Calcic Bicarb Alk.)	.065	.027	Tr.	001	.70	207	.28	3.6	4 3	....	4 1	.....

Tr., Trace; (a), Heavy Trace.

The above table shows how several of the high-priced and much-vaunted lithia waters are such only in name, while some of the supposedly pure spring-waters are no better than water from an average farm-spring.

The character of well-water is often justly open to grave suspicion. Being derived from those strata of the soil which are most likely to be contaminated by the products of animal and vegetable decompositions, the unwholesomeness of the water is inversely proportional to the degree of saturation of the soil with the products of decay. It has been found by experiment that, when organic matter largely diluted with water is allowed to percolate through soil, it undergoes a gradual decomposition in the presence of certain minute organisms, nitrates and nitrites being formed at the expense of the ammonia and other organic combinations. If, however, the soil is saturated with organic matter in excess, and in a state of concentration, putrefaction takes place, and the conversion of the organic matter into nitrates and nitrites is retarded.

Deep or Artesian Wells.—The name artesian is derived from the province of Artois, France, where these wells were sunk centuries ago. They are formed when a boring taps a water-bearing stratum confined between two impervious geological formations. This water-bearing stratum forms a subterranean reservoir which is fed by the percolation of the surface at some point where the upper impervious stratum is either fissured or absent. This is known as the catchment area. This area may be near or far from the point where the well is sunk and it may be subject to pollution, and there is, therefore, no absolute assurance that because a well is deep the water is always pure. Sedgwick and Prescot found the following numbers of bacteria in a series of deep wells in Massachusetts:—

TABLE VIII.

Depth of Well in feet.	Number of Bacteria Per Cubic Centimetre.
100	30
193	269-254
213	101-106
254	150-135
377	48-54
454	205-214

Pfuhl, a well-known German authority, cites an instance of pollution passing through 180 feet of gravel. The chief objection to artesian wells is their high contents in mineral substances, which impart to the water a permanent hardness. In some regions the amount of iron is so great as to act destructively on the pipes. Thus, in the town of Gloucester, N. J., the artesian wells which supplied that town with water had to be abandoned, owing to the excess of iron in the water.

The following analyses of the water from the four artesian wells in Gloucester were made by Messrs. Hamlin and Morrison:—

TABLE IX.

	Parts Per Million.			
Well Number	1	2	3	4
Calcium carbonate	45	21	00	00
Magnesium carbonate	25	19	17	12
Calcium sulphate	51	49	65	73
Sodium chlorid	9	11	18	16
Iron oxid and aluminum	14	11	22	62
Matter insoluble in acid	00	00	32	30
Volatile and inorganic matter	28	6	76	30
Nitrates	00	00	00	00
Nitrites	00	00	00	00
Iron	9	7	9	14
Total solids	172	117	220	223

The quantity of water to be obtained from artesian wells is very uncertain, depending, as it does, on the extent of the catchment area, the rainfall, and the number of taps along the subterranean water-course. In some localities it may be impossible to obtain an artesian supply, and again the supply may be large at first and gradually diminish.

Drinking-water is sometimes procured by melting snow or ice. It is not probable that water derived from these sources is unwholesome, although there is strong popular prejudice against it. Ice and snow may, however, contain large amounts of impurities, as already referred to, and be for this reason unfit for use.

The following qualities are desirable in water for drinking and domestic purposes:—

1. The water should be colorless, transparent, sufficiently aërated, of uniform temperature throughout the year, and without odor or decided taste.

2. The mineral constituents (magnesium and lime salts) should

not be present in greater proportion than 4 or 6 parts per 100,000. More than this gives to water that quality known as "hardness."

3. There should be but little organic matter present, and no living or dead animal or vegetable organisms.

4. The water should be almost free from ammonia and nitrous acid, and should contain but very small quantities of nitrates, chlorides, and sulphates.

5. It should contain less than one milligramme of lead per litre. A larger proportion than this is likely to be followed by lead poisoning.

6. It should contain no pathogenic bacteria and but few water bacteria.

IMPURITIES IN WATER.

The transparency and the color of water are affected by the presence of suspended or dissolved mineral or organic matters. If, after standing for a time, the water deposits a sediment, this is dependent upon insoluble matters. If the sediment turns black when heated in a porcelain capsule over an alcohol or gas flame it contains organic matter. If the sediment or residue effervesces upon the addition of hydrochloric acid the presence of carbonates is indicated. Water may be colored by metallic salts or by vegetable matter. It may also contain large quantities of mineral or organic matter, or even living organisms, without especially diminishing its transparency. For example, the ova of tape-worms may exist in water in considerable numbers and yet remain perfectly invisible except under the microscope.

The presence of sulphur compounds, or of various vegetable and animal organisms (sponges, algæ, etc.), may give to water an unpleasant odor and taste. In the oil regions of this country most of the drinking-water is contaminated with petroleum, which is very disagreeable to one unaccustomed to it. It is not probable that the small quantities of the oil imbibed with the water have any deleterious influence upon the organism.

Many works on hygiene fix a limit to the amount of solid matter allowable in drinking-water. The International Congress of Hygiene, at Brussels, fixed the limit at 50 parts in 100,000. It is impossible, however, to say of any particular specimen of water that its content of solid matter, whether organic or mineral, will be prejudicial to health, without trial. At the same time it is prudent to reject all waters containing a considerable proportion of solid organic matter, as determined by the degree of blackening on heating the sediment or residue after evaporation, or by determination of nitrogen.

The hardness of water is due to the presence of earthy carbonates, or sulphates, or both. If the hardness is due to carbonates it is dissipated by heat, as in boiling the water; the carbon dioxide is driven off, and the base (calcium or magnesium oxide) is precipitated upon the bottom and sides of the vessel. This is termed "temporary hardness." The hardness due to the presence of earthy sulphates is not removed upon heating the water, and is termed the "permanent hardness." The hardness depending upon both the carbonates and sulphates is called the "total hardness."

The proportion of the above-mentioned earthy salts present in a given specimen of water is determined by what is called the soap test. This test depends upon the property which lime and magnesia salts possess of decomposing soap (oleate and stearate of soda). The quantity of a solution of soap of a definite composition decomposed by a quantity of hard water indicates the amount of the salts present.

DISEASES DUE TO IMPURE DRINKING-WATER.

Hard water is popularly believed to be the cause of calculous diseases and of goitre and cretinism, but no reliable observations are on record showing that the belief is founded upon fact. At the same time it is undoubtedly true that calcareous waters produce gastric and intestinal derangements in those unaccustomed to their use.

Large amounts of suspended mineral matter are frequently present in river-water, and may give rise to derangements of the digestive organs. If there is carbonate of lime present, the water can be easily clarified by the addition of a small quantity of alum. Sulphate of lime and a bulky precipitate of hydrate of alumina are formed, which carry the suspended matters to the bottom. About 10 centigrammes of crystallized alum are sufficient to clarify a litre of water. This amount of alum is too small to affect the taste of the water perceptibly. This method is frequently used to clarify and render fit for use the water of the Mississippi River, which is usually very muddy.

Lately, the city of St. Louis, which derives its water-supply from the Mississippi River, has been using ferrous sulphate and lime as a coagulant, instead of alum. The action of either of these coagulants is to conglomerate the fine particles of clay and thus facilitate their sedimentation. At the same time these coagulated solid particles carry with them the bacteria, and a purification of 90 to 98 per cent. results.

Although the opinion is widespread that water containing much mineral matter, either in solution or in suspension, is deleterious to health, there is very little evidence absolutely trustworthy upon this point.

The presence of large quantities of organic matter in water, whether these matters be of animal or vegetable origin, must always be looked upon with suspicion. The observation was made by Hippocrates twenty-three centuries ago, that persons using water from marshes, *i.e.,* water containing vegetable matter, suffer from enlarged spleens. Many physicians, both of ancient and modern times, seem to have held this opinion, but the first positive observation in medical literature is the now classical one of the ship *Argo,* reported by Boudin.[12] In 1834 the transport *Argo,* in company with two other vessels, carried 800 soldiers from Bona, in Algiers, to Marseilles. The troops were all in good health when they left Algiers. All three of the vessels arrived in Marseilles on the same day. In two of them there were 680 men, not one of whom was sick. Out of the remaining 120 men who were on the third vessel, the *Argo,* 13 died during the passage, and 98 of the 107 survivors suffered from paludal fevers of all forms. None of the crew of the *Argo* were sick, however. The two vessels exempt from sickness, and the crew of the *Argo,* had been supplied with pure water, while the soldiers on the latter vessel had been furnished with water from a marsh. This water was said to have a disagreeable odor and taste. The testimony of a large number of East India physicians is also quoted by Parkes in support of the view that malarial fevers are often caused by impure drinking-water. The observations of Dr. Charles Smart, upon the production of "mountain fever" of the Western territories, have already been referred to. It is more than likely, however, that the cases on the *Argo* were typhoid fever.

The causation of typhoid fever and cholera by impure drinking-water will be presently referred to.

There can be very little doubt that diarrhea and dysentery are frequently caused by water which has been contaminated with decaying organic matter. The evidence in favor of this amounts practically to demonstration. Of course, in this as in the other instances cited disease is caused not by the organic matter, but by the specific bacteria with which the organic matter is usually associated.

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[12] Quoted in Parkes, *op. cit.*, p. 48; Nowak, Lehrbuch der Hygiene, p. 51; and in numerous other publications on Hygiene.

It must not be forgotten that the ova of certain animal parasites, such as distoma hematobium, filaria sanguinis hominis, and medinensis, anchylostoma duodenale, and possibly of round-worm are frequently present in polluted water.

The relation of typhoid fever to the water-supply is probably the most important phase of the study of water from a hygienic standpoint. Typhoid fever is the disease most frequently caused by sewage-polluted water, and next to tuberculosis and pneumonia it is the principal cause of sickness and death. There occur annually in the United States about 50,000 deaths from typhoid fever, the estimated number of cases being at least 500,000. The manner in which typhoid fever is caused by a polluted water-supply is as follows: The cause of typhoid fever is a bacillus discovered by Eberth and Koch, in 1880, and first isolated and studied in pure culture by Gaffky, in 1884. This bacillus is taken in with the food and drink which contain it, and is excreted from the body of the typhoid fever patient with the feces. The latter gains access to the nearest water-supply, and the typhoid bacilli infect the water, which becomes the means of conveying the bacilli to other susceptible individuals. In this way epidemics of typhoid fever originate in towns and cities which are obliged to drink the sewage of other municipalities located on their watershed. Of course, there is always a possibility of direct infection by coming in contact with the patient's feces or urine, but such mode of transmission, while possible in isolated cases, cannot result in epidemics.

Many instances are on record where outbreaks of typhoid fever have been clearly attributable to pollution of the drinking-water by the germ of the disease from a previous case.

One of the most remarkable of these outbreaks is that recorded by Dr. Thorne.[13] About the end of January, 1879, typhoid fever began suddenly in the adjoining towns of Caterham and Red Hill. Within six weeks 352 cases occurred. All other sources of the disease were excluded except the drinking-water, to pollution of which it was traced with almost absolute certainty. Caterham contained 558 houses and Red Hill 1700. Of the former 419 and of the latter 924 drew their drinking-water from a common supply, having its source in a well several hundred feet deep. The insane asylum, with 2000 inmates, and the military barracks in Caterham used water from a private well. There was no typhoid fever among the last two com-

[13] Report of the medical officer to the Local Government Board for 1879. Quoted in Fodor: Hygienische Untersuchungen, etc., II Abth., p. 261.

munities. During January one of the workmen engaged in some excavation near the public well was taken ill with diarrhea and fever, —probably typhoid—but was still able to continue his work. His dejections were often voided where they were certain to become mingled with the water of the common supply. This man's diarrhea began on January 5th and continued until the 20th of the month, during which time he remained at work. On the latter date he was compelled to quit work and take to his bed. Exactly two weeks from the beginning of the man's sickness, on January 19th, the first case of typhoid occurred in Caterham, and then rapidly increased. The first case occurred, therefore, just fourteen days—the incubative period of typhoid—after the presumed infection of the drinking-water by the dejections of the sick laborer, who had come from Croydon, where typhoid fever was at the time prevalent. Within two weeks from the appearance of the first case the epidemic had reached its height, and then rapidly declined, disappearing almost entirely in a month after the outbreak. It was shown by Dr. Thorne that nearly all the houses in which the disease appeared were supplied with water from the source above mentioned, while other houses in the immediate vicinity of the infected ones remained free from the disease.

In 1874 there was an outbreak of typhoid fever in the town of Over Darwen, in which nearly 10 per cent. of the inhabitants were attacked. Here the source of the disease was also traced to an infected water-supply.

Dr. Buchanan has shown that an outbreak among the students of the University of Cambridge was likewise attributable to an infected water-supply.

In 1885 an epidemic of typhoid fever began in Plymouth, a mining town of 8000 or 9000 inhabitants, situated in the Wyoming coal region of Pennsylvania, and on the right bank of the Susquehanna River. The epidemic began in April, and lasted until the ensuing September. There were 1104 persons attacked by the disease, of which number 114, or 10.3 per cent., died. The careful inspection made into the history of this epidemic revealed the fact that the public water-supply had unquestionably become polluted by the fecal discharges of a single person who was affected with the disease. This man had visited Philadelphia on December 25, 1884, and while there contracted typhoid fever. He returned to his home, on the banks of the stream from which Plymouth derived its water-supply, in January, and was ill for several weeks. During his illness the fecal discharges that were passed during the night were thrown upon the snow within a few feet of the stream. From March 21st to March 23d a thaw occurred, and during the early days of April there were frequent warm showers. As a result, the entire mass of dejecta which accumulated during this man's illness was washed directly into the stream. About two weeks later the epidemic broke out.

In 1895, Grand Forks, N. D., a village of about 6000 population, had 1500 to 2000 cases (25 per cent. of her population) and about 200 deaths.

Previous to the epidemic the city water-supply was taken from the Red Lake River, which is a small, unnavigable stream. Twenty-four miles above Grand Forks, by car line, Crookston is situated, with a population at that time of about 3000. During the summer of 1894 they had a good many cases of typhoid fever at Crookston. Their main sewer passed under one of the railroad embankments just before emptying into the Red Lake River. Some time during the summer the embankment crushed in the sewer, shutting it off. The sewage then came to the surface and formed a small stagnant pond held back by the embankment. This remained for about two months, continually increasing in amount. Just about the time that ice formed on the Red Lake River this sewer under the track was opened up and the dammed-back pond of sewage allowed to flow out rapidly underneath the ice. This was the time of year when the water in the river would be quite low, so that there was little chance for proper dilution and aëration. As a result, some two or three weeks after this sewage was opened, the young people of Grand Forks took sick by the dozens, then by the hundreds. The degree of virulency seemed to be unusually severe.

In 1903, Ithaca, N. Y., the home of Cornell University, was stricken by a severe epidemic of typhoid fever. Of a population of 13,000, 1350 took sick and 78 died. The cause was traced to the pollution of the water-supply.

During the same year an epidemic of typhoid fever occurred in Butler, Pa., a city of 18,000 population, in which 1348 persons were stricken within the short period of ninety days and 111 deaths occurred, as given in the report of the State Board of Health. This town was supplied with water from a stream more or less polluted, but just prior to the epidemic the private water company installed a mechanical filter which was doing satisfactory work until October, when, on account of the changes in the pumping station, the filter was shut off at intervals to allow work to proceed on these changes; and immediately there appeared the epidemic.

Within ten days after the polluted water began to be pumped direct the physicians were overwhelmed with calls. By November 29th the disease was so widespread and serious that a public mass meeting was called and a relief committee organized. In order to meet the expense of the committee $25,000 was voluntarily subscribed and it was estimated that $75,000 would be needed. Nurses and physicians were procured from Pittsburg, Philadelphia, and other places. The work at the station was rushed to completion at the earliest possible moment, but to December 17, 1903, there was a total of 1270 cases reported, with 56 deaths.

In this case the infection was traced to the drainage from a miner's cabin in which there was typhoid fever. The drainage from this cabin was directly into a small branch, the flow from which entered into the stream from which the supply was taken, at a point a few yards above the intake to station.

In 1904 an epidemic of typhoid fever occurred in Columbus, Ohio, with a population of 140,000. The number of cases was 1640, number of deaths 166. The source of the epidemic was traced to the pollution of the Scioto River with the sewage from the State Hospital.

Quite recently a severe epidemic of typhoid fever occurred in Scranton, Pa. This epidemic was investigated by Dr. Robin and the following are excerpts from his report:—

"A visit to the Bureau of Health showed at a glance the seriousness of the conditions as well as the determined effort on the part of the officials to meet them successfully. Every desk in the office had behind it a busy worker. Dr. Keller, the superintendent, was busily engaged receiving reports and giving orders. Every few minutes a messenger, police officer, or inspector came in with a report and for instructions. Physicians came in for information, and the telephones were in constant use. The whole aspect reminded one of army headquarters during an important battle.

"On December 3, 1906, 5 cases of typhoid fever were reported to the Bureau of Health. From that date to December 12th, 20 cases were reported. There is every reason to suppose that typhoid cases occurred prior to that date, and in larger numbers than were reported, the attending physicians having diagnosed them as grippe. On December 12, 24 cases were reported, and from that date up to January

5, 1907, the number of cases reported reached 970, with 77 deaths attributed, of which 55 were officially reported.

"The cases of typhoid fever are practically confined to the central part of the city and West Scranton, which were supplied with high service from the Elmhurst Reservoir. The disease does not appear to be confined to any particular class of people, the rich and poor suffering alike, nor is there any relation of the epidemic to the sanitary conditions of certain sections of the city. While the poor suffer most on account of a lack of means, and their sufferings are more in evidence, the well-to-do and the rich contribute their full quota to the morbidity and mortality list. The deaths of many prominent men and women have already been chronicled, and many a happy home has been shattered by this dread disease.

"The consensus of opinion of all the officials, local as well as State, with the exception of the Scranton Gas and Water Company, is that the water supply is to blame for the epidemic. The city of Scranton, with a population of about 120,000, is supplied with water obtained from mountain streams. These are intercepted by four small storage reservoirs of about 1,000,000 gallons each, and merge into what is known as Roaring Brook. The latter empties into the Elmhurst Storage Reservoir of a capacity of 1,600,000,000 gallons, and from this, overflowing a dam, passes through a pipe to No. 7 reservoir, from which the city is ordinarily supplied. A pipe-line also passes from the Elmhurst reservoir to Lake Scranton, a storage reservoir of 2,000,000,000 gallons capacity. When the flow over the dam at the Elmhurst Reservoir is insufficient to supply the city, the supply is augmented by drawing on Lake Scranton. The watershed is sparsely populated and there are no large centres of pollution, the only village of any size being Moscow, with a population of about 900, which drains directly into the Roaring Brook. However, two railroad lines pass along the branches of the Roaring Brook, the Erie and D., L. & W., and these form a possible source of pollution.

"The water-works are owned by the Scranton Gas and Water Company and are estimated by the owners to be worth $12,000,000.

"The water has been of good quality and there is no record of any marked pollution of the supply, nor would the mortality of typhoid fever in the past indicate that the supply was not comparatively pure. In the report of the Bureau of Health for 1905, the following statement is made:—

" 'The city of Scranton can proudly boast of its pure and unlimited water supply, as also the protection given to its water-sheds. The bacteriologist, Dr. Wilson, has, on numerous occasions, examined specimens from the different reservoirs at different times, and found them in excellent condition.' This statement seems to find corroboration in the low typhoid fever mortality, the deaths from typhoid fever being in 1905-1906, 11 and 25 respectively.

"However, amidst all this security and confidence, the blow struck. Whether the sudden contamination of the water-supply came from passengers suffering or convalescent from a mild form of typhoid fever, on either, or both of the railroads; whether it came from one or more of the hunters who have hunted on the water-shed; whether from some visitor at the hotel at Moscow, which drains into the Roaring Brook, is not known. The fact, however, is that the supply in the Elmhurst Reservoir was found badly polluted, and what is of the greatest importance, the typhoid bacilli have been actually discovered in some of the samples of water analyzed at the State Laboratories at Harrisburg. This, I believe, is the first instance in this country of actually demonstrating the presence of typhoid bacilli in water suspected of causing typhoid fever. In view of this fact, I made special inquiries, and was assured by Dr. Johnson and Mr. Snow that the bacillus which the State bacteriologist isolated from the water, responded to all the cultural and other tests, and was found identical with the typhoid bacillus isolated from the discharges from typhoid patients at Scranton. This remarkable and unique demonstration establishes beyond doubt not only the cause of the Scranton epidemic, but the relation of water-supplies to typhoid epidemics in general.

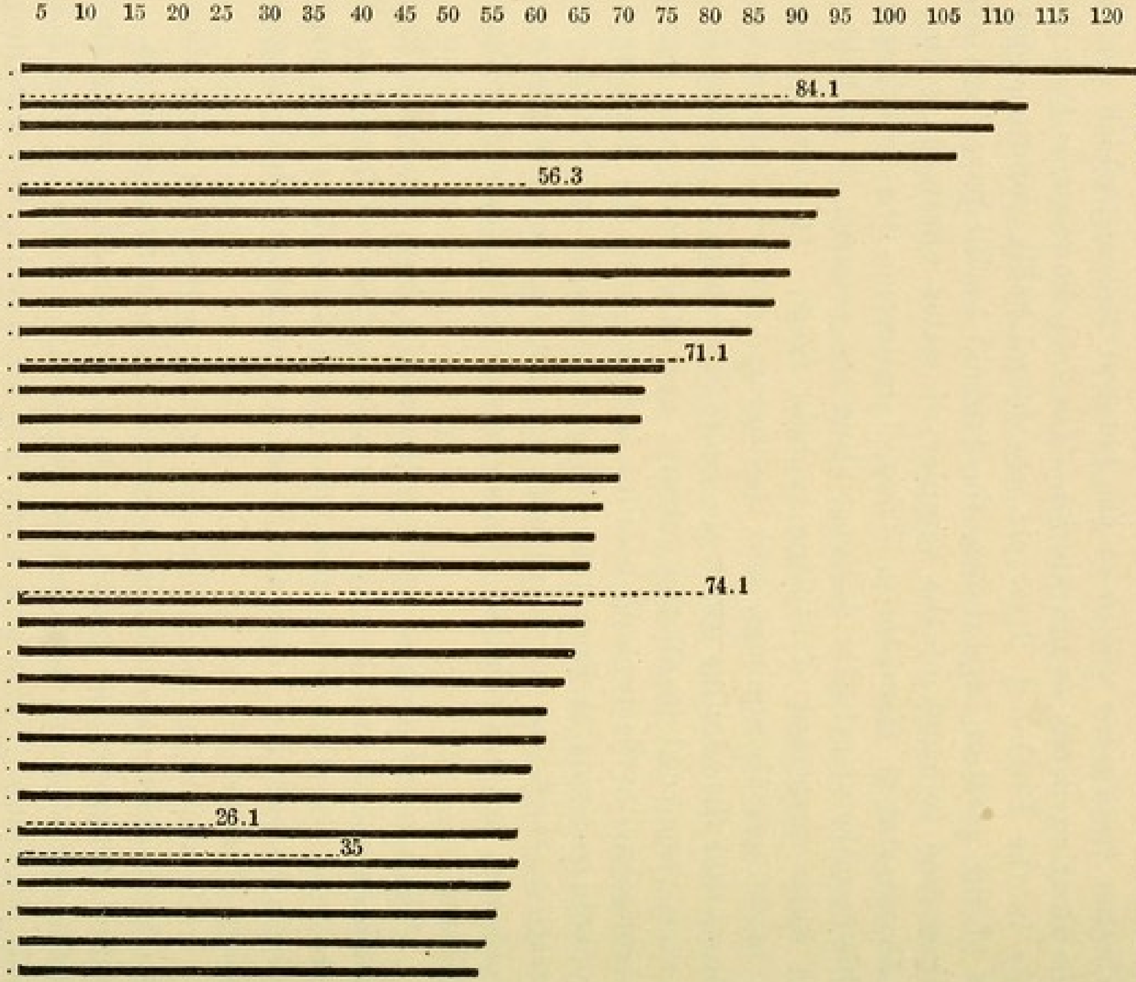
"As a result of these findings the supply from Elmhurst Reservoir has been cut off and the city of Scranton is supplied from Lake Scranton. As a further precaution, the health authorities have urged the people to boil the water and milk, a precaution which is generally being observed.

"It should be noted that the health authorities have shown remarkable ability and zeal in coping with the serious situation. Daily bulletins apprise the people of the exact situation, while thorough disinfection of the premises is rigorously enforced. The hospitals and charitable institutions have lent their entire forces to meet the conditions prevailing at the present time, while the press has all along supported and helped the administration. As a result there is no panic. The situation is viewed calmly and sensibly, and there is every reason to believe that the epidemic will soon be under control.

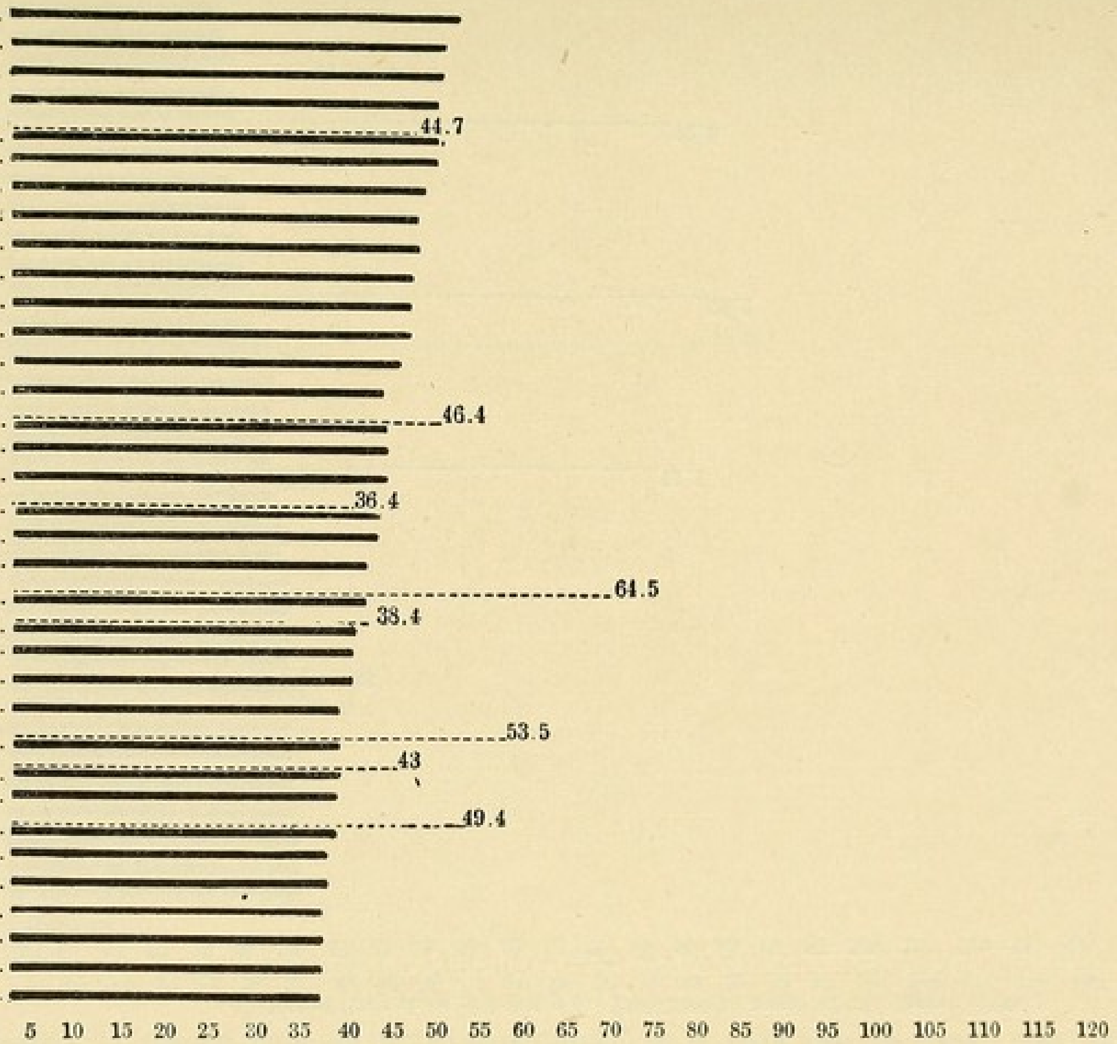
"The Scranton epidemic still further emphasizes the fact, long

TABLE X.—*Typhoid Mortality in American Cities of 30,000 and Over for 1898, 1899, and 1900. Average per 100,000.*

(Dotted lines show mortality for 1890-1896 in some of the larger cities.)



CITY		SOURCE OF WATER SUPPLY
Charleston, S. C.	122	Artesian Wells.
Pittsburg, Pa.	108	Allegheny River.
Youngstown, Ohio	105	Mahoning River.
Troy, N. Y.	102	Piscanenkill and Hudson Rivers.
Knoxville, Tenn.	88	Tennessee R.; mech. filter.
Allegheny, Pa.	86	Allegheny R.; filter crib.
Johnstown, Pa.	83	Mountain streams.
York, Pa.	83	Springs.
Wheeling, W. Va.	82	Ohio River.
Albany, N. Y.	79	Hudson River; unfiltered.
Washington, D. C.	68	Potomac River.
Galveston, Texas	67	Artesian Wells.
San Antonio, Texas.	67	Artesian Wells.
Chester Pa.	64	Delaware R.; mech. filters.
Norfolk, Va.	64	Lakes; mech. filters.
Superior, Wis.	63	Lake Superior.
Mobile, Ala.	62	Springs.
Duluth, Minn.	62	Lake Superior.
Louisville, Ky.	60	Ohio River.
Evansville, Ind.	60	Ohio River.
Lancaster, Pa.	59	Conestoga Creek.
Little Rock, Ark.	58	Arkansas River.
Spokane, Wash.	57	Spokane River.
Terre Haute, Ind.	57	Wabash R.; mech. filter.
Richmond, Va.	55	James River.
Montgomery, Ala	54	Artesian wells.
New Orleans, La.	54	Mississippi River.
Philadelphia, Pa.	54	Schuylkill and Delaware Rivers.
McKeesport, Pa.	53	Youghiogheny River.
Binghamton, N. Y.	51	Wells-Susq'hanna R.; mech. filter
Reading, Pa.	50	Mountain streams and creek,
Allentown, Pa.	49	Springs.

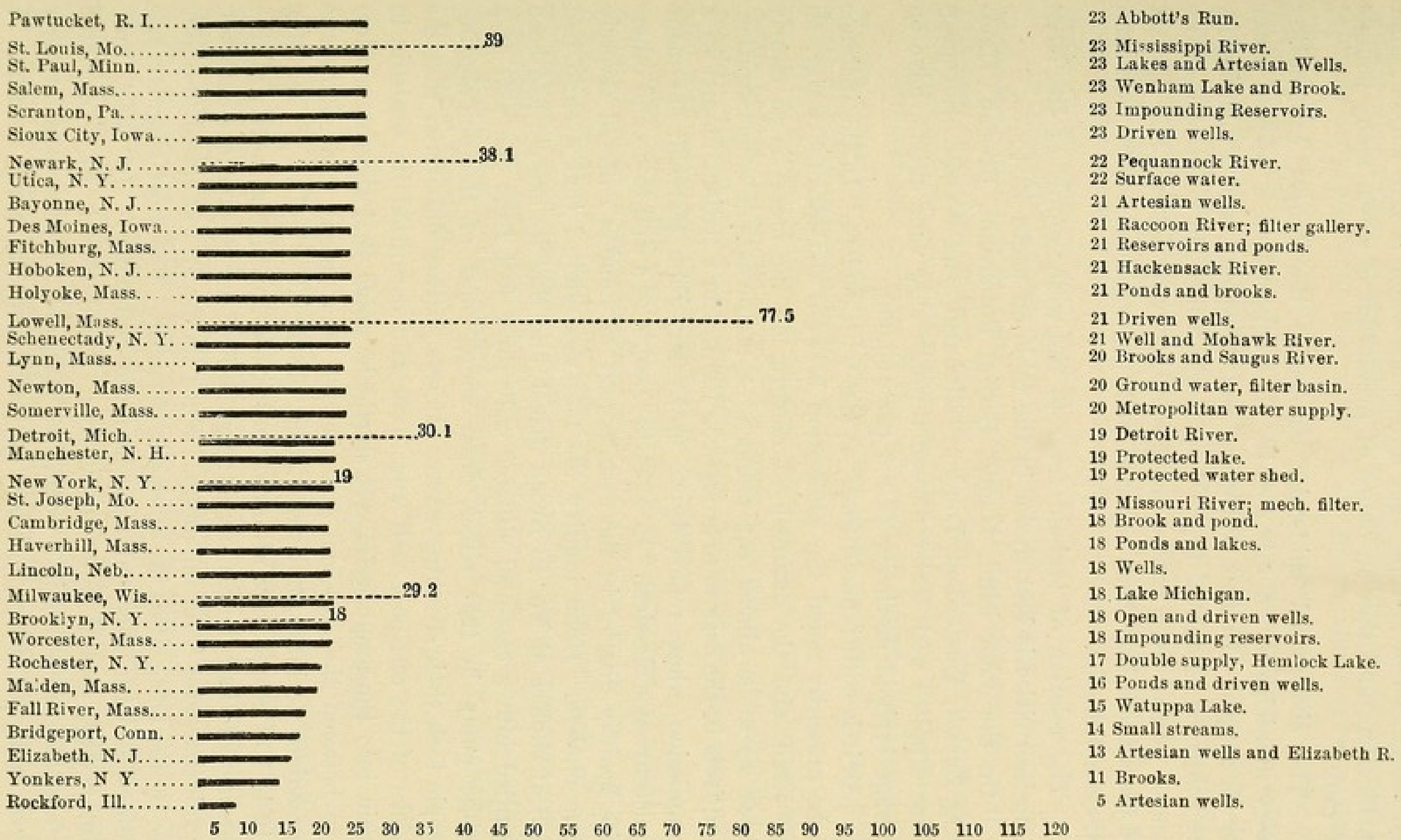


Wilmington, Del.	48	Brandywine Creek.
Hartford, Conn.	47	Brooks.
Dallas, Texas	47	Trinity River.
Kansas City, Kan.	46	Missouri R.; mech. filter.
Nashville, Tenn.	46	Cumberland R.; filter gal.
Portland, Ore.	46	Lake Sebago.
Birmingham, Ala.	45	Cahaba River and Creek.
Springfield, Ill.	44	Sangamon River; filter gal.
Springfield, Ohio.	44	Subterranean filter gallery.
Los Angeles, Cal.	43	Springs.
Topeka, Kan.	43	Open and driven wells.
Elmira, N. Y.	43	Chemung R. & Creek; mech. filter.
Harrisburg, Pa.	41	Susquehanna River.
Waterbury, Conn.	40	Mountain brook; Naugatuck R.
Cleveland, Ohio.	40	Lake Erie.
Canton, Ohio.	40	Artesian Wells and Springs.
Butte, Mont.	40	Mountain streams.
Covington, Ky.	39	Ohio River.
Minneapolis, Minn.	39	Mississippi River.
Denver, Colo.	38	Platte R. and Creek; mech. filter.
Indianapolis, Ind.	38	Driven wells; filter gallery.
San Francisco, Cal.	37	Mountain streams.
Grand Rapids, Mich.	36	Springs and Grand R.; filter gal.
Trenton, N. J.	36	Delaware River.
Paterson, N. J.	35	Passaic River.
Quincy, Ill.	35	Mississippi River; mech. filter
Baltimore, Md.	35	Impounding reservoirs.
South Bend, Ind.	35	Artesian wells.
Cincinnati, Ohio.	35	Ohio River.
Augusta, Ga.	34	Savannah R.; mech. filter.
Savannah, Ga.	34	Artesian wells.
Camden, N. J.	33	Delaware River.
Houston, Texas	33	Artesian wells.
Memphis, Tenn.	33	Artesian wells.
Altoona, Pa.	33	Springs and small streams.

TABLE X.—(*Continued.*)—*Typhoid Mortality in American Cities of 30,000 and Over for 1898, 1899, and 1900. Average per 100,000.*

(Dotted lines show mortality for 1890-1896 in some of the larger cities.)

City	Dotted line (1890-1896)		Source of water supply
Davenport, Iowa	28.5	32	Mississippi R. mech. filter.
Seattle, Wash.		32	Lake Washington.
Toledo, Ohio		32	Maumee River; Filter Basin.
Columbus, Ohio		41	Wells and Scioto R.; filter gal.
Fort Wayne, Ind.		31	Wells.
Kansas City, Mo.		31	Missouri River; sed. and coag.
Syracuse, N. Y.		31	Skaneateles Lake.
Boston, Mass.	32.5	30	Lake Cochituate and Sudburg.
Dayton, Ohio	36	30	Driven wells.
New Bedford, Mass.		30	Acashnut River and pond.
New Haven, Conn.		30	Several lakes.
Salt Lake City, Utah		30	Mountain streams and creek.
Akron, Ohio		29	Wells and lake.
Wilkesbarre, Pa.		29	Laurel River; mech. filter.
Auburn, N. Y.		28	Owasco Lake.
Chicago, Ill.	71.1	28	Lake Michigan.
Erie, Pa.		28	Lake Erie; filter crib.
Omaha, Neb.		28	Missouri River.
Portland, Ore.		28	Canal and Calapooga River.
Buffalo, N. Y.	34.3	27	Niagara River.
Springfield, Mass.		26	Springs and brooks.
Lawrence, Mass.	75.2	25	Merrimac River; sand filter.
Saginaw, Mich.		25	Saginaw River.
Tacoma, Wash.		25	Creek and Sponaway Lake.
Taunton, Mass.		25	Ponds.
Brockton, Mass.		24	Salisbury Brook.
Chelsea, Mass.		24	Metropolitan water supply.
Jersey City, N. J.	72.5	24	Pequannock River.
Peoria, Ill.		24	Open wells.
Providence, R. I.	36.4	24	Pawtuxet River.
Dubuque, Iowa		23	Underground water.
Oakland, Cal.		23	Impounding reser.; mech. filter.


Pawtucket, R. I. — 23 Abbott's Run.
St. Louis, Mo. — 39 — 23 Mississippi River.
St. Paul, Minn. — 23 Lakes and Artesian Wells.
Salem, Mass. — 23 Wenham Lake and Brook.
Scranton, Pa. — 23 Impounding Reservoirs.
Sioux City, Iowa — 23 Driven wells.
Newark, N. J. — 38.1 — 22 Pequannock River.
Utica, N. Y. — 22 Surface water.
Bayonne, N. J. — 21 Artesian wells.
Des Moines, Iowa — 21 Raccoon River; filter gallery.
Fitchburg, Mass. — 21 Reservoirs and ponds.
Hoboken, N. J. — 21 Hackensack River.
Holyoke, Mass. — 21 Ponds and brooks.
Lowell, Mass. — 77.5 — 21 Driven wells.
Schenectady, N. Y. — 21 Well and Mohawk River.
Lynn, Mass. — 20 Brooks and Saugus River.
Newton, Mass. — 20 Ground water, filter basin.
Somerville, Mass. — 20 Metropolitan water supply.
Detroit, Mich. — 30.1 — 19 Detroit River.
Manchester, N. H. — 19 Protected lake.
New York, N. Y. — 19 — 19 Protected water shed.
St. Joseph, Mo. — 19 Missouri River; mech. filter.
Cambridge, Mass. — 18 Brook and pond.
Haverhill, Mass. — 18 Ponds and lakes.
Lincoln, Neb. — 18 Wells.
Milwaukee, Wis. — 29.2 — 18 Lake Michigan.
Brooklyn, N. Y. — 18 — 18 Open and driven wells.
Worcester, Mass. — 18 Impounding reservoirs.
Rochester, N. Y. — 17 Double supply, Hemlock Lake.
Malden, Mass. — 16 Ponds and driven wells.
Fall River, Mass. — 15 Watuppa Lake.
Bridgeport, Conn. — 14 Small streams.
Elizabeth, N. J. — 13 Artesian wells and Elizabeth R.
Yonkers, N. Y. — 11 Brooks.
Rockford, Ill. — 5 Artesian wells.
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120

ago recognized in Europe, that no surface water is safe without final purification, and that an ounce of prevention is worth many pounds of cure."

The above-cited epidemics emphasize the danger confronting every municipality in this country that depends on a surface water for its supply. In fact, Pittsburg and Allegheny, and Philadelphia, are subjected to annual typhoid epidemics which, in point of destruction of human lives, exceed any other agency of death. For the last 14 years there have been reported in Pittsburg some 30,000 cases and over 4200 deaths.

The relation of typhoid fever to the water-supply of the large American cities is best shown in the table on pages 72 to 75.

On the other hand, Hague, Berlin, Rotterdam, Breslau, Hamburg, Zurich, Amsterdam, London, Edinburgh, and Warsaw, European cities supplied with water filtered through slow sand filters, have an average typhoid mortality of 8.3 per 100,000.

As it is with typhoid fever, so also with cholera. In the instance to be presently noted the connection between the infected water, on one hand, and the outbreak of cholera, on the other, is so clearly shown as to be almost equivalent to a mathematical demonstration. The facts in the case were brought to light after a patient inquiry by a commission, whose report drawn up by Mr. John Marshall has made the occurrence classical. In 1854 the people of a well-to-do and otherwise healthy district in the eastern part of London suffered severely from cholera. Upon inquiry the fact was elicited that a child had died of cholera at No. 40 Broad Street, and that its excreta had been emptied into a cess-pool situated only three feet from the well of a public pump in that street, from which most of the neighboring people took their drinking-water. It was further discovered that the bricks of the cess-pool wall were loose and permitted its contents to drain into the pump-well. (It should be noted that the communication between the cess-pool and the well was direct; that there was immediate drainage, not percolation through the soil.) In one day 140 to 150 people were attacked, and it was found that nearly all the persons who had the malady during the first few days of the outbreak drank the water from the pump. When the pump was closed to public use by the authorities the epidemic subsided. The most singular case connected with this outbreak was the following: In West End, Hampstead, several miles away from Broad Street, there occurred a fatal case of cholera in a woman 59 years old. This woman formerly lived in Broad Street, but had not been there for many months. A cart, however, went daily from Broad Street to West End, carrying, among other things, a large bottle of water from the pump referred to. The old lady preferred this water to all others, and secured a daily supply in the manner stated. A niece, who was on a visit to the old lady, drank of the same water. She returned to her home, in a high and healthy part of Islington, was likewise attacked by cholera and died. There were, at this time, no other cases of cholera at West End, nor in the neighborhood of these last two persons attacked.

Most of the English medical officers in India hold strongly to the view that cholera is spread by polluted drinking-water, and the evidence in its favor is very strong.

In 1885 Dr. Robert Koch discovered the cholera spirillum in a water-tank in Calcutta, used as a source of domestic supply, and in this way furnished another link in the chain of evidence connecting the spirillum, the drinking-water, and the outbreak of the disease.

The evidence in favor of the influence of impure drinking-water on the causation of other diseases than those mentioned is not sufficient to justify any conclusions at present.

The source of a water-supply may be pure, yet pollution may occur before the water is used by persons to whom it is distributed. Supply-pipes may become defective, and the water become contaminated with sewage or other deleterious substances.

Aside from the practical question of the causation of disease by polluted water, a more abstract and esthetic idea is involved in consciously taking any impurity into the system. The instincts of man, as well as of most animals, revolt at it. These inborn instincts, which constitute the sanitary conscience, as Soyka says, demand purity of food and water, as they insist on cleanliness of the body, of clothing, and of the dwelling.

STORAGE AND PURIFICATION OF WATER.

Wherever a large supply of water is needed, unless drawn direct from a well or spring, or pumped directly from its source, arrangements for storage are necessary. Cisterns and large reservoirs are made use of for this purpose. River-water, especially, requires a period of rest, in a storage reservoir, in order to allow deposition of the large amount of suspended matter in it. Prolonged storage also gives opportunity for the conversion of possibly deleterious organic compounds into simple and perhaps harmless combinations. Usually, in an elaborate system of water-works, a series of reservoirs is built, in which the water is stored successively, so that before its final distribution through the street-mains it has become quite clear and pure. Filtration on a large scale is also used in connection with storage reservoirs in order to secure greater purity of the water.

In the distribution of water, care should be taken that nothing deleterious is taken up by the water in its passage through the pipes. Lead-poisoning is not infrequent from drinking-water that has passed through a long reach of lead pipe, or which has been standing in a vessel lined with lead. Tanks and storage systems should therefore not be lined with lead, and the use of lead pipe in the supply service should be avoided as much as possible. Fortunately, most natural waters possess a considerable portion of carbon dioxide, which forms with the lead an almost insoluble carbonate of lead. This carbonate of lead is deposited on the inside of the pipes, and protects both the pipes against erosive action from other constituents of the water, and also prevents the contamination of the water by the lead. An excess of carbon dioxide in the water renders this deposit soluble, and may cause serious poisoning. Any water which is shown by analysis to contain over 1 milligramme of lead per 100,000 is dangerous and should be rejected.

Owing to the possibility of defilement of the water from improper construction of hydrants, all outdoor hydrants should be discouraged as much as possible, and should be replaced by a simple tap-cock indoors. The pipes should also be laid deep enough under-ground, or otherwise protected against freezing in winter.

A number of methods, all more or less efficient, have been introduced to purify water when it needs purification before being fit for use. These methods either comprise filtration or seek to purify the water without the aid of this process. One of the methods of purification without filtration consists in exposing the water to the air in small streams. This was proposed by Lind, more than a century ago, and has since been frequently revived. The water is passed through a sieve, or a perforated tin or wooden plate, so as to cause it to fall for a distance through the air in finely-divided currents. By this process sulphuretted hydrogen, offensive organic vapors, and possibly dissolved organic matters are removed. This process has been used in Russia on a large scale.

By boiling and agitation, carbonate of lime, sulphuretted hydrogen, and organic matter are removed or rendered innocuous. Vegetable germs are usually destroyed, although Tyndall has shown that some bacterial germs withstand a temperature higher than that of boiling water. Pathogenic germs are, however, all destroyed by boiling water acting on them for ten minutes, as shown by Dr. G. M. Sternberg.[14]

As has already been mentioned,[15] alum is one of the readiest and most efficient means of removing suspended matters from water. However, it should not be used in large quantities.

Permanganate of potassium is sometimes used to purify water containing considerable organic matter. The permanganate rapidly oxidizes the organic matter, and is believed to render it harmless. There is no certainty, however, that the germs of specific diseases are destroyed by the action of this salt, in the proportion in which it could be used for the purposes of water purification.

A yellow tint is given to the water by the permanganate, which is due to finely-divided peroxide of manganese. This does no harm, but is unpleasant. Bromine has been used for a similar purpose, and is claimed to give very good results. The bromine may be neutralized by ammonium or other alkali.

In 1904, Moore and Kellerman,[16] of the Bureau of Plant Industry, United States Department of Agriculture, advocated the use of copper sulphate, first for the destruction of algæ, and later for the purification of water. They found that in proportion of 1 : 100,000 copper sulphate is an efficient germicide, destroying the colon and typhoid bacilli. It was also discovered that copper vessels are capable of purifying water through action of the colloidal copper which is taken up by the contents. For a time these claims received enthusiastic endorsement from many quarters, and it seemed as though the difficult problem of water-purification in a ready manner had been satisfactorily solved. However, the enthusiasm cooled down considerably when reports began to appear from various laboratories, showing that the claims of Kellerman and his followers are greatly overdrawn. Aside from the fact that it would not be safe to introduce copper sulphate into the system, even in minute and theoretically harmless quantities, for a long time, the fact has been brought out that the germicidal action of copper is very uncertain. Among the bacteriologists who reported adversely to this new method, Clark and Gage, of the Lawrence Experiment Station, have furnished the most damaging evidence. In an article on the bactericidal action of copper[17] the authors very properly emphasize that "the weak point

[14] Report of Committee on Disinfectants, 1888.
[15] See page 64.
[16] U. S. Dep't Agriculture. Bur. Plant Ind., Bull. No. 64.
[17] The Jour. of Inf. Diseases, Supplement No. 2, Feb., 1906.

in the conclusions of Moore and Kellerman with regard to the destruction of typhoid by copper is that they were drawn from analyses in which the largest amount of water tested was 1 c. c., and the usual amount tested was less than .01 c. c., It is generally conceded, especially when dealing with laboratory cultures, that the great majority of the typhoid bacilli are quickly destroyed by conditions unfavorable to their growth. It has also been repeatedly shown that a few germs are much more resistant than the majority, and may survive even under the most unfavorable conditions for many days. All epidemiological evidence points to the conclusion that the germs which are able to live under unfavorable conditions are also extremely pathogenic, and that, while it may help to destroy the majority of the bacilli, no method of sterilizing water is thoroughly effective unless it will accomplish the destruction of the especially resistant individuals.

"It is unsafe to conclude that because a certain species of bacteria, especially a pathogen like B. typhosus, is not found in a loopful of the water, or even in 1 c. c., that there is no danger from the use of that water. The average drinking-glass holds about 300 c. c., and until repeated tests of volumes as large as 100 c. c. have been made and the germ proved to be absent, the water under observation cannot safely be said to be free from the test forms."

The authors have used large quantities of water in their experiments and have varied the experiments to cover the ground thoroughly. Their conclusions are:—

"The treatment of water with copper sulphate or by storing it in copper vessels has little practical value, for the following reasons:—

"1. The use of any method of sterilization which is not absolutely effective is dangerous in the hands of the general user, tending to induce a feeling of false security, and leading to the neglect of ordinary precautions which would otherwise be employed.

"2. The removal of bacteria, B. coli and B. typhosus, by allowing a water to stand in copper vessels for short periods, while occasionally effective, is not sure, and the time necessary to accomplish complete sterilization is so long that the method would be of no practical value to the ordinary user. Furthermore, metallic copper seems to have little more germicidal power than iron, tin, zinc, or aluminum.

"3. Although the removal of B. coli and B. typhosus is occasionally accomplished by dilute solutions of copper sulphate, these organisms may both live for many weeks in water containing copper sulphate in greater dilutions than 1 : 100,000; and in order to be safe dilutions of 1 : 1000 must be used, in which case the water becomes repugnant to the user because of its strongly astringent taste.

"4. In some instances very dilute solutions of copper sulphate or colloidal copper absorbed from contact with clean metallic copper, appear to have a decidedly invigorating effect on bacterial activity, causing rapid multiplication, when the reverse would have been true had the water been allowed to stand the same length of time without any treatment."

Regarding the effect of copper and other metals on B. coli, the authors found that the organism disappears under the action of the respective metals in the following number of days: zinc, 10 days; iron, 15 days; tin, 41 days; aluminum, 41 days; copper, 43 days; lead, 97 days; and in another experiment: zinc, 10 days; copper, 10 days; tin, 23 days; iron, 23 days; lead, 23 days; aluminum, 31 days.

Filtration.—The purification of water by filtration has been shown to be the most reliable means of removing both suspended matter and bacteria from polluted water. Filtration is practiced on a small scale—domestic filters—and on a large scale. Of the domestic filters only those made of unglazed porcelain (the Pasteur filters) or infusorial earth (the Berkefeld filter) are to be relied upon. These filters are made of a porous material, the pores forming tortuous channels in which the bacteria lodge and are retained. After a time the filter becomes permeated with bacteria and the latter are pushed through, as it were, by the incoming armies. To make them yield a satisfactory effluent, the filtering unit should be frequently scrubbed and sterilized in the oven or by boiling at least once a month. Maignen's domestic filter, made of granulated charcoal and asbestos, is said to be quite satisfactory. All other domestic filters on the market, and their name is legion, are practically worthless, if not actually harmful because of the false security which they give.

On a large scale, water may be purified by sedimentation, slow sand-filtration, or the English method, rapid sand-filtration, or the American method, which is also known as mechanical filtration.

In the process of sedimentation the water is confined in one or more large reservoirs holding 30,000,000 to 50,000,000 gallons and allowed to become clarified by the particles of mud falling to the bottom. Incidentally, the bacteria are carried down and some oxidation of the organic matter takes place. Usually about 75 per cent. of purification takes place by this method. In St. Louis the water is treated with iron sulphate and lime before final sedimentation. By

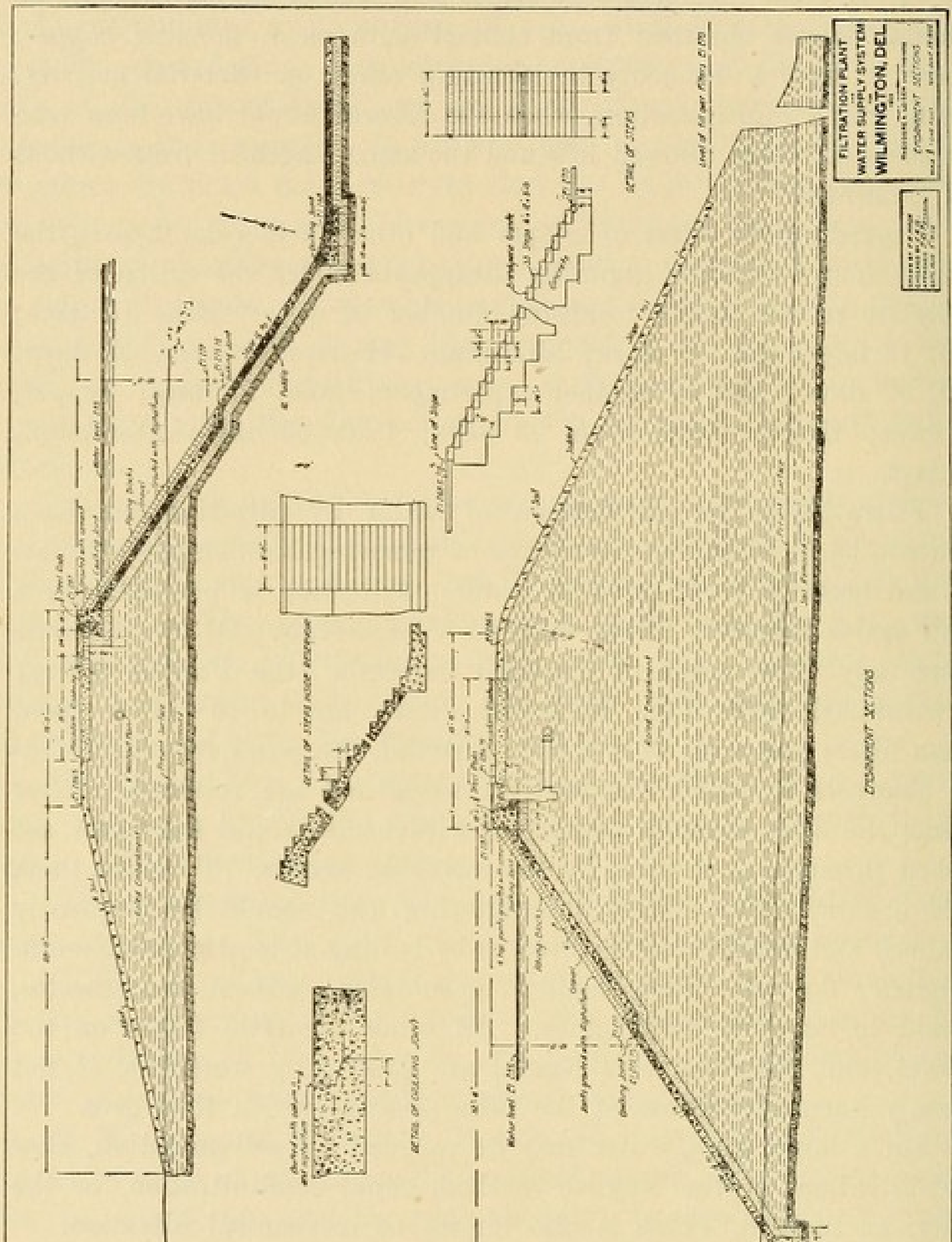


Fig. 4.—Plans of 30,000,000 Gallon Storage Reservoir Recently Constructed in Wilmington, Del.

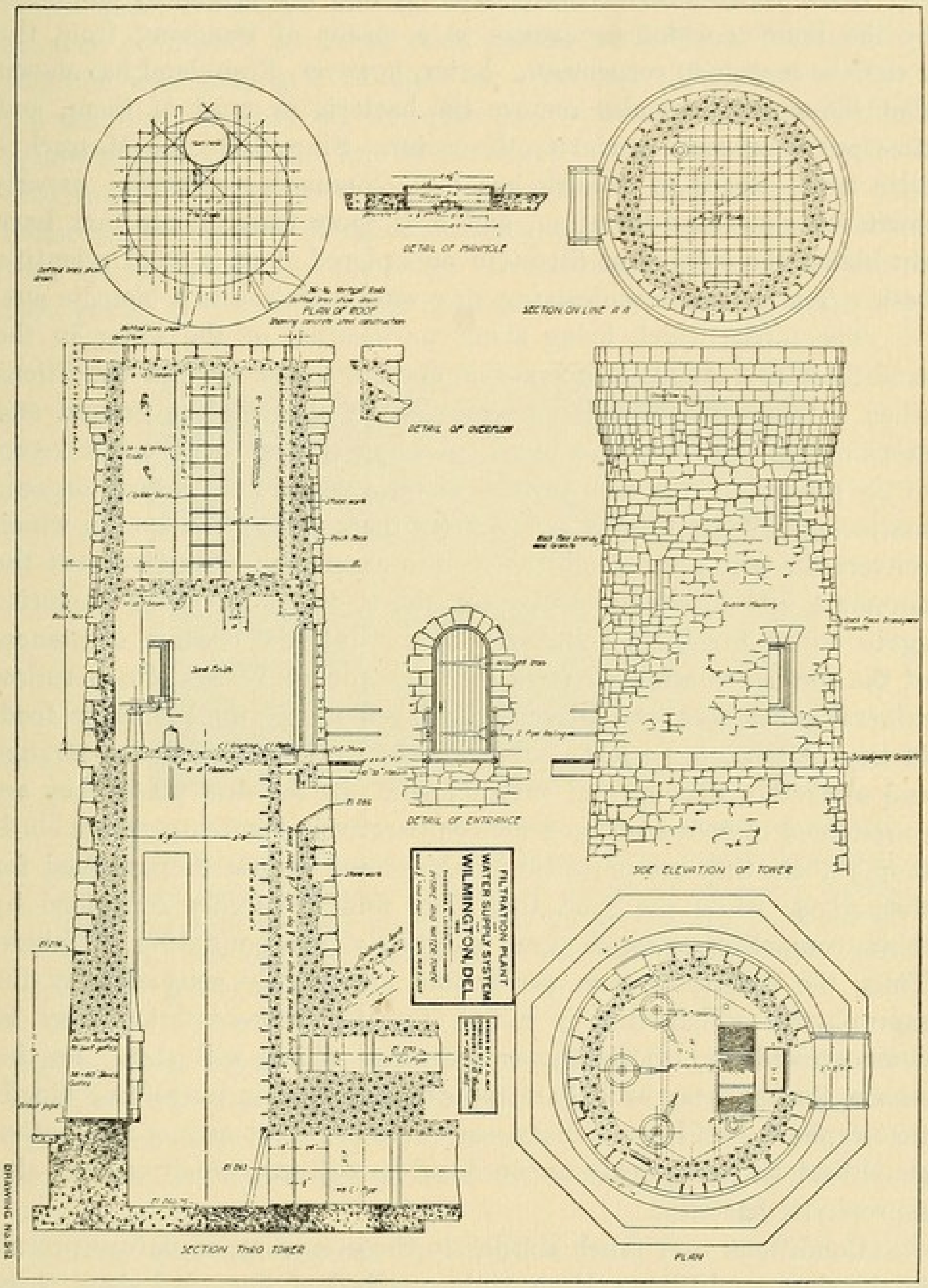


Fig. 5.—Plans of Intake and Water-tower Used in Connection with the Reservoir.

this method the effect of sedimentation is greatly enhanced and the purification of the water is much greater.

Slow Sand Filtration.—This method was originally employed by the London water companies as a means of removing from the water the matter in suspension. Later, however, Frankland has shown that the sand-filters also remove the bacteria or most of them, and thus purify as well as clarify the water. Since 1890 the Massachusetts State Board of Health has been conducting extensive experiments on slow sand-filtration, and it is these experiments that have elucidated the subject of filtration and placed it on a solid scientific basis. The principle underlying slow sand-filtration is a biologic one.

The forces which bring about purification of the water in the sand-filter are exactly the same as operate under natural conditions when a foul surface pool percolates slowly through the ground and crops out in the form of a pure, sparkling spring. The upper layers of the ground swarm with various bacteria which live on dead organic matter, so-called saprophytes. Among them are certain species which convert the nitrogenous substances into ammonia; others convert the ammonia into nitrites and nitrates, the so-called nitrifying bacteria; again others break up cellulose; in a word, the organic substances of the water are attacked from all sides and converted into harmless mineral substances, the latter to be taken up by the plants as food. If any pathogenic bacteria happen to be present they find a strange and altogether uncongenial environment. In the first place, they are accustomed to body-heat, and the comparatively low temperature chills them; then, they are parasitic in nature and cannot prepare food for themselves, while the food that they find is rapidly consumed by their competitors, which are in greatly predominating numbers. Thus, the pathogens soon perish and are rapidly consumed by the saprophytes. That this is not a fanciful representation may be demonstrated by laboratory experiments, which will show, for instance, that anthrax bacilli are rapidly destroyed in putrefying blood; that typhoid bacilli soon disappear in feces; that any of the pathogenic bacteria are quickly crowded out in cultures which contain also saprophytic bacteria.

Conditions very much similar to those existing in nature prevail in the slow sand-filter. Here we have a bed of fine sand about three feet thick, through which the water percolates at a rate of 3,000,000 to 4,000,000 gallons per acre per day. While the water passes through the sand, the suspended matter is strained out and is deposited between the sand-grains, in the upper inch or two. The infusoria, algæ, and bacteria in the water become entangled in what is now a very fine sieve and form a slimy film about the sand-grains, on the surface of the bed. No sooner are the various bacteria domiciled than they at once commence to work, each species performing its particular function and making a struggle for existence. The surface film of the sand-bed, or what the Germans call "schmutzdecke" (mud-film), is now teeming with life and is the field of energetic biologic activity, the result of which is the transformation of the complex organic molecules into simple inorganic compounds. Any pathogenic bacteria that may be present in the water become enmeshed in this film and soon perish in the unfavorable environment. In time the upper mud-

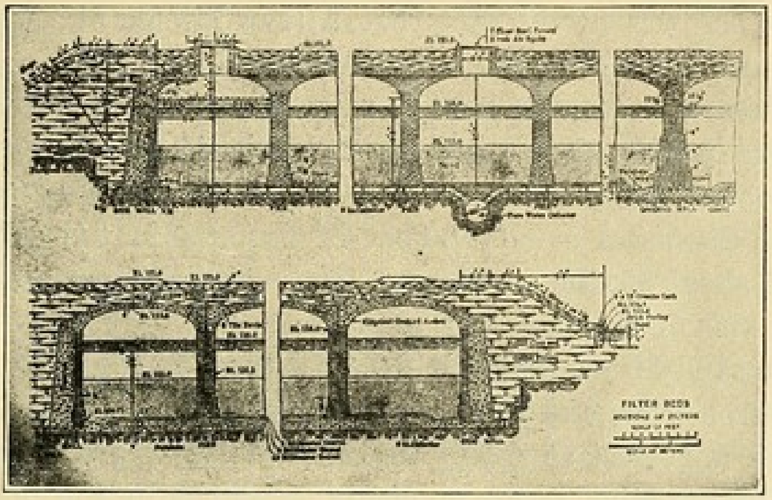


Fig. 6.—Plans of Slow Sand Filters. These consist of concrete basins, on the floor of which are laid tile or terra cotta underdrains; over these, from three to six inches of gravel in successive layers, beginning with the very large sizes at the bottom and the finest at the top; over this about three feet of fine sand, and over this three to four feet of water.

film becomes more and more compact, until only a comparatively small amount of water passes through. This happens, under ordinary circumstances, about once in three weeks. When this occurs, the filter is drained, the upper inch of sand removed by means of shovels, and filtration resumed.

The greatest impetus to filtration and the most remarkable demonstration of its efficiency in preventing water-borne diseases were furnished by the epidemic of cholera which visited Hamburg in 1892. The cities of Hamburg and Altona are separated by an imaginary line, so that nothing in their surroundings or in the nature of their population distinguished one from the other. Both cities depend for their water-supply on the polluted river Elbe, with this difference, that while the intake for Hamburg is situated above the city, that for Altona is situated below Hamburg, *i.e.,* the water-supply of Altona receives additional pollution of some 800,000 inhabitants. When the epidemic broke out Hamburg suffered a loss of 1250 lives per 100,000, while the number of deaths in Altona was only 221. So clearly defined was the path pursued by the epidemic that in one street which marks the division between these towns, the Hamburg side was stricken down with cholera, whilst that belonging to Altona remained free. It was found that in the houses supplied with the Hamburg water cholera was prevalent, whilst those furnished with Altona water remained free from the disease. Now, the reason for this difference was in the fact that Altona filtered the water, while Hamburg did not. Fate, moreover, furnished additional proof of this fact. During the ensuing winter, when the epidemic of cholera had almost died out in Hamburg, an outbreak of the disease occurred in Altona. A searching inquiry was instituted and it was found that instead of the usual small number of bacteria in the effluent from the filters, about 50, the number rose to 1000 and more in a c. c. The cause for this inefficiency was soon discovered. It was found that one of the sand-filters, which had been cleaned during the frost, had become frozen over, and was consequently not able to retain the bacteria. But imperfect as the filters then were, they nevertheless saved the city from another severe epidemic, as shown by the limited number of cases.

As a result of his studies of the Altona filters, R. Koch arrived at the following conclusions:—

1. The real effective agent in removing micro-organisms from the water is the layer of slimy organic matter which forms upon the surface of the sand.

2. If this surface be removed by scraping, or its continuity affected in any way, as by freezing of the surface, the number of bacteria which pass through the filter increases considerably; in fact, both cholera and typhoid germs may pass in sufficient numbers to cause an epidemic amongst those who use the imperfectly filtered water.

3. Filtration should not exceed a rate of 2,000,000 gallons per acre.

4. After a filter-bed has been scraped, water should be allowed to stand upon it for at least 24 hours to allow of the slime depositing before filtration is commenced and the water which first passes should be wasted.

5. Each separate filter-bed must, when in use, be investigated bacteriologically once each day.

6. Filtered water containing more than 100 bacteria per cubic centimetre should not be allowed to reach the pure-water reservoir.

Perhaps no single investigation has contributed as much towards our knowledge of the underlying principles of filtration as the experiments performed at the laboratories of the Massachusetts State Board of Health since 1890.

The more important results of these experiments may be summarized as follows:—

1. The depth of sand, within certain limits, exerts but little influence on the efficiency of a sand filter, except when the rate of filtration is high; with moderate rapidity of filtration (2,000,000 gallons per acre daily) one foot of sand is as effective as five feet.

2. The effect of scraping the sand to remove the clogged surface is to cause an increased number of bacteria to pass through the filter. Usually the filter requires three days' use after scraping to reach a maximum degree of efficiency. The effect of scraping is more marked in shallow than in deep filters, and with high rates than with low rates of filtration.

3. Over 80 per cent. of the bacteria removed are found in the upper inch of sand, and 55 per cent. in the upper quarter-inch. The B. prodigiosus, which is very like the typhoid bacillus in its mode of life in water, was not found below the upper inch.

4. The average depth of sand necessary to be scraped from the surface of the filter was $^1/_4$ inch, but was found to vary with the size of the sand, decreasing as the fineness of the sand increased.

5. Much less water will pass a filter at 32° F. than 70° F., owing to the increased viscosity of the water.

6. Within certain limits and under equal conditions the quantity of water passed between successive scrapings is not influenced by the rate of filtration.

7. Finer sands require more frequent scrapings than coarser sands.

8. Shallow filters require more frequent scrapings than deeper ones.

9. During the summer months the temperature and other conditions for continuation of life of bacteria at the surface of filters are more favorable than at any other time.

Experiments performed at Wilmington, Del., by Dr. A. Robin, indicate that excellent efficiency may be obtained at a rate of 4,000,-

000 gallons per acre per day, if the raw water is passed, previous to filtration, through a preliminary filter, which removes about 50 to 75 per cent. of the turbidity and bacteria.

Following the remarkable demonstration of the efficiency of slow sand-filtration in removing cholera bacilli from the water, sand-filters were installed in almost all the large cities of Europe, and wherever installed have reduced typhoid mortality to a very small percentage.

In this country, the first slow sand-filter was built by Kirkwood, in Poughkeepsie, N. Y., in 1877. This filter, however, was operated without any particular regard to the scientific aspect of filtration, and under disadvantageous climatic conditions.

The first filter which has contributed very largely to our knowledge of the subject, and which has served as a model for other plants, is the slow sand-filter constructed in Lawrence, Mass., in 1893. This filter has been in operation ever since, giving excellent results both as to the improvement of the polluted Merrimac water and the reduction of the typhoid mortality in the city. This is shown in the following table:—

TABLE XI.

Death Rate Per 100,000.

Year.	Before Filtration.	Year.	After Filtration.
1885	42.0	1893	86.6
1886	57.5	1894	50.0
1887	117.5	1895	18.6
1888	120.0	1896	16.2
1889	137.5	1897	13.9
1890	133.3	1898	33.0
1891	122.0	1899	18.1
1892	111.1	1900	18.0

Following the introduction of slow sand-filtration in Lawrence, slow sand-filters have been constructed in a number of American cities, the most notable of which is Albany, N. Y. In the latter city a covered slow sand-filter was constructed by Mr. Hazen in 1899. The improvement in the mortality from typhoid fever and diarrheal diseases has been very marked, as shown by Mr. Bailey, the superintendent, in his report for the year ending 1901:—

"An examination of the health records of the city shows some interesting features coincident with the commencement and continued operation of the filter, as follows:—

TABLE XII.

Death Record.

	General Av. previous 10 yrs.	1899	1900	Diarrheal Av. previous 10 yrs.	1899	1900	Typhoid Av. previous 10 yrs.	1899	1900
October	153	138	144	5	2	5	4	4	5
November	162	138	135	3	0	1	5	0	4
December	194	148	133	6	1	0	7	1	0
		1900	1901		1900	1901		1900	1901
January	235	135	188	6	1	2	11	3	2
February	197	146	157	6	2	0	11	1	3
March	215	180	164	5	5	1	12	3	1
April	197	202	156	4	1	0	9	5	1
May	173	152	139	3	0	1	4	4	1
June	159	112	145	10	7	1	4	1	3
July	191	162	142	39	27	11	4	3	0
August	162	116	134	21	16	14	7	6	3
September	148	125	139	12	5	12	6	4	4
Total ...	2186	1754	1776	120	67	48	84	35	27
Reductions, per cent...		19.77	18.76		44.17	60.00		58.33	67.86

"There has been no general sanitary improvement in the city in this time other than the improvement of the water due to filtering. These figures show facts, and should be susceptible to accurate inter-

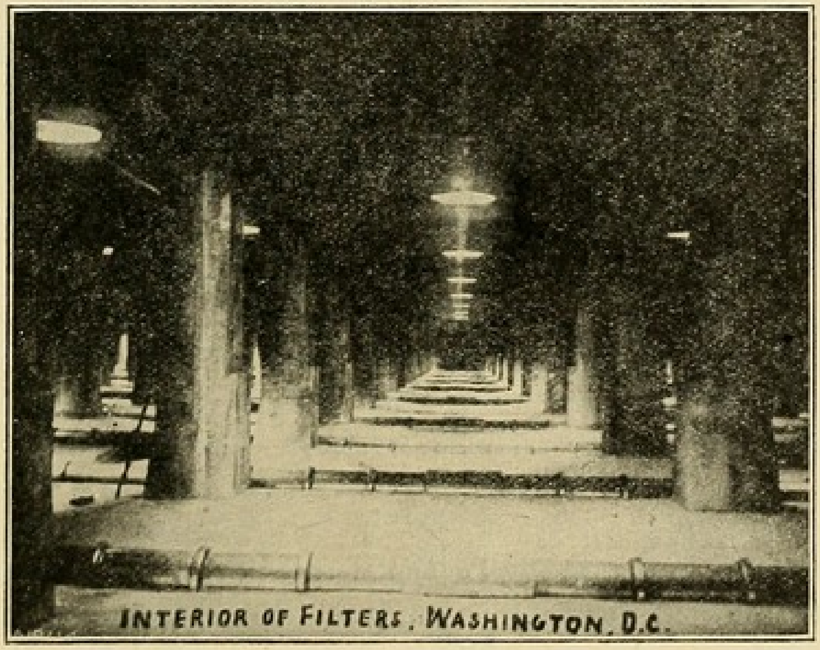


Fig. 7.—Showing Interior of Filter Recently Constructed in Washington, D. C.

pretation. My inference from them is, that, as a result of the pure water now being supplied, there is a better general condition of health, as shown by a decided reduction in diseases caused by filth and disease-germs that are water-borne."

The Albany filter has continued to give excellent results from a sanitary standpoint. Slow sand-filters have been constructed in Providence, R. I., Washington, D. C., Hudson, N. Y., Mount Vernon, N. Y., Far Rockaway, L. I., Ilion, N. Y., Yonkers, N. Y., Somersworth, N. H., Ashland, Wis., Superior, Wis., St. Johnsbury, Vt., Milford, Mass., Nantucket, Mass., Nyack, N. Y., Lambertville, N. J., Salem, N. J., Rock Island, Ill., Grand Forks, N. D.; and are in the course of construction in Philadelphia, Pa., Pittsburg, Pa., and Wilmington, Del.

Our experience thus far gained from the results of filtration enables us to make the general proposition that properly filtered water is fully equal in its hygienic purity to a pure supply from natural sources. This is shown by Hazen in the following table:—

TABLE XIII.

Deaths from Typhoid Fever per 100,000 per Annum.

PLACE	Date of Change	Five Years Before Change	Five Years After Change	Percentage of Reduction
Zurich, Switzerland......Filtration.	1885	76	10	87
Hamburg, Germany......Filtration.	1892-93	47	7	85
Lawrence, Mass..........Filtration.	1893	121	25	79
Albany, N. Y. ....Filtration	1899	104	28*	73
Lowell, Mass., River water to ground water	1895-96	97	21	78
Newark, N. J., River water to upland water..........................	1892	70	16	77
Jersey City, N. J., River water to upland water..................	1896	77	24	69
Averages..................	....	85	19	78

* Four years.

MECHANICAL FILTERS.—In the mechanical, rapid or American system of filtration, the water is conducted through sand in about the same manner as in slow sand-filters. In a mechanical filter the action is both mechanical and chemical, the foreign substances in the water being retained in the sand mechanically, while their retention is aided by the application of chemicals. There is no biological activity in a mechanical filter as there is in the slow sand-process. By reason of the assistance of the chemicals, and by virtue of the absence of the biological activity on a mechanical filter, it can be operated at much higher rates than slow sand or "biological" filters as they may be called. The usual rate at which mechanical filters are operated is 125,000,000 gallons per acre per day, while slow sand-filters are operated at about the rate of 3,000,000 gallons per acre per day. A more rapid passage of the water through a slow sand-filter would be liable to wash the bacteria from the sand-grains about which they live, and so interfere with the successful operation of the filter.

The chemicals usually used in mechanical filters are sulphate of aluminum or sulphate of iron and lime. The way these chemicals act is as follows: When sulphate of aluminum is used, it is led into the supply somewhere before the water enters the filters and there combines with the lime naturally present in nearly all waters to form hydrate of aluminum and sulphate of calcium. The sulphate of calcium remains in solution in the water, but the hydrate of aluminum, being insoluble, agglomerates, by means of its stickiness, the bacteria and other particles in suspension in the water, into masses of such size that they cannot pass between the sand-grains as they would if they had not been massed together by the action of the chemicals. When sulphate of iron and lime are used, the action is exactly similar, only instead of having hydrate of aluminum we have hydrate of iron. Having all the foreign particles in the water agglomerated in one of these ways, they are much more easily retained by the sand than in the slow sand process, consequently the filter can be operated at a more rapid rate. Being operated at a more rapid rate, the dirt accumulates on the surface of the sand faster than it does in a slow sand plant, with the consequent necessity of more frequent cleaning.

In mechanical plants the cleansing of the sand is accomplished by turning a current of filtered water upward through the sand, and at the same time agitating the whole bed of sand by means of rakes driven mechanically or by compressed air forced through the sand from below. By either means of agitation the sand-grains are forced rapidly against each other and all foreign matter is forcibly removed from their surfaces, and carried by the current of water to the top of the filter, whence it is conducted to the sewer by pipes arranged for that purpose. The operation of cleaning a mechanical filter usually takes about ten minutes, and the frequency with which it has to be performed depends entirely upon the character of the water treated. Ordinarily a filter has to be cleaned about every twenty-four hours, and it requires from 2 per cent. to 5 per cent. of the filtered water for cleaning purposes.

Regarding the efficiency of mechanical filters, it may be said that, when carefully constructed and skillfully operated, they give hygienic efficiency equal to that of a slow sand-filter; but, on the other hand, the mechanism of operation is much more complex, the possibility of some unlooked-for derangement greater, with consequent liability to get out of order and thus result in imperfect purification of the water.

The comparative utility of slow sand and mechanical filters was summarized by Col. A. M. Miller, John W. Hill, and Rudolph Hering, acting as a commission of experts for Pittsburg, Pa. The following is an extract from their report, and the conclusions deduced:—

"It was found by the experimental work carried on by the former commission, for Pittsburg conditions, that as to first cost mechanical filtration was the cheaper process. Upon reviewing the subject at the present time, we are of the same opinion, but would add that the expense of operation being greater for the mechanical filters, the total expense of the two methods becomes nearly equal, and the preference should depend on other than financial considerations.

"As to efficiency in removing bacteria, the preference between the two methods is not marked, *provided constant intelligent care is given in equal measure to manipulation of both processes.*

"It cannot be denied, however, in the absence of such care, that if any irregularity occurs in the operation of the system, the rapid or mechanical filter would present the greater danger, by passing a much larger quantity of unfiltered water into the mains, before a proper correction is likely to be made.

"As to the adaptability of the effluent for steaming purposes, the weight of evidence is decidedly in favor of slow sand-filtration. It was found by the Filtration Commission of 1897, that the latter process caused less scale and less corrosive action on the plates of steam boilers.

"Slow sand-filters are to be preferred from the standpoint of operation. Slight neglect or inattention, or mistaken judgment in the management of the filters, cannot at once seriously damage the effluent. Rapid or mechanical filters require an exact proportionment of coagulant day by day, and sometimes hour by hour to obtain the desired results. While such careful attention can sometimes be attained,

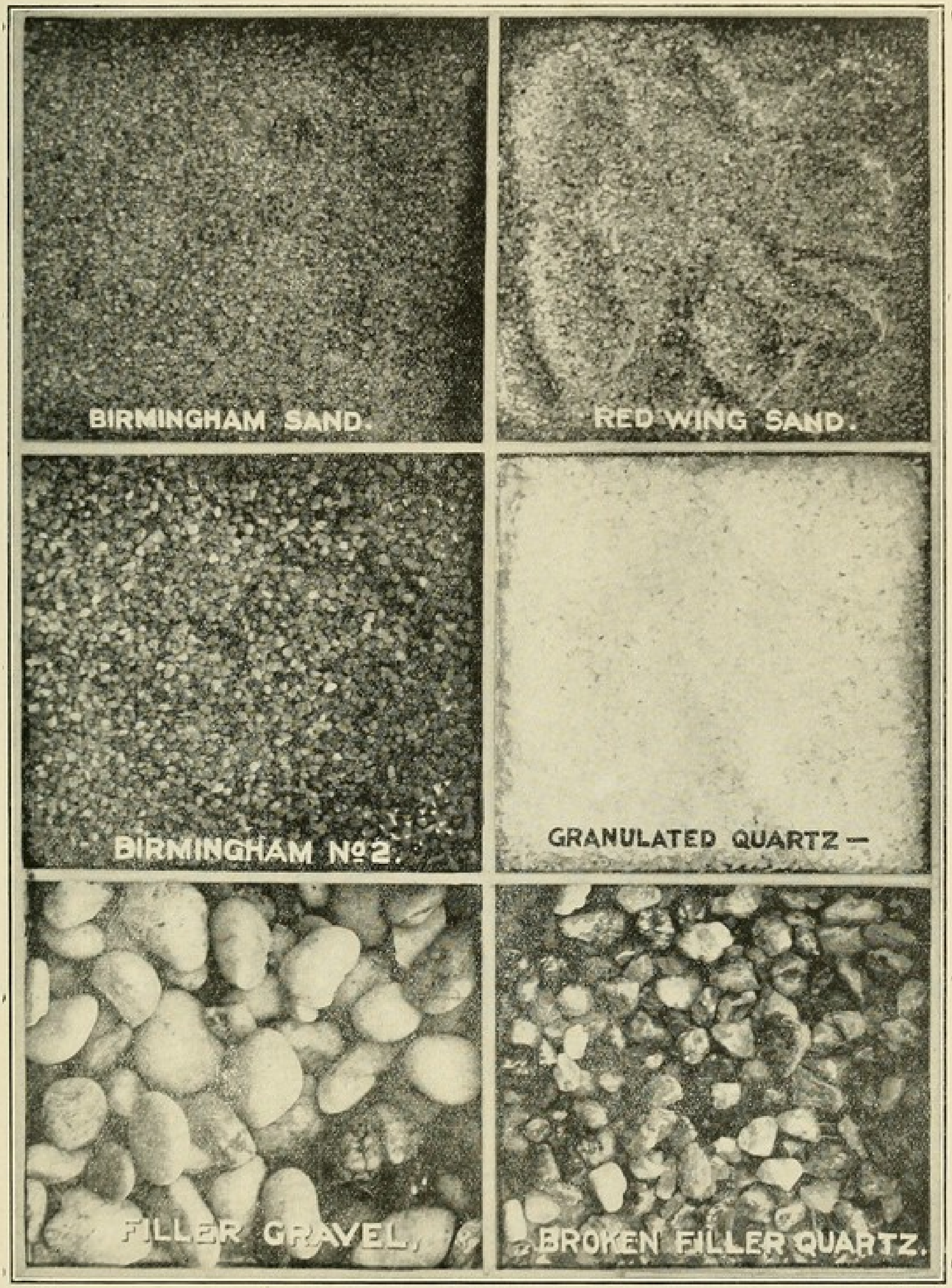


Fig. 8.—Showing Exact Size of Filtering Material Used in Construction of Sand Filter. (By courtesy of the Pittsburg Filter Manufacturing Company.)

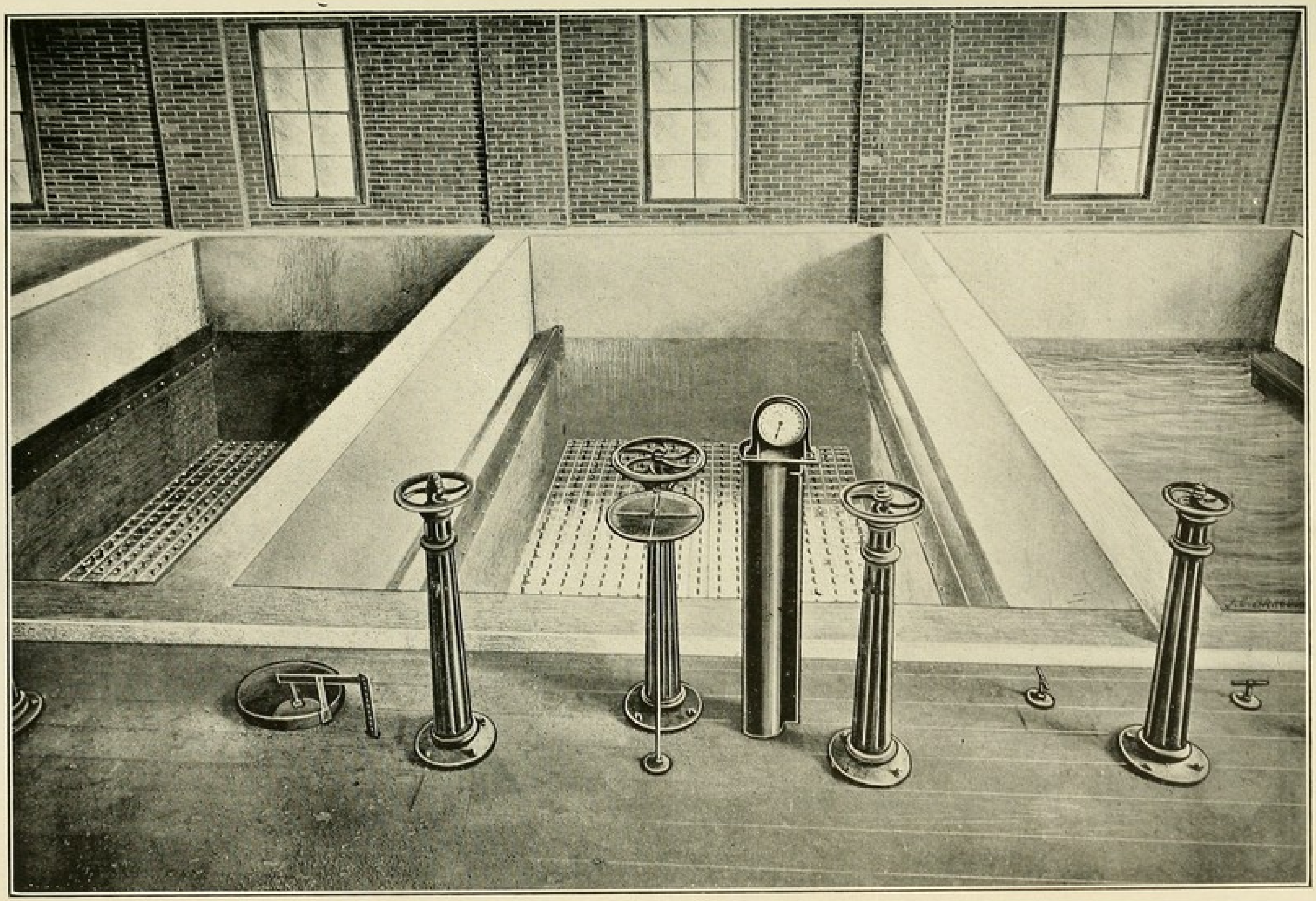


Fig. 9.—Showing Interior of Mechanical Filter. (By courtesy of the Pittsburg Filter Manufacturing Company.)

it nevertheless must be admitted that the simplicity of operation of the slow sand-filters is a decided advantage.

"We therefore are of the opinion that slow sand-filtration as recommended by the Commission which reported to Council in 1899, is most suitable because:—

"1. It is most simple and durable.

"2. It is most effective under existing circumstances.

"3. The cost of construction and operation is reasonable, and, according to careful estimates, no greater than for any other practicable system."

Similar views are expressed in a very excellent report submitted by Mr. T. A. Leisen, chief engineer of the Wilmington Water Department.

Other Methods of Water Purification.—Of the other methods, the use of ozone is the only one deserving consideration. There is no doubt that ozone destroys the bacteria in the water without in any way changing its composition. However, the method is still in the experimental stage, and its utility on a large scale remains to be demonstrated.

EXAMINATION OF WATER.

The average consumer judges of the quality of the drinking-water by means of his special senses of sight, smell, and taste. Water which is turbid or emits a disagreeable odor is unreservedly condemned, while clear, sparkling water free from odor is just as unqualifiedly pronounced "pure." Those of us who are familiar with the history of typhoid epidemics and have had opportunity to examine drinking-water by means of special methods know how fallacious such a crude judgment is. Water that is clear and sparkling may contain the germs of typhoid fever or may be polluted with sewage which, in the course of decomposition, gave rise to carbonic acid. It takes many billions of bacteria to render a glass of water perceptibly turbid, and it requires considerable fresh sewage to impart to it a fecal odor. On the other hand, a turbid water, although objectionable from an esthetic point of view, may be entirely wholesome, and a disagreeable odor may be due to inoffensive vegetable compounds or harmless algæ.

This evident inability to form a ready judgment of the quality of a drinking-water has led the sanitarian to seek the aid of the chemist, who, it was supposed, could readily detect by means of chemical analysis the injurious substances in the water under suspicion. However, it soon became evident that a chemical analysis of water for sanitary purposes differs essentially from any other kind of analysis which the chemist may be called upon to make. The finding of arsenic or some poisonous alkaloid in a suspected fluid is decisive, and a report on such finding is merely a statement of fact. In the analysis of water, on the other hand, the findings are purely relative and must be properly interpreted before they can be of any value. A drinking-water, to use the legal phraseology, is indicted on circumstantial evidence, and it depends on the erudition and ability of the chemist to so interpret and connect the evidence as to make out a clear case for or against the suspected water.

The object of a chemical analysis of water is to discover whether or not pollution with objectionable organic impurities has taken place. By "objectionable organic impurities" we understand those which are from human or animal sources and are capable of conveying the germs of disease. In other words, we look principally for fecal contamination, inasmuch as the germs of typhoid fever, cholera, dysentery, and other intestinal disorders are excreted with the feces, and together with the feces gain access to the water. By itself, organic matter in the minute quantities in which it is present in water is not injurious to health, even if derived from sewage. It is only because this organic matter may be the carrier of disease germs that it becomes a matter for serious consideration. Therefore, organic matter derived from plants or vegetables removed from the possibility of infection with disease-producing bacteria has no significance from a sanitary standpoint, and its presence in drinking-water in no way renders it unwholesome.

It is thus evident that the aim of the sanitary chemist is to discover, first, the presence of organic matter which would indicate pollution, and, second, to determine the source of this organic matter. How well these two requirements are fulfilled by a chemical analysis will be made clear later.

Dead organic matter in water, as elsewhere, is not in a state of stability. Through the agency of certain bacteria, in the presence of oxygen, it continuously undergoes material changes, becoming resolved into simpler inorganic compounds. The nitrogenous substances are converted into ammonia, and the latter into nitrous and finally nitric acid, the two acids combining with bases usually present to form nitrites and nitrates, respectively. These changes may be best illustrated by the following scheme:—

Organic matter	Carbon—Carbon dioxide.			
	Hydrogen Nitrogen	Ammonia	Nitrous acid (Nitrites) Water	Nitric acid (Nitrates).

This process, may it be remarked in passing, is a beneficial one, since by its means purification of polluted water is accomplished and the decaying organic matter converted into useful plant food.

These changes, under favorable conditions, take place incessantly so long as there is a supply of dead organic matter and the necessary bacteria are present. Therefore, the amount of organic matter in water represents that portion which has not yet undergone disintegration—the organic nitrogen or so-called albuminoid ammonia—as well as the various intermediary products of the portion which has undergone or is undergoing disintegration—free ammonia, nitrites and nitrates. The quantitative relation of these products of oxidation to each other as well as to the unoxidized nitrogenous matter will depend on the original amount of the organic matter and the rapidity with which oxidation has taken place. Therefore, an analysis which discloses these various stages of oxidation reveals also not only the presence but the retrogressive course of the organic matter. Given a water containing relatively large amounts of albuminoid and free ammonia, together with nitrites and nitrates, the indications would be that such water contains a large amount of organic matter in a state of incomplete oxidation; in other words, the contamination is recent. On the other hand, the presence of nitrates, in the absence of nitrites, with only small amounts of free and albuminoid ammonia, would indicate complete oxidation or a previous pollution. It goes without saying that pure water should contain only traces of albuminoid and free ammonia and should be free from nitrites and nitrates, the latter, if in small quantity, being rapidly appropriated by the water-plants. It is to be expected that in deep wells removed from the possibility of pollution, the water will contain very slight amounts of ammonia and no nitrites or nitrates, or mere traces, although free ammonia may sometimes be present in large amounts as a result of oxidation of vegetable matter or nitrates by ferric oxide.

In addition to organic matter, water contains various salts, the most important and constant of which is sodium chloride, or, occasionally, magnesium and calcium chloride. These chlorides are derived from the sea or geological formations rich in salts. The amount of chlorides will vary with the natural source and remains fairly constant. However, when the water is polluted with sewage or household refuse the chlorides will increase in proportion to the degree and nature of the pollution, and this increase serves as a reliable indication of past or present pollution. This index, however, is of value only when the normal chlorine contents of the water in question or of waters in the immediate neighborhood are known. There are a number of serious objections to the data obtained by a chemical analysis. (1) Excessive free ammonia in ground-waters may be the result, as has been mentioned, of the oxidizing action of iron or other metals on the nitrates present, while in surface waters it may be produced by the action of a fungus Crenothrix (Brown). (2) The nitrites found in deep-well water may be the result of the reduction of nitrates normally present in the soil and, consequently, in no way represent organic pollution. One of the chief objections, however, is that a chemical analysis does not reveal the nature of the organic matter, whether of vegetable or animal origin. Admitting that a certain water contains an excess of organic matter, the question arises, Does this organic matter represent harmless vegetables or dangerous sewage? The chemist cannot answer this question with a certainty which would preclude a "reasonable doubt." Yet a water contaminated even with large amounts of vegetable matter, while not the best kind of water to drink, is nevertheless, free from danger. It is true, that if the ammonia on distillation is given off rapidly and the nitrites and chlorine are excessive, the indications that the organic matter is derived from sewage are reasonably clear, but the rapidity with which ammonia even from the animal matter is given off is only comparative and there is no way of gauging it, while a correct interpretation of the excessive amount of chlorine as compared with the normal chlorine standard of that particular locality presupposes a previous study of unpolluted waters which is seldom made and which often cannot be made.

The other objection, one of a much more serious nature, is that water may be organically pure and yet contain germs of disease. Instances are cited by a number of authors showing that water-supplies pronounced on chemical evidence to be above suspicion have been proved to have caused serious epidemics of typhoid fever or dysentery. Thus Dr. Thresh, in his well-known book on "Water and Water-supplies," cites a number of such instances.

The water from the river Ouse, below where it receives the sewage of Buckingham, to which an epidemic of typhoid fever was attributed, was analyzed by the public analyst, who reported that it "does not appear from the analysis to contain sewage matter."

The Beverly water-supply, which became polluted with infected sewage from an asylum, giving rise to a typhoid epidemic, was pronounced by the chemist to be "of a very high degree of purity, and eminently suitable for drinking and domestic purposes."

Analysis of water from the sewage-polluted Trent showed that "there is no evidence of the product of sewage contamination."

The well-water supplying Houghton-le-Spring became contaminated with sewage from a farm, causing a sudden outbreak of typhoid fever. The chemist who analyzed the water reported that "this water is very free from indications of organic impurity. . . . It is a good water for drinking purposes."

The reason for this evident failure on the part of the chemist to detect dangerous pollution is not difficult to find. A generally pure water may become contaminated with an amount of sewage too small to give evidence of its presence when diluted with several million gallons of water, yet this small amount of sewage may contain numerous specific germs the presence of which cannot be detected by a chemical analysis. Again, the sewage may have undergone complete oxidation and the end-products taken up by the plants, leaving no perceptible evidence of the pollution, while many of the specific germs which have been present in the original sewage remain viable and capable of causing disease.

However, the employment of chemical analysis for comparing different waters in the same locality or a certain water at different times is of undoubted value. In this connection, the data obtained by a chemical analysis are both accurate and valuable. Also in the study of filtration, especially of the slow sand type, chemical analysis of the raw water and effluent made from time to time furnishes valuable evidence of the efficiency of the filter in removing turbidity and color, and bringing about the nitrification of organic matter which is the essential feature of this process of water-purification.

Bacteriological Examination.—With the advent of bacteriology, and especially after the introduction of Koch's plate method of isolation of bacteria, the hopes of the sanitarian had been revived. It was supposed that at last we have a method by means of which we may detect the specific causes of disease in water, and thus place the examination of water on the same certain basis as the detection of poisons. With the knowledge that typhoid fever is usually caused by the drinking-water and after the discovery by Koch that cholera is of similar origin, it was expected that the typhoid bacilli and the cholera spirilla could be detected in the suspected water. Unfortunately, disappointment followed all attempts in this direction. It soon became evident that while a certain water had been the cause of either a cholera or typhoid epidemic, as established by all evidence at hand, neither the cholera spirillum nor the typhoid bacillus could be detected in such waters. The cause for this failure was found in the great predominance of water bacteria which overgrow and obscure the few specific parasites, rendering their discovery impossible. The effort may be compared to looking for a needle in a haystack. While not entirely abandoned, the search for specific micro-organisms has not been made the object of routine examinations; and until some satisfactory method is devised by which the saprophytic bacteria may be entirely eliminated and the number of the specific micro-organisms increased so as to have them present in very small quantities of the water, the bacteriologist must depend upon other data upon which a conclusion as to the quality of the water may be reasonably based. It was thought for a time that the number of bacteria in the water could serve as an index of pollution, and a number of standards of bacterial purity have been suggested by various authors. Thus, Koch considers 100 bacteria per cubic centimetre as the safe limit for drinking-water; Miquel raises the standard to 1000; Crookshank agrees with this standard, while Macé and Migula claim that 250 to 500 bacteria is the highest limit for a good drinking-water. These or any other arbitrary standards based on mere number of bacteria are as fallacious as the "standards" proposed from time to time for ammonias, nitrites, nitrates, etc. The number of bacteria in water will vary greatly with the medium, the reaction of the medium, the length of time the colonies are allowed to develop, dilution, etc. And therefore, number alone, while indicating the presence of organic matter, does not necessarily show that the water contains pathogenic germs. This fact can be more readily ascertained by determining the number of bacteria which develop on bile-agar[18] at body temperature and the presence or absence of bacillus coli.

Dr. De Chaumont[19] classifies water under the four heads of Pure and Wholesome Water, Usable Water, Suspicious Water, and

[18] The bile-agar medium is prepared according to the following formula:—

Agar	1.5	gms.
Sodium taurocholate	.5	"
Peptone	2.0	"
Water	100	c. c.

This is prepared as usual and 1 per cent. lactose added.

[19] Parkes' Hygiene, vol. i, pp. 103-106.

Impure Water. The characters of these waters are arranged in a series of tables, the essential details of which are given in Table XIV.

TABLE XIV.

Chemical Constituents.	Pure Water. I. Parts in 100,000.	Usable Water. II. Parts in 100,000.	Suspicious Water. III. Parts in 100,000.	Impure Water. IV. Parts in 100,000.
Chlorine in solution .	Under 1.4000	Under 4.2857	4–7	Above 7.1428
Solids " total .	" 7.1428	" 42.8571	43–71	" 71.4285
" " volatile	" 1.4000	" 4.2857	4–7	" 7.1428
Ammonia, free or saline	" 0.0020	" 0.0050	0.0050–0.0100	" 0.0100
Ammonia, albuminoid	" 0.0050	" 0.0100	0.0100–0.0125	" 0.0125
Nitric acid in nitrates	" 0.0323	" 0.5000	0.5–1.0	" 1 0000
" " nitrites	Nil.	Nil.	0.0500	" 0.0500
Nitrogen in nitrates .	" 0.0140	" 0.1129	0.1243–0.2373	" 0 2415
Total nitrogen . . .	" 0.0230	" 0.1252	0.1255–0.2465	" 0.2601
Oxygen absorbed by permanganate and acid within half an hour at 140° F. . .	" 0.0250	" 0.1000	0.1000–0.1500	" 0.1500
Total hardness . . .	" 8.5	" 17.3	Above 17.0	" 28.5
Permanent hardness .	" 3.0	" 5.7	" 5.7	" 8.7
Phosphoric acid in phosphates . . .	Traces.	Traces.	Heavy traces.	Heavy traces
Sulphuric acid in sulphates	"	Under 3.000	Above 3.000	Above 4.2857
Heavy metals . . .	Nil.	Traces.	Traces.	Any except iron.
Hydrogen sulphide .	"	Nil.	Nil.	Present.
Alkaline sulphides .	"	"	"	"

PHYSICAL CHARACTERS.

No. I. Colorless, or bluish tint; transparent, sparkling, and well aërated; no sediment visible to naked eye; no smell; taste palatable.

No. II. Colorless, or slightly greenish tint; transparent, sparkling, and well aërated; no suspended matter, or else easily separated by coarse filtration or subsidence; no smell; taste palatable.

No. III. Yellow, or strong, green color; turbid; suspended matter considerable; no smell, but very marked taste.

No. IV. Color, yellow or brown; turbid, and not easily purified by coarse filtration; large amount of suspended matter; very marked smell or taste.

MICROSCOPICAL CHARACTERS.

No. I. Mineral matter; vegetable forms with endochrome; large animal forms, no organic *débris*.

No. II. Same as No. I.

No. III. Vegetable and animal forms more or less pale and colorless; organic *débris;* fibres of clothing, or other evidences of house-refuse.

No. IV. Bacteria of any kind; fungi; numerous vegetable and animal forms of low types; epithelia, or other animal structures; evidences of sewage; ova of parasites, etc.

Methods of Water Analysis. — TURBIDITY. — This may be determined either by the platinum wire method or by comparison of the sample with known quantities of silica suspended in water. The standard of turbidity adopted by the United States Geological Survey is "a water which contains 100 parts of silica per million in such a state of fineness that a bright platinum wire one millimetre in diameter can just be seen when the centre of the wire is 100 millimetres below the surface of the water, and the eye of the observer is 1.2 metres above the wire. The observation being made in the middle of the day, in the open air, but not in sun-light, and in a vessel that the sides do not shut out the light so as to influence the results. The turbidity of such water shall be 100."[20]. To carry out this method, a wooden rod 5 feet long and 1 inch square is taken and a small platinum wire 1 millimetre in diameter inserted about 1 inch from the end. The rod is then graduated, the mark of 100 being placed at a distance of 100 millimetres from the centre of the wire. The intermediary graduations are made according to a table furnished by the United States Geological Survey (Circular No. 8, 1902). The mark on the rod at which the platinum wire vanishes is the turbidity in parts per million. The silica method, which is much more convenient, consists of a standard suspension of one gramme of dried diatomaceous earth in one litre of distilled water. This represents a turbidity of 1000 parts per million. From this stock suspension, standards for comparison are prepared by diluting certain quantities with distilled water. Thus 1 c. c. diluted with 100 c. c. of water equals a turbidity of 10 parts per million. The comparison is made in 100 c. c. Nessler tubes or glass-stoppered bottles.

Significance.—Turbidity is objectionable from an esthetic standpoint, although highly turbid water may be entirely wholesome, and *vice versa.* However, no one likes to drink muddy water, and for this reason turbidity enters as an important factor in determining the quality of a given water or in deciding upon the desirability and methods of filtration.

COLOR.—The color of a water is determined by comparing 100 c. c. of the sample with an equal quantity of a standard prepared from a solution containing 1.246 grams of potassium platinic chloride per litre. This solution has a color of 500.

Significance.—Color in water has the same significance as turbidity, and unless due to organic or inorganic impurities such as

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[20] Report of Committee on Standard Methods of Water Analysis, American Public Health Association, 1905.

sewage or dyes, has no effect on the quality of the water from a purely hygienic standpoint.

Odor.—The odor is determined by violently shaking a bottle half full of the sample and then smelling it. The odor generated by heating is determined as follows: About 150 c. c. of the sample are poured into a 400 c.c. beaker. The beaker is covered, placed on a hot plate, and heated to just below boiling. The beaker is then shaken and the odor detected by the smell.

Significance.—The odor of water may indicate its source as well as the presence of sewage. Objectionable odors, however, may be caused by certain micro-organisms. Thus, a "fishy" odor is caused by *Uroglena,* an "aromatic" or "rose geranium" odor by *Asterionella,* and a "pig-pen" odor by *Anabena.* A very disagreeable odor is caused also by *Crenothrix.*

Total Solids.—This is determined by evaporating 100 c.c. of the water in a weighed platinum dish, drying the residue in an oven at 105° C. for thirty minutes, and then weighing. The weight of the residue in milligrams equals parts per million.

Organic Nitrogen.—The presence and amount of organic nitrogen in a given water are determined as free ammonia, albuminoid ammonia, nitrites, and nitrates. These substances represent the various stages of decomposition which organic nitrogen undergoes in its transformation from a complex to a simple compound.

Free Ammonia.—This is determined by distilling 500 c. c. of the sample in a flask connected with a condenser. The distillate is collected in glass cylinders (Nessler tubes) and a small amount of Nessler reagent[21] added and the distillate compared with standards prepared by adding definite quantities of ammonium chloride to pure water. As a rule 150 c. c. of the first distillate contain all of the free ammonia.

Albuminoid Ammonia.—After the free ammonia is distilled off, the distillation is interrupted and 50 c. c of an alkaline solution of potassium permanganate[22] added. The distillation is resumed and carried on until four or five Nessler tubes are collected. The distillate in each tube is then treated as above.

Nitrites.—One hundred c. c. of the sample are decolorized, if

[21] This reagent reacts with minute quantities of ammonia. It is made by dissolving 50 gms. of potassium iodide in water and adding a saturated solution of mercuric chloride, enough to produce a permanent precipitate. 400 c. c. of a 50-per-cent. solution of potassium hydrate are added, and the whole diluted to one litre.

[22] This is prepared by dissolving 200 gms. of potassium hydroxide and 8 gms. of potassium permanganate in a litre of distilled water.

necessary, with aluminum hydrate and poured into a 100 c. c. Nessler tube. To this are added 1 c. c. of sulphanilic acid solution (8 grammes of sulphanalic acid in 1000 c. c. of dilute acetic acid, specific gravity 1.04) and 1 c. c. naphthylamine solution (5 grammes of naphthylamine in 1000 c. c. of dilute acetic acid). The tube is covered, allowed to stand for ten minutes, and the resulting pink color compared with standards containing definite amounts of sodium nitrite in solution, the standards having been treated in the same manner as the sample.

NITRATES.—Twenty c. c. or less of the sample are evaporated on a water-bath and the residue treated with 1 c. c. of phenolsulphonic acid (phenol, 30 grammes; concentrated sulphuric acid, 370 grammes). About 10 c. c. of water are added and enough ammonia to render the liquid alkaline. The liquid is then transferred to a 100 c. c. Nessler tube, distilled water added to the 100 c. c. mark, and the yellow color matched with standards containing definite amounts of potassium nitrate, and treated as above.

Significance.—With the exception of deep waters, which may contain large amounts of nitrogen as free ammonia (due to reduction of nitrates) and still be pure, the presence of excessive quantities of organic nitrogen indicates pollution. An excess of free ammonia (above 0.06 parts per million), especially if nitrites are present, points to recent pollution, while an excess of nitrates (above .2 parts per million for surface-waters and 2 parts per million for ground-waters) points to past pollution. As to albuminoid ammonia, Wanklyn holds that if the water contains above 0.10 per million it begins to be very suspicious, and if over 0.15 parts per million, it should be condemned absolutely. This standard is regarded by Mason as too rigorous.

OXYGEN CONSUMED.—One hundred c. c. of the sample are measured into a flask, 10 c. c. of dilute sulphuric acid[23] and 10 c. c. of solution of potassium permanganate[24] added; the flask is then placed in a bath of boiling water and kept there for exactly thirty minutes. At the end of that period, the flask is removed, 10 c. c. of ammonium oxalate solution[25] added, and the clear fluid titrated with the standard permanganate solution until a faint but distinct color is obtained.

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[23] One part of sulphuric acid to 3 parts of distilled water.

[24] This standard solution contains 0.4 gm. of potassium permanganate in one litre of distilled water.

[25] This solution contains 0.888 gm. of ammonium oxalate in one litre. One c. c. of this solution should neutralize one c. c. of the permanganate.

Each cubic centimetre of the standard permanganate in excess of the oxalate solution represents 0.0001 gram of oxygen consumed by the sample. This, multiplied by 10, equals parts per million.

Significance.—This determination indicates the presence of organic carbon. If the oxygen required is high and the ammonias excessive, the indications are that the pollution is of vegetable origin; while if the ammonias are high and the oxygen required low, the pollution is in all probability animal in character.

CHLORINE.—Solutions required: 1. Standard silver-nitrate solution. To 1 litre of pure distilled water add 4.788 grammes of pure silver nitrate ($AgNO_3$). One cubic centimetre of this solution is equivalent to 1 milligramme of chlorine. 2. Potassium-chromate solution. A 10-per-cent. solution of potassium chromate (K_2CrO_4) in distilled water free from chlorine.

Process: To 100 c. c. of the water to be tested add a few drops of the potassium-chromate solution, and then run in the silver-nitrate solution from a graduated burette, adding it drop by drop and stirring the water continually with a glass rod. Continue until a faint but permanent orange-red tint has been produced, showing that all the chlorine has been combined with the silver, the persisting reddish tint being due to silver chromate. The number of cubic centimetres of silver-nitrate solution used indicate the number of milligrammes of chlorine in 100 c. c. of the water, or the parts per 100,000; this multiplied by 10 gives the number of milligrammes of chlorine in 1 litre, or parts per million. If the water contain but little chlorine, the test will be more accurate if 250 c. c. of the water be first evaporated over a water-bath to about 50 c. c. before proceeding as above: four times the result will then give the number of milligrammes of chlorine in 1 litre. Should it be desired to express the proportion in terms of sodium chloride, multiply the result, obtained as above, by 1.648; or make up the silver-nitrate solution by adding 2.905 grammes to the litre, each cubic centimetre of this solution being then equal to 1 milligramme of sodium chloride.

Significance.—Chlorine, or its compounds, when present in drinking-water, indicates generally sewage pollution. It is true that chlorine may be in excess in water, and the latter, nevertheless, be entirely free from sewage or urine, but this occurs only where there is a natural deposit of chlorine compound in the soil from which the supply is drawn. If communication with the sea or salt-deposits is excluded, the chlorine may be assumed to be due to the inflow of sewage.

HARDNESS.—Solutions required: 1. Soap solution. Dissolve about 10 grammes of Castile or soft soap in 1 litre of weak (35 per cent.) alcohol. 2. Standard lime solution. Dissolve 1.11 grammes pure calcium chloride in 1 litre of distilled water. One cubic centimetre of this solution is equivalent to 1 m. g. of calcium carbonate ($CaCO_3$). Process: First, find how much of the soap solution is needed to make a lather with 100 c. c. of distilled water, as follows: Place the water in a flask holding about 250 c. c. and run in the soap solution from a burette, a few drops at a time, corking and shaking the flask well after each addition. The lather should have a depth of about one-fourth of an inch, and should be permanent for at least five minutes. Then standardize the soap solution by diluting 5 c. c. of the standard lime solution to 100 c. c. with distilled water and finding how many cubic centimetres of the soap solution are necessary to make a permanent lather with it. This quantity, less the number of cubic centimetres needed to make a lather with the 100 c. c. of distilled water, represents the amount of soap solution that will neutralize 5 m. g. of calcium carbonate or its equivalent. Lastly, determine in the same way the number of cubic centimetres of soap solution necessary to make a permanent lather with 100 c. c. of the water to be examined; subtract the quantity necessary for 100 c. c. distilled water and estimate the amount of calcium carbonate or its equivalents present, as follows: For example, it takes 2 c. c. of soap solution to make a lather with the distilled water and 12 c. c. with the diluted lime solution. Then, 12 — 2 = 10 c. c. = 5 m. g. calcium carbonate, and each cubic centimetre of the soap solution = 0.5 c. c. of the standard lime solution, or 0.5 m. g. calcium carbonate. Consequently, if 100 c. c. of the water examined require 17 c. c. of soap solution, it must contain $(17 - 2) \times 0.5 = 7.5$ m. g. calcium carbonate or its equivalent, and 1 litre of the water contains 75 m. g. calcium carbonate.

LEAD, COPPER, AND IRON.—To 50 or 100 c. c. of the water in a white porcelain dish, or in a tall glass jar, over white paper, add a few drops of ammonium sulphide,—$(NH_4)_2S$. A dark coloration or precipitate indicates the presence of either lead, copper, or iron, due to the formation of the respective sulphide. Then add a few drops of hydrochloric acid (HCl). If the color disappear, iron only is present; if it persist, lead or copper is present. In the latter case, add a few drops of acetic acid and about 1 c. c. of a strong solution of pure potassium cyanide. If the color disappear, it is due to copper; if it remain, lead is present. If lead only is present in the water, the above test will detect $^1/_{10}$ grain per gallon. The above test may be corroborated as follows: Partly fill two test-tubes with the original water; to one add a little potassium-chromate solution; an opacity and the deepening of the color to a canary yellow indicates lead. To the second add a drop of dilute hydrochloric acid and a few drops of potassium-ferrocyanide solution; a blue color indicates iron, either ferrous or ferric; a bronze or a mahogany-red color indicates copper. Quantitative tests for the above metals may be made by making standard solutions of the respective elements, treating a measured quantity of the original water with the proper reagent, as indicated, and comparing the color produced with that given by a definite quantity of the respective standard solution.

PHOSPHATES.—Solution required, ammonium molybdate: Dissolve 10 grammes of molybdic anhydride in 41.7 c. c. of ammonia (NH_4HO),—sp. gr. 0.96,—and pour slowly into 125 c. c. of nitric acid (HNO_3),—sp. gr. 1.20; allow to stand in a warm place for several days till clear. Process: slightly acidify 500 c. c. of the water with nitric acid, evaporate to about 50 c. c., add a few drops of ferric chloride (Fe_2Cl_6) and ammonia in slight excess. Filter, dissolve the precipitate in the smallest possible quantity of nitric acid, and evaporate to 5 c. c. Heat nearly to boiling; add 2 c. c. of ammonium-molybdate solution; keep solution warm for one-half hour. If there is an appreciable quantity of precipitate, collect it on a small, weighed filter-paper, wash with distilled water, dry at 100° F., and weigh. The weight of the precipitate multiplied by 0.05 gives the amount of phosphates as PO_4 in the 500 c. c. of water.

Bacteriological Examination.—The following method of procedure has been recommended by the committee on laboratory methods of the American Public Health Association:—

MEDIA.—The standard medium for determining the number of bacteria in water shall be nutrient gelatin, and for polluted waters which cannot be plated promptly after collection agar may be substituted. All variations from these two media shall be considered as special media. If any medium other than standard gelatin is used, this fact shall be stated in the report. For general work the standard reaction shall be 1 per cent. acid, but for long-continued work upon water from the same source the optimum reaction shall be ascertained by experiment and thereafter adhered to. If the reaction used, however, is different from the standard, it shall be so stated in the report.

PROCEDURE.—Shake at least twenty-five times the bottle which contains the sample. Withdraw 1 c. c. of the sample with a sterilized pipette and deliver it into a sterilized Petri dish 10 centimetres in diameter. If there is reason to suspect that the number of bacteria is more than 200 per cubic centimetre, mix 1 c. c. of the sample with 9 c. c. of sterilized tap or distilled water, and so on. Shake twenty-five times and measure 1 c. c. of the diluted sample to a Petri dish. If a higher dilution is required, proceed in the same manner, *e.g.*, 1 c. c. of the sample to 99 c. c. of sterilized water, or 1 c. c. of the once diluted sample to 99 c. c. of sterilized water, and so on. In the case of an unknown water it is advisable to use several different dilutions for the same sample. To the liquid in the Petri dish add 10 c. c. of standard gelatin at a temperature of about 30° C., or 10 c. c. standard agar at a temperature of about 40° C. Mix the medium and water thoroughly by tipping the dish back and forth, and spread the contents equally over the bottom of the plate. Allow the gelatin to cool rapidly on a horizontal surface and transfer to the 20° C. incubator as soon as it is hard. Incubate the culture for forty-eight hours at a temperature of 20°C. in a dark, well-ventilated incubator where the atmosphere is practically saturated with moisture. After this period of incubation place the Petri dish on a glass plate suitably ruled, and count the colonies with the aid of a lens which magnifies at least five diameters. So far as practicable, the number of colonies upon the plate shall not be allowed to exceed 200. The whole number of colonies upon the plate shall be counted, the practice of counting a fractional part being resorted to only in case of necessity.

When agar is used for plating, it will be found advantageous to use Petri dishes with porous earthenware covers in order to avoid the spreading of colonies by the water of condensation.

For the detection of B. coli and other specific bacteria consult text-book on bacteriology.

QUESTIONS TO CHAPTER II.

WATER.

For what purposes do people need water? Why should the supply be pure? What is the quantity needed by each person daily, and what quantity should be supplied per head in towns and cities for all purposes? How may waste of water be prevented? What is the objection to the use of water-meters?

What is the original source of all fresh water? How is rain-water usually collected and stored? What are the objections to underground cisterns? What is the only material of which underground cisterns should be made?

From what source do most cities and towns derive their water-supply? What precautions must be observed regarding such a source? What are some of the minor objections to the use of river-water? What peculiar diseases may be due to such water? What is the most serious objection to the use of river-water for domestic purposes?

How does a running stream purify itself? Can this self-purification be relied upon? Can it be stated definitely when a stream once polluted becomes fit for use again? Is it safe to use water from a stream known to have been contaminated by sewage?

What is usually the quality of water from fresh-water lakes and ponds? What large city uses lake-water entirely? What precautions must be observed regarding such a source of supply? To what is the offensive taste and odor of water from small lakes or storage-reservoirs often due?

Does water purify itself absolutely in freezing? What matters may be found in ice? Are all pathogenic micro-organisms destroyed by freezing? What part of ice is the purest?

What class of persons usually derive their drinking-water from springs and wells? What is the relative purity of spring- and of well-water? Why? What changes take place in diluted organic matter in percolating through the soil? To what are these changes due? What may retard or check these changes? Is water containing nitrites and nitrates necessarily dangerous? Of what are nitrites and nitrates an indication?

Name some of the qualities that are desirable in water for drinking or domestic purposes. When is a water said to be hard?

To what is the hardness of water due? What is the distinction between "removable" or "temporary" and "permanent" hardness, and what is meant by "total" hardness? How is the degree of hardness determined, and upon what does the test depend? Describe the test. Why is hard water objectionable for domestic use?

What diseases and derangements of health may be due to hard water? Is the evidence absolute regarding all of these? What troubles may large amounts of suspended mineral matter cause? How may such water be clarified? What mineral in the water is essential to the process?

What may be the effect of large quantities of organic matter in the water? What infectious diseases may be due to impure drinking-water? What other organisms harmful to health, other than bacteria, may be found in drinking-water? Name some notable places where epidemics have been undoubtedly caused by impure drinking-water. How may a milk-supply be infected by impure water? How might a water be polluted in distribution, even though the source be pure?

What is the advantage of a prolonged storage of river-water? What waters should not be stored in lead-lined cisterns or conveyed in leaden pipes? What is the greatest amount of lead permissible in water?

In what ways may water be purified on a large scale? Explain the process of sand filtration.

What methods may be used in the household for the purification of water? How may the water be softened? How may disease germs and other organisms in water be destroyed? How may organic matter be removed? What are some good filtering materials? What are some of the essential requisites of a good house-filter? What is necessary that every house-filter may be safe for use? Are any filters absolutely germ-proof?

How are the color, transparency, and odor of water determined, and what is the standard of comparison? Is a turbid or colored water necessarily harmful, and may a perfectly-clear water be dangerous to use?

How are the total solids of a water determined quantitatively? Describe the permanganate-of-potash test for the determination of the organic matter in water. What does an excess of chlorine or chlorides in water generally indicate, and why? How may these be determined quantitatively? If sewage contamination of a water be suspected, how may the suspicion be confirmed? Why should the presence of nitrites or nitrates in water excite the suspicion of sewage contamination. Give a test for each. By what reagent is the presence of ammonia determined?

How may we know whether an excess of chlorides is due to sewage contamination or not? What is the probable source of ammonia if in excess and in company with nitrates, etc.? Which is supposed to indicate the most recent contamination, nitrites or nitrates? What does the presence of nitrates without nitrites or ammonia indicate? What lime-salt is most readily removed by boiling?

What relation has the organic matter to the nitric acid?

Into what four classes may water be divided? Name some of the characteristics of these different classes.

What are the solutions needed in the quantitative test for chlorine? What is the strength of each, and what is the relation of the silver-nitrate solution to chlorine? What is the use of the potassium-chromate solution?

How may the result be expressed? What solutions are used in testing for nitrates quantitatively?

In testing for hardness, why is a standard lime solution necessary? What should be the characteristics of the lather produced by the soap solution? Why is alcohol used as a solvent for the soap? What is the underlying principle of this test?

How may lead, copper, or iron be detected in water? How may you distinguish between the respective sulphides of the above metals? How may the above test respecting any one of the metals be corroborated? How delicate is the test, as regards lead? How might a quantitative determination of these metals be made? What is the principal reagent used in the test for phosphates?

How may a bacteriological examination of water be made? What precautions must always be observed in such examinations?

CHAPTER III.

FOOD.

In order to preserve health and vigor it is necessary for animal beings to consume at intervals a sufficient quantity of substances known as food. Alimentary substances, or foods, may, therefore, be briefly defined as materials which, taken into the body and assimilated, sustain the processes of life, promote growth, or prevent destruction of the organized constituents of the body.

According to Atwater,[1] a food is a "material which, when taken into the body, serves to either form tissue or yield energy, or both." This definition includes all the ordinary food-materials, since they build tissue as well as yield energy; but it excludes creatin, creatinin, and other so-called meat-extractives and likewise thein or caffein of tea and coffee, as they neither build tissue nor yield energy.

QUANTITY AND CHARACTER OF FOOD NECESSARY.

It has long been known, as the result of the empirical observation of feeding large bodies of people, that the various proximate principles composing the tissues must be combined in certain definite proportions in the food in order to preserve the normal degree of health and vigor of the body. Within a comparatively recent period physiologists have made experiments upon animals and human beings which have led to the same conclusions, and have enabled these proportions to be fixed with more or less exactness.

Considering man as an omniverous animal, it may be laid down as an invariable rule that the following four alimentary principles are necessary to his existence.[2] Neither of these principles can be dispensed with for a prolonged period without illness or death resulting.

1. *Water.*—This must be supplied in sufficient quantity to permit the interchange of tissue to be carried on in the body.

2. *Salts.*—Inorganic compounds of various kinds are necessary to the preservation and proper construction of the tissues. They are all found in sufficient quantities in the various alimentary substances

[1] U. S. Department of Agriculture, Bul. No. 21.
[2] Physiologie, Landois, 2te Aufl., p. 448.

consumed by man and the lower animals. A deficiency of inorganic constituents in the food is followed by disease.

3. *Proteids.*—Organic nitrogenous material, either animal or vegetable, is a necessary constituent of the food of man. Continued existence is impossible without a sufficient supply of nitrogenous substances.

4. *Fats or Carbohydrates.*—The organic non-nitrogenous or carbonaceous principles of food are also necessary to the continuance of health. They are supplied either by fats or by carbohydrates (sugar, starch, etc.), which may, within certain limits, be used as substitutes for each other. Voit has shown that 17 parts by weight, of starch, are equivalent as carbonaceous or oxidizable food to 10 parts of fat.

The physiology of nutrition has been very carefully studied by a large number of experimental physiologists, who have arrived at conclusions differing widely from those generally accepted by the older writers on the subject. The division of foods into plastic and respiratory foods, or, in a general way, into proteids, or muscle-builders, and fats and carbohydrates, or oxidizing foods, is now no longer recognized in science. It has been established that proteid tissues are not alone the result of proteid food, and that the accumulation of fat in the body is not altogether due to the excessive consumption of fats and carbohydrates. It has been further shown, contrary to the general belief, that the nitrogenous or proteid tissues are not used up during hard labor any faster than when at perfect rest, but that, on the contrary, increased muscular exertion is attended by increased consumption of stored-up fat.

These facts have led to a modification of the standard dietaries formerly employed. At present the standards of the quantity of food principles required to maintain equality between bodily income and expenditure are those calculated by Professor Voit, and Professor Atwater in this country, after many experiments upon human beings and the lower animals. These standards are as follow:—

TABLE XV.

ADULT MALE OF AVERAGE WEIGHT.

	At Rest.	Moderate Labor.	Severe Labor.
Proteids	110 grammes	118 grammes	145 grammes
Fats	50 "	50 "	100 "
Carbohydrates . .	450 "	500 "	500 "

TABLE XVI.

Comparative Cost of Digestible Nutrients and Energy in Different Food Materials of Average Prices.[3]

[It is estimated that a man at light to moderate muscular work requires about 0.23 pounds of protein and 3,050 calories of energy per day.]

Kind of Food Material	Price per Pound	Cost of 1 Pound Protein[4]	Cost of 1000 Calories Energy[4]	Amounts for 10 Cents: Total Weight of Food Material	Protein	Fat	Carbohydrates	Energy
	Cents	*Dollars*	*Cents*	*Pounds*	*Pound*	*Pound*	*Pounds*	*Calories*
Beef, sirloin	25	1.60	25	0.40	0.06	0.06	....	410
Beef, sirloin	20	1.28	20	.50	.08	.08	....	515
Beef, sirloin	15	.96	15	.67	.10	.11	....	685
Beef, round	16	.87	18	.63	.11	.08	....	560
Beef, round	14	.76	16	.71	.13	.09	....	630
Beef, round	12	.65	13	.83	.15	.10	....	740
Beef, shoulder clod	12	.75	17	.83	.13	.08	....	595
Beef, shoulder clod	9	.57	13	1.11	.18	.10	....	795
Beef, stew meat	5	.35	7	2	.29	.23	....	1,530
Beef, dried, chipped	25	.98	32	.40	.10	.03	....	315
Mutton Chops, loin	16	1.22	11	.63	.08	.17	....	890
Mutton, leg	20	1.37	22	.50	.07	.07	....	445
Mutton, leg	16	1.10	18	.63	.09	.09	....	560
Roast pork, loin	12	.92	10	.83	.11	.19	....	1,035
Pork, smoked ham	22	1 60	13	.45	.06	.14	....	735
Pork, smoked ham	18	1.30	11	.56	.08	.18	....	915
Pork, fat salt	12	6.67	3	.83	.02	.68	....	2,950
Codfish, dressed, fresh	10	.93	46	1	.11	....	....	220
Halibut, fresh	18	1.22	38	.56	.08	.02	....	262
Cod, salt	7	.45	22	1.43	.22	.01	....	465
Mackerel, salt, dressed	10	.74	9	1	.13	.20	....	1,135
Salmon, canned	12	.57	13	.83	.18	.10	....	760
Oysters, solids, 50 cts. per qt.	25	4 30	111	.40	.02	....	.01	90
Oysters, solids, 35 cts. per qt.	18	3.10	80	.56	.03	.01	.02	125
Lobster, canned	18	1.02	46	.56	.10	.01	....	225
Butter	20	20.00	6	.50	.01	.40	....	1,705
Butter	25	25.00	7	.40	....	.32	....	1,365
Butter	30	30.00	9	.33	....	.27	....	1,125
Eggs, 36 cents per dozen	24	2,09	39	.42	.05	.04	....	260
Eggs, 24 cents per dozen	16	1.39	26	.63	.07	.06	....	385
Eggs, 12 cents per dozen	8	.70	13	1.25	.14	.11	....	770
Cheese	16	.64	8	.63	.16	.20	.02	1,185
Milk, 7 cents per quart	3½	1.09	11	2.85	.09	.11	.14	885
Milk, 6 cents per quart	3	.94	10	3.33	.11	.13	.17	1 030
Wheat flour	3	.31	2	3.33	.32	.03	2 45	5,440
Wheat flour	2½	.26	2	4	.39	04	2.94	6,540
Corn meal, granular	2¼	.32	2	4	.31	.07	2 96	6,540
Wheat breakfast food	7½	.73	4	1.33	.13	.02	.98	2,235
Oat breakfast food	7½	.53	4	1.33	.19	.09	.86	2,395
Oatmeal	4	.29	2	2.50	.34	.16	1.66	4,500
Rice	8	1.18	5	1.25	.08	....	.97	2,025
Wheat bread	6	.77	5	1.67	.13	.02	.87	2,000
Wheat bread	5	.64	4	2	.16	.02	1.04	2,400
Wheat bread	4	.51	3	2.50	.20	.03	1.30	3,000
Rye bread	5	.65	4	2	.15	.01	1 04	2,340
Beans, white, dried	5	.29	3	2	.35	.03	1.16	3,040
Cabbage	2½	2.08	22	4	.05	.01	.18	460
Celery	5	6.65	77	2	.02	....	.05	130
Corn, canned	10	4.21	23	1	.02	.01	.18	430
Potatoes, 90 cents per bushel	1½	1.00	5	6. 7	.10	.01	.93	1,970
Potatoes, 60 cents per bushel	1	.67	3	10	.15	.01	1.40	2,950
Potatoes, 45 cents per bushel	¾	.50	3	13.33	.20	.01	1 87	3,935
Turnips	1	1.33	8	10	.08	.01	.54	1,200
Apples	1½	5.00	8	6.67	.02	.02	.65	1,270
Bananas	7	10.00	27	1.43	.01	.01	.18	370
Oranges	6	12.00	40	1.67	.01	....	.13	250
Strawberries	7	8.75	47	1.43	.01	.01	.00	215
Sugar	6	....	3	1.67	....	....	1.67	2,920

[3]Principles of Nutrition and Nutritive Value of Food. By W. O. Atwater. U. S. Dept. Agr. Bull. No. 142.

[4]The cost of 1 pound of protein means the cost of enough of the given material to furnish 1 pound of protein, without regard to the amounts of the other nutrients present. Likewise the cost of energy means the cost of enough material to furnish 1,000 calories without reference to the kinds and proportions of nutrients in which the energy is supplied. These estimates of the cost of protein and energy are thus incorrect in that neither gives credit for the value of the other.

As the average weight of women is less than that of men, a reduction of from 15 to 20 per cent. in the various food principles may be made for the female ration.

The relative proportion of nitrogenous to non-nitrogenous principles in this ration is about 1 to 5. In the older diet standards, *e.g.*, Moleschott's, the proportion of nitrogenous to non-nitrogenous principles is much larger, being, for a man at moderate labor, proteids, 130 grammes; fats, 84 grammes; and carbohydrates, 404 grammes, or about 1 to 3.75.

While from ignorance, or motives of economy, many men sustain life and preserve health at hard labor on rations varying considerably from the standard above given, it is probable that, all things being considered, the most perfect physiological ration would also be the most economical. Thus, Professor Vaughn proposes a daily ration consisting of bread, cod-fish, lard, potatoes, bacon, beans, milk, sugar, and tea in such proportions as to furnish 123 grammes proteids, 70 grammes fats, and 550 grammes carbohydrates. The total cost or money value of this ration at present prices is about thirteen cents. In actual food value it is not inferior to the daily fare of the *habitué* of Delmonico's. (See Table XVI.)

In estimating the food requirements of the organism, account is taken of the fact that the body takes in potential energy in the form of food and generates kinetic energy in the form of heat and motion.

"Heat and muscular power are forms of force or energy. The energy latent in the food is developed as the food is consumed in the body. The process is more or less akin to that which takes place when coal is burned in the furnace of the locomotive. For the burning of the food in the body or the coal in the furnace, air is used to supply oxygen. When the fuel is oxidized, be it meat or wood, bread or coal, the latent energy becomes active, or, in technical language, the potential energy becomes kinetic; it is transformed into heat and power. As various kinds of coal differ in the amount of heat given off per ton, so various kinds of food and food ingredients give off different amounts of energy; that is, have different values as fuel in the body."[5]

The unit of measurement of the fuel-valve of food is a *calorie*, which is the amount of heat required to warm one gramme of water one degree centigrade. One calorie is equal to about 1.54 foot-tons; in other words, one calorie, when transformed into mechanical power, would lift one ton 1.54 feet.

[5] Atwater. U. S. Department of Agriculture, Bull. No. 142.

TABLE XVII.

Standard Dietaries (Hutchison).

For a man at moderate muscular work.

Food Materials	Amount	Proteids	Fats	Carbo-hydrates	Fuel Value
I.	*Ounces*	*Pounds*	*Pounds*	*Pounds*	*Calories*
Beef, round steak	13	0.14	0.12	......	695
Butter	3	......	0.16	......	680
Potatoes	6	0.02	......	0.15	320
Bread	22	0 12	0.02	0.75	1760.
	44	0.28	0.30	0.90	3455
II.					
Pork, salt	4	......	0.21	......	880
Butter	2	......	0.11	......	450
Beans	16	0.23	0.02	0.59	1615
Bread	8	0.04	0.01	0.28	640
	30	0.27	0.35	0 87	3585
III.					
Beef, neck	10	0.10	0.09	......	550
Butter	1	......	0 05	......	225
Milk, one pint	16	0.04	0.04	0.05	325
Potatoes	16	0.02	......	0.15	320
Oatmeal	4	0.04	0.02	0.17	460
Bread	16	0.09	0.02	0.56	1280
Sugar	3	......	......	0.19	345
	66	0.29	0.22	1.12	3505
IV.					
Beef, upper shoulder	10	0.09	0.13	......	800
Ham	6	0.06	0.13	......	650
Eggs, two	3	0.03	0.02	......	135
Butter	2	......	0.11	......	450
Milk, one pint	16	0.04	0.04	0.05	325
Potatoes	12	0.01	......	0.11	240
Flour	9	0 05	0.01	0.38	825
Sugar	1	......	......	0.06	115
	59	0.28	0.44	0.60	3540

TABLE XVII—(Continued).

Standard Dietaries (*Hutchison.*)

For a man at moderate muscular work.

FOOD MATERIALS	Amount	Proteids	Fats.	Carbo-hydrates	Fuel Value
V.	*Ounces*	*Pounds*	*Pounds*	*Pounds*	*Calories*
Sausage	4	0.03	0.11	......	510
Codfish	14	0.07	......	......	140
Butter	2	......	0.11	......	450
Milk, one pint	16	0.04	0.04	0.05	325
Beans	5	0.07	0.01	0.18	505
Rice	2	0.01	......	0.10	205
Potatoes	16	0.01.	......	0 23	420
Bread	9	0.04	0.01	0.28	640
Sugar	3	......	......	0.19	345
	71	0.27	0.28	1.03	3540
VI.					
Beef	8	0.08	0.10	......	560
Mackerel, salt	4	0.04	0.04	......	230
Eggs, two	3	0.03	0.02	......	135
Butter	2½	......	0.13	......	565
Cheese	1	0.02	0 02	......	130
Milk, one pint	16	0.04	0.04	0.05	325
Potatoes	8	0 01	......	0.08	160
Rice	2	0.01	......	0.10	205
Bread	9	0.05	0.01	0.32	720
Sugar	1½	......	......	0 09	175
	55	0.28	0.36	0.64	3205

The caloric value of the different food-stuffs has been estimated by Atwater as follows:—

Protein, fuel value, 4.1 calories per gram, or 1859 calories per pound. Fats, fuel value, 9.3 calories per gram, or 4218 calories per pound. Carbohydrates, fuel value, 4.1 calories per gram, or 1859 calories per pound.

To calculate the caloric value of any food, multiply the number of grammes of proteins by 4.1, the number of grammes of fat by 9.3, and the number of grammes of carbohydrates by 4.1.

An ideal ration, suggested by Mrs. E. H. Richards, consists of proteids, 106.80 grammes; fats, 57.97 grammes, and carbohydrates, 389.80 grammes. On the other hand, Professor Chittenden, of Yale, maintained himself for nine months in an excellent physical condition and in perfect nitrogenous equilibrium on a ration which consisted of about one-third the usual requirement of proteids, while the total daily fuel-value of his diet was only about one-half the usual requirement. He also experimented on a group of thirteen volunteers from the Hospital Corps, United States Army. They ranged in age from 21 to 43 years, and were of different nationalities. These men did average work, engaging daily in gymnastics and other physical labor. Their daily menu, with slight variations, was about as follows:—

Breakfast.—Boiled hominy, 150 grammes; milk, 125 grammes; sugar, 30 grammes; butter, 10 grammes; bread, 30 grammes; coffee, one cup.

Dinner.—Split pea soup (thick), 200 grammes; bread, 75 grammes; mashed potatoes, 100 grammes; pickles, 30 grammes; coffee, one cup; pie, 120 grammes.

Supper.—Suet-pudding, 150 grammes; apple-sauce, 125 grammes; crackers, 25 grammes; tea, one cup.

Total nitrogen, 7.412 grammes. Fuel value, 2000 calories. On this diet, poor in nitrogen, these men lived for six months, and at the end of the experiment were in a better physicial condition than when they commenced.

A group of eight young college athletes were kept for five months on a diet equally poor in proteids, with the result that they gained in strength.

What has thus far been said about the ingredients of food and the ways they are used in the body may be briefly summarized in the following schematic manner (Atwater):—

Nutritive ingredients (or nutrients) of food.

- Food as purchased contains—
  - Edible portion ...... *e.g.*, flesh of meat, yolk and white of eggs, wheat, flour, etc.
    - Water.
    - Nutrients ..
      - Protein.
      - Fats.
      - Carbohydrates
      - Mineral matters.
  - Refuse. *e.g.*, bones, entrails, shells, bran, etc.

Uses of nutrients in the body.

Protein .... *e.g.*, white (albumen) of eggs, curd (casein) of milk, lean meat, gluten of wheat, etc.	Forms tissue	All serve as fuel to yield energy in the forms of heat and muscular power.
Fats .... *e.g.*, fat of meat, butter, olive oil, oils of corn and wheat, etc.	Are stored as fat.......	
Carbohydrates .... *e.g.*, sugar, starch, etc.	Are transformed into fat.	
Mineral matters (ash) .. *e.g.*, phosphates of lime, potash, soda, etc.	Share in forming bone, assist in digestion, etc.	

In addition to maintaining a proper proportion between the various alimentary principles, it is necessary to vary the articles of food themselves, otherwise they are liable to prove nauseating. The necessity of variety in the food, in order to preserve the appetite, is familiar to every one.

If a man wished to live on beef alone he would be obliged to eat about 2 kilogrammes per day in order to get a sufficient amount of non-nitrogenous food. Of potatoes, in order to get enough nitrogenous food, he would have to eat 8 kilogrammes. No human stomach could prove equal to the task of digesting this excess of material. On the other hand, it is to be noted how perfect the combination of the various principles is in human milk. In cow's milk, which is nearest in composition to human milk, the non-nitrogenous principles are deficient. Hence, the important practical point that when ordering milk diet for a patient a small portion of carbonaceous food (bread, rice, or sugar) must be added if the standard of health shall be reached or maintained.

Climate has probably very little influence upon the amount of food required by the individual. The actual quantity of food consumed varies little between various races or in different parts of the earth. It is true, however, that a larger proportion of fat is required in cold climates. That fatty articles of food readily undergo oxidation and furnish a large amount of animal heat is proven both by observation and experiment.

The albuminoid proximate principles of the food, proteids, are represented by the nitrogenous constituents of organic tissues. These are the vitellin and albumin of eggs, albumin, fibrin, globulin, myosin, syntonin, and other nitrogenized principles of flesh and blood; the casein of milk, the gluten, fibrin, and legumin of cereal and leguminous seeds and plants, gelatin, and chondrin.

Fat constitutes an integral component of animal tissue, and is found in abundance as a constituent of nerve-tissue, marrow, and subcutaneous connective tissue. In food it is represented especially in the fatty tissue of meat, the yelk of eggs, butter, etc.

The carbohydrates are represented especially by various products of the vegetable world, as sugar, starch, dextrin, etc.

Water and various other inorganic proximate principles, chief among which are compounds of calcium, sodium, and potassium, are usually found in sufficient proportion in the other alimentary substances.

The food should be taken in appropriate quantities and properly prepared. A larger quantity than necessary may overtax the digestive organs and thus yield less than the required amount of nutritive material to the body.

Physical exertion increases the consumption of fatty principles. Hence, as in the case of the athlete or prize-fighter in training, larger quantities of these principles are required to keep the nutrition of the body at the standard of health. During mental work, however, less carbohydrate material is consumed than during physical labor.

The greater consumption of carbohydrates during muscular exercise is shown by the following table, which gives the amounts of carbon dioxide and nitrogen excreted by a man at rest and during labor:—

Table XVIII.

	CO_2 Excreted.	Nitrogen Excreted.
At rest	912 grammes	36.3 grammes.
At work	1284 "	36.3 "

In youth the processes of combustion (production of carbon dioxide) go on with greater rapidity than after adult life is reached. For this reason young persons rarely get fat, the fat-producing food being burnt up in the body by the greater metabolic activity of the young cell. Hence, fats and carbohydrates should form a larger relative proportion in the diet of the young than in that of grown persons.

Low external temperature causes a greater and more rapid consumption of fat than high external temperature. During febrile conditions, however, the destruction of stored-up fat in the body—the wasting away—is one of the most notable phenomena; hence the importance of supplying fat and fat-producing food in chronic febrile diseases.

"Der Mensch *ist* was er *isst*," said Ludwig Feuerbach.[6] The pungency of the epigram is somewhat lost in the translation, which is, literally, "Man *is* what he *eats*." The intimate relations of mental, moral, and physical conditions of health to the quality and quantity of food deserve the earnest attention of the educated physician and sanitarian.

CLASSIFICATION OF FOODS.

Foods and victuals are generally divided into foods proper and so-called accessory aliment. The classification is not exact, however, as the latter, which are commonly regarded as articles of luxury, may under certain circumstances become necessities, and hence should not be considered as forming a separate class.

Foods are either of animal or vegetable origin. Those derived from animal sources are milk, the flesh of animals, birds, reptiles, and fish, and the eggs from the three last named.

The foods derived from the vegetable kingdom comprise the seeds of various plants (cereals, legumes), roots, herbs, ripe fruits, the fleshy envelopes of various seeds (which may properly be classed with the fruits), and various fungi.

There are also in common use a number of beverages, *e.g.*, water, alcoholic liquors, alkaloid infusions (tea, coffee, cocoa), etc.

In addition, a number of substances or compounds are in common use as condiments. Their function is either to render victuals more palatable, or to promote digestion and assimilation. Vinegar, mustard, and common salt are familiar examples.

FOODS OF ANIMAL ORIGIN.

Milk.—Human milk is, so far as known, the one perfect food for man found in nature. It contains, in proper proportion, representatives of all the different classes of proximate principles necessary to nutrition. One hundred parts contain about 2.5 parts of proteids

[6] Gottheit, Freiheit und Unsterblichkeit von Standpunkt der Anthropologie, p. 5.

(casein and albumin); 3.9 parts of fat (butter); 6.0 parts of sugar, and .5 of salts. The reaction of human milk is slightly alkaline; that of fresh cow's milk is neutral.

In human milk there are 12.9 parts of solid matter to 87.1 of water, while in cow's milk the proportions are: Proteids, 4.0 per cent.; fats, 3.4 per cent.; sugar, 3.8 per cent.; salts, 0.6 per cent., or 11.8 total solids and 88.2 water.[7]

Of the solids in milk, cow's milk contains more proteids, while human milk is richer in fats and sugar. Hence, in using cow's milk as a substitute for human milk the proteids are diluted by the addition of water, and the non-nitrogenous components increased by adding sugar, and, under some circumstances, fat (cream).

Goats' and asses' milk are sometimes used as substitutes for human milk, but they do not approach much nearer in composition to the latter than does cows' milk.

On standing, the fatty constituent of milk, the cream, separates, and on account of its less specific gravity rises to the surface, where it forms a layer of varying thickness.

After standing a longer interval the milk undergoes certain physical and chemical changes. Lactic acid is formed at the expense of part of the sugar of milk (a sort of fermentation taking place), and, acting upon the casein, produces coagulation. This is the so-called "bonny-clabber." When the fermentation continues, especially under a slightly elevated temperature, the solid portion becomes condensed (curd), and a sweetish-acid, amber-colored liquid, the whey, separates. The curd, after further fermentation, under appropriate treatment, becomes converted into cheese.

Whey is sometimes used alone or mixed with wine as an article of diet for the sick.

Butter is made from the cream by prolonged agitation in a churn. The fat-globules adhere to each other and form a soft, unctuous mass, of a yellowish color, solid at ordinary temperatures. After the butter is all removed in this way the balance of the cream remains in the churn as buttermilk. This is an article of considerable nutritive value, although its excess of acid renders it unsuitable as an article of diet in many cases.

The specific gravity of fresh milk should not be below 1030. It should, however, be borne in mind that the richest milk is not always that which has the highest specific gravity. In fact, a sample of rich milk, containing a large proportion of cream, may show, when

[7] Average of a number of analyses.

tested with the lactometer, a lower specific gravity than a specimen of much poorer milk. Hence, the lactometer, although a useful instrument in guarding against excessive dilution of milk with water, is not a very trustworthy guide in determining the quality of the milk.

Objections are often urged against the use of so-called "skim-milk," *i.e.*, milk from which the cream has been removed. In some cities in this country the police, or representatives of the sanitary authorities, seize and confiscate all skim-milk found in possession of dealers. There appears to be no rational basis for the opinion held by many that skim-milk is not a proper and useful article of food. Before the lactic-acid fermentation has taken place it differs from fresh milk merely in the fatty and other matters removed in the cream. It contains nearly all of the proteids, sugar, and salts of whole milk, and may be used as an article of food with great advantage and entire safety. In certain disordered states it is of exceptional value as an article of diet. The sole objection of any weight to skim-milk is that it may be at times sold fraudulently as fresh milk. This is, however, a question of little sanitary interest, but one principally of commercial ethics.

Milk is frequently adulterated by the addition of water. More deleterious substances are rarely found. An excess of water gives the milk a bluish tinge and reduces its specific gravity. The addition of water may become especially dangerous by introducing the virus of some of the acute infectious diseases. Thus, the localized epidemics of typhoid fever have, in quite a number of instances, been traced to mixing the milk with water containing the germ of this disease. It should, however, be stated that milk which contains the germ of typhoid fever has not necessarily been adulterated by the addition of water. The typhoid bacillus may have been introduced with the water used in washing the can, and adhered to the sides of the latter. In filling the can with milk a good culture medium is supplied in which the typhoid bacillus flourishes. Diphtheria may also be communicated through the milk, by the latter becoming directly contaminated by the specific germs of this disease.

It has long been a mooted question whether acute or chronic infectious diseases of the milk-giving animal may be communicated to persons using the milk of such animals. While there is little positive knowledge upon the subject, it would seem prudent to avoid the use of milk from diseased animals, if possible, or to destroy any organic virus the milk may contain by previously boiling the milk. After thorough boiling little fear need be entertained of communicating either acute or chronic infectious diseases through this medium. Demme and Uffelmann have reported cases which seem to demonstrate the possibility of tuberculous infection through the medium of the milk. Professor Bang, of Copenhagen, made a series of experiments and observations which led him to the conclusion that the milk of tuberculous cows and tuberculous women, in which there are no lesions in the mammary gland, only exceptionally contains the contagion. Professor Bang, at the same time, points out that the milk from tuberculous udders is extremely dangerous, and that the tubercle bacilli are to be found not only in the milk itself, but in the cream, buttermilk, and butter made from it; and that such milk is sometimes infective by ingestion, even after exposure of 65° C. of heat, and by injection into the peritoneal cavity after exposure of 80° C.

The infectiousness of the milk of cows suffering from splenic fever (milzbrand, anthrax) has been proven by Bollinger and Feser. Anthrax bacilli have been found in such milk by Chambrelent and Moussons.

The agency of milk in the spread of scarlet fever is well recognized, but the manner in which the contagion gains access to the milk is not well understood. Several years ago an incident happened in England which seems to prove a close connection between this widespread and fatal disease and a disorder in the milk cattle. The evidence in support of this view is as follows: Mr. W. H. Power, of the English Local Government Board, was detailed to investigate certain outbreaks of scarlet fever which seemed to have especial relation to the milk-supply from a particular dairy-farm. Upon inspection this dairy was found to be in excellent sanitary condition as regards cleanliness, water-supply, sewerage, etc., and for a time considerable difficulty was experienced in locating the cause of the outbreaks. Improbable as it may at first sight appear, it seems to have been incontestably established that the epidemics of scarlatina were due to the use of milk obtained from cows attacked by a peculiar disease manifested by a vesicular eruption followed by ulceration of the udder. The chain of circumstances connecting the disease in the cows with the outbreak of scarlet fever in certain districts in London, supplied with milk from the diseased cows, was so strongly forged by the able investigator into whose hands the work had been committed by the authorities, that hardly a doubt can exist that the one disease owed its origin to the other.

The pathological evidence furnished by Dr. Klein lends strong support to the view that the Hendon cow disease and scarlet fever are intimately related to each other. A bacterial organism was found in the material from the ulcerated udders of the sick cows, which presents similar characteristics to a micro-coccus found by the same observer in the blood of scarlet-fever patients. These results, however, require more extended investigations before they can be unreservedly accepted.

The milk of cows fed upon the refuse of breweries and distilleries —"swill-milk"—is believed by many physicians to be unwholesome. If so, it is, probably, only by reason of the unfavorable hygienic conditions under which the animals are kept. If the stables are clean, dry, well-ventilated, and the animals receive plenty of fresh air and exercise, swill-fed cows should produce as nutritious milk as when they are fed upon different food. Much of the agitation against "swill-milk" is more prompted by political demagogism than by scientific knowledge.

The milk of animals suffering from certain diseases is often dangerous to health. In some of the Western and Southern United States, cows are not infrequently attacked by an acute febrile disease called "the trembles," from one of the prominent symptoms. The milk of cows suffering from this disease produces severe gastro-intestinal disorder, collapse, fever, etc., in the consumer. This disease, called "milk-sickness," is fatal in a pretty large proportion of cases. It is said that the flesh of animals with "the trembles" will, if eaten, produce similar dangerous effects. A late writer (Dr. Beach, of Ohio) estimates that 25 per cent. of the Western pioneers and their families died of this disease.

For the ready determination of the quality of milk, instruments known as lactoscopes, lactometers, and creamometers are used. The lactoscope indicates the opacity of the milk, upon which the proportion of cream depends. One convenient modification of the lactoscope is the little instrument termed the pioscope. This consists of a disk about $6^1/_2$ centimeters in diameter, with a slight depression in the centre. A little milk is placed in the depression and covered with a glass disk, clear in the centre and opaque around the border, which is divided into six divisions of different shades, varying from white to dark gray. The quality of the milk is marked upon the division whose color corresponds with that of the milk in the centre.

A better, but still not very accurate indicator of the quality of the milk, is the creamometer. This consists of a cylindrical glass vessel with the upper half divided up into hundredths. The glass is filled up to the zero mark with milk, and allowed to stand until all the cream has separated. The thickness of this layer is then read off on the scale. In Chevallier's instrument, 10 per cent. of cream is the minimum proportion that should be furnished by the milk.

The specific gravity, which is a fair guide to the quality of the milk, with the reservations above mentioned, is measured by means of the lactometer or lactodensimeter. The specific gravity of good cows' milk should not be less than 1029.

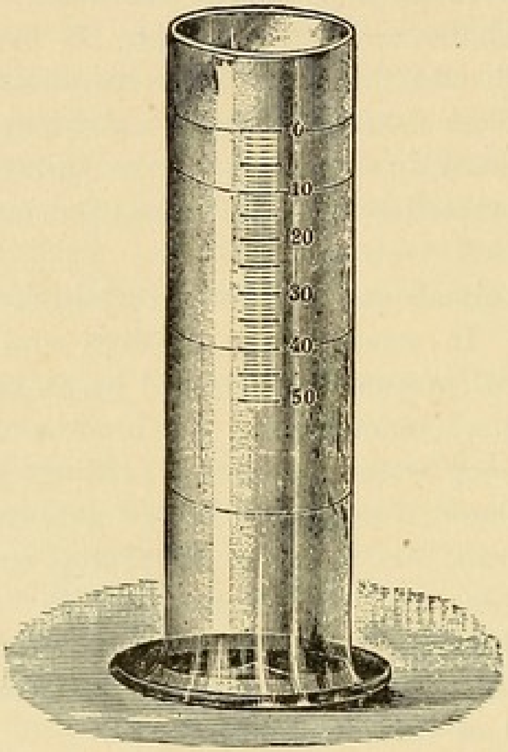

Fig. 10.—Chevallier's Creamometer.

In order to prevent the rapid fermentation of milk various methods of preservation have been adopted. The addition of alkalies, or antiseptics, retards the lactic-acid fermentation, while the abstraction of a portion of the water and addition of sugar (condensed milk) preserves it for an indefinite time. The mere addition of water restores it to nearly its original condition.

Tyrotoxicon in Milk.—This substance, first found in poisonous cheese, and later in milk, ice-cream, custards, etc., is believed by Professor Vaughan to be the cause of true cholera infantum, and many of the clinical phenomena of this disease lend strong support to such a view. The conditions under which the poison is developed have not yet been sufficiently studied to enable correct conclusions to be drawn. Recent studies, however, indicate that the summer diarrhea of infants is caused by putrefactive bacteria in milk. The intimate relation between milk containing large numbers of bacteria and diarrheal diseases in infants and children is becoming more and more apparent.

Butter.—Butter is of especial value as food on account of the large amount of easily digestible fat which it contains. It is almost always used as accessory to other articles of food, to render them more palatable. When pure and fresh, it is one of the most delicious of foods. It soon undergoes the butyric-acid fermentation, however, becoming "rancid," as it is termed, when it is unfit for food.

The great demand for butter and its consequent high price have led to its extensive sophistication. Butter is now very largely substituted by an artificial substitute termed oleo-margarine, or butterine. This artificial butter is made from beef-suet by the following process: Fresh beef-fat is melted at as low a temperature as possible, never higher than 52° or 53° C. [126° to 128° F.]. All membrane and tissue are then removed, and the resulting clear fat is put into presses, where the stearine is extracted. The liquid fat, free from tissue, and with nearly all its stearine removed, is known as "oleo-margarine oil." The next step in the process is the "churning." The oil is allowed to run into churns containing milk and a small quantity of coloring-material (annatto), where, by means of rapidly-revolving paddles, it is churned for about an hour. When this part of the process is complete, the substance is drawn off from the bottom of the churn into cracked ice. When cool it is taken from the ice, mixed with a proper quantity of salt, and is then worked like butter and put into firkins for the market. It is also moulded into attractive prints in imitation of dairy-butter.[8] When the materials from which oleo-margarine is made are sweet and clean, and when the process of manufacture is properly conducted, the resulting product is an entirely harmless article, and probably differs very little in nutritive value from butter itself. The only objection to oleo-margarine is a commercial one. It is so much like butter that dishonest dealers find it possible to substitute this product for the higher-priced natural product.

Cheese.—The value of cheese as a food depends upon the large amount of proteids and fat which it contains. The rich varieties of cheese, such as Fromage de Brie and Roquefort, contain on an average 35 per cent. of fat and 27 per cent. of proteid compounds. Parmesan contains only about 18 per cent. of fat and nearly 40 per cent. of

[8] Dr. W. K. Newton, Fifth Annual Report of the State Board of Health of New Jersey, 1881, p. 107.

proteids, while Edam and Cheshire cheese, which may be considered as standing about midway between the above, contain 30 per cent. of fat and nearly 28 per cent. of proteids. From these figures it appears that cheese is one of the most nutritious aliments obtainable, but it cannot be eaten in large quantities at a time, as it is exceedingly liable to cause disturbances of the digestive organs. The constipating property of cheese is well known to the public.

The relative value of different kinds of cheese in alimentary principles is given in the following table:—

TABLE XIX.

KIND OF CHEESE.	Proteids (per cent.).	Fats (per cent.).	Sugar (per cent.).	Salts (per cent.).
Cheshire	27.68	27.46	5.89	5.01
Edam	24.07	30.26	4.48	4.91
Holland	29.48	26.71	2.27	4.62
Roquefort.	27.69	33.44	3.15	5.35
Neufchâtel	17.44	40.80	5.21	2.05
Parmesan	41.19	19.52	1.18	6.31

Cheese is not often adulterated. The only articles used with success in its sophistication are lard and oleo-margarine, which are incorporated with the casein during the process of manufacture. It sometimes undergoes chemical changes which render it intensely poisonous when eaten.

Professor V. C. Vaughan, of the University of Michigan, has ascertained that the substance causing the poisonous symptoms is a chemical compound termed by him tyrotoxicon. This same poison has also been found by Professor Vaughan and other chemists in ice-cream and fresh milk, which produced poisonous symptoms when consumed. The poison is supposed to be a ptomaine produced by the agency of a micro-organism, which has, however, not yet been isolated.

Meat.—The flesh of mammals, reptiles, birds, fish, and invertebrate animals is used as food by man. Falck[9] has classified the varieties of animals which furnish food to the inhabitants of Europe. There are 47 varieties of the mammalian class, 105 of birds, 7 of amphibia, 110 of fish, and 58 of invertebrates.

[9] Das Fleisch, Gemeinverstændliches Handbuch der Wissenschaftlichen und Praktischen Fleischkunde.

Meat is the most important source of proteids in the food. In the more commonly used varieties of meat the proteids and fats constitute from 25 to 50 per cent. of the entire bulk, the proportion depending largely upon the age of the animal and its bodily condition. The following table shows the influence of these two factors upon the relative proportions of the fats and proteids in the meat:—

TABLE XX.[10]

	Proteids (per cent.).	Fats (per cent.).
Moderately fat beef	21.39	5.19
Lean beef	20.54	1.78
Veal	10.88	7.41
Very fat mutton	14.80	36.39
Fat pork	14.54	37.34
Lean pork	19.91	6.81
Hare	23.34	1.13
Lean chicken	19.72	1.42

The flesh of animals, which is neutral in reaction immediately after death, soon becomes acid in consequence of the formation of lactic acid. The acid, acting upon the sarcolemma and the muscular fibre, renders it softer and more easily permeable by fluids when cooking, and more susceptible to the action of the gastric juice when the meat is taken into the stomach.

Certain kinds of meat—mutton and venison, for example— are often kept so long before being eaten that a considerable degree of putrefaction has taken place when they are brought upon the table. The wisdom of this practice is questionable from a hygienic point of view.

Meat is sometimes eaten raw, but it is usually first cooked. The methods of cooking in general use are boiling, frying, roasting, broiling, and baking. By either of these methods of cooking, when properly carried out, the nutritious properties of the meat are preserved, and it is rendered digestible. The culinary art deserves the closest attention of students of hygiene.

A number of soluble preparations of meat (beef-extract, beef-essence, beef-juice) are found in the market, and highly recommended as containing all the nutritious qualities of the meat from which they

[10] Abridged from Loebisch; article "Fleisch" in Realencyclopædie d. ges. Heilkunde, vol. v, p. 340.

are prepared. These, and similar products of domestic preparation (broths and teas), contain in reality very little nutritive material, but are of use almost solely as stimulants to the appetite and digestion. They have a place in the dietary of the sick but their nutritive value is small.

On the other hand, a number of partly or wholly predigested (peptonized or pancreatized) preparations of meat are offered for sale, many of which have a high nutritive value. They cannot, however, be used as articles of diet except for a short time, or as a temporary succedaneum for meat in diseases attended with weakness or derangement of the digestive organs. Most of the predigested beef-preparations on the market owe their effect to the large amounts of alcohol which they contain.

Meat may be unfit for food from various causes. Thus the flesh of animals dying from certain diseases—splenic fever, pleuro-pneumonia, tuberculosis in its advanced stages, cow- or sheep- pox—should not be used as food when it can be avoided. Cases are on record proving the poisonous character of meat from animals which suffered, at the time of death, from some of the above-mentioned diseases. The most important condition to be borne in mind is that certain parasites (trichina spiralis, echinococcus, cysticercus), which frequently infest the flesh of animals, especially hogs, not infrequently give rise to serious or even fatal diseases in persons consuming such meat. Any meat containing these parasites or suspected of containing them, should therefore not be used as food unless precautions be first taken to destroy the life of the parasite.

Of the parasites mentioned the trichina spiralis is the most important in this connection, as it frequently occurs in the flesh of hogs, rats, dogs, cats, and other carnivorous animals. Rats are said to be infested with the parasite more frequently than any other animals. The trichinæ are found in two forms, one, the mature form, inhabiting the intestinal canal. The immature form, or muscle trichinæ, are found in striped muscle, coiled into spirals and encysted in a fibrous capsule. They gain access to their host in the following manner: Flesh containing living trichinæ is taken into the stomach, where the muscular tissue and the fibrous envelope are dissolved, and the inclosed worms set free. These mature in the intestinal canal, where sexual reproduction takes place, and the young embryos pass through the intestinal walls and other tissues until they become imbedded in striated muscle. Localized epidemics of trichinosis have been reported in this country and Europe, and in nearly every instance the source of the disease has been traced to the ingestion of uncooked pork. Meat known to be trichinous should not be used unless in times of great scarcity. It may, however, be rendered innocuous by thorough cooking. A temperature of 60° to 70° C. (140° to 160° F.) destroys the life of the parasite and renders the meat safe. On account of the frequent occurrence of trichinæ in pork, this meat should never be eaten unless thoroughly cooked. It has been ascertained that salted and smoked pork is not free from danger, as the parasites are not killed in the process of curing the meat. Hence, ham and sausage should not be eaten raw, as the danger from these articles is almost equally as great as from fresh pork.

Cysticercus cellulosa, the transition form of one variety of tape-worm, and which is the parasite in measly pork, may also gain entrance to the human body, and, failing to undergo development, cause very serious lesions of various organs and tissues. The frequency of tape-worm is evidence that pork is often thus diseased.

The use of partially decayed meat or fish has often been the cause of serious or fatal illness. Sometimes the illness partakes of the character of septic infection. In these cases it is probable that the morbid process is due to the action of the organisms of putrefaction. In other cases the symptoms are widely different. These cases have been the source of much perplexity to physicians and toxicologists until very recently. Selmi, Husemann, Brouardel, Casali, and others have drawn attention to certain intensely poisonous chemical compounds found in decomposing flesh, and which have been named by Selmi *ptomaines*. While there is still much uncertainty concerning the nature of these compounds, it seems pretty well established that when flesh undergoes decomposition, in the absence of oxygen, certain unstable chemical combinations are formed which act as violent poisons. Selmi, followed by most toxicologists, believes these compounds to be alkaloids, analogous to the vegetable alkaloids, such as morphine, atropine, etc. Casali, on the other hand, disagrees with this opinion, and believes the ptomaines to be amido compounds. Husemann regards Casali's hypothesis as plausible, inasmuch as the formation of amido compounds in animal and vegetable bodies during decomposition is well established.

The form of poisoning due to the organisms of putrefaction is not infrequent. An extensive outbreak of this nature occurred at Andelfingen, in Switzerland, in 1839. A musical festival was held, at which there were over 700 present. Out of these 444 were suddenly attacked by violent gastro-enteric and nervous symptoms. Ten of the patients died. The illness was traced to roast veal, which had been kept in a warm place for two days after roasting, and which was probaly in a state of partial decomposition.

The class of cases which seem more probably due to the action of ptomaines or related poisons, have been frequently observed after eating sausages or canned meats. Sausage poisoning is not rarely observed in Germany. It has been ascertained that the internal portions of the sausage are the most poisonous. It is supposed that the ptomaines, which are formed in the absence of oxygen, are the active agents in the production of the train of symptoms. Poisoning by canned meat seems to be due to a similar poison.

In July, 1885, an outbreak of disease, due to eating unwholesome beef, was caused at Momence, Illinois. Chemical examination of specimens of the meat showed the presence of an alkaloidal body which was believed to be a ptomaine, but its nature was not definitely determined.

Fish, oysters, crabs, and lobsters frequently give rise to symptoms of poisoning. In most of these cases the poisoning is probably due to partial decomposition, but it is a well-known fact that oysters and crabs are unfit for food at certain seasons. Some persons, however, are subjects of a peculiar idiosyncrasy, in consequence of which shell-fish always produce certain unpleasant symptoms, among which nettle-rash and a choleraic attack are most prominent.

That form of fish-poisoning known among the Spaniards in the West Indies as *siguatera* is, however, very grave. The mortality is large, and in many cases death succeeds rapidly upon the attack. The symptoms are as follow: Sometimes suddenly, sometimes preceded by dizziness and indistinct vision, great prostration and paralysis occur. Often death follows the onset of the symptoms in two and three hours. Exceptionally in less than twenty minutes. In most cases consciousness is totally lost; in others it persists, with interruptions, until death. Sensation and the powers of speech and deglutition fail. The jaw muscles become paralyzed, the pulse is slowed, and the temperature diminished. There is sometimes vomiting, but no purging. The secretion of the kidneys is also checked. Dr. McSherry states[11] that he has seen all these symptoms produced by eating oysters, lobsters, and crabs, unseasonably.

In Russia a form of poisoning has often been observed which results from eating salted sturgeon. In the fresh state these fish are perfectly wholesome, but when salted and eaten raw they produce a

[11] Health and How to Promote it, p. 143.

very fatal illness. The mortality is said to reach 50 per cent. of those attacked. No cases traceable to this cause have been observed in this country. Recent investigations show that many cases of meat poisoning are caused by the bacillus of Gaertner, which belongs to the colon group of intestinal bacteria, while other cases are caused by a bacillus discovered by Van Ermengem in 1896—the bacillus botulinus.

It has been shown, beyond question, that the flesh of beeves suffering, when killed, from splenic fever, will produce this disease in the human subject.

In 1874 an extensive and violent outbreak of an acute disease, characterized by vomiting and purging, fever and dizziness, occurred at Middleburg, in Holland. Three hundred and forty-nine persons were attacked, of whom 6 died. The outbreak was traced to eating liver-sausage (Leberwurst), in which the characteristic bacillus of splenic fever was found on microscopic examination. In July, 1877, an outbreak of choleraic disease, from eating carbuncular meat, occurred in the town of Wurzen. In the latter epidemic the bacillus of splenic fever (*Bacillus anthracis*) was found in the intestinal canal and in the blood of those attacked.

In Detmold, in Germany, an outbreak of violent gastro-intestinal inflammation, accompanied by a high fever, occurred. Among the 150 persons attacked 3 died. The disease was traced to eating the meat of a cow suffering, before death, from pleurisy (probably pleuro-pneumonia).

In July, 1880, 72 persons who had eaten of certain beef and ham-sandwiches in Welbeck, England, were attacked by choleraic diarrhea; 4 of the cases died. Inflammation of the lungs and small intestines was the most prominent pathological condition found post-mortem. The smaller blood-vessels of the kidneys were filled with finger-shaped bacilli, which, when cultivated and inoculated into guinea-pigs, rats, and white mice, produced similar pathological conditions. At Nottingham, England, in 1881, a number of persons were attacked by a similar train of symptoms after eating baked pork. One case terminated fatally out of the 15 attacked. It is uncertain whether the meat in these two instances was from diseased animals or whether it had undergone partial decomposition. The former is the more probable supposition, although the organisms found were neither those of splenic fever nor swine plague, but resembled those of symptomatic anthrax (black leg or black quarter).

Whether the flesh of tuberculous animals can communicate tuberculosis to the consumer is still an unsettled question. Foreign veterinarians and hygienists who have studied the question incline to the view that there is danger of such transmission. At the International Sanitary Congress of 1883, at Brussels, the subject was discussed, and M. Lydtin, the chief veterinary surgeon of the Grand Duchy of Baden, submitted the following propositions, which were adopted by the Congress—

1. That the flesh and viscera of tuberculous animals may be used as food, provided the disease is only commencing, the lesions extending to but a small part of the body, the lymphatic glands being still healthy; provided the tubercle centers have not undergone softening, and provided the carcass is well nourished and the flesh presents the characters of meat of the first quality. 2. That the flesh of animals showing very pronounced tuberculous infection should be saturated with petroleum, and afterward burned under the direction of the police. 3. That the milk from cows affected with pulmonary phthisis, or suspected of having it, should not be consumed by man or other animals, and the sale of it should be strictly prohibited.

The congress for the study of tuberculosis, which met in Paris in 1888, adopted resolutions of a more decided character against the use of meat and milk from tuberculous animals. Recent investigations fully substantiate the opinions expressed at these congresses.

Certain animals can devour with impunity substances which are intensely poisonous to human beings. The flesh of the animals may be impregnated with these poisons, and cause serious and fatal illness in persons partaking of it. In this way may, perhaps, be explained the cases of poisoning sometimes following the eating of partridges and other birds.

The prevention of disease from tainted meat is one of the most important problems of public hygiene. Food animals should be inspected by qualified inspectors before slaughtering, to exclude animals suffering from diseases that would vitiate the meat. When the meat is exposed for sale upon the dealer's stall it should be again inspected, and all found unfit for use as food confiscated and destroyed. Meat, in which the presence of trichinæ or other parasites is suspected, should be examined microscopically.[12] The recent disclosures in connection with the scandalous neglect of sanitary precautions in the

[12] The prevention of the diseases of animals by National and State authorities is one of the most logical and thorough-going means of preventing disease from unwholesome meat. The American Public Health Association has for some years devoted considerable attention to the investigation of the diseases of animals and means for their prevention. The Department of the Interior of the National Government has likewise made the diseases of cattle and hogs a subject of study and published some valuable reports thereon.

packing-houses in Chicago emphasize the necessity of great vigilance in the inspection of meats at these establishments. However, these disclosures, unpleasant as they were at the time, led to prompt eradication of the existing evils.

Eggs.—Although eggs contain a large amount of the proteid and fatty alimentary principles, their value as food has probably been greatly overrated. The savory taste and ready digestibility of eggs have, however, rendered them a popular article of food. For obvious reasons, the eggs of the common barnyard fowl are most frequently used, those of ducks and geese being far inferior in flavor to the first named, and being likewise less easily obtained.

The method of cooking eggs is generally supposed to have considerable influence upon their digestibility. According to Dr. Beaumont's experiments made on Alexis St. Martin, raw eggs are digested in one and a half to two hours, fresh-roasted in two hours and fifteen minutes, soft-boiled or poached in three hours, and hard-boiled or fried in three and a half hours. These experiments are, however, of very little value as a basis for general conclusions. It is probable that a hard-boiled egg is quite as easily digested in the healthy stomach as a raw one, if care be taken to masticate it well and eat bread with it, so that it is introduced into the stomach in a finely-divided state.

Eggs readily undergo putrefaction, when sulphuretted hydrogen is formed in them in large quantities. When this has taken place they are manifestly unfit to be used as food.

FOODS OF VEGETABLE ORIGIN.

Bread.—The various cereal grains, when ground into flour, are used in making bread. The flours of wheat, rye, barley, buckwheat, and Indian corn are almost exclusively used in bread-making. The bran or cortical portion of grain contains a larger percentage of proteid principles than the white internal portion; hence, flours made from the whole grain (bran flour, Graham flour) if finely ground are more nutritious than the white flours. The latter are, however, more digestible, and hence furnish a larger proportion of nutriment, because the principles contained in white flours are absorbed and assimilated to a greater degree.

Good bread should be light, porous, and well baked. The lightness and porosity are due to carbon-dioxide gas imprisoned in cavities of the dough during the process of bread-making. By adding yeast to the dough a fermentation is caused in the latter, in consequence of which a portion of the starch is converted into sugar, and then into alcohol and carbon dioxide. During the process of mixing the dough the entire mass becomes permeated by the gas, which, on heating, expands and leaves the numerous large and small cavities throughout the loaf which indicate properly made bread.

Instead of yeast some persons use leaven, which is simply a portion of fermenting dough saved from a previous baking. A small quantity of this added to a mass of dough starts up the fermentation in a similar manner to that of yeast.

The production of carbon dioxide by fermentation in the dough goes on at the expense of part of the starch. It has been proposed, therefore, to supply the carbon dioxide from without, thus saving the entire amount of the carbohydrates present in the flour. This is accomplished in two ways—first, by the use of some alkaline carbonate or bicarbonate (bicarbonate of sodium, carbonate of ammonium), the carbon dioxide being set free on the application of heat; or, secondly, by forcing gas, previously prepared, into the dough by means of machinery.

Flour is not infrequently adulterated with chalk, gypsum, pipeclay, and similar articles. These are easily detected by adding a mineral acid, which produces effervescence when it comes in contact with the alkaline carbonate used as an adulterant. Potato- and bean- meals are also used as adulterants of the higher grades of flour. Bakers often mix alum with inferior grades of flour. This imparts a greater degree of whiteness to the bread, and, in addition, enables it to retain a large proportion of water, thereby increasing the weight of the loaf.

Formerly diseased grain (ergotized rye) often caused outbreaks of disease when the flour made from the diseased grain was used in bread-making. At present time such accidents rarely occur. In some parts of Italy it is said that an endemic disease—pellagra—is caused by the consumption of diseased Indian corn. The evidence in favor of this view, is, however, not unquestioned.

Potatoes and rice are often used with satisfaction as substitutes for bread. They both contain a large proportion of carbohydrates. Indian corn (hominy) and oatmeal are likewise wholesome and nutritious foods of this class.

The leguminous seeds (beans, peas, lentils) furnish a food containing a large percentage of proteids. According to the analyses of

Kœnig[13] the average composition of the most frequently used legumes in the dried condition is as follows:—

TABLE XXI.

	Beans.	Peas.	Lentils.	Ground-nuts[14]
Water, per cent. . . .	13.6	14.3	12.5	6.5
Solids, per cent. . . .	86.4	85.7	87.5	93.5
Proteids, per cent. . .	23.1	22.6	24.8	28.2
Fats	2.3	1.7	1.9	46.4
Carbohydrates, per cent.	53.6	53.2	54.7 }	15.7
Cellulose, per cent. . .	3.9	5.5	3.6 }	
Ash	3.5	2.7	2.5	3.2

Beans, peas, and lentils are often added to other articles of food with advantage. An important article of food for armies has been made of various legumes ground into flour and mixed with fat, dried and powdered meat, salt, and spice. This constitutes the so-called "Erbswurst," or pea-sausage, which formed such an important part of the dietary of the German army in the Franco-German war of 1871. Bean- and pea- meals are also used sometimes as additions to other flours in bread-making. The dried leguminous fruits cannot be used as regular articles of diet, however, as they soon pall upon the taste, and produce indigestion, nausea, and other intestinal derangements.

Green Vegetables.—The plants usually classed together as "vegetables," the products of the market-garden or truck-farm, comprise cabbages, turnips, parsnips, onions, beets, carrots, tomatoes, lettuce, green peas and beans, and similar articles. They all contain a large proportion of water, a variable proportion of sugar, and a small percentage of proteid principles. Much of their palatability and digestibility depends upon the methods by which they are prepared for the table. All garden vegetables should be used soon after being gathered, as they rapidly undergo decomposition, and are liable to produce derangements of the digestive organs if used under these conditions.

Fruits and Nuts.—These generally contain large quantities of sugar and fats. They form agreeable additions to other articles of diet, but are insufficient to sustain life. The use of fruits usually

[13] Die Menschlichen Nahrungs und Genussmittel, ii, p. 288.

[14] The American pea-nut, the fruit or nut of *Arachis hypogæa*.

produces copious intestinal evacuations, and they are, therefore, especially to be recommended to persons of sedentary occupations, in whom torpidity of the bowels is so frequently present.

Condiments.—Various aromatic herbs and seeds are used as additions to other articles of food, to increase their sapidity and to promote a larger flow of saliva and gastric juice, and so assist digestion. Mustard, pepper, allspice, and vinegar are the principal condiments. Within certain limits they are not injurious, but the tendency in the use of all stimulants is to exceed a healthful limit. Condiments, as well as other stimulants, should be used in moderation.

COOKING.

Much more attention than is generally given should be paid by physicians to the culinary art. The manner in which food is cooked has no little influence upon its digestibility. There can be no question that the extreme prevalence of functional indigestion in this country is almost exclusively dependent upon bad cooking.

The various methods of cooking are boiling, frying, roasting, broiling, and baking. By either of these methods food can be cooked so as to be palatable as well as digestible; on the other hand, the choicest article can be utterly spoiled and rendered unfit to be taken into the human stomach. It depends, therefore, not so much upon the method of cooking, as upon the knowledge and art of the cook.

Boiling.—Meats of all kinds are rendered tender and digestible by boiling. In order to retain the flavor of meat, the water should be boiling when the meat is put into it. By the heat of the boiling water the albumin on the outside of the meat is coagulated and the juices and flavor are retained within. After a few minutes the temperature of the water should be reduced to 71° to 77° C. (160° to 170° F.), and maintained at that height until the meat is tender. By this process a much more savory piece of beef, mutton, or fowl can be obtained than where the meat is put into cold water and thus gradually heated. The latter method is, however, the proper one to be followed when good soup or broth is desired.

In boiling vegetables, as much care is necessary as in boiling meat or fish. Potatoes and rice should be steamed, rather than boiled.

The difficulty of obtaining a good cup of coffee, especially in the northern part of the United States, illustrates the prevailing ignorance upon one of the simplest points in the art of cooking. Coffee should never be served in the form of a decoction; that is to say, it should never be boiled. Properly made it is an infusion, like tea, which no one ever thinks of boiling. The difference between an infusion (especially if made by percolation) and a decoction of coffee can only be appreciated by those who have enjoyed the one and endured the other.

Frying.—Frying, if properly done, is really nothing less nor more than boiling in oil or fluid fat of some kind. Olive-oil is preferable, but is not essential; butter, beef-drippings, lard, or probably cotton-seed oil may be substituted for it without disadvantage. The principle of frying depends upon the fact that the temperature of oil can be raised to such a height as to produce instant coagulation on the surface of meat, fish, or other objects immersed in it while hot; this film of coagulated albumin imprisons the juices and flavors of the meat or fish, and prevents the fat entering and soaking the fibers with grease. Small fish or birds, properly fried, are justly regarded as delicacies by connoisseurs, but the process of saturating these objects with fat while gradually heating them produces a dish that is anything rather than grateful to the palate, or conducive to good digestion.

Roasting.—The fame of the "roast beef of Old England" has passed into song, but, at the present day, beef and other meats are rarely roasted, either in this country or abroad. As Sir Henry Thompson well expresses it,[15] "the joint, which formerly turned in a current of fresh air before a well-made fire, is now half stifled in a close atmosphere of its own vapors, very much to the destruction of the characteristic flavor of a roast." It is probable that the old method of roasting before an open fire produced not only the most savory, but likewise the most nutritious and digestible, meat. It is to be much regretted that the process has fallen so greatly into disuse.

Broiling and Baking.—These methods of cooking are modifications of the process of roasting. Meats or fish, carefully broiled or baked, preserve their natural juices and flavors to a great extent, and retain their digestibility and nutritions properties. Of all methods of cooking these are probably the best known and most satisfactorily applied in this country.[16]

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[15] Food and Feeding, p. 45. London, 1880.

[16] Every one interested in the proper application of the principles of cookery should study the Lomb prize essay of the American Public Health Association, by Mary Hinman Abel, upon "Practical, Sanitary, and Economic Cooking." This little book can be obtained of Dr. I. A. Watson, Secretary, Concord, N. H.; price, 25 cents. See, also, an essay on "The Art of Cooking," by Edward Atkinson, LL.D., in Popular Science Monthly, November, 1889.

ALIMENTARY BEVERAGES.

The alimentary beverages may be divided into two classes,—those depending for their effect upon the alcohol they contain, and those whose active principles reside in certain alkaloids. They are used chiefly as digestive and nervous stimulants.

BEVERAGES CONTAINING ALCOHOL.

The physiological action of alcohol has been pretty fully worked out by Binz and his pupils, and by other experimenters. From these researches, it appears that the first effect of taking alcohol, sufficiently diluted, into the stomach is to increase the flow of the saliva and gastric juice. This effect is probably reflex, and results from a stimulation of nerve terminations in the stomach. The alcohol is rapidly absorbed, and is carried in the blood, without undergoing chemical change, to the nervous centres, lungs, and tissues generally. In the brain the alcohol probably enters into combination with the nervous tissue, modifying the normal activity of the various centres, either increasing the activity, if the alcohol is in small quantity (stimulating effect), or diminishing it if in larger quantity (depressing effect), or entirely suspending the activity of the centres, if in sufficiently large quantity (paralyzing effect).

Alcohol stimulates the vasodilator nerves, causing dilatation of the smaller vessels; in consequence of this the blood is largely sent to the periphery of the body; the blood-pressure diminishes, and heat-radiation is increased. At the same time a portion of the alcohol is used up in the lungs in the production of animal heat, thus economizing the expenditure of fats and proteid, and acting as a true respiratory food. Alcohol does not contribute nutritive material to the body; it only permits that which is stored up to be saved for other uses, by furnishing easily-oxidizable (combustible) material for carrying on the respiratory process, and supplying animal heat.

During the use of alcohol the excretion of urea is diminished. This shows that waste of tissue is retarded in the body.

Regarding the statement of some authorities that alcohol does not undergo any change in the body, but is excreted unchanged, Binz asserts[17] that alcohol appears in the urine only when exceptionally large quantities have been taken, and then in very small proportion. It is not excreted by the lungs, the peculiar odor of the breath being

[17] Realencyclopædie d. ges. Heilk., Bd. I, p. 183.

due not to the alcohol, but to the volatile aromatic ether, which is oxidized with greater difficulty, and so escapes unchanged.

While alcohol produces subjectively an agreeable sensation of warmth in the stomach and on the surface of the body, the bodily temperature is not raised. The subjective sensation is due to the dilatation of the blood-vessels and the sudden hyperæmia of those parts.

During fevers and other exhausting diseases, alcohol is invaluable to prevent waste of tissue and sustain the strength. It does not act merely as a stimulant to the circulation and nervous system, but, as above pointed out, saves the more stable compounds by furnishing a readily oxidizable respiratory food.

When taken in small doses by healthy persons, alcohol diminishes the temperature by increasing heat-radiation. When large quantities are taken, the bodily temperature is reduced by diminishing heat production, as well as by increased radiation. This is shown in the condition known as dead-drunkenness, in which the temperature is sometimes depressed as much as 20° F. below the normal. Cases in which the temperature sank to 75°, 78.8°, and 83° F. have been reported, with recovery in all cases.

In discussing the physiologic effect of alcohol Dr. Hall[18] makes use of what he regards as the "deadly parallel" between food and alcohol:—

Food.	Alcohol.
1. A certain quantity will produce a certain effect at first, and the same quantity will always produce the same effect in the healthy body.	1. A certain quantity will produce a certain effect at first, but it requires more and more to produce the same effect when the drug is used habitually.
2. The habitual use of food never induces an uncontrollable desire for it, in ever increasing amounts.	2. When used habitually it is likely to induce an uncontrollable desire for more, in ever increasing amounts.
3. After its habitual use a sudden total abstinence never causes any derangement of the central nervous system.	3. After its habitual use a sudden total abstinence is likely to cause a serious derangement of the central nervous system.
4. Foods are oxidized slowly in the body.	4. Alcohol is oxidized rapidly in the body.
5. Foods, being useful, are stored in the body.	5. Alcohol, not being useful, is not stored in the body.
6. Foods are the products of constructive activity of protoplasm in the presence of abundant oxygen.	6. Alcohol is a product of decomposition of food in the presence of a scarcity of oxygen.

[18] The Journal of the American Medical Association, vol. xlviii, No. 5, 1907.

Food.	Alcohol.
7. Foods (except meats) are formed in nature for nourishment of living organisms and are, therefore, inherently wholesome.	7. Alcohol is formed in nature only as an excretion. It is, therefore, in common with all excretions, inherently poisonous.
8. The regular ingestion of food is beneficial to the healthy body, but may be deleterious to the sick.	8. The regular ingestion of alcohol is deleterious to the healthy body, but may be beneficial to the sick (through its drug action).
9. The use of food is followed by no reaction.	9. The use of alcohol, in common with narcotics in general, is followed by a reaction.
10. The use of food is followed by an increased activity of the muscle cells and brain cells.	10. The use of alcohol is followed by a decrease in the activity of the muscle cells and brain cells.
11. The use of food is followed by an increase in the excretion of CO_2.	11. The use of alcohol is followed by a decrease in the excretion of CO_2.
12. The use of food may be followed by accumulation of fat, notwithstanding increased activity.	12. The use of alcohol is usually followed by an accumulation of fat through decreased activity.
13. The use of food is followed by a rise in body temperature.	13. The use of alcohol may be followed by a fall in body temperature.
14. The use of food strengthens and steadies the muscles.	14. The use of alcohol weakens and unsteadies the muscles.
15. The use of food makes the brain more active and accurate.	15. The use of alcohol makes the brain less active and accurate.

The constant use of alcohol produces in all the organs an excess of connective tissue, followed by fatty degeneration and the condition known as cirrhosis. The organs most frequently affected are the stomach, liver, and kidneys. Serious pathological alterations also occur in the circulatory, respiratory, and nervous systems.

Alcohol is not necessary to persons in good health. Probably most persons, regardless of their state of health, do better without it. Its habitual use in the form of strong liquors is to be unreservedly condemned. The lighter wines and malt liquors, if obtained pure, may be consumed in moderate quantities without ill effects. Even in these forms, however, the use of alcohol should be discouraged or, perhaps, prohibited in the young.

Neither in hot nor in cold climates is alcohol necessary to the preservation of health, and its moderate use even produces more injury than benefit. The Polar voyager and the East Indian merchant are alike better off without alcohol than with it.

It has long been a prevalent belief that the use of alcohol enables persons to withstand fatigue better than where no alcohol is used.

A large amount of concurrent testimony absolutely negatives this belief.[19]

The predisposition to many diseases is greatly increased by the habitual use of alcohol. Sun-stroke, the acute infectious diseases, and many local organic affections attack, by preference, the intemperate. A recent collective investigation by the British Medical Association brought out the fact that croupous pneumonia is vastly more fatal among the intemperate than among those who abstain from the use of alcoholic liquors.

A further investigation by Baer has shown that the average expectation of life among users and dealers in alcoholic liquors is very much shortened. The following table gives a comparative view of the expectation of life in those who abstained from and those who used alcohol:—

TABLE XXII.

EXPECTATION OF LIFE.

Age.	Abstainers.	Alcohol Users.
At 25	32.08 years.	26.23 years.
" 35	25.92 "	20.01 "
" 45	19.92 "	15.19 "
" 55	14.45 "	11.16 "
" 65	9.62 "	8.04 "

Table XXIII shows the influence of alcohol upon the mortality from various diseases:—

TABLE XXIII.

	General Male Population (per cent.).	Alcohol Venders (per cent.).
Brain disease	11.77	14.43
Tuberculosis	30.36	36.57
Pneumonia and pleuritis	9.63	11.44
Heart disease	1.46	3.29
Kidney disease	1.40	2.11
Suicide	2.99	4.02
Cancer	2.49	3.70
Old age	22.49	7.05

[19] See Parkes' Hygiene, 6th ed., vol. i, pp. 315-327.

Alcohol as a beverage is consumed in the various forms of spirits, wines, and fermented liquors. The varieties of spirits most frequently used are brandy, whisky, rum, and gin. They are all procured by distillation.

Brandy is distilled from fermented grape-juice, and has a characteristic aromatic flavor. When pure and mellowed with age it is the most grateful to the palate of all distilled spirits.

Whisky is distilled from barley, rye, oats, corn, or potatoes. Each of these has a peculiar flavor, depending upon the particular volatile ether formed during the distillation. Rye-, barley-, and corn-whiskies are almost exclusively used in this country.

Rum is distilled from molasses, and is a favorite ingredient in hot punches. It is often used with milk, eggs, and sugar, in the preparation of eggnog, a highly nutritious, stimulating drink, which is often prescribed with great benefit in acute and chronic wasting diseases.

Gin is an ardent distilled spirit, flavored with oil of juniper. It has a widely-spread popular reputation as a cure for kidney diseases, but is probably oftener responsible for the production of these diseases than for their cure.

All of the above-mentioned liquors contain from 40 to 60 per cent. of alcohol, and should always be diluted before being taken into the stomach, in order to prevent the local irritant effects of the alcohol upon the gastric mucous membrane.

Wine is the product of the alcoholic fermentation of the saccharine constituents of fruits. Wine is usually derived from the grape, though other fruits may also furnish it. The stronger wines (sherry, port, maderia) contain from 16 to 25 per cent. of alcohol. The lighter wines (hock, red and white Bordeaux and Burgundy wines, champagnes) contain from 6 to 15 per cent. of alcohol. Some also contain considerable free carbonic acid (sparkling wines), of which the champagnes are types. The red and white Bordeaux and Rhine wines are probably the least objectionable of these beverages for habitual use. They contain sufficient alcohol to be lightly stimulant, have a pleasant acid flavor, and are least likely to produce the bad effects which usually follow in the wake of the habitual use of the stronger wines or ardent spirits.

Preference should be given to the wines of domestic manufacture, on account of the great probability of adulteration of the favorite brands of foreign wines. Many of the California, Virginia, New York, and Ohio wines compare very favorably in flavor with those imported from abroad. The more reasonable cost of these domestic wines is also a point in their favor.

Cider is the fermented juice of apples. It frequently produces unpleasant gastric and intestinal disturbances when drunk, on account of the large quantity of malic acid contained in it. Although it is usually ranked as a "temperance drink," it is quite capable of causing intoxication when consumed in large quantities.

Beer is the fermented extract of barley, mixed with a decoction of hops and boiled. It should be prepared only of malt, hops, yeast, and water, and should contain from 3 to 4 per cent. of alcohol, 5 to 6 per cent. of extract of malt and hops, 2 to 4 per cent. of lactic and acetic acids, and from $^1/_4$ to $^1/_2$ per cent. of carbonic acid. This ideal is, however, rarely attained in the article sold by the liquor dealer. Numerous adulterations are practiced on the unsuspecting consumer. The hops are frequently substituted by aloes, calamus, and ginger, or by the more deleterious picric acid or picrotoxin. The rich brown color, sweetness, body, and creamy foam are produced by caramel and glycerin. The more expensive barley-malt is substituted by starch and rice, or grape-sugar and molasses.

Ale, porter, and brown-stout are merely varieties of beer—some containing more sugar, others more extractive matter.

Beer and its correlatives have considerable dietetic value, owing not merely to the alcohol they contain, but largely to the sugar and acids entering into their composition. When used to excess they often cause a considerable accumulation of fat.

Kumys is the national beverage of the nomadic tribes of Tartary. It consists of the milk of mares which has undergone fermentation, partly lactic and partly alcoholic in character. Recently it has been introduced into Europe and also into this country, where it is made of cows' milk. It is a palatable, nutritious stimulant, and is often very useful as a dietetic article in disease. Kumys may be prepared according to the following formula: To one pint of fresh milk add one tablespoonful of sugar and $^1/_6$ cake of compressed yeast. Put in bottle with patent stopper, place in warm room or near the stove for 6 to 12 hours, then cool on ice and serve. Kumys has proved a very valuable agent in the treatment of gastro-intestinal diseases.

Kefyr is a product of the fermentation of milk which bears some resemblance to kumys. The following table (Table XXIV) gives a comparative view of the composition of true kumys, the same prepared from cows' milk, and kefyr:—

TABLE XXIV.

	True Kumys (per cent.).	Cows' Milk Kumys (per cent.).	Kefyr (per cent.)
Proteids	2.20	2.35	3.12
Fats	2.12	2.07	1.95
Sugar	1.53	1.81	1.62
Lactic acid	0.90	0.40	0.83
Alcohol	1.72	1.90	2.10
CO_2	0.85	0.80	0.92

As bearing on the question of intemperance, it may be well to mention that many patent medicines which are largely consumed by the laity for their supposed curative effect owe their virtues to the large amounts of alcohol which they contain. The following is a list of the more popular tonics, analyzed principally by the Massachusetts State Board of Health:—

TABLE XXV.

	Alcohol, Per cent.
Liebig Company's Cocoa Beef Tonic	23.2
Schenck's Seaweed Tonic, "entirely harmless"	19.5
Atwood's Quinine Tonic Bitters	29.0
Boker's Stomach Bitters	42.6
Burdock Blood Bitters	25.2
Copp's White Mountain Bitters, "not an alcoholic beverage"	6.0
(It should be noticed that this "tonic" contains more alcohol than the strongest beer.)	
Drake's Plantation Bitters	33.2
Green's Nervura	17.2
Hoofland's German Bitters, "entirely vegetable and free from alcoholic stimulant"	25.6
Hostetter's Stomach Bitters	44.3
Kaufmann's Sulphur Bitters, "contains no alcohol"	20.5
(As a matter of fact no sulphur was found in this preparation.)	
Paine's Celery Compound	21.0
Walker's Vinegar Bitters, "contains no spirit"	6.1
Warner's Safe Tonic Bitters	35.7
Ayer's Sarsaparilla	26.2
Hood's Sarsaparilla	18.8
Dana's Sarsaparilla	13.5
Peruna	28.0
Warner's Safe Cure	15.60
Kilmer's Swamp Root	10.90
Toneco Stomach Bitters	35.50
Angostura Bitters	50.17

The dose recommended on the labels is from a teaspoonful to a wineglassful from one to four times a day, "increased as needed."

The pure food law recently enacted by our national government requires the amount of alcohol in a medicinal preparation to be plainly stated on the label. Whether this will remove the existing evil of selling alcohol under the guise of medicine remains to be seen.

THE ALKALOIDAL BEVERAGES.

The virtues of the alkaloidal beverages depend upon certain alkaloids which differ very little in their chemical composition or physiological effects, and upon certain volatile aromatic constituents of the various articles used. The principal articles employed in the preparation of these beverages are coffee, tea, chocolate, maté, and coca. It is estimated that 500,000,000 people drink coffee, 100,000,000 tea, 50,000,000 chocolate, 15,000,000 maté or Paraguay tea, and 10,000,000 coca. All of these are active nervous stimulants and retarders of tissue-waste. They are all liable to produce serious functional disturbances of the nervous, digestive, and circulatory systems if used to excess. Anæmia, digestive derangements, constipation, pale, sallow complexion, loss of appetite, disturbed sleep, nervous headaches, and neuralgias are the most marked of these effects.

On the other hand, when taken in moderate quantities, the alkaloidal beverages enable the consumer to withstand cold, fatigue, and hunger; they promptly remove the sensation of hunger, and diffuse a glow of exhilaration throughout the body.

Coffee.—Coffee is the ripe fruit (seed) of the *Caffea Arabica,* a native of Arabia and Eastern Africa, but now cultivated in other tropical regions of the world. The fruit consists of two flat-convex beans, the flat surfaces of which are apposed to each other. These are enclosed in a fibrous envelope which is sometimes used as a cheap substitute for the coffee-bean.

The beverage, coffee, is an infusion of the roasted and ground bean in hot water. Its virtues depend upon the alkaloid, caffein, and an aromatic oil. The latter, being volatile, is driven off by long-continued heat. Hence boiled coffee lacks the grateful aroma of that which is made by simply infusing the ground bean in hot water.

The great demand for coffee and its comparatively high price have caused it to be extensively adulterated and substituted by other natural and artificial products. Artificial coffee-beans have been made of clay, dough, or extract of chicory, colored to imitate the natural bean. The fraud is easily detected by placing the beans in water, when the artificial product soon falls to pieces, while the natural beans undergo no change of shape or consistence.

Ground coffee as found in the stores is usually adulterated. The materials used for sophistication are: The grounds of coffee previously used, the roasted root of chicory, acorns, rye or barley, carrots, sun-flower seeds, caramel, and a number of articles of similar value, generally harmless.

Tea.—The plants which furnish the tea-leaves are natives of China, Indo-China, and Japan. The tea-leaves contain a crystalline alkaloid, thein, identical in composition and properties with caffein. The various sorts of tea found in the market (green and black teas, etc.) differ only in the relative proportion of tannin and thein contained in each. The aromatic principle also varies somewhat in the different sorts.

Tea is adulterated to quite as great an extent as coffee, the leaves of various plants bearing more or less resemblance to tea-leaves being added to the latter. Much of the tea found in the market is colored artificially with Prussian blue and iron oxide. These additions are harmless, as they are not soluble in water.

Chocolate.—Cocoa, from which chocolate is derived, is widely different in composition from tea and coffee. In addition to its active principle, theobromin, which is identical with caffein, it contains nearly 50 per cent. of fat, which renders it an article of high nutritive value.

Maté, or Paraguay tea, guarana, and coca are used to a considerable extent in some parts of South America as substitutes for coffee and tea. Their composition is not well known, but their effects are believed to depend upon alkaloidal principles similar to caffein and thein.

TOBACCO.

Closely connected with the subjects treated in this chapter are the effects of the constant use of tobacco upon the human system. The depressing effects of tobacco, due principally to the nicotine, upon the nervous and digestive systems have long been recognized. Recently, however, it has been found that very serious symptoms are produced upon the sense of vision by the constant or excessive use of tobacco. A special form of amaurosis, termed tobacco amaurosis, has been frequently noticed since attention was first called to it by Mackenzie.

ADULTERATIONS OF FOODS.

The adulteration of food-products has received considerable attention of late, no more, however, than the seriousness of the subject demands. There is hardly a food-product which is not sophisticated by the unscrupulous manufacturer, and, while most of the adulterants are harmless, many are injurious to health. The following list from Battershall gives an adequate idea of the *common* adulterations. As to the *uncommon* adulterants, they include such palatable substances as sawdust, horseliver, oak-bark, colored earths, factory sweepings, brick-dust, and numerous others which the ingenuity of the manufacturer suggests, and which baffle all efforts at detection, owing to their uncommonness. The *regular* list, then, includes:—

Bakers' chemicals	Starch, Alum.
Bread and flour	Other meals, Alum.
Butter	Water, Coloring matter, Oleomargarine and other fats.
Canned foods	Metallic poisons. Preservatives,
Cheese	Lard, Oleomargarine, Cottonseed oil, Metallic salts.
Cocoa and chocolate	Sugar, Starch, Flour.
Coffee	Chickory, Peas, Rye, Corn, Coloring matter.
Confectionery	Starch-sugar, Starch, Artificial essences, Poisonous pigments, Terra alba, Plaster-of-Paris.
Honey	Glucose syrup, Cane-sugar.
Malt liquors	Artificial glucose, Bitters, Sodium bicarbonate, Salt.

Milk	Water, Removal of fat, Preservatives.
Mustard	Flour, Turmeric, Cayenne pepper.
Olive oil	Cottonseed oil, Other oils.
Pepper	Various ground meals.
Pickles	Salts of copper.
Spices	Pepper dust, Starch, Flour.
Spirits	Water, Fusel-oil, Aromatic ether, Burnt sugar.
Sugar	Starch-sugar.
Tea	Exhausted tea-leaves, Foreign leaves, Indigo, Prussian blue, Gypsum, Soapstone, Sand.
Vinegar	Water, Sulphuric acid.
Wine	Water, Spirits, Coal-tar and vegetable colors, Factitious imitations.

Of 61 samples of milk purchased of milk-dealers in the city of Wilmington and examined by the Delaware State Board of Health Laboratory, 39 contained formalin, 12 were skimmed, 3 were watered, 5 were skimmed and watered, and 2 were suspicious.

The superficial observer will probably conclude that adulteration is accidental and irregular; that it depends entirely on the honesty and business integrity of the individual manufacturer. This is far from being the case. Sophistication is an economic factor in the struggle for trade. Cheaper products are demanded by the poor, and cheaper products are supplied; but as the only way to cheapen them is to sophisticate, adulteration is practiced as a *bona fide* business measure. As a result, we have fraud reduced to a system; fraud not regulated by conscience or principles; fraud from which the otherwise honest man does not shrink, but, nevertheless, fraud which robs the poor man of the money he earns by the sweat of his brow.

This fact has been clearly brought out by the Senate Committee appointed to investigate the extent and nature of adulteration of foods (Senate Report, Vol. 3, No. 516). "The adulteration of prepared or manufactured foods," says the committee, "is very extensively practiced, and in many cases to the great discredit of our manufacturers. It is only fair to say, however, that a large proportion of the American manufacturers who are engaged in adulterating food-products do so in order to meet competition, and it is the expression of those gentlemen to say: 'We would be glad to get out of the business of adulterating. We would like to quit putting this stuff in our coffee, and would be willing to brand our syrups for what they are, but our competitors get a trade advantage which we cannot surrender.'"

In a recent report of the Illinois State Food Commission (1899-1900) we find the following table of adulterations detected during the year:—

TABLE XXVI.

Article of Food.	Number Analyzed.	Number Adulterated.
Baking powder	44	44
Butter	49	36
Catsup	47	45
Cider (apple)	3	1
Cider (orange)	1	1
Coffee	15	0
Condensed milk (bulk)	4	1
Condensed milk (cans)	22	4
Cream of tartar	11	2
Honey	22	9
Jellies, Jams, etc.	13	9
Lemon extracts	34	27
Milk	29	5
Olive oil	25	13
Sugar (granulated)	1	1
Vanilla extract	26	20
Vinegar	360	192
Total	712	412

The recently enacted pure food law will remedy the evil of misbranding so far as interstate commerce goes, but will not prevent adulteration of foods and food-products within the limits of any single State. State legislation will be required to meet these conditions in each State.

THE EXAMINATION OF FOOD.

It would be manifestly inadvisable to attempt to detail the methods for the determination of the purity and healthfulness of the many articles of food that make up the daily dietaries of the people at large; but since occasions are constantly arising when it is desirable to know something of the condition of certain food-stuffs which are used by practically every one, and which are especially liable to sophistication or adulteration, the following notes are, therefore, added as being within the scope of the chapter:—

Milk.—Good milk should be ivory-white in color, opaque, of neutral or slightly-alkaline reaction, and should have no sediment nor any unusual taste or odor. The specific gravity should be 1029 or above; the proportion of cream, from 10 to 40 per cent. by volume; the fats, 3 per cent. or more, and the total solids 12.5 per cent. or more. The number of bacteria should not exceed 500,000 per cubic centimetre.

The color is enriched by a high percentage of cream, but too rich a color or one with a reddish or yellowish tint may indicate the addition of annatto. A poor color indicates that the milk is deficient in fat, and may be due to skimming or watering, or both, but a peculiar blue color is sometimes produced by the growth of a certain fungus in the milk. The lessening of fat also tends to make the milk translucent and less opaque.

An acid reaction, unless very slight, indicates "souring" of the milk or the addition of some preservative, such as salicylic or boric acid; while a strongly-alkaline reaction points to the addition of some substance like chalk, sodium carbonate, etc., to increase the specific gravity. Such addition is verified by a high percentage of total solids and by the effervescence of the latter upon the addition of a drop or two of hydrochloric acid.

The specific gravity is determined by means of the lactometer, in using which corrections must be made for the temperature if the latter varies much from 60° F., the standard. The specific gravity is slightly raised by skimming the milk, since the cream is lighter than the whole milk, and, theoretically, a very high percentage of cream tends to lower the specific gravity; but, in reality, a milk rich in cream is also rich in other solids that keep the specific gravity high or, at least, normal.

The percentage of cream is determined by the creamometer, which should be covered and in which the milk should stand for eight or ten hours.

The principal sophistications of milk are by watering, skimming, the addition of solids to increase the specific gravity or to act as preservatives or to mask "souring," and the addition of annatto and the like to enrich the color. Watering is indicated by a low specific gravity and by a low percentage of cream and of total solids. Skimming is indicated by a low percentage of cream and poor color, though the latter may be disguised by the addition of annatto, etc. The specific gravity will be very slightly raised by the skimming, but if the milk has been both skimmed and watered the density will be lowered.

To Determine the Percentage of Total Solids.—Weigh a small evaporating dish, preferably platinum. Add 5 or 10 c. c. of milk, and weigh the dish and milk to get the weight of milk. Evaporate to dryness over a water-bath, completing the drying in a water-oven until there is no further loss of weight. Weigh the dish and contents (total solids) ; subtract the weight of dish and divide by the weight of milk. The result is the percentage of total solids.

To Determine the Percentage of Ash.—Ignite the total solids over the naked flame until all black specks have disappeared. Cool and weigh. Divide the weight of ash by weight of milk. The result is the percentage of ash.

To Determine the Percentage of Fats.—Proceed as above with 10 c. c. of milk and evaporate till the residue is a tenacious pulp. Extinguish the flame, fill the dish half-full of ether, and stir and pound the residue thoroughly with a glass rod ; filter through a small filter-paper, reserving the filtrate ; add more ether to the residue, stir as before and filter, repeating the process three times, or till the residue is perfectly white. Wash filter-paper well with ether, and evaporate all the ether to dryness. Weigh the residue (the fat) and divide by the weight of milk. Result : percentage of fat. The fat can be more conveniently determined by the use of the Babcock tester. This is a centrifugal machine holding two or more graduated bottles especially made for this purpose. The test is performed as follows : Measure 17.6 c. c. of milk and an equal quantity of strong sulphuric acid (sp. gr. 1.82) and pour into the bottle. Mix by shaking gently until curd dissolves. Place in centrifuge and revolve at 1000 revolutions per minute for five minutes. Fill the bottles to the highest graduation with hot water and whirl for one minute longer. Read on the scale the space occupied by the column of fat which rises to the top. The lower margin of this column indicates the percentage of fat.

Test for Annatto.—A percentage of cream considerably lower than color of milk would indicate justifies the suspicion that some coloring matter has been used. This is generally annatto. Coagulate one ounce of milk with a few drops of acetic acid, and heat; strain and press out excess of liquid from curd. Triturate the curd in a mortar or dish with ether. Decant the ether and add to it 10 c. c. of a 1-per-cent. solution of caustic soda. Shake and allow to separate; pour off the upper layer into a porcelain dish. Put in two small discs or strips of filter-paper. Evaporate gently; annatto will dye the discs an orange or buff color. Moisten one disc with dilute sodium carbonate to fix the color. Touch the other disc with a drop of stannous chloride; annatto will give a rich pink color. This test is sensitive to 1 part of annatto in 1000 of milk, and with milk in any condition.

Detection of Cane-sugar in Milk and Cream.—Mix 15 c. c. of milk or cream with .1 gram resorcin and 1 c. c. conc. hydrochloric acid and heat to boiling. In presence of cane-sugar a fine red color is produced, while pure milk turns brownish; 0.2 per cent. can thus be detected. Levulose gives the same reaction, but glucose does not.

Test for Boric Acid.—In igniting the total solids, boric acid, or boron, gives a greenish tinge to flame. Place in a porcelain dish one drop of milk, two drops of strong hydrochloric acid, and two of saturated tincture of turmeric. Dry on a water-bath, remove as soon as dry, cool and add one drop of ammonia on a glass rod. A slaty-blue color, changing to green, is given if borax is present. This test will show $^1/_{1000}$ grain of borax. Less will give the green color, but not the blue.

Formaldehyde.—The milk is diluted with an equal volume of water. Sulphuric acid containing a trace of ferric chloride is added so that it forms a layer beneath the milk. Under these conditions, milk, in the *absence* of formaldehyde, gives a slight greenish tinge at the juncture of the two liquids, while a *violet* ring is formed when formaldehyde is present even in so small a quantity as 1 part in 200,-000 of milk.

Sodium Carbonate.—Ten c. c. of milk are mixed with an equal volume of alcohol and a few drops of a 1-per-cent. solution of rosolic acid added. Pure milk shows merely a brownish-yellow color, but in the presence of sodium carbonate a more or less marked rose-red appears. This test is made more delicate by using a comparison cylinder containing the same amount of milk known to be pure.

Butter.—Good butter should have a good taste, odor, and color; it should not be rancid, and should not contain too much salt, nor should it have any added coloring matter. The average composition should be about as follows: Fat, 82 per cent.; casein, 2 per cent. (not over 3 per cent.); ash or salts, 2 per cent.; water, 13 per cent.; milk-sugar, 1 per cent. Butter-fat is a compound of a glycerine with certain fatty acids, some of them volatile and soluble in hot water, others non-volatile and insoluble in hot water.

Oleo-margarine consists of ordinary animal (or vegetable) fats melted, strained, cooled with ice, worked up with milk, colored, and salted. These fats are usually beef or mutton, lard or cotton-seed, palm- or cocoa-nut- oil. If care and cleanliness are observed in the manufacture, oleo-margarine is not harmful or innutritious, but it should not be sold as butter.

Fraud is to be detected by observing the difference in composition and properties of the fats. The following table, from Kenwood's "Hygienic Laboratory," will show the characteristic difference in the fats:—

Butter-fat.	Beef-fat.
1. The specific gravity is very rarely below 910, never below 909.8.	Is never above 904.5.
2. The soluble, volatile fatty acids average between 6 and 7 per cent., never below 4.5 per cent.	Rarely more than ½ per cent.; never above ¾ per cent.
3. The insoluble fatty acids form about 88 per cent. of the total weight of butter-fat.	Generally about 95 per cent.
4. The melting-point of the fat varies from 86° to 94° F.; is usually from 88° to 90° F.	Rarely, if ever, above 82° F.
5. Is readily and completely soluble in ether.	Less so, and leaves a residue.
6. Under the microscope pure butter consists of a collection of small oil-globules with an occasional large one. No crystals, except when the fat has been melted.	The contours of the small oil-globules are less distinct, and the larger ones are more numerous and irregular in size. Crystals of the non-volatile acids are often seen.

To Determine the Specific Gravity.—Melt a quantity of the butter in a beaker on a water-bath at about 150° F. After a time, when the fat is perfectly clear and transparent, carefully decant from the lower stratum of water, curd and salt on to a fine filter; collect the filtrate and pour into a specific-gravity bottle, which has been previously weighed, both when empty and when filled with water at 100° F. See that the bottle is exactly full of the fat; wipe clean and weigh when the temperature is as near 100° F. as possible, because solidification soon begins at this temperature. Subtract the weight of the bottle, divide by the weight of the water, and multiply by 1000. The result is the specific gravity.

To Find the Melting-point.—Pour a little melted fat into a small test-tube ($2'' \times 1/4''$). Partly fill two beakers of unequal size with cold water; place the test-tube in the smaller (taking care to allow no water to mix with the fat), and the smaller in the larger, and gently heat the outer beaker. Suspend a thermometer in the smaller, near the test-tube, and note the temperature when the fat *begins* to melt. This is the melting-point.

To Determine the Percentage of Insoluble (Non-volatile) Fatty Acids.—To 5 grammes of butter-fat add 50 c. c. of alcohol containing 2 grammes of caustic potash (KHO) and boil gently for fifteen or twenty minutes to saponify the fat. Dissolve the soaps thus formed in 150 to 200 c. c. of water and decompose with about 25 c. c. of dilute hydrochloric acid. The separated fatty acids are collected upon a weighed filter-paper, washed with 2 litres of boiling water, dried at 95° to 98° C., and then weighed. The weight of these insoluble fatty acids should not be over 90 per cent. of the weight of the butter-fat.

Flour and Bread.—Wheat-flour should be almost but not perfectly white, also smooth and free from grit; it should have no moldy or unpleasant odor, and, unless made by the new process, should be cohesive when lightly compressed in the hand. There should be no signs of parasites or fungi under the microscope. The proportion of gluten should be more than 8 per cent.; of water, less than 18 per cent., and of ash, less than 2 per cent.

To Determine the Percentage of Water and Ash.—In a weighed platinum (or porcelain) dish place about 50 grammes of flour, weigh and dry over a water-bath for an hour or so; then complete the evaporation in a water-oven until there is no further loss of weight; weigh, subtract this weight less the weight of the dish from the original weight of the flour. The result is the percentage of water. Then ignite the dried flour in the dish and incinerate till there are no longer any black particles and only the ash remains; cool, weigh, and divide by the original weight of the flour. The result is the percentage of ash.

To Determine the Percentage of Gluten.—By means of a glass rod, mix a weighed quantity of flour with a *little* distilled water into a stiff dough; then repeatedly wash away the starch and soluble constituents, kneading the dough with the rod or fingers and continuing until the wash-water comes away clear; the gluten and a small amount of fat and salts remain. Spread out on a weighed dish or crucible-lid, dry in a water-oven, and weigh. Divide by the original weight of the flour. The result is the approximate percentage of gluten. The gluten should pull out in long threads, otherwise it is poor.

An excess of water impairs the keeping-quality and lessens the amount of nutriment in the flour. An excess of ash indicates the addition of mineral substances. A deficiency of gluten indicates that the flour is not pure wheat-flour. Parasites and fungi especially affect or live in old or damp and inferior flour.

To Test for Mineral Substances.—Shake a little flour in a test-tube with some chloroform, and allow it to stand for a few moments. The flour floats and any mineral matter sinks to the bottom, when it can be removed with a pipette and examined under a microscope.

Wheat-bread should be fairly dry, light, and spongy; clean and nearly white; of pleasant taste; not sodden, acid, or musty; no parasites or moldiness. It should contain no flour other than wheat; but little, if any, alum; no copper sulphate; and should not yield over 3 per cent. of ash.

Test for Alum.—Add 5 c. c. of a 5-per-cent. tincture of logwood and 5 c. c. of a 15-per-cent. solution of ammonium carbonate to 25 c. c. of water; soak a crumb of the bread in this for a few minutes; drain and gently dry. Alum is indicated by a violet or lavender color, its absence by a dirty-brown color on drying.

Test for Copper Sulphate.—Draw a glass rod dipped in a solution of potassium ferrocyanide across a cut slice of the bread; copper is indicated by a streak of brownish-red color.

Test for Ergot in Flour or Bread.—Add liquor potassæ; a distinct, herring-like odor (due to propylamine) is appreciable if ergot be present.

An excess of water, an unnatural whiteness, and a low percentage of ash in bread indicate the addition of rice. Potatoes give an increased percentage of water and an alkaline ash.

QUESTIONS TO CHAPTER III.

FOOD.

What is a food? What reasons have we for stating that the proximate food principles must be combined in definite proportions to maintain a normal degree of health? What are the alimentary principles necessary to man's existence? Why do we need water? What are the functions of the salts in our foods? Is existence possible without a sufficient supply of nitrogenous food? What is the relation of starch to fat as oxidizable food?

Are the proteid tissues of the body derived solely from the nitrogenous foods? What are the sources of the body-fat? What tissues are mostly consumed during work?

What is the relation between the proximate food principles, and what amount of each is necessary in the standard daily diet of a man at rest? At moderate labor? At hard work? About what is the relation of nitrogenous to non-nitrogenous food? Of nitrogen to carbon? Is a standard diet necessarily an expensive one? How may it be selected? What is a calorie?

Why is a variety in the kind of food necessary? Why may not a man live on nitrogenous foods, like meat, alone? Why not on non-nitrogenous food, like potatoes?

Has climate much influence upon the amount of food needed? Has it upon the kind of food? What kind of food is especially beneficial for a laboring man in cold weather? Where do we find the proteid principles of food? Where the fatty? Where the carbohydrates? The salts? Why should only a moderate amount of food be taken, and why should it be properly prepared? What are some of the factors that increase the consumption of carbonaceous foods? Does increased physical labor increase the demand for nitrogenous foods? Which requires the most carbonaceous food, physical or mental labor? What maladies especially require fat-producing foods? Has the food that a man eats anything to do with his moral character?

How may we classify food? Name some of animal origin. From the vegetable kingdom. What is the function of condiments? Of stimulants?

Why is milk so nearly a perfect food? What is the average composition of cows' milk? What is the difference between human milk and cows' milk? What other substitutes are sometimes used for human milk?

What is cream? What changes take place in milk upon standing for some time? To what are these changes due? What is made from the curd? Has whey, or butter-milk, any food value?

What should be the specific gravity of milk? How is it determined? What may lower the specific gravity? What may raise it? Has "skim-milk" a food value? What is the objection to its sale?

How is milk frequently adulterated? How may this be detected? Why is the addition of water dangerous? How else might the milk become infected?

May infectious diseases be transmitted from the cow to man through the milk? How may this danger of infection be avoided? What diseases are especially likely to be thus conveyed by the milk? Give an account of the "Hendon cow disease." May the milk of animals suffering from certain febrile diseases be dangerous to health? Is the milk of cows fed on distillery or brewery refuse necessarily unwholesome?

How may the quality of a milk be determined? What is a lactoscope? What is a creamometer? What should be the minimum percentage of cream? How may the rapid fermentation of milk be prevented? What is tyrotoxicon, and to what is it due?

What is butter? What is its food value, and why? What change does it undergo in becoming "rancid"? How is it often sophisticated? What is oleo-margarine or butterine? How is it made? Is it unwholesome, and is there any objection to its use if sold under its proper name? Upon what does the value of cheese depend? Is it nutritious? Why cannot large quantities be eaten at a time?

What are the richest kinds of cheese? Is cheese often adulterated? How may cheese be made more digestible? What dangerous change may it undergo, and to what is this due?

Why is meat such an important article of food? What is the percentage of proteids and fats in the meats commonly used? Upon what does the variation between these two principles depend? Should meat be cooked and eaten immediately after death? Should it be kept too long after death before being used? Why should meat be always cooked? What are the common methods of cooking? Are beef-extracts really nutritious? Are partially or wholly predigested preparations of meat nutritious? What is the objection to their continued use?

What conditions may render meat unfit for food? How may the various parasites in meat be destroyed? What animals are apt to be infested with trichinæ? In what two forms are the trichinæ found in animals? How do they gain access to the muscles? May salted or smoked meat contain living trichinæ? Of what parasite is the *Cysticercus cellulosa* a transition form?

What may be the result of using partially-decomposed meat or fish? To what are the serious results due? How are the ptomaines produced? What is their probable chemical nature? What peculiar idiosyncrasy have some people regarding shell-fish? What infectious diseases may be transmitted to human beings by the consumption of infected meat? When and by whom should meat be inspected?

Why are eggs so highly valued for food? In which form are eggs most digestible? Why do eggs undergo putrefaction so readily?

What cereals are used in making bread? What part of the grain contains the greater proportion of proteids? Is all the gluten to be found in the bran? Which flours are most nutritious and which most digestible? What are some of the characteristics of good bread? To what is the porosity due, and how is it produced? How may the loss of starch by fermentation be avoided? How is flour often adulterated? Why is alum added to flour? What disease of grain may be harmful to the health of the users?

What is the chief constituent of potatoes and rice? In what principle are the leguminous foods especially rich? Wherein is the chief value of green vegetables? Why are fruits and nuts valuable as articles of diet? What rule should be observed regarding the use of condiments?

Why should physicians know considerable about cooking? What are the various methods of cooking? What is the effect of boiling upon meats? What points are to be observed in the boiling of meat? In the making of soups, etc.? What valuable principle is lost if vegetables are boiled too long? What is the secret in making good coffee? What is frying? How should it be done? How should meats be roasted? Why are broiling and baking generally satisfactory processes?

Into what two classes may alimentary beverages be divided? For what are those of the second class used? What is the physiological effect and action of alcohol upon the nerve-centres? Upon the circulation? Is it changed before absorption? Does it nourish the body? Does it supply heat? Does it raise the body-temperature? What effect has it on heat-production and heat-radiation? On tissue waste? How is it excreted? What effect have small amounts of alcohol upon digestion? What pathological changes are brought about by the constant use of alcohol? Is it necessary or beneficial to persons in good health? Why is it so valuable in fevers and wasting diseases? Does it enable persons to withstand fatigue? To what diseases is the predisposition increased by the habitual use of alcohol? What effect has it upon the expectation of life and upon the mortality from various diseases? If used habitually, what forms should be chosen? What is the difference between spirits, wines, and malt liquors? What is brandy? From what is whisky made? How much alcohol do the various spirits contain, and what rule should be observed regarding their use? What percentage of alcohol do the various wines contain? Which are the least objectionable for habitual use? What can be said regarding the domestic wines? To what disturbances may cider give rise, and why? From what articles alone should beer be made? How much alcohol should it contain? With what substances is it often sophisticated? Have beer, ale, etc., a dietetic value, and why? What may be the result when beer is used to excess? What are kumys and kefyr? Why are they valuable in sickness? How much alcohol does each contain? Upon what do the virtues of the alkaloidal beverage depend? What are the principal articles employed in their preparation? What is the physiological action of all these substances? What are some of the effects if they are used to excess? What is their effect when used in moderation? May they be used as substitutes for alcohol?

What is coffee, and what alkaloid does it contain? What else does it contain that gives value to the beverage? How is coffee adulterated, and how may fraud be detected? What is tea, and what alkaloid does it contain? How may it be adulterated? Why is cocoa of greater food value than tea or coffee? What is its active principle, and what is its relation to thein and caffein? What is the difference between cocoa and chocolate? What are the effects of tobacco upon the human system, and to what are they due?

What are some of the characteristics of good milk? What may affect its color? Its reaction? Its specific gravity? How is it usually sophisticated or adulterated? How is the percentage of total solids determined? Of fats? What would a high percentage of ash indicate? Give a test for annatto. For boric acid. For formaldehyde.

What are the characteristics of good butter? What is the difference between it and oleo-margarine and similar compounds? What two kinds of fatty acids does butter-fat contain? What are some of the distinctions between butter-fat and beef-tea or mutton-fat? How is the specific gravity of butter-fat determined? The melting-point? The percentage of insoluble fatty acids?

What are some of the properties of good wheat-flour? Of wheaten bread? How is the percentage of gluten in flour determined? The presence of added mineral substances? What does a low percentage of gluten indicate? In what kind of flour are parasites, etc., found? What is a test for alum in bread? Should bread contain any alum? What flours or starches may be used to sophisticate wheat-flour?

CHAPTER IV.

SOIL.

HIPPOCRATES treated at length, in one of his works, of the sanitary influences of the soil. Others of the older writers, especially Herodotus and Galen, called attention to the same subject, and Vitruvius, the celebrated Roman architect, who flourished at the beginning of the Christian era, taught that a point of first importance in building a dwelling was to select a site upon a healthy soil.

From this time until the beginning of the eighteenth century, very little of value is found in medical literature bearing upon this subject. In 1717, however, Lancisi published his great work on the causes of malarial fevers, in which he laid the foundation for the miasmatic theory of malaria, and pointed out the relations existing between marshes and low-lying lands and those diseases by common consent called malarial. Other authors of the eighteenth and the early part of the nineteenth centuries refer to the connection between the soil and disease, but exact investigations have only been made within the last thirty years.

When it is considered that the air that human beings breathe, and much of the water they drink, are influenced in their composition by the matters in the soil, the great importance of possessing a thorough knowledge of the physical and chemical conditions of the soil becomes evident to every one.

PHYSICAL AND CHEMICAL CHARACTERS OF THE SOIL.

In the hygienic, as in the geological sense, rock, sand, clay, and gravel are included in the consideration of soils.

The soil, as it is presented to us at the surface of the earth, is the result of long ages of disintegration of the primitive rocks by the action of the elements, of the decomposition of organic remains, and, possibly, of accretions of cosmical dust. The principal factor, however, is the action of water upon rock, in leveling the projections of the earth's surface produced by volcanic action.

Soils vary considerably in physical and chemical constitution. A soil may, for example, consist exclusively of sand, of clay, or of disintegrated calcareous matter. Other soils may consist of a mixture of two or more of these, together with vegetable matter undergoing slow oxidation. In forests, a layer of this slowly-decomposing vegetable matter of varying thickness is found, covering the earthy substratum. This organic layer is called *humus,* and when turned under by plough or spade, and mixed with the sand or clay base, it constitutes the ordinary agricultural soil.

THE ATMOSPHERE OF THE SOIL, OR GROUND-AIR.

The interstices of the soil are occupied by air or water, or by both together. The soil's atmosphere is continuous with, and resembles in physical and chemical properties, that which envelops the earth. Its proportion to the mass of the soil depends upon the degree of porosity of the soil, and upon the amount of moisture present. In a very porous soil, such as, for example, a coarse sand, gravelly loam, or coarse-grained sandstone, the amount of air is much greater than in a clayey soil, granite, or marble. So, likewise, when the soil contains a large proportion of water, the air is to this extent excluded. The porosity of the various soils, as evidenced by the amount of air contained in them, is much greater than would, at first thought, be supposed. Thus, it has been found that porous sandstone may contain as much as one-third of its bulk of air, while the proportion of air contained in sand, gravel, or loose soil may amount to from 30 to 50 per cent.

The ground-air is simply the atmospheric air which has penetrated into the interstices of the soil and taken part in the various chemical decompositions going on there. In consequence of these chemical changes the relative proportions of the oxygen and carbonic acid in the air are changed—oxygen disappearing and giving place to carbon dioxide. It is well known that during the decay of vegetable matter in the air carbon dioxide is formed; one constituent of this compound, the carbon, being derived from the vegetable matter, while the oxygen is taken from the air. Hence, if this action takes place where there is not a free circulation of air, as in the soil, the air there present soon loses its normal proportion of oxygen, which enters into combination with the carbon of the vegetable matter to form carbon dioxide.

Over thirty years ago, MM. Boussingault and Lévy, two distinguished French chemists, examined the air contained in ordinary agricultural soil, and found that the oxygen was diminished to about one-half of the proportion normally present in atmospheric air, while the carbon dioxide was enormously increased. The exact results obtained by Boussingault and Lévy were as follows:—

In 100 volumes of ground-air there were 10.35 volumes of oxygen, 79.91 volumes of nitrogen, 9.74 volumes of carbon dioxide. In atmospheric air, on the other hand, there are in 100 volumes 20.9 volumes of oxygen, 79.1 volumes of nitrogen, 0.04 volume, or about $^1/_{25}$ of 1 per cent. of carbon dioxide.

In spite of the striking results obtained by these two chemists, very little attention was paid to them by sanitarians, as very few seemed to have any clear notion of the relations existing between the motions of the air above ground and that under ground.

In 1871, however, Professor von Pettenkofer, of Munich, published the results of his own examinations into the constitution and physical conditions of the ground-air, and the relations of the latter to the propagation of epidemic diseases. These researches, which created a widespread interest in the subject, were extended by other observers in all parts of the world. These observers, prominent among whom were Professors Fleck, Fodor, and Soyka, in Germany; Drs. Lewis and Cunningham, in India; Professor William Ripley Nichols, in Boston; and Surgeons J. H. Kidder and S. H. Griffith, of the U. S. Navy, in Washington, demonstrated that the increase of carbon dioxide in the ground-air is due to increased vegetable decomposition and to lessened permeability of the soil. A permeable, that is to say, a sandy or gravelly soil is likely to contain less carbon dioxide in its atmosphere than a dense, less permeable clay, although the amount of decomposition going on and the production of carbon dioxide in the former may considerably exceed the latter. In the loose, sandy soil the circulation of the air is less obstructed, and the carbon dioxide may easily escape and be diffused in the superincumbent air, while the close-pored clay imprisons the carbon dioxide and prevents or retards its escape into the air above.

The disappearance of oxygen from the ground-atmosphere is coincident with the production of an equivalent amount of carbon dioxide. It appears from this that in the soil an oxidation of carbonaceous substances takes place, the product of which is found in the excess of carbon dioxide in the ground-air.

Professor Nichols has found the proportion of carbon dioxide in the air taken from a depth of 3 metres below the surface in the "made-land" of Boston to amount to 21.21 per thousand, the observation having been made in August. In December, at a depth of 2 metres, the proportion was 3.23 per thousand. Fodor, in Buda-Pesth, found the proportion of carbon dioxide to be 107.5 per thousand (over 10 per cent.), the air having been taken from a depth of 3 metres.

The ground-air also teems with micro-organisms of various kinds, these being occasionally pathogenic. While in the great majority of instances the micro-organisms found are ordinary mold or fermentation fungi and bacteria of decay and putrefaction, disease-producing bacilli have also been observed in a number of instances. Among the latter are the bacillus of tetanus (Nicolaier), of anthrax (Frank), of malignant edema (Koch and Gaffky), and of typhoid fever (Tryde).

It may not be inappropriate to refer here to the claim of Professor Domingos Freire, of Brazil, to the discovery of the germ of yellow fever in the soil of a burial ground near Rio Janeiro. The exhaustive investigations of Surgeon-General G. M. Sternberg, of the U. S. Army, under the direction of the government, have disposed effectually of the claims and pretensions of the Brazilian scientist, and established the fact that Freire's organism has no pathological significance whatever—at all events, that it has no relation to yellow fever.

Cholera bacilli have not been found in the soil, but C. Fränkel has shown experimentally that they can grow and multiply in the soil at various depths. At a depth of $1^1/_2$ metres their development was constant and progressive throughout the year. With regard to typhoid bacilli, Houston found that under ordinary condition they die out in the course of a few days to a few weeks.

When the soil is dry, these organisms may be carried hither and thither in the movements of the ground-air, and thus be transported to a distance.

Movements of the ground-atmosphere are principally due to differences of pressure and temperature in the air above ground. Owing to such differences the air from the soil frequently permeates houses, entering from cellars or basements. In winter, when the air of houses is very much more heated (and consequently less dense) than the air out-of-doors, the difference of pressure thus caused draws the ground-air up through the house, while the cold, external atmosphere penetrates the soil and occupies the place of the displaced ground-air.[1] A similar effect occurs in consequence of heavy rains. The water fills

[1] It is, of course, not strictly correct to say that the air *is drawn up* through the house by the diminution of pressure; it being rather *forced* out of the soil by the colder and denser outside air; but the phrase is sufficiently exact and will be readily understood.

up the interstices of the soil near the surface, and forces the ground-air out at points where the pores remain open. These places are the dry ground under buildings, where the air escapes and passes through floors and ceilings into the house above. Heavy rains may thus be the cause of pollution of the air in houses. The greater the porosity of the soil, the more likely is this to happen. This pollution of the house-air may be prevented by having impervious floors and walls to cellars and basements, or by interposing a layer of charcoal between the ground and the floor of the house. The latter does not prevent the passage of the ground-air, but the charcoal layer absorbs or arrests the noxious matters—filters the ground-air, as it were.

In the spring and early summer the ground being colder than the air above it, and the ground-air consequently heavier and denser, the latter is not easily displaced. It is, perhaps, due to this fact that those infectious diseases which are probably dependent upon the movements of the ground-air are less prevalent in the spring and early summer than in the latter part of the summer, autumn, and early winter. In the autumn the ground-air being warmer than the air above ground is easily displaced by the latter and forced out into the streets and houses to be inspired by men and animals. The colder outside air penetrates the interstices of the soil and forces out the impure ground-air.

The researches of Fodor have demonstrated that the proportion of carbon dioxide in the ground-air may be taken as an approximate measure of the impurity of the soil whence the air is taken. The influence of the permeability of the soil, as before pointed out, must, however, not be overlooked in estimating the signification of the carbon dioxide. Fodor has shown that the proportion of carbon dioxide in the ground-air, and consequently the amount of organic decomposition, is greatest in July and least in March. That the carbon dioxide is derived from the decomposition of vegetable matter has been proven by Pettenkofer. This observer examined specimens of air brought from the Lybian desert, and found that the proportion of carbon dioxide in the ground-air was exactly the same as in the air collected above ground. There being no vegetable growth in the desert there can, of course, be no vegetable decomposition going on in the soil.

The excess of carbon dioxide in the ground-air is an indication of the deficiency of oxygen, as has been shown. The air at a depth of 4 metres below the surface was found to contain only from 7 to 10 per cent. of oxygen—one-half to one-third of the normal proportion.

Many basements occupied by people as living-rooms extend from 1 to 3 metres underground, and hence are liable to be supplied with an atmosphere approaching in impurity that just mentioned. It requires no very vivid imagination to appreciate the dangers to health that lurk in such habitations.

THE WATER OF THE SOIL, OR GROUND-WATER.

At a variable depth below the surface of the ground, a stratum of earth or rock is found through which water passes with difficulty, if at all. Above this there is a stratum of water which moves from a higher to a lower level, and which varies in depth at different times according to the amount of precipitation (rain- or snow- fall), and according to the level of the nearest body of water toward which it flows. This stratum of water is termed *ground-water,* and has within the last few years assumed considerable importance from its apparently close relation to the spread of certain of the infectious diseases. The direction of horizontal flow of ground-water is always toward the drainage-area of the district. Thus, it is usually toward lakes, rivers, or the sea. Rains, or a rise in the river, cause a rise in the ground-water, while long-continued dry weather, or a low stage of the river which drains off the ground-water, causes a fall in the latter. On the sea-coast the ground-water oscillations probably correspond with the tides. The writer is not aware of any observations made to determine this point, with the exception of a single instance mentioned by Dr. De Chaumont. In Munich, where the ground-water flows toward the river Isar, which divides the city, it has been found that the annual range or oscillation (the difference between the highest and lowest level during the year) is about 3 metres, while the horizontal movement amounts to 5 metres per day. In Buda-Pesth the annual range was found by Fodor to be less than 1 metre, while in some portions of India it amounts to more than 12 metres. As it is from the ground-water that the greater portion of the supply of drinking-water in the country and in villages and small towns is drawn, it becomes at once manifest how important it is to prevent, as far as possible, pollution of this source. Cess-pools and manure-heaps and pits, of necessity, contaminate the soil and also the ground-water for a distance below and around them, and such water is clearly unfit for drinking and other domestic purposes. Hence, the reason why wells should not be placed too near privies and manure-heaps or pits becomes apparent.

Between the level of the ground-water, or that portion of the soil where its pores are entirely occupied by water—where, in other words, the ground is *saturated*—and the surface, is a stratum of earth more or less *moist;* that is to say, the interstices of the soil are partly filled with water and partly with air. It is in this stratum that the processes of organic decay or putrefaction are most rapidly going on, in consequence of which the pollution of the ground-air occurs. The oxidation of non-nitrogenous matter in the soil results in the formation of carbon dioxide. On the other hand, nitrogenized compounds are oxidized into nitric acid and nitrates. When, however, putrefaction occurs, nitrous acid, or nitrites and ammonia, are formed, the oxidation not proceeding far enough to result in nitric acid.

Recent observations seem to show that these processes of decomposition are initiated and kept up by *bacteria,* just as fermentation in liquids containing sugar can only take place in the presence of the yeast-plant. It has been found that when non-putrefactive decomposition goes on, there are always present multitudes of one variety of these minute organisms; while if putrefactive decomposition is going on, a number of other varieties of these organisms are present. Just as, when a fermenting liquid becomes putrid, the yeast-plant disappears and its place is taken by the ordinary bacteria of putrefaction, so in the soil, if the access of oxygen, which is necessary to the life of the bacteria of decay, is prevented, these organisms die and are succeeded by the organisms of putrefaction. It has been found that in a soil saturated with water the bacteria of decay cannot live, while those of putrefaction may flourish, because these latter organisms can sustain life and develop in the absence of oxygen. Professor Fodor's researches indicate that the most prominent organism of non-putrefactive decomposition or decay is that which is termed by Cohn *bacterium lineola;* and that the *bacterium termo* is the principal organism of putrefaction.

DISEASES SPREAD BY SOIL IMPURITIES.

Given now an area of soil, say the ground upon which a house or city is built, with a moist stratum in which the processes of decay are active, and imagine a rise in the ground-water. The ground-air, charged with carbon dioxide and other products of decomposition, is forced out of the pores of the soil by the rising ground-water, and escapes into the external air, or through cellars and basements into houses, and may there produce disease. But the saturation of the soil with water prevents the further development of the bacteria of decay, and this is checked, or putrefaction may take place. If now the ground-water sinks to its former level or below, the processes of decay again become very active in the moist stratum, and large quantities of carbon dioxide and other inorganic compounds are produced. If the germs of infectious or contagious diseases have been introduced into the soil, they also multiply and, by gaining access to the well or stream from which the drinking-water is obtained, they may cause infection. Professor De Chaumont has laid down the rule that a soil with a persistently low stage of ground-water, say 5 metres below the surface of the ground, is healthy; a persistently high stage of ground-water, less than $1^1/_2$ metres below the surface, is unhealthy; while a fluctuating level of the ground-water, especially if the changes are sudden and violent, is very unhealthy. This would lead us to expect that places where this fluctuation is very great would show a large mortality from such diseases as are attributed to impurities in the soil. And this we find especially true in India. In certain localities in India, cholera, for example, is endemic; that is to say, the disease is never entirely absent in such localities. Calcutta is one of these places. The rainy season begins about the first of May and continues until the end of October. During the next six months there is very little rain. It is fair to assume that the ground-water rises during the rainy season and checks decay and the multiplication of the germs of the disease in the soil, and that these processes become more active as the dry season advances and the ground-water level falls. If we note the death-rate from cholera in Calcutta it will be found that it bears a distinct relation to the movement of the ground-water. The deaths from cholera begin to increase from October and reach their height in April. Dr. Macpherson, who has written a very elaborate history of Asiatic cholera, shows this relation very clearly. For twenty-six years the average rain-fall was 157 centimetres. From May to October 142 centimetres fell, while the remaining 15 centimetres fell from November to April. The average number of deaths from cholera annually was 4013. Of these, 1238 died in the rainy season, while 2775, nearly three-fourths, died during the period of dry weather.

In the cholera epidemics of 1866 and 1873 in Buda-Pesth, the same relations existed between the ground-water and the cholera. As the level of the ground-water rose the cholera diminished, while the disease increased upon the sinking of the ground-water. Exactly the same behavior was exhibited by the disease in Munich in 1873.

There seems good reason to believe that typhoid fever bears some relation to the movements of the ground-water in the same way as above explained for cholera. Pettenkofer, Buhl, and Virchow have shown that the death-rate from typhoid fever has a distinct and definite relation to the ground-water oscillations. This has been incontestably proven for two cities, Munich and Berlin. When the level of the ground-water is above the average, typhoid fever decreases; when it is below the average, the number of cases becomes greater. Dr. H. B. Baker has demonstrated that the fluctuation of the ground-water level in the State of Michigan is similarly followed by a change in the morbidity and mortality from typhoid fever.[2]

Over thirty years ago Dr. Henry I. Bowditch, of Boston, called attention to the frequent connection between cases of pulmonary consumption and dampness of the soil upon which the patients lived. After a very extended and laborious investigation Dr. Bowditch formulated these two propositions:—

"*First.*—A residence in or near a damp soil, whether that dampness be inherent in the soil itself or caused by percolation from adjacent ponds, rivers, meadows, or springy soils, is one of the principal causes of consumption in Massachusetts, probably in New England, and possibly other portions of the globe.

"*Second.*—Consumption can be checked in its career, and possibly—nay, probably—prevented in some instances by attention to this law."[3]

Dr. Buchanan, of England, about the same time showed that the thorough drainage of certain English cities had markedly diminished the deaths from consumption in the drained cities. So far as the writer is aware, not a single fact has been established which militates against the law laid down by Dr. Bowditch, and so strongly supported by the statistical researches of Dr. Buchanan, yet hardly any notice has been taken of these results by physicians. Few know anything of them, and still fewer seem to have made practical use of such knowledge in advising patients. As corroborative of the views of Dr. Bowditch, the rarity of consumption in high and dry mountainous districts or plateaus may be cited.

A study of the topographical distribution of consumption in the State of Pennsylvania, by Dr. William Pepper, apparently confirms Dr. Bowditch's conclusions in nearly every particular. It is now

[2] The Relation of the Depth of Water in Wells to the Causation of Typhoid Fever, Public Health, vol. x, p. 184-213.

[3] Consumption in New England and Elsewhere, 2d ed., p. 87. Boston, 1866.

known that the direct cause of consumption is the bacillus tuberculosis, discovered by Dr. Robert Koch. The relation between soil-moisture and the increase of consumption will probably be found in the more favorable conditions of development of the tubercle bacillus furnished by a moist medium.

DISEASES OF ANIMALS PROBABLY DUE TO SIMILAR CONDITIONS OF THE SOIL.

The modern study of the sanitary relations of the soil is still in its infancy. Whatever definite knowledge has been gained relates merely to physical or chemical conditions of the soil and its atmosphere and moisture, or possibly the relations of these to the spread of certain diseases in human beings. But there is, perhaps, a wider application that may be made of such knowledge than has been heretofore suggested. The domestic animals which form such a large portion of the wealth of this country—horses, cattle, sheep, and hogs—are liable to infectious and contagious diseases, as well as are human beings, and many millions of dollars are lost annually by the ravages of such diseases. Now, from what is known of such diseases as *splenic fever* among cattle, and of the so-called *swine-plague,* it does not appear improbable to the writer that the source of infection is a soil polluted by the poisonous germ of these diseases. The laborious investigations of M. Pasteur in France have shown that the cause of splenic fever, when once introduced into a locality, will remain active for months, and even years, and it seems probable that a study of the soil in its relation to the diseases of domestic animals is a subject to which attention may profitably be given.

It is well known that milch-cows frequently suffer from a disease identical in its nature with consumption in human beings. It is believed by many that the milk of such animals is not only unfit for food by reason of its poor quality, but that it may convey the disease to human beings when used as food. The observations of Bowditch and Buchanan, quoted above, show that consumption in man may be, and doubtless is, frequently favored by soil-wetness. It seems probable that the same cause should produce similar effects in the lower animals, and it is the writer's firm conviction that an examination into the circumstances under which cows become attacked by consumption would prove this probability a fact.

DRAINAGE.

In many soils drainage is necessary in order to secure a constant level of the ground-water at a sufficient depth below the surface. Drainage and sewerage must not be confounded with each other. Drainage contemplates only the removal of the ground-water, or the reduction of its level, while sewerage aims to remove the refuse from dwellings and manufactories, including excrementitious matters, waste-water, and other products, and in some cases the storm-water.

Sewers should never be used as drains, although for economy's sake sewer- and drainage- pipes may be laid in the same trench. Sewer-pipe must be perfectly air-tight and water-tight to prevent escape of its liquid or gaseous contents into the surrounding soil and rendering it impure. Drainage-pipe, on the other hand, should be porous and admit water freely from without. Escape of the contents of the drain-pipe into the surrounding soil will not produce any pollution of the latter.

The best material for drains is porous earthenware pipe, or the ordinary agricultural drain-tile. Coarse gravel or broken stones may also be used, and prove efficient if the drains are properly constructed. Referring again to the aphorism of Professor De Chaumont, that a persistently low ground-water, say 5 metres down, or more, is healthy; that a persistently high ground-water, less than $1^1/_2$ metres from the surface, is unhealthy, and that a fluctuating level, especially if the changes are sudden and violent, is very unhealthy, the necessity appears obvious, that in the construction of drainage-works the drains should be placed at a sufficient depth to secure a level of the ground-water consistent with health. This depth should never be less than 3 metres, and, if possible, not less than 5 metres. Care must be taken that the outflow of the drain is unobstructed, in order that the soil may be kept properly dry at all times.

In the absence of a proper mechanical system of drainage, the planting of certain trees may efficiently drain the soil. It has been found that the eucalyptus tree has produced drying of the soil when planted in sufficient numbers in marshy land. The roots absorb a prodigious quantity of water, which is then given off by evaporation from the leaves. Sunflower-plants have a similar effect upon wet soils. It is for this reason that the planting of eucalyptus trees is recommended in malarial regions.

QUESTIONS TO CHAPTER IV.

THE SOIL.

Why is it necessary to possess a knowledge of the physical and chemical conditions of the soil? What substances are included in the consideration of soils? Of what is the surface soil composed? How do soils vary in composition, physically and chemically?

What occupies the interstices of the soil? Upon what does the proportion of air in the soil depend? Is this proportion comparatively great or small? What relation has the soil-air to the atmosphere air, and what causes the difference in composition? In what way does the soil-air differ from the atmospheric air? Has the soil-air any definite composition? What are the factors governing the variation in composition? What kind of a soil will be likely to contain most carbon dioxide and least oxygen? What does this indicate? What micro-organisms are always to be found in the soil-air? What pathogenic organisms may also make the soil and soil-air their habitat? How may these be carried from place to place? To what are movements of the ground-air due? How may this soil-air gain access to our houses, and what measures should be taken to prevent its entrance? When is the danger greatest? Why are certain infectious diseases less prevalent in spring and early summer than in autumn? Why is there greater danger of infection from these diseases at night than in the day-time? Is the carbon dioxide of the soil-air a measure of the impurity of the soil? What causes the excess of carbon dioxide? When is the proportion of carbon dioxide greatest? Why are living-apartments below the surface of the ground very apt to be unhealthy?

What is meant by the term "ground-water"? Where is it to be found? Has it a definite current? In what direction is the flow? Upon what does the level of the ground-water depend? What class of the population derive their drinking-water largely from the ground-water? What are some of the sources of contamination of the ground-water? What are some of the deductions to be made accordingly?

In what part of the soil do the processes of organic decay and putrefaction occur most readily? What are the causes of these processes? What are some of their products? What is the distinction between non-putrefactive decomposition or decay and putrefaction?

How may disease be spread by the rise and fall of the ground-water? What two infective diseases are especially apt to be transmitted in this way? Give instances that tend to prove this. Upon what other disease has a damp soil a directly causative influence? What diseases of animals are likely to be influenced in a similar manner? How deep below the surface should the soil-water persistently be that the soil may be healthy? What effect upon health has a suddenly and markedly fluctuating soil-water? Is a soil with its water persistently near the surface apt to be healthy?

What do we mean by drainage, and what are its object and function? What is the difference between it and sewerage? How should drains be laid? What is the best material for drains? What precautions must be observed in the laying of drains? How may the surplus water be taken from the soil otherwise than by drains?

CHAPTER V.

REMOVAL OF SEWAGE.

In all larger communities certain arrangements are necessary to secure a prompt and efficient removal of excreta and the refuse and used water of households and manufacturing establishments, the sweepings of streets, and rain-water.

The total quantity of excrementitious products—feces and urine—for each individual, including men, women, and children, has been estimated by Professor von Pettenkofer as 90 grammes of fecal and 1170 grammes of urinary discharge daily. This would give for a population of 1000 persons 34,000 kilogrammes of feces and 428,000 litres of urine per year. If to this is added a minimum allowance of 159 litres of water per day to each individual, a complete sewerage system for a population of 1000 persons would require provision for the discharge of 160,000 litres of sewage passing through the sewers every day. In this estimate storm-water and such accessory feeders of the sewers are omitted.

The organic matters contained in sewage, even if free from the specific germs of disease, give rise to noxious emanations, which, when inhaled, probably produce a gradual depravement of nutrition that renders the system an easier prey to disease. For this and other reasons it is important that such measures be adopted as will secure the removal of sewage matters from the immediate vicinity of houses as quickly as possible after they have been discharged.

The impregnation of the soil with sewage produces a contamination of ground-air and ground-water, which may become a source of grave danger to health. By polluting the ground-water it eventually vitiates the well-water, which is nearly always derived from that source.

The system of removal of excrementitious matters which any community will adopt depends to a considerable extent upon financial considerations. Although the sanitarian must insist upon the pre-eminent importance of the cause of public health, his suggestions will receive little attention from municipal or State legislatures unless they can be carried out without involving the community too deeply in debt. For this reason it is a matter of great practical importance that the student of sanitary science should make himself familiar with the relative cost as well as with the hygienic significance of the various methods of sewage removal in use.

The different systems in use for the removal of sewage matters may be considered in detail under the following five heads:—

1. The common privy, or privy-vault system.
2. The Rochdale or pail system, and its modifications.
3. The earth- or ash- closet system.
4. The pneumatic system of Liernur.
5. The water-carriage systems.

1. The Privy and Privy-well Systems.—While from a sanitary point of view privies of all kinds, whether wells or cess-pits, are to be unreservedly condemned, it is not likely that they will cease to be built for many years to come. It becomes necessary, therefore, to point out by what means the objections against them may be diminished, and their evil consequences in some measure averted.

In the first place, a privy-vault should be perfectly water-tight, in order to prevent pollution of the surrounding soil by transudation of the contained excremental matters. The walls should be of hard-burned brick laid in cement. The cavity should be small in order that the contents may be frequently removed, and not allowed to remain and putrefy for months or years. A water-tight hogshead sunk in the ground makes an economical privy-tank or receiver. A privy must not be dug in a cellar, or in too close proximity to the house-walls. Unless these last precautions are taken the offensive gases from the mass of decomposing fecal matter in the privy will constantly ascend into and permeate the air of the house.

All privies should be ventilated by a pipe passing from just under the privy-seat to a height of about a metre above the roof of the house. A gas-flame, kept burning in the upper portion of this pipe, will increase its ventilating power by creating a strong and constant upward current.

Deodorization of the contents of privies may be secured in a measure by means of sulphate of iron, phenyle, carbolic acid, chloride of lime, or dry earth. The first named is probably the most economical, most easily applied, and very effective. A solution containing from $^1/_2$ to 1 kilogramme of the salt in 4 litres of water is poured into the privy as often as necessary to prevent offensive odors. This solution may be conveniently prepared by suspending a basket or bag containing about 25 kilogrammes of the sulphate in a barrel of water. In this way a saturated solution will be maintained until the salt has been entirely dissolved. Phenyle is likewise a good deodorizer as well as an excellent disinfectant.

The most rigid deodorization by chemicals will, however, be less effective than thorough ventilation, for it must be remembered that the mere destruction of an offensive odor is not equivalent to removing all the deleterious properties that may be present. It is not at all certain that those elements of sewage which are the most offensive to the sense of smell are most detrimental to health.

Privies should be emptied of their contents at stated intervals. A strict supervision should be exercised over them by the municipal authorities in cities and towns to prevent overflowing of their contents.

In many places the method of removing the contents of privies is the primitive one with shovel, or dipper and bucket. In most cities and large towns, however, the privy-vaults or tanks are now emptied by means of one of the so-called odorless excavating machines, of which there are a number of patents. The process is rarely entirely odorless, however, as the carelessness of the workmen frequently permits offensive gases to escape and pollute the air for a considerable distance. All the different forms of the apparatus act upon the pneumatic principle. One end of a large tube is carried into the cess-pool or vault to be emptied and the other attached to a pump, by means of which the material is pumped into a strong barrel-tank carried on wheels. At the top of the tank is a vent, over which is placed a small charcoal furnace to consume the foul gases escaping from the vent.

In some cities and many of the smaller towns and villages in this country the primitive midden or pit system is still in use. A shallow pit is dug in the ground, over which is erected the privy. When the pit is full another is dug close by the side of it, and the earth from the new pit thrown upon the excrement in the old one. The privy is then moved over the new pit, and this is used until it too becomes full. The proceeding is repeated as often as the pit becomes filled up with the excreta, until in the course of a few years all the available space in a yard has been honey-combed with the pits. Then the custom adopted in overcrowded cemeteries is followed, namely, the first pit is dug out again and the cycle is repeated.

In other cities the privy-well system is largely in use. This is—next to the midden or shallow pit just described—the most pernicious system for the disposal of excreta that can be imagined. The wells are dug to such a depth as to reach the subterranean flow of water, in which the soluble excremental matters are constantly carried off. Hence these receptacles rarely fill up or need cleaning. For this reason they are popular with property owners; for, next to the primitive midden, they are the most economical of all the various methods adopted. The utter perniciousness of the system is, however, plain, because the soil for a considerable distance around each of these wells becomes a mass of putrid filth, contaminating the ground-water which feeds the drinking-water supplies in the vicinity; polluting also the ground-air, which eventually reaches the surface, or the interior of houses, when the pressure of the outside atmosphere diminishes or the ground-water level rises. It must, therefore, be evident that the best ventilating arrangements, or the most thorough and consistent disinfection, can have very little, if any, effect in removing the very grave objections to this baneful system.

The privy-well system for the removal of excreta cannot be recommended for adoption by any sanitarian.

2. The Rochdale, or Pail-closet System.—The Rochdale system of removal of excreta has won the support of many distinguished sanitarians on account of its simplicity, its economy, and its compliance with most sanitary requirements. The excreta, both solid and liquid, are received into a water-tight pail, either of wood or metal, and removed once or oftener a week, a clean and disinfected pail being substituted for the one removed. In Rochdale, Manchester, and Glasgow in Great Britain, in Heidelberg in Germany, and in other cities abroad, where this system has been introduced, it has worked satisfactorily. In this country a modification of the pail system, known as the Eagle Sanitary Closet, has been introduced by a firm in Charleston, S. C. The receptacle consists of an enameled-iron reservoir, with a neck just large enough to fit under the seat of the privy, and a quantity of disinfectant solution is put into the receptacle to prevent putrefaction of the excreta. The receptacles are replaced by clean ones every week.

Mr. James T. Gardner, Director of the New York State Sanitary Survey, says, in a special report on methods of sewerage applicable in small towns and villages, concerning the pail system[1]:—

"Rochdale is a city of some 70,000, and Manchester of between 400,000 and 500,000 inhabitants. The higher class of houses are allowed to have water-closets, but four-fifths of the people are obliged

[1] Second Annual Report of New York State Board of Health, pp. 322, and 323.

to have 'pail-closets' in their yards built according to plans of the Health Department. Their essential features are: A flag-stone floor, raised a few inches above the level of the yard; a hinged seat, with a metal rim underneath for directing urine into the pail, which stands on the flag directly beneath the seat; a hinged front and back to the seat, so that the pail or tub may be easily taken out and the place cleaned; and a 6-inch ventilating pipe from under the seat to above the roof. In Rochdale they use a wooden pail or tub made of half of a disused paraffine cask, holding about 40 kilogrammes; in Manchester the 'pail' is of galvanized iron and holds 40 litres. Under the direction of the authorities, they are removed once a week in covered vans, which bring clean tubs to be put in the place of the full ones taken away. Each tub is covered with a close-fitting double lid before removal. The tubs are taken to a depot, where their contents are deodorized and prepared as manure by mixing with ashes and a small proportion of gypsum to fix the ammonia. Subsequently, street-sweepings and the refuse of slaughter-houses are added. At Manchester there is by the side of each closet a very simple ash-sifter, from which the ashes fall into the tub and help to deodorize its contents.

"The manure at Rochdale sells for about four-fifths of the cost of the collection and preparation.

"In 1873 the net cost to the town of removing and disposing of the house dry refuse and excrement was only about $95 per annum per 1000 of population—less than 10 cents a person per annum.

"The system has been in operation more than twelve years.

"The tubs are removed in the daytime without offensive odor.

"Where ashes are frequently thrown into the tubs at Manchester, very little odor is to be perceived in the closets.

"For the villages of the State, which can have no general water-supply, I would unhesitatingly advise the use of the 'pail' or tub system as practiced in Manchester, England, as being, from a sanitary point of view, an immense improvement over the death-breeding *privy-vaults* in common use. The cheapness of the plan and the smallness of the original outlay of brains and money, in comparison with that needed to build a good sewer system, will make it possible to introduce a tub-privy system into most villages half a century before sewers would meet with any consideration.

"At a small cost the existing privy-vaults can be cleaned and filled, and the privies altered into healthful tub-closets. The town authorities must then arrange for the removal of the tubs once a week, and for their thorough cleansing and disinfecting. Any isolated house, or group of houses, can use the tub system, taking care of it themselves. If the plan is adopted in villages it will doubtless spread into the country, and become the most powerful means of abolishing the fatal privy-vaults which are poisoning the farm-wells."

3. Earth- and Ash- Closets.—The earth- and ash- closets are devices in use to a large extent in England, and to a less degree in this country, for the purpose of rendering human excreta inodorous by covering them immediately after they are voided with dry earth

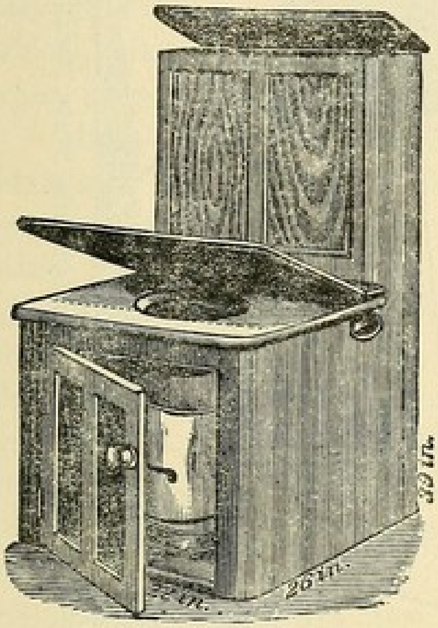

Fig. 11.

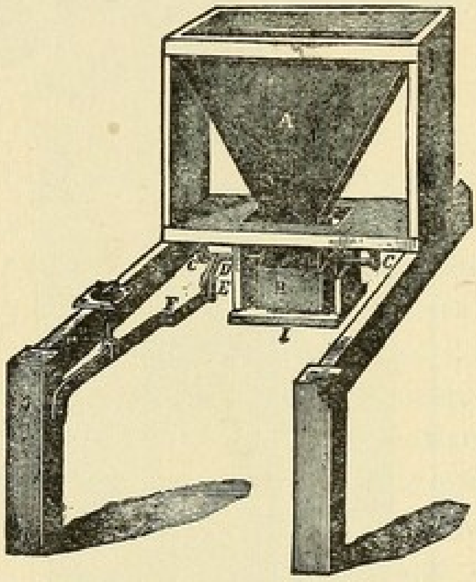

Fig. 12.

Fig. 11.—Pull-up Handle Commode, Showing the Door Open for Removing Pail. The flap of the seat and earth reservoir are also partially raised to show the construction.

Fig. 12.—Showing the Apparatus Mounted on Bearers as when Fixed. Seat removed, showing mechanical arrangement.

or ashes. The earth-closet is the invention of the Rev. Henry Moule, of England, and consists of an ordinary commode or closet, the essential feature of which is a reservoir containing dried earth or ashes, a quantity of which, amounting to about twice the quantity of feces voided, is thrown upon the evacuation either by hand or by means of an automatic apparatus called a "chucker." Just as in the ordinary water-closet, by raising a handle a supply of water is thrown into a hopper to wash down the feces into the soil-pipe, so, in the usual form of the earth-closet, raising the handle projects a quantity of earth upon the evacuated feces and urine. By this means the excreta are rendered entirely inodorous and dry. The contents of the closets may be collected into a heap in a dry place. In the

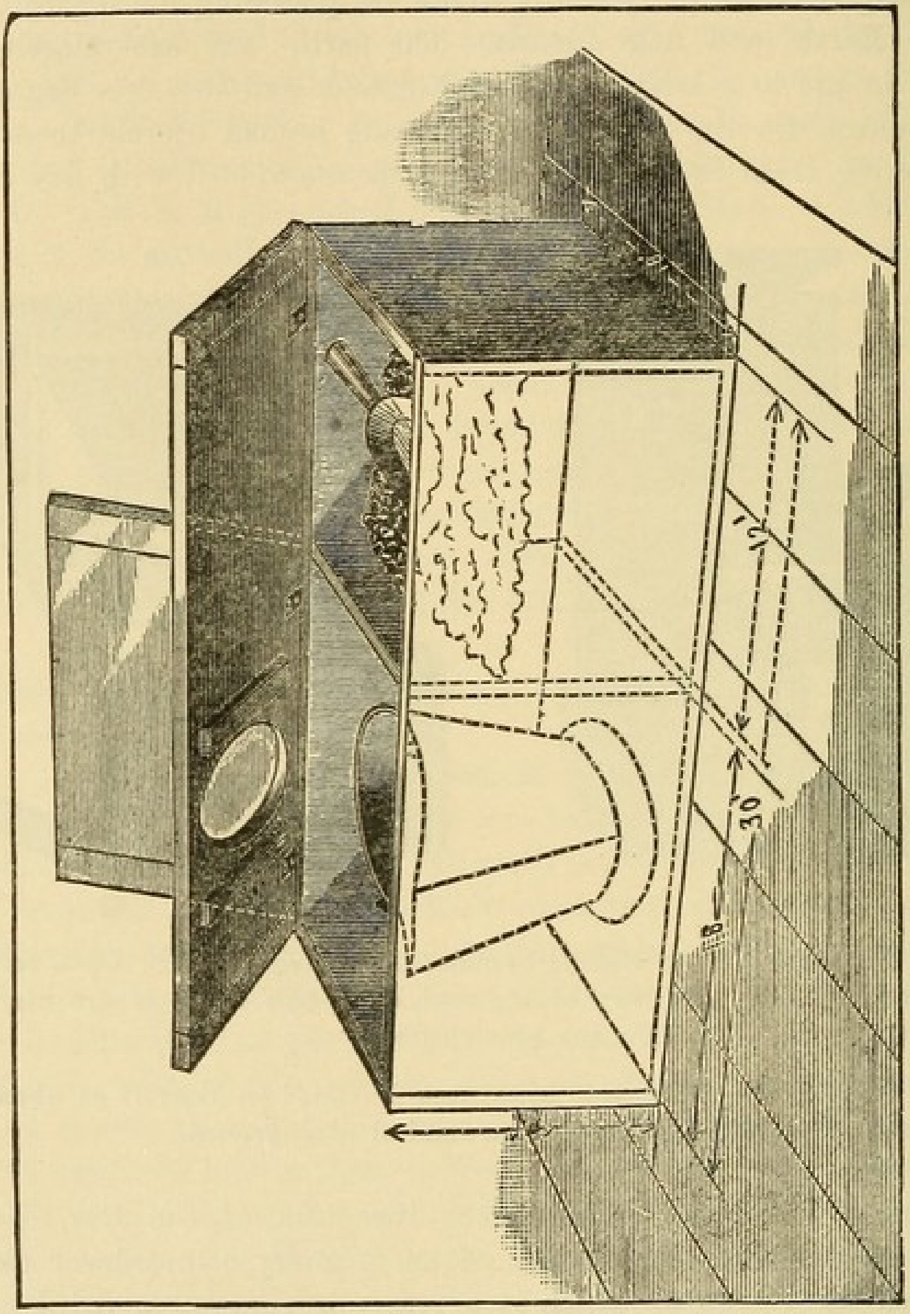

Fig. 13.—Dry Closet. (From Report of the Pennsylvania State Board of Health.)

course of a few months the organic constituents have become oxidized, and the earth may be used over again for a number of times. A well-known sanitarian states that he has used sifted anthracite coal-ashes ten or twelve times over in the course of three years. During this time the material under no circumstances gave any indication that it was "anything but ashes, with a slight admixture of garden-soil."[2]

Dr. Buchanan, of England, comparing the advantages of the earth-closet with those of the water-closet, says: "It is cheaper in original cost; it requires less repairs; it is not injured by frost; it is not damaged by improper substances being thrown down it; and it very greatly reduces the quantity of water required by each household."[3]

In cities and towns the removal of the excreta should be carried out by or under the immediate direction of the municipal sanitary authorities. If this is neglected, abuses are liable to creep in which will vitiate the performance of any system, however faultless when properly managed.

Many advocates of the pail, dry earth, or privy systems urge the advantage of the large quantity of valuable manure which can be realized by converting the excremental matters into poudrette and other fertilizing compounds. Experience has shown, however, that the cost of preparing a satisfactory fertilizer from human excrement is much greater than can be realized from its sale. In all places in Great Britain and the continent of Europe where it has been tried the decision is against its practicability. The agricultural consideration should, however, be a secondary one, if the systems mentioned are economical and meet the sanitary requirements (which the privy system certainly does not). The adoption of one or other of them may be secured where more perfect but more complicated and expensive systems may be out of the question.

4. The Pneumatic System of Liernur.—A system which seems to be useful in larger cities, especially where the topographical conditions are such as to render necessary mechanical aid in overcoming obstacles to natural drainage, is the pneumatic system devised by Captain Liernur, of Holland, and generally known as the Liernur system. It consists of a set of soil-pipes running from the water-closets to central district reservoirs, from which the air is exhausted at stated intervals. When a vacuum is created in the reservoir the contents of the water-closets and soil-pipes are driven forcibly into the reservoir by the pressure of air. The district reservoirs are connected by a separate system of pipes with a main depot, and the transfer of the fecal matter from the former to the latter is also accomplished with

[2] The Sanitary Drainage of Houses and Towns, Waring, p. 250. 2d ed., 1881.

[3] Quoted in Waring, above cited, p. 264.

the aid of pneumatic pressure. The complete system of Liernur provides that at the main depot the fecal matter shall be treated with chemicals, evaporated, and converted into a dry fertilizer—poudrette. It appears from the published reports that while the system has been partially adopted in three Dutch cities, in only one of them, Dortrecht, has the machinery for manufacturing poudrette been established. With reference to this Erismann[4] says: "It seems never to have been in regular working order, for the fecal masses are mixed with street-sweepings and ashes into a compost-mass which causes no little discomfort in the neighborhood by the offensive odors. In Amsterdam the fecal matters, which frequently do not find a ready sale, are partly made into a compost with sweepings, partly used to fertilize meadows, or simply discharged into the water."

As to the practical working of the system the opinions differ widely. While the majority of sanitarians, including Virchow, von Pettenkofer, and Mr. Rawlinson, objected to it as not fulfilling the demands of hygiene, the system has also been criticized by engineers as not being in accordance with the well-known principles of their science.[5]

Two other plans for the removal of fecal matter by pneumatic pressure have been invented, namely, the Shone and the Berlier systems. Neither of these has been adopted to any considerable extent. Both seem to the author to fall far short even of the merits of the Liernur system.

5. The Water-carriage System of Sewerage.—Two systems of removal of sewage by water-carriage are in use at the present time. They are technically known as the "combined" and the "separate" systems. In the former, which is the system upon which the most of the sewers in this country are constructed, all excreta, kitchen-slops, waste-water from baths and manufacturing establishments, as well as storm-water, are carried off in the same conduits. In the separate system, on the other hand, the removal of the storm-water is provided for, either by surface or underground drains, not connected with the sewers proper, in which only the discharge from water-closets and the refuse-water from houses and factories are conveyed. In the separate system the pipes are of such small calibre

[4] Von Pettenkofer und Ziemssen: Handbuch der Hygiene. II Th., II Abth., 1 Hefte, p. 140.

[5] Papers by Maj. C. H. Latrobe and Col. Geo. E. Waring, Jr., in Fifth Biennial Report Md. State Board of Health. See also, in favor of system, a paper by Dr. C. W. Chancellor, in same publication, and an elaborate description by the same author in Trans. Med. and Chir. Faculty of Md., 1883.

that a constant flow of their contents is maintained, preventing deposition of suspended matters and diminishing decomposition and the formation of sewer-gas.

In the combined system, on the other hand, the sewers must be made large enough to receive the maximum rain-fall of the district. This requires a calibre greatly in excess of the ordinary needs of the sewer, and furnishes favorable conditions for the formation of sewer-gas and the development of minute vegetable organisms. The ordinary flow in a sewer of large calibre is usually so sluggish as to promote the deposition of solid matters and the gradual obstruction of the sewer.

It is the opinion of the most advanced sanitarians that the separate system fulfills the demands of a rational system of sewerage better than any other at present in use.

The separate system of sewage, indorsed as it is by high engineering and sanitary authorities, and by a satisfactory, practical test in the city of Memphis and in the town of Keene, N. H., seems to the author to possess merits above any other plan for the removal of excreta and house-wastes. The following description is from a paper by Colonel George E. Waring, Jr.: "A perfect system of sanitary sewerage would be something like the following: No sewer should be used of a smaller diameter than 6 inches (15 centimetres): *a*, because it will not be safe to adopt a smaller size than 4-inch (10 centimetres) for house-drains, and the sewer must be large enough to remove whatever may be delivered by these; *b*, because a smaller pipe than 6-inch would be less readily ventilated than is desirable; *c*, and because it is not necessary to adopt a smaller radius than 3 inches (5 centimetres) to secure a cleansing of the channel by reasonably copious flushing.

"No sewer should be more than 6 inches (15 centimetres) in diameter, until it and its branches have accumulated a sufficient flow at the hour of greatest use to fill this size to half full, because the use of a larger size would be wasteful, and because when a sufficient ventilating capacity is secured, as it is in the use of a 6-inch pipe, the ventilation becomes less complete as the size increases, leaving a larger volume of contained air to be moved by the friction of the current, or by extraneous influences, or to be acted upon by changes of temperature and volume of flow within the sewer.

"The size should be increased gradually, and only so rapidly as is made necessary by the filling of the sewer half full at the hour of greatest flow.

"Every point of the sewer should, by the use of gaskets or otherwise, be protected against the intrusion of cement, which, in spite of the greatest care, creates a roughness that is liable to accumulate obstructions.

"The upper end of each branch sewer should be provided with a Field's flush-tank of sufficient capacity to secure the thorough daily cleansing of so much of the conduit as from its limited flow is liable to deposit solid matters by the way.

"There should be sufficient man-holes, covered by open gratings, to admit air for ventilation. If the directions already given are adhered to, man-holes will not be necessary for cleansing. The use of the flush-tank will be a safeguard against deposit. With the system of ventilation about to be described, it will suffice to place the man-holes at intervals of not less than 1000 feet (305 metres).

"For the complete ventilation of the sewers it should be made compulsory for every householder to make his connection without a trap, and to continue his soil-pipe above the roof of the house. That is, every house connection should furnish an uninterrupted ventilation-channel 4 inches (10 centimetres) in diameter throughout its entire length. This is directly the reverse of the system of connection that should be adopted in the case of storm-water and street-wash sewers. These are foul, and the volume of their contained air is too great to be thoroughly ventilated by such appliances. Their atmosphere contains too much of the impure gases to make it prudent to discharge it through house-drains and soil-pipes. With the system now described, the flushing would be so constant and complete and the amount of ventilation furnished, as compared to volume of air to be changed, would be so great, that what is popularly known as 'sewer-gas' would never exist in any part of the public drains. Even the gases produced in the traps and pipes of the house itself would be amply rectified, diluted, and removed by the constant movement of air through the latter.

"All house connections with the sewers should be through inlets entering in the direction of the flow, and these inlets should be funnel-shaped so that their flow may be delivered at the bottom of the sewer, and so that they may withdraw the air from its crown; that is, the vertical diameter of the inlet at its point of junction should be the same as the diameter of the sewer.

"All changes of direction should be on gradual curves, and, as a matter of course, the fall from the head of each branch to the outlet should be continuous. Reduction of grade within this limit, if considerable, should always be gradual.

"So far as circumstances will allow, the drains should be brought together, and they should finally discharge through one or a few main outlets.

"The outlet, if water-locked, should have ample means for the admission of fresh air. If open, the mouth should be protected against the direct action of the wind.

"It will be seen that the system of sewerage here described is radically different from the usual practice. It is cleaner, is much more completely ventilated, and is more exactly suited to the work to be performed. It obviates the filthy accumulation of street-manure in catch-basins and sewers, and it discharges all that is delivered to it at the point of ultimate outlet outside the town before decomposition can even begin. If the discharge is of domestic sewage only, its solid matter will be consumed by fishes if it is delivered into a water-course, and its dissolved material will be taken up by aquatic vegetation.

"The limited quantity and the uniform volume of the sewage, together with the absence of dilution by rain-fall, will make its disposal by agricultural or chemical processes easy and reliable.

"The cost of construction, as compared with that of the most restricted storm-water sewers, will be so small as to bring the improvement within the reach of the smaller communities.

"In other words, while the system is the best for large cities, it is the only one that can be afforded in the case of small towns.

"Circumstances are occasionally such as to require extensive engineering works for the removal of storm-water through very deep channels. Ordinarily, the removal of storm-water is a very simple matter, if we will accept the fact that it is best carried, so far as possible, by surface gutters, or, in certain cases, by special conduits, placed near the surface.

"It is often necessary, in addition to the removal of house-waste, to provide for the drainage of the subsoil. This should not be effected by open joints in the sewers; because the same opening that admits soil-water may, in dry seasons and porous soils, permit the escape of sewage matters into the ground, which is always objectionable.

"Soil-water drains may be laid in the same trench with the sewers, but preferably, unless they have an independent outlet, on a shelf at a higher level. When they discharge into the sewer they should always deliver into its upper part, or into a man-hole at a point above the flow-line of the sewage."[6]

The establishment of a system of sewerage presupposes a constant and abundant supply of water to keep all closets clean and all house-drains and street-sewers well flushed. Where this cannot be obtained, sewers would be likely to prove greater evils than benefits. In such cases one of the methods of removal of excreta before mentioned, either the pail- or earth- closet system, should be adopted.

The final disposal of sewage is a problem that depends for its solution partly upon the agricultural needs of the country around the city to be sewered, partly upon the proximity of large bodies of water or running streams. When the city is situated upon or near large and swiftly-flowing streams, the sewage may be emptied directly into the stream without seriously impairing the purity of the latter, although the principle of thus disposing of sewage is wrong. Dilution, deposition, and oxidation will soon remove all appreciable traces of the sewage of even the largest cities. Where, on the other hand, the stream is inadequate in size to carry off the sewage, or where, as in the Seine and Thames, the current is sluggish, some other method of final disposal must be adopted.

In many cities of Great Britain and the continent of Europe the disposal of the sewage by irrigation of cultivated land has been practiced for a number of years. The reports upon the working of the system are generally favorable, although some sanitarians express doubts of the efficiency of the system. In using sewage for the irrigation of land, two objects are secured: first, the fertilization of the land by the manurial constituents of the sewage, and second, the purification of the liquid portion by filtration through the soil. The organic matters which have been held back by the soil undergo rapid oxidation in the presence of air and the bacteria of decay, and are converted into plant-food, or into harmless compounds. Sewage irrigation, as practiced in Europe, must make provision for the disposal of a very large proportion of water in the sewage (street-wash, storm-water), which requires much larger areas of land than would be needed if only sewage material proper (water-closet and kitchen-waste) was thus to be disposed of. Recent experiments have shown that the purification of sewage is a biological process depending on the action of bacteria.

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[6] The Sewering and Drainage of Cities, Waring, Public Health, vol. v, p. 35.

The more important bacteria found in sewage are[7] :—

OBLIGATORY ANAEROBES.

Spirillum rugula.—Gives rise to fecal odor.

Spirillum amyliferum.—Acts as a vigorous ferment.

Bacillus butyricus.—Gives rise to much gas.

FACULTATIVE ANAEROBES, OR AEROBES.

Bacillus putrificus coli.—Decomposes albuminous substances, with liberation of ammonia.

Bacillus mycoides, proteus vulgaris.—Produces ammonia from nitrogenous matter and denitrification.

Bacillus fluorescens putridus.—Produces trimethylamine.

Micrococcus ureæ.—Converts urea into ammonium carbonate.

Bacillus lactis aërogenes.—Produces carbon dioxide and hydrogen.

Bacillus coli communis.—Produces gas, chiefly hydrogen.

Bacillus subtilis.—Rapidly consumes oxygen.

Proteus sulphureus.—Produces hydrogen sulphide and mercaptan.

Bacillus sulphureum.—Liquefies gelatin and casein and produces hydrogen sulphide.

In addition, several other species of bacteria are present in sewage, the action of which is not definitely known. Of disease-producing bacteria, bacillus choleræ, bacillus dysenteriæ (Shiga), bacillus typhosus, streptococci, and staphylococci have been found.

These bacteria produce certain changes in the organic matter, resolving the highly complex organic molecules into simple inorganic compounds.

The changes taking place in sewage are as follows (Rideal) :—

TABLE XXVII.

	Substances dealt with	Characteristic Products
INITIAL		
Transient aërobic changes by the oxygen of the water supply rapidly passing to :	Urea, Ammonia, and easily decomposable matters.	
FIRST STAGE		
Anerobic liquefaction and preparation by hydrolysis.	Albuminous matters. Cellulose and fibre fats.	Soluble nitrogenous compounds. Phenol derivatives. Gases. Ammonia.

[7] Sewage and the Bacterial Purification of Sewage. S. Rideal, 1901.

TABLE XXVII.—(*Continued*).

	Substances dealt with	Characteristic Products
SECOND STAGE Semi-anerobic breaking down of the intermediate dissolved bodies.	Amido compounds. Fatty acids. Dissolved residues. Phenolic bodies.	Ammonia. Nitrites. Gases.
THIRD STAGE Complete aëration: nitrification.	Ammonia and carbonaceous residues.	Carbon dioxide, water, and nitrates.

Based on these principles, various methods of purification of sewage have been adopted.

1. **Broad Irrigation.**—This method is defined by the Royal Commission on Metropolitan Sewage Discharge as "the distribution of sewage over a large surface of ordinary agricultural land, having in view a maximum growth of vegetation (consistent with due purification) for the amount of sewage supplied."

2. **Irrigation with Copious Underdrainage.**—This method is defined as "the concentration of sewage, at short intervals, on an area of specially-chosen porous ground, as small as will absorb and cleanse it; not excluding vegetation, but making the produce of secondary importance."

3. **Sedimentation or Chemical Precipitation, Followed by Broad Irrigation or Filtration.**—In this system the sewage is precipitated by lime or iron sulphate, the precipitate allowed to settle, and the supernatent liquid is distributed over large areas of land or made to pass through sand filters. The latter method is employed successfully in Worcester, Mass. However, the difficulty of disposing of the sediment, or "sludge," is quite serious and greatly impairs the utility of the system.

4. **Sterilization by Heat and Disinfection.**—These methods, while no doubt the most efficient, are not practical on a large scale.

5. **Bacterial Purification.**—This system, otherwise known as the "septic tank" method, is the outcome of a series of experiments made since 1865, which proved that the disintegration and final purification of sewage are due to the action of micro-organisms. In 1865, Dr. A. Mueller wrote: "The contents of sewage are chiefly of organic origin, and in consequence of this an active process of decomposition takes place in sewage, through which the organic matters are gradually dissolved into mineral matters, or, in short, are mineralized, and

thus become fit to serve as food for plants. To the superficial observer this process appears to be a chemical self-reduction; in reality, however, it is chiefly a process of digestion, in which the various—mostly microscopically small—animal and vegetable organisms utilize the organically fixed power for their life purposes."

The "septic tank" is merely a large cesspool in which the sewage undergoes putrefactive changes brought about by the activity of anaërobic bacteria.

"The septic or bacterial tank may be built of concrete, brick, masonry, or wood, and it may be covered or not, though a light covering of boards, to prevent the wind and rain breaking up the surface scum, may be advisable. An airtight covering is necessary only when the tank is located in a portion of the community where its odors would become a nuisance. The tanks should be large enough to hold the sewage of 2000 persons for one day, or about 55,000 gallons. In the most approved tanks there are two compartments, the first being about ten feet deep by seven feet long and eighteen feet wide and known as the 'grit chamber,' as it is designed to receive the grit and heavier settlings from the sewage. Into this the crude sewage is led by two inlet pipes, which discharge about five feet beneath the surface, so as not to disturb either the surface crust or the settled sediment. From this first chamber the contents flow through submerged openings in the partition wall into the second compartment, which is about seven feet deep, sixty-five feet long, and of the same width as the first. The flow is maintained at a rate to take twenty-four hours from entrance to exit. The effluent is brownish yellow in color and more or less offensive in odor.

"In the septic tank, as in the cesspool, the anaërobic or putrefactive bacteria are the active agents, and so energetic are they on a warm day that the contents of the tank seem fairly to boil, though, of course, the temperature is but slightly above that of the surrounding air. The microbes penetrate the solids floating in the sewage, and their gaseous products accumulate in such volume as to carry the solids to the surface of the tankage, sometimes with sufficient force to project them through the overlying crust. It is this and the escaping gas which give the boiling appearance on a hot day. The whole mass is very actively at 'work,' and the process is identical with that which takes place in a jar of 'working' apple-butter or preserves insufficiently cooked or insufficiently supplied with cane sugar. In short, the process is one of fermentation, and by it 40 to 60 per cent. of the organic matter is removed, while over the bottom of the tank accumulates the small percentage of 'ash' or mineral matter originally combined in the sewage, amounting to a deposit of something over a foot per year. The gas generated is rich in hydrocarbons and may be used for fuel or illumination."

From the "septic tank" the sewage, which is now completely hydrolyzed, is passed through beds of either broken brick, cinders, coke, or stone, the so-called "contact beds," or sand, to which the term "filter-bed" is applied. While passing through these beds, the remaining organic impurities are oxidized by the aërobic bacteria.

The rate of filtration is about 500,000 gallons per acre per day.

The resulting effluent is clear, colorless, practically odorless, and practically free from sewage bacteria. Such an effluent may be safely emptied into a stream without danger of polluting it.

The "septic tank" treatment of sewage has been also employed for the purification of the sewage on a small scale. The following adaptation is recommended by the Illinois State Board of Health[8]:—

"This plant consists of two tanks, the first the septic tank proper; the second, a discharging tank. The septic tank is, in construction, practically a cistern 4 feet in diameter and about 3 feet deep. The sewage from the house enters this tank through a lightly trapped pipe, the flow from the ordinary household preventing the back-flow of air. Across the center of the tank is a wall, which divides it into two chambers of equal size. The height of this wall is exactly to the point of outflow.

"The sewage from the house enters the first chamber of the septic tank with considerable force, causing some disturbance of the contents. The flow over the dividing wall into the second chamber, however, is even and slow, so that the contents of the second chamber are not disturbed, and the flocculent matter settles readily to the bottom.

"The bacterial action on the contents of this tank is often so complete that there is no appreciable residue or sludge, and in this case the tank will rarely if ever have to be cleaned out. In some instances, however, the tank will require occasional cleaning. The sludge from a well-constructed tank is not offensive, and may be disposed of without difficulty.

"The sewage is carried into the discharging chamber (which is a cistern 6 feet in diameter and about 4 feet in depth), through a deeply trapped pipe. The second or discharging tank should be of sufficient size to hold the overflow from the septic tank for a period

[8] Bull. No. 2, 1906.

of 12 to 24 hours. At the bottom of the discharging tank is an automatic siphon, which is opened automatically when the effluent reaches a certain height in the tank or chamber—a height of about $2^1/_2$ feet. Through this siphon the contents of the chamber will pass in a very few moments, at which time the siphon will automatically close and the chamber will again refill.

"From the siphon, a pipe conducts the effluent to the place of discharge, usually on a lawn, or in a pasture or field.

"The effluent is usually entirely without odor and is inoffensive in every way. It may be discharged upon a lawn, provided the lawn is well under-tiled and drained, or it may be emptied into any stream, provided the water from the stream is not used for drinking purposes. While it is true that raw sewage is frequently directed into streams whose water is used for domestic purposes, it is contrary to the policy of the State Board of Health to sanction even the discharge of this comparatively harmless effluent into such streams."

A number of small septic tank disposal plants have been constructed in the vicinity of Wilmington, Del., for the disposal of the sewage from large residences. The results have proved quite satisfactory.

Garbage.—By garbage is meant refuse from the kitchen. This should be collected in air-tight receptacles and frequently removed for final disposal. The latter may be effected either by feeding the garbage to hogs or cremation. While cremation is the more expensive of the two processes, it is also the more sanitary and should be preferred on that account.

QUESTIONS TO CHAPTER V.

REMOVAL OF SEWAGE.

Why must arrangements be made in all large communities for the removal of sewage? To what do the organic constituents of sewage give rise, and what is the effect upon health of the continued inhalation of these products? How else may the impregnation of the soil with sewage endanger health? What, then, is the object of any system of sewage removal? What will likely govern the choice and adoption of a sewage-removal system by any community?

What different systems are in use at the present time? Which of these is the worst and most unsanitary? In case the privy system is to be considered, what conditions should be insisted upon? How may a privy be ventilated? Why should a privy not be located in a cellar nor too near the house? What substances may be used to deodorize the contents of privy-vaults, and how? Are deodorizers always disinfectants, and is the danger necessarily removed when the odor is destroyed? How often should privy-vaults be emptied? How may this be done without offense to the senses? What are the grave objections to the midden or shallow-pit system, and to digging the vault or cess-pool to the level of the ground-water?

What is meant by the Rochdale or pail-closet system? What are some of its advantages? What can be said of its efficacy for large communities and for the economy of administration? What is an earth-closet, and upon what does its efficacy depend? What are some of its advantages?

Describe the pneumatic system of Liernur. Has it apparently been satisfactory in its workings? What other systems have employed the pneumatic principle, and with what success?

What do we mean by the water-carriage system of sewerage? What two systems are embraced under this head? What is the distinction between the two? Which is in most common use? What must be the size of the sewers in the combined system, and what are the consequent objections? Why does the separate system seem the better? Describe the latter in detail. What governs the size of the drains in the separate system? How is this system kept clean and free from obstruction? How is it to be ventilated? How does it differ in this respect from the combined system? What are some of the especial points to be observed in the construction? What may be said as to cost of construction and as to the ultimate disposal of the sewage? Why should sewers not be employed to drain the subsoil? How may this be done?

What does the establishment of a sewerage system presuppose? If plenty of water cannot be had, what system of sewage removal should be adopted?

In what way may we finally dispose of the sewage? What are the objections to discharging it into running streams? How will it be finally disposed of in such a stream? What is meant by the irrigation, the sub-irrigation, and the filtration methods? What becomes of the organic matter of the sewage in each case? What of the sewage water? What sort of soil is needed for the irrigation method? What can be said of the disposal of sewage and garbage by cremation? What chemicals are used for the precipitation of sewage? What action have bacteria on sewage? What is the septic tank method of purification of sewage? How may this method be used on a small scale? How should garbage be disposed of?

CHAPTER VI.

CONSTRUCTION OF HABITATIONS.

THE importance of observing the principles of hygiene in the construction of habitations for human beings is not sufficiently appreciated by the public. Architects and builders themselves have not kept pace with the sanitarian in the study of the conditions necessary to be observed in building a dwelling-house which shall answer the requirements of sanitary science.

In an investigation conducted by Dr. Villermé[1] it was found that in France, from 1821 to 1827, of the inhabitants of arrondissements containing 7 per cent. of badly-constructed dwellings, 1 person out of every 72 died; of the inhabitants of arrondissements containing 22 per cent. of badly-constructed dwellings, 1 out of 65 died; while of the inhabitants of arrondissements containing 38 per cent. of badly-constructed dwellings, 1 out of every 45 died.

Inseparable from the question of the defective construction of dwellings is that of overcrowding in cities, because the most crowded portions of a city are at the same time those in which the construction of dwellings is most defective from a hygienic standpoint. The following tables show the relations of the death-rate to density of population in various large cities of Europe, and also the relations between overcrowding in dwellings and the mortality from contagious diseases:—

TABLE XXVIII.

RELATION OF DEATH-RATE TO DENSITY OF POPULATION.

City	Mean Number of Inhabitants to each house	Average Death-rate per 1000 Inhabitants
London	8	24
Berlin	32	25
Paris	35	28
St. Petersburg	52	41
Vienna	55	47

[1] Quoted in Realencyclopædia d. ges. Heilk., Bd. ii, 71.

In Glasgow, the death-rate in apartments with 1.31 occupants is 21.7 per 1000, while in apartments with 2.05 occupants the rate is 28.6 per 1000.

In Buda-Pesth, in 1872-73, it was found that out of every 100 deaths from all causes there were, from contagious diseases:—

20	deaths	in	dwellings	with	1 to 2	persons	in	each	room.
29	"	"	"	"	3 " 5	"	"	"	"
32	"	"	"	"	6 " 10	"	"	"	"
79	"	"	"	"	over 10	"	"	"	"

Dr. Jose A. de los Rios gives the following statistics, bearing upon the mortality of cholera, in relation to the number of persons occupying one room when attacked by it:—

Of 10,000 persons attacked by cholera, and living 1 person to the room, 68 died.

Of 10,000 persons attacked by cholera, from 1 to 2 to the room, 131 died.

Of 10,000 persons attacked by cholera, living 2 to 4 to the room, 219 died.

Of 10,000 persons attacked by cholera, living 4 or more to the room, 327 died.

These figures show very clearly the vital importance of the application of sanitary laws in the construction and occupation of dwellings.

The direct relation of overcrowding to pulmonary tuberculosis has been firmly established by recent statistics. Not only do the absence of light, air, and sunshine usually found in overcrowded tenements favor the long life of the tubercle bacillus, but the aggregation of people, many of whom are tuberculous, tends to a rapid dissemination of the disease. The tuberculosis problem will never be satisfactorily solved so long as the housing of the poor will remain in the wretched condition in which we see it to-day in large cities.

Another curious and suggestive point is presented by some statistical researches on the mortality of Berlin, in regard to the death-rate among persons living in different stories of houses. It was found, for example, that the mortality in fourth-story dwellings is higher than in the lower stories. Even basement dwellings furnish a lower death-rate. Still-births, especially, occur in a larger proportion among the occupants of the upper stories of houses. This may be explained by the unfavorable effects of frequent stair-climbing, especially on pregnant women.

It is in the death-rate among young children that the effects of overcrowding and unsanitary construction of dwellings are especially manifest. The mortality returns from all the large cities of the world give mournful evidences of this every summer.

The researches of Dr. H. I. Bowditch upon soil-wetness, to which reference has already been made in a previous chapter, show conclusively that persons living in houses situated upon or near land habitually or excessively wet, are especially prone to be attacked by pulmonary consumption. Dr. Buchanan[2] has corroborated the truth of Dr. Bowditch's observations by showing, from the records of a number of cities and towns of Great Britain, that, with the introduction of a good drainage system, bringing about a depression and uniformity of level of the ground-water, the mortality from consumption and other diseases very markedly diminished. The following table, showing the proportionate amount of this diminution, is abridged from the official reports[3]:—

TABLE XXIX.

RESULTS OF SANITARY WORK.

Name of Place.	Population in 1861	Average Mortality per 1000 before Construction of Works	Average Mortality per 1000 since Completion of Works	Saving of Life (per cent.)	Reduction of Typhoid Fever Rate (per cent.)	Reduction in Rate of Phthisis (per cent.)
Banbury	10,238	23.4	20.5	12½	48	41
Cardiff	33,954	33.2	22.6	32	40	17
Croydon	30,229	23 7	18.6	22	63	17
Dover	23,108	22 6	20.9	7	36	20
Ely	7,847	23.9	20.5	14	56	47
Leicester	68,056	26 4	25.2	4½	48	32
Macclesfield	27,475	29.8	23.7	20	48	31
Merthyr	52,778	33.2	26.2	18	60	11
Newport	24,756	31.8	21.6	32	36	32
Rugby	7,818	19.1	18.6	2½	10	43
Salisbury	9,030	27.5	21.9	20	75	49
Warwick	10,570	22.7	21.0	7½	52	19

The following must be taken into account in building a house in accordance with sanitary principles:—

I. SITE.

The building-site should be protected against violent winds, although a free circulation of air all around the house must be se-

[2] Ninth and Tenth Reports of the medical officer to the Privy Council.
[3] Sanitary Engineering, Baldwin Latham, p. 2. Chicago, 1877.

cured. Close proximity to cemeteries, marshes, and injurious manufacturing establishments or industries must be avoided if possible. A requisite of the highest importance is the ability to command an abundant supply of pure water for drinking and other purposes. A neglect of this precaution will be sure to result to the serious inconvenience, if not detriment, of the occupants of the house.

II. CHARACTER OF THE SOIL.

The soil should be porous and free from decomposing animal or vegetable remains, or excreta of man or animals. It should be freely permeable to air and water, and the highest level of the ground-water should never approach nearer than 3 metres to the surface. The fluctuations of the ground-water level should be limited. In this connection, attention is again called to the aphorism of Dr. De-Chaumont.[4]

It is impossible to say positively that any kind of soil is either healthy or unhealthy, merely from a knowledge of its geological characters. The accidental modifying conditions above referred to, viz., organic impurities, moisture, the level and fluctuations of the ground-water, are of much greater importance than mere geological formation. The late Dr. Parkes, however, regarded the geological structure and conformation as of no little importance, and summarized the sanitary relations of soils, variously constituted, as follows[5]:—

"**1. The Granitic, Metamorphic, and Trap Rocks.**—Sites on these formations are usually healthy; the slope is great, water runs off readily; the air is comparatively dry; vegetation is not excessive; marshes and malaria are comparatively infrequent; and few impurities pass into the drinking-water.

"When these rocks have been weathered and disintegrated they are supposed to be unhealthy. Such soil is absorbent of water; and the disintegrated granite of Hong Kong is said to be rapidly permeated by a fungus; but evidence as to the effect of disintegrated granite or trap is really wanting.

"In Brazil the syenite becomes rapidly coated with a dark substance and looks like plumbago, and the Indians believe this gives rise to 'calentura' or fevers. The dark granitoid, or metamorphic trap, or hornblendic rocks in Mysore are also said to cause periodic fevers; and iron hornblende, especially, was confirmed by Dr. Heyne, of

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[4] Chapter iv, p. 130.

[5] Practical Hygiene 6th ed., vol. i, p. 359.

Madras, to be dangerous in this respect. But the observations of Richter on similar rocks in Saxony, and the fact that stations on the lower spurs of the Himalayas on such rocks are quite healthy, negative Heyne's opinion.

"**2. The Clay Slate.**—These rocks precisely resemble the granite and granitoid formations in their effects on health. They have usually much slope, are very impermeable, vegetation is scanty, and nothing is added to air or drinking-water.

"They are consequently healthy. Water, however, is often scarce, and as to the granite districts, there are swollen brooks during rain, and dry water-courses at other times, swelling rapidly after rains.

"**3. The Limestone and Magnesium Limestone Rocks.**—These so far resemble the former that there is a good deal of slope and rapid passing off of water. Marshes, however, are more common, and may exist at great heights. In that case, the marsh is probably fed with water from some of the large cavities which in the course of ages become hollowed out in the limestone rocks by the carbonic acid in the rain, and form reservoirs of water.

"The drinking-water is hard, sparkling, and clear. Of the various kinds of limestone, the hard oolite is best and magnesium is worst; and it is desirable not to put stations on magnesium limestone if it can be avoided.

"**4. The Chalk.**—The chalk, when mixed with clay, and permeable, forms a very healthy soil. The air is pure, and the water, though charged with calcium carbonate, is clear, sparkling, and pleasant. Goitre is not nearly so common, nor apparently calculus, as in the limestone districts.

"If the chalk be marly, it becomes impermeable, and is then often damp and cold. The lower parts of the chalk, which are underlaid by gault clay, and which also receive the drainage of the parts above, are often very malarious; and in America some of the most marshy districts are in the chalk.

"**5. The Sandstones.**—The permeable sandstones are very healthy; both soil and air are dry; the drinking-water is, however, sometimes impure. If the sand be mixed with much clay, or if clay underlies a shallow sand-rock, the site is sometimes damp.

"The hard millstone-grit formations are very healthy, and their conditions resemble those of granite.

"**6. Gravels** of any depth are always healthy, except when they are much below the general surface, and water rises through them. Gravel hillocks are the healthiest of all sites, and the water, which often flows out in springs near the base, being held up by the underlying clay, is very pure.

"7. **Sands.**—There are both healthy and unhealthy sands. The healthy are the pure sands, which contain no organic matter, and are of considerable depth. The air is pure, and so is often the drinking-water. Sometimes the drinking-water contains enough iron to become hard, and even chalybeate. The unhealthy sands are those which, like the subsoil of the Landes, in southwest France, are composed of silicious particles (and some iron) held together by a vegetable sediment.

"In other cases sand is unhealthy from underlying clay or laterite near the surface, or from being so placed that water rises through its permeable soil from higher levels. Water may then be found within 3 or 4 feet of the surface; and in this case the sand is unhealthy and often malarious. Impurities are retained in it and effluvia traverse it.

"In a third class of cases the sands are unhealthy because they contain soluble mineral matter. Many sands (as, for example, in the Punjab) contain magnesium carbonate and lime-salts, as well as salts of the alkalies. The drinking-water may thus contain large quantities of sodium chloride, sodium carbonate, and even lime and magnesian salts and iron. Without examination of the water it is impossible to detect these points.

"8. **Clay, Dense Marls, and Alluvial Soils Generally.**—These are always regarded with suspicion. Water neither runs off nor runs through; the air is moist; marshes are common; the composition of the water varies, but it is often impure with lime and soda salts. In alluvial soils there are often alterations of thin strata of sand, and sandy, impermeable clay. Much vegetable matter is often mixed with this, and air and water are both impure.

"The deltas of great rivers present these alluvial characters in the highest degree, and should not be chosen for sites. If they must be taken, only the most thorough drainage can make them healthy. It is astonishing, however, what good can be effected by the drainage of even a small area, quite insufficient to affect the general atmosphere of the place; this shows that it is the local dampness and the effluvia which are the most hurtful.

"9. **Cultivated Soils.**—Well-cultivated soils are often healthy; nor at present has it been proved that the use of manure is hurtful. Irrigated lands, and especially rice-fields, which not only give a great surface for evaporation, but also send up organic matter into the air, are hurtful. In Northern Italy, where there is a very perfect system of irrigation, the rice-grounds are ordered to be kept 14 kilometres (8.7 miles) from the chief cities, 9 kilometres (5.6 miles) from the lesser cities and the forts, and 1 kilometre (1094 yards) from the smaller towns. In the rice countries of India [and America] this point should not be overlooked."

Where a wet, impermeable, or impure soil must, of necessity, be chosen as a building-site, it should be thoroughly drained. The minimum depth at which drains are laid should be not less than $1^1/_2$ metres below the floor of the cellar or basement. Such a soil should be covered with a thick, impervious layer of asphaltum or similar cement under the house, in order to prevent the aspiration of the polluted ground-air into the building.

It is a frequent custom in cities to fill in irregularities of the building-site with street-sweepings and garbage, which always contain large quantities of decomposing organic matters. This is a gross violation of the plainest principles of hygiene. It is almost equally reprehensible to use such decaying or putrefying organic material for the purpose of grading streets or sidewalks in cities and towns.[6] It should be the constant endeavor of all sanitary authorities to prevent pollution of the soil as much as possible in villages, towns, and cities.

Where houses are built on the declivity of a hill, the upper wall should not be built directly against the ground, as it would tend to keep the wall damp. A vacant space should be left between the wall and the ground to permit free access of air and light.

In addition to, or in default of, drainage, the dryness of soil can be promoted by rapidly-growing plants, which absorb water from the soil and give it out to the air. The sunflower and the eucalyptus tree are the most available for this purpose.

III. THE MATERIAL OF WHICH THE HOUSE IS BUILT.

The nature of the most appropriate building material depends upon so many collateral circumstances that definite rules cannot be

[6] During the very fatal epidemic of yellow fever in New Orleans, in 1878, it was ascertained that a contractor for street-work used the garbage and street-scrapings to grade the bed of the streets. Even though in this case it may not have intensified the epidemic in these localities, the practice is so contrary to the simplest sanitary laws that it should nowhere be tolerated. The author is aware, however, that the "made-ground" of nearly every city in this country is composed largely of just such material. All sanitarians should protest against a continuance of this pernicious practice.

laid down. As a general rule, moderately hard burned brick is the most serviceable and available material. It is easily permeable by the air, and so permits natural ventilation through the walls, unless this is prevented by other means. It does not absorb and hold water readily; hence, damp walls are infrequent if brick is used. It is probably, of all building material, the most durable. On account of its porosity a brick wall is a poor conductor of heat. It therefore prevents the rapid cooling of a room in cold weather, and likewise retards the heating of the inside air from without in summer. Another very great advantage is its resistance to a very high degree of heat, brick being probably more nearly fire-proof than any other building material.

In hot climates light wooden buildings are advantageous because they cool off very rapidly after the sun has disappeared. On account of the numerous joints and fissures in a frame building, natural ventilation goes on very readily and to a considerable extent.

Next to brick, granite, marble, and sandstone are the most serviceable building materials. Very porous sandstone is, however, not very durable in cold climates, as the stone absorbs large quantities of water, which, in consequence of the expansion accompanying the act of freezing, produces a gradual but progressive disintegration. Recently, concrete has been successfully employed as a building material.

The application of paint to the walls, either within or without, almost completely checks the transpiration of air through the walls, thus limiting natural ventilation. Calcimining, on the other hand, offers very little obstruction to the passage of air. Wall-paper is about midway between paint and lime-coating in its obstructive effect on atmospheric transpiration.

Newly-built houses should not be occupied until the walls have become dry. Moisture in the walls is probably a not infrequent source of ill health; it offers favorable conditions for the development of fungi (possibly disease-germs), and by filling up the pores of the material of which the walls are composed, prevents the free transpiration of air through them.

Moisture of the walls is sometimes due to the ascent of the water from the soil by capillary attraction. This can be prevented by interposing an impervious layer of slate in the foundation-wall.

Where the moisture is due to the rain beating against the outside walls, and thus saturating them if composed of porous materials, a thorough external coating of impervious paint will prove a good remedy.

IV. INTERIOR ARRANGEMENTS.

A. Size of Rooms, and Ventilating and Heating Arrangements.— The rooms in dwelling-houses should never be under $2^1/_2$ metres in height from floor to ceiling. In sleeping-rooms the initial air-space should never be less than 35 cubic metres for adults, and 25 cubic metres for children under 10 years of age. Provision must be made for changing this air sufficiently often to maintain it at its standard of purity; *i.e.,* less than 7 parts of carbon dioxide per 10,000. The details for accomplishing this will vary with the architect's designs, the material of which the house is constructed, the climate, and the season. The principles laid down in the section on ventilation (Chapter 1) should be adhered to. In cold weather the air should be warmed, either before its entrance into the room or afterward, by stove or fire-place. Galton's jacketed stove, or fire-place, seems to answer this purpose admirably. The details of the heating apparatus must be left to individual taste, or other circumstances. It may be noted, however, in passing, that the prevailing method of heating houses by means of hot air is objectionable for various reasons: partly, because the air is usually too dry to be comfortable to the respiratory organs; partly, because organic matter is frequently present in large proportions, and gives the air an offensive odor when the degree of heat is high enough to scorch the organic matter. Both these objections are, however, removable; the first by keeping a vessel of water constantly in the furnace, so that the hot air can take up a sufficient proportion of vapor in passing through, and, the second, by having the furnace made large enough so that the temperature need never be raised to a very high degree. Heating by hot water or steam is preferable to the hot-air furnace. Both of these methods are, however, more expensive to install.

Where special ventilating arrangements are necessary, air-inlets may be inserted at appropriate points in the walls of the room, facing toward the air. A simple arrangement is that known as the Bury Ventilator, shown in Figs. 14 and 15. It consists of a wooden block interposed between the bottom of the lower window-sash and the window-frame. The air passes into the room through the openings in the block, as shown in the illustration. The separation of the upper and lower sashes, when the ventilator is in place, also adds to the efficiency of the ventilation, as the air passes in through the space so formed.

A cheaper ventilator can be made by simply tacking a strip of canvas, binders' board, or manilla paper, 20 to 25 centimetres wide, across the lower portion of the window-frame, and then raising the

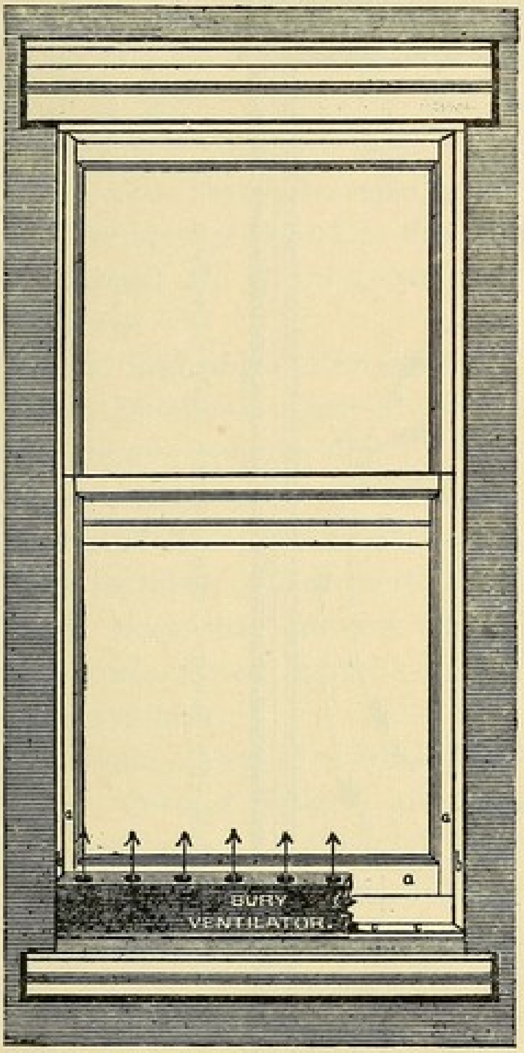

Fig. 14.

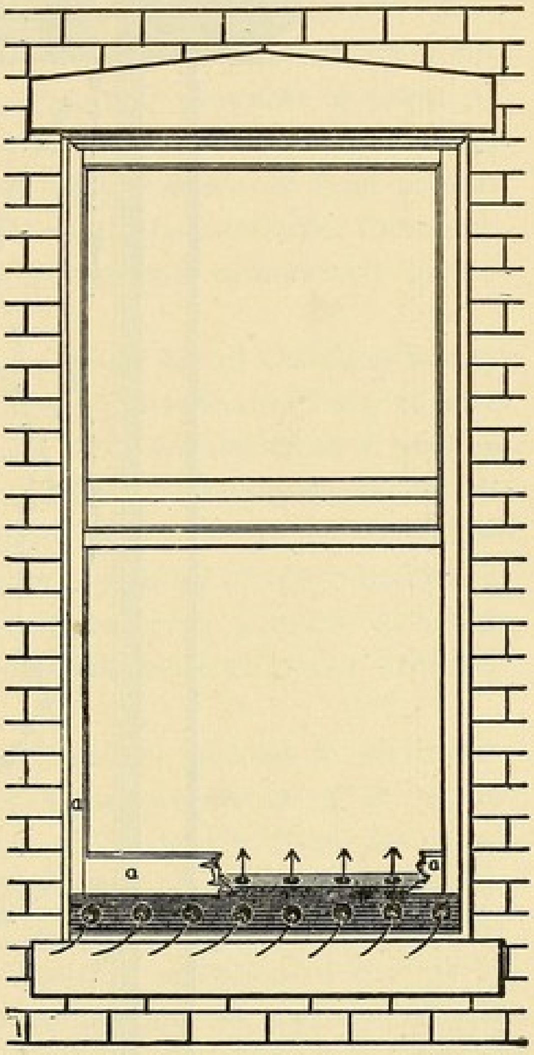

Fig. 15.

Fig. 14.—*a, a*, Sash. *b, b*, Window-jambs. *c, c*, Window-sill. This cut represents the view from within the Bury Ventilator, in operation. It is broken away at one end to show the sash raised above the outer holes to admit the air.

Fig. 15.—*a, a*, Sash. This cut represents the view from without the Bury Ventilator, in operation. The *sash* is broken away to show the ventilator behind, with the fresh air passing in.

sash 10 to 15 centimetres. The air will pass in under the lower and between the lower and upper sashes and pass upward toward the ceiling and then gradually diffuse itself through the room. In summer a counter-opening may be obtained for the escape of foul air by lowering the upper sash, while in winter a stove or fire-place will furnish a good exit.

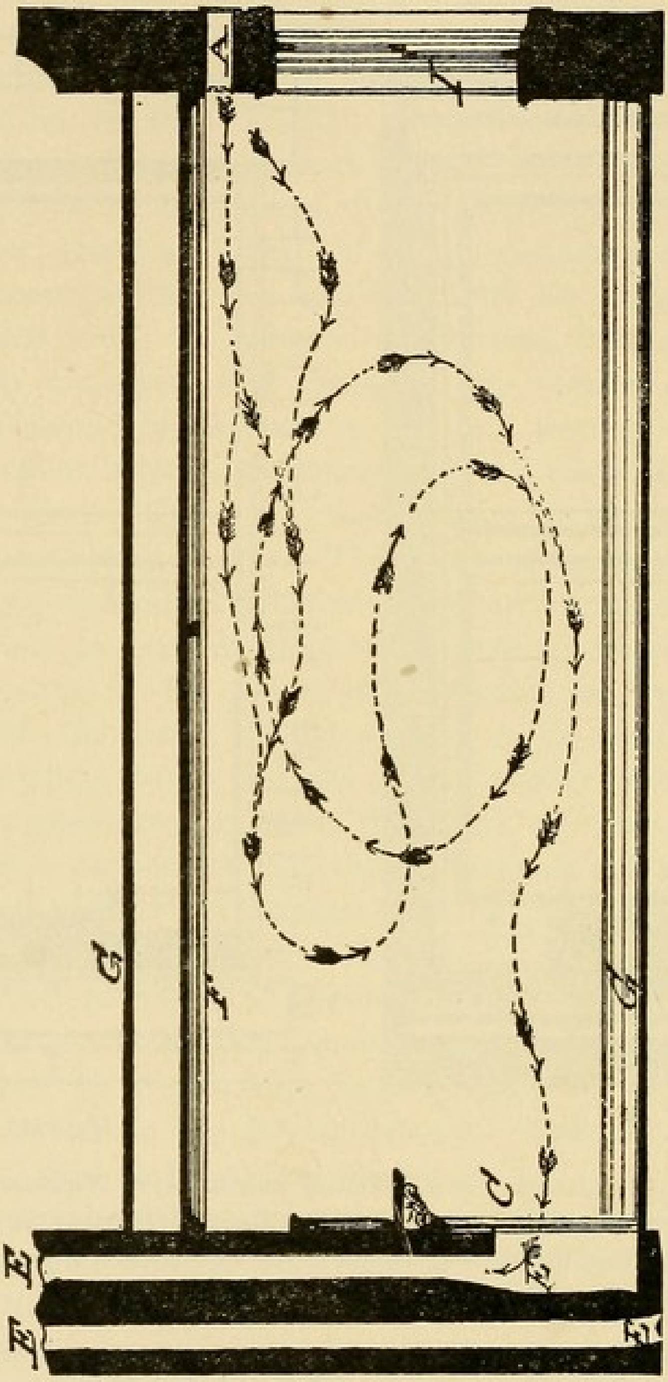

Fig. 16.—Ventilation of a Room Containing an Open Fireplace.

Fig. 16 shows the probable course of the air-currents in a room ventilated by means of a fresh-air inlet near the ceiling and an open fire-place. *A* is the inlet; *C*, the fire-place; *G*, the floor; *F*, ceiling; *E E*, flues.

B. Internal Wall-coating.—A point of considerable importance in the outfitting of dwelling-houses is the material used for coating or decorating the inside of the walls. Green paint and green-colored wall-papers should be rejected. The reason for avoiding this color is the following: Bright-green pigments and dyes are largely composed of some compound of arsenic, which becomes detached from the wall or paper when dry and, being inhaled, produces a train of symptoms which have been recognized as chronic arsenical poisoning. Many cases have been reported in which serious and even fatal poisoning has been produced in this way.[7] It would be advisable, therefore, to discard all bright-green tints in paints and ornamental paper-hangings.

C. Lighting.—Provision should be made in all dwelling-houses for an abundant supply of sunlight. Every room should have at least one window opening directly to the sun. It is not sufficient to give an ample window-space, which should be in the proportion of one to five or six of floor-space, but the immediate surroundings of the house must be taken into account. Thus, close proximity of other buildings, or of trees, may prevent sufficient light entering a room, although the window-space may be in excess of that required under ordinary circumstances.

Some form of artificial light will also be needed in all dwellings. Certain dangers are necessary accompaniments of all available methods of artificial illumination. The danger from fire is, of course, the most serious. This danger is probably least where candles are used, and greatest where the more volatile oils (kerosene, gasolene) are employed. The use of candles results in pollution of the air by carbon dioxide and other products of combustion to a greater degree than when other illuminating agents are used; they also give out a larger amount of heat in proportion to their power of illumination. Kerosene gives a good light when burned in a proper lamp, and is cheap, but the dangers from explosion and fire are considerable. The danger from explosion can be greatly reduced by always keeping the lamp filled nearly to the top, and never filling it near a light or fire. The danger of explosion is increased when the chimney of the lamp is broken, as then the temperature of the metal collar, by which the burner is fastened to the lamp, is rapidly raised[8] and the oil vaporized. If, at the same time, the lamp is only partially

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[7] Arsenic in Certain Green Colors, F. W. Draper. Third Annual Report Mass. State Board of Health, 1872, pp. 18-57.

[8] H. B. Baker, in Report Mich. State Board of Health, 1876, p. 48.

filled with oil, the space above it is occupied by an explosive mixture of air and the vapor of the oil. If this is heated to a sufficient degree an explosion will take place.[9]

The use of coal-gas is probably attended by less danger than the lighter oils, but by more than other means of illumination. In addition to the dangers from fire and explosions, which are inevitable accompaniments of defects in the fixtures, the escaping gas is itself exceedingly poisonous from the large amount of carbon monoxide it contains. It is, in fact, a very frequent occurrence in large cities that persons are killed by the inhalation of gas which has escaped from the fixtures or was allowed to escape from the burner through ignorance. That variety of illuminating gas known as "water-gas" is more dangerous to inhale than coal-gas owing to the larger proportion of carbon monoxide contained in it. Recent experiments by T. A. Maass indicate that the toxic action of illuminating gas is due in part to some factor aside from the carbonic oxide, as it is so much more toxic than CO alone. The "natural gas" used as a fuel and illuminant in some places in the United States is especially dangerous from the total absence of odor. The gas may escape in large quantity and fail to give notice of its presence except by an explosion, if ignited, or by producing asphyxia in those who incautiously venture into the air permeated by it. The slight but continuous escape of gas from defective or leaky fixtures may produce a grave form of anemia. Chronic CO poisoning is probably of more frequent occurrence in cities than is generally suspected.

The electric light (Edison's incandescent system) is probably open to less objection on the score of danger than any other of the illuminating systems mentioned. There is no trustworthy evidence that the electric light has any unfavorable influence on the vision, although Regnault supposed it would have a bad effect upon the ocular humors on account of the large proportion of the violet and ultra-violet rays it contained. In order to remove this objection Bouchardat advised the wearing of yellow glasses by those compelled to use this light for close work. The advantages of the incandescent light, besides the brilliant white light it gives, are that it is steady and does not produce any heat, nor does it pollute the air with carbon dioxide and other products of combustion. Professor von Pettenkofer has shown experimentally that the pollution of the air by the products of combustion is very much greater when gas is used

[9] See an instructive paper by Prof. R. C. Kedzie, in Report Mich. State Board of Health for 1877, p. 71 *et seq.*

than where the electric light is employed. The electric arc-lights are extremely dangerous on account of the high potential maintained in the wires, and the difficulty of thoroughly insulating the latter. Many deaths have occurred from this source, and unless a method is discovered and adopted by which the voltage of the arc-light current can be greatly diminished without decreasing the efficiency of the light, this method of lighting must soon be given up in cities, owing to its danger, not only to those directly brought in contact with the conductors, but to others who may indirectly get in the way of the errant current.

In writing, sewing, reading, or other work requiring a constant use of accurate vision, the light, whether natural or artificial, should fall upon the object from above and on the left side. Hence, windows and burners should be at least the height of the shoulder and to the left of the person using the light.

Increased ventilation facilities must be provided where artificial light (except the electric light) is used to any extent. It has been calculated that for every lighted gas-burner 12 to 15 cubic metres of fresh air per hour must be furnished in addition to the amount ordinarily required in order to maintain the air of the room at the standard of purity.

V. WATER-SUPPLY.

The water-supply of a dwelling-house should be plentiful for all requirements, and its distribution should be so arranged that the supply for every room is easily accessible. Where practicable, water-taps should be placed on every floor, both for convenience and for greater safety in case of fire. It is also a result of observation that personal habits of cleanliness increase in a direct ratio with the ease of obtaining the cleansing agent. The inmates of a house where water is obtainable with little exertion are much more likely to be cleanly in habits than where the water-supply is deficient or not readily procured.

VI. HOUSE-DRAINAGE.

Provision must be made for the rapid and thorough removal of waste-water and excrementitious substances from the house. This is most easily and completely accomplished by well-constructed water-closets and sinks. Water-closets should, however, not be tolerated in any room occupied as a living- or bed- room. It would doubtless be very much more in accordance with sanitary requirements to have all permanent water-fixtures, water-closets, and bathing arrangements placed in an annex to the dwelling proper. In this way the most serious danger from water-closets and all arrangements having a connection with a cess-pool or common sewer—permeation of the house by sewer-air—could be avoided.

Water-closets, however, presuppose an abundant supply of water. Unless this can be obtained and rendered available for flushing the closets, soil-pipe, and house-drain, the dry-earth or pail system should be adopted. Privies should not be countenanced. Experience in several large cities of Europe has demonstrated[10] that the pail system can be adopted with advantage and satisfactorily managed even in large communities.

As house-drainage may be considered the first and most important link in a good sewerage system, a brief description will be here given of the details of the drainage arrangements of a dwelling-house. The rapid and complete removal of all fecal and urinary discharges, lavatory- and bath- wastes, and kitchen-slops must be provided for. For these purposes are needed, *first,* water-closets and urinals, wash-basins and bath-tubs, and kitchen- or slop- sinks; *second,* a perpendicular pipe, with which the foregoing are connected, termed the soil-pipe; and *third,* a horizontal pipe, or house-drain, connecting with the common cess-pool or sewer.

A. Water-closets.—There are five classes of water-closets in general use. They are the pan-, valve-, plunger-, hopper-, and washout-closets.

Pan-closets are those found in most old houses containing water-closet fixtures. Just under the bowl of the closet is a shallow pan containing a little water, in which the dejections are received. On raising the handle of the closet, the pan is tilted and the water at the same time is turned on, which washes out the excrement and sends it into or through the trap between the closet and the soil-pipe. It will be readily understood that the space required for the movement of the pan—the "container," as it is termed—is rarely thoroughly cleansed by the passage of water through it. Fecal matter, paper, etc., gradually accumulate in the corners of the container, and, as a consequence, pan-closets are always, after a brief period of use, foul. There are other defects in the construction of the pan-closet which render it untrustworthy, but the one especially pointed out—the

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[10] See Chapter v, p. 139.

impossibility of keeping it clean—is enough to absolutely condemn its use, from a sanitary point of view. It is decidedly the worst form of closet that can be used.

Valve-closets are merely modifications of the pan-closet. The bottom of the bowl is closed by a flat valve, which is held in its place by a weight. By moving a lever the valve is turned down, allowing the excreta to drop into the container. The only differences between the pan- and valve-closets are that in the latter a flat valve is substituted for the pan of the former, and that this allows the container

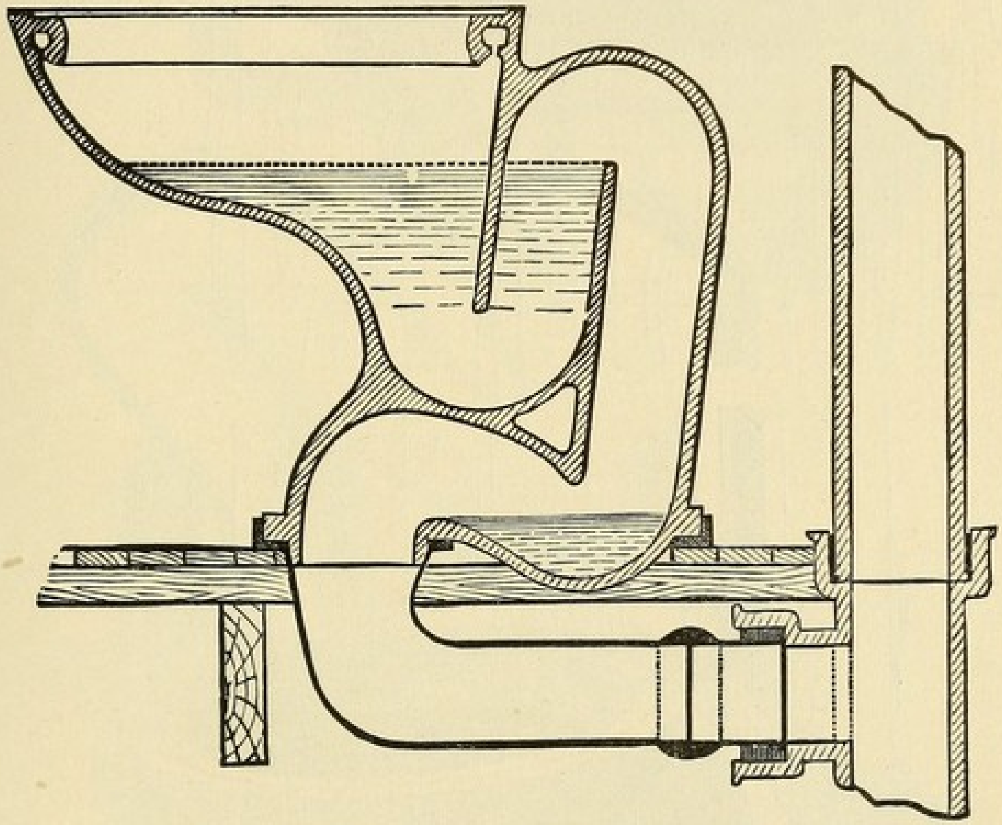

Fig. 17.—The "Dececo" Closet (New Form).

to be made smaller. Otherwise there are no advantages in the valve-closet. Considered from a sanitary standpoint, the valve-closet is no worse than the pan-closet, and but very little, if any, better.

The third variety, or plunger-closet, has several marked advantages over the two just described. The characteristic feature of the closets of this class is that the outlet, which is generally on one side of the bowl, is closed by a plunger. This bowl is always from one-third to one-half full of water, into which the excreta fall. On raising the plunger, the entire contents of the bowl are rapidly swept out of the apparatus into the soil-pipe, the bowl thoroughly washed out

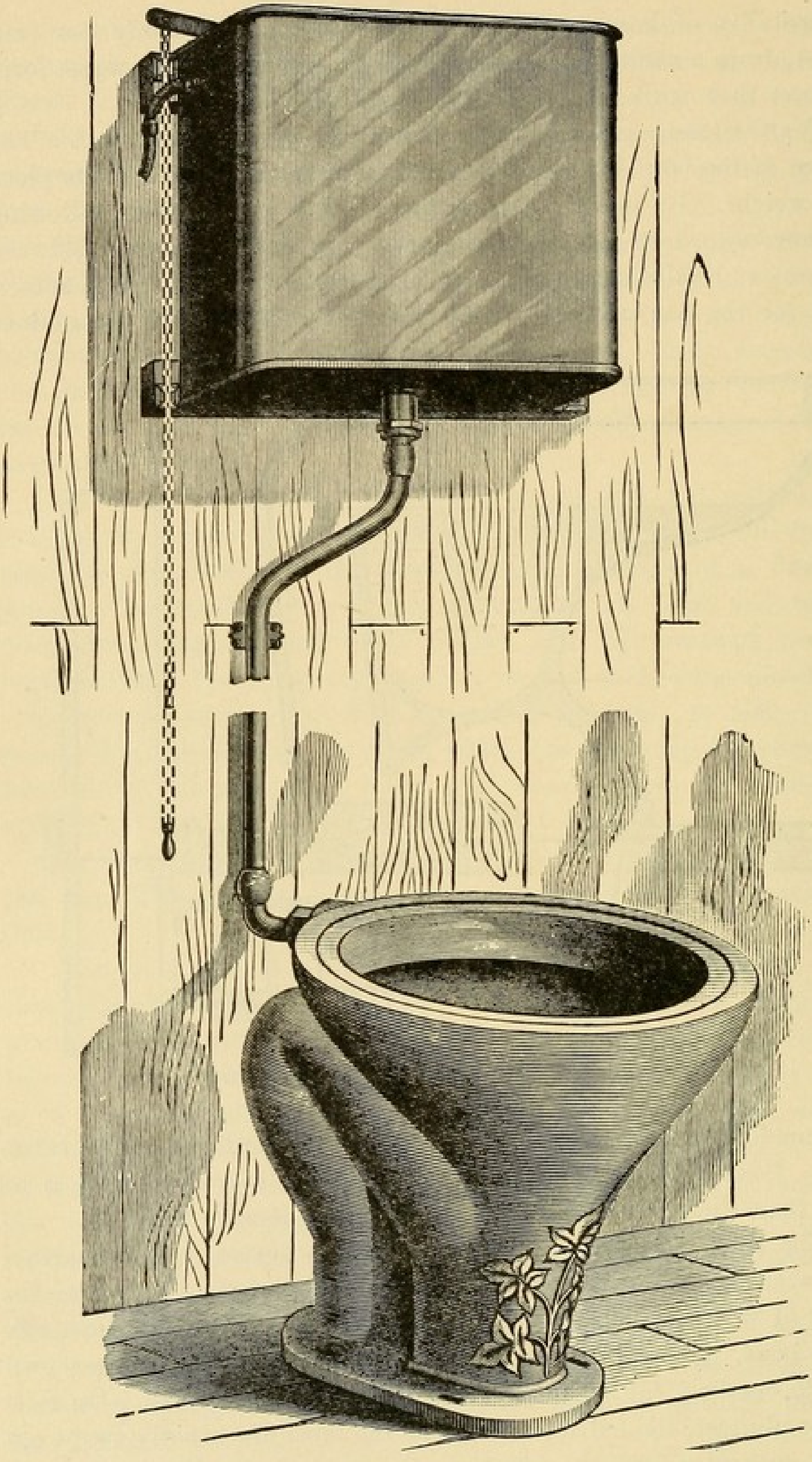

Fig. 18.—The "A. G. M." Closet.

by a sudden discharge of water, and, on closing the outlet with the plunger, the bowl is again partly filled with water. An overflow attachment prevents accumulation of too large a quantity of water in the bowl. This overflow, however, sometimes becomes very foul and objectionable. The Jennings, Demarest, and Hygeia are types of this class. The principal objection is that the plunger sometimes fails to properly close the outlet, allowing the water to drain out of the bowl, and thus destroying one of its principal advantages. The mechanism is also somewhat complicated and likely to get out of order.

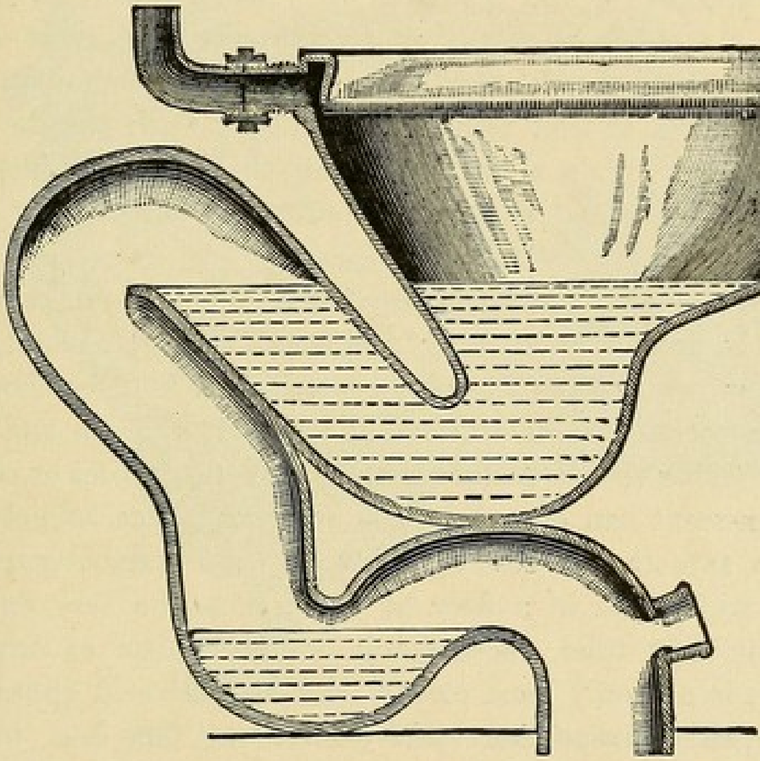

Fig. 19.—Sectional View of "A. G. M." Closet.

The hopper-closet consists of a deep earthenware or enameled iron bowl, with a water seal trap directly underneath. The excreta are received directly into the proximal end of the trap, and when the water is turned on the sides of the bowl are washed clean and everything in the bowl and trap swept directly into the soil-pipe. There is no complicated mechanism to get out of order, the trap is always in sight, and the entire apparatus can always be kept clean and inoffensive, as there are no hidden corners or angles for filth to lodge. This form of closet is, all things considered, one of the best for general use.

The "wash-out" closets are of various shapes, some having the trap in the bowl itself, others having a double water-trap. They are generally simple in construction, and not likely to get out of order. They do not present any decided advantages over the simple hopper, although at the present time they are more used than any other form of closet. Of the recent improvements in this form of closet may be mentioned the "A. G. M.,"[11] shown in view with intern in Fig. 18, and in section in Fig. 19, and the "Dececo," Fig. 17, invented by Col. George E. Waring. In the latter the automatic siphon principle, so ingeniously used by Rogers Field in the construction of the automatic flush-tank, is applied to the scouring of a water-closet. Practical experience for a number of years has demonstrated the great usefulness of this closet. If the delivery of water from the flushing-cistern is properly regulated, at first rapid to thoroughly wash out the closet and connections, and then slow to re-establish the proper depth of seal in the trap, the closet should be thoroughly satisfactory in its workings.

Water-closets should not be inclosed in wooden casings, as is almost universally done. Everything connected with the closet, soil-, and drain- pipes, water-supply, and all joints and fixtures should be exposed to view so that the defects can be immediately seen and easily corrected. By laying the floor and back of the closet in tiles or cement, such an arrangement can even be made ornamental, as suggested by Waring,[12] who says that a closet "made of white earthenware, and standing as a white vase in a floor of white tiles, the back and side walls being similarly tiled, there being no mechanism of any kind under the seat, is not only most cleanly and attractive in appearance, but entirely open to inspection and ventilation. The seat for this closet is simply a well-finished hard-wood board, resting on cleats a little higher than the top of the vase, and hinged so that it may be conveniently turned up, exposing the closet for thorough cleansing, or for use as a urinal or slop-hopper."

Where the arrangement here described is adopted, extra urinals are unnecessary and undesirable. Where they are used they should be constantly and freely flushed with water, otherwise they become very offensive. The floor of the urinal should be either of tiling, slate, or enameled iron.

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[11] Manufactured by the Myers Sanitary Depot, New York.

[12] Sanitary Condition of New York City, Scribner's Monthly, vol. xxii, No. 2, June, 1881.

B. Water-supply for Closets.—The water-supply for flushing water-closets should not be taken directly from the common house-water supply, but each closet should have an independent cistern large enough to hold a sufficient quantity of water for a thorough flushing (20 to 30 litres) every time the closet is used. The objections to connecting the water-closet directly with the common house-supply are, that there is often too little head of water to properly flush the

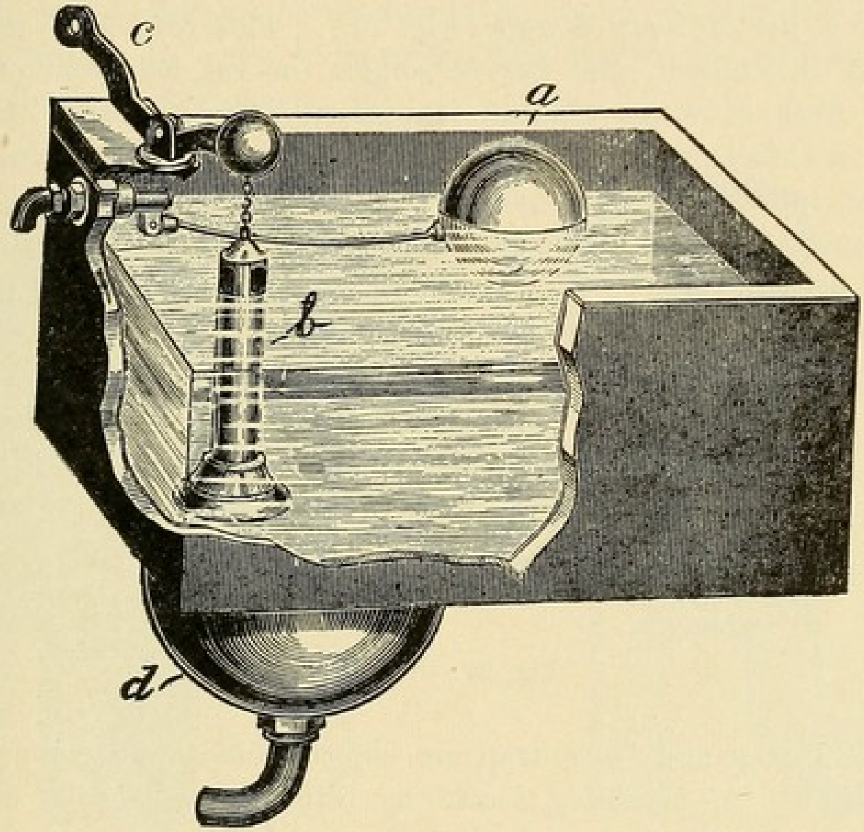

Fig. 20.—Flushing Cistern for Water-closets.

basin; and, secondly, if the water be drawn from a fixture in the lower part of the house, while the valve of a water-closet in an upper floor is open at the same time, the water will not flow in the latter (unless the supply-pipe is very large), but the foul air from the closet will enter the water-pipe, and may thus produce dangerous fouling of the drinking-water. Hence, separate cisterns for each water-closet should always be insisted upon.

The arrangement of these cisterns is often difficult to comprehend. Fig. 20 shows the interior arrangement of one form. The ball-shaped float, *a,* cuts off the supply when the tank is full, while opening the valve, *b,* by means of the crank, *c,* discharges the water. The rounded annex, *d,* contains water enough to partly fill the closet-bowl and trap after the contents have been washed out by the rapid flush.

C. Traps.—Every water-closet, urinal, wash-basin, bath-tub, and kitchen-sink should have an appropriate trap between the fixture and the soil-pipe. The trap should be placed as near the fixture as practicable, as pointed out above; in the best forms of water-closet the bottom of the closet itself forms part of the trap.

Traps differ in shape and mechanism. The simplest and usually efficient is the ordinary **S**-trap (Fig. 21). This trap is of uniform diameter throughout, and has no angles for the lodgment of filth. A free flush of water cleanses it perfectly, and it rarely fails to furnish a sufficient obstruction to the passage of sewer-air from the soil-pipe, unless the water has evaporated or been forced out under a back-pressure of air in the soil-pipe, or been siphoned out, and thus the seal broken.

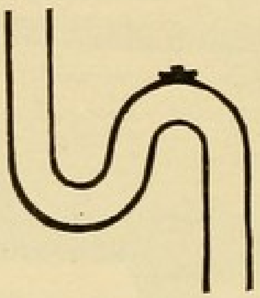

Fig. 21.—S-Trap.

The **D**-trap and bottle-trap are objectionable on account of the great liability of becoming fouled by filth lodging in the corners, while in the mechanical traps, like Bowers' ball-valve trap, Cudell's trap, and others of this class, there is always danger of insufficient seal by filth adhering to the valve, and thus preventing its exact closure.

Most of the traps now furnished by the dealers in plumber's supplies have an opening in the highest part for attaching a vent-pipe. It has been found that the seal in most traps can be broken by siphonage, if the pressure of air on the distal side (the side toward the soil-pipe) of the trap is diminished, or, on the other hand, by increase of pressure in the soil-pipe the water in the trap may be forced back into the fixture, and thus sewer-air enter the room. By providing for a free entrance and exit of air to the trap this breaking of the seal can be prevented. The ventilation of traps is, however, an evil, as it furnishes an additional means of evaporation, and when the fixture is not in frequent (daily) use the seal is sooner broken. The elaborate extra system of ventilation of traps, so generally insisted upon by plumbers and sanitary engineers, is unnecessary. If the soil-pipe is of the proper size and height, siphonage of traps will not be likely to occur. The waste-pipe connecting the fixture and the soil-pipe should be as short as possible; in other words, all water-closets, urinals, baths, and lavatories should be placed as near the soil-pipe as practicable, in order to have no long reaches of foul waste-pipe under floors or in rooms.

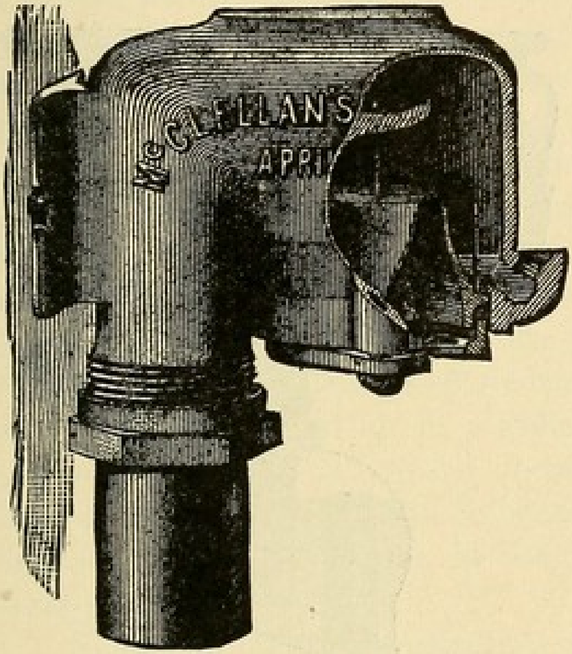

Fig. 22.

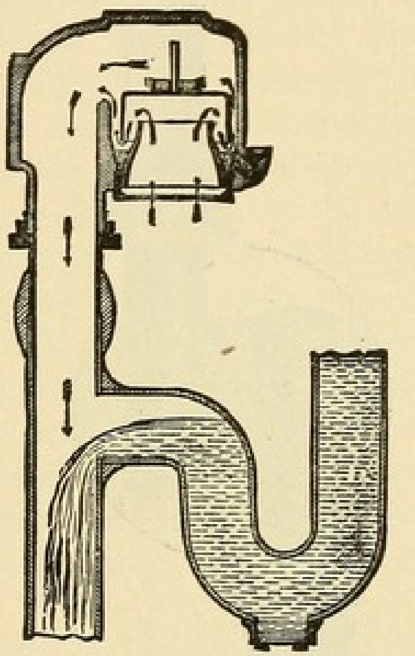

Fig. 23.

Fig. 22.—Sectional View of Vent, with Cap in Normal Position.

Fig. 23.—Sectional View of Vent, with Cup Lifted out of the Mercury by the Inflowing Current of Air Indicated by the Arrows.

Dr. E. S. McClellan has recently invented a trap which obviates many of the objections urged against all previous devices, and is intended to meet the defects of the **S** and other traps. It consists of a body containing a light, inverted cup, with its edges resting in an annular groove containing mercury, which forms an absolute seal against the escape of sewer-air. When a slight diminution of pressure occurs on the sewer side of the cup, the greater external pressure lifts the cup out of the mercury and permits a free inflow of air until the wonted equilibrium is re-established, when the cup drops back into the mercury by gravity, and effectually closes the trap against any outflow. With this trap siphonage of the seal is impossible. Fig. 22 shows this trap with the cup down, and Fig. 23 with the cup raised, allowing inflow of air.

For an ordinary wash-bowl or bath-waste (which should always be trapped), the Connolly globe-trap, shown in Figs. 24 and 25, is an excellent fixture. It is impossible, under ordinary circumstances, to break the seal by siphonage.

D. The Soil-pipe.—The vertical pipe connecting the water-closets and other fixtures with the house-drain is called the soil-pipe. It

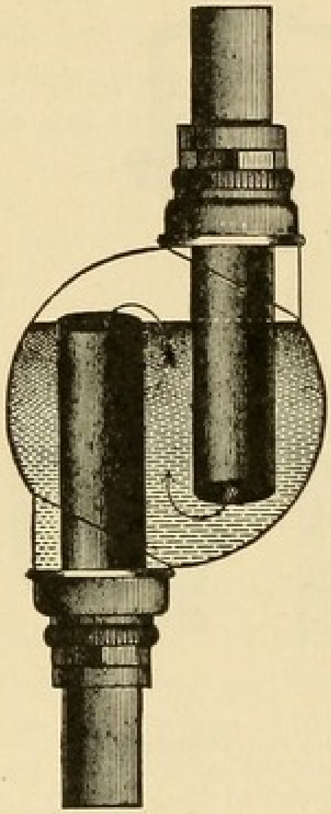

Fig. 24.—Connolly Globe-trap.

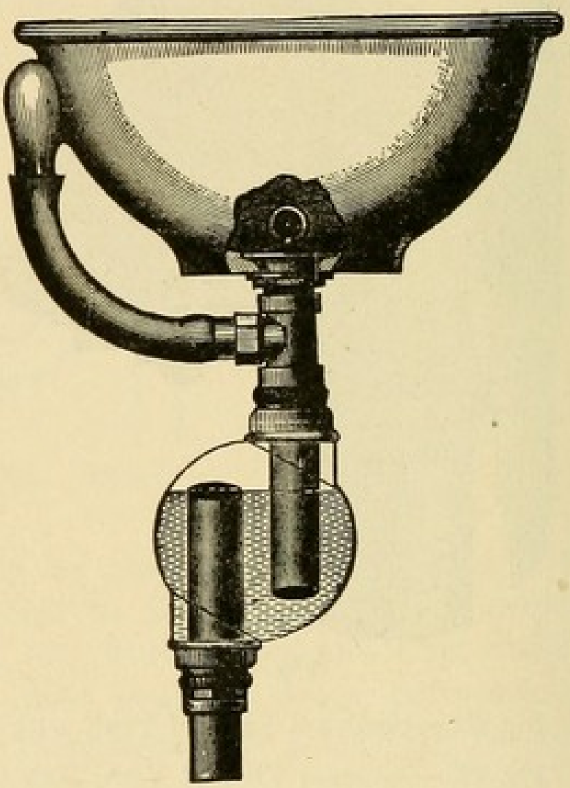

Fig. 25.—Globe-trap Attached to Basin.

should be of iron, securely jointed, of an equal diameter (usually 10 centimetres) throughout, and extend from the house-drain to from $1^1/_2$ to 2 metres above the highest point of the house. The connections of all the waste-pipes from water-closets, baths, etc., should be at an acute angle, in order that an inflow at or nearly at right angles may not produce an obstruction in the free passage of air up and down the soil-pipe. The diameter of the soil-pipe, at its free upper end, should not be narrowed; in fact, according to Col. Geo. E. Waring, the up draught is rendered more decided if the upper extremity of the soil-pipe is widened.[13] The internal surface of the pipe should be smooth, and especial care should be taken to prevent projections inward at the joints; otherwise, paper and other matters will adhere to the projections, and gradually obstruct the pipe.

E. The House-drain.—The horizontal or slightly inclined pipe which connects the lower end of the soil-pipe with the sewer or cesspool, the point of final discharge from the house, should be of the same diameter and material as the soil-pipe. The joints should be made with equal care, and the pipe should be exposed to view throughout while within the house-walls. If sunk below the floor of the cellar it should be laid in a covered trench, so that it may be readily inspected. The junction between the vertical and horizontal pipe should not be at a right angle, but the angle should be rounded. The drain-pipe should not be trapped. This is contrary to the advice of sanitary authorities generally, but the author thinks it unadvisable to trap the drain-pipe. There should be no obstruction to the outflow of sewage from the house, and a trap in the drain-pipe is of no avail against the passage of sewer-air from the sewer or cesspool into the soil-pipe, if the pressure of air in the former is increased. Furthermore, if the passage of air backward and forward between the sewer and the external air at a sufficient height (above the roofs of houses, for example) is free and unobstructed, the sewers (or the cesspool, as the case may be) will be better ventilated than if any obstruction to such free circulation, in the form of a trap, be placed in the drain-pipe.

Nearly all sanitary authorities direct that an opening for the admission of fresh air—"fresh-air inlet"—should be made in the drain-pipe, before its connection with the sewer or cesspool. This is done with the view of having a constant current of fresh air entering near the base of the soil-pipe and passing upward through it. Theoretically, the current ought always to pass in this direction. Practically, however, the current is found, at times, to pass the other way, and the foul air from the soil-pipe may be discharged into the air near the ground, where it would be much more likely to do harm than when discharged high up in the air beyond the possibility of being breathed.

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[13] Am. Architect, p. 124, Sept. 15, 1883.

OFFICIAL SUPERVISION OF THE SANITARY ARRANGEMENTS OF DWELLINGS.

In most towns and cities the municipal authorities have provided for an official inspection of buildings, to prevent neglect of precautions against fire and other manifest dangers to life. It is only very recently, however, that the authorities of some of the larger cities in this country have enacted laws to prevent improper construction of house-drainage works. Although none of these laws or ordinances cover the subject completely, yet their proper enforcement must result in great advantage.

Within the past few years, following the example of Edinburgh, volunteer associations have been organized in various cities of this country, with the object of securing constant expert inspection and supervision of the drainage arrangements of dwellings and other necessary sanitary improvements.

The good results accomplished by the Newport Sanitary Protection Society, the New Orleans Auxiliary Sanitary Association, and other similar bodies attest the usefulness of such organizations.

THE INTERIOR ARRANGEMENT OF THE HOUSE.

A dwelling is neither a store-house for furniture, a museum, nor a picture gallery. It is a place to live in with comfort and in accordance with hygienic rules. The interior furnishing, therefore, should be simple and neat. The furniture, and only so much of it as is needed for comfort, should be of such construction as not to gather dust. Upholstered furniture, with the exception of plain leather, is unsanitary and should not be tolerated. The floors should be polished and covered with rugs. The guiding principle in all cases should be a maximum of space and a minimum of dust.

QUESTIONS TO CHAPTER VI.

CONSTRUCTION OF HABITATIONS.

Why should the principles of hygiene be observed in the construction of dwellings? What relation is there between badly-constructed and overcrowded dwellings in cities? Between overcrowded dwellings and the death-rate, either general or from contagious diseases? What class of persons are especially affected by overcrowding and unsanitary conditions of their dwellings?

What points should be taken into consideration in building a house? What things are to be sought and what avoided in selecting a site? On what kind of soil should the house be built? How far should the ground-water be below the surface, even at its highest? What must be known about a soil to determine whether it is sanitarily suitable for building purposes? What is the usual judgment concerning sites on granite, trap, or metamorphic rocks? What if they have been disintegrated? What regarding those on the clay slate? Limestone and magnesian limestone? Chalk? Sandstone? Gravel? Sands? Clays and alluvial soils? Cultivated lands? Which of the above is probably the best, on general principles, for the site for a dwelling? Where a site is wet or the soil is impure, what must be done? What is the minimum depth at which drains for the soil-water should be laid? How else may the drying of the soil be promoted? How should a cellar or basement over an impure soil be paved? What precaution should be observed in building a house against a hill?

What are some of the materials of which the walls of a house may be built? What are the advantages of good brick? Why should very porous sandstone not be used for building purposes in cold climates? What is the effect of paint upon house-walls? Has calcimining or white-washing the same effect? Has wall-paper? How soon should newly-built houses be occupied? To what are moist walls sometimes due, and how may they be obviated?

What should be the minimum height of rooms in dwelling-houses? How much air-space should there always be in sleeping-rooms for adults and children? What is the standard of purity of the air that should be maintained constantly? What are the objections to heating by hot-air furnaces, and how may these objections be avoided? How may a room be ventilated without expensive apparatus?

What colors should be avoided in wall-paper and paints for inside work, and why? What should be the proportion of window-space to floor-space, and what other points should be observed in the day-lighting of rooms? What are the forms of artificial light used for household illumination, and what are the dangers accompanying each? What are some of the especial advantages of the incandescent electric light? From what direction should the light come for writing, reading, etc.? Why must there be increased ventilation where artificial lights (except incandescent electric) are used? How much fresh air per hour is needed to properly dilute the impurities produced by burning illuminating gas?

What points are to be observed regarding the water-supply of a dwelling? Why should it be both abundant and convenient?

How are waste-waters and excrementitious matters most readily removed from a house? Where would it be best to have all fixtures, etc., of a house-drainage system located, if possible? What do water-closets, etc., presuppose? If this cannot be had, what system should be adopted instead? For what must a proper house-drainage system provide? What are the component parts of such a system?

Where should water-closets never be located? What five classes of water-closets are there? Which of these are most objectionable, and why? Describe briefly the construction of a pan- and a valve- closet. In what way is a plunger-closet better than a pan- or valve closet? Wherein is it sanitarily imperfect? Why is the hopper-closet one of the best? What two kinds of hopper-closet are there? What can be said of the wash-out closets? What is the principle of siphon closets? Why should water-closets and other fixtures not be inclosed in wooden casings? How may the surroundings of such closets and fixtures be further improved? Why should the water-supply for closets not be taken directly from the house-supply? How much should the flushing cistern hold?

What are traps? Where should they be located? How many should there be in any system of house-drainage? What is the simplest form of trap? What are its advantages? Upon what does the value of a trap depend? What is to be avoided in the selection of a trap? What is meant by siphonage? How can this be prevented? To what part of the trap is the vent-pipe to be attached? Where should the other end of the vent-pipe open? How else may the seal of a trap be broken? What is the principle of McClellan's anti-siphon trap?

How long should the waste-pipe connecting the fixtures with the soil-pipes be? What is the soil-pipe? Of what dimensions should it be? Where should its upper extremity end? What other precautions should be observed in regard to the soil-pipe?

What is the house-drain? What care must be observed in the laying of it? What can you say regarding a trap between the house-drain and sewer? If a trap is thus located, what else must there be between the trap and the house, and why? What can be said regarding the official supervision of sanitary arrangements in dwellings? What principle should underly the furnishing of a house?

CHAPTER VII.

CONSTRUCTION OF HOSPITALS.

SITE.

If the choice of a site for the habitations of healthy persons is a matter of vital importance, as was pointed out in the last chapter, it needs no argument to impress upon the reader the actual necessity of choosing a site with wholesome surroundings for a habitation for the sick. In selecting a site for a hospital, therefore, it is of prime importance to avoid a location where unsanitary influences prevail.

While a hospital should always be easily accessible, it is not desirable that it should be in a noisy or crowded part of a city. Where a hospital is primarily designed for the reception of accident or "emergency" cases, it is, of course, necessary to have it near to where accidents are likely to occur. In a city this will probably be in the most crowded and noisy part.

The direction of the prevailing winds from the city should be avoided in selecting a site for a hospital.

Free admission of sunlight and air must be secured to all parts of the hospital. An elevated location is therefore desirable, although exposure to violent winds must, if possible, be avoided.

The soil upon which a hospital is built should be clean, easily drained, with a deep ground-water level, not liable to sudden oscillations. The neighborhood of a marshy or known malarious region should be avoided.

THE BUILDINGS.

The building area must be large enough to permit the construction of buildings in accordance with the modern recognized principles of hospital construction. Overcrowding is not permissible, either of the ground by buildings or of the buildings by patients.

Having determined the number of patients for whom provision is to be made and the character of the diseases to be treated, an estimate must be made of the area necessary for a hospital. Taking into account all the buildings needed, the area required will be—for two or more storied buildings—not less than 30 square metres per bed.

If one-story buildings are to be erected more space will be required, and if infectious diseases are to be treated in the hospital the above space-allowance must be doubled or even trebled. In the Johns Hopkins Hospital, in Baltimore, the area occupied by the buildings is 56,000 square metres, and provision is to be made for 300 patients. This, covering, of course, the area occupied by the administration building, nurses' home, kitchen, dispensary, operating and autopsy theatre, laundry, etc., gives an area of 187 square metres per bed. The actual allowance of floor space per bed is $11^1/_2$ square metres; for patients with infectious diseases the space-allowance is nearly treble, being 29 square metres.

Within recent years the principles of hospital construction have undergone considerable modification. While formerly a large hospital consisted usually of one large, two or more storied building, in which all the various departments were comprised under one roof, the aim has recently been to scatter the wards as much as practicable, consistent with reasonable ease of supervision and administration. Under the former plan, with large wards connected by common corridors and stairways, ease of administration was primarily secured; in the latter, the most important object of a hospital, "a place for the sick to get well in," is more nearly attained. While many hospitals are still being constructed on the old plan, of a single block of several stories in height, nearly all sanitary authorities are agreed that the plan of separate pavilions of one or, at most, two stories, in which the buildings are entirely disconnected, or connected only by means of an open corridor for convenience of administration, is best for the patients, and, leaving out of account the cost of the ground, is also the most economical.

The recent development of the pavilion system of hospitals may be attributed largely to the success obtained in treating the sick and wounded in the simple barrack hospitals during the late war between the States. The army barrack hospital is the original type of the pavilion hospital of the present day.

Each pavilion consists of one or two wards, containing from ten to thirty beds altogether. In each pavilion or ward is also a bath- and wash- room, water-closet, dining-room, scullery, attendants' room, and sometimes a day-room for patients able to be out of bed.

The two-story pavilion is built on the same plan, and is generally adopted in cities, or where economy of space is desirable for financial reasons, and where no infectious diseases are treated. Where practicable, one-story pavilions should always be adopted, as they are more easily heated, ventilated, and served than two-storied buildings.

When a number of pavilions or wards are connected by a corridor with each other, and with a central or administration building

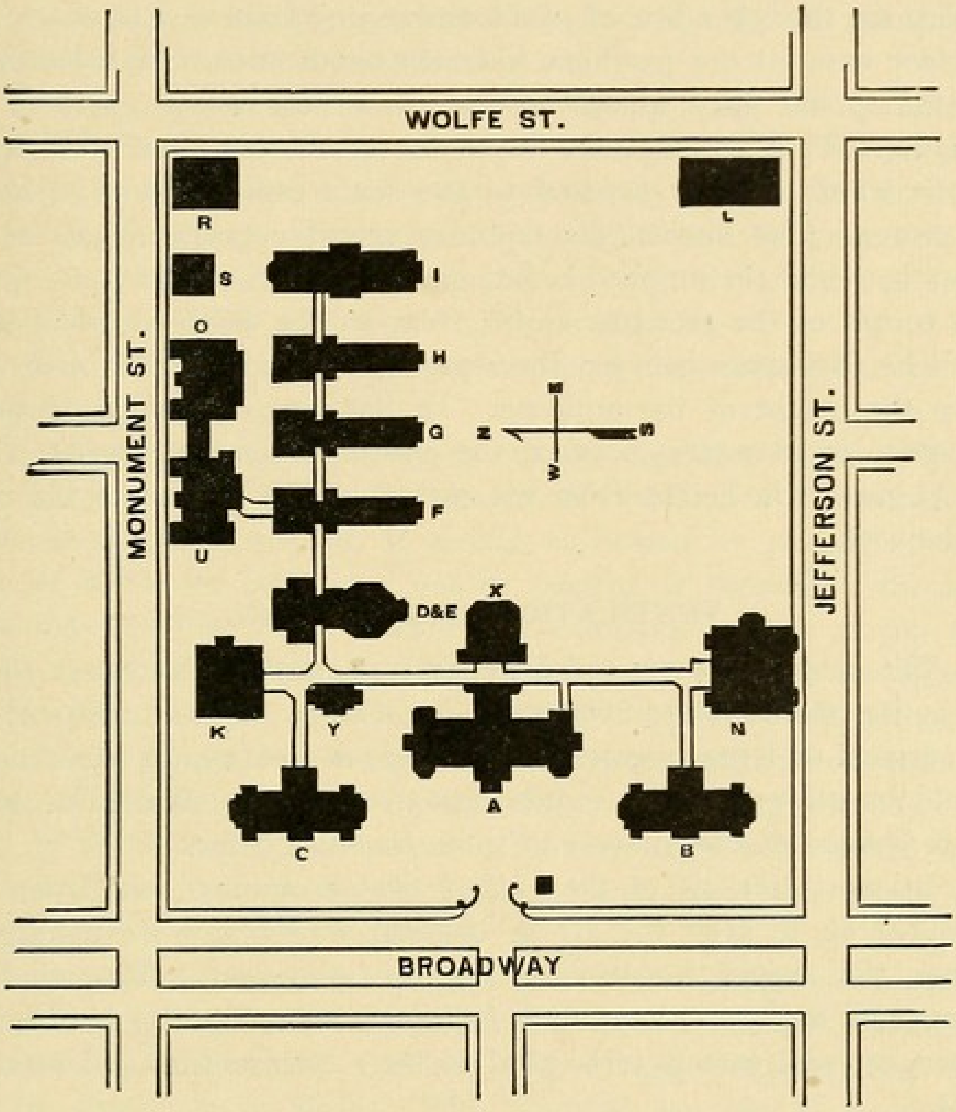

Fig. 26.—Plan of Johns Hopkins Hospital. *A*, Administration Building. *B*, Female Pay-ward. *C*, Male Pay-ward. *D*, Male Surgical Ward. *E*, Female Surgical Ward. *F*, Male Medical Ward. *G*, Female Medical Ward. *H*, Gynecological Ward. *I*, Isolating Ward. *K*, Kitchen. *L*, Laundry. *N*, Nurses' Home. *O*, Dispensary. *R*, Pathological Building. *S*, Stable. *U*, Amphitheatre. *X*, Apothecary's Building. *Y*, Bath-house.

and other service buildings, the aggregation constitutes a modern pavilion block-hospital. The Johns Hopkins Hospital, already referred to, is a model of this class, and its plans should be studied in detail by all who are more particularly interested in hospital construction.

The general wards are in one- and two- story buildings, connected by a corridor with each other and with the administration and service buildings. In addition to two buildings containing private rooms and small wards for patients able to pay for the extra accommodations, there is a line of pavilions running from east to west. The corridor cuts all the pavilions near the north ends of the buildings, separating the ward almost entirely from the service part of the building. This arrangement leaves the south, east, and west fronts of the wards entirely exposed to the sun's rays—a very important advantage. The kitchen and laundry are at opposite angles of the grounds, while the autopsy building is placed in the extreme north-east corner of the grounds, as far from all the wards as practicable.

The free space between the separate pavilions should be at least twice the height of the building. In the Johns Hopkins Hospital, the space is 18 metres between the one-story common wards, which are 11 metres in height from the surface of the ground to the ridge of the roof.

VENTILATION AND HEATING.

The cubic space (initial air-space) per bed in the wards should not be less than 1500 to 2000 cubic feet (42 to 56 cubic metres), and for surgical or lying-in cases and contagious diseases, 70 cubic metres should be allowed. The ventilating arrangements should secure an entire change of the air two to three times an hour.

In most sections of the United States, natural ventilation can be relied on to keep the air in hospital wards pure (assuming, of course, the proper construction of the buildings). The windows, doors, and walls are important factors in securing this ventilation. Hence, especial care is to be paid to their construction and arrangement.

Many German, French, and English authorities on hospital building urge the importance of making the walls impervious by cement, glass, or paint. The peculiar odor known as "hospital odor," it is asserted, cannot be prevented in any hospital in which the floors, walls, and ceilings are not absolutely impervious. The American practice is generally in favor of walls which permit transpiration of air. In the experience of the author the imperviousness of the walls is not necessary to secure freedom from hospital odor. It remains a question for serious consideration whether the diminution of natural ventilation would not counterbalance any good resulting from non-absorptive walls.

The interior of the walls should be perfectly smooth and plain; no projections, cornices, or offsets of any kind are permissible. The desirability of this restriction was clearly expressed over a hundred years ago by John Howard: "From a regard to the health of the patients, I wish to see plain, white walls in hospitals, and no article of ornamental furniture introduced."[1]

Windows should run quite to the ceiling, and should not be arched, but finished square at the top. There should be one window for every two beds. The window-sash should be double to retain heat, and the lights heavy, clear glass. Ventilation can be promoted by raising the outer sash from below and lowering the inner one from above. The insertion of a Sherringham ventilator at the top of the inner sash will aid in giving the incoming air-current an upward direction.

Heating is best accomplished by introducing hot air from without, or by stoves or fire-places in the centre of the wards. Where hot air is introduced from without, it should be heated by passing it over steam or hot-water coils, and not by passing it through a furnace, which may produce super-heating and excessive dryness of the air.

In a series of experiments by Dr. Edward Cowles at the Boston City Hospital,[2] the air was heated to 32° C. by passing it over steam-coils. It was admitted to the wards by numerous inlets 30 centimetres square. The best velocity for ventilating and warming purposes was found to be 54 metres per minute. Exit openings were in the ceiling, and it was found best to make them large, as by this means the rapidity of exit currents is reduced.

Where the warming of the ward must be accomplished by stoves or fire-places in the ward, the best plan, for square and octagon wards, is to have a large central chimney with arrangements on the four sides for fire-places or stoves. This chimney can also be used as a very efficient ventilating shaft throughout the year by a device put in practice by Mr. John R. Neirnsee, architect of the Johns Hopkins Hospital.[3] In oblong wards, two or more large stoves, placed at equal distances along the centre of the wards, will heat the wards effectually.

Floors should be made of tiles, slate, or oak or yellow-pine lumber. If wood is used, it should be well seasoned, perfectly smooth,

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[1] An Account of the Principal Lazarettos of Europe, etc., p. 57. London, 1791.

[2] Report of the Massachusetts State Board of Health for 1879, pp. 231-248.

[3] Hospital Construction and Organization: Plans for Johns Hopkins Hospital, p. 335 *et seq.* New York, 1875.

and all joints accurately made. The floor should be kept constantly waxed to render it impervious to fluids.

The space between the floor and ceiling below should be filled with some fire-proof non-conducting material, such as cement or hollow bricks, in order to isolate each floor or ward as much as possible from others, both to prevent transmission of noise and extension of fire.

All corners and angles on the inside of the building should be rounded to facilitate the removal of dust.

In cleaning up, care should be taken not to stir up the layers of dust too much by active sweeping and dusting. The floors, furniture, door- and window- casings should be wiped off with damp cloths. Soiled bedding, clothing, dressings, and bandages must be promptly removed from the ward. Mattresses and other bed-clothing should not be shaken in the ward.[4]

Water-closets or (where the dry method of removal of excreta is in use) earth- or pail- closets should be placed where they can be easily reached by the patients, but the apartment in which they are placed must not open directly into the ward. The entrance to this apartment should be from the corridor or, better still, from the open air. The ventilation of water-closets should be independent of and entirely distinct from that of the ward or other part of the hospital building.

It is, of course, unnecessary to more than call attention to the vital importance of the prompt removal of all excreta, both solid and liquid, from the ward or hospital building. To attempt disinfection of excreta and allow them to remain in the ward after being voided is a pernicious practice, which should under no circumstances be permitted. All utensils for the reception of excreta, bed-pans, etc., should be immediately emptied and thoroughly cleansed.

Urinals are not advisable; the simple hopper-closet with hinged, hard-wood seat, as described in Chapter VI, is sufficient.

A bath-room and lavatory should be attached to every ward. It should be placed in the service building, and be easily accessible to the patients. There should also be portable bath-tubs in order that baths may be given in the wards when necessary.

Every large general hospital should also have a special apartment or building where baths of various kinds, such as medicated, vapor, Turkish, and Russian baths, could be given. In lying-in hos-

[4] A. Wernich: Ueber Verdorbene Luft in Krankenræumen. Volkmann's Samml. Klin. Vortr., No. 179, p. 24.

pitals, special arrangements for giving vaginal and uterine douches must also be furnished.

A daily water-supply of at least 450 litres per bed should be provided. The water should be easily accessible from the wards and various parts of the service building.

All water-closets, soil- and waste-pipes must be properly trapped; all joints must be properly made and all sewer connections made on the most improved plans. All work of this sort should be properly tested before being accepted, and frequently inspected afterward.

No sewer or house-drain should be laid under a ward.

A disinfecting chest for disinfecting soiled clothing, bedding, dressings, etc., should be placed in the basement of the ward, and connected with the latter by an iron chute, closing perfectly by an iron top. The best and most convenient disinfectant is steam. This is also the best means to destroy vermin in clothing and bedding.

It is questionable whether a nurse's room should be attached to a hospital ward. The nurse's place, when on duty, is in the ward itself, not in a room separate from it. Where there is a nurse's room, it should not be furnished with sleeping arrangements, for this is a strong temptation to neglect of duty on the part of the nurse. A nurse not on duty should not be permitted to remain about the ward.

A ward-kitchen should be in the service building, where articles of food can be kept hot or cold when necessary, and where special dressings, cataplasms, hot water, etc., can be prepared. A small gas-stove only should be allowed in the ward-kitchen, as the regular meals of the patients are prepared in the central kitchen, which should be totally detached from the hospital. The ward-kitchen can be easily utilized as a nurse's room, and in a small hospital can also be used as a store-room for the patients' body- and bed- linen and clothing.

The dining-room for patients able to be out of bed should be in the service building. A room with a good light and well ventilated and heated should be selected for this purpose. In the intervals between meals this room could be used as a day-room for such patients as should be out of bed, but who are not able to be in the open air.

A dead-house, containing a dead-room, autopsy-room, and a room fitted up for rough microscopic and possibly photographic work, is a necessity to every well-appointed general hospital. The dead-house should be entirely separate from the ward buildings.

The kitchen should be separate from the other buildings, and in large hospitals should also be the central station for the heating arrangements, if hot water or steam is to be used. The laundry may be connected with it. The kitchen should be connected with the wards by means of a covered corridor to avoid exposure in carrying the food to the wards.

The administration building should contain office-rooms for the superintendent and resident physician, pharmacy, library, reception-rooms for visitors, living-rooms for one or more assistants, and dwellings for the superintendent and resident physician.

THE ADMINISTRATION AND MANAGEMENT OF A GENERAL HOSPITAL.

The general management of a hospital should be under the direction of a superintendent, who, besides being a medical man, should be especially qualified by study and experience for the work. The superintendent of a large hospital should not be expected to perform any of the routine professional work in the wards, but he should be responsible for the service, both professional and lay, in the hospital. He should be the financial officer, and in all other things concerning the hospital his judgment should decide. He should have sufficient assistance to permit all necessary duties to be promptly performed. For this purpose he should have a secretary, or clerk, who should not be a medical man; otherwise the attention of the latter might be withdrawn from his clerical duties to the more interesting professional work in the hospital. The plan advocated by some authorities, to have two superintendents for large hospitals—one of whom shall be a medical man and direct only the professional work of the hospital, while the other shall have charge of the administrative functions—does not commend itself to the author. It involves a division of responsibility which will, in nearly all cases, eventually lead to differences of opinion likely to prove unfavorable to the best interests of the hospital.

It is customary in this country to appoint as resident physicians and surgeons in hospitals, recent graduates, whose functions are usually limited to carrying out the directions of the visiting physicians and surgeons, and sometimes to act on their own responsibility in emergencies. This system has some advantages for the physicians, but is usually detrimental to the best interests of the patients. The resident medical officer in a large hospital should always be a thoroughly qualified, experienced physician, capable of deciding promptly when the occasion arises, and he should be responsible to the superintendent for the proper performance of his professional duties. Necessarily, a physician with the qualifications indicated, would demand a very much larger salary than is usually paid resident physicians, but it should be understood that no hospital in which the good of the patient is the first consideration can be conducted on a cheap basis.

Visiting physicians and surgeons and all resident medical officers should be chosen with reference to their general and special qualifications for the duties expected of them. It would seem to be a good plan to make the selections for subordinate positions, at least, by competitive examination.

The sick in a hospital should be properly classified. Male and female patients should, of course, be treated in separate wards. A primary classification into medical, surgical, and obstetrical cases or wards is also indicated. Infectious diseases, such as typhoid fever, erysipelas, cholera, yellow fever, croupous pneumonia, etc., should not be treated in the same wards with rheumatism, Bright's disease, cardiac and nervous disorders, or simple digestive derangements. It is questionable, however, whether it is advisable to make a very elaborate classification of the various diseases except in very large hospitals.

An accurate record, made at the time of observation, and not written from memory afterward, should be kept of the history and progress of every case. The record should show not merely the symptoms and diagnosis, but the medical and hygienic treatment. In most hospitals where such records are kept the entries are made either in a simple memorandum-book or in a more or less complicated case-record. A simple form of case-record has been devised by Surgeon-General Walter Wyman, of United States Marine-Hospital Service, which seems to possess advantages that render its general adoption desirable.

In hospitals where cases of surgical diseases and injuries are received, a special apartment should be fitted up as an operating-room. Operations should not be performed in a ward in the presence of other patients.

QUESTIONS TO CHAPTER VII.

CONSTRUCTION OF HOSPITALS.

What would govern you in selecting a site for a hospital? What will go to determine the building area? In calculating the area required for buildings, what relation has it to the number of beds in the hospital? In the wards, what should be the actual minimum floor-space for each bed for non-infectious and for infectious diseases? What is the difference in the principles of modern hospital construction and of those formerly in vogue? What are some of the advantages of the modern plan? What was the prototype of the present system? How many wards should each pavilion contain at the most? How many beds in each ward? What conveniences should there be in each ward or pavilion? What is meant by a pavilion block-hospital? What space should there be between the separate pavilions?

What cubic space per bed should there be in the ordinary wards? What cases need more, and how much? How often should the air be entirely changed in the wards? Should the walls be pervious or impervious to the passage of air? How should the walls be finished? How many windows should there be in each ward? How high should they be?

What is the best way to heat a hospital ward? How should hot air be warmed? If a ward is to be warmed by fire-places or stoves, how should they be arranged?

Of what materials should the floors be made? How should they be treated? What should there be between ceilings and the floors above? Why? How should the corners and angles of floors and ceilings be finished?

How should the wards be cleaned? What should be done with soiled bedding, etc.?

Where should the water-closets, etc., be located? How should they be ventilated?

How much water should be furnished per bed? Why should no sewer or house-drain be laid under a ward? Where should the nurses' rooms be? Where the ward kitchen and dining-room? What is the administration building for, and what should it contain? What officers are necessary for the management of a hospital? What are their duties? How should the resident physicians be qualified and selected? How should the sick be classified, and what wards should there be in a general hospital? Mention some of the details that should be noted in the case records.

CHAPTER VIII.

SCHOOL HYGIENE.

During the period of childhood and youth the organism yields readily to impressions and forces, both external and internal, and it is therefore important that the child be safeguarded during this formative period, and surrounded with those influences which make for good. Considering the number of years spent in acquiring an education and the length of time each day devoted to study, most of which is spent in the school-room, it will be readily understood why a special chapter should be devoted to this particular theme. School hygiene includes the consideration of the sanitary principles underlying the construction of school-houses and school-furniture, ventilation and heating; the proper amount of time to be devoted to study at different ages; the special diseases of school-children, their causes, and means for their prevention. It also embraces the personal hygiene of the scholar and his general health and habits.

These matters are of interest to the scholar himself, to his parents, the citizen in general, and especially to the physician; because as a physician he is specially fitted by his special education and training to serve on school-boards and committees of education, and because he is so often called on to treat those maladies of childhood which have been caused by unsanitary conditions in school life, or are largely influenced thereby.

In the construction of school-houses the same hygienic principles are applicable as in dwelling-house construction. The selection of a site for the school-building should command the same careful consideration that is necessary in determining upon a site for a dwelling. It should be of sufficient elevation to insure good drainage, not only of the sewage and refuse collected in the building, but also of surface- and rain- water flowing over the soil. Proximity to marshes and other unsanitary surroundings should be avoided. If the soil is damp it should be properly drained, and all sources of insalubrity in the neighborhood avoided or, if possible, removed.

Especially should there be plenty of space around the building to insure good external ventilation, to insure the admission of an abundance of light, and to provide ample play-grounds for the children. School-buildings should not be located in close proximity to factories, or to trades giving off smoke, dust, or noxious odors.

School-houses should not be over three stories high; corridors and stairways should be wide, straight, and well lighted. All stairs should be securely built, and be guarded with ample, strong railing. All doors should open outward to permit ready egress and reduce the danger of accident in panics from any cause.

Fire-drills should be held at stated intervals under direction of the teachers.

In addition to the study- or recitation- rooms, provision should be made for play and calisthenic-exercise rooms. Well-lighted and ventilated side-rooms should be provided for the reception of outside clothing, umbrellas, overshoes, etc. These articles should not be kept in the recitation- or study- rooms.

Floors should be made of accurately-joined flooring, and rendered impervious by oil or paraffine coating.

All corners and angles should be rounded, to prevent the accumulation of dirt.

Appropriate measures must be employed to prevent the permeation of the building by ground-air.

The foundation-walls should be laid in Portland cement, and coated inside and out with the same, and the floors should be laid in at least ten inches of cement. This will insure a damp-proof basement as well, which may be used as play-rooms during inclement weather, provided they be properly heated and ventilated.

The inside walls of school-rooms may be tinted a neutral gray, or light blue or green. Ceilings should be white. Walls and ceilings should not be painted, but lime-coated to permit free transpiration of air.

Schools should be so constructed as to permit of ready heating and ventilation, cleaning, and keeping clean. In large schools the method will usually be by furnace-heated air, although a better method would probably be by steam- or hot-water pipes.

What is known as the "Smead system" is a most excellent one. It is a combined system of heating and ventilation, consisting of a hot-air furnace, the fresh heated air being admitted through one set of registers, placed in the wall near the floor, and the foul air being taken out through another set of flues on the same side of the room and at the same level. This "used-up" air is then carried from the building through a system of ducts passing beneath the floors of the rooms, the heat, by this arrangement, being further utilized to heat the floors as it escapes. In rural districts the school-room may be heated by means of a stove, provided with a jacket or cylinder surrounding it, and several feet in height. This is made of tin or

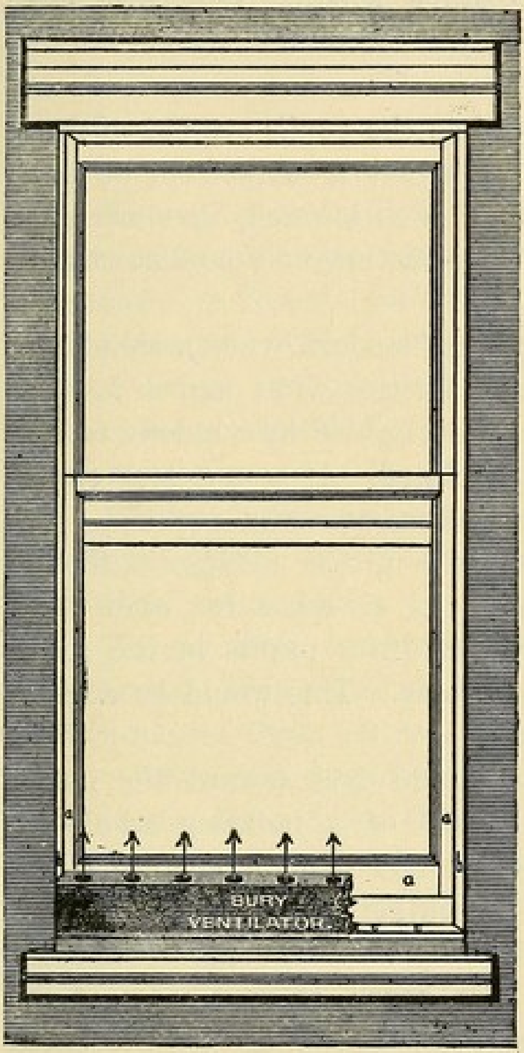

Fig. 27.

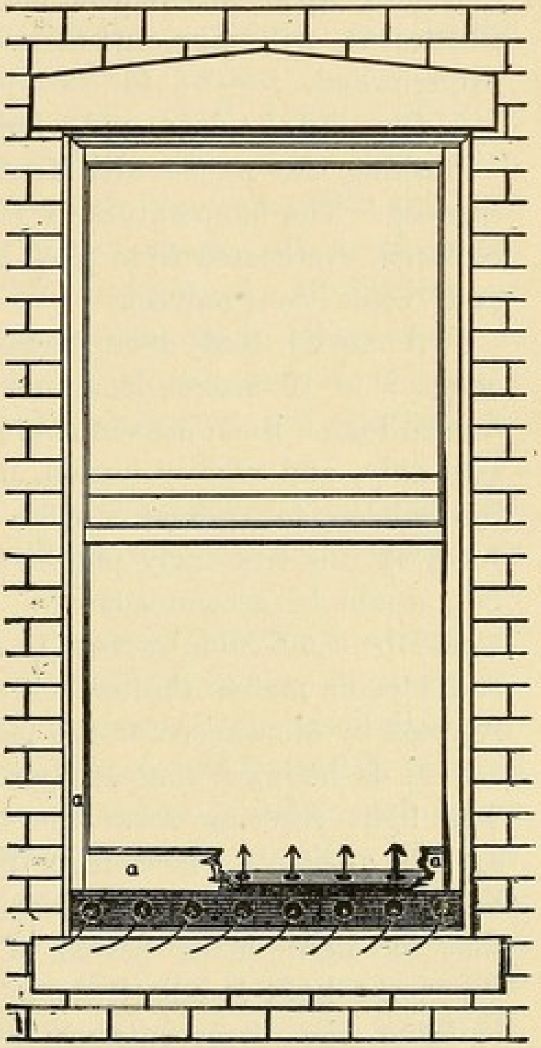

Fig. 28.

Fig. 27.—*a*, *a*, Sash. *b*, *b*, Window-jambs. *c*, *c*, Window-sill. This cut represents the view from within the Bury Ventilator, in operation. It is broken away at one end to show the sash raised above the outer holes to admit the air.

Fig. 28.—*a*, *a*, Sash. This cut represents the view from without the Bury Ventilator, in operation. The *sash* is broken away to show the ventilator behind, with the fresh air passing in.

zinc. In the floor, beneath the stove, holes are bored to admit fresh air, which, warmed in passing over the stove, is deflected upward, and diffused, by means of the jacket.

The ventilation of school-rooms must be carried out on the principles indicated in Chapter I. With careful and intelligent teachers, natural ventilation will give better satisfaction than a complicated artificial system. Where windows and doors must be largely depended upon for ventilation, the Bury window ventilator, here illustrated, will give satisfactory results unless the school-room is overcrowded.

Opening the doors and windows when the pupils are out of doors —flushing the rooms with fresh air—is not a method to be commended. The temperature of the room is so lowered, that when the children, overheated from play, return to it, they may become chilled, and "colds" be produced.

A model study-room, according to modern views, should be about 9 to 10 metres long, not over 7 metres wide, and 4 to 4 $^{1}/_{2}$ metres high. Such a room could be easily lighted by windows on one side only, and readily heated and ventilated. It would also enable the teacher to exercise a close supervision over the pupils. In a room of this size forty pupils would be a proper number, although fifty could be accommodated. The initial air-space for each pupil would be 5.60 cubic metres if there were fifty pupils in the room, and 7 cubic metres if there were only forty. This would be slightly reduced by allowance for the teacher.

It is believed that study-rooms should face toward the north. The light entering from the north side of a building would be equable during a whole day. While a larger window surface would be necessary than with an easterly or southerly exposure, it is held that the light, being devoid of all glare, would be more effective. When the light is admitted on the east, south, or west sides of the building, the direct entrance of the sun's rays must be prevented by curtains, by means of which the amount and proper distribution of the light is regulated with difficulty.

The windows of the school-room should reach from about the height of the pupil's shoulder (when seated) to the ceiling. Arches or overhanging cornices over the windows should be avoided, as they cut off much light. For the same reason the near proximity of other high buildings and of trees should be avoided in selecting a site for a schoolhouse. The window area should be not less than one-fifth of the floor area, otherwise the light will be deficient.

The light should be admitted only from the left side of the pupil. When admitted from the right side the shadow cast by the pen in writing interferes with good vision; if admitted directly in front of the pupil, the glare of the light will injuriously affect the eyes; while, if it can enter from behind, the book or paper of the pupil will be so much in shadow as to compel him to lean so far to the front in bringing his eyes nearer to book or paper that nearsightedness is very likely to be developed. Furthermore, if the light is admitted into the room at the backs of the pupils, the eyes of the teacher are liable to suffer from the constant glare.

In a school-room of the dimensions above stated, a row of windows on one side, forming an area of glass of one-fifth of the floor-space, will thoroughly and satisfactorily illuminate the room, with the least unfavorable influence upon the organs of vision. It is advisable, therefore, to always insist upon this arrangement of lighting of school-rooms. Where artificial light is used in a school-room, it should be in the proportion of one burner to every four pupils. All burners should be provided with chimneys and vertical reflectors.

Electric lights, properly shaded, or toned down with ground glass or tinted globes, are to be preferred, as they do not require any additional ventilation.

Water-closets and privies should not be placed in cellars or basements. This would seem to be self-evident, and yet in many city school-houses these places of retirement are in this unsuitable location. When it is considered that large schools are frequently warmed by hot air taken from the cellar, it furnishes an additional reason to avoid this location for water-closets. On the contrary, the custom, in some country schools, of placing the privy at a considerable distance from the school-room and in an exposed situation is almost equally reprehensible, as the pupils, especially girls, are prone to neglect obeying the calls of nature, from which neglect many disorders arise. These "garden-houses" should be connected with the school-house by a covered way.

Desks should be slightly sloping, the edge nearest the pupil being about 1 inch (2.5 centimetres) higher than his elbows. The front edge of the seat should project a little beyond the near edge of the desk, so that a plumb-line dropped from the latter should strike the seat near its front edge. If the seat is not thus brought slightly under the desk, the pupil is compelled to lean forward in writing, which position prevents proper expansion of the chest and increases the blood-pressure in the eyes—a condition promotive of nearsightedness.

Seats should be only high enough so that the feet rest flat upon the floor. If they are higher, a foot-board must be provided. Children should not be condemned to the cruelty of having their feet dangling "between heaven and earth" while they keep their seats. Seats and desks should be graded according to the sizes of the pupils—not their ages or standing in the class.

An ideal seat and desk would be one made to measure for each pupil, but this is manifestly impracticable, inasmuch as with the constant growth of the child the seats would be rapidly outgrown.

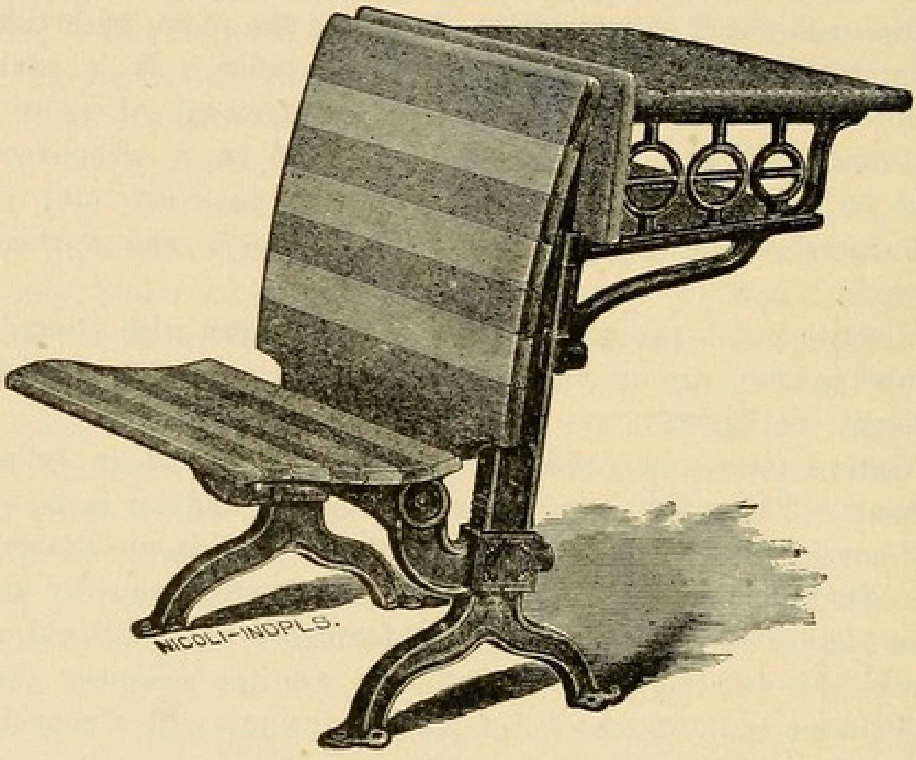

Fig. 29.—Adjustable School-desk (Front View).

The desk shown in Fig. 29[1] is adjustable to children of different sizes, and seems to solve the problem which has so long puzzled the school sanitarian. The desks are made for a single pupil and the seat and desk are independently adjustable. The frame is of iron and the seat, back, and desk of hard-wood lumber.

Blackboards should not be placed at a greater distance than 10 metres from the farthest pupil. The ground of the board should be a dead black, without lustre. In writing exercises upon the board, care should be taken that the letters and figures are made sufficiently large, and with rather heavy strokes of the crayon, in order that they may be easily seen from the most distant part of the room. It

[1] Made by the Rushville School Furniture Company, Rushville, Ind., U. S. A.

has recently been demonstrated that a black letter on a white ground can be seen at a greater distance than a white letter on a black ground. Hence, it might prove advantageous to the eye-sight of school-children to substitute for the present blackboard and chalk, a white board and black crayon. In some European lecture-rooms this plan has been adopted with satisfaction.

Young children should not be kept at the same study or in the same position for long at a time. The exercises should be frequently varied. It is especially with children in the primary grades that care should be taken not to overburden their minds with too many hours of study, or too long continuance at the same exercise.

Children should not be placed in a regular school much, if at all, before the completion of their 7th year. Between the ages of 5 and 7 they may be sent to a kindergarten. From 7 to 9 years they should be kept at their studies not longer than three hours daily; from 9 to 12 years four hours may be allotted them; and from 12 to 16 years they may be kept at mental work five to six hours daily. This does not mean that pupils are to be kept continuously at their studies during these hours, but that they should be neither compelled nor permitted to study longer than these periods each day. It is believed that these figures represent the capacity for endurance in the majority of children, and they should be adopted in all schools where the largest return in mental acquirements is desired at the least expenditure of health. Excess of time expended in study is almost certainly followed by physical deterioration. "A little less brain: a little more muscle," for our children, is a legitimate demand that we may make of legislators and school-boards.

Gymnastic exercises should form part of the daily routine in all schools. These exercises should take place, when practicable, in the open air. Playing, romping, laughing, and singing should be encouraged, rather than the natural tendency to boisterous play restrained. It is especially desirable that female children should be encouraged to take part in these diversions. The desire, on the part of many parents, to see little girls deport themselves as young ladies, before the time even when they write their age in two figures, is very reprehensible, and deserves the most unqualified condemnation. Molière's satirical remark, "Il n'y a plus d'enfants,"[2] seems to be literally true at the present day.

The principal diseases incident to school-life are myopia, spinal deformities, nervous and digestive disorders, pulmonary phthisis, and

[2] There are no more children."

the communicable diseases, viz.: chicken-pox, small-pox, erysipelas, measles, rötheln, scarlatina, typhoid fever, and contagious ophthalmia. By judicious sanitary measures these can all be very much diminished and some entirely prevented.

It has been shown by the examination of the eyes of school-children that near-sightedness increases progressively from the lowest to the highest classes. Children who enter school with an hereditary tendency to myopia, or who are, perhaps, already near-sighted

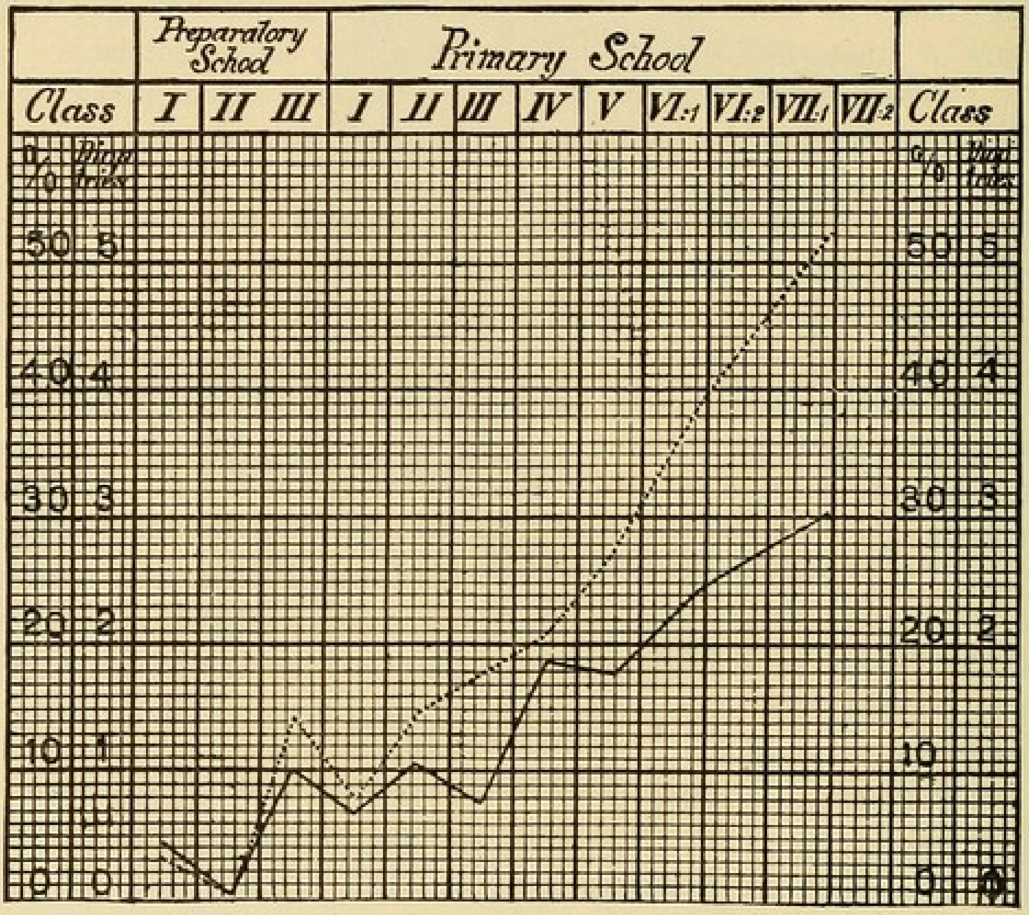

Fig. 30.—Myopia According to School-classes—Boys.

to a slight degree, soon become more intensely myopic; while others, who may be even hypermetropic on entering school, will be found to have become near-sighted during school-life. In examinations of over 30,000 pupils of grammar and high schools in Germany, Austria, Russia, and Switzerland, it has been found that the average proportion of near-sightedness is a fraction over 40 per cent., varying, in the different classes, from 22 per cent. for the lowest to 58 per cent. for the highest classes. These figures represent the averages of all the examinations made. In some particular schools, for example in the gymnasium (high school) of Erlangen, the percentage in the higher classes was 88 per cent., in the gymnasium of Coburg, 86 per cent., and in the gymnasium of Heidelberg the proportion of myopic students in the highest class is said to have reached 100 per cent. in 1877. In the primary schools the percentage was found to be much lower. Recent investigations in the schools of Stockholm, by Widmark, show that among school-children examined under 7 years of age there was no myopia. In the higher classes the myopia increases not only in degree, but in frequency. The diagrams, Figs. 30 and 31, show graphically the increase in degree and fre-

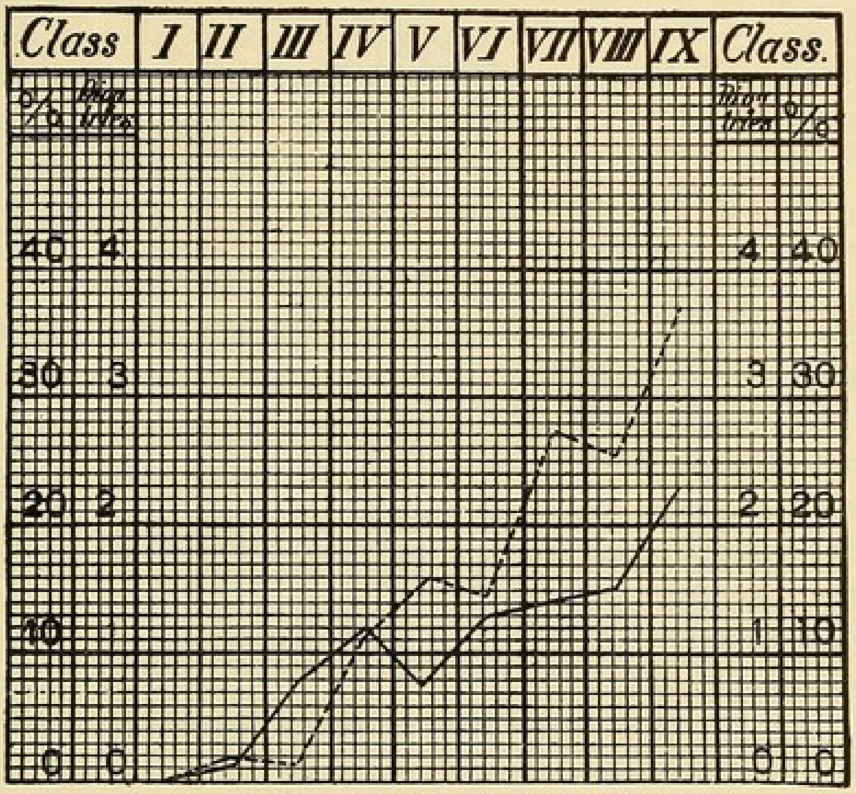

Fig. 31.—Myopia According to School-classes—Girls.

quency of myopia in the several school-classes. These observations show that the number of myopic individuals bears a constant relation to the intensity of use of the visual organs. The results of the observation of different observers in different countries also uniformly point to the conclusion that not only does the number of near-sighted pupils increase as the higher classes are reached, but the degree of myopia increases likewise. Thus, a pupil who may have only a moderate degree of myopia on entering the school will have myopia in a higher degree as he advances in his classes. Erismann found, on reexamining the same pupils annually, that in six years 13.14 per cent.

of those examined had developed myopia from emmetropia, while in 24.57 per cent. of near-sighted pupils the degree of myopia had increased.[3]

The principal causes of the prevalence of near-sightedness in schools are badly-arranged or insufficient light, bad air, over-heating of the school-rooms, improper construction of desks compelling children to lean forward while reading or writing, and badly-printed text-books. The use of small type, poor paper, and bad press-work in text-books is very reprehensible. The type technically known as *Long Primer* is the smallest that should be used in text-books. That badly-arranged light and improper seats are causes of myopia has been shown by Forschutz in his examinations of the pupils in the public schools of Coburg. He found that in the newer schools, in which the light and seats are better arranged, the percentage of near-sight decreased. The average percentage of those examined in 1874 was 21, while in 1877 it had been reduced to 15,[4] showing the great improvement due to the application of correct sanitary principles in the construction of school-houses.

Defective hearing has recently been shown to be especially frequent among school-children. A Berlin aurist found 1392 children out of 5902 (23.6 per cent.) suffering from ear disease of some kind. Dr. Samuel Sexton, of New York, and the late Dr. Chas. F. Percivall, director of music in the public schools of Baltimore, have arrived at similar results after examination of a large number of school-children.

Spinal curvature is present in a large proportion of the children attending schools. Statistics are not very full upon this subject, but one author, Guillaume, states that he found lateral curvature of the spine in 218 out of 731 school-children—a proportion of 29.5 per cent. This, of course, includes the slighter degree of curvature, which cannot be properly termed a disease. Among 30,000 Danish school-children 13 per cent. had some variety or degree of spinal deformity. M. Eulenburg,[5] found that among 1000 persons with lateral curvature of the spine, the disease began in 887 between the ages of 6 and 14; that is to say, during the years of school-life. Girls are affected more than ten times as often as boys, the proportion being 93.43 per cent. in the former and only 6.57 per cent. in the latter.

[3] Erismann, Die Hygiene der Schule, in von Pettenkofer und Ziemssen's Handbuch der Hygiene, II Th., 2 Abth., p. 30.

[4] Quoted by Cohn in Realencyclopædie d. ges. Heilk., Bd. XII, p. 263.

[5] Realencyclopædie d. ges. Heilk., Bd. XI, p. 564.

The especial causes of spinal curvature occurring during school-life are improperly-constructed seats and desks and an improper position of the body. Many pupils habitually assume a "twisted" position, which is very liable to produce spinal distortion in children of weak muscular development. The manner in which a desk that is too high for the pupil may produce spinal distortion is very well shown in Fig. 32. An improper position is more likely to be unconsciously assumed by girls than by boys. The clothing is responsible for this, for when the girl files into her place behind the desk, her clothing, hanging loosely about her, is swept back and forms a

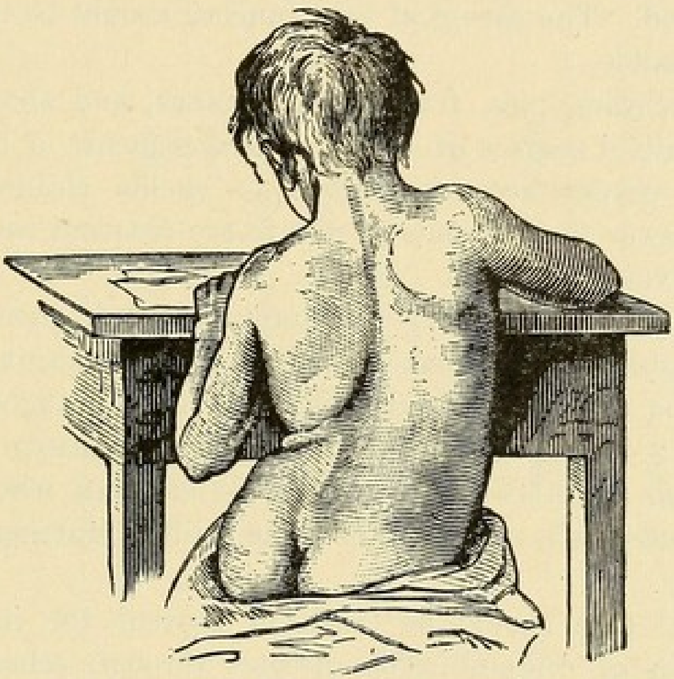

Fig. 32.—Showing Influence of a High Desk in Causing Spinal Curvature.

pad, upon which she sits with one buttock. Another cause of this is a habit many girls have of sitting on one foot. The greater elevation of her seat on that side throws the spinal column out of the vertical line, which is compensated by a partial twisting of the trunk. The attention of teachers should be directed to this faulty habit, which can be easily corrected, and its consequences averted by timely interference.

Nervous disorders are comparatively frequent among school-children. Headaches are often due to insufficient ventilation, improper food, bad digestion, and excessive mental strain. Defective light may also be the cause of headaches by causing ocular fatigue.

Disordered menstruation in girls is a frequent cause which is not to be overlooked. Hysterical and imitative affections are not infrequent, and sometimes pass through entire schools, including even the teachers. Girls are, of course, more subject to this class of disorders than boys, but the latter are not entirely exempt.

Chorea is one of the nervous disorders which should debar the child who has it from school, not only on the child's own account, but also because the trouble may be transmitted to other children through association and imitation.

Derangements of the digestive organs are exceedingly frequent among school-children. They can generally be traced to the use of improper food. The eating of cold lunches should be discouraged as much as possible.

Nuts, candies, pies, fruit-cakes, bananas, and above all, pickles are most fruitful sources of digestive derangements of children. The absence of proper accommodations to enable children—especially girls—to answer the demands of nature are frequent sources of digestive and nervous disorders.

The seeds of pulmonary consumption are frequently implanted during school-life. A neglected cough; bad ventilation, under which term may be comprised overheating and cold draughts, as well as polluted air; improper position of the body, excessive mental work, underfeeding, and the failure to exclude children who are the subjects of tuberculosis, may, any of them, be the starting-point of this fatal disease.

Especial care should be taken to prevent the introduction or dissemination of communicable diseases through schools. The importance of this duty should be at all times impressed upon school-boards and teachers. In the first place, no child should be admitted within the door of the school-room unless it first presents undoubted evidence of protection against small-pox, either by having passed through a previous attack or by a proper vaccination. In case of an actual or threatened epidemic of small-pox the entire school, including teachers, should be vaccinated.

Children should not be admitted to school coming from a house where there is at the time, or has recently been, a case of communicable disease, such as small-pox, diphtheria, scarlet fever, or measles. They should be excluded in each case for a period of time equivalent to the incubation of the given disease. It goes without saying that no child having itself been sick with a communicable disease should be admitted to school until entirely restored to health.

Table XXX.

Vacher's Table.

Diseases.	Time from Inception to Beginning of Eruption.	Time from First Precursory Symptom to Beginning of Eruption.	Time from Beginning of Eruption to Cessation of Pyrexia.	Time from Beginning of Eruption till Patient Ceases to be Infective.
Small-pox	13 days (range, 7 to 21 days.)	2 days (range, a few hours to 7 days)	14 days	56 days
Modified small-pox	13 days (range, 7 to 21 days)	2 days (range, a few hours to 7 days.)	14 days	35 days
Chicken-pox	13 days (range, 4 to 17 days.)	2 days (range, a few hours to 3 days.)	5 days (range, 3 to 7 days.)	17 days
Measles	14 days (range, 7 to 21 days)	4 days (range, 1 day to 9 days)	6 days	27 days
German measles	14 days (range, 10 to 20 days.)	1 day (range, *nil* to 3 days.)	7 days	14 days
Scarlatina	4 days (range, a few hours to 14 days.)	1 day	7 days	49 days
Diphtheria	5 days (range, 1 day to 14 days.)	2 days (range, a few hours to 4 days.)	14 days	28 days
Idiopathic erysipelas	5 days (range, 2 to 14 days.)	1 day	14 days	35 days
Typhus fever	19 days (range, a few hours to 28 days.)	7 days (range, 3 to 7 days.)	7 days (range, 7 to 14 days.)	21 days
Typhoid fever	21 days (range, 1 day to 28 days.)	7 days (range, 7 to 12 days.)	21 days (range, 14 to 23 days.)	28 days
Mumps	18 days (range, 8 to 25 days.)	4 days	7 days	21 days

TABLE XXXI.

Whitelegge's Table.

Diseases	Quarantine to be Required after Exposure to Infection.	Earliest Date of Return to School After an Attack.
Small-pox	18 days	When all scabs have fallen off.
Chicken-pox	18 days	When all scabs have fallen off.
Scarlet fever	14 days	Six weeks, and then only if no desquamation or sore throat.
Diphtheria	12 days	Three weeks, if convalescence is complete, and no bacilli remain.
Measles	16 days	Three weeks, if all desquamation and cough have ceased.
German Measles	16 days	Two to three weeks, according to the nature of the case.
Whooping Cough	21 days	Six weeks from the commencement of the whooping, if the characteristic spasmodic cough and whooping have ceased. Earlier, if all cough be gone.
Mumps	24 days	Four weeks, if all swelling has subsided.

School quarantine should be established for the following diseases: In *small-pox* and *chicken-pox,* until every scab has fallen. In *whooping cough,* until the spasmodic cough and characteristic whoop have ceased. In *diphtheria,* for at least three weeks, but in every case until a bacteriological examination of nose and throat proves that none of the specific organisms are present, and there must also be no discharge from the nose, throat, ears, or eyes, and no albuminuria. In *scarlet fever,* for six weeks from the time the rash appears, provided also that desquamation and cough have ceased. In *measles,* until desquamation is complete. In *contagious ophthalmia,* until complete recovery of the patient. In every case there must be thorough and efficient disinfection of the home, clothing and person of the child before he returns to school.

When a case of contagious disease has accidentally obtained entrance to the school, the pupils should be dismissed for the day, and the room thoroughly disinfected by means of formaldehyde.

Teachers are not infrequently guilty of the grave imprudence of sending pupils from the school to the house of an absent child to inquire the reason of the latter's non-appearance at school. It frequently happens that the absent child is sick, and the messenger is invited to the sick-room to see his or her class-mate. There can be no room for doubt that scarlet fever, diphtheria, and measles have often been introduced into schools in consequence of such thoughtlessness on the part of teachers.

All schools should be inspected daily by a physician appointed for the purpose.

In order to promote the proper hygienic management of schools, all teachers should be required to submit to an examination in the principles and practice of hygiene, at least so far as school hygiene especially is concerned. This is a demand that school-boards could reasonably insist upon, and there can be no question that the improvement in the health of the pupils would amply justify it.

In all boarding-schools there should be an infirmary, properly equipped for isolating cases of communicable disease. This infirmary should preferably be located in the upper story of the building, or in an isolated wing.

A phase of school life which is seldom discussed and generally tabooed is the sexual development of the pupils. There is no doubt that vicious sexual habits are often acquired at schools, more especially boarding schools and dormitories. It should be incumbent upon teachers to keep a watchful eye on this phase of school life with a view of detecting vicious practices. The course on school physiology should include the study of sexual development in plants and the lower animals; while among the older pupils the results of sexual abuses and venereal diseases may be properly discussed.

QUESTIONS TO CHAPTER VIII.

SCHOOLS.

What does the hygiene of schools comprise? What principles are applicable in the construction of school-houses? What is to be sought, and what avoided, in the selection of a site?

What should be the limit of height for school-houses? What rooms are needed besides those for study or recitation? What precautions must be observed regarding stairs, railings, and doorways? How may the ground-air be kept out of the building? What kinds of floors should the various rooms have?

What will be probably the best means of heating a school-house? What is the usual method in large schools? Which will usually give the best ventilation, natural or artificial? When and how may school-rooms be ventilated to advantage?

How large should an ordinary school-room be? What are the advantages of a room of this size? How many pupils would this accommodate, and about how much air-space would each have? Is this sufficient?

On which side of the room should the windows be, if possible? How should the seats and desks be arranged in relation to the windows? What should be the relation of window-area to floor-area? How high should the windows be above the floor, and how near to the ceiling should they reach? What are the objections to windows on two sides of the room? Will windows of the above dimensions properly illuminate the room? How much artificial light will be needed for proper illumination? What should be the color of walls and ceilings?

Where should the water-closets, etc., of a school be located? What supervision of these must be exercised?

How high should school-seats be? What should be the relation of seat to desk, and how high should the latter be? Why should the front edge of the seat be brought under the desk?

How far should the black-boards be from the pupils? On which side of the room? How should the surface be finished?

When should a child begin to go to school? What is the maximum time advisable for daily study at the respective ages? What should be the length of lessons and recitations for each age? What is an almost certain result of too long study-hours? What should form part of the daily school-routine? Should this be taken from the recess period, or should it be part of the school-work?

What are some of the diseases incident to school-life? Can these be prevented? Are they altogether due to school-life? How does the proportion of cases of near-sightedness vary in school-children? Is the increase one of degree or of frequency? What are the causes of this excess of myopia? If these causes are avoided or corrected, will the prevalence of myopia decrease?

What other sense is defective among school-children? What physical deformity is very prevalent? What are the special causes of this deformity? Why is it apt to be more common among girls? At what age is the deformity most apt to begin?

What nervous disorders are frequent among school-children? What are some of the causes of chronic headache? What pupils are most subject to hysterical affections? What are some causes of nervous disorders? Of digestive disturbances?

How may consumption or other forms of tuberculosis be due to the school-life? What precautions should be observed in regard to the prevention of the spread of infectious diseases among school-children? What diseases are to be especially guarded against, and how shall this be done? What should be the shortest limit of quarantine against a pupil that has had any one of these diseases? If a case of infectious disease gains entrance to the school, what is to be done? Why should teachers be required to pass an examination on the principles of hygiene?

CHAPTER IX.

INDUSTRIAL HYGIENE.

One of the most interesting chapters in the study of hygiene is that which treats of the relations of occupations to health and life. While it is unquestionable that certain occupations are intrinsically dangerous to health, there can be no doubt that in many instances incidental conditions not necessarily connected with the occupation are factors in the production of disease. Such factors are bad ventilation and other insanitary surroundings, as well as in many cases want of sufficient or proper food.

Occupations induce disease by compelling the workmen to inhale irritating, poisonous, or offensive gases, vapors, or dust; or by causing the absorption through the skin or mucous membranes of irritating or poisonous substances. Changes of temperature, as exposure to great heat or cold, produce diseases which are, in some instances, characteristic. In another class of cases the excessive use of certain organs, as the nervous system, the eyes, the vocal organs, or various groups of muscles, produce characteristic morbid effects. Again, a constrained attitude while at work, a sedentary life, or occupations involving exposure to mechanical violence are recognized sources of disease and death.

The table on page 247 gives the mortality and average age at death of all decedents over 20 years of age whose occupation was specified, in the State of Massachusetts, for thirty-one years and eight months. The total number of decedents was 144,954; the average age at death, 50.90 years. Subdivided into classes and individual occupations, the results are given in Table XXXII.

The latter table cannot be absolutely relied upon for several reasons, the principal of which is that the table is incomplete. Many of the occupations are merely temporary, and persons are constantly shifting from the pursuit of one calling to another. Judges and lawyers, for example, should be included under one heading, while the class "students" should be excluded altogether. The table shows, however, very clearly, the relations of certain occupations to longevity. It is seen, for example, that agriculturists have the greatest expectation of life. Next to these come mechanics engaged out-of-doors. Professional men come next, and of these clergymen and members of

Table XXXII.

Occupations of Persons whose Occupations were specified, and whose Deaths were registered in Massachusetts during a period of thirty-one years and eight months, ending with December 31, 1874.[1]

Occupations.	Number of Persons.	Average Age at Death.
Class I. *Cultivators of the Earth:* Farmers, Gardeners, etc.	31,832	65.29
Class II. *Active Mechanics Abroad*	10,893	56.19
Brick-makers	106	46.85
Carpenters and Joiners	6,150	53.33
Caulkers and Gravers	180	58.59
Masons	1,662	50.33
Millwrights	118	59.14
Riggers	161	52.25
Ship-carpenters	873	58.53
Slaters	81	40.99
Stone-cutters	1,025	40.90
Tanners	537	50.36
Class III. *Active Mechanics in Shops*	16,576	47.57
Bakers	471	47.04
Blacksmiths	2,402	53.26
Brewers	28	47.11
Cabinet-makers	781	48.84
Calico-printers	9	52.11
Card-makers	39	48.23
Carriage-makers and Trimmers	276	48.21
Chair-makers	138	41.77
Clothiers	84	56.50
Confectioners	85	44.11
Cooks	112	40.82
Coopers	927	59.22
Coppersmiths	101	45.89
Curriers	366	41.50
Cutlers	131	39.21
Distillers	27	56.85
Dyers	143	45.17
Founders	361	42.51
Furnace-men	133	43.42
Glass-blowers	132	37.88
Gunsmiths	250	48.86
Hatters	356	54.67
Leather-dressers	179	47.23
Machinists	2,097	41.67
Millers	278	57.14
Musical-Inst. mkrs.	33	46.73
Nail-makers	174	41.49
Pail- and Tub-makers	5	36.60
Painters	1,850	45.07
Paper-makers	288	48.29
Piano-forte-makers	111	43.33
Plumbers	131	35.53
Potters	40	56.67
Pump- and Block-makers	89	54.79
Reed-makers	9	42.78
Rope-makers	248	58.05
Tallow-chandlers	67	54.93
Tinsmiths	375	41.05
Trunk-makers	48	39.60
Upholsterers	124	38.82
Weavers	480	44.95
Wheelwrights	507	56.98
Wood-turners	76	52.07
Mechanics (not specified)	2,015	44.84
Class IV. *Inactive Mechanics in Shops*	17,233	43.87
Barbers	403	39.81
Basket-makers	70	61.63
Book-binders	150	40.12
Brush-makers	53	43.11
Carvers	90	34.00
Cigar-makers	154	38.36
Clock- and watch-makers	100	52.86
Comb-makers	134	51.38
Engravers	124	40.88
Glass-cutters	76	43.16
Harness-makers	423	48.74
Jewelers	468	40.34
Operatives	2,138	39.16
Printers	717	38.62
Sail-makers	217	53.21
Shoe-cutters	362	42.94
Shoe-makers	9,772	44.61
Silver or Gold smiths	92	46.13
Tailors	1,393	47.34
Tobacconists	43	50.35
Whip-makers	99	42.63
Wool-sorters	155	48.09

[1] Thirty-third Registration Report of Massachusetts, p. cvi *et seq.*

TABLE XXXII (*Continued*).

OCCUPATIONS.	Number of Persons.	Average Age at Death.
CLASS V. *Laborers* (no special trades) . . .	28,058	47.41
Laborers	27,382	47.49
Servants	389	40.10
Stevedores	76	52.09
Watchmen	193	50.06
Workmen in Powder-mills	18	39.67
CLASS VI. *Factors Laboring Abroad, etc.*	7,035	36.29
Baggage-masters . . .	37	34.08
Brakemen	246	26.44
Butchers	537	50.19
Chimney-sweeps . . .	4	34.50
Drivers	327	38.88
Drovers	17	49.29
Engin'rs and Firemen	567	38.77
Expressmen	216	41.30
Ferrymen	9	53.78
Lighthouse-keepers .	10	60.40
Peddlers	417	45.18
Sextons	81	59 94
Soldiers	2,885	28 37
Stablers	354	42.54
Teamsters	1,282	40.35
Weighers and Gaugers	24	60.67
Wharfingers	22	50.00
CLASS VII. *Employed on the Ocean*	8,844	46.44
Fishermen	433	42.82
Marines	4	41.25
Naval Officers	58	50.00
Pilots	82	60.38
Seamen	8,267	46.45
CLASS VIII. *Merch'ts, Financ'rs, Ag'ts, etc.*	15,977	48.95
Agents	376	46.76
Bankers	49	57.61
Bank Officers	151	55.14
Boarding-House kprs.	75	47.96
Book-sellers	73	53.05
Brokers	198	49.58
Clerks and Book-kprs.	3,435	35.93
Druggists and Apothecaries	255	42.37
Gentlemen	1,512	68.42
Grocers	517	47.59
Innkeepers	467	50.04
Manufacturers . . .	1,375	51.23
Merchants	3,927	54.17
News-dlrs. and Car'rs	27	41.22
R. R. Agents or Conductors	318	39.85
Saloon- and Restaurant-keepers . . .	299	40.90
Stove-dealers	12	45.25
Telegraphers	5	28.80
Traders	2,908	48.08
CLASS IX. *Professional Men*	5,175	50.81
Architects	29	47.07
Artists	186	44.18
Civil Engineers . . .	117	42.32
Clergymen	965	58 57
Comedians	32	37 31
Dentists	114	41.61
Editors and Reprtrs.	87	46.68
Judges and Justices .	18	64.11
Lawyers	676	56.45
Musicians	266	41.59
Photographers . . .	10	36.80
Physicians	1,166	54.99
Professors	45	55.93
Public Officers . . .	437	55.37
Sheriffs, Constables, and Policemen . .	158	53.76
Students	288	23.23
Surveyors	86	51.44
Teachers	495	41 79
CLASS X. *Females* .	3,343	39.13
Domestics	1,037	46 64
Dress-makers	259	43.36
Milliners	136	39.42
Nurses	116	61.06
Operatives	703	27.82
Seamstresses	289	46.50
Shoe-binders	48	43.12
Straw-workers . . .	73	34 83
Tailoresses	233	47.49
Teachers	442	31.27
Telegraphers	7	24.43

the bar have the first and second places respectively. The expectation of life of physicians is above the average, being nearly 55 years. Mechanics engaged in active work in-doors may expect to live 3.70 years longer than those whose occupation requires them to retain a more or less constant position.

Occupations which are accompanied by the formation of much dust, either inorganic or organic, are especially unfavorable. They usually produce disease of the respiratory organs, which may eventuate in phthisis. In the table it is seen that the average age at death of stone-cutters was 40.90; of cotton-factory operatives—male, 39.16; female, 27.82;[2] of cigar-makers, 38.36; and of cutlers, 39.21 years. These figures more or less closely approximate the conditions which have been shown to exist in England and on the Continent of Europe. In Sheffield, the workmen who grind and polish cutlery, called "dry grinders," are said to suffer from a characteristic pulmonary affection termed "grinders' asthma" (emphysema) in the proportion of 69 per cent. of the whole number employed. The average duration of life of the needle-grinders of Derbyshire is 30.66 years. Among the cutlery-grinders of Solingen, in Rhenish Prussia, Oldendorff found 29 per cent. suffering from pulmonary affections, while the average age at death of the "dry grinders" was 40.7 years.

OCCUPATIONS PREJUDICIAL TO HEALTH.

The diseases of occupations may conveniently be divided into the following classes:—

1. Diseases due to the inhalation of irritating or poisonous gases and vapors.
2. Diseases due to the inhalation of irritating or poisonous dust.
3. Diseases due to the absorption or local action of irritating or poisonous substances.
4. Diseases due to exposure to elevated or variable temperature or atmospheric pressure.
5. Diseases due to excessive use of certain organs.
6. Diseases due to a constrained attitude and sedentary life.
7. Diseases from exposure to mechanical violence.

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[2] These figures must be accepted with much reserve. While it is probable that the average age at death among women engaged in different occupations is less than that of men engaged in the same occupations, the figures in Table XX, Class X, cannot be used as a basis of comparison. So many women are annually withdrawn from the various occupations by marriage, which places them under different conditions, that the statistics of the occupations of women in the table are untrustworthy.

1. DISEASES DUE TO THE INHALATION OF IRRITATING OR POISONOUS GASES OR VAPORS.

Sulphurous-acid gas is used in various trades as a bleaching agent. In the manufacture of straw hats and in the drying or "processing" of hops this agent is extensively employed, and the people engaged in these industries frequently suffer from respiratory and digestive disorders. These are, however, rarely serious. If free access of air is allowed, the dangers to health in the above employments are very slight.

Nitric-acid fumes may be dangerous to health when inhaled in a concentrated form, but very few cases are on record where any positively deleterious influence can be traced to this agent.

Hydrochloric-acid fumes may prove deleterious to the workmen in soda manufactories, where the fumes are disengaged during the so-called "sulphate process." But the danger is probably slight. On the other hand, attention has recently been called to a peculiar effect of hydrochloric-acid fumes upon the workmen in fruit-canning establishments. The men who seal or "cap" the cans after being filled are the ones affected. The lesion has been described by Dr. W. Stump Forwood, who says concerning it: "The constant inhalation of the fumes of muriatic acid, associated as they are with the lead solder, which the busy "capper" neglects to protect himself against, soon produces inflammation of the mucous membrane of the nose, which finally results in ulceration. With some patients, after the removal of the cause and the application of proper treatment, recovery takes place after two or three months; but with those who have a scrofulous taint in their constitutions this ulceration is exceedingly intractable, and, in spite of all treatment, proceeds for months and even years, until the septum is finally perforated. And, strange to say, it is the common experience of those who have suffered that, as soon as perforation takes place, all the soreness and consequent annoyance disappears and the patient recovers, with, of course, a permanent opening in the nasal septum."[3] Dr. Forwood adds that anointing the nose, both within and without, several times a day, and avoidance of the acid fumes as much as possible, will prevent the peculiar affection.

Ammonia rarely causes disturbance of health in workmen brought into contact with it. When present in the air in large proportion it may give rise to serious symptoms. As it is often used to

[3] Phila. Med. and Surgical Reporter, June 30, 1883.

prevent the poisonous effects of mercury (*q. v.*). care should be taken that the proportion of the vapor in the air of the work-room should not exceed 5 per cent.

Chlorine gas is very deleterious in its effects upon the workmen brought in contact with it in the various industries in which it is employed. Nearly one-half of the workmen engaged in the manufacture of chlorinated lime and in bleaching become affected.

The respiratory organs are principally attacked. Pneumonia is exceptionally frequent. If an affected individual is predisposed to consumption the latter disease is soon lighted up, and quickly proves fatal. The effect of the inhalation of concentrated chlorine is thus graphically described by Hirt[4]: "The workman suffers from violent cough and extreme dyspnœa. In spite of the aid of the auxiliary respiratory muscles, the entrance of air to the lungs is insufficient, and the widely-opened eyes, the pale-bluish color, and the cold perspiration plainly show the mortal agony of the patient. With this the pulse is small, the temperature decreased. Soon after removal from the impregnated atmosphere these phenomena disappear, and a few hours later the workman is found enveloped in chlorine and hydrochloric-acid vapors in his accustomed place in the factory. The attacks seem to be but rarely fatal."

The constant inhalation of an atmosphere strongly impregnated with chlorine produces a cachectic appearance, bronchial catarrh, loss of the sense of smell, and a prematurely aged appearance. When this stage of chronic chlorine poisoning has been reached complete health can rarely be re-established, even if the patients be entirely removed from the irritating atmosphere.

Carbon monoxide is often present in the air of gas-works, iron smelting-works, and coke or charcoal furnaces. The workmen engaged in these industries often suffer with diseases of the respiratory organs, digestive disturbances, and general debility. Acute poisoning from carbon monoxide is relatively frequent, as already pointed out.[5] The prominent symptoms are at first violent headache, dizziness, and roaring in the ears. These symptoms are followed by great depression of muscular power, nausea, and vomiting. The vomited matters sometimes gain entrance into the trachea, and may thus produce strangulation. Unconsciousness, convulsions, and asphyxia rapidly succeed. Paralyses of the sphincters and of groups of other

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[4] Von Pettenkofer und Ziemssen's Handbuch der Hygiene, etc., II Th., 4 Abth., p. 30.

[5] See Chapter I, p. 26.

muscles are often present. The pulse is at first somewhat increased, but soon becomes slower. The respiration is slow and stertorous, and the temperature falls from 2.5° to 3° C. (3° to 4° F.). Glycosuria often occurs. If death does not occur in the attack, the patient frequently suffers from great depression, both physical and mental; loss of appetite, constipation, and various paretic conditions.

The slow or chronic form of poisoning by carbon monoxide is characterized by headache, dizziness, slow pulse and respiration, nausea, and sometimes vomiting and purging. Loss of memory and diminution of mental activity are also said to be effects of the continued inhalation of air charged with carbon monoxide.

Carbon dioxide is found as one of the constituents of the "choke-damp" in mines. There is reason to believe that this is often the source of ill health and death in miners, even where the symptoms of acute carbon-dioxide poisoning are not present. Hon. Andrew Roy[6] says that "it is more insidious than direct in its operations, gradually undermining the constitution and killing the men by inches." Difficulty of respiration and weakness are the only symptoms calling attention to the pernicious effects of the gas. Where, however, the proportion of carbon dioxide is large, acute poisoning occurs. This is manifested by the following symptoms: Loss of consciousness and of the power of voluntary motion. In some cases there are convulsions; in others the above symptoms are preceded by difficult respiration, headache, depression, drowsiness, or psychical excitement. Recovery usually soon follows after removing the patient into a purer atmosphere.

Vintners, distillers, brewers, and yeast-makers are said to suffer from the effects of carbon dioxide occasionally, but serious results from this cause are probably very infrequent.

It may not be amiss to call attention here to another dangerous mixture of gases sometimes found in mines, and which is occasionally the source of appalling accidents. This is the so-called "fire-damp" or light carburetted hydrogen (CH_4). When this gas is mixed with atmospheric air in the proportion of 6 to 10 volumes per cent., the mixture becomes violently explosive if ignited. The danger does not cease with the explosion, however, for in this act the free oxygen present is consumed in the formation of carbon dioxide, and the workmen then die asphyxiated, or from the effects of "choke-damp." The dangers from "fire-damp" can be largely averted by thorough ven-

[6] Third Annual Report State Mine Inspector of Ohio. Quoted in Buck's Hygiene and Public Health, vol. ii, p. 243.

tilation and by the use of the safety-lamp of Sir Humphrey Davy, which gives warning of the presence of the gas and permits the workmen to escape before the explosion takes place.

Sulphuretted hydrogen, when present in the air in large proportion—as, for example, in privy-vaults, cess-pools, and sewers—may produce serious or fatal poisoning. Formerly, when vaults were cleaned in the primitive way, these accidents were frequent; but at the present day, owing to improved methods of removing excreta, they are comparatively rare. The precautions advised in a preceding chapter[7] should be borne in mind when it is necessary for workmen to enter such places.

The gases resulting from the *putrid decomposition of organic substances,* such as are found in tanneries, glue- and soap-works, and similar industries, are popularly believed to give rise to various diseases. There are no observations on record, however, to show that such is the case. As a matter of fact, the workmen engaged in the industries mentioned, seem to be exceptionally healthy, and to resist to a considerable degree the ravages of phthisis and epidemic diseases.

Bisulphide of carbon is used in the arts principally in the process of vulcanizing India rubber, and for extracting oils from seeds and fatty bodies. The constant inhalation of the vapor of bisulphide of carbon produces a train of symptoms to which attention was first attracted by Delpech in 1856. The symptoms have been observed frequently since that time. The following account is from Hirt[8]:—

"Some days, or even weeks or months, after beginning this occupation, the workmen complain of a dull headache, becoming more severe toward evening. This symptom is soon followed by joint-pains, formication, and itching on various parts of the body. A more or less troublesome cough is present, but it is not accompanied by any characteristic sputa. The respiration is regular, the pulse somewhat increased in frequency. During this time certain individuals exhibit a marked exaltation of their intellectual powers; they talk more than formerly, and show an interest in matters in which they at other times show no concern. There is, however, very rarely distinct mental disease. The sexual desires are increased in both sexes, menstruation becomes irregular, and the urine possesses a faint odor of bisulphide of carbon. In this manner several weeks or months pass away. Very gradually the physical exaltation disappears, and a profound depres-

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[7] Chapter I, p. 28.

[8] *Op. cit.*, p. 66.

sion, melancholy, and discouragement succeed, coupled with which is often loss of memory. Vision and hearing become less acute, and the sexual activity is completely destroyed. Anesthetic spots appear on various parts of the body, and numbness of the fingers prevents the workman from performing any fine work."

The disease never proves fatal, but the normal condition of the individual is rarely re-established when the disorder has advanced to the extreme stages mentioned.

Iodine and bromine vapors, when inhaled by workmen engaged in their preparation, produce symptoms of poisoning which are sometimes very serious. Acute, iodic intoxication consists in severe laryngeal irritation, headache, conjunctivitis, and nasal catarrh. Occasionally there is temporary loss of consciousness. Chronic iodic cachexia is often found among the workmen. In certain cases atrophy of the testicles and gradual disappearance of sexual power have been observed. In the manufacture of bromine, a form of bronchial asthma has been observed among those engaged in the establishment. No symptoms corresponding to those of chronic iodism have been observed among the workmen in bromine.

The inhalation of the vapors of *turpentine* produces, in a considerable number of those constantly exposed to them, diseases of the respiratory organs, beginning with cough and, at times, resulting in consumption. In other cases derangement of the digestive organs, strangury, and, in a few cases, bloody urine have been observed. Nervous disturbances are rare after the inhalation of turpentine, and are limited to headache, roaring in the ears, or flashes of light before the eyes.

Petroleum vapor, when inhaled in a concentrated state, produces symptoms similar to those of anesthetics. When exposed for a long time to diluted petroleum vapor, workmen sometimes suffer from chronic pulmonary catarrhs or from nervous derangements. Among the latter are disturbances of mental activity, loss of memory, giddiness, and headache. These symptoms are, however, rare. More frequent are pustular or furuncular affections of the skin, which are probably due to the direct irritant effect of the vapor.

Lead poisoning is one of the most characteristic diseases of artisans. It attacks workmen engaged in the roasting and smelting of lead ores; in the manufacture of white and red lead and of lead acetate and chromate; in type-making, in painting, and, in short, in all occupations in which the workman is compelled to inhale the vapor or dust of lead, or in which it is conveyed in some manner to the digestive organs. It is believed also that it can be absorbed by the skin and produce its poisonous effects upon the economy. The average duration of life in the roasting and smelting furnaces is 41 years; of painters, as shown by Table XXXII, 54.07 years. Of the latter 75 per cent. are attacked by one of the forms of lead poisoning, colic being most frequent. In the manufacture of white lead more than half of the workmen suffer from lead poisoning during the first year, lead colic being present in 60 per cent. of all the cases.

In most sugar-of-lead manufactories 60 per cent. of all the operatives constantly suffer from some form of lead poisoning.

Poisoning has also been observed in workmen engaged in the manufacture of various pigments of which the acetate of lead is the base (*e.g.*, lead chromates). Among type-founders the symptoms of lead poisoning are not very rare, and even compositors sometimes suffer from lead poisoning. In the latter case the lead must be absorbed through the skin in order to produce its effects.

The various forms in which lead poisoning affects the individual are the lead cachexia, manifested by loss of weight, discoloration of the skin, the characteristic blue lining along the gums, diminution of the salivary secretion, a sweetish taste, and offensive odor of the breath; then lead colic, the features of which are well known; lead paralysis, the characteristic "wrist-drop," which requires prompt and intelligent treatment, otherwise permanent atrophy of the affected muscles often takes place. Among other nervous manifestations of the poison is a painful affection of the lower extremities, attacking joints and flexor muscles, and remittent in character. At times anesthesia of the skin of the head and neck is present. In rare cases serious mental derangement occurs. Other grave nervous lesions, such as the so-called saturnine hemiplegia and tabes, are happily extremely rare among workmen in the metal at the present day.

Mercurial poisoning is frequent among the artisans who work in the metal. The smelters of the ore suffer severely and in a large proportion of the entire number employed. Their average age at death is 45 years. Mirror-makers suffer most severely of all artisans who come in contact with the vapors of the metal. It is beyond question that the confinement in badly-ventilated work-rooms is largely responsible for the poisonous effects of the metal upon this class. The special forms in which the poisonous effects are manifested in mirror-makers are salivation, mercurial tremor, and nervous erethism, but, in addition, a very large proportion suffer from pulmonary consumption. It is stated that 71 per cent. of the total deaths among mirror-makers (those who coat the glass with the mercury alloy) are from phthisis.

Among women the symptoms are aggravated, and abortion frequently occurs. Of the children of women suffering from mercurial poisoning born living at term, 65 per cent. die within the first year.

In the Almaden quicksilver mines in Spain a considerable proportion of the workmen suffer from the milder symptoms of mercurial intoxication (gingivitis, salivation, or dryness of the mouth). The more severe manifestations (tremor, convulsions, contractures, violent muscular pains, paralysis, cachexia) are much less frequent, and latterly not so severe as they were formerly.

Fire-gilders, fulminate-makers, and physical instrument makers not infrequently suffer from the deleterious effects of inhaling the vapor of mercury. Hatters are also liable, to a considerable extent, to the poisonous effects of the metal.[9]

It has been found that upon sprinkling the floor of the work-room of mirror-makers with aqua ammonia, so as to impregnate the atmosphere with ammonia, the bad effects of mercury on the system are markedly diminished. Care must be taken, however, not to use the ammonia to excess, otherwise the diseases caused by this agent may attack the workmen.

Zinc or copper vapors, or possibly a combination of the two, given off from the brass, which is an alloy of these metals, produces a peculiar train of symptoms known as "brass-founders' ague." The symptoms are described by Hirt, who has suffered from two attacks of the affection himself, as follows[10] "A few hours after attending the process of brass-casting, one notices a peculiar, uncomfortable sensation over the whole body. More or less severe pains in the back and general lassitude cause a discontinuance of the ordinary occupation. While the pains appear now here, now there, and are extremely annoying, no changes in the pulse or respiration are noticeable. In a short time, however, usually after the patient has taken to the bed, chilliness comes on, which soon increases to a decided rigor, lasting fifteen minutes or longer. In the course of an hour or less the pulse now reaches a rapidity of 100 to 120 beats per minute. A tormenting cough, combined with a feeling of soreness in the chest, comes on. In consequence of the repeated acts of coughing, the increasing frontal headache produces exceeding discomfort. Soon, however, usually after

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[9] Hatting as Affecting the Health of Operatives, L. Dennis, Report New Jersey State Board of Health, 1879; Connecticut State Board of Health, 1883.

[10] *Op. cit.*, p. 122.

a few hours, the height of the attack is reached; free perspiration indicates the stage of defervescence, and during the gradual diminution of the symptoms the patient falls into a deep sleep, lasting several hours. On awakening, a slight headache and lassitude only remain as reminders of the attack."

It is said that about 75 per cent. of the workmen in brass-foundries are attacked by this affection; the attack is liable to be repeated at every exposure.

A chronic form of poisoning is said to occur among zinc-smelters after following their occupation for ten to twelve years. It consists of hyperæsthesia, formication, and burning of the skin of the lower extremities, soon followed by alteration in the temperature and tactile sensation, and diminution of the muscular sense. Paresis of the lower extremities sometimes comes on. The disease has not yet been sufficiently investigated.

Aniline vapor is exceedingly poisonous when inhaled in a concentrated state. Hirt describes an acute form which usually results fatally: "The workman falls suddenly to the ground; the skin is cold, pale; the face is cyanotic, the breath has the odor of aniline, the respiration is slowed, and the pulse increased. The sensation, diminished from the beginning of the attack, gradually entirely disappears, and death follows in a state of deep coma."[11] There is a milder form which comes on after several days of exposure. It is characterized by laryngeal irritation, diminution of appetite, headache, giddiness, great weakness, and depression. The pulse is rapid, small, and irregular. Respiration is little altered. There is decrease of sensibility of the skin. Convulsions may occur, but are usually of short duration.

The chronic form of aniline poisoning is characterized by three sets of symptoms: those affecting the central nervous system, the digestive tract, and the skin. Among the first are lassitude, headache, roaring in the ears, and disturbances of sensation and motion of greater or less degree.

The digestive derangements consist in eructations, nausea, and vomiting.

The cutaneous lesions are eczematous or pustular eruptions, and sometimes round, sharply-circumscribed ulcers with callous borders.

There is no trustworthy evidence that in the manufacture of *aniline colors* poisonous symptoms are produced in the workmen.

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[11] *Op. cit.*, p. 127.

2.—DISEASES DUE TO THE INHALATION OF IRRITATING OR POISONOUS DUST.

The inhalation of air containing particles of organic or inorganic matter has long been accepted as a cause of certain special diseases of artisans. The diseases so caused are usually limited to the pulmonary organs, and consist of acute and chronic catarrh, emphysema of the lungs, pneumonia, interstitial inflammation of the lungs—the so-called fibroid phthisis or pulmonary cirrhosis.

Coal-dust is inhaled by coal-miners, charcoal-burners, coal-handlers, firemen, chimney-sweeps, foundry-men, lead-pencil makers, etc. Chronic bronchial catarrhs are most frequent, while phthisis and emphysema are almost absent from the list of diseases affecting these workmen. Dr. W. B. Canfield has reported an interesting case of pneumonoconiosis in which there was coincident bacillary phthisis.[12] The table on page 247 shows that the expectation of life of foundry-men, furnace-men, firemen, and chimney-sweeps is much below the average.

Metallic dust is inhaled by blacksmiths, nailers, cutlers, locksmiths, file-cutters, cutlery- and needle- polishers, etc. While in this class of workmen cases of bronchitis and pneumonia are relatively frequent, much the largest proportion suffer from phthisis. A table compiled by Hirt shows that out of the total number of sick in the different classes of workmen the cases of phthisis were:—

62.2	per cent.	for	file-cutters,
69.6	"	"	needle-polishers,
40.4	"	"	grinders,
12.2	"	"	nailers.

The Massachusetts table gives the average duration of life for blacksmiths at 53.26 years, of nail-makers at 41.49 years, and of cutlers at 39.21 years. The needle-polishers at Sheffield, as already stated, have only an average duration of life of 30.66 years. In this work and that of grinding knives, scissors, and similar articles, the metallic dust is mixed with mineral dust (particles of silica from the grindstone). This mixture seems to be much more deleterious than metallic dust alone, as shown by the shorter average duration of life and the enormous percentage of cases of consumption.

Mineral dust is inhaled by the workmen in a large number of different industries. The grinders in the ground-glass factories suffer most severely. Hirt found the average duration of life in grinders

[12] Trans. Med. and Chir. Fac., Md., 1889.

who began this occupation after their 25th year to be 42.50 years, while in those who began at the age of 15 the average duration was 30 years.

Millstone cutting is also a very dangerous occupation. Peacock[13] gives the average age of these workmen at 24.1 years. Stone-cutters generally suffer frequently from phthisis, probably largely in consequence of the constant inhalation of the mineral dust produced during their work. The Massachusetts table gives the average age at death of these workmen at 40.90 years, while Hirt's table gives a much lower age, namely, 36.3 years. Potters and porcelain-makers are exposed to similar dangers from their occupation, but to a much less degree. The table on page 247 gives the average age at death at 56.67 years—rather a high average.

Slaters and workmen in slate-quarries suffer in a large proportion of cases from chronic pneumonia, and die at a comparatively early age.

Masons and carpenters have an average duration of life of 50.33 and 53.33 years, respectively. One-third of all the diseases from which they suffer affect the respiratory organs.

Gussenbauer has reported a very interesting series of cases of a peculiar inflammatory affection of the diaphyses of the long bones in the artisans who are engaged in the manufacture of pearl buttons.

Gem-finishers are exposed not only to the inhalation of dust, but to poisonous gases (carbon monoxide) and vapors (lead). The proportion of sickness among them is very high.

Vegetable Dust.—The workmen compelled to inhale vegetable dust are those who work in tobacco, cotton-operatives, flax-dressers, paper-makers, weavers, wood-turners, millers, and laborers in grain-elevators.

Workmen in tobacco usually suffer, within a few weeks after beginning work, from a nasal, conjunctival, and bronchial catarrh, which soon passes off, as the mucous membranes seem to become accustomed to the irritation. Nausea is also frequent at first, due probably to the absorption of small quantities of nicotine. Females exposed to the tobacco-dust usually suffer from digestive and nervous troubles. They are also said to abort frequently.

Dr. R. S. Tracy,[14] as a result of his observations among cigar-makers in New York, states that the fecundity of these people is much

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[13] Quoted by Merkel, in von Pettenkofer und Ziemssen's Handbuch der Hygiene, II Th., 4 Abth., p. 197.

[14] Buck's Hygiene and Public Health, vol. ii, p. 62.

less than the average. Three hundred and twenty-five families visited had only 465 children, an average of 1.43 to each family. Dr. Tracy is inclined to attribute this to the frequent abortions that occur among the females exposed to the inhalation of tobacco-dust. According to the Massachusetts table, cigar-making is an unfavorable occupation, the average age at death being 38.36 years.

Cotton-operatives, flax-dressers, weavers, and workmen in paper-mills are subject to various diseases of the respiratory organs. Coetsem, as long ago as 1836, described a peculiar pulmonary affection among cotton-operatives, which he termed *pneumonie cotonneuse.* The observation does not seem to have been verified by others; at all events, the author is unable to find any other record of a similar affection in the literature of the subject. Among weavers the mortality from phthisis is comparatively high. Among paper-makers Hirt found an average duration of life of 37.6 years. The people who sort rags are liable to a fatal infectious disease, "rag-sorters' disease" (Hadernkrankheit[15]), which resembles in all respects, and is probably nothing less than, anthrax. No cases have been reported in this country, but, as the importation of rags from abroad is carried on to a considerable extent, no apology is believed to be necessary for calling attention to it. The "wool-sorters' disease" is similar in its nature.

Millers suffer in a large proportion of cases from pulmonary affections, especially bronchial catarrh and pneumonia. According to Hirt, 20.3 per cent. of all the diseases of these workmen are pneumonias, 9.3 per cent. bronchial catarrhs, 10.9 per cent. phthisis, and 1.9 per cent. emphysema. The average duration of life is 45.1 years. The Massachusetts table gives 57.14 years—a very much more favorable exhibit.

The laborers in grain-elevators are compelled to inhale a very irritating dust, which causes acute and chronic catarrhs of the respiratory organs. Dr. T. B. Evans, of Baltimore, has reported a series of cases of catarrhal pneumonia in these workmen, which were characterized by some very peculiar features. Brush-making, according to the statistics of Hirt, is a very dangerous occupation. Nearly one-half of the deaths among brush-makers are from phthisis, due, in great measure, to the inhalation of the sharp fragments of bristles produced in trimming the brushes. In the Massachusetts table the average duration of life is given at 43.11 years.

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[15] See article by Soyka, Realencyclopædie d. ges. Heilk, Bd. VI, p. 165.

3.—DISEASES DUE TO THE ABSORPTION OR LOCAL ACTION OF IRRITATING OR POISONOUS SUBSTANCES.

Arsenic is used in the manufacture of green pigments and for various other purposes in the arts. In the preservation of furs and in taxidermy it finds extensive use. In the preparation of the pigment known as Paris green the workmen are frequently entirely covered by a layer of the poisonous salt. The poisonous symptoms occur in consequence of the absorption of the poison through the skin or from its local action, and but rarely on account of inhalation of vapors or dust in which it is contained. The most marked symptoms are chronic gastric catarrh, superficial erosions in the mouth, dry tongue, thirst, and a burning sensation in the throat. These symptoms may continue for months, or even years, and gradually produce a complete breaking down of nutrition and the vital powers. Violent itching skin eruptions of an eczematous character are not infrequent complications of the internal symptoms.

Lewin has described a localized pigmentation of the skin in workmen (engravers) in silver. The left hand is especially affected. The occurrence of the affection is explained by the numerous slight injuries of the hands by the graver's tools and the local absorption and decomposition of the silver.

Phosphorus produces two classes of effects in persons subjected to its influence. The milder effects are produced by the inhalation of the fumes of the substance, and are limited to digestive disturbances and diseases of the pulmonary organs. The severer symptoms are only observed among the employés in match-factories, and are due to the local action of the phosphorus upon the tissues affected.

The characteristic disease produced by phosphorus is a painful periostitis of the lower or upper jaw. The limitation of the affection to this locality is believed to be due to the action of the phosphorus dissolved in the saliva. The fact that the lower jaw, with which the saliva comes more thoroughly in contact, is most frequently affected seems to indicate that this view is the correct one. The disease begins, on an average, five years after the beginning of the employment. Hirt estimates the proportion of employés in match-factories attacked at 11 to 12 per cent. The first symptom of the disease is toothache, soon extending to the jaw. The cervical glands swell up; the gums become reddened and spongy; abscesses form about the diseased teeth, from which large quantities of thin, offensive pus are discharged. Examination with a sound reveals carious, nodulated bone. The cheeks become swollen, erysipelatous, and may suppurate and discharge pus externally.

Hutchinson has reported a case in which the long-continued internal administration of phosphorus as a medicine produced maxillary necrosis.

The destruction of the soft tissues continues until resection of the jaw is finally undertaken and the disease checked by surgical intervention, and removal of the patient from the influence of the pernicious substance.

Dr. J. Ewing Mears reported[16] 16 cases of phosphorus necrosis. He concluded "that the antidotal powers of turpentine have been established, both in neutralizing the effects of the poison upon operatives during their work and also in the treatment of the early stage of the disease. The disease is to be prevented by the adoption of thorough methods of ventilation, stringent rules with regard to cleanliness, and the free disengagement of the vapors of turpentine in all the apartments of factories in which the fumes of phosphorus escape."

In the manufacture of *quinine* a troublesome eczema is caused in about 90 per cent of the employés. It seems to be due to emanations given off from the boiling solutions. It begins with intense itching, followed by swelling and the formation of vesicles, which soon burst and form crusts. There is considerable fever when the swelling is great. It is said that blondes are more frequently affected than those of dark complexion. The disease soon disappears if the work is given up.

The workmen engaged in the manufacture of *bichromate of potassium* are said to suffer from an ulceration of the nasal mucous membrane very similar to that already described as due to the vapors of hydrochloric acid (p. 250). Rapidly-spreading, deep ulcers are also said to form if the bichromate comes in contact with abraded surfaces of the skin.

The *strong alkali* handled by tanners frequently produces fissured eczemas of the hands, which are painful and often difficult to cure.

The workmen in *petroleum refineries* frequently suffer from acneiform or furuncular eruptions.

Among glass-blowers, syphilis is frequently communicated by an infected mouth-piece which is used by the men in turn.

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[16] Trans. Am. Surg. Association, 1887.

4.—DISEASES DUE TO EXPOSURE TO ELEVATED OR VARIABLE TEMPERATURE OR ATMOSPHERIC PRESSURE.

Cooks and bakers are exposed almost constantly to a high temperature, which produces an unfavorable influence upon health and predisposes them to diseases of various kinds. The Massachusetts table shows that cooks have a much shorter duration of life than bakers, although the statistics of both trades are unfavorable.

The prevailing diseases among cooks and bakers are rheumatism and eczematous eruptions, generally confined to the hands, forearms, and face.

Blacksmiths, founders, and firemen suffer from the intense heat to which they are exposed, in addition to the inhalation of coal-dust, as has already been pointed out. The stokers in the engine-rooms of steamships suffer especially from the excessively high temperature to which they are subjected by their occupation. A form of heart-weakness, described by Levick as "fireman's heart," is prevalent among them.

Sailors, farmers, coachmen, car-drivers, and teamsters are subjected to stress of weather, changes of temperature, and storms. They suffer frequently from rheumatism, acute bronchitis, pneumonia, and Bright's disease. Car-drivers are said also to suffer from painful swelling of the feet, varicose veins and ulcers, and mild spinal troubles.[17]

Sun-stroke is not confined to any class of artisans, but persons who perform very hard labor, especially in a confined atmosphere, suffer most frequently.

The effects of *compressed air* on workmen in tunnels and deep mines have already been referred to.[18] The most serious symptoms occur not when the individual is subjected to the increased pressure, but when the pressure is too rapidly diminished.

5.—DISEASES DUE TO THE EXCESSIVE USE OF CERTAIN ORGANS.

The prevalent belief that the overuse of the intellectual faculties is a frequent cause of mental disease is not borne out by facts. Men and women who perform an amount of mental work regarded by

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[17] A. McL. Hamilton in Report New York Board of Health, p. 444, 1873.
[18] Chapter I, p. 11.

most persons as excessive have, in spite of this, a long duration of life. There are no exact statistics upon this subject, but Caspar made the following estimate of the average duration of life among professional men: Clergymen live 65; merchants, 62.4; officials, 61.7; lawyers, 58.9; teachers, 56.9; and physicians, 56.8 years. In the table on page 248 the figures are somewhat less favorable, although corresponding in general with those of Caspar. Hence, it is seen that, of professional men, those whose occupation compels the exercise of high mental powers have a higher duration of life than any other class, except farmers and mechanics engaged actively out of doors. Those professional occupations only which necessitate a more or less irregular mode of life and frequent subjection to physical exhaustion and dangers from contagious disease, such as the work of physicians and journalists, make an unfavorable showing in the statistics. The proposition may be laid down that it is not mental *activity*, however great, but mental *worry* that tends to the abbreviation of life.

The occupation of a tea-taster is said to produce a peculiar nervous condition, manifested in muscular tremblings, etc., which compels the individual to give up the work in a few years.

Persons who test the quality of *tobacco*, an occupation corresponding to that of tea-taster, are said to suffer from nervous symptoms which may include amaurosis and other grave affections.

Those persons who are compelled to use their eyes constantly upon minute objects frequently suffer from defective vision. So engravers, watch-makers, and seamstresses are liable to near-sightedness, amaurosis, and irritation of the conjunctiva. Public speakers and singers frequently suffer from catarrhal or even paretic conditions of the throat, which usually disappear on relinquishing the occupation for a time.

Telegraph operators and copyists suffer from a peculiar convulsive affection of the fingers, called "writers' cramp." Cigar-makers are also said to suffer from a similar cramp of the fingers used in rolling cigars. Performers on wind instruments are liable to pulmonary emphysema, on account of the pressure to which the lungs are frequently subjected. Boiler-makers often suffer from deafness, in consequence of their constant existence in an atmosphere in a state of continual violent vibration. The affection is generally recognized as "boiler-makers' deafness." Dr. C. S. Turnbull has reported several cases of "mill-operatives' deafness." Its characteristic is an inability to hear distinctly except during a noise.

6.—DISEASES DUE TO A CONSTRAINED ATTITUDE AND SEDENTARY LIFE.

It is probable that the large mortality and morbidity rate of persons whose occupations keep them confined within doors are due, next to the defective ventilation, to the constrained attitude which most of them necessarily assume. Thus, carvers, book-binders, engravers, jewelers, printers, shoe-makers, book-keepers, and cigar-makers all have a low average duration of life. It is found, likewise, that many of these artisans suffer most from pulmonary and digestive troubles, among the former being phthisis, and among the latter constipation, dyspepsia, and hemorrhoids.

7.—DISEASES FROM EXPOSURE TO MECHANICAL VIOLENCE.

It will be seen, by reference to the table on page 248, that all persons whose occupations involve an intimate contact with machinery, and in the pursuit of which accidents frequently happen, have a short duration of life. Persons liable to these dangers are machinists, operatives in factories, workmen in powder-mills, baggage-masters, brakemen, drivers, engineers, firemen, and other workmen on railroads. Aside from the diseases to which some of these classes are liable in consequence of exposure to variable atmospheric conditions, the grave accidents to which they are so frequently exposed render their occupations extremely dangerous. Brakemen on freight railroads, for example, are classed by insurance companies as the most hazardous "risks," and some companies refuse to take them at all. The table on page 248 tends to confirm the conclusion of the insurance companies, for, excluding the class of "students," which, for manifest reasons, cannot be used as a comparison, brakemen have the shortest average duration of life of all the occupations noted in the table.

QUESTIONS TO CHAPTER IX.

INDUSTRIAL HYGIENE.

How may various occupations induce disease? Are such diseases always necessarily due to the occupations, or are there incidental factors that might be avoided? What classes of men have the greatest expectation of life? What occupations are especially unfavorable to health? What diseases do they usually produce? How may diseases of occupations be conveniently classified?

What disorders are liable to be produced by the inhalation of the gases of the mineral acids? What peculiar symptoms may be due to the constant inhalation of the fumes of hydrochloric acid? What effect has ammonia gas? What disease is frequently due to the constant inhalation of chlorine gas? What other disease is also especially favored by it? What are some of the symptoms produced by the gas in a concentrated state? By the constant inhalation of the gas?

In what occupations is carbon monoxide often given off to the air? What are some of the acute symptoms produced by it? What of the chronic poisoning by gas? Is there any evidence that carbon dioxide in small amounts may cause symptoms of chronic poisoning? What are some of the manifestations in cases of acute poisoning by this gas? What other gas is often found in mines, and how may it be dangerous to life? How may its dangers be avoided?

Where may sulphuretted hydrogen be found in quantities sufficient to produce serious results? What are some of the evil effects due to the inhalation of the vapor of bisulphide of carbon? Of iodine and bromine? Of turpentine? Of petroleum?

In what occupations are the laborers subject to lead poisoning? What effect has it on the duration of life? In what forms may lead poisoning manifest itself? What proportion of workers in lead are affected by it?

What proportion of workers in mercury are affected by that metal? To what disease are mirror-makers especially prone? What are some of the symptoms of mercurial intoxication? What peculiar effect has the metal upon female laborers and their children? How may the bad effects of mercury be diminished?

What are the symptoms of "brass-founders' ague"? Is it common among the class indicated? What symptoms may indicate chronic zinc poisoning?

What are the symptoms of acute poisoning by aniline vapor? What peculiarities characterize chronic aniline poisoning? Are these or others liable to be produced in those employed in the manufacture of aniline colors?

What class of diseases is especially apt to be caused by the continued inhalation of dust? What is the most common affection among those who inhale coal-dust in large quantities? From what pulmonary disease are they exceptionally free? Is the expectation of life among this class of workmen high? What diseases seem to be especially favored by the inhalation of metallic dust? Which of these is the most frequent? What is the effect of a mixture of metallic and mineral dust? What occupations have a high morbidity and mortality from phthisis? What from chronic pneumonia or other pulmonary affections? To what peculiar affection are pearl-button-makers subject?

What workmen habitually inhale vegetable dust? What disturbances are due to the inhalation of tobacco-dust? What effect has it on fecundity, and why?

To what diseases are workers in cotton and flax subject, and from which one especially is the mortality high? What is the average duration of life among paper-makers? To what disease are rag- and wool- sorters liable? From what affections do millers and workers in grain-elevators suffer? Why is the mortality from phthisis so high among brush-makers?

What substances are liable to cause disease by absorption or local action? What are some of the symptoms common to those working with arsenic? What two classes of effects are observed among those exposed to phosphorus vapors? To what is each class due? What may be used as a preventive and antidote to such cases of phosphorus poisoning? What malady is associated with the manufacture of quinine? What other substances may produce eczema or ulceration in their preparation or manufacture?

What diseases are favored by continued exposure to high temperatures? In what occupations are such disturbances accordingly prevalent? What class of laborers are subject to sudden changes or to extremes of temperature? What are some of the maladies that may be, in part, traced to such cases? What are the effects of compressed air upon laborers in it, and when are they manifested?

What diseases or disturbances may be due to the excessive use of certain organs? Is there any evidence that excessive mental activity leads to mental disease? What is a factor in the production of the latter? Why is the mortality-rate so high among those who follow sedentary or in-door occupations? What disturbances are most common to these pursuits? In what occupations are the laborers especially liable to mechanical violence? Is the average duration of life of such workmen low or high?

CHAPTER X.

MILITARY AND CAMP HYGIENE.

HYGIENE applying especially to military life has made great advances in recent years, and as the causes of epidemic diseases formerly considered the inevitable accompaniment of war have one by one been made manifest, many fatal camp maladies have lost in the eyes of the medical officer much of their former menace.

The soldier of the present day has many more comforts than before. Each year sees the adoption of improvements in food, shelter, or clothing, while the care of the sick and wounded in active service approaches more nearly an ideal standard.

I.—THE RECRUIT.

The raw recruit, sometimes awkward and slovenly, often unprepossessing in appearance, is the material from which armies are made.

The selection, therefore, of men capable physically and mentally of being trained into disciplined soldiers lies at the very foundation of military hygiene. At first glance nothing would seem to be easier than for a physician to detect unsoundness in an applicant for a soldier's life. As a matter of fact, experience and knowledge of military conditions are requisites to properly select recruits. Many defects of structure in no way affecting the actual bodily health, or, from the standpoint of the examiner of life insurance, the expectation of life, are properly considered bars to enlistment. A man suffering from or predisposed to disease is of course at once rejected, but the accepted recruit must have the free use of all of his limbs; his hearing, vision, and speech must be perfect; he must be of ample chest measurement and justly proportioned. An inquiry must also be made into his personal and family history, and persons presenting the appearance of tramps, vagabonds, or hard drinkers, or manifesting lack of intelligence, are to be rejected, even if apparently able-bodied.

Only under very exceptional circumstances are recruits under 21 years old accepted in the United States army. Some medical officers of experience think that for tropical service the minimum age should be even greater, and that an ideal army for such service would be composed of men between 25 and 45 years of age.

The height of a recruit is at present fixed at 5 feet 4 inches as a minimum for all branches.

The maximum height for cavalry is 5 feet 10 inches, and the maximum for artillery and infantry is governed by the rule for weight, as follows:—

The minimum weight for all recruits is 124 pounds, except for the cavalry, in which enlistment may be made without regard to a minimum weight if proportions and chest-measurements are satisfactory. The maximum weight for artillery and infantry is 190 pounds, for cavalry and light artillery, 165 pounds.

Up to and including the height of 67 inches the recruit should weigh 2 pounds for every inch. The same rule applies to men of greater height, but with the addition of 5 pounds for every inch above 67.

The difference between the chest-measurement at inspiration and expiration should be at least 2 inches in men of 67 inches in stature or below, and 2½ inches above that height.

These rules are considered to give a fair standard of physical proportions, but a slight deviation from them is allowed in specially desirable recruits. Vaccination of all accepted men is compulsory.

2.—THE TRAINING OF THE SOLDIER.

The preliminary drill of a recruit is generally purely calisthenic. The "setting-up drill" of the United States army is admirably adapted for its purposes, to render the recruit supple and alert, quick to respond to the word of command, and to give him an upright and graceful carriage. Although especially intended for the recruit, a certain amount of this exercise is given to all soldiers throughout their entire period of service.

All the muscles of the body are brought into play, and the effects of the exercise on the muscular development of young and ungainly recruits are soon seen.

The movements in the manual of drill with the rifle have the disadvantage of being largely unilateral, and when once learned are so automatically performed that the calisthenic benefit of bodily exercise is not to any extent gained thereby.

Exercises of agility are practiced by cavalrymen and light artillerymen especially. The skill attained in fancy horsemanship by many of the soldiers is only excelled by the best professional circusriders. For infantry, wall-scaling and the crossing of obstacles while carrying arms and equipment are taught.

Exercises of endurance consist of practice marches with full equipment, and lastly there is the special training in the use of the implements of war.

The defective recruit who has been improperly selected, very soon, under military training, shows his incapacity for the service. A man with flat-foot plays out on the march; with a crippled thumb he can never properly handle his rifle; with even a slight defect in hearing he spoils the manual of his company by inability to properly catch the word of the drill-master. These are samples of some of the commoner defects which are often overlooked in apparently able-bodied men by the average physician examining men for the military service, and which must be specially guarded against when war requires the enrollment of thousands of volunteers, and when inexperienced medical examiners must of necessity be relied upon.

3.—THE FOOD OF THE SOLDIER.

An army ration is one day's allowance for one soldier. The rations for an organization are drawn in bulk for periods of days, usually ten, except the fresh meat, which is delivered on certain days by the contractor, and fresh bread, which is drawn daily. The supervision of the company mess and the management of the use of the rations are within the province of the company commander, and are by no means his least important duties.

The ration of the United States army is the most liberal and diversified of any in the world.[1] Each soldier is entitled to a *per diem* allowance as follows:—

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[1] A new ration order, issued by the War Department April 3, 1908, materially improves the already excellent U. S. ration. The allowances of the standard meat, bread, and vegetable components are not greatly changed, but the selective articles are more diversified, giving greater latitude to issuing and purchasing officers, and being adapted to different markets and conditions of service. Salt pork and salt beef have been stricken from the list. Canned meats are allowed when impracticable to furnish fresh. Turkey and chicken are allowed on national holidays. Half an ounce of butter or oleomargarine is added to the ration, and a like amount of evaporated cream for the soldier's coffee. The vegetable ration is increased to 20 ounces. There are some other minor changes, and, in addition to the usual or "garrison ration," the allowances to be issued under special conditions are listed at length, as in the "field ration," the "haversack ration," the "travel ration," the "emergency ration," and the "Filipino ration" for the use of the native scouts in the Philippine Islands.

The whole order is too long to insert in a short chapter on military hygiene, but all the really important changes are here given.

TABLE XXXIII.

Meat Components.

Fresh beef	20 oz.
Or fresh mutton	20 oz.
Or bacon	12 oz.
Or pork	12 oz.
Or salt beef	22 oz.
Or dried fish (cod)	14 oz.
Or fresh fish (cod whole)	18 oz.
Or pickled fish (mackerel)	18 oz.
Or canned fish (salmon)	16 oz.

Bread Components.

Flour	18 oz.
Or soft bread	18 oz.
Or hard bread	16 oz.
Or corn meal	20 oz.

Vegetables and Miscellaneous.

Potatoes	16 oz.
Or potatoes 80 per cent. and onions 20 per cent.	16 oz.
Or potatoes 70 per cent. and canned tomatoes 30 per cent.	16 oz.
Dried fruits (various)	2 oz.
Sugar	2 2/5 oz.
Or molasses	16/25 gill.
Or cane syrup	16/25 gill.
Coffee (green)	1 3/5 oz.
Or coffee (roasted)	1 7/25 oz.
Or tea (green or black)	8/25 oz.
Vinegar	8/25 gill.
Salt	16/25 oz.
Pepper	1/25 oz.
Baking powder (in field only)	16/25 oz.
Soap	16/25 oz.
Candles	6/25 oz.

The nutritive value of a ration, of course, varies greatly, according to the choice made from the selective articles in the foregoing list.

The most nutritive combination that a soldier can get in any one day consists of 61 ounces of food, containing, by metric weight, 97.79 grams of fat, 600.74 grams carbohydrate, 164.27 grams proteids, with a total fuel value of 4061 calories. If the selection is made from the least nutritive articles of the ration, a soldier may receive food allowance for one day of as low a value as 2321 calories.

The field ration for service in campaign consists of bacon, hard bread, beans, dried fruit, sugar, coffee, etc., with fresh vegetables when obtainable. It has a value, even without the vegetables, of 4448 calories.

The German army issues rations of the following values (Atwater):—

German ration, peace footing	2800	calories.
" ordinary war footing	3095	"
" extraordinary war footing	3985	"

and the fuel value of the diets of men performing hard labor in civil life have been estimated as follows:—

Active muscular labor, Atwater (American)	4060	calories.
Men at hard work, Voit (German standard)	3370	"
Active laborers, Playfair (English standard)	3630	"

The ration of the United States army is thus seen to be superior to the highest German ration, and to equal or exceed the accepted standard diet of working men in civil life.

In Alaska the already liberal army ration is increased still further; vegetables by one-half, bacon one-third.

In the Philippine Islands the regular ration is issued, and although the question of a special diet possibly better adapted for tropical climates has been much discussed, the consensus of opinion of officers, both staff and line, is against changing an allowance which has proved so satisfactory.

Each article of the ration has a fixed money value, which may be drawn instead of some of the articles, and expended for the purchase of food not in the ration.

The money so acquired becomes a part of the "company fund," along with money received as the organization's share of profits of the post exchange, the post bakery, etc. With a company fund judiciously expended, and with extra vegetables from gardens cultivated at the station, organizations in the United States army generally fare excellently. Recent improvements in field cooking-ranges and ovens make it now possible to serve as good meals in stationary camps as in permanent posts. Much of the sickness and consequent inefficiency of hastily-raised bodies of troops is due to lack of knowledge in drawing, managing, and cooking the ration. No training is, therefore, more valuable for organizations of the National Guard that that received in the summer camps, where, under army regulations, they assume the entire management of their own subsistence. Company cooks are now very well paid, and properly so, as on their efficiency the health of the command very largely depends.

4.—THE CLOTHING OF THE SOLDIER.

With due regard to economy, the uniform of the soldier must be well made and of good material. In the United States army, the blue uniform with brass buttons is now only used in garrison and for dress purposes. In common with most of the large foreign nations, and owing to the great range of modern firearms, a color inconspicuous and harmonizing with the landscape has been adopted for field work. To an enemy armed with modern rifle, using smokeless powder, troops uniformed in colors contrasting strongly with their surroundings offer a splendid target and are at a great disadvantage. Even the glint of sunlight on polished buttons or weapons at a distance of several miles may attract the enemy's attention and result in increased mortality or strategical failure. The present field uniform is of an olive-drab or khaki color with buttons and metallic ornaments in bronze. It is made in different weights, for temperate, arctic, and tropical climates, and does not easily show the effects of wear.

Underclothing, head-covering, and foot-gear are of good quality, much improvement having been made in the shoes furnished by the Quartermaster's Department. With infantry the care of the feet is a paramount consideration; well-fitting shoes and stockings are, therefore, of the utmost importance.

The field uniform may be rendered tolerably waterproof by lanolin or one of the other modern processes, and this is required by regulation. For protection against heavy rains and for use when sleeping on the damp ground, the soldier is provided with a rubber poncho, or blanket.

So much fault was found with the method of carrying the blankets, extra clothing, etc., in a knapsack strapped on the back, and also with the very heavy cartridge belt around the waist, that a radical change has been found necessary in the "heavy marching order" equipment.

An ammunition-belt is still used around the waist, but is suspended by straps from the shoulders. Additional ammunition, when necessary in field service, is carried in a "bandolier" worn diagonally across the body. To the suspending straps are attached the canteen, filled with water, and the haversack, containing rations and mess-implements. Blankets, poncho, extra clothing, etc., are worn in a roll over the shoulder. The total weight which must be carried by a soldier in heavy marching order, including his clothing, is about 70 pounds, a load far too heavy to allow celerity of movement, and probably distinctly injurious to health. An ordinary day's march or two may be made with full equipment without undue fatigue, especially if the destination is a camp of some permanence, where the troops may rest several days. In very active service a reduction in the weight of the equipment may be required and must first fall upon the extra clothing carried in the blanket roll. By discarding overcoat, extra clothing, one blanket, and either the rubber poncho or shelter-tent half, the roll is brought down to its lowest limit, the total weight carried being then below 50 pounds. The present method of adjusting the load of the foot soldier is a great advance on the former way, and allows even the full equipment to be carried with much less fatigue than before.

5.—THE DWELLING OF THE SOLDIER.

At permanent military stations the troops are housed in barracks—buildings either of one or two stories, constructed of stone, brick, or wood. A barrack for a single organization should contain large dormitories or squad-rooms, suitable bed-rooms for non-commissioned officers and the cooks, a large recreation- or day- room, kitchen, store-room, lavatory, and an office for the company commander and the first sergeant. In the United States army, the barracks constructed in recent years leave little to be desired, from the sanitarian's standpoint. At some of the older stations, buildings originally hastily or cheaply constructed have been added to or altered from year to year, and are, in consequence, more or less unfitted for military occupancy. Such posts, however, are either being gradually abandoned or else, it having been decided that the location is to be permanent, entirely new buildings are in course of construction or provided for. There is no single accepted model in the United States army for barracks. A number of plans have been approved for buildings of various material and design.

The use of the buildings, whether for infantry, cavalry, or artillery, the climate and soil of the proposed location, the cost and availability of material, must all be taken into consideration in so large a country as the United States. Some of the modern barracks are double and house two organizations, but single barracks present so many advantages that they have been very wisely adopted. For the proper location of barracks, a dry and well-drained site is required, with exposure on all sides to sunlight and air. The building materials should be the best of their kind, and especial care taken to avoid dampness. A dry cellar under the whole building, when the nature of the soil permits, is a great advantage. In tropical countries the first floor should be raised several feet from the ground, to permit a free circulation of air beneath the building. Ample window-space and broad verandas are also important features in hot climates, where the soldier's life is passed almost entirely in the open air.

Ventilation in the tropics presents no difficulties, but in cold climates the dormitories of soldiers are apt to be either imperfectly heated or badly ventilated.

The minimum initial air-space per man should never be below 600 cubic feet, and this amount is not enough unless the means of ventilation are exceptionally good. One thousand cubic feet should be looked upon as the ideal allowance per man, and approached as nearly as economy will permit in the construction of new barracks. Each bed should also be allowed a minimum floor-space of 50 square feet. In the construction of barracks the same rules apply as in the building of any habitation intended for the use of a large number of occupants.

Wood is to be avoided as far as possible, and fire-proof material substituted.

Floors should be of hard wood, tongued and grooved, and laid upon iron beams and cement. No wood should enter in the construction of the walls, the inside finish must be smooth, and all corners rounded.

Plumbing must be exposed throughout its course, and it is a good plan to have the lavatory and water-closets in a detached structure reached by a covered way, although when properly constructed and cared for there is no great objection to their location in the basement.

In France, barracks built according to the designs of M. Tollet have proved very satisfactory, but seem not to have been universally adopted on account of expense. These are built on the pavilion plan; the first floor is elevated above the ground, on which a layer of cement has been placed. The walls are double, with air-space between, and the materials fire-proof. They are said to be very dry, well ventilated, and easily heated. In the British army, pavilion barracks of simple construction are also much used. A pure and simple water-supply and perfect disposal of excreta and wastes are, of course, absolutely essential to health of troops in garrison.

At some sea-coast forts, United States troops still inhabit casemates, but it is likely that in a few years the last of such extremely unhygienic quarters will be abandoned. Casemates are damp, dark, and badly ventilated, and the inhabitants are apt to suffer from rheumatism and troubles of the respiratory organs.

On the march and in camp the soldier is sheltered in tents, of which the simplest form is the shelter-tent. Each soldier has as a part of his personal equipment one shelter-half and a light, jointed pole. By buttoning together their two pieces a small tent is formed, beneath which two men can crawl and keep themselves and equipments dry, except in driving rain-storms. For expeditions when camp is made every night, it is extremely useful, but it affords only a slight protection in very inclement weather or in extremely cold climates.

The conical wall-tent now used is a modification of the old Sibley tent. It is circular, with a perpendicular wall three feet in height, surmounted by a cone open at the top. The top may be covered in whole or in part by a canvas hood, which prevents the entrance of rain, but which can be opened for ventilation. There is a single central pole standing upon an iron tripod, between the legs of which a stove may be placed in cold weather.

This tent is economical, protects well from even driving rain, and is especially comfortable for field work in winter.

The floor-space is 212 square feet, and its capacity 1450 cubic feet.

According to the strict letter of the regulations, 20 foot-soldiers, or 17 cavalrymen with their saddles, etc., are supposed to occupy one tent. Not more than half this number can, however, be comfortably housed, and, as a matter of fact, the tentage issued to a command is never so strictly limited. Objections to the conical tent are that it is very uncomfortable in hot weather, and that the part of the floor-space on which a full-grown man may walk erect is very limited.

The common or "A" tent is oblong, has a wall of 2 feet, is 6 feet 10 inches in height, and its floor-space is 57 square feet. Its capacity is only 250 square feet, and the ridiculously excessive number of six infantrymen or four mounted men is assigned to it by regulation. In a permanent camp, two men only can be perfectly comfortable in this tent, but they may be made exceedingly so, as there is ample space for their field cots and all their equipments.

The officers' wall-tent is very comfortable for two occupants, as it is much larger than the common tent, and is provided with a canvas fly or second roof, which protects perfectly from rain and makes the tent much cooler in hot weather.

The hospital tent is the largest and by far the most comfortable tent used in the army. It is a wall-tent with a fly, and it opens at both ends, so that several tents may be joined to make a ward for the sick. The tent is 14 by 15 feet floor-space, and 12 feet high, accommodating very comfortably six patients and their cots. Hospital tents, though intended only for the sick, have been sometimes issued to troops in more or less permanent camps in the tropics. When floored and framed, the occupants are as well off as when in barracks.

All tents should be properly ditched to prevent flooding from rain, and they should be frequently struck and exposed, inside out, to the sun-light. The ground covered also must be occasionally cleaned and sunned. Movable floors and frames for tents increase very much the comfort of camp life, and should always be constructed in camps of any permanence.

The interior of a tent is apt to become stuffy and damp, so that the walls should always be kept elevated in good weather during the daytime, allowing the greatest possible circulation of air.

When camps are to be occupied for many months, especially in winter, it is always advisable, on the score of economy as well as health and comfort, to shelter the soldiers in huts or cabins instead of tents. Huts may be constructed of logs plastered with mud, or roughly-dressed lumber lined and roofed with canvas. During the Spanish-American war, several large general hospitals on the pavilion plan were put up, for temporary use, of unpainted wood covered with tar-paper. There are in the market also several patterns of portable dwellings, which can be taken apart and shipped in packages of convenient size, portions of the floors and walls being used for the packing boxes. It is possible that for armies of occupation such movable houses may prove practicable and economical.

6.—SANITARY CARE OF CAMPS.

Sanitation in well-built posts is a simple matter enough, merely requiring that existing excellent conditions be maintained. In camp life the health of the troops depends on most minute attention being given to small things. Military discipline is at the bottom of good hygiene, and the custom of trained soldiers to keep every article in its place, and always ready for inspection, is a powerful factor towards preserving their health. All rubbish must be daily removed and burned. Kitchen garbage and fragments of food from the mess must be deposited in covered receptacles periodically emptied and cleaned. The ground around the tents is to be kept scrupulously clean, and to this end it is better that all shrubbery be cleared away, although shade-trees should not be harmed nor grass disturbed. Waste material must never be dumped near the camp; if not destroyed, it must be carried far away. The camp kitchens must be sheltered from rain, and the food screened from flies and dust. A pure water-supply having been obtained, the source, the receptacles, and the drinking vessels must be kept uncontaminated. The proper disposal of excreta in a large camp is a most important subject, and often presents many difficulties. The simplest method is to dig latrine pits for each organization, and cover the excreta therein, at frequent intervals, with some of the excavated earth; but most medical officers now condemn the use of the privy pit for any but marching commands, or camps of very short duration. Unless there is a constant watch kept, some excreta is always exposed long enough to attract swarms of flies, which afterward contaminate food in the kitchens and at the mess. The earth, unless perfectly dry, does not deodorize efficiently, and if the ground-water is high the pits cannot be made of sufficient depth. The use of quicklime in and around the pits is advocated, or, better still, they may be burned out every day with dry grass or leaves saturated with kerosene. A sanitary field latrine authorized by the War Department in 1899, and since used at many permanent camps, has proved so satisfactory that its use to the exclusion of any other would seem always advisable. The latrine consists of a trough made of stout galvanized iron 14 feet long, 22 inches wide at the top, parabolic in cross-section, and with a maximum depth of 18 inches. This is set in a wooden frame, used as a crate in transportation. One end of the trough is elevated 4 inches from the level. It is covered by a seat which may be easily lifted, and has places for seven men. The holes are cut away so that the seat cannot be soiled either in front or rear, and a slanting board arranged so that the men cannot stand on the seat. For use, the trough is filled with water to a depth of 6 inches at its lower, and 2 inches at its upper end, and one-sixth of a barrel of lime is mixed in daily. Toilet paper must be used, and the contents of the trough stirred vigorously with a paddle three times a day. No other care is necessary, as the apparatus is clean, odorless, and does not attract flies. A gutter to serve as a urinal, kept sprinkled with lime, is connected to the trough at its upper end. The latrine is covered with a rough wooden shed, the dimensions of which, even to the various boards comprising it, are specified in orders. To empty the trough, an odorless excavator is necessary: a large, tight, barrel-shaped tank on wheels, with a powerful suction-pump. One such excavator is enough for many latrines, and the troughs must be emptied daily. The mixture of milk-of-lime and fæcal matter is quite harmless and has considerable fertilizing value. In future no large stationary camp should be established in the United States without this method of excreta disposal, which is the cheapest and most effective yet devised. As there is always difficulty in compelling the soldiers to use the sinks for urination, especially at night, it is advisable to have galvanized iron cans for urine placed at intervals in the company street, sprinkled inside with lime, to be removed and cleaned in the morning; otherwise the ground near the tents will be contaminated with urine.

In camp sanitation the voluntary coöperation of the soldier can never be relied upon. Close inspection, with rigid enforcement of sanitary rules by commanding officers and medical officers is absolutely necessary.[2]

7.—CAMP DISEASES.

When the causes of disability and death in the military service are looked into, it is found that disease is a far greater factor in both, than wounds and injuries. In even the bloodiest wars the total number killed outright or dying from wounds never equals the number dying from sickness.

Under the name of "camp diseases" may be included all the maladies to which soldiers are especially liable in field-work or war. All of these exist in civil life, but the conditions of camp life are particularly favorable to their widespread prevalence.

Dysentery and Diarrhea.—Troops in campaign have always been especially subject to dysentery and diarrhea. In the civil war about one-fourth of all deaths in the army were from these two diseases. Even now, with the many advances made in medical knowledge, and especially in military hygiene, intestinal diseases rank first in the United States army as causes of disability and death. In 1902, for every 1000 men there were 290.61 admissions and 2.53 deaths from intestinal complaints. In actual war the rates greatly increase.

The causes of intestinal troubles in troops may be summed up as impure water, badly cooked food, exposure to wet and cold, and lowered vitality due to other diseases, such as malaria.

Among troops in the tropics the most serious disease of this nature is dysentery, due to the presence of an animal organism, the Ameba dysenteriæ, in the intestines. The disease is generally insidious in its approach and exceedingly difficult to cure. Not only has it caused the loss of many valuable lives in the service, but numbers of soldiers have been discharged for disability, as incurable, to live lives of semi-invalidism and probably to die finally of exhaustion, or from intercurrent attacks of diseases which the weakened bodies are unable to resist. Of dysentery and much of the diarrhea, impure

[2] The field latrine described in the text has fulfilled all that was expected of it, but since this chapter was written it has been largely superseded by the "McCall" incinerator, which received a thorough test at the camp of U. S. troops at the Jamestown Exposition. This device is a privy and incinerator combined. The fecal matter and urine are totally consumed by fire on the spot where they have been deposited, necessitating no handling and but little daily labor. The apparatus is in two sections, one of which is in use as a privy while the other acts as an incinerator. The process of incineration is achieved without any noxious gases being given off.

water is the principal and possibly the only cause, and in the Philippine Islands the one sanitary rule exceeding all others in importance, and most insisted upon, is the purification, by boiling or distillation, of all drinking water furnished to the troops.

It is practically impossible to prevent individual soldiers absent from camp or post, or during the march, from slaking their thirst at the nearest source, and, therefore, dysentery still claims its quota of victims annually. When to impure water are added bad food, unsanitary surroundings, and reduced vitality, a form of acute dysentery may, assuming epidemic proportions, sweep through the camps with the virulence of cholera. This variety is not amebic, but is due to the Bacillus dysenteriæ of Shiga and sometimes possibly to other bacterial organisms. In civil life it occurs in overcrowded prisons and asylums, causing great mortality. A very important feature in the prevention of dysentery and the more serious forms of diarrhea among troops is prompt attention to the treatment of every slight digestive trouble, both by proper diet and medicines, for it often happens that an attack of acute intestinal indigestion, with simple diarrhea, is the starting-point for chronic diarrhea or amebic dysentery. The use of a woolen abdominal band when sleeping in the field is to be recommended. In the intense heat of the tropics there is no need to undergo the discomfort of wearing the band in the daytime, but at night the abdomen may easily become chilled, and the flannel binder is both comfortable and useful as a preventive measure.

Malarial Fevers.—Next to intestinal diseases, malarial fevers and the resulting cachexia are accountable for the largest percentage of sickness in the United States army. Troops serving in the tropics suffer greatly from malaria, and when a command is once thoroughly poisoned with the malignant form of the disease it is practically destroyed, as far as its usefulness in war is concerned.

In the Spanish-American war the Fifth Corps, nearly all regulars and the flower of the army, was, as a result of the operations in front of Santigo de Cuba, so affected with pernicious malaria that nearly all officers and enlisted men returned to the United States complete physical wrecks, necessitating either long furloughs or discharges for disability.

The discovery of recent years, that malarial fevers are caused by several varieties of animal parasites in the blood and are conveyed from man to man by the bite of certain infected mosquitoes of the family Anopheles, has led to methods of prevention founded upon positive knowledge, instead of the former vague ideas of infection as due to noxious emanations from swamps, exposure to the night air, etc.

In countries where malaria is prevalent, troops must be protected as far as practicable from the attacks of mosquitoes, by the use of screens and netting. Swampy and low-lying camps are avoided when possible, not on account of any toxic properties in marsh air, but on account of the well-known prevalence of mosquitoes in such places. In tropical countries inhabited by more or less uncivilized races, a safe distance should always be allowed between the camp and the native village. The inhabitants are sure to be more or less infected with a chronic form of malaria. They have, it is true, acquired a certain tolerance of the disease, and as they are not usually very sensitive to the annoyance of bites of insects, they never use screens.

The mosquitoes infesting their huts are exceedingly apt to harbor the malarial parasites, and a single night's camp made in a native village by a party of white men, unprotected by mosquito-bars, is often followed by an outbreak of fever. It is generally thought that a half mile is a safe distance to allow between the village and the camp. At military posts, cantonments, or permanent camps, a general war of extermination should also be waged against the insects. As the eggs of mosquitoes are deposited in standing water and the larvæ live therein, all swamps, ponds, and puddles should be drained, or, when this is impracticable, the surface of the water should be kept covered with a thin film of petroleum, renewed about every two weeks. Wells, cisterns, and receptacles for drinking-water must be covered with wire screens. The fertility of the female mosquito is so great that thousands of the insects may be developed in cast-off tin cans, broken pots and bottles, which have collected rain-water and which are so universally found on badly-kept premises. Such rubbish must, therefore, not be permitted.

Malaria can undoubtedly be banished from a community when each householder is held responsible for the maintenance of conditions unfavorable to the growth of mosquitoes on his premises.

Sometimes, as in many places in the Philippines, mosquito-destruction on a large scale is entirely impracticable, the submerged rice-fields and thick jungles presenting too many breeding places for the insects. For instance, in palm-trees, at the junction of each great leaf with the stem there is a hollow space generally containing several quarts of water, each of which spaces may be the breeding-place of myriads of mosquitoes. Under such conditions, of course, preventive measures must largely consist in protection of the individual, rather than in insect-destruction. Malarial fevers are diminishing rapidly in the United States army as a result of our present clear understanding of cause and effect.

Yellow Fever.—The demonstration of the fact that yellow fever is also transmitted by mosquitoes, of the family Stegomyia, has taken it from the list of diseases which are to be much feared by armies in the future.

The as yet unknown infective agent is in the blood of patients only during the first three days of the attack, and a mosquito ingesting the blood of a patient during this time does not transmit the disease until about twelve days have elapsed. Yellow fever has never been much of a camp disease, but troops occupying cities on the seacoast in countries where it prevails have sometimes suffered terribly.

The disease has been entirely eliminated in Cuba by screening the patients during their short infective period, and by destroying the mosquitoes in the infected house and those near by. There is hardly a doubt but that a little concerted effort on the same lines in the few places where yellow fever now exists will cause the complete extinction of this disease in its endemic centers.

Typhoid Fever.—This is always a serious and unfortunately a most common disease of camps. Pollution of the drinking-water supply by the excreta of typhoid patients is usually assigned as the cause. While epidemics occurring in villages and cities are perhaps generally with reason traced to an impure water-supply, it is very likely that the typhoid fever of camps is transmitted from man to man in a much more direct way. During the Spanish-American war, the camps of volunteer soldiers in the United States were swept by this disease, although in many instances the water-supply was beyond suspicion of contamination. It being taken for granted as a fact that several hundred men can hardly be collected into a camp, anywhere in the United States, without at least one case of typhoid fever existing among them on arrival, the conditions of camp life will account for the spread of the disease. Unless the fæcal discharges of all men are at once disinfected or removed, flies may carry infection from excrement in the sinks to food in the kitchens. Soil-pollution in and around tents from unrecognized cases of typhoid fever, and contamination by the sick of clothing, towels, utensils, etc., may in many different ways transmit the germ of the disease to other soldiers. The board of medical officers who studied the typhoid fever in the volunteer camps of 1898 traced, in many companies and regiments, the gradual progress of the disease from tent to tent, and from man to man. Preventive measures against typhoid fever in camps should then include not only furnishing the troops with pure water, but also the immediate destruction or disinfection of all excreta, rigid protection of the soil from contamination, and careful personal hygiene.

Cholera.—The precautions against typhoid fever apply also to Asiatic cholera. During the recent severe epidemic in the Philippine Islands, some garrisons were entirely free from cholera, although natives were dying by hundreds in the immediate neighborhood. It is hardly too much to say that nearly every case of cholera among the troops could be traced to a violation of the hygienic ru'es prepared for the soldier's guidance. Sterilization of drinking-water and the avoidance of native food and beverages, especially fruits and green vegetables eaten uncooked, were the leading measures taken.

Phthisis.—Phthisis is now a rare disease in armies, as cases are promptly removed from barracks as soon as recognized, and in the United States army are sent to a special hospital at Fort Bayard, New Mexico. Opportunities for infecting others are thus avoided, and the patients given an excellent chance for recovery by suitable open-air treatment in a good climate.

Typhus fever and **scurvy** have not for years figured in the list of camp diseases. In the light of modern hygienic knowledge it is not likely that they will again exist to any extent.

Venereal Diseases.—The most discouraging feature of the sick report of armies is the great prevalence of venereal disease. Especially in service when troops come into contact with a savage or half-civilized race is the large ratio of non-effectiveness from this cause particularly noticeable. In places under martial law, regulation of prostitution, with frequent inspection of the women, periodical examination of the soldiers, and prompt segregation of all infected persons, will reduce venereal disease to very low limits. In times of peace, and under civil law, regulation of prostitution does not carry out all the claims of its advocates. It never reaches clandestine vice, and may even have a tendency to encourage it. Public opinion among English-speaking people is so entirely antagonistic to the regulation and licensing of prostitution, that it is quite hopeless to advocate it, even were it proved to be much more effective than the experience of foreign nations seems to indicate.

Frequent inspections of the soldiers and prompt treatment in hospital, together with suitable instructions to recruits as to the dangers of venereal disease, are never to be neglected, although it must be confessed these are sadly inadequate means of prevention.

QUESTIONS TO CHAPTER X.

MILITARY AND CAMP HYGIENE.

What subjects may be considered under this head? Why should an army be composed of sound and healthy individuals? Who should be excluded from an army or body of troops? What is the lowest age at which recruits should be enlisted? What the highest age? What should be the minimum measurements of the recruit? Who should make the physical examination of the latter?

What can be said for the present army ration of the United States? What besides insufficient quantity and variety of food may cause digestive disturbances and innutrition in camp?

What part of the United States soldier's clothing at present is most apt to cause physical discomfort? What change might be made to advantage in the manner of carrying the extra clothing? How is it now carried?

What usually constitutes the dwelling of the soldier? What is a military barrack, and what is its general plan? What is to be said about the location of barrack lavatories, kitchens, and dining-rooms, sinks, and latrines? On what kind of soil should barracks be located?

What sort of tents are used in the army? What are the advantages of the simple shelter tent? What may take the place of tents in winter? What is of the first importance in all camps, and what is necessary to secure this?

In actual war what relation do the deaths from disease bear to those from injuries received in battle? What are the most fatal diseases of camp life? What are the causes leading to this fact? What other class of diseases is especially apt to be frequent among soldiers? What effect has the malarial poison on those sick with other diseases? What would lessen the prevalence of malarial fevers in camp-life? How may typhoid fever be propagated in camps and garrisons? What respiratory diseases are common in camps, and to what are they due? What two diseases, formerly common in camp-life, are now rare? What contagious diseases are especially associated with the soldier? By what means may their spread be restricted?

CHAPTER XI.

MARINE HYGIENE.

Marine Hygiene may be briefly defined as being a specially developed branch of General Hygiene. While the ultimate aims of both are identical, marine hygiene differs from land hygiene in that it presents for our study and investigation a series of peculiar environmental conditions, under the influences of which the individual members or communities of the sea-faring class are obliged to live and which are quite distinct from those which would surround the same individuals or communities if they were living on land. The marine sanitarían, therefore, stands between the sea-faring man on the one hand, and his peculiar and quite artificial environments on the other, endeavoring to maintain and promote the health, comfort, and happiness of the former by preventing or modifying, as far as it may be within his knowledge and power, the injurious influences of the latter.

In the United States and in several of the European monarchies a distinction is made between *marine* and *naval* hygiene. This distinction always appeared to be more apparent than real, until, within recent years, the modern battleship and cruiser were evolved and appeared on the scene. Since then there can no longer be any doubt about the fact that there is indeed a wide difference between the influences upon human life of the conditions prevailing on these ships as contrasted with those existing on merchant ships. This difference is indeed so great that it deserves the special attention and study of the hygienist, and will continue to receive them in the future. Within the limited space of this article only those conditions will be discussed that prevail on both classes of ships alike.

HISTORICAL.

The seaman, as regards his original composition, his character and instincts, as well as other human traits, may safely be said to have differed at no time from any other individual average member of the human family. The descriptions with regard to his life and character that we read about in history are indicative more of what can become of any normally constituted human being under the educational influences either of a life of romance and adventure, or of degraded conditions and inhuman treatment, or both these combined, than they are of any more essential difference in the original make-up of the man. He is, in other words, like any other man, more or less the result of the life he leads.

In former times, when away on long voyages in sailing ships, away for long periods of time from home and friends, the seaman was often at the mercy of inhuman and cruel masters, who exacted excessive work in return for insufficient food, scanty clothing, poor lodging, abuse, and neglect when sick or disabled. The history of those early days abundantly shows how little attention, especially, was paid to sanitary matters; in fact, how little was known with regard to such matters. No records of ships' sanitation were kept. Some of the earliest recorded accounts of the medical treatment directed against the diseases peculiar to ships we find in a book published in 1693 by a Dutch surgeon named Verbrügge, while Vrolingh adds a brief description of the provisions that were supplied to the men at those times and of the scurvy that they suffered from.

The more important works on marine hygiene, in the beginning of the last century, were those of Lind, Rouppe, Duhamel de Monceau, Poissonier-Deperrières, Smollet, Blane, Clark, and Meunier. About the middle of the last century the works of Forget, Fonssagrives, Macdonald, Wilson, Turner, and Gihon came into prominence, and towards the end of the nineteenth century the quite advanced works of Richard et Bodet and of Dr. Arthur Plumert appeared.[1]

Instead of regular sanitary records, kept by medical officers, we will have to depend upon the fragmentary accounts in ships' logs, kept by masters of vessels, for the very earliest records we possess with regard to sanitary matters on ship-board. According to these, the ravages of disease, at times, must have been positively appalling. Thus, for example, Admiral Anson, in 1741, reports the loss, within a few weeks, of 200 men by scurvy alone out of a complement of 600 men; he landed on Juan Fernandez with but 8 men able to do duty. Geary, in 1779, is said to have had at one time in his squadron 2400 cases of scurvy; and Rodney, in 1780, once lost from 50 to 55 men of the same disease weekly, out of a complement of men numbering only 2000.

Ships' fevers were of the more frequent occurrence according to

[1] Also the following works on Naval Hygiene: Nocht, "Schiffshygiene," Berlin, 1905; Belli, "Igiene Navale," Rome, 1905; Couteaud et Girard, "L'Hygiène dans la marine de guerre moderne," Paris, 1905; "Jan et Planté Hygiène navale," in Brouardel et Mosny's "Traité d'Hygiène," 1907.

reports. Under this head were summed up what we would now distinguish as typhus, typhoid, malarial, and other fevers. Thus, Lind, among others, says of a French fleet of vessels which, in 1757, was on its way from Louisburg to Brest: "This fleet was engaged in transporting 1000 convalescents from the various hospital tents at Louisburg to Brest. After the sixth day out most every one of these had died." Blane, while fleet-surgeon of 40 line-of-battle ships, with 21,608 men, cruising in the West Indies between 1780-1783, reports the loss of 3200 men from disease and but 1148 men from the enemy's guns, and he attributes this enormous death-rate to bad quarters, overcrowding, insufficient ventilation, poor food, and bad drinking-water combined. Many of the men, especially those who were obliged to work below, actually died from suffocation.

In the "Souvenirs d' un Admiral," Jurien de la Gravières, the following note by Admiral Latouche was found: "The ships of his squadron arrived at the 'Station du Nord' in the following condition: The *Cornette*, with a complement of 400 men, had thrown 37 overboard and sent 122 to the hospital; the *Nécessaire,* out of a complement of 80 men, had thrown 13 overboard and sent 21 to the hospital; the *Theobald* had thrown 136 into the sea and landed 129 in the hospitals, arriving with only 35 men in all in port."

It is said that the men on these ships were crowded together so closely that there was scarcely as much breathing space for them as is generally allowed a man in his coffin. There was no provision whatever made for ventilation, much less for lighting. The decks below were both foul and dark, so that the human breath was believed to be fatal. Often the berth-decks were used for live-stock for fresh meat, and most of the men and all the sick were usually kept on this deck. The men, as a rule, were provided with but one suit of clothes, and this was worn until it literally dropped off their bodies. The only means they had of washing their clothes was to tow them alongside the ship in the sea-water while under way. The hammocks, we are told, were never taken off their hooks, neither were they scrubbed or aired, and one hammock often had to serve for the berthing of two men; and these conditions prevailed on some of the station-ships down to 1856. The care of their persons was left entirely to the men themselves, the officers deeming it beneath their dignity to bother themselves about such details. No drills of a systematic order were performed, and punishment for the slightest infraction against the prevailing and mostly cruel regulations was usually prompt and of the most brutal nature.

In spite of the shining example of Captain Cook, who, during his three-years' cruise, between 1772-1775, lost but one man of his crew, through a wise application of the simplest laws of health and humane treatment of his men, his experiences and the lessons it should have left behind went almost entirely unheeded. This, more than anything else, shows that nothing short of the strictest laws and regulations can ever be depended upon to improve the sanitary conditions of the seaman, his life and surroundings. To see that these are enforced and carried out is the duty of the ship's sanitarian.

Finally, the following anecdote, which is recorded as a part of the history of those days, may be cited, as illustrating the indifference to sanitary matters of the then class of masters of vessels who held undisputed sway. The story is told of an English admiral who was asked to stop his ship for the purpose of picking up the second surgeon, who had just fallen overboard. The admiral positively refused to pick the man up, saying that it was only the question of a useless man on board, anyway.

MORBIDITY AND MORTALITY OCCURRING IN SEAFARING PEOPLE.

Although it must, perhaps, be admitted that the encouraging results obtained in recent years with regard to a decrease in morbidity and mortality rates among seafaring people, and which we find repeatedly recorded in these days, are in great part directly traceable to the improvements made in ships' construction, yet it must, I think, be likewise granted that, were it not for the great advances that have been made, more or less simultaneously, in scientific hygiene, the above-mentioned favorable results could not have been attained. Experience, both past and present, has repeatedly shown that without constant vigilance shown in the administration of hygienic laws, without constant sanitary supervision of the men on board ships, we would repeat the sad experiences of the past, in less time than it would take to tell it, in spite of iron ships that are run by steam instead of sail. The fact that scurvy and other diseases did not come from the wood of which the old ships were built, was clearly shown during the three-years' cruise of Captain Cook (1772-75), and the other fact that these same diseases are ready to recur on board any of the modern iron ships when allowed to lapse under the same unsanitary conditions as used to prevail in the old wooden ships a hundred years ago, are likewise well established by the reports of scurvy and other filth-diseases, known to occur up to the present day. To the improvements made in ships' construction we must, therefore, add those made in experimental hygiene and sanitary supervision.

Better food, better water, more suitable wearing apparel, more light below decks, and, above all, more and a better quality of air, these are the direct results of the work done by hygienists and which the seafaring people never again will do without on board their ships. But, notwithstanding these improvements in both ships' construction and hygienic living, there is still enough left to show that the life of the seaman, with regard to his home, his clothing, his food, the climatic influences to which he is exposed, his social comforts and enjoyments, are different from those of the rest of mankind. All these more or less abnormal conditions of life must still lead to certain diseases other than filth-diseases, that will ever be peculiar to the seafaring class and the causes of which we must find out and try to eliminate.

The lines along which we must proceed with our work will become clear to us from a study of the morbidity and mortality rates. These statistics will give us the first needed information. They will show us not only the nature, but also the extent, of the inroads which disease is making into the seafaring population, as well as the influence which sanitary regulations have had from time to time upon their course. Notwithstanding the fact that Captain Cook, during his long cruise of three years, lost but one man from his crew, by wisely following out the laws of hygienic living on board his ship, his brilliant example did not produce the widespread influence that it should, and was, apparently, only reluctantly followed. Among the autocratic masters of the seas of those times, precepts were without influence; regulations of the strictest order alone produced any effect.

According to Blane, the annual mortality in the English fleet in 1780 was 12.5 per cent.; in 1811 it had gone down to 4 per cent., and, during the period from 1830-64, it had dwindled down to 1.3 per cent. This astounding diminution of the mortality rate of the English fleet is directly traced to a sanitary regulation which was issued by the Admiralty in 1791, revised and improved in 1797. This means an immense saving of human lives.

Very valuable statistical tables have been worked out for us by Friedel, quoted by Kulenkampf. According to these authors, the morbidity and mortality of the English fleet, during the years 1830 to 1864, were as follows: The mean annual strength of the fleet, calculated for the entire period of 34 years, was 35,269 men, among whom occurred, on the average, 121.2 per cent. cases of sickness; 2.69

per cent. of which resulted in being invalided from the service and 1.33 per cent. died. The influence upon morbidity and mortality of the different stations is well shown in the following table:—

TABLE XXXIV.

Stations.	Number of Sick.	Died.	Daily Number of Sick.
1. East Indies and China	178.8%	3.13%	8.88%
2. West Africa	158.0%	3.39%	6.58%
3. West Indies and America	142.2%	2.0%	5.83%
4. Mail Service	82.3%		
5. Home Stations	89.3%	0.74%	4 8%
6. Australia		0.45%	4.38%

The relative percentage distribution among the more important diseases may be seen in table XXXV:—

TABLE XXXV.

Diseases.	Per Cent. of Mean Strength.	Diseases.	Per Cent. of Mean Strength.
Phlegmonous inflammations	23.3	Variola	0.15
Catarrhs	19.3	Erysipelas	0.47
Fevers (typhoid and malarial)	10.9	Tuberculosis	0 6
Diarrheas	10.3	Pneumonia and pleuritis	1.7
Rheumatism	7.8	Delirium potator	0.28
Dysentery	1.8	Scurvy	0.1
Cholera	0.12		

In order to show the progress in sanitation made since that time, it will perhaps suffice to quote some figures from the more recent report of the Surgeon General of the United States Navy on the present state of the

Health of the Navy and Marine Corps of the United States:— During the year 1902, the average strength of the active list of the Navy was 31,240. The total number of admissions to the sick-list, for all causes, during the year 1902, was 22,645, or 76.8 per cent. There were 18,882 admissions for disease and 3,763 for injuries. The daily average of patients was 3.5 per cent. of mean strength. The total number of sick days was 374,466, or an average of 12.05 sick days for each man in the Navy and Marine Corps, with an average duration of 16.53 days' treatment for each case.

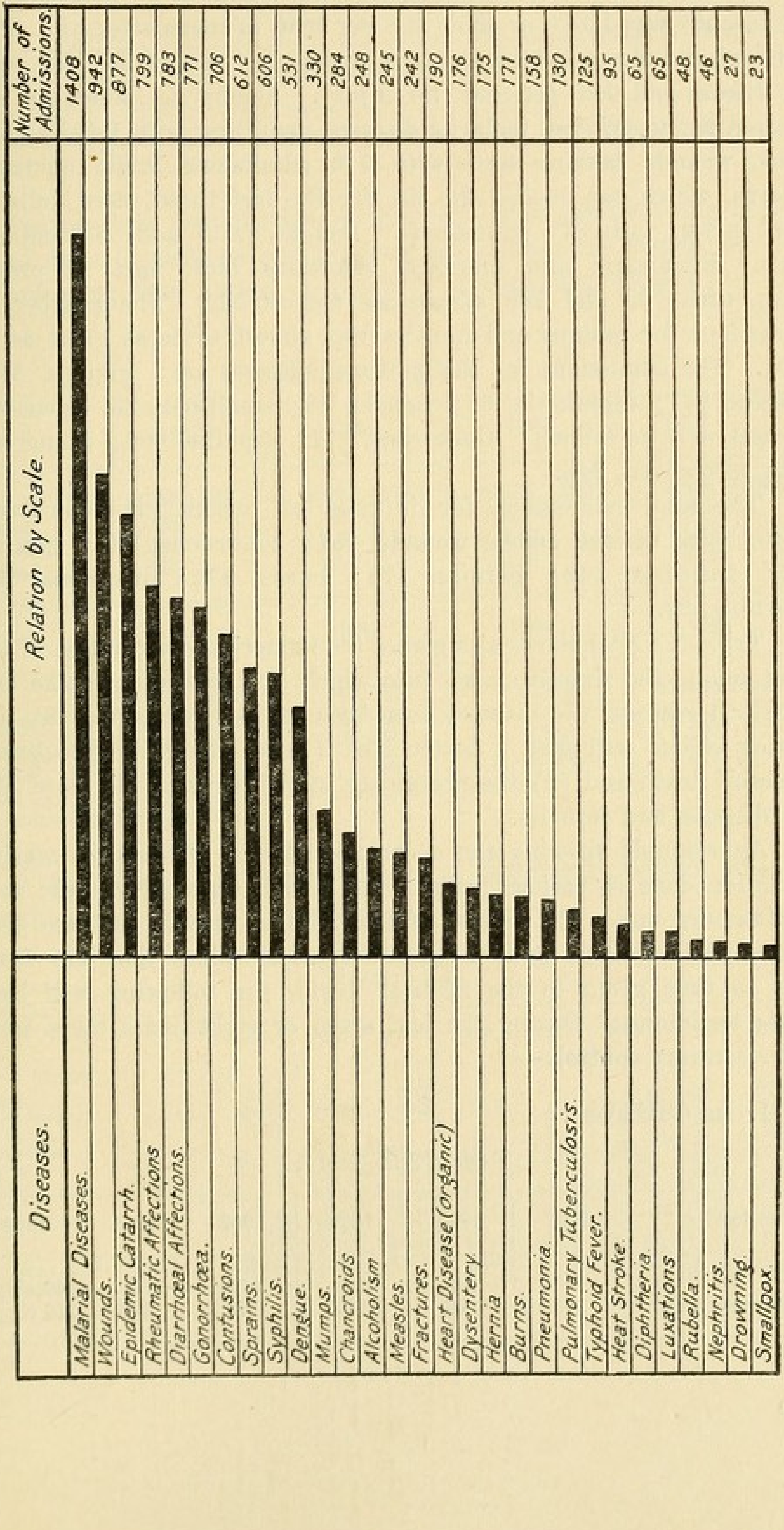
TABLE XXXVI.

Classification of Diseases	Remaining from Last Year	Admitted	Readmitted	Discharged to Duty	Invalided: To Hospital	Invalided: From Service	Invalided: On Leave	Invalided: To Govmt. Hospital for Insane	Deserted	Died	Continued to Next Year	Total Number of Sick Days
CLASS I. Parasites and parasitic diseases	3	270	17	127	159	1	....	....	....	....	3	718
CLASS II. General infectious diseases (nonvenereal)	62	2,769	371	2,433	672	16	2	....	....	15	64	21,345
CLASS III. Constitutional disorders of nutrition	1	46	17	26	31	5	....	....	....	....	2	566
CLASS IV. Diseases of the nervous system	23	1,039	121	914	210	41	1	2	....	2	21	7,288
CLASS V. Diseases of the visual apparatus	8	254	33	184	82	18	2	....	1	....	8	2,447
CLASS VI. Diseases of the auditory apparatus	3	164	12	108	58	8	1	....	....	1	3	939
CLASS VII. Diseases of the olfactory apparatus	....	47	.....	41	5	....	....	....	....	....	1	134
CLASS VIII. Diseases of the nutritive apparatus: Subsidiary class 1—Diseases of the digestive apparatus	22	2,664	143	2,466	287	10	2	....	....	4	60	12,453
Subsidiary class 2—Diseases of the circulatory apparatus	5	219	40	134	109	30	....	....	....	3	8	3,004
Subsidiary class 3—Diseases of the respiratory apparatus	24	1,089	54	913	196	1	....	....	....	2	25	7,009
CLASS IX. Diseases of the motory apparatus	4	461	56	403	102	6	1	....	1	....	8	3,635
CLASS X. Diseases of the cutaneous apparatus	25	1,348	78	1,297	114	4	....	....	1	....	35	11,823
CLASS XI. Venereal diseases and diseases of the genito-urinary apparatus	71	2,522	294	2,043	735	27	....	....	2	....	80	26,261
CLASS XII. Cysts and new growths	2	43	3	31	15	2	....	....	....	....	....	389
CLASS XIII. Injuries	54	2,364	109	2,120	236	24	....	....	....	33	84	21,612
CLASS XIV. Extraneous bodies	....	12	.....	12	....	....	....	....	....	....	....	47
CLASS XV. Poisons	5	339	17	329	19	3	....	....	....	5	5	1,378
CLASS XVI. Feigned diseases	....	4	.....	3	1	....	....	....	....	....	....	20
Total	312	15,674	1,373	13,614	3,061	196	9	2	5	65	407	121,068

Chart I.

Causes of Death.	Relation by Scale.	No. of Deaths.
Drowning.		27
Pneumonia		15
Typhoid Fever.		14
Wounds.		14
Pulmonary Tuberculosis.		13
Starvation		12
Bright's Disease		9
Fracture.		9
Valvular Heart Disease.		8
Alcoholism		8
Cholera.		6
Poisons.		6
Bronchitis, Chronic.		4
Dysentery, Acute.		4
Remittent Fever.		4
Appendicitis.		3
Endocarditis.		3
Smallpox.		3
Burns.		2
Cancer.		2
Cholera Morbus.		2
Concussion.		2
Contusion		2
Miliary Tuberculosis.		2
Diphtheria.		2
Yellow Fever.		2
Hæmorrhage (Stomach)		2
Intestinal Obstruction.		2
Peritonitis.		2
Abscess of Liver.		2
Abscess.		1
Angina Pectoris.		1
Apoplexy.		1
Asthma.		1
Intestinal Catarrh.		1
Dilation of Heart.		1
Dengue Fever.		1
Diabetes.		1
Dysentery, Chronic.		1
Heart Failure, Simple.		1
Intermittent Fever.		1
Thermic Fever.		1
Gastro-Enteritis.		1
Meningitis.		1
Myocarditis.		1
Œdema of Lungs.		1
Middle Ear Disease.		1
Paralysis.		1
Pleurisy.		1
Pyæmia		1
Septicæmia.		1
Tuberculosis.		1
Ulcer of Stomach.		1
Rupture of Abdominal Organs.		1
Paralytic Dementia.		1

CHART II.


Diseases.
Relation by Scale.
Number of Admissions.
Malarial Diseases. 1408
Wounds. 942
Epidemic Catarrh. 877
Rheumatic Affections 799
Diarrhœal Affections. 783
Gonorrhœa. 771
Contusions. 706
Sprains. 612
Syphilis. 606
Dengue. 531
Mumps. 330
Chancroids 284
Alcoholism 248
Measles. 245
Fractures. 242
Heart Disease (organic) 190
Dysentery 176
Hernia 175
Burns. 171
Pneumonia. 158
Pulmonary Tuberculosis. 130
Typhoid Fever. 125
Heat Stroke. 95
Diphtheria. 65
Luxations 65
Rubella. 48
Nephritis. 46
Drowning. 27
Smallpox. 23

The number of persons invalided from the service (including retirements of officers for disabilities and transfers to hospitals for the insane) was 1,144, or about 3.8 per cent. of mean strength. Two hundred and eleven deaths occurred during the year, or 0.41 per cent. for disease and 0.26 per cent. for injury. Among the causes for admission to the sick-list, malarial diseases stand first with 1,408 admissions, wounds ranking next with 942 admissions, while epidemic catarrh, which has headed the list for the last three years, falls to third place, with 877 admissions. Dengue fever adds 531 admissions. Rheumatic and diarrheal affections rank next in prevalence, with 799 and 783 admissions respectively. The number of admissions for mumps and measles was almost twice as great as in 1901. The admissions for the epidemic diseases are: mumps, 330; measles, 245; diphtheria, 65; rubella, 48; small-pox, 23. Venereal diseases were as follows: Gonorrhea, 771; syphilis, 606; chancroid, 284; alcoholism, 248.

The total admissions for injuries of various character were 2,940, being divided among wounds, 952; contusions, 706; sprains, 612; fractures, 242; hernias, 175; burns, 171; luxations, 65; drowning, 27.

Table XXXVI shows at a glance the numerical distribution of the cases among the sixteen classes into which, for convenience sake and statistical reasons, the diseases have been divided, while the two adjoining charts will give a better idea (1) of the more prominent causes of death and (2) the prevalence in the Navy of the more special diseases and injuries.

An example showing the enormous amount of work in marine sanitation done in various ports of the world, especially in the port of Hamburg under Dr. Nocht, of the detailed records that are kept and of the excellent and valuable statistical tables that are from time to time given to the medical world, the following will bear ample testimony: During the last seven or eight years there were under sanitary control:—

I. In Cuxhaven:

TABLE XXXVII.

1896	1897	1898	1899	1900	1901	1902
78	116	148	229	579	665	846 ships.
Disinfected were . .	105	97	130	172	126	116 ships.

II. In Hamburg:

TABLE XXXVIII.

1895	1896	1897	1898	1899	1900	1901	1902
19,359	16,375	15,458	13,218	14,099	14,430	17,708	19,302 ships

During these examinations it was noted that the following numbers of cases of sickness had occurred on board these vessels on the trip preceding their arrival in the port of Hamburg, namely:—

TABLE XXXIX.

	1895	1896	1897	1898
	2,763 (143)	3,923 (144)	3,197 (122)	7,624 (105)
Internal....	2,038	1,867	2,355	2.379
External....	294	1,599	417	4,939
Venereal....	431	357	425	306
	1899	**1900**	**1901**	**1902**
	9,805 (173)	10,789	14,365	15,163 cases
Internal....	3,554	4,818	6,087	5,513 "
External....	5,932	5,631	7,221	8,260 "
Venereal....	319	340	1,057	1,390 "

Brackets ( ) mean deaths.

Their distribution among the most important diseases was as follows:—

TABLE XL.

	1895	1896	1897	1898	1899	1900	1901	1902
Cholera	5 (4)	1	2 (2)	....	....	....	....	14 (7)
Yellow fever	40 (24)	48 (26)	6 (5)	2 (2)	1	10 (8)	2	5 (4)
Variola	6 (2)	3	1	....	3	1	1	3
Diphtheria	....	1	1	1	1	1	4	4 (1)
Malaria	635 (5)	961 (12)	867 (20)	584 (3)	517 (27)	404 (21)	591 (14)	593 (2[illegible])
Typhoid	7 (2)	10 (3)	3 (2)	7 (1)	5	6 (1)	33 (1)	17 (6)
Dysentery	10	33 (5)	23 (4)	12 (1)	13 (2)	10 (1)	25 (2)	22
Consumption	25 (10)	9 (3)	20 (2)	11 (3)	8 (5)	13 (8)	20 (6)	11 (2)
Scurvy	37 (2)	76 (11)	12 (1)	1	5	12	35 (4)	22
Beri-beri	5 (3)	17 (5)	2[illegible] (7)	12 (4)	39 (19)	11 (8)	14 (8)	45 (3)
Heat and heat-stroke	83 (9)	54 (10)	27 (7)	69 (15)	27 (2)	86 (19)	63 (3)	....
Heart disease	....	....	....	15 (3)	23 (8)	23 (7)	28 (5)	42 (21)

During the last three years the number of cases of sickness occurring among passengers on 138 steamers that came into the port of Hamburg was 3450. Two hundred and thirty-nine of these ended fatally and 1380 were infectious diseases: measles, scarlatina, rubeola, diphtheria, variola, etc.

On one ship two cases of plague occurred. Relatively numerous are said to be abortions and uterine hæmorrhages, caused by seasickness. On board these same steamers 4802 seamen received medical treatment; among these 389 cases were infectious diseases, with 25 deaths. The annual average number of sick seamen, derived from the records of the last eight years, as arriving in the port of Hamburg, is 2343, being distributed, likewise by annual averages, as follows: Internal diseases, 1047; external diseases, 795; venereal diseases, 553. According to the calculations of Dr. Nocht, every physician employed on these steamers, during a forty-days' trip, had under treatment, on the average, ten serious cases of sickness.

Casualties and Disabilities Due to Shipwreck.—The total loss in vessels caused by shipwreck, during a period of ten years, amounted on an average, (1) in the English merchant marine, to 2.43 per cent.; (2) in the French merchant marine, to 2.36 per cent.; and (3) in the German merchant marine, to 1.86 per cent. In the German service the total loss of human life due to these accidents was 0.53 per cent. of the crews. The Seaman's Insurance Bureau at Hamburg, in its annual report for 1893, gives the following valuable information with regard to these casualties:—

TABLE XLI.

Accidents Reported.

Vessels	Number of Men	Number of Accidents	Accidents per 1000	Deaths per 1000
Steamers	24,636	1,423	57.76	6.09
Sailing vessels	15,595	636	40.79	21.74
Employed	1,277	5	3.92	

The Seaman's Insurance Bureau, in 1892, had on its books 43,023 insured seamen and paid insurance to 1668 persons. Out of this number the disability incurred by 1571 persons proved to be but temporary and lasted less than 13 weeks; of the remaining 97, 8 remained permanently disabled and the rest died. The total number of registered sea-going vessels at the time was 2742 sailing ships, manned by 17,522 men, and 986 steamers, manned by 24,113 men.

TABLE XLII.

Accidents Occurred as follows:

Year	Number of Ships	Number of Men	Died	Number of Passengers	Died
1889	116	1,015	208	331	274
1890	92	937	169	174	7
1891	116	1205	177	160	30

THE DRAINAGE OF SHIPS.

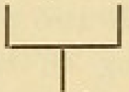
We say of a city or town that it is drained either according to the combined or the separate system, in accordance as to whether all the offal is discharged combinedly through one set of pipes, or whether the rain and the washwater are made to flow through a pipe system separate from this. In keeping with this nomenclature we may say of a ship that it is drained in accordance with the principles of the separate system. For, although the methods of ships' drainage are perhaps more complicated than are those of cities and towns, they, naturally, may be divided into two principal methods:—

1. The sea-water coming on board, the rain-water, the wash-water, the water circulating in the pipes of the flushing system, after passing through the various closets, the refuse from the kitchen, the ashes from the furnaces, are all made to pass overboard in the most direct ways.

2. The refuse matters from the engine- and boiler- rooms, those from the various magazines and storerooms, the rain-, sea-, and wash-water from the lower decks, all these find their way into the lowest and most dependent compartments of the ship by gravity, finally collecting in what is known as the bilge-room. Thence the combined mixture, known as bilge-water, is pumped overboard by powerful stationary suction-pumps. These suction-pumps generally terminate, with their open mouths looking downward, within a few inches from the bottom of the ship, being protected by wire gauze baskets to keep out solid matters. Their arrangement, while simple enough in a wooden ship, or even an iron merchant-ship, in a fully equipped modern battleship, the number of pipes of all sizes, their many valves and cross connections, are positively bewildering, and none but an expert can be entrusted with the laying out of a complete system in perfect and absolutely reliable working order. The drains are usually divided into main, auxiliary, and secondary drains, according to size. The large fifteen-inch main drain on a big battleship is only used to

pump out very large quantities of water in case the ship's bottom is punctured; while the auxiliary drains are employed in pumping out the accumulated bilge-water at regular intervals, and the secondary drains connect with the smaller local accumulations.

The pumping and drainage system below the protective or watertight deck of a modern man-of-war may be said to be divided into three parts, viz: emergency, surface, and double-bottom drainage. Each part is provided with separate and distinct piping, working independently, if desired, yet so interconnected with the others by means of valves that they all may be made to work in unison.

The main drain (see Fig. 33) may be styled the emergency part, and consists of a pipe, ranging in size from 5½ inches to 15½ inches, according to the size and type of the ship, and extending from the after part of the forward fire-room to the after part of the after engine-room; its flanges are made water-tight on every main watertight bulkhead it is made to pierce. The main drain generally runs on one, usually that side of the vessel where the center line longitudinal watertight bulkhead is fitted, throughout the length of the boiler compartments, branching  shape just aft of the forward bulkhead of the engine space, a branch being carried into each engine-room and connected to the main centrifugal pump in each of these compartments. In each compartment traversed by the main drain is a suction valve, the full diameter of the pipe, operated at the valve and also by means of a rod from the deck above. Branches from this main drain are led through the center-line bulkhead and fitted with valves at the end, so that all of the main machinery compartments are connected directly to this large emergency drainage pipe.

Each steam-pump throughout the machinery space, which in any manner is connected with drainage, has a suction connection with the main drain, so that one pump or all pumps may be made to work on this pipe whenever required to do so. The main drain is used only in case of an emergency, that is, when the water in any compartment is found to be rising above the floor-plates and cannot be controlled by the other drainage connections. Such an emergency would arise only on account of a vessel striking rocks or taking ground, thus injuring the inner bottom and causing a leak of great magnitude, or by a torpedo striking below the water line and injuring one or more watertight subdivisions.

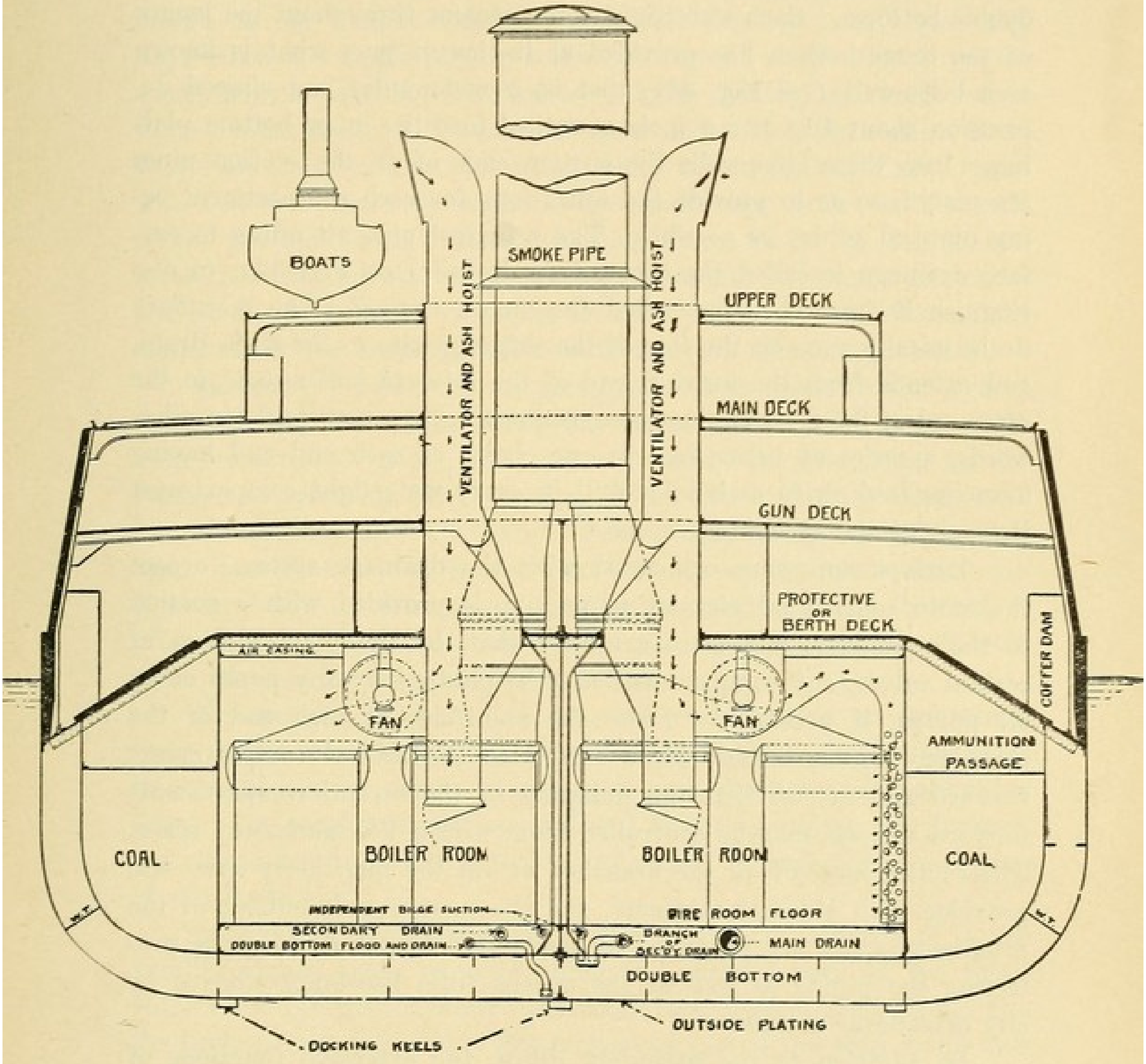


Fig. 33.—Cross-section of Ship, Showing Arrangement of Drainage System.

By *surface drainage* is meant the drainage of all water that collects on top of the inner bottom in engine- and boiler- rooms, in store-rooms or other places throughout the whole length of the ship, not in double bottoms. Each watertight compartment throughout the length of the inner bottom has provided at its lowest part what is known as a bilge-well (see Fig. 33), that is, a rectangular, cup-shaped depression about 10 x 18 x 6 inches, worked into the inner bottom plating. Into these bilge-wells the suction ends of all the suction pipes are placed, so as to provide the conditions for each compartment being pumped as dry as possible. The principal pipe attending to surface drainage is called the "secondary drain" (see Fig. 33), to distinguish it from the pipe called the "main drain." The secondary drain usually runs on the side of the ship opposite to the main drain, and extends from the forward end of the forward boiler-room to the after end of the after engine-room, connecting to a manifold (in other words, a series of valves cast in one chest) at each end and having branches leading to each bilge-well in every watertight compartment throughout the machinery space.

Each steam-pump connected with the drainage system, except the main centrifugal circulating pumps, is provided with a suction to the secondary, and is so arranged that, by the manipulation of certain valves, any compartment may be pumped by any pump or by all pumps, if necessary. From the manifold, at each end of the machinery space, branch pipes extend to the several compartments forward and aft, so that the pumping of the several compartments forward and aft may be controlled from within the machinery space. The suction ends of all the branches within the machinery space are provided with Macomb strainers, and the suction ends outside of the machinery space are protected by perforated box-strainers, thus protecting the piping as well as the pumps from becoming clogged by any extraneous matter.

In addition to the secondary drain, the extensive functions of which may now be realized from the above description, a separate pipe, known as the independent "bilge suction" (see Fig. 33) is led from each steam-pump to the bilge-well of its own compartment, so that each compartment may, by its own pump, be kept dry without dirtying up the secondary drain. For pumping the crank-pit a small pump on the main shaft of the engine, known as the "shaft bilge-pump," is provided. This crank-pit, however, is also connected to the secondary drain and an independent suction, so that, in case the shaft bilge-pump is out of order, the water in the crank-pit may still be taken care of.

The double bottom is either flooded or pumped through a pipe known as the "double-bottom pumping or flooding main" (see Fig. 33), which is a single pipe in boiler space and a single pipe in engine space, with a branch controlled by a valve leading into each water-tight compartment of the double bottom and with a connection direct to the sea and to one or two steam-pumps within the machinery space. The double bottoms throughout the machinery space are the only places provided with a flooding connection; while the double bottoms forward and aft the machinery space have suction connections only, and are pumped by means of the secondary drain through the manifold in the forward boiler-room and the after engine-room.

Summary.—From the foregoing brief description it will be seen that the main drain is an emergency drain, being used only to reduce large volumes of water; it is never brought into requisition for the purpose of reducing surface water. That the secondary drain, with its ramifications and auxiliaries, is employed to reduce all surface water usually collecting in the machinery space or such water as collects in holds or store-rooms, or for pumping out the forward or after tanks; finally, that the double bottom and flooding main looks after all water within the double bottoms.

No suction pipes are led into the coal bunkers or magazines. Such water as collects under the floor-ceilings of the coal-bunkers is pumped out by means of a hose passed through the coal-bunker door. The magazines proper, without handling rooms, are pumped out after a flooding by means of a hose passed through a cap in the top of the magazine.

In most of the wooden ships the bilge-room consists of a triangular-shaped space running along the entire length of the ship's bottom and inclosed between the bottom, the loose deck-planking. and the keelson (see Fig. 34). The numerous ribs of the ship divide this space transversely into a number of partitions, between which, however, communications are established through borings, forming the so-called waterways (see Fig. 35). In iron ships, the ribs being further apart, these partitions are broader and more spacious, as well as deeper (Fig. 35).

When double bottoms were introduced, and when these were used for the storage of iron tanks containing feed-water for the boilers, the bilge-spaces underwent a lateral displacement and came to be located between the inclined planes of the ship's sides and those

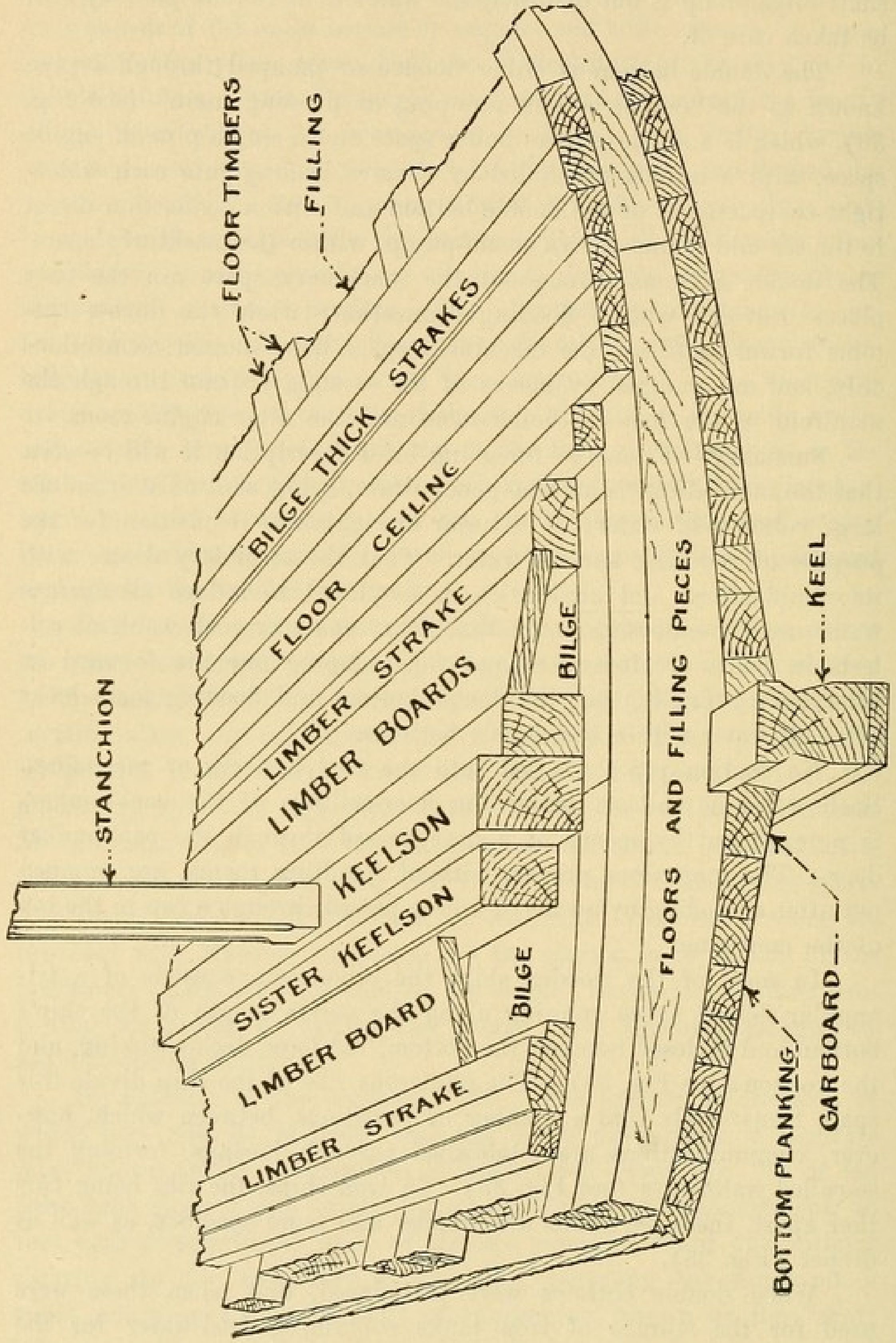


Fig. 34.—Showing Arrangement of Deck-planking.

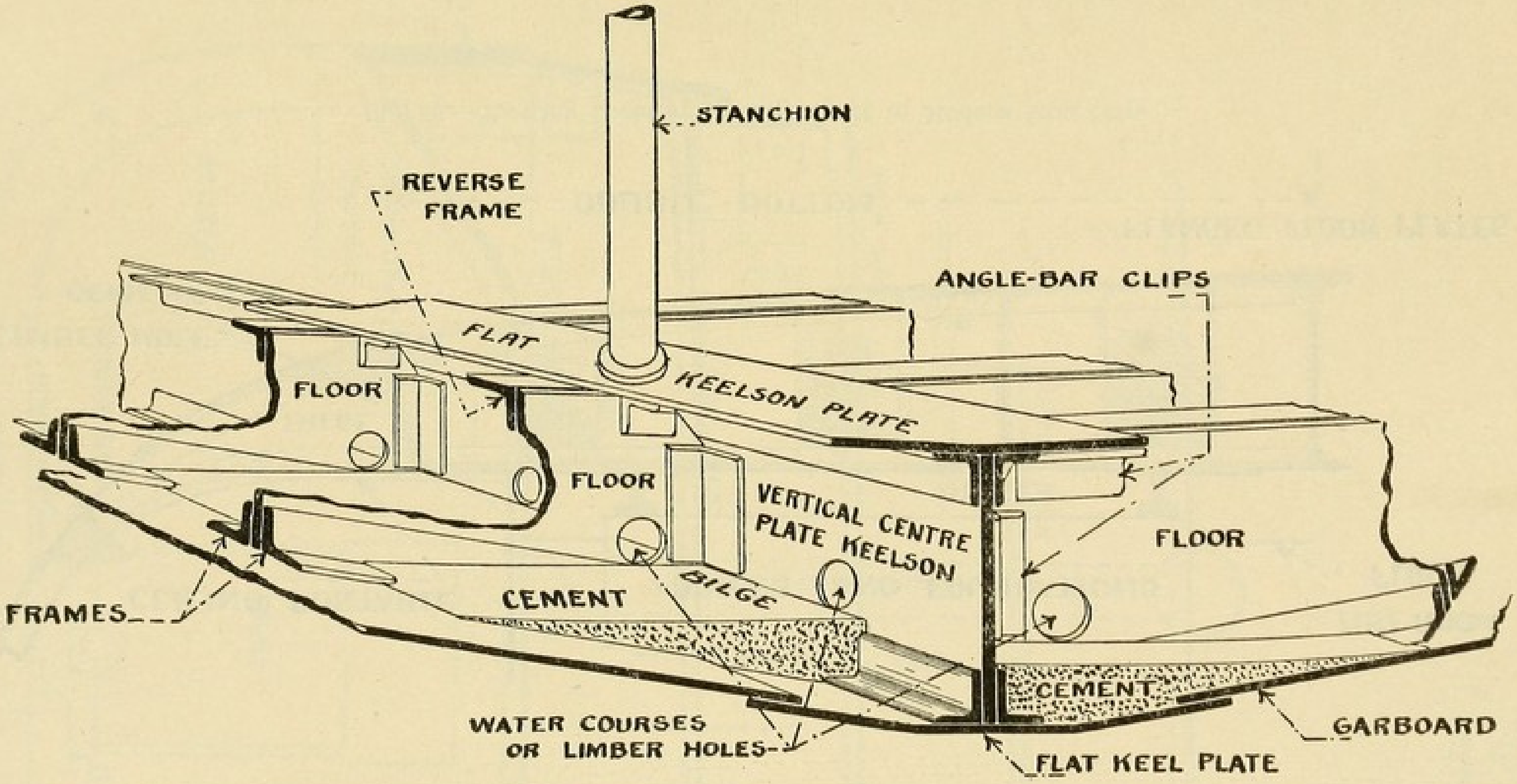


Fig. 35.—Showing Location of Limber Holes.

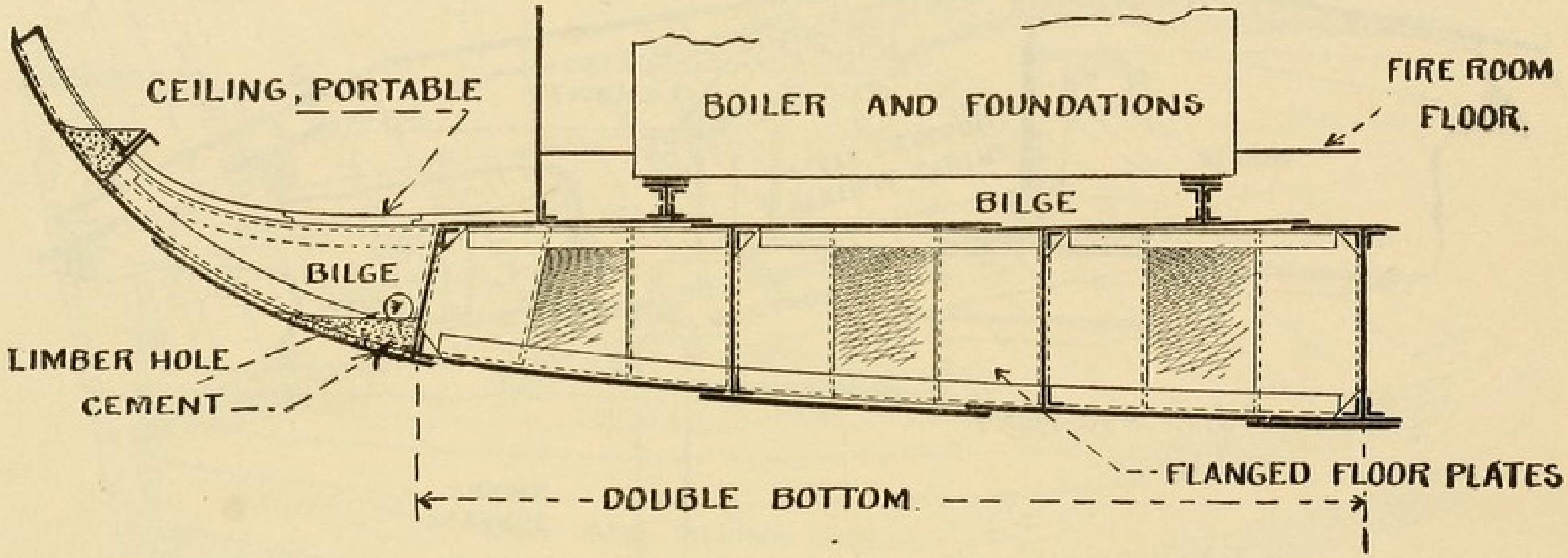


Fig. 36.—Showing Location of Bilge-space in Modern Iron Ship.

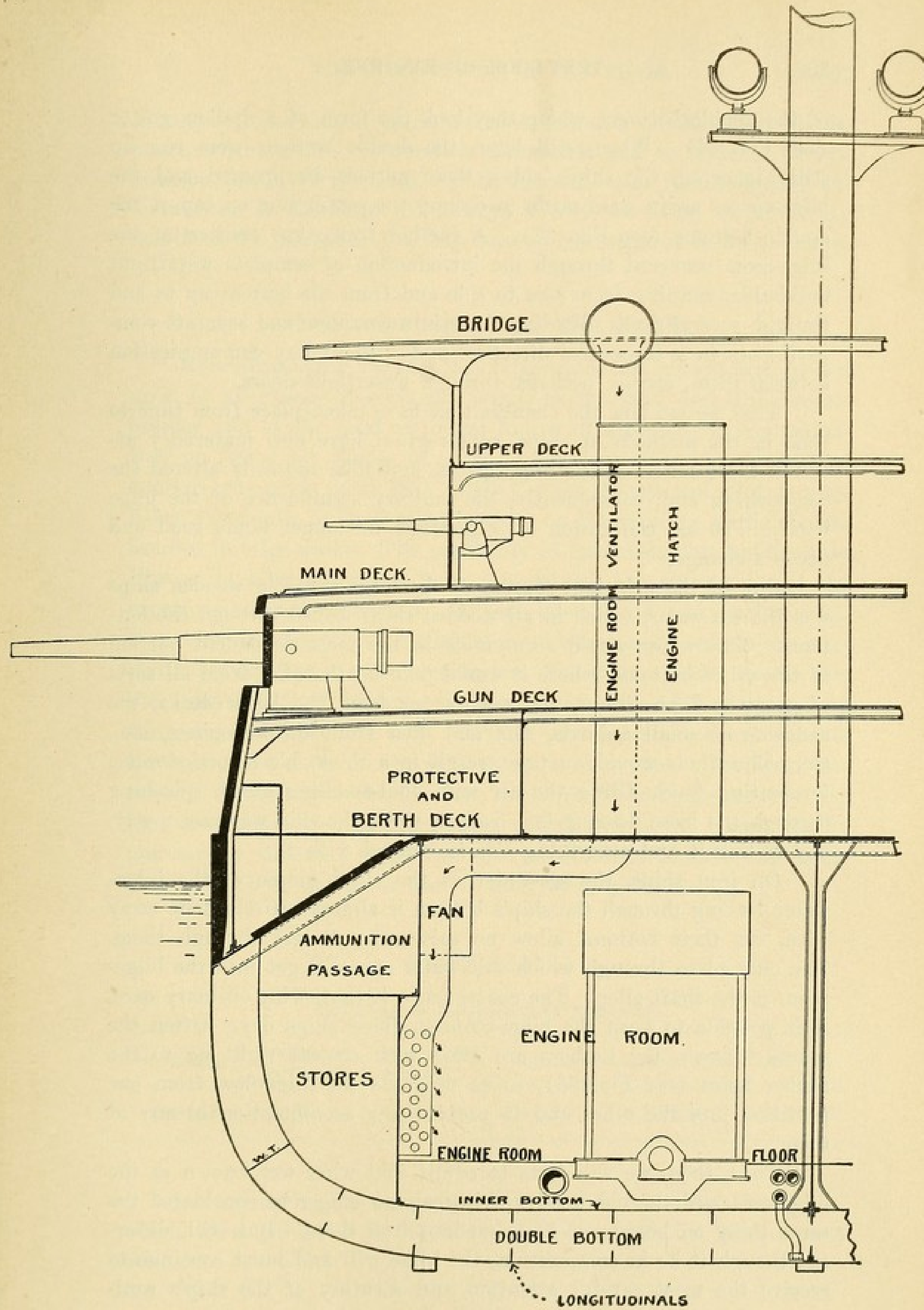


Fig. 37.—Showing Location of Bilge-space on Top of Double Bottom.

of the double bottoms, where they took the form of a shallow gutter (see Fig. 36). When, still later, the double bottoms were run up still higher on the ship's sides, these gutters disappeared and the bilge-spaces again were made to occupy the center line on top of the double bottoms (see Fig. 37). A further transverse division of the bilge-room occurred through the introduction of complete watertight bulkheads, running from side to side and from the bottom up to and through several decks, dividing these into complete and separate compartments in a transverse direction and without any communication between them, except, perhaps, through watertight doors.

Thus we see how the changes that have taken place from time to time in the methods of ships' construction have also materially affected the location of the bilge-spaces, and thus radically altered the composition and, consequently, the sanitary significance of the bilge itself. The old conception of bilge-water no longer holds good and needs a change.

One of the principal sources of the bilge-water in wooden ships was the sea-water, which in all wooden ships leaked through the bottoms. This water would accumulate in the most dependent portion of the ships' bottoms, where it would take up the offal from all sorts of cargo and provisions, the wash-water from the lower decks, the cadavers of small animals, dirt and dust from the sweepings, etc., etc. The whole would, in time, result in a thick, black, malodorous, fermenting fluid, filling the air with foul-smelling gases, splashing through the loose flooring laid over it, while the ship was under way, and soiling it and everything else in contact with it.

On iron ships, the sea-water as the chief source of the bilge-water leaking through the ship's bottom is almost entirely done away with, for their bottoms allow no salt water to get through them. The only place through which salt water can still get into the bilge-room is the shaft-alley. The consequence is that, with ordinary care, it is possible to keep the bilge-room in these ships dry. Often the spaces between the timbers are filled with cement right up to the limber holes (see Fig. 36), so as to guide the bilge-flow from one partition into the other and to prevent any accumulation in any of them.

Thus, then, we will have to admit that what was known as the bilge on board the old wooden ships can no longer be considered the same thing on board our more modern iron ships. But still, different though it be in composition, the bilge will and must continue to receive the most careful attention and scrutiny of the ship's sanitarian, as remaining a source of contamination of the ship's atmosphere, whenever it is allowed to accumulate and to undergo decomposition inside of the ship. Both chemical and bacteriological examinations of the bilge will always have to be done, whenever the health of the personnel of a ship becomes a matter of serious concern.

THE COMPOSITION OF THE BILGE.

Notwithstanding the fact that bilge-water had always been looked upon by all classes of seafaring people as the most dreadful disease-breeder and as the most universal source of atmospheric contamination on board all classes of ships, no serious scientific attempt at analysis was made until 1885 (Belli), when Nicati and Rietsch published the results of their investigations on the viability of the cholera bacillus in bilge-water. The possibility of importing this bacillus into Europe in bilge-water had been thought of, but the results of the experiments proved negative. A year later, Koch and Gaffky made some experiments on the disinfection of bilges and came to the conclusions that mercuric bichloride was the most efficient means for the disinfection of bilges and bilge-water. In 1891 Forster and Ringeling published the most thorough and painstaking experiments that had been made on the subject up to that time. The most important fact brought out by their experiments and observations was that the composition of bilge-water varied within the widest limits, not only in different ships, but also in different parts of the same ship, as is best shown in one of their own tables:—

TABLE XLIII.

Variatioms in Composition of Bilgewater.

Dry Residue	Combustible Substances	Oxygen Consumed	Chlorine	Sulphuric Acid	Ammonia
58–244.8	0.1–165.2	0.06–11.4	1.6–86.3	0.11–2.65	0.002–0.91

Interesting in this connection are the observations of Dr. Nocht, which were published in 1893 and which are shown in the next table:—

TABLE XLIV

Showing Composition of Bilge.

Ship	Where Formed	General Properties
Sail (wood)	Cargo-room	Brown, turbid, muddy
" "	" "	Black, turbid, very muddy
" (iron)	" "	Yellowish, clear, thick
Steamer (iron)	Machine-room	Clear, colorless
" "	Cargo-room	Turbid, black, very muddy
" "	Machine-room	Opaque, colorless, no sediment

Odor	Reaction	Chlorine per Litre	Number of Germs per Cubic Centimeter
Sweetish	Neutral	9,585	325,000
Stinking	Slightly Alkaline	12,780	100,000
No odor	Strongly Alkaline	49,500	300
No odor	Neutral	664	15,000,000
Foul	Slightly Alkaline	10,615	3,000,000
No odor	Neutral	5,573	4,500

Two years later Ringeling discovered two pathogenic anaërobes (septic vibrio and tetanus) in a portion of water taken from near the keel of a ship, and in 1896 Rocci, then surgeon in the Royal Italian Navy, studied the disinfectant value of milk of lime upon the most common bacteria found and isolated from bilge-water. The very latest and, at the same time, the most thorough and extensive examinations into the composition of bilge-water ever made are those published by Dr. Carlos M. Belli, of the Royal Italian Navy. These results are so important, especially as representing the facts as they exist on board men-of-war, that his tables have been in part reproduced.

An examination of these tables shows that Belli employed the most up-to-date chemical, microscopical, and bacteriological methods in his work on bilge-water. Of quite particular interest are his inoculation experiments. He inoculated animals subcutaneously with samples of bilge-water amounting to $^3/_4$ cubic centimeter for a dose, in order to ascertain whether they produced any possible pathogenic effect. In none of his many experiments was such an effect noted, although his animals were kept under observation for two months after being inoculated. He, moreover, tested the cultural properties of various types of bilge-water in both the natural state as well as after filtering it through Berkefield filters. As test-objects, 24-hour cultures of typhoid, cholera, icteroides, and staphylococcus pyog. aur. were used. Although the numerous and important details of this most extensive investigation on the composition of bilge-water must be

TABLE XLV.—*Analyses of Bilge-water in Warships.* (*Belli.*)

Physical Characters and Chemical Composition in Grammes per Litre of Water.

Type of Bilge	Ships	Color	Appearances	Odor	Temperature Centigrade		Reaction	Suspended Matters	Dry Residue	Oxygen Consumed	Ammonia	Nitrous Acid	Nitric Acid	Chlorine	Fats	Sulphur-hydrogen	Iron
					Of Air	Of Water											
Machine-room	Monzambano	Whitish	Turbid with rusty ppt.	No odor	4.1	2.6	Acid	0.55	16.160	0.004	0.088	0.001	0.033	7.000	0.063	None	Abundant
	Calabria	Colorless	Clear	Oily	29.4	27.8	Alkali corresp. 0.210 gm. per litre NaO_4	15.40	37.320	0.028	0.0008	......	0.004	17.040	9.680	"	None
	Dogali	Yellowish	Very turbid	Oily	28.2	28.1	Alkali corresp. 0.490 gm. per litre NaO_4	44.74	29.060	0.007	0.000	0.000	0.000	13.490	42.000	"	"
	C. Alberto	Colorless	Clear	Oily	27.1	39.1	Neutral	11.31	45.620	0.0185	0.000	0.000	0.000	17.750	9.126	"	"
Room for Boilers	Monzambano	Brown	Turbid, ppt. of coal	No odor	4.1	3.8	Acid	1.28	41.120	0.005	0.069	0.007	0.027	1.650	0.000	None	Trace
	Calabria	Blackish	Very turbid	No odor	29.4	40.1	Alkali corresp. 0.110 gm. per litre NaO_4	8.30	187.100	0.056	0.008	0.000	0.0066	91.945	0.000	"	Small qu.
	Dogali	Yellowish	Turbid	No odor	28.2	32.4	Neutral	18.29	50.380	0.002	0.0085	0.000	0.000	21.300	0.000	"	Trace
	C. Alberto	Whitish	Turbid	Odor naphtha	27.1	42.4	Neutral	2.75	11.280	0.0119	0.0006	0.000	0.000	6.325	0 000	"	"
Provisions	Monzambano	Whitish	Turbid-Culex larvæ	No odor	4.1	2.5	Acid	3.44	1.520	0.0042	0.085	0.002	0.011	0.150	0.000	None	Trace
	Calabria	Black	Very turbid	Vinous odor	29.4	28.5	Acid corresp. 4.07 per gm. HCl litre	8.60	37.120	0.2097	0.034	0.000	0.021	2.485	0.000	"	Copions
	Dogali	Black	Very turbid	Vinous odor	28.2	27.9	Acid corresp. 2.656 gm. HCl per litre	1.25	42.500	0 0096	0.021	0.000	0.000	11.005	0 000	"	"

TABLE XLVI.

Bacteriological Examination of Bilge-water. (Belli.)

Bilge-type	Ships	Average Number of Bacteria per c.cm.	Species Identified
Engine-room	Monzambano	239,000	Many colonies of chromogenic saprophytes; some colonies resembling bacillus coli.
	Calabria	2,141,000	Few hyphomycetes, and of the schizomycetes those common in seawater.
	Dogali	984,000	Very few schizomycetes; chromogenic cocci and few bacilli, of which fluor liquefaciens are in greatest number; few proteal.
	C. Alberto	307,000	Numerous colonies of hyphomycetes; of the schizomycetes, some colonies of cladothrix; large numbers of chromogenic water coco and bacilli.
Boiler-room	Monzambano	362,000	Sparse number of fungi, many fluor liquefaciens.
	Calabria	1,016,000	Mostly hyphomycetes and blastomycetes; few speeies.
	Dogali	3,289,000	Very large number of schizomycetes, common to engine-rooms.
	C. Alberto	1,000,000	Sparse hyphomycetes; schizomycetes, common to engine-rooms.
Provision-room	Monzambano	652,000	Various colonies of proteal and potato-bacilli.
	Calabria	333,000	Principally blastomycetes, less hyphomycetes.
	Dogali	1,261,000	Mostly all blastomycetes; few hyphomycetes, some colonies of sarcina lutea.

TABLE XLVII.

Microscopical Examination of Bilge-water. (Belli.)

Type of Bilge	Ships	Results
Machine-room	Monzambano	Crystals of organic and inorganic salt, protozoa.
	Calabria	Pretty large numbers of algæ and protozoa, crystals, hemp-threads.
	Dogali	Salt crystals, no living forms.
	C. Alberto	Salt crystals, hemp-threads, no protistæ.
Boiler-room	Monzambano	Coal-dust.
	Calabria	Coal-dust, no living forms.
	Dogali	Coal-dust, few protozoa (ameboid and rhizopod forms.)
	C. Alberto	No living forms, sparse carbon particles and salt crystals.
Provision-room	Monzambano	Mineral and vegetable dust, numerous rhizopods and flagellates.
	Calabria	Salt crystals, vegetable fibres and grains, few protozoa.
	Dogali	Vegetable fibres and hairs, salt crystals, no protozoa.

studied in the original monograph in order to be properly appreciated, it would seem unavoidable to give a brief summary of the results in this place.

1. Bilge-water of the Engine-room Type.—To judge from the amount of chlorine which this water contained, it was concluded that the basis of it was salt-water mixed with a certain amount of sweet water derived either from rain-water or condensed water, added to which a variable amount of machine-oil was found. The relative proportions in the amounts of ammonia, nitrous acid, nitric acid, organic matters present; the absence, on the other hand, of sulphuretted hydrogen, naturally led to the conclusion that the processes of decay in this type of water are extremely slight. This is, moreover, confirmed by the absence of bacteria, always present in decaying substances. These waters possess no pathogenic properties.

2. Bilge-water of the Boiler-room Type.—The chemical analysis of the waters belonging to this type shows that, in ships lying at anchor, these waters are preponderatingly made up of sweet water, formed in all probability from the feed-water of the boilers and part of which is spilled in the process of filling. In ships under way it changes its character from a sweet to a salt water. Here, also, processes of decay were absent.

3. Bilge-water of the "Cambuse" Type.—The chemical, microscopical, and bacteriological characters of this type were found to vary quite considerably. The sedimentary portion, under the microscope, showed small grains, fibers, hairs from planks, many forms of crystals, algæ, and protozoa. The most common type resembled sea-water mixed with various contents from barrels. Acetic fermentation was frequently present, while other processes of decay were absent.

4. Bilge-water of the Store-room Type.—This type of water is essentially a sweet water with which a small amount of salt water is mixed. It is probably for the most part rain-water. Processes of decay are here present constantly.

It will be seen that, from the physical, chemical, and microscopical characters of these four different types of bilge-water, it is easy to distinguish one from the other; but even without taking these into account, it is still possible to distinguish the engine-room bilge by the oil with which it is mixed; that from the boiler-room by the coal-dust or soot which it contains; that from the cambuse by the acetic acid; and that from the store-rooms by the foul odor of the decaying substances which it contains.

From a hygienic point of view it is worthy of being emphasized that the different bilge-waters in battleships, especially those from the engine- and boiler- rooms, show either no evidence at all of decay going on in them, or that the evidence is present only to a very slight degree. This condition can only be the result of the better sanitary attention which these places receive on men-of-war, when contrasted with similar places on merchant ships. In the bilge-waters coming from beneath store-rooms, chemical examination, even here, shows evidence of advanced processes of decay in spite of the fact that the stores in question could not naturally be considered as very decayable. One of the most interesting facts brought to light by the bacteriological examination is this: that the engine- and boiler- room bilges of battleships contain either no proteæ at all or their numbers are very small, while the store-room bilges literally teem with them.

The persistently negative result obtained from the inoculation of bilge-water into experimental animals would indicate that, at least under ordinary conditions, these waters are free from both pathogenic germs and poisons. This, of course, does not exclude the possibility that, under other conditions, they might become the carriers of pathogenic germs, although, as has been shown, this danger even then would not be of long duration, since experiments have shown that the vitality of pathogenic germs in these waters rarely endures beyond five days. It was also found that the dirtier such water was, the less the chances of the survival of disease-producing germs would be.

Altogether, then, it would seem, from an analysis of the total results of these investigations, as if the dangers to the ships' personnel from the bilge-waters on board battleships had been slightly exaggerated, or could not, at any rate, be at all compared to what they are on ships of the mercantile marine. Such a result, it must, however, be remembered, can only be due to the strict sanitary supervision accorded the bilges on men-of-war generally. Frequent cleansing of the bilges, aided by regular timely disinfection, must, in the end, be depended upon for rendering all kinds of bilges absolutely free from danger to the health of the men.

THE SHIP.

1. Construction.—Desirable as it would seem, by way of an introduction into marine sanitation, to give a brief outline of ships' construction, space does not permit here to give more than the gross divisions of a typical vessel. Fortunately, the points regarding marine architecture that it is absolutely necessary for the sanitarian to know are few, and need hardly extend beyond a knowledge of the materials of which a ship is built, its various divisions and compartments and the special uses to which these are put, in order to enable him to successfully trace the sources of mischief to human life produced thereby. The marine sanitarian need not be a constructor, any more than the public health officer need be an architect or an engineer.

For the marine architect by profession, the problem of constructing a small gunboat varies immensely from that of a large battleship, while for the marine sanitarian most of the problems that come within his province remain, fundamentally at least, the same in both cases. Thus, every ship of no matter what type or description is more or less damp, dark between decks, and difficult to ventilate thoroughly, so that it may safely be taken for granted that dampness, darkness, and poor air are the three main and most constant factors entering into every problem of ships' sanitation. When we add to these extreme heat for all large steam vessels of modern construction, we have indeed all the four elements against the influences of which sanitarians must direct their principal efforts.

The difference between merchant ships and warships grows wider every year. Thus, for instance, in a modern Lloyd steamer there are at present five decks. Beginning from above downward we have, first, the sun-deck; next, the promenade deck; third, the upper deck; fourth, the main deck; and fifth, the 'tween-deck. Below the last deck and abaft the engine-room there is the shaft-alley, and in the corresponding situation forward of the boiler-room we have the coal-bunkers and the various store-rooms for provisions. On the berth-deck, from bow to stern, there are the bunks for the steerage passengers, and also on the main deck forward of the smoke-pipe. The crew lives on the forward part of the upper deck, under the forecastle. The first cabins and the rooms for the officers are on the promenade and upper decks.

The cubic space to be allowed per man is nowadays prescribed by law in every civilized country, and usually amounts to 100 cubic feet, with a minimum floor area of 9 feet. This is said, especially by English surgeons, to be too small an amount, but, while admitting the justice of the complaint, as Kulenkampf and Nocht have pointed out, part of the unhealthfulness of the quarters lies on the side of the interior arrangements of their living spaces, as well as in the insufficiency of the available air-space. Nocht, in 1895, measuring 100 ships, found the amount of air-space allowed per man to be 125 cubic feet, that is, somewhat in excess of the minimum allowance required by law. Nocht, also, is of the opinion that internal cleanliness and a more judicious arrangement of the interior of the living spaces would be productive of greater good than an increase in the cubic capacity alone would be.

Very different and somewhat more complicated and difficult to understand than in a merchant steamer, are the various divisions and subdivisions of a modern first-class battleship. A large 16,000-ton battleship, complete in all its parts, in full motion and in action, approaches perhaps nearer to a colossal living organism than any other product of human ingenuity of recent date.

To begin with, everything about such a vessel, that can be, is made of steel or iron, to resist not only the waves in the heaviest storms, but also the heaviest armor-piercing shot and shell. Fig. 38 is intended to represent, schematically, the main divisions of one of the latest types of a first-class battleship. It will be noticed that the thickest line in the drawing, running fore and aft and inclining slightly at either end, divides the entire ship into an upper and a lower half. This line indicates the position of what is known as the protective or armored deck. All the other decks are above the protective deck, and below it we find all the store-rooms, boiler-rooms, coal-bunkers, engine-rooms, steam-steering rooms, magazines, ammunition passages, and trimming tanks.

The different decks, from above downwards and extending between the two military masts are the bridge, upper deck, main deck, gun-deck, protective or berth deck; with a flying bridge, situated above the bridge around the forward military mast. The berth-deck proper is that part of the protective deck which is continued in an even plane forward and aft respectively from the protective deck, from the points at which the armored deck inclines downward for a short distance, forming an acute angle with the berth-deck.

As a general rule, all the men's living quarters are on that portion of both the gun-deck and berth-deck which is forward of the after turrets, while the officers' quarters, with their mess-rooms, are on the same decks abaft the after turret. Immediately beneath that part of the armored deck included between the two military masts, are the engine-, fire-, and dynamo- rooms. Forward of the dynamo-room and abaft the engine-room respectively and between the protective deck and the inner bottom, we have what are known as the upper and lower platforms, which carry stores and ammunition. Between the inner bottom and the outside plating there are the

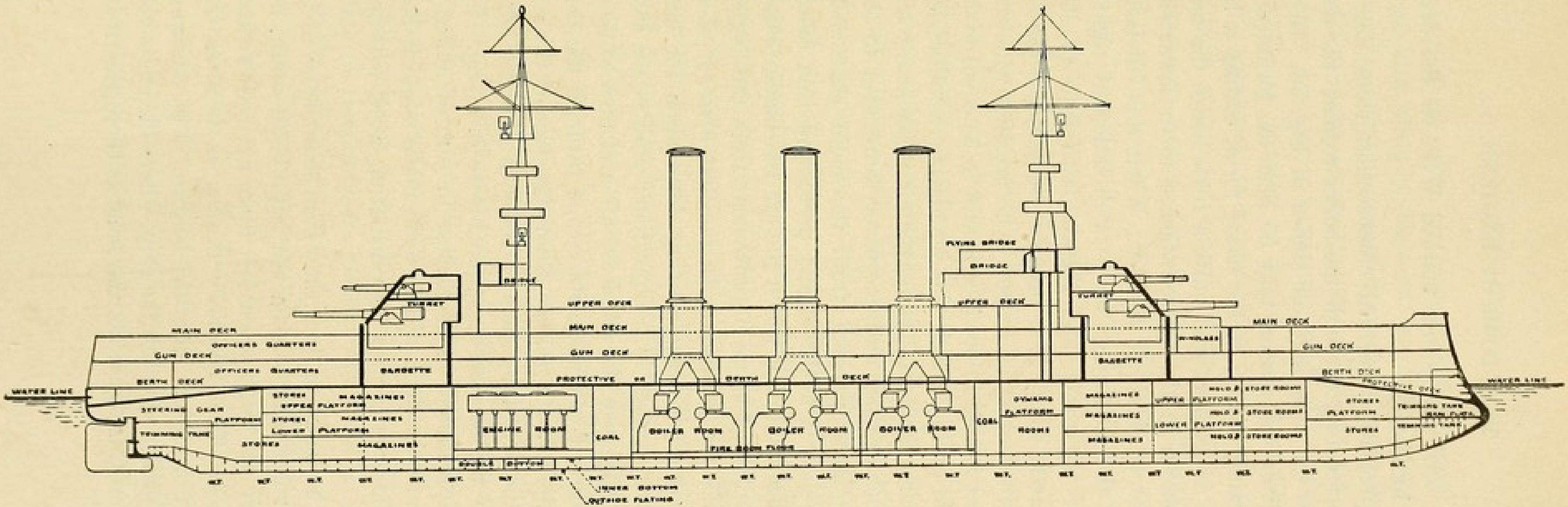


Fig. 38.—Showing Plan of Large, Modern Battleship.

double bottoms. All the points marked W.T. on the drawing concern watertight bulkheads.

Fig. 33 represents a vertical cross-section from the same type of ship as the preceding, through the boiler-rooms; the decks shown in this figure are the same as those shown in Fig. 38. In the boiler-room, to the left of the reader, may be seen the terminal of one of the large ventilating shafts, of the usual form, ending a little below the plane of the deck above and quite a little above the heads of the men. The lid shown in the figure attached to its lower end is to be closed in case forced draft is desired. When this lid is closed, the air is driven by the adjoining fan in a direction at right angles to the long axis of the shaft, and thence down into the boiler-room toward the furnaces, where it is intended to increase the combustion of fuel and the production of steam. The pressure which this forced draft arrangement is able to produce is said to be equal to $1\frac{1}{2}$ ounces. On the right side of the sketch the ventilating terminal is shown to have a different arrangement. Here, the air is purposely shown to be carried down much further and, moreover, conducted to the sides of the room before being released from the main shaft. The figure was intended to show a flattened and perforated iron casing applied against the bulkhead through which the air was made to enter. This arrangement is proposed as an improvement from the hygienic standpoint, on the following grounds: In the first place, it is very desirable to keep the cold air from pouring down upon the heads of the stokers and firemen, steeped in perspiration; and, in the second place, the arrangement will give the admitted air a chance to do more ventilating work before it can make its escape through the centrally located exhaust pipe. In its passage from the sides of the room to the center it passes the breathing zone of the men at work, and this furnishes them with the necessary oxygen before escaping. The deeper down the cool, imprisoned air is carried in case of a hot room, the greater the distance which it will have to make while it becomes hot and rises, and the greater also its ventilating work will be before it can escape again.

Beneath the boiler-room floor the figure shows some of the drains. On the extreme right may be seen the large main drain, nearest the middle line, where the bilge is located, there are the two independent bilge suction-pipes. The secondary drains, as well as the double-bottom floor and drain-pipes, may also be seen. Fig. 33 represents one side of a vertical section through the ship, where the engine-rooms are; the points shown in this figure are the same as those shown in the preceding.

The amount of cubic air-space for the living quarters of the crew, though still stingily dealt out on board many of the modern warships, may perhaps be regarded as all that can be expected under the present strenuous circumstances. With a crew of from six to eight hundred men on a battleship, with the constantly increasing number of officers required on board, and the ever-increasing additions in new apparatus and machinery from year to year, the constructor of such a ship has indeed a large contract on hand, if he is to furnish quarters for all, that are to be satisfactory from all points of view. From the point of view of sanitation, of course, if any one thing is more important than another, that thing is pure air. For no one can study thoroughly the history of sanitation in ships, its gradual and slow development in connection with life at sea and in ships, without coming to the conclusion that human *overcrowding* or its equivalent, bad air, has been the most constant and ever-present factor in contributing to render such a life unhealthful. Paradoxical as it may seem, it is nevertheless a fact recorded in history, that men in ships, at work below decks, have suffocated from want of air, while a gale of wind was blowing outside. The recognition by ship-builders and of all maritime nations of the present day, of the fact that a certain minimum amount of cubic air-space should be allowed every living man on board and that an efficient ventilation, besides, is to be maintained, may, therefore, with excellent reasons, be regarded as a signal victory over the conditions of the past and as the most important achievement of modern marine sanitation.

Although there are no laws in existence in any navy with regard to the cubic air-space to be allowed per man on board a warship, such as are to be found for merchant vessels and to which the naval constructor or commander is absolutely obliged to conform, the necessity for some definite allowance is, nevertheless, so urgent, that it practically always forms one of the important factors in the calculations in the designs for every new vessel. The result, of course, as might be expected, is not a uniform one, varying with the individual ideas of the designer, all the way from 2 to 5 cubic meters, or from 70 to 175 cubic feet.

Some very interesting, as well as instructive, calculations as regards the allowance of cubic air-space on board warships have been furnished us by Dr. C. M. Belli, of the Royal Italian Navy, quite recently. Belli, in his hygienic report on the second-class battleship *Varese,* has calculated with great exactness, as well as judgment, the actually available air-space per man under different conditions.

Making due allowance for the number of men occupying the different sleeping quarters, and deducting the number that is always expected to be on duty in other parts of the ship under the usual routine in force, and which latter varies in accordance with the whereabouts of the vessel whether in port or at sea, he arrives at the conclusions shown in the succeeding table:—

TABLE XLVIII.

Sleeping Quarters	Number of Men	Total Cubic Air-space in meters	Per Man, Meters	Per Man in Port, Meters	Per Man at Sea, Meters
Gun-deck, forward . .	30	200	6.66	8 73	13.33
" " amidship . .	300	1,562	5.20	6.50	10.40
Berth deck, forward . .	20	161	8.05	10.60	16.10
" " amidship .	50	452	9.00	11.30	18.08
" " aft	50	234	4.68	5.80	9.36

Although the above calculations show a most generous provision of air-space and speaks well for the sanitary provisions made in the Italian Navy, calculations on the same principles as those made by Dr. Belli on other warships would no doubt reveal the fact that the actually available breathing space for the men is greater than the calculated air-space is. Notwithstanding, however, this deduction, it is also a matter of exact calculation that the available breathing-space on some of our own vessels does not come up to one-half of the allowance shown in the above table as existing on the *Varese*.

2. Cleanliness.—Our conception of the term "cleanliness" in general varies quite considerably at the present time from what it was in prebacterial times. While, for instance, not many years ago, the surgeon was quite confident that his hands were clean when he had scrubbed them in soap and water, continued inquiry and investigation have convinced him since then that absolute cleanliness of the hands is practically unattainable. The methods employed for producing absolute cleanliness of persons and things are so complex and require so much professional knowledge that they will probably always remain in the possession of the professional few and never be mastered by the lay masses.

Not long ago, a ship, for instance, was considered quite clean when its decks were soaked in salt water, its atmosphere saturated with moisture, and a smell of turpentine and paint permeated the living spaces. After an expensive experience of many years, we have found out that a wet ship is not necessarily a clean ship; that dampness on board a ship is, indeed, one of the conditions favoring bacterial growth and the perpetuation of epidemics. Still, it would not be hard to find a deck officer, even at the present day, on a modern ship, who would not express great astonishment if told that his clean-looking ship was nevertheless in a dangerously unsanitary condition. Much missionary work is yet required to generalize the knowledge of the principles of ordinary cleanliness.

The problem of cleaning the decks of a ship is nearing its solution on those vessels in which linoleum has been used for deck covering. Here, the daily deluge with salt water has ceased to be necessary, and a moist wiping is both sufficient and effectual in producing the ordinary state of cleanliness. The atmosphere between decks has become much drier since this change occurred. But, unfortunately, there is still a considerable number of officers in the service who cannot get away from the antiquated system of giving the ship under their command a daily "ducking," and the sanitarian, therefore, finds it still necessary sometimes to remonstrate.

That the old fight for dry decks was really founded on good and sufficient grounds has been abundantly shown by the morbidity statistics. Friedel, quoted by Plumert, compared the morbidity between two English ships, the *Centurio* and the *Conqueror*. On board the former none but dry holy-stoning was practiced, while on the latter the decks were scrubbed after the usual manner, by a daily wetting with plenty of salt water and a more thorough weekly one. The morbidity records on the two vessels were as shown in the succeeding table:—

TABLE XLIX.

Diseases	Centurio	Conqueror
Fevers	4	99
Pneumonia	2	33
Catarrh of respiratory organs	132	198
Sore throat	62	179
Dysentery	....	10
Skin diseases	189	257
Summary	389	776

The medical officer, while rarely consulted with regard to the general method of keeping the ship clean, is often asked for suggestions when the bilge is to be cleaned. On this subject he should, therefore, be able to give expert advice. The method of treating the bilge, in most cases, consists in a combination of the process of cleansing with salt water with some process of disinfection.

In dealing with the bilge, it is by no means an indifferent matter whether the contents of the bilge are pumped out into the sea-water before being disinfected, or whether their disinfection is to be effected first. The bilge-room may contain infectious germs which it is not safe to pass on into the waters in which the ship lies at anchor. Then again, the mixing of the disinfectant with the bilge-water, having to be done very thoroughly and so that all parts of the bilge will be brought into intimate contact with it, it will make considerable difference in the result and the method to be employed whether the ship is under way or whether she lies quietly at anchor. When in motion all parts of the bilge-room will naturally be deluged with the disinfecting fluid; when at anchor, an artificial circulation of the disinfectant must be started with pumps and pipes. The fluid from the most dependent portion of the bilge, usually aft, must be pumped forward, whence it runs aft again by simple gravity, and thus circulates through the entire bilge space.

In the experiments of Koch and Gaffke on the *Freya* and *Hyäne,* the disinfecting fluid was first mixed with the bilge-water and, the ship lying quietly at anchor, the mixture was pumped from aft forward, thus causing it to circulate and become thoroughly mixed. After this disinfected bilge-water had been pumped out, enough disinfecting fluid was put into the bilge-room to make it rise to the same level occupied by the bilge-water previously disinfected and pumped out.

The results obtained by Koch and Gaffke are summed up in the following conclusions: (1) With corrosive sublimate the most resisting bacilli may be destroyed; (2) corrosive sublimate must be added to the bilge-water in sufficient quantity to produce the reaction of mercuric salt; (3) the mixing must be thorough; (4) the disinfection may be regarded as accomplished after an exposure of 18 hours; (5) after the bilge-room has been rinsed out four times, the amount of mercury remaining behind is so small that it is harmless. The strength of the solution to be employed is 7 : 2-3000 and salt water is the usual solvent. After the disinfection the bilge-room is dried and its floor and sides covered with minium paint. In the German service the bilge is cleaned in this manner once in two weeks.

3. Disinfection.—The naval surgeon is rarely called upon to superintend the disinfection of an entire ship. This is usually done at quarantine stations, where the necessary appliances and machinery will be found in constant readiness, with a trained personnel to run them. There are, however, many minor disinfections to be done on board every ship which the ship's surgeon must be prepared to execute, and which, to do them well, require, nevertheless, a perfect knowledge of the art of disinfection and its practical applications in all the various branches on his part.

While in civil life we may make a theoretical distinction between sanitary science and hygiene, or between a mere sanitarian (whose duty it is to prevent) and the hygienist or, in this case, the professional disinfector (whose duty it is to remove the infection after it has invaded a ship), the naval surgeon must be both and cannot well afford to draw a strict line between these two functions if he is to do his full duty by his command. Besides, the whereabouts of war vessels are not always convenient to the regular disinfecting stations.

A vessel, especially a war vessel, is rarely so badly infected as to need a disinfection throughout. There is no more reason for fumigating the hold of any vessel because a case of measles has appeared in the cabin or the steerage, than there is for disinfecting the basement of a tenement on account of the appearance of a case in one of the upper stories of the building. In a wooden vessel or iron merchant ship, with free communications between the various compartments, the danger of spreading any contagion throughout all parts of the ship is, of course, very great, but on a battleship, for instance, with its two hundred separate compartments, this danger is considerably less apparent.

Of the utmost importance, however, is it to choose the proper method in special cases. In this respect, the naval surgeon finds himself frequently in a difficult position because of being obliged to devise both the means and the apparatus in order to gain his ends. He will then realize that nothing short of a thorough preliminary training in the principles and practice of the art can ever help him out of the difficulty.

Sometimes, the composition of the vessel to be disinfected will determine the choice of the method. A wooden vessel, for example, requires a most thorough mechanical cleansing and a longer exposure to germicidal agents than an iron one, in order to insure penetration and thorough disinfection, on account of the spongy nature of the wood, as compared with the smooth surfaces of iron plates.

It is sometimes of as much importance to know what to disinfect as how to do it. Thus, the cargo of a vessel is rarely infected except in case of plague, where the rats carry the infection into the deepest parts of the ships and bilges. The rats must be thoroughly destroyed, and after their destruction so handled that the infection cannot spread from the cadavers. In the disinfection of living spaces it should always be remembered that metal and all bright work are ruined by sulphur and bichloride and that, therefore, the use of formaldehyde and carbolic acid must be resorted to instead. In using steam it must be kept in mind that leather and furs are ruined by it. When water-tanks are suspected of harboring the larvæ of mosquitoes and the ship happens to be in salt water, the water may safely be pumped out, because the larvæ, neither of anopheles nor of stegomyia, ever develop in salt water. When, however, the ship is in sweet water, petroleum should be first employed. In case the water-tanks are infected with the germs of cholera, typhoid, or dysentery, the water in them should in all cases be thoroughly disinfected or boiled by steam. A vessel known to be infected with yellow fever should always be given a preliminary fumigation with sulphur or pyrethrum powder, before being inspected, in order to either kill or benumb the infected insects and thus protect the inspectors.

On the broadest general principles, while steam and formaldehyde must be considered the best agents for the disinfection of bedding and clothing, as well as living spaces, there are a number of infectious diseases that require special treatment and consideration. Thus, during epidemics of cholera special vigilance must be kept upon the water supply and the pipe connections; in case of plague, it is to rats that we must pay special attention; in yellow fever, certain species of mosquitoes must be destroyed; in case of the exanthems, bedding, clothing, and the patient's skin must receive the lion's share of our efforts. In all cases alike, the ship's decks must be disinfected, since Belli has shown in an experimental study that the ordinary methods of scrubbing with either salt water or lye, as is commonly done, does not expedite the disappearance of infectious germs.

The most important disinfecting agents that should be kept on hand aboard every sea-going vessel are sulphur, steam, formaldehyde, lime, bichloride of mercury, and, of late, coke must be added to the list. *Sulphur,* for some time in disrepute, on account of its lack of penetrating power and its failure to kill spore-bearing germs, has recently regained part of its lost prestige, since it became known that it kills mosquitoes and other disease-bearing animal parasites. The best method for ships' use is the iron-pot method. The sulphur is usually used in lumps that are saturated with alcohol and then lit. Five pounds of sulphur for each 1000 cubic feet of air-space produce a 5 per cent. gas, which is sufficient to kill all non-spore-bearing organisms within sixteen hours. Care should be taken that the articles to be treated by this method are not too dry.

Steam is perhaps the most widely used disinfecting agent, as well as the most valuable of any used on board ships. Steam-pipes may be found conveniently located in almost any part of a ship, and can be tapped for a supply of steam. In case no regular steam disinfecting apparatus is at hand, such an apparatus may be extemporized and made out of a vinegar or wine barrel or some iron water-tank. Streaming steam has the same power as boiling water, and an exposure of half an hour is generally sufficient to kill very resisting spores. It may, therefore, safely be used and depended upon for destroying the infectious agents of any of the communicable diseases. It should be remembered that steam shrinks woolens and injures silks, it ruins leather, fur, skins of all kinds also rubber shoes, mackintoshes, and other articles of impure rubber.

Formaldehyde.—A gas is, of course, the ideal form of a disinfectant, and formaldehyde comes, perhaps, nearer to that ideal than any other gas, in spite of the fact that it has some very decided limitations, not the least of which is its lack of penetrating power. Solutions, unless immersion can be maintained for a long enough time without injury to the material, are not so valuable. Several years ago, von Esmarch devised a method by means of which it was thought possible to eliminate the shortcomings of both steam and formaldehyde. The method aimed at a combination of steam and formaldehyde in a chamber in which the air was rarified at the same time. By adding the vapor of formaldehyde to steam it was hoped that steam might be used at a lower temperature than 100° C., and thus its injurious effects on some of the fabrics be eliminated. By causing a partial vacuum in the disinfecting chamber it was hoped that the penetrating effect of formaldehyde could be materially increased. Kister and Trautmann, in some recent experiments with von Esmarch's method, made with the object of testing its applicability on a large scale, obtained results that were not quite as promising as they had been led to expect. Although the combination of steam with a 2 per cent. atmosphere of formaldehyde gave evidence of increased disinfecting power, it was noted that the mixture, at a temperature of 75° C. and under a reduction of the pressure equal to 520 millimetres, failed to kill all the spores and did not uniformly penetrate all parts of the chambers. The method, however, seems promising, and its further perfection will be only a matter of time.

Formaldehyde occurs in the market in several forms. The 40 per cent. solution is known as formalin, and this is sometimes used for the generation of the gas in a special generator. Ten ounces of this fluid are considered quite sufficient for each 1000 cubic feet of air-space. Sometimes the gas is developed directly from wood alcohol. When the vapor of wood alcohol is passed over incandescent platinum, the alcohol is reduced to an aldehyde. By the use of the Kuhn lamp three pints of wood alcohol may be reduced in two hours, and the amount of gas thus produced is said to be sufficient for the disinfection of 1000 cubic feet of space. For the purpose of disinfecting clothing in a trunk, which often needs to be done when officers return from leave of absence and report infectious diseases in their families, not less than 50 cubic centimetres of formalin for each cubic foot of space is required. (Rosenau.) Mail matter is ordinarily disinfected by clipping the corners off the envelopes and introducing a few drops of formalin with an eye-dropper, and several drops are also put on the outside cover and the whole shut up in a tight box, which is then placed in a warm room for six hours. The box should be opened out of doors. Formalin is also a convenient disinfectant for urine, excreta, and sputum, because of its possessing the property of combining with the albuminous matters without causing their coagulation. On account of its nontoxic properties it is, moreover, often employed in the disinfection of food-products. Large quantities of bulbs, roots, nuts, fruits, and similar articles, coming from infected districts, are treated by immersion into a 5 per cent. solution of formalin without harm. Bulbs so treated keep from rotting for a long time.

Lime.—Milk of lime, which is slaked lime mixed with about four times its volume of water, is one of the most useful disinfectants for excreta and privy-vaults. Chlorinated lime, in the United States Army officially prescribed in the form of a 4 per cent. solution for use in the disinfection of the excreta from the sick, combines the effect of both lime and chlorine. When used for ships' holds or rooms, 1½ pounds of it mixed with 6 ounces of strong sulphuric acid are supposed to be sufficient to produce the purification of 1000 cubic feet of space. As is the case with sulphurous acid, chlorine gas acts more energetically in the presence of moisture.

Mercuric Chloride.—One of the most popular of the disinfectants is mercuric chloride. A solution of 1 : 1000 will surely kill all spore-bearing organisms at ordinary temperature within half an hour. Articles of clothing may be thoroughly disinfected by immersion into a solution of 1:2000 for two hours; a solution of 1:15,000 inhibits both fermentation and putrefaction.

Carbon Monoxide.—In carbon monoxide we possess one of the most efficient gases for the destruction of rats in ships. Nocht and Giemsa have recently devised an ingenious apparatus in which the gas is produced by the incomplete combustion of coke. Part of the heat produced by the combustion is used to furnish the steam necessary for running a water-pump and ventilator. The gases resulting from the combustion of coke are heavily charged with carbon dioxide, the pressure of which prevents them from forming an explosive compound when mixed with air. This protective action of CO_2 is secured when the latter reaches an amount equal to twice that of the carbon monoxide content. As determined by the apparatus of Orsat, the composition of the gaseous mixture produced in the generator is CO, 4.95 per cent.; CO_2, 18 per cent.; and N., 77.05 per cent. by volume. Four hundred and five cubic metres of the gas can be produced in one hour. The gas has a specific gravity of 1085. Before beginning the disinfection the men must leave the ship. In order to kill all the rats in a ship, it suffices to generate an amount of gas which equals one-half to three-quarters the capacity of the ship. The process of disinfection being over, all that is necessary, in order to get rid of the gas, is to start the ventilators and open the hatches. This may be done after an exposure of six hours.

Mice are used for testing the atmosphere for CO. These animals, which are very sensitive to CO, must be found alive after a two-hours' residence in any compartment, before the ship is pronounced safe for re-occupancy. The method is not only reliable and thorough, but also quite inexpensive.

THE NAVY RATION.

While it cannot be expected, in the limited space allotted to this article, that we enter at all into the special physiology of nutrition or into the chemistry of food-stuffs, it is, on the other hand, unavoidable and necessary to touch upon those of the leading principles and methods according to which the nutritive values of those of the food-substances that are in common use on board sea-going vessels, and included in the navy ration, are ordinarily determined.

In the ordinary walks of life a man chooses not only what articles he eats, but also how much of these he thinks he needs, and the free play of his instincts generally leads him to select from a bill-of-fare the diet best adapted for his maintenance. In naval and military organizations this free choice or selection as regards a man's diet is greatly limited, inasmuch as the latter is provided for him by some one else. Hence it will readily be seen how very important it is that this provided diet should answer in all respects to the full requirements of the average working man.

The diet-list made out on board ship ought to differ, therefore, from an ordinary bill-of-fare, in giving, upon careful examination, the results characterizing a perfectly constructed and in every respect complete meal. The meals for the day, to be called perfect, must show that they contain in proteids, fats, and carbohydrates not only the proper amounts, but also the right relative proportions of each. When the examination shows that this is the case, then our list of articles ceases to be a mere "bill-of-fare" and becomes a *"ration,"* intended to meet all the required needs of the normal, working human organism for a period of twenty-four hours. Since the distribution of the different articles of food-stuffs, on board ship, at any rate, is left to the commissary yeoman, a man not generally in possession of the knowledge required to perform that duty according to the best principles of the physiology of nutrition, and since, moreover, the influence of the continuous faulty distribution of food-stuffs upon the larger number of men must prove disastrous in the long run, it behooves the sanitary officer to keep an eye on the diet of his men and correct any mistake made in this respect. He should, therefore, be familiar with the methods employed to determine the food values of any diet, as well as know when a diet is complete in all respects, and when it is not.

The food value of any edible substance is generally expressed by the number of calories or heat units which one gram or any other definite quantity of it will develop when completely burned in a calorimeter. The amount of heat that is developed during the combustion, for instance, of one gram of a substance in a calorimeter is exactly the same that is produced when one gram of the same substance is completely oxidized within the body. In a living organism about 30 per cent. of this value can be put out in the form of mechanical work, while the remainder passes off in the form of heat. We know, thanks to the researches of Voit, that an average adult laborer performing his daily work puts out in mechanical work and heat the equivalent of about 3000 calories. In order, therefore, that the man shall not lose his weight, his daily diet must be such as to balance his loss and have a combined caloric value of at least 3000 units. If we furthermore take into calculation that about 400 of these units, at least, must come from proteids, 500 from fats, and the remainder from carbohydrates, we have the most necessary data for the calculation of the man's diet. Thanks to the labors of Voit and Rubner and their numerous pupils, these determinations have been greatly simplified in recent years.

Outside conditions, personal and racial habits, climate, age, and sex may alter the relative proportions of proteids, fats, and carbohydrates in a certain diet; but the above proportions must stand as answering to the average requirements of an adult workingman in a temperate climate. In calculating the dietary value of a ration we must also allow for an unavoidable loss in the preparation of the different parts of it. In meats a loss of 20 per cent. of the raw material is generally allowed for bones; in salted herring, 37 per cent.; in pickled herring, 29 per cent. Potatoes boiled and then peeled lose 7 per cent. Potatoes peeled raw lose 30 per cent. In the case of eggs 10 per cent. in weight is deducted for the shells, etc. Another source of loss from the gross weights is in the different degrees of digestibility of foods, for which allowance must also be made. As a general rule, animal foods are much more completely digested than foods of vegetable origin. Rubner has shown that the proteids from meat and milk disappear almost entirely, while those from bread, and especially vegetables, reappear in the feces in considerable proportions.

A simple and approximately accurate method for calculating the nutritive value of a diet has recently been published by Schumburg. He makes a slight difference in the food value between animal and vegetable proteids, giving the former a value of 3.5 and the latter a value of 3.1. The fats have a value of 8.8 and the carbohydrates one of 3.7. Given, then, the various constituents of a diet, expressed in proteids, fats, and carbohydrates, their weight stated in grammes, multiplied by their respective values, the several amounts added together would give a sum corresponding to the total food value of a diet in numbers of calories or nutrient units. Remembering that a sufficient diet for an adult workingman must have at least 2000 nutrient units, and that the proportion of proteids, fats, carbohydrates, and salts in a complete diet should be as 150, 100, 500, and 35, we should have an easy and simple method of ascertaining and controlling the dietary value of any meal.

It is on these principles, and with the aid of the usual tables of the food values of the different articles entering into the composition of a diet to be found in every work on physiology or hygiene, that the following diet table of the new naval ration has been worked out.

A reduction of about 25 per cent. of the quantity of every article in the table, with the exception of the usual quantities of bread, butter, coffee, milk, and sugar, was made for certain necessary and unavoidable waste which occurs in their preparation. In calculating the food values of the customary quantities of bread, butter, coffee, milk, and sugar which are served out at every meal, the value of coffee as a food was disregarded. It may be added that the coffee is replaced, especially for supper, by cocoa or tea.

Table L.

Diet table prepared from one week's allowance of the new United States naval ration.

SUNDAY.

Food Allowed	Weight in Grams	Contents in Grams			In Nutrient Units			Sum.
		Protein	Fats	Carbohydrates	Protein	Fats	Carbohydrates	
Breakfast:								
Baked beans	135	32.8	2.0	66.2	101.7	17.6	244.9	364.2
Pork	90	15.8	19.8	....	55.3	174.2	....	229.5
Catsup	....	....	....	....	....	....	....	....
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	209.6	366.9	876.5	1,453.0
Dinner:								
Roasted veal	360	72.2	32.4	....	252.7	285.1	....	537.8
Potatoes, mashed	270	5.4	.5	55.9	16.7	4.4	206.8	227.9
Dressing	....	....	....	....	....	....	....	....
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	322.0	464.6	8 8.4	1,625.0
Supper:								
Ham, boiled	1 0	27.5	52.0	....	96.2	457.6	....	553.8
Jelly	112	.2	....	36 0	.6	....	133.2	133.8
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	149.4	632.7	764.8	1,546.9

Total nutrient units in day's ration, 4,625.

MONDAY.

Breakfast:								
Quaker oats	90	10.8	4.0	5 .2	33.5	35.2	193.1	261.8
Bacon, fried	180	17.1	136.8	....	63.3	1 203.8	....	1 267.1
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	149.4	1,414.1	824.7	2,388.2
Dinner:								
Beef, roasted	360	80 3	102.9	....	281.0	905.5	....	1 186.5
Peas	180	41.0	3.2	94.3	127.1	28.2	348.9	504.2
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Potatoes	360	7.2	.7	74.5	22.3	6.2	275.6	304.1
Sum	....	....	....	....	483.0	1,115.0	1,256.1	2.854.1
Supper:								
Cold beef	180	40.1	51.5	....	140.3	453.2	....	593.5
Pudding—								
Rice	1 0	11.7	1.8	141.3	36.3	15.8	522.8	574.9
Sugar	90	.4	....	86.8	1.2	....	323.2	324.4
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	230.4	644.1	1,477.6	2,352.1

Total nutrient units in day's rations, 7,594.4.

TABLE L —(*Continued.*)

Diet table prepared from one week's allowance of the new United States naval ration.

TUESDAY.

Food Allowed	Weight in Grams	Contents in Grams: Protein	Contents in Grams: Fats	Contents in Grams: Carbohydrates	In Nutrient Units: Protein	In Nutrient Units: Fats	In Nutrient Units: Carbohydrates	Sum.
Breakfast:								
Hash—								
Ham	180	27.5	52.0	....	96.2	457.7	....	553.8
Potatoes	345	6.9	.7	71.4	21.4	6.2	264.2	291.8
Onions	45	.8	.1	4.6	2.5	.8	17.0	20.3
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	172.7	639.7	912.8	1,725.2
Dinner:								
Soup—								
Beans	90	21.9	1.4	44.1	67.9	12.3	163.2	243.4
Pork	360	63.0	79.2	....	220.5	697.0	....	917.5
Tomatoes	45	.6	.1	2.0	1.8	.8	7.4	10.0
Pickles	90	....			....	....	....	....
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	342.8	885.2	802.2	2,030.2
Supper:								
Stew—								
Tomatoes	360	6.8	1.2	11.9	21.0	10.6	44.0	75.6
Bread	90	7.8	.9	67.0	24.2	7.9	247.0	279.1
Butter	15	....	12.2	....	....	107.4	....	107.4
Sugar	45	.2	....	43.4	.6	....	161.6	162.2
Cold beef	180	40.1	51.5	....	140.0	453.2	....	593.2
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	238.4	754.2	1,0:4.2	2,076.8

Total nutrient units in day's ration, 5,832.

WEDNESDAY.

Food Allowed	Weight in Grams	Contents in Grams: Protein	Contents in Grams: Fats	Contents in Grams: Carbohydrates	In Nutrient Units: Protein	In Nutrient Units: Fats	In Nutrient Units: Carbohydrates	Sum.
Breakfast:								
Baked beans	180	43.8	2.8	88.2	135.8	24.6	326.3	486.7
Pork	90	15.8	19.8	....	55.3	174.2	....	229.5
Catsup	....	....	....	....	....	....	....	....
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	243.7	373.9	957.9	1,575.5
Dinner:								
Sausages (Frankfort)	225	39.4	90.0	....	137.9	792.0	....	929.9
Cabbage	500	8.0	1.5	28.0	24.8	13.2	103.6	141.6
Turnips	270	3.5	.5	21.9	10.8	4.4	81.0	96.2
Potatoes	180	3.5	.4	37.3	10.8	3.5	138.0	152.3
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	236.9	988.2	954.2	2,179.3
Supper:								
Macaroni	110	9.9	.5	84.7	30.7	4.4	313.4	348.5
Cheese	45	14.0	11.0	1.0	49.0	96.8	3.7	149.5
Butter	10	....	8.4	....	....	73.9	....	73.9
Tomatoes	45	.6	.1	2.0	1.5	.8	7.4	9.7
Beef, corned	110	24.5	31.6	....	85.7	278.0	....	363.7
Bread, butter, etc.	....	16.8	19.7	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	219.5	629.0	956.1	1,804.6

Total nutrient units in day's rations, 5,559.4.

TABLE L.—(*Continued.*)

Diet table prepared from one week's allowance of the new United States naval ration.

THURSDAY.

Food Allowed	Weight in Grams	Contents in Grams			In Nutrient Units			Sum.
		Protein	Fats	Carbohydrates	Protein	Fats	Carbohydrates	
Breakfast:								
Stew—								
Beef	1̊80	40.1	51.5	....	140.0	453.2	....	593.2
Potatoes	270	5.5	.5	55.9	17.0	4.4	206.8	228.2
Carrots	45	.6	.2	5.0	1.5	1.7	18.5	21.7
Turnips	30	.4	......	3.0	1.5	....	11.1	12.6
Tomatoes	25	.3	....	1.0	1.0	....	3.7	4.7
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	213.6	634.4	871.7	1,719.7
Dinner:								
Beef, corned	360	56.1	94.3	....	196.0	829.8	....	1,025.8
Beets	110	1.8	.1	10.7	6.0	.8	39.5	46.3
Turnips	135	1.7	.3	11.0	5.5	3.0	40.7	49.2
Potatoes	180	3.5	.4	37.3	10.8	3.5	138.0	152.3
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	....	1,012.2	849.3	2,132.9
Supper:								
Rice	110	7.2	1.1	86.4	22.3	9.6	319.6	351.5
Eggs	72	6.0	6.0	....	21.0	52.8	....	73.8
Sugar	80	.4	....	77.2	1.2	....	285.6	286.8
Flavoring extract	....	....	....	....	....	....	....	....
Beef, corned, c ld	135	21.0	35.4	....	73.5	311.5	....	385.0
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	270.6	549.0	1,236.8	1,956.4

Total nutrient units in day's ration, 5,809.

FRIDAY.

Food Allowed	Weight in Grams	Protein	Fats	Carbohydrates	Protein	Fats	Carbohydrates	Sum.
Breakfast:								
Ham	180	27.5	52.0	....	96.2	451.6	....	547.8
Potatoes	315	6.3	.6	65.2	19.5	4.4	241.2	265.1
Onions	22	.1	....	2.0	.3	....	7.4	7.7
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	168.6	631.1	880.2	1,679.9
Dinner:								
Mutton, roasted	360	273.6	61.2	21.6	957.6	544.0	79.9	1,581.5
Peas	180	41.0	3.2	94.3	127.1	28.1	347.8	503.0
Butter	16	1.2	13.8	.1	4.0	118.8	.3	123.1
Potatoes, mashed	360	7.2	.7	74.5	22.3	6.1	277.6	306.0
Bread, butter, etc.	....	16.8	18.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	1,163.6	872.1	1,337.2	3,372.8
Supper:								
Salmon	270	57.2	34.6	....	200.2	304.5	....	504.7
Fruit, canned	90	.7	....	7.2	1.4	....	26.6	2 .0
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	254.2	479.6	658.2	1,392.0

Total nutrient units in day's ra'ion, 6,444.8.

TABLE L.—(*Continued.*)

Diet table prepared from one week's allowance of the new United States naval ration.

SATURDAY.

Food Allowed	Weight in Grams	Contents in Grams			In Nutrient Units			Sum.
		Protein	Fats	Carbohydrates	Protein	Fats	Carbohydrates	
Breakfast:								
Soup—								
Mutton	180	136.8	30.6	10.8	478.8	269.3	40.0	788.1
Potatoes	270	5.4	.5	55.9	16.8	4.4	207.2	228.4
Carrots	70	.8	.3	6.4	2.4	2.6	23.6	28.6
Onions	20	.3	.1	2.0	.3	.8	7.4	8.5
Turnips	90	1.2	.2	8.0	3.7	2.2	29.6	35.5
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum.	....	....	....	....	554.6	454.4	639.4	1,948.4
Dinner:								
Beans	70	17.0	1.0	34.3	52.1	8.8	126.9	187.8
Pork	360	63.0	79.2	....	220.5	685.2	....	905.7
Tomatoes	50	.6	.1	2.0	1.5	.8	7.4	9.7
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	326.7	869.9	765.9	1,962.5
Supper:								
Sausage, bologna	180	31.5	72.0	....	110.2	633.6	....	743.8
Cheese	90	26.5	21.6	1.8	92.4	190.0	6.6	289.3
Bread, butter, etc.	....	16.8	19.9	170.7	52.6	175.1	631.6	859.3
Sum	....	....	....	....	255.2	998.7	638.2	1,892.4

Our table is intended to show the food values, expressed in proteids, fats, and carbohydrates, that are contained in the different articles of food actually served out to the men during a week on board the U. S. S. *Prairie.* The table, incidentally, shows many points of considerable interest that are worthy of study; these I need not point out. The cardinal point brought out in the calculation is that the average daily number of nutrient units served in the form of food, per man, amounts to 5953, just twice the number required by an adult workingman of an average weight of 70 kilos. Hence our examination has shown conclusively that the new ration, as handled on board the U. S. S. *Prairie,* is overwhelmingly in favor of the quantitative sufficiency of the same.

As regards the relative proportions existing between proteids, fats, and carbohydrates, we have seen that they must accord with certain percentage requirements. A properly constructed ration must contain, according to the accepted standard, 20 per cent. in proteids, $13^{3}/_{10}$ per cent. in fats, and $67^{7}/_{10}$ per cent. in carbohydrates. The following "table of percentages" is intended to exhibit the results of an examination of our ration in this respect:—

TABLE LI.

Table of Percentages.

Days of the Week	In per cent.			Differences		
	Proteids	Fats	Carbo-hydrates	Proteids	Fats	Carbo-hydrates
Sunday	14.8	31.6	53.6	−5.2	+18.3	−13.1
Monday	11.4	41.8	46.8	−8.6	+28.5	−20 9
Tuesday	13.0	39.0	48.0	−7.0	+25 7	−19.7
Wednesday	12.6	35.8	51.6	−7 4	+22 5	−15.1
Thursday	11.3	37.8	50.9	−8.8	+24.5	−15.8
Friday............	24.6	30.8	44 6	+4.6	+17.5	−22.1
Saturday..........	19.6	40.0	40.4	− .4	+26.7	−26.3
Average	15.3	36.7	48.3	−4.7	+23.4	−18.4

In this table the various sums of the nutrient units in proteids, fats, and carbohydrates for the three daily meals expressed in percentages, occupy the first three columns and the plus and minus deviations from the required normal standard the last three columns. The table shows that the fats are in excess of the standard, while both the proteids and carbohydrates show marked deficiencies.

The conclusion reached after an examination of the diet table given above is that, from the point of view of sufficiency, the ration exceeds the requirements, but apart from this shows certain limitations.

WATER-SUPPLY.

Although all naval vessels and nearly all the larger vessels of the mercantile marine are at present supplied with distillers for the production of drinking-water from sea-water, they cannot be said to be entirely independent of the water-supplies from natural sources on shore. Circumstances arise on every vessel, and often at that, under which the water-tanks are filled with water from shore, and naval sanitarians, therefore, cannot yet afford to disregard the general hygiene of water-supplies from all sources. Since, however, this subject is treated of in another part of this work, the supply of drinking-water from sea-water, as usually done on board ships, will alone be spoken of in this connection.

On board all of the vessels of the United States Navy the so-called United States Standard Evaporator is used (see Fig. 35). This evaporator is made of several sizes, the largest of which possesses a productive capacity of 10,000 gallons of distilled water per diem. The general design is identical for all sizes. The apparatus

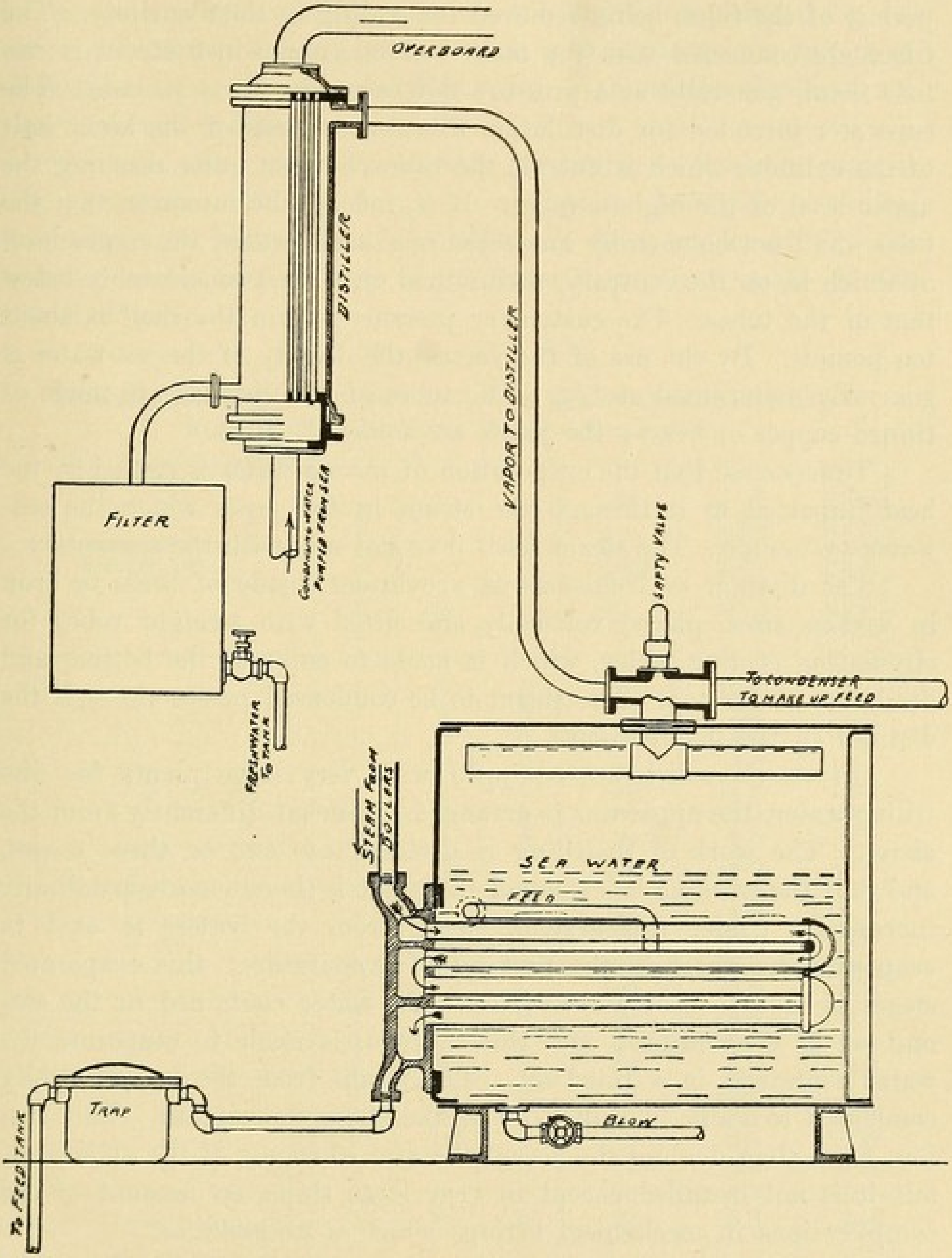


Fig. 39.—Distilling Plant as Installed in Vessels of the United States Navy.

consists of two parts, namely: (1) the evaporator, and (2) the distiller, sometimes called the condenser. The evaporator consists of a hollow, cylindrical shell, made of steel and placed horizontally. The lower half of this cylinder is occupied by tubes running lengthwise and fixed in their positions at either end to a pair of plates which permit of the tubes being removed for sealing in their entirety. The tubes are connected with the main boilers, from which steam is run into them, generally at a pressure not exceeding forty pounds. The sea-water intended for distillation fills that portion of the lower half of the cylinder which is outside the tubes, but not quite reaching the upper level of the highest tubes. It is, indeed, the intention that the tubes shall not be entirely immersed in the salt-water, the upper level of which is, on the contrary, maintained on a level considerably below that of the tubes. The customary pressure within the shell is about ten pounds. By the use of the valves, the density of the sea-water is generally maintained at $^4/_{32}$. The tubes of the distiller are made of tinned copper or brass; the joints are soldered.

Thus we see that the evaporation of the sea-water is caused by the heat imparted to it through the steam in the pipes which the sea-water surrounds. The steam itself does not mix with the sea-water.

The distiller or condenser is a cylinder, made of brass or iron in various sizes, placed vertically and fitted with straight tubes for circulating cooling water, which is made to enter at the bottom and discharge at the top. The steam to be condensed passes through the distiller in the inverse sense.

On vessels which are equipped with very large plants for distilling water, the apparatus is arranged somewhat differently from the above. The work of distilling is divided into two or three stages, and thus the working efficiency of the plant is thereby correspondingly increased. Under this system, steam from the boilers is used to evaporate the water in the first set of evaporators; this evaporated steam is used to heat and evaporate the water contained in the second set of evaporators; and this in turn, is made to evaporate the water contained in a third set. The steam from the last is finally condensed to water in a distiller of the above description. This system more than doubles the actual thermal efficiency of the apparatus, but it is not installed except in very large ships, on account of the complications in mechanical fittings which it necessitates.

The precautions usually observed are as follows: (1) The plant should be used only when pure sea-water is available. (2) For drinking-water, the apparatus should not be used to its full capacity, in order to reduce priming or carrying of salt-water directly over into the distillate. (3) Tests of the complete plant to be made daily to insure tightness of all the joints. (4) The water level in the evaporators is to be kept low. (5) When the ship is under way and rolling heavily, the plant must be worked at its lowest capacity. (6)

The pressure of the cooling water in the distiller is limited by departmental order to thirty pounds, which is to minimize the danger of salt-water leaking into the distiller. (7) Tests of the distillate are to be made every fifteen minutes.

That the water produced by this evaporator is liable to contain certain substances not expected to be present in chemically pure distilled water may be seen from the adjoining table, which exhibits the results of twenty-two analyses of the water it produces, made on the U. S. S. *Prairie*.

TABLE LII.

Tabulated Results of Twenty-two Analyses of Water Distilled from Salt Water by the United States Standard Evaporator.

U. S. S. *Prairie*, Gulf of Paria, January, 1902	Free Ammonia	Nitrites	Nitrates	Chlorine, in Milligrams per Litre	Hardness, in Milligrams Calcium Chloride	Organic Matter, Represented in Milligrams of Oxygen per Litre
3.	+	0	0	220	10.0	0.0
4.	0	0	0	30	5.0	2.0
5.	+	0	9	20	4 0	3.5
6.	+ +	0	0	10	6.0	1.7
7.	+	0	0	50	11.0	3.6
8.	+ +	0	0	20	16.0	2.0
9.	+	0	0	24	7 0	3.2
10.	0	0	0	130	13.0	6.5
13.	+	0	0	8	4.0	2.0
14.	+	0	0	12	4.0	3 0
16.	+	9	0	20	5.5	3.0
17.	+	0	0	20	6.0	3.0
18.	+ +	+ +	+	160	10.0	4.0
20.	0	0	0	30	4.5	4.5
21.	0	0	0	30	5.0	5.0
22.	0	0	0	20	5.0	3 0
23.	0	+ +	0	90	10.0	2.5
25.	0	0	0	12	7 0	2.0
26.	0	0	0	20	8.0	3 0
27.	0	0	0	32	6.0	2.0
28.	0	0	0	80	8 0	120.0
30.	0	0	0	32	5.0	3.0

These impurities are occasioned by defects in the water-making plant. The defects consist in slight leaks in the coils of the patent evaporator, which contain about forty-eight conical steam-joints, which are apt to work loose after long and hard usage. It may be readily seen that any leak of boiler steam through any of these joints must carry into the distiller whatever impurities it contains, such as salts of all kinds, rust, or grease.

The defect can be remedied by filling the coils of the patent evaporators with steam from the low-pressure side of the larger third evaporator. The effect of this change is to make the evaporating plant one of "double effect." The steam from the boilers enters the large evaporator-coils and evaporates salt-water. The steam from this evaporator, before going to the distiller, is condensed in the coils of the two smaller evaporators, and only passes through the distiller to be cooled. Of course, any leak from the steam side to the water side of the small evaporators involves a slight loss of efficiency, but such a leak, no matter how great, can no longer make the distillate impure.

Besides the impurities due to defects in the central distilling plant, we sometimes find that the drinking-water is contaminated from other sources. While the water taken from the distiller proves to be pure, an analysis of the water taken from any spigot may show that it is not safe to drink. Such impurities can be due only to dirty water-tanks or to faulty pipe connections. Thus, for instance, it will sometimes happen that one of the tanks is used for other purposes than the storage of the purest drinking-water and, before it was cleaned, drinking-water from the distiller is again run into it. Iron pipes may cause the water to be contaminated with iron rust, and lead pipes may contaminate it with small amounts of lead. All this goes to show how necessary it is that the water on board ship must be analyzed occasionally, and that the mere fact that the water is distilled must not be allowed to throw the sanitarian off his guard.

With regard to the daily allowance of water per man, there are no hard-and-fast rules in the navy according to which this is regulated. The natural consequence of this is, as might be expected, that the supply varies directly on board the different vessels with the individual caprice or the understanding of the officer in command, being dealt out liberally on some and parsimoniously on others. While there is, generally, enough drinking water allowed, there is in all the ships too much economy shown in the supply of the men with sweet water for purposes of bathing and washing clothes.

The result of this false economy is, first, that the men cannot keep their skins as clean as they ought to; and, second, for washing their clothes, the men with the cleanest habits and instincts will often get sweet water from forbidden sources and store it away in buckets which they hide in all conceivable places for future use, until they are discovered by the inspecting officer, when, of course, they not only lose the water, but are reported and punished for the misdemeanor. When it is considered, from a sanitary point of view, that it is economy to be lavish with the water supply, and that especially sailors should be so trained that cleanliness of person must become for them a habit, it will at once be seen how pernicious this practice is.

The great necessity for a proper care of the skin becomes especially apparent in the tropics, where, owing to the increased activity of the sweat-glands, skin eruptions and cutaneous abscesses are of the most frequent occurrence. Such troubles not only greatly add to the discomfort of the men, but are the efficient causes for numerous and frequent admissions to the sick-list, resulting in a loss to the service of a great many working days. That better facilities for bathing, for both officers and men, should be provided on board all the ships of the navy than are at present available is a fact upon which all officers agree. It is the duty of the sanitarian to do all in his power and urge this necessity upon the constructors of new vessels whenever he can.

Since it is, of course, out of the question that a sufficient number of bath-tubs be provided for a large ship's company, shower-baths can alone be considered for the men. In some of the larger war vessels of the German navy places for showers have been provided in which fifteen men may receive a douche at one time, so that, according to the calculations of Nocht, 300 men may be served in two hours' time, at an average expenditure of 1200 gallons of water. Since, besides this, 1½ gallons is the minimum allowance of water per man and per day for purposes other than drinking, we have here a basis for calculating the total water-supply needed for twenty-four hours and for the capacity of the distillers that are required to furnish the same.

The first receiving ship in the United States navy on which the wash-rooms and bath-rooms for the men have received the attention at all commensurate with their importance is the recently converted ship *Lancaster* at the Navy Yard, League Island, Pennsylvania. This ship provides accommodations for 720 men. The wash-room is on the forward part of the spar deck, having a cubic capacity of 3584 feet, and contains 12 reversible wash-basins, all supplied with hot and cold water. The bath-room has a cubic capacity of 2040 feet and contains 8 showers, supplied with hot and cold water, the temperature of which may be regulated. This very excellent arrangement calls for the widest possible general application on all sea-going vessels of the navy.

Before leaving the subject of the water-supply, a few words must be added on the scuttle-butt question. The scuttle-butt, so-called, is an iron tank filled with water and provided with one or more spigots near the bottom of it, from which the men take their drinking-water by means of a cup. This cup is suspected of being the means of the spread of infectious disease on shipboard, especially during the prevalence of epidemics like diphtheria, mumps, etc. Numerous recommendations have been made to eliminate this danger, one of the most recent ones being that of Dr. C. F. Stokes, U.S.N., who suggested that the cup be immersed in a solution of formaldehyde of 1:2500 while not in use. While this practice would undoubtedly diminish the chances of transmission of infection, it could not be said that it would altogether prevent it.

When we consider that the feeling of thirst generally manifests itself in a number of men at the same time, and that often from twenty to thirty men may be observed standing in a line and waiting their chances to use the same cup, the paraldehyde solution would not get a chance to act on any infectious material left on the cup by a previous drinker before the next one came along. The only possible way of preventing the transmission of infection by means of the cup is to do away with the cup altogether, and serve water through a fountain so constructed that a small stream of water may be directed into the back part of the mouth without the drinker having a chance to touch the little spout with his lips. This might easily be effected by converting the scuttle-butt into a cylinder provided at intervals on its circumference with several cup-shaped depressions, from the bottom of each of which a small stream of water is forced out by gravity and which could be regulated by a sort of spring-lock. While the rim of the depression might touch the face of the drinker, the cup-shaped depression ought to be made deep enough so that the lips could not touch the nipple of the spout. In order to catch the small amount of water that is spilt in the operation, a circular trough connected with a soil-pipe could be placed below the fountain.

VENTILATION.

Ventilation may be either natural or artificial. In nature, wind-currents are created by temperature differences. High temperatures over any point on the earth's surface cause the atmosphere to expand and, consequently, to rise; low temperatures have the opposite effect. A current is caused, therefore, proceeding from centres of low towards centres of high temperatures. We speak of ventilation as being natural, whenever air-currents are created by atmospheric temperature differences alone; ventilation becomes artificial whenever these natural currents are assisted by other physical or mechanical agencies.

The ventilation which is constantly taking place in our houses and dwellings may be taken as an example of natural ventilation. The porous nature of the building materials, the winds, the differences between the temperatures of the inside and outside air, are the efficient causes of this ventilation. In an experiment by von Pettenkofer it was found that in a room of 75 cubic metres capacity, one complete change of air occurred in one hour through a difference in temperature between inside and outside of 20° C. Under ordinary conditions, the cold air will enter below and the warmer air will make its escape from the top of the building.

Such natural ventilation, it will readily be seen, could never be expected to occur in a ship. A ship's bottom and sides are practically made both air- and water- tight. Hence, whatever fresh air is expected to get into a vessel must come from the top side and be made to find its way to all the various parts below before it can be said that the ship is at all ventilated. Since, moreover, a ship is divided into many separate compartments not in direct communication with the general ship's spaces, the air (the deeper it descends the warmer it must get) will be returned before it reaches the deepest parts of the ship; it thus must happen that a large portion of the inside of a ship will never be ventilated by natural means at all. This is also the reason why the air in ships is always found to be growing more and more contaminated, the deeper down towards the bottom it is examined. We may now also understand why it is that, in order to ventilate all ships effectively, we must resort to ventilation by artificial means.

Since the most economical, thorough, and efficient ventilation is that ventilation which aids the natural currents existing inside of a vessel, all artificial systems should be so arranged as to meet this *most important* requirement. In a steamer, for instance, of modern construction, such as a cruiser or battleship, with enormous fires and engine-rooms, large steam-pipes, and a number of auxiliary engines situated, for the most part, in the middle of the ship's space and radiating considerable amounts of heat, air-currents from all parts of a vessel would, under average conditions, move in their direction; that is, from the *colder, lower,* and *peripheral* portions toward the *warmer, higher,* and *central* parts of the compartments. All supply shafts in a ship, in accordance with this principle, should, therefore, be made to reach as nearly as possible the bottom and the most peripheral parts of any compartment to be ventilated, before being allowed to set free the imprisoned air which they brought down from above and which is intended for the ventilation of any particular compartment; while the outlets for the foul air should, for the same reasons, be nearest the middle line and open flush with the deck ceiling. It is in this manner only that any compartment can be most efficiently, as well as most economically, ventilated.

Different Methods of Ventilation.—A ship is said to be ventilated either by the vacuum or the plenum method, according as the greater motive power is in the discharge or in the supply part of the system. The power may be solely in either one or the other of the two parts, or it may be shared between them. Its predominance in the one or the other determines the "vacuum" or the "plenum" character of the system. (Woodbridge.)

Vacuum Method.—This method causes a current of air in an enclosure by a partial vacuum within it. Into such an enclosure the air then flows through every available channel, both provided and accidental. From whatever points, therefore, the pressure may be greater than in the enclosure ventilated by the vacuum method, from thence it will move toward that enclosure. Each space, therefore, is more or less at the mercy of its surroundings and of conditions beyond the control of its occupants. The vacuum method of ventilation on shipboard puts the breather at the point of discharge of foul air, and sends into the living spaces specimens of air from every part, near or remote, whether filled with pure or foul air.

Plenum Method.—This method, by putting each compartment under slight pressure, prevents leakage of air from adjoining compartments. It tends to accelerate the escape of foul air through natural outlets, and gives the occupants control over the source and the velocity of their air-supply. The method puts the breather at the point of supply and, consequently, in a position to breathe the best of air. It is recommended as the best by Rubner, Kirchner, Karl Schmidt, Notter, Harrington, Woodbridge, and Munson. It will supply a steady current of fresh air to all the compartments in a ship alike, and by tending to produce even conditions of temperature and pressure it will prevent untoward currents and countercurrents between the different enclosures, in spite of free communication existing between them.

The ideal aim of any ventilating system, in theory at least, would be the getting rid of foul air in an enclosure and the replacing of this by fresh air, without the two becoming mixed. In practice, however, and as Rubner has long since pointed out, we are obliged to take our air for inspiration out of the same reservoir into which we send our expiratory air. It would, therefore, seem impossible for any ventilating system to so sharply separate the good air from the foul air as to prevent the two from becoming mixed to a certain extent. All artificial ventilation must, accordingly, proceed after the manner of a process of dilution, and be so arranged as to keep the enclosed air from reaching a composition very much different from outside air. This is more especially the case on board all ships, naval as well as mercantile, under just such conditions when ventilation comes into play most beneficiently, namely, during maneuvres and in bad weather. It is, consequently, far more important to provide means for an abundant supply of fresh air in the ventilating of ships than it is to provide those for getting rid of foul air. The more general introduction of the plenum system in ships' ventilation is, therefore, most desirable, as well as in the most perfect keeping with the requirements.

Since the details of ship ventilation and the principles of the examination of air, as well as the sources of its contamination, have been very recently discussed by Beyer and Plumert, we may conclude this chapter by giving a description of the type plans for the ventilation of some of our newest designs of battleships.

But before giving this description, mention must be made of an important discovery as regards the composition of the air enclosed in the double bottoms, by Dr. C. M. Belli. It had been known for a long time that the air in these places became after a time so bad that it was dangerous to enter them, without testing the air first by means of a candle, and whenever that went out the air in them was renewed with a portable ventilator. It was always believed that the cause of the asphyxia was an accumulation of CO_2 in these places.

Belli, on the contrary, found, by a number of eudiometric analyses of specimens of air collected from these double bottoms, that while the CO_2 was present in the proportion of 1.4 per cent., the oxygen had decreased from 20 to 3 per cent. Hence it would seem that all previous cases of asphyxia reported as occurring in the double bottoms were due to a want of oxygen rather than to the presence of too much CO_2. Further experiments showed that the oxygen was indeed absorbed by the linseed oil and minium, a mixture with which the iron sides and bottoms of these compartments are thickly coated. It would not be surprising if it should be found, on further experimentation, that a want of oxygen more than the accumulation of CO_2 was, after all, the real cause of the insufferable condition of the atmosphere of places in ships other than the double bottoms. Experimental inquiries alone can establish the truth of this supposition.

The Ventilating System of the Idaho and Mississippi.—The *Idaho* and *Mississippi* are sister ships and classified as first-class sea-going and coast-line battleships. Their length and breadth, at load water-line, are 375 and 77 feet respectively. The displacement is 13,000 tons. They have a bridge deck, upper deck, main deck, berth or protective deck, and an upper and lower platform. They will each carry a complement of not less than 720 officers and men.

According to the designs of these vessels, it is the intention to provide artificial ventilation for all quarters, living spaces, passages, store-rooms, and magazines below the main deck, as well as for the air-spaces over the boiler- and engine- rooms and around magazines; for the water-closets and similar enclosures above the main deck and for turrets. The hull-ventilating arrangements for these vessels were designed in accordance with what are considered the latest approved methods, the efficiency of which was demonstrated by numerous experiments. The system has been so subdivided as to render unnecessary the piercing of any of the principal water-tight bulkheads with the ducts except where shown in the type plans (Figs. 36, 37, and 38).

These vessels, having a system of hatches and skylights opening through the various decks in nearly vertical lines, in a number of the principal subdivisions, it was not considered necessary to install both "supply" and "exhaust" systems for any spaces except the dynamo-rooms. The main hull ventilation will therefore, be fitted as shown in the type plans (see Figs. 36, 37, and 38) with the single-way system. The water-closets, etc., on the main deck will be ventilated on the "exhaust" system and the remaining compartments, except the dynamo-rooms, on the "supply" or "plenum" system only.

The ducts are designed to pass the number of cubic feet of air per minute through each terminal as may be seen on the type plans (see Figs. 36, 37, and 38), or to equal the total number of cubic feet per minute for each compartment as marked on the plans, with the fans running at a speed corresponding to 1 ounce pressure with restricted delivery. This will allow the air to be renewed in the various spaces approximately as follows:—

1. Officers' quarters and crew space, berth deck outside of transverse armor, in about twelve minutes, or four times in one hour.

2. Officers' quarters, crew space, and general work-shop, within transverse armor, in about five minutes, or twelve times in an hour.

3. Water-closets and crew's head in about five minutes.

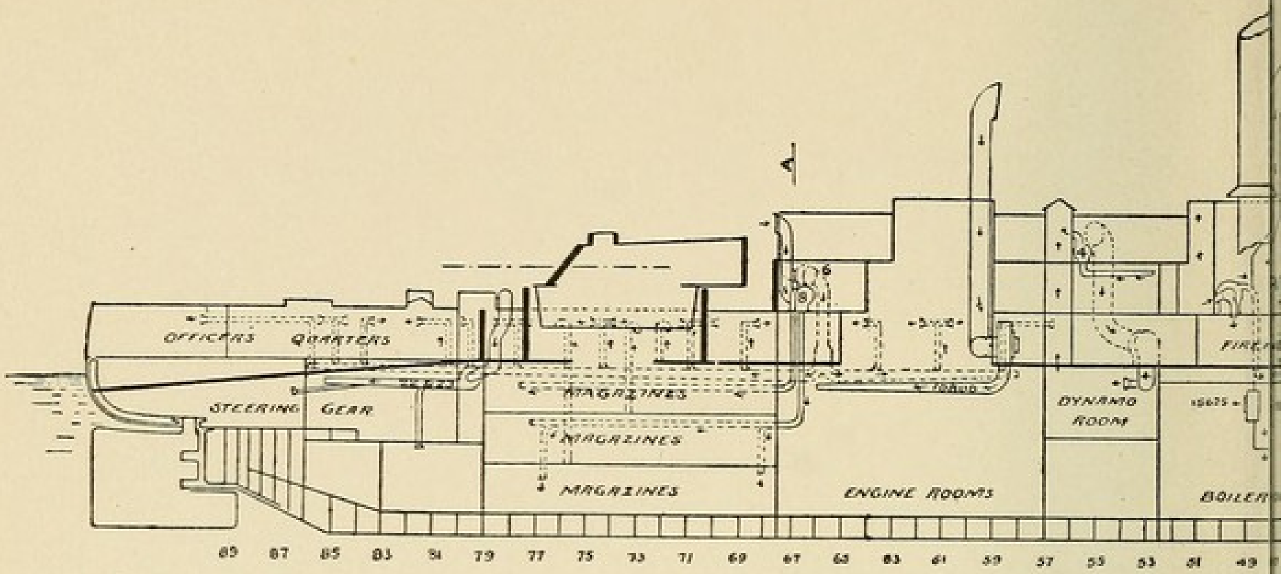
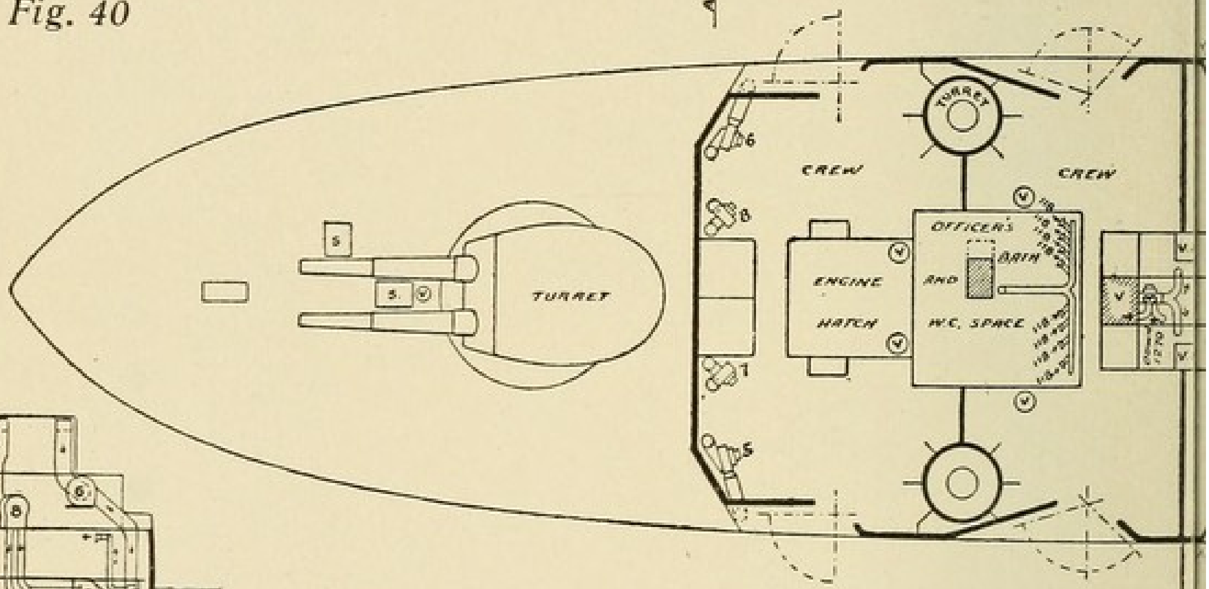
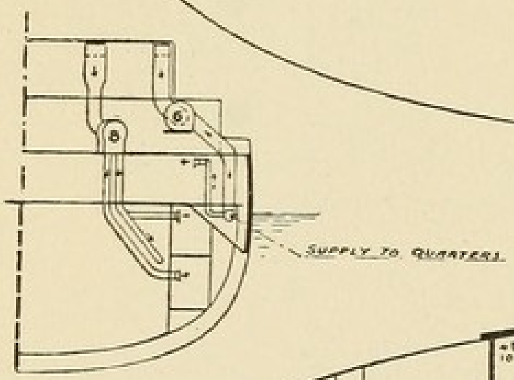


Fig. 40





SECTION AA.

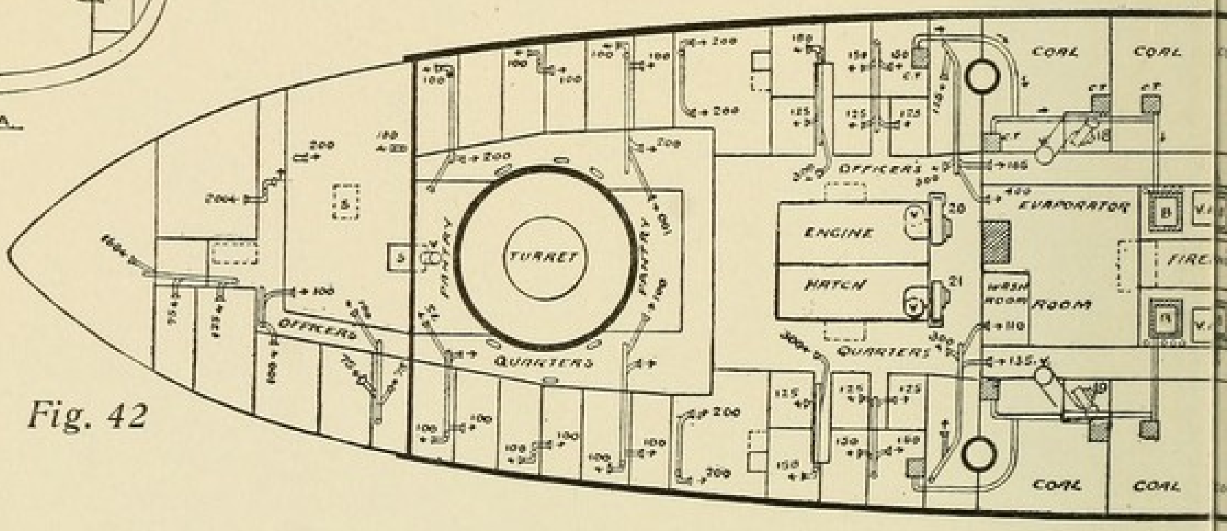


Fig. 42

Figs. 40, 41, 42.—Plans showing Arrangem

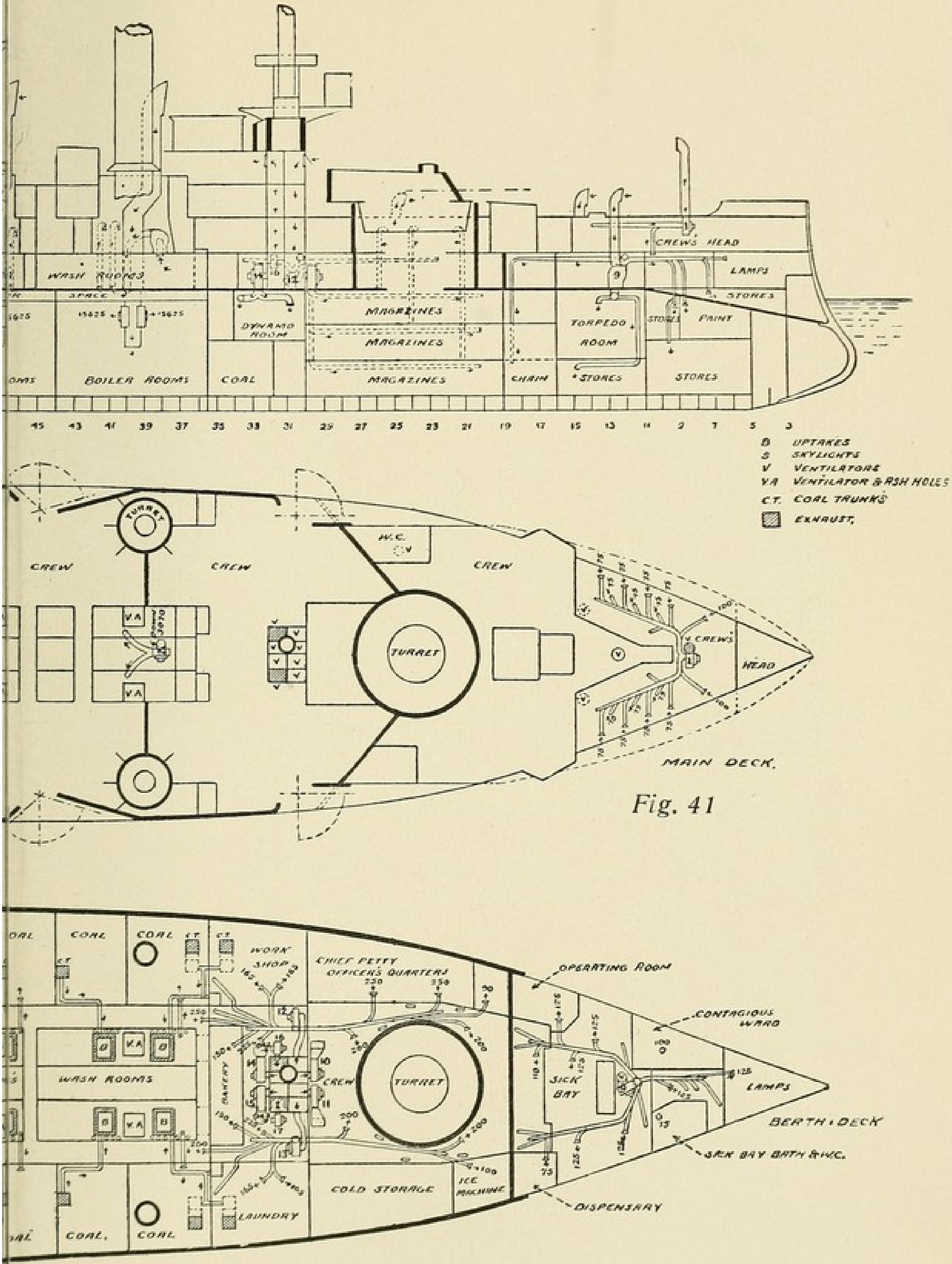


Fig. 41

of Ventilation on the Idaho and Mississippi.

4. Store-rooms in general, magazines, and passages in about eight minutes.

5. Engine-rooms and steering compartments in about two minutes.

6. Evaporator-rooms in about two and a half minutes.

7. Air-space over boilers in about one minute.

8. Dynamo-rooms in about three-quarters of a minute.

Twenty-three fans are required for the ventilating system of these vessels, all to be electrically driven and to be located as indicated on the plans (see Figs. 36, 37, and 38).

Fan No. 1.—To exhaust from water-closets, etc., on the main deck forward of bulkhead No. 15, and also from sick-bay water-closet and contagious ward.

Fans Nos. 2 and 3.—To exhaust from firemen's wash-rooms, evaporator-rooms, and passages on berth deck, between bulkheads 35½ and 57. The discharges from these fans to be used for ventilating the air-spaces over boilers.

Fan No. 4.—To exhaust from officers' water-closets on main deck between bulkheads 52½ and 59. The discharge to be used to assist exhaust from after dynamo-room.

Fans Nos. 5 and 6.—To supply fresh air to officers' quarters and to compartments above protective deck abaft bulkhead 57.

Fans Nos. 7 and 8.—To supply fresh air to magazines and store-rooms below protective deck, between bulkheads Nos. 67½ and 79, and also to ammunition passages aft of frame 48.

Fan No. 9.—To supply fresh air to sick-bay, operating room, dispensary, store-rooms, and passages above protective deck and forward of bulkhead No. 19; and also to all compartments below protective deck and forward of bulkhead No. 19, except chain lockers and trimming tanks.

Fans Nos. 10 and 11.—To supply fresh air to magazine and store-rooms below protective deck, between bulkheads Nos. 19 and 30.

Fans Nos. 12 and 13.—To supply fresh air to compartments on berth deck between bulkheads Nos. 19 and 35½ and to ammunition passages between frames 30 and 48; also to communication room, and forward distribution board-room.

Fans Nos. 14 and 15.—To supply fresh air to forward dynamo-room.

Fans Nos. 16 and 17.—To exhaust from compartment between bulkheads Nos. 30 and 35½ on berth deck, the discharge to be used to assist exhaust from the forward dynamo-room.

Fans Nos. 18 and 19.—To supply fresh air to after dynamo-room and after distribution board-room.

Fans No. 20 and 21.—To supply fresh air to engine-rooms.

Fans Nos. 22 and 23.—To supply fresh air to steering compartments and store-rooms on upper platform aft of bulkhead No. 79; also to hold between bulkheads Nos. 79 and 83.

It is the intention to supply all these fans with power sufficient to run them continuously, when necessary, at a speed required to produce $1\frac{1}{2}$ ounces pressure, under conditions of shop test, but to have such variation in speed as will permit them to run under ordinary service conditions at the speed required to produce 1 ounce pressure.

In designing the ventilating system for these ships, great care has been taken to allow for the loss of capacity due to frictional resistance, and special attention was paid to the bends in the ducts, none of which are to be made with a radius of throat smaller than the diameter of the duct. It was found by experiment that the loss due to friction in a twenty-foot length of straight duct is about 10 per cent., and that the loss in a ninety-degree bend, when properly constructed, with a radius of throat not less than the diameter of the duct, is about the same amount. If the bends are made with a sharp joint or with a smaller radius, the loss will be greater. The ducts are to be made smooth inside and free from all internal projecting lips and other obstructions. The branches and terminals will be made to leave the main duct at an angle of not more than 15 degrees to the direction of the air-current and be curved to the desired direction by a very easy bend. All magazine terminals will be fitted with automatic ball attachment and cage, protected by portable one-half inch wire mesh covering the same. McCreery or other equally effective adjustable elbows, fitted with butterfly dampers, will be used for terminals in all quarters, living spaces, and elsewhere, as shown in type plans (Figs. 36, 37, and 38). All the openings of these elbows are to be fitted with portable wire mesh, not less than one-half inch. All other terminals to be stationary and, except those ending in valves, to be fitted with plain butterfly dampers and portable iron mesh, not less than one-quarter inch. All terminals to be bell-mouthed to twice their area, where fitted with wire mesh.

TABLE LIII.

Tabulated Index to Artificial Ventilation Arrangements of "Idaho" and "Mississippi," Shown in Part in Figs 36, 37, and 38.

FAN	SPACE	Time of Air-Renewal Minutes	Cubic Feet Per Minute About
EXHAUST No. 1—Main deck Capacity, 1725 cubic feet per minute 1 oz. pressure	Crew's head, over water-closets	6	800
	" " urinals	6	450
	" " wash-basins	6	300
	Contagious ward	6	100
	Sick bay bath-room	6	75
EXHAUST No. 2—Main deck Capacity, 3070 cubic feet	Exhaust from firemen's wash-room and supply to air-space over boilers	1	3070
EXHAUST No. 3—Main deck Capacity, 3070 cubic feet	Exhaust from firemen's wash-room	1	1270
	" " dynamo-room and supply to air-space over boilers	1	1800
EXHAUST No. 4—Upper deck Capacity, 943 cubic feet	From officers' bath and water-closet space	4	943
SUPPLY No. 5—Main deck Capacity, 4640 cubic feet No. 6— 4640 cubic feet	Captain's after-cabin	10	160
	" dining-cabin	10	200
	" state-room	10	125
	" bath-room	10	75
	" office	10	100
	" pantry	10	50
	Ward-room Dining-room	10	400
	" state-rooms behind armor	4	100
	" state-rooms not behind armor	10	75
	" pantry	4	150
	Junior and warrant officers' mess-rooms (each)	4	400
	Junior and warrant-officers' state-rooms (each)	4	125 150
	Junior and warrant-officers' pantries (each)	4	125
	Country in vicinity of officers' quarters	4	2100
SUPPLY No. 7— Capacity, 4640 cubic feet No. 8— Capacity, 4640 cubic feet	Magazines on upper platform	8	2200
	" " lower "	8	1650
	" in hold	8	350
	Passages and handling-rooms	8	3150
	Storerooms	8	1620
SUPPLY No. 9—Berth deck Capacity, 5320 cubic feet	Sick Bay	3½	600
	Operating-room	3½	125
	Dispensary	3½	75
	Lamp-room	8	125
	Paints and oils	8	200
	Torpedo manipulating-room	8	1600
	Fresh water tank space	8	200

TABLE LIII.—(*Continued.*)

Tabulated Index to Artificial Ventilation Arrangements of "Idaho" and "Mississippi," Shown in Part in Figs. 36, 37, and 38.

FAN	SPACE	Time of Air-Renewal Minutes	Cubic Feet Per Minute About
SUPPLY No. 10— Capacity, 3690 cubic feet No. 11— Capacity, 3690 cubic feet	Magazines on upper platform " on lower " " in hold Passages and handling-room Store-rooms	8 8 8 8 8	1850 1720 1080 1200 940
SUPPLY No. 12—Berth deck Capacity, 3070 cubic feet No. 13— Capacity, 3070 cubic feet	Bakery Workshop Chief petty officers' quarters " " " wash-room Crew space, berth deck Ice machine room Ammunition passages Passages Communication-room Laundry	8 5 5 5 5 5 8 8 8 5	150 330 500 90 400 100 2170 1300 80 300
SUPPLY No. 14—Berth deck Capacity, 5320 cubic feet No. 15— Capacity, 5320 cubic feet	To forward dynamo-room	$\frac{3}{4}$	10,640
EXHAUST No. 16—Berth Deck Capacity, 943 cubic feet No. 17— Capacity, 943 cubic feet	Crew space	8	1886
SUPPLY No. 18—Berth deck Capacity, 5320 cubic feet No. 19— Capacity, 5320 cubic feet	To after dynamo-room	$\frac{3}{4}$	10,640
SUPPLY No. 20— Capacity, 10,800 cubic feet No. 21— Capacity, 10,800 cubic feet	To engine-rooms	2	21,600
SUPPLY No. 22— Capacity, 1190 cubic feet No. 23— Capacity, 1190 cubic feet	To steering gear Storerooms	2 8	1615 765
SUPPLY Two in each boiler-room each 15,625 cubic feet	Each boiler-room		31,250

QUESTIONS TO CHAPTER XI.

MARINE HYGIENE.

Define marine hygiene. In what respects does it differ from naval hygiene? What are the causes of the decrease in morbidity and mortality in modern ships as contrasted with those in the old ships? What is the mortality rate among seafaring people in recent times? Name some of the most prevalent diseases.

On what system is a ship drained? What are the separate functions of the main, secondary and auxiliary drains, respectively? How is the bilge formed? Where is the bilge-room located? What changes in the construction of ships have affected the location of the bilge space and how? How is the composition of the bilge affected by these changes? What is a bilge-well? What is a Macomb strainer and its object?

What is the chemical and bacteriological composition of bilge-water? How many distinct types of bilge-water may be distinguished on board a man-of-war? What are the distinguishing characters in each? What are the chances of bacterial infection from infected bilge-waters?

What are the different decks on a merchant ship called? Name the different decks on a battle-ship? What is the location of the engine- and fire-room? What and where are the double bottoms? Describe the location of the men's quarters. What is the usual cubic air-space per man allowed, (1) on merchant ships, and (2) on war-vessels?

What is the effect of dampness on shipboard on the health of the men? How is the bilge-room cleaned? Name some of the special precautions to be observed in the disinfection of ships in special cases. Enumerate the most necessary disinfecting agents on board, and define the uses of each. Describe in detail the process of Nocht and Giemsa for the extermination of rats.

What is meant by the term "ration" and what is the difference between it and an ordinary "bill-of-fare"? What are the food values per gram of proteids, fats, and carbohydrates respectively? What are the relative proportions in proteids, fats, and carbohydrates to which the composition of a complete meal should correspond?

Describe the U. S. standard evaporator. What may be the sources of contamination in the water distilled by this machine? What are the substances occasionally found in such water? What is a reasonable allowance per man and per day on board ship? What are the dangers of the scuttle-butt cup and how are they to be prevented?

Give an example of natural ventilation. What is the object of artificial ventilation, and how must it be arranged to be most effective as well as economical? What are the different methods of artificial ventilation, and what does each method do? Which of the two is best adapted to ships? Describe the main features of the ventilating system of the *Idaho* and *Mississippi*.

CHAPTER XII.

PRISON HYGIENE.

ALTHOUGH the frightful mortality which formerly seemed a necessary accompaniment of the life of the convict has in the past half-century markedly diminished, the death-rate among prisoners is still very greatly in excess of that of persons of the same age in a state of liberty.

The observations and labors of John Howard, the self-sacrificing philanthropist, and of Elizabeth Fry, directed the attention of legislators to the necessity of reform in the conduct of prisons and the treatment of prisoners. As a consequence of the labors of these reformers, the principles of prison discipline have been more fully developed during the past forty years by students of social science everywhere, and certain propositions have been formulated, which govern, to a greater or less degree, legislation upon this subject. These propositions are, briefly, as follow:—

Prisoners must be properly classified according to the nature of their crime and the duration of imprisonment.

The two sexes must be strictly separated, and no opportunity given for intermingling while in the prison.

Female prisoners should have female attendants exclusively. Male watchmen or other attendants should not be allowed in the female department of a prison.

All prisoners must be kept employed at some manual labor, not necessarily for profit, but as an agency in the moral reformation of the convict.

Punishments for infractions of discipline must not be excessive.

Efforts should be constantly made tending to the reclamation of criminals from their life of sin and crime.

Due care must be taken by the State to preserve the health and life of the prisoner whom the State has deprived of liberty and the opportunity of taking care of himself.

A proper classification of prisoners, according to the degree of their criminality, the nature of the crime of which they have been convicted, or the length of time for which they have been sentenced, is now insisted upon by all students of prison discipline. As this subject more nearly concerns the social or legal relations of prisoners rather than their sanitary interests, it is here passed over with a mere mention.

The separation of the sexes, necessity of female attendants on prisoners of the same sex, employment of prisoners, and moral reformation of criminals likewise belong especially to the social aspects of the question, and can find no discussion in this place.

Regarding the remaining proposition, however, that which demands that the State shall exercise due care over the prisoner's health, it comprises a question that demands consideration in a text-book of hygiene.

There is now a general concurrence of opinion that the State, in depriving any person of liberty, has no right to subject the individual suffering such deprivation to any danger of disease or death. In other words, the State has no right to abbreviate the life of the convict sentenced to prison. This proposition requires that the State see to it that the prisoner is well fed, well clothed, and well housed; that he shall be well cared for when sick, and that when his term of imprisonment expires he shall be set at liberty, with only such effect upon his normal expectation of life as would result from the ordinary wear and tear of life upon his health.

It must be confessed, however, that the State is very far short of attaining this object. The mortality of convicts, even in the best-regulated prisons, where especial attention is paid to the sanitary requirements of such buildings, is three times as great as among workmen in mines, confessedly one of the most dangerous occupations. If insurance companies desired to insure the lives of prisoners, the companies would be obliged, in order to secure themselves against loss, to make the premium equivalent to an advance in age of twenty years. This means that a free person has as long expectation of life at 40 years as a prisoner has at 20. Attention is again called to the fact that the conditions in the most favorably situated and liberally managed prisons only are here considered. What the results are in other institutions, less favorably constructed and managed, will be apparent from the following brief statement: Mr. George W. Cable[1] has shown that in some of the prisons in the Southern States, under the vicious lease system, the mortality is eight to ten times greater than in properly constructed and managed prisons elsewhere. In Louisiana, for example, 14 per cent. of all the prisoners died in 1881;

[1] Century Magazine, February, 1884.

and in the convict wood-cutting camps of the State of Texas one-half of the average number so employed during 1879 and 1880 died.

The mortality of prisoners is greatest in the second, third, and fourth year of their confinement. In Millbank Prison, in England, the death-rate per 1000 was 3.05 in the first year, 35.64 in the second, 52.26 in the third, 57.13 in the fourth, and 44.17 in the fifth years of imprisonment.

The diseases most frequent among prisoners are pulmonary phthisis and diseases of inanition, manifested by general dropsy. Consumption furnishes from 40 to 80 per cent. of all deaths. When prisoners are attacked by acute febrile or epidemic diseases (small-pox, cholera, dysentery), the mortality is much higher than among persons in a state of liberty. This fatality is due to an anemic or cachectic condition, which has been called "the prison cachexia,"—a depravement of constitution which yields readily to the invasion of acute diseases. Recently a number of model prisons have introduced modern sanatorium treatment of consumptive prisoners.

Prisons should be built upon a healthy site, be properly heated and ventilated, have an abundant water-supply, and be supplied with facilities for a prompt and thorough removal of sewage. Baths and lavatories should be conveniently arranged in order that thorough cleanliness can be enforced.

The problem of feeding prisoners requires careful study. The food should not only be sufficient in quantity and of good quality, but it should be well cooked, and the bill-of-fare varied often in order to avoid creating a disgust by an everlasting sameness. Prisoners often suffer from nausea and other digestive derangements, brought on solely by the monotonous character of the daily food.

In workshops and sleeping-rooms, dormitories or cells, the cubic air-space allowed to each inmate should not be less than 17 cubic metres, with proper provision for ventilation. The use of dark or damp cells as places of confinement is a relic of the barbarism in the treatment of convicts against which John Howard raised his voice so effectively in the last century. An abundance of sun-light should be admitted into every room in which a human being is confined.

An important hygienic measure is daily exercise in the open air. It should be regularly enforced, and its modes frequently varied in order that it may not degenerate into a mere perfunctory performance.

Punishment for infractions of the prison discipline should be inflicted without manifestation of passion, and only under the immediate direction of some official responsible to the State. It is questionable whether physical punishments, such as whipping, tricing up by the thumbs with the toes just touching the floor, bucking and gagging, and similar barbarities should be permitted under any conditions. The permission to exercise such power is extremely liable to be abused by officials. The system of leasing out prisoners to private parties which prevails in some of the southern United States is vicious in the extreme, because it places the convict under the control of persons not responsible to the State, and, in the majority of instances, morally unfitted to wield the power of inflicting punishment.

QUESTIONS TO CHAPTER XII.

PRISON HYGIENE.

How does the mortality of those who are in prison compare with those of the same age who are free? What philanthropists called early attention to the abuses of prisons and prisoners? What fundamental propositions now practically govern prison legislation? Why must the State exercise due care over the prisoner's health? What must the State do to attain this object? Does it succeed in doing it? How does the excessive mortality compare with that of dangerous occupations? How does the expectation of life compare with that of those outside of prison? What is the mortality where the lease-system obtains? When is the mortality among prisoners greatest? What diseases are most frequent among prisoners? What is the effect of acute febrile or epidemic diseases upon prisoners? To what is this due?

What principles should be observed in prison construction? What points should be particularly observed regarding the food of prisoners? How much air-space should be allotted to each prisoner, whether in workshops or cells? What precautions should be taken against dampness and absence of sunlight? What is another important measure that should be enforced daily? How should all punishments be inflicted, and what ones should be prohibited? What can be said of the lease system?

CHAPTER XIII.

PERSONAL HYGIENE.

All sanitary and hygienic precautions relate more or less directly to the person, but those principles which concern most intimately the habits and body of the individual, rather than his surroundings and environment, are conveniently grouped in a class denominated *Personal Hygiene.*

EXERCISE AND TRAINING.

Exercise is the performance of work, or overcoming resistance. To be efficacious from a hygienic standpoint, it must affect not only all the voluntary muscles, but every organ and tissue of the body.

The healthy functions of the bodily organs can only be maintained by more or less constant use. A muscle or other organ that is unused soon wastes away, or becomes valueless to its possessor. On the other hand, trained use of the various organs makes them more effective for the performance of their functions. Thus, by practice, the eye can be trained to sharper vision; the ear to distinguish slight shades of sound, the voice to express varying emotions, the tactile sense to accurately appreciate the most minute variations of surface and temperature, and the hand to greater steadiness or the performance of difficult and complex feats. The effectiveness of other organs, muscles, or groups of muscles can also be increased by systematic training, as is seen in the athlete and gymnast.

When a muscle contracts, the flow of blood through it is increased. Hence, contraction of a muscle, which consumes or converts stored-up energy, at the same time draws upon the circulation for a new supply of food-material to replace that consumed. The activity of the circulation through a muscle in action results in increased nutrition and growth of the muscle.

During muscular action the activity of the respiratory process is increased. A larger quantity of air is taken into the lungs, more oxygen is absorbed by the blood, and an increased elimination of carbon dioxide takes place. The experiments of Pettenkofer and Voit show that, while in a state of rest the average absorption of oxygen in twelve hours amounted to 708.9 grammes, during work the amount reached 954.5 grammes. For the same period the elimination of carbonic dioxide was: during rest, 911.5 grammes; during work, 1284.2 grammes.

Upon the circulation muscular exercise likewise exerts a manifest influence. The action of the heart is increased both in force and frequency, the arteries dilate, and the blood is sent coursing through the system more rapidly than when the body is at rest.

Cutaneous transpiration is also promoted by muscular exercise. In this way some of the effete matters in the system are removed, being held in solution and carried through the skin in the perspiration, helping out the kidneys in the performance of their function, and saving them from undue wear and tear.

There can be no question that systematic training of the muscles has a favorable influence upon health and longevity. Persons who are actively engaged in physical labor, other things being equal, are healthier, happier, and live longer than those whose occupation makes slight demands upon their muscular system. In default of an active occupation the latter class is forced, if good health is desired, to adopt some form of exercise which will call the muscles into activity.

The principal methods of physical training are walking or running, rowing, swimming, out-of-door games, such as golf, tennis, foot-ball, and base-ball, and the various in-door gymnastic exercises. Rapid walking or running is one of the best methods of physical exercise, for, not only are the muscles of the legs and thighs developed, but the capacity of the chest is increased—one of the principal objects of physical training. By combining walking with some form of in-door gymnastics, such as practice with dumb-bells, Indian clubs, rowing-machines, or pulley-weights, nearly all the good effects of the most elaborate system of training can be obtained.

For the gymnastic exercises various forms of useful labor may be substituted with advantage, such as wood-chopping or sawing, or moderate work at any physical labor.

The scheme of studies in our public-school system should include physical training for both sexes. This is a question not merely of individual, but of national importance. Weak and unhealthy children are not likely to grow up into strong and healthy men and women; and the latter are necessary for the perpetuity of the nation. The time seems to have arrived when physical education should no longer be looked upon as a whim of unpractical enthusiasts and hobby-riders, but as an indispensable element in every school curriculum.

There is a tendency among instructors in physical training to make their systems too complicated, or dependent upon expensive or cumbersome apparatus. This is to be deprecated. All the muscles of the body can be called into action by very simple exercises, easily learned and readily carried out.

An important preliminary to all methods of training is a thorough physical examination of the pupil by a competent physician, in order to determine whether certain exercises are allowable. For example, in all organic heart affections exercises of a violent character must be interdicted. A boy or man with valvular disease of the heart cannot run, row, or swim with safety. The organ is easily overtasked in this condition and liable to fail in its function.

One of the simplest and best methods to cause the pupil to assume a correct position of the body, and to acquire ease and grace in his movements, is to teach him the "setting-up," as practiced in the United States army.[1]

In walking, a free, swinging step should be acquired, with the head erect, shoulders thrown back, and the chest well to the front, the whole body from the hips upward inclining slightly forward. The clothing should be loose around the upper part of the body, in order not to interfere with the freest expansion of the chest, and to give the lungs and heart ample room for movement. Even in-door gymnastic exercises alone, when practiced under intelligent provision, will accomplish very favorable results, as shown by the following table:—

TABLE LIV.

Showing Average State of Development on Admission to Gymnasium; Average State of Growth and Development after Six Months' Practicing Two Hours a Week, and Average Increase During that Time. (Bowdoin College Gymnasium, under Dr. D. A. Sargent. Two Hundred Students from the Classes of 1873 to 1877, inclusive. Average Age, 18.3 Years.)[2]

	On Admission.	After Six Months' Practice.	Average Increase.
Height	170.0 cm.	170.6 cm.	0.6 cm.
Weight	60.7 kg.	61.6 kg.	900.0 gms.
Chest (inflated)	87.5 cm.	91.8 cm.	4.3 cm.
Chest (contracted)	80.6 "	82.4 "	1.8 "
Forearm	25.0 "	26.8 "	1.8 "
Upper arm (flexed)	27.5 "	29.0 "	1.5 "
Shoulders (width)	38.7 "	40.5 "	1.8 "
Hips	78.7 "	84.4 "	5.7 "
Thigh	48.7 "	52.6 "	3.9 "
Calf	31.2 "	33.0 "	1.8 "

[1] Upton's Infantry Tactics. School of the Soldier, Lesson I.

[2] Apparatus used: Weights, 4500 to 6750 grammes; Dumb-bells, 1125 grammes; Indian clubs, 1575 grammes; Pulleys.

The table on the following page shows the average rate of increase in development in a two years' and a four years' class in Amherst College, and also the percentage of increase in one four years' class from entrance to graduation. The interesting fact has been brought out by Mr. Delabarre that tobacco-smoking has a decidedly deleterious effect upon the rate and percentage of physical development in students. In weight non-smokers gained 24 per cent. over smokers; in height, 37 per cent., and in chest-girth, 42 per cent.

However necessary for the preservation of health physical exercise may be, overexertion should be carefully avoided. Overstrain and hypertrophy of the heart are often the results of excessive exertion. Dr. Da Costa has described a form of "irritable" and weak heart occurring especially among soldiers, which he has clearly traced to overexertion. Severe labor and violent athletic exercises have been followed by like serious results. Long-distance pedestrianism has furnished, within recent years, quite a number of individuals who were broken down in health by the excessive strain on the physical organization involved. Cardiac strain is not infrequent among this class. Spasm, paralysis, or atrophy of muscles sometimes results, when these are exhausted by uninterrupted or excessive exercise. This effect is shown by writers' and telegraphers' cramp, and similar affections. For these reasons it is important that exercise both for health and for actual work should be so regulated as to conduce to the individual's benefit, and not to his detriment.

As to the amount of exercise required, Dr. Egbert says (Hygiene and Sanitation, p. 283): "It is hard to determine how much exercise any given person ought to take, as the personal equation varies so much. The average healthy man should probably do work equivalent to 150 foot-tons daily. The work of walking on a level at the rate of three miles per hour is said to be equal to that of raising one-twentieth of the body-weight through the distance walked. According to this, a man of 150 pounds in walking one mile does work equal to 17.67 foot-tons, and his total daily physical labor should be equivalent to walking about nine miles at the above rate to get the proper amount of daily exercise. This seems like an excessive amount, but if the actual physical work of one's customary vocation be taken from this, it will not leave so very much for the daily health-task; and while the natural disinclination of many to exercise grows stronger by indulgence, and while urgent reminders are wanting and the evils arising from the neglect, abuse, or misuse of exercise are not so very immediate or apparent, the latter are still certain to result, and are not at all consistent with good and perfect health."

Table LV.

Showing Physical Gains of Students in Amherst College During a Part and During the Whole of the College Course. (Prof. E. Hitchcock, Dr. H. H. Seelye, and Mr. F. A. Delabarre.)

	Gain of Two Years' Class.		Gain of Four Years' Class.		Per Cent. of Increase in Class of '91.	
	Metric.	English.	Metric.	English.		
Weight	[a]2.6	[d]5.72	5.40	11.8	8.9	Weight, 8.9
Height	.11	.43	.16	.63	0.6	
Sternum	.3	.11	.11	.43	0.7	
Navel	.4	.15	.9	.35	1.2	Height, 2.72
Pubes	.8	.31	.5	.19	3.3	
Knee	.4	.15	.12	.47	0.4	
Sitting	.14	.55	.18	.7	1.3	
Girth, Head	.5	.19	.7	.27	0.5	
Neck	.10	.39	.14	.55	2.5	
Chest repose	.14	.55	.41	1.61	3.0	
Chest full	.9	.35	.34	1.33	1.0	
Belly	.10	.39	.41	1.61	4.1	
Hips	.15	.59	.36	1.41	2.4	
Right thigh	.19	.74	.24	.94	3.0	
Left thigh	.13	.51	.25	.98	3.1	
Right knee	.4	.15	.6	.23	0.8	
Left knee	.3	.11	.7	.27	1.1	
Right calf	.9	.35	.13	.51	2.8	
Left calf	.11	.43	.10	.39	2.3	Girth, 2.72
Right instep	.2	.07	.8	.31	0.8	
Left instep	.2	.07	.9	.35	0.8	
Upper right arm	.13	.51	.13	.51	6.3	
U. R. A. contracted	.11	.43	.17	.66	6.4	
Upper left arm	.14	.55	.16	.62	7.8	
Right elbow	.6	.23	.6	.23	3.5	
Left elbow	.6	.23	.5	.19	3.5	
Right forearm	.4	.15	.5	.19	3.3	
Left forearm	.3	.11	.6	.23	3.1	
Right wrist	.1	.03	.2	.07	0.0	
Left wrist	.2	.07	.3	.11	0 6	
Breadth, Head	.1	.03	.3	.11	0.6	
Neck	.2	.07	.4	.15	1.8	
Shoulders	.11	.43	.19	.74	3.6	Breadth, 2.93
Nipples	.7	.27	.13	.51	6.4	
Waist	.2	.07	.9	.35	3.4	
Hips	.2	.07	.11	.43	1.8	
Right-shoulder elbow	.3	.11	.4	.15	1.1	
Left-shoulder elbow	.2	.07	.4	.15	0.8	
Right elbow-tip	.2	.07	.10	.39	1.5	
Left elbow-tip	.2	.07	.6	.23	1.5	
Length, Right foot	.2	.07	.5	.19	1.1	
Left foot	.1	.03	.4	.15	1.1	
Stretch of arms	.19	.74	.24	.94	1.3	
Horizontal length	.14	.55	.20	.78	0.6	
Strength	[a].73	[d]160.9	.82	180.8	26.9	
Lungs	[a].30	[d].66	.64	1.41	27.8	
Back	[a]2.8	[d]61.7	.28	61.7	24.0	
Chest dip	[b]2.6	. .	2.3	. .	38.0	Strength, 25.31
Chest pull up	[b]1.1	. .	1.2	. .	20.5	
Legs	[a].33	[d]72.7	.37	81.5	26.0	
Right forearm	[a].5	[d]11.0	.7	15.4	23.7	
Left forearm	[a].5	[d]11.0	.5	11.0	15.6	
Capacity of lungs	[c]1.2	[e]73.2	3.6	219.6	4.0	Capacity, 4.00
					A total average gain of 5.87 per cent.	

a—Kilos. b—Units. c—Litres. d—Pounds. e—Cubic inches. All others, Millimetres, and Inches and Tenths.

BATHS AND BATHING.

The most important sanitary object of bathing is cleanliness. A secondary object of the bath is to stimulate the functions of the skin, and to produce a general feeling of exhilaration of the body. Baths are used of various temperatures. A cold bath has a temperature of from 4° to 24° C. (40° to 75° F.); a tepid bath from 24° to 30° C. (75° to 85° F.); a warm bath from 30° to 38° C. (85° to 100° F.); and a hot bath from 38° to 43° C. (100° to 110° F.).

Tepid, warm, or hot baths are used principally as cleansing agents or as therapeutic measures. They cause dilatation of the cutaneous capillaries, diminish blood-pressure, and reduce nervous excitability. The hot bath is also a method of restoring warmth to the body in cases of shock, or to remove the immediate effects of injurious exposure to low temperature.

The so-called Russian and Turkish baths, so popular in the larger cities of this country, are modifications of vapor- and hot-air baths, or rather combinations of these with cold baths. The Turkish bath is especially to be recommended for its depurative and invigorating effects.

Cold baths are used not merely for their cleansing effects, but principally for their stimulating effects upon the system. When first plunging into a cold bath there is usually a momentary shock; the respiration is gasping, and the pulse is increased in frequency. These symptoms disappear in a few moments, however, and reaction follows. To a healthy person a cold bath is a delightful general stimulant, removing the sense of fatigue after physical exertion and causing an extremely refreshing sensation throughout the body.

As a therapeutic measure, the cold bath has a wide field of usefulness. For the reduction of the bodily temperature in fevers and inflammatory diseases, and especially in heat-stroke, it is more prompt and effective than any other agent at the command of the physician.

Sea-bathing.—The most stimulating form of the cold bath is doubtless the salt-water bath as taken at the sea-shore. The revulsive effect of the impact of the waves and breakers upon the skin and the stimulation due to the saline constituents of the sea-water heighten the invigorating effects of the simple cold bath. The beneficial results of sea-bathing are, however, not entirely due to the bath, but are to a great degree dependent upon the bracing air of the sea-shore, absence of the care and anxieties of business, and the temporary change in food and habits that a residence at the sea-side involves. Nevertheless, salt-water baths are more stimulant to the skin than those of simple water, and part of the good effects of sea-bathing can often be obtained from a salt-water bath taken at home. The following mixture of salts dissolved in about 125 litres of water for one bath makes a fairly good substitute for a sea-bath:—

Take of Chloride of sodium (common salt)....	4	kilogrammes.
Sulphate of sodium (Glauber's salt)..	2	"
Chloride of calcium	½	kilogramme.
Chloride of magnesium...............	1½	"

There is a prevalent popular belief that it is extremely dangerous to enter a cold bath when heated or perspiring. The author is of the opinion that this belief is erroneous. The stimulant and bracing effects of the cold bath are most manifest if it be taken while the individual is very warm or bathed in perspiration. Several years ago the author made a series of observations upon himself to determine the effects of the cold bath when the body was warm. Every afternoon a free perspiration was provoked by a brisk walk of about 2 kilometres in the sun. As soon as the clothing could be cast off, and while the body was still freely perspiring, a plunge was taken into a fresh-water bath of about 15.5° C. (60° F.). No ill results followed; on the contrary, the sensation immediately following the bath, and for six or eight hours afterward, was exceedingly pleasant. The health remained perfect, and the weight decidedly increased during the two months the practice was continued. There is probably no danger to a healthy person in this practice, but it is considered advisable to immerse the head first ("take a header"), to avoid increasing the blood-pressure in the brain too greatly, which might result if the body were gradually immersed from the feet upward.

The following series of rules have been issued by the English Royal Humane Society, and are all worth observing by bathers: "Avoid bathing within two hours after a meal. Avoid bathing when exhausted by fatigue or from any other cause. Avoid bathing when the body is cooling after perspiration. Avoid bathing altogether in the open air, if, after having been a short time in the water, there is a sense of chilliness, with numbness of the hands and feet; but bathe when the body is warm, provided no time is lost in getting into the water. Avoid chilling the body by sitting or standing undressed on the banks or in boats, after having been in the water. Avoid remaining too long in the water, but leave the water immediately if there is the slightest feeling of chilliness. The vigorous and strong may bathe early in the morning on an empty stomach. The young, and those who are weak, had better bathe two or three hours after a meal; the best time for such is from two to three hours after breakfast. Those who are subject to giddiness or faintness, or suffer from palpitation or other sense of discomfort at the heart, should not bathe without first consulting their medical adviser."

To these instructions may properly be added that a warm or hot bath should be avoided if the person is liable to exposure to cold within a few hours after the bath; that women should, as a ru'e, not take a cold bath while menstruating, or during the last two months of pregnancy; and that persons suffering from organic heart disease should especially avoid surf-bathing.

After bathing the body should be thoroughly dried with soft towels, otherwise eczematous eruptions are liable to follow in the parts subject to friction from opposing surfaces of the skin, as in the groins, the perineum and inner surface of the thighs, the armpits, or the under surface of the breasts in women in whom these organs are large and pendant.

Friction of the skin with a coarse towel, or so-called "flesh-brush," is a popular practice, but is not to be universally commended. The hyperemia of the surface thus produced may sometimes induce cutaneous diseases (erythema, eczema, psoriasis) in those predisposed.

One of the most serious dangers of cold bathing, but which is not sufficiently appreciated, is the tendency to nausea and vomiting if the stomach contains much food. There can be no doubt that many cases that are called "cramp," and which frequently result in drowning, are due to this cause.[3]

Cramps of the various muscles sometimes occur, rendering the bather helpless, and if in deep water he is liable to drown before assistance can reach him.

In drowning death takes place by asphyxia. The respiration is arrested by the submersion of the head, the carbonized blood gradually poisons the system, and the heart ceases to beat. So long as the heart will react to its appropriate stimulus the person may be restored to life. The first thing to do, therefore, after a recently-drowned person is taken out of the water, is to attempt to re-establish the arrested respiration. Several methods are in use for this purpose. Sylvester's is one of the simplest. It is as follows:—

The body being placed on the back (either on a flat surface or, better, on a plane inclined a little from the feet upward), a firm cushion or similar support (a coat rolled up wi'l answer) should be placed under the shoulders, the head being kept in a line with the

[3] So far as the author is aware, Dr. John Morris, of Baltimore, first called especial attention to this source of danger.

trunk. The tongue should be drawn forward to raise the epiglottis and uncover the windpipe. The arms should be grasped just above the elbows and drawn upward until they nearly meet above the head, and then at once lowered and replaced at the side. This should be immediately followed by pressure with both hands upon the belly, just below the breastbone. The process is to be repeated fifteen to eighteen times a minute.

Several years since the Michigan State Board of Health published a method which is comprehensive, effective, easily understood, and readily carried out. This method has also been adopted by the United States Life-Saving Service. The following are the details of the Michigan method:—

Rule 1.—Remove all the obstructions to breathing. *Instantly* loosen or cut apart all neck- and waist- bands; turn the patient on his face, with the head down hill; stand astride the hips with your face toward his head, and, locking your fingers together under his belly, raise the body as high as you can without lifting the forehead off the ground, and give the body a smart jerk to remove mucus from the throat and water from the windpipe, hold the body suspended long enough to slowly count *one—two—three—four—five,* repeating the jerk more gently two or three times.

Rule 2.—Place the patient on the ground face downward, and, maintaining all the while your position astride the body, grasp the points of the shoulders by the clothing; or, if the body is naked, thrust your fingers into the armpits, clasping your thumbs over the points of the shoulders, and *raise the chest as high as you can* without lifting the head quite off the ground, and hold it long enough to slowly count *one—two—three.* Replace him on the ground with his forehead on his flexed arm, the neck straightened out, and the mouth and nose free; place your elbows against [the inner surface] your knees and your hands upon the sides of his chest *over the lower ribs, and press downward and inward* with increasing force long enough to slowly count *one—two.* Then suddenly let go, grasp the shoulders as before, and raise the chest; then press upon the ribs, etc. These alternate movements should be repeated ten or fifteen times a minute for an hour, at least, unless breathing is restored sooner. Use the same regularity as in natural breathing.

Rule 3.—After breathing has commenced *restore the animal heat.* Wrap him up in warm blankets, apply bottles of hot water, hot bricks, or anything to restore heat. Warm the head nearly as fast as the body lest convulsions come on. Rubbing the body with warm cloths or the hands and slapping the fleshy parts may assist to restore warmth and the breathing also.

If the patient can *surely* swallow, give hot coffee, tea, milk, or a little hot sling. Give spirits sparingly, lest they produce depression.

Place the patient in a warm bed, and give him plenty of fresh air. Keep him quiet.

Beware! *Avoid delay. A moment* may turn the scale for life or death. Dry ground, shelter, warmth, stimulants, etc., at this moment are nothing—*artificial breathing is everything*—is the *one remedy*—all others are secondary. *Do not stop to remove wet clothing.* Precious time is wasted and the patient may be fatally chilled by exposure of the naked body, even in summer. Give all your attention and efforts to restore breathing by forcing air into, and out of, the lungs. If the breathing has just ceased, a smart slap on the face or a vigorous twist of the hair will sometimes start it again, and may be tried incidentally. Before natural breathing is fully restored, do not let the patient lie on his back unless some person holds the tongue forward. The tongue by falling back may close the windpipe and cause fatal choking.

Do not give up too soon; you are working for life. Any time within two hours you may be on the very threshold of success without there being any sign of it.[4]

In all large cities and towns provision should be made for free public baths, conducted under official supervision, and for the especial use and benefit of the poorer classes. General cleanliness is not merely a factor in the preservation of the public health, but there is good reason to believe that the cause of good order and decency would likewise be promoted by furnishing the public the means of easily and cheaply keeping clean. Many cities in the country have established public baths upon an increasingly generous scale, and these are very popular and have doubtless been of great benefit. The author has shown[5] that about five-sixths of the inhabitants of the large cities in the United States have no facilities for bathing except such as are afforded by a pail of water and sponge, or in summer the proximity of some body of water easily accessible. The most economical and best form of bath for public use would doubtless be the needle or rain bath recommended by the author in the paper referred to. Mr. W. P. Gerhard has also strongly advocated this form of bath.

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[4] Report of Michigan State Board of Health, 1874, pp. 91-99.

[5] Address in State Medicine, Journal American Medical Association, July 2, 1887.

It would be well if boards of health and building commissioners would issue no permits for dwelling-houses, the plans for which do not include proper water-supply and bathing facilities.

CLOTHING.

The primary object of clothing is the protection of the body against the injurious influences of heat, cold, and moisture. Secondarily, the moral sense of civilized communities demands that the nude human body shall not be exposed in public. Hence, there are moral as well as sanitary reasons for the wearing of clothing; only the latter can be considered in this place.

Bodies radiate or absorb heat accordingly as they are surrounded by a medium having a lower or a higher temperature than themselves. In order, therefore, to avoid chilling of the human body if exposed to a temperature below 37° C. (98.6° F.), clothing must be worn to prevent or retard radiation of the body-heat. Exposure of the unprotected body to a low temperature would not only cause chilling of the surface owing to the rapid loss of heat, but would incidentally produce congestion of internal organs by causing constriction of the superficial capillaries.

Clothing is also worn as a protection against great heat. The head, especially, needs protection from the sun's rays. Evidence is accumulating to the effect that direct sun-light, if excessive, is equally injurious.

The materials from which clothing is made are, principally, cotton, linen, wool, silk, and the skins of animals. Of these, probably the most universally used is *cotton*. It is cheap, durable, does not shrink when wet, absorbs little water, and conducts heat readily. It is therefore especially valuable for summer garments, allowing rapid dissipation of the body-heat and evaporation of the perspiration.

Linen conducts heat even better than cotton, and is for this reason largely used for summer clothing. Its principal advantage over cotton is that it is more durable and less harsh to the skin.

Wool absorbs water readily and is a bad conductor of heat. It is therefore valuable as a winter garment, retarding radiation from the body. Woolen undergarments should be worn at all seasons, in order to prevent too rapid changes of the surface, and so invoking diseases depending upon chilling of the body. Clothing of pure wool (flannels) is liable to irritate the skin of some persons. A mixture of wool and cotton, known as "Saxony wool," is softer and less irritating, and makes a serviceable substitute for pure wool.

Silk is often used for undergarments. It is light, soft, and a bad conductor of heat.

Linen-mesh combines the advantage of both cotton and wool, and is an excellent material for undergarments.

The skins of animals, with the fur on, are often used for outside clothing. They furnish great protection against severe cold. The skin is impermeable to wind and rain, while the thick, pilous covering of fur retards to a very great degree the radiation of heat. In British America, the Northwestern States and Territories, and in the Arctic regions, the use of skin clothing is necessary for comfort.

As a protection against moisture (rain and snow) *rubber cloth* is used for overcoats, etc., but it is not now so much employed as formerly, because, while it serves effectually in keeping out the rain, it prevents evaporation of the perspiration, increasing the liability to chill, and rendering the person wearing it very uncomfortable, except in cold weather. Outer garments waterproofed after the method known as the "Cravenette" process, and made of almost any material desired, are now substituted.

Leather is used almost exclusively in the manufacture of footwear. It is sometimes used, however, for other articles of clothing, such as coats, trousers, etc. It furnishes most effective protection against cold.

The *color* of the clothing is of great importance. Exposed to the sun, white wool or silk absorb very little more heat than linen or cotton, but the same material, of different colors, when exposed to the sun's rays, exhibits marked differences in absorptive capacity. The following table shows the results of some experiments of Pettenkofer. The material used was cotton shirting of the colors named:—

White absorbed	100	heat units.
Light Sulphur Yellow absorbed	102	" "
Dark Yellow absorbed	140	" "
Light Green absorbed	155	" "
Turkey Red absorbed	165	" "
Dark Green absorbed	168	" "
Light Blue absorbed	198	" "
Black absorbed	208	" "

When protected from the sun's rays, however, the material becomes important and the color is of little consequence. Wool, being a bad conductor of heat, retards radiation from the body, and is hence the best material for winter clothing.

Gases and vapors are absorbed by clothing and also disease-germs may be conveyed from place to place. It has been found that woolen clothing possesses this power of absorption to a much greater degree than linen or cotton. The bad odor of a crowded room or of tobacco-smoke frequently clings to woolen garments for days, although they may be exposed constantly to the air during the interval. It would be advisable, therefore, that physicians attending infectious diseases, hospital attendants and nurses, should wear linen or cotton clothing instead of woolen.

Clothing should be made to *fit* properly. It should not restrain muscular movements, obstruct the circulation, or compress organs. Hence, corsets, belts, and garters are to be condemned. It is a fact of common observation that moderately loose clothing is warmer than close-fitting.

Especial attention should be given to the shape and fitting of foot-wear. Boots and shoes are usually made with little regard to the physiological anatomy of the foot, and as a result the feet of most Americans are deformed, beauty and usefulness being in a great degree sacrificed to the Moloch of fashion.[6]

Dyes used for coloring fabrics are sometimes poisonous. The author has repeatedly seen troublesome eruptions, and even ulcerations of the legs, from wearing stockings dyed with aniline compounds.

By appropriate treatment clothing can be made *non-inflammable.* Tungstate and phosphate of soda are used to reduce the inflammability of fabrics. The addition of 20 per cent. of tungstate of soda and 3 per cent. of phosphate of soda to the starch-sizing used for stiffening linen is effective. The material is not injured by it, and a smooth surface and polish can be obtained under the hot iron. Prof. Kedzie has recommended borax for the same purpose. He says: "The simplest and easiest way to make your cotton and linen fabrics safe from taking fire is to dissolve a heaped teaspoonful of powdered borax in one-half pint of starch solution. It does not injure the fabric, imparts no disagreeable odor, and interferes in no way with the subsequent washing of the goods. It does not prevent the formation of a smooth and polished surface in the process of ironing. Borax can be found in every village, and is within the reach of all. It is a cheap salt, and its use for this purpose is very simple."[7]

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[6] See a practical paper by Dr. Benj. Lee, A Shoe That Will Not Pinch, in Sanitarian for June, 1884, p. 493.

[7] Michigan State Board of Health, p. 181, 1880.

RECREATION AND REST

Recreation is not by any means idleness, but a variety of occupation, and oftentimes is hard physical work. By its means a relaxation of both mind and body from the worries and fatigues of one's daily avocation may be effected. No rule can be laid down as to the exact amount of sleep necessary, for it is a matter of habit, age, and temperament. Generally speaking, young persons require more sleep than the aged. The most refreshing sleep is supposed to be that taken during the early hours of the night, but the habit, where necessary, of sleeping any time during the twenty-four hours may be acquired. The following simple rules should be observed:—

Do not eat heavy meals late at night. Have fresh air in the sleeping-room the year round, but do not have the bed in a draught. Do not sleep with an artificial light burning in the room; it requires increased provision for ventilation, and, by shining in the eyes, produces inflammatory troubles of the lids. Do not have carpets or hangings in the sleeping-room, but let the furniture be of the very simplest kind. If two people occupy the same room, they should occupy separate beds. Do not sleep in any garments worn during the day. Have the night-garments loose and comfortable: warm in winter, cool in summer. Have the bed-coverings light but warm, remembering that a number of layers makes a warmer covering than the same weight of material woven in one piece. Do not sleep on feather beds. Sleep with the head low and not with it propped up on several pillows, because this interferes with deep breathing, contracts the chest, and favors stoop shoulders. Lie on the right side when you first go to bed; it hastens food which may be in the stomach towards the pylorus and aids digestion, favoring natural sleep.

QUESTIONS TO CHAPTER XIII.

EXERCISE AND TRAINING.

What is absolutely necessary for the maintenance of the healthy functions of the body? What is the effect of disuse upon any organ? Of training?

What occurs when a muscle contracts? What is the result of increased activity of circulation in a muscle? What is the effect of muscular action on the respiratory process? What is the difference as to the absorption of oxygen in a state of rest and during work? As to the elimination of carbon dioxide and water? What is the effect of muscular action upon the circulation? Upon the cutaneous transpiration?

What is the effect of systematic training upon health and longevity? What are some of the principal and best methods of physical training? What is one of its most important objects? How may the various methods be combined with benefit?

What should be included among the studies and work of all public schools? For what purposes? What is the tendency among instructors in physical training? Is this necessary, or not? Why?

What is an important preliminary to all methods of training? Why? How may a pupil be taught to assume and maintain a correct position and carriage of the body?

How should a person walk? What attention should be given to the clothing worn during exercise? What will be some of the results of systematic physical training properly pursued?

What are some of the results of overexertion? Does it make a difference whether the exercise is too long uninterrupted or whether it is excessive in amount and character?

BATHS AND BATHING.

What is the most important object of bathing? For what other purposes may baths be taken? What are the respective temperatures of so-called cold, tepid, warm, and hot baths? What are the physiological effects of the last three? In what surgical emergencies may the hot bath be used? For what are cold baths used? What are their physiological effects? How may the cold bath be used therapeutically?

What is the most stimulating form of cold bath? To what are its beneficial effects due? How may a salt-water bath be prepared at home? Is there any danger to the healthy in cold bathing while the body is perspiring freely? What precaution should be taken before entering a cold bath? What rules may be laid down for bathing in the open air? When is the best time for bathing? Who should not bathe without previous medical advice? When should hot baths not be taken? What should follow all baths?

What is one of the most serious dangers of cold bathing? How does death take place in drowning? What is the indication that one apparently drowned may still be restored to life? Describe Sylvester's method of artificial respiration. What is the method adopted by the United States Life-Saving Service? What is essential after breathing has been re-established? How should spirits be given? How long should efforts to restore respiration be continued? What is to be avoided?

What are some of the arguments in favor of public baths in large cities?

What is the most economical form of bath for public use?

CLOTHING.

What is the primary object of clothing? What are some of the secondary objects? What are the probable results of exposing the unprotected body to low temperature? What part of the body needs special protection against heat?

What are the principal materials from which clothing is made? Which of these is most universally used? Why? In what respect is linen superior to cotton? Why are cotton and linen not suited for winter wear or cold climates? Why are silk and wool better for such uses? Why should wool be worn next the skin? What gives silk its value? Why are furs so warm? What are some of the objections to the use of rubber clothing? For what is leather chiefly used?

Of what importance is the color of the clothing? What colors absorb least and what ones most heat? If protected from the sun's rays, which is the most important in the absorption of heat, material or color?

What deleterious or harmful matters are absorbed or cling to clothing? What kinds of clothing have the greatest power of absorption? What precautions should those attending cases of infectious diseases observe?

Why should clothing fit properly? What parts of the clothing should not be too tight? What disturbances may result from the wearing of clothing that is too tight? How may improperly-dyed clothing create trouble? How may clothing be rendered practically non-inflammable?

CHAPTER XIV.

DISPOSAL OF THE DEAD.

When life is extinct in the animal body decomposition begins. This may be either putrefactive or non-putrefactive. The difference between the two processes has been explained by Liebig. In putrefaction of organic matters only the elements of water take part in the formation of the new compounds which result, while in non-putrefactive decomposition or decay the oxygen of the air always plays an important part. Putrefaction can go on under water, while decay can only take place when the supply of free oxygen is abundant.

The prompt removal of the bodies of the dead from the immediate vicinity of the living is a matter of prime sanitary importance. If death results from a contagious or an infectious disease, the necessity for the removal of the corpse is evident. But, even where there is no danger of propagation of infectious disease, the products of putrefaction and decay may give rise to serious derangements of health if allowed to pollute the air.

The chief methods of disposal of the dead are burial in the earth, entombment in vaults, and cremation.

INTERMENT.

The most common method of sepulture is burial in the earth. The corpse is usually inclosed in a case (coffin) of wood or metal, and buried from 1 to 2 metres deep. Here decomposition sets in, which is at first putrefactive and later on non-putrefactive. In the course of several years, from five to ten, the entire body, with the exception of the bones, has usually disappeared and become converted into a dry mold.

The soil of a burial-ground should be dry and porous, so as to be easily permeated by the air. In a sandy or gravelly soil the decay of a corpse is much more rapid than in a moist, clayey soil. In the latter the bodies more readily undergo putrefaction, or become converted into a substance termed adipocere. It has been calculated that in a gravelly soil the decay of a corpse advances as much in one year as it would in sand in one and two-thirds, and in clay in two and one-third years. The decay of the dead bodies is dependent upon the presence of living vegetable organisms. If the access of free oxygen is prevented, the bacteria of putrefaction will thrive and cause putridity. If, however, the soil is loose, porous, and easily permeable by the air, the bacteria of decay will be present and produce their characteristic effects.

The barometric pressure seems to affect the decomposition of dead bodies. For example, at the refuge of St. Bernard, in the high Alps, the bodies of those dying are not buried, but exposed to the air, where they undergo a drying, shrinking, and mummification instead of putrefaction or decay.

Alternate saturation and drying of the soil promotes the rapidity of decay.

Certain occupations are said to produce changes in the tissues which resist decay. Thus, tanners are supposed to resist the final changes of the tissues longer than persons of other occupations. Shakespeare makes the grave-digger in Hamlet say: "A tanner will last you nine years." The corpses of those poisoned by phosphorus, arsenic, sulphuric acid, or corrosive sublimate also decay more slowly than in cases of infectious diseases.

All the tissues may be converted into adipocere, but in the large majority of cases only the fat and connective-tissues undergo this change.

SUPPOSED DANGERS OF BURIAL-GROUNDS.

Popular sanitary literature teems with supposed instances of the injurious influences of cemeteries upon the health of persons living in their vicinity. An unprejudiced consideration of the subject shows, however, that there is no trustworthy evidence that any of the gases exhaled by decaying or putrefying bodies are injurious to health. The air of closed burial-vaults may be dangerous from the large proportion of carbon dioxide contained in it, but the other gaseous products of decomposition have no deleterious effects. The dangers to health from the proximity of cemeteries are doubtless very much exaggerated. Pettenkofer and Erismann have shown that a single large privy-vault, containing about 17 cubic metres of excrement, gives off nearly as large an amount of putrefactive gases in the course of one year as is exhaled by a burial-ground containing 556 decomposing corpses in ten years.

Where bodies are properly buried, and the ground is not overcharged by corpses, it is not probable that infectious diseases are propagated from interred bodies. There are no facts on record which show that such an event has occurred.

The dangers of pollution of water by cemeteries have also been much overestimated. The purifying power of soil strata, through which the water is compelled to percolate before reaching the well after becoming charged with the products of decomposition, is in most cases sufficient to remove all deleterious matters. It must be admitted, however, that it is not desirable to have a well or other source of water-supply in close proximity to a burial-ground.

Cemeteries should not be located within a city, but must be easily accessible. The soil should be dry gravel or sand, with a low ground-water level. The graves need not be deeper than 1½ metres to the top of the coffin.

ENTOMBMENT IN VAULTS.

Burial-vaults in churches or in the open air should be discountenanced. The gases of decomposition are given off directly to the air without the modifying power of the soil, and often constitute a nuisance, even if not deleterious to health. Entombment in vaults or crypts has not a single favorable circumstance to recommend it.

CREMATION.

Within recent years the rapid incineration of the dead in properly-constructed furnaces has been frequently recommended. In the United States a cremation furnace was built years ago at Washington, Pa., by the late Dr. J. C. LeMoine. Among the remains of those cremated were those of the late Dr. Samuel D. Gross, the distinguished surgeon. The practice has not gained very many adherents, however, although cremation societies have been organized and furnaces built in several of the cities throughout the country. Aside from the objections urged by the more conservative classes, who desire to adhere to the time-honored custom of interment, serious legal objections have been brought forward. In cases where poisoning is suspected some time after death, the cremation furnace would have destroyed every evidence of crime, and conviction of a criminal poisoner could not be obtained.

The real advantages of cremation, such as rapid destruction of a corpse, economy of space in keeping the remains, and avoidance of pollution of the soil by decaying bodies, and possible pollution of air and water, are more than counterbalanced by the expense and the medico-legal objection mentioned. From a sanitary point of view, cremation is not necessary in this country. A proper regulation of cemeteries will prevent any possible dangers to the living from pollution of the air, soil, or water by the decaying remains of human beings.

INTERMENT ON THE BATTLE-FIELD.

After battles, the disposal of the bodies of the slain is often a serious problem. Naegeli proposes the following method of interment: After selecting the place of burial, the sod and layer of humus are removed from a sufficiently large surface and thrown to one side. The corpses are then laid upon the denuded place, and the layers of corpses separated by sand, gravel, or fine brush-wood. A trench is then dug around the pile of dead and the soil gained is thrown over the corpses until they are covered to a depth of 1 metre, when the humus and sod are placed over the whole. This furnishes a dry grave in which decay rapidly takes the place of putrefaction, and the corpses soon molder away. The same procedure may be followed in cases of epidemics where the number of deaths is too great to properly bury them in single graves.

Before leaving this subject it may be well to consider the matter of funerals. The pernicious custom of public funerals in cases of contagious diseases cannot be too strongly condemned. In fact, public funerals in such cases should not be permitted by the health authorities. To minimize the danger, the bodies of persons dead of contagious diseases should be wrapped in sheets wet with a solution of bichloride of mercury (1:500), and the coffin kept securely closed. Still more pernicious is the custom of disposing of the clothing and other personal property of the dead of contagious diseases by either distributing them among friends, donating to the poor, or selling to second-hand dealers. Many epidemics of contagious diseases have had their origin in this way. There should be a strict law prohibiting the sale of any article with which the deceased has come in contact during the last illness, unless such article is thoroughly disinfected.

QUESTIONS TO CHAPTER XIV.

DISPOSAL OF THE DEAD.

What is the difference between putrefactive and non-putrefactive decomposition? Why must the dead be removed from the living? What are the chief methods of disposal of the dead? Which is the most common?

Why should the soil of burial-grounds be dry and porous? Upon what is the decay of dead bodies dependent? What is the usual length of time required for the decay of a human body? What may affect the length of this period? What changes other than decay may the body undergo?

Is there any evidence that the air from cemeteries is dangerous to health? In what way may the air from a closed burial-vault be detrimental? Is it probable that infectious disease-germs are disseminated from dead bodies? Is the pollution of water by cemeteries probable? What agents serve to prevent this? Where should cemeteries be located, however? Why should entombment in vaults be discountenanced?

What are the advantages of cremation? What are the objections to it? Is it necessary, from a sanitary point of view, in this country?

How may the bodies of the dead be interred after battles, or in case of very fatal epidemics? What are the advantages of this method?

What precautions should be observed in cases of contagious diseases?

CHAPTER XV.

THE GERM THEORY OF DISEASE.

THE ruling doctrine in the pathology of the present day is the germ theory of disease. Based upon the doctrine of *omne vivum ex vivo,* and supported by strong experimental and clinical evidence, it is accepted by the great majority of physicians. Its advocates claim that the large class of diseases known as contagious or infectious are all due to the presence in the blood or tissues of minute organisms, either animal or vegetable. Many other diseases, not at present included in the above class by general pathologists, are also believed, by the adherents of the germ theory, to be caused in the same way. The following constitutes a brief review of the most prominent facts in the history of the doctrine:—

The doctrine of the vital nature of the contagion of disease—the *contagium animatum* of the older writers— was held in a vague way by many of the physicians of the past, but it was not until the latter part of the last century that the theory took definite shape. In the works of Hufeland, Kircher, and Linné, the idea is expressed with more or less directness that the propagation of infectious diseases depends upon the implantation of minute independent organisms into or upon the affected individual. This hypothesis was, however, first clearly enunciated and defended with great force by Henle in 1840. Three years earlier, Cagniard de la Tour and Schwann had established a rational basis for the theory by their observations upon the yeast-plant and its relation to fermentation. In 1835 Bassi had discovered in the bodies of silk-worms affected by *muscardine,* a disease of these insects which proved very destructive, a parasite which was soon shown to be the cause of the disease. Within the next few years, Tulasné, DeBarry, and Kuehn proved that certain fungi were the causes of the potato-rot and other diseases of plants. Schoenlein, Malmsten, and Gruby, between 1840 and 1845, demonstrated that those skin diseases of man classed as *the tineæ* were due entirely to the action of vegetable parasitic organisms.

Up to this time the germ theory, as now accepted, had received no support from experiments. All the diseases claimed as parasitic were purely local; so far as the parasitic nature of the general diseases was concerned, all was hypothetical. In 1849, Guérin Méneville discovered a corpuscular organism in the blood of silk-worms affected by the *pébrine,* which was later proven by Pasteur to be the true cause of this destructive disease. Pollender, in 1855, and Brauell, in 1857, found numerous minute rod-like organisms (bacteria) in the blood of animals dead from splenic fever or anthrax. In 1863 Davaine investigated the subject more fully, and showed beyond doubt that the little organisms discovered by Pollender were the true cause of anthrax. The more recent researches of Robert Koch upon the history of these bacteria or bacilli of splenic fever have removed all doubt of their etiological significance.

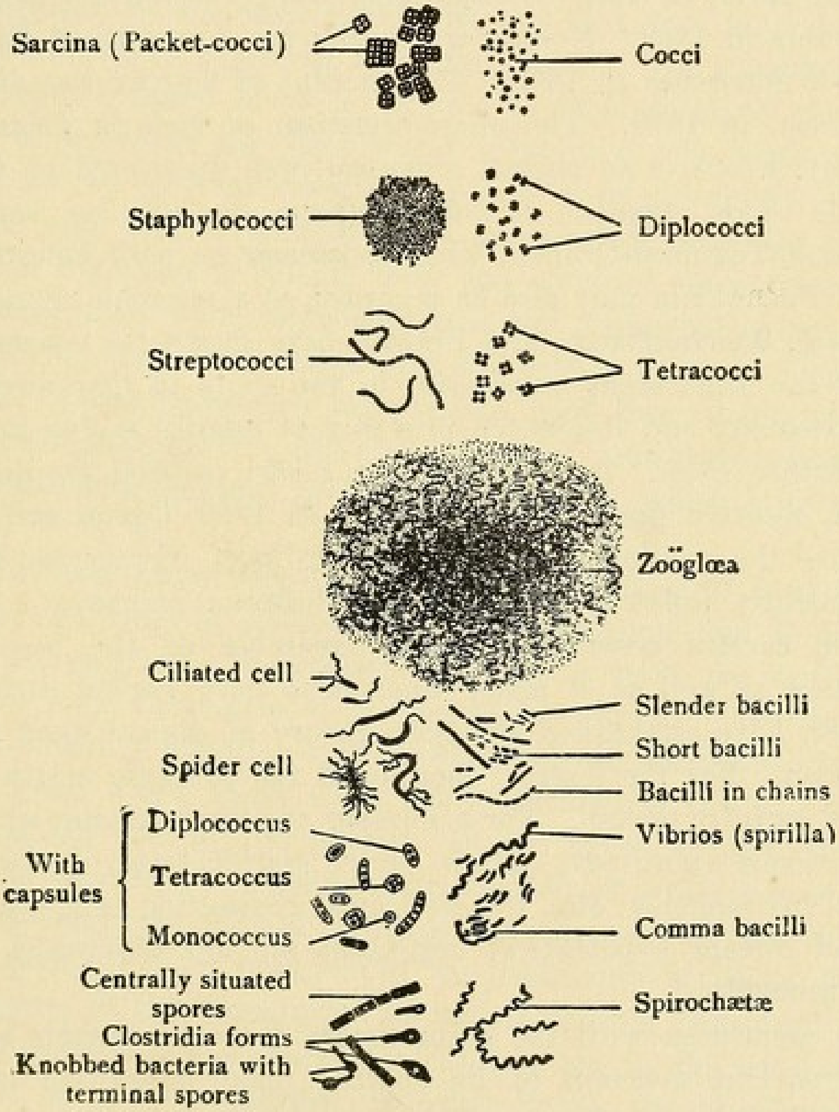

Fig. 43.—Forms of Bacteria. (From Schenk.)

In 1883 the last-named observer startled the medical world by the assertion that consumption or tuberculosis was a disease of microbic origin, and dependent upon the presence, in the affected tissues, of an organism which he named *Bacillus tuberculosis*. Much controversy arose upon this point, but Koch fortified his position so strongly with proofs, both experimental and clinical, that it may now be regarded as fully demonstrated. Koch has likewise shown (1885) that Asiatic cholera is due to a bacterial organism, termed by him the "comma bacillus," from its shape. It is generally regarded by bacteriologists, however, to belong to the class of organisms known as spirilla, and not to the bacilli. Eberth discovered the bacillus which is now generally accepted as the cause of typhoid, in 1880; Fehleisen, the micrococcus of erysipelas, in 1883; Obermeier, the spirillum of relapsing fever, in 1868; Schutz and Löffler discovered the bacillus of glanders in 1882; Neisser announced the discovery of the micrococcus of gonorrhea in 1879. The bacillus of leprosy was discovered by Hansen, in 1879. The micro-organism of malaria (plasmodium malariæ), which is an animal organism, was discovered by Laveran, in 1881. This organism is different from the *Bacillus malariæ* of Klebs and Tommasi-Crudeli, which possesses no pathological significance. Pneumonia may also be regarded as a microbic disease, since Sternberg, Weichselbaum, and Fränkel have shown the constant presence of the diplococcus lanceolatus in the sputa in that disease. In 1884, Nicolaier and Rosenbach proved that tetanus is due to a bacillus, *Bacillus tetani*. In the same year Löffler isolated the diphtheria bacillus, observed previously by Klebs. In 1892, Canon and Pfeiffer discovered the bacillus of influenza, and in 1894, Yerzin and Kitasato independently isolated the bacillus of bubonic plague.

The careful observations and researches of the investigators mentioned, as well as of many others who have worked earnestly in this field, have established the germ theory of disease upon a secure foundation. For the diseases mentioned the parasitic origin may be accepted as fully proven. For a number of others, among which may be mentioned small-pox, yellow fever, scarlet fever, typhus fever, measles, hydrophobia, etc., the etiological connection between the disease and certain hypothetical organisms not yet discovered appears highly probable.

In connection with the germ theory there has arisen of late a very important question in its bearing upon preventive medicine. This is the value of the so-called protective inoculations against infectious diseases. The protective influence of vaccination against small-pox is firmly established by indubitable evidence. Within recent years a procedure introduced by Pasteur to protect animals against certain fatal infectious diseases, such as splenic fever, fowl-cholera, and rabies, has claimed much attention. Pasteur's observations were first made upon the disease termed chicken-cholera. He found that the blood of the dead fowls, or of those attacked by the disease, swarmed with bacteria. Inoculations of healthy fowls with this diseased blood, or with the bacteria alone, carefully freed from all animal fluids, produced the same disease. The bacteria were therefore assumed to be the cause of the disease. The investigator then took a quantity of these bacteria and "cultivated" them through a number of generations, using sterilized chicken-broth as a culture medium. Fowls inoculated with the result of the last cultivation were still attacked by the same symptoms, but in a very mild degree, and almost uniformly recovered from the disease. On subsequent inoculation with infected blood no effect was produced upon the "vaccinated" fowls, while the same blood introduced into fowls not "protected" by the previous inoculation produced its customary fatal effect. Pasteur and others repeated these experiments with the organisms found in the blood in splenic fever and obtained similar results. Inoculations made with emulsions from the desiccated spinal cords of animals that died from rabies have also proven protective against this disease. These protective inoculations have been made upon large numbers of sheep, cattle, and man, with very remarkable success. The "protective inoculations" produce an immunity which is more or less lasting.

The most important discovery along the lines of immunity was made by Behring, in 1892. This observer found that if diphtheria bacilli are cultivated in bouillon for about a week, the medium contains the toxic substances of the bacilli in solution. The bacilli may then be entirely removed by filtration and the clear fluid represents the toxin, of which about 0.001 cubic centimetres will kill a guinea-pig weighing 250 to 300 grams. If this toxin is injected into an animal in gradually increasing doses, neither of which is large enough to prove fatal, the animal acquires an immunity to the diphtheria toxins, which are the products of the diphtheria bacillus. Now, the blood-serum of this immunized animal is capable of neutralizing the toxic properties of the diphtheria toxin either in the test-tube or in the body of another animal; in other words, the blood-serum contains antitoxins.

For practical purposes, a healthy horse is injected with gradually increasing doses of toxin, beginning with 0.1 cubic centimetres and ending with several doses of 500 cubic centimetres each. At the end of about six weeks from five to nine quarts (according to the size of the horse) of blood are withdrawn from the jugular vein, the blood allowed to coagulate, and the clear serum prepared for the market. This serum is the diphtheria antitoxin. This antitoxin, when injected into a person suffering from diphtheria, will neutralize all of the free toxins circulating in the blood, and the outcome of the case depends entirely on whether, at the time the antitoxin is used, the toxin particles are mostly free or combined with the tissue cells. In the latter event the antitoxin is powerless to accomplish very much, and the issue is fatal. It is for this reason that the modern physician employs antitoxin at the earliest possible stage of the disease, so as to neutralize the free toxins before they have a chance to combine with the cells. For this reason also a small dose of antitoxin, when injected into persons exposed to the infection, may prevent the development of the disease. The introduction of antitoxin in the treatment of diphtheria has reduced the mortality from diphtheria from 50 to about 10 per cent.

Tetanus antitoxin, elaborated by Behring and Kitasato, in 1890, is based on the same principles and prepared very much in the same manner, with the exception, of course, that the tetanus bacillus is cultivated under anaërobic conditions. From a therapeutic standpoint, however, the antitoxic serum is not as useful as in the case of diphtheria. The reason given is that by the time the symptoms of tetanus develop, the toxin is practically combined entirely with the nerve-cells and, therefore, cannot be neutralized. On the other hand, when the antitoxin is used at the time the invasion of the bacillus occurs, or during the period of incubation, the development of the disease may be prevented with absolute certainty. It is this fact that led veterinarians to use tetanus antitoxin in every case of suspicious wound in a horse, a practice which should be followed by the physician in case of any suspicious wound in man.

The immunity conferred by the use of antitoxins is passive and temporary, the body of the patient not participating in its production. In the case of other infections which are caused by micro-organisms not possessing soluble toxin, the immunization must be active, and can only be accomplished artificially by the employment of "vaccines" prepared from the bodies of the dead germs. This form of immunity, which may be called "bacterial," depends for its production on altogether different forces, namely, the property of the white blood-cells to attract and devour bacteria, or, as Metchnikoff termed it, "phagocytosis." However, before invading micro-organisms can be imbibed by the phagocytes they must be acted upon or prepared by another substance which is present in the blood. This substance, whatever its nature, renders the bacteria capable of becoming imbibed by the phagocytes, and has been recently designated by Wright and Douglas as "opsonins" (from *opsono,* I prepare food for). The relative power of phagocytosis in the blood of a patient suffering from an infection, as compared with the phagocytic power of the blood of a healthy individual towards the same germ, is called the "opsonic index."

These, however, are not the only defensive forces. There are no doubt a number of other substances in the tissues and fluids of the animal organisms which protect the latter against disease, and it is the weakening of any or all of them that makes infection possible. The subject of immunity is a very wide one, and it is only now that we are beginning to understand it. The time will no doubt come when every infectious disease will be either prevented or cured by stimulating the production of the necessary defensive agents.

THEORIES OF IMMUNITY.

No treatise on hygiene is complete without a consideration of the factors concerned in the protection of the animal organism against infection, or overcoming infection already present. Broadly speaking, the natural tendency of the body is to keep along the line of health. Any deviation from that line is promptly met by an effort on the part of the organism to correct its course and re-establish a healthy equilibrium. A foreign body in the eye is instantly flooded with tears in order that it may be washed out. Failing in that, an inflammatory reaction is set up, the object being to surround the irritant by adhesion and thus shut it off from further irritation. A fractured limb is immediately placed by Mother Nature in a state of enforced rest, owing to the excruciating pain which the motion of the limb produces, and at first a temporary and then a permanent splint (callus) are placed around the fragments, remaining there until restoration of continuity. Certain poisons which are generated in the course of normal metabolism are neutralized and eliminated so as to prevent self-poisoning. A local invasion of pus-producing bacteria (staphylococcus, streptococcus, etc.) is a signal for an immediate concentration of armies of leukocytes in an attempt to destroy the invader, and, failing in that, an effectual barrier against further invasion is formed through a process of inflammation which results in the formation of a membrane, the so-called pyogenic membrane. The invasion of bacteria into the general circulation, or the absorption of their products (toxins), stimulates the production of substances in the body which destroy the micro-organisms or neutralize their poisons. Thus, the natural forces of the body are continuously at work, maintaining the organism in a state of health. When these forces become inadequate, or are temporarily deranged, disease or a deviation from the normal line results.

Immunity may be defined as a natural or acquired resistance to disease. Generally, the term refers to infectious diseases. Immunity may be racial, as the immunity of the negro to yellow fever, or individual; it may be active, when the result of natural infection or inoculation, or passive, when produced by the introduction of substances derived from animals actively immunized, as in the case of antitoxin treatment. Immunity, furthermore, may express itself against the bacteria (antibacterial), the toxins (antitoxic), or against cells from an animal of a different species (cytolytic).

In order to more fully appreciate the relation of the subject of immunity to hygienic problems, it may be well to consider briefly the two factors involved in the causation of infectious diseases. These are: the specific micro-organism or the exciting cause, and the resistance of the individual or the predisposing cause. The former may be likened to a plant-seed, the latter to the soil. Given a vigorous seed and a poor soil, no growth will take place. Similarly, a favorable soil and a poor seed will remain barren. To get the best results, both the seed and the soil must be in the very best condition. This is precisely the case in infection. A virulent micro-organism remains powerless in the absence of a predisposition, nor will infection occur in the presence of a predisposition with an avirulent micro-organism. As neither virulence nor resistance are constant factors, the resulting infection will vary in each individual case, from a mild to a fatal attack. The virulence of a micro-organism, under natural conditions, is increased by passage through the bodies of susceptible individuals, and decreased by passage through the bodies of relatively insusceptible persons. This explains the rise and fall of an epidemic. At first, the most susceptible individuals in a community are attacked. As the specific micro-organism passes through the bodies of these victims it gains in virulence, and the epidemic gains in fury until the most insusceptible individuals are reached, when the virulence of the micro-organism begins to decline, and the epidemic dies out. The virulence of bacteria may also be influenced by climatic and atmospheric conditions and by association of two or more species which either increases or decreases the virulence of the respective species. This association is known as symbiosis. On the other hand, the predisposition or susceptibility of the individual may be increased by bad hygienic surroundings, chronic poisoning, alcoholism, fatigue, and overwork of the nervous system, exposure to cold, improper diet, drugs, surgical operations, injuries, previous disease. In preventing infection, therefore, we should aim at a destruction of the bacteria, or at least a reduction of their virulence by the use of antiseptics, etc., and at the same time we should enhance the resistance of the individual. In other words, we must render the seed inactive and the soil unfavorable.

The accepted theories of immunity are (1) Metchnikoff's theory of phagocytosis and (2) Ehrlich's side-chain theory. Each explains part of the phenomenon, and the truth probably lies between the two.

(1) According to Metchnikoff and his followers, certain cells in the animal body possess, in common with ameba and other unicellular organisms, the property of incorporating and digesting foreign substances. These substances are attracted by the cells by a bio-physical process known as chemiotaxis, which may be positive or negative, depending on whether the foreign body is attracted or repelled. The presence of the foreign body within the cell stimulates the production of cellular enzymes, *cytases*, which act as digestive ferments. The entire process is called *phagocytosis*, from the Greek φαγεῖν, to eat, and κυτος, cell. In the human body, two chief varieties of phagocytes are present: (*a*) The *microphages*, which are the polymorphonuclear leukocytes of the blood, and (*b*) the *macrophages*, which include the large mononuclear leukocytes, the fixed connective tissue cells, and other cells possessing phagocytic properties. The microphages exert a special digestive action on bacteria, while the macrophages possess special activity toward animal cells and protozoa. When the digestive ferment of the microphages, the microcytase, is given off by the cells and is circulating in the blood, the blood-serum acquires bacteriolytic or cytolytic properties.

In insusceptible or immunized animals the specific bacteria are attracted by the microphages and ingested and digested. However, before the digestion of the bacteria can take place, they must undergo certain alteration, and this is accomplished by a specific substance, also the product of the leukocytes, called *fixateur*, or fixative, which corresponds to the "immune-body" of the German schools, or the "opsonins" of Wright and Douglas. These opsonins are present in the blood of every individual to a degree proportionate to his resistance to a given infection. When infection takes place, the organism is depressed at first, and the opsonins are diminished, or what is called a "negative phase" takes place. As soon as the organism recovers from this primary depression, the opsonins increase, and a "positive phase" is reached.

Briefly stated, the process of immunity, according to Metchnikoff, is as follows:—

(*a*) The pathogenic bacteria invade the body.

(*b*) The microphages are attracted to the bacteria and the latter are fixed and ingested.

(*c*) The presence of the bacteria stimulates the production of *cytase,* which acts on the "sensitized" bacteria, resulting in a complete digestion of the latter or bacteriolysis.

It will be observed that while Metchnikoff's theory explains immunity against the action of bacteria and toxic cells, it fails to explain antitoxic immunity. The latter is best elucidated by the theory elaborated by Ehrlich and his followers.

2. *The Lateral-chain Theory.*—According to this theory, the animal cell is made up of numerous bio-chemical atom-groups, the so-called biogen molecules. These groups possess specific affinities for similar groups in either food or other organic molecules. These atom-groups or side-chains in the cell are called *receptors,* while the corresponding groups in the food-molecule are called *haptophores* (from the Greek ἅπτειν, to touch, and φερειν, to bring). In the process of nutrition, the receptors unite with the haptophores of the food-molecule, and thus the latter becomes an integral part of the cell. With food-molecules of a more complex composition, the process is somewhat different. Here the food-molecule cannot enter into combination with the receptor of the cell unless it is in some way modified. This modification or elaboration of the complex food-molecule is accomplished by receptors possessing two different atom-groups. One atom-group possesses an affinity for a ferment-like substance present in the blood-plasma—complement—which prepares the food-molecule, which then combines with the other atom-group. Receptors possessing two such atom-groups are called *amboceptors.*

Extending this hypothesis to the explanation of immunity, we assume that a molecule of bacterial toxin behaves toward the cell very much like a food-molecule, with this difference: A toxin molecule possesses two atom-groups, a haptophorous group, which combines with the receptors of the cell, and a *toxophorous* group, which exerts a poisonous effect on the cell. If the amount of toxin is not sufficient to destroy the cell, the latter is stimulated to an over-production of receptors, which are cast off and circulate freely in the blood. These free receptors anchor the toxin molecules as soon as they enter the circulation, and thus prevent their combining with the cells. In this manner antitoxic immunity is established and maintained. In the light of this hypothesis, antitoxin is blood-serum containing free receptors, and by its introduction into the system in cases of infection (diphtheria, tetanus) we administer free receptors, which circulate in the blood and anchor the toxin molecules, which are thus neutralized before they can combine with the cells. The immunity produced by the injection of antitoxin is called passive, and is especially characterized by its short duration, contrasting with the lasting immunity produced in the body of an individual who overcomes successfully the infection.

In the case of the more complex bacterial bodies or toxic foreign cells, the amboceptors are the protective agents. Here, while one atom-group combines with the complement which fixes the bacteria, or the cells, the other destroys them. As a result of immunization or natural infection the amboceptors are produced in excess, and the free amboceptors circulate in the blood, rendering it bactericidal or cytolytic, as the case may be.

QUESTIONS TO CHAPTER XV.

THE GERM THEORY OF DISEASE.

What is meant by the germ theory of disease? When did this doctrine first take definite shape? When was it first clearly enunciated, and by whom? What basis was there then for it? What subsequent evidence soon developed? What was the first evidence of the parasitic nature of general diseases? Who discovered and who first demonstrated the true cause of anthrax? Who proved tuberculosis to be of microbic origin? When? What other diseases are now known to be caused by specific micro-organisms? What others are probably due to a like cause?

What effect has the establishing of the germ theory upon preventive medicine? What is meant by protective inoculation? What evidence is there that this is possible? How do disease germs produce their characteristic effects upon the system? How may the inoculating material be prepared? How is diphtheria antitoxin prepared? How do antitoxins act? What are "opsonins"? What is the "opsonic index"?

Define immunity. Name varieties of immunity. What factors are requisite to the production of an infectious disease? How is the virulence of a micro-organism increased? How may the resistance of the individual be diminished? How may infection be prevented? Name the accepted theories of immunity. Describe Metchnikoff's theory. Define *cytases, microphages, macrophages;* what are their respective functions? What are receptors? How is nutrition of the cell brought about? How do toxins combine with the cell? What is the function of amboceptors? What rôle do the receptors play in immunity? What is the difference in the mode of action of receptors and amboceptors?

CHAPTER XVI.

CONTAGION AND INFECTION.

THE adjectives "contagious" and "infectious" are used to designate certain diseases which are propagated by immediate contact, or through the intervention of some other medium, from the sick to the healthy. The matters in which reside the morbific power are micro-organisms.

The differentiation between contagion and infection is not easy. Many of the diseases commonly called contagious are also infectious; that is, they are propagated not merely by direct contact, but also by air, water, or food which may have become infected with the morbific agent. Syphilis, for example, may be regarded as simply a contagious disease; at the present day, at least, we cannot conceive of syphilis to be propagated by breathing infected air or drinking water contaminated with the poison of syphilis. Cholera and typhoid fever, on the other hand, are examples of infectious diseases, neither of them being directly contagious, but conveyed from sick to well through the medium of contaminated water, or food. Between these two stand small-pox and typhus fever (and perhaps the other exanthemata), which are not merely contagious, but infectious also.

The contagious and infectious diseases are of particular interest to sanitarians, because it is believed that by judicious carrying out of sanitary measures they can be prevented. Hence they are sometimes termed preventable diseases. Another peculiarity of the infectious diseases is that they usually occur in groups of cases. Thus, small-pox, measles, scarlet fever, typhus fever, diphtheria, and others of the class do not occur sporadically, as it is termed; that is to say, it rarely happens that only one case of small-pox is observed in a locality, unless active measures are at once taken to stamp it out. Usually a number of cases occur successively, and in most instances the succeeding cases can be traced ultimately to the first case.

Contagious and infectious diseases frequently appear as epidemics. Authorities differ as to the proper definition of an epidemic; that is, given the population of a place, how many cases of an infectious or contagious disease are necessary before the disease can be considered epidemic at such place. The following formula was given by the

New Orleans Medical and Surgical Association in response to the query: "Under what circumstances is it proper to declare such diseases (diphtheria, scarlet fever, measles, small-pox, yellow fever, etc.) epidemic in a place?" The answer given is that the disease should be declared epidemic when the number of cases should reach these proportions[1]:—

For a population of	100		5	per cent.	
" " "	500		4	"	"
" " "	2,000 to	5,000	22½	"	thousand.
" " "	6,000 to	10,000	16	"	"
" " "	20,000 to	50,000	8	"	ten thousand.
" " "	50,000 to	100,000	4	"	" "
" " "	200,000		1	"	" "

A disease is said to be *pandemic* when it spreads rapidly over a great extent of country, and *endemic* when it is constantly present in a place. Diseases which may be prevalent in certain localities, *i.e.*, endemic, not infrequently spread over larger areas of country—overflow their borders, as it were—and become epidemic or pandemic. Thus cholera, which is endemic in certain districts of India, frequently spreads over adjacent territory, and at times the epidemic wave, as it has been called, rolls over nearly the whole world. Plague, malarial and yellow fevers make similar epidemic excursions into other countries, or sections of country, at a distance from the places where they are endemic.

Contagious and infectious diseases possess another peculiarity in that a certain time is required after the introduction of the poison into the system before the disease manifests itself by its typical symptoms. This is called the "stage of incubation," and varies for different diseases. The following table shows the stage of incubation of a number of such diseases:—

TABLE LVI.

Incubation of Infectious Diseases.

Measles	10 days.
Small-pox	12 "
Mumps	18 "
Diphtheria	3 "
Scarlet fever	3 "
Whooping-cough	14 "
Typhoid fever	14 "
Typhus fever	1 to 2 "
Chicken-pox	4 "
Erysipelas	4 "

[1] Public Health, vol. vi, p. 416, 417.

The period during which the infectiveness of the patient lasts also varies. In some cases it probably depends upon the measures taken to prevent the spread of the disease, *e.g.*, disinfection of the patient and his surroundings.

The London Clinical Society has made public a report by one of its committees, which has for several years carefully studied the questions of incubation and the duration of infection. The conclusions reached do not differ essentially from those in the above table, but as they are given somewhat more in detail they are here appended:—

Diphtheria, two to seven days; oftenest two.

Typhoid fever, eight to fourteen days; sometimes twenty-three.

Influenza, one to four days; oftenest three to four.

Measles, seven to eighteen days; oftenest fourteen.

Mumps, two to three weeks; oftenest three weeks.

Rubeola, two to three weeks.

Scarlet fever, one to seven days; oftenest two to four.

Small-pox, nine to fifteen days; oftenest twelve.

Further investigations were made with regard to the time and duration of the infective period.

Diphtheria was found to be infective during the period of incubation, attack, and convalescence.

Mumps and rubeola are also infective for three or four days before the onset of the parotiditis and appearance of the rash.

The contagiousness of measles speedily disappears, and does not continue in disinfected persons for over three weeks.

Typhoid fever is infectious from the time of onset until two weeks after the fever has gone and convalescence set in.

As is well known, the contagiousness of scarlet fever varies greatly, but is generally continued a very long time—certainly until desquamation ceases, and sometimes as long as eight weeks.

THE CARRIERS OF INFECTION.

The germs of infectious or contagious diseases may be conveyed either by inanimate objects which come in contact with the original source of the disease or by living animals. Of the former, air, food, water, and clothing, the latter included under the general term "fomites," have already been discussed. The transmission of disease by animals, especially by insects, is a subject which has assumed considerable importance of late. Leaving aside the strictly animal diseases which are communicable to man, as anthrax, glanders, hydrophobia, actinomycosis, etc., we will consider only the instances in which the animal acts as a passive agent, or an intermediary host. Thus, oysters from sewage-polluted beds have been responsible for epidemics of typhoid fever. The bacillus coli has been found in the bodies of such oysters, while Chantemesse and others have demonstrated the possibility of oysters carrying the typhoid bacillus. Certain snails appear to be intermediate hosts for worms parasitic to man. The most important disease-carriers, however, are the insects. These may either convey the germs mechanically, or inoculate them by stinging or biting, or act as intermediate hosts. Thus, flies may carry on their legs or within their bodies the germs of cholera, typhoid fever, tuberculosis, and other infectious diseases, and deposit them on the food or drink which is subsequently consumed by man. There is abundant evidence to prove that in many instances epidemics of typhoid fever have been caused through the agency of the domestic fly. During the Spanish-American War several camps were visited by epidemics of typhoid fever, and in every instance flies were demonstrated as the carriers of the infection. Fleas, bed-bugs, spiders, and lice may and often do transmit disease by biting the individual and inoculating the wound with the bacteria which are present on the proboscis. In the case of mosquitoes, there are certain species which act as the intermediary host and are essential factors in the propagation of disease. Thus, the plasmodium malariæ, a protozoön which is the specific cause of that disease, undergoes two cycles of development: an asexual cycle in the human body, and a sexual cycle in the body of the mosquito of the genus *anopheles*. When the mosquito draws the blood from a person suffering from malaria, the flagellate forms of the parasite (*microgametocytes*) are developed in its stomach. The flagella (*microgametes*, or male elements) are discharged, move towards other non-flagellated forms of the parasite (*macrogametes*, or female elements) and fertilize them, The fertilized parasites then invade the intestinal wall and form a cystic structure (oöcysts), containing numerous minute rods or sporozoöits which have resulted from the segmentation of the parasite. The oöcysts eventually rupture and the sporozoöits find their way into the veneno-salivary glands of the mosquito, to be introduced into the next person who is so unfortunate as to receive the sting of the infected mosquito. Once in the circulation of man, the parasites invade the red blood-cells and there undergo multiplication by segmentation.

Recently it has been demonstrated that yellow fever is transmitted by another species of mosquito, *stegomyia fasciata*, probably in a similar manner; while Manson has shown that the mosquito (*culex*) acts as the intermediary host of the parasite of elephantiasis (*filaria sanguinis hominis*).

Of the higher animals, rats have been shown to be the carriers of bubonic plague, a disease to which they are subject.

The prophylaxis of diseases transmitted by insects and the higher animals is to be accomplished by cleanliness, destruction of the pests whenever possible, and avoidance of contact with animals harboring the germs of disease.

QUESTIONS TO CHAPTER XVI.

CONTAGION AND INFECTION.

What is the difference between a contagious and an infectious disease? Give examples of each. What diseases do not belong to either of these classes? What other names might be given to contagious and infectious diseases? How do they usually occur? What are their exciting causes? How may they be prevented?

What is an epidemic? When may a disease be declared epidemic in a city of 10,000 persons? When is a disease pandemic? When endemic? May an endemic disease become epidemic or pandemic?

What other peculiarities do contagious and infectious diseases possess? What diseases have the longest period of incubation? What ones the shortest? How does the period of incubation support the germ theory? What other definite period has each of these diseases? What is the usual duration of a case of typhoid fever? Of scarlet fever? Of measles? Does this support the germ theory? How long does a typhoid patient remain infective? How long a diphtheria patient? A scarlet-fever patient? (See chapters on School Hygiene and Quarantine.) Upon what does the danger and period of infectiveness depend? Are these diseases all likely to confer immunity against future attacks? Which are most likely to do this? What rôle do animals play in the transmission of disease? Name insects which act as intermediate hosts in the transmission of malaria. Of yellow fever. Describe the mode of transmission of malaria by the mosquito.

CHAPTER XVII.

HISTORY OF EPIDEMIC DISEASES.

An important part of the knowledge of the sanitarian is that which relates to the history of the great epidemic diseases which have at various periods devastated large areas of the inhabited world. In this chapter the history of these diseases will be briefly traced. Although some of these diseases have nearly or quite ceased, a knowledge of their habits and of the causes that finally led to their extinction is of great value, for the reason that the principles and measures of prevention which were effective in times past are the same which must apply at present and in the future. Hence, time spent in looking back over the fields traversed and noting victories won will not be wasted.

The epidemic diseases which will here claim attention are the Oriental plague, the sweating sickness, small-pox, Asiatic cholera; typhus, typhoid, scarlet, relapsing, and yellow fevers; diphtheria, dengue, epidemic influenza, and syphilis. In addition, some information will be given on certain of the diseases of animals transmissible to man. Among these are sheep-pock, actinomycosis, bovine tuberculosis (perlsucht), rabies, anthrax (milzbrand), and glanders.

THE ORIENTAL PLAGUE.

The Oriental plague, bubonic plague, the black death, or simply the "plague," or great pestilence, overtopping in its fatality all other pestilences, is mentioned by a number of the Greek and Latin medical authors. The first account which clearly refers only to this disease is given by Procopius. According to this and other contemporary authors, the disease began to spread in the year 542 from Lower Egypt, passing in one direction along the coast of Northern Africa, and in the other invading Europe by way of Syria and Palestine. In the course of the succeeding years this pandemic reached "the limits of the inhabited earth," in the language of the writers of the day. The disease prevailed about half a century, and produced the greatest devastation wherever it appeared. "Cities were devastated, the country converted into a desert, and the wild beasts found an asylum in the abandoned haunts of man."[1]

[1] Warnefried, quoted by Hirsch, Hist-Geographische Pathologie, I, p. 350.

The plague is an acute infectious disease caused by a bacillus (*bacillus pestis*) and characterized by an affection of the lymphatic system, *i.e.*, inflammation and swelling of the external and internal lymphatic glands. Accessory symptoms are petechial spots upon the skin, and hemorrhages from various organs, as the stomach, nose, kidneys, rectum, and uterus. Those attacked suffer in varied degrees of intensity. In some, a fulminant form occurs which carries off the patient within three days; there is another class of cases in which buboes develop, with accompanying fever and hemorrhages; and finally, a light form, rarely fatal, in which only the local symptoms are manifested. In the great pandemic plague of the fourteenth century cough and bloody expectorations were very frequent. In the later epidemics hemorrhage from the lungs has been rarely noticed as a symptom.

About the middle of the fourteenth century the bubonic plague made a second incursion into Europe from its home in the East. A most graphic description of its ravages is given by Boccaccio in the "Decameron." This author states that in 1359, "between March and July following, according to authentic reckonings, upward of 100,000 souls perished in the city (Florence); whereas, before that calamity it was not supposed to contain so many inhabitants."

This terrible epidemic was forcibly characterized by its common name, "the black death." Hecker estimates that during its continuance, from 1347 to 1351, 25,000,000—one-fourth of the probable total population of Europe—died. In various cities the mortality was —in London, 100,000; in Paris, 50,000; in Venice, 100,000; in Avignon, 60,000; in Marseilles, 16,000, in one month. It was said that in all England scarcely a tenth part of the population escaped death from the disease.

The moral effects of this great pandemic of the plague were hardly less deplorable than the physical. Religious fanaticism held full sway throughout Europe, finding its vent in all manner of excesses. The so-called Brotherhood of the Cross, otherwise known as the Order of Flagellants, which had arisen in the thirteenth century, but had been suppressed by the ecclesiastical authorities, was revived during the black pestilence, and large numbers of these religious enthusiasts roamed through the various countries on their great pilgrimages. Their power increased to such a degree that Church and State were forced to combine for their suppression. One consequence of this fanatical frenzy was the persecution of the Jews. These were accused of being the cause of every evil that befell mankind, and many were put to death.

In the fifteenth and sixteenth centuries the plague was generally diffused throughout Europe, and in the second third of the seventeenth century its final incursion into the Occident took place. The great epidemic in London, so graphically described by Defoe,[2] occurred in 1665. In the early part of the eighteenth century (1720) the plague visited Marseilles and Toulon; from 1769 to 1772 it was epidemic in Moldavia, Wallachia, Poland, and Southern Russia; near the close of the eighteenth and in the beginning of the nineteenth century, in Transylvania, Wallachia, Southern Russia, and Greece. In 1878 and 1879, and in 1885, the plague threatened a new irruption into European territory, being epidemic in the district of Astrachan, on the Caspian Sea. In 1894 it was reported epidemic in certain parts of China.

Although the bubonic plague has never been observed in America in epidemic form, and has spared Europe almost entirely during the present century, it still persists in certain countries of Asia and Africa, especially in Arabia, Mesopotamia, Persia, and the coast of Tripoli. A number of cases of plague occurred a few years ago in San Francisco, in the Chinese quarters.

The older authors ascribed the origin of the plague to various real or supposed conditions. Comets, conjunctions of the planets, "God's just punishment for our sins," and similar causes were advanced to account for the outbreaks. Most of the writers of the post-medieval and modern epochs ascribed the disease to meteorological conditions. Observing the fact that the plague never advanced into the torrid zone, and that an epidemic generally ended with the advent of hot weather, a high temperature was believed to be incompatible with the existence of an epidemic, and a cold or temperate climate was considered necessary to an outbreak of the disease. The exceptions to the rule are so numerous, however, that the theory of the climatic or meteorological origin of the plague failed of support. The theory which ascribed the origin of the epidemics to the influence of certain hot and dry winds or a high humidity is also insufficient. Certain geological formations have been supposed to furnish favorable conditions for the development of the disease. Facts show, however, that the disease has prevailed epidemically and endemically in various parts of the earth, and of the most diverse geological character. A certain elevation above sea-level has been held to confer immunity, but recent observations in India show that this belief is unfounded.

[2] Journal of the Plague in London.

even places at an elevation of 10,000 feet above sea-level giving no security against attack.

There is, however, one point upon which nearly all writers who mention the fact at all agree. That is that *bad hygienic conditions* are always present where plague prevails. Nearly all observers who have left their impressions on record mention the accumulation of filth in the houses and streets, deficient removal of excrementitious and other sewage matters, crowding and imperfect ventilation of dwellings as causes favoring the development and spread of the pestilence. All point out the necessity of the removal of these evils as the most important prophylactic measure to be adopted, and all of them call attention to the fact that those classes of the population most exposed to these unfavorable influences suffer most from the violence of the epidemic.

The later reports of the epidemics in Persia, India, Mesopotamia, and Russia agree in asserting that nothing seems to have promoted the epidemic and endemic prevalence of the plague so much as the material wretchedness of the inhabitants of those countries. In a collection of papers on the plague, printed by a British Parliamentary Commission in 1879, occur these statements: "The filth is everywhere," says Mr. Rennie, one of the reporters—"in their villages, their houses, and their persons. Their dwellings are generally low and ill-ventilated, except through their bad construction; and the advantage of the natives in other parts of India, of living in the open air, is lost to the villagers of Ghurwal, from the necessity of their crowding together for mutual warmth and shelter against the inclemency of the weather." Dr. Dickson, reporting on the plague in Irak Arabi, in 1876, says: "The most palpable and evident of all the causes which predispose an individual to an attack of plague during an epidemic outbreak is *poverty*. No other malady shows the influence of this factor in so striking a degree; so much so, indeed, that Dr. Cabiadis styles the plague *miseriæ morbis*. In his experience (1876-77, in Bagdad) he found that the poor were seldom spared, the wealthy hardly ever attacked."[3]

The manner of the transmission of the plague has now been discovered to be by infected rats and fleas. Hence, it may be termed an infectious disease, although it is not improbable that it may be communicated by direct contact both of persons and of fomites.

These considerations indicate the measures of prevention to be

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[3] Hirsch, *op. cit.*, p. 370.

adopted. They consist of a rigid quarantine of persons and fomites, prompt and complete isolation of infected individuals and localities, and destruction (by fire) or thorough disinfection by steam or sulphurous-acid gas of all materials capable of conveying the virus of the disease, and especially the destruction of rats.

THE SWEATING SICKNESS.

This name concisely characterizes an epidemic disease which for the first time appeared in the city of London and other parts of England in the autumn of 1485. According to Lord Bacon,[4] the disease began about the 21st of September and lasted until near the end of October. It broke out a second time in the summer of 1507; a third time in July, 1518, spreading in the course of six months throughout England. In May, 1529, the disease made its appearance again in the latter country, spreading thence over a great part of the continent of Europe. Another very malignant epidemic broke out in the spring of 1541, lasting through the summer, and limited in its ravages to England.

With this outbreak, in 1551, this disease disappeared entirely in England, and has not re-appeared there up to the present day. In the beginning of the eighteenth century, however, a disease very similar in its symptoms and course broke out in Picardy and other districts of Northern France, being confined for a number of years to this section of the country. Toward the end of the century it spread to the south of France, and since that time has appeared epidemically at intervals, 195 distinct outbreaks having been observed in the course of 168 years, from 1718 to 1887. The disease has frequently appeared in Italy since 1755, and in various parts of Germany since 1801. In Belgium it has been observed at a few places within the present century.

The disease appeared suddenly, often at night-time. The patient was attacked with palpitation of the heart, dyspnea, great anxiety and oppression, and profuse perspiration. A miliary eruption often appeared on the skin. In favorable cases these symptoms diminished in the course of one or two days, the urinary secretion, which had been suppressed, was restored, and the perspiration became gradually less free. Recovery ensued in from one to two weeks. In grave cases there were, in the beginning of the attack, violent headache, delirium,

[4] History of Henry VII.

convulsions, followed by a comatose condition, from which the patients rarely recovered.

This disease is undoubtedly of an infectious nature, as proved by its rapid spread and limitation to certain localities. It appears most frequently in the spring and summer, and is nearly always observed in marshy or damp localities. Its spread is favored by a high temperature and humidity. There is no apparent connection between the outbreaks of the sweating sickness and overcrowding or other unsanitary conditions; in fact, it is stated by numerous observers, both old and recent, that children, the aged, and generally the poorer classes were remarkably exempt from the disease. The recent epidemic in France, in 1887, was investigated by Dr. Brouardel, Chantemesse, and other epidemiologists, but no trustworthy conclusions as to the nature of the disease have yet been reached.

Since the first appearance of Asiatic cholera in France, in 1832, an apparently intimate connection has been observed between the occurrences of that disease and outbreaks of sweating sickness. A disease strongly resembling the sweating sickness has also been observed in India in districts contiguous to places where cholera was at the time epidemic.[5]

SMALL-POX.

The earliest details concerning small-pox are derived from certain Chinese records, according to which it appears that this disease was known in China upward of 2000 years ago. It was also known at a very early period in India. It is believed to have been introduced into Europe in the second century by a Roman army returning from Asia. It is believed that the Emperor Aurelius died of small-pox, which prevailed in his army at the time of his death.

The first distinct references to small-pox in medical literature occur in the writings of Galen, in the second century. Rhazes, in the ninth century, wrote upon the disease, describing it very accurately.

The almost universal susceptibility to small-pox caused widespread devastation wherever it appeared previous to the introduction of vaccination. The statement is made that in England, in the last century, about one person in every three was badly pock-marked. The mortality from the disease was exceedingly great, being, in the latter half of the eighteenth century, about 3000 per million of inhabitants annually.

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[5] Murray, Madras Quart. Med. Journ., 1840-41. Quoted in Hirsch, *loc. cit.*, p. 83.

In India the mortality from small-pox has been exceedingly great within the last twenty years. From 1866 to 1869, 140,000 persons died in the Presidencies of Bombay and Calcutta, having a population of about 40,000,000. Several years later, from 1873 to 1876, 700,000 died from this disease.

China, Japan, Cochin China, the islands of the China Sea, and Corea are frequently ravaged by small-pox. In the latter country nearly all the inhabitants are said to bear evidence of an attack of the disease.

The Samoyedes, Ostiaks, and other natives of Eastern Siberia have frequently suffered from devastating epidemics. In Kamtchatka the disease was introduced in 1767 and produced frightful ravages. Many villages were completely depopulated.

In Mexico small-pox was introduced by the Spaniards in 1520. In a short time it carried off over 3,500,000 of the natives. In the Marquesas Islands one-fourth of the inhabitants have fallen victims to the disease since 1863.

It was first introduced into the Sandwich Islands in 1853, and carried off 8 per cent. of the natives.

Australia, Tasmania, New Zealand, and the Fejee Archipelago remain exempt to the present day from small-pox. It has several times been carried to Australia by vessels, but has always been promptly checked by the vigilance of the authorities.

On the Western Hemisphere small-pox was unknown before the arrival of the European conquerors. It has been spread by the whites or imported African slaves to nearly all the Indian tribes of both continents. When it attacks large communities unprotected by previous outbreaks of the disease, or by inoculation or vaccination, its ravages are frightful. The mortality of unmodified small-pox is usually between 30 and 40 per cent.

Small-pox is a highly contagious and infectious disease. It is produced by actual contact, by inoculation, and by inhaling an atmosphere charged with the poison. In order to cause an outbreak two factors are necessary: first, a number of individuals susceptible to the disease, and, second, the introduction into the body in some manner, of the virus upon which it depends.

Small-pox is spread from (1) persons sick with the disease; (2) others, not themselves sick or susceptible, but coming in contact with the poison; (3) fomites (cotton, wool, etc.), and (4) the bodies of persons dead with small-pox. It is also probable that the air in the immediate vicinity of a person sick with small-pox becomes charged with the poison and able to convey the disease. It is at present impossible to fix the distance to which this infectiousness of the air extends, but it does not ordinarily reach beyond the room in which the patient is confined.

It is a fact of common observation that the darker races are more commonly attacked, and the disease is likewise more fatal among them. The mortality among negroes is much larger than among other races.

It is a current belief that small-pox is only contagious after the development of the pustules. This is a serious error. It is probably contagious in all stages of the disease; certainly as early as the first appearance of the eruption, and probably even in the stage of preliminary fever.

One attack of small-pox usually confers immunity from the disease for life. This rule has its exceptions, however, which, if not numerous, are yet not infrequent. The author has seen a case in which the patient suffered from a third attack of the disease.

The popular belief, that persons suffering from any acute or chronic disease are less liable to be attacked by small-pox than those at the time in good health, is erroneous. On the contrary, the subjects of chronic disease, such as consumption or dyspepsia, are much more liable to succumb to an attack of small-pox than persons previously in good health.

It is true, however, that individuals suffering from some other acute infectious disease, like scarlet fever, measles, typhoid fever, etc., are generally, though not absolutely, exempt from an attack of small-pox during the time they are sick with such disease. But if they are exposed, after recovery, to the small-pox infection, their liability to an attack is as great as in those who have not passed through a similar disease. A number of cases have been reported by Curschmann,[6] in which infection by small-pox took place on the day in which convalescence from typhoid fever was established.

The author has reported a case[7] in which the patient passed through an attack of erysipelas during the incubative stage of small-pox. From all the evidence attainable, the incubative stage was not prolonged by the intercurrent erysipelas.

Epidemics of small-pox usually begin in the autumn or winter, and lessen in violence as warmer weather approaches. The spread

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[6] Ziemssen's Cyclopœdia, vol. ii.
[7] Medical News, July 7, 1883.

of the disease is slow at first, increasing in rapidity as the foci of infection multiply.

When the poison is imported into a community late in the spring or during the summer, the increase in the number of cases is exceedingly gradual until colder weather sets in. If it is introduced during the winter, the disease spreads much more rapidly, but decreases, and sometimes almost disappears, during the summer. On the return of cold weather, however, the epidemic starts out with a new lease of activity and presents great difficulties to its restriction.

A number of observers, among whom are Coze and Feltz, Lugenbühl, Weigert, Strauss, Garré, and Wolff, claim to have discovered specific organisms in the contents of variolous pustules, in the blood of patients with the disease, and in vaccine lymph. Expert bacteriologists are, however, not willing to accept the evidence hitherto furnished as conclusive.

Inoculation.—The prevention or restriction of such a universal and fatal pestilence as small-pox is a matter of the deepest importance. The first attempt to limit its fatality dates from the end of the seventeenth century. It became generally known in Europe, about the year 1700, that the intentional inoculation of variolous matter into healthy individuals induced an attack of the disease, which generally ran through its various stages with less virulence than when the disease was contracted in the usual manner. In 1716 and 1717 two papers were published in the "Transactions of the Royal Society of England" giving an account of the process of inoculation. The attention of the public was especially directed to the matter, however, by the famous letter of Lady Mary Wortley Montagu, dated April 1, 1717. This letter is as follows[8]: "Apropos of distempers, I am going to tell you a thing that will make you wish yourself here. The small-pox, so fatal and so general amongst us, is here entirely harmless by the invention of *ingrafting,* which is the term they give it. There is a set of old women who make it their business to perform the operation every autumn, in the month of September, when the great heat is abated. People send to one another to know if any of their family has a mind to have the small-pox; they make parties for this purpose, and when they are met—commonly fifteen or sixteen together—the old woman comes with a nut-shell full of the matter of the best sort of small-pox, and asks what veins you please to have opened. She immediately rips open that you offer to her with a large needle—which gives you no more pain than a common scratch—and

[8] The letter is addressed to Mrs. S. C. (Sarah Chiswell).

puts into the vein as much matter as can lie upon the head of her needle, and after that binds up the little wound with a hollow bit of shell; and in this manner opens four or five veins. The Grecians have commonly the superstition of opening one in the middle of the forehead, one in each arm, and one on the breast, to make the sign of the cross; but this has a very ill effect, all these wounds leaving little scars, and is not done by those that are not superstitious, who choose to have them in the leg or that part of the arm that is concealed. The children or young patients play together all the rest of the day, and are in perfect health until the eighth. Then the fever begins to seize them, and they keep their beds two days, very seldom three. They have rarely above twenty or thirty in their faces, which never mark; and in eight days' time they are as well as before their illness. Where they are wounded there remain running sores during the distemper, which I don't doubt is a great relief to it. Every year thousands undergo this operation; and the French ambassador says pleasantly: 'They take the small-pox here by way of diversion, as they take the waters in other countries.' There is no example of any one that has died in it, and you may believe that I am well satisfied of the safety of the experiment, since I intend to try it on my dear little son.

"I am patriot enough to take pains to bring this useful invention into fashion in England; and I should not fail to write to some of our doctors very particularly about it, if I knew any of them that I thought had virtue enough to destroy such a considerable branch of their revenue for the good of mankind. But that distemper is too beneficial to them not to expose to all their resentment the hardy wight that should undertake to put an end to it. Perhaps, if I return, I may, however, have courage to war with them."

Soon after the date of this letter the writer's son was inoculated in Turkey, and four years later her daughter also, being the first subject inoculated in England. The practice soon became popular, but several fatal cases among prominent families brought it into disrepute, and for about twenty years very few inoculations were made in England. It was revived about the middle of the century by the founding of a small-pox and inoculation hospital in London. This continued in operation until 1822. The records of this institution showed that only three in a thousand died of the disease thus communicated. The practice has now fallen into desuetude, being superseded by vaccination and prohibited by law in England.

Inoculation was introduced into this country in 1721 by Dr. Zabdiel Boylston, of Boston, who had his attention directed to the practice by Cotton Mather, the eminent divine.[9] During 1721 and 1722, 286 persons were inoculated by Boylston and others in Massachusetts, and 6 died. These fatal results rendered the practice unpopular, and at one time the inoculation hospital in Boston was closed by order of the Legislature. Toward the end of the century an inoculating hospital was again opened in that city.

Early in the eighteenth century inoculation was extensively practiced by Dr. Adam Thomson, of Maryland, who was instrumental in spreading a knowledge of the practice throughout the Middle States.[10]

In China and India, and perhaps other eastern countries, inoculation was practiced at a very early period.

The inoculation of variolous matter, although it mitigated to a very great degree the attack of small-pox following, had one very serious objection, aside from the small death-rate which was a direct consequence of it. This was the fact that inoculation always produced small-pox, and thus assisted in propagating the disease; for, however mild the induced disease might be, the inoculated individual was liable to communicate small-pox to others in the most virulent form. Hence, nothing short of universal inoculation, which was manifestly impracticable, would succeed in reducing the danger from the disease.

Vaccination.—It had been noticed at various times that a pustular disease which sometimes appears on the udders of cows, called cow-pox, had not infrequently been transmitted to the hands of the dairy-maids and others having much to do with cows. In the course of time it was also noticed that persons who had been thus attacked never suffered from small-pox. This protective power of cow-pox was known as early as 1713, and in 1774 Benjamin Jesty, a Gloucestershire farmer, performed vaccination for the first time on record, inoculating his wife and two sons with cow-pox matter as a protection against small-pox.

It is said that when it became known that Jesty had vaccinated his wife and sons, "his friends and neighbors, who had hitherto looked upon him with respect, on account of his superior intelligence and honorable character, began to regard him as an inhuman brute, who

[9] Dr. John R. Quinan (Md. Med. Journ., June 23 and 30, 1883) believes the claim of Dr. Boylston to be the first American inoculator open to question. The evidence presented is, however, insufficient to discredit the claim of the Boston physician.

[10] See Quinan, *loc. cit.*, p. 114.

could dare to practice experiments upon his family, the sequel of which would be, as they thought, their metamorphosis into horned beasts. Consequently the worthy farmer was hooted at, reviled, and pelted whenever he attended the markets in his neighborhood."[11]

In 1791 a school teacher in Holstein also inoculated three boys with the matter of cow-pox, but nothing is known of the subsequent history of these cases.

Although the above facts are clearly established, it is to Edward Jenner, a modest country doctor of Berkeley, in the county of Gloucester, England, that the merit of demonstrating the protective power of cow-pox against small-pox, and of diffusing a knowledge of this fact, is due. Jenner had his attention directed to the asserted protection conferred by cow-pox during the period of his apprenticeship. After a residence in London as a pupil of John Hunter, he returned to the country to practice his profession. About the year 1776 he began studying the question, and gathering evidence of the protection afforded against small-pox by the accidental inoculation of cow-pox virus. For twenty years he studied the subject, patiently awaiting an opportunity to put his belief to the test of experiment. On the 14th of May, 1796, he made his first vaccination on a boy named James Phipps. Six weeks later he inoculated this boy with variolous matter, but without success, no small-pox resulting. Two years later he published his pamphlet, entitled "An Inquiry into the Causes and Effects of the Variola Vaccinæ," etc., in which he detailed his observations and experiments. This publication produced a great sensation in the medical world, and, although much opposition was at first manifested towards his views, he soon gained many adherents.

Vaccination, as the operation for the inoculation of cow-pox virus is termed, was rapidly introduced into all civilized countries, and soon demonstrated its good effects by greatly restricting the prevalence of small-pox. It is generally believed that the first one to practice vaccination in this country was Dr. Benjamin Waterhouse, of Boston, in the summer of 1800; but Dr. John R. Quinan has recently shown[12] that vaccination was introduced into Maryland, by Dr. John Crawford and Dr. James Smith, at least as early as the date generally assigned for its introduction into Massachusetts.

It was believed by Dr. Jenner, and afterward conclusively shown by a number of distinguished experimenters, that vaccinia, as the disease produced by cow-pox inoculation was called, was merely a modi-

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[11] London Lancet, September 13, 1862.

[12] Quinan, *loc. cit.*, pp. 118, 131.

fication of small-pox as it existed in the cow. Small-pox virus, when inoculated upon the cow, produced cow-pox; but the latter, re-inoculated upon man, produced cow-pox (vaccinia), and not small-pox. These experiments, however, have not been successful in all instances, and the identity of the two diseases, while generally recognized, is not absolutely established. Sheep-pock and horse-pock, or "grease," are probably merely modifications of the disease produced by inoculating small-pox into those animals.

When cow-pox virus is successfully inoculated into the human system—that is, when a person is successfully vaccinated—the following local and general symptoms are observed:—

In the case of a primary vaccination, *i.e.*, where the individual has not been previously vaccinated or attacked by small-pox, the point where the vaccination is made shows no particular change for the first two days. If the vaccination is successful, a small, reddish papule appears by the third day, which, by the fifth or sixth day, has become a distinct vesicle of a bluish-white color, with a raised edge and a peculiar, central, cup-like depression called the umbilication. By the eighth day this vesicle has become plump, round, and pearl-colored, the central umbilication being still more marked. At this time a red, inflamed circle, called the areola, appears, surrounding the vesicle and extending usually in a radius of from one-half to two inches when fully developed. This inflammatory ring is pretty firm, and there is more or less general fever and often enlargement and tenderness of the axiliary glands. After the tenth day the areola begins to fade, and the contents of the vesicle dry into a hard, brownish crust or scab, which falls off between the twentieth and twenty-fourth days, leaving a punctated scar, which gradually becomes white.

When the vaccinia has passed through all of these stages, especially if the vesicle filled with pearly lymph, and the areola have been well developed, the vaccination may be considered a success, and the individual protected against small-pox for a number of years, if not for life. Recently the doctrine has been strongly advocated that vaccination is not absolutely protective until a subsequent inoculation of vaccine fails to "take." According to this view, vaccination should be repeated until it fails any longer to exhibit any local reaction. When this has been attained the individual may be considered absolutely protected for life. Theoretically, this view has much in its favor, but there is, as yet, not sufficient evidence to establish it as a law.

It may be stated as an established fact that vaccination, although carefully performed and successful, does not confer absolute immunity from small-pox for life. The protective power seems to wear out after a time and the individual then again becomes susceptible to small-pox. An attack of small-pox in a vaccinated individual is, however, nearly always much milder than where there had been no vaccination. There is no fact in the entire range of medicine better established than this: that small-pox in vaccinated persons is a much less dangerous disease than typhoid fever, while in unvaccinated cases the mortality ranges from 30 to 40 per cent. An approximate guide to the beneficent influence of vaccination upon the mortality from small-pox is furnished by a table in Seaton's report on vaccination. Before the introduction of vaccination the mortality from small-pox per million of inhabitants of England, was nearly 3000 per year. After the introduction of vaccination the mortality was reduced to 310 per million per year.

The most remarkable and convincing statistical evidence on the question is given by Drs. Seaton and Buchanan, of England. During the small-pox epidemic in London, in 1863, they examined over 50,000 school-children, and found among every thousand without evidence of vaccination 360 with scars of small-pox, while of every thousand presenting some evidence of vaccination only 1.78 had any such traces of small-pox to exhibit.[13] The reliability of general mortality statistics may be called in question—in some cases, with justice; but the significance of these figures cannot be evaded.

The upper and outer surface of the arm is usually chosen as the point where the virus is inserted, although any part of the body which can be protected against friction, or other mechanical irritation, may be selected. The method varies slightly in the hands of different vaccinators. The two methods most frequently in use are scarification and erasion. The former method has the indorsement of Mr. Seaton, the high English authority. The method of erasion—scraping off the epidermis until the papillary layer of the skin is laid bare—is now most frequently used in this country. The best instrument to use is a clean thumb-lancet; in default of this, an ordinary sewing-needle answers well. Where animal vaccine is used, the ivory slip or sharpened quill may also be used with satisfaction to make the scarification or erasion. Whatever instrument is used, it should always be kept perfectly clean.

A point of vital importance is that which relates to the proper

[13] Seaton, "Vaccination," in Reynold's System of Medicine, vol. i, p. 291. Second edition.

age at which children should be vaccinated. Ordinarily, vaccination should be performed within the first six months of life. In time of danger from a threatened, or in the presence of an actual, epidemic, infants may be vaccinated when only one day old.

In order to secure permanent protection against small-pox, revaccination should be performed after a certain interval. Some place the period at which this second vaccination should be done at five years, while others allow a longer interval—seven, eight, or ten years. The law of Prussia is that every child that has not already had small-pox must be vaccinated within the first year of its life, and every pupil in a public or private institution is to be revaccinated during the year in which his or her twelfth birthday occurs.

This law was passed in 1874. Prior to this time the mortality from small-pox was 15 to 20 per 100,000 of the population. Since the law was enacted the small-pox mortality has varied from 0.3 to 3.6 per 10,000. Not a single death from small-pox occurred in the German army between 1874 and 1882.[14]

A revaccination, even if successful, seldom passes through all the typical stages of a primary vaccination. The vesicle rarely becomes so full and plump, and is more frequently flat and irregular in outline. Swelling of the axillary glands and other complications also seem to be more frequent than in cases where the vaccination is done for the first time.

The question whether the lymph direct from the cow or humanized lymph is the more efficient has caused much discussion. The objections urged against the use of humanized virus are: first, that its protective power has become diminished by transmission through many generations; second, that it is liable to transmit other diseases, such as syphilis, tuberculosis, scrofula, etc.; third, that it is frequently difficult to obtain in sufficient quantities in an emergency, such as an actual or threatened epidemic.

The first objection is disproved by the testimony of many of the most distinguished medical men in Europe and this country. Humanized vaccine virus, when properly inoculated, seems to be as completely protective against small-pox as that taken direct from the animal. Among its advantages are, that it "takes" more readily and runs through its stages of development in a shorter time, and that it will retain its active properties for a greater length of time than animal virus. The physician can usually control the source whence he obtains it. He can watch over the subject that furnishes it

[14] Frölich, Militär-Medicin, p. 461.

and reject that which is suspicious. With humanized lymph collected by the physician himself there can be no doubt as to its purity or age; with animal lymph furnished by the cultivators of that article there can be no certainty about either of these important points.

That syphilis has been inoculated with humanized virus can no longer be open to doubt. The recent experiment of Dr. Cory, of England, has settled this question definitely. With care, however, this sad accident can easily be avoided, and the fact that syphilis has been so rarely transmitted by vaccination is sufficient evidence that the danger of such infection is not very great.

The most serious objection against the exclusive use of humanized lymph, is, that in grave emergencies, such as a rapidly-spreading epidemic of small-pox, it is difficult to obtain a sufficient supply of the lymph. However, humanized virus can never be obtained under the same strict asepsis as prevails in the production of animal virus, and its employment is not justifiable on this account, if for no other reason.

Humanized virus is inoculated, either in the fresh state, *i.e.*, the lymph is taken directly from the vesicle on the seventh day and inoculated directly into the arms of other individuals, or else the vesicle is allowed to dry into a crust, with which a thin paste is made by moistening with water at the time of vaccination. The readiest way of using the crust is to crush a small fragment between two small squares of glass, then moistening it with a drop of warm (not hot) water, and smearing it on the spot where the vaccination is to be made. With a lancet a number of cross-scarifications are then made, and the virus well rubbed in. Only so much of the crust should be moistened as will be used at the time. Particular care must be taken not to use saliva for moistening the crust. Aside from being unclean, there is danger of producing blood-poisoning by inoculating certain of the oral secretions.[15]

Animal virus is obtained by inoculating a calf or heifer with virus from another case of cow-pox, or by re-inoculating humanized vaccine virus into the animal. The vesicles are opened on the seventh day or at the end of ninety-six hours (Copemann) and ivory points or the ends of quills coated with the lymph and dried with a gentle heat, or the pulp is rubbed up with 50 per cent. glycerin and drawn up in fine glass tubes. The whole operation, from beginning to end, is done under strict asepsis.

In vaccinating with animal virus, the quill or ivory point is first

[15] See Sternberg and Magnin, Bacteria, p. 355. Second edition.

moistened with a drop of water to soften the adhering lymph; the scarification or abrasion of the skin is then made with the lancet or needle, and the virus rubbed well into the scarified spot, or, in using the glycerinized virus, the latter is simply rubbed into the scarified area.

In using animal virus the successive stages of development are usually one or two days later than when humanized virus is used. In the former case the areola is rarely developed before the ninth day.

Certain complications are likely to occur in the course of the vaccinia, of which the student should be aware.

When the areola appears there is usually more or less fever. Sometimes the constitutional manifestations are decidedly marked, fever of a high grade being not uncommon. In addition to the glandular enlargement and tenderness, an outbreak of roseola sometimes comes on about the ninth or tenth day. This eruption may be mistaken for scarlet fever, but if it is remembered that two infectious diseases rarely co-exist in one individual during their full development this error will be avoided.

Erysipelas involving the entire arm is sometimes observed as a complication of vaccination. This, in nearly every case, depends upon some depravement of the patient's constitution, malnutrition, bad sanitary surroundings, or, perhaps, more frequently, chronic alcoholism. Individuals who are habitually intemperate in the indulgence of alcoholic liquors are especially unfavorable subjects for vaccination. The results are, fortunately, rarely serious to the patient.

Another inconvenient complication of vaccination is the formation of a deep, ill-looking, sloughing ulcer at the vaccinated point. This is the result of infection with impure virus or lack of cleanliness in making the scarification. It should be borne in mind that a very sore arm, especially if followed by the formation of an ulcer or gangrenous sore, may not be protective against small-pox. Such a patient should not be considered properly vaccinated, and must be revaccinated as soon as he recovers, or immediately if there is any danger of small-pox infection.

Children with eczematous eruptions, however, localized upon any portion of the body, should not be vaccinated until the eruption is first cured, except in times of danger from small-pox. The eczema will be almost certainly rendered worse in consequence of the general hyperemia accompanying the febrile reaction, and the physician who performs the vaccination will be blamed for causing the skin disease.

The author has placed on record[16] two cases of general psoriasis following vaccination, and other cases have been since reported. Urticaria and exudative erythema have also been repeatedly observed.

As before stated, syphilis may be communicated to the vaccinee by vaccine virus obtained from a syphilitic subject, but this accident is infrequent. There can be little doubt that some of the cases reported as "vaccinal syphilis" are cases of tardy hereditary syphilis, lighted up by the general systemic disturbance following vaccination. In some cases tetanus has followed vaccination. This unfortunate complication may be due either to the tetanus bacilli gaining access to the virus in the process of preparation, or infection of the patient during vaccination.

Next in importance to vaccination in the prophylaxis of small-pox is prompt isolation of the sick. No one but the medical and other attendants of the sick should be allowed to come in contact with them. All attendants and other persons exposed to the infection should, of course, be promptly vaccinated, unless this has been successfully done within the previous year or two. Disinfection of all discharges from the patient and of the room and its contents, after the patient has recovered or died, must be practiced. The best disinfectants in small-pox are bichloride of mercury, free chlorine, sulphurous acid, and formaldehyde.

When it is learned that a person has small-pox, if he is not removed to a special hospital, a room should be prepared for his occupancy. The carpets should be taken up and the floor kept clean. Window-curtains and unnecessary furniture and drapery should be removed from the room. After recovery of the patient the bed-clothing must be thoroughly disinfected with steam or sulphurous acid, or destroyed by fire. The individual himself should not be allowed to mingle with healthy persons until all danger of infection is passed and the surface of his body has been thoroughly disinfected.

At a conference of sanitary officials in the city of Chicago (May, 1894) the following propositions were adopted. They represent the most advanced conclusions of competent authority upon the most practical means of limiting the spread of small-pox:—

"1. The city should be divided into districts containing not more than 10,000 people.

"2. Each district should be placed under the supervision of a competent medical inspector with necessary assistants to (*a*) make a house-to-house inspection; (*b*) to successfully vaccinate, within

[16] Journal Cutaneous and Venous Diseases, vol. i, No. 1, p. 11.

the shortest possible time, all persons who have not been vaccinated during the outbreak, and that the first vaccination be within seven days; (*c*) to properly disinfect all houses and their contents where small-pox occurs.

"3. Necessary means and appliances for efficient disinfection of materials, premises, etc., should be provided as the exigencies of each district may require.

"4. Each case of small-pox should be immediately removed to a suitably constructed and properly equipped and officered isolation hospital.

"5. Except in extreme cold weather, hospital tents, as prescribed in the United States Army Regulations, floored and warmed, are preferable to the average hospital or private dwelling, and increase the chances of recovery of the patients. Cases of small-pox necessarily detained in their own homes should, with their attendants, be rigidly isolated during the period of danger, and physicians visiting such patients professionally shall be subject to such regulations as may be prescribed by the local health officer.

"6. Persons exposed to small-pox contagion should be immediately vaccinated or revaccinated, and kept under observation for not less than fourteen days from time of last exposure.

"7. It is the sense of this conference that where such measures are all enforced it will not be necessary for neighboring cities and states to exclude all persons who come from such city who are not protected against small-pox by vaccination, and to require disinfection of all baggage and merchandise capable of conveying small-pox infection."

ASIATIC CHOLERA.

A disease which causes the death of three-fourths of a million of human beings where it is endemic within the space of five years, and which makes periodical excursions, spreading over nearly the entire inhabited globe with destructive violence, must surely command the interested attention of every intelligent person. Asiatic cholera is endemic in India, where it probably originated centuries ago. Some authors claim to have found satisfactory evidence of its existence in the writings of the classical authors of India and Greece at a period as early as the second century of the Christian era. The evidence is, however, not beyond question. In the sixteenth and seventeenth centuries European travelers in the East gave pretty exact accounts of the disease. One of the most definite of these was given by Gaspar Correa, an officer in Vasco de Gamma's expedition to Calicut. He states that Zamorin, the chief of Calicut, lost 20,000 of his troops by the disease. A still more definite and the first trustworthy account is that of Sonnerat, a French traveler. He describes a pestilence having all the characters now recognized as belonging to Asiatic cholera, which prevailed in the neighborhood of Pondicherry and the Coromandel coast in 1768 and 1769, and which carried off 60,000 of those attacked by it within a year. Dr. McPherson, in his "History of Cholera," gives numerous references which indisuptably establish the endemic existence of the disease in India prior to the present century.

Being endemically prevalent over a greater or less area of India for many years, cholera finally, in 1817, crossed the boundaries of that country, and, advancing in a southeasterly direction, invaded Ceylon and the Sunda Islands in 1818. In a westerly direction the disease was carried to the islands of Mauritius and Réunion, and reached the African coast in 1820. During this year it also traveled northeasterly, devasting the Chinese Empire for the two following years, reaching Nagasaki, in Japan, in 1822.

In 1821 the disease spread from India in a westerly direction, extending along the east coast of Arabia to the border of Mesopotamia and Persia. In the spring of 1822 it began with renewed violence, following the river Tigris to Kurdistan, and, extending farther in a westerly direction, reached the Mediterranean coast of Syria. In the following year, 1823, it extended from Persia into Asiatic Russia, reaching Astrachan on the European border in September, but dying out nearly everywhere beyond the borders of India during the ensuing winter.

In 1826 cholera again advanced from India, reaching Orenburg in Russia, in 1829, and in the following winter appeared in St. Petersburg. Extending to the north and south, it invaded Finland and Poland the same year. From Persia the disease spread to Egypt and Palestine in 1830-31.

From Russia the pestilence invaded Germany in 1831, passing thence in 1832 into France, the British Isles, Belgium, the Netherlands, Norway, and Sweden. In the latter year cholera crossed the Atlantic Ocean for the first time, being carried to Canada by emigrants from Ireland, and spreading thence to the United States by way of Detroit. In the same year it was imported into New York by emigrants, and rapidly spread along the Atlantic coast. During the winter of 1832 it appeared at New Orleans, and passed thence up the Mississippi Valley. Extending into the Indian country, causing sad havoc among the aborigines, it advanced westward until its further progress was stayed by the shores of the Pacific Ocean. In 1834 it reappeared on the east coast of the United States, but did not gain much headway, and in the following year New Orleans was again invaded by way of Cuba. It was imported into Mexico in 1833. In 1835 it appeared for the first time in South America, being restricted, however, to a mild epidemic on the Guiana coast.

While the pestilence was advancing in the Western Hemisphere, it also spread throughout Southern Europe, invading, in turn, Portugal, Spain, and Italy.

Extending in an easterly direction from India, the disease reached China and Japan in 1830-31; westwardly, Africa was invaded in 1834, and ravaged by the epidemic during the following three years.

This second extensive outbreak of cholera ended in 1837, disappearing at all points beyond the borders of India. In 1846 the disease again advanced beyond its natural confines, reaching Europe, by way of Turkey, in 1848. In the autumn of this year it also appeared in Great Britain, Belgium, the Netherlands, Sweden, and the United States, entering by way of New York and New Orleans. In the succeeding two years the entire extent of country east of the Rocky Mountains was invaded. During 1851 and 1852 the disease was frequently imported by emigrants, who were annually arriving in great numbers from the various infected countries of Europe. In 1853 and 1854, cholera again prevailed extensively in this country, being, however, traceable to renewed importation of infected material from abroad. In the following two years it also broke out in numerous South American States, where it prevailed at intervals until 1863.

Hardly had this third great pandemic come to an end before the disease again advanced from the Ganges, spreading throughout India, and extending to China, Japan, and the East India Archipelago during the years 1863 to 1865. In the latter year it reached Europe by way of Malta and Marseilles. It rapidly spread over the Continent, and in 1866 was imported into this country by way of Halifax, New York, and New Orleans. This epidemic prevailed extensively in the Western States, but produced only slight ravages on the Atlantic coast, being kept in check by appropriate sanitary measures. In the same year (1866) the disease was also carried to South America, and invaded, for the first time, the States bordering on the Rio de la Plata and the Pacific coast of the Continent.

While the epidemic was thus advancing westward from its home in India, it was at the same time spreading northwardly over the entire western part of Asia, and in a southeasterly direction over Northern Africa. In the latter continent it prevailed from 1865 to 1869.

Cholera never entirely disappeared in Russia during the latter half of the sixth decade, and in 1870 it again broke out with violence, carrying off a quarter of a million of the inhabitants before dying out in 1873. It spread from Russia into Germany and France, and was imported, in 1873, into this country, entering by way of New Orleans and extending up the Mississippi Valley. None of the Atlantic-coast cities suffered from the epidemic in 1873, and since that year the United States have been entirely free from the disease, with the exception of a few imported cases in New York Harbor in 1887.

In June, 1883, a new epidemic of cholera broke out in Egypt, where it raged with great violence. The disease first appeared in Damietta, near the outlet of the Suez Canal. It was unquestionably imported from India, probably Bombay, where it prevailed as early as the month of May. At the time of the outbreak in Damietta that city was overcrowded with people who had come to attend a great religious fair and festival. It has been proven that pilgrims from Bombay were among the attendants at this fair. The epidemic came to an end in Egypt in the autumn of 1883. In the same year (1883) a small outbreak occurred in Marseilles, but intelligence of it was carefully suppressed by the authorities. The disease does not seem to have spread from this centre, but in June of the following year cholera broke out in Toulon, having probably been imported in a transport ship returning from Tonquin. This outbreak was very violent and rapidly spread throughout Southern France, Italy, and Spain. After apparently dying out during the winter, it reappeared in the spring of 1885 with renewed violence. The total number of cases in Spain alone in the latter year was over one-third of a million, with nearly 120,000 deaths.

In the summer of 1885 cholera also broke out in a virulent form in Japan, and, after a cessation during the following winter, recurred with increased fatality in 1886. In the latter year there were over 100,000 deaths from the disease in that country.

During 1886 and 1887 cholera continued in Southeastern Italy and in the Austrian dominions at the head of the Adriatic. A few cases occurred in France and Germany, but by stringent sanitary measures an epidemic was averted.

In November, 1886, cholera was carried to South America in an Italian ship, the "Perseo," bound from Genoa to Buenos Ayres. The disease rapidly spread in the Argentine Republic, and, crossing the

Andean range, invaded the Pacific coast of the South American continent for the second time, reaching Chili and Bolivia and threatening Peru and Brazil. In Chili alone there were over 10,000 deaths in the first six months of 1887. The further progress of the epidemic was arrested and the entire Western Hemisphere is now free from the disease.

From July to December, 1889, cholera prevailed with considerable virulence in Mesopotamia. In 1890 it reappeared in Spain; in 1892 in France and Germany, raging with great violence in Hamburg. Nearly 8000 persons died from the disease in the latter city. Some cases were brought thence to New York, but the active sanitary measures taken were successful in preventing its further spread.

This brief historical sketch of all the epidemics of cholera observed beyond the borders of India demonstrates several facts: first, that the home or breeding-place of cholera is in India, especially the delta of the Ganges, whence it spreads at intervals throughout the world; second, that it always advances along the lines of travel of large bodies of human beings; and third, that it advances, by preference, along water-routes. Exceptions undoubtedly occur, but the rule is a general one. The disease seems to spread with difficulty along the lines of railroad. When the disease has extended from New Orleans it has always been up the Mississippi Valley, expending its violence upon the river cities—Vicksburg, Memphis, St. Louis, and Cincinnati.

Several factors must concur before there can be an epidemic of cholera. These are: first, the cholera poison; second, certain local conditions of air, soil, or water; and, third, individual predisposition. Without a concurrence of all these conditions no outbreak can occur. If, by any means, the co-existence of these three conditions can be prevented, cholera can be averted. The following are facts bearing upon this question: Cholera is communicated through the agency of a specific poison. This does not admit of doubt. The researches of Dr. Robert Koch, of Germany, have established the fact that a micro-organism found in the intestinal discharges of cholera patients and in the bodies of those dead with the disease is the active agent in propagating the malady. This organism, named by Koch the "comma bacillus," from its general resemblance to a comma, was first discovered by this eminent pathologist in the intestinal contents of cholera corpses in Egypt, in 1883, and in the following year more thoroughly studied in Calcutta, whither he had been sent by the German government to pursue his investigations. It has been demonstrated that this germ is always present in the discharges of cholera patients, and up to this time it has not been found in any other disease. Experiments upon animals have also shown that cholera can be produced in the latter by introducing the germ into their bodies in various ways. The demonstration of the bacterial nature of cholera seems to be complete.

While cholera cannot be regarded as personally contagious in the same sense or in the same degree as small-pox, there can be no doubt that it is spread only by the poison from other cases of the disease. Generally this disease is conveyed by water polluted by the dejections of cholera patients. The regularity of its march along routes by which the intercourse of human beings takes place, and always in connection with other cases of cholera, proves this. There is no undoubted case on record where genuine cholera has been spontaneously developed outside of India.

That certain geological and perhaps meteorological conditions are necessary for the propagation or virulence of the poison of cholera is beyond dispute. Outbreaks usually take place during the summer or autumn, and nearly always partly or entirely die out during cold weather. Further, in nearly all epidemics, certain cities or towns, or portions of a town, into which persons sick with cholera are brought, and where the poison of the disease is thus imported, remain exempt from the effects of the epidemic. The inference to be drawn from this fact is that in such localities the local conditions are unfavorable to the development of the poisonous germ, and it becomes inert.

In India all the local conditions favorable to the propagation of the cholera-germ are found. The filthy personal habits of the people, the overcrowding, the intense heat, the lack of sufficient, appropriate, or properly-prepared food, and the extensive pollution of the water-supply, all combine to produce the necessary conditions of development of the cause of cholera. These conditions, doubtless, to a considerable extent, give rise to that depression of the system which seems necessary to constitute the individual predisposition to become infected.

Given, then, at any place, a number of persons of a lowered degree of vitality—that is to say, persons not capable of resisting unfavorable influences upon their health under unfavoring conditions; given conditions of climate, water, and soil more or less similar to those existing in India: only the introduction of the third factor, the cholera poison, is needed to cause an outbreak. In many cities of this country and Europe, as proven by the epidemics in Toulon, Marseilles, Naples, and other cities of Italy and Spain, the conditions are present which would furnish the most favorable breeding-place for the cholera-germ if introduced.

The dejections and vomited matters of cholera patients contain the active agent which produces the disease. The contagious principle contained in these excretions, the cholera-germ or "comma bacillus" discovered by Koch, may gain an entrance into the body through the drinking-water or through infected air. Probably both modes are equally competent channels of infection. The prevailing theory is that pollution of the drinking-water is the most frequent source of the rapid spread of the disease. A very striking instance of this occurred in London during the epidemic of 1854, which has already been referred to,[17] and during the cholera epidemic in Hamburg in 1893.

Another striking instance of the communication of cholera by polluted water has been reported by Mr. John Simon, long the chief medical officer of the English "Local Government Board." The facts are as follow: The Lambeth Water Company drew its supply from the Thames, at Ditton, above the influence of the London sewage and the tidal flux. The Southwark and Vauxhall Company drew its supply from the river near Vauxhall and Chelsea. The water of the Lambeth Company was tolerably pure, and that of the Southwark and Vauxhall Company was very impure. The water of both companies was distributed in the same district at the same time and among the same class of people, the pipes of the two companies being laid pretty evenly in the same areas, in many places running side by side in the same streets, and the houses supplied being pretty equally distributed. The deaths from cholera in the houses supplied by the Lambeth Company were at the rate of 37, and in the houses supplied by the Southwark and Vauxhall Company at the rate of 130, to every 10,000 persons living. It appears, therefore, that of the drinkers of the foul water about three and a half times as many as those who drank the pure water died of cholera.

In addition to the influence of polluted drinking-water in spreading cholera, must be mentioned articles of food contaminated with the infectious matter of the disease. It is also no longer open to question that persons may become infected by handling the clothing and bedding of cholera patients. Laundresses are in special danger from this source.

[17] See *ante*, page 64.

The prophylaxis against cholera comprises such measures as will prevent the admission of the cholera-poison into a community, arrest the development of the poison after its introduction, and reduce the individual susceptibility to attack.

It is evident from the foregoing that if the introduction of the cholera-poison could be prevented no outbreak of the disease could occur. With this in view, some have urged the enforcement of a strict policy of non-intercourse with the infected localities. But at the present day few sanitarians advocate these extreme measures. A modified system of restricted intercourse is supported by many authorities, who claim that by the adoption of a thorough system of maritime inspection, disinfection, and observation—a rational quarantine, in fact—the poison can be rendered ineffective or its entrance into a community prevented.

The best authorities, however, think that it is not only easier, but far more effective to place the threatened locality in such a sanitary condition that the development of the cholera-poison cannot take place. The contrast between the effectiveness of quarantine and local sanitation as safeguards against cholera has been well expressed by von Pettenkofer, who compares cholera epidemics to powder explosions. The virus of cholera, he says, is the spark that evades the strictest quarantine; the powder is the *ensemble* of local conditions which predispose to the outbreak. "It is wiser, therefore, to seek out and remove the powder than to run after and try to extinguish each individual spark before it drops upon a mass of powder, and, igniting it, causes an explosion which blows us into the air with our extinguishers in our hands."

The measures of sanitation to be enforced are such as will secure cleanliness of person, of habitation and surroundings, of air, of water, and of soil. Pollution of the soil should be especially guarded against, for a polluted soil means impure air and water, and these mean, if not an infectious disease, at least a heightened receptivity to its influence. The quality of the drinking-water used must be above suspicion of contamination by the poison. Unless the latter can be positively excluded, all drinking-water should first be boiled. It may then be cooled by pure ice.

The individual predisposition to cholera is best guarded against by keeping the body clean and well nourished, and the mind free from worry. Underfeeding, anxiety, overwork, exposure to extremes of temperature, intemperance in eating and drinking should all be avoided, as they tend to reduce the resistance of the system to the influence of the morbid poison.

Certain measures of personal prophylaxis which have proven useful heretofore should be adopted wherever cholera prevails. One of the best of these is the use of sulphuric-acid lemonade as a drink. Ten to 15 drops of dilute sulphuric acid in a glass of water, sweetened with sugar, may be drunk instead of water. Experience with it during the epidemic of 1866 has demonstrated its great value as a preventive of cholera. The later researches of Koch have also shown that the "comma bacillus," or spirillum, cannot live in acid solutions. Hence, it is probable that if the contents of the stomach were always kept acid no infection could occur through absorption from the stomach.

A painless diarrhea, called cholerine, attacks many persons during cholera epidemics. This disorder is easily curable if promptly attended to, but if allowed to run on it may develop into a malignant attack of cholera.

Among the means of securing prompt treatment of the poorer classes in times of epidemics is the establishment of numerous public dispensaries, where medical aid can always be obtained. The establishment of such dispensaries and, if possible, of temporary hospitals in the crowded portions of cities is a very important part of the prophylactic treatment.

Inasmuch as it seems definitely established that the discharges from the stomach and intestines are the active agents in propagating the disease, the immediate disinfection of such discharges is vitally important. The stools and vomited matters must be rendered innocuous by germicidal agents, such as mercuric chloride, carbolic acid, or chloride of lime.

Clothing and bedding should be disinfected with superheated steam, thorough boiling, or fumigation with sulphur dioxide or chlorine. Infected articles of this kind should not be sent to a laundry until they have been thoroughly disinfected by one of the above-mentioned means.

Apartments which have been occupied by cholera patients should be thoroughly disinfected before being re-occupied, and afterward freely exposed to the air by opening doors and windows. The walls may also be washed with a solution of mercuric chloride.

The most efficient disinfectant is mercuric chloride in the proportion of 1 part in 2000 of the material to be disinfected. The readiest way of securing disinfection with this agent is to add a solution of 1 to 1000 to an equal proportion of the discharges to be rendered innocuous. The mercuric chloride acts slowly, and hence the infected material should be exposed to the action of the disinfecting agent for at least two hours before it can safely be thrown into sewers or cess-pools.

There are several serious objections to the indiscriminate use of mercuric chloride by the public as a disinfectant. In the first place, it is intensely poisonous, and its perfectly transparent and inodorous solution might be readily accidentally drunk and cause fatal results. To reduce this danger, the Committee on Disinfectants of the American Public Health Association recommended the addition of permanganate of potash or of sulphate of copper (blue vitriol) to color the solution. Another serious objection to mercuric chloride is that it cannot be used where the disinfected material must pass through lead pipe, as this is rapidly corroded by the sublimate. In many water-closets it cannot therefore be used.

Chloride of lime (bleaching powder) has been found to be a very rapid and efficient disinfectant, as well as a deodorizer; but the chlorine, upon which its effectiveness depends, is often so deficient in proportion, and the compound so readily deteriorates that, unless a preparation can be obtained that contains at least 25 per cent. of available chlorine, it may prove injurious by causing a false sense of security. A trustworthy preparation may be dissolved in water, when required, in the proportion of 1 to 100. An objection to its use is the pungent odor of chlorine, which is very offensive to many persons.

Dr. Koch recommends carbolic acid, which he has shown will kill the "comma bacilli" in a dilution of 1 to 20 of water. The ordinary preparations of carbolic acid sold as disinfectants are, however, not to be relied on, many of them not containing more than 2 per cent. of the acid. Further dilution of these agents would altogether destroy their disinfecting power. The purer article is, on the other hand, too expensive to be used as a disinfectant.

Little's soluble phenyle is an efficient disinfectant in the proportion of 2 per cent. (1 to 50). It is furnished of uniform strength, is moderately cheap, non-poisonous, and readily miscible with water. In addition to its disinfecting power, it is also an excellent deodorizer, promptly removing all odors of decomposition and putrefaction. Its only objection is a rather pungent although not unpleasant odor, which somewhat resembles creasote.

In the very beginning of an epidemic, prompt isolation of the sick and thorough disinfection of the surroundings of the patient may check the spread of the disease. Much cannot be expected from these measures, however, unless the local sanitary conditions are such as offer a hindrance to the development of the cholera-poison. It is plain, therefore, that prophylactic measures against cholera, to be effective, must be brought into requisition before the epidemic has begun. After the outbreak of the disease it may be too late to put the threatened locality in a good sanitary condition. It is of the highest importance that preventive measures be enforced early. Above all, the purity of the drinking-water must be safeguarded.

RELAPSING FEVER.

Relapsing fever was first clearly described by Dr. John Rutty, in his "Chronological History of the Weather, Seasons, and Diseases of Dublin from 1725 to 1765."[18] During the last century relapsing

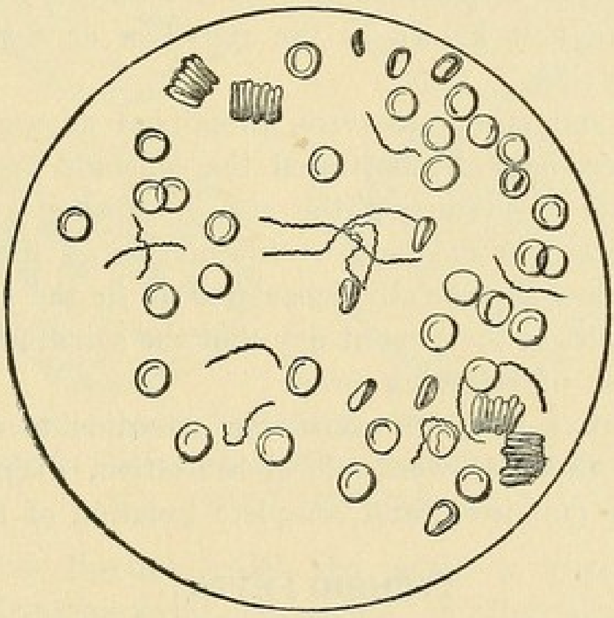

Fig. 44.—Spirochæta Obermeieri. × 380.

fever was frequently met with in epidemic form in Ireland and Scotland. In 1847 the disease invaded a number of the larger cities of England. From 1868 to 1873 it prevailed extensively in England and Scotland. On the continent of Europe it was first observed in Russia in 1833. In Germany it was not recognized as a distinct disease until 1847, but did not prevail epidemically until 1868. Since then it has often been observed in that country.

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[18] London, 1770.

Relapsing fever is very prevalent in India, where it was first observed in 1856 by Sutherland. In China and in the countries of Africa bordering on the Red Sea the disease has been recognized by observers.

In the United States it was first observed among emigrants in Philadelphia in 1844, and again in 1869. It was conveyed to other places, but has never prevailed extensively in this country. It has not been observed in the United States since 1871.

The predisposing causes of relapsing fever are, above all, bad sanitary surroundings. Want and overcrowding seem to be much less important factors than in typhus fever.

Although relapsing fever has, since it was first clearly distinguished from typhus and other continued fevers, been recognized as an eminently contagious and infectious disease, it was not until 1873 that its immediate cause became known. In that year Obermeier discovered in the blood of patients ill with this disease a minute, spiral, mobile organism, now known as the *spirillum* or *Spirochæte Obermeieri*. (Fig. 44.)

Obermeier and other observers, prominent among whom is Dr. Henry V. Carter, have demonstrated the constant presence of these organisms in the blood during the attack. Carter and Koch have induced the disease in monkeys by inoculation of the parasite, and Moschutkowski has successfully inoculated it in the human subject. No doubt can exist at the present day that the spirillum of Obermeier is the true cause of relapsing fever.

The preventive measures consist in attention to details of personal hygiene; in other words, local sanitation, disinfection of infected materials (fomites), and complete isolation of the sick.

TYPHOID FEVER.

The first accurate clinical accounts of typhoid fever date from the seventeenth century, when Baglivi, Willis, Sydenham, and others described cases of fever which in their clinical characters correspond to the disease now known as typhoid fever. Strother, however, in 1729, first gave a description of the anatomical characters of the disease, which he says is a "symptomatical fever, arising from an inflammation, or an ulcer, fixed on some of the bowels." Bretonneau and Louis, in France; Hildenbrand, in Germany; William Jenner, in England; and Drs. Gerhard and Pennock, in this country, clearly pointed out the essential distinction between typhoid and other fevers.

At the present day typhoid fever is met with everywhere throughout the world. It is at nearly all times a constituent of mortality tables. It affects by preference persons between the ages of 15 and 30 years, although no age is entirely exempt. It is always more prevalent in the autumn and winter.

The disease is due to a micro-organism which gains entrance into the body through the digestive tract. The micro-organism was first observed by Eberth and Gaffky, and is termed bacillus typhosus. It is found in the intestinal canal, and especially in the characteristic intestinal lesions of this fever. It is contained in the dejections of patients. The disease is not immediately contagious, like typhus fever.

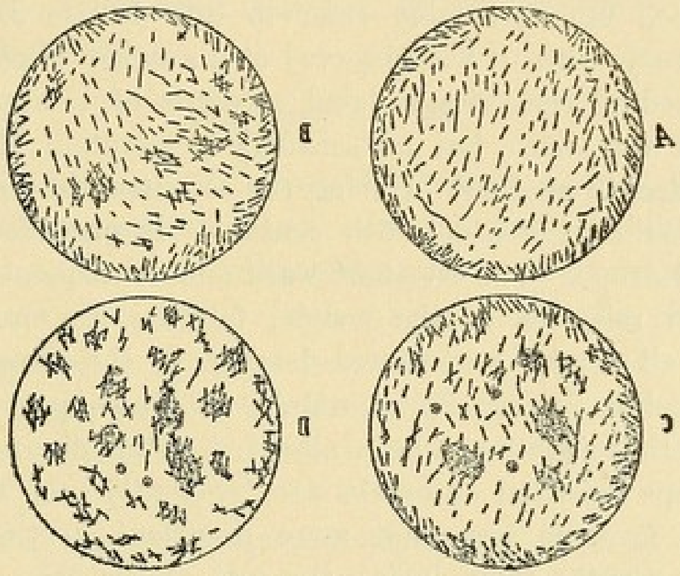

Fig. 45.—Pure Culture of Typhoid Bacilli, showing Clumping when Brought in Contact with Blood from Typhoid Patients. (Widal reaction.)

The medium through which the poison is introduced into the body may be drinking-water, food, milk, or other articles containing the infective agent. Localized epidemics due to infected water, milk, and oysters have been frequently reported.[19]

At present the evidence is in favor of the view that cases of typhoid fever are always derived from pre-existing cases. The germ may exist in sewage and be carried from place to place; it may be carried into the soil from cess-pools receiving typhoid dejections, and thus gain access into wells and pollute the drinking-water. By the admixture of such water with milk or other food the disease may be propagated. The germs are frequently carried by flies.

The prophylactic measures against typhoid fever comprise iso-

[19] See *ante*, pp. 61-64.

lation of the sick, prompt disinfection of the discharges, and cleanliness in the widest sense. The water- and food- supplies must be carefully guarded against contamination with the bacillus, excreta must be removed from the immediate vicinity of dwellings. The requisites for prevention may be summed up as pure air, pure water, uncontaminated food, and a clean soil.

TYPHUS FEVER.

Wide-spread pestilences are nearly always accompaniments of famine and war. Of all pestilential diseases, none is so regular in its coincidence with these conditions as typhus fever. The earliest accounts which unquestionably refer to this disease date from the eleventh century, when it was observed at a number of places in Italy. In the succeeding centuries isolated accounts of it appeared in the chronicles of the times, but no scientific description of it appeared until the sixteenth century. During the seventeenth, eighteenth, and the early part of the nineteenth centuries it prevailed extensively throughout Europe. The constant wars and consequent disturbances of the social relations of the people, famines, overcrowding, filth, excesses of all kinds, contributed largely to the development and spread of typhus fever. For a number of years past no extensive epidemic of the disease has been observed, although in this country and in Europe localized outbreaks are frequently met with.

Typhus fever is somewhat more prevalent in the winter and early spring months than during the rest of the year, but not very markedly so.

At present, typhus fever is nearly always limited to times and places where the conditions favoring its development exist. Wherever overcrowding, in connection with filth, insufficient food, and bad habits are present, typhus fever is likely to be a visitor. Thus, in overcrowded and ill-ventilated emigrant ships, in jails and workhouses, and in camps, especially when stress of weather compels the crowding together of soldiers in close huts or barracks, the disease frequently breaks out.

When typhus appears in a community, those classes of the people who are subjected to the conditions just mentioned are almost exclusively attacked. In cities, the dwellers in crowded tenements, or in courts and alleys, suffer most severely—are, in fact, almost the only ones attacked. An exception must, however, be made in the case of hospital physicians and attendants where typhus-fever patients are treated. The mortality among these is always large.

Typhus fever is contagious and infectious. The cause is unknown. An exposure for a length of time to an atmosphere impregnated with the poison may suffice to induce an attack. The poison may also be conveyed from place to place in fomites. Physicians may carry it in their clothing, if they have been exposed to typhus atmosphere.

The prevention of typhus fever consists in the institution of such measures as will secure pure air, pure water, a clean soil and dwellings, and cleanliness of body and clothing. When an outbreak occurs, the sick should be promptly isolated, the well persons removed from the building in which the cases have occurred, and efficient measures of disinfection carried out. The sick should be treated in the open air as much as possible.

YELLOW FEVER.

The West India Islands, the Gulf coast of Mexico, the northern part of the Atlantic coast of South America, and a limited section of the west coast of Africa constitute the present home of yellow fever. From this area (the so-called "yellow-fever zone") the disease is frequently transported to contiguous or distant countries. The South Atlantic and Gulf coasts of the United States and the shores of the Caribbean Sea are the most liable to the epidemic visitation of this pestilence.

The first trustworthy account of an epidemic of yellow fever dates from the year 1635, when it prevailed on the Island of Guadeloupe. This and the adjoining islands of Dominica, Martinique, and Barbadoes were invaded a number of times in the fifty years following the above date. Jamaica was invaded in 1655 and Domingo the year after. In 1693 the first appearance of the disease is mentioned in the United States, being observed in Boston, Philadelphia, and Charleston. In 1699 it appeared as an epidemic in Vera Cruz, and re-appeared in Philadelphia and Charleston. Since the year 1700, the disease has appeared in an epidemic form, at one or more places within the present limits of the United States, eighty times, the last considerable invasion being at Jacksonville and other places in Florida, and Decatur, in Alabama, in 1888, and to a lesser extent in New Orleans in 1903. It has also been endemic in Cuba until recent years.

In South America yellow fever appeared for the first time in 1740. In 1849 the disease was imported into Brazil, and has since then been endemic. Peru and the Argentine Republic have also suffered several severe visitations of yellow fever since 1854.

On the west coast of Africa, yellow fever seems to be endemic in the peninsula of Sierra Leone, where it has been frequently observed since 1816. It has also prevailed epidemically in Senegambia and a number of the islands off the northern portion of the west African coast. In Europe, Spain and Portugal have been the only countries to suffer from yellow-fever epidemics.

Although the causes of yellow fever cannot be definitely stated, it is well known that it only occurs endemically within the tropics, and prevails epidemically elsewhere only during the summer. Of 180 epidemics observed in the United States and Bermudas, 154 began in July, August, and September. Of the remaining 26, none began in the six months from November to April.

A temperature of 26° C. and a high humidity are generally considered essential to produce an outbreak of the disease. Of other necessary meteorological conditions nothing is known.

That the specific cause of yellow fever is a micro-organism appears probable from a consideration of the clinical history of the disease and its mode of propagation. Up to the present time, however, none of the various organisms described as causative have made good the claims advanced by their discoverers. Surgeon-General Sternberg has shown that neither the organism of Freire, of Carmona, of Babes, of F. S. Billings, of Finlay, or of Gibier is the true cause of yellow fever.

It seems to be well established that the most filthy and insanitary portions of cities are those principally ravaged by yellow fever. It has also been firmly established that the disease is propagated through the agency of a certain species of mosquito (*stegomyia fasciata*), the latter acting as an intermediate host.

Yellow fever is not endemic within the limits of the United States, and has probably never originated here. The instances in which it has appeared to do so may be explained by the persistence of the morbific agent through one or more winters, or by a new importation which has escaped observation.

Yellow fever frequently breaks out on shipboard and causes much loss of life. There is no evidence that it originates on ships; it is only acquired after intercourse with an infected ship or infected place.

The question of personal contagion of yellow fever has been decided negatively. The disease is infectious, but persons sick with the disease do not communicate it, the disease being communicated from the sick to the well by the bites of infected mosquitoes.

The preventive measures indicated against yellow fever appear from the foregoing: they are strict sanitary inspection to prevent the introduction of a person sick with the disease; to prevent the mosquitoes from coming in contact with yellow fever patients; and to employ such measures as would lead to the extermination of mosquitoes.

When the disease becomes epidemic in a city, the inhabitants should be removed to temporary camps beyond the infected area. The experience of the city of Memphis in 1879, and that of various localities in Florida in 1888, New Orleans, and especially Cuba, encourages the hope that by prompt isolation of the sick and strict enforcement of sanitary measures with especial reference to mosquitoes, the terrors of yellow fever can be largely averted. The sick should be promptly isolated, and protected by screening.

SCARLET FEVER AND MEASLES.

The early history of these two contagious eruptive fevers is inextricably blended together. Up to the latter half of the seventeenth century the distinction between the two was not made by writers. Sydenham was among the first who clearly separated scarlet fever from measles and gave it a distinct name. Since the Great English Hippocrates, the essential character of scarlet fever has been recognized by all physicians, and now it is never, or but rarely, confounded with measles.

Of the two diseases, measles is somewhat more generally prevalent, although both occur usually in epidemics. There is hardly a country in which measles has not been observed, while the continents of Asia and Africa have remained measurably exempt from scarlet fever up to the present time, although epidemics have been recorded in India and Japan.

Hirsch states that scarlet fever was first observed in this country in 1735, at Kingston, Mass., quoting as authorities Dr. Douglass, of Boston, and Dr. Colden, of New York. The latter, however, in a letter to Dr. Fothergill,[20] clearly describes diphtheria, and not scarlet fever. Its distribution is now general, but it is said to be much milder in the southern than in other portions of the United States. The prevalence of measles is not limited to any geographical section.

[20] Medical Observations and Inquiries, vol. i, p. 221. London, 1776.

Epidemics of measles usually begin during cold weather. Of 530 epidemics observed in Europe and North America, 339 occurred during the colder and 191 during the warmer months. In 213 of these, the height of the epidemic occurred 135 times in winter and spring, and only 78 times during summer and autumn. Scarlet fever epidemics occur more frequently in autumn than at any other season.

The cause of scarlet fever or of measles is not to be sought in climatic influences, insanitary surroundings, or special natural conditions of air, water, or soil. Both diseases are contagious and infectious, and the contagion is transmitted either by fomites (clothing, letters, etc.), infected air, drinking-water, or milk.

Several observers have claimed the discovery of the specific organism of scarlet fever, but no trustworthy evidence has yet been furnished that the problem is solved. On a previous page reference has been made to the probable connection between a disease of milk-cattle and scarlet fever.

The measures for the prevention of both diseases are isolation and thorough disinfection.

DIPHTHERIA.

Under the names of Syriac and Egyptian ulcers, Aretæus, a writer of the second century, described various forms of malignant sore throat. The disease now called diphtheria prevailed at various places in Europe during the Middle Ages. In this country it was first observed about the middle of the last century, and in 1771 Dr. Samuel Bard, of New York, described it very accurately. Although repeated severe outbreaks occurred in Europe in the early part of the present century, it was not until 1857 that it again attracted attention by its epidemic prevalence in the United States. Since that time it has spread throughout the country, and is at present one of the most generally diffused, as well as one of the most fatal, of the contagious diseases. In certain epidemics its malignancy is very marked, while in others it seems to be a rather mild affection.

Diphtheria is personally contagious. The infecting agent is a micro-organism first described by Löffler. The bacillus can be demonstrated in the secretions from the throat or nose of diphtheria patients. The diphtheria bacillus may also be present in the throats of healthy individuals who are at the time insusceptible to the disease, but are nevertheless carriers of the infection.

The question as to the identity of diphtheria and croup is not merely a clinical one, but has an important bearing upon preventive medicine. If croup is a non-contagious and non-infectious disease no precautions will be necessary to prevent its spread to healthy persons. If, on the other hand, diphtheria and croup are identical in nature, the danger of infection is equally great in both diseases. With the evidence furnished by the bacteriologist before us, we can have no further doubt as to the identity of the two diseases.

Diphtheria is inoculable upon animals, and may through this medium be transmitted to man.

Persons sick with diphtheria should be carefully isolated; no one but the immediate attendants should be allowed to come in contact with the patients. Table utensils, bedding, and clothing used by the sick should be thoroughly disinfected by steam or boiling water before being used by others. Intimate contact with the sick, such as

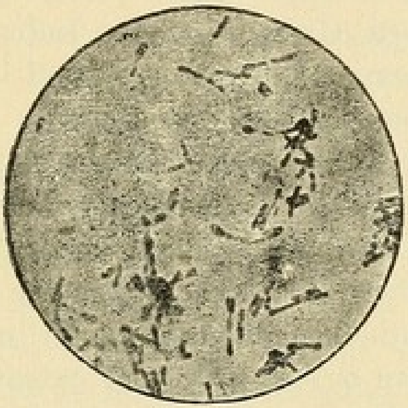

Fig. 46.—Diphtheria Bacilli. (Park.)

kissing, should be strictly prohibited. There seems no room for doubt that the diphtheria bacillus can also be carried in the clothing. Hence, physicians and nurses should be especially careful in personally disinfecting themselves after contact with a case of diphtheria. After death or recovery of the patient, the apartment occupied during the illness should be disinfected.

Children recovering from diphtheria, scarlet fever, measles, or small-pox, should not be permitted to attend school for at least four weeks after recovery. It is believed that there is danger of infection for a period about as long as this, and, besides, the patients are apt to be weakened from the effects of the disease, and not able to resist the strain of continuous mental effort. The safest plan is to maintain quarantine until two successive cultures from the throat show absence of diphtheria bacilli.

DENGUE.

The disease known as break-bone fever, dandy fever, and by various other names, was first discovered in the United States in 1780, by Dr. Benjamin Rush. Dr. Rush describes an epidemic which prevailed during the summer and early autumn of that year under the name of "bilious remittent fever," but the symptoms of the disease hardly leave any doubt that it was dengue. In 1779 and 1780 it was also observed on the Coromandel coast, in Egypt, and on the island of Java. In 1784 to 1788 dengue also prevailed in various cities of Spain. In 1818 an epidemic appeared in Lima, in which nearly every one of the 70,000 inhabitants was attacked.

In 1824-25 the disease again prevailed widely in India, where it was known as the "three-day fever." Isolated outbreaks occurred in that country until 1853, when it again appeared as a wide-spread epidemic, and in 1872 another epidemic outbreak occurred in the East, extending from Eastern Africa to Arabia, India, and China.

In 1826 an epidemic of dengue appeared in Savanah, and in the following two years spread over the southern portion of the United States and the West Indies, reaching the northern coast of South America. In 1845 to 1849 the disease was observed in Rio Janeiro; in 1848 to 1850 in the South Atlantic and Gulf States. In 1854 it was observed in Southern Alabama, and in the same year in the West Indies. In 1873 another epidemic appeared in the lower Mississippi Valley, and in 1880 an outbreak of some extent occurred in New Orleans, Charleston, and other places on the Gulf and South Atlantic coasts.

Dengue always begins in the summer or early autumn, and ceases abruptly with the advent of cold weather. It is almost exclusively limited to hot countries. It spreads with extreme rapidity wherever it appears. It is not contagious; the manner of its propagation is not known. The susceptibility to the disease appears to be almost universal; it frequently prostrates the majority of the inhabitants where an outbreak occurs. During the epidemic in Calcutta in 1871-72, 75 per cent. of the population were attacked. In the United States similar epidemics have been repeatedly observed.

Dengue is rarely fatal. It seems to be propagated through the atmosphere. No measures of prevention are known or available.

EPIDEMIC INFLUENZA.

Accounts of epidemic influenza can be traced back to the year 1173, when the disease was observed coincidently in Italy, Germany, and England. It has prevailed epidemically, at varying intervals, to the present time. In the fourteenth century 3 epidemics are recorded; in the fifteenth, 4; in the sixteenth, 7; in the seventeenth, 46. Of these, 15 were very extensive, some of them prevailing over both hemispheres contemporaneously.

On the American continent influenza was first recorded in 1627, when it prevailed in New England, where it again broke out in 1625. Following this there is no notice of the disease in America until 1732, when an epidemic began in the New England States, which extended over the entire globe. Epidemics occurred during the remainder of the eighteenth century in 1737, 1757, 1761, 1767, 1772, 1781, 1789, and 1798. During the present century the disease has prevailed more or less extensively in this country at thirteen different times, the last epidemic of any considerable extent being in 1897.

In November, 1889, an epidemic began in Russia which rapidly spread throughout Northern Europe, reaching the United States about the beginning of 1890, recurring in 1891 and 1892. The epidemic was complicated in many cases by pneumonia of a fatal character. The disease manifested itself in two principal forms, the catarrhal and the nervous. Epidemics more or less severe in character have occurred since.

A curious feature of epidemics of influenza is the coincident occurrence of outbreaks of a somewhat similar affection among animals, horses and dogs being especially attacked.

Influenza is an acute, specific, infectious disease, not directly contagious. It is caused by a very minute bacillus first observed by Pfeiffer. The disease frequently appears over a large area of country almost simultaneously. Peculiarities of climate, season, meteorological conditions, geological formation, or racial characteristics have no apparent influence upon the causation or spread of the disease. It occurs more frequently in the winter and spring than during the summer or autumnal months. The investigation into the epidemic of influenza among horses, referred to in a previous chapter,[21] seems to indicate, however, that a moist and impure atmosphere intensifies the disease.

No measures of prophylaxis can be indicated except avoidance of anything tending to depress the vital powers, as well as disinfection of the upper respiratory passages by the use of local antiseptics.

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[21] Chapter I, p. 29.

EPIDEMIC CEREBRO-SPINAL MENINGITIS.

This disease was first recognized in Geneva in 1805. In the following year it was noted in various places in the United States. Both in Europe and in this country localized outbreaks of the disease occurred between the dates above mentioned and 1816. At this time the disease seemed to die out altogether, but in 1822 it re-appeared in various parts of Europe and America.

Cerebro-spinal meningitis appeared in 1857 in the southwest of France, and during the following ten years spread over a large part of the country. Algiers, Italy, Denmark, and Ireland were also visited by the scourge. In 1854 and 1861 Sweden experienced its ravages, and in 1859 Norway was invaded by the disease, which continued for nearly a decennium in the latter country. From 1860 to 1867 the disease prevailed in Holland, Portugal, Germany, Ireland, and Russia.

After the termination of what may be called the first epidemic, in 1816, cerebro-spinal meningitis was not again observed in this country until 1842. In the eight years succeeding, it prevailed epidemically throughout almost the whole United States. From 1861 to 1873 it was noted frequently in various parts of the country. Since the latter year the reports of its occurrence in this country have been limited to sporadic cases or localized outbreaks.

Cerebro-spinal meningitis is an acute infectious disease, very fatal in its tendency. It is contagious. The disease is caused by a diplococcus discovered by Weichselbaum (*Diplococcus intracellularis meningitidis*). Climate has no influence upon its origin, but season seems to stand in a positive relation to its causation. About three-fourths of the epidemics noticed have occurred during the winter and spring months. The disease seems to show no preference for peculiarities of topographical or geographical formation. Overcrowding, overwork, and uncleanliness have an important influence in determining an outbreak. It is especially a disease of youth and adolescence. Out of 975 cases occurring in New York only 150 were over 20 years of age, while of the remainder 665 were under 10.

The prophylactic measures to be adopted against cerebro-spinal meningitis consist in careful attention to the sanitary conditions of dwellings and streets, avoidance of overwork and overcrowding during times of epidemic, isolation of the sick, and disinfection of the sick-room after the termination of the disease.

SYPHILIS.

In the year 1494, Charles VIII of France, in command of a large army, invaded Italy, and early in the following year besieged Naples. During the investment of the city a very severe disease, characterized by ulcers on the genitals, violent pains in the head and limbs, and generalized cutaneous eruptions broke out among the besiegers and spread rapidly throughout the army and civil population. On the return of the army to France, after the termination of the war, the disease rapidly spread throughout Europe, and the literature of the early part of the sixteenth century, both medical and lay, teems with references to it.

From the locality and other circumstances connected with its epidemic appearance the disease acquired various names. Thus, the French called it *morbus Neapolitanus,* or *mal d'Italie,* while the Italians termed it *morbus Gallicus,* or *mala Franzos.* At a very early period it was, however, clearly recognized that the disease was communicated during sexual intercourse, and hence it was usually described in medical writings under the name *lues venerea,* while in the popular literature it still figured as the Frenchman's disease (*morbus Gallicus*). The name *syphilis* was first used in a poem descriptive of the disease, written in 1521 by Fracastor, a physician of Verona.

The extraordinary outbreak of the disease toward the end of the fifteenth century led to many speculations concerning its origin. As it attacked persons in all ranks and conditions of life, "sparing neither crown nor cross," in the words of a contemporary poet, the favorite explanation was that meteorological influences had much to do with its causation. Many ascribed it to the malign influence of the stars. The Neapolitans attributed it to the wickedness of their enemies, the French, while the latter laid the blame on the filth and immorality of the Italians. The Spaniards claimed that it had been imported from America by Columbus, whose first expedition returned to Europe in 1493. There are records, however, which prove that the disease already existed in Italy in the latter year. In other parts of Europe the Jews, who had been driven out of Spain by the terrors of the Inquisition, were accused of this, as of many other misfortunes which befell the people. When it was definitely established that the disease was communicated almost solely by sexual intercourse, the theory of its transatlantic origin became very popular. It is characteristic of human nature to refer the origin of troubles resulting from its own vices to some other source, if possible. This theory of the American origin of syphilis is still held by some writers. Within a few years, Dr. Joseph Jones, of New Orleans, claims to have found evidences of syphilitic disease in the skulls and other bones from some of the prehistoric Indian mounds in Mississippi. These observations of Dr. Jones, have, however, not been verified by others.

Although the first great epidemic of syphilis is clearly traceable to the period between the years 1493 and 1496, an examination of the older literature reveals many descriptions of disease which can only be explained by assuming them to refer to syphilis. The Old Testament Scriptures contain numerous references to diseases of the genital organs. In most instances these troubles are ascribed to the wrath of God, although in some cases a pretty shrewd hint is given as to the causation of the affections. Finály[22] remarks that the Hebrew word translated in all versions of the Bible by "flesh" signifies also the virile member. In this light, the references in Leviticus, XIII-XV; Numbers, XXV, 1-9, XXXI, 16-18; Deuteronomy, IV, 3; Joshua, XXII, 17; I Samuel, V, 6, 9, 12; Psalms CVI, 28-30; I Corinthians, X, 8; Ephesians, II, 11; and Colossians, II, 13, receive a new interpretation. Numerous innuendoes in the Latin classics, and more or less exact descriptions in the medical writings of Greece, Rome, China, and India, leave no room for doubt that venereal diseases, and probably among them syphilis, have existed from the earliest times.

At the present day syphilis is the most widely prevalent of all contagious diseases. In 1873 Dr. F. R. Sturgis estimated that in New York 1 person out of every 18 suffered from it. This is considered a moderate estimate. Dr. J. William White, of Philadelphia, pronounces the opinion that "not less than 50,000 people of all classes in that city are affected with syphilis." On this basis Gihon estimates the number of syphilitics in the United States at one time at 2,000,000.[23]

The disease is transmitted, in the vast majority of cases, during the performance of the sexual act, but there are numerous other ways in which it may be and frequently is communicated. In the special literature of the subject are records of many cases in which the disease was acquired through a kiss, a bite, the act of suckling (from infant to nurse, and conversely), using a pipe, glass-blowers' mouthpiece, the finger of a midwife, the instrument of the dentist or sur-

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[22] Arch. f. Dermat. u. Syphilis, II Jahrg. 1 Heft., p. 126.

[23] The Prevention of Venereal Diseases by Legislation, Sanitarian, June, 1882.

geon, inoculation of syphilitic secretion mixed with saliva in the process of tattooing, and many other ways. Numerous cases have been reported where physicians were inoculated on the finger while examining a syphilitic patient. Recent observations seem to show that the disease is caused by a spirillum—*Spirocheta pallida.*

The prophylactic measures which suggest themselves from a consideration of the nature of the disease are isolation of those infected, regular inspection of the class of persons through whom the disease is most frequently transmitted, *i.e.,* prostitutes, and individual precautions against acquiring it. Greater attention to cleanliness of the genital organs on the part of those indulging in promiscuous intercourse would aid largely in reducing the number of cases of syphilis.

Recent investigations by Metchnikoff show that syphilitic infection may be prevented by the local use of a salve containing calomel, 33 grams; lanolin, 67 grams, and petrolatum, 10 grams. The application must be made within a few hours after coitus. Hypodermic injection of a solution of atoxyl (an arsenical preparation), in doses of 75 centigrams, followed by 60 centigrams, will prevent infection within two weeks.

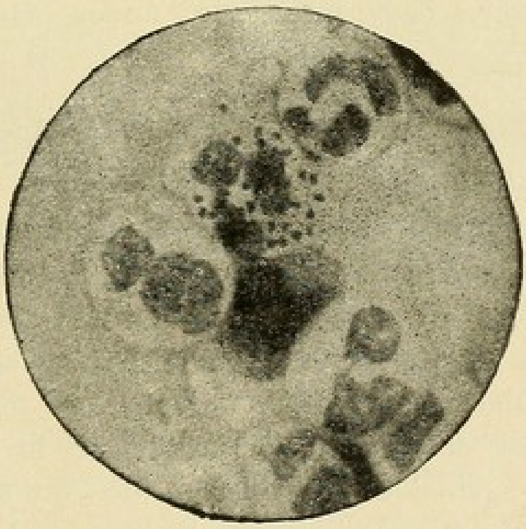

Fig. 47.—Micrococci Gonorrhea in Pus. (Park.)

GONORRHEA.

Gonorrhea is one of the venereal trio which is responsible for more misery, ill health, and "race suicide" than any other single sociologic factor. It has been estimated that fully 80 per cent. of cases of pelvic disease in women is caused by gonorrhea; 20 per cent. of blindness is due to gonorrheal infection of the new-born; 50 per cent. of all involuntary childless marriages are attributed to the same cause. Fitch asserts that of every one hundred women who have married men formerly infected with gonorrhea, hardly ten remain well. The disease is caused by a diplococcus (*Micrococcus gonorrheæ* or *gonococcus*) first observed by Neisser, in 1879.

It is communicated through direct contact by sexual intercourse with individuals suffering from the disease, either in acute or chronic form. The chief source of infection is prostitution, and in considering prophylaxis we must deal with one of the most intricate social problems—the so-called "social evil." It is generally conceded that education of the young of both sexes in the danger lurking in promiscuous intercourse and a general dissemination of knowledge concerning sexual functions and venereal diseases will go far toward remedying the evil. It is claimed that an injection of a few drops of a 20 per cent. solution of protargol post-coitum will prevent infection. Blindness can be prevented by attention to the eyes of the new-born, and instillation into the eyes of one drop of a solution of silver nitrate, 2 grains to the ounce.

The third member of the venereal group—the soft chancre, or chancroid—is a localized ulceration caused by a bacillus discovered by Ducrey, in 1890. The affection is communicated through sexual intercourse, and seems to be propagated under conditions of extreme uncleanliness.

DISEASES OF ANIMALS COMMUNICABLE TO MAN.

Sheep-pock.—This is a highly contagious and infectious disease of sheep, resembling, in its symptoms, course, and fatality, small-pox as it occurs in the human race. It is believed by Bollinger to be different from the form of small-pox produced in sheep, goats, horses, and other animals by the inoculation of human small-pox. Sheep-pock can be inoculated upon other animals and man, but only produces a local disease at the point of inoculation in the latter. Sheep may be protected against this disease by inoculation with sheep-pock virus (ovination), or by vaccination with vaccine lymph. The peculiarity of sheep vaccinia is that it is a more or less generalized disease, the pustules being distributed over the body. Sheep-pock, when inoculated upon human beings, does not produce a generalized infectious disease, but remains entirely local.

Actinomycosis.—Veterinarians have frequently observed a disease attacking the jaws of cattle and producing tumors, often with ulcerated surfaces. The bone is usually involved. The disease has heretofore been generally considered a sarcomatous growth. It is not seldom observed among the cattle in the western stockyards, where it is known in the vernacular as "swell-head." Recent investigations by Ponfick have shown that the growth consists of a vegetable parasite (actinomyces), and that it is inoculable upon other animals, and may be conveyed to man. A considerable number of cases have been observed in human beings in Germany, where the disease was first described by Ponfick, and several cases have been reported in this country.

Bovine Tuberculosis (Perlsucht).—In cattle, tuberculosis occurs in two forms, miliary tubercles and cheesy masses in the lungs, and firm, pearly nodules on the serous membranes. These nodules do not break down, but may become calcified.

Bovine tuberculosis is a frequent disease among cows kept in

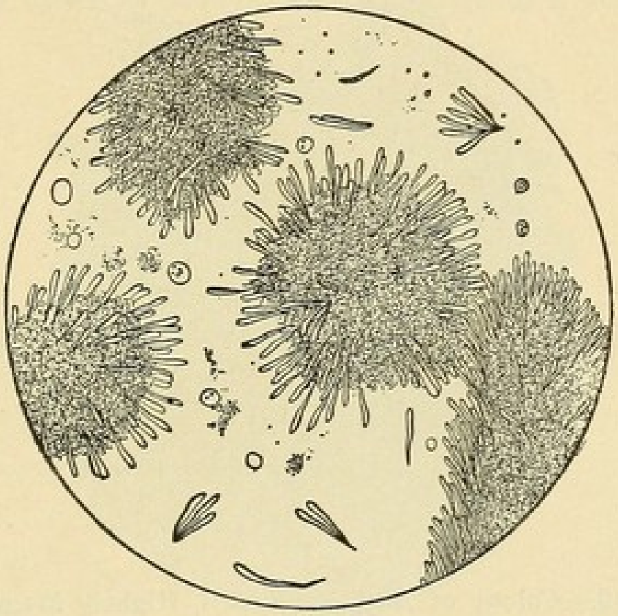

Fig. 48.—Actinomyces Hominis (Lung). × 350.

damp, dark, and ill-ventilated stables. The disease, which is essentially the same as human tuberculosis, tubercle bacilli being present in the neoplasms, is believed to be transmissible to human beings by means of the milk or flesh of tuberculous animals. The sale of the meat of tuberculous cattle should be prohibited.

Rabies.—Hydrophobia in the brute, and its communicability to man through a bite, has been known from the remotest antiquity. It occurs in dogs, foxes, wolves, horses, and other animals, and may be transmitted from any of them to human beings.

The contagium of rabies, the infective poison, is contained principally in the saliva, and is usually inoculated by the teeth of the mad animal.

Pasteur has shown that the greatest virulence of the rabies poison resides in the brain and spinal cord of the animal suffering from the disease. By attenuation of this virus, the nature of which has not yet been definitely determined, its virulence could be diminished, and by inoculation of men and animals with the attenuated virus protection against the disease could be secured. The fact seems likewise established that the period of incubation of the inoculation-rabies is much shorter than that acquired in the usual way by bites of rabid animals. Hence, inoculation with the attenuated virus protects the bitten individual against the fatal outbreak of the unmodified disease.

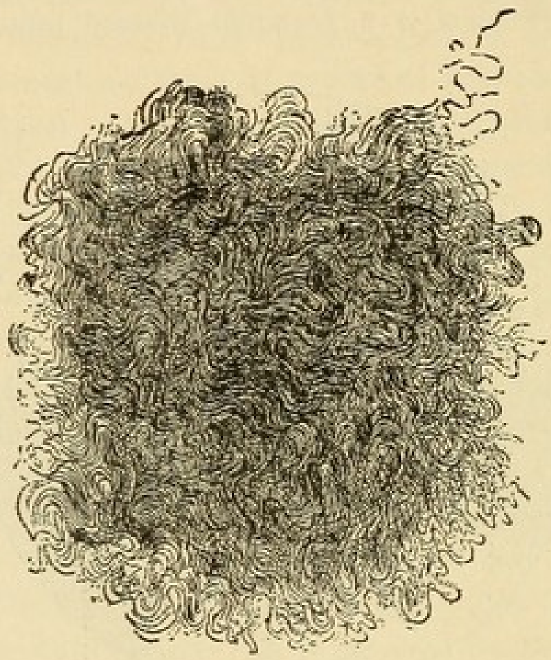

Fig. 49.—Colony of Anthrax Bacilli, slightly Magnified. (After Flügge.)

Anthrax.—Anthrax, or splenic fever (milzbrand), is an acute, highly contagious and infectious disease of herbiverous animals, which may be transmitted by inoculation or the ingestion of the virus to other animals and to man.

The disease is due to a minute vegetable organism which is found in the blood and tissues of the diseased animals. This organism, *Bacillus anthracis,* was first discovered by Pollender, and has been thoroughly investigated by Davaine, Pasteur, Koch, and others.

Inoculation of these bacilli or their spores always produces the disease in susceptible animals. Skins of animals not infrequently contain the virus, which may then gain access to the blood of persons engaged in handling them. Knackers, butchers, wool-sorters, and other persons liable to come in contact with sick animals, or handling their flesh or hides, are subject to the infection, either by direct inoculation (through abrasions of the skin, etc.) or by inhalation of the spores of the bacillus. An intestinal form of anthrax in man, *mycosis intestinalis,* is sometimes produced by the consumption of meat of animals suffering, when killed, of splenic fever. Numerous instances have been reported. The diagnosis has been verified by discovering the bacillus of anthrax in the blood and various organs of the individuals attacked.

In view of the dangerous character of the disease, persons coming in contact with animals suffering from anthrax should be warned of their peril. In order to protect other animals in a herd, strict isola-

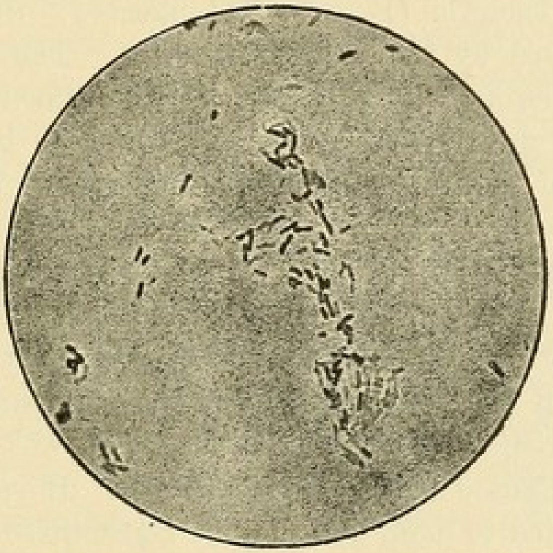

Fig. 50.—Bacillus Mallei. (Park.)

tion of the infected, thorough disinfection of the stables occupied by them, and deep interment of the cadavers of those dead from the disease are indicated. The vaccination of animals with cultures of anthrax bacilli attenuated by being grown at 42° C. for twenty-four to forty-eight hours has been found to protect animals against infection.

Glanders.—Glanders, or farcy, is a very fatal contagious disease of horses which may be communicated to other animals and to man. The cause of glanders has been discovered by Löffler to be a bacillus resembling the bacillus tuberculosis. Pure cultures of this bacillus, known as *Bacillus mallei,* were inoculated into animals, and followed by glanders in a number of the cases.

The infection in man may occur either upon the seat of excoriations of the skin or mucous membranes, especially those of the nose, conjunctiva, and possibly by inhalation of infective particles floating in the air.

Animals with glanders should be promptly killed and their cadavers cremated or deeply buried. No part of the body of any animal dead with glanders should be allowed to be used. Infected stables should be thoroughly disinfected.

RESUMÉ OF SOME OF THE INFECTIOUS DISEASES.

The following brief summary of the more important infectious diseases will be found useful:—

Abscesses.—Localized suppuration, caused principally by the so-called pyogenic cocci (staphylococci, streptococci, etc.), but may be caused by other bacteria (B. coli, B. typhosus). So-called "cold abscesses" are caused by the tubercle bacillus. The affection may be prevented by thorough sterilization of instruments and dressings which come in contact with a wound, as well as by rendering such wound free from germs. *Laboratory diagnosis:* Demonstration of germ in the pus.

Actinomycosis.—Caused by a fungus, *actinomyces bovis* or ray fungus. It is a disease of animals communicated to man by way of the alimentary or respiratory tract or wounds. Prophylaxis includes the destruction of the abscesses. *Laboratory diagnosis:* Demonstration of characteristic fungus in the discharges.

Anthrax.—Caused by *Bacillus anthracis.* It is a disease of animals communicated to man, and may be transmitted by direct contact or by insects, the consumption of flesh from the diseased animal (intestinal anthrax), or inhaling the dust from the hair of the infected animals (pulmonary anthrax, or wool-sorters' disease). The prophylaxis includes isolation of the diseased animals, the complete destruction of the carcasses, and vaccination of the exposed stock. *Laboratory diagnosis:* Demonstration of characteristic bacillus in the blood or point of infection.

Cholera.—Caused by *Spirillum choleræ.* Transmitted by water and food, principally the former. The period of quarantine, one week. Prophylaxis consists in sterilizing the food and drink, and disinfection of the stools. *Laboratory diagnosis:* Cultivation of the spirillum from the feces.

Diphtheria.—Caused by *Bacillus diphtheriæ* of Klebs-Löffler. Transmitted by direct contact, fomites, and air. Period of quarantine, until two successive cultures from the throat are negative. Prophylaxis consists in isolation, disinfection of upper respiratory passages by mild antiseptics, immunization with antitoxin, disinfection of premises. *Laboratory diagnosis:* Cultivation of the Klebs-Löffler bacillus on blood serum, from the throat of suspected patients.

Dysentery.—The bacillary form is caused by *Bacillus shigæ,* the amebic form by *Ameba dysenteriæ.* Transmitted by water and food. Prophylaxis consists in disinfection of the stools and sterilization of food and drink. *Laboratory diagnosis:* The cultivation of the bacillus from the feces or the microscopic demonstration of the ameba.

Glanders.—Caused by *Bacillus mallei.* Transmitted by inhalation of, or infection of wounds with nasal secretions and discharges from infected animals. Prophylaxis consists in disinfection of secretion and destruction of carcasses. *Laboratory diagnosis:* Injection of culture from secretion into guinea-pigs; development of swelling of testicle is characteristic; to detect latent glanders, use mallein.

Gonorrhea. — Caused by *Micrococcus gonorrheæ* (gonococcus). Transmitted by sexual contact, rarely fomites. Prophylaxis consists in strict avoidance of promiscuous intercourse and local disinfection after such intercourse. *Laboratory diagnosis:* Demonstration of the gonococci in the discharge, or cultivation on serum-agar.

Hydrophobia. — Caused by unknown micro-organism. Transmitted by bites of rabid animals. Prophylaxis consists in the destruction of animals suffering from rabies and isolation of those bitten; cauterization of wound and Pasteur treatment. *Laboratory diagnosis:* Reproduction of the disease by subdural inoculation into the lower animals; demonstration of certain histological changes in the ganglia of suspected animals.

Influenza.—Caused by *Bacillus influenza* of Canon and Pfeiffer. Transmitted by fomites and inhalation. Prophylaxis consists in isolation and disinfection of discharges. *Laboratory diagnosis:* Demonstration of bacillus in the secretions from respiratory passages.

Leprosy.—Caused by the *Bacillus lepræ.* Believed to be transmitted by insects. Prophylaxis consists in isolation and destruction of insects and vermin. *Laboratory diagnosis:* Demonstration of the bacillus in the affected tissues.

Malaria.—Caused by the *Plasmodium malariæ.* Transmitted by mosquitoes (anopheles). Prophylaxis consists in destruction of mosquitoes and prophylactic use of quinine. *Laboratory diagnosis:* Demonstration of the parasite in the blood, either fresh or stained, of the patient.

Measles.—Supposed to be caused by a bacillus discovered by

Canon and Pielicke. Transmitted by direct contact and fomites. Period of quarantine, sixteen days. Prophylaxis consists in isolation, disinfection of fomites, skin, and secretions from nose and mouth, and final fumigation of sick-room.

Mumps.—Cause unknown. Transmitted by direct contact. Period of quarantine, twenty-four days. Prophylaxis consists in isolation and disinfection of secretions from upper respiratory passages.

Plague.—Caused by *Bacillus pestis.* Transmitted by rats, fleas, and inhalation of patient's sputum. Period of quarantine, ten days. Prophylaxis consists in isolation, destruction of rats and vermin, and disinfection of all discharges. *Laboratory diagnosis:* Demonstration of the bacillus in the pus from the buboes; animal inoculation.

Pneumonia.—Caused by *Diplococcus lanceolatus* (pneumococcus). Transmitted by fomites. Prophylaxis consists in isolation and disinfection of sputum. *Laboratory diagnosis:* Demonstration of the pneumococci in the sputum.

Relapsing Fever.—Caused by *Spirillum obermeieri.* Mode of transmission obscure; possibly insects. Prophylaxis consists in the protection from bites of insects. *Laboratory diagnosis:* Demonstration of the spirillum in the blood.

Scarlet Fever.—Cause unknown. Transmitted by direct contact, fomites, milk. Period of quarantine, ten days after exposure; period of isolation of patient, about six weeks. Prophylaxis consists in isolation, disinfection of skin and fomites, and final fumigation of sick-room.

Small-pox.—Cause unknown. Transmitted by direct contact and fomites. Period of quarantine, 16 days after exposure; period of isolation of patient, until disappearance of eruption. Prophylaxis consists in isolation, vaccination, disinfection of skin and fomites, and final fumigation.

Syphilis.—Supposed to be caused by *Spirocheta pallida.* Transmitted by direct contact (coitus, kissing) and fomites. Prophylaxis consists in disinfecting the mouth of patient and exclusive use of eating and drinking utensils. The patient should be enjoined from kissing and such contact with the well as would be liable to lead to infection. Physicians and dentists should be particularly careful not to infect themselves, and more especially not to become carriers of infection. *Laboratory diagnosis:* Demonstration of the spirochete in the lesions.

Tetanus.—Caused by *Bacillus tetani.* Transmitted by infecting deep wounds with earth containing the micro-organism. Prophylaxis consists in free incision, cauterization, and injection of antitetanic serum. *Laboratory diagnosis:* Demonstration of the bacillus on the objects which caused the injury, by the aid of animal inoculations.

Typhoid Fever.—Caused by the *Bacillus typhosus.* Transmitted through water, milk, food, and fomites, also by contact with infected feces. Prophylaxis consists in disinfection of stools and urine of patient as well as fomites; purification of polluted water-supply; sterilization of suspected food and drink; protection against flies. *Laboratory diagnosis:* Demonstration of the typhoid bacillus in the blood; Widal test; test of urine for diazo-reaction.

Typhus.—Cause unknown. Transmitted by direct contact, fomites, and air. Period of quarantine, fourteen days; period of isolation, about four weeks. Prophylaxis consists in isolation and final fumigation.

Tuberculosis.—Caused by *Bacillus tuberculosis.* Transmitted by inhalation of dried sputum, consumption of infected food. Prophylaxis consists in disinfection of sputum and protection of food-supply. Final fumigation of premises. *Laboratory diagnosis:* Demonstration of the tubercle bacillus in the sputum or other discharges; the tuberculin test.

Whooping Cough.—Cause unknown. Transmitted by direct contact and by inhalation of ejected secretions. Prophylaxis consists in isolation, disinfection of sputum, and final fumigation of premises.

Yellow Fever.—Cause unknown. Transmitted by bite of mosquito (*stegomyia fasciata*). Period of quarantine, fourteen days after exposure. Prophylaxis consists in protection against mosquitoes.

QUESTIONS TO CHAPTER XVII.

HISTORY OF EPIDEMIC DISEASES.

Of what advantage is the study of the history of epidemic diseases? What are some of the most important maladies of this class? To what are they all due?

What are some of the synonyms of the Oriental plague? What are some of its characteristic symptoms? What is the date of the first clear account of it? How long did this epidemic persist? When did it make its second incursion into Europe? What was one of the peculiar symptoms of this epidemic? What was its estimated mortality? What were some of its moral effects? When was its final incursion into Western Europe? What minor epidemics of it have there been since? When was the last, and where? Is it now endemic anywhere? To what was its origin formerly ascribed? What conditions are always present when the plague prevails? What is another evident factor in its causation? How is it generally transmitted? Is it a germ disease? What are the measures of prevention therefore indicated?

What is the sweating sickness? What are some of its characteristic symptoms and peculiarities? What is evidently its nature? Is there any class exempt from it? What favors its spread? What relation has it to cholera? When did it first appear in England? When for the last time? Where has it appeared since? Have there been many outbreaks in Europe?

What are the earliest details regarding small-pox? When was it supposed to have been introduced into Europe? Who made the first distinct reference to it in medical literature? When? What was the estimated mortality from this disease in Europe previous to the introduction of vaccination? Where has it been very fatal in its devastations in recent years? What other countries and peoples have suffered from it? What is the mortality from unmodified small-pox? How is the disease transmitted? What factors are necessary to cause an outbreak? What may carry the poison? For what distance about a patient may the air be infectious? In what stages of the disease is it contagious? What races are more commonly attacked, and among which is it more fatal?

Does one attack of small-pox always confer future immunity from the disease? Wherein is the popular belief, that persons suffering from an acute or chronic disease are less liable to incur small-pox than the healthy, at fault? Which maladies are most likely to afford this immunity? When does such immunity appear to cease?

When do epidemics of small-pox usually begin? In what seasons do they spread most rapidly? Does the disease spread rapidly at first? Has the specific organism of small-pox been certainly discovered?

When was the first attempt to limit the fatality of small-pox by inoculation made in Europe? When was the practice introduced into England, and by whom? What were the details of the method as then practiced? What were the characteristics of the disease thus produced? Was the practice altogether without danger to the one inoculated? What other grave objection was there to such inoculations? When was the practice of inoculation introduced into America, and by whom? How long was it continued in England and in America? Where was it practiced before its introduction into Europe?

What led to the discovery of vaccination? Who first practiced it? When? To whom is due the merit of demonstrating and publishing the value of vaccination? When did he perform his first vaccination, and with what results? When did he publish the first pamphlet in relation to it? When was vaccination introduced into America, and by whom?

What is the relation of vaccinia (cow-pox) to small-pox? What are the symptoms produced in the case of a successful vaccination? When may the individual be considered to be thoroughly protected? Is the immunity absolute for life? What is the character of an attack of small-pox in an individual who has once been vaccinated? Does repeated vaccination increase the immunity? What effect has vaccination had on the mortality from small-pox? On the prevalence of the disease?

What important precaution should be observed in all vaccinations? Why? When should children be vaccinated? When should they be revaccinated? What are some of the peculiarities following upon revaccination? What are some of the objections urged against humanized virus? Are these all valid? What are some of its advantages? How is it to be inoculated? How is animal virus obtained? How is it to be used? In what way do the results from using it differ from those of humanized virus?

What complications are likely to occur in the course of the vaccinia? What are some of the causes of these complications? What subjects are unfavorable ones for vaccination? When may vaccination be properly delayed? What diseases may be communicated by or may follow vaccination? What cases should be promptly revaccinated?

What besides vaccination is highly important in the prophylaxis of small-pox? What precautions should be observed in the care of one sick with small-pox? What are the best disinfectants for such cases? When is all danger of infection over?

Where is Asiatic cholera endemic? What can be said of its ravages there? When were the first authentic accounts of it given? When did the disease first become epidemic outside of India? What were some of the countries visited? When did it first appear in England? When and where in America? When did this outbreak from India end? When did it again become pandemic, and how long before it again reached the United States? What were the ports through which it entered? How long did it persist in this country? How long in South America? When was the next visitation to this country? What parts of South America were first invaded at this time? Where else was cholera raging during these periods, and where was it practically endemic?

When was the last serious importation of the disease into this country, and by what port did it enter? Where else, and when, have there been important epidemics since this date? What does the history of all these epidemics demonstrate? What factors must concur that there may be an epidemic? What is the specific cause of cholera? Who discovered it? When? Is the disease contagious? How is it spread? What conditions seem to be necessary for its propagation? When do outbreaks usually occur, and when do they subside? Why is the disease endemic in India? How do these conditions predispose the victims to the disease? Are these conditions peculiar to India? Where else may they exist?

How is the specific organism given off from the human body? How does it usually gain entrance into others? What evidence is there of this (see chapter on Water)? What other agencies may aid in disseminating the disease?

What are the measures of prophylaxis against cholera? How can the entrance of the disease into a community be prevented? What measures of local sanitation may be even more effective? Why? How shall the drinking-water and food be rendered harmless?

How may one guard against an individual predisposition to cholera? What measure of personal prophylaxis is useful? What is the *rationale* of this? What disease may simulate cholera during an epidemic, and to what is it often due?

In times of cholera epidemics, what sanitary measures are to be established? What disinfectants are to be used? What articles are to be disinfected, and how? What are some of the objections to the indiscriminate use of the bichloride of mercury? What may be used in its stead? What does Koch recommend, and what objection is there to its use? What plan should be pursued at the beginning of an epidemic?

When was relapsing fever first described? When was it first observed in America? When did it last appear here? What predisposing conditions favor it? What is its specific exciting cause? Where is the germ found? What are the preventive measures to be used against relapsing fever?

How long has typhoid fever been known as a distinct disease? Where is typhoid fever common? When is it most prevalent? What persons and ages are most subject to it? To what is the disease due? Where is it found? Is the disease contagious? Where is the poison developed? Does it arise *de novo?* How may the poison be conveyed to human beings? What prophylaxis may be employed against typhoid fever? What are the requisites for prevention?

When were the earliest authentic accounts of typhus fever made? What predisposing conditions favor its development and spread? When is it more prevalent? By what is it limited? Where is it apt to occur? What class of persons is most likely to be attacked? Is it contagious? How may it be prevented? What measures are to be pursued during an outbreak of the disease?

Where is the present home of yellow fever? What localities are most liable to epidemics of this disease? What is the date of the first authentic account of it? When and where did it first appear in the United States? Has it ever originated here or been endemic? How many times has it been epidemic in this country in the last two centuries? When and where was the last epidemic? In what season do epidemics occur? In what climates may it be endemic? What climatic conditions seem to be necessary for an outbreak? What is probably its specific cause? Has this been discovered? What is one of the principal factors in its spread? Is the disease contagious? How is the poison conveyed? What is necessary to the propagation of the disease? What preventive measures are to be employed against yellow fever?

What is to be done, should the disease become epidemic in a city? Will this be efficacious in most cases?

Who first distinguished between scarlet fever and measles? Which disease is more prevalent? What countries have been practically exempt from scarlet fever? When was scarlet fever first observed in America? When do epidemics of measles usually begin? When of scarlet fever? What is the exciting cause of each disease, and how may it be conveyed? Have bad hygienic surroundings an influence in the propagation of either disease? What are measures for prevention in both cases?

How old is the history of diphtheria? When was it first observed in this country? When did it again prevail epidemically here? How are various epidemics marked? Is it contagious? How may it be conveyed? What is the exciting cause? Is diphtheria identical with croup? What plan should be pursued for prevention regarding the two diseases? Is diphtheria transmissible to animals? What precautions should be taken with a person sick with diphtheria? How long should children who have had diphtheria, scarlet fever, small-pox, or measles be detained from school? Why?

What is dengue? When and by whom was it first observed in the United States? When does an epidemic begin, and when does it stop? To what countries is the disease limited? Is it contagious? How is it propagated? Who are susceptible? What are the measures of prevention that may be employed? Is the disease fatal?

What is the date of the earliest accounts of epidemic influenza? What are some of its synonyms? When did it first prevail in America? When was the last epidemic? How was this one complicated? Are animals subject to this disease? Is it contagious? How is it transmitted? When is it most prevalent? What are the measures of prophylaxis against it?

When was epidemic cerebro-spinal meningitis first recognized? When did it appear in America? When was the first epidemic here? When the next? When the last? Is it contagious or infectious? What is its tendency? When is it most liable to occur? What influence has climate upon it? What factors seem to favor an outbreak? What ages are most subject to it? What is the prophylactic treatment?

When and where does syphilis seem to have had its origin? Are there any traces of evidence of its existence before this? What can be said of its comparative prevalence? How is it usually transmitted? In what other ways may it be conveyed? What prophylactic measures are indicated?

What are some of the serious diseases of animals communicable to man? What is sheep-pock, and what is its peculiarity when inoculated upon human beings?

What is actinomycosis? What are some of the synonyms? To what is it due?

In what two forms does tuberculosis occur in cattle? Is it common among them? How is it related to human tuberculosis? How may it be transmitted to man? What precautions should be enforced to prevent this transmission?

What is rabies? How is it transmitted? Where is the contagium contained? Where does the poison of greatest virulence reside? How may the virus be cultivated, and what changes take place in it? How may immunity against the disease be produced? Who discovered and advocated this method of inoculation?

What is anthrax? What are some of its synonyms? To what is it due? How may it be transmitted? What are the measures of prophylaxis against it, both for man and animals?

What is glanders? To what is it due? How may infection occur? What should be done with animals sick with this disease? What else should be done?

CHAPTER XVIII.

ANTISEPTICS, DISINFECTANTS AND DEODORANTS.

Much confusion exists in the popular mind, and even among physicians, as to the exact meaning of the terms at the head of this chapter. By many they are used synonymously, and hence frequently give rise to ambiguity and misunderstanding.

Antisepsis, which is so frequently confounded with disinfection, should be more accurately defined than is usual by writers. An antiseptic is an agent which retards, prevents, or arrests putrefaction, decay, or fermentation. It does not necessarily destroy the vitality of the organisms upon which these processes depend. An antiseptic may also arrest the development of the organisms which cause infectious diseases, and may hence be used as a preventive of such diseases. But antiseptics do not destroy the life of disease-germs, and hence cannot be relied upon when such organisms are present.

By disinfection, in the proper and restricted use of the term, is meant the destruction of the specific infectious material which causes infectious diseases. If the view is accepted that all infectious diseases are due to micro-organisms or germs, then a disinfectant is equivalent to a germicide. In sanitary practice and experimental investigations this view is, in fact, adopted. In testing the action of various disinfecting agents upon infectious material, the biological test is the one universally relied upon by experimenters, and no observations upon disinfection based upon chemical tests alone would be accepted by sanitarians as conclusive. It may therefore be assumed for practical purposes that no agent can be accepted as a disinfectant if it is not also a germicide. From this it follows that disinfection, to be trustworthy, must be thorough. "There can be no partial disinfection of infectious material; either its infectious power is destroyed or it is not. In the latter case there is a failure to disinfect."[1] Obviously, also, there can be no disinfection in the absence of infectious material. Fecal discharges, a diseased body or corpse, clothing, bedding, an apartment, a ship, or a hospital ward may or may not be infected. In the former case we may speak of disinfecting them; in the latter it would be an inappropriate use of the word.

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[1] Report of Committee on Disinfectants of the American Public Health Association, p. 236.

Confusion is also liable to arise by considering disinfectants and deodorizers as synonymous. Deodorants merely remove the offensive odors, and may not possess any disinfecting power whatever. Thus, one of the most efficient disinfectants at our command (mercuric chloride) is not a deodorizer at all, except by preventing putrefaction. On the other hand, some of the most effective deodorants have only a subordinate position in the scale of disinfectants.

Careful investigations have shown that there is a wide divergence between various disinfecting agents in their influence upon disease-germs, some being efficient in high dilutions, while others require to be brought in contact with the germs in great concentration. For example, mercuric chloride will act as an efficient poison to certain disease-germs (anthrax spores) in the proportion of 1 to 1000, while zinc chloride must be used in the proportion of 1 to 5 (or 20 per cent.).

It has been further discovered that different disease-germs present varying resisting power to the same disinfecting agent, some being easily destroyed, while others are much more resistant. For example, the following table shows a number of experiments made by Dr. Meade Bolton for the American Committee on Disinfectants:—

TABLE LVII.

ORGANISM.	Chloride of Lime.	Mercuric Chloride.	Carbolic Acid.
Typhoid bacillus	1 : 2000	1 : 10,000	1 : 100
Cholera spirillum	1 : 2000	1 : 10,000	1 : 100
Anthrax spores	1 : 100	1 : 1000	1 : 50 (Uncertain.)
Staphylococcus aureus . . .	1 : 200	. . . . .	1 : 100
Staphylococcus citreus . .	1 : 50	. . . . .	1 : 100
Staphylococcus albus . . .	1 : 200	. . . . .	1 : 100

Assuming that infectious diseases are caused by micro-organisms, and that these are different from the micro-organisms of ordinary decay or putrefaction, it can be readily understood that the processes of organic decomposition may themselves act as disinfectants. It is known, for example, that when a fermenting liquid putrefies, the organisms of fermentation disappear and give place to the organisms of putrefaction (bacterium termo, etc.). So, likewise, the bacilli of anthrax and of tuberculosis are killed by the putrefactive process, if this takes place in the absence of free oxygen. Furthermore, the reproduction of organisms of a certain kind ceases when certain chemical changes take place in their environment. Fermentation in a saccharine liquid ceases and the ferment-organisms die when the accumulation of the product of the fermentation (alcohol) has reached a certain proportion, although there may still be undecomposed sugar present. In like manner it is intelligible that the products of micro-organisms may eventually destroy their producers, and so place a limit to the morbid process. The specific cause of small-pox, yellow fever, cholera, and similar infectious diseases is rapidly destroyed when decomposition of the corpses of those dead with such diseases sets in. Hence, the reason why infectious diseases are not spread from cemeteries.

From the foregoing it may be gathered that disinfection consists chiefly in a struggle against organized disease-germs.[2] As, however, experiments and observations have shown that the life-history of disease-germs varies with the different organisms involved, it becomes evident that specific directions concerning disinfection can be given only when the life-history of the specific organism is known.

The American Committee on Disinfectants, to whose work reference has already been made, divides disinfectants into two classes: those efficient for the destruction of infectious material containing spores, and those which will destroy infectious material only in the absence of spores. The recommendations of the committee, covering not only the appropriate disinfectant to be used for the destruction of the organisms, but also the conditions under which the agent should be used, are as follow:—

The most useful agents for the destruction of spore-containing infectious material are:—

1. *Fire.* Complete destruction by burning.
2. *Steam under pressure.* 105° C. (221° F.) for ten minutes.
3. *Boiling in water* for half an hour.
4. *Chlorinated lime.*[3] A 4-per-cent. solution.
5. *Mercuric chloride.* A solution of 1 to 500.

For the destruction of infectious material which owes its infecting power to the presence of micro-organisms not containing spores, the committee recommends:—

1. *Fire.* Complete destruction by burning.
2. *Boiling in water* for ten minutes.
3. *Dry heat.* 110° C. (230° F.) for two hours.
4. *Chlorinated lime.*[3] A 2-per-cent. solution.

[2] Mueller und Falk, in Realencyclopœdie d. ges. Heilk., Bd. IV., p. 62.

[3] Should contain at least 25 per cent. of available chlorine.

5. *Solution of chlorinated soda.*[4] A 10-per-cent. solution.

6. *Mercuric chloride.* A solution of 1 to 2000.

7. *Sulphur dioxide.* Exposure for twelve hours to an atmosphere containing at least 4 volumes per cent. of this gas in presence of moisture.[5]

8. *Carbolic acid.* A 5-per-cent. solution.

9. *Sulphate of copper.* A 5-per-cent. solution.

10. *Chloride of zinc.* A 10-per-cent. solution.

The committee would make the following recommendations with reference to the practical application of these agents for disinfecting purposes:—

For Excreta.

(a) In the sick-room:—

1. Chlorinated lime in solution, 4 per cent.

In the absence of spores:—

2. Carbolic acid in solution, 5 per cent.
3. Sulphate of copper in solution, 5 per cent.

(b) In privy-vaults:—

1. Mercuric chloride in solution, 1 to 500.[6]
2. Carbolic acid in solution, 5 per cent.

(c) For the disinfection and deodorization of the surface of masses of organic material in privy-vaults, etc.:—

Chlorinated lime in powder.

For Clothing, Bedding, etc.

(a) Soiled underclothing, bed-linen, etc.:—

1. Destruction by fire, if of little value.
2. Boiling for at least half an hour.
3. Immersion in a solution of mercuric chloride of the strength of 1 to 2000 for four hours.
4. Immersion in a 2-per-cent. solution of carbolic acid for four hours.

(b) Outer garments of wool or silk, and similar articles, which would be injured by immersion in boiling water or in a disinfecting solution:—

1. Exposure in a suitable apparatus to a current of steam for ten minutes.
2. Exposure to dry heat at a temperature of 110° C. (230° F.) for two hours.

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[4] Should contain at least 3 per cent. of available chlorine.

[5] This will require the combustion of between 1½ to 2 kilogrammes of sulphur for every 28 cubic metres of air-space. The vaporization of liquid sulphur-dioxide can be more accurately regulated.

[6] The addition of an equal quantity of potassium permanganate as a deodorant, and to give color to the solution, is to be recommended.

(c) Mattresses and blankets soiled by the discharges of the sick:—

1. Destruction by fire.
2. Exposure to superheated steam (105° C. = 221° F.) for ten minutes. (Mattresses to have the cover removed or freely opened.)
3. Immersion in boiling water for half an hour.

Furniture and Articles of Wood, Leather, and Porcelain.

Washing, several times repeated, with solution of carbolic acid, 2 per cent.

For the Person.

The hands and general surface of the body of attendants of the sick, and of the convalescents, should be washed with—

1. Solution of chlorinated soda diluted with nine parts of water (1 to 10).
2. Carbolic acid, 2-per-cent. solution.
3. Mercuric chloride, 1 to 1000.

For the Dead.

Envelop the body in a sheet thoroughly saturated with—

1. Chlorinated lime in solution, 4 per cent.
2. Mercuric chloride in solution, 1 to 500.
3. Carbolic acid in solution, 5 per cent.

For the Sick-room and Hospital Wards.

(a) While occupied, wash all surfaces with—

1. Mercuric chloride in solution, 1 to 1000.
2. Carbolic acid in solution, 2 per cent.

(b) When vacated:—

Fumigate with sulphur dioxide for twelve hours, burning at least 1½ kilogrammes sulphur for every 28 cubic metres of air-space in the room; then wash all surfaces with one of the above-mentioned disinfecting solutions, and afterward with soap and hot water; finally throw open doors and windows and ventilate freely.

For Merchandise and the Mails.

The disinfection of merchandise and of the mails will only be required under exceptional circumstances; free aëration will usually be sufficient. If disinfection seems necessary, fumigation with sulphur dioxide will be the only practicable method of accomplishing it without injury.

Rags.

(a) Rags which have been used for wiping away infectious discharges should at once be burned.

(b) Rags collected for the paper-makers during the prevalence of an epidemic should be disinfected, before they are compressed in bales, by—

1. Exposure to superheated steam (105° C. = 221° F.) for ten minutes.
2. Immersion in boiling water for half an hour.

Ships.

(a) Infected ships at sea should be washed in every accessible place, and especially localities occupied by the sick, with—

1. Solution of mercuric chloride, 1 to 1000.
2. Solution of carbolic acid, 2 per cent.

The bilge should be disinfected by the liberal use of a strong solution of mercuric chloride.

(b) Upon arrival at a quarantine station, an infected ship should at once be fumigated with sulphurous-acid gas, using 1½ kilogrammes of sulphur for every 28 cubic metres of air-space; the cargo should then be discharged on lighters; a liberal supply of the concentrated solution of mercuric chloride (1 to 32) should be thrown into the bilge, and at the end of twenty-four hours the bilge-water should be pumped out and replaced with pure sea-water; this should be repeated. A second fumigation after the removal of the cargo is recommended. All accessible surfaces should be washed with one of the disinfecting solutions heretofore recommended, and subsequently with soap and hot water.

For Railway-cars.

The directions given for the disinfection of dwellings, hospital wards, and ships apply as well to infected railway-cars. The treatment of excreta with a disinfectant before they are scattered along the tracks seems desirable at all times, in view of the fact that they may contain infectious germs. During the prevalence of an epidemic of cholera this is imperative. For this purpose the standard solution of chlorinated lime is recommended.

From the foregoing it would appear that heat, chlorinated lime, mercuric chloride, solution of chlorinated soda (Labarraque's solution), carbolic acid, sulphate of copper, zinc chloride, and sulphur dioxide (sulphur fumes) are the most generally available disinfectants.

The following "general directions" for the practical application of disinfection are given by the committee:—

Disinfection of Excreta, etc.—The infectious character of the dejections of patients suffering from cholera and typhoid fever is well established; and this is true of mild cases and of the earliest stages of these diseases, as well as of severe and fatal cases. In cholera, diphtheria, yellow fever, and scarlet fever all vomited material should also be looked upon as infectious. And in tuberculosis, diphtheria, scarlet fever, and infectious pneumonia the sputa of the sick should be disinfected or destroyed by fire. It seems advisable, also, to treat the urine of patients sick with an infectious disease with one of the disinfecting solutions below recommended.

Chloride of lime, or bleaching powder, is perhaps entitled to the first place for disinfecting excreta, on account of the rapidity of its action. The following standard solution is recommended:—

Dissolve chloride of lime (chlorinated lime, bleaching powder) of the best quality[7] *in pure water in the proportion of 6 ounces to the gallon* (*45 grammes to the litre*).

Use 1 quart (1 litre) of this solution for the disinfection of each discharge in cholera, typhoid fever, etc.[8] Mix well, and leave in the vessel for at least one hour before throwing into privy-well or water-closet. The same directions apply for the disinfection of vomited matters. Infected sputum should be discharged directly into a cup half full of the solution.[9] A 5-per cent. solution of carbolic acid may be used instead of the chloride-of-lime solution, the time of exposure to the action of the disinfectant being four hours.

Disinfection of the Person.—The surface of the body of a sick person or of his attendants, when soiled with infectious discharges, should be at once cleansed with a suitable disinfecting agent. For this purpose, solution of chlorinated soda (liquor sodæ chlorinatæ—Labarraque's solution) diluted with 9 parts of water, or the standard solution of chloride of lime diluted with 3 parts of water, may be used. A 2-per-cent. solution of carbolic acid is also suitable for this purpose, and under proper medical supervision the use of a solution of corrosive sublimate (1 to 1000) is to be recommended.

In diseases like small-pox and scarlet fever, in which the infectious agent is given off from the entire surface of the body, occasional ablutions with the above-mentioned solution of chlorinated soda are recommended.

In all infectious diseases the body of the dead should be enveloped in a sheet saturated with the standard solution of chlorinated lime, or with a 5-per-cent. solution of carbolic acid, or a 1 to 500 solution of corrosive sublimate.

Disinfection of Clothing.—Boiling for half an hour will destroy the vitality of all known disease-germs, and there is no better way of disinfecting clothing or bedding which can be washed than to put it through the ordinary operations of the laundry. No delay should occur, however, between the time of removing soiled clothing from the person or bed of the sick and its immersion in boiling water, or in one of the following solutions until this can be done:—

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[7] Good chloride of lime should contain at least 25 per cent. of available chlorine. Recently nascent chlorine for disinfecting purposes has been obtained on a large scale by the electrolysis of sea-water.

[8] For a very copious discharge use a larger quantity.

[9] Recently a small spitting-cup made of stiff paper has been introduced especially for the use of consumptives. The cup is carried about by the patient or kept within reach. When the cup has been in use for a time, and before the sputa can become desiccated, it is thrown into the fire and burned.

Corrosive sublimate, 1 gramme to the litre (1 to 1000), or carbolic acid (pure), 8 grammes to the litre.

The articles to be disinfected must be thoroughly soaked with the disinfecting solution and left in it for at least two hours, after which they may be wrung out and sent to the wash.[10]

Clothing or bedding which cannot be washed should be disinfected by steam in a properly-constructed disinfection chamber. In the absence of a suitable steam disinfecting apparatus, infected clothing and bedding should be burned.

Disinfection of the Sick-room.—In the sick-room no disinfectant can take the place of free ventilation and cleanliness. It is an axiom in sanitary science that it is impracticable to disinfect an occupied apartment for the reason that disease-germs are not destroyed by the presence in the atmosphere of any known disinfectant in respirable quantity. Bad odors may be neutralized, but this does not constitute disinfection in the sense in which the term is here used. These bad odors are, for the most part, an indication of want of cleanliness or of proper ventilation, and it is better to turn contaminated air out of the window or up the chimney than to attempt to purify it by the use of volatile chemical agents, such as carbolic acid, chlorine, etc., which are all more or less offensive to the sick, and are useless so far as disinfection—properly so called—is concerned.

When an apartment which has been occupied by a person sick with an infectious disease has been vacated, it should be disinfected. The object of disinfection in the sick-room is mainly the destruction of infectious material attached to surfaces or deposited as dust upon window-ledges, in crevices, etc. If the room has been properly cleansed and ventilated while still occupied by the sick person, and especially if it was stripped of carpets and unnecessary furniture at the outset of his attack, the difficulties of disinfection will be greatly reduced.

All surfaces should be thoroughly washed with the standard solution of chloride of lime, diluted with 3 parts of water, or with 1 to 1000 solution of corrosive sublimate. The walls and ceiling, if plastered, should be subsequently treated with a lime-wash. Especial care must be taken to wash away all dust from window-ledges and other places where it may have settled, and thoroughly to cleanse crevices and out-of-the-way places. After this application of the disinfecting solution, and an interval of twenty-four hours or longer for free ventilation, the floors and wood-work should be well scrubbed with soap and hot water, and this should be followed by a second, more prolonged exposure to fresh air, admitted through open doors and windows.

As an additional precaution, fumigation with sulphurous-acid gas is to be recommended, especially for rooms which have been occupied by patients with small-pox, scarlet fever, diphtheria, typhus fever, and yellow fever. But fumigation with sulphurous-acid gas alone, as commonly practiced, cannot be relied upon for disinfection of the sick-room and its contents, including bedding, furniture, infected clothing, etc., as is popularly believed.

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[10] Solutions of corrosive sublimate should not be placed in metal receptacles, for the salt is decomposed and the mercury precipitated by contact with copper, lead, or tin. A wooden tub or earthen crock is a suitable receptacle for such solutions.

When fumigation is practiced, it should precede the general washing with a disinfecting solution heretofore recommended. To insure any results of value, it will be necessary to close the apartment to be disinfected as completely as possible by stopping up all apertures through which the gas might escape, and to burn not less than 3 pounds of sulphur for each 1000 cubic feet (1½ kilogrammes to 28 cubic metres) of air-space in the room. To secure complete combustion of the sulphur, it should be placed, in the form of powder or small fragments, into a shallow iron pan, which should be set upon a couple of bricks in a tub partly filled with water, to guard against fire. The sulphur should be thoroughly moistened with alcohol before igniting it.[11]

Disinfection of Privy-vaults, Cess-pools, etc.—When the excreta (not previously disinfected) of patients with cholera or typhoid fever have been thrown into a privy-vault this is infected, and disinfection should be resorted to as soon as the fact is discovered, or whenever there is reasonable suspicion that such is the case. It will be advisable to take the same precautions with reference to privy-vaults into which the excreta of yellow fever have been thrown, although we do not definitely know that this is infectious material.

For this purpose the standard solution of chloride of lime may be used in quantity proportioned to the amount of material to be disinfected, but where this is considerable it will scarcely be practicable to sterilize the whole mass. The liberal and repeated use of this solution, or of a 5-per-cent. solution of carbolic acid, will, however, disinfect the surface of the mass, and is especially to be recommended during the epidemic prevalence of typhoid fever or of cholera.

All exposed portions of the vault, and the wood-work above it, should be thoroughly washed down with the disinfecting solution. Instead of the disinfecting solutions recommended, chloride of lime in powder may be daily scattered over the contents of the privy-vault.

Disinfection of Ingesta.—It is well established that cholera and typhoid fever are very frequently, and perhaps usually, transmitted through the medium of infected water or articles of food, and especially milk. Fortunately, we have a simple means at hand for disinfecting such infected fluid. This consists in the application of heat. The boiling temperature maintained for half an hour kills all known disease-germs. So far as the germs of cholera, typhoid fever, and diphtheria are concerned, there is good reason to believe that a temperature considerably below the boiling-point of water will destroy them. But in order to keep on the safe side, it is best not to trust anything short of the boiling-point (100° C. = 212° F.) when the object is to disinfect food or drink which is open to the suspicion of containing the germs of any infectious disease. During the prevalence of an epidemic of cholera it is well to boil all water for drinking purposes. After boiling, the water may be filtered, if necessary, to remove sediment, and then cooled with *pure ice* if desired.

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[11] Liquid anhydrous sulphur-dioxide may be used, and will probably give better results than combustion of sulphur.

In recent years formaldehyde gas has taken the place of sulphur for aërial disinfection of rooms, fomites, etc. The following is freely quoted from a circular issued by the Illinois State Board of Health:—

Formaldehyde (otherwise known as methyl aldehyde, formic-aldehyde and "formalin") exists in several forms, but is principally known as gas. Its germicidal properties were not recognized until 1886, and were not put to use until 1890. The formaldehyde gas is the vapor of wood alcohol which has undergone a chemical change. The gas is produced by passing the vapor of wood alcohol over platinum or platinized carbon in an incandescent state. Many portable apparatus for the production of formaldehyde gas directly from wood alcohol have been devised during the past seven or eight years, but none have proved satisfactory.

The aqueous solution of formaldehyde gas, known as formaldehyde or formalin, is a 40-per-cent. solution of the formaldehyde gas in water. Many of the commercial preparations do not contain 40 per cent. of formaldehyde. The concentration of the solution can not exceed 40 per cent. This preparation, if properly made, is a powerful bactericide and is preferable to corrosive sublimate as a germicide, cost not considered, although it is much slower in action. Several processes have been devised for the liberation of formaldehyde gas from its watery solution. The solution when exposed to the air gives off a considerable quantity of the gas, especially when sprayed on large surfaces. If sprayed on blankets or sheets, or articles of clothing, hung in the room or on the walls, the liberation of the gas will be so rapid as to compel the operator to leave the room. These facts have given rise to the belief that exposure of the gas in this manner will be sufficient to cause disinfection. The results, however, do not confirm this. There is much uncertainty as to the amount of gas which is evolved, and the behavior of the gas is at times very capricious.

The most common method of obtaining formaldehyde gas from the watery solution at the present time is by means of apparatus designed to regenerate the gas by boiling the solution under pressure. Many generators operating on this principle are to be found on the market. Several of these are complicated machines requiring skill to properly operate. As some of the generators require constant attention, it has been found necessary to place them outside of the apartment being disinfected and to pass the gas into the room by means of a tube run through a keyhole. The diffusion of the gas produced in this way is slow, particularly in large areas, tending to concentration at a few points and to the formation of paraformaldehyde. This method of disinfection cannot be recommended.

With the Schering method of disinfection, which consists in the rapid evaporation of paraform pastilles, said to contain 100 per cent. pure formaldehyde, many tests have been made by the Illinois State Board of Health during the past five years. The results were generally satisfactory, when the gases evolved were thoroughly mixed with the watery vapor. This method, however, is expensive; much care must be used in the working of the generator, and it has been found very difficult after disinfection to rid the premises of the gas. In one of the experiments the vapor ignited. The experiments were conducted with the Schering formalin disinfector (not the lamp) manufactured by Schering & Glatz, New York.

Formaldehyde candles, which are composed of a variable amount of paraformaldehyde, pressed in cylindrical form in a tin container, are now offered to physicians and health authorities as a means of disinfection. It is claimed that, by burning the paraform, the heat produced causes the solid to revert to the gaseous form. No dependence whatever should be placed on these candles.

The evaporation of the solution of formaldehyde by means of heat in an ordinary kettle is one of the simplest methods of disinfection with formaldehyde, and as a result has proven the most effective. This is termed the Breslau method. Many health authorities have testified to its efficiency during the past seven years.

While the results obtained with some of the methods of formaldehyde disinfection formerly suggested have been generally satisfactory, failures were at times experienced when the conditions were apparently ideal; while under unfavorable conditions of temperature and humidity, ineffective disinfection was of frequent occurrence.

Recently an exceedingly simple method of generating the gas by pouring formaldehyde solution over the crystals of potassium permanganate in an open vessel has been suggested, and gives promise of overcoming the objections which have stood in the way of the more general adoption of formaldehyde as a disinfecting agent. This method primarily offered the advantages of absolute simplicity in operation, requiring no special apparatus and no fire. In addition to this, exhaustive experimental work has demonstrated that, in practical disinfection, the method is unusually efficient, the effectiveness seeming to depend less upon the conditions of humidity and temperature than that of any other method.

The only apparatus required is a large, open vessel, protected by some non-conductive material to preserve the heat within. An ordinary milk-pail, set into a pulp or wooden bucket, will answer every purpose, although a special container, devised for physicians and health officers, will be found of considerable advantage. This container or generator consists of a simply constructed tin can with broad, flaring top. Its full height is 15½ inches, the height to the flaring or funnel-shaped top being about 8 inches. The lower or round section is 10 inches in diameter, while the funnel is 17½ inches in diameter at the top. This container is made of a good quality of tin, is supplied with a double bottom with ¼-inch air-space between the layers of tin, and is entirely covered on the outside with asbestos paper. The asbestos paper and double bottom serve to effectively retain the heat which is generated by the vigorous chemical reaction occurring within the generator and which is essential to the complete production and liberation of the gas. The special container can be made by any tinner of ordinary intelligence and costs but a few dollars.

With the room sealed, as is essential to any form of aërial disinfection, the crystals of potassium permanganate (3½ ounces to each 1000 cubic feet of air-space) are placed in the container. Over this salt is poured "formalin" or the 40-per-cent. aqueous solution of formaldehyde (1 pint for every 1000 cubic feet of air-space). The formaldehyde gas is promptly liberated by the vigorous chemical reaction of the formalin and the potassic salt and rises from the generator in immense volume in the form of an inverted cone. It is consequently essential that all preparations be made in advance and that the operator leave the room at once on the combination of the two chemicals.

The doors or windows of exit should be promptly closed and sealed and the room left closed for at least six hours.

The results obtained by this method in experiments conducted in the laboratories of the Illinois State Board of Health, under varying atmospheric conditions, and with a rather wide range of temperature, prove the method peculiarly effective, while the simplicity of the operation, the small expense of the apparatus (in fact, its successful operation without apparatus of any kind, if necessary), and the moderate cost of operation serve to commend it.

However, even this method is not entirely free from danger of fire. Dr. C. T. White, while experimenting on disinfection, observed that in some instances spontaneous combustion of the formaldehyde gas takes place after the addition of the formaldehyde to the permanganate of potash. Mr. C. H. La Wall, who investigated this phenomenon, ascribes it to the rapid formation of heat in the presence of organic matter, and suggests the employment of small quantities of permanganate, not over 4 to 8 ounces to a charge, placed in several containers surrounded with large cones containing water. There should be no flame in the room.

The following substances are antiseptics, but in the strength given cannot be depended upon as disinfectants:—

TABLE LVIII.

Thymol	1: 80,000.
Bichloride of mercury	1: 40,000.
Oil of mustard	1: 33,000.
Acetate of alumina	1: 6310.
Bromine	1: 5597.
Picric acid	1: 5000.
Iodine	1: 4000.
Sulphuric acid	1: 800-1: 3353.
Permanganate of potassium	1: 3000.
Camphor	1: 2500.
Eucalyptol	1: 2500.
Chromic acid	1: 2200.
Chloride of aluminum	1: 2000.
Hydrochloric acid	1: 1700.
Benzoic acid	1: 1439.
Quinine	1: 1000.
Boric acid	1: 200-1: 800.
Salicylic acid	1: 200-1: 800.
Carbolic acid	1: 500.
Sulphate of copper	1: 400.
Nitric acid	1: 400.
Biborate of soda	1: 200.
Sulphate of iron	1: 200.
Creasote	1: 200.
Arsenious acid	1: 100.
Pyrogallic acid	1: 62.
Tr. chloride of iron	1: 25.
Alcohol	40 to 95 per cent.

The agents mentioned in the above list may all be used with satisfactory results in surgical and obstetrical practice as antiseptics, but it must be borne in mind that the great danger in treating wounds comes from carrying infectious particles to them in the hands or instruments of the operator. In order to render these aseptic the most thorough measures of disinfection, such as heat, strong chemical disinfectants, and physical as well as chemical and biological cleanliness are indicated. In a surgical wound, or in the vagina and uterus of the parturient woman, the use of antiseptics is entirely secondary to disinfection, under which may primarily be understood rigid cleanliness.

In public and private sanitation, antiseptics have, as in practical surgery, a subordinate importance.

Deodorizers are sometimes useful in sanitary practice, but care must be taken not to look upon deodorization as equivalent to disinfection. Among the most useful deodorizers are chloride of zinc, chloride of lime, permanganate of potassium, and a number of the agents mentioned in Table LVIII.

QUESTIONS TO CHAPTER XVIII.

ANTISEPTICS, DISINFECTANTS, AND DEODORANTS.

What is an antiseptic? How may it be used? Is it necessarily a disinfectant? Why? Is a disinfectant an antiseptic? Why? Why must disinfection be thorough to be of any value? What is necessary that there may be disinfection? How is the term often popularly, but incorrectly, used?

What is the essential difference between a disinfectant and a deodorant? What is a germicide? What is the true test of the value of a disinfectant? Have deodorants as such any real sanitary value? How do disinfectants differ in relation to disease-germs? How do the latter differ in relation to the former? How may the products of putrefaction, fermentation, or decay act as disinfectants? How may the products of the disease-germs themselves act as antiseptics or disinfectants?

How may disinfectants be classified? What are the most useful agents for destroying spore-containing infectious material? How should these be used? What do we call disinfection by fire or heat? What agents may be used to disinfect infectious matter not containing spores? Which are most efficacious? What is an essential factor in the successful use of all disinfectants?

In what diseases may the excreta be infected? What disinfectants may be used for excreta in the sick-room? In cess-pools? Why is mercuric chloride not so efficacious here? What is the objection to the use of carbolic acid in typhoid fever? Why is chlorinated lime such a valuable disinfectant? How much chlorine should it contain? How should it be prepared? What is "milk of lime," and what value has it as a disinfectant for excreta?

How may soiled underclothing, bed-linen, etc., be disinfected? How long should clothing be boiled in order to thoroughly disinfect it? How may clothing that would be harmed by immersion or chemicals be disinfected? What will be the effects on clothing of chlorine and sulphur gases? How may mattresses, blankets, etc., be disinfected? How long should the active process require?

What are some of the best disinfectants for use on the person? How may the danger of infection from a case of scarlet fever, small-pox, etc., be lessened? How should the bodies of those dead of infectious diseases be cared for?

What can be done in the way of disinfection during the occupancy of the sick-room? What are the only disinfectants available? What value will deodorants have here? What method is to be followed as soon as the sick-room is vacated? Describe in detail.

How may suspected merchandise and the mails be purified? What treatment should rags, etc., undergo? What is the method prescribed for the disinfection of a ship? For railway-cars? (See chapter on Quarantine.)

How may articles of food and drink be made sterile and safe for use?

How are antiseptics and disinfectants to be used, and for what purpose, in surgical and obstetrical practice?

What is formaldehyde? What is the usual method of using formaldehyde? What is the best method?

CHAPTER XIX.

VITAL STATISTICS.

The registration of vital statistics comprises the recording of the births, marriages, deaths, and diseases of a city, State, or nation. The facts thus secured must be properly classified and studied, for in no other way can a knowledge of the health of the inhabitants of such communities be obtained, and a real test is thus also furnished of the actual efficiency of sanitary undertakings. We may, indeed, study disease both by observation and experiment, thus learning that some maladies are more preventable than others and discovering their causes and means of prevention; and it is also true that for smaller or special communities, such as armies, navies, schools, or special classes of workmen, the health status may be obtained by direct methods but for large communities this is clearly impracticable, and the sanitarian is obliged to depend upon the census and the above-mentioned registration.

The census is the count of its population which every civilized country makes at certain intervals, its returns also including particulars as to age, sex, race, occupation, etc. From the sanitarian's standpoint the age-record is, next to the population, the most important return, for the death-rate varies most according to age. In this country the census now furnishes various data for localized "sanitary districts," which may be even smaller than city wards, and these data afford the basis of comparison for variations in different parts of the same city and at different periods.

The records of births, marriages, deaths, and diseases are obtained from the registration bureau, having been furnished the latter by duly authorized persons. The duty of registration should devolve upon the sanitary administration, such as the local or State board of health, this being the most appropriate medium for the collection of the information in question, while the individual returns should obviously be made to the bureau by the attending physician in each case. And, as these returns should be as accurate as possible, especially as regards the diagnosis of preventable diseases and the determination of the causes of death, both primary and secondary, it is one of the reasons why the State should carefully determine the qualifications of the physicians whom it allows to practice within its confines.

From a sanitary point of view, the most important object of a registration of vital statistics is to "give warning of the undue increase of disease or death presumed to be due to preventable causes, and to indicate the localities in which sanitary effort is most desirable and most likely to be of use."[1]

It should be remembered that the following fundamental principles that underlie all statistical inquiries must be considered in the examination and analysis of any records or reports of the kind in question:—

1. The numerical units with which the inquiry has to do must be constant, definite, and precise in character; if any lack these qualities, such should be omitted altogether. Hence the care that should be observed in the diagnosis of all cases.

2. Groups of the numerical units must be so arranged that no unit is in more than one group at a time, and so that there can be no question as to the group in which each unit belongs. This is comparatively simple where the grouping regards only the age, sex, race, etc., but the difficulty increases with the complexity of facts and requires special talent to properly analyze and develop all possible features.

3. There must be a standard to express the relation of each group to the sum of the individual unit. This is usually 100, 1000, or some multiple of either.

4. The relation of each group to the total units is not a constant one unless all the factors which govern that relation are fixed and invariable—a condition which obviously does not obtain in vital statistics. The limit of variation in the relation of the component groups to the total, in two or more similar series, may, however, be expressed mathematically, and the variation itself will be found to diminish as the sum of individual units increases. Thus if, in the formula $m + n = q$, m be the number of units in one group and n the number in the other, the limit of variation will be indicated by the expression $2\sqrt{\frac{2mn}{q^2}}$; or, again, the relative value of two or more series is as the square root of the number of units in the respective series.

The arithmetical mean is often used in vital statistics, and this

[1] J. S. Billings, "Registration of Vital Statistics," American Journal of the Medical Sciences, vol. lxxxv, p. 37.

will always approximate the invariable if the number of units is sufficient, but it must be remembered that the relation expressed by the average in one case cannot be predicated positively of any other. As Dr. Guy says, "Averages are numerical expressions of probabilities; extreme values are expressions of possibilities."

The graphic representation of statistical results is of advantage, since it brings their salient features clearly before the attention of the observer.

The numerical units with which we are cencerned in vital statistics are persons, either living or dead, and these are divided into groups, according to age, sex, race, etc. Populations tend naturally to increase, the natural increment being measured by the difference in the number of births and deaths; but the actual increment depends upon how this is modified by the relation between immigration and emigration. If these factors were all constant, the population would increase in geometrical progression; but as this is not so it cannot be exactly determined for periods other than those in which the census is taken. However, in determining the population for years other than census years, it is customary to assume that the same rate of increase continues as prevailed between the last two censuses, and to calculate the population therefrom by means of geometrical progressions or logarithms. The number of houses in a city will help to determine the approximate population, for the average number of persons to the house in any city remains about the same from year to year. Such counts, as well as police censuses, are, however, almost always too high. In small and slowly-growing districts one-tenth of the difference in population of the last two censuses may be taken for each year since the last census. The population is always counted and annual birth- and death- rates calculated in this country for the middle of the year.

REGISTRATION OF BIRTHS.

The collection of data for an accurate registration of births is much more difficult than the record of deaths. Instead of requiring physicians and midwives in attendance at the confinement to report births, it would be more equitable and probably more effectual to compel the parents, under penalty for failure, to record the birth of each child at the board of health. The items usually included in birth returns are: date and place of birth, sex and color of child, names of father and mother, parents' nativity and age, and father's occupation. Sometimes the residence of the mother, number of children previously borne by the same mother, whether the child is legitimate or not, and various other details are also added. It is evident that for sanitary purposes most of this information is entirely irrelevant. It seems to the author that, for the purpose of the sanitarian and medical statistician, the date and place of birth, sex and color of the child, and age, nativity, and occupation of both parents are sufficient.

REGISTRATION OF MARRIAGES.

The record of marriages is of no interest to the sanitarian. If, however, the registration could be made by a competent medical man, and the physical condition of the contracting parties noted, valuable deductions might be made in time, especially if the parties themselves and their offspring could be kept under observation for many years. This, however, is so manifestly impracticable that it barely deserves notice in this place.

REGISTRATION OF DISEASES.

As has been seen in Chapter XIX, a large class of diseases are communicable from one individual to another, either directly, by contact, or mediately, by infection. In large communities it is therefore important that the sanitary authorities should possess information of the presence and prevalence of these diseases, in order that measures may be instituted for their restriction. It is true that in most cases the registration of deaths gives but too mournful evidence of the more fatal of the diseases of this class, but destructive epidemics could probably be frequently averted if preventive measures could be enforced early. Besides, in the case of dengue and epidemic influenza the death-rate may be so small that, if the registration of deaths were alone depended upon, no evidence whatever might be attainable of the epidemic prevalence of such diseases.

The registration of prevailing diseases is, therefore, one of the most important duties of the registrar of vital statistics. Prompt notices of all cases of infectious, miasmatic, or contagious diseases coming under their professional notice should be required of all physicians. It is unquestionably just, however, that the physicians required to perform this duty should be properly compensated by the public, whose interests they serve.

REGISTRATION OF DEATHS.

The data entered upon the record of death should comprise the name, age, sex, color, nativity, descent, occupation, and civil condition of decedent, with date, place, and cause of death. Under the heading "Descent" the birthplace of each parent should be given. Occupation should be accurately specified. The place of death should indicate the exact locality (number of street) where it occurred. Both proximate and predisposing causes of death should be entered, and any complications which may have influenced the fatal termination should be noted on the record.

The record should be in the possession of the local health authority before a permit for the burial of the deceased is granted. If this is not insisted upon, the report will soon be omitted and the registration become defective. In fact, any system that puts off the collecting and recording of the death returns until the end of the year will fail to register from 25 to 40 per cent. of the number.

DEATH-RATE AND BIRTH-RATE.

In order to calculate the annual death-rate of a place two facts are required to be known: first, the acutal or estimated population (generally obtained, as indicated, from the census), and, second, the number of persons who died in the district during the year. The number of deaths is divided by the population, which gives the death-rate for each individual for the year. To find the death-rate per 1000 the rate as found above is multiplied by 1000. Thus, the total number of deaths in the city of Philadelphia during 1893 was 23,655, and the estimated population 1,115,562. The death-rate for the year was 21.20 per 1000, obtained as follows:—

$$\frac{23{,}655 \times 1000}{1{,}115{,}562} = 21.20 \text{ per M.}$$

To calculate the annual death-rate per 1000 of a place from the returns for one week, the weekly population is first ascertained and then the number of deaths for the week divided by the weekly population and the quotient multiplied by 1000. The following example will render this clear:—

The exact number of weeks in a year is 52.17747. The total population is divided by this number, giving the weekly population. This gives for Philadelphia, assuming the above estimate to be correct, a weekly population of 21,381. For the week ending June 3, 1893, the deaths in that city numbered 388. The annual death-rate per 1000—that is to say, the number of deaths in each 1000 of population, if the same rate be maintained throughout the year—is obtained as follows:—

$$\frac{388 \times 1000}{21,381} = 18.15 \text{ per M.}$$

The daily death-rate is obtained in a similar manner, the divisor for obtaining the daily population being 365, 24226, and the monthly population is found by multiplying the daily population by the number of days in the respective months. But it should be remembered that these rates for such short periods cannot by any means accurately indicate the actual annual rate, and that they are to be used only for comparing the rates for similar periods at different seasons, etc.; otherwise, with such large populations and such short periods the probabilities of error are too great for the results to be of any value.

The annual zymotic or infectious death-rate, or that for any one disease, is obtained in the same manner as the general annual death-rate, and likewise the birth-rate. Or, to find the annual death-rate per 1000 of population for this class of diseases, the following calculation may be made. Thus, out of the above 388 deaths, 84 were from infectious diseases:—

$$\frac{84 \times 1000}{21,381} = 3.93 \text{ per M. per annum.}$$

Or, if the percentage of deaths from infectious diseases be desired, the procedure would be as follows:—

$$\frac{84 \times 100}{388} = 21.65 \text{ per cent. of the total deaths.}$$

As an exception to the rule, the rate of infant mortality or infantile death-rate is indicated by the ratio of deaths of children under one year to the number of births recorded for the year, and is found by multiplying the number of infantile deaths by 1000 and dividing by the number of births; for example, for the year just quoted the decedents under one year of age numbered 5710; the total number of births for the same year was 30,737. Hence—

$$\frac{5710 \times 1000}{30,737} = 185.77 \text{ per 1000 births.}$$

Nineteen of the 388 deaths for the week ending June 3, were of colored persons. The death-rate of these to the total population is found in a similar manner to the above; but if it is desired to ascertain the death-rate of the colored population alone, the weekly colored population must first be obtained, and the rate calculated from this by the above formula.

There are a number of factors that affect the general death-rate, such as the size of the community, habits of life, age- and sex- distribution, occupation of the bulk of the inhabitants, etc. For the country and small towns the rate should be from 9 to 16 per 1000, gradually increasing until for the largest cities it amounts to from 18 to 21 per 1000. Death-rates reported below these figures would indicate that all the deaths had not been recorded, or that the population had been overestimated; rates above would be evidence that there were special causes at work demanding sanitary investigation and improvement.

Among the causes that make the mortality among infants and children high are parents too young or sickly, hereditary taints, unhealthy environments, improper and insufficient food and clothing, and, not rarely, infant life-insurance. It is simply the manifestation of one of the workings of the law of "the survival of the fittest." In localities newly settled, where the proportion of adults to children is greater than the normal, the death-rate is naturally lower; though it is conceivable that the occupations in which the adults engaged and the vicissitudes and unsettled conditions, both sanitary and social, of a new settlement might cause or tend to cause a very high mortality. Since more males die than females, the sex-distribution will also have its influence on the death-rate, especially if there is a preponderance of one sex over the other in any locality.

Many conditions affect the death-rate from the different diseases, namely, age, race, sex, occupation, environment, seasons, temperature, etc. The zymotic death-rate, and especially that part of it due to typhoid fever, may be an extremely good index of the actual value and benefit of sanitary improvements and the enforcement of hygienic laws. Thus, the mortality from typhoid fever in England and Wales has been reduced more than 50 per cent. since the introduction and enforcement of the general sanitary regulations in that kingdom.

On account of lack of registration of all cases of disease, it is practically impossible to determine the sick-rate of a community or population; but it is said that the sickness of a community amounts to the disablement of one person for two years for every death, and the records of English beneficial societies seem to show that each member averages about one and one-half weeks' sickness annually.

The following definitions are introduced because the terms are frequently used in discussions of vital statistics, and especially of life-insurance. The comparative mortality figure indicates that the same number of persons that gave 1000 deaths in the whole population would furnish the deaths indicated by the figure in the city or locality in question. Thus, if the comparative mortality figure of a place is 925 and the death-rate of the country is 20, there are 1000 deaths for every 50,000 of the whole population and the death-rate of the given place is 18.5. For $20:1000::x:925$ and $x=18.5$.

The average or mean age at death is ascertained by adding up the ages of all the decedents and dividing the sum by the number of deaths. Unless it is derived from the life-tables of an entire generation, it is not a fair index of longevity or of sanitary conditions, since it is affected considerably by the age-distribution of the population from which it is compiled.

The expectation of life at any age is the average number of years which persons of that age may expect to live. For the newborn it is the same as the mean duration of life, and, "as applied to communities, it is the mean life-time of a generation of persons traced by the life-table method from birth to death, and is the only true test of the health of populations." A life-table is computed from the number and ages of the living and of those that die, these factors being obtained from the average population for each age and sex, and from the total death-returns between two or more censuses. It is, as Dr. Farr says, "a barometer which indicates the exact measure of the duration of life under given circumstances, and is indispensable in gauging the influence of sanitary or insanitary conditions."

It is only when the population does not vary as to age- or sex-distribution that the mean duration of life is identical with the average age at death. Otherwise, for any person at any age it is the same as the expectation of life. The probable duration of life is equivalent to the age at which any number of newborn children will be reduced one-half, the same conditions persisting. With a million children as a basis, it is less than forty-five years for males and about forty-seven years for females.

It will be evident, on a little thought, that there must be many sources of error in calculations based upon such uncertain data as are derived from the registration of births and deaths as conducted in most cities in this country. Besides, the subject of vital statistics is essentially abstruse, and requires no little readiness in mathematics to appreciate its profounder bearings. Hence, in the foregoing chapter, no attempt has been made to penetrate beyond the immediate practical aspects of the questions involved.

QUESTIONS TO CHAPTER XIX.

VITAL STATISTICS.

What is comprised in the registration of vital statistics? How are they to be made of use? Of what value are the recorded statistics to the sanitarian? How else may disease be studied? Why may not the same methods of determining the general health be applied to large communities as to small ones?

What is the census? What returns of interest to the sanitarian does it make? Which of these are the most important? Why? What is the advantage of furnishing returns for "sanitary districts," and what is meant by the latter?

What returns are to be obtained from the registration bureau? Who furnishes these returns? Who should have charge of the registration? Why? Why should physicians make the returns? Why should the State take care in the licensing of physicians to practice? What is the most important object of the registration of vital statistics?

What are the fundamental principles underlying all statistical inquiry? What units or cases should be omitted? What renders the classification of groups difficult? What is the usual standard of comparison? When is the relation of component groups to the total constant? How may the probable limit of variation be determined? What tends to make the arithmetical mean approach the invariable? How may the relative value of different series of the same kind of cases be determined? What is the difference between averages and extreme values? Of what value is the graphic method of representing statistical results?

What are the units of vital statistics? How may they be divided into groups? What is the natural increment of a population? How does this differ from the actual increment? If the factors were constant, how would a population increase? Why? Why cannot the population be determined exactly for intercensal periods? What is the usual and most accurate way of determining it? How else may it be estimated? What is the fault of counts made by local authorities or police censuses? At what time of the year is the count always made? For what time are annual death-rates, etc., calculated?

Why is the collection of data for birth-records difficult? Who should make the return? What items are usually included in the returns? Which are the only ones of value to the sanitarian and medical statistician? Why is the record of marriages of no sanitary interest? How might it be made so? Is this practicable?

What classes of diseases should be reported and recorded? Why? What epidemic diseases might escape notice by the statistician if only reported in death-returns? When should the returns of infectious diseases be made? Should there be any recompense for the returns to the physicians?

What data should be given by a death-certificate? Which items should be accurately specified? What care should be taken in reporting the cause of death? When should the burial-permit be issued?

What factors are required in order to calculate the death-rate of a locality? How is the death-rate for the year obtained? How may the annual death-rate of a place be calculated from the death-returns for one week? What is the weekly and the daily population? How is the monthly population found? What is the objection to rates determined from returns for such short periods? Of what value are they?

What is meant by the zymotic or infectious death-rate? How may it be determined? How is the percentage of deaths due to infectious disease determined? How is the rate of infant mortality determined?

What factors affect the general death-rate? What is a fair death-rate for small communities? For large cities? What do higher rates than this usually indicate? What do lower ones? What causes make the mortality so high among infants and young children. What may make the death-rate of a community lower than the normal? What higher? How may sex-distribution affect the death-rate? What conditions or factors affect the mortality from the different diseases? How may the zymotic death-rate be an index of the value of sanitary measures?

Why is it so difficult to determine the sick-rate of a community? How may the total amount of sickness be approximately estimated?

What is meant by the comparative mortality figure? What by the average age at death? Is this necessarily a fair index of longevity? What affects it? What is meant by the expectation of life? Of what value is it when applied to communities? What is a life-table, and how is it computed? Of what value is it to sanitarians? When is the mean duration of life identical with the average age of death? What is meant by the probable duration of life? Why are calculations of vital statistics liable to be unreliable or inaccurate?

CHAPTER XX.

QUARANTINE.

By quarantine is meant the adoption of restrictive measures to prevent the introduction of diseases from one country or locality into another. The term itself conveys no definite idea, being derived through the Italian from the Latin "quadraginta," meaning "forty" and implying forty days—the period of detention imposed on vessels by the first quarantines established at Venice in 1403. The old significance of the term is entirely lost in its present application, which is quite general. Thus, besides regular maritime quarantine, mention is often made of land, railroad, cattle, shot-gun, house, and even room quarantine.

The name of a disease or article of merchandise may be used in a prefix, as in "yellow-fever quarantine," small-pox, cholera, or rag quarantine. Moreover, quarantines are described as properly beginning at the port of departure, and as quarantine of inspection only, the fumigation and detention being imposed at some neighboring station. The term, therefore, is applied not only to establishments, but indifferently to persons, animals, diseases, localities, and measures.

There is need of a clear understanding with regard to the term, for when, as occasionally, quarantine is ridiculed, or the assertion is made that the English disbelieve in quarantine, a wrong impression will be received, unless it is understood that only particular and obsolete forms of quarantine are meant, and not quarantine in the broad sense just mentioned.

The subject admits of two natural divisions—maritime and land quarantine; but before describing them attention is called to the following table, containing a list of diseases that are ordinarily found in official quarantine proclamations:—

This list illustrates the growth of the sanitary idea and belief in quarantine. For many years, as now at some ports, the list was limited to yellow fever, typhus, cholera, and small-pox. It was thus limited at Boston prior to 1881, since which date diphtheria, scarlet fever, typhoid fever, and measles have been added. The statutes of New York define as quarantinable "yellow fever, measles, cholera, typhus or ship fever, small-pox, scarlatina, diphtheria, relapsing fever, and any disease of a contagious, infectious, or pestilential character

TABLE LIX.

Quarantinable Diseases.

Disease	Period of Incubation, in days			
	Shortest	Longest	Usual	Authority and Remarks.
Plague	3	8	3 to 5	Kitasato.
Yellow fever	1	7	2½	Da Costa, Bartholow, Reed, Carver.
Cholera	2	14	2 to 4	Bartholow.
Typhus fever	1	21	5 to 14	Bristow.
Small-pox	5	20	10	Da Costa.
Measles	7	14	10	Da Costa.
Diphtheria	2	10	2 to 5	Bartholow.
Typhoid fever	7	28	21	Bartholow.
Scarlet fever	1	Weeks	4 to 7	Da Costa.
Relapsing fever	5	7	6	Bartholow.
Dengue	1	10	5	Bartholow.
Leprosy	..	..	....	Undetermined.

which shall be considered by the health officer dangerous to the public health."

At Gibraltar, the English sanitary authorities include dengue and epidemic rose-rash among the diseases subject to their quarantine regulations.

Another addition to the list in this country is leprosy, to prevent the introduction of which, and in accordance with a resolution of the American Public Health Association, a prohibitory circular was issued by the Surgeon-General of the Marine-Hospital Service, December 23, 1889.

Other diseases which may properly call for quarantine are mumps, whooping cough, chicken-pox, epidemic dysentery, glanders, tetanus, beriberi, epidemic influenza, and pulmonary tuberculosis.

Influenza may be considered quarantinable under certain circumstances, a successful quarantine being reported by Dr. Trudeau, whose cottage sanitarium, in the Adirondacks, New York, was thus kept exempt during the epidemic of 1890.

With regard to pulmonary tuberculosis the ground is taken by the writer that this disease, at least among immigrants, should be excluded from the United States by quarantine.

FOREIGN QUARANTINE.

The object of maritime quarantine being protection against the importation of contagious or infectious disease, chiefly from abroad, through the medium of vessels, their crews, passengers, and cargoes, it is most logical that restrictive measures should begin at the port of departure. Following are the regulations prepared by the Surgeon-General of the Public Health and Marine-Hospital Service of the United States and promulgated by the Secretary of the Treasury, April 1, 1903. All quarantine regulations are subject to occasional revision under the Act of Congress approved February 15, 1893.

QUARANTINE REGULATIONS.

Quarantinable Diseases.

1. For the purpose of these regulations the quarantinable diseases are cholera, yellow fever, small-pox, typhus fever, leprosy, and plague.

Foreign Regulations.

Quarantine Regulations to be Observed at Foreign Ports and at Ports in the Possessions and Dependencies of the United States.

Bills of Health.

2. Masters of vessels departing from any foreign port, or from any port in the possessions or other dependencies of the United States for a port in the United States or its possessions or other dependencies, must obtain a bill of health, in duplicate, signed by the proper officer or officers of the United States as provided for by law, except as provided for in paragraph 4.

The following form is prescribed:—

Form No. 1937.

United States Bill of Health.

Name of vessel, ———. Nationality, ———. Rig, ———. Master, ———. Tonnage, gross, ———; net, ———. Iron or wood. Number of compartments for cargo, ———; for steerage passengers, ———; for crew, ———.

Name of medical officer, ———.

Number of officers, ———.

Number of members of officers' families, ———.

Number of crew, including petty officers, ———.

Number of passengers, cabin, ———.

Number of passengers, steerage, ———.

Number of persons on board, all told, ———.

Port of departure, ———.

Where last from, ———.

Number of cases of sickness and character, during last voyage, ———.

Vessel engaged in ——— trade, and plies between ——— and ———.
Sanitary condition of vessel,———.
Nature, sanitary history, and condition of cargo, ———.
Source and wholesomeness of water supply, ———.
Source and wholesomeness of food supply, ———.
Sanitary history and health of officers and crew, ———.
Sanitary history and health of passengers, cabin, ———.
Sanitary history and health of passengers, steerage, ———.
Sanitary history and condition of their effects, ———.
Prevailing diseases at port and vicinity, ———.
Location of vessel while discharging and loading—open bay or wharf, ———.
Number of cases and deaths from the following-named diseases during the past two weeks:

Yellow fever	———	———
Asiatic cholera	———	———
Cholera nostras or cholerine	———	———
Small-pox	———	———
Typhus fever	———	———
Plague	———	———
Leprosy	———	———

Number of cases of sickness and character of same while vessel was in this port, ——— ———.
Any conditions affecting the public health existing in the port of departure or vicinity to be here stated, ———.
I certify that the vessel has complied with the rules and regulations made under the act of February 15, 1893, and that the vessel leaves this port bound ——— for ———, U. S. of America, via ———.
Given under my hand and seal this ——— day of ———, 190 .

(Signature of consular officer:) ——— ———,
——— ———.

3. Vessels clearing from a foreign port or from any port in the possessions or other dependencies of the United States for any port in the United States, its possessions or other dependencies, and entering or calling at intermediate ports, must procure at all said ports a supplemental bill of health in duplicate signed by the proper officer or officers of the United States, as provided in the law. If a quarantinable disease has appeared on board the vessel after leaving the original port of departure, or other circumstances presumably render the vessel infected, the supplemental bill of health should be withheld until such sanitary measures have been taken as are necessary.

The following form is prescribed:—

Supplemental Bill of Health.

Port of ———.

Vessel ———, bound from ——— to ———, U. S. A.
Sanitary condition of port, ———.

State diseases prevailing at port and in surrounding country, ———.

Number of cases and the deaths from the following-named diseases during the past two weeks:—

TABLE LX.

Table of Diseases.

Diseases	No. of Cases	No. of deaths	Remarks (Any condition affecting the public health existing in the port to be stated here.)
Yellow fever	......	....	
Asiatic cholera	......	....	
Cholera nostras, or cholerine	......	....	
Small-pox	......	....	
Typhus fever......	......	....	
Plague	......	....	
Leprosy	......	....	

Number and sanitary condition of passengers and crew landed at this port.

Cabin, No. ——. Sanitary condition and history, ———.

Steerage, No. ——. Sanitary condition and history, ———.

Crew, No. ——. Sanitary condition and history, ———.

NOTE.—If disembarked on account of sickness state disease, ———.

Number and sanitary condition of passengers and crew taken on at this port, and sanitary condition of effects.

Cabin, No. ——. Sanitary condition and history, ———.

Steerage, No. ——. Sanitary condition and history, ———.

Crew, No. ——. Sanitary condit'on and history, ———.

Sanitary condition of effects, ———.

Sanitary history of vessel since leaving last port.

(Cancel Form A, B, or C, as the case requires.)

Form.

A.—To the best of my knowledge and belief—

(Form A will be used at intermediate ports where the vessel does not enter and clear.)

B.—I have satisfied myself that—

(Form B will be used at intermediate ports where the vessel enters and clears.)

} no quarantinable disease has appeared aboard since leaving ———.

C.—Since leaving ———the following quarantinable disease has appeared on board ———, and I certify that the necessary sanitary measures have been taken.

I certify also that with reference to the passengers, effects, and cargo taken on at this port, the vessel has complied with the rules and regulations made under the act of February 15, 1893.

Given under my hand and seal this ——— day of ———, 190 .

(Signature of consular officer:) ——— ———,

——— ———.

4. Under the act of Congress approved August 18, 1894, vessels plying between Canadian ports on the St. Croix River, the St. Lawrence River, the Niagara River, the Detroit River, the St. Clair River, and the St. Mary's River, and adjacent ports of the United States on the same waters; also vessels plying between Canadian ports on the following-named lakes, viz,, Ontario, Erie, St. Clair, Huron, Superior, Rainy Lake, Lake of the Woods, and Lake Champlain, and ports in the United States; also vessels plying between Mexican ports on the Rio Grande River and adjacent ports in the United States, are exempt from the provisions of section 2 of the act granting additional quarantine powers and imposing additional duties upon the Marine-Hospital Service, approved February 15, 1893, which requires vessels clearing from a foreign port for a port in the United States to obtain from the consular or medical officer a bill of health. During the prevalence of any of the quarantinable diseases at the foreign port of departure, vessels above referred to are hereby required to obtain from the consular officer of the United States, or from the medical officer of the United States, when such officer has been detailed by the President for this purpose, a bill of health, or a supplemental bill of health, in duplicate, in the form prescribed by the Secretary of the Treasury.

Inspection of Vessels Leaving Foreign Ports and Ports in the Possessions or other Dependencies of the United States for Ports in the United States or its Possessions or other Dependencies.

5. The officer issuing the bill of health shall satisfy himself, by inspection, if necessary, that the conditions certified to therein are true, and is authorized, in accordance with the law, to withhold the bill of health or the supplemental bill of health until he is satisfied that the vessel, the passengers, the crew, and the cargo have complied with all the quarantine laws and regulations of the United States.

6. Inspection is required of—

(*a*) All vessels from ports at which cholera, yellow fever, or plague prevails, or at which small-pox or typhus fever prevails in epidemic form.

(*b*) All vessels carrying steerage passengers; but need only include the inspection of such passengers and their living apartments, if sailing from a healthy port.

7. Inspection of the vessel is such an examination of the vessel, cargo, passengers, crew, personal effects of same, including examination of manifests and other papers, food- and water- supply, the as-

certainment of its relations with the shore, the manner of loading, and possibilities of invasion by small animals as will enable the inspecting officer to determine if these regulations have been complied with.

8. When an inspection is required, it should be made by daylight, as late as practicable before sailing. The vessel should be inspected before the passengers go aboard, the passengers just before embarkation, and the crew on deck; and no communication should be had with the vessel after such inspection except by permission of the officer issuing the bill of health.

Requirements with Regard to Vessels.

9. Vessels, prior to stowing cargo or receiving passengers, should be mechanically clean in all parts, especially the hold, forecastle, and steerage; the bilges and limbers free from odor and deposit. The air streaks should be sufficient in number and open for ventilation.

10. Any portions of the vessel liable to have been infected by any communicable disease should be disinfected before the issuance of the bill of health.

11. The air-space, ventilation, food- and water- supply, hospital accommodations, and all other matters mentioned therein promotive of the health and comfort of the passengers must be in accordance with the provisions of the act of Congress approved August 2, 1882, entitled "An act to regulate the carriage of passengers by sea."

12. At ports where cholera prevails in epidemic form, special care should be taken to prevent the water- and the food- supply from being infected. The drinking-water should be boiled and the food thoroughly cooked and protected against contamination by flies, etc.

13. At ports where yellow fever prevails, in addition to the other measures presented hereafter, precautions should be taken to prevent the introduction of mosquitoes on board the vessel. Water-tanks, water-buckets, and other collections of water about the vessel should be guarded in such a manner that they shall not become breeding-places for mosquitoes. Measures should also be taken to destroy mosquitoes that may have come on board. Baggage destined directly or indirectly for any State should be disinfected at the request of the health officer of said State. All baggage from such ports must be rigidly inspected and the exclusion of mosquitoes assured.

14. At ports or places where plague prevails, every precaution must be taken to prevent the vessel becoming infected through the agency of rats, ants, flies, fleas, or other animals. At such ports or places the vessel should not lie at a dock, or tie to the shore, or anchor

near any place where such animals may gain access to the vessel. In case cables are led to the shore they should be freshly tarred and provided with inverted cones or such other devices as may prevent rats and other animals passing to the ship. The introduction of vermin on board the vessel from lighters and all other sources should be guarded against. In such ports sulphur fumigation should be resorted to in the holds when empty and from time to time during loading in order to destroy vermin.

15. At all infected ports or places, communication between the vessel and shore should be reduced to a minimum.

16. Vessels carrying passengers from any port or place where quarantinable disease prevails in epidemic form should have one medical officer; and from ports where cholera or plague prevails in epidemic form should have two medical officers if more than 250 passengers are carried.

Cargo.

17. Earth, loam, soft or porous rock should not be taken as ballast at ports infected with cholera or plague. Street-sweepings, city cleanings, or anything containing organic refuse should not be taken as ballast from any port. Where practicable, hard rock or clean beach sand or sea-water ballast should be given preference.

18. Household goods, personal effects, bedding, and second-hand articles generally, coming from a district known to be infected with cholera, small-pox, typhus fever, or plague, or as to the origin of which no positive evidence can be obtained, and which the consular or medical officer has reason to believe are infected, should be disinfected prior to shipment. Measures should be taken with articles of this class from districts infected with yellow fever to insure their freedom from mosquitoes.

19. New merchandise in general may be accepted for shipment without restriction, and articles of new merchandise—textile fabrics and the like—which have been packed or prepared for shipment in an infected port or place, with a special view to protect the same from moisture incident to the voyage, may be accepted and exempted from disinfection.

20. Certain food products, viz., unsalted meats, sausages, dressed poultry, fresh butter, fresh milk (unsterilized), fresh cheese, coming from cholera-infected localities or through such localities, if exposed to infection therein, should not be shipped. Fresh fruits and vegetables, from districts where cholera prevails, shall be shipped only

under such sanitary supervision as will enable the inspector to certify that they have not been exposed to infection.

21. All rags and textile fabrics used in the manufacture of paper and for other purposes which are collected, packed, or handled in any foreign port or place, with the exceptions as hereinafter specified, shall, prior to shipment to the United States, be subjected to disinfection by one of the prescribed methods. (Jute bags or bagging used in baling cotton, old rope, new cotton, or linen cuttings from factories not included.) The disinfection of the articles mentioned above shall be performed under the supervision of a United States consul or a medical officer of the United States, and a certificate in duplicate, signed by said consul or medical officer, shall be issued with each consignment of same, which certificate shall identify the articles and state that they have been disinfected in accordance with the United States quarantine regulations. The original certificate of disinfection shall be attached to the consignee's invoice, and where the articles are carried by sea the duplicate certificate of disinfection shall be attached to the bill of health issued to the vessel conveying the same.

Exceptions.—Such articles shipped from the dominion of Canada directly to the United States shall be exempt from this requirement if accompanied by affidavits demonstrating to the satisfaction of the collector of customs at the port of arrival that they have actually originated in Canada and have not been shipped from a foreign country to Canada, and thence shipped to the United States; and further, that the port or place where collected or handled has been free from quarantinable diseases for thirty days prior to shipment.

22. New feathers for bedding, human and other hair (unmanufactured), bristles, wool, hides not chemically cured, coming from a district where cholera or plague prevails, shall be refused entry into the United States until thirty days have elapsed since last exposure in case of cholera, and sixty days in case of plague, unless unpacked and disinfected. Feathers which have been used should be disinfected, and invariably by steam.

Bristles which have been boiled, and wool and new feathers which have been packed in naphthalin preparatory to shipment, may be shipped without further treatment.

Dry hides packed in naphthalin may be shipped as chemically cured hides.

Unsalted green hides from a district where cholera prevails must not be shipped.

23. The articles enumerated in the preceding paragraph coming

from a district where small-pox, typhus fever, cholera, or plague prevails in epidemic form, should be refused shipment unless disinfected as hereinafter provided.

24. Nothing in these regulations shall be construed to modify or affect in any way any existing restrictions promulgated by the secretary of the Treasury at the instance of the Bureau of Animal Industry, Department of Agriculture, regarding the importation of hides of neat cattle.

25. Any covering, shipped from or through an infected port or place, and which the consul or medical officer has reason to believe infected, should be disinfected.

26. Any article presumably infected, which can not be disinfected should not be shipped.

Passengers and Crew.

27. Passengers, for the purposes of these regulations, are divided into two classes: cabin and steerage.

28. When practicable, passengers should not ship from an infected port.

29. No person suffering from a quarantinable disease, or scarlet fever, measles, diphtheria, or other communicable disease, should be allowed to ship.

30. Steerage passengers and crew coming from cholera-infected districts should be detained five days in suitable houses or barracks located where there is no danger from infection, and all baggage disinfected.

31. Steerage passengers and crew from districts not infected with cholera, shipping at a port infected with cholera, unless passed through without danger of infection and no communication allowed between such persons and the infected locality, should be treated as those in the last paragraph.

32. Cabin passengers coming from cholera-infected districts embarking at a clean or an infected port should produce satisfactory evidence as to their exact places of abode during the five days immediately preceding embarkation. And if it appears that they or their baggage have been exposed to infection, the baggage should be disinfected and the passengers detained under medical supervision a sufficient time to cover the period of incubation since last exposure.

33. Steerage passengers and crew who, in the opinion of the inspecting officer, have been exposed to the infection of yellow fever, should

be held under medical observation in a place free from danger of infection for a period of five days before embarkation.

34. Steerage passengers and crew, coming from districts where small-pox prevails in epidemic form, or who have been exposed to small-pox, should be vaccinated before embarkation, unless they show evidence of having acquired immunity to small-pox by previous attack or recent successful vaccination.

35. Steerage passengers and crew who, in the opinion of the inspecting officer have been exposed to the infection of typhus fever, should not be allowed to embark for a period of at least twelve days after such exposure and the disinfection of their baggage.

36. Steerage passengers and crew who, in the opinion of the inspecting officer, have been exposed to the infection of plague should be held under medical observation in a place free from danger of infection for a period of seven days before embarkation, and their baggage disinfected.

37. Cabin passengers coming from plague-infected districts, whether embarking at a clean or an infected port, should produce satisfactory evidence as to their exact places of abode during the seven days immediately preceding embarkation. And if it appears that they or their baggage have been exposed to infection the baggage should be disinfected and the passengers detained under medical supervision a sufficient time to cover the period of incubation since the last exposure.

38. Should quarantinable disease appear in the barracks or houses in which passengers are undergoing detention, no passenger from said houses or barracks who has been presumably exposed to this new infection should embark until after the expiration of the period of incubation of the disease in question subsequent to the last exposure to infection and the application of all necessary sanitary measures.

39. All baggage of steerage passengers destined for the United States should be labeled. If the baggage is in good sanitary condition the label shall be a red label bearing the name of the port, the steamship on which the baggage is to be carried, the word "passed" in large type, the date of inspection, and the seal or stamp of the consular or medical officer of the United States. All baggage that has been disinfected shall bear a yellow label, upon which shall be printed the name of the port, the steamship upon which the baggage is to be carried, the word "disinfected" in large type, the date of disinfection, and the seal or stamp of the consular or medical officer of the United

INSPECTION CARD.

[Immigrants and Steerage Passengers.]

Port of departure ——— ——— Date of departure ——— ———

Name of ship ——— ———. Last permanent residence ——— ———

Name of immigrant ——— ———.

Inspected and passed	Passed at quarantine, port of	Passed by Immigration Bureau, port of
.... [Seal or stamp of consular or medical officer.]	..............., United States. .... [Date.]	.... [Date.]

[The following to be filled in by ship's surgeon or agent prior to or after embarkation.]

Ship's list or manifest ——— ———. No. on ship's list or manifest ——— ———.

Berth No.	Steamship inspection.	1st day.	2	3	4	5	6	7	8	9	10	11	12	13	14	To be punched by ship's surgeon at daily inspection.
....																

VACCINATED.

[Signature or Stamp.]

[Reverse Side.]

Keep this Card to avoid detention at Quarantine and on Railroads in the United States.

Diese Karte muss aufbewahrt werden, um Aufenthalt an der Quarantüne, sowie auf den Eisenbahnen der Vereinigten Staaten zu vermeiden.

Cette carte doit être conservèe pour éviter une détention à la Quarantaine, ainsi que sur les chemins de fer des Etats-Unis.

Deze kaart moet bewaard worden, ten einde oponthoud aan de Quarantijn, alsook op de ijzeren wegen der Vereenigde Staten te vermijden.

Conservate questo biglietto onde evitare detenzione alla Quarantina e sulle Ferrovie degli Stati Uniti.

Tento lístek musíte uschovati, nechcete-li ukarantény (zastavení ohledně zjistěni zdraví) neb na dráze ve spojenych státech zdrzení byti.

Tuto kartocku treba trímat' u sebe aby sa predeslo zderzovanu v karantene aj na zeleznici ve Spojench Státoch.

States. It is understood, and it will be so printed on the blank, that the label is not valid unless bearing the consular or medical officer's stamp or seal.

40. Each steerage passenger shall be furnished with an inspection card (see page 483). This card, stamped by the consular or medical officer, is to be issued to every member of a family as well as to the head thereof.

41. In a port where any quarantinable disease prevails, the personnel of vessels should remain on board during their stay in such port.

42. Passengers and crews, merchandise and baggage, prior to shipment at a noninfected port, but coming from an infected locality, should be subject to the same restrictions as are imposed at an infected port.

RECORDS, REPORTS, ETC.

43. The officer making the inspection will preserve in his office a record of each inspection made and of each immunity certificate given; a copy of each certificate of disinfection and of each bill of health issued.

A weekly report of the transactions of his office shall be forwarded to the Surgeon-General at Washington, D. C.

44. In addition to the duties prescribed, the medical officer when detailed in accordance with the act of Congress approved February 15, 1893, shall furnish such reports to the Surgeon-General of the Public Health and Marine-Hospital Service as he may be able to make upon sanitary conditions and other matters affecting the public health and the welfare of the Service administration.

Requirements at Sea.[1]

45. The master of a vessel should observe the following measures on board his vessel:—

(*a*) The water-closets, forecastle, bilges, and similar portions of the vessel liable to harbor infection should be disinfected and frequently cleansed.

(*b*) Free ventilation and rigorous cleanliness should be maintained in all portions of the ship during the voyage and measures taken to destroy rats, mice, fleas, flies, roaches, mosquitoes, and other vermin.

(*c*) A patient sick of a communicable disease should be isolated

[1] These requirements are largely advisory in character, but it is nevertheless true that a careful compliance with them should tend, at the port of arrival, to largely relieve the stringency of quarantine measures.

and one member of the crew detailed for his care and comfort, who, if practicable, should be immune to the disease.

(*d*) Communication between the patient or his nurse and other persons on board should be reduced to a minimum.

(*e*) Used clothing, body linen, and bedding of the patient and nurse should be immersed at once in boiling water or in a disinfecting solution.

(*f*) The compartment from which the patient was removed should be disinfected and thoroughly cleansed. Articles liable to convey infection should remain in the compartments during the disinfection when gaseous disinfection is used.

(*g*) Any person suffering from malaria or yellow fever should be kept under mosquito bars and the apartment in which he is confined closely screened with mosquito netting. All mosquitoes on board should be destroyed by burning pyrethrum powder (Persian insect powder) or by fumigation with sulphur. Mosquito larvæ (wigglers or wiggle-tails) should be destroyed in water-barrels, casks, and other collections of water about the vessel by the use of petroleum (kerosene); where this is not practicable, use mosquito netting to prevent the exit of mosquitoes from such breeding-places.

(*h*) In the case of plague, special measures must be taken to destroy rats, mice, fleas, flies, ants, and other vermin on board.

(*i*) In the case of cholera, typhoid fever, or dysentery, the drinking water should be boiled and the food thoroughly cooked. The discharges from the patient should be immediately disinfected and thrown overboard.

46. An inspection of the vessel, including the steerage, should be made by the ship's physician once each day.

47. Should cholera, yellow fever, small-pox, typhus fever, plague, or any other communicable disease appear on board ship while at sea, those who show symptoms of these diseases should be immediately isolated in a proper place; the ship's physician should then immediately notify the captain, who should note same in his log, and all of the effects liable to convey infection which have been exposed to infection should be destroyed or disinfected.

48. The hospital should be disinfected as soon as it becomes vacant.

49. The dead should be enveloped in a sheet saturated with one of the strong disinfecting solutions, without previous washing of the body, and at once buried at sea or placed in a coffin hermetically sealed.

50. A complete clinical record should be kept by the ship's surgeon of all cases of sickness on board, and the record delivered to the quarantine officer at the port of arrival.

51. The following disinfecting solutions are recommended for use at sea:—

Formulæ for strong disinfecting solutions.

BICHLORIDE OF MERCURY. (1:500.)

Bichloride of mercury..........................	1 part
Sea water..	500 parts
Mix.	

CARBOLIC ACID. (5 per cent.)

Alcohol	50 parts
Carbolic acid, pure.............................	50 parts
Mix.	
Then add fresh water..........................	900 parts

Formulæ for weak solutions.

BICHLORIDE OF MERCURY. (1:1,000.)

Bichloride of mercury..........................	1 part
Sea water..	1000 parts

CARBOLIC ACID. (2½ per cent.)

Carbolic acid, pure............................	25 parts
Fresh water......................................	1000 parts

FORMALIN. (5 per cent.)

Formalin (or formol)...........................	50 parts
Water	950 parts

It is suggested that a vessel should carry for every 100 passengers: bichloride of mercury, 5 pounds; carbolic acid, 10 pounds; alcohol, 10 pounds, and formalin, 10 pounds.

EFFICIENCY OF FOREIGN REGULATIONS.

The wisdom of this method of procedure and the efficient working of these regulations are demonstrated by the following statement taken from the report of the medical officer of the Marine-Hospital Service on duty at Naples, Italy, where, during the summer of 1893, cholera was epidemic:—

"From the 15th of July to August 17th there were eight vessels cleared from Naples with steerage passengers—four for New York and four for South American ports. The first to leave was the *Karamania*, for New York, on July 15th. No cholera at that time existed in Naples. The first case occurred in Naples on the night of the 16th, and the result of the bacteriological examination was not known until the afternoon of the 17th or morning of the 18th.

"The passengers for the *Karamania* and the ship itself were put through the established routine. The ship was cleaned; ventilation, etc., altered to conform with the United States law; closets and hospitals put in good order; water- and food- supply attended to; passengers inspected and vaccinated, and both their baggage and clothing searched for food. Three days after sailing, *i.e.*, on the 18th, a death from cholera occurred, and just before reaching New York there were two more. It is not unlikely that the infection in the first cases was traceable to the same source as those occurring in Naples on the 16th. It is more than probable that but for the careful exclusion of food brought by passengers there would have been more cases on the remaining three ships for the United States. The regulations governing infected ports were rigidly enforced. The first vessel to leave, four days after the cholera was announced, was the *Massilia*. Her passengers were met at the trains and conducted immediately on board; were there isolated three days, and all their baggage transferred across city unopened. All food was carefully looked into; all from persons or baggage excluded; and the baggage of a few, about whose antecedents there was doubt, disinfected by steam. The ship was warped out some distance from the pier every night, and an inspector kept on board night and day. There being no cholera known to exist anywhere in Italy outside of Naples, it was not thought necessary to disinfect all baggage or isolate for five days. She arrived safely in New York without mishap. The remaining two for the United States were the *Weser* and *Cashmire;* in both cases the regulations were enforced in detail. One lay about a mile and a half off shore during her five days. The other cruised at sea. In both cases an inspector was kept aboard day and night. Both escaped cholera.

"The four for South America, with the result in each case, were as follows: The figures are not official, but are practically accurate in every respect. All were turned back by the South American authorities: *Vencinzio Florio*—about 50 deaths; *Andrea Dorio*—90 on way out, total not ascertained; *El Remo*—84 deaths; *Carlo R.*—about 230 deaths.

"To summarize, then, eight ships left Naples. The water-supply was the same and the food about the same; the class of passengers identical, and their places of origin similar—in many cases identical. All four leaving without precautions became floating pest-houses. Of the four for the United States the one leaving before cholera appeared in Naples had three deaths; the other three were made to conform to the regulations, and all escaped. In other words, every ship that left Naples had cholera except those in whose case the 'infected port' regulations were carried out; and of the five that had cholera, the only one that escaped with less than 50 deaths was the one on which our 'non-infected port' regulations were enforced, she having only 3 deaths *en route*. In addition, the enforcement of the regulations compelled the abandonment of a number of other sailings for the United States. The escape of the *Massilia, Cashmire,* and *Weser* may be 'post,' not 'proper hoc,' but we certainly have the right to consider the evidence to be strongly on the side of 'propter.'"

DOMESTIC QUARANTINE.

The trans-oceanic part of the voyage completed, the vessel arrives in the waters of the United States, and here she is confronted by a municipal, State, or national quarantine station, where the question will be determined whether the measures prescribed have been carried out, whether they have been effective in the particular case, and, in fine, whether the vessel, her crew, passengers, and cargo, are or are not a menace to the health of the city and the country at large.

MARITIME QUARANTINE STATIONS.

In describing a maritime quarantine station it should be borne in mind that the details in the plant must vary in accordance with the special demands of each port.

Thus, it is not to be expected that at Charleston, where immigration is limited, there should be the same provisions for detention of immigrants as at New York, through whose portals more than one-third of a million of immigrants pass each year; or San Francisco, where enter the throng of travelers and immigrants from the far East.

We should not expect that Boston, in the more salubrious North, would have the means or adopt the practice of discharging ballast, cleaning and fumigating every vessel from an infected port, which is the invariable custom at Pensacola.

But, leaving these variations for subsequent notice, the first thing to be considered, in the establishment of a complete maritime quarantine, is proper location. This must be at a point remote from city or village boundaries, and not likely to be encroached upon by urban growth. It should be more or less removed from the channels of commerce, and yet be easily accessible. Indifference to proper location could very readily make the quarantine station a source of danger instead of a protection.

THE QUARANTINE PLANT.

The requirements of a maritime quarantine station may be enumerated as follows: 1. A boarding-station. 2. A boarding-vessel. 3. Anchorages. 4. Wharves with warehouse, disinfecting machinery, and machinery for discharge of ballast. 5. Lazaretto, or hospital for treatment of contagious diseases. 6. Hospital for treatment of non-contagious diseases. 7. Barracks for the detention, in groups, of suspects, or persons who have been exposed to contagion or infection. 8. Bath-house. 9. Water-supply. 10. A cremation furnace. 11. Quarters for medical officers. 12. Laundry.

1. The Boarding-station.—This includes a boat-house, with boatmen's quarters so located as to avoid infection from the Lazaretto, and to be within easy reach of passing commerce.

2. Boarding-vessel.—The facilities for boarding and inspection will vary with the location of the station, whether within the limits of a land-locked harbor or exposed to the full force of wind and sea. In the former case a steam- or naphtha- launch, or even a row-boat, will suffice; but in the latter case the boarding-boat must be a steamer, preferably of the sea-going tug-boat type, for it must be remembered that any delay in making the inspection inflicts hardship on commerce, and must inevitably produce discontent and complaint.

3. Anchorages.—Two anchorages, one for infected and one for non-infected vessels. The anchorage for the detention of the infected vessel should be conveniently removed from the main establishment and safely remote from the track of commerce. Its position should be sheltered, and good holding-ground for vessels' anchors is of the first importance. The channel to the anchorages, and, if necessary, their boundaries, should be plainly marked by buoys.

4. Wharves.—A wharf or pier is a prime essential in the equipment of a complete station, and should be located in water at least twenty feet deep, and should be of such length that the largest vessels trading at the port can lie there safely; at least, in all ordinary weather. Upon this wharf there should be a warehouse for the storage of baggage and portions of cargo (practically, cargo is never fully discharged, being disinfected *in situ*). On the wharf should be placed the steam disinfecting chambers, sulphur-furnaces, and tanks for holding disinfecting solutions. (At certain stations the disinfecting apparatus is necessarily placed on a barge.) When required, a special, additional wharf should be provided for the discharge of ballast.

Steam Disinfecting Chambers.—The principle of disinfection by steam was first advocated by Dr. A. N. Bell, of Brooklyn; but the credit of first designing apparatus for the special purpose belongs to Dr. Joseph Holt, and his design was subsequently improved upon by Dr. Wilkinson and others.

Steam Chambers.—These chambers consisted of cylindrical shells, made of strong boiler-iron, 40 to 50 feet long and 7 to 8 feet in diameter (inside measurement), furnished with doors at each end. The steam was admitted directly to the interior of the chamber, and in addition there was a coil of pipe for the application of dry heat. These chambers were fairly efficient in action, but there was a great waste of space, and with the exercise of every possible care there was always more or less wetting of fabrics by the water of condensation. Many improvements have been made from time to time in the construction of steam disinfecting chambers, those constructed for the national quarantine station at San Francisco, Cal., being of the same general construction, but dispensing with the coil of pipe, and substituting therefor a jacket surrounding the entire chamber.

The most recent steam chambers are of rectangular section, 16 feet in length, 4 feet 6 inches in width, and 5 feet 6 inches in height, and are provided with steam-tight doors opening at either end. The chambers are constructed of an inner and outer steel shell 2½ inches apart, with cast-iron end frames, intermediate truss bands, and of staybolt construction.

The doors have concave steel plates riveted to cast angle frames fitted with heavy rubber gaskets; they are handled by convenient cranes, and drawn tight by drop-forged steel eye-bolts, swinging in and out of slots in the door-frames. The rectangular form is adopted in preference to the round, as it gives the most effective space during exposure, with little loss of steam, and enables cars on tracks to be readily handled in and out. The jacket is used to give perfect circulation and distribution of heat, to prevent condensation, and to dry the goods exposed. The jackets, which are filled with steam during the entire operation of the plant, make the chambers drying ovens; so that the articles to be disinfected are brought to the required temperature before the admission of steam to the inner chamber, and are thoroughly dried after the steam has been exhausted.

In the experiments of Professor Koch in connection with Dr. Wollfhügel it was found that hot air alone, even at a temperature of 230° to 248° F., after an exposure of three hours, would not with certainty destroy bacilli and spores. It is necessary, therefore, to eliminate the possibility of the pocketing of air, or of a mixture of air and steam, during exposure. To prevent this an inspirator is attached to the system of piping, whereby a vacuum of 10 to 15 inches is produced in the chamber prior to the admission of steam. In previous chambers this important point was neglected, and this accounts for the unreliable results obtained by a number of disinfecting plants.

For convenience of handling the goods to be disinfected, each chamber is provided with two cars of light wrought-iron construction, with removable trays with bottoms of galvanized-iron wire netting, and having a series of bronze wardrobe-hooks in the top of the framework, thus permitting the articles to be laid out upon the trays, or in the case of finer clothing, to be hung upon the hooks. The doors at both ends allow the cars to be brought in at one end and removed at the other, thus securing complete separation of infected and disinfected articles. After exposure the cars, upon being unloaded, are returned to the working end of the chamber by means of transfer tables and side-tracks, permitting a continuous working of the plant.

The system of piping is so arranged that steam may be admitted to the top or bottom of the chamber at will, through several openings, and has perfect circulation. Galvanized-iron hoods are placed in the chambers, so that steam is not forced directly on the clothing. The chamber is provided with thermometers to register the temperature, vacuum and steam-gauges, safety-valves, traps, and is covered with magnesia non-conducting covering.

Sulphur-furnace.—For a long time the method of sulphur fumigation pursued was to put into iron pots a quantity of sulphur varying from three to four pounds to one thousand cubic feet, igniting this by means of alcohol, and to place them in the hold or apartment to be disinfected. An apparatus has been designed for the purpose of producing SO_2 in greater percentage, and consists of a furnace built on the reverberatory plan, with a series of shelves arranged one above another, each shelf carrying a pan of burning sulphur. A forced draught is kept up by means of a fan-blower connected at the bottom. The draught of air charged from the burning sulphur is made to reach and pass over the shelf above by means of apertures made by shortening the shelves alternately at their rear and front extremities. With an experimental furnace, Dr. Kinyoun states that "repeated experiments gave from 14 to 16 per cent. of SO_2, temperature 21° C., while burning sulphur in a closed place gave only 6 per cent. at 21° C.—*i.e.,* the air would not support the combustion of sulphur above that percentage."

This has been almost entirely superseded by a furnace that is simpler in construction, and which has given admirable results in practice. The furnace is double, and has been provided with small fire-boxes at each end, over which are placed two shallow cast-iron pans five feet long, and the whole inclosed in a frame of sheet-iron. The sulphur is placed in the pans and a fire lighted in the furnaces, melting the sulphur, which quickly ignites. To prevent too rapid combustion baffle plates are arranged, and the proper quantity of air is admitted through adjustable valves in the furnace-fronts. The fumes of sulphur dioxide thus generated are collected and carried into a reservoir, from which they are sucked by an exhaust fan, and are thence forced through piping and large flexible hose to the apartment to be fumigated.

The sulphur-furnace in use at the Louisiana Quarantine Station is the same in general principle, with the addition that the air supplied to the burning sulphur is aspirated from the hold of the vessel, and then forced into the furnace.

Disinfection by Germicidal Solutions.—The apparatus for the use of the disinfecting solutions consist of a tank or tanks elevated above the level of the floor of the wharf to a sufficient height to force the solution through a hose and nozzle to the parts of the ship to be reached. The tank is to be filled by a steam-pump, and the solution is easily made by surmounting the tank with a keg perforated by numerous holes, in which keg the powdered bichloride is to be put, and the water for filling the tank pumped over it.

It is a much better plan to have the bichloride solution distributed by means of a special pump (made of iron to prevent amalgamation), as, with the pressure of the pump behind it, it penetrates much more deeply into cracks and crevices and, in fact, knocks the dirt and filth out of them.

5 and 6. Hospitals.—The propriety of having separate hospitals for contagious and non-contagious diseases is so obvious that it need not be dwelt on here, and the necessity of a separate establishment for suspects, until the nature of their complaint can be positively made out, is patent and only in accord with expediency and the ordinary instincts of humanity.

7. Barracks.—Barracks for the detention of suspects are not an essential part of the equipment of every quarantine station, but are a necessity only at such stations as are situated at the great ports of entry, which are the ports of arrival of the vast hordes of immigrants who seek our shores. Barracks are an indispensable adjunct in the management of ship-loads of immigrants suspected of being infected with cholera, typhus fever, and small-pox, and would be required in the case of yellow fever but for the fact that there is little or no immigration from the yellow-fever zone.

The barracks should be commodious, substantial, and yet of simple and inexpensive construction. They should be well ventilated and so arranged that every part of the building is under constant surveillance, and so subdivided that the inmates are divided into small groups and intercourse between the groups prevented. The immigration laws require that the immigrants shall be listed and arranged in groups of thirty, and it would be well that this number be preserved as the unit for segregation. The barracks should be furnished with bunks, arranged in tiers one above the other, and furnished with bedding of a simple and inexpensive character.

Clothing of a simple but sufficient kind, and capable of easy laundering, should be provided in sufficient quantity to furnish each inmate of the barracks with a change while his or her own personal effects are undergoing the process of disinfection. Attached to the barracks there should be a kitchen, thoroughly equipped with all the facilities for furnishing hot food of a simple character for the number of inmates provided for by the barracks. Dining-rooms should be arranged, and special care should be taken to prevent the carrying of any food into the barracks. It is perhaps needless to say that, in the barracks, the sexes should be separated, and the better arrangement is to have two buildings—one for men and one for women and children.

Latrines.—Latrines of ample size should be provided, and should be so arranged that all dejecta may be received into metallic vessels containing a germicidal solution of acknowledged potency; or, if the dejecta are to be received into a sewer, there should be some provision made for their complete disinfection prior to their discharge into the sea or a cess-pool.

8. Bath-house.—Bathing facilities are an important part of the equipment of a quarantine station designed for the handling of large numbers of suspects. The best form of bath for the purpose is the shower- or rain-bath, it being more easily managed, more expeditious, and probably more efficacious than the tub-bath. The bath-house should be provided with a room for disrobing, from which the suspects will pass into the bathing-stalls proper, and there receive a bath the temperature of which is under the sole control of the bath-attendant. From the bath the suspect will pass into a robing-room, where he will be given a suit of sterile clothing, while the clothing which was removed in the disrobing-room is carried by proper attendants to the disinfecting apparatus, there to be rendered safe by sterilization.

9. Water-supply.—An abundant supply of pure water is not only a desideratum, but a prime necessity, at all quarantine stations where it is designed to accommodate cholera suspects. It would be desirable to provide a supply of twenty gallons per capita per day, and no arrangement will probably give such good results as the sinking of an artesian well, if the nature of the soil and the geological formation permit. If it is impracticable to sink such a well, the next best plan would be to arrange for the distillation or sterilization, by boiling, of a sufficient quantity of water for drinking purposes.

10. Crematory.—A crematory is a desirable part of the equipment of every quarantine station, as it admits of no argument that cremation is the best possible method of disposing of the bodies of those dead of contagious or infectious disease. In addition, it would be desirable that all garbage and waste about a quarantine station be incinerated to prevent the possibility of infection.

11 and 12.—Detailed description of quarters for medical officers and of laundry is unnecessary.

Having thus considered the necessities and the desiderata in the equipment of a quarantine station, it is now proper to consider the regulations governing them, and for this purpose are here appended the regulations prepared by the Supervising Surgeon-General of the Marine-Hospital Service, and promulgated by the Secretary of the Treasury on April 26, 1894. These regulations are to be considered a minimum for the stations under municipal and State control, some of which have additional requirements:—

Domestic Regulations.

Quarantine Regulations to be Observed at Ports and on the Frontiers of the United States and its Possessions and Dependencies.

Preamble.

52. At or convenient to the principal ports, quarantine stations should be equipped with all appliances for the inspection and treatment of vessels, their passengers, crews, and cargoes.

53. For all ports where such provisions have not been made, inspection stations should be maintained. An inspection service should be maintained for every port throughout the year.

54. At a fully equipped quarantine station there should be adequate provision for boarding and inspection, apparatus for mechanical cleansing of vessels, apparatus for disinfection by steam, by sulphur, by formaldehyde, by disinfecting solutions, or any other method prescribed in these regulations; also a clinical laboratory, hospitals for contagious and doubtful cases, a steam laundry, detention barracks for suspects, bathing facilities, a crematory, a sufficient supply of good water, and a proper system for the disposal of sewage.

55. The personnel of quarantine stations in the yellow-fever zone and on fruiters and other vessels of regular lines bound for southern ports from ports where yellow fever prevails should be immune to yellow fever.

56. At quarantine stations all articles liable to convey infection should be handled only by the employees of said station unless the services of the crew of the vessel in quarantine are indispensable.

57. Vessels having been treated at national quarantine stations that are located a considerable distance from the ports of entry of said vessels may be inspected by the local quarantine officer, and if for any sanitary reason it is considered inadvisable to admit the vessel, he should report the facts immediately by telegraph, when possible, to the Surgeon-General of the Public Health and Marine-Hospital Service, detaining the vessel pending his action.

58. The following regulations are the required minimum standard and do not prevent the addition of such other rules as, for special reasons, may be legally made by State or local authorities.

Inspection.

59. Every vessel subject to quarantine inspection, entering a port of the United States, its possessions or dependencies, shall be

considered in quarantine until given free pratique. Such vessel shall fly a yellow flag at the foremast head from sunrise to sunset, and shall observe all the other requirements of vessels actually quarantined.

60. Vessels arriving at ports of the United States under the following conditions shall be inspected by a quarantine officer prior to entry:—

(*a*) All vessels from foreign ports except those enumerated in paragraph 4.

(*b*) Any vessel with sickness on board.

(*c*) Vessels from domestic ports where cholera, plague, or yellow fever prevails, or where small-pox or typhus fever prevails in epidemic form.

(*d*) Vessels from ports suspected of infection with yellow fever, having entered a port north of the southern boundary of Maryland without disinfection, shall be subjected to a second inspection before entering any ports south of said latitude during the quarantine season of such port.

61. The inspections of vessels required by these regulations shall be made between sunrise and sunset, except in case of vessels in distress.

62. In making the inspection of a vessel, the bill of health and clinical record of all cases treated during the voyage, crew and passengers' lists and manifests, and when necessary, the ship's log shall be examined. The crew and passengers shall be mustered and examined and compared with the lists and manifests and any discrepancies investigated. The clinical thermometer should be used in the examination of the personnel of vessels under suspicion. When a freight manifest shows that rags and other articles requiring disinfection under these regulations are carried by the vessel, a certificate of disinfection, signed by a United States consul or a medical officer of the United States, shali be exhibited and compared with same. If no certificate of disinfection is produced the collector of customs at the port of entry shall be notified of same by the quarantine officer. The collector of customs shall then hold such consignment in a designated place separate from other freight pending the arrival of the certificate of disinfection; and in the event of its nonarrival, the articles shall be disinfected as hereinbefore prescribed, or shall be returned by the common carrier conveying the same.

63. The medical officers of the United States, duly clothed with authority to act as quarantine officers at any port or place within the United States, and when performing the said duties, are hereby au-

thorized to take declarations and administer oaths in matters pertaining to the administration of the quarantine laws and regulations of the United States. (Act of March 2, 1901, sec. 12.)

64. No person, except the quarantine officer, his employees, United States customs officers, pilots, or other persons authorized by the quarantine officer, shall be permitted to board any vessel subject to quarantine inspection until after the vessel has been inspected by the quarantine officer and granted free pratique, and all such persons so boarding such vessel shall, in the discretion of the quarantine officer, be subject to the same restrictions as the personnel of the vessel.

65. Towboats or any other vessels having had communication with vessels subject to inspection shall themselves be subject to inspection.

66. After arrival at a quarantine station of a vessel carrying immigrants and upon which there has appeared during the last voyage a case of cholera, small-pox, typhus fever, or plague, and after quarantine measures provided by regulations of the Treasury Department have been enforced and the vessel given free pratique, it is hereby ordered that notification of the above-mentioned facts be transmitted by the quarantine officer to the Commissioner of Immigration at the port of arrival, who shall be requested to transmit, by mail or telegraph, to the State health authorities of the several States to which immigrants from said vessel are destined, the date of departure, route, number of immigrants, and the point of destination in the respective States of the immigrants from said vessel, together with the statement that said immigrants are from a vessel which has been subject to quarantine by reason of infectious disease, naming the disease. This information is furnished to State health officers for the purpose of enabling them to maintain such surveillance over the arriving immigrants as they may deem necessary.

67. When a vessel arriving at quarantine has on board any of the communicable but non-quarantinable diseases, the quarantine officer shall promptly inform the local health authorities of the existence of such disease aboard and shall make every effort to furnish such notification in ample time, if possible, to permit of the case being seen by the local authorities before discharge from the vessel.

Quarantine.

68. Vessels arriving under the following conditions shall be placed in quarantine:—

(*a*) With quarantinable disease on board or having had such disease on board during the voyage.

(*b*) Any vessel which the quarantine officer considers infected.

(*c*) If arriving at a port south of the southern boundary of Maryland in the season of close quarantine, May 1 to November 1, directly or via a northern port, from a tropical American port, unless said port is known to be free from yellow fever.

(*d*) In the case of vessels arriving at a northern port without sickness on board from ports where yellow fever prevails, the personnel shall be detained under observation at quarantine to complete five days from the port of departure.

(*e*) Towboats and other vessels having had communication with vessels subject to quarantine shall themselves be quarantined if they have been exposed to infection.

69. Vessels arriving under the following conditions need not be subject to quarantine:—

A. Vessels from yellow fever ports bound for ports in the United States north of the southern boundary of Maryland, with good sanitary condition and history, having had no sickness on board at ports of departure, enroute, or on arrival, provided they have been five days from last infected or suspected port.

B. Vessels engaged in the fruit trade may be admitted to entry without detention, provided that they have complied in all respects with the special rules and regulations made by the Secretary of the Treasury with regard to vessels engaged in said trade.

General Requirements at Quarantine.

70. Pilots will be detained in quarantine a sufficient time to cover the period of incubation of the disease for which the vessel is quarantined, if, in the opinion of the quarantine officer, such pilots have been exposed to infection. The dunnage of pilots shall be disinfected when necessary.

71. No direct communication shall be allowed between any vessel in quarantine and any person or place outside, and no communication whatever between quarantine or any vessel in quaratine and any person or place outside except under the supervision of the quarantine officer.

72. Street cleanings, street sweepings, or any other form of ballast containing organic refuse must be discharged at the quarantine station.

73. No presumably infected ballast shall be allowed to leave the quarantine station until disinfected.

74. After a vessel has been rendered free from infection, it may be furnished with a fresh crew and released from quarantine, while all or part of the personnel are detained. Under these circumstances the quarantine officer must exercise the greatest care that the vessel shall not become reinfected, especially by contact with persons in quarantine or infected objects.

75. Vessels detained at any national quarantine will be subject to such additional rules and regulations as may be promulgated from time to time by the Surgeon-General.

76. The form of certificate which shall be issued to a vessel by the health officer when he releases her from quarantine shall be prescribed by the Surgeon-General of the Public Health and Marine-Hospital Service, and shall embody the statement that the vessel has in all respects complied with the quarantine regulations prescribed by the Secretary of the Treasury, and that in the opinion of the quarantine officer she will not convey quarantinable disease, and that said vessel is granted free pratique to enter her port of destination, the name of which is to be embodied in the blank.

77. The persons detained shall be inspected by the physician twice daily, and be under his constant surveillance, and no intercourse will be allowed between different groups while in quarantine.

78. No articles from an infected vessel shall be carried into the place of detention until disinfected.

79. Cleanliness of quarters and of person shall be enjoined and daily enforced. Disinfection shall be practiced where there is any possibility of infection.

80. The water and food supply shall be strictly guarded to prevent any contamination.

81. Water-closets, urinals, privies, or troughs shall be provided, and their contents disinfected before they are discharged.

82. In any group in which communicable disease appears, the sick will be immediately isolated in hospital, and the remaining persons in the group and their effects appropriately treated and then removed to other quarters if possible, and the compartments disinfected.

83. Communication between the physician and attendants of the hospital and those detained in other parts of the quarantine station shall be reduced to a minimum.

84. No convalescent shall be discharged from quarantine until

after a sufficient time has elapsed to insure his freedom from infection, and this is to be determined by bacteriological examination where possible.

85. No other person shall be discharged from quarantine until the period of incubation of the disease has elapsed since the last exposure to infection.

86. The body of no person dead of quarantinable disease shall be allowed to pass through quarantine until one year has elapsed since death. Such bodies must be transported in hermetically sealed coffins, the outsides of which have been carefully disinfected.

In the case of the bodies of such persons as may have died on the voyage or upon arrival at quarantine, cremation should be resorted to if practicable and consented to; if not, the body should be wrapped without preliminary washing in a sheet saturated with a solution of bichloride of mercury 1:500 and buried, surrounded by caustic lime.

87. The quarantine officer shall report to the Secretary of the Treasury all violations of the quarantine laws. He should also report the facts in the case to the Surgeon-General of the Public Health and Marine-Hospital Service.

88. The quarantine officer shall report to the collector of customs any vessel which arrives without the bill of health hereinbefore prescribed.

89. All vessels requiring inspection under these regulations must present to the collector of customs at the port of entry the quarantine certificate above prescribed.

Special Regulations on Account of Cholera.

90. For the purpose of these regulations five days shall be considered as the period of incubation of cholera.

91. If the vessel carry persons from cholera-infected ports or places, a bacteriological examination should be made of any cases of diarrhea to exclude cholera before granting free pratique.

92. If cholera has appeared on board, remove all passengers from the vessel and all of the crew, save those necessary to care for her; place the sick in hospital. Carefully isolate those especially suspected and segregate the remainder in small groups. No communication should be held between these groups. Those believed to be especially capable of conveying infection must not enter the place of detention until they are bathed and furnished with non-infected clothing; nor

shall any material capable of conveying infection be taken into the place of detention, especially food and water.

93. Water and food supply must be strictly guarded to prevent contamination and issued to each group separately.

94. Food of a simple character, sufficient in quantity, thoroughly cooked, shall be issued to those detained in quarantine. No fruit or uncooked vegetables shall be permitted.

95. The greatest care must be exercised to prevent the spread of the infection through the agency of flies or other insects.

96. The dejecta from all persons in quarantine on account of cholera shall be disinfected before final disposition.

97. The water supply of the vessel, if suspected of infection, must be disinfected and then changed without delay; the casks or tanks disinfected and after thorough rinsing refilled from a source of undoubted purity, or the water furnished must have been recently boiled.

98. The baggage or effects of passengers and crew that may have been exposed to infection must be disinfected.

99. Articles of cargo which have been exposed to infection and are liable to convey the same must be disinfected.

100. Living apartments and their contents and such other portions of the vessel as have been exposed to infection must be disinfected.

101. Water ballast taken on at a cholera-infected port should be discharged at sea, or if discharged in fresh or brackish water must previously be disinfected. Vessels arriving with water ballast presumably infected must return to sea under guard in order to discharge such ballast. If practicable the tanks should be disinfected before being flushed, and refilled with sea water.

Special Regulations on Account of Yellow Fever.

102. For the purpose of these regulations, five days shall be considered as the period of incubation of yellow fever.

103. Where practicable remove the sick to hospital; remove and isolate all persons not required for care of vessel.

104. For the destruction of mosquitoes there shall be a preliminary and simultaneous fumigation of all parts of the vessel by sulphur dioxide gas. In cabins containing articles liable to damage by sulphur dioxide, pyrethrum powder may be burned instead.

105. If, from the disposition of the cargo or any other reason, the previous fumigation is deemed not to have been effective, a com-

plete fumigation is now to be done, simultaneously, of the whole vessel. Measures are in all cases to be taken to destroy larvæ of mosquitoes aboard.

106. The personnel of the vessel shall be detained five days from completion of disinfection, or if they have been removed before disinfection of the vessel, their detention shall begin from last possible exposure to infection.

If cases of yellow fever have occurred aboard, the time of detention at stations south of the southern boundary of Maryland must be extended to six days.[2]

107. If the vessel has in all respects complied with the quarantine regulations to be observed at foreign ports in such cases, and has been disinfected under the supervision of an accredited medical officer of the United States at the port of departure, she may, upon arrival at her port of destination in the United States, with good sanitary history and in good condition, be subject to the following treatment:—

(*a*) If arriving in five days or less, she may be admitted to pratique without disinfection or further detention than is necessary to complete the five days.

(*b*) If arriving after five days and within ten days, she may be immediately fumigated and admitted without detention.

(*c*) If arriving after a longer voyage than ten days, she shall be treated as if she had not been subjected to any previous treatment.[3]

108. Passenger traffic without detention may be allowed during the close quarantine season, May 1 to November 1, from ports infected with yellow fever to ports in the United States south of the southern boundary of Maryland under the following conditions:—

(*a*) Vessels to be of iron or the best class of wooden vessels, and to be cleaned immediately prior to taking on passengers. The officer issuing the bill of health to these vessels shall withhold the same if the vessel is not in first-class sanitary condition and complying in every respect with the conditions stated in this paragraph.

(*b*) The vessel must lie at approved moorings in the open harbor; must not approach the wharves, nor must the crew be allowed ashore at the port of departure. Every possible precaution must be

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[2] The period of incubation of yellow fever is not rarely over five days.

[3] If the vessel should have been in transit for a considerable number of days, it is obvious that a case of yellow fever may have occurred and recovered, leaving the vessel infected, and not affording any opportunity to the quarantine officer to determine same.

taken to prevent the ingress of mosquitoes, and to provide for the destruction of these should they find ingress.

(*c*) All passengers and crew must be immune to yellow fever and so certified by the United States medical officer.[4]

109. The disinfection of baggage for yellow fever is not required, but baggage destined directly or indirectly for any State shall be disinfected at the request of the health officer of said State. All baggage shall be inspected and the absence of mosquitoes definitely proven. The presence of any mosquitoes, regarding the infection of which the quarantine officer has doubts, shall be sufficient grounds for such further measures as the quarantine officer may deem justifiable.

Special Regulations on Account of Small-pox.

110. For the purpose of these regulations, fourteen days shall be considered as the period of incubation of small-pox.

111. On all vessels arriving with small-pox on board, or having had small-pox on board during the voyage, any of the personnel who have been exposed to the infection of the disease must be vaccinated or detained in quarantine not less than fourteen days, unless they show satisfactory evidence of recent successful vaccination or of having had small-pox.

112. Vessels arriving with small-pox on board which has been properly isolated and other sufficient precautions taken to prevent the spread of the disease need not be quarantined further than the removal of the sick, the disinfection of all compartments, baggage, and objects that have been exposed to the liability of infection, and such vaccination of the personnel as required in paragraph 111.

113. On vessels arriving with small-pox on board and where the proper isolation and other precautions have not been taken, all those whom the quarantine officer believes to have been exposed to the infection will be detained unless they have had small-pox or unless they show satisfactory signs of having been properly vaccinated within one year.

114. Living compartments and their contents or any other part of the vessel exposed to the infection must be disinfected.

115. The baggage and effects of passengers and crew that have been exposed to the infection must be disinfected.

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[4] The evidence of immunity which may be accepted by the sanitary inspector is: First, proof of previous attack of yellow fever; second, proof of continued residence in an endemic focus of yellow fever for ten years.

Special Regulations on Account of Typhus Fever.

116. For the purpose of these regulations twelve days shall be considered as the period of incubation of typhus fever.

117. Vessels in otherwise good sanitary condition, but having typhus fever on board which has been properly isolated, need not be quarantined further than the removal of the sick, and disinfection of the compartments and their contents exposed to infection.

118. If the case has not been isolated, or the disease has spread on board from person to person, the vessel will be quarantined, the sick removed, and those who have been exposed to the infection detained under observation.

119. Vessels in bad sanitary condition, on which the disease has appeared, will be quarantined until thoroughly cleansed and disinfected throughout; the sick will be cared for at isolated hospitals, and those exposed to the infection detained under observation.

120. The baggage and effects of passengers and crew that have been exposed to the infection must be disinfected.

121. Living compartments and their contents, or any other parts of the vessel exposed to the infection, must be disinfected.

Special Regulations on Account of Leprosy.

122. Vessels arriving at quarantine with leprosy on board shall not be granted pratique until the leper with his or her baggage has been removed from the vessel to the quarantine station.

123. No alien leper shall be landed.

124. If the leper is an alien passenger and the vessel is from a foreign port, action will be taken as provided by the immigration laws and regulations of the United States. And to this end the case shall be certified as a leper and reported to the nearest commissioner of immigration.

125. If the leper is an alien and a member of the crew and the vessel is from a foreign port, said leper shall be detained at the quarantine at the vessel's expense until taken aboard by the same vessel when outward bound. Such case of leprosy should be promptly reported to the collector of customs at the port of arrival of the vessel, and the collector shall exact a bond from the vessel for the reshipment of the said alien leper upon the departure of the vessel.

Special Regulations on Account of Plague.

126. For the purpose of these regulations seven days shall be considered as the period of incubation of plague.

127. In those actually exposed to the infection of plague the administration of antipest serum is regarded as a valuable prophylactic measure; for the prevention of the introduction of plague into a community liable to the introduction of plague through commercial intercourse, immunization by Haffkine's prophylactic is to be recommended.

128. Vessels infected with plague, or suspected of such infection, should be anchored at a sufficient distance from the shore or other vessels, to prevent the escape of rats by swimming.

129. In inspecting vessels from plague-infected ports, or vessels with plague on board at port of departure, en route or on arrival, the personnel of the vessel should be examined with special reference to the glandular regions, cervical, axillary, and inguinal, and for such examination as much clothing should be removed as may interfere with the thoroughness of the process. When possible, females should be examined by female inspectors.[5]

130. In the inspection of vessels for plague, special attention must be directed to the discovery of cases of a mild type or of the pneumonic form of the disease. Suspected or doubtful cases should be subjected to bacteriological examination before the vessel is released.

131. On all plague-infected vessels, any of the personnel of such vessels who, in the opinion of the quarantine officer, are infected or have been exposed to infection, shall be bathed and body clothing and hand baggage disinfected.

132. Nothing shall be thrown overboard from the vessel, not even deck sweepings. Such material shall be burned in the furnaces of a steamer, or in a place specially designated, but not in the galley.

133. Special precautions must be taken against rats, mice, ants, flies, fleas, and other animals, on account of the danger of the infection of the disease being spread through their agency.

134. As soon as practicable, there shall be a preliminary disinfection with sulphur dioxide for the purpose of killing rats and vermin, before further disinfecting processes are applied to the vessel and her cargo. The killing of any escaping rats shall be provided

[5] The examination herein provided being an exceedingly delicate matter, the greatest possible care is to be used by the quarantine officer to avoid any grounds for complaint of indecent exposure, and more particularly with regard to females.

for by a water guard in small boats, and no person with abrasions or open sores should be employed in the handling of the vessel or her cargo.

135. The vessel shall be submitted to a simultaneous disinfection in all parts with sulphur dioxide to insure the destruction of rats and vermin. The rats shall be subsequently gathered and burned, due precautions being taken not to touch them with the bare hands, and the places where found disinfected with a germicidal solution; and the quarantine officer shall assure himself that the vessel is free of rats and vermin before granting free pratique.

136. Disinfection of vessels for plague shall be as follows:—

With cargo: After twelve hours' exposure to sulphur dioxide, the upper 4 to 6 foot layer of cargo may be removed and placed on lighters exposed to the sun. This process of disinfection by night, and removal of successive layers of cargo by day, to be continued until hold is empty.

137. Vessels without cargo shall be disinfected by sulphur dioxide, followed by germicidal solutions, in accordance with the general regulations for disinfection, paragraphs 156 to 185.

Canadian and Mexican Frontiers.

138. When practicable, alien immigrants arriving at Canadian or Mexican ports, destined for the United States, shall be inspected at the Canadian or Mexican port of arrival by the United States consular or medical officer, and be subjected to the same sanitary restrictions as are called for by the rules and regulations governing United States ports.

139. Inspection cards will be issued by the consular or United States medical officer at the Canadian or Mexican port of arrival to all such alien immigrants, and labels affixed to their baggage, as is required at foreign ports in the case of those coming direct to any port of the United States.

140. If any person be found suffering from a quarantinable disease, or be presumably infected, he shall be denied entry or shall be kept under quarantine observation so long as danger of conveying the infection exists.

141. Any baggage or other effects believed to be infected shall be refused entry unless disinfected in accordance with these regulations.

142. Persons coming from localities where cholera is prevailing

shall not be allowed entry until after five days have elapsed since last presumable exposure to infection, and their baggage disinfected.

143. During the quarantine season persons not positively identified as immune to yellow fever, coming from places where yellow fever prevails, will not be permitted to enter until they have been away from said localities five full days.

144. Persons coming from localities where small-pox is prevailing shall not be allowed entry without vaccination, unless they are protected by a previous attack of the disease or a recent successful vaccination. The baggage of persons from such localities shall be disinfected.

145. Persons coming from localities where typhus fever prevails in epidemic form shall not be allowed entry until twelve days have elapsed since their last possible exposure to infection and the disinfection of their baggage.

146. Persons coming from localities where plague is prevailing shall not be allowed entry until seven days have elapsed since their last possible exposure to infection and the disinfection of their baggage.

147. No common carrier which is infected, or suspected of being infected, shall be allowed to enter the United States until after such measures have been taken as will render it safe.

148. Articles of merchandise, personal effects, etc., which are presumably infected, shall not be allowed entry into the United States until after disinfection.

149. Rags gathered and baled in Canada, accompanied by affidavits that the ports or places where collected or handled were free from quarantinable disease for thirty days prior to shipment, may be admitted to entry; but rags from foreign ports shipped through Canada shall not be admitted to entry unless they are accompanied by a certificate of a United States consul or medical officer of the United States that they have been disinfected, or until after they have been unbaled and disinfected at the port of arrival.

150. Where not otherwise specifically stated, the rules and regulations for maritime quarantine shall be applied at stations on the Canadian and Mexican frontiers; and the methods of disinfection shall be those prescribed in these regulations.

Special Regulations Relating to Naval Vessels.

151. Vessels of the U. S. Navy may be granted the hereinafter stated exemptions from quarantine regulations, but are subject to

quarantine inspection upon arrival at a port of the United States.

152. The certificates of the medical officers of the U. S. Navy as to the sanitary history and condition of the vessel and its personnel may be accepted for naval vessels by the quarantine officer boarding the vessel in lieu of an actual inspection.

153. Vessels of the U. S. Navy having entered the harbors of infected ports, but having held no communication which is liable to convey infection, may be exempted from the disinfection and detention imposed on merchant vessels fom such ports.

Inspection of State and Local Quarantine.

154. In the performance of the duties imposed upon him by the act of February 15, 1893, the Surgeon-General of the Public Health and Marine-Hospital Service shall, from time to time, personally or through a duly detailed officer of the Public Health and Marine-Hospital Service, inspect the maritime quarantines of the United States, State and local, as well as national, for the purpose of ascertaining whether the quarantine regulations prescribed by the Secretary of the Treasury have been or are being complied with. The Surgeon-General, or the officer detailed by him as inspector, shall, at his discretion, visit any incoming vessel or any vessel detained in quarantine, and all portions of the quarantine establishment, for the above-named purpose, and with a view to certifying, if need be, that the regulations have been or are being enforced.

155. The Surgeon-General of the Public Health and Marine-Hospital Service is authorized, when in his discretion such action is necessary in the interest of the public health, to remand, by direction of the Secretary of the Treasury, any vessel to the nearest national, State, or local quarantine station provided with proper facilities for handling infected vessels.

Disinfectants Authorized by these Regulations and the Proper Methods of Generating and Using Same.

Physical Disinfectants.

156. Burning. Of unquestioned efficiency, but seldom required.

157. Boiling. Very efficient and of wide range of applicability. The articles must be wholly immersed for not less than thirty minutes in water actually boiling (100° C.). The addition of 1 per cent. of carbonate of soda renders the process applicable to polished steel, cutting instruments, or tools.

158. Steam:—

(*a*) Flowing steam (not under pressure). Flowing steam (not under pressure) when applied under suitable conditions is an efficient disinfecting agent. The exposure must be continued thirty minutes after the temperature has reached 100° C.

(*b*) Steam under pressure without vacuum. Steam under pressure will sterilize, provided that the process is continued twenty minutes after the pressure reaches 15 pounds per square inch. The air must be expelled from the apparatus at the beginning of the process. If impracticable to obtain the designated pressure, a longer exposure will accomplish the same result.

(*c*) Steam under pressure with vacuum. Steam in a special apparatus with vacuum attachment is the best method of applying steam under pressure, the object of the vacuum apparatus being to expel the air and to promote the penetration of the steam. The process is to be continued for twenty minutes after the pressure reaches 10 pounds to the square inch.

Gaseous Disinfectants.

159. Sulphur dioxide. Sulphur dioxide is efficient, but requires the presence of moisture. It is only a surface disinfectant, and is lacking in penetrating properties. An atmosphere containing 4.5 per cent. can be obtained by burning 5 pounds of sulphur per 1000 cubic feet of space. This amount would require the evaporation or volatilization of about 1 pint of water. Under these conditions the time of exposure should be not less than twenty-four hours for bacterial infections. A shorter time will suffice for fumigation necessary to kill mosquitoes and other vermin.

160. The sulphur may be burned in shallow iron pots (Dutch ovens) containing not more than 30 pounds of sulphur for each pot, and the pots should stand in vessels of water. The sulphur pots should be elevated from the bottom of the compartment to be disinfected in order to obtain the maximum possible percentage of combustion of sulphur. The sulphur should be in a state of fine division, and ignition is best accomplished by alcohol; special care to be taken with this method to prevent damage to cargo of vessel by fire; or the sulphur may be burned in a special furnace, the sulphur dioxide being distributed by a power fan. This method is peculiarly applicable to cargo vessels.

161. Liquefied sulphur dioxide may be used for disinfection in

place of sulphur dioxide generated as above, it being borne in mind that this process will require 2 pounds of the liquefied gas for each pound of sulphur as indicated in the above paragraphs.

162. Sulphur dioxide is especially applicable to the holds of vessels, or to freight cars and apartments that may be tightly closed and which do not contain objects injured by the gas. Sulphur dioxide bleaches fabrics or material dyed with vegetable or aniline dyes. It destroys linen or cotton goods by rotting the fiber through the agency of the acids formed. It injures most metals. It is promptly destructive to all forms of animal life. This property renders it a valuable agent for the extermination of rats, insects, and other vermin.

Formaldehyde Gas.

163. Formaldehyde gas is effective if applied by one of the methods given below. Formaldehyde gas has the advantage as a disinfectant that it does not injure fabrics or most colors. It is not poisonous to the higher forms of animal life. It fails to kill vermin such as rats, mice, roaches, bedbugs, etc. The method is not applicable to the holds of large vessels. Formaldehyde is applicable to the disinfection of rooms, clothing, and fabrics, but should not be depended upon for bedding, upholstered furniture, and the like, when deep penetration is required.[6]

164. Many formaldehyde solutions do not contain 40 per cent. of formaldehyde, and all are apt to deteriorate with time. It is therefore necessary to use a quantity in excess of the amount prescribed in these regulations, unless the solution has been recently analyzed.

165. The following methods of evolving the gas may be used:—

(*a*) Autoclave under pressure, 3 to 12 hours' exposure.

(*b*) Lamp or generator, 6 to 18 hours' exposure.

(*c*) Spraying, 12 to 24 hours' exposure.

(*d*) Formaldehyde and dry heat in partial vacuum, 1 hour's exposure.

166. The minimum number of hours' exposure as given above applies to empty rooms of tight construction containing smooth, hard surfaces; the maximum number of hours' exposure applying in all cases to textiles and other articles of a similar kind requiring more or less penetration.

167. Autoclave under pressure. This method has considerable

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[6] It should be noted that formaldehyde disinfection is more efficient in warm, moist or still weather than in cold, dry or windy weather.

penetrating power when applied as detailed below. Rooms or apartments need no special preparation beyond the ordinary closing of doors and windows. Pasting, caulking, or chinking of ordinary cracks and crevices is not necessary. The doors of lockers and closets and the drawers of bureaus should be opened. In this apparatus use formalin (40 per cent.), with the addition of a neutral salt, such as calcium chloride (20 per cent.). The gas must be evolved under a pressure not less than 45 pounds. After the gas is separated from its watery solution the pressure may be allowed to fall and steam projected into the compartment to supply the necessary moisture. Use not less than 10 ounces of formalin per 1000 cubic feet, and keep the room closed for three to twelve hours after the completion of the process. For large rooms the gas must be introduced at several points as far apart as possible. It is applicable to the disinfection of clothing and fabrics suspended loosely in such a manner that every article is freely accessible to the gas from all directions.

168. Lamp or generator. This method requires an apparatus producing formaldehyde by a partial oxidation of wood alcohol, and in using it the room or apartment should be rendered tight as practicable. Oxidize 24 ounces of wood alcohol per 1000 cubic feet, and keep the room closed for six to eighteen hours, in accordance with the provisions of paragraph 165. This method leaves little or no odor. When applied to clothing and textiles, the articles should be suspended in a tight room and so disposed as to permit free access of the gas. (See also Par. 166.) The wood alcohol should be of 95 per cent. strength, and should not contain more than 5 per cent. of acetone.

169. Spraying. The formalin (40 per cent.) should be sprayed on sheets suspended in the room in such a manner that the solution remains in small drops on the sheet. Spray not less than 10 ounces of formalin (40 per cent.) for each 1000 cubic feet. Used in this way a sheet will hold about 5 ounces without dripping or the drops running together. The room must be very tightly sealed in disinfecting with this process, and kept closed not less than twelve hours. The method is limited to rooms or apartments not exceeding 2000 cubic feet. The formalin may also be sprayed upon the walls, floors, and objects in the rooms.

170. Formaldehyde with dry heat in partial vacuum. This method has superior penetrating powers and is specially applicable to clothing and baggage. The requirements of this method are (1) dry heat of 60° C. sustained for one hour; (2) a vacuum of 15

inches; (3) formaldehyde evolved from a mixture of formalin with a neutral salt, in an autoclave under pressure, using not less than 30 ounces of formalin (40 per cent.) for 1000 cubic feet; and (4) a total exposure, under these combined conditions, of one hour.

171. The stated times of exposure to sulphur dioxide and formaldehyde are sufficient to destroy bacterial infection due to non-spore-bearing organisms, providing that the infection is present on the surface. If the room is of peculiar construction, so as to impede the diffusion of the gas, or if the room is a dirty one, or if on account of any other condition rendering the germicidal action of the gas more difficult, the time of exposure should be proportionately increased, or supplanted by other methods.

Chemical Solutions.

172. Bichloride of mercury. Bichloride of mercury is a disinfectant of undoubted potency and wide range of applicability. It cannot be depended upon to penetrate substances in the presence of albuminous matter. It should be used in solutions of 1 to 1000. The solubility of bichloride of mercury may be increased by using sea water for solution, or by adding 2 parts per 1000 of sodium or ammonium chloride to the water employed.

173. Carbolic acid. Carbolic acid in the strength of 5 per cent. (see par. 51) may be substituted for the bichloride of mercury, and should be employed in the disinfection of the cabins and living apartments of ships to obviate injurious action on polished metals, bright work, etc.

174. Formalin. Formalin containing 40 per cent. of formaldehyde may be used in a 5-per cent. solution as a substitute for bichloride of mercury or carbolic acid, and is useful for the disinfection of surfaces, dejecta, fabrics, and a great variety of objects, owing to its non-injurious character.

APPLICATION OF DISINFECTANTS IN QUARANTINE WORK.

175. Hold of iron vessel, empty, shall be disinfected by either:—

(*a*) Sulphur dioxide generated by burning sulphur 5 pounds per 1000 cubic feet of air space, or liberated from 10 pounds of liquid sulphur dioxide, sufficient moisture being present in both cases; time of exposure, twenty-four hours. (See par. 159.)

(*b*) Washing with a solution of bichloride of mercury, 1:1000.

176. Holds of wooden vessels, empty, shall be disinfected by:—

(*a*) Sulphur dioxide in the manner prescribed above, followed by

(*b*) Washing with a solution of bichloride of mercury.

177. In the case of all vessels, both iron and wooden, when treated for yellow fever or plague infection, the first process shall be a preliminary fumigation by sulphur dioxide in the manner previously stated in paragraph 159-160, in order to insure the destruction of mosquitoes, rats, and other vermin.

178. Holds of cargo vessels, when cargo cannot be removed, shall be disinfected in so far as possible by sulphur dioxide not less than 4 per cent. per volume strength, and where possible this should be generated from a furnace to minimize danger of fire in cargo.

179. Living apartments, cabins, and forecastles of vessels shall be disinfected by one or more of the following methods:—

(*a*) Sulphur dioxide, the destructive action of the gas on property being borne in mind.

(*b*) Formaldehyde gas.

(*c*) Washing with solution of bichloride of mercury, 1:1000 or 5-per-cent. solution of formalin, or 5-per-cent. solution of carbolic acid, preference being given to carbolic acid for application to polished woods, bright metals, and other objects injured by metallic salts.

The forecastle, steerage, and other living apartments in bad sanitary condition must be disinfected by method (*a*) followed by method (*c*).

180. Mattresses, pillows, and heavy fabrics are to be disinfected by:—

(*a*) Boiling.

(*b*) Flowing steam; *i.e.,* steam not under pressure.

(*c*) Steam under pressure.

(*d*) Steam in a special apparatus with vacuum attachment.

181. Clothing, fabrics, textiles, curtains, hangings, etc., may be treated by either of the above methods from (*a*) to (*d*) inclusive, as circumstances may demand, or by formaldehyde gas or sulphur dioxide where the article is of a character which will not be damaged by sulphur dioxide.

182. Articles injured by steam, such as leather, furs, skins, rubber, trunks, valises, hats and caps, bound books, silks, and fine woolens should not be disinfected by steam. Such articles should be disinfected by formaldehyde gas or by any of the agents allowed in these regulations which may be applicable thereto. Those which will be injured by wetting should be disinfected by a gaseous agent.

183. Clothing, textiles, and baggage, clean and in good condition,

but suspected of infection, can be efficiently and least injuriously disinfected by formaldehyde gas, generated by one of the methods prescribed in paragraph 165—(*a*), (*b*), or(*d*).

184. Textiles which are soiled with the discharge of the sick or presumably are deeply infected, must be disinfected by:—

(*a*) Boiling.

(*b*) Steam.

(*c*) Immersion in one of the germicidal solutions.

185. Cooking and eating utensils are always to be disinfected by immersion in boiling water or by steam.

It is the intention of the act of February 15, 1893, under which these regulations were framed, to have them act uniformly and without discrimination against any place, and at the same time to not interfere with the operation of any additional regulations imposed by State or local authority.

MANAGEMENT OF A QUARANTINE STATION.

Inspection.—Upon the arrival of a vessel at a quarantine station, during the active quarantine season, she should be boarded without delay, and the following general routine followed, with such modifications as may be demanded by the local conditions or dictated by the experience of the quarantine officer. In the event of the arrival of several vessels at the same time, they should, as a rule, be boarded as nearly as possible in the order of their arrival, the rule of "first come, first served" being observed; though it may be remarked that, in the event of the arrival, at nearly the same time, of a vessel carrying passengers and one carrying cargo only, there will usually be little opposition on the part of ship-masters if the passenger-ship is inspected first. Arrived on board, it is well to demand the immediate attendance of the master, not only from the fact that all information must be sought from him, but to impress all concerned with the fact that the authority of the boarding-officer is, for the time, absolute. The master should then be required to produce for inspection his bills of health, the ship's manifest, and the crew- and passenger-lists, if the ship carry passengers. These should be carefully scrutinized, the number of crew and passengers being noted or borne in mind, and note being made of any articles of cargo that come within the proscription of the regulations. All special consular certificates bearing on doubtful articles of cargo had better be looked into at this time. A careful inspection of the ship should now follow, particular attention being paid to the condition of the living-apartments of the officers and crew, as their condition of cleanliness or the reverse sometimes forms an important index to the cleanliness of the whole ship. The hatches should be removed, and such portions of the cargo as come directly under them be subjected to scrutiny. If the vessel is in ballast, the hold should be entered, explored, and mental note made of the condition of the ship's inner planking or skin, whether dry and sound or rotten and damp. If possible, a limber plank should be lifted, and the condition of the bilges noted. In the comparatively inaccessible places fore and aft there will likely be found deposits of trash and filth, and the chain-lockers should be carefully examined to see whether the cables have been properly washed prior to stowing. The inspection of the ship proper completed, the inspection of persons should be entered into.

Every person borne upon the ship's papers as passenger or member of the crew should be personally seen by the boarding-officer or his assistant, and no excuse whatever should be taken for an absence from this muster. In vessels suspected of the infection of plague or yellow fever, the temperature of passengers and crew should be taken to assist in the detection of cases of these diseases in the early stages, and to this end every quarantine station should be supplied with a liberal number of good clinical thermometers. Take nothing for granted, and compel the master to explain any discrepancies between the lists and the actual number presenting themselves for examination. The decision must now be reached whether the vessel goes free under the regulations or is to be detained in quarantine. If the former, the certificate of inspection is filled out, and the master notified that he is at liberty to proceed. If the latter, the vessel is directed to a suitable anchorage, and the yellow quarantine flag is hoisted at the foremast-head. Quarantine procedures proper now begin, and much depends on the nature of the disease quarantined against; the nature and condition of the ship, whether light, in ballast, or loaded. If there are passengers on board, these are landed, bathed, and assigned to quarters in the barracks. The vessel is laid alongside of the wharf and the disinfecting processes prescribed by the regulations entered upon.

TREATMENT OF YELLOW-FEVER VESSELS.

A vessel infected with yellow fever is one which has on board actual cases of the disease, or which contains mosquitoes of the genus *Stegomyia fasciata* which have had opportunities of biting persons infected with yellow fever, either at the port of departure or upon the voyage. If there are *Stegomyia fasciata* on board a ship and a case has occurred on board within three or four days, these mosquitoes must be regarded as infected, unless the utmost care has been taken to screen the patients from their attacks. If the ship is from a yellow-fever port, that is to say, where yellow fever actually prevails, and presents *Stegomyia fasciata* on board, these Stegomyiæ are presumably infected, and if as much as twelve days have elapsed on the voyage, are capable of conveying yellow fever to non-immunes. The treatment of yellow fever vessels, therefore, is limited to efforts directed to kill mosquitoes in the living apartments and in the holds of the vessel and to preventing their breeding in places favorable to their development. Various means can be adopted to this end. The burning of sulphur—two pounds per 1000 cubic feet, time of exposure twelve hours—is efficacious. If it is apprehended that the sulphur fumes will be injurious or prejudicial to clothing, hangings, bright work, polished metal, etc., pyrethrum powder may be substituted for the sulphur, burning one pound per 1000 cubic foot, the time of exposure to be about three hours. Pyrethrum powder is not an insecticide; it simply stupefies the insects, and at the expiration of this time the room or apartment should be cautiously opened and the stupefied mosquitoes swept up and burned. The use of pyrethrum, therefore, would generally be limited to the living apartments and especially to the cabins of ships; sulphur is safer, more efficacious, and easier of application in the forecastles and holds.

Should there be patients sick with yellow fever upon the vessel on the arrival at quarantine, these should be at once removed to the infectious hospital if their condition permits it, and the remainder of the crew and passengers should be inspected twice daily until the time of danger, that is to say, the period of the incubation of the disease, five or six days, has elapsed. In the care and treatment of these passengers detained in quarantine on account of yellow fever, care should be taken to immediately isolate every febrile case and to thoroughly protect it by mosquito netting or wire gauze from the access of mosquitoes until a positive diagnosis is arrived at. If there are no mosquitoes, or care is taken to prevent the infection of mosquitoes, there will be no spread of the disease. The ballast and cargo of vessels from yellow-fever ports are only dangerous in so far as they may harbor infected mosquitoes. The matter can be summed up in the dictum: "A vessel or a house infected with yellow fever is a vessel or house which contains within its walls infected mosquitoes of the genus *Stegomyia fasciata*." (Reed.)

TREATMENT OF PLAGUE VESSELS.

In vessels departing from a port where plague prevails, precautions against plague should be commenced at the port of departure. This disease has of late years been robbed of much of its traditional terror, owing to the fact that its cause, its nature, and the methods of handling it in epidemic form have become better understood. In the ordinary or bubonic type of the disease, there is little danger to be apprehended from the patient himself. In the cases pneumonic in type from their inception, or becoming pneumonic as a secondary infection, the patient is dangerous, as the sputum contains the organism of the disease.

The spread of plague seems to be generally effected by means of rats or mice, though insects, such as fleas, bedbugs, ants, etc., may also play a part, not by directly conveying the plague microörganism, but their bites, irritated by scratching, affording an avenue of entrance for the plague bacillus, which may be carried on the bodies or feet of the insects, or *possibly* conveyed in their dejecta.

A most essential precaution in a port infected with plague is to prevent the access of rats, mice, and other vermin on board ship. This is best accomplished by not allowing the ship to approach the dock; but if this is necessary for the purpose of loading, the ship should be breasted off five or six feet from the walls of the dock, and the lines and chains leading ashore should be protected by rat-guards or cones surrounding the lines, their large open ends directed toward the shore. If these are impracticable, or not to be obtained, the lines or chains should be freshly tarred, and, as the rat is more prone to move by night than by day, the gang-ways or planks connecting the ship and the shore should be removed before sunset.

A case of plague developing on the voyage should be isolated, and any articles which may be soiled or infected by the patient should be disinfected or, in the absence of means for accomplishing this, should be destroyed.

Careful observations should be made upon voyages from plague-infected ports to ascertain any marked sickness or increased mortality among the rats which almost always are found on shipboard. Experience has shown that an outbreak of plague in man is almost invariably preceded by an increased mortality among rats and mice.

Arriving at a quarantine station, vessels infected with plague, or suspected of such infection, should be anchored at a sufficient distance from the shore or from other vessels to prevent the escape of rats by swimming. The personnel of the vessel, passengers and crew, should be subjected to a rigid inspection, if there have been cases of plague during the voyage, and this inspection should be so conducted that the condition of the glandular regions of the body, the subcervical, axillary, and inguinal, may be ascertained. Special attention should be directed to the detection of mild or ambulant cases of the disease, and any case of illness partaking of the nature of a severe bronchitis or of pneumonia should be the subject of a special investigation and, if possible, a bacteriological examination.

On plague-infected vessels, any of the crew who, in the opinion of the quarantine officer, have been exposed to the direct infection of plague should be bathed, and any of their belongings supposed to have been exposed to infection should be disinfected. Measures should be at once entered into to insure the destruction of rats, mice, fleas, bugs, and even flies and ants, on account of the danger of the spread of infection through their agency. This is best accomplished by a simultaneous disinfection of the ship by sulphur dioxide. During this process, the escape of rats should be guarded against, and any rats found escaping should be killed by shooting or by means of sticks or other implements. The rats and mice killed by this fumigating process should be gathered, and it is best not to handle them with the naked hands. They should be collected with gloves and their bodies burned, and the spots upon which they have been found dead should be disinfected by actually boiling water or by one of the germicidal solutions, and the vessel should not be considered as free from danger until she is free from rats. The last International Sanitary Conference of Paris, 1903, lent themselves to the declaration that merchandise, in itself, was incapable of conveying the infection of plague, and was only dangerous when soiled or contaminated by plague-stricken rats. Should it be necessary to disinfect a ship infected with plague and containing cargo, this disinfection should be conducted in a fractional manner, by removing a portion of the cargo and exposing it to sun and air upon lighters. Sulphur dioxide is then to be generated or introduced into the holds overnight, and during the next day a further portion of the cargo, not exceeding four to six feet in depth, should be removed. The holds are then closed again and the fumigation is repeated, and this process is continued until all cargo is removed. If the vessel contains no cargo, the holds should be disinfected by sulphur dioxide, dead rats sought for, gathered, removed, and burned, and a general disinfection by means of germicidal solutions should then follow. The water supply of a vessel plays no rôle in the dissemination of plague.

If the vessel arriving with plague on board has a large number of passengers, these passengers should be removed, segregated into small groups, and held under observation for the period of the incubation of the disease, which is now considered as about seven days. Those who have been especially exposed to the infection should be segregated by themselves, and should form the subject of careful observation one or more times during the day. Any persons in these groups presenting suspicious symptoms of illness should be removed to the observation hospital; and if these cases should declare themselves to be plague of either the bubonic or pneumonic type, they should be at once removed from the suspect to the infectious hospital.

The International Sanitary Conference of Paris, 1903, recommended that all vessels engaging in passenger travel should be provided with a sufficient quantity of anti-pest serum for the treatment of actual cases of plague and for the immunization of those exposed to its infection. This suggestion is well worthy of serious consideration, as the serum is an almost certain prophylactic and affords the only successful method known of treating actual cases of the malady.

TREATMENT OF CHOLERA VESSELS.

In the event of the arrival of a ship actually infected with Asiatic cholera, or suspected of such infection, a much more difficult problem confronts the quarantine officer, for the conditions differ widely from those obtaining in the case of the yellow-fever ship. In a majority of cases the cholera ship carries a large number of passengers, a great majority of whom belong to the immigrant class, and the difficulty of handling these is largely increased by the carelessness of their personal habits, their ignorance and disregard of the first laws of personal hygiene, and the discomfort, crowding, and bad sanitary condition of their quarters on board ship. Here many sources of danger must be looked into, and it is almost certain that a disregard of any one of them will be followed by a terrible retribution in the shape of new outbreaks of the disease.

The first thing to be done in the treatment of a cholera-infected ship is to remove her human freight, and this should be done as rapidly as is consistent with safety. The occupants of the compartment of the ship in which cholera has appeared should receive our first and most careful attention. They must be landed at once, bathed with all possible precaution and thoroughness, furnished with clean, sterile clothing, and isolated in the barracks and regarded as especially dangerous. Those actually sick with the disease should be at once carried to the contagious hospital, and those sick with any complaint whatever isolated in the suspect hospital pending the determination of the actual nature of their disease.

The foregoing applies particularly to the steerage passengers. The question of the treatment of the cabin and saloon passengers is one that will call for all the tact and ingenuity of the quarantine officer, and even then he will be liable to savage criticism and censure through the friends of the cabin passengers detained. It must be remembered that these passengers are luxuriously lodged and catered for with every delicate attention that ingenuity and long experience, sharpened by active competition, can suggest. On board ship they are most carefully guarded from intrusion on the part of the steerage passengers, and, in fact, are as nearly on a separate ship as possible. Is it always necessary to subject these people to the inconveniences and possible hardships that are inseparable from a detention in quarantine barracks? The answer is that each case must be decided on its individual merits, and much will depend on the extent to which the ship seems infected, the seeming source of the infection, and the facilities which exist on board ship for maintaining a sharp line of demarkation between the steerage and saloon.

If, on investigation, it seems that the choleraic outbreak is due to infected food smuggled on board by the emigrants, to infection probably brought aboard in the hand-baggage of the same class of passengers; if, in fine, it would seem to be due to conditions limited to the steerage, it *might* seem to be the part of wisdom to leave the cabin passengers in their luxurious quarters while the processes of disinfection and detention were in progress. If, on the contrary, the infection seems to be due to a polluted ship's water-supply; if there have been any cases of diarrhœal disease among the cabin passengers; if the infection seem to be distributed equally to the steerage and to the saloon, then all must be landed alike, and undergo barrack detention, at least until the disinfection of the ship is thoroughly complete.

The barracks for the cabin passengers must, of course, be of a different character from those provided for the steerage. They must be subdivided into small rooms, and, instead of bunks, must be furnished with comfortable cots, bedding, and simple, but neat and efficient, toilet facilities. A separate kitchen and table must be provided for this class of passengers, and the whole situation may be summed up by saying that the relative difference on shipboard should be preserved on shore during the detention in quarantine.

SPECIAL MEASURES AGAINST CHOLERA.

Other features of quarantine administration are well expressed in the following extract from the editorial pages of the Philadelphia *Medical News* of October 15, 1887, showing the measures necessary to extinguish an incipient epidemic of cholera and to prevent its spread. Such measures are as follow:—

"(*a*) Speedy recognition and isolation of the sick; their proper treatment; absolute and rapid destruction of the infectious agent of the disease, not only in the dejecta and vomit, but also in clothing, bedding, and in or upon whatever else it finds a resting-place.

"(*b*) The convalescents should remain isolated from the healthy as long as their stools possibly contain any of the infecting agent; before mingling again with the well they should be immersed in a disinfecting bath, and afterward be clothed from the skin outward with perfectly-clean vestments, which cannot possibly contain any of the infectious material.

"(*c*) The dead should be well wrapped in cloth thoroughly saturated in a solution of corrosive sublimate (1 to 500), and, without delay, *cortège*, or lengthy ceremonial, buried near the place of death in a deep grave, remote as possible from water which may, under any circumstances, be used for drinking, washing, culinary, or other domestic purposes. (Cremation, of course, is by far the safest way of disposing of cholera cadavers.)

"(*d*) Those handling the sick or the dead should be careful to disinfect their hands and soiled clothing at once, and especially before touching articles of food, drinking, or culinary vessels.

"(*e*) In the case of maritime quarantine, the well should be disembarked and placed under observation in quarters spacious enough to avoid crowding, and so well appointed and furnished that none will suffer real hardships.

"(*f*) Once having reached the station, those under observation should be separated in groups of not more than twelve to twenty-four, and the various groups should, under no pretext, intermingle. The quarters for each group should afford stationary lavatories and water-closets in perfect working condition, adequate to the needs of the individuals constituting the group, and supplied with proper means of disinfection. There should be a bed raised above the floor, proper coverings, and a chair for each member of the group, each person being required to use only his own bed. There should be a common table of sufficient size to seat around it all the members of the group, who should be served their meals from a central kitchen, and with table-furniture belonging to the station and cleaned by the common kitchen scullions.

"(*g*) Drinking-water, free from possible contamination and of the best quality, should be distributed in the quarters of each group as it is needed, and in such a manner that it is received in drinking-cups only. There should be no water-buckets or other large vessels in which handkerchiefs, small vestments, children's diapers, etc., can be washed by the members of any group.

"(*h*) Immediately after being separated into groups in their respective quarters, every person under observation should be obliged to strip and get into a bath (a disinfecting one is preferable), and afterward be clothed with fresh, clean vestments from the skin outward. Every article of clothing previously worn should be taken away and properly disinfected.

"(*i*) Then all of the personal effects should be at once removed to a separate building, washed (if possible), and thoroughly disinfected, or if necessary, destroyed. After disinfection they should be temporarily returned to the members of groups, when occasion requires a further change of clothing.

"(*k*) Under no circumstances whatever should washing of clothing by those under observation be permitted. All used clothing should be first thoroughly disinfected (by boiling, when possible), and then should be cleansed, the disinfection and washing being done by a sufficiently trained and absolutely reliable corps of employees supplied with adequate appliances.

"(*l*) All those under observation should be mustered in their own quarters, and be subjected to a close medical inspection, *while on their feet,* at least twice every day, in order to discover and isolate, as soon as possible, new cases which may develop; and, of course, the clothing and bedding of these new cases should be treated without delay in the manner already mentioned. In the meantime, a watch should be set over the water-closets for the purpose of discovering cases of diarrhœa, and, when discovered, such cases should be temporarily separated from the rest. They should receive judicious medical attention at once, and precautions should be taken as if they were undoubted but mild cases of cholera.

"(*m*) The quarters should be kept thoroughly clean, and every surface upon which infectious material could possibly be deposited, including the floors, should be washed with a strong disinfectant twice daily, and oftener when necessary. Evacuations from the bowels should be passed into a strong disinfectant; the hopper of the closet should be then flushed and finally drenched with a quantity of the same disinfectant.

"(*n*) For the proper attention to the sick, there should be two or more competent and experienced physicians, assisted by a sufficient corps of intelligent and efficient nurses, with hours of duty so arranged that a physician, with a sufficient number of nurses, shall be in constant attendance in the wards of the hospital.

"(*o*) For the prompt recognition and separation of new cases, their temporary medical attention, the proper treatment of discovered cases of diarrhœa or cholerine and of other maladies, and the immediate correction of every insanitary practice or condition by constant, vigilant, and intelligent supervision, there should be at least two or more competent and experienced physicians, with hours of service so arranged that a physician is on duty night and day among those under observation; and he should have, subject to his orders at any and every moment, a sufficient and efficient corps of nurses and laborers to carry out properly and promptly his directions.

"(*p*) In order to prevent the intermingling of the various groups, to enforce obedience and order, and to make it absolutely impossible for the quarantined and their personal effects to have any communication with the exterior, a well-organized and sufficiently large police corps should patrol the borders of the stations and the buildings day and night.

"(*q*) Any group among whom there have developed no new cases of cholera or of choleraic diarrhœa, during the preceding eight or ten days, may be regarded as harmless, and allowed to leave quarantine after each one is finally immersed in a disinfecting bath and reclothed with clean garments from the skin outward, the garments removed being destroyed or thoroughly disinfected and cleansed, as already indicated.

"As yet no reference has been made to the crew, ship, and cargo. What has been said of the treatment of those under observation applies to every one of the ship's inhabitants. The observation, isolation, and cleansing of the crew and their effects could safely be performed aboard ship if necessary. The ship should be thoroughly cleansed and disinfected, particular attention being given to the quarters of the emigrants and crew."

The following general regulations were promulgated for the government of camps and barracks for the detention of cholera suspects during the summer of 1892:—

Regulations for Cholera Camp.

(Prepared in the Marine-Hospital Bureau.)

The surgeon in command of the quarantine camp to have absolute authority over the police and sanitary regulations of the camp, and to see that they are obeyed.

Camp to be divided into two divisions—detention and hospital. Former for housing of suspected cases and well persons from infected localities and the latter for treatment of sick.

Detention Camp.

1. Persons destined for this camp to be assigned to specific quarters in tents. First to be subjected to disinfecting bath, and clothed afterward with fresh vestments. Not to leave this camp except by permission or order of surgeon in command.

2. Persons in detention camp to be inspected twice daily or oftener by medical officer or assistant, while standing, to ascertain any new cases which may develop.

3. New cases of cholera in detention camp to be immediately transferred to hospital camp for treatment, and all their effects disinfected, as well as the tent in which they may occur.

4. Guards to patrol detention camp night and day, to prevent intercourse between the two divisions of the camp.

5. Water-supply for entire camp to be boiled for drinking. To be dealt out to each person in cups or glasses for potable purposes. May be acidulated with diluted hydrochloric acid under supervision of a medical officer.

6. If there be room, the detention camp to be segregated into divisions of not more than twenty persons. No intercommunication should be permitted between the groups.

7. All clothing removed from persons entering detention camp to be subjected to steam heat (unmixed with air), not less than 100° C. (212° F.), for one-half hour, or boiling for one hour. Leather and rubber goods to be immersed in 3-per-cent. carbolic-acid solution until thoroughly saturated.

8. The washing of clothing not to be permitted by the detained persons under any pretext. After above disinfection, all laundry-

work to be then done by the force of employees. The clothing of detained suspects should be kept in separate building after disinfection, and re-issued as required for change.

9. Cleanliness and disinfection of quarters and person to be enjoined and enforced daily. Disinfectants to be used where there is any possibility of infection.

10. At the expiration of five days, if no case of cholera or choleraic diarrhœa has developed in a given group segregated as above, those composing the group may be discharged, after a final disinfection of person and clothing.

11. All water-closets, urinals, privies, or troughs should be provided with latrines similar to those of the cholera camp, and means should be provided for their thorough disinfection before their contents are discharged into pits of unslacked lime.

12. Food issued shall be simple, thoroughly cooked, and served at stated hours. No fruit permitted.

Hospital Camp.

1. Day sick calls at 8 A.M. and 4 P.M.; oftener, if necessary.

Night call, 12 P.M., by night physician; oftener, if circumstances require.

2. There shall be one nurse for every hospital tent, who shall be on duty in six-hour watches.

Night nurses according to circumstances. Female nurses for cases occurring in that sex.

Nurses should be instructed in the necessity of personal hygiene and the sources of infection.

3. Vomited matter and stools to be received into earthen vessels, and at once disinfected with 3-per-cent. solution of carbolic acid or 1 to 500 $HgCl_2$ combined with 2 parts of HCl to each part of $HgCl_2$; then thrown into a pit of unslacked lime, or discharged into the sea.

4. All soiled linen or clothing that cannot be disinfected to be immediately destroyed by burning.

5. When death occurs, body to be immediately buried, swathed in sheets saturated with 1 to 500 $HgCl_2$. Place of interment to be selected to avoid contamination of water-supply.

6. No persons having personal contact with the sick or dead shall leave the hospital camp without practicing disinfection, as specified above.

DANGER FROM FLIES IN QUARANTINE.

In this article it has been suggested that all dejecta and vomited matters of cholera patients be received into vessels containing an efficient germicidal solution; and this is not only for the reason that the said dejecta and vomited matters may infect any one who comes into inadvertent contact with them, but has an important bearing on the health of those who are resident in the neighborhood of the quarantine station. It has been abundantly proved that the ordinary house-fly is capable of conveying in its intestinal tract, for a considerable length of time, living and active cholera spirilla. Knowing how constantly flies deposit their ordure on articles of food, it can easily be seen how great a menace to public health would be engendered by allowing stools containing the bacilli to remain without instant disinfection. The safer plan is, therefore, to not trust to subsequent disinfection, which might be overlooked in the press of other matters, but to receive the dejecta into the germicidal solution so that no time will be lost and no chances of infection may remain.

DANGER FROM MOSQUITOES IN QUARANTINE.

As the consensus of opinion seems to be that the mosquito *Stegomyia fasciata* is the sole means for the dissemination of yellow fever, particular attention should be paid to guard patients in quarantine suffering from yellow fever from the attacks of this insect. Not only should the patient be carefully screened by mosquito nets, or by being kept in apartments rendered mosquito-proof by wire netting, but every effort made to prevent the breeding of this variety of mosquito in the neighborhood of a quarantine station. It is probable that this mosquito is a normal denizen of every quarantine station from the Rio Grande to the capes of Virginia, and measures for their prevention would consist in the thorough screening of all water-containers, water-barrels, or cisterns, and the filling in of all pools or collections of water which would form favorable places for their breeding and development.

The *Stegomyia fasciata* is essentially a house mosquito and fresh water is necessary for its development. The collections of water which may ordinarily be found about a house, as in wash-bowls, wash-tubs, tin cans, broken bottles, etc., are particularly favorable places for its development, and these should be guarded against at a quarantine station or in its immediate vicinity.

THE NATIONAL QUARANTINE SERVICE.

The protection of the United States in the exclusion of quarantinable diseases is provided for at the forty national maritime inspection and disinfection stations located in the waterways and ports of entry upon the Atlantic, Gulf and Pacific coasts. The principal stations are as follows:—

Perth Amboy, N. J.; Delaware Breakwater Quarantine Station, Lewes, Del.; Reedy Island Quarantine Station, Delaware River; Cape Charles Quarantine Station, Fisherman's Island, Va.; South Atlantic Quarantine Station, Blackbeard Island, Sapelo Sound, Georgia; Brunswick Quarantine Station, Brunswick, Ga.; Key West Quarantine Station, Tortugas Islands, Fla.; Gulf Quarantine Station, Ship Island, Miss.; San Diego Quarantine Station, San Diego, California; San Francisco Quarantine Station, Angel Island, San Francisco Bay, California; and Port Townsend Quarantine Station, Port Townsend, Washington; Southport, N. C.; Savannah, Ga.; Fernandina, Jacksonville, Miami, Key West, Punta-Gorda, Cedar Keys, Apalachicola, and Pensacola, Fla., and Astoria, Oregon.

DESCRIPTION OF THE NATIONAL QUARANTINE STATIONS ON DELAWARE BAY AND RIVER.

It may prove of interest to briefly describe a national quarantine station, and no better example can be found than the stations at Delaware Breakwater and at Reedy Island, Delaware River. These stations, while in a measure separate and distinct, are intended to work in connection with each other and to afford complete protection against the importation of contagious and infectious disease through the medium of the commerce which seeks the port of Philadelphia and the ports of entry on Delaware Bay, and situated in the States of Delaware, New Jersey, and Pennsylvania. At the station at Delaware Breakwater, which is situated at the mouth of Delaware Bay and immediately upon the point formed by Cape Henlopen, is the reservation, forty acres in extent, and surrounded by a substantial picket-fence ten feet in height. Within this enclosure is located the quarantine plant proper, consisting of commodious hospitals for contagious and non-contagious diseases, and barracks for the accommodation of one thousand suspects, fitted with bunks and provided with bedding and a full supply of clothing for both males and females. In connection with these barracks are a large kitchen, fully equipped with steam cooking-apparatus of the most improved description and a commodious mess-hall. There has been also provided a building containing a boiler for operating the pumps, a bath-house, and laundry, which latter is equipped with appliances for washing all soiled clothing and for subjecting them to the boiling process. In this building there is also located a steam disinfecting chamber of the most modern and improved type, and adjoining this building is a bath-house fitted with twenty shower- and two tub-baths, all provided with hot and cold water. An artesian well has been sunk, capable of supplying twenty thousand gallons of water per day, and this water is raised by a powerful pump to elevated tanks, and from these distributed to the barracks, kitchens, hospitals, laundry, and bath-house.

Latrines are provided and furnished with iron containers holding a strong disinfecting solution, and provision is made for emptying these containers into a sewer, which, in turn, empties into a sewer common to the bath-house and laundry, which discharges into the sea. The danger of soil contamination by alvine discharges is reduced to a minimum, and the water-supply likewise protected. Outside of the fence is a large brick house, which furnishes executive and administrative offices and quarters for the medical officers on duty at the station. In front of the executive building is a lofty flag-staff, which affords the means for communicating by signals with vessels in quarantine and arriving in the offing.

Within a few hundred yards of the reservation is a long iron pier, which affords ample facilities for the landing of passengers.

Situated fifty-five miles above the Breakwater, and forty-five miles from Philadelphia, is the Reedy Island Quarantine Station, on and near the island of that name. Upon the island itself are situated the residence of the medical officer, quarters for employees, and a cottage hospital. A boat-house is connected with the island by a gangway. The quarantine plant proper is located on a pier situated on the edge of the channel, and in thirty feet of water. The pier is two hundred feet in length, and presents a frontage of nearly four hundred feet, owing to the placing of an ice-break above and below the pier. This affords room for the accommodation of the largest vessels, and upon the wharf is situated the disinfecting plant, consisting of two steam chambers; a sulphur-furnace, fan and engine for driving the same; tanks for disinfecting solutions and a pump and hose for their distribution; a fire-pump, and tanks for the storage of water for fire and steaming purposes.

There are only small barracks at this station, it being the plan that the vessel shall receive quarantine treatment at this point, and that the passengers shall undergo their detention in the barracks at the Breakwater station.

Another national station which deserves special notice from its peculiarities is the quarantine vessel *Jamestown,* which can be considered a floating quarantine station. The *Jamestown* was turned over to the U. S. Marine-Hospital Service by the Navy Department for quarantine use. She is one of the old-fashioned sailing-vessels of the navy, is very strongly and solidly constructed, and is one hundred and sixty-six feet long, thirty-six feet beam, and has a displacement of eight hundred and eighty-eight tons. She has been fitted for her present use by being housed in, and there have been placed on board a steam disinfecting chamber, a sulphur-furnace, tank for bichloride solution, and bath-rooms. In addition to these, she has been fitted as a place of detention for two hundred and fifty to three hundred immigrants, and is in all respects a complete quarantine station, and capable of doing valuable service in smooth water.

AIDS TO NATIONAL QUARANTINE.

In aid of the national quarantines, sanitary inspectors are appointed by the Marine-Hospital Service at special points of danger, either in the United States or abroad. Through the State Department consular notification from foreign ports is received regularly by mail, or, in emergency, by cable, and the information thus received, and that received also from home ports, is communicated, by the Marine-Hospital Bureau, to all quarantine authorities, and others, by means of a weekly publication known as the "Public Health Reports."

An important source of information concerning the movements of vessels in every portion of the world is the "Maritime Register," published in New York. The United States Collectors of Customs are efficient aids, having, by law, the power of search and detention of vessels, and having exceptional knowledge of the sanitary condition of the shipping at their respective ports. The Revenue-Cutter Service, a national coast patrol, gives frequent and efficient aid; the Light-house Establishment and Coast Survey render valuable assistance in locating and buoying the anchorages, and the Life-Saving Service, with its constant patrol of the coast, guards against the entry of a vessel at an unusual point. The surf-men are required to rake together and destroy dunnage and other material likely to be infected that have been thrown overboard and washed ashore from infected vessels. Finally, the Marine-Hospital Service, having, besides the quarantines, the care of the sick of the merchant vessels of the United States, with one hundred and twenty-six physicians stationed at the larger and many of the smaller ports, is ready at a moment's notice to extend indefinitely its quarantine service.

NATIONAL INSPECTION OF ALL QUARANTINES.

The Act of Congress approved February 15, 1893, while contemplating that State and local quarantines shall not be disturbed in the exercise of their functions, provided said quarantines are administered in accordance with the law and the regulations made thereunder, further provides that the rules and regulations of local quarantines shall be examined by the Surgeon-General of the Marine-Hospital Service, and also that such additional rules and regulations as may be deemed necessary shall be made by the Secretary of the Treasury, and shall be enforced by the State or local quarantine authorities. If the latter refuse, or are unable to enforce them, the law further provides that the President of the United States shall detail or appoint an officer for this purpose. To carry out the intent of this law all the quarantines of the United States, national, State, and local, are inspected periodically by an officer of the Marine-Hospital Service. Following are the instructions prepared for the inspecting officers:—

Instructions to Medical Officers of the Marine-Hospital Service Detailed to Make Inspections of State and Local Quarantines.

Treasury Regulations.

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In the performance of the duties imposed upon him by the act of February 15, 1893, the Supervising Surgeon-General of the Marine-Hospital Service shall, from time to time, personally or through a duly-detailed officer of the Marine-Hospital Service, inspect the maritime quarantines of the United States, State and local, as well as national, for the purpose of ascertaining whether the quarantine regulations prescribed by the Secretary of the Treasury have been, or are being, complied with. The Supervising Surgeon-General, or the officer detailed by him as inspector, shall, at his discretion, visit any incoming vessel, or any vessel detained in quarantine, and all portions of the quarantine establishment for the above-named purpose, and with a view to certifying, if need be, that the regulations have been, or are being, enforced.—J. G. CARLISLE, *Secretary.*

General Instructions.

A. Your inspections will include all ports within your district where vessels are allowed to enter and discharge cargo, and ports which may be used as ports of call.

B. A separate report will be made of each station visited.

C. Visit every part of the quarantine establishment, and take necessary precautions to prevent the conveyance of contagious or infectious disease through the medium of your own person.

D. Visit the custom-house for the purpose of ascertaining whether the regulations with regard to bills of health and quarantine certificates are being observed; also, the immigration station for any pertinent information.

E. Reports of a statistical character and descriptive of the quarantine, called for herein, need be made but once in every six months, namely, on the date nearest the 1st of January and the date nearest the 1st of July; but any changes that have been made since the last general report should be immediately recorded.

In making your report you will follow the special instructions in their order, referring to each by number.

Special Instructions.

1. Describe the quarantine station, location, buildings, anchorages, etc. Give limits of anchorage for non-infected and for infected vessels; facilities for inspection of vessels; apparatus for disinfection of vessels and of baggage; facilities for removal and treatment of the sick, and for the removal and detention of suspects; mail and telegraph facilities, etc.

2. Give *personnel* of the station or port; name of the quarantine officer or officers; post-office address; total number of officers and subordinates, etc.

3. Transmit copies of the laws under which the local quarantine is maintained, and copies of the quarantine regulations; also describe the quarantine customs of the port as they are carried out.

NOTE.—There are sometimes slight, but possibly important, variations from the letter of the local regulations in the administration of quarantine. Also, local regulations generally allow a wide latitude to the quarantine officer, and how this latitude is used—*i.e.*, how the quarantine officer interprets the spirit of the regulations—is very important.

4. State what quarantine procedures, either under printed regulations or by custom, are enforced at the port, in addition to the requirements of the Treasury Department.

It should also be stated whether there is undue or unnecessary detention or disinfection of vessels.

5. State whether the inspection is maintained throughout the year or for what period, and what *treatment* of vessels is enforced during the entire year.

6. Are vessels from other United States ports inspected?

7. Describe quarantine procedures in the inspection of vessels, and, if infected, the treatment. Give time in quarantine (*a*) between arrival and commencement of disinfection, (*b*) time occupied by disinfection, and (*c*) time after completion of disinfection of vessels until discharge.

Note.—Quick or slow handling of a vessel is of more importance commercially than the question of fees. The time lost is the vessel's heaviest expense, generally.

8. What communication is held with vessels in quarantine (and, before quarantine, by pilots, etc.), and how regulated? Is there any intercommunication allowed among vessels in quarantine?

9. State what will be done with a vessel infected with cholera; second, a vessel infected with yellow fever; third, a vessel infected with small-pox (said vessels carrying or not carrying immigrants), and what conditions are regarded as giving evidence of the vessel's infection in each case.

10. State whether records are kept, at the station, of the cases of disease that have occurred during the voyage, on arrival and during detention.

11. Transmit schedule of quarantine fees, and give other fees and expenses necessarily and usually attendant on quarantine, as tonnage, ballast, wharfage charges, etc.

12. Make a statement showing the number of vessels arriving at the port during the preceding calendar year, by months, (*a*) from foreign ports; (*b*) from foreign ports in yellow-fever latitudes via domestic ports; (*c*) from domestic ports. Show, also, the character of the commerce carried on by the port—*i.e.*, from what countries chiefly the vessels come, and whether in cargo, ballast, or empty.

13. State results of your visit to (*a*) the Custom-house; (*b*) the Immigration Bureau.

14. State whether, in your opinion, the quarantine facilities are sufficient to care for the shipping entering the port.

15. Name the quarantine regulations of the Treasury Department which are not properly enforced, and state specifically whether the regulations regarding inspection and disinfection, and particularly the period of observation after disinfection, of vessels are observed.

16. Mention any facts which, in your opinion, should be known to the Department, bearing directly or indirectly upon the quarantine service, and make such recommendations as seem proper.—WALTER WYMAN, *Surgeon-General.*

NOTE.—Report to be written on legal-cap paper (on one side only), signed, and inclosed in this blank as a cover.

INLAND QUARANTINE.

Under Inland Quarantine will be described The Sanitary Cordon, Camps of Probation, Railroad Quarantine, Disinfection Stations, and Inspection Service.

THE SANITARY CORDON.

This consists of a line of guards, military or civil, thrown around a district or locality, either to protect the same from the surrounding country when infected, or to protect the surrounding country from the infected district or locality. When a given locality is infected, and the adjacent territory is regarded as suspicious, it may be necessary to establish a double cordon, the first one embracing the whole suspected territory at its outer edge, the second investing more closely the well-defined infected locality. After the expiration of a sufficient time to prove that the area between the cordons is not infected, or has been cleared of infection, the first cordon may be removed. Hospitals and camps of probation may be necessary adjuncts to the cordon. The most noted example of the sanitary cordon is found in the history of the plague-epidemic in Russia in 1878. A colony on the river Volga, called Wetljankaja, with a population of 1700 inhabitants, became infected with the Oriental plague, which extended to the neighboring villages. A military cordon was made to embrace all the infected district. The inhabitants of the focus of infection, Wetljankaja, were removed, property appraised for re-imbursement by the government, and the village burned. An additional cordon was thrown around Zarizin, a neighboring commercial city of importance and terminus of the Russian railway system. The cordons were maintained several months, and the plague was stamped out. (See Abstract Sanitary Reports, vol. i [Bulletin's], page 78.) The sanitary cordon is the customary method of preventing the spread of epidemic disease in the eastern countries.

In the United States, when yellow fever prevailed in Pensacola, in 1882, to the extent of 2200 cases, the navy-yard reservation, whose boundary-line is within two miles of the city limit, and with a population of about 1500, was successfully guarded by means of a cordon and non-intercourse.

The following year, 1883, the navy-yard itself was infected, and a cordon was thrown around it to protect the city of Pensacola, and was maintained for a period of sixty days. This cordon was under the management of the Surgeon-General of the Marine-Hospital Service, aid having been requested of the national government. The Collector of Customs of Pensacola was made the agent to execute the orders of the Marine-Hospital Bureau, and to the President of the local Board of Health was intrusted the immediate command of the line and guards. The cordon entirely surrounded the land-boundary of the naval reservation. Its line was four miles in length, one mile of it through a dense thicket, and was marked by blazed trees and flags. Forty men were employed as guards, an equal number being selected from each of the two political parties. Two captains were appointed, and were obliged to supervise the line night and day.

The sentinel posts were furnished with tents, and two guards were allotted to each post, taking alternate watches of four hours each. A detention or probation camp was established and placed in charge of a physician, where persons wishing to leave the reservation were obliged to pass a probationary period of twenty days. Not more than half a dozen persons were received in this camp. The government expended about $20,000 in these restrictive measures, which were entirely successful. Not one person got through the cordon line. The success was due largely to the thorough discipline maintained by the Collector and the President of the Board of Health.

Yellow-fever Cordon in Texas.—In 1882, yellow fever prevailing in Mexico, along the Rio Grande, and in Brownsville, Texas, a sanitary cordon was established by the Surgeon-General of the Marine-Hospital Service, on request of the Governor of the State, extending along the line of the railroad from Corpus Christi, on the Gulf of Mexico, inland to Laredo, on the Rio Grande. This line was one hundred and eighty miles northeast of Brownsville, the triangular territory thus hemmed in by the cordon on one side, the Rio Grande on another, and the Gulf on the third, being all suspected territory, although the fever prevailed in only one corner of it—viz.: in Brownsville. All persons were detained at least ten days at the cordon before being allowed to pass northward—a period of probation to insure that no one having the disease should carry it farther north. As soon as practicable another cordon was established much nearer to Brownsville, only thirty miles from it, the line extending from the mouth of the Sol Colorado, on the Gulf of Mexico, to Santa Maria, on the Rio Grande. After a time sufficient to prove that no more fever prevailed between the two cordons, the first one was removed. Within the second line, where the fever prevailed, chiefly in Brownsville, a hospital was established and dispensaries opened for the gratuitous treatment of all applicants.

Upon the Mexican side of the Rio Grande the fever continued to spread northwardly, and, in order to oppose it, still another cordon had to be established on the American side of the river, extending from Santa Maria on the south to Laredo on the north, a distance of five hundred miles. Three hundred guards, well mounted (Texan cow-boys), were employed in this cordon, and, while the disease was being stamped out in Brownsville, any further importation from Mexico was thus prevented. In Mexico the fever continued to spread until the authorities finally adopted measures similar to the above.

The epidemic of yellow fever in Brunswick, Ga., in 1893, gave rise to the necessity of establishing a sanitary cordon to protect the surrounding country from the danger incident to the panic-engendered flight of the inhabitants of that town. On account of the peculiar situation of Brunswick the difficulties to be met were very great. Not only were numerous roads to be guarded, but three water-passages from the city into the surrounding country had also to be watched. The cordon, therefore, partook of the nature of both a land and water patrol, and the difficulties were successfully overcome, and no well-authenticated instances of escape through the lines were established.

Much violent language has been used concerning the hardships imposed by the sanitary cordon, but in the presence of an epidemic the authorities who are responsible need to pay more heed to the efficiency of the cordon than to individual complaints. It should be borne in mind that the sanitary cordon is not intended to bottle up all the people who are caught within an infected district. On the contrary, it is intended as a means of exit to those who will not carry with them contagious disease to the people beyond.

The cordon, then, imposes simply a period of detention corresponding to the incubative period of the prevailing disease. Ample preparation must be made for housing and feeding, in camps or other quarters, persons awaiting the expiration of the detention period; and hospitals must be provided for the treatment of those who develop sickness. Provision must also be made for the disinfection of suspected baggage.

CAMPS OF PROBATION.

Camps of probation or detention should be established with all the precision of arrangement and regard for site, water, and drainage that pertain to a military camp. Every effort should be made to make the camp as comfortable and cheerful as possible, and to this latter end amusements and entertainments such as might be suggested by the campers themselves should be encouraged. Every necessity in the matter of food, bedding, and the ordinary comforts of life should be anticipated, to prevent any just cause of complaint. Such a natural division of the inhabitants should be made as seems desirable at the time, those of equal intelligence and refinement naturally seeking each other's company. The greatest concern is to prevent the camp itself from becoming infected. To this end no baggage should be allowed within the camp-boundary without previous examination or fumigation, to ensure its freedom from mosquitoes; and every refugee should be examined by a physician before being admitted to the camp. No one should be received who does not intend to proceed to an uninfected locality after his probation. In other words, a camp of probation should not be used as one of refuge.

The camp must be surrounded by guards to prevent egress or ingress, excepting through the established portal. At least twice or three times in the twenty-four hours all refugees should be inspected in their quarters, and any case of sickness at once be isolated and watched and screened from mosquitoes until the diagnosis is certain. If the case is one of the prevailing disease, the patient must be removed immediately to the hospital, which should be at a safe distance, half a mile or more, from the camp. Before leaving the camp, clothing should be fumigated to destroy mosquitoes, and he should be given a certificate that he has passed the required period of probation. A clear distinction must be made between camps of probation and camps of refuge. Camps of refuge are simply residence camps established to receive the population of an infected community, when it has been determined to depopulate the infected district.

Depopulation of a house, a block, a district, or a whole city, if possible, the people moving into camps, is now recognized as a valuable means of controlling an epidemic; and there may be either camps of probation or simply camps of refuge, or both, according to the requirements of the situation. Camps of refuge, in connection with depopulation, were suggested by the late Surgeon-General Woodworth, in 1878, and the measure was practically carried out at Memphis, in 1879, by the establishment of Camp Mitchell. "But the establishment of a camp to which persons from infected points could go, be kept under observation a sufficient length of time to demonstrate they were not infected, have their baggage disinfected, and be given 'free pratique,' is apparently a new departure in inland quarantine."

Camp Perry, Fla.—Such was Camp Perry, Florida, described by the surgeon in charge, W. H. H. Hutton, in the Marine-Hospital Service Report for 1889. The site was admirably chosen by Passed Assistant Surgeon John Guitéras, upon a bluff on the south side of St. Mary's River, the dividing line between Florida and Georgia, about forty miles north of Jacksonville, Fla., which city was in the throes of a yellow-fever epidemic. The camp was opened August 20, 1888. It consisted, in its completed stage, first, of 50 wooden cottages built elsewhere and transported on cars. Their dimensions were 12 feet by 10, and 10 feet in height, constructed of plain lumber, with cracks battened, and windows on each side with swinging shutters. Each held four cots, chairs, and toilet-stand, while unused clothing was neatly arranged on the rafters above. Besides the 50 cottages there were a quartermaster and guard-house, commissary building, dining-room and kitchen, and laundry, built of rough lumber; 2 Ducker portable barracks, each 18 by 35 feet, provided with 12 beds each, and 350 tents, used principally by the single men, the employees and guards, and the colored refugees. So far as known, this is the first camp of the kind ever established; at least, in the United States. The cottages were arranged in a quadrangle around a parade-ground two acres in extent, and the tents were arranged in streets and alleys in the rear of the cottages. The accommodations were sufficient for 600 people, and extra tents were on hand so that, if required, 1000 persons could have been provided for, or 3000 per month, allowing for only ten days' detention of each person. Two hundred hospital tents will accommodate 1200 people comfortably, according to Surgeon Hutton, who states that the small **A**-tents are unsuited for women and children, but will answer for men or boys. Wire-mattress cots should be provided. The Marine-Hospital officer at Savannah, Ga., was the purchasing agent for the camp, and promptly forwarded all subsistence supplies on requisition by mail or telegraph.

Discipline of the Camp.—On arrival of a train, each passenger was personally examined by a physician, his health-certificate scrutinized, and he was made to await the examination of others. Hand-bags, clothing, and loose wearing-apparel were left in the baggage-car for disinfection. The refugees were then conducted to the quartermaster's room for registration and assignment to quarters. On first arrival they were placed in the southern part of the camp, and in two days, there being no sickness, were moved forward several cabins, and this progression was repeated until the time for discharge.

Twelve guards were employed, under the command of a captain, and were divided into squads of four each. The schedule was so arranged that each guard was on duty two hours and off duty four.

A bugler announced the several calls, as follow:—

5.30 A.M.	Reveille.
6.00 A.M.	Breakfast, employés.
7.00 A.M.	Breakfast, guests.
9.00 A.M.	Surgeon's call and inspection.
12.00 M.	Dinner, employés.
1.20 P.M.	Dinner, guests.
4.30 P.M.	Surgeon's call and inspection.
5.30 P.M.	Supper, guests.
6.00 P.M.	Supper, employés.
6.30 P.M.	Retreat and change of guard.
9.00 P.M.	Retiring taps.

The yellow-fever hospital camp, under the special charge of Dr. Faget, was located one-half mile from the probation camp. It consisted of 2 frame buildings, 2 hospital and 12 smaller tents, arranged in a double-crescent shape, the avenue in the middle presenting an attractive appearance.

Of the 12 small tents, 4 were for nurses, 3 for employees, 2 for convalescents, and 1 each for drug-store, storage- and dead-house. One of the hospital tents was used as a dining-room for employees, convalescents, and parents of the sick.

The hospital was established September 3, 1888, and between that date and November 24th 35 cases of yellow fever were admitted and treated, 3 died, and 32 were discharged. Twelve hundred and eleven refugees were received into Camp Perry, nearly all of whom were from the infected district of Jacksonville.

Thirty-five cases of yellow fever were caught by the ten days' detention, but no case of fever was contracted at the camp, and of the 1208 refugees who passed the required detention and proceeded to different parts of the country, so far as known, not one subsequently developed or carried the disease elsewhere. The general plan of the preventive measures adopted during this epidemic will be described under Railroad Quarantine.

Detention Camp, Waynesville, Ga.—The epidemic of yellow fever in Brunswick, Ga., in 1893, caused the establishment of another camp of probation near Waynesville, Ga. Following is the report of the medical officer in command:—

"SIR: I have the honor to present the following report of the operations of the detention camp near Waynesville, Ga.

"The camp was officially opened for the reception of refugees from Brunswick, Ga., on the 18th of September, 1893, and closed by the order of Surgeon, R. D. Murray, Marine-Hospital Service, permitting the return of all refugees to their homes in Brunswick, November 30, 1893.

"Four hundred and thirty-one persons availed themselves of the privileges of the camp, of whom about two hundred and twenty-five were white and the remainder black and colored.

"The site of the camp was selected by Surgeon W. H. H. Hutton, and was twenty-three miles west of Brunswick, immediately upon and on the south side of the Brunswick and Western Railway, and upon an eminence about twenty-five feet above the level of the surrounding country, which is generally swampy, and within a mile of the margin of what is locally known as the Buffalo Swamp. As is usual in this section, the elevation was covered with a dense growth of yellow-pine, scrub-oak, and black-gum trees. The soil was a gray, sandy loam, overlying a stratum of yellow clay, and the natural drainage of the site in all directions was good.

"On my arrival I found that, under the direction of Surgeon Hutton, an area of two hundred feet had been cleared of trees and undergrowth, and at the four corners of this square rough but substantial buildings had been erected, which were used, respectively, as kitchen, white and colored dining-rooms, guard-room, quartermaster's store-room, executive office, telegraph office, and commissary. A depot and baggage-room were provided at the railway. Along the lines connecting these buildings, at intervals of twelve feet, were placed wall-tents, twelve by fourteen feet, with flies, and subsequently further rows of tents were pitched behind these and opening on streets fourteen feet wide. All tents were provided with substantial floors raised six inches above the ground, and the following equipment was provided: For each inmate, one spring, wire-bottomed cot, one cotton mattress, one hair pillow, two sheets, one pillow-case, and, for each tent, two tin wash-bowls, two tin cups, and two wooden chairs. Remarkable ingenuity was displayed by the inmates in the construction of articles of furniture from packing-cases, waste lumber, etc. The tents proved of good quality in service, and quite comfortable in all weather. It is suggested, however, that any future tents be constructed with a wall two feet higher and of one foot greater pitch. A hospital establishment of two buildings was provided at a distance of one-half mile from the camp. A lofty pine-tree was fitted with a topmast, and served as a staff for the display of the national colors from sunrise to sunset each day.

"The following routine was observed, the calls being given by the bugle:—

5.30 A.M.	Reveille and attendants' breakfast.
6.00 A.M.	Breakfast.
8.00 A.M.	Sick call.
12.00 M.	Dinner.
4.00 P.M.	Sick call.
5.00 P.M.	Supper.
Sunset	Retreat and call to quarters.
9.00 P.M.	Tattoo.
9.15 P.M.	Taps (extinguish lights).

"The meals were substantial, abundant, and as varied as possible. In all cases women and children were served at the first table, and the races were served in separate dining-rooms.

"The following rules were announced, and seemed to work well in practice:—

"1. At reveille all inmates will rise and prepare for breakfast.

"2. All quarters must be clean, floors swept, and beds made up before first sick call.

"3. Meals will be served in the dining-rooms only, and at stated hours, and no meals shall be carried from the dining-rooms to any quarters, except upon the written order of the medical officer, renewed from day to day.

"4. At sick calls all inmates will repair to their quarters, and be there visited and inspected by the medical officer, who will prescribe or advise as he may deem best.

"5. All suspicious cases of disease will be isolated at once, and until such time as the nature of the same may be determined.

"6. All cases of infectious disease will be treated only in the hospital provided for the purpose.

"7. No baggage from infected localities shall be brought into camp until disinfected by such process as may be directed, and only such wearing-apparel as may be deemed absolutely necessary will be brought into camp after the disinfecting process.

"8. All wearing-apparel shall be a second time disinfected before discharge from camp.

"9. Any person taken ill between two sick calls shall at once notify the nearest guard, who will, in turn, at once notify the medical officer.

"10. Guards are enjoined by their vigilance to prevent the commission of any nuisance near any quarters; should such nuisance be discovered, the inmates of the nearest quarters will be required to police the same under the supervision of the guard, who will make report of the same.

"11. Inmates will confine themselves to the inner lines of the camp after retreat (sunset) call.

"12. While innocent enjoyment will be encouraged, the strictest propriety of conduct will be demanded and enforced.

"The discipline of the camp was, in the main, good throughout. But two confinements for misbehavior were required during the entire duration of the camp.

"All baggage was submitted to steam disinfection upon arrival at and departure from camp. The apparatus used was devised by Surgeon H. R. Carter, Marine-Hospital Service, and was constructed in a baggage-car, the steam being supplied by a locomotive.

"In addition to other duties, nearly sixteen hundred cars, boxes, and flats were disinfected for the B. and W. Railway, sulphur fumigation being used for the boxes and drenching with acid solution of bichloride of mercury (1 to 800) for flat cars. This disinfection of cars enabled the traffic into Brunswick to be carried on with a minimum of delay and hardship.

"Two cases of yellow fever occurred among the inmates of the camp, one resulting in recovery, one in death. Both cases occurred in the persons of sailors who had arrived in Brunswick on vessels trading there, and both would seem to show a period of incubation of at least five days, thus justifying our detention of ten days."

THE INFLUENCE OF THE MOSQUITO UPON THE MANAGEMENT OF YELLOW FEVER.

Such was formerly the routine of the management of detention and probation camps. With the advance of definite knowledge on the subject of the etiology and methods of conveying yellow fever, this would be modified in certain particulars where the camp is intended for the prevention of the spread of yellow fever. The disinfection of baggage from the place infected with yellow fever would no longer be required further than to insure the destruction of mosquitoes that might be contained therein; and the methods for the prevention of yellow fever within the camp from cases arising in inmates after entry would be limited to screening them from the access of mosquitoes and to the elimination of places and conditions favorable to the multiplication of the *Stegomyia fasciata*.

THE MANAGEMENT OF EPIDEMICS OF YELLOW FEVER IN THE LIGHT OF THE MOSQUITO TRANSMISSION OF THE DISEASE.

As may be well imagined, the promulgation of the mosquito doctrine of the transmission of yellow fever, and its general acceptance by scientists and sanitarians, has necessitated some radical departures in the handling of epidemics of yellow fever. Whereas it was formerly considered that fomites were the principal agent in the dissemination of the infection, it is now generally recognized that these articles play absolutely no rôle in the transmission of the disease, and that measures for the suppression of an epidemic must be based upon the destruction of the mosquito of the genus *Stegomyia fasciata* and the shielding of actual cases of yellow fever from the attacks of these insects. It seems to be accepted that if there are no mosquitoes of this genus, or if such mosquitoes are not allowed to bite individuals sick with yellow fever, there will be no spreading of the disease.

The following extracts from publications of the Public Health and Marine-Hospital Service show clearly the basis upon which restrictive epidemic measures are founded, and the report of the management of the epidemic of yellow fever in Laredo, Texas, and at various points along the Texas-Mexican border in 1903, give a clear idea of the practical application of measures founded upon this doctrine.

Far from making the work of the sanitarian more easy, this doctrine has necessitated more rigorous care even than was formerly necessary, and it is easy to see that a failure to recognize cases early, to screen them from the bites of mosquitoes, or to destroy mosquitoes and the places favorable for their breeding, will be followed by disastrous results in the shape of a spread of the epidemic. Cases of yellow fever plus the existence of mosquitoes of the genus *Stegomyia fasciata* will always mean more cases of the disease. Absolute shielding of cases of the disease from the attacks of mosquitoes, and the destruction of the breeding places of such mosquitoes, will result in a disappearance of the epidemic. In fact, were all febrile cases of whatever nature protected from the attacks of the insects, and were mosquitoes not allowed to propagate by careful and rigorous attention to the accepted methods for their destruction, there need be no spread of the disease; but a failure in any minute particular to follow out these two principles would render any efforts for the suppression of the epidemic largely negatory.

It is notoriously a matter of difficulty to recognize cases of yellow fever in a city or locality where the disease has not recently prevailed in epidemic form, and therefore too much stress cannot be laid upon the necessity of screening all febrile cases until a positive diagnosis can be made. This applies equally to the conveyance of malarial fevers by mosquitoes of the genus *Anopheles,* as to yellow fever by the *Stegomyia.* Not only is the mosquito dangerous to the public health, but the malarial or yellow fever patient is prejudicial to the *Anopheles* or *Stegomyia* by infecting it prior to rendering it a vehicle for the transmission of infection. The infection of yellow fever is only contained in the blood of the yellow-fever patient during the first three or four days of the malady, and by this time the nature of the illness can usually be determined.

THE CAMPAIGN OF PROPHYLAXIS AGAINST YELLOW FEVER ON THE TEXAS-MEXICAN BORDER, 1903-04.

The epidemic of 1903 having ended, it became necessary, in view of sanitary and climatic conditions, to inaugurate a vigorous campaign of prophylaxis along the Texas-Mexican border and in all places in Texas where the disease had prevailed during 1903, to guard against a recrudescence of the fever in the spring of 1904.

"A sanitary inspection of the territory situated in the triangles between San Antonio, Laredo, Corpus Christi, and Brownsville was inaugurated and officers detailed to investigate the conditions along the lines of railway travel to detect any possible recrudescence of the disease. A campaign of instruction, showing the methods of drainage, destruction of mosquitoes, oiling of water-containers, etc., and the screening of all yellow fever patients, was carried out, supplemented with aid in fumigation of premises, etc., where requested, and no doubt the generally satisfactory condition of affairs at this time

(September 30, 1904) is due to this early anticipatory sanitary campaign in aid of the State and local authorities.

"In addition to the measures already enumerated, it was considered advisable as a precautionary measure to prepare, pack, and store small camp outfits at five points upon the Louisiana-Texas border, thereby saving time in shipment should an emergency arise. These camp outfits were accordingly stored at the selected points."

It is pertinent to add that the measures were entirely successful, no yellow fever making its appearance in Texas during the summer of 1904.

RAILROAD QUARANTINE AND INSPECTION SERVICE.

Railroad quarantine and inspection service may be described by a brief account of the actual measures of this nature made use of during the yellow-fever epidemic in Florida, in 1888, of which Camp Perry, just described, was an important adjunct. (For details, see annual reports Marine-Hospital Service, 1888 and 1889.)

The Governor of Florida made application to the national authorities, July 16th, for aid, and it was determined to prevent further spread of the disease by disinfecting all baggage from infected localities before permitting its transportation into other States, and by enforcing, upon all persons from infected localities seeking to leave the State, a probationary detention of ten days.

Accordingly, disinfection stations were established at two points, through which all persons leaving Florida by rail were obliged to pass. One of these was at Live Oak, in Northwestern Florida; the other at Way Cross, Georgia, near the boundary-line of Northeastern Florida. The only other means of egress from the State was from the seaports; but healthy sea-ports maintained a vigorous quarantine against people from the infected districts, and infected sea-ports were not visited by the steam-ship lines, because their vessels would thereby be made liable to quarantine detention at other ports. The fumigation of baggage at Live Oak and Way Cross was accomplished by means of box-cars specially prepared, and subsequently in warehouses, the agent being sulphur dioxide.

Regarding persons, the inspectors, properly uniformed and wearing official shields, boarded the trains when the latter arrived at the inspection stations, and demanded of each passenger a certificate, showing where he had been during the previous ten days, which certificate was considered valid only when it bore the seal or signature of some officer of health, or recognized municipal authority. The inspectors themselves were kept informed regarding all infected or suspected localities, and a person coming from such locality was either made to return to it or given the option of going to the camp of probation, there to spend the ten days' period of probation before being allowed to enter other States.

This was Camp Perry, previously described, located 38 miles south of the Way Cross Station, and 40 miles north of Jacksonville, where the epidemic prevailed chiefly. All egress from Jacksonville was, perforce, through Camp Perry and its ten days' probation.

This camp was a means of protecting not only other States, but the uninfected portions of Florida itself, more particularly Southern Florida, whose health authorities refused to admit within their limits the refugees from the infected districts unless they had passed the period of probation at Camp Perry. To assist in this protection to Southern Florida, no person was allowed to board a south-bound train between Way Cross, on the north, and Orange Park, a station 20 miles south of Jacksonville.

Moreover, through south-bound trains were boarded at Way Cross, and all passengers compelled to furnish evidence of coming from healthful localities. The evidence consisted of certificates from local authorities, baggage-checks, or railroad-tickets showing they were purchased in the North, and in some instances letters showing by the superscription and stamps where the person had been.

No train, excepting the special government train, was allowed to stop at Camp Perry. A government train also carried those who had passed the period of probation from Camp Perry to a point 3½ miles distant, Folkstone, where they were transferred to a regular train running as far north as Way Cross, Ga., where another transfer had to be made to a regular north-bound train. No Florida passenger-car was allowed to go north, and more than 1000 baggage- and freight-cars were disinfected by government officers before being allowed to leave the State.

Train-inspection Service during the Brunswick Epidemic.—During the Brunswick epidemic the following regulations for the inspection of trains were promulgated and enforced:—

"Inspectors will allow none to board a train, unless with a certificate, between Way Cross and Savannah.

"If certificate can be examined before boarding, without detention to train, it must be done, and those which are unsatisfactory will not be allowed to board.

"After boarding, the certificate and the person must be carefully examined and the inspector assure himself that the passenger is not recently from Jesup or any infected locality.

"If the passenger is known to be a recent resident of Jesup or any infected locality, or to have been in such place during the past two (2) weeks, he will not be allowed to board, even if he has a certificate.

"If, after boarding, either the certificate or the examination of passengers is not satisfactory, the passenger will be turned over to the city authorities at Way Cross or Savannah, or at the place where he desires to stop. If between these places, the facts to be noted and reported.

"A record will be kept of the names of all passengers inspected, name of signer of certificate and his rank, date of inspection, date of certificate, and place of boarding train; and where passenger is bound and what disposition is made of him, whether passed or turned over to local authorities; also any other facts worth notice.

"Inspectors will aid local quarantine authorities in any way in their power consistent with their duties, and give them any information, obeying all local quarantine regulations. Inspectors report to Surgeon Carter, United States Marine-Hospital Service, or A. P. English, M.D."

The methods of railroad quarantine may also be studied in a review of the action taken to prevent the introduction of small-pox into the United States from Canada, where it prevailed extensively in the fall and winter of 1885, and January and February, 1886.

The following regulations were issued by the Surgeon-General of the Marine-Hospital Service, October 10, 1885:—

"The act approved April 29, 1878, entitled "An act to prevent the introduction of contagious or infectious diseases into the United States," provides that no vessel or vehicle coming from any foreign port or country where any contagious or infectious disease exists, or any vessel or vehicle conveying persons, merchandise, or animals affected with any contagious disease, shall enter any port of the United States, or pass the boundary-line between the United States and any foreign country, except in such manner as may be prescribed under said act.

"Attention is now directed to the prevalence of the contagious and infectious disease of small-pox in Montreal and other places in the Dominion of Canada, and the law referred to is held to apply alike to trains of cars and other vehicles crossing the border, and to vessels entering ports on the northern frontier.

"Because, therefore, of the danger which attaches to the transportation of persons and baggage, and articles of merchandise, or animals, from the infected districts, the following regulations are framed, under the direction of the Secretary of the Treasury, and subject to the approval of the President, for the protection of the health of the people of the United States against the danger referred to:—

"1. Until further orders all vessels arriving from ports in Canada, and trains of cars and other vehicles crossing the border-line, must be examined by a medical inspector of the Marine-Hospital Service before they will be allowed to enter the United States, unless provision shall have been made by State or municipal quarantine laws and regulations for such examination.

"2. All persons arriving from Canada, by rail or otherwise, must be examined by such medical inspector before they will be allowed to enter the United States, unless provision has been made for such examination.

"3. All persons coming from infected districts, not giving satisfactory evidence of protection against small-pox, will be prohibited from proceeding into the United States until after such period as the medical inspector, the local quarantine, or other sanitary officer duly authorized, may direct.

"4. The inspectors will vaccinate all unprotected persons, who desire or are willing to submit to vaccination, free of charge. Any such person refusing to be vaccinated shall be prevented from entering the United States.

"5. All baggage, clothing, and other effects, and articles of merchandise, coming from infected districts, and liable to carry infection, or suspected of being infected, will be subjected to thorough disinfection.

"6. All persons showing evidence of having had small-pox or varioloid, or who exhibit a well-defined mark of recent vaccination, may be considered protected; but the wearing-apparel and baggage of such protected persons who may come from infected districts, or have been exposed to infection, will be subjected to thorough disinfection as provided.

"7. Customs officers and United States medical inspectors will consult and act in conjunction with authorized State and local health authorities so far as may be practicable, and unnecessary detention of trains or other vehicles, persons, animals, baggage, or merchandise, will be avoided so far as may be consistent with the prevention of the introduction of disease dangerous to the public health into the United States.

"8. Inspectors will make full weekly reports of services performed under this regulation.

"9. As provided in Section 5 of said act, all quarantine officers or agents acting under any State or municipal system, upon the application of the respective State or municipal authorities, are empowered to enforce the provisions of these regulations, and are hereby authorized to prevent the entrance into the United States of any vessel or vehicle, person, merchandise, or animals prohibited under the act aforesaid.

"10. In the enforcement of these regulations there shall be no interference with any quarantine laws or regulations existing under or to be provided for by any State or municipal authority."

The following are the special instructions for the guidance of sanitary inspectors, issued by Surgeon H. W. Austin, in charge of the inspection service on the Canadian frontier from Buffalo, N. Y., to the Atlantic coast during the epidemic above referred to (see Marine-Hospital Report, 1886) :—

Regulations for Sanitary Inspectors.

"The following instructions will be observed by the sanitary inspector on the following-mentioned railroads crossing the United States boundary-line—viz., the Grand Trunk Railway, at Rouse's Point, N. Y., and Island Pond, Vt.; the Passumpsic Railroad, at Newport, Vt.; the Central Vermont Railroad, at Highgate Springs or Saint Albans; the Canada Atlantic, at Rouse's Point, N. Y., and the Southeastern Railway, at Richford, Vt.:—

"All persons bound for the United States coming from Montreal, or other places in Canada where small-pox prevails, must produce satisfactory evidence to the inspector that they are protected by a recent vaccination, or submit to this operation before they are allowed to cross the boundary-line.

"Inspectors will vaccinate all unprotected persons free of charge.

"Persons coming from Montreal, or suburban villages, will be carefully questioned as to their residence, whether small-pox has occurred in their families, or whether they have been in contact with the disease.

"Inquiries should also be made relative to their baggage, whether it consists of bedding, household goods, etc., likely to be infected; and if any person or article of baggage is considered by the inspector infected or likely to introduce the disease into the country, he or it should not be permitted to cross the line into the United States.

"You may consider persons protected who may show evidence of having had the small-pox or varioloid, or who exhibit a well-defined mark of vaccination. Accept as evidence of protection a certificate from any physician in good standing that the person presenting the same has been successfully vaccinated. Should you doubt the validity or authenticity of the certificate, you may refuse any such person presenting the same the privilege of crossing the border unless he submits to vaccination. Baggage known to have come from any infected district, and believed to be infected, will be thoroughly fumigated with sulphur at Rouse's Point, Saint Albans, Richford, Newport, and Island Pond.

"Weekly reports should be made to Surgeon H. W. Austin, United States Marine-Hospital Service, Burlington, Vt., of the number of trains inspected, number of persons examined, number of persons vaccinated, number of pieces of baggage fumigated, and any other information relative to services performed by the inspector."

It will be observed that all the railroads, five in number, over which passengers or freight might be brought direct from Canada into the New England States, were guarded.

Besides the line commanded by Surgeon Austin (Atlantic coast to Buffalo), another line was under the direction of Passed Assistant Surgeon Wheeler, at points east of Buffalo, and still another on the Michigan frontier, under command of Surgeon W. H. Long. These lines were established at the request and with the co-operation of the authorities of the respective States. Thirty-six inspectors were employed at 37 stations, who examined 49,631 persons on railroad-trains, vaccinated 16,547, and detained or sent back 603. The contents of more than 7000 pieces of baggage were disinfected. The measures taken were successful.

In 1893, at a time when there was imminent danger that cholera might be introduced into the sea-board cities of the United States and carried by immigrants to the far West and the interior cities and towns, a most carefully formulated plan of railroad medical inspection of immigrants was drawn up; and while it was, fortunately, never necessary to carry out the provisions made at the time, the following regulations will well show the scope and general design of the protective and restrictive measures contemplated:—

RAILROAD MEDICAL INSPECTION OF IMMIGRANTS.

TREASURY DEPARTMENT,
Office of the Supervising Surgeon-General United States
Marine-Hospital Service,

WASHINGTON, AUGUST 23, 1893.

Instructions for the Guidance of Medical Officers of the Marine-Hospital Service, Sanitary Inspectors, and others concerned.

1. One or more medical inspectors shall accompany immigrants from the point of departure of each immigrant train, and shall immediately commence making a careful inspection of every passenger—man, woman, and child—upon the train. This inspection shall consist in identifying each passenger with the health card or cards he or she may hold, and satisfying himself as to the health of each person at the time of said inspection. He shall pass through the train once every hour or oftener, if he has reason to believe any person is suffering with diarrhœa or other symptoms of cholera.

2. The railroad companies will be expected to furnish earth-closets, which should be used, and the regular closets of the car are to be locked. These earth-closets shall be destroyed, before the train reaches it destination, at such points as the railroad officials shall designate. It shall be the duty of the inspector to see that the earth-closets are kept clean and frequently disinfected, and the cars properly ventilated and free from all offensive odors and dirt.

3. He shall, upon the least suspicion of cholera among the immigrants, have the suspected person or persons immediately removed to the hospital car at the rear of the train, disinfect all ejecta, and take every precaution possible to prevent the spread of the disease among the passengers by thoroughly disinfecting that portion of the car occupied by the suspects, the simplest means for this purpose being a solution of bichloride of mercury in the proportion of 1 to 800.

4. The inspectors will at once notify the conductor of the train upon the first appearance of a suspicious case, in order that the hospital car may be switched off at the first designated switch, and the health officer of the county in which said switch is located be immediately notified to take charge of this car.

5. It is expected that the railroads will furnish a car for hospital purposes, in which the seats can be readily converted into beds suitable for the care of the sick. The necessary bedding will be furnished by the United States Marine-Hospital Service.

6. Disinfectants, consisting of packages of bichloride of mercury

and an alkali, will be furnished the medical inspector in proper quantities for adding to a two-gallon wooden bucket of water; also a quantity of carbolic acid in solution and other approved disinfectants. Each hospital car shall be equipped with a dozen two-gallon wooden buckets for holding disinfecting fluids, half a dozen mops, one or more hand force-pumps with rose sprinklers, one or more commodes and bed-pans, half a dozen eight-ounce hard-rubber syringes, half a dozen tumblers, one dozen rubber sheets, and one dozen feeding-cups for administering medicine. There shall also be furnished an oil-stove for heating water, and several tin boilers and tin cups.

7. *Medical supplies, etc.,* consisting of tannic acid, hydrarg. chloridum mite, tincture of opium, mustard or mustard papers, chloroform or ether sulph., whisky, brandy, and one or more hypodermic syringes; also supply of Squibb's Diarrhœa Mixture for checking looseness of the bowels or premonitory diarrhœa.

WALTER WYMAN,
Supervising Surgeon-General.

INTERSTATE QUARANTINE.

The general principles governing interstate quarantine are the same as those pertaining to the maritime and foreign quarantines, with the exception that, instead of dealing with ships as the media of transportation, we must deal with trains on railroads, lines of stage-coaches, and steam-boats plying on the inland waters of the United States. The principles are almost sufficiently elaborated in the previous sections on train inspection in the case of yellow-fever epidemics, and the precautions which were under consideration for the prevention of the spread of cholera by means of emigrant trains.

An important matter is the one of notification. It will be seen, by a study of the regulations for interstate quarantine which follow, that State and municipal health officers are requested to notify the Supervising Surgeon-General of the appearance of any of the quarantinable diseases in their States or localities, thus enabling appropriate measures to be taken to prevent their spread without the loss of valuable time, for time in the management of epidemics is of the utmost importance. Many an epidemic which has assumed vast proportions would, if recognized in time, have been capable of easy management and of being confined to the seat of its first outbreak. It is always comparatively easy to confront an open enemy; it is the insidious spread of disease, either unrecognized or concealed for reasons of business policy, that causes delay in the inception of preventive measures, and is most to be dreaded from a sanitary standpoint.

The following are the regulations prepared in the Marine-Hospital Bureau to prevent the introduction of contagious diseases into one State or Territory or the District of Columbia from another State or Territory or District of Columbia. It is expected that additional regulations will be promulgated from time to time as circumstances demand:—

Interstate Quarantine.

ARTICLE I.—QUARANTINE DISEASES.

1. For the purpose of these regulations the quarantinable diseases are cholera (cholerine), yellow fever, small-pox, typhus fever, leprosy, and plague.

ARTICLE II.—NOTIFICATION.

1. State and municipal health officers should immediately notify the Supervising Surgeon-General of the United States Marine-Hospital Service, by telegraph or by letter, of the existence of any of the above-mentioned quarantinable diseases in their respective States or localities.

ARTICLE III.—GENERAL REGULATIONS.

1. Persons suffering from a quarantinable disease shall be isolated until no longer capable of transmitting the disease to others. Persons exposed to the infection of a quarantinable disease shall be isolated, under observation, for such a period of time as may be necessary to demonstrate their freedom from the disease.

All articles pertaining to such persons, liable to convey infection, shall be disinfected as hereinafter provided.

2. The apartments occupied by persons suffering from quarantinable disease, and adjoining apartments, when deemed infected, together with articles therein, shall be disinfected upon the termination of the disease.

3. Communication shall not be held with the above-named persons and apartments, except under the direction of a duly-qualified officer.

4. All cases of quarantinable disease, and all cases suspected of belonging to this class, shall be at once reported by the physician in attendance to the proper authorities.

5. No common carrier shall accept for transportation any person

suffering with a quarantinable disease, nor any infected article of clothing, bedding, or personal property.

Bodies of persons who have died from any of the said diseases shall not be transported save in hermetically-sealed coffins, and by the order of the State or local health officer.

6. In the event of the prevalence of small-pox, all persons exposed to the infection, who are not protected by vaccination or a previous attack of the disease, shall be at once vaccinated or isolated for a period of fourteen days.

7. During the prevalence of cholera, all the dejecta of cholera patients shall be at once disinfected, as hereinafter provided, to prevent possible contamination of the food- and water-supply.

ARTICLE IV.—YELLOW FEVER.

In addition to the foregoing regulations contained in Article I, the following special provisions are made with regard to the prevention of the introduction and spread of yellow fever:—

1. Localities infected with yellow fever, and localities contiguous thereto, should be depopulated as rapidly and as completely as possible, so far as the same can be safely done; persons from non-infected localities, and who have not been exposed to infection, being allowed to leave without detention. Those who have been exposed, or who came from infected localities, shall be required to undergo a period of detention and observation of ten days, from the date of last exposure, in a camp of probation or other designated place.

Clothing and other articles capable of conveying infection shall not be transported to non-infected localities without disinfection, *i.e.*, inspection to determine the presence of possibly infected mosquitoes, and appropriate measures of fumigation to destroy them.

2. Persons who have been exposed may be permitted to proceed without detention to places willing to receive them, and incapable of becoming infected, when arrangements have been perfected to the satisfaction of the proper health officer to insure their detention in said places for a period of ten days.

3. The suspects who are isolated under the provisions of paragraph 1, Article III, shall be kept free from all possibility of infection.

4. So far as possible the sick should be removed to a central location for treatment.

5. Buildings in which yellow fever has occurred, and localities believed to be infected with said disease, must be disinfected as thoroughly as possible.

6. As soon as the disease becomes epidemic, the railroad-trains carrying persons allowed to depart from the city or place infected with yellow fever shall be under medical supervision.

7. Common carriers from the infected districts, or believed to be carrying persons and effects capable of conveying infection, shall be subject to sanitary inspection, and such persons and effects shall not be allowed to proceed, except as provided for by paragraph 2.

8. At the close of an epidemic the houses where sickness has occurred, and the contents of the same, and houses and contents that are presumably infected, shall be disinfected as hereinafter prescribed.

ARTICLE V.—DISINFECTION.

For Cholera.

1. The dejecta and vomited matters of cholera patients shall be received into vessels containing an acid solution of bichloride of mercury (bichloride of mercury, 1 part; hydrochloric acid, 2 parts; water, 1000 parts) or other efficient germicidal agent.

2. All bedding, clothing, and wearing-apparel soiled by the discharges of cholera patients shall be disinfected by one or more of the following methods:—

(*a*) By complete immersion for thirty minutes in one of the above-named disinfecting solutions.

(*b*) By boiling for fifteen minutes, all articles to be completely submerged.

(*c*) By exposure to steam at a temperature of 100° to 102° C. for thirty minutes after such temperature is reached.

3. Any woodwork or furniture contaminated by cholera discharges shall be disinfected by thorough washing with a germicidal solution as provided in paragraph 1, Article V.

For Yellow Fever.

4. Apartments infected by occupancy of patients sick with yellow fever shall be disinfected by one or more of the following methods:—

(*a*) By thorough washing with one of the germicidal solutions mentioned. If apprehension is felt as to the poisonous effects of the mercury, the surfaces may, after two hours, be washed with clear water.

(*b*) Thorough washing with a 5-per-cent. solution of pure carbolic acid.

(*c*) By sulphur dioxide, twenty-four to forty-eight hours' exposure, the apartments to be rendered as air-tight as possible.

5. Bedding, wearing-apparel, carpets, hangings, and draperies infected by yellow fever shall be disinfected by one of the following methods:—

(*a*) By exposure to steam at a temperature of 100° to 102° C. for thirty minutes after such temperature is reached.

(*b*) By boiling for fifteen minutes, all articles to be completely submerged.

(*c*) By thorough saturation in a solution of bichloride of mercury, 1 to 1000, the articles being allowed to dry before washing.

Articles injured by steam (rubber, leather, containers, etc.), to the disinfection of which steam is inapplicable, shall be disinfected by thoroughly wetting all surfaces with (*a*) a solution of bichloride of mercury 1 to 800, or (*b*) a 5-per-cent. solution of carbolic acid, the articles being allowed to dry in the open air prior to being washed with water, or (*c*) by exposure to sulphur fumigation in an apartment air-tight, or as nearly so as possible.

(Recent investigations have proved that in disinfection for yellow fever less attention need be paid to fomites, but more to the extermination of mosquitoes.)

For Small-pox.

6. Apartments infected by small-pox shall be disinfected by one or both of the following methods:—

(*a*) Exposure to sulphur dioxide for twenty-four to forty-eight hours.

(*b*) Washing with a solution of bichloride of mercury 1 to 1000, or a 5-per-cent. solution of pure carbolic acid.

7. Clothing, bedding, and articles of furniture exposed to the infection of small-pox shall be disinfected by one or more of the following methods:—

(*a*) Exposure to sulphur dioxide for twenty-four to forty-eight hours.

(*b*) Immersion in a solution of bichloride of mercury 1 to 1000, or a 5-per-cent. solution of pure carbolic acid.

(*c*) Exposure to steam at a temperature of 100° to 102° C. for thirty minutes after such temperature is reached.

(*d*) Boiling for fifteen minutes; the articles to be completely submerged.

For Typhus Fever.

8. Apartments infected by typhus fever shall be disinfected by one or both of the following methods:—

(*a*) Exposure to sulphur dioxide for twenty-four to forty-eight hours.

(*b*) Washing with a solution of bichloride of mercury 1 to 1000, or a 5-per-cent. solution of pure carbolic acid.

9. Clothing, bedding, and articles of furniture exposed to the infection of typhus fever, shall be disinfected by one or more of the following methods:—

(*a*) Exposure to sulphur dioxide for twenty-four to forty-eight hours.

(*b*) Immersion in a solution of bichloride of mercury 1 to 1000, or a 5-per-cent. solution of pure carbolic acid.

(*c*) Exposure to steam at a temperature of 100° to 102° C. for thirty minutes after such temperature is reached.

(*d*) Boiling for fifteen minutes, the articles to be completely submerged.

(Lately fumigation with formaldehyde gas has taken the place of sulphur dioxide.)

MUNICIPAL QUARANTINE.

It is now generally conceded that a small number of cases of certain ones of the quarantinable diseases may exist in a city of considerable size, without giving rise to serious apprehension, if intelligent and vigorous measures for the prevention of its spread are taken, and if scientific measures for the isolation of patients, the surveillance of those exposed to infection, and the disinfection of apartments and articles infected are carried out. It is regarded as very important that the sick should be removed to centrally-located hospital establishments for treatment, thus increasing ease of management and administration, and diminishing the number of foci of infection. The surveillance of those exposed to infection should, in general, be for a period of time equal to the usual period of incubation of the disease to which they have been exposed. In the case of small-pox it may be unnecessary at times to detain the suspects the full period of incubation, provided they are vaccinated and their clothing and personal effects are rendered safe by efficient disinfection. They should, however, be kept under observation.

For the suppression of small-pox in cities in which it has made its appearance, and in which it threatens to become epidemic, the following suggestions, made by the health authorities of the Northwest, will undoubtedly prove of value:—

1. The city should be divided into districts containing not more than 10,000 people.

2. Each district should be placed under the supervision of a competent medical inspector with necessary assistants (*a*) to make a house-to-house inspection; (*b*) to successfully vaccinate, within the shortest possible time, all persons who have not been vaccinated during the outbreak, the first vaccination to be completed within seven days; (*c*) to properly disinfect all houses and their contents where small-pox occurs.

3. Necessary means and appliances for efficient disinfection of materials, premises, etc., should be provided as the exigencies of each district may require.

4. Each case of small-pox should be immediately removed to a suitably constructed and properly equipped and officered isolation hospital.

5. Except in extreme cold weather, hospital tents, as prescribed in the United States Army Regulations, floored and warmed, are preferable to the average hospital or private dwelling, and increase the chances of recovery of the patients. Cases of small-pox necessarily retained in their own homes should, with their attendants, be rigidly isolated during the period of danger, and physicians visiting such patients professionally should be subject to such regulations as may be prescribed by the local health officer.

6. Persons exposed to small-pox contagion should be immediately vaccinated and kept under observation for not less than fourteen days from time of last exposure.

7. It is the sense of this Conference that unless such measures are enforced, it will be necessary for neighboring cities and States to exclude all persons from such city who are not protected against small-pox by recent vaccination, and to require proper disinfection of all clothing, baggage, and merchandise capable of conveying small-pox infection.

The subject of municipal quarantine naturally suggests a subdivision of the subject, viz., domiciliary quarantine, or the exercise of restrictive measures against a particular house or part of a house on account of the occurrence of a quarantinable disease within its limits. These can best be accomplished by the stationing of guards to see that none enter or leave the infected premises except those necessary to care for the sick, viz., physicians and nurses. All intercourse between the outside world and the house under quarantine should be carried on by messengers who should not be allowed to enter the premises, but who should report to the guards.

It would be most desirable that the physicians and nurses, on leaving the premises, should practice personal disinfection of hands, at least; though, of course, it would be better if, in addition to this, a change into sterile clothing were made prior to coming into contact with the public.

It goes without saying that the room of the patient should be absolutely closed to the ingress of all save the physicians and nurses, and it is a practice of considerable value to provide all room-openings with curtains or hangings, which are to be kept constantly wet with a germicidal solution. The dejecta, vomited matter, and sputum should be promptly disinfected according to circumstances. When the disease has terminated, the house or apartments are to be thoroughly disinfected by one of the methods prescribed in the regulations, the method chosen being adapted to the disease which has prevailed. For the purposes of municipal disinfection the Marine-Hospital Service has had constructed portable apparatus for the use of steam and sulphur, which are, in effect, the same apparatus as have been previously described in this article, modified to meet their special requirements.

An important factor in the measures taken to suppress any epidemic disease is a house-to-house inspection, to ascertain the actual number of cases existing. Whether this inspection should include the whole city, or only the infected district, is a matter for the exercise of judgment; but, when required, the inspections should be made at intervals corresponding with the usual periods of incubation of the disease under observation.

A very important field for the exercise of municipal and domiciliary quarantine is furnished by those contagious and infectious diseases which, while causing large mortality, seldom prevail in epidemic form, viz., measles, scarlet fever, diphtheria, and tuberculosis.

MEASLES.

Measles may be dismissed with a few words. The course of the disease, uncomplicated, is usually so benign, especially in children, that all that is necessary is isolation. At the conclusion of the case or cases the apartment should be well aired, and it may be advisable to subject the room and the contents, bedding, and clothing to fumigation by sulphur or formaldehyde.

DIPHTHERIA AND SCARLET FEVER.

With diphtheria and scarlet fever the conditions are far different. The diseases are virulent: the infection is subtle, and their spread very much to be dreaded. Vigorous effort alone can prevent their spread. Dwellings where the disease prevails must be placarded, special hospitals should be provided, and disinfection should be intelligently performed by competent municipal authority.

The regulations of the Board of Health of the District of Columbia are given here, as embodying the more recent practice in the management of these diseases:—

Regulations to Prevent the Spread of Diphtheria and Scarlet Fever.

"The following regulations, provided for in the Act of Congress approved December 20, 1890, are promulgated for the information of all concerned:—

"The act referred to provides, in Section 2, 'That it shall be the duty of the health officer, in conjunction with the attending physician, to cause the premises to be properly disinfected, and to issue the necessary instructions for the isolation of the patient; in Section 3, 'That it shall be the duty of physicians, while in attendance upon cases of scarlet fever and diphtheria, to exercise such reasonable precautions to prevent the spread of the said diseases as may be prescribed by the health officer of the District of Columbia in regulations'; in Section 6, 'That the word "regulations," as herein used, shall be held to mean, also, rules, orders, and amendments.'

"The term 'scarlet fever,' as applied in the act, shall be held to include scarlatina, scarlet rash, and canker rash, and *each and every case* must be reported upon the forms provided.

"Warning-signs shall remain displayed on houses, in cases of scarlet fever, for a period of not less than four weeks, and in cases of diphtheria for not less than three weeks from date of report to the health officer, and for a longer period, unless report of recovery by the physician in attendance has been made.

"In cases of death, the warning-sign shall remain displayed upon premises for a period of not less than seven days, and longer, unless the health officer is satisfied that all proper means have been employed for prevention of the spread of the contagion.

"It shall be the duty of the householder, in every case where a warning-sign has been displayed from the premises which he or she occupies, to report promptly the removal of such sign at any time within the periods given.

"It shall be the like duty of the physician in attendance to make such report to the health officer of the removal of warning-signs, unless assured that the report has been made by some one from the premises where the disease is prevailing or has prevailed.

"It shall be the duty of the physician in attendance to report, in every instance, on the forms provided, whether or not children in the family or other children in the same building attend school, and at what school-building or buildings.

"Children shall not be permitted to return to school from infected premises, except upon presentation of the proper certificate from the health officer.

"All persons suffering from either diphtheria or scarlet fever are to be isolated in rooms as far removed as possible from those occupied by other persons in the building, and upon the top floor, where it is practicable. No person, other than the physician in attendance, the examining official, and the nurse or nurses, shall be admitted to such room during the prevalence of the disease.

"Every room occupied by a patient suffering from either diphtheria or scarlet fever shall be cleared of all needless clothing, carpets, drapery, and other materials likely to harbor the poisons of the disease.

"Soiled bed- and body-linen shall be immediately placed in vessels of water containing a solution of bichloride of mercury, chloride of zinc, or other suitable disinfectant.

"Excremental discharges from the patient shall be received in vessels of water containing such a solution, and all vessels used shall be kept scrupulously clean and thoroughly disinfected.

"Discharges from the throat, nose, and mouth shall be received upon pieces of cloth, which must be immediately burned.

"All persons recovering from either diphtheria or scarlet fever shall be considered *dangerous,* and shall not be permitted to associate with others, or to attend school, church, or any public assembly, until a certificate has been furnished by the health officer to the effect that they may go abroad without danger of disseminating the contagion.

"It shall be the duty of the person in charge of the premises where a case of diphtheria or scarlet fever exists, to exercise all reasonable care in the prevention of the commingling of persons who come into contact with the patient, or any other persons, whereby the contagion might be disseminated.

"The body of a person who died from either diphtheria or scarlet fever shall be immediately disinfected and placed in a coffin, which shall be tightly closed, and shall not be taken to any church or place of public assembly, and shall be buried within forty-eight hours, unless otherwise ordered by the health officer.

"No public funeral shall be held in a dwelling in which there is a case of either diphtheria or scarlet fever, nor in which a death from either of said diseases has recently occurred.

"Immediately upon the recovery of a person who has been suffering from either diphtheria or scarlet fever, or upon the death of a person who has been so suffering, the room or rooms occupied shall be thoroughly disinfected by exposure for several hours to the fumes of chlorine gas, or of burning sulphur, and shall thereafter be thoroughly cleaned and exposed to currents of fresh air.

"All clothing, bedding, carpets, and other textiles which have been exposed to the contagion of the disease shall be either burned, exposed to superheated steam, or thoroughly boiled.

"No person shall interfere with or obstruct the entrance, inspection, and examination of any building or house, by the inspectors or officers of this department, when there has been reported the case of a person sick with either scarlet fever or diphtheria therein."

Diagnosis of Diphtheria.—For the more prompt and certain diagnosis of diphtheria, small wooden boxes are distributed to the various pharmacies in Washington, each box holding two glass tubes, one tube containing a small cotton swab, the other containing solidified blood-serum as a culture medium. Each tube is sterilized and plugged with cotton. The following notice is inclosed in each box:—

Directions for Making Cultures in Suspected Cases of Diphtheria.

"The patient should be placed in the best light attainable. and, if a child, properly held. In cases where it is possible to get a good view of the throat, depress the tongue and rub the cotton swab gently, but freely, against any visible pseudomembrane or exudate.[7]

"In other cases, including those in which the exudate is confined to the larynx, open the mouth and pass the swab back till it reaches

[7] This should be done before any germicide has been applied, and, if this has been done, allow at least an hour to intervene before making the inoculation.

the pharynx, and then rub it freely against the mucous membrane. Without laying the swab down, withdrew the cotton plug from the culture-tube, insert the swab, and rub that portion of it which has touched the exudate gently back and forth along the surface of the blood-serum. Then replace the swab in its own tube, plug both tubes, and send the whole outfit at once to the laboratory.

"A report will be forwarded the following morning, by mail, or can be obtained by telephone."

TUBERCULOSIS.

With the discovery by Koch of the cause of tuberculosis, and the numerous researches made by him and other observers into the nature of the tuberculous poison, has grown conviction, of late years, that tuberculosis, being communicable, is to a large extent preventable. The *bacillus tuberculosis*, is the etiological factor of most importance in the spread of tuberculosis; it has been proved that it is contained in large numbers in the sputum of tuberculous patients, and that, unlike most microörganisms, its vitality is not destroyed by drying. Therefore, with the careful disinfection or destruction of the expectoration of tuberculous patients, one most important factor in the dissemination of tuberculosis will be removed. In almost all large hospitals, at the present day, the practice obtains of either isolating the tuberculous patients or of segregating them in special wards or apartments. With a view of preventing the spread of tuberculosis, the Board of Health of New York City has issued in English, German, Hebrew, and Italian the following circular for popular instruction:—

"Consumption is a disease which can be taken from others, and is not simply caused by colds. A cold may make it easier to take the disease. It is usually caused by germs which enter the body with the air breathed. The matter which consumptives cough or spit up contains these germs in great numbers; frequently millions are discharged in a single day. This matter, spit upon the floor, wall, or elsewhere, is apt to dry, become pulverized, and float in the air as dust. This dust contains the germs, and thus they enter the body with the air breathed. The breath of a consumptive does not contain the germs, and will not produce the disease. A well person catches the disease from a consumptive only by in some way taking the matter coughed up by the consumptive.

"Consumption can often be cured if its nature is recognized early and proper means are taken for its treatment. In a majority of cases it is not a fatal disease.

"It is not dangerous for other persons to live with a consumptive if the matter coughed up by the consumptive is at once destroyed. This matter should not be spit upon the floor, carpet, stove, wall, or street, or anywhere except into a cup kept for that purpose. The cup should contain water, so that the matter may not dry, and should be emptied into the closet at least twice a day, and carefully washed with hot water. Great care should be taken by a consumptive that his hands, face, and clothing do not become soiled with the matter coughed up. If they do become soiled, they should be at once washed with hot water and soap. When consumptives are away from home, the matter coughed up may be received on cloths, which should be at once burned on returning home. If handkerchiefs are used (worthless cloths which can be burned are far better), they should be boiled in water by themselves before being washed.

"It is better for a consumptive to sleep alone, and his bed-clothing and personal clothing should be boiled and washed separately from the clothing belonging to other people.

"Whenever a person is thought to be suffering from consumption, the name and address should be sent at once to the health department, on a postal card, with a statement of this fact. A medical inspector from the health department will then call and examine the person to see if he has consumption, providing he has no physician, and, if necessary, will give proper direction to prevent others from catching the disease.

"Frequently a person suffering from consumption may not only do his usual work without giving the disease to others, but may also get well, if the matter coughed up is properly destroyed.

"Rooms that have been occupied by consumptives should be thoroughly cleaned, scrubbed, whitewashed, painted or papered before they are again occupied. Carpets, rugs, bedding, etc., from rooms which have been occupied by consumuptives, should be disinfected. The health department should be notified, when they will be sent for, disinfected, and returned to the owner free of charge; or, if he so desire, they will be destroyed."

In view of the possibility that patients convalescing from diphtheria may harbor the bacilli for some time after disappearance of clinical symptoms, it is advisable to maintain quarantine until two successive cultures show the absence of diphtheria bacilli from the throat.

THE SANATORIUM TREATMENT OF TUBERCULOSIS.

As a restrictive measure against the spread of tuberculosis, the sanatorium treatment of the disease affords results which are hardly less gratifying than the curative effects of such treatment. This will be readily appreciated when it is remembered that every consumptive in his home is a possible and potential focus for the dissemination of the infection, and that when he is removed to a sanatorium there is one less center of infection to be dealt with. It has been demonstrated that under judicious and scientific administration the consumptive sanatorium does not become itself infected, and that the patients under the influence of a liberal dietary, life practically in the open air, regulated exercise and regular habits of life, improve or become actually cured in a percentage of cases which is very gratifying, and affords strong grounds for hope in the gradual abolition of pulmonary tuberculosis.

The results attained in the treatment of tuberculosis at the Fort Stanton Sanatorium, Fort Stanton, N. M., are thus summarized by Surgeon P. M. Carrington, who is in command of the station:—

"1. Given a sufficient length of stay recovery may be expected in a very large percentage in first stage uncomplicated cases.

"2. Recovery or arrest may be expected in a fair proportion of second and third stage cases and all the afebrile cases in which there remains sufficient sound lung tissue to support life, but we should exercise caution lest we be premature in pronouncing second and third stage cases cured.

"3. Results in permanent febrile cases, especially those in which there is a wide range of daily temperature, are not better than in less favorable climates.

"4. Hemorrhages seem less liable at this altitude than at the sea-level.

"5. Heredity plays an unimportant part in the causation of the disease."

QUESTIONS TO CHAPTER XX.

QUARANTINE.

What is meant by quarantine? From what is the term derived? Has it now any definite limitation as to time? To what is the term applied? What are the two natural divisions of quarantine? What are the principal quarantinable diseases? What determines the length of quarantine for each of these? Should tuberculosis be quarantinable?

What is meant by foreign quarantine? What regulations are now to be observed at foreign ports by vessels clearing for the United States? What officers have charge of this foreign quarantine?

What are some of the points considered in the bill of health? What are some of the requirements with regard to vessels and their cargoes? Regarding passengers and crew? What are the objects of the inspection card given to passengers?

What requirements are to be observed at sea? What method is prescribed for the disinfection of vessels? Of cargoes? What can be said of the efficiency of the foregoing regulations?

What is meant by domestic quarantine? What will govern the equipment of a maritime quarantine station? What are required at a fully-equipped station? What is the method of construction of the most recent steam disinfecting chambers, and in what ways are they superior to the earlier models? What precautions are to be observed in operating them? What is the principle of construction of the sulhpur-furnaces now used at quarantine stations, and wherein are they superior to other methods of producing sulphurous-acid? How is the gas to be conveyed into the holds of vessels, etc.? What apparatus is provided for using germicidal solutions Where barracks are necessary, how should they be arranged and equipped? What facilities for bathing should be provided? What is to be said of the water-supply?

What regulations are to be observed at ports of entry and on the frontier? What points are covered by the inspection, and what vessels are exempt from inspection? What vessels are to be quarantined, and for how long? What are the general requirements at quarantine? What treatment must cholera-infected vessels undergo in quarantine? What is the prescribed method of disinfection? What routine is to be observed with passengers detained on account of cholera?

Under what conditions may traffic be allowed from ports infected with yellow fever? What inspection is required of State and local quarantines? What regulations govern the Canadian and Mexican frontiers? What are some of the points to be observed in the successful management of a quarantine station?

What is the treatment required for cholera-infected vessels? What special measures are to be taken against cholera? Who has supreme command of a cholera camp, and how is it to be divided? What are the regulations to be observed in the detention camp? In the hospital camp? Why should infected dejecta and ejecta be disinfected immediately upon discharge?

How many national quarantine stations are there, and where are they located? Give a brief description of those in the Delaware Bay and River. What government vessel is used as a quarantine station?

What are some of the aids to national quarantine? What inspection is required of all quarantines? What is required of all State and local quarantines? What are the instructions, both general and special, to the officers detailed to inspect State and local quarantines?

What is meant by inland quarantine? By the sanitary cordon? When and where has the latter been employed in the United States, and with what success? What is a camp of probation? What is the difference between it and a camp of refuge? How should a camp of probation be equipped, managed, and guarded? What should be the daily routine of such a camp? What regulations should be promulgated and enforced for such a camp? Have these camps been efficacious in preventing the spread of disease?

What is the purpose of railroad quarantine, and how is it to be carried out? How may it be facilitated by train-inspection service? What rules are to be adopted for railway quarantine? What action has been taken to prevent the introduction of small-pox, etc., from Canada? What are the regulations issued for the guidance of sanitary inspectors? What provisions are there for the medical inspection of immigrants on board trains?

What general principles govern interstate quarantine? What are the regulations covering it? Which of these is the most important? What special provisions are made respecting yellow fever? What are the methods of disinfection prescribed, respectively, for cholera, yellow fever, small-pox, and typhus fever?

What are the essential points of municipal quarantine? What precautions are to be taken to prevent the spread of small-pox, measles, diphtheria, and scarlet fever? To what extent should domiciliary quarantine be carried? How long should it be maintained?

How may a diagnosis of diphtheria be made? What means may be taken to prevent the spread of tuberculosis?

Give a synopsis of the quarantine laws of the United States. What is the maximum penalty for attempting to enter a port in evasion of them? What information of value to quarantine officers, etc., is furnished weekly? When and by whom may travel and traffic from infected ports and places be prohibited? Who has supreme charge of the enforcement of the quarantine regulations? In what department of the government does the supervision of quarantine belong?

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