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SANITATION
FOR PUBLIC HEALTH NURSES

(THE FUNDAMENTALS OF PUBLIC HEALTH)

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EDITOR'S PREFACE

The development of Public Health Nursing in the United States has naturally created a demand for literature. Not only must material be available for the hospital training schools and the rapidly developing post-graduate courses in Public Health Nursing, but also for the nurses throughout the country who are realizing that to read is as necessary in the nursing profession, as in the medical profession already rich in literature. The general public too is beginning to feel an increasingly intelligent interest in this form of health work. To meet these needs, it is proposed to publish a series of books dealing with the various aspects of Public Health Nursing. The authors selected will be recognized authorities and each subject will be so treated as to bring out the underlying principles and broad possibilities of development, and also the practical working details, which together will make the books of value to nurses.

Each volume will be complete in itself, but it is hoped that, through careful editing, duplication and omission will be avoided and that the series as a whole will make possible a comprehensive study of the entire field of Public Health Nursing.

MARY SEWALL GARDNER.

PREFACE

This book was written to give to Public Health Nurses a concise view of the fundamentals of modern Public Health as it is to-day; more particularly of such aspects of modern Public Health as may be conveniently listed under Sanitation.

Public Health deals with all the physical welfare of all mankind, and its subdivisions are, like all the subdivisions of any other great subject, more or less artificial. Thus Sanitation, although dealing strictly speaking only with "surroundings," yet cannot escape consideration of the individual who is "surrounded," for it is the reaction of the individual to his surroundings that makes his surroundings important. So Hygiene, dealing strictly speaking only with the operation of the individual's body, nevertheless requires modifications without end, depending on variations in the surroundings, for it is to meet these variations successfully that Hygiene exists.

Neither Hygiene nor Sanitation should be carried to conclusions which are too excruciatingly logical. It would not be wise, even if practicable, to secure for the body sanitation so perfect that the smooth working of the automatic compensations and adaptations of the body, its most "vital" function, degenerate from disuse, as in a perpetual "rest cure." Nor is it well to devote such a surplus of time and energy to Hygiene, that the body is engaged merely in meeting extreme conditions, artificially imposed, as in spectacular competitive athletics.

In Public Health as in all other human movements, it is necessary to keep the end in view and not to make the mere means an end; for thus are "fads" built up, to the distress of all real Public Health. The real end sought in Public

Health, is the physical development of the human race in such a manner as to secure, for all, true physical comfort, with high physical efficiency, and long life; and this includes not merely the promotion of health, but even more urgently, at this stage, the elimination of disease.

Health is in general of internal origin; its sources are as obscure as those of evolution, sources that are perhaps identical for both. Disease is in general of external origin, and its factors are therefore infinitely more amenable to our control. Hence it is that Sanitation, while having some evident relationship to health, has far more importance as the great weapon available to us against disease, while Hygiene is as yet on a very dubious and uncertain basis, awaiting still the development of present-day Physiology to a practical stage. When we know as well the practical applications of Physiology to Hygiene as we know the practical applications of Bacteriology to Therapeutics, we shall be far better equipped than we can possibly be at present to prescribe for Health. At present our prescriptions must necessarily be largely against Disease.

That this book may, with all its shortcomings, be of service to that great factor in racial regeneration, the woman technically trained for service in Public Health—the Public Health Nurse—is the high ambition of the writer.

Modern Public Health is working towards a conscious effort at brain-guided Evolution, at the purposeful Stockraising of the human race, too long neglected.

It is to the Public Health Nurse, the coming supervisor of those Stockraising operations, that this book is offered.

H. W. Hill.

St. Paul, Minn.

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CHAPTER I

HYGIENE, SANITATION, PUBLIC HEALTH. DEFINITIONS AND RELATIONSHIPS

Public Health deals with all that mankind may do to advance the physical welfare of any of mankind. It is thus much more than, while it includes, that which the individual may do to advance his own personal physical welfare. Yet individual health and racial health are obviously intimately related. If every individual were in health, the race would necessarily be so also. Unfortunately, many individuals, and especially children, can do little or nothing for themselves. Public Health is, therefore, altruistic in principle as regards the individual, while from the racial standpoint it is a pure business proposition, for that which advances the physical welfare of any individual is just so much a pure gain to the race; every disease, defect or disability of any individual is just so much a detriment to the race.

Hygiene is that part of Public Health which deals with the proper operation of the living body at any age or stage and under all the various and changing circumstances, good and bad, which may surround it. It is for the body exactly what the practical art of the chauffeur, applied in every sort of weather, on every sort of road, in city and in country, is for the automobile. Its theoretical goal is the perfect adaptation of the physical operation of the individual's body to his surroundings.

Sanitation, the complement of Hygiene, is another part of Public Health. It relates to securing the best surroundings for the body operation. It is analogous to the art of providing for the automobile perfect garages, perfect roads, perfect conditions for auto-operation generally. Its theoretical goal, as generally understood, is the perfect adaptation of the surroundings to the physical operation of the individual's body. (See also Chap. I, p. 9.)

Public Health deals with both the individual and his surroundings: therefore, with hygiene and sanitation; but it takes into account also the effect of one individual and his surroundings on other individuals and their surroundings. To continue the automobile parable, public health would not only secure perfect driving (hygiene), on the best of roads (sanitation), but would also insure that no automobile ran into or otherwise interfered with any other automobile; and that no garage, however well operated to suit the needs of any one automobile, should interfere with or be disadvantageous to any other garage or automobile.

Hygiene then applies to the individual; Sanitation to the surroundings of the individual; and Public Health to masses of individuals, in all their interrelations. A hermit on a desert island might practice Hygiene and Sanitation, but until he had at least one companion, he could not practice Public Health in full.

Public Health in a narrow sense may be looked upon as the Hygiene and Sanitation of the race rather than of individual persons. Public Health in its broadest sense is the struggle for existence of the individual "writ large" into the struggle for existence of all mankind. The "tendency to health" is part of the "tendency to evolution."

Hygiene, Sanitation and Public Health may each exist in the absence of the other two. A *roue* in a palace lives a most unhygienic life under the most perfect of sanitary surroundings, just as a green chauffeur may get his auto into trouble on the best of roads. Conversely a nurse in an infectious hospital may live a perfectly hygienic life under almost the worst of unsanitary surroundings, i. e., constant contact with the very sources and breeding places of disease, her infectious patients; just as a good chauffeur will keep his machine running well in mud or snow, even though he have a mere shack for a garage. Again our highly hygienic and sanitary passenger steamers on the Great Lakes formerly polluted the lake water with their toilet discharges, producing typhoid fever cases to an alarming extent amongst the lake-shore dwellers who drank that water. They thus observed Hygiene and Sanitation for themselves and their passengers, but not Public Health, since the latter always takes into consideration "the other fellow." Finally, Public Health without Hygiene or Sanitation is illustrated by the "shot-gun quarantine" of the Southern States in the old days of yellow fever, when the stricken village was patrolled on all sides by the surrounding population, armed and ready to prevent the escape of anyone from the infected locality.

Although Hygiene and Sanitation are generally used as if they applied only to well people, there certainly is a hygiene and a sanitation of the sick, the arts of caring for, and conducting the physical affairs of the sick body, and of providing the best surroundings for it. Indeed, the applications of these arts of hygiene and sanitation to the sick antedated their application to the well and grew up together as the art of Therapeutics, which includes medicine, surgery and nursing in all their phases. Public Health, however, deals properly with both sick and well, although usually and chiefly, as regards the sick, in their interrelations with the well and with each other; usually leaving the Hygiene and Sanitation of the sick to its traditional sphere, Therapeutics. But in its broadest conception Public Health includes Therapeutics as well as Hygiene and Sanitation, and thus applies to all mankind, in every physical relation.

Public Health as a whole presents in all its details two obviously different, but often confused, groups of effort. One of these concerns itself with the *prevention* of disease, defect or disability; the other, with the *promotion* of every form of physical welfare (health).

At first sight these two seem to be identical. Can Health be promoted without excluding disease? If you prevent disease, surely you secure health? Think, however, that a man in business who merely succeeds in escaping bankruptcy is by no means on a plane with him who makes a fortune. A chauffeur may drive his auto without accident or breakdown, but this does not make of him a Barney Oldfield. So a community may be free of all disease, yet have no really physically perfect specimen in it.

Lincoln freed the slave from his chains at a stroke; but the sixty years of effort following have not yet raised the negro to the white man's level. By dynamiting rocks and lighting shoals one may prevent wrecks, but building up a high-class Navy is obviously a very different matter.

The cave man in his day just succeeded in not being killed and eaten, and to him that mere escape from death was life. We know life as infinitely more than merely not dying. So the prevention of disease, the escape from actual sickness, while a big thing in itself, is yet far short of the ideal, which is the development of the physical body to its highest state of vigor, alertness, capacity for work, for enjoyment, for long life. Moreover, the promotion of health in its true sense, the development of the body to its highest degree, gives no guarantee against disease any more than it gives a guarantee against accident. The physically perfect man succumbs to many diseases, if exposed to them. The physical wreck many times escapes.

Another and very practical reason for recognizing clearly the important differences between these two divisions of Public Health is this: we know a very great deal about preventing sickness (at least some kinds of sickness), but we do not know much about promoting health. We have trained men, laws, a whole mechanism, well developed, for preventing sickness. We have a few, and as yet scattered, feeble and rather jerky efforts here and there at promoting health. Some day these two great groups of activities may be fused; but our chief endeavor for a long time yet must lie in preventing sickness, not in promoting health. If you analyze our health movements, whatever they may be called, you will find their real burden is the fight against disease, defect and disability, not the development of physical perfection. Even our best marriage laws are aimed merely at stopping the propagation of the diseased and the defective, not at producing a physically perfect race.

Both Hygiene and Sanitation may each be similarly subdivided into the same two lines of work, the prevention of disease and the promotion of health; but Therapeutics, dealing with the individual already sick, contemplates chiefly merely restoration of that individual to a state where he is no longer sick, and turns him over then to other hands.

In the prevention of disease, Hygiene concerns itself chiefly with the art of eluding or evading causes of sickness which may exist in the surroundings; while Sanitation aims at removing such causes from the surroundings entirely.

In the promotion of health, Hygiene aims at developing the body to meet all exigencies, while Sanitation strives to supply such surroundings that untoward exigencies will not arise.

Public Health, dealing broadly with both, but rather with the interrelations of individuals in masses than with the individuals themselves, emphasizes Sanitation (the removal of causes of sickness) rather than Hygiene in the prevention of disease, Hygiene (the proper operation of the body) rather than Sanitation in the promotion of health; in both instances selecting the safest, most conclusive and, for masses of people, the most readily carried out of the courses open to it. (See also Chap. II, p. 12.)

Since the prevention of disease is our fundamental first step in Public Health, and since we know more about it than we do about promoting health, the study of Public Health begins naturally with the study of the prevention of disease, and we are at once compelled to recognize that we can prevent only some diseases.

Naturally, the diseases we can prevent are those the immediate causes of which are known so sufficiently well that we can preferably (a) remove their causes from the surroundings entirely; or, failing that, (b) introduce some obstacle into the sequence of events leading to the development of the disease which will prevent the disease from achieving its development.

Earlier medicine recognized the disease only after it was established in the body and aimed at checking it there or even curing it.

Modern medicine searches for the origin of the attack, traces the sequence of events leading up to the first appearance of disease in the body and then seeks to abolish the cause or to interfere with this sequence at some critical point, so that the disease does not appear at all.

Consider, for example, a case of poisoning by opium, strychnine or arsenic. True, if the patient is already sick, suffering, dying, he calls for Therapeutics, i. e., for treatment to check the disease, to rid him of the poison, to draw him back to life and health again, if possible.

But Public Health, on studying the sequence of events by which he became a victim, can demonstrate that his attack might have been prevented by breaking up that sequence at many points. He bought the poison at some drug store, let us say: a sociological remedy would be the forbidding of such sales. He took it home and swallowed it: physical means might have been used to prevent him from getting it to his mouth. After it was down, it might have been pumped up again, another physical obstacle; or, possibly, in the case of arsenic say, an antidote, a chemical obstacle, might have been administered before the poison took effect. Finally, one can imagine that relatives, friends or guardians, foreseeing that he might some day take a fatal dose of, say opium, might have insisted that he be immunized against that drug, so that although he bought it, took it home and swallowed it, it still had no effect. This immunization would furnish a biological obstacle to the sequence of events. In brief, the prevention of any disease depends, like victory in battle, on our ability, first, to destroy the enemy, or failing that, to divine what the enemy must do to win, and then not let him do it.

All this is so entirely simple and obvious that it seems hardly worth repeating. Yet the example given is a close parallel in outline of our chief methods of preventing any disease. Nearly all the diseases that we really understand, and therefore can attempt to prevent, are, at bottom, *poisonings*. The poisons come to us always in some sort of container, but not necessarily a bottle; very often they come in living containers, germs; and most of them damage us because we take these poison germs into our mouths.

In tuberculosis, pneumonia, the venereal diseases, scarlet fever, typhoid and the rest, the poisons which produce them follow a fairly regular procedure in entering our bodies; and if we break into that procedure, we prevent their entry. In some diseases the cause itself may be abolished or removed, as leprosy was from Europe in the middle ages. In others, the cause remains, but its operation may still be interfered with.

We do not understand cancer, diabetes, Bright's disease, and we, therefore, are helpless along Public Health lines to prevent them; although by early recognition of their existence we can do something along Therapeutic lines to alleviate or cure.

The preventable diseases are then chiefly the poisonings. When these poisons are simple chemical poisons already well known, the interference with the sequence of events by which they reach and harm us is usually so obvious that it is hardly worth discussion. Poisoning by alcohol may be conclusively prevented by preventing its manufacture. In some industries, it is true, poisonings by the materials handled in the business, lead, phosphorus, trinitrotoluol, etc., constitute problems requiring careful study; not so much, however, of the principles of prevention, as of the adjustments necessary in the various industrial processes so that these principles may be economically followed. These few and simple chemical poisonings, however, produce comparatively an insignificant total of cases or of deaths as compared with the wholesale biological poisonings which the race suffers from those poisons which are the products of small living plants and animals, so small as to be invisible, which pass unseen from one person to another and bring their poisons with them; those little living poison vials which we know as "germs."

Since then the infectious diseases form the mass of the preventable diseases, it is necessary to study them at least sufficiently to understand their general features, and more particularly to understand the general course which they all more or less closely follow in maintaining and propagating themselves upon the human race. Only so can the sequence of events which leads up to them be understood; and only so can methods of prevention, physical, chemical, biological, sociological, be intelligently carried out.

We really know pretty well the physical, chemical and biological methods of prevention. The real problem of to-day is the sociological. Modern medicine, although the last word is very far from being said—indeed, we have learned only part of the alphabet, and so to speak can only spell as yet the words of one syllable, with that part we have learned—modern medicine does know pretty well where and how the sequence of events in the propagation of infectious diseases can and should be broken, usually at a different point in each different disease.

But to secure the breaking of this sequence in the hurly-burly of the swarming human life about us remains in many cases a study for sociology. Public Health deals with "the other fellow," and he, alas, does not always coöperate, even for his own good.

Summary: Hygiene deals with the operation of the individual body and aims to secure maximum efficiency, with minimum wear and tear, and to reach physical perfection, with comfort and long life, by skilful compensations and adaptations to the surrounding conditions, whatever they may be.

Sanitation aims at securing for the individual body the best of surrounding conditions, thus minimizing the exigencies it must meet, and lessening the need for compensations and adaptations.

Public Health includes both, but also the interrelations of individual with individual, of surroundings with surroundings; it aims to correlate the Hygiene and Sanitation of all individuals, to the ultimate physical welfare of the whole race.

Each of the three possess two subdivisions, one relating to the prevention of disease, the other to the promotion of health. Sanitation is a practical weapon chiefly in the first, Hygiene in the second. Public Health, although it includes both the prevention of disease and the promotion of health, yet at the present stage of our knowledge and social development, recognizes that the most immediately important and immediately feasible efforts concern themselves with the prevention of disease; that the most serious, as well as the most preventable, of the "preventable diseases" are the infectious diseases; and that therefore sanitation as thus defined, and since it deals with infectious diseases, is at the present time the most immediately important subdivision of Public Health.

CHAPTER II

THE GENERAL COURSE OF AN INFECTIOUS DISEASE

Sanitation, in seeking to carry out what was described in the last chapter as its most successful and also its most useful function, the prevention of disease, finds open to it two different courses of procedure. The first and earliest recognized consists in endeavoring to modify those factors in the surroundings of the individual which may contribute to the spread of "spreadable" diseases. The second, a much later recognized but a much more important procedure, is the removal, from the surroundings, of the causes of the "spreadable" diseases themselves.

Bound by the crude teachings of the earlier days, the surroundings with which the earlier sanitation chiefly dealt were the inanimate surroundings, since these were then held to be the chief factors in the spread of "spreadable" diseases, or even, in a still earlier day, to be the actual causes of them.

We now appreciate that the only surroundings of the individual which can act as causes of spreadable diseases are not inanimate but animate, the germs of the disease in question; and that, moreover, these "animate surroundings" are not present, as a rule, in or on inanimate things, but in or on the animate bodies of man or animal: in brief, that the chief danger to the individual, so far as these diseases go, lies not in his physical surroundings but in his biological associates.

The earlier sanitation, therefore, and naturally enough, dealt chiefly with physical surroundings, air, water, food, clothing, building materials, houses, drains, and dealt with them not in what we now know to be their more important relation, that of contributing to the promotion of health, but in what we now know to be their less important relation, that of possible contribution to the propagation of disease.

Modern sanitation regards the finding of infectious persons or animals and their exclusion from the surroundings as its most important function in the prevention of disease; and considers the improvement of the physical surroundings a secondary and relatively feeble weapon to this end, worth while at all in the prevention program only because the recognition and exclusion of all possible infection is very difficult; and such precautions against the unrecognized and therefore unexcludable modicum as may be carried out through improved surroundings, seem the logical, because at present they appear to be the only, further measures of this kind that can be taken. (Note that the importance of control of physical surroundings for the prevention of diseases decreases in proportion as the success of efforts at exclusion of infectious biological associates increases: and increases as the success of exclusion decreases.) Since then sanitation, dealing with surroundings, finds its chief function in the prevention of disease; since in striving to exercise this function, it finds that the most important and prevalent of the preventable diseases are the infectious; and since it finds the most radical and efficient method of dealing with them is to remove their causes from the surroundings entirely, sanitation must necessarily first and foremost consider how to recognize these infectious diseases as they exist in their human or animal hosts, because their recognition is necessarily the first step towards their exclusion.

We shall, therefore, take up the chief points in the recognition of the most common of the infectious diseases of this part of the world.

Although each infectious disease has its own peculiarities, by which it can be recognized, and through one or more of which it can usually be approached to its own disadvantage or destruction, yet all show a certain family resemblance, present a more or less similar history, follow a more or less similar course, spread by more or less similar means, inflict more or less similar damage, and can be combated by more or less similar procedures; while nearly all of them confer one (very costly) boon, a more or less complete immunity to a subsequent attack of the same disease.

Hence this general history and course, more or less characteristic of all infections, is worth studying before the specific peculiarities of each infection are considered in detail.

Turning now to this general course which our infectious diseases all more or less closely follow, I have prepared a diagram (see p. 14) which is very useful in getting this general course firmly in mind.

One of the many points which our ordinary infectious diseases have in common, is this—each depends absolutely for its appearance on the same essential, the introduction, to the body, of the germ of that particular disease. As you cannot product strychnine poisoning by swallowing opium, as you cannot produce opium poisoning by swallowing strychnine, so you cannot contract diphtheria, except from the diphtheria germ, nor tuberculosis except from the tuberculosis germ.

It is true that in some of our obscurer diseases, erysipelas, the various blood poisonings, etc., it would appear that perhaps one particular germ is responsible for many apparently very different clinical symptoms. But so far as our regular ordinary infectious diseases go, the essential feature of each is its own particular germ, without which that particular disease cannot exist.

These germs are merely tiny poisonous plants or animals, as the strychnine plant and the opium plant are large poison-

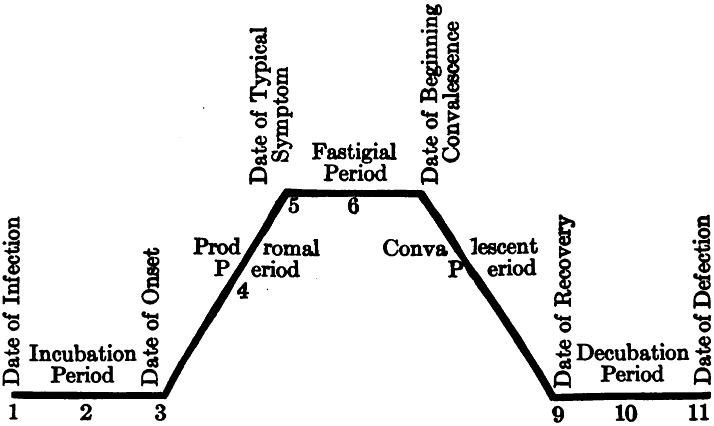

Diagram of the General Course of an Infectious Disease

1 = date of entry of germs to body;
corresponds with 11 = date of exit of germs from the body.
2 = period of increase of germs;
corresponds with 10 = period of decrease of germs.
3 = date of first symptoms;
corresponds with 9 = date of last symptoms.
4 = period of increasing illness;
corresponds with 8 = period of decreasing illness.
5 = date of symptom characteristic of the disease in question;
corresponds with 7 = date of symptoms beginning to vanish.
6 = period of height of the disease.

ous plants; or as the cobra and the cotton-mouth are large poisonous animals.

Strychnine and opium are derived from the plants from which they come. We know these poisons as chemically extracted powders, strychnine and morphine. Snake venom is a liquid, prepared in a special poison gland in the snake's mouth.

In the case of the disease germs, however, we do not encounter, as a rule, mere extracts of the plant or mere secretions of the animal. We swallow, or otherwise take in, the living plants or animals whole; and they proceed to manufacture their poison inside of us. These little germs are so small that we are never conscious of their presence as such, never taste them or feel them, nor does their first entry to our bodies give any sensation of illness whatever. We usually do not become aware of their presence until they have developed so much of their poison that we are already poisoned; fever being one of their most common effects.

The poisons of the different germs are themselves different; they each affect the body in ways as distinct from each other as are the differences between strychnine poisoning and opium poisoning.

Thus it is that the physician usually first knows what particular germ he is dealing with in any given case, not by the discovery of that germ in the patient's body, but by the particular poisoning symptoms the patient shows. Just as he recognizes the difference between strychnine poisoning and opium poisoning by the very different train of symptoms each presents, so he distinguishes scarlet fever poisoning from typhoid fever poisoning by the peculiarities of the symptoms each of these presents. True, the physician may often desire to find the germ itself, either to confirm his diagnosis, or to help him make a diagnosis in obscure cases, or for other purposes, and he then calls in the aid of the bacteriological laboratory; but primarily the physician recognizes that disease germs are present in the body by the presence of symptoms in the patient; and proceeds to discover what particular disease germ is present by a study of the particular symptoms shown.

Since no infectious diseases can develop until the germ of that disease enters the body, the study begins with that entry to the body, however the entry may be effected. The day on which this entry occurs is known as the date of infection. The history of the disease in that particular body begins then. The disease itself does not at once show itself, however. An interval, known as the incubation period, intervenes between infection and the actual development of the illness.

The actual date of infection cannot by any means always be surely determined in every individual case. When the patient comes to the physician he is usually already ill, else he would not have come. The date of the entry of the infection must, therefore, in such instances, be established by inquiry directed to determining when he was in contact with some other person, sometimes with an animal, showing similar symptoms, or at least, similarly infected; or was otherwise exposed. In very many instances it will be discovered that the present patient was in contact with such a source of infection for several days, a week, or a month, before becoming ill himself, and it is then impossible to decide absolutely on what particular day the poison entered his body first.

But now and then the opportunity arises to decide the date of infection absolutely, as when a well child visits for one day another child, who is sick, and then develops a similar attack later on.

From large numbers of such observations we now know the respective lengths of the incubation periods pretty accurately for all the ordinary infectious diseases. When, therefore, a patient comes to us already sick, we can often decide the date when he was infected, not from any definite history of exposure, although that is the most conclusive way, but by finding out when he was first sick, and then calculating back from that date the number of days characteristic of the incubation period of the particular disease from which he is suffering.

The date of infection then, determined as above, marks the beginning of a period during which the patient, although he has within him the germ or seed of the disease, which will later sprout up so to speak, is just as well as ever. One might compare the date of infection with the instant at which a match is touched to the fuse of a time-bomb. The bomb does not explode right away; to all appearances it is the same bomb as it ever was since it left the factory. But in truth, it is in a state very different from any state it ever was in before, as the unlucky looker-on finds out if he waits long enough.

The period between the date of infection and the appearance of the first symptoms—between lighting the bomb-fuse and the explosion of the bomb—is the incubation period. If we know when the fuse was lighted (date of infection), and the length of the fuse (incubation period), we know when the bomb will explode.

We do not know completely what is happening in the body during this incubation period. One thing surely is going on—a development of the germs in opposition to such forces of the body as may be present to oppose them. If the body-forces triumph over the poison, the disease fails to develop, of course. If the germ-poisons triumph, the disease appears.

The period of incubation, then, is the period between the date of infection and the date of the earliest symptoms. The patient is quite well during this period—is not, in fact, a patient yet, but only a potential patient. Indeed, he may never develop the disease at all. During this period of incubation, the potential patient, in some diseases, and despite the fact that he is not yet sick in any way, is infectious; that is, he may give to others the disease germs he is carrying about with him. This is true of diphtheria, of typhoid fever, of cholera, and some others. But the potential patient, during the incubation period, is not infectious in other diseases—for instance, in smallpox, chicken pox, measles, German measles, scarlet fever, the patient is, in the incubation period, harmless to others, and remains harmless all through the incubation period right up to the time when the first symptoms appear.

Here we have facts of immense importance. The person infected with diphtheria, typhoid, cholera, but not yet sick (perhaps he may never become sick), yet is, and may a long time remain, infectious. Such persons are called carriers, which means well persons who are infected, who can give the germs of disease they carry to others, yet are not sick, and may never, perhaps, become sick. Because they are infected they are dangerous: if they do not become sick they are doubly dangerous; for if they become sick, the presence of the infection may be recognized and they may be isolated, while if they do not become sick they may go on for days, weeks, months or years, infecting other people, but unrecognized as the source of the infection. These people, infected but not sick, may be looked upon as having an incubation period of abnormal length, and I have suggested classifying them as prolonged incubation carriers, or more briefly "prolonged incubates," to distinguish them from another group of carriers to be discussed later. We have such prolonged incubate carriers in diphtheria, typhoid, cholera, because the normal incubation period in these diseases is infectious, and if prolonged, remains infectious. We do not have them in smallpox, chicken pox, measles, German measles or scarlet fever, because the normal incubation period of these diseases is noninfectious and, therefore, even if prolonged, it still remains noninfectious.

Returning to the consideration of the ordinary course, we find that, marking the end of the normal incubation period, comes the date of earliest symptoms. The patient is now sick, and usually shows some fever, headache, digestive upset, feels sick. If he is seen at this early stage, all that usually can be certainly determined at once is that he is sick; what germ is responsible cannot yet be definitely settled from his symptoms because there is as yet usually no definite differentiation of the symptoms. He "is sickening for" something, as the phrase goes, but for what is not yet usually determinable absolutely. My favorite diagnosis at this state is—"He may have anything, or nothing; isolate him and hold him for observation." Nearly every slight ailment due to infection, as well as nearly every serious one, begins in this way and cannot be differentiated with certainty at this stage from the symptoms alone.

This date of first symptoms is also called, for obvious reasons, the date of onset. The patient is infectious at this stage in almost all our infectious diseases. In diphtheria, typhoid, cholera, he has been infectious from the earlier date of infection, but in many of the other diseases of this part of the world, the infectiousness begins at this date of onset. When a patient of this latter group becomes sick and is promptly isolated, the damage he has done in infecting others is confined to what he has done since he became sick, an interval which can be reduced by watchfulness and prompt isolation to a few hours, or, at most, a day. But in the former group, since the patients are infectious during the whole of the incubation period and are also well during this period, the damage they may do before becoming sick is the damage done during days or even weeks of infectiousness preceding any possible recognition of their condition as being dangerous at all, so far as symptoms go.

This date of earliest symptoms, or date of onset, ends the incubation period and ushers in a new period, the period of prodromal symptoms, or more shortly, of prodomes; that is, of symptoms preceding the fully developed, fully recognizable, fully differentiated disease. The bomb has exploded; but although we recognize the explosion, we have not yet determined what kind of bomb it is—gas, incendiary, etc.

The prodromal period ends with the development of some striking symptom, typical of the particular disease from which the patient is suffering. This typical symptom is a rash in measles, German measles, scarlet fever; a membrane in diphtheria; a swelling of the face in mumps; an eruption in smallpox and chicken pox, and so on. The bomb has now disclosed its character definitely—as mustard gas, chlorine, flame, etc.

Between, then, the date of onset and the date of the appearance of the typical symptoms we have a period of prodromes, in which the initial fever, headache, digestive upset, general feeling of sickness, more or less common to all these infections, grow worse. But they do not merely grow worse; they grow worse in a more or less different way in each disease; and therefore, even before the typical symptom appears, one may make a guess during the prodromal period as to what the disease is; usually, however, it is only a guess, until the typical symptom appears. The length of the prodromal period is itself one of the best differential signs because the prodromal periods vary for each disease, just as the incubation periods do. Knowing the lengths of the incubation periods is important as permitting the fixing of the date of infection (by calculating back from the date of earliest symptoms) and thus giving a clue to the source of the infection, the probable persons, other than our patient, exposed to the same source, and other similar public health information. The length of the prodromal periods are similarly important; and also aid much in diagnosis (see also Chap. IV, p. 44).

When the typical symptom has appeared—the eruption, rash, or whatever it may be—the disease passes into the third period or fastigium. This is the stage that the general public recognizes. It is the full blossom, so to speak, of the clinical symptoms, the full crop resulting from the original implantation of the seed. Curiously enough, it has not always been clearly understood that, whatever the disease may be as disclosed to the observer by the final development of the typical symptoms and the full-blossomed fastigial period, the disease has always been the same from the first. The prodromal stage in measles is none the less measles, although its symptoms may not be differentiated enough for recognition. A patient does not "sicken for" measles—he has it, as soon as he is sick at all. It is only our recognition of what he has that is delayed by the indefiniteness of the prodromes; the prodromes themselves are measles, or whatever the disease may be, just as truly as is the full-blossomed attack. An apple is an apple, even in the seed. The typical symptom makes a stage in the disease truly; but it makes it only to us. It is a landmark only because it strikes our attention clearly, not because it marks any vital change in the attack itself.

The fastigium or fastigial period begins then with this arbitrary but convenient date, the date of the appearance of the typical symptom. It continues to the beginning of convalescence—a date which in some diseases is sharp cut and definite, as in pneumonia, where the temperature may drop from 104 degrees to normal in 24 hours; but which in other diseases is, like the coming of Spring, a shadowy period rather than a date.

The period of the fastigium is in most diseases an infectious period—and in most diseases it was the only period recognized as infectious until quite recent years. The length of this period varies a good deal. Convalescence may be delayed by complications, relapses, etc. Yet in general the fastigial period has a more or less definite length in each disease; about one week in diphtheria, about three weeks in typhoid fever, and so on.

The date of the beginning of convalescence ushers in the convalescent period, which ends with the date of complete recovery—a date somewhat indefinite, of course, and yet which can be fixed approximately from temperature and other records. This period of convalescence is very variable in different diseases and is by no means constant in any disease. Infectiousness continues during convalescence in almost all diseases. It is a peculiarly dangerous period because the stress and strain of the fastigial period is relaxed, the patient is able to "sit up and take notice," he feels lonely and wants to see friends and relatives, who are themselves anxious to see the patient, to kiss the patient, condole with him, etc. Moreover, the improvement in the patient's physical condition is usually construed subconsciously to mean a lessening of the danger of infection from him. But this idea is just as mistaken as is the idea that the prodromal period is not dangerous.

It is obvious that the convalescent period is the converse of the prodromal period; the patient is growing better, rather than worse, the disease is lessening, not increasing. But this does not affect the question of infection. There are few exceptions to the rule that the patient is infectious from the moment the very first symptom of the disease has appeared up to the moment when the very last symptom has disappeared.

But even on complete cessation of the symptoms, the history of the disease in that patient is not necessarily complete. This is particularly true of diphtheria, typhoid fever and cholera. *Preceding* the *appearance* of the *earliest* symptom was the incubation period, during which the germs introduced at the date of infection were increasing in number, this increase resulting in the appearance of the first symptom itself. The potential patient is well but infectious.

But now *following* the *disappearance* of the *last* symptom, we have a converse period, in which the germs are decreasing in number, this decrease ending normally with their final complete disappearance. Matching the term given the first stage, incubation, indicating an increase of the germs, I have suggested for this last stage, the term decubation, indicating a decrease in the germs. Matching the term, infection, for the first entry of the germs, I have suggested the term, defection, for their final exit.

The decubation period then extends from the date of final recovery of the patient to the date of final exit of the germs from the body—from complete recovery to defection.

The patient is well during this decubation stage, just as he is in the incubation stage. Moreover, just as he is infectious in some diseases during incubation, notably in typhoid, diphtheria and cholera, so he is infectious during decubation in the same diseases. Just as he is noninfectious during incubation in many other diseases, so he is noninfectious during decubation in these other diseases. Perhaps it would be more correct to say that in these other diseases there is no decubation period, but this is not proven.

How long is the decubation period? While there are, no doubt, certain average lengths for each disease, yet we know also that the decubation period varies even in the same disease very much. Thus in diphtheria it probably averages about two weeks; yet it has been prolonged, on the authority of State Board of Health records in Minnesota, to nineteen months, and it is not infrequently six to ten weeks long. In typhoid fever the average decubation period is probably a month, but there is on record at least one case in which it lasted 54 years.

Just as persons who, never having had the disease, may become infected and so enter the incubation stage, but may never develop the earliest symptoms, remaining infectious, nevertheless, for shorter or longer periods, or even for their whole remaining lives, so persons who have had the disease and have recovered from it, thus going into the decubation stage, may never reach defection—i. e., the germ may continue in their bodies and render them infectious for long periods or even for the rest of their lives.

Just as we called the former group of carriers prolonged incubation carriers, or "prolonged incubates," so we may call the latter group prolonged decubation carriers, or "prolonged decubates."

Both kinds of carriers are equally dangerous. The value of recognizing the distinction made here lies in the fact that the prolonged incubate—the infected person who has never been sick—is particularly hard to locate because there is no guide to his whereabouts except the existence of otherwise unaccounted for outbreaks of an infectious disease in his neighborhood. But the prolonged decubate has at least one identification mark, the fact that he has had the disease in question. Thus, if an outbreak occurs which bears the earmarks of being due to a carrier, we can question those whom we suspect, and if anyone of them ever had the disease, that one may be searched for the germ, with good reason, on the hypothesis that he may be a prolonged decubate. But if he fail to prove up as the guilty party, and if we are, therefore, forced to conclude that a prolonged incubate is responsible, we are confronted by the necessity of examining in detail all the associated well persons, since any one of them may be the guilty party.

The patient who has recovered entirely from an attack of an infectious disease is, to all appearance, just the same individual as he was before, whether he continues infectious or not. But really he is profoundly different. One of the ways in which he may be different has just been outlined—if he remains infectious after recovery, he is now a menace to all nonimmune associates, as he was not, before he had the disease. But whether he is infectious or not, the recovered patient is almost always different in another way—he cannot again suffer (for a time at least) from the same disease. In brief, the attack has more or less immunized him to similar attacks. The immunity may be lifelong, as in smallpox, or only a few months long, as in diphtheria; and actual tests can demonstrate the presence of the protective agent in the blood in some diseases, notably in diphtheria. This immunity to an infectious disease is as specific as the germ. No disease immunizes the patient against any other disease, but only against itself. Thus, scarlet fever immunizes only against scarlet fever, diphtheria only against diphtheria, real measles only against real measles, and so on.

Prolonged decubates are, of course, immune—they have recovered from the disease. But prolonged incubates are also immune—else they would develop the disease. We know how the prolonged decubate is immunized; he is immunized by his previous attack. We do not yet know how the prolonged incubate is immunized.

Summary: Sanitation may deal ultimately with the promotion of health, but at the present time deals chiefly with the prevention of defect, disability and disease; and its more important function lies in preventing infectious diseases.

The infectious diseases are due to tiny forms of life, plant and animal, entering the body, growing in it, and poisoning it through the products of their activities.

Various as these infectious diseases are, they yet show a certain family likeness in the courses they respectively run and, therefore, the history of all infectious disease in the body may be divided into five more or less recognizable periods, marked out by six more or less definite dates. The six dates and four of the periods lend themselves to grouping into pairs, each member of each pair bearing a converse relation to the other. Thus the date of infection, or entry, of the germ, pairs with the date of defection, or exit of the germ. The date of first symptoms, or onset, pairs with the date of last symptoms, or recovery; the date of the typical symptom pairs with the date of beginning convalescence. So also the period of incubation, or increase of the germs, pairs with the period of decubation or decrease of the germs; and the period of prodromal symptoms, preceding the fully developed disease, pairs with the period of convalescence, following the fully developed disease. (See diagram, p. 14.)

Infectiousness, as well as illness, exists in almost all infectious diseases from the date of earliest symptoms to the date of full recovery, the chief exception being pulmonary tuberculosis. (See p. 86.) But in certain diseases, notably in typhoid, diphtheria and cholera, the infectiousness begins before the illness and lasts after recovery, i. e., it extends from the date of infection to the date of defection. In these diseases either the infectious incubation period or the infectious decubation period may be greatly prolonged, even to the whole remaining life of the patient. Thus become established two types of well carriers, prolonged incubates and prolonged decubates, distinguishable only by the fact that the one has not, the other has, suffered from the disease in question. An attack of an infectious disease confers one boon—and one only—immunization, and this only at an immense risk of death and of damage.

CHAPTER III

TYPHOID FEVER AS A TYPICAL INFECTIOUS DISEASE. PARA-TYPHOID FEVER: TYPHUS FEVER

Typhoid fever makes one of the best infectious diseases for study as an introduction to the study of other infectious diseases, because it is so well known; is so thoroughly understood; has such very marked characteristics; shows all the typical stages of any infectious disease; has these stages long and definite; because its control and even its abolition are possible in principle; finally, because both control and abolition have become accomplished facts wherever the proper measures have been carried out.

Typhoid fever has long been a type of the normal course of an unchecked epidemic; it is now a type of a checked epidemic also. Its history is a history of misunderstandings gradually cleared up, costly errors gradually corrected, an example both lamentable because of the many defeats and encouraging because of the final victory.

Typhoid fever, although it has existed doubtless since time immemorial, was not differentiated from typhus fever until about one hundred years ago. Its very name, typhoid fever,—which means *like typhus*—indicates the difficulties our ancestors struggled with, even so recently as the year 1800, in recognizing the differences between different diseases. To us typhus fever and typhoid fever are as distinct as an apple is from a banana, because our methods of study of disease have so greatly improved, more particularly in the last forty or fifty years. It is easy for us with high-power rifles and armored cars to smile at our ancestors' deadly fear of wolves—but our ancestors moved slowly on foot or, at best, with horses: their guns carried short distances, with small penetration and took a long time to load. As methods and knowledge develop, the infections we dread to-day will eventually take their place with the typhoid fever and the wolves of the past.

Typhoid fever is due to a germ, a sausage-shaped germ (bacillus), much of the size and shape of the tubercle bacillus, but capable of moving rapidly about in water by its own powers—a very ordinary, commonplace and innocent-looking little particle of protoplasm, very like hundreds of other germs which are harmless. It acts as do all disease germs through the poisons it produces, and like most other germs it must get into the body and multiply there, in order that these poisons may make us ill. It enters the body almost invariably through the mouth, thus again following the pathway of most disease germs. We swallow it, as we do nearly everything small that enters our mouths. If it survives immersion in the acids of the stomach, it passes into the intestine. In the intestine it makes much trouble locally, producing inflammation of the intestinal walls; but it also passes through the walls into the blood stream, just as the food does, and like the food is distributed to every part of the body. In this again it is like other germs, which are all very similar in size and shape, and are, therefore, naturally similarly influenced by the same physical conditions; if one germ can follow a given route, others can. Indeed, most minute particles like dust, coal smoke, etc., have the same sort of history in the body.

Reaching the blood stream, however, and passing to various parts of the body are only the initial stages. When two hundred immigrants enter a great city, they pass on to its streets, and quickly disappear. Each immigrant has some ultimate fate awaiting him, but those fates vary much. Their two hundred fates are each influenced by a thousand considerations. Their respective nationalities will drift them here and there, their habits of living, the sorts of food they like; later their various abilities in correlation with the conditions they happen to meet will spell their success or failure. Pure accident has determined the final outcome often. Just so, the great succession of all kinds of germs we constantly swallow find their fates as an ultimate resultant of a composition of forces, the main factors in which are accident, their own abilities, the conditions they encounter. Such of the disease germs as encounter conditions under which they can live, may survive and grow, and it is these alone which have a chance to poison the body.

Typhoid germs, then, enter the mouth and are swallowed, absorbed, begin to grow and produce their poisons. The day on which this entry occurs is the date of infection. They show no signs of their presence by any recognizable disturbance, however, for an average of two weeks. True, they are in the body in millions; they are escaping in the feces from the intestine; they are in the blood also and can be detected there, wandering about through it. The prospective patient is at this stage dangerous to others, through his feces, because the germs are in them, and his feces are leaving his body. He is not as a rule infectious through the blood (although the germs are there also), simply because the blood as a rule does not leave his body. But he himself shows as yet no poisoning. If he is not susceptible to the typhoid poisons, he will remain unpoisoned indefinitely; and so long as the germs remain within him he will be a prolonged incubate carrier—a person who continues in the incubation period of a disease without arriving at the development of the disease itself. This is the least common outcome of typhoid infection. But perhaps another fate awaits him; while in the incubation period, the germs, instead of developing, may, for reasons unknown, die out and leave him untouched. He is not a carrier now, for the germs have left him. This is by far the most common result of infection in typhoid fever; the germs enter but fail to obtain a footing. The development of the disease, as a result of infection, is a relatively rare occurrence. What it is that determines which of these three possible results will follow infection we do not yet know in detail.

Typhoid fever, then, has an incubation period of two weeks, during which the prospective patient is well, as in all the incubation periods of all the infectious diseases: and also is infectious, which is not true of all infectious diseases, but only of some of them, notably of typhoid fever, diphtheria and cholera; also of colds, influenza, pneumonia, gonorrhea, and indeed of nearly all those diseases characterized by infection of parts of the body, such as the nose, mouth, lungs, eyes, intestines, genito-urinary system, etc., which communicate with the outer world. The incubation period terminates with the onset of the disease. The onset of typhoid fever is usually very gentle and is often overlooked. The patient, no longer a prospective patient but an actual patient, showing some at least of the effects of the poisoning, very rarely guesses what is the matter with him. Very rarely is a physician consulted during the stage thus ushered in, which is, of course, the prodromal stage. Very rarely, be it said, would the physician recognize what was the matter with the patient if he did see him at this stage. The physician who may know that a typhoid epidemic exists or that the patient has been associating, perhaps as nurse, with a typhoid case, may suspect what is wrong; but under other circumstances this stage is rarely recognized, even if seen; certainly almost never in the first three or four days. During these three or four days and, indeed, for about the first week, the history of typhoid fever prodromes is as follows: headache; general malaise; painful bones; fever, rising day by day in staircase fashion; perhaps diarrhea, more or less marked, possibly a slight stiffness of the neck. In general, the patient keeps on at work, thinking each day he will feel all right the next, but finding on the next day that he really feels a little worse. About the end of the sixth or seventh day he gives up, goes to bed, calls a physician.

Now, this seventh day is usually not only the day of going to bed and the beginning of the physician's visits, but it is usually the end of the prodromal period also. It is, in other words, the day of the appearance of the typical symptom, which in the case of typhoid fever is known as the rose-spot, an eruption in the skin, usually over the belly, sometimes on the back. Rose-spots are small elevations about the size of the end of an ordinary match-stick, rather flat, rose-red. Three or four to a dozen or so at a time appear; last a day or two or three, and fade, others appearing at other points. Watch a physician examining a patient for rose-spots and you will note that he presses them with his finger to see if the color vanishes temporarily; and rings them with ink or a flesh pencil so that he may know if they will later disappear permanently. The typhus spots, in distinction to the typhoid spots, do not disappear on pressure, and remain for a long time in the places where they first appeared; both characteristics being due to the fact that they are not mere concentrations of blood in the blood vessels, like the typhoid spots; they are composed of blood or blood pigments, lying loose in the tissues, escaped from broken or injured blood vessels.

About the time the rose-spots appear, the patient shows two other signs of typhoid fever. One he has already shown for some time, the presence of typhoid bacilli in the feces and blood, often in the urine. Now he shows also the Widal reaction. His blood, diluted with water, and mixed with known typhoid bacilli, will make those bacilli cease the active movements that are characteristic of these particular germs; and will further make the separate little individual "sausages" cling together in masses. Why this is, what makes the blood act in this way, we do not know. We do know, however, that if a given disease germ is active in a given body, the blood of that body generally acquires, sooner or later, the power of, first, stopping the movements of the germ if it has any, and second, in any case, of making the separate individuals cling together in little masses. The blood having this power does not necessarily have also the power of killing the germs—for they will often go on multiplying after they are thus stuck together (agglutinated).

The typhoid patient is now, after the typical symptom (the rose-spot) has appeared, in the fastigium of the disease. This period is characterized usually by fever, diarrhea, great weakness, mental dullness, and great danger of hemorrhage from the intestine, or perforation of the intestine, both due to the ulcers which develop in the intestine, destroying more or less thoroughly in spots the wall of the intestine.

Bronchitis and pneumonia are not infrequent complications; also, as in most infectious diseases, kidney inflammations.

After three or four weeks of varying fortunes, the patient, if not yet dead, begins to mend, and a rather prolonged convalescence follows, also with very varied incidents, until at last he is "quite better."

But personal recovery does not end his infectiousness. The decubation period follows, during which the germs are still present, still escaping in the feces, perhaps in the urine, and the patient is, therefore, still infectious. In many cases this situation continues a month or so, ending with defection, i. e., the final disappearance of the germs. But in others, fortunately a rather small proportion of the total, this decubation period continues. Such persons are recovered but continue dangerous to others. They have had the disease; they have developed the carrier state from the decubation stage, and therefore they are called prolonged decubation carriers, or shortly, prolonged decubates. This condition may last months, years, or a lifetime. At present there is no certain way of clearing them up, i. e., of rendering them noninfectious. Their defection may occur on its own account, but how or why we do not know, so that we cannot induce it artificially.

The patient recovered from typhoid is to all appearances like any other person. But one character he has gained which he had not before—he is now incapable, for a time at least, of taking the disease again. He is, temporarily, immune. This immunity lasts two or three years. It is a general characteristic of infectious diseases that one attack confers immunity, more or less lasting, to subsequent attacks. To be thus immunized is, of course, one compensation—and the only compensation, from the physical standpoint—of having suffered from an infectious disease.

Immunity is so useful and valuable an acquisition that people will often urge having a disease in order to escape it afterwards. This seems something like committing suicide because you cannot bear to think of dying; but in some cases it is a logical procedure. Before vaccination against smallpox was known, this method against smallpox was prevalent in England: and it was proposed that the American physicians who went to Serbia to combat typhus should have that disease here first under good home conditions, so that they would escape it in Serbia where not only would their relief work be interfered with if they did have it but also recovery would be hampered by the relatively poor facilities for treatment.

Immunity, however, is not necessarily dependent on having the actual disease. It has been found that, at bottom, immunity is dependent on the body learning to deal with the poison of the disease, and that the poison may be administered artificially in such ways as to avoid the ordinary symptoms and damage done by a natural infection, while nevertheless securing the immunity desired.

Such immunity may be secured against typhoid fever by dosing the individual who desires immunity with the dead germs rather than the living germs. One fundamental advantage is that the dose of the poison thus administered is limited. If living germs enter the body, and multiply successfully, there is no telling where that multiplication will stop, and therefore no telling where the poisoning will stop. But with the dead germs, the initial dose of poison is the total dose; there can be no multiplication. In the Great War, every one of the soldiers in all the European armies was thus inoculated, as it is called, against typhoid fever with astonishing results.

So much for the outline of an attack of typhoid fever. Its public health relationships now require consideration. We have dealt with the patient, the course of the disease, the dangers to others which develop from the patient. What obstacles can we place in the way of the disease, so that it will not develop at all? You will remember that in, say, arsenic poisoning, the poisoning might have been prevented by very various means, by interposing very various obstacles between the source of the poison and its ultimate destination in the patient's system. These were sociological, or preventing his access to the poison; physical, or mechanical, by interrupting the poison on its course to him; chemical or neutralizing the poison; biological, or immunizing the patient beforehand.

Exactly similar in principle, although very different in details of application, are the methods for interrupting the course of the typhoid poison from its source in one person's body to its destination in another person's body.

I have already discussed the biological obstacle constituted by immunizing the patient against typhoid fever, by the injection of dead typhoid bacilli. Simple chemical methods for destroying the germs in the body have yet to be discovered. So far all attempts have failed. The fact is, that we can neutralize a thing like arsenic in the stomach because it is so different from us that we can find substances which will put it out of action without hurting us. But germs are made of protoplasm as we are. They are, if not second cousins of ours, at least 42nd cousins. This is obvious if we consider that they live on the same things we live on, vegetable matters, animal matter, etc. It is still more obvious that disease germs are made of the same things we are made of when we remember that when they feed, they feed on *us*. Hence, one of the greatest problems in medicine is still to find any substance which, when introduced into the body, will destroy the germs without destroying the almost exactly similar substance surrounding them, that is, ourselves. Quinine in malaria, some of the drugs now used in treating syphilis, seem to have the happy faculty of injuring us slightly less than they do the germs, so that carefully administered doses may just succeed in putting the germs out of business, while just escaping putting the patient out of business. In typhoid fever, no simple chemical method of disinfecting the interior of the body or of neutralizing the typhoid poisons are known. Outside the body, however, simple chemicals may be used to destroy the germs. Chloride of lime solution, for instance, added to the infected feces or urine destroys the typhoid germs present; other disinfecting solutions may be used for the germs on bed clothing, the patient's skin, the attendant's hands, etc. If the patient's discharges are placed undisinfected in the sewage of the community and if, as often happens, this sewage finally reaches a public water supply and so may be drunk by other persons, the germs may be arrested on their course to these persons by physical means—notably by filtration of the water or disinfecting it, as with chlorine or ozone. But back of all such biological, physical, mechanical or chemical methods are the sociological—the provision by education, by the careful structure of social relations, of such an understanding of typhoid fever, and of such a will to conquer it, that the proper precautions become part of the life of the race. Then the typhoid germ will die out and disappear from the globe, making further precautions against it unnecessary.

Taking now in detail the series of events leading up to infection of a prospective patient, we may start with the germ itself. Where does it breed, flourish, depart from, on its path to a new realm? Old ideas said that it arose from decomposing vegetation in swamps, rotting garbage in the backyard, sewer-gas, etc. We find, however, that there is only one place in nature, outside of the laboratory, where typhoid germs grow and flourish and from which the germs depart for pastures new. That place is the human body. However the typhoid germ of to-day may have got its start as a disease-producing organism, away back in the dawn of history, we know that to-day it does not rise afresh by spontaneous generation or in any other way; to-day it arises merely by propagation from previous typhoid germs, and this propagation occurs practically nowhere else than in the human body.

From the infected human body, the infected discharges, feces, urine, may pass to other bodies by the hands of attendants, in water, on food, in milk, or through flies. On the skin-surface they are harmless, but once they are introduced into the mouth, by food, or hands, or utensils, etc., and so are swallowed, infection is achieved.

Evidently, then, the great sociological remedy for typhoid fever includes finding the infected person and such supervision of that person as will prevent his germs from reaching other people's mouths. This is true of most other infectious diseases also. In typhoid fever we have a further method, not applicable to most other infectious diseases unfortunately, that of immunizing all persons so that if the typhoid germs do enter their mouths, the results will be *nil.* The finding of, and the preventing of spread from, the infectious person is the highest art of Sanitation relating to the prevention of disease, constituting as it does the complete removal of this particular danger from the surroundings and leading ultimately to the abolition of the disease from the world. The immunization of the individual so that the germs will not hurt him belongs rather to Hygiene, since it deals with the care of the individual body itself.

The lesser remedies consist in guarding such surroundings as may contribute to the spread of the disease, if its spread is not or cannot be stopped at the fountain head, the infected person. These lesser remedies deal with the purification of sewage, and of water; the guarding from infection of milk and food; the elimination of fly-access to typhoid infected excreta: but all are relatively onerous and expensive, as well as relatively inefficient, theoretically, when compared with the finding and segregating of the infectious person. Yet it must be admitted that the difficulties from the sociological standpoint in finding and isolating the infectious person, have not proved, in the case of typhoid fever, less than those encountered in the more advertised and better understood methods established for purification of water, etc.; and in practice, these methods, combined with immunization, have eliminated typhoid fever as a serious menace wherever they have been faithfully followed.

Typhoid fever has two close relatives which nevertheless are quite distinct. These are known as Paratyphoid A and Paratyphoid B. They are due to germs much like the typhoid bacillus in many respects. They exhibit symptoms much like those of typhoid. The blood of a typhoid patient, which agglutinates typhoid bacilli, will agglutinate the paratyphoid bacilli also, if it is used in sufficient strength. Nevertheless, closely allied as they are, inoculation with dead typhoid fever germs, which protects the inoculated person against typhoid fever, does not protect against paratyphoid; and vice versa. Indeed, even the two paratyphoid diseases, A and B, are so distinct in this respect that the germ of each protects against itself but not against the other.

Paratyphoid fever has about the same incubation period as typhoid fever, a more abrupt outset, a shorter course and a lower fatality.

We really know comparatively little about these diseases because they are in this country rather rare; they have not long been differentiated from typhoid fever, and being of less importance, they have attracted less attention. They are usually overlooked or mistaken for mild typhoid unless laboratory tests are carefully made. The most conclusive of these is the testing of the blood for presence of the germ.

Typhus fever, the disease from which typhoid fever derives its name (this derivation being a standing monument to the crudity of earlier medicine), is not at all like typhoid fever in origin, development, infectiousness or other parts of its history.

Typhus fever is first of all due to a totally different germ, although it is not yet conclusively accepted that this germ has been successfully identified. We know it is something different from the typhoid germ, however, because the typhoid germ never has been known to produce anything remotely like typhus as we know it. This typhus germ is conveyed from one person to another wholly by lice, body lice or head lice, in which respect it resembles the germ of trench fever, which is similarly carried. The typhus patient is infectious, but only through the lice, which must bite the patient and then the prospective patient. In a louse-free hospital, etc., a typhus patient is quite incapable of transmitting the disease.

Summary: Typhoid is one of the best examples of the characteristics of an infectious disease, presenting a definite incubation period of two weeks, a prodromal period of one week, a fastigium variable, but in general of three weeks, a prolonged convalescence, and a decubation period averaging perhaps a month.

Typhoid fever is contracted by swallowing the discharges of the bladder or bowel of a previous patient, or of a prolonged incubate, or prolonged decubate, carrier. Since these discharges may enter water supplies and milk supplies; or may be carried to foods by food handlers or flies; or may be transferred directly from the patient on the hands of attendants, etc., all the main avenues of infection are illustrated in the natural history of this disease.

Paratyphoid fever, in two varieties, simulates mild typhoid clinically rather well, but the two varieties are due to germs quite distinct from each other and from the typhoid fever germ, although all three germs are closely related to each other.

Typhus fever, despite its name, is wholly and totally distinct in every way from typhoid and paratyphoid fevers. It is conveyed by the louse, which is infected through biting a typhus patient; and is combated by getting rid of such infected lice and by preventing the infection of lice, by preventing the biting of typhus patients by lice.

CHAPTER IV

MORE ERUPTIVE INFECTIOUS DISEASES: SCARLET FEVER AND DUKE'S; MEASLES AND GERMAN MEASLES; SMALLPOX AND CHICKEN POX.

Scarlet Fever, Duke's Disease, Measles and German Measles constitute another convenient group of the eruptive diseases. They show as their typical symptoms pronounced rashes, symmetrically distributed over the body-surface: a rash being a more or less extensive but usually relatively *mild* congestion or inflammation of a *considerable area* of the skin, generally obviously red or pink.

Smallpox and chicken pox form still another group of the eruptive diseases, but are characterized by an *intense* inflammation of relatively very *small areas* of skin, which areas are generally numerous and are also symmetrically scattered over the body-surface.

These diseases may be further subdivided into pairs, the first consisting of scarlet fever and Duke's (scarlatinoid German measles), the eruptions of which are similar to each other; the second consisting of measles and German measles proper (measly German measles), the eruptions of which also are similar to each other but differ markedly from those of the first pair: the third of smallpox and chicken pox, the eruptions of which are again similar to each other, but differ markedly from those of both the other pairs.

The members in each pair have other relations to each other, already illustrated in the case of the previously described eruptive diseases, typhoid fever and paratyphoid fever. In each pair the first member named is a relatively severe disease, the second a relatively mild one—and in each pair the differentiation of the severe member from the mild member is not only rather difficult sometimes because of the resemblances they may bear to each other, but also very important always because of other differences between them—differences in the severity of the diseases, in the Therapeutics called for, and especially in the Public Health procedures required.

These five diseases (Duke's and German measles proper being really at bottom the same disease) have in common the feature that we do not know the germs which produce them; although we are confident that they are produced by germs, and moreover that each is produced by a different germ.

That all these five diseases must be produced by germs of some kind is evidenced by the close parallelisms in their histories to the histories of other diseases which germs are known to cause, such as typhoid fever, diphtheria, etc. They all show an infection date, incubation period, onset date, prodromal period, etc., exactly as do typhoid and diphtheria. They are like them in being infectious, and also in being infectious in the same general ways. They confer immunity to a second attack just as the known germ diseases do.

That each of these five diseases must be produced by a different germ in each disease is evidenced by the fact that despite the clinical resemblances of the paired members to each other, no one of the five, if transferred from a patient to another person, ever gives rise to any other of the five but always reproduces itself and itself only: in brief, each "breeds true." Again, the immunity conferred by an attack of any one of them is an immunity to itself only, not to any other. Thus scarlet fever gives rise to scarlet fever only, never to Duke's, measles, German measles, smallpox or chicken pox, while the patient who has recovered from scarlet fever is immunized against scarlet fever only, not against Duke's, measles, German measles, smallpox or chicken pox—and this may be repeated for every member of both groups, except, of course, for Duke's and German measles, which being really the same disease in different guises, are interchangeable in infectiveness and in immunity.

In these respects again these pairs parallel the pair, typhoid fever and paratyphoid fever, neither of which gives rise to the other, neither of which immunizes against the other.

This point is so explicitly emphasized here because the older physicians often maintained that chicken pox was simply mild smallpox, that German measles was simply mild measles; but the noninterchangeability of infectiveness and of immunity, now established, indicates that these diseases, however closely alike in clinical history at times, are really due to distinct germs.

In describing the first four, scarlet fever, Duke's, measles and German measles, we find one very easily disposed of—Duke's disease is in all probability simply German measles; but it is German measles which shows a rash like that of scarlet fever, and it is therefore clinically distinguished from German measles proper, which shows a rash like that of measles. Hence every descriptive statement concerning German measles may be made also of Duke's, except as regards the rash.

Scarlet fever is derived from previous scarlet fever patients: carriers have been described, but confirmation of their existence is lacking. It is true that occasionally patients, long after apparent recovery, seem to have given rise to new cases, but the question remains unsettled as to whether or not such infective cases were in fact completely recovered cases or not; for it is well known that discharging ears, etc., following scarlet fever, remain infective for months.

Scarlet fever is transmitted from the infected person in the discharges of his nose and mouth, hence in the mouth-spray, and through the hands of the patient; and through all other hands, as of attendants, which touch the patient, or things the patient has touched, in such a way as to pick up even invisible smears of these discharges. Ocasionally, milk, food, etc., may become infected from a patient or an attendant and convey the infection to consumers.

Not only these discharges but also the discharges from infected ears, or from any open wound on the patient's body, are dangerous to others, if conveyed to the prospective patient's mouth or probably to an open wound.

Measles and German measles are similarly conveyed so far as the nose and mouth discharges are concerned. Curiously enough, discharging ears, etc., in measles and German measles appear not to be infectious. Carriers are unknown.

The incubation period of scarlet fever is usually five to seven days. In measles the incubation period averages ten days, with a range of nine to eleven. In German measles (and therefore in Duke's) the incubation period is fourteen to seventeen days.

The onset of scarlet fever is abrupt, the temperature rising to 103°, 104° or 105° in a few hours and the typical symptom, the rash, appears almost always within twenty-four hours.

The onset of measles is less abrupt; the temperature rises more slowly and less high; the rash does not appear until the fourth day.

The onset of German measles (and therefore of Duke's) is scarcely preceptible: usually the rash (measly in German measles, scarlatinoid in Duke's) is the first symptom noted. In other cases, symptoms of a moderate cold, with redness of the eyes, may precede the eruption by a few hours.

While a conclusive diagnosis between the four rash diseases cannot always be made at the moment of onset, the later prodromal symptoms, before the rash appears, often furnish considerable evidence pro or con.

For instance, the mere length of the prodromal period helps much. If the rash appears without prodromes, or after very slight and short prodromes, one can be pretty confident, before examining the rash even, that the disease is neither scarlet fever nor measles. Again, if the prodromes have continued two or three days and the rash has not yet appeared, both German measles and scarlet fever may be pretty safely eliminated. So also if a rash appears on the fourth day of prodromes, it is, from that very fact alone, very likely to be the rash of measles.

The character of the prodromes aids much also in diagnosis. Scarlet fever prodromes present a restless, excited patient, with a highly flushed face, enlarged glands at the side of the neck below the angle of the jaw, a sore throat, a strawberry tongue, which, while chalky-white over most of the surface, due to the presence of a heavy coating, is a striking pink at the edges and has also pink spots scattered through the white coating. These spots are the bare tops of enlarged papillæ, all but submerged by the coating. The face often shows a remarkable paleness of the upper and lower lips and chin (circum-oral pallor), contrasting strongly with the enhanced redness of the cheeks. Finally, almost all scarlets vomit more or less before the rash appears.

Contrast with this picture the prodromal picture of a measles patient. Drowsy and irritable rather than excited, the measles patient shows symptoms like a heavy cold; congested eyes, distressed by bright light; a running nose; a mild bronchitis; a brassy cough; slight, if any, glandular enlargement; nothing striking in throat or tongue, but frequently spots on the insides of the cheeks (Koplik's spots), red with a whitish center. These spots are seen to perfection about the second or third day of the attack. They enlarge and fuse together by the time the rash appears, as a rule, giving a general dull redness, not strikingly distinctive.

In German measles (and therefore in Duke's), there may be no prodromes, the rash and the symptoms coming together. If there be prodromes they precede the rash but a few hours. They are like the prodromes of measles, but much milder, as well as much shorter; there are no Koplik's spots; and there is in most cases a peculiar enlargement of a single gland, behind each ear, right upon the mastoid bone.

This gland feels to the examining finger exactly like the half of a split green pea lying with its flat side against the bone, just under the skin. In measles one gland on one mastoid may be enlarged, but in German measles (and Duke's) usually both mastoids show this enlarged gland.

When the rashes appear the diagnosis is usually settled. Scarlet fever differs from measles and German measles in that the rash of scarlet fever seldom, if ever, appears on the face, while that of both kinds of measles almost invariably does appear there. All the rashes occur on the neck and just below the jawbone, but scarlet fever seldom, if ever, extends higher.

The intense redness of the cheeks of the scarlet fever patient must not be mistaken for part of the true scarlet fever rash. It can be distinguished from the true rash by its intense continuous uninterrupted redness. The true rash is typically *not* a perfectly continuous rash, but, at least at first, is composed of very small red areas close together, with white skin between. It is true that these areas tend to fuse in time; but the redness of the cheeks is continuous from the first.

Again, the face seldom peels in scarlet fever, while all other parts of the body affected by the rash do peel, sometimes extravagantly, i. e., the superficial skin layers loosen and strip off, usually in sizable flakes.

The scarlet fever rash begins usually on the chest below the collar bones and extends rapidly. Examination of the outlying portions of the rash will show its discrete character: the central older portions may fail to show this because of the gradual fusion of the multiple tiny separated red areas. It is not palpable, i. e., the reddish areas are not raised above the surrounding white skin sufficiently to be detected by the touch.

The scarlet fever rash is usually little developed on the legs, but here a marked gooseflesh, each hair-base being ringed with red, aids in recognizing the disease.

The scarlet fever rash may fade quickly. Typically, however, it lasts about four to seven days.

The measles rash appears first on the face and neck. It is usually much like a crop of dark red pimples, at first flat, then conical, raised from the surrounding skin. These pimples, however (sometimes at this stage confused with the eruption of smallpox), quickly flatten out, while their bases extend in irregular blotchy fashion; and thus is formed a curiously irregular pattern of raised dull red rash, with correspondingly irregular patches of normal skin between. This is best seen (as indeed all the rashes are) on the smooth hairless area of the inner surfaces of the forearms.

The measles eruption is not only always on the face, but very frequently shows on the palms and soles as well as on the rest of the body. It is quite palpable on the body, so long as the fusion is not so extensive that no normal white skin is left. It is not palpable on the palms or soles, and is not likely to be on the face, because on the face little of the skin surface escapes unaffected.

If one were blindfolded and presented with a typical case of scarlet fever and a typical case of measles, it should be quite possible to distinguish them by running the tips of the fingers lightly over the erupted areas on the body. The scarlet fever rash would be smooth or at most gooseflesby; that of measles would be velvety, and the irregular hollows of normal skin between the irregular plateaus of elevated rash should be easily recognized.

The measles rash also lasts four to seven days. In fading it often leaves a faint brownish discoloration; sometimes a fine "branny" desquamation follows.

The German measles *measly* rash (found in German measles proper) is like a faint, nonelevated, feeble imitation of the measles rash. Often it appears much as if someone had dipped the tip of a finger in rouge and touched the skin lightly at numerous points, leaving his finger marks faintly outlined. This rash rarely lasts over three days. It occurs on the face but is seldom found on palms or soles.

The German measles *scarlatinoid* rash (found in Duke's disease) is like a feeble imitation of the scarlet fever rash, but being really a German measles rash, occurs on the face as well as the body.

Considering now the fastigia of these diseases, the Duke's and German measles cases may be dismissed from consideration. They are seldom sick enough to stay in bed unless kept there forcibly and usually go on to complete recovery in three or four days from the rash.

The measles case, however, is likely to be pretty sick for three or four days at the height of the eruption and remains more or less indisposed as long as the rash lasts. The complication most to be feared is severe bronchitis, even pneumonia, and it is currently believed that tuberculosis often follows later on.

As in all severe infections, so, in measles, the kidneys may be affected. Sometimes severe inflammation of the middle ear, with rupture of the drums, occurs. Ordinarily the measles case is all right again in a week.

In scarlet fever, the early days of the rash show a very sick patient with high fever, severe sore throat, much swollen glands, often delirium; the tongue, now stripped of its coating, is a brilliant red, its now naked enlarged papillæ standing out prominently (cat's tongue). The complications are chiefly of the kidneys and ears, although almost anything in the nature of sepsis may happen.

After a week or so the patient is likely to be over the acute symptoms, but complications, especially those of the kidneys and ears, may develop in an apparently otherwise flourishing patient as late as the third or fourth or fifth week; and, on account of this, cases of scarlet fever are always sources of anxiety to the attendants until at least the sixth week, regardless of how well they have done so far.

When the scarlet fever rash begins to fade, usually about the fourth to seventh day, some desquamation appears on the chest; later on the hands, and about the second to third week, on the feet. The order of place, and the extent of desquamation are exceedingly variable. Light cases may show almost none, very late, and chiefly on the hands. My rule has been never to discharge an alleged case of scarlet fever as "not scarlet fever," because of lack of desquamation, unless four weeks have elapsed since the alleged onset.

No case of scarlet fever should be discharged as non-infectious in less than five weeks; nor at this time, or later, regardless of how much later it may be, unless no complications exist, the temperature has been normal for at least a week and there has been no discharge from ears or any open wound for at least a week. A discharging ear in scarlet fever may give the disease to others twenty weeks or more after the onset.

These eruptive diseases are infectious so long as the patient is systemically ill. German measles, of either the scarlatinoid or the measly variety, is probably infectious for not over a week all told; measles for not over two weeks; but in scarlet fever the evidence points to a minimum period of danger of five weeks and a maximum lasting until complete systemic recovery and complete recovery also of all wounds or mucous membrane inflammations.

Smallpox and chicken pox form a pair of eruptive diseases characterized by relatively intense inflammation of multiple small areas of the skin.

Smallpox is a traditional terror of the human race, a name to conjure with it if is desired to scare a community into hysterics. Chicken pox is so relatively innocuous from the standpoint of damage to the patient that most physicians neglect to study it sufficiently to be at all at ease in differentiating it from smallpox, a serious oversight when the occasion for a diagnosis arises. These together form one of those curious pairs of diseases already described—one severe, one mild, closely alike in many respects, absolutely different at bottom, probably due to closely allied germs, yet not interchangeable in either infection or immunity.

In all these pairs, there is no difficulty in diagnosing typical cases; for instance, ordinary typhoid and ordinary paratyphoid are fairly distinct clinically. But mild typhoid and severe paratyphoid are, unless perhaps in retrospect, with difficulty differentiated, except by the finding of their respective germs in the blood or by working out their respective agglutinating reactions. In scarlet fever and Duke's, in measles and German measles, in smallpox and chicken pox, aids of this kind are not available or are too cumbersome for ordinary use. Hence a real difficulty presents itself at times, even to the specialist, in distinguishing a mild case of the severer disease from a severe case of the milder disease—and very often the diagnosis can be arrived at in a given case only from a review of the features presented, not at any one time, but throughout the whole course of the attack.

One step can never be in doubt, however; prompt isolation is indicated whenever any of the infectious diseases is suspected. Whatever further details in handling the situation may be needed can be worked out later, after the diagnosis has developed.

Smallpox goes back into the dawn of history. It has killed, injured and disfigured whole races, to a degree which is hardly appreciable now. In the middle of the Eighteenth Century one-fourth of Europe died of this disease and every third person on the street was marked with pocks. Kings, emperors, warriors, suffered as well as the commoners and slum dwellers. It was considered almost inevitable then, even in the best circles; and not only inevitable, but even desirable, as it is now in parts of French Canada, where some, at least, of the more ignorant habitants, have conjured up a belief that suffering from it in this life relieves the sufferer of purgatory in the life to come. We should not be too proud of our superior position as to smallpox, however, since we, in general, still believe in the inevitableness of measles, and even, obscurely, in its virtues. The Mayor of a Canadian city, himself a medical man, advocated so recently as 1917, that all mothers insist on their children having measles as a protection against future tuberculosis!

Smallpox occurs in a modified form, in cattle, and may be contracted from an infected animal. Such infection from the cow usually depends on the contents of the cow's skin-eruption reaching a human wound. The human so infected is thereafter completely immune to smallpox for about seven years, partially immune for a much longer time. The process of purposely giving this modified smallpox to a human by inoculation into the skin is known popularly as vaccination.

When smallpox is contracted from the human patient, it is done chiefly by taking into the mouth the discharges of the nose or mouth of the smallpox patient in the form of mouth-spray or of smears on hands. The contents of a smallpox pustule, introduced into the mouth or nose or into a cut or other open wound will also convey the disease. Chicken pox is contracted from the mouth-spray of the patient and from smears on hands, but it would appear that the contents of the vesicles of chicken pox are not capable of giving the disease, however introduced into a new body.

The incubation period of smallpox is usually from ten to fourteen days in the severer forms, but may extend to eighteen or twenty days in the mild. The incubation period of chicken pox is fifteen to eighteen days. Prospective patients during incubation are not infectious in either disease.

The onset of smallpox is fairly abrupt. The prodromal period lasts two to three days in the severe forms, but may be four to five days in the milder. Fever, headache, pains in the bones, especially the back, are the striking feature. These symptoms are so like many cases of grippe that, at this stage, a differentiation is often impossible. The back pains are often extremely severe and grinding in character. It has been suggested that the only way a man can appreciate the pains of childbirth is to suffer smallpox prodromes. The prodromes of chicken pox are very mild and of short duration, rarely more than half a day. Usually, especially in children, there are no prodromal symptoms.

A history of successful vaccination within seven years, and the confirmation of the history by the presence of a good vaccination scar, helps much in deciding doubtful cases, since smallpox seldom develops in such a patient. A previous attack of smallpox is even more conclusive, since smallpox very seldom repeats in the same person. Vaccination against smallpox is not of the slightest protection against chicken pox, nor is a previous attack of smallpox; but a previous attack of chicken pox is practically a complete protection against chicken pox, although it has not the slightest protective effect against smallpox or against vaccination.

The typical symptom of smallpox appears on the third or fourth day in the severe form, but may be delayed to the fifth or sixth in the mild form. In both chicken pox and smallpox the eruption consists at first in subcuticular, reddish spots (macules), appearing in smallpox on the face, and wrists, in chicken pox on the face and body. These macules continue to increase in number in both diseases but remain as such in smallpox for about twenty-four hours, while in chicken pox they change rapidly into red elevations (papules), varying in size, and often elliptical. These in turn develop a little fluid in the top (vesicles), so that in twenty-four hours the chicken pox case may already show a mixture of macules, papules and vesicles while the smallpox case still shows only macules.

In the second twenty-four hours the earlier macules of smallpox have become small, round papules; the later macules which have not yet become papules are mixed with them. In chicken pox at this time the vesicles have developed into quite large, thin-walled, tense "water-blisters"; many of these are likely already to have been broken by scratching, friction of clothing, rolling over in bed, etc. A new crop of macules may now appear, and go through the same regular stages.

Smallpox in the third twenty-four hours may present a few macules and some papules, but most of the papules have by this time gone on to the early vesicular stage. The walls of the smallpox vesicles are thick and white, the fluid within cannot be seen clearly through the thick white covering, and the vesicles are too tough to break readily. There is commonly a slight depression in the center of the top of each vesicle, constituting "umbilication."

The chicken pox lesions go on from the vesicular stage to dessication, the vesicles breaking down, or drying up; in the former case leaving little red, raw sores at the apex of the raised lesion, which later crust over; in the latter, a dried shell, lying over the apex. The patient usually has no further trouble except his anxiety to be released from isolation before the crusts and shells have completely disappeared.

The smallpox lesions, on the other hand, enlarge somewhat during the next three or four days, and their contents tend to become more or less purulent. The depressions in the centers disappear so that the pustules bulge roundly from the skin.

The smallpox patient, at the appearance of the eruption, is usually immensely better than during the previous prodromal stage; so much so that he frequently fails to connect his previous illness with the eruption at all, and is genuinely surprised when, in presenting himself to the physician on account of the eruption, inquiries are made as to a previous illness; which illness he admits, but hastens to point out that it had no connection with the spots and indeed had quite disappeared before he noticed them.

During the first week of the eruption the smallpox patient continues to feel far from seriously ill, even in the severer forms of the disease. In the milder forms, pustulation is slight or absent, and the lesions, towards the end of the week, dry down without breaking, the patient having little to do thereafter but await their final disappearance, which is not very much slower in arriving than in chicken pox.

In the severer forms, however, the pustulation is definite; the patient becomes septic; by the seventh day of the eruption very severe illness may supervene. The real horrors of smallpox may now develop,—the skin floated up in large patches by the fusion of many pustules—pain, delirium, vile odors, etc. The amount of pus in the skin has been determined in at least one case; and proved to total five quarts. Eyes, ears, kidneys, may be severely or irreparably damaged and as in other septic conditions, almost anything may happen. Such cases may be months in recovering. They are rarely seen now. For the past eighteen years, the prevailing smallpox has been of a mild type with a death rate even less than that of chicken pox, which death rate is almost nonexistent, the few which succumb being the very young or the very old.

Smallpox is known to be infectious through the crusts and scales as well as through the nose and mouth and hands; and until the crusts and scales are wholly gone, the patient should be isolated. A similar rule is followed in chicken pox, and so long as the ordinary physician is not trained definitely, while a student, to differentiate chicken pox and smallpox clearly, this rule may be regarded as a proper "safety first" precaution against mistaken diagnosis. The opinion is growing, however, that, allowing it to be true that chicken pox lesions are not infective even at their height and so can not be infective during their decline, genuine chicken pox cases may be safely discharged as soon as recovery is complete, notwithstanding that the scales and crusts may have not wholly disappeared.

In distinguishing smallpox from chicken pox, the following summary of differential features may be useful:—

Smallpox occurs in persons of any age who have not had it before, and who have never been successfully vaccinated; or if successfully vaccinated were so a long time previously. Smallpox shows a definite prodromal period of two to three days; an abrupt improvement just before the eruption appears; the eruption appears on face and wrists, and develops relatively slowly; the lesions because they are deep-seated are uniform in size, small, round, hard, do not break down easily; they are relatively more numerous on the extremities than on the body; they almost always are present in both palms and in both soles.

Chicken pox may occur in anyone who has not had chicken pox before; prodromes are absent or slight, except in adults where they may exist for a day or two; the eruption corresponds with illness beginning rather with an improvement in illness already existing: the eruption appears on the face and body and develops rapidly; the lesions are larger than those of smallpox, and irregular in size; also irregular in shape, some round, some oval or elliptical; they are soft, and in the vesicular stage are very commonly found broken. They are relatively more numerous on the trunk than on the extremities: it is not rare to find them in one or two of the palms or soles; but they are relatively few and far between in these situations as compared with smallpox lesions.

Two oft-repeated fallacies in diagnosis should be mentioned: these are that chicken pox *never* occurs in the palms and soles, and that, therefore, every case showing palmar or solar lesions is smallpox; that chicken pox *never* shows sores in the mouth—and that therefore, every case with sores in the mouth is smallpox. The facts are that *almost all* chicken pox cases do show one or more lesions on one or more palms or soles and one or more spots in the mouth.

In making a diagnosis, the most constantly reliable distinguishing points are—the presence or absence of prodromes; the presence or absence of broken lesions; the presence or absence of irregular-shaped lesions; and the relative distribution on the body and the limbs. The mere severity of the attack is no criterion, and there is no excuse more feeble than the excuse offered by the physician who misses a case of smallpox, to the effect that he made his mistake because he did not think the case was sick enough to be smallpox.

SMALLPOX VACCINATION BY PUNCTURE IN THE ARMY

TECHINQUE

1. The sleeve is rolled up.
2. Orderly 1 washes the arm with soap and water.
3. Orderly 2 washes the arm with rectified spirits.
4. Orderly 3 washes the arm with ether.
5. Orderly 4 breaks the capillary tube of glycerinized vaccine and sets the rubber bulb or other method of expelling contents, handing it to Orderly 5.
6. Orderly 5 expels the vaccine at three (or four) points on the arm, marking out a triangle (or square) having not less than 2 inches between the points.
7. Orderly 6 sterilizes an ordinary sewing needle and hands it to the medical officer.
8. The medical officer punctures the arm through the drops of vaccine. Six tiny punctures, drawing no blood, are made through each drop, each set of six occupying a space of not more than $^1/_8$ in. square. The needle is held almost parallel with the surface. Not over one-thousandth of an inch of the needle point enters the epithelial layer. A peculiar little "snick" is felt as the needle point goes in.
9. Orderly 7 wipes off the vaccine.
10. The sleeve is pulled down.

NOTES ON TECHNIQUE

(a) The total time from pulling up the sleeve to pulling it down again need not exceed one minute.

(b) After the orderlies have had a little practice three men per minute can be vaccinated without haste or carelessness.

(c) No after-treatment whatever is required; none should be used; the only direction to the men is LEAVE IT ALONE.

(d) Use no bandage, adhesive plaster, shield or other protective dressing *whatever*.

RESULTS

I. In those not previously successfully vaccinated (and who have not had smallpox) nothing is found for several days; then develops a typical vaccinal lesion, consisting of one, two, three, or four firm pustules corresponding with the areas punctured. If *left alone*, without bandage or shield, etc., these remain firm and whole; then dry down into hard "buttons" which finally detach themselves, leaving a clean healed base, constituting a typical vaccine scar. If bandages, shields, etc., are used, the moisture from the perspiration thus retained, macerates the otherwise firm wall of the pustule, which then breaks, creating an ulcer open to infection.

II. In those who have been previously successfully vaccinated (or who have had smallpox), a raised red papule develops in a few hours; itches a little, sometimes develops a number of tiny vesicles over its surface, then dies down and disappears. This is the anaphylactic or accelerated reaction, indicating usually that immunity exists, sufficient to prevent typical vaccinal lesions.

III. Occasionally a mild reaction of this kind, instead of disappearing, develops into a typical vaccinal lesion, the anaphylactic papules developing into ordinary vaccine pustules instead of receding and drying up. These pustules then run the ordinary course described under 1. Evidently here the immunity from the previous vaccination, while sufficient to give anaphylaxis, was not complete enough for protection.

IV. Very occasionally no reaction of any kind follows the puncture. Only in such cases need revaccination be done. The probable explanation in the few cases observed was improper technique or old vaccine.

NOTES ON RESULTS

(a) Certain rare cases showed the anaphylactic reaction (II) although, according to the history given, they never had been successfully vaccinated and never had had smallpox. They showed history of "chicken pox" however. We investigated two of these cases, communicating with the mother of each and securing from her a detailed account of the alleged attack of "chicken pox." In one case it was quite evident from the mother's description that the attack was really smallpox; in the other, it was extremely probable that it was smallpox.

(b) The only "bad arms" out of many hundreds of vaccinations by this method that have come to my attention were constituted by slight inflammations about the bases of ulcers, due to prematurely knocking off the dried "buttons" after the vaccination process was quite complete, the buttons having become somewhat loosened but not ready for removal. It must be added, however, that some arms which had been bandaged despite instructions to the contrary flared up more than was necessary, and in a few instances the pustules opened.

For civilian practitioners, not able to employ eight or nine assistants to do the washing, etc., the technique, nevertheless, is so simple that no one vaccination operation need take over five minutes. Its great advantages in civil life are:

(c) Not even adolescent girls object to the punctures; there is no fainting, etc.

(d) There is no waiting, after the vaccination is done, for the vaccine to dry. The instant the puncturing is finished, the surplus vaccine is wiped off and the sleeve pulled down.

(e) There are no bad arms, and there is no loss of time due to bad arms.

(f) In all open methods of vaccination (scraping, scarifying, cross-hatching, etc.) one obvious source of "bad arms" is infection of the open wound, during and after the removal of the epidermis, from the mouth-spray of the vaccinator, his assistants, and the patients themselves, especially if there be a number of the latter, crowding the office and all talking at once, as often happens. In the puncture method no epidermis is removed; moreover, the process is so rapid and the exposure of the arm so short, that this really serious source of infection in the older method is almost completely eliminated.

Summary; The eruptive infectious diseases of this part of the world may be classified in pairs, each pair consisting of a rather severe disease with more or less fatality, and a rather mild disease, with little or none.

They are—Typhoid and Paratyphoid. (See Chap. III)
Scarlet Fever and Duke's (scarlatinoid German Measles)
Measles and German Measles proper.
Smallpox and Chicken pox.

In typhoid fever and paratyphoid fever the patient is infectious from infection to defection, with a decubation period of noteworthy length, sometimes greatly prolonged. In the other three pairs, infectiveness does not begin until onset; and terminates, except in smallpox and scarlet fever, with return of the temperature to normal; in some instances (notably in measles and chicken pox) before all the lesions have necessarily completely healed. In smallpox the crusts and scales and in scarlet fever all open wounds and inflamed mucous membranes must be entirely restored to normal before the patient is safe.

In most of the above it is noteworthy that the incubation periods of the severer members of each pair are somewhat shorter than those of the milder member, while the prodromal periods are decidedly longer. (See table following.)

	Incubation Period (days)	*Prodromal Period (days)*	*Prodromal Symptoms*	*Typical Symptoms*
Typhoid	14	7	Gradually increasing fever and malaise.	Rose-spots; few, small; on belly and back: readily disappear on pressure.
Paratyphoid	14	3 or 4	Similar, but more abrupt.	Similar.
Scarlet Fever	5–7	1	Abrupt fever; sore throat; strawberry tongue; vomiting.	Rash; rosy, consisting of tiny spots, later fusing; not raised; not on face.
Duke's	14–17	0	Like slight cold.	Rash; feeble, irregular imitation of above, but occurs on face.
Measles	9–11	4	Slowly rising fever: running nose, congested eyes; bronchitis; brassy cough; Koplik's spots.	Rash; dark-red, pimply at first, rapidly flattening into irregular plateaus; palpable; present on face.
German Measles	14–17	0	Like slight cold.	Rash; feeble, irregular imitation of above.
Smallpox	10–14–20	3–4–5	Severe fever; sore throat; pains in bones, especially back.	Macules, papules, vesicles, pustules, slowly developing; papules, vesicles, and pustules, hard, round, small, uniform, chiefly on face and extremities. Don't break down.
Chicken pox	15–18	0	Slight indisposition.	Macules, papules, vesicles, *not pustules*, rapidly developing; papules, vesicles, soft, sometimes oval, varying much in size; chiefly on face and body. Break down early.

CHAPTER V

INFECTIOUS DISEASES OF THE THROAT, LARYNX AND ADJACENT AREAS: DIPHTHERIA, TONSILITIS, SEPTIC SORE THROAT, VINCENT'S ANGINA, WHOOPING COUGH, MUMPS, COLDS

Diphtheria, Tonsilitis, Septic Sore Throat and Vincent's Angina, make a convenient group, characterized in typical cases by some form of visible exudate or membrane in the throat or adjacent parts. They may all exist without this obvious exudate or membrane, a fact often overlooked, especially in olden times.

One of the most valuable advances of medicine in recent years is the general recognition in all diseases that exceedingly mild and atypical cases may occur; and that these are exceedingly dangerous cases, simply because they are likely to escape recognition, and therefore are likely to be permitted to spread themselves throughout the population; a danger all the more serious since these mild cases are often quite as capable of reproducing themselves in severe form as are the severe forms themselves.

To the study of this sore throat group, and especially to the study of mild diphtheria, is due the emphatic and widespread attention now paid to mild forms of all infections.

The cause of diphtheria is not at all sewer-gas or other bad smells or emanations from decomposing vegetable matter, as was taught thirty years ago, but is a germ, one of the most thoroughly studied and well known of all germs, the *bacillus diphtheriæ*. Curiously enough it is probably not a true bacillus, yet it has so long been so considered that little harm is done in continuing the name.

Tonsilitis, on the other hand, has not been shown to be due to any one definite germ, but appears to be the result of the activities of several different germs, operating singly or together. It appears to be a far less specific disease than is diphtheria, and probably awaits, as typhus did up to a hundred years ago, some brilliant student of medicine who will differentiate it into two or more different diseases now inextricably confused.

Septic sore throat and Vincent's angina are examples of exactly this differentiation applied, however, to the older conception of diphtheria, rather than of tonsilitis. In former days there can be no doubt that all membranous throat affections were indiscriminately labeled as diphtheria, while nonmembranous throat affections were labeled as not diphtheria: the diagnosis was, in brief, anatomical, that is, based on the physical condition found, rather than etiological, which means based on the cause. On the latter basis we now recognize several distinct diseases, besides diphtheria, amongst the membranous affections; and we also recognize that diphtheria is not necessarily a membranous disease itself.

Diphtheria in two common situations was not recognized as diphtheria until the diphtheria germ was shown to be present as the cause. One of these clinical varieties is the old membranous croup, now recognized as laryngeal diphtheria; the other was not even dignified by a name, but was considered a simple affection of the nose: we now recognize it as nasal diphtheria and as responsible for many a "mysterious" and "untraceable" diphtheria epidemic.

Diphtheria is a disease intensely interesting in its every feature: one of these is the confinement of its membrane in most instances to a very limited area in the throat. Why does it not spread forward over the insides of the cheeks, over the tongue, over the roof of the mouth? Why does it not spread down the œsophagus, the stomach, the intestine?

Why does it sometimes spread into the ears and nose and larynx, yet why, since it can thus spread, does it usually fail so to spread? To these questions we have no answer as yet. We can say that the areas invaded are "more susceptible" or "less immune" than the areas not invaded, but what does this mean? We do not know. Septic sore throat and Vincent's angina are not thus limited in spread forward into the mouth or on the inside of the cheeks; yet these also fail to affect the œsophagus.

Diphtheria is again interesting because it is primarily a local disease, the ill effects in the rest of the body being due, not to the extension of the germ from its original focus, but clearly and definitely to the distribution from the germ, remaining in its original place, of soluble poisons which the germ there produces.

In tonsilitis, septic sore throat and Vincent's angina, the general poisoning is due also to absorption from the chief focus, but is probably due to absorption of the broken down germs themselves, rather than of soluble poisons they produce.

On account of possessing this soluble poison, the diphtheria germ and the diphtheria germ-poison were amongst the first to be definitely distinguished and separated from each other. The soluble poison (toxin) thus separated provided the first and most successful antitoxin yet made, because the poison in this definite germ-free condition is available for inoculation into animals (horses chiefly), thus inducing them to manufacture the antitoxin in the effort to immunize themselves against the toxin.

No such definite immunization process against tonsilitis, septic sore throat or Vincent's angina has yet been developed.

Diphtheria is contracted by mouth-spray, and hands, from previously infected persons, or by hands from things the infected persons have recently touched: occasionally through milk infected by mouth-spray or hands. It is infectious in incubation, throughout the attack, and in decubation. Carriers, both incubate and decubate, are well known and rather common; in fact such carriers were detected in diphtheria before they were definitely found in any other disease.

The incubation period of pure diphtheria is short, being one to three days as a rule: the prodromal period is still shorter, one-half to one day generally, and presents nothing diagnostic; the typical symptom is the membrane, but it does not always develop in typical form: the fastigium is about a week in uncomplicated cases; and recovery from the acute symptoms is fairly prompt. Unfortunately, pure diphtheria is not often seen, most cases being complicated by the presence of a variety of other germs, of which staphylococci and streptococci, as yet unsorted as to form and virulence, probably constitute the most usual and important. The natural history of pure diphtheria is now difficult of study partly because of the presence of other germs, but chiefly because antitoxin is almost universally used in all cases brought to a physician's attention. The descriptions handed down from pre-antitoxin days make diphtheria a horrible disease in which the patient choked to death from overwhelming masses of membrane, or died later from the systemic poisoning. We see the latter now at times in neglected cases, but the former is rare, even in such cases. Why, we do not know.

Tonsilitis is, like diphtheria, a disease of short incubation and rapid onset: its typical symptom is the development of multiple small white spots on the tonsils, lasting a day or two: the patient is likely to have a higher temperature and to feel much sicker than does the diphtheria patient at the same stage: but usually recovers, and without the paralysis which makes diphtheria so much dreaded.

Septic sore throat is due to a streptococcus derived from previous cases, in the same ways as is diphtheria; but it may be contracted directly from cows suffering from a streptococcus infection of the udder or teats. The membrane is more extensive and more friable than the diphtheria membrane, and may spread forward in the cheeks. Enormous involvement of the glands and swelling (œdema) of the surrounding tissues is evident. The incubation and prodromal periods are like those of diphtheria. The fatality is high and cases that recover drag on more slowly than diphtheria.

Vincent's angina is due to a mixed infection of two different germs, a fusiform or spindle-shaped germ and a spiral form. Not much is definitely know of these germs as yet. Perhaps they are different stages of the same germ. The membrane occurs on pharynx and tonsils, but also on the gums back of the wisdom teeth and in other locations in the mouth.

It is not fatal as a rule. In incubation and prodromes it is much like the previously described throat infections; usually the attack is short-lived and the patient well in a week.

The complications of diphtheria are peculiarly those of the poisoning effect of the absorbed poison on the nervous system, heart and kidneys.

Paralyses are common, especially slight paralyses affecting the soft palate and resulting in regurgitation of liquids through the nose when the attempt to drink is made; the voice, of course, is affected also. These paralyses may affect the limbs. Loss of knee-jerks is common. The most serious result is heart failure, which often terminates fatally cases which appear to be in other respects on the high road to recovery.

In septic sore throat, heart and kidneys must be watched most carefully, and infection of the ears is common. In fact anything may happen of a septic character.

The combination of diphtheria and septic sore throat is a desperate one; few recover, even if treated early and thoroughly.

Tonsilitis is itself comparatively harmless, although the patient often suffers more acutely for a day or two than the diphtheria patient at the same stage. But recurrent attacks of tonsilitis seem to indicate more or less constant infection with germs capable of producing what is generally called rheumatism. Vincent's angina shows no marked complications as a rule.

The treatment of diphtheria is, unlike the treatment of most of these infections, specific. We know the poison (diphtheria toxin); we know the substance (diphtheria antitoxin) capable of neutralizing it in the body. The patients who recover without artificial aid do so because they manufacture this antitoxin themselves in sufficient quantity to prevent the poison overwhelming them. The secondhand antitoxin, manufactured in the horse in advance and ready for artificial administration to the patient, accomplishes the same end, but can be given in enormous doses promptly, instead of awaiting its development at the mercy of the toxin versus the patient's own antitoxin-making power.

Early treatment with sufficient doses of antitoxin is the secret of success. Not less than 10,000 units should be given at the first dose, 20,000 if the patient is seen after the second day, 30,000 or more if seen first after the third day. These doses should be repeated in each case within eight hours unless marked improvement has occurred. In early cases intramuscular injection is indicated—into the buttocks or outer aspect of the thigh about its middle. In late or severe cases, intravenous injection is called for, because the intramuscularly-placed serum is absorbed more slowly. Subcutaneous injections should not be used, at any stage, for absorption is too slow, and the pain of inoculation is greater than in either of the other methods—an important item in children, especially since it is usually necessary to give another dose later. The immunity conferred by antitoxin is not lasting—two weeks at the most. Toxin-antitoxin mixtures give more permanent results.

In about ten per cent of patients a rash will develop as the result of the injection, usually about a week later, and is often startling to those not familiar with serum treatment. It is due to the fact that *horse serum* has been used, not to the antitoxin proper—normal horse serum will produce the same effect.

Anaphylactic shock may occur and will be discussed later. Asthmatics and persons showing horse-sensitiveness (see Chap. VIII, p. 100), should not receive antitoxin unless in extreme necessity. It should be administered in such cases thus—one drop only should be injected; wait an hour; if no evil effects have occurred, give the rest; if they have occurred and the patient has survived, give the rest.

The heart of a diphtheria patient should be treated with the greatest consideration, whether the disease be mild or severe, whether the antitoxin treatment has been followed well or ill, whether the case is first seen early or late. This means, *rest in bed,* with an absolutely effortless régime for the patient, to last at least two weeks, better three, after the membrane is gone. Such patients would, in my hands, receive a standardized digitalis preparation from the moment the acute symptoms moderated, in order to provide such additional rest for the heart as may be thus possible. In advanced cases, Rowntree advises heroic, even toxic, doses of digitalis for the same end.

Septic sore throat and Vincent's angina should receive antitoxin first and then the attempt to differentiate them from diphtheria should follow. The time otherwise lost in waiting for the results of the bacteriologicial examination is too precious to risk in delay. If these examinations show the attack is not diphtheria, no harm is done; if they show it is diphtheria, ten to twenty-four hours are saved.

Tonsilitis is best treated by removing the tonsils, after the acute attack has subsided.

Whooping cough is now chiefly encountered in children but is said to have been, centuries ago, a serious and fatal disease of adults, death resulting from starvation due to the incessant vomiting induced by the severe spasmodic cough.

Its cause is supposed to be a germ which, lying amongst the microscopic hair-like projections which line the windpipe, acts as a mechanical rather than a chemical irritant. These hair-like projections are so immensely numerous that they may be compared to the "pile" of velvet. They have a wave-like motion directed upward toward the larynx and thus tend to sweep from the windpipe to the outside all mucus, etc., which otherwise would accumulate in the windpipe. The germs of whooping cough, becoming involved with these hairs, stimulate the body to a spasmodic, and at times convulsive, effort to remove them, giving rise to the desperate cough and incidentally to the vomiting so characteristic of whooping cough. Whether this be the correct explanation or not, it is true that the fever, etc., common to germ *poisoning* is not much in evidence, in whooping cough, thus tending to support the idea of mechanical irritation rather than of a toxin. If a toxin is the irritant, it would appear to be extremely local in action.

The immunity conferred by whooping cough may be looked upon as an argument for the existence of a toxin, which, however, must be a very mild one, and perhaps confers a local rather than a systemic immunity. Almost all the damage (herniae, emphysemata, etc.) done by whooping cough is due to the *strain* induced by the spasms of coughing or to incidental infections engrafted on the whooping cough proper.

The incubation period is seven to fourteen days; the prodromal period lasts about a week; the typical symptom is the whoop. The prodromal symptoms consist in a dry, barking expiratory cough, spasmodic and explosive, with vomiting; the whoop is inspiratory, coming immediately at the end of a series of violent prolonged expiratory coughs. In some cases the whoop is not strongly in evidence.

Of cases in children under one year, twenty-five per cent die: in the second year about fifteen per cent die. After the age of three, fatalities are rare; but, in the aggregate, whooping cough ranks with measles and scarlet fever as a cause of early demise, standing next to pneumonia in this regard.

The fastigium is long—a matter of weeks or even months.

Whooping cough doubtless is infectious during the incubation period, and certainly is during the severe prodromal stage; probably also for several weeks after the whoop has appeared. While usually it is considered that contact with a patient is not safe until a week after the whoop has disappeared, it is now thought that few cases require so prolonged an isolation, and that if four weeks have elapsed since the whoop appeared the danger of infection is usually over, whether the whoop continues or not. Practically, however, the difficulty of securing the general isolation of any whooping cases, if others are commonly known to be released while still whooping, is so great that it is probably best to isolate all during the persistence of the whoop at least; and if there be no whoop, until the spasmodic cough has ceased. No specific treatment has yet been firmly established as of definite value. Immunity is fairly complete and lasting.

Mumps, as characterized by great swellings in front of the ears, over the angle of the jaw, is well known, but there are a number of varieties not so well recognized even by the medical profession.

The germ is unknown, but the disease is doubtless transmitted by mouth-spray and hands as in the other affections of the naso-pharynx.

Its incubation period is from fourteen to twenty-five days; the prodromal period is from 0–1 day: the typical symptom is the swelling of one or more of the salivary glands; the parotid gland, situated over the angle and upon and behind the upright portion of the jawbone; the submaxillary gland, situated just to the inner side of the horizontal portion of the jawbone, about two-thirds of the way forward from the angle to the chin; the sublingual gland, just to the inner side of the jawbone, at the chin itself. Any one or any combination of two, three, four, five or all six of these glands may swell in mumps; if more than one swells, they may swell together or one may follow the other, almost immediately or after considerable delay. The most frequently observed form of mumps consists in the parotid swelling on one or both sides, the swellings of the other salivary glands often being overlooked or mistaken for swellings of some of the lymphatic glands which lie in the same neighborhood. The distinction is made partly by noting the exact location of the swelling, partly by the fact that the swellings in mumps are rarely tender to the touch. Lymphatic glands, when swelling rapidly to a size sufficient to simulate mumps, are very tender.

With or without the swellings of the salivary glands, mumps sometimes shows swellings of the breasts (in either sex), of the ovaries in females, and often of the testicles in males. Moreover, attacks characterized by these swellings, whether they be associated with swellings of the salivary glands or not, appear to be infectious. Hence a mumps epidemic cannot be controlled if attention be confined to cases of parotid swelling only (as is often done) i. e., if the submaxillary or sublingual varieties be overlooked; nor can it be controlled unless the cases showing only swellings of the other glands (breasts, ovaries, testicles) be detected and isolated also.

The mumps fastigium lasts a week or ten days, without much fever, pain or other disturbances as a rule after the first two or three days. The patient is doubtless noninfectious as soon as complete recovery occurs, but is usually not considered safe for release from isolation until the eighteenth day.

Mumps is not infectious during incubation nor after recovery. Carriers are unknown. Immunity is fairly complete and lasting.

"Common colds" are well spoken of in the plural, since there are, theoretically, at least, sixty-five varieties, and probably double or treble that number. Two varieties are noninfectious; all the others are infectious.

The striking feature of a cold of any variety is a swelling of the internal "skin" or mucous membrane covering certain much curved plates of bone (the turbinates), situated within the nose, over the roof of the mouth.

This "angioneurotic œdema of the turbinates" may be caused by irritants of various kinds, or by nervous impulses. The mucous membrane of the much curved plates (the turbinates) is, like the wattles of a turkey, composed in part of a mass of blood-channels, subject to rapid and extensive swelling when the blood-channels are distended; to collapse, when they are emptied. These blood-channels are controlled as to blood-supply by nervous impulses tending to regulate the admission or escape of the blood. Under direct local irritation, as from an irritating gas (chlorine, ammonia) or irritating particles (coal dust) or from germs, swelling may occur, with an increase in the activity of the mucus-secreting glands, giving rise, first, to a stuffed-up feeling in the nose, and then to a running of the nose. If the irritant be a simple mechanical or chemical one, it is likely to cease to act soon, and then the mucous membranes gradually revert to their normal condition, unless infection occurs. If due to germs in the first place, the "cold" is likely to continue for weeks or more.

The nervous control of the mucous membrane blood-supply may be disturbed also by a chill of a small distant part of the body, notably by a draft on a small area of the head, neck, back, etc. A *general* chill of the body is not likely to induce this form of "nervous" or "reflex" cold. Persons falling through ice in winter and immersed up to the neck for some considerable time rarely suffer from a cold afterwards, although when lying warm in bed, a draft on one small area of head or back may produce a bad "cold" in the same person.

This nervous cold usually recovers promptly when the part chilled by the draft is warmed and comforted; unless, again, infection follows.

The other 63 (or more) colds are varieties of germ infection, the irritant being supplied by the poisons of germs which are implanted on the mucous membranes themselves.

The infectious colds may arise in three ways; one way, already mentioned, is by implantation of infection on a mucous membrane already disturbed by simple mechanical or chemical irritants or reflexly by a chill; the second is by the development of germs already on the mucous membrane, but doing no harm until the irritant or chill swells the membrane, increases the secretions and permits their increased multiplication. The third, and probably the most common, is the implantation, on an otherwise normally functioning mucous membrane, of germs from a previously existing case of "cold" in another person. Attacks would appear to confer little or no immunity.

There are doubtless persons chronically infected (carriers), but these are, probably, unlike most other "carriers," not immune, and are therefore subject to development of the germs on exposure to nasal irritants or to drafts. The absence of immunity makes these cold carriers contrast markedly with diphtheria or typhoid carriers in that the former are subject to disease from the germs they themselves carry, while the latter are not.

It is likely, however, that in most persons any one attack tends to pass in regular stages from infection, through incubation, prodromes, fastigium, convalescence and decubation, to defection—and that once defection has occurred, drafts, dust, etc., cannot result in any but the very temporary irritative or reflex cold until reinfection occurs. This probably explains the immunity to colds of isolated persons living under even very severe conditions—such as Peary's party at the Pole. Presumably defection had occurred in all the party and there was no one to reinfect them. In ordinary community life the extreme prevalence of colds results in almost continuous re-infection of all the nasopharynges of the community—hence in such communities, drafts, dust, etc., may be in an indirect way an adjuvant to the development of infections; but they are not in themselves the cause of such infections.

Summary: Diphtheria, Septic Sore Throat, Vincent's angina (and the scarlatina sore throat previously described) form a group of throat affections characterized by more or less definite membranes, the differences between which are not sufficiently constant to make diagnosis sure without bacteriological help, at least in the early stages of the diseases. Any one of them may be complicated by the presence of any one or more of the others. Their incubation and prodromal periods are short, their fastigia from half a week to one or two weeks.

Diphtheria is most to be dreaded because of its paralysis, septic sore throat because of its fatality from toxæmia.

Since diphtheria antitoxin cannot do harm in any of these diseases, and should be given early in the disease and in big doses, to do good in diphtheria, it is never worth while to wait until the diagnosis is clear. The proper method is to give antitoxin first and make the diagnosis by bacteriological methods later.

Tonsilitis, a relatively harmless affection, can be recognized clinically, as a rule, when it occurs in typical form, and requires no treatment other than warmth, rest, and refreshment. If recurrent, the tonsils should be removed.

Whooping cough is of interest because of its very insignificant causation by mechanical irritation, or, at most, a very slight and local biochemical irritation; because it is nevertheless infectious, by transfer of the biological irritant; because the immunity which develops is perhaps a local immunity only; because the excessive by-products of the irritation, cough, strain, vomiting, infection with other invaders, results in a high death rate, especially amongst young children.

Mumps is chiefly of interest because of its peculiar multiple swellings of widely separated glands.

Common colds are chiefly of interest because of their prevalence and disagreeable rather than dangerous features, because of their immense variety and because of the apparent absence of any immunity resulting even from severe and prolonged attacks. (Owing to the comparatively small medical regard paid to common colds, but little is really known about them, the account given above being rather an attempt to correlate miscellaneous fragmentary observations than the result of detailed study of individual cases.)

CHAPTER VI

POLIOMYELITIS AND CEREBRO-SPINAL MENINGITIS; SYPHILIS AND GONORRHEA

Poliomyelitis (Acute Epidemic Anterior Poliomyelitis; Infantile Paralysis), is a disease recently very prevalent and much studied. The serious injuries are primarily in the spinal cord or parts of the brain; and it is believed to be transmissible, although how it is transmitted remains to be proved.

Nowhere is better illustrated the extreme local specificity of some of the biological poison-bearers known as germs, for this disease affects seriously practically only one set of the intricate network of nerve pathways, namely, those which conduct *motor* impulses, those which take to the muscles the orders of the brain to move. It affects even this set practically in but one portion of their path from brain to muscle—that portion which lies in the front half of the spinal cord. Whatever incidental damage the germ of poliomyelitis may do, the essential damage, that from which all the terrible clinical results flow, is the minute damage done in the cord or sometimes in the brain: damage which in the same degree elsewhere would be of the most trivial moment.

One of the noteworthy points connected with this disease is the fact that "shingles" (herpes zoster) is the result of a somewhat analogous infection of the corresponding *sensory* portion of the cord, in which injuries just as slight and hardly half an inch distant produce entirely different clinical features, because of the different functions of the parts involved.

Poliomyelitis has a supposed incubation period of one to two weeks, a prodromal period of 0–7 days, and its typical symptom is paralysis of voluntary muscle somewhere; one muscle, a group or several groups, anywhere in the body, depending on what particular nerve paths are involved in the central damage.

The prodromal symptoms may be those of a mild sore throat, of a slight digestive upset, or of a mild grip. Sometimes the patient has twitching or convulsive movements. Pain on movement, tender points and profuse sweating are often present.

The diagnosis can only be made with surety when paralysis develops, unless the presence of the causal germ can be demonstrated by inoculation experiments.

Doubtless many of the light attacks pass unrecognized or even unnoticed, especially if they do not go as far as paralysis; these are known as abortive cases.

The germ is in dispute, although no doubt a germ is responsible and the poison has been demonstrated. Perhaps the germ is widespread at all times and takes on this peculiar power of affecting the nervous system only under, at present, unknown circumstances. Certainly it is true that most outbreaks occur in hot weather, usually in dry, hot weather. Curiously enough, active, well-developed cases do not appear often to give rise to other cases, even in the same family, and the summer epidemics usually cease when the schools open, i. e., when opportunities for the spread of infectious diseases generally are greatly increased.

We do not know much about its infectiveness, but it is supposed to be spread by mouth-spray and hands, thus moving from person to person until it reaches a susceptible one. If this is true, susceptibility must be rare; or else the difficulties the germ encounters in passing successfully from nose or mouth to its destination in the central nervous system must be great. Specific treatment is being developed along the line of immune sera of recovered patients.

Cerebro-spinal meningitis contrasts with poliomyelitis, while also in some clinical points resembling it. Its incubation period and its prodromal period are supposed to be about the same respectively in length as those of poliomyelitis; the fastigium varies immensely in different cases, but is usually a matter of weeks.

Poliomyelitis affects chiefly certain portions of the interior of the nervous system, cerebro-spinal meningitis rather the exterior, and the coverings, of the cord and brain. Poliomyelitis produces typically paralysis. Cerebro-spinal rather tends to excessive stimulation of the nerves leading to the muscles, hence to spasms, convulsions, etc., although later paralysis may develop. Poliomyelitis is chiefly in evidence in children, cerebro-spinal meningitis much more largely occurs in adults. Both are supposed to have approximately the same incubation period, and somewhat the same prodromal period; but cerebro-spinal meningitis, when recognized as such, is usually ushered in by headaches, stiff or retracted neck, and vomiting. The typical symptom of cerebro-spinal meningitis is not paralysis but spasm, often of the eye muscles.

Inability to straighten the knee, if the thigh be put first at right angles to the body (Kernig's sign), is commonly present.

A crucial distinction is obtained by lumbar puncture, the fluid of poliomyelitis being clear, that of cerebro-spinal [illegible]eningitis cloudy—the latter usually also containing the [illegible]al germ, the meningococcus, which can readily be found [illegible]er the microscope and grown in culture.

Cerebro-spinal meningitis and poliomyelitis resemble each other in that the infectious period and mode of infection are still in doubt. Active cases in both diseases, although looked upon with great fear, seem seldom to produce new cases clearly traceable to them. The infective agent is supposed to be passed on from person to person until a susceptible one is found. As in poliomyelitis, it is conceivable that immunity has not so much to do with the escape of those exposed as has difficulty in the germ's progress from the nose to the central nervous system, but the fact that cases respond admirably to treatment with a specific antidotal serum (Flexner's), seems to make it likely that an unusual lack of self-made protective bodies in certain rather rare individuals, rather than any other reason, accounts for the complete escape of so many exposed persons, and the high fatality amongst the very few.

The meningococcus is quite the like gonococcus in many respects and it has been suggested that it may be a modified form of the gonococcus, but this is as yet purely speculative.

The treatment of cerebro-spinal meningitis which has proved most successful consists in (a) repeated lumbar punctures, allowing the escape of the accumulated fluid and thus relieving pressure, (b) the use of Flexner's serum to replace the withdrawn fluid, *to the extent only of one-third of the amount withdrawn* (in order to avoid restoring the pressure just relieved by the withdrawal), (c) the use of vaccines, autogenous preferably.*

Syphilis, Gonorrhea and Chancroid constitute a group known as the venereal diseases, concerning which the general public is little informed because of a false sentiment which has banished them from mention until very recent years. The result has been deplorable. Not only have these diseases spread under the most unsuspected circum-

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* See "Minnesota Medicine," Nov., 1919. Hill.

stances, in about half the instances to innocent persons, but also nearly all the cases, innocent or not, have been the prey of the most unscrupulous exploitation by charlatans, and also by well-meaning but ignorant persons, to an extent which has caused infinite misery, while contributing even more than in the case of tuberculosis, an almost equally evilly exploited disease, to the propagation of the disease.

Concealment, mystery, subterfuge, unwillingness to face the facts in which, unfortunately, the medical profession has had its share, have, as always, resulted in conditions ten times worse than the damage such tactics were supposed to avoid.

It is remarkable that so lately as 1916 the word syphilis occurred first in a Canadian newspaper, although thinly veiled and unscrupulous advertisements regarding it had been carried in all newspapers everywhere for at least a generation.

The United States has been little, if any, in advance of Canada, either in consideration of the subject or in action upon it; although at the present time most aggressive and praiseworthy activity has taken the place of neglect and inertia.

Syphilis is a chronic disease, due, like tuberculosis, to a germ of comparatively slight virulence, but of great staying powers. It does not complete its course in the body rapidly like scarlet fever, diphtheria or even typhoid fever, but remains more or less active for many years.

The syphilis germ is probably of the animal rather than the vegetable kingdom, a protozoan rather than a bacterium. It usually enters the body through a scratch or abrasion of the skin or a mucous membrane. Notwithstanding that it is so constantly spoken of as a venereal disease, a proportion of cases are contracted from ordinary contact—use of the same towels, pipes, drinking glass, etc., although, of course, the majority are venereal. But even the venereal cases are by no means necessarily illicit; at least half of the total cases being innocently acquired, as from husband to wife or vice versa. It is possible, though usually held improbable, that mouth-spray and hands may enter into its transfer exactly as in scarlet fever or diphtheria. Certainly this is possible in those cases where the infecting individual is afflicted with open sores in mouth or nose.

The incubation period of the initial sore or chancre is variable, roughly, three weeks. It appears as a firm, hard pimple, enlarges, and typically disappears again, leaving perhaps a scar, often not. Usually nothing further happens for several weeks, when a number of symptoms related to the surface of the body appear, sores in the mouth and on the tongue, sore throat, rashes of various kinds, falling out of the hair, together with bone-pains, anæmia, general debility. These tend to disappear in time, especially under treatment, although in neglected cases very terrible conditions may arise.

Two or three years or more later, the third stage, that of tumors, developing under the skin or internally, appears. Often, especially in treated cases, this stage is delayed for almost a lifetime, appearing late and ending miserably an otherwise healthy and successful life.

A fourth development is the parasyphilitic stage in which, without actual tumors, a general poisoning of the nervous system occurs, giving rise to many of our aged crippled, both in body and in mind.

It is, like many diseases, transmissible to the child *in utero*, i. e., before it is born. Fortunately many syphilitic parents lose their children by premature birth or in the early months after birth.

The first and second stages of syphilis are infectious. Immunity seems to exist to second infections so long as the first infection is present (tolerance). On complete cure, the disease may be contracted a second time.

Gonorrhea has often been described as a "cold" affecting the mucous membranes of the genital tract. Unfortunately, while this description is not a bad one, the implication that the disease is therefore mild and negligible is lamentably false, for the "cold" is usually accompanied by severe symptoms, and complete recovery is rare. As real "head colds" present carriers who, not being immune, infect others, and themselves constantly suffer from recurrences, so also does gonorrhea, but much more frequently. Again, as a "head cold" often extends along the passages connected with the site of the initial trouble, i. e., along the eustachian tube to the ear, by other openings to the antra or frontal sinuses, or to the pharynx and windpipe or even the lungs, so in gonorrhea extension to connected parts occurs, with resulting complications of many descriptions.

From fifty to eighty per cent of all major operations on women are traceable to gonorrheal infections, while an immense number of cases of stricture, prostatitis, cystitis, etc., in men are due to the same organism. Blindness in children, the result of infection of the eyes in the very process of birth, is far too common, although the comparative rarity of this disease of the eyes in adults, despite the prevalence of gonorrhea in its ordinary forms, points to a high average of insusceptibility of the eyes, for transfer of gonorrheal infection to the eyes by the hands must be very common, yet gonorrheal ophthalmia is relatively rare.

An extremely regrettable form of innocently acquired gonorrhea is found amongst little girls in institutions. Probably started in each institution from the hands of infected attendants, it seems to be spread by hands, clothing, etc., until in many institutions it appears to be ineradicable.

Gonorrhea has an incubation period of from three days to two weeks, and is probably infectious during this period. The prodromal period is short and indefinite, terminating with the appearance of the discharge. The acute symptoms, pain, fever, etc., last a week or more and in uncomplicated cases, tend to lessen, the discharge becoming chronic. Defection is rare according to modern teaching, the germs entering into the various ramifications of the organs and lying in wait for later activities. Few cases even under the best treatment are completely recovered within six weeks; noninfectiousness is of late years considered a very rare stage, if it is ever reached at all.

Hereditary syphilis and gonorrhea, in the true sense of heredity, are very uncommon. In the sense that they are contracted by the child at birth or before birth from the parents, hereditary syphilis is very common.

Soft chancre or chancroid is a comparatively mild affection, usually appearing as a ragged, shallow ulcer, highly infectious but easily controlled by antiseptic treatment. Its chief interest lies in the fact that the syphilis chancre is often present with it and escapes recognition because obscured by the much worse looking and more extensive chancroid.

The modern Therapeutic treatment of syphilis has two advantages: one that it controls the disease in the patient with remarkable power; the second that it quite rapidly makes the patient noninfectious by killing the germ in, or driving it from, the surface lesions. Confusion of mind sometimes leads the patient who is thus rendered noninfectious to believe that he is cured—an unfortunate mistake in all cases.

The control of the venereal diseases consists in finding and isolating the infected persons. It is true that these exist in enormous numbers and decubate carriers not actively sick are, in gonorrhea especially, very common.

The eradication of prostitution, and proper marriage laws preventing marriage of infected persons, would do much toward checking its spread. Rendering syphilitics noninfectious is not difficult, but the successful treatment of gonorrhea is not yet compassed in the same definite manner. If Public Health men could be given their choice of abolishing absolutely only one or the other of these diseases, most would vote for the abolition of gonorrhea.

Persons in infectious stages of either disease should not be allowed contact with normal individuals, but it is far more important to isolate syphilis than gonorrhea, because carriers of the latter, apart from the sexual act, or the care of children, are not extremely dangerous to others.

Summary: Poliomyelitis and cerebro-spinal meningitis are affections of the nervous system, the latter clearly of infectious character, the former probably so. The exact methods of transfer are not definitely known in either disease but "carriers" are supposed to play the important rôle.

In syphilis and gonorrhea, transfer commonly depends on direct contact of an infected lesion of a patient (or decubate carrier in the case of gonorrhea) with a mucous membrane, or a wound of the prospective patient. But indirect transfer on hands, towels, etc., is not unknown.

CHAPTER VII

TUBERCULOSIS, HUMAN AND BOVINE; LEPROSY

Under the term Tuberculosis are included two chronic diseases, produced by two distinct but closely related and relatively nonvirulent germs. Neither of these diseases is strikingly fatal in its effects, when its germ acts alone, i. e., without associated secondary invaders, such as streptococci, staphylococci, etc.

In association with other germs, however, particularly streptococci and staphylococci, the germs of tuberculosis produce extremely serious affections.

Two hundred years ago one-fourth of mankind died of tuberculosis. This figure has now been reduced (or has reduced itself) to about one-tenth.

As in the instance of typhoid fever and paratyphoid fever, the two diseases in the human still known under the general name of tuberculosis remained undifferentiated for long years. Moreover, as in the instance of membranous croup and diphtheria, clinical variations in tuberculosis which we know now to be due to the same germ, were for long supposed to be quite different entities. Thus the old time scrofula, or "Kings' evil," so called because supposed to be cured by the touch of a royal hand, is merely a form of skin and gland tuberculosis.

In distinguishing the two diseases known under the general name tuberculosis from each other, the crucial difference is this—lung tuberculosis is due practically only to one of the two germs; the rest of the clinical forms of tuberculosis, such as tuberculosis of bones, joints, glands, abdomen, brain, etc., are due sometimes to one germ, sometimes to the other.

The tuberculosis germ which affects the human lung is known as the germ of human tuberculosis, or, for convenience, the human germ: the tuberculosis germ which does not affect the human lung, although it may, like the human germ, affect other parts of the body, is derived from cattle, and is known as the germ of bovine tuberculosis—or shortly, the bovine germ.

The human germ differs bacteriologically from the bovine germ: it differs, however, much more importantly in its source and in the damage it does to the human.

The source of the bovine germ is practically exclusively cattle; it enters the human body practically exclusively in raw cow's milk; it does not escape from the human body to new human bodies, practically speaking, because in the human body it is practically confined to parts of the body, bones, joints, etc., not in communication with the outside world. It affects the human race chiefly in childhood, the number affected diminishing rapidly as age increases, so that bovine tuberculosis after sixteen years of age is practically unknown.

The human germ is derived always from a previous human case, and practically always from a previous human lung case. This is for the obvious reason that the lung is in communication with the outside world and the germs can thus escape readily to other persons.

The human germ comparatively seldom affects the young child, but the damage it does increases after puberty is reached, until in the adult it is a very serious restriction to human life and human welfare. The human germ, while affecting all parts of the body, involves the lungs in eight-ninths of all cases.

Two theories concerning the disease caused by the human germ are held—one is that the human germ is usually implanted in childhood, when it sometimes develops clinical symptoms and results in death: generally, however, it lies dormant until adolescence when the strains connected with puberty, going out to make a living, etc., "lower general resistance" and result in the dormant germ becoming active.

The other theory (my own) offers the hypothesis that the admitted existence of bovine tuberculosis in children has confused the issues; that the two diseases have not been so clearly and logically distinguished in epidemiology as they have been in pathology; that the admitted prevalence of infection in children is infection with the bovine, not the human germ; that the human germ does not reach the majority of children until adolescence, because it is not until then that children come largely into contact with adult cases, that is, with infectious stages. Hence that, broadly speaking, childhood infection with tuberculosis is made up of little human and much bovine; adult tuberculosis, of much human and little bovine; and that infection occurs in parallel ages—children receiving theirs chiefly from cattle, little from humans, adolescents chiefly from humans, little from cattle.

The incubation period of tuberculosis, that is, from the time the germ enters the body until clinically recognizable symptoms can be discovered, is often three months. In young children who die of tuberculosis in six months or a year after birth, it is obvious that the incubation period must be very short. In older people it is hard to determine just when infection occurs, but I have seen at least one instance in which the period from infection to death in a girl of nineteen was only four months.

Let it be said that three months is often the period from infection to the time when the disease *might* be detected. One of the sad things about tuberculosis is that the disease seldom is detected until it has already progressed far in the prodromal stage, or even reached the typical symptom, i. e., the appearance of the germs in the sputum.

The symptoms of the prodromal stage are loss of weight, rapid pulse, easy exhaustion, afternoon temperature, sometimes slight cough, occasional bloody sputum, perhaps enlarged glands, perhaps râles in the chest, perhaps pains in the chest, always a tuberculin reaction. The presence of the latter, however, is a very uncertain aid in recognizing active tuberculosis because it is present in so large a portion of the healthy population—probably (in my opinion) because of the practical universality of the infection with bovine bacilli through the almost universal custom of drinking raw cow's milk.

The prodromal period varies in length immensely, yet probably averages about three years. There are much shorter and also much longer cases, as already quoted, but this is probably the average, at least in adolescents and adults.

The typical symptom, arbitrarily chosen it must be admitted, is the breaking down of the lung tissue affected by the disease, with the escape of the germs to the outside world. This is chosen as the typical symptom because it is unfortunately true that in most cases it is not until this stage is reached that the disease is recognized, while by this symptom it always can be recognized if the symptom be present.

It is not until the germs appear in the sputum that the case can be considered dangerously infective. After this stage is reached, however, the case is infectious by mouth-spray and hands as in any other disease where the germs are present in the mouth; also, doubtless, by the bowel discharges because a good part of the sputum is swallowed.

It is at this stage also that the patient is as a rule very sick, and shows the effect of the streptococci and staphylococci, on which the breaking down of the lung depends, by his septic temperature.

From this on, the destruction of lung tissue, the hemorrhages, the constant cough, the increasing emaciation and weakness, constitute a direful picture only too well known. This fastigial period, while very variable, averages perhaps two years and usually, alas, ends in death. Recovery, when it occurs, is rarely complete, and defection is almost unknown, the patient usually retaining the germs in the body, and not infrequently suffering from subsequent recurrences.

It is said that new infections do not occur, however, as long as the old germs are still present (tolerance). The patient is not necessarily infectious after clinical recovery; this depending solely on whether or not the germs are escaping in the sputum or elsewhere.

Tuberculosis is, like syphilis and gonorrhea, a disease so familiar to, and yet so little understood by, the general public, that inevitably all sorts of fantastic beliefs, superstitions, half-truths have grown up about it.

A long list of fallacies concerning tuberculosis have been exploded in the last twenty or thirty years, but are worth reviewing.

One form at least was believed curable by the "King's" touch, others by the smell of a stable. (The smell from an illuminating gas plant even to-day ranks high in popular superstition as a cure for whooping cough!)

Drinking raw cow's blood, fresh and warm, is another alleged "cure."

The belief in excessive quantities of oxygen, having a pseudo-scientific backing, was held even by some medical men, despite the fact that the human tubercle germ itself requires oxygen and indeed grows in the lungs rather than elsewhere.

Ozone has had its worshipers and many a resort has thrived on its ozone reputation, notwithstanding that Remsen and such other authorities declare that there is no such thing in nature, except for an instant at a time, as during a thunderclap—despite also the proof of the poisonous properties of ozone developed in experiments carried on at the British House of Parliament, where the attempt was made to purify the air by adding one part in a million of ozone; such disastrous results followed that the medical journals took serious editorial notice of them, and issued solemn warnings against imitating the experiments.

Another exploded tradition relates to the heredity of tuberculosis. True, "it runs in families"—but only just as any other infection does, neither more nor less. If the parents have it in an infectious stage, the children cannot escape infection any more than they would escape if the parents had smallpox or syphilis or mumps,—more especially since the disease is a prolonged one. We do not usually call measles a family disease, yet if one member has it, all who are in contact with that one while infectious will take it, unless they are immune.

Another fallacy, now far less widespread than in earlier days, was that which regarded alcohol as a stand-by in treatment. Alcohol, as it affects tuberculosis, is a detriment from whatever standpoint it is considered, and whether taken as "booze" or in patent medicine. Moreover, since no medicine is known which is good for tuberculosis, no patent medicine, alcoholic or nonalcoholic, can be good, either.

Perhaps one of the greatest fallacies of all is the teaching so prevalent in the last few years, but now rapidly disappearing, that the problem of tuberculosis can be solved by curing early, noninfectious (prodromal) cases, rather than by preventing spread from infectious fastigial cases.

Suppose that in smallpox or scarlet fever we concentrated our attention on treatment of cases before the eruption appeared, took them to hospitals, did everything for them; that, as soon as the eruption appeared we dismissed the patient to his home, because there was nothing further to be done to save him. Granting it were true that the appearance of the eruption in smallpox or scarlet fever indicated the case as hopeless (which, of course, it does not), even so, would not such a procedure be the height of folly—not on the patient's account only, but because of the spread of infection from him to others when he went home? Why try to stop any disease by curing those now sick, if you do not also try to prevent more cases becoming sick? Why save at the spile of cure while wasting at the bung of infection? Remember also that we cannot save by any means all of the prodromal cases—a large proportion go on to the fastigial stage and die, even if treated early. Again, concentrating all resources on the prodromal case means much wasted effort, for many of these recover on their own account, treatment or no treatment.

Another fallacy of tuberculosis is the teaching that it is most abundant amongst the poor. This is about as sagacious a statement as is the statement that blue eyes are most abundant amongst the poor. Both statements are true, but it is also true that brown eyes and gray are most abundant amongst the poor—and so also are noses! Why? Because the poor constitute ninety-five per cent of the population and everything but money *is* more abundant amongst them than amongst the rich! But if we consider proportions we find a different story, the rich presenting as great a percentage of cases as the poor, or even greater.

Another fallacy is the oft-claimed immunity of persons over forty. A great authority stated a few years ago that he and others of his age had no personal interest in tuberculosis, that all his antituberculosis work was purely altruistic, because he himself was past the dangerous period—because he was over forty.

The facts are that comparatively few people who are old have tuberculosis, because there are comparatively few old people; but the total of all the old people show practically the same percentage of cases as the total of all the young people show.

Again, we hear repeated everywhere that dusty trades are the dangerous trades—the implication being that the dust has something to do in the development of the disease. A few years ago the connection was presumed to consist in the presence in the dust of tubercle bacilli; when this was exploded, the connection was maintained to be the deleterious effects of the dust in injuring the lung tissue and giving the germs a better chance to develop. It has been found, however, that the injuries produced, by coal dust at least, seem to have an actual protective effect against tuberculosis! If dust is really deleterious, why have farmers, who live notoriously dusty lives, one of the very lowest of the tuberculosis death rates?

The real relation between occupation and tuberculosis (in my judgment) is this—tuberculosis is high in those trades which are characterized by, first, close association of the workers with each other, and second, being of such a nature that cases of tuberculosis may continue at work although in far advanced phases—i. e., may continue at work during infectious stages.

Thus stone workers, cigar makers, etc., may continue work as far advanced cases; lumbermen cannot, as a rule, because their work is too severe for advanced cases to perform. This results in the situation that anyone who is starting out in life and elects to be a stone worker or cigar maker thereby practically elects to sit next or opposite to an open case of tuberculosis day after day—he elects to expose himself thoroughly to tuberculosis. If, however, he elects to be a lumberman, he thereby elects to eat and sleep and work with nontuberculous persons, i. e., he elects not to expose himself to this disease. So intimate will be his contact with his fellow workmen in a lumber camp that he will contract anything they have, to which he is susceptible, from lice to smallpox, but he will not contract tuberculosis, because it is not there to contract—there is no source of infection from which he may become infected. (See also Dawn of the Health Age; Appendix: Benjamin Moore.)

Human tuberculosis is, then, an infectious disease like diphtheria, or typhoid fever, due to similar germs spread in exactly the same ways, having similar stages, and controllable by like methods. But it is long drawn out; it is chronic rather than acute; it is mild and slow, not severe and rapid.

Carriers in the true sense are not widely recognized, and immunity, although demonstrated, is slow in development and perhaps slight in degree. No specific treatment is known, although tuberculin seems to help in some forms.

The treatment of tuberculosis is the treatment of all infectious diseases for which we have no specific antitoxin or other specific agent, i. e., the treatment is the same as for scarlet fever or for mumps—rest in bed, proper nourishment, fresh air, and care of incidental infections, with the hope that these measures will keep the patient from dying long enough for the patient to make his own antidotal bodies, or at least develop sufficient fibrous tissue about the lesions to limit further growth. Corresponding to the long drawn-out character of the disease, these factors, in treatment take on peculiar emphasis and interrelate even more importantly than in the acuter diseases; but they are nevertheless the same factors.

Leprosy is a disease due to a germ which is probably as closely allied to the germ of tuberculosis as the paratyphoid germ is to the typhoid germ, or as the bovine tuberculosis germ is to the human tuberculosis germ. Its incubation period is unknown but is supposed to be a matter of many years; its prodromal period is perhaps one to two years.

Recovery is very rare, so that the fastigium usually corresponds with the remainder of the patient's life, which may be many years.

Modern leprosy is not the leprosy of the Bible, so far as minute comparison of the disease as described in the Bible and as it occurs now in nature will allow a decision.

Leprosy, apparently, begins in the nose, with ulceration, etc. It may then affect chiefly the skin (tubercular form), or chiefly the nerves (anæsthetic form) or occur in mixed form.

It is of interest as being one formerly widespread disease which has been banished by segregation; the leprosaria of Europe several centuries ago being more numerous than our tuberculosis sanatoria are now.

It is of interest also because of its relatively noninfectious character and the intimate and prolonged character of the contact usually necessary to its spread.

Summary: Under the term tuberculosis two separate diseases exist in the human, one derived almost exclusively from cattle, through drinking raw cow's milk; the other almost exclusively from human cases, through the mouth discharges of infectious stages of the pulmonary disease. The former affects chiefly children and is almost unknown after sixteen years of age; the latter affects chiefly adults, and, as an infectious stage of the pulmonary disease, is almost unknown before sixteen years of age.

Human lung tuberculosis is simply an infectious disease like scarlet fever or typhoid fever, but long drawn-out in every particular, having a relatively long incubation period, with relatively extremely long prodromal and fastigial periods. It is infectious during the fastigial period.

Carriers are unknown; immunity is slow in development and not complete; tolerance has been asserted to exist.

The treatment is nonspecific and therefore consists in rest, food, and fresh air, exactly as in other infectious diseases for which specific treatment is not yet available. Its control at the present time depends chiefly on the restriction of spread from existing cases.

In leprosy, transfer is probably on the same basis as in tuberculosis. The frequency of the finding of leprosy bacilli in the nose makes it seem likely that nasal secretions enter into it; but open lesions anywhere on the body also show the bacilli.

CHAPTER VIII

IMMUNITY; ANAPHYLAXIS

Immunity to a disease may be defined as a condition of the body such that the germs of that disease will not develop in the body or, if the germs do develop, the poisons they secrete will not injure the body.

The possession by certain species of animals of immunity to diseases affecting other species has long been recognized; for instance, horses do not take measles. So also has the possession by certain individuals of an immunity not shared generally by others of the same species; for instance, many persons will not take diphtheria.

The explanations of such immunities have, however, been numerous and sometimes weird.

The earlier conceptions of infection were based on the supposed action of devils, and immunity to their action was naturally sought through wearing of charms—the rabbit's foot, horse-chestnut, and copper-wire waistbelt of to-day being relics of these superstitions; and the electric belt a modernized outgrowth.

One method of securing immunity—i. e., by by having an attack of the disease and recovering from it—must have been observed early in the history of the race; and artificially inducing the disease under favorable conditions "to have it over with" rather than waiting until it came of itself, runs back, as a deliberate medical practice, into the dawn of history—existing, for smallpox at least, in China and in Siam long before it was advanced in England.

Perhaps the best explanation offered in olden times for the immunity thus resulting was the exhaustion by the disease of some particular substance it required in the body, thus leaving nothing for a subsequent attack to feed on.

The explanation offered to-day is quite different, however, and has a great deal of experimental proof behind it. Briefly it is this—such immunity is due to manufacture by the body of antidotal substances, sometimes directed against the germ, sometimes against the poisons, but in either instance eliminating the harmful effects.

The presence of the antidotal body may be congenital (born with the person), constituting "natural immunity"; or may be "acquired" in several ways in later life; by an attack of the disease, as in measles; by the artificial implantation of a living germ (virus) as in smallpox; by the artificial injection of a dead germ (vaccine) as in typhoid fever; or by the artificial injection of a germ-poison (toxin) as in immunizing horses against diphtheria in order to produce antitoxin.

All these methods stir up the body to make its own antidote, and hence the immunity thus obtained is known as "active immunity." Such immunity is generally as strong and as lasting as can be had under the present state of our knowledge.

If, however, instead of using a germ or a germ-product to stir up the body to make its own antidote, we borrow enough ready-made antidote to confer immunity from another body already immunized, already in possession of the antidote, the immunity thus conferred is known as "passive immunity." Such borrowed immunity is of inestimable service in the treatment of diphtheria, where the blood serum containing the antitoxin is borrowed from an immunized horse; and it has been successful in pneumonia and in poliomyelitis, where the blood serum containing the antidotal substance is borrowed from previous patients who have recovered; their recovery being evidence that they have manufactured considerable quantities of the antidote themselves.

But since it is borrowed, since it is not the result of a stirring up to make its own antidote of the body on whose behalf it is borrowed, such passive immunity, while invaluable for the moment in meeting the acute exigency due to the poisoning from which the patient is already suffering, does not last; it does not confer an active immunity such as would be conferred if that body had succeeded in learning to make its own antidote.

Without going too elaborately into the supposed mechanism of immunity, we may summarize the chief points thus—the reason that any germ-product can act as a poison on the body is that it possesses a chemical structure capable of combining with some important chemical structure in the body, and by so combining with it, of spoiling it for the purposes of the body, thus producing some form of upset of the body-processes, i. e., some form of "disease." Active immunity is attained when the body succeeds in making for itself, passive immunity is attained when the body succeeds in borrowing ready-made, a substance unimportant to the body otherwise, but which possesses this same power of combining with and so of satisfying the poison—in other words, of putting the poison out of action.

Indeed, immunization against a germ-poison is not much different in principle from the very ancient plan of protecting one's tender fingers from a lobster's claws by giving the lobster something else to grasp instead.

The difference between active and passive immunity is the difference between the man who has developed a calloused finger to offset the lobster, and the man who must find a stick to give it. The former carries a permanent "antidote" with him—the latter is helpless the moment he lays down the stick, until he gets another one.

One may illustrate immunity also thus—suppose a peaceful village is invaded by bandits. If there be nothing in the village they can steal, they pass through it and do no harm. Many germs, no doubt, pass daily through our bodies, into our blood vessels and disappear—doing us no harm because there is nothing their products can combine with. This is an immunity from nonresistance—or, perhaps better, from nonreaction.

But in another village the bandits see things they want. They attack, steal and destroy. The inhabitants never having been attacked before, may manufacture weapons on the spur of the moment, and put up a resistance. Perhaps they succumb, but, if they beat the bandits, then woe betide the next invaders, for the inhabitants now have the weapons all ready, which before they had to make while actually at war. They have an active immunity due to their own development of a hitherto unknown art: example, protection against smallpox or typhoid fever, though having the disease.

Again, we may imagine the villagers not relying on themselves but rushing off to borrow aid from neighbors who, from previous attacks, have become warlike themselves. True, the aid thus secured may save for the moment, but the borrowed help fades away and the village is then as open to attack as ever. They secured a passive immunity which saved them truly for the time, but it does not make them any better off for the future: example, use of diphtheria antitoxin in treatment of diphtheria.

These analogies may be pushed still farther. One may imagine a certain village learning by experience what weapons to use against bandits armed with spears; yet remaining as helpless as ever against bandits armed with rifles; learning to use rifles against the new enemy; yet remaining helpless against an enemy armed with bombs; and so on. This illustrates the specificity of immunity, for the germ of each different disease attacks with a different weapon, and the body which can fight measles successfully because of experience with measles must learn all over again if attacked by scarlet fever, before it can fight scarlet fever. Artificial immunity through smallpox, or typhoid vaccination, say, may be compared to training the villagers to arms by mimic warfare against comparatively tame bandits imported especially to practice on—and so on.

Finally one may imagine the peaceful villagers being foresighted enough to borrow aid from their war-like neighbors before the bandits actually arrive and thus to prevent the invasion of their village. This is done when diphtheria antitoxin is given, not in the course of an attack, but to a person who has been exposed, and before the disease develops. Such antitoxin so given is called a prophylactic dose—and really does prevent the attack. It lasts, however, only about two weeks and if the exposure continues (as of a nurse in a diphtheria ward) it must be renewed every two weeks to give continuous protection.

Active immunity then is a condition in which the body, having been subjected to an invader, has learned to deal with it so that that particular invader, on a second appearance, can no longer harm it.

There is, however, a converse condition in which an invader which is, at its first appearance, harmless, does, on its second appearance, cause much trouble. Instead of the introduction to the body of a primarily *harmful* substance resulting in subsequent *immunity* to that substance, a primarily *harmless* substance injected into the body may result in producing a *susceptibilty* to that substance, so that, on a second injection, serious or even fatal symptoms may develop.

Thus, white of egg injected into a guinea pig for the first time produces no observable effect whatever. If, however, about ten days later the guinea pig be injected with white of egg again, he will twitch his nose, scratch it, pass urine and feces, tremble, gasp, and die, all in a minute or two. This effect, that of producing susceptibility, is called anaphylactic in contradistinction to the production of immunity, which is prophylactic.

In the guinea pig anaphylaxis is characterized by contractions of involuntary muscles all over the body—hence in the nose-twitching, the emptying of bladder and bowel, the gasping, the latter being due to violent spasms of tiny muscles surrounding the bronchioles, shutting off the guinea pig's supply of air.

Now, if instead of white of egg, milk had been used the first time, then milk, if used the second time, would give the same results. But if white of egg were used for the first injection, milk for the second (or vice versa), no ill effects would result. If horse serum were used the first time, and horse serum the second time, death would ensue; but if horse serum were used the first time and white of egg or milk the second time, nothing would happen.

In brief, each anaphylaxis-producing substance injected makes the guinea pig susceptible to itself, not to any other.

So far the susceptibility-producing bodies discovered are all proteins. No substance not a protein can on injection render the body susceptible in this way to a second injection. Moreover, the protein must be injected into the substance of the body; it is not sufficient, as a rule, to take it by the mouth. Again, and very fortunately for us, the human body is far less ready to develop anaphylaxis than is the guinea pig body. Nevertheless, repeated injections of antitoxic or other similar substances, since they are usually derived from horse or other serum, and therefore contain protein, carry with them the danger of anaphylaxis, especially if the second injection is made at an interval of eight or more days from the first. Injections made at intervals shorter than a week, whether in the guinea pig or in man, are usually not productive of anaphylaxis.

If it becomes essential to give horse-serum injections in any form to a person who has had horse-serum injections eight days or more before, the danger may be offset by giving only a minute dose the second time (say one drop). If anaphylaxis follows, it is likely to be relatively mild and on recovery, serum may be given *ad lib.* If anaphylaxis does not occur within an hour, it may be assumed that the person is not anaphylactic, and may safely receive the rest of the dose.

In asthmatics, this plan should be followed even in giving the first injection of all, and repeated trials, using a drop at a time, will prove the safest. The reason the danger of anaphylaxis in asthmatics is so great remains unsettled. Certain rare individuals are "horse-sensitive," i. e., are made sick by any substance from a horse, even the smell of a stable, the sickness often taking the form of an attack not unlike an acute temporary hay fever. The injection of horse serum into such persons is attended by very great danger, and should be avoided if possible. It has been proposed that antitoxins, etc., should be prepared for the special use of such persons from some animal other than a horse.

While anaphylaxis develops in its most severe and striking form when proteins are injected into the body substance, it is supposed that proteins introduced into the body otherwise than by injection may at times produce anaphylaxis; and even if they enter the body only by the mouth. Certain skin eruptions, following the ingestion of certain foods in certain individuals (rashes from eating strawberries or shell fish are examples not uncommon), seem to be due to a mild anaphylaxis. Hay fever is now often attributed to anaphylaxis due to pollen-protein entering into the body, perhaps through minute scratches on the mucous membranes of the nose, etc.

A relation probably exists between immunity and anaphylaxis, but is not yet clearly understood. Immense numbers of extremely delicate experiments have been made on both subjects and enormous advances in knowledge have been achieved but the last word is still far from being said.

One most practical point should be clearly seen, however,—that immunity to disease is, so far as yet clearly determined, a specific thing, each disease having its own specific antidote. Obviously such immunity cannot be due to the presence in the body of a general antidote to all diseases, else an attack of one infectious disease would immunize the body to all the others. We know that diseases so closely similar as measles and German measles do not immunize against each other, that germs so closely related in so many ways as are those of typhoid and paratyphoid are not, nevertheless, related in this way.

Moreover, we find that there is no known process of securing a specific immunizing agent against any one of these diseases, other than that of inducing the body to manufacture the immunizing agent in response to an attack from the poison of the disease in question.

Any physician who might try to immunize against smallpox, by diet, by exercise, by "living in accordance with the rules of health," or in any other manner short of the introduction of the smallpox poison to the body in question, and therefore the manufacture by the body of a specific antidote, would in these days be considered guilty of malpractice. So with all the other diseases concerning which our knowledge is clear and definite.

Notwithstanding the clearness of the relations of each immunity to its specific cause as above outlined, in all the well-understood diseases, there remains a widespread tendency to assume that the relation of immunity to its causes in less well-understood diseases is quite different—and this is particularly true of respiratory diseases, notably, tuberculosis, pneumonia and influenza. The logical position would be to admit that we do not know what those relations are. It certainly is illogical to assume and still more to teach that these unknown relations are entirely unlike those of the better known group. Yet it is daily taught concerning tuberculosis, pneumonia and influenza that immunity may be secured by a process totally unsuccessful in any of the well-understood infections—that is, by avoiding strain, by cleanliness and by right living in general.

The recent epidemic of influenza, since its victims were of every conceivable physical status, not merely those of poor physique, has surely demonstrated either that immunity cannot be secured by good physical status, or that a good physical status is so subject to insidious, unrecognizable and sudden depressions from unknown causes that the protection it is alleged to give is practically worthless. When a disease can be shown to attack only or chiefly, the old, the infirm, the sufferer from "low vitality," it may be reasonable to assume that immunity depends on the converse conditions. But let us never forget that no disease was ever more closely identified with poverty, starvation and misery in general, physical and otherwise, than typhus fever—and yet that typhus fever has been demonstrated to be a definite infection, depending on a definite germ-poison, conveyable only in a definite way, assailing anyone who is so infected without regard to physical status, and producing an immunity which once acquired in this way, cannot be upset by any depression of vitality, by any degree of the poverty, starvation, misery, etc., so long held to be its cause.

To leave no misunderstanding on the subject, let us suppose a thousand *unvaccinated* athletes in the pink of condition, and a thousand broken-down, but *vaccinated*, hoboes were all equally exposed to smallpox; perhaps five athletes would escape the disease, perhaps five hoboes would take it, and those only if their vaccinations were of more than seven years' standing.

The same thing, *mutatis mutandis*, is true of measles and relatively true of all the other infections in which a definite immunity exists.

Moreover, if a vaccinated athlete became a broken-down hobo, his specific protection against smallpox would be as good as ever, except as the time element might enter into it. In other words, general health and specific immunity have no close relationship to each other.

But, on the other hand, we may believe that there is some virtue in a good physical status, not as an aid to escaping infection, but to surviving it. Doubtless, if a thousand *unvaccinated* athletes and a thousand *unvaccinated* hoboes were equally exposed to smallpox, there would be no practical difference in the number of each group who contracted the disease; but there probably would be a difference in the death rate, probably in favor of the athletes. The difference probably would not be very great, however, because the recovery from an infectious disease depends primarily on the rapidity with which the antidote is manufactured by the body in relation to the rapidity with which the toxin is manufactured by the germ; and this ability to manufacture the antidote is not to be measured by the general physical status of the patient nor is the manufacture of the toxin affected by it either. Actual tests with the Schick reaction show ninety per cent of young children and ninety per cent of adults are immune to diphtheria—hence that this immunity exists to this enormous extent quite irrespective of tender years or adult development and also quite independent of physical condition otherwise, for our populations are not made up of ninety per cent weaklings or ninety per cent athletes either.

This ability to manufacture antidotes being independent of physical status and also being the chief factor in recovery, no great effect on death rates can be expected of the physique factor, which, nevertheless, probably does have some effect. That physique factor may be defined as the ability of the human mechanism to meet increased strains.

Let us compare the strength of a normal heart to that of a certain spiral steel spring. Evidently a weight which will stretch that spring four inches would stretch a weaker spring perhaps eight inches and might break a still weaker one. So we may argue, with every appearance of logic, that a certain dose of toxin (the weight) would stop a weak heart (the spring) more readily than it would stop a strong one. But in disease, that "certain dose" is seldom applied; the dose is always a very uncertain dose, and its uncertainty is due in part to the variability of the rate of manufacture of the antidote as well as of the variability of the rate of manufacture of the poison.

If we had one thousand springs varying in strength from one hundred pounds to ten pounds, and attached to each a fifty-pound weight, we should, of course, have them survive the strain or break, in exact proportion to their relative strengths as above or below the fifty-pound breaking point. But if the weights were applied by a thousand different experimenters, each of whom held up the weight or dragged it down with his hands so that its effect was not uniform; moreover, if each held up or dragged down his weight to a differing extent from his neighbor, it is easy to see that the outcome would be far from accordance with the initial strength of the springs. (The different "experimenters" who, in this illustration, introduce the variable factor which cannot be estimated are intended to represent the variations of rate in the manufacture of toxin by the germs in composition of forces with the variations of rate in the manufacture of anti-toxin by the patient.)

The fifty-pound weight, strongly supported by the experimenter, would fail to break the thirty-pound spring, while the fifty-pound weight, heavily dragged down, might break the eighty-pound spring. Crude as this illustration must necessarily be, it does carry with it an explanation which is at least plausible, of the reason why the strong man may die of a disease from which a weaker man recovers.

We may conclude then that as there are no extraneous circumstances which will produce specific resistance, so there are none that will depress or raise it.

This conclusion is probably correct concerning most of the infections, and within that range of extraneous circumstances which is within the range of compensations of the body. Extremes of starvation, of cold, of heat, of injury, of poisoning with alcohol, and perhaps other drugs, may perhaps so injure the body as to reduce even a specific systemic resistance—yet there has been recorded, so far as I am aware, no instance of a well-vaccinated person contracting smallpox because he was drunk at the time of exposure, if he was immune enough to escape smallpox on exposure while sober; nor of a person immune to measles contracting measles because he was, at the time of exposure, chilled through, if he were immune enough to escape when not chilled.

On the other hand, *local* immunity as contrasted with systemic immunity may be destroyed by sufficiently severe accidents, as when a broken bone suppurates at the break; but here the depression of vitality is so extreme that one can imagine almost all the local mechanism of life breaking down at that point. An analogous systemic condition, so severe as to offset a systemic immunity to the same degree, would be all but equivalent to death of the whole body, and I am not prepared to deny that in the death agony even a specific systemic immunity might be involved in the general wreck.

Curiously enough, many of those who admit the truth of every point here made, will nevertheless still teach the age-old fallacy that general health does protect against infection, and will excuse themselves on the ground that general health is so much to be desired that it should be urged for every reason, even on the false ground that it prevents disease.

But my view of the responsibilities of Teachers of Public Health differs from such an one. To me it seems that teachers of Public Health may be compared to persons detailed on a liner to instruct passengers on what life-preservers they should wear in case the liner sinks. What would be thought of the instructor who taught his passengers that warm, well-fitting clothing was all-sufficient to save them from a death by drowning? True, he would be advocating a good, a pleasant, a much-to-be desired thing, something very useful, even necessary, to the success and comfort of their everyday life. But everyone knows exactly what would happen to his passengers in case the liner sank. So also the false prophets who teach health as a prevention against infection—their followers and they themselves go down on every hand because they trust to that which is incapable of saving; and trust to it in spite of evidence on every hand, from the very deaths they themselves see, that such teaching is obviously fallacious.

But equally fallacious is the absurd converse—that good physical status encourages infection. So strongly was this believed of typhoid fever, not many years ago, that it was thought necessary by Sir Wm. Osler to deny it solemnly—and I myself have listened to a high medical authority attempting to *explain* it, i. e., to explain a something which needs no explanation because it does not exist! The fallacy is one of observation merely—it was based wholly on meager knowledge of the facts and still more meager insight into them. The truth is this—typhoid fever is common in pioneer countries because of the free exchange of human discharges under the crude conditions of life found in pioneering settlements. In pioneer countries the only people who can contract typhoid, or anything else, are, of course, the people who are there—and such people, being pioneers, are naturally of excellent physique. Typhoid is rare amongst the "effete civilizations" where physical weaklings are supposed to be more common—not because the weaklings are protected by their weakness, but because they have advanced to a degree of civilization where they do not so freely swallow the discharges of each other.

Summary: Immunity to infectious diseases can be attained only by (a) excluding from the body the germs which produce them, or (b) allowing the germs (or their poisons) to enter the body, with the object of stirring up the body through their poisons to manufacture the necessary antidotal substances. This latter is the sense in which the term immunity is used in medical literature.

Such immunity is specific; once acquired it becomes a function of that body until such time as it fades away; it cannot be developed by any means at present known to us other than by the admission to the body of the specific poisons of disease; nor can it be destroyed or depressed so far as we know by any means whatever unless it be by death.

Anaphylaxis on the other hand is a state of susceptibility induced by the introduction to the body of a protein substance in itself not poisonous at all. These protein substances under circumstances not yet understood, may on introduction stir up the body in such a manner that subsequent admission of the same protein is no longer harmless but may produce a variety of symptoms or even death.

CHAPTER IX

EPIDEMIOLOGY—THEORY AND PRACTICE

Epidemiology may be described as including the science and the art of dealing with epidemics—hence, as we now understand them, with infectious diseases.

Early epidemiology varied according to the peoples involved and the stage of development in science they had reached.

The earliest explanations of the great plagues and pestilences attributed them to the malignity of offended devils, or of offended gods—but later, natural phenomena on a great scale, such as unusual conjunctions of the planets; unusual severity or unusual mildness of the weather; the stirring up of soils; floods; the stagnation of waters which usually flowed; everything or anything out of the way, that happened to be coincident with the outbreak, earned the blame for it. Bad smells of all kinds have for ages been considered causes of disease—especially the smells of a deserted battlefield. So strong is this belief even to-day that after the battle of the Marne the Pasteur Institute of Paris was compelled to issue a statement that a pestilence need not be feared despite the unburied bodies left on the ground! Everyone knows now that the healthiest body of men ever assembled lived in the fearful conditions of the trenches of the front line, unharmed by the stench, for months.

We now understand that epidemics arise merely by the transfer of the infectious agent, a germ of some kind, from one living body to another living body; and that outside agencies, unless they affect that transfer in some way, are seldom if ever responsible. Thus, climatic temperature does affect yellow fever and malaria, but it does so by affecting the respective mosquitoes concerned or the germs they carry. Night is the great time for contracting malaria, because the malaria mosquito bites at night, and so on. But, broadly speaking, epidemics depend, first, on the existence of an infected person, and second, on the contact of that person with nonimmune associates to whom the disease may spread, these again passing it on to still others. In brief, every case of infection to-day, typhoid, tuberculosis, syphilis, etc., is a direct descendant of antecedent cases, going back in a direct line to the dawn of history, just as the new-born babe of to-day is traceable back and back to the same period.

Since epidemics may, and in fact, must arise from single cases, one case is to be considered in epidemiology as much as any other number. The ideal of the modern field epidemiologist is to find the first case of every potential outbreak, and to confine the total "outbreak" to that single case.

The recognition of the individual diseases (diagnosis), and a detailed knowledge of the natural history of each, especially as regards infective stages, methods of transfer, etc., are obviously essential to the proper handling of such cases from the preventive standpoint. Epidemiology is interested in the infected person only as he may be a menace to others, and not on his own account; it disregards the infected individual as soon as he is so handled as to prevent spread of infection from him, and thereafter devotes itself to providing for the safety of those not yet infected. The point of view of the epidemiologist is hence the converse of that of the therapeutist. The latter devotes himself to the sick and pays little or no attention to the well. A union of epidemiology and therapeutics is hardly advisable, because of their diversity in objects and methods; but a more complete understanding of the experts in each department by those in the other, and better coördination and coöperation in the work itself, are much needed.

Epidemiology as it is concerned in the diagnosis and natural history of some of the more common diseases has been dealt with. The ways in which this knowledge may be applied naturally follows.

The initial object of the older epidemiology and of much that goes under that name to-day, seems to have been the prevention of the spread of disease, quite as military leaders might devote themselves to restricting and interfering with, by all means possible, the operations of the enemy. But the greatest military leaders have always held that war can have no decisive results if energy is diverted to any issue other than the one great issue, the destruction of the enemy's army, and that provided this end be gained, apparent losses in any other direction go for naught in the final grim accounting, neither loss of territory, of ships, of money, of munitions, or of men.

In Public Health I think the same thing holds, and no diversion of the energies of Public Health to any side-line, however much it may appeal as desirable, humanitarian or indirectly useful, can make up for negligence to attain our real objective, not the mere restriction of disease, but its abolition. Once that end is reached, the objectives of the immense strain and effort involved in our present indirect operations, so laborious and so comparatively unfruitful, would become accomplished almost of themselves as natural sequences of the victory; or become quite unnecessary.

How can disease be abolished? Perhaps we should first consider what disease is, for one hears often wondering speculations on the mystery of disease, as if it were something supernatural, some terrible disorder in nature, something foreign to life, a special curse of some kind.

Disease, however, is a normal thing. It is the reaction of the body to stimuli which we do not desire. Warmth we enjoy, but to such heat as may raise a blister we object. Yet the processes which raise the blister are every bit as normal, as much under law, as are the processes which make the gentle warmth appreciated. If a bridge breaks under a load too great for it, we deplore the accident, call it a mysterious dispensation and so forth; yet if it did not break under a load too great for it, we would have ten times the reason to be frightened, for that would mean the reign of natural law had ended and that we could never again tell whether a stone would rise or fall when left unsupported, whether a match, when struck, would burn in air, explode the universe, or bring on a rainstorm!

Many who will admit that disease is simply a natural reaction to stimuli, a natural reaction but one we do not want, still exercise themselves about the origin of disease, its awfulness, its ultimate causelessness, its unnecessary imposition on our lives.

Thus arose the earlier speculations, attributing disease to the malignity of devils, or to the wrath of God.

Most mysteries in this world are mysterious merely because the explanation is so much on the surface, so close under the eye, that, like one's own lower eyelid, it is not readily seen. Most diseases, so far as we understand them, originate from a very common, ordinary, and wide-world impulse in which we all share, the desire for food. The ancient caveman looked, no doubt, upon the fearful giant brutes that hungrily dogged his every movement as dreadful curses, not to be understood, set upon him by devils. Yet he went out himself, pursued and killed his prey, rabbit or deer or dove, and brought it home for his family to eat with pride and joy, thanking his gods. He did not realize that to the rabbit, deer and dove, he was that same dreadful curse the wolf and the tiger were to him. Coming down the ages, man has driven off—in many instances wholly abolished—these early curses of the race, finding the larger ones comparatively easy to destroy, the smaller ones very difficult. As civilization has increased, the size of man's enemies has diminished, until in great cities now the visible ones are rats, mice and bedbugs; the invisible ones, hardest of all to fight, are germs.

Most disease, then, is nothing more than the converse of man's own attacks on other species in search of food—it is the attack of other species upon man in the same search. True, we have narrowed the name disease to the attacks of very small enemies, too small to be seen readily, but the principle is the same; and in a broad sense, man himself is a disease of cattle, sheep, hogs and what else of living creatures man eats. The attacks of germs are not malignant, devilish, un-understandable at all—the germs, quite unconscious of man, seek merely what man himself does, to make their living in the easiest way from their surroundings.

All life comes from life—but all life feeds on life, too. We eat sheep, tuberculosis germs eat us. If there is any malignant deviltry about it, it is on our part rather than on the part of the germs, for we do our destruction of other living things deliberately, and with full knowledge of what we do, while the germs do not know even that we exist at all. As well be wrathful with a stone falling from a height upon us as with a diphtheria germ which kills a loved one.

All this is obvious and it would be wasted time to say it, were it not that we encounter, even to-day, so many and such absurd maunderings of the human intellect on this subject.

Admitting then that epidemiology has for its object the pursuit and killing of tiny foes, just as our forefathers pursued and killed tigers or wolves, we should understand in what ways we can make our knowledge of the germs' habits help us to destroy them.

Our most valuable knowledge is that infectious diseases are caused by certain germs; our next most valuable is the more recent knowledge that most of these germs live only in the living body. This at once narrows our hunting-field from the whole universe to the human race chiefly.

When it was first known that germs caused disease, it was supposed that disease germs could grow and flourish almost anywhere—particularly in sewage, garbage, filth and dirt of every kind.

We know now that disease germs are the aristocrats of the race; they cannot stand the rough and tumble life of all out-doors. They must have the special features of a regular palace to preserve their tender specialities—a palace which we supply them, warmed, darkened, admirably stocked with food and all conveniences, in the form of our own bodies. They take advantage of our internal sanitary arrangements, made for our own benefit, and live like lords in our tissues, having their food supplied, and their excreta removed, at no expense to them, by our own systems of food supply and of waste disposal. They are parasites, indeed, "toiling not, neither do they spin," unwelcome guests who make themselves at home in our own proper substance. But when they leave these quarters so luxurious, they quickly die in the cold, hard, unfeeling outside world, where they miss the warmth, the water, the food, the darkness, the atmosphere, and the waste disposal system we furnish to them.

In brief, in our hunt for disease germs, we must first hunt men—those men (women and children also) who harbor the germs and from whose bodies they radiate to others. There are, of course, some exceptions; some disease germs flourish in some other animal rather than in man, reaching man only incidentally. The bovine tuberculosis germ is such an one.

Some disease germs also have a stage (spore) in which they can survive the hardships of the outer world, where most disease germs die; for instance, anthrax and tetanus. But these germs, as disease producers, are fortunately few and rather rare. Could we be rid of all but the few disease germs that flourish outside the living body we should be practically without serious disease at all.

If we should ever succeed in an attempt to corral *all* the infected bodies, and to prevent spread from them until such time as the germs have died out, our problem would be solved—disease, at least, infectious disease, would be abolished.

How are the infected bodies to be located? Here we have a technical problem—the recognition of the infected state in those persons who may come under examination; and a sociological problem—the securing of the examination of the population in sufficient detail to locate the infected. The first we can manage after a fashion; the second, amongst civilians is very difficult to carry out in detail, for all infections, under present circumstances. In the army, it is comparatively simple; and in the Great War was the chief factor in subduing those infections against which artificial immunizations could not be used.

In carrying out the detailed examination of every individual, the noninfected may be passed on to a segregated group, the others rejected to the general population. This is the method followed in securing an uninfected army. But while admirably adapted to the purpose in hand, the securing of a noninfected group, it leaves the mass of the population in the same situation as ever.

We may imagine the converse; an examination of everyone involved, and the segregation of the infected; this is the process followed within the army, when an infectious disease develops in any unit. But practical as this is in the army, it is obviously extremely difficult to carry out in complete detail in civil life, except with groups, such as school children, who assemble daily at a specified point and may there be examined. In a heterogeneous population whose daily lives are not subject to the minute control of a central authority, this is almost impracticable for the acute diseases, which require prompt action and daily inspections of all those exposed. For the chronic diseases, involving examinations once a month, or once a quarter, it will probably be effective before many years have passed, and there should be combined with this an arrangement for emergency daily inspections in case of epidemics.

Fortunately, the complete system above outlined for the supervision and control of all diseases is not essential to the control of all the acute infections. These, as a rule, can be handled by a method more conservative, as a whole, of time and energy, but requiring exceedingly keen and energetic intensive work at the time of emergency.

This system may be thus outlined. On the occurrence of a case of infectious disease, say scarlet fever, mumps, tuberculosis, that case is isolated. Theoretically, further damage from that case is thus ended. If the case is placed in charge of a trained nurse at home, or removed to a hospital, the isolation is real. If, however, it is left at home with only the parents to care for it, the therapeutic attention needed is usually given, conscientiously and even overzealously, but true isolation of the patient or proper care of the patient's discharges is rare. For this reason, the introduction of an infectious disease into the ordinary household usually means that one, or more, or all, of the remaining susceptible persons in the household contract it also.

Hence the epidemiological unit for this purpose is the household rather than the individual. Even when prompt and complete isolation at home, or removal to hospital is carried out, one or more members of the household will often prove, by coming down with the disease, that infection had already occurred, before the isolation went into effect.

Obviously, then, after isolating the patient, the next thing is to determine what is to be done with those already exposed by the patient. To all such the term "contacts" is applied.

The older system was a shutting up of cases and contacts together, until the danger period, extending sometimes long after the patient's death or recovery, might be over. As new cases developed amongst those thus quarantined, the period of segregation was extended.

Under such a system, the occurrence of an infectious case in a household often meant financial ruin, for not only were the expenses of the sickness itself to be met, as in non-infectious cases, but also the income of the household stopped, while persons transiently present as guests, or visitors, or even those who might be present on a brief business call might be shut up also with the household. The rank injustice of all this, the over-burdening of all concerned, the interruption of business, led to every form of deceit and trickery to escape quarantine. People were afraid to call a physician unless the death of the patient was imminent, and disease spread because of these very natural and proper sociological objections to this fearfully crude blanket quarantine. A study of the natural history of each individual infection, the determination of incubation periods, of infective stages, etc., made possible the much more humane as well as far more scientific system of procedure now in use.

The modern practice is as follows—first, the contacts are investigated to determine whether they are immune or not, for instance, as to their history of vaccination against smallpox; or of having had the disease itself before in smallpox and in other diseases where immunity develops, etc. Satisfied on this point, the epidemiologist releases the contacts who are immune to the disease in question, and troubles them no further; except to direct them how to avoid carrying the disease on their hands or in their throats, if they remain in the home with the patient.

For those contacts who are not immune already, immunization may be practiced, as by vaccination in smallpox and typhoid, inoculation of antitoxin in diphtheria; in vaccination against smallpox, the contact should remain under observation long enough to see if a "take" occurs, since it may be that the protection has been supplied too late. Often it can be determined by calculation of dates of exposure in correlation with the incubation period of the disease whether or not the vaccination is too late. If vaccinated within the first three days after first exposure, escape is usual. The later the vaccination, the less is the chance of escape.

For those contacts who are not already and cannot be at once immunized for any reason, the period of detention for observation is calculated, and the contact is detained and watched *during that period only*, thus immensely cutting down the length of quarantine as compared with that of the old practice. The principles involved in calculating this period of observation are—given a number of contacts, a case of the disease in question cannot occur amongst them as the result of exposure to the original patient any earlier than the date to be found by adding the minimum known incubation period of that particular disease to the date on which the original patient first exposed any of the contacts; while the last case of the disease in question cannot develop amongst the contacts later than the date to be found by adding the maximum known incubation period of that disease to the date on which the original patient last exposed any of the contacts.

In a household, where all members were continuously in contact with the original case both before and after the disease developed, the date on which that case first became infective plus the minimum incubation period indicates the date of possible occurrence of the first new case; the date of isolation of the original case plus the maximum incubation period indicates the date of possible occurrence of the last case. For any other contacts, such as visitors, who may have seen the case only at a time later than the date of infection, or who ceased to be in contact with him earlier than the date of isolation, corresponding differences in the periods during which they may develop the disease will necessarily exist.

Because the prodromal stages of many infections are often overlooked, or go unrecognized for what they are, the maximum prodromal period should be added to the maximum incubation period in calculating the last day of observation for nonimmune contacts.

To illustrate: Suppose that mumps develops in a family on November 5th and is at once isolated; all who have had mumps may be disregarded, and even those who have not had it (unless exposed to the same source as that from which the original case became infected), may go free until November 17th, but must thereafter be under observation until December 2nd. It is thus worked out—mumps developing November 5th has already been infectious November 4th, possibly November 3rd. The earliest new case from the original one, will develop not less than fourteen days later, i. e., November 17th. The original case being isolated on November 5th and therefore no more infection from him occurring, the last possible case will have its onset twenty-five days later, i. e., on November 30th; but since the typical symptom may be delayed a day or even two, December 2nd is the date for release of the nonimmune contacts. Note that the infectious period of mumps is so short that the patient may be released safely by November 24th or even earlier, i. e., before the nonimmune contacts are freed.

Should new cases occur amongst the contacts, if any, their nonimmune contacts must in turn be similarly handled. Ideally, all contacts should be isolated each by himself during the observation period, for then, if any one of them develops the disease, he has no contacts, and there is, therefore, no further extension of quarantine for anyone else.

To illustrate further: If a case of scarlet fever is seen first on November 5th and inquiry shows the rash appeared November 3rd, the assumption is that the patient was first sick November 2nd. The history may confirm this, or may show the patient began to be sick November 1st. In any case it is safe to assume that he was not infectious October 31st. Hence those nonimmune contacts whose exposure to him occurred only on October 31st or earlier may be disregarded, as well as *all* the immune contacts. Those nonimmunes exposed November 1st who later develop the disease will develop it as a rule by November 6th, possibly as late as November 8th. Those exposed on the day of isolation, November 5th, may develop it by November 10th or even as late as November 12th. Since scarlet fever has at times a very short incubation, the proper practice would be to disregard any "safe" interval and to keep under observation all nonimmune contacts for one clear week from the date of isolation of the patient, unless in individual instances it can be shown that the exposure terminated earlier than such date of isolation.

What constitutes "observation of contacts" to a satisfactory point? In schools or in the army or under similar conditions, examining the contacts twice daily for any signs of onset, whatever the theoretical shortcomings may appear to be, will be found satisfactory. Continuous observation is naturally even better, and might theoretically be secured, in the case of children at home, from intelligent parents, and in the army, by the companions of the contacts, or even by the contacts themselves.

Unfortunately, intelligent and trustworthy coöperation cannot be generally expected amongst civilians who are not in school, factory or other place where inspection is possible; self-watchfulness, daily or semi-daily reporting to a physician, even daily visits by a physician will theoretically achieve the same ends. The disadvantages of these plans are offset by great advantages, in the comparatively small restriction of liberty imposed on the contact, permitting him to go on with his school, drill, work, etc., as the case may be. Where such methods are not practicable, the contacts may be shut up during the period of observation, but each should be separated from the others—for if not, the development of the disease in any one of them means a renewed opportunity for the infection of the others shut up with him, and hence an extension of the period of observation of these others to a date the maximum length of the incubation period further on.

These principles once thoroughly understood will be subject to many modifications and readjustments, and such are permissible provided the main issue is attained, the prevention of contact of nonimmunes with infected persons.

Tuberculosis should be dealt with on exactly the same principles, and the venereal diseases also.

The dealing with the discovered patient and his contacts to prevent further spread of the disease is the first and most crucial step. The second step which should immediately follow is the search for the source of the infection of the existing patient, in order that further extension from that source may be terminated, and also that other cases, not yet known to exist, may be discovered by a search of the contacts of that source.

If, for instance, a case of diphtheria be discovered, the isolation of the patient and the handling of his contacts is obviously to be done at once. The next step is the search for the source of the diphtheria infection of the now isolated case.

These sources are determined by careful inquiry directed to determining the associates of the patient during a period to be calculated by counting *back* from the date of onset both the *minimum* incubation period of the disease in question, and the *maximum* period. The interval between the two dates thus found must include the date of infection.

Thus, if a mumps case is first sick November 3rd, he must have been infected not later than fourteen days before (October 19) and not earlier than twenty-five days before (October 8). He was infected then at some time on or between these two dates, and a complete history of his activities between these two dates must necessarily include a history of his infection. But of course, really complete histories are difficult to obtain.

Unfortunately, especially amongst civilians, nearly everybody meets so many strangers every day that to trace all the associates of any one person can seldom be achieved—many are in fact unknown to him. The greater the number of patients who come down with an infectious disease from a single source, the easier it is to determine the source, because obviously we do not require to trace the total associates of every patient during the whole period of possible infection, but only those associates which *all* the patients *had in common.* Moreover, if there are a large number of patients, their incubation periods, while *ranging* back fourteen to twenty-five days, will be *massed* chiefly about eighteen to nineteen days back—and by calculating eighteen to nineteen days back from the date on which most of the cases develop, the date of infection for all can be fixed much more closely, i. e., within a day or two, hence increasing very much the chances of discovering the source.

What is that source? The source is a human case or a carrier in most of the ordinary infections. Occasionally, however, more particularly in typhoid fever, the identity of the human source may be obscured by the fact that the discharges from that source may have been conveyed to the patients, not by direct contact of person with person, but through an indirect route of infection, such as flies, or other insects, water or milk or food. In the case of typhoid fever, then, it is necessary, after determining the probable time of infection, to include in the inquiry regarding human associates at that time, inquiries as to the water supply, milk supply, and food supply, insects, etc., *common to all* the patients at that time. In the infectious diseases other than the intestinal, milk is the most likely indirect route of infection, although it is relatively seldom that anything but direct contact operates in the nonintestinal infections.

In a few diseases, these procedures are modified by the availability of special methods of search for the infected persons. In diphtheria, for instance, instead of isolating the contacts of the patient for a week, cultures of their noses and throats may be made at once and examined after incubation next morning. Those persons whose cultures prove free of diphtheria germs may be released. So also in searching for the source of infection of the diphtheria case, instead of investigating each associate by questioning, etc., cultures may be made of all, and the guilty one thus detected—the cultural method having the further great advantage of detecting "carriers," who have never been sick, as well as infected persons from whom a history of being sick may be obtainable. In typhoid fever, Widal reactions may be made of those persons who lie under suspicion, as sources of an outbreak; and those showing positive reactions may be examined for the presence of typhoid germs in feces or urine. Elaterium administered to such persons is said to give 800 times the chance of finding the germs in the feces that could be expected from examining the feces without such administration.

On the finding of a definite source of infection, appropriate steps to isolate the person, or to disinfect or otherwise render harmless the route, are obviously required.

Where the source of infection is a water supply from which infection cannot be eliminated, purification of the water must be resorted to.

In the case of a milk supply where further infection cannot be stopped, pasteurization should be installed—in fact all milk supplies should be pasteurized at all times, thus practically eliminating milk as a route of infection for any infection. Where infection of food cannot be ended, all such foods should be cooked before being eaten. Flies cannot be destroyed as a rule, but they can be prevented from becoming infected—in the case of intestinal diseases, by excluding them from outdoor toilets or other places where typhoid discharges may be exposed.

Summary: Epidemiology, while including all that is known of infectious diseases, finds its chief application in the study of the transmission of disease from living body to living body; and its chief end is to interfere with that transmission in order to prevent the further propagation, in new foci, of more germs, which in turn may spread to still more new foci.

Its ultimate object is to so restrict the breeding grounds of infectious disease germs that they may be limited to so small a number of animals or persons as to permit the final step, the destruction of the few germs thus left, after which the particular germs so destroyed will be extinct—and with them of course the diseases they produce.

CHAPTER X

OUTLINE OF BODY OPERATION; OXYGEN IN THE BODY; VENTILATION

The operation of the human body cannot be understood unless the general structure and plan of the body is clear.

The body may be compared to a great hotel. The mouth is the main entrance, chiefly for food supplies, but the unbidden guests of disease here enter also, usually with the food, or under the wing of casual visitors, like fingers, spoons, etc., which latter do not go beyond the "lobby," but suffice to shield the germs in their unobtrusive entrance.

The stomach and intestines may be considered the kitchen where the food supplies are prepared for distribution to the individual guests (cells) all over the hotel. There is no common dining room. The meals are all served to the guests in their rooms. The garbage, that is, material that never left the kitchen—waste material that could not be used for food—the wrapping paper, so to speak, the rinds, and so on, are discharged as feces.

The food itself is passed through the walls of the kitchen (intestine) into an automatic service device (blood stream) which conveys the food to every part of the body, down the narrow corridors (blood vessels) along which the guest rooms are lined up, to the number of hundreds of millions.

The guests reach out to the conveyor and take from the passing load of food whatever they need and can get. They put back into the conveyor their waste products. The conveyor circulates back to the kitchen for more food, but on the way gets rid of the waste matter the guests have loaded into it, at the kidneys, which really represent the sewage disposal system.

Germs growing in any confined space soon poison themselves off with the accumulation of their own waste products, and so would our hotel-guests, but for the constantly moving device before their doors by which they can get rid of these excreta. Thus it is that when germs also settle down in the body they do not destroy themselves by their own excreta as they often do in other situations, for in the body they take advantage of our food-supply and sewage disposal system, receiving their fresh food and getting rid of their sewage exactly by the same mechanism which our own cells use.

This automatic carrier device (the blood stream) does not carry food and sewage only, however. A large part of what we call food is really fuel, to be burned up in the guest chambers, and it is necessary not only to carry to the guest chamber this food-fuel, and not only to remove to the kidneys the "ashes" and other wastes, but also to supply oxygen that the fuel may burn, and to provide an outlet for the "smoke" (carbon dioxide). This also the blood stream does, taking in the oxygen at the lungs and bringing back the "smoke" to the same point for discharge. True the fire is flameless, and the smoke invisible, but this is a tribute to the perfection of the combustion, for smoke in the ordinary sense is visible only because of the unconsumed fuel it contains, the result of imperfect combustion.

These permanent guests, which in their teeming, crowded millions, make up our bodies, are each composed of a semisolid little aggregation of protoplasm, that substance of which all living things are made.

These guests (cells) are actively alive. They are, in brief, tiny biological engines, obtaining their energy from food-fuel and turning that energy to different uses according to the various specialties which have developed amongst them. The activities of the body as a whole are the summation of infinite numbers of tiny food-fuel explosions in these engines, exactly as the movements of an auto are the resultants of the gasoline explosions in its cylinders. In an auto, the separate explosions can be distinguished by the ear at times; but if the engine is running fast they make a continuous hum or roar, just as the vibrations of a violin string are from their rapidity individually indistinguishable to us and give a single clear note. The infinitely greater number of explosions in our tiny body-engines (cells) produce a variety of unified results, each composed of fusions of the various kinds of explosions; and showing themselves in muscle cells as actual motion of our hands or feet, etc., in gland cells as the production of special substance needed in the body, and so on.

Having in mind this general outline of the body functions, we may now consider in some detail the functions in the body of some of our most important body supplies,—air, water, food—as we have already considered some of the uninvited poisons that creep in with them.

The functions of air within the body are not difficult to understand. Pure air on the earth's surface consists, in 100 parts, of nitrogen, about 80 parts; of oxygen, about 20 parts; and of small amounts of carbon dioxide, about 4 parts in 10,000; together with traces of several other gases, hydrogen, argon, neon, etc., to which we need not give further heed. Of course, air often contains still other things, more or less extraneous and variable. One of these, of great importance, is water, on its way down from the clouds as rain, or on its way up to the clouds as vapor; dust, from meteors (a very appreciable amount) and from the earth's surface, the latter containing bits of everything on the earth's surface, the dry detritus of all creation; gases, from factories, from natural deposits in the earth, or, loosed by bacteria, from organic matter which they are decomposing; insects and insect eggs, plant pollen, spores of fungi, bacteria, etc., etc.; finally air close to the earth's surface always contains a variable amount of heat.

It is the business of our breathing apparatus (nose, windpipe, lungs) to strain this air of all we do not want and take in to our blood stream only what we do want, which is the oxygen. Useful as nitrogen is to us, we cannot use it in its elemental form as nitrogen gas; it must be chemically combined with other elements before we can use it; and therefore the immense amounts of nitrogen in the air are as such useless, except as they mechanically dilute the oxygen. The carbon dioxide of the air is probably useless to us, also; we make so much of it ourselves in our own bodies that the small amount of it in pure air can hardly affect the total in our lungs; dust we catch in traps formed by our much twisted turbinated bones, our noses, mouths and throats. We swallow almost all that we thus trap; little if any enters the lungs by the windpipe.

The various gases artificially produced as from factories, etc., are usually too slight in amount to matter, but when they are concentrated, as in military gas-attacks, or in leaks from gas-fixtures in our homes, they may become very dangerous. Usually our noses warn us so that we may escape in time.

Water vapor and heat are, beside oxygen, the most important constituents of the air surrounding us. From a practical standpoint, the oxygen on the earth's surface is always present in sufficient amount for all our purposes, and maybe dismissed from further consideration. But water vapor and heat are very variable and it is these variations that furnish almost all our difficulties with "ventilation" or the securing of "good air." In order to make this important matter clear, it is necessary to review some exploded fallacies concerning air, still held in many quarters.

The most widespread of these fallacious views attributed the unquestionably detrimental effect of "bad" or "impure" air or "lack of ventilation" to a diminution in the oxygen; to an accumulation of carbon dioxide thrown out by the body; or to both. But since the worst ventilated "slum" is never air-tight, the oxygen of the outside air rapidly enters through cracks, etc., or through the walls themselves, and the excess carbon dioxide leaves by the same routes. Hence such a "slum" hardly ever can show a reduction of oxygen to a point below 19 parts per 100, or an increase of carbon dioxide to a point above 1 part. Direct experiments show that the oxygen must be reduced to 15 parts per 100 before any effect on the body can be detected; and that the carbon dioxide must rise to 3 parts per 100 to attain the same end. Moreover, since the normal content of the lung air cell ranges, for oxygen, about 16 parts per 100, for carbon dioxide about 4.5 parts per 100, and since the air in the air cell is the only air the body ever uses, because this is the only air that ever comes in contact with the blood, it is obvious *that the air of the worst ventilated slum can hardly ever approach,* in reduction of oxygen or increase of carbon dioxide, *the only air actually ever used by the body under any circumstances!*

Tests for carbon dioxide in occupied rooms were carried out as a routine measure before the above facts were given due weight, and the "ventilation" was "condemned" or not upon the amounts of carbon dioxide found as compared with an arbitrary standard of "permissible impurity." At first, the carbon dioxide test was considered of value as determining directly the "poisonous properties" in the air, then supposed to be due to the carbon dioxide itself. When this view was abandoned, the carbon dioxide test was continued on the assumption that, although the carbon dioxide in the amounts found was in itself harmless, yet the production of carbon dioxide in the body paralleled the production of a mysterious "volatile organic poison" which would therefore be present in corresponding amounts also.

It now appears, however, that the alleged proofs of the presence of such a "volatile organic poison" are wholly fallacious; and that in all probability no such poison exists.

The popular opinion that the smells of an occupied unventilated room are physically injurious (other than as they may affect persons æsthetically) are negatived by the consideration that those smells come chiefly from the human bodies present—and if those substances, which, when diluted in the air, produce the smells, are not poisonous in their concentrated form in the body where they originate, it is difficult to conceive of their being poisonous after they have left the body and been reduced by mixture with the air to a minute fraction of their former concentration. Actual experiments demonstrate that such smells have no effect upon any measurable function of the body unless perhaps a slight indefinite, inconstant and evanescent one upon the appetite.

To what then is due the "badness" of "bad air"? We are considering air "polluted" by the presence of living bodies in it—not of course, impurity due to smoke, gases of various kinds, etc., introduced from sources other than the human body (say leaks from gas-fixtures, etc.), the sources and effects of which are obvious and definite.

The ordinary "bad" air of occupied "unventilated" rooms is "bad" because of too great heat, or too great humidity. Now, lack of heat (cold), or lack of humidity (dryness) are detrimental and are readily recognized, especially the former.

But air which is "bad" from the lack of sufficient heat or of sufficient humidity is not usually described as "bad" or "impure" but is usually described definitely as too cold or too dry and does not fall into the classification of results of "poor ventilation" although it should be included as "bad" equally with that air which is "bad" for the converse reasons. This inconsistency exists because the causes of such "badness" of air as cold or exceeding dryness, are not only obvious, but also are rather readily remedied. If the room is too cold, everyone acknowledges the condition and all subscribe to the remedy, but if it is too hot, the excess of heat is not always appreciated by everyone, nor the usual remedy of cooling always applied with general consent.

In brief, ordinary "bad" air is "bad," not because it lacks the essentials for supplying the lungs with oxygen, or for removing carbon dioxide from them, but because it lacks the essentials for properly cooling the skin, one essential function of the latter being exactly that which a radiator performs for an automobile engine—the elimination of the surplus heat generated in the operation of the engine.

The sixteen square feet of skin surface of the body are cooled by conduction if the skin is in contact with anything cooler than itself—hence by the air surrounding the body as a rule, unless that air equals or exceeds in its own temperature that of the skin. The skin is cooled also by radiation of heat to surrounding objects which are cooler than itself. But the air and the surrounding objects may be much warmer than the skin on hot days in the tropics, in the stokeholes of steamers, etc., or in those experiments where men were deliberately inclosed in ovens heated to 250 degrees Fahrenheit. In such cases the temperature of the body would rapidly rise to a fatal point by the accumulation of its own heat, if it were not that a third mechanism for cooling the body exists, the evaporation of sweat. To evaporate a pint of water rapidly by boiling, a great deal of heat must be supplied—i. e., some source of heat must part with its heat to the water in order that the water may evaporate. The total amount of heat which must be supplied in order to evaporate a pint of water is the same whether it be evaporated rapidly or slowly. Hence a pint of water evaporated from the skin takes from the skin slowly as much heat as would the same pint take from a stove rapidly if it were to boil away completely.

It is easy enough to see that the particular temperature of the air in a given place affects its ability to properly cool the body. It is not so easy to see that the humidity of the same air affects the proper cooling of the body also, unless it is remembered that, if the air be free of moisture, evaporation into it is very rapid; that if it be already saturated with moisture, further evaporation into it cannot occur at all; and that obviously intermediate grades of humidity affect the rapidity of evaporation in intermediate degrees.

If the air or other surrounding objects be sufficiently cool to absorb heat from the body satisfactorily, evaporation from the body is unnecessary as a method of cooling, and, if it occur, may result in the total cooling being too great, i. e., in chilling the body. In cold, dry weather, such chilling does tend to occur, but is offset in its extent by two factors, a reduction, by the contraction of the skin blood vessels, of the amount of sweat supplied to the skin for evaporation, and by the fact that cold air has a relatively very low capacity for taking up water vapor, i. e., does not encourage evaporation much.

In hot, dry air, the heat of the body is not taken away by the air, but the skin blood vessels are dilated, sweating is free, the air being warm and dry has a great capacity for water vapor, i. e., encourages the evaporation of the sweat; and thus the cooling of the body is secured.

In hot, moist air, the nonremoval of the heat by the air and the pouring out of sweat occur exactly as in hot, dry air, but the moisture already in the air prevents the evaporation of the sweat, so that proper cooling does not occur and heat sickness, even death, may follow.

In cold, moist air it might be theoretically worked out that since the cooling by the air is sufficient, the capillaries contracted and no opportunity provided for evaporation of such sweat as is exuded, the conditions would be satisfactory. Another factor, however, enters in, making cold damp excessively hard to bear and likely to result in excessive chilling of the body. That factor is the high latent heat of water. In brief, a pint of cold air will not abstract as much heat from the body as a pint of cold water of the same temperature. In a cold, damp atmosphere, the heat of the skin is removed by the cold water in the air as well as by the air itself, as it is not in the case of cold, dry air. Hence the well-known miseries of a moderately cold but damp day as compared with the relative comfort of a much colder but dry day.

Modern ventilation then consists in securing air suitable for cooling the body without cooling it too much. The ideal indoor adjustment for ordinary homes would appear to be a temperature of 60 degrees Fahrenheit and a moisture of 50 to 60 degrees relative humidity.

Active circulation of the air is especially desirable where the occupants of the room are sitting or otherwise at rest. This is because the body itself throws out heat and humidity, warming and humidifying the air immediately about it in excess of the general figures for the general air of the room. Circulation of air tends to remove this self-manufactured "heat-and-humidity blanket" which is so obvious in summer weather, especially on windless days; movement through a still atmosphere (as in driving, riding in an open street car, etc.) tends to sweep away this blanket. Walking or running removes it also, but the cooling thus attained is offset by the increased output of heat due to the exercise.

Clothes act to retain this heat-and-humidity blanket close to the skin, and so to mimimize the heat-loss by conduction, as well as by radiation and evaporation. In winter, particularly out of doors, this retention of the heat-and-humidity blanket is very desirable. In summer the converse is true.

Summary: The human body can best be understood if it is considered as parallel in structure and operation with, although of course, immensely more complicated than, machines of human manufacture. We then find the main outlines of its care, the chief principles on which it works, are not merely similar to, but really identical with, the machines familiar to us in daily life.

This is particularly true of the much misunderstood subject "ventilation," which would now appear to have little if anything to do with furnishing oxygen to the body, but to be concerned chiefly in taking away surplus heat from the body; to be in fact a procedure which should have for its object the "cooling of our engines" not the furnishing of "draft for our furnaces."

Practical ventilation is no longer concerned with the rapid changing of the air in a room; rather it consists in such a juggling with available sources of heat, cold, humidity and air circulation as will maintain approximately a temperature of 60 degrees and a humidity of 50 to 60, with movement of the air sufficient to disrupt the "heat and humidity blankets" otherwise formed. In winter, control of the heating is the most practically important, control of the humidity the next; in summer, control of the circulation.

CHAPTER XI

FOOD

We are made of the crust of the earth—a relatively thin film, a few feet in thickness, which is all of this earth that we encounter or use.

The crust of the earth is made of us, also—our ancestors and our other predecessors, plant and animal. The circulation of the crust of the earth upward through plant forms, eaten by animals, and downward again to the soil has been going on for millions of years, so that no particle of the new-born baby of to-day is in reality any more "new" than the particles of the oldest rocks. It is more than obvious that the same baby, arriving at manhood, and weighing then say 150 pounds, against the ten he weighed at birth, has gained 140 pounds more of the crust of the earth, woven into his substance; besides many other pounds which have been added and lost during the intervening years.

Of this material in the human about seventy per cent is water; water makes up most of the blood, which speeds through the blood vessels; and of the lymph, that clear salty liquid which surrounds the cells and permeates all the tissues, forming the physical medium of exchange between the blood in the smallest blood vessels (capillaries) and the cells themselves. The fast-flowing blood, coming from the intestines and lungs, passes its new burden of food and oxygen into the lymph surrounding the cells. The cells take up from the lymph the food and oxygen they required and pass back into the lymph their waste products, carbon dioxide, etc.

The lymph in turn parts with these to the blood stream as it passes on to the veins and so back to the kidneys and lungs, for purification and a new load of food and oxygen.

It is estimated that the blood circulates at a rate such that its stay in the capillaries where these exchanges with the lymph occur does not ordinarily exceed one second in duration; and that a given blood cell takes about half a minute to make the round trip from heart to toe or finger and back again.

The salty lymph, which thus bathes the cells and in which they live, has been compared with the sea water in which the lowest free-living single-celled organisms of ancient times spent their humble lives; from which they took their food; and into which they passed out their waste products. Thus arises the poetic conception that we are still marine animals, carrying the sea within us rather than around us. Formed we seem to be of descendants of this ancient single-celled organism, aggregated together; our cells no longer independent, and each internally complete in itself, but highly differentiated, specialized and interdependent; yet still showing the hereditary features. As a matter of fact, we know that each aggregation of cells constituting a human body originated from a single cell in the mother's ovary, and so, it is believed, the individual repeats in brief the supposed history of the race.

Nor is this true only biologically. Sociologically also the race is now an aggregation of specialized, differentiated, interdependent units, derived by direct descent from ancestors who in their day performed perforce, each for himself, all the external functions of living which are now divided amongst specialists. In the pioneer days, not long since passed in this country each family was complete in itself; butchering, weaving, leather-working, carpentering, whatever was done must be done by the same few persons. Now the butcher knows no weaving, the weaver cannot butcher, the leatherman could not shoe a horse or make a staple, and with this specialization comes interdependence. True, did occasion arise, the man of to-day might awkwardly and slowly revert to the allround capabilities of his ancestors, as Robinson Crusoe did upon his island. But our body cells have been specialized too long and cannot so revert; if they are separated from their "social fabric" they perish, as a rule, notwithstanding that experimentally they may be kept alive for hours or even days at times by special precautions.

The sketch given in the previous chapter sufficiently well outlines that system in the human body by which the food enters the mouth and finally reaches the ultimate cell. But what is food? What are its functions?

Food is necessarily of the same ultimate composition as the body, since it goes to build up the body and to make up its bulk. The ultimate composition of the body, stated in terms of the elements entering into it, includes carbon, hydrogen, nitrogen, oxygen, phosphorus, sulphur, iron, magnesium, calcium, iodine, fluorine, copper, etc.—about eighteen of the eighty elements of the earth. But none of these except oxygen are found as elements in the body; they exist always in various chemical combinations, many of which are extremely complicated in chemical structure, and many more of which are as yet not structurally understood at all. Moreover, with the exception of oxygen, the body cannot use as food any of these elements as such, but only when they are available in combinations more or less intricate, such as those produced by and in the bodies of other animals or of plants. Thus, although carbon, nitrogen, hydrogen, oxygen, phosphorus, sulphur, etc., form the body, and form also the foods of the body, it would be absolutely useless to present to the body a meal consisting of carbon as charcoal, nitrogen as a gas, etc. Indeed, the nitrogen of the air is continually entering the body through the lungs and is found in the blood in small proportions—but passes out again unused, despite the demand of the body for nitrogen, because it cannot be used by the body in its elemental form.

How then is the gap bridged between the elements and the complicated combinations of the elements needed for food? Chiefly by plant action, aided importantly by certain bacteria of the soil. The bacteria are not only responsible for the decomposition of dead animals and plants back into the soil, but some of them aid in the recomposition of these fragments into plants again; and one or two species act to bring into the combinations the nitrogen of the air as well as other elements. Chemical affinities account for the simpler combinations of numerous elements, for few elements remain long in contact with other elements without some union occurring, forming salts, acids or alkalies, which again may recombine. But the more delicate combinations of carbon, nitrogen, hydrogen, oxygen, phosphorus, sulphur, etc., forming the living tissues of plants, require that strange factor of life to produce them, living bacteria, living plants, living animals.

On the other hand, living tissue cannot be used alive as food. Direct combination of living matter with living matter is too relatively rare and difficult and occurs on too small a scale to ever be a method of nourishing our bodies; although, of course, it is the starting of bisexual reproduction.

The bulk of the three hundred million meals a day eaten in the United States must be supplied in the form of dead tissue, animal and plant, i. e., of tissue already changed from living tissue, already somewhat disintegrated.

True, one may swallow a living oyster or a living onion, but these are dead, and disintegrated to some extent, before they pass into the blood stream. This disintegration is known as digestion, the breaking down of plant and animal tissues from their high estate in living bodies; not to their elements, for then they would be useless; but part way down, to a point at which they can be used by living tissue for incorporation into its own substance or as fuel. The apt comparison of tearing down an old house to use its stones for building of a new one, its wood for fuel, is a true one so far as our knowledge goes. One could not build a new house out of the old just as it stands, nor on the other hand, would the ultimate chemical elements of the old house be of value. But the old house may be reduced to fragments and these may then be used as building materials.

When we come to examine the materials which long experience has shown as constituting human food we find that, various in source and appearance as they may be, yet they can be classified as fats (animal fats and vegetable oils), composed of carbon, oxygen and hydrogen; carbohydrates (sugars, starches, etc.), composed of the same three elements in other combinations; proteins (lean meat, white of egg, etc.), composed of the same three elements and the very important element nitrogen; condiments (spices, flavors, etc.), water; salts; and a series of very interesting substances, hardly foods, but apparently necessary to the use of foods by the body, known as vitamins. These vitamins have been much studied of late years; not everything is clear about them; but it would appear that, in some cases at least, they act to introduce the food into the cell. One may rather fancifully imagine the individual cell as fishing in the lymph surrounding it for its food. Rod-fishing without a hook would catch few fish, and it would seem that the vitamins supply something analogous to a chemical hook by which the cell can actually secure and take into itself the food which otherwise, however abundantly it might surround the cell, would not be available to it.

The salts of the food include table salt, of course, but salts are found also in all the plant and animal tissues used for food, and in all ordinary drinking waters also.

Starches and sugars are found chiefly in plants and vegetables, yet also as animal starch (glycogen), and as sugars derived therefrom, in animal tissues. Proteins are found in that portion of animal foods constituted by the lean parts of meat and fish, the whites of eggs, etc., but they are also found in plants. Vitamins, of which but little is yet known, appear to be ultimately of vegetable origin always, and are found in fresh vegetables chiefly. When found in fresh milk or meat or other animal products, they are nevertheless of vegetable origin, derived directly from the vegetable diet of the animals in whose tissues or products they occur.

The functions of these different substances in the body are many and various, but may be classified as follows: vitamins in some way make the other materials available to the cells, and constitute therefore a very important feature of every diet; salts enter directly into the structure of the tissues, notably and evidently into the structure of the bones; and also serve important physical uses in maintaining the relative tensions of the various liquids of the bodies. Water acts as the great conveyor of food, oxygen, waste products, carbon dioxide, and many other substances, to and fro in the body, forming the immensely ramified and rapid internal transportation system of the body; it lubricates the body, cell on cell, fiber on fiber, joint surface on joint surface; by its evaporation from the skin surface it furnishes a most important factor in cooling the body. Carbohydrates and fats supply part of the fuel of the body, but do not appear to enter into the ultimate structure of the moving, feeling, thinking, parts, which are protein. It is the proteins of the foods, and only parts of these, that can become or replace the proteins of the body. They alone contain the essential nitrogen which enters into the composition of these, the highest and most delicately complicated of all chemical structures, the ultimate repositories of life itself. Part of the proteins of the food, the nonnitrogenous fragments broken off from them in digestion, are used also as fuel.

Hence the body may be supplied with fuel from fats and carbohydrates alone, but cannot grow or even repair the waste of its essential protein tissues without protein food. One may starve to death on a most abundant diet if it be composed wholly of the nonnitrogenous substances.

On the other hand, since protein foods supply both nitrogenous fragments necessary for growth and repair of proteins, and also nonnitrogenous fragments suitable for fuel, life may be prolonged indefinitely, although not with comfort, on a diet of proteins alone, provided, of course, vitamins, salts and water are present also.

The ideal diet has been much discussed, and in the feeding of great aggregations of people becomes a tremendously important matter from every standpoint of health, efficiency and economics. Since we ourselves *are* food, there is no more important subject to us in all the physical universe. The questions that arise are very naturally—what foods are best? in what quantities should they be taken? Since we have no one perfect food as the gods of Greece had, in what proportions should our imperfect foods be joined to give best results? Again, since the bulk of the human race is financially limited in its ability to select its foods, what are the best of those most economically available? Granting all these questions are solved, there are still immensely important questions of production in the right proportions, transportation, a surplus provision for lean years, and other age-old problems. The Great War has emphasized to all how important these essentials are, submerged though they had been until all but forgotten, in the superfluities of Peace.

The problems of food and feeling have been solved by rule of thumb since man began upon the globe.

If they had not been, man would have disappeared long since. Modern food investigations have therefore not been in the nature of discoveries or constructive inventions: rather they have been analytic—attempting to discover the underlying principles of those food practices which long generations have established as wise and suitable; and to discover also the reasons for disasters, like scurvy and beri-beri, following improper diets when these are forced upon mankind by unfortunate circumstances. Crude shortage of food, starvation, was common enough in bygone generations; and our liturgies preserve in their prayers against famine, one great dread our ancestors had before them continually, in addition to their dread of plague and pestilence.

Transportation facilities have grown to such completeness that world shortage is all but impossible, so long as the transportation systems remain intact; but potential local famines are constantly occurring and constantly requiring relief from areas more fortunate in crops or stocks; and disease from diet, abundant enough in itself but deficient in essential elements, or otherwise improper, is still found, even in our most civilized communities and countries.

The bulk of the race is, even to-day, far from having complete knowledge of the principles of proper feeding and even farther from consistent practice of them.

Part of this ignorance is dependent on the relatively low degree in which those who deal in foods, from production to cooking, are held in the popular estimation. The farmer, the butcher, the baker, the cook, are all looked upon as performing rather menial services, although as a matter of fact, they perform almost the sole really important and essential functions of the human race. Only motherhood itself can equal in its importance the production and preparation of the food materials which first permit motherhood and then the growth of the child to manhood. The green soldier may look down upon the military cook, but the old soldier regards him as the chief essential to success. If you will only feed your men well, they will do anything, but "bad food means bad service," everywhere.

Foods can be classified on the basis of their fuel values as, high-grade fuel, medium, poor, etc.

It has been found that a pound of coal will yield, when completely burned, just so much heat, varying with the kind and quality of coal, but always the same for the same kind and quality. It is true we do not burn it completely in our furnaces or stoves; we waste the heat we do get from it, letting most of it go up the chimney; or we may use the heat we do use for very trivial purposes. But so much carbon, the principal constituent in coal, always can yield just so much heat, whether we waste it or not. Just so with different foods. If we take a turnip, or a pound of meat and burn it carefully as we would burn a pound of coal in testing it, we find a certain amount of heat produced —far less than a pound of coal would produce, of course, but exactly the same otherwise. Turnips and meat would make poor fuel for a stove or furnace, because there is so much water in them, but once they are dried out, the rest of them burns well, as we find in garbage incinerators. Now, very careful and elaborate experiments have shown that when meat or turnip is taken into the body and burned, the exact amount of heat it would have yielded if completely burned in a stove or furnace is yielded in the body, less about ten per cent wastage that can be perfectly accounted for. Knowing this, it is not hard to understand that now long series of experiments have determined for nearly every kind of food the exact fuel value, and this forms a very fair way of classifying the relative values of these foods to the body. It is not a perfect way, however; the fuel value of coal is very high indeed, but since we cannot eat coal, that fact does not help us. The fuel value of wood is high, too, but although some animals can use wood for fuel in their bodies, we humans cannot, so the fuel value of wood is no use to us. So also with grass and hay. Cows and horses can use those, but we cannot. We have to find out by experience what things we can eat first, but once we know that, then knowing the fuel values of these different things also allows us to compare them pretty well. It must not be supposed that fuel value is the whole thing, however.

As previously explained, many of the different animal and vegetable foods that we eat, contain, in a crude state, some two or all three of the main things, protein, fat, carbohydrate: and they contain them in different proportions, Instead of laboriously testing the fuel value of every individual food, it is much easier and better to know the fuel value of protein, of fat, and of carbohydrate. Then we can, by simply analyzing the food, calculate the fuel value without further trouble.

Heat enough to raise the temperature of one liter of water one degree centigrade, is called a Calorie. About one pound of protein, completely burned, would yield heat enough in burning to boil about four and a half gallons of water that was just at the freezing point when the heat was first applied to it. (In actual tests, protein burned yields more heat than this, but in the body it is not all used for fuel, but partly to replace worn-out tissues, so that in the body it produces the heat above described.)

Carbohydrates have the same heat value in the body that the proteins have: but the fats have over twice the heat value, i. e., would boil twice as much water; a pound of lard, for instance, completely burned, would bring to boil about ten gallons of freezing water.

Now, the body requires varying amounts of fuel, depending on age, sex, height, weight, amount of work done, and many other things. Thus a young infant needs perhaps an average of 100 Calories a day, i. e., enough food-fuel heat to bring to boil a quart of freezing-cold water. An active adult man, doing hard, muscular work, will need from 3,000 to 4,000 Calories, or even more—enough to bring to boil eight or ten gallons of freezing-cold water.

Now, theoretically, a man could get the 3,000 to 4,000 Calories he needs from a pound of lard, but fancy feeding a man a pound of lard a day, and nothing else! Moreover, he would starve to death on it, despite its fuel value, for pure lard contains no protein, i. e., no muscle or other protein tissue-builder. Theoretically, also, a man would get the heat he needed from about two and a quarter pounds of granulated sugar, but again he would soon give out for lack of protein, even if he could manage to "down" pure sugar three times a day as his only food. Theoretically, also, two and a quarter pounds of protein would suffice him, with nothing else. It is true he would not starve to death on this, but he would miss the quick-burning fats and sugars, and would not "feel right" or healthy or happy.

The proportions of each form of food, then, is important. One might say that since we need all three kinds, just divide the total Calories we need by three, and eat protein enough to supply one-third, fat enough to supply one-third, and carbohydrates enough to supply one-third. Doubtless this would make a tolerable diet, but experience and experiment go to show that an average adult man, doing reasonably hard work, gets along best on about the following amounts for one meal in the following proportions:

Protein	1 1/2 oz.	=	170 Calories
Fat	7/8 oz.	=	230 Calories
Carbohydrate	6 oz.	=	700 Calories
	8 3/8 oz.		1100 Calories

So much is clear; but now comes the real difficulty. We do not have protein in one can, fat in another, carbohydrates in another, in such shape that people will eat and enjoy them, day after day. We must carefully select such commonplaces as meat, potatoes, bread, fruit, etc., so that the total eaten will represent these things in the proper proportions; giving after all a very commonplace appearance on the table.

To show how it is done, an illustration is given here, together with the necessary tables for a number of the ordinary foods.

EXAMPLE OF BALANCED RATION

(Meat and Potatoes and Bread)

Desired for one average meal:—

Protein	42 grams	= 1 1/2 oz.
Fat	25 grams	= 7/8 oz.
Carbohydrate	170 grams	= 6 oz.

PERCENTAGE OF FOOD CONSTITUENTS IN MEAT, POTATOES, BREAD

	Protein %	*Fat* %	*Carbohydrate* %
Lamb Chop	17.6	28.3	0.0
Potato	2.2	0.1	18.0
White Bread	9.2	1.3	53.1

Evidently all three supply protein, while the potatoes and bread supply the carbohydrate, and the chop supplies the fat chiefly. If we are to have no waste, we must calculate the chop on the basis of the fat, thus 7/25 (28 per cent) of the chop is fat; 7/8 of 1 ounce of fat we require in the meal; hence we need chop enough so that 7/25 of it will weigh 7/8 of an ounce; that is, the whole chop should weigh 25/7 of 7/8; which equals 3 1/8 oz.

This not only supplies us fat, but part of the one and a half ounces of protein we require, i. e., about 1/6 (17.6 per cent) the chop is protein; hence 1/6 of 3 1/8 ounces (1/6 of 25/8) equals about ½ ounce. The rest of the protein we may get from the potatoes and bread. Of course a great many combinations might be made. If we discard the bread and use potatoes only for carbohydrate, the six ounces of carbohydrate would require over two pounds (say 33 ounces) of potatoes to supply it, for the carbohydrate content of potatoes is only between 1/5 and 1/6 of their total weight. Incidentally, this would add protein to the extent of about 1/45 (2.2 per cent) of the total weight, i. e., about ¾ of one ounce, or nearly enough to make up the protein deficiency in the 3 1/8 ounces of chop.

However, few people would wish to eat over two pounds of potatoes at a sitting; most people would rather substitute bread for part of it. The white bread given is nearly three times as strong in carbohydrates as the potatoes; hence one ounce of bread would replace nearly three ounces of potatoes, and furnish one-half more protein. Suppose then we replace say two-thirds of the 33 ounces of potatoes already figured by bread: i. e., leave out 23 ounces of potatoes and add 10 ounces of bread: then we will have about 1 4/5 ounces of carbohydrates from the potato and about 5 1/3 ounces from the bread, making somewhat over the six ounces required: and we should have ¼ ounce of protein from the potato, about 1 ounce from the bread. Thus we would obtain nearly the proportions desired: thus—

		Protein	*Fat*	*Carbohydrate*
Chop	3 1/8 oz.	½ oz.	7/8 oz.	0.0
Potato	10 oz.	¼ oz.	1/10 oz.	1 4/5
Bread	10 oz.	9/10 oz.	1/7 oz.	5 1/3

I. e. 1½ oz. protein; over 1 oz. fat; over 7 oz. carbohydrate.

There is an average wastage of ten per cent., increasing with the vegetable and carbohydrate foods, and hence this combination would be very nearly correct. We have not figured in any butter or sugar: they would reduce the amount of fat required in the meat and bread; and would make up for some of the carbohydrate. The combinations that might be made are almost inexhaustible. Thus, another chop weighing 3 1/8 ounces would make up for half the bread so far as protein was concerned, although doubling the fat required; the loss in bread would cut the carbohydrate by over 2½ ounces. However, the extra fat, having more than twice the heat value of the carbohydrate, would very nearly balance the loss of carbohydrate.

On the other hand, the potato might be cut in two without much damage to the meal, if half a chop (of 3 1/8 ozs. in weight) were added, for this would more than supply the protein lost, and the fat added would supply enough heat value to make up the loss of carbohydrate. Of course, sugar in coffee, tea or taken as candy or in pies, would make up carbohydrate requirements very fast, for sugar, weight for weight, yields nearly double the carbohydrate in bread.

Summary: Food is to the body both repair stuff and fuel. Proteins act in both capacities, but other foods are confined to acting as fuel, except in so far as their own bulk when stored in the body actually makes them part of the body. This is rather obvious in the case of fat, which while it cannot furnish any building material for those essential parts of the body which move, feel, think, or otherwise act as living matter, yet does form in the mere condition of storage, some of the padding of the body.

The fuel values of food in the body are practically identical with their fuel values outside the body. Their values have been determined and can be used in preparing diets, etc.

The human race has discovered a wide range of practicable diets, from the fish and meat diet of the Eskimo to the rice and butter diet of the East Indian. So long as the basic principles already laid down are followed, it seems to make little difference in the long run what of recognized foods is eaten if only it is good and plenty. No general rules can be made applicable to everyone. The wise will "try all things" and "cling fast to that which is good"—good for *them*, not for others. A diet, however good for others, that makes *you* sick is useless to *you;* and the converse is just as true.

CHAPTER XII

WATER

Water in the body serves much the same purposes as in the outside world, for it is the great solvent and carrier of all that will dissolve in it; the great carrier, in suspension, of all that will not dissolve; the great lubricant; and through its evaporation, a great cooler. In all animal and plant bodies water acts also to permit the passage through the thin tissue membranes bathed in it, of salts which thus may penetrate the membranes which form the walls of cells, etc., and thus may rise from the tips of far-buried rootlets to the topmost twigs of trees hundreds of feet high.

Water is, theoretically, a chemical combination of hydrogen and oxygen (H_2O), and nothing else. Practically, it is, like dust, "a part of all that it has met." Thus, a "pure" drop of water, newly formed by union of its constituent gases, almost instantly becomes "impure" by the absorption of surrounding gases, oxygen, nitrogen, etc. Particles of dust adhere to its surface or sink into it, and in a little time it is a microcosm, containing in some degree samples of all the world.

The natural history of water is a circulation, somewhat like that of food, already described, but of course far simpler.

Descending upon the earth, as rain, snow, hail, dew, etc., it passes down into the earth (ground water) or runs along its surface (surface water), and in great part is sooner or later evaporated again, to rise to the sky again, form clouds again, and again descend.

The surface water may sink into the soil and become ground water, the ground water may flow along impervious layers of soil far below the surface, until it reaches the open in a spring or marsh, a lake or pond or river, and so becomes surface water.

True, a proportion, relatively a small proportion, of the total water, returns to the clouds by evaporation from the surfaces of plants and animals, whose bodies it has entered. But whatever the devious paths by which water circulates on the great round, it circulates continuously, and the great bulk of it remains pretty much intact, going the rounds. True, some water is, no doubt, destroyed in the chemistry of mineral, plant and animal. True, some is manufactured, as in the lightning flash, and in all forms of combustion, both in actual fires, and in the slower burning which constitutes the operation of the living organism. But such destructions and additions are small, and the sum total of water on the globe changes its identity but slowly, despite its great and rapid changes in form and function.

Curiously enough, dust, the antithesis of water to our minds, seems to be necessary to that stage of this circulation we know as rain. But for the dust of the atmosphere, the clouds would not form, and raindrops would be unknown. Doubtless, electrical reactions are involved, but the dust-particle is essential to the combination. Such dust is derived, of course, in considerable measure from the earth itself, swept up by winds; but meteors, cold on entering our atmosphere, rapidly blaze forth with heat from friction with the air, and burn out to fine ashes, which float as tiny particles for a long time, before they settle on the earth itself. In the absence of all dust we might have dew, but not rain.

Such being the general history of water, its impurity, beginning so very early in its history and growing always greater, becomes a matter of considerable importance to us who drink it. Of what kinds are these impurities and to what extent may they be dangerous? If all water, practically, is impure, how shall we purify it sufficiently for our purposes?

It becomes obvious at once that what we may properly designate an impurity of water from the chemist's standpoint, may be to us a quite harmless or even useful substance. The newly condensed raindrop absorbs oxygen and nitrogen, etc., from the air, and is therefore no longer water and water only, but water plus these gases dissolved in it. But we take into our bodies every instant through our lungs immensely more of both these gases than we are ever likely to take dissolved in water, however large our drinking-glass may be. So also with dust-particles, gathered by the raindrop in its descent through the dust-laden air. We breathe that same air all the time; the dust in it settles upon all our food; and thus the raindrop does not necessarily add anything new to our bodies in that line at all.

The drops fall on the earth, and if the water courses over the surface of the soil, it is likely to pick up, both in solution and suspension, more or less of all it flows over, and when it reaches some stream, or marsh, or pond, it carries with it these things it has collected and adds them to the rest that other similar drops have brought to the same rendezvous.

Whether the collected materials thus brought together are harmful to the human drinker who may use that water depends entirely upon what the materials collected really are. In general, the inorganic salts, even the organic extracts, thus brought to stream or pond, are harmless in themselves or are so diluted by the water which has brought them that they hurt neither fish nor mammal, bird or insect, that may use those waters.

But if in their surface-travels, the raindrops meet and carry into the drinking supply living disease germs, lying on the soil, and if the water is used for drinking before these germs have died or settled out, damage may obviously follow. So often has this happened, so often have drinking supplies been thus infected by inflowing increments of surface water, or by direct deposit in them of infected discharges, that public health rightfully assumes all surface waters in inhabited districts are likely to be infected at some time or other, and rightfully demands that the humans who use them as drinking supplies shall purify them first to prevent certain diseases.

But raindrops, sinking at once or after surface-flow into the soil, will travel through that soil only a short distance before all solid particles are filtered from it in that passage, and thus ground waters, although often rich in soluble constituents, dissolved from the soil in passing through it, are usually free of particles in suspension, and therefore free of germs. Springs, which are merely outcroppings of ground waters, corresponding with outcroppings of the impervious soil-layers that the ground waters follow, and wells in all close-textured soils, are usually free of germs, certainly of disease germs.

Water supplies may be divided for different purposes in different ways, for instance into private and public, on the basis of the number of persons using each supply; into surface or ground water supplies; into soft or hard; pure or contaminated, etc. Each of these divisions may be subdivided; surface-supplies, into streams, rivers, ponds, lakes, etc.; ground waters into deep and shallow, etc. Notes on some of the most important divisions follow here.

Rain water considered as a condensation of evaporated water, at the moment of its formation high in the air above us is theoretically a pure distillate, but in its descent it gathers gases, dust, etc., to an extent so great that in cities the first rain that falls in each shower tends to be very "dirty" before it even strikes a roof or pavement, and this is proved, obviously to everyone, by the great clearing of the atmosphere of such a city which follows even a small shower, a literal washing of it clean for the time being. In country districts a similar washing occurs in rain storms, but since the air is clearer, the rain is not so "dirty" when it meets the earth. Of course, after the first few minutes of a continuous downpour, the rain falls through an atmosphere already washed. For collecting rain water, therefore, rejection of the first of every shower is a wise precaution, and many houses are provided with a shifting outlet for the eaves-trough system which permits the rejection of the first of each fall, the intention being that only the later, cleaner, rain water shall be collected.

Obviously, however, rain falling on a pavement or street or road or field is difficult to collect and likely to be very dirty; the rain falling on roofs is less subject to such dirt; and because collected at a higher level, is more readily conducted by simple gravity to some one place for storage. But even our roofs are dirty; dust and bird excrement are usually present, and, until washed clean by the first part of a shower, the roof and eaves trough contribute their full share to "dirtying" the water, which furnishes an added argument for the rejection of the first part of each fall.

The collected rain water from the roof is usually, in this country, conducted to a concrete underground cistern, of bottle-shape, and thence is raised to the house by pumps of various kinds.

Serious disease-producing contamination of rain water in this country is rarely found, because of the small chances of infection with excreta of human beings, and because also rain water is rarely used except for washing purposes. On the other hand a deep brown color and a rather disagreeable woody odor is rather common, due to defects in collection, carelessness in storage, etc.

In certain southern regions, rain that falls during the rainy season is very carefully collected and stored as the chief water supply for the dry season.

Surface waters from ponds, lakes, rivers, are often piped to neighboring localities, and pumped. Such waters in wild regions are usually safe enough but when in inhabited regions generally require purification.

Ground waters form the water supply of half of our population, that half in the rural districts, since that half uses wells of various kinds, usually a well to each household. Very many thousands of these "holes in the ground" are scattered everywhere throughout the world.

Tapping various water-layers according to their respective depths, and varying widely in construction of their walls, and on account of the facilities afforded to dirt and to small animals to enter them, the tastes of the waters from these wells vary widely also. No more curious example of the force of habit can be found than the attachment of each household to its own well and the repugnance of each household to the other wells in the neighborhood. Each household becomes so used to the tastes and smells of its own well that they mostly pass unobserved, while the tastes and smells of the neighbor's well, because different, seem abominable. To a stranger, all the wells have strong tastes and odors, as a rule, and all are disagreeable also as a rule.

No more widespread fallacy in Public Health exists than the attributing to these wells of typhoid fever. In creviced rock, in limestone formations, very occasionally as the result of artificial perforations of the soil by small animals or roots of trees, contamination of a well with infected discharges through the soil may occur; and, theoretically at least, surface wash in heavy storms and certainly in floods may carry such contamination into the mouth of any well directly.

But in sandy and clay soils, contamination of a well by the carriage to it through the soil of living disease germs is all but impossible, and occurs so seldom as to be negligible; while contamination through the mouth of any well in any soil is also very rare.

In sandy soils, and also in clay soils, chemical contamination from neighboring closets, barn yards, etc., is often very considerable, but the bacterial content is extremely low or even zero, as a rule.

The vast majority of all the cases of typhoid fever attributed to wells are really due to infection from surface waters, from flies, or from contact with other cases. This freedom from responsibility for typhoid fever is especially true of the household well. When a battery of wells forms the common water supply of communities, contamination sometimes occurs; but usually from inexcusably poor arrangements of the water pipes and sewers, presenting the opportunity for more or less interchange between them, than from anything inherently dangerous in the wells themselves.

Several types of wells are common; the dug well, three or four feet in diameter, and twenty to sixty feet deep has its dimensions controlled by the necessities of excavation, the diameter being such that the well-digger may use pick and shovel, the depth by the increase in his difficulties as he descends. Such wells are usually lined to prevent caving; by wood, stone or brick, laid up without mortar, or by stone or brick mortared, by concrete, etc. If the well is intended to tap only the water stratum at its bottom, the walls are made tight. If it is intended to use all the water strata it may pass through, the walls are built of porous material or left with numerous openings.

Molds and fungi often develop on the lining and doubtless affect the taste of the water, although otherwise harmless. A wooden lining, especially at the area which is alternately wet and dry as the water rises and falls, is apt to decay and further add flavors and smells. In general, all such "contaminations" are harmless, and even the frogs and rats that may fall into the well may be placed in the unæsthetic rather than in the dangerous list. In standpipes, the young of birds having nests in the roof of the standpipe often fall into the water but appear to do no harm to it. Such animals do furnish, however, a possible source of the otherwise unexplained colon bacilli sometimes detected by bacterial analysis in waters apparently not open to contamination from sewage. That the mouth of a dug well should be sufficiently elevated above the surrounding soil to avoid surface wash, and sufficiently protected by a tight impervious cover to prevent dirt brought by the feet of those who come to draw the water from being washed back into the well seems very obvious, yet many wells fail on at least the second feature, partly on account of a curious superstition which requires an opening for admitting air to the well. This superstition is widespread despite the almost equally widely believed fact that deep waters, and especially springs, coming from unaërated depths, are usually of very excellent quality.

Driven wells consist of a sharp brass point, screwed on the end of a short length of 1¼" pipe driven down into the ground; another length of pipe is screwed into the first, and the driving is continued; this process is repeated until from ten to thirty feet of pipe have been used. A pump is attached and the water is drawn directly from the soil.

Such wells evidently can be driven only in comparatively soft soils, usually of sand, and the soil must be fairly full of water to yield any worthwhile flow. The mere fact that such wells cannot be driven in rock or limestone means that, if successfully driven, the soil is of a character furnishing good filtration, and hence such wells practically always furnish water free of bacterial contamination, although frequently the chemical contamination is high because of the free flow of the water and the relatively small depths reached.

Drilled wells varying from 1¼" to 12" or more in diameter, are sunk by machine-driven drills of various designs; the main thing of interest from the public health angle is that they are usually lined with continuous steel or iron pipe for a considerable distance, i. e., to at least the first considerable water-bearing stratum, and that therefore the water supplied by them comes from considerable depths, without any chance, as a rule, of surface contamination, except by some unfortunate muddle in connections between the water pipes and neighboring sewers. It must, however, be borne in mind that the water strata admitted to the well, at whatever depth found, *may* originate from a contaminated area at a distance, and *may* have flowed underground in a channel, rather than through a pervious stratum, and hence *may* be contaminated or be subject to contamination. Even such deep waters should be analyzed, therefore, for precaution's sake, before unqualified indorsement is given to them. On the other hand, serious contamination is extremely rare; and the analyst must especially beware of colon bacilli found in the water from such wells, in samples taken during or soon after the sinking of the well. Colon bacilli are almost inevitably introduced in the process of sinking the well, on the pipes themselves, since they are hauled and dumped to await use without any "bacteriological precautions" whatever, and therefore inevitably pick up colon bacilli from horse manure, etc., in their vicissitudes. Driven wells are usually from 100 to 2000 feet deep.

Bored wells, usually a foot in diameter, are sunk by an auger-like arrangement, turned by a horse-mill or engine. They are usually lined with wood. They run 30 to 100 feet in depth and are similar to dug wells in their characteristics, except that they cannot be entered for cleaning purposes.

Any well may tap a stratum of water unsuitable, on chemical grounds, for one or more uses; thus iron, sulphur, a large quantity of mineral salts, etc., may be encountered. Various special forms of purification may be employed or the well carried deeper to a more suitable water-layer. Precautions to exclude the undesirable layer are, of course, necessary, if this be done.

Everyone who finds an unusually bad tasting or unusually salty water at once dreams of a fortune to be made in bottling and selling it "for medicinal purposes." It is true that a "fortuitous concourse" of salts, etc., *might* be imagined to occur, which *might* be of some advantage to some human system, but the finding of such a ready-made combination in nature is extremely rare. So widespread is this superstition concerning "medicinal waters," however, that fortunes have been made on merits which were of the slimmest or even wholly nonexistent. But, so long as we carry chestnuts to ward off rheumatism, or wear red flannel when our throats are sore, "medicinal waters" will continue to inspire faith in their values that no arguments will alter.

Purification of waters, leaving aside methods for reducing hardness, removing iron, and otherwise improving waters chemically unfit for ordinary purposes, usually means the removal from it of disgusting or dangerous material, chiefly the latter. Reduced to its essentials, dangerous contamination consists chiefly (in this country) of living typhoid, paratyphoid or dysentery germs; and their removal or destruction can be achieved (a) by boiling for a minute, (b) by sufficiently refined filtration, (c) by disinfection.

Boiling, a useful emergency domestic measure, is conclusive; but it is difficult to secure uniformly and universally throughout a community for any length of time. Filtration is an art applicable only to large bodies of water, and efficient only when conducted by most conscientious experts, having every facility and absolute control. Disinfection is now the most easily and generally employed method for destroying bacteria in water supplies and, in its simplest form, consists in admitting chlorine gas to the supply in certain definite proportions according to the needs.

Domestic filters, except of the Berkefeldt or Pasteur type, are almost invariably far worse than useless, and give to their users a wholly unwarranted confidence in the use of the water coming from them which may be disastrous. Even the Berkefeldt and Pasteur filters are successes only under the most constant and strenuous supervision, such as they practically never receive outside of a bacteriological laboratory.

Hence, for private supplies, the purity of the supply should be unquestioned and nothing left to the purification processes, sure to be badly operated and neglected. Fortunately, wells usually can be made to furnish such supplies.

For public supplies, deep wells, if they can be successfully operated, are usually excellent, but are apt to be unreliable in quantity. Surface waters practically always require purification, usually filtration, or chemical disinfection, or both. It is worth remembering that where it is possible to impound waters for a month before use, that alone will insure their freedom from dangerous bacteria.

Diseases carried by water supplies in this country include typhoid and dysentery chiefly, paratyphoid occasionally; such carriage occurs practically only as the result of admission to them of unsterilized human feces or urine from persons already infected with the respective germs.

Summary: The action and uses of water within the body are very similar to those outside the body.

Pure water, in a strict sense, is unknown. Public health demands, however, from all water supplies which are to be introduced into the human body a degree of purity which will insure the elimination of poisons, chemical or biological.

The most serious and widespread of these poisons in this country are the germs of typhoid fever, of dysentery, and perhaps at times of other intestinal diseases.

CHAPTER XIII

MILK

Milk is a secretion of a gland of the skin, supposed to be in origin a sebaceous gland greatly enlarged for this purpose. Cow's milk is practically the only product of a living animal (except human milk) which is used as human food; it is the only product of any animal which is habitually used in a raw state as human food; it is the only human food which is proved to be solely responsible for a specific infectious disease in the human (bovine tuberculosis); and it is the only human food which carries widely and at relatively frequent intervals infections of many kinds to its consumers. In so far as it has been used to replace human milk in infant feeding, the damage it has done to the human race is well-nigh incalculable. Apparently it was introduced for this purpose some hundreds of years ago, to offset the evils, then considered greater, of the infamous developments of wet-nursing as a trade. Originating thus in the desire of human mothers to shirk their natural duties, the universal use of cow's milk for human babies has been woefully avenged upon the human race in loss of infant human life.

Drawn from the udder of a dirty, hairy animal, often by almost equally dirty and careless humans, its dirt content concealed by its own opacity, subject to rapid bacterial deterioration which is expensive and difficult to prevent, it is small wonder that it ranks as the dirtiest of human foods; but it is a curious commentary on human observation and consideration of obvious facts that this, the dirtiest one, should be the one selected to be taken raw!

The dirtiness of milk, although the favorite feature discussed in indignation meetings against its usual producers, is really its least objection, for the "dirt" is usually, although harmful to the milk itself, of no great physical detriment to the milk-consumer.

It is the presence in cow's milk of tubercle bacilli that is the more positive danger. To demand "clean milk" from cows that are tuberculous is "straining out the gnat and swallowing the camel" with a vengeance.

The milk of any one species of animal seems to fit exactly the needs of the young of that species; but this peculiar adaptation is not interchangeable, and there is no parallel in nature of this interchange of cow's milk for human which the human species forces upon its young; nor is there any parallel in nature for the use of milk for any one of an age above that of infants; although such use is, it must be said, relatively harmless.

Having said so much, let it now be added that cow's milk contains representatives of all the chief forms of food,—proteins, fats, carbohydrates, salts, water, vitamins (the latter coming, not from the cow, however, but from her food, if the latter contains them) and even of condiments, for it has been shown that the peculiar flavor of cow's milk comes from a substance practically always present, cow manure. Its calorific value is about 310 Calories per pound, equal to about a ¼ pound of beefsteak.

Water forms about 87% of cow's milk; the proteins (chiefly caseinogen, the substance which when precipitated as casein, is used as the basis of cheese and billiard-balls) form about 3.3%: the fats, similar to those of the cow's body, and which when concentrated to 18% or more make cream, form about 4%; the carbohydrates, chiefly lactose, form about 5%. All these percentages are subject to variation in different breeds, or different individuals.

Cream, obtained by allowing the fat globules to rise to the surface, or by centrifugalizing the milk, thus throwing the heavier water to the outside and leaving the lighter fat at the center of the circle, contains usually about 2.5% protein, 18.5% fat, 4.5% lactose and 74% water, and when thus constituted, has a calorific value of 865 per pound; but it can be concentrated to 40% fat.

The whiteness and opacity of milk is due to the caseinogen, which is present in a minutely fine suspension which reflects the light; although the fat globules would give to it some whiteness and opacity without the caseinogen. The fat is present in minute globules of varying size, each more or less smeared with protein, so that they do not coalesce readily without shaking; shaking persistently succeeds in fusing them, thus forming butter.

The souring of milk was long held to be due to some inherent characteristic and also was attributed to thunderstorms at times. So constant is the souring of milk after withdrawal from the udder that, if it be not an inherent quality, which, of course, it is not, it must be due to something introduced into it almost inevitably; briefly, these are bacteria of more or less certain characters, know as lactic acid bacteria because their striking action is the conversion of the lactose present in milk into lactic acid. The acid precipitates the caseinogen as casein, forming the curds or clots of sour milk, and gives the sour taste.

Lactic acid bacilli are usually present not only on and about the cow but also in the very teats of the udder and therefore almost inevitably enter the milk when it is withdrawn in the usual manner. But milk drawn off by extraordinarily careful methods, designed to avoid such contamination, has been kept indefinitely in its original state, simply because there were none of these germs in it to change it.

In all attempts to secure cow's milk at its best, five points stand out as chiefly valuable—the cow itself, cleanliness, cold, quickness in transportation and use, and cost.

If the cow is free of tuberculosis, it may yield milk free of the germ, but if the cow has tuberculosis, the germs of that disease are likely to enter the milk, sometimes by way of the udder, but more often by way of the manure, which so invariably finds its way into the milk.

Moreover, tuberculosis may be derived from nontuberculous cows, for the manure of tuberculous bovine associates may reach the nontuberculous cow's milk.

In other respects a cow may be dangerous to the consumer, by infecting the milk with streptococci from lesions of the teats or udder, which apparently have been shown to be causes of widespread epidemics of septic sore throat. It is probable that intestinal disturbances of the cow may, by admission of the manure to the milk, be carried to the human.

The breed of cow controls the percentage composition of the milk to a fairly definite extent, Holstein milk being notably dilute as compared with Jersey; but otherwise there would appear to be little to choose between them. The richer Jersey milk used to be highly valued, simply because it did contain more fat, but realization of the dangers of overfeeding the human infant thus with fats have changed this view, and Holstein milk is now considered at least equally good.

The characteristics of the other breeds are not sufficiently pronounced in these particular points to stand out very sharply.

From what has been said previously, it is obvious that, to protect milk from dirt, extraordinary care is needed at every stage of milking and in all handling of the milk after it is drawn.

Since milk contains so much nutrient material for bacterial growth, and is seeded with so many bacteria to start with, the only remaining condition needed to secure great numbers of bacteria in the milk is a suitable temperature, and this is found at 50 to 80 degrees F. If milk is kept down to 40 degrees F. or less, the germs do not grow so fast. Now, milk from the cow is warm, and takes a long time to cool, especially if it be kept in bulk (as in a pail or can). Of course it cannot cool below the temperature of its surroundings, and hence rapid cooling to a low temperature is to be had only by special devices, such as pouring the milk in a thin sheet over coils of pipe in which circulates a low-temperature brine. The common method of standing a can of milk in a spring is slow and inefficient as a rule. Packing the can in ice is better, but of course does not equal in rapidity the cold brine or similar methods.

It is not sufficient to cool the milk down rapidly; it must be kept cold until it is consumed. From dairy to consumer it must be environed with low temperature; a refrigerator car for rail transportation, ice in the delivery wagons, ice at the home, if the best results are sought.

Even with all precautions all ordinary milk will "spoil" because of bacterial growth, for none of the practicable precautions described above are perfect. If ordinary milk is old, it is also to a greater or less extent changed, verging on to souring. Curiously, this is a protection against the more delicate germs that may be introduced into it, for even a slight degree of souring restrains or kills most of these. Hence it is that milk-borne epidemics of diphtheria, scarlet fever, etc., are comparatively rare in big cities where the milk reaching the consumer is already old; while the relatively fresh milk of the small town, being fresh, is more likely to preserve alive, long enough to reach the consumer, any infectious disease germs which may have gained entrance.

Many a tirade against "dirty milk," the "careless farmer," etc., true enough in itself, is yet unreasoning because to secure really clean milk requires that what is practically an aseptic surgical operation be performed upon the cow. This is beyond the skill or the facilities of almost every milk producer, unless he charges such prices for his milk that the ordinary consumer will not by any means pay them. Certified milk approximates purity, but its cost renders it available to only about one per cent of any average population, and, therefore, certified milk is absolutely no solution for the great milk question.

This milk question is really a choice between raw dirty milk at a price consumers will pay, and raw clean milk at a price only one per cent will pay. From this dilemma we escape by pasteurization or other heating of the milk, which not only helps greatly in the mere conservation of it by delaying souring, but also, and more important, destroys any disease germs which may be present. Of these latter, the most frequently present are the germs of bovine tuberculosis. Pasteurization or boiling of milk will kill these, as it will kill other disease germs, and it is worth while on this ground alone, particularly since raw milk is the only carrier of bovine tuberculosis that merits serious attention. When it is remembered that bovine germs cause about seven per cent of all the tuberculosis found in the human (and this chiefly in children under 16 years) it is obvious that pasteurization (or boiling) of milk is a very worthy object to pursue.

Condensed milks, milk powders, etc., when the processes through which they pass are equivalent in disinfecting action to pasteurization, are, in this respect, highly to be commended. It is true that heating processes tend to destroy in milk the vitamins so essential to the growth and welfare of the young human body. Any infant restricted entirely to a diet of heated milk may develop scurvy. Care should be exercised, therefore, to supply the required vitamins from some other source. Orange juice, lemon juice, raw cabbage juice, raw turnip juice, are quite capable of furnishing these necessary materials; and children may with safety be fed on heated milk exclusively if these juices be supplied in small quantities every day.

With older children, on a mixed diet, no special precautions are required, beyond supplying to them, indeed to all adults also, some fresh raw vegetable or fruit to eat each day.

Modification of cow's milk to make it approximate more closely to human milk is a wise procedure. Human milk has less caseinogen than cow's milk and the curd formed in the infant's stomach is looser and dissolves more readily. Human milk contains less salts than cow's milk but more fat, sugar and lecithin. If water be added to cow's milk to reduce the casein to the human standard, the sugars and fats are depressed still further, and it is necessary to add sugar and fat to restore the balance. However, since some of the constituents of cow's milk are inherently somewhat different from those of human milk, this modification does not yield by any means a perfect substitute. Anaphylaxis is supposed to account in some instances at least for the deleterious effects of cow's milk on the human, and this would add another argument for boiling cow's milk for human babies, since this may destroy the substances producing the anaphylaxis.

In brief, cow's milk is at best only a fair substitute, and at worse a fatal substitute, for the proper food of human infants, which is human milk.

Wet nursing is attended by so much difficulty and expense that the substitution for it of bottled human milk, withdrawn by processes quite similar to those used in milking cows, from Wasserman and tuberculosis tested mothers who can spare it, is a solution which has passed the experimental stage and promises not only to supply the needed food to babies who might otherwise perish miserably, but also provides to those mothers who can meet the tests a legitimate means of livelihood just at the time that both they and their babies need it most. This is especially true of the unmarried mother.

Diseases caused by milk include those carried from the cow itself, of which bovine tuberculosis and streptococcus infections seem to be the chief; and those implanted in the milk by those who handle it. The latter include almost all the ordinary infectious diseases of this part of the world. The mouth-spray of the milk man, talking, singing, or sneezing over the wide-mouthed milk pail, and his hands, carrying nose, mouth, bladder and bowel discharges from himself, contaminate the milk directly and indirectly every day. When these discharges contain infection, that infection enters the milk and the consumer receives it into his mouth. True, there are many slips between the cow and the lip which save the consumer, but raw milk is a constant, though unfortunately not a constantly realized, menace.

Summary: Cow's milk is an excellent food for older children and adults, provided it is cooked in some way to destroy its almost constant content of bovine tubercle bacilli. For human infants it is, raw or cooked, a dangerous food at best and in the broad sense, a menace to the human race, comparable only to pneumonia in its fatalities.

Of milk products (butter, cheese, etc.) practically the same may be said. Those products so prepared that any original infection of the milk is destroyed furnish good foods, but those in which infection is presented are as dangerous as milk itself.

CHAPTER XIV

FLIES, MOSQUITOES, ETC.

A complete chapter on the smaller members of the animal kingdom harmful to man would be much larger than this whole book. Flies, mosquitoes, lice, fleas, bedbugs, woodticks, and the common itch-mite alone are treated of here, and these only superficially.

The fly that causes intestinal diseases in this zone is chiefly *musca domestica,* the house fly. It is distinguished from the stable fly, which latter bites, most readily by observing that the house fly has depending from its head and enlarging towards its lower end, a proboscis, or trunk, which it lets down upon its food; the latter a forward curving spike, tapering from the head to its free extremity. The domestic fly has had all sorts of evil names thrown at it, but its chief really serious accomplishment against human happiness is achieved by carrying to food from outdoor toilets or open-air deposits of human feces, infectious disease germs, chiefly those of typhoid or dysentery. While, doubtless, the fly may carry tubercle bacilli from tuberculosis sputum, diphtheria from infected discharges on pillows, etc., the fly is not an important factor in any but the intestinal diseases, since in the others its effects are quite overshadowed by the much more serious methods of transfer, mouth-spray and hands, which moreover operate between meals and in winter as well as summer.

House flies carry infection on their feet and also in their intestines, the contents of which they deposit everywhere as fly-specks. These fly-specks are in part fecal, but the great majority are the result of a regurgitation or vomiting of intestinal contents.

These flies originate in all species from eggs (ova) which may be deposited by the mother as eggs, but in some species are carried by the mother until the eggs hatch within her body, whereupon she deposits the already active maggots (larva). These become pupæ, and finally reach the adult stage, the whole period from egg to adult (imago) taking about twelve days.

Flies breed by preference in horse manure, hence, about stables; cow manure seems to be their next choice. Garbage will often show maggots, but there is not much chance that flies will develop from such maggots, if the garbage is in a pail, for at a certain stage it seems necessary for the prospective fly to enter dry soil for a time, and it cannot well do this through a pail bottom. Everyone must have noticed how thick flies are in dry summers, how few in wet summers: exactly the converse of the conditions favorable to mosquitoes.

To get rid of flies is no small task. It is often stated that "ordinary cleanliness" alone is necessary, but I have seen flies so thick as to be a physical nuisance in very "clean" localities where moreover I could find no fly-breeding place at all. To keep flies out of a house is very difficult unless there is perfect screening of every door and window and unless the screens are kept continually closed, which they never are, especially if children or careless adults use the screen doors. Once flies are admitted, the screens prevent their exit, and flies so trapped must be "swatted," caught with flypaper, or poisoned. (Formalin, *1 in 40 of water*, disposed in saucers where the flies will drink it, is quite efficient.)

The real injury that flies do to the human is limited, for practical public health purposes, in this country, to the carriage of typhoid fever and dysentery from outdoor toilets to the milk and food of the humans in the neighborhood. The most practical procedure, not to get rid of flies, but to make them relatively harmless, consists in so screening and otherwise protecting outdoor toilets that flies cannot get to the excrement within. Half an hour's work expended on an ordinary outdoor toilet is sufficient to make it safe. The rules are simple—see that no unscreened opening is left from the vault to the open air; screen all necessary openings from the vault that communicate with the open air, such as windows, vent pipes, air holes, etc., and permanently close all others, except the door; on the door use a door-spring or even better a rope-brick-pulley device to insure that the door of the closet is not left standing open.

Mosquitoes in the northern United States and Canada are more a nuisance than a danger, but where the malaria or yellow fever germs are found certain genera of mosquitoes are known to carry them to new human victims. These genera are, for malaria, Anopheles, and for yellow fever, Stegomyia. It is well to know the readily distinguishable physical characters of the former at least, in all the four stages, egg, larva, pupa, adult.

The contrasts with Culex, the ordinary genus, are quite definite. Culex eggs occur up-ended, in rafts, looking much like a broad, flat, irregular bundle of very small cigars, floating so that each cigar is vertical. Anopheles eggs tend to float each one by itself horizontally, instead of in rafts and vertically.

The larvæ ("wigglers") of the Culex at rest, like the Culex eggs, take a more or less vertical position, hanging from the surface of the water, head downward, their breathing tubes, which come from the tail end, thrust out to get the air. The Anopheles larvæ breathe similarly but lie along the surface, horizontally.

The differences between the pupæ are not so striking, but the adult Culex appears grayish, and humpbacked, while the Anopheles maculipennis appears black and carries its body in a straight line with its proboscis. Only the female "bites" in any genus; apparently blood is necessary to egg-laying. Both Anopheles and Stegomyia are harmless unless they become infected, the first with malaria by biting a patient in whom the malaria germs are circulating, the second by biting a patient in whom the (hypothetical) yellow fever germs are circulating. Both are harmless even then for 8 to 12 days, during which the malaria germ is known to be, and the yellow fever germ is believed to be, undergoing various changes which end with the presence of the germ in the salivary glands of the mosquito. After this stage is reached, the disease germs may be transmitted in biting. So far, no other method of transmission (except direct transfer of blood from patient to prospective patient) is known for either disease.

Two methods are employed for getting rid of these mosquito-borne diseases; one consists in preventing the mosquitoes from biting infected persons, thus keeping the mosquitoes uninfected, and therefore harmless; the other consists in preventing the breeding of mosquitoes and destroying those already in existence.

Mosquitoes need water, protected water, in which to breed. Rain barrels, cisterns, quiet, shallow, fish-less pools, etc., are necessary. If wind or wave or bird or fish can reach the eggs, larvæ or pupæ, their chances are small of reaching the adult's stage. Again, larvæ and pupæ must breathe while in the water, and by covering the water with a film of oil, they are prevented from reaching the air with their breathing tubes.

To get rid of mosquitoes is much simpler than to get rid of flies. Drainage of swamps or pools, covering with oil such as cannot be drained away, placing fish in ornamental waters which it is wished to retain, at the same time clearing the edges of reeds and weeds that might protect the larvæ from bird or fish, destroying old cans which lie about half-filled with rain water, clearing eaves where rain water may rest, and such like measures, will soon reduce or totally abolish them. Rain barrels or cisterns may be made mosquito proof by a layer of oil, the water being drawn off as required from below the oil.

Three forms of lice are common, in the human, the head louse, the body louse and the pubic louse or "crab." They also have the four stages from egg to adult and, in this country, seem to be restricted to annoyance of their host, although if once infected they may carry, by biting, typhus fever, trench fever and perhaps relapsing fever.

The head louse fastens its eggs to the hairs and although a mixture of equal parts of kerosene and olive oil, soaked into the hair over night, will kill all stages, the egg shells still remain, and are best removed by soaking in warm vinegar and then using a fine toothed comb.

Body lice, on stripping the infested person, will be found chiefly along the seams of the clothing. A thorough bathing of the infested person, with sterilization of the clothing (baking, steaming, gasoline, etc.) will secure their riddance.

"Crabs" cling close—"blue mass" (mercury ointment) or strong disinfectant solutions will dislodge them, but shaving the affected parts is almost a prerequisite.

Fleas, leaving infected rats to bite the human, are the chief means of carriage of the bubonic plague.

Bedbugs, by biting an infected person may carry on their mouth-parts some of the infections to their next victim, but no particular disease has been associated with them as yet.

Wood-ticks carry the Bitter Root Valley or Rocky Mountain spotted fever, a very serious and fatal disease found in a rather limited area in Montana and vicinity.

The itch-mite, about 1/100th of an inch in diameter, is responsible for scabies or "the itch." The female burrows into the skin to lay its eggs and lies at the bottom of the burrow. These eggs develop and the impregnated females move on to make new burrows in the same person or in a new victim who comes too closely into contact with the first.

This disease, an exceedingly irritating and, if neglected, possibily fatal disease (fatal from irritation, sleeplessness, infection of the scratched areas, etc.) is readily cured by treatment with sulphur ointment or potassium sulphurata. Obstinate cases may be painted with Balsam of Peru.

Summary: The larger parasites of this part of the world are not of serious public health importance except as they carry to the human the smaller parasites of disease, as house flies carry typhoid fever, or as the Anopheles mosquito carries malaria.

The itch-mite is in itself so irritating that it is itself a cause of great discomfort and annoyance, as are also lice and bedbugs, yet even so, their serious effects are chiefly due to disease germs admitted to the body in consequence of their activities, although in some persons, their bites seem to produce quite marked disturbances.

CHAPTER XV

"CLEANLINESS" AND "HEALTH"

Hospitals of 100 to 50 years ago, as a general proposition, were the chief rendezvous of the most virulent disease germs to be found in their respective communities, more particularly of the pus-cocci. Sterilizing of instruments, dressings, clothing, bedding etc., was not even dreamed of. Pus was supposed to be part of the physiological process of healing, and wounds that were not "suppurating nicely" were induced to do so, as a therapeutic measure. Dust, disorder, uncleanliness of every variety, existed. Trained nurses were unknown. Fifty to seventy per cent of all major operations died—of infection, as we now know. Puerperal septicæmia was so common that child-birth was a most perilous experience. All this was considered natural, normal, "part of the game."

Then germs as the cause of infection were discovered. They were at first supposed to be in the air of the hospitals, as well as in or on every pus-stained rag or soiled sheet. Extraordinary precautions against the utter "uncleanliness" of the day wrought miracles—puerperal septicæmia became a scarcity, pus disappeared. In the popular, even in the professional mind, infection and dirt became inextricably identified. Hence the ultra cleanliness of the modern hospital—which moreover carries with it psychic effects that are immensely grateful to patient, nurse and physician. Order, decency, cleanliness, brightness, good ventilation, etc., so excellent in themselves, became synonymous with abolishing infection. All this, developing from the surgical side, became transplanted in principle to the medical side also. The disinfection of wounds, carried out in surgical operations through the carbolic spray (listerism), was translated in the contagious wards into the form of a carbolic-acid-saturated sheet hung over the doorway. Listerism was later found unnecessary in surgery, for infection was worked out as a matter, not of the air but of hands, and things hands touched; of infected surgical appliances, dressings, etc., that touched wounds. But air infection still remained a fetish on the medical side up to within the last decade or so; hands as a source of infection were overlooked almost entirely in the medical wards for contagious diseases. Every other form of "cleanliness" was encouraged, but hands went unwashed, and "cross-infection" (attributed to air), continued.

Thus originated the idea that *dirt*, *dust* and *infection* were *identical* and it must be conceded that in the old crowded, dirty, carelessly conducted hospitals, they nearly always *occurred together*.

But every surgeon now would reject the cleanest instruments, dressings, etc., that had not been sterilized; so would every trained surgical nurse—and why? Because both realize that "cleanliness" (short of sterilization) is useless, that cleanliness (short of sterilization) and infection may exist together; in brief, that a cleanliness which can be estimated by the eye will not guarantee a surgical cleanliness —for absence of infection cannot be estimated by the eye.

This was the hospital end of the story; but in the slums physicians and nurses observed that it was the case of obstetrics with "dirty sheets", in the poorest, dirtiest surroundings, which could be almost guaranteed a safe delivery; and that the cases where infection followed were oftenest in the "clean" surroundings of the well-to-do, where every surgical and nursing service was abundantly at hand. This was startlingly true in earlier days—and for the discovery of the reason, Oliver Wendell Holmes earned everlasting fame. The slum dweller was dirty, but the dirt was free of the streptococci which alone produced puerperal septicæmia; the aristocrat was clean, but the scrubbed nurse and well-washed obstetrician brought with them, from the infected hospitals, not slum dirt, it is true, but streptococci!

Simple as the difference is between dirt in its broad sense and infection, even to-day the popular mind confuses them eternally, while both nurse and physician repeat the old aphorisms without reflecting that their own present day knowledge, even their own practice, teaches another doctrine.

Does dirt produce disease? Not unless it is infected dirt. Does cleanliness prevent disease? Not unless it is dealing with infection and there it must be a cleanliness carried to the point of sterilization. Thorough sterilization alone would make surgical instruments or dressings safe, although they were not "clean" in the ordinary sense of fresh and spotless, because sterilization would remove the only factor that can do harm.

For what is "dirt" apart from infection? Dirt is "misplaced matter," particles of substances, usually harmless or even useful in bulk, but as small particles, useless; and because small, readily moved and readily attached to other things.

The "dirt" of a living room floor consists of earth from the street, which in the street, on the lawn or in the garden is appropriate, useful, necessary; of fluff from rugs, i. e., shreds, which before they became shreds, were essential portions of the rugs, cherished and even expensive; epithelial scales and hair from the members of the family—scales which, before they were shed, it was a delight to touch or kiss, hair that, before it came out, was a joy to the owner and a pleasure to the beholder; and so on.

Now by what blind stupidity or confusion of mind the same substance which, forming part of its original whole, is valuable, admirable, harmless, can suddenly become on being detached, the hated, dangerous, disease-producing "dirt" no logical mind can see.

All this is general; now let us come to the particular. Typhoid fever, even of late years, has been characterized millions of times as a "dirt disease," something peculiarly disgusting, peculiarly despicable, peculiarly so dependent on neglect of ordinary "good manners" in the matter of cleanliness, of scrubbing floors, of bathing, etc., as to be really a reproach, a disgrace.

Now, we know definitely that about one-third of all typhoid fever comes through public water supplies. It would be nonsense to attribute the disease in a water epidemic to dirty floors, lack of bathing, etc., or to prescribe for preventing it, a general reformation of the housekeeping, family or municipal; for, so long as the water supply is the only source infected, the "cleanest" person who drinks the infected water will be subject to the disease, the "dirtiest" person who does not drink that water will escape—unless indeed he bathes and inadvertently swallows some of the water in the process; or brushes his teeth; or washes his lettuce with the infected water before eating it! What is needed for prevention in such an outbreak is exclusion of the typhoid germs from the water supply, or disinfection of the water—not "cleanliness" in any ordinary sense.

Let us consider a typhoid epidemic spread by flies, as about one-third of all typhoid is spread. Here the "clean" suffer again despite their "cleanliness," unless they exclude flies from their food. The "dirty" people escape, if they escape flies! Dirty and clean escape, flies or no flies, if the toilets they use are fly proof; dirty or clean, both escape, even if the toilets are not fly proof, provided no typhoid feces or urine are deposited in the toilets or elsewhere where flies may reach them. True, if we stretch the term "cleanliness" again beyond all ordinary significance, to indicate the exclusion or disinfection of all typhoid feces, a surgical asepsis carried over into everyday life, then, and then only, may we call typhoid a dirt disease. On the other hand, if we exclude or kill the typhoid germs, then all other cleanliness may be abandoned, and yet no typhoid flourish.

Another one-third of typhoid comes to us through the hands of patient and attendants, soiled by the patient's discharges; through milk and food, and in the rarer ways, such as use of contaminated towels, use of contaminated toilets, etc. These latter catch the popular imagination as important, but really furnish a very small proportion of the total cases.

Here the relation to "dirt" seems more direct. If patient and attendants wash their hands religiously after every least contact with the infectious discharges, if no typhoid carrier smears a toilet seat with his discharges, or handles milk or food for others with unwashed hands just after a visit to the toilet, then these methods of transfer surely disappear. But cleanliness of this kind is beyond the ordinary meaning of the term as used by ninety-nine per cent of the population. The trained nurse herself sometimes fails in the rigid laborious technique of hand washing, even while in attendance on an actual case of infection. How much less can it be expected that the vast untrained general population, men, women, and children, will follow such a technique, when they have no such impressive reminder as actual attendance on a case to keep the matter before them? The vast majority of the race exchange their bowel discharges on their hands all the time without apparent harm, unless and until typhoid discharges (or those of dysentery or cholera, etc.) are introduced into the cycle. In those communities where typhoid feces are not present, no typhoid develops, be the people dirty or clean. In most communities where typhoid is introduced, "dirty" and "clean" succumb to those "hand-carried" methods, unless it be the very, very few experts who recognize the danger, wash their own hands and eat nothing but heated food, lest other hands may have infected it.

In no sense whatever then is typhoid a "dirt" disease, unless we stretch the term beyond all ordinary usage. The attempt has been made to make the term "dirt" synonymous with feces, by deriving it from "drit," the old word for feces. But these bright schemers after Public Health through etymology, were so obsessed by typhoid that they overlooked the point that if they interpreted "dirt" to mean "feces," such an interpretation left all other "dirt diseases" out in the cold, for not being due to "feces," they, etymologically, could not be to "dirt!"

In brief, like so many other questions, this question of the relation of dirt to disease hinges on a definition; and there is no more dangerous or elusive misteaching than misteaching based on giving to ordinary words a special meaning. "Dirt" to all ordinary housekeepers means visible débris in tiny particles, requiring scrubbing, washing or sweeping to remove it. (In some sections "dirt" is used to mean earth; thus, a "dirt road" is contrasted with a paved road or "a load of dirt" is distinguished from a load of gravel or a load of sand.)

"Dirt," to all ordinary housekeepers, is some sticky or greasy or smeary substance; dust is the same material exactly, but dry and free from grease or other substance that would make it cling. Usually dirt is something of a dark color also. Soot is the typical dirt, black, smeary, clinging, and soot is more or less antiseptic! Flour, starch, talcum powder, because they are white, are not called "dirt" as a rule, especially when used for cosmetic purposes. Clothing, of colors appropriate to hide the particular "dirt" they chiefly encounter, is often worn for cosmetic effect; the miller wears a white coat, the autoist a cream-colored "duster," and so on.

There is no known infection due to anything greasy, to anything sticky or smeary, to anything dry and dusty—apart from the contained germs of disease, if any they contain. On the other hand water, itself the symbol of cleanliness, may carry typhoid fever; milk may carry any infection; food, the very antithesis of "dirt" in the popular mind, is constantly infected.

Dirt "must be seen, to be appreciated": and disease germs, outside the laboratory, are never visible. Yet I have had a sanitary officer observe concerning a pond covered with green spirogyra—"Ha, look at the typhoid growing there—an awful neighborhood!" As a boy, I avoided, because I had been taught to regard it as producing disease, the condensed water rising from a sewage manhole, purer than fresh fallen dew though such a mist really is!

The Eskimos who never wash—cannot wash, as a rule, for there is almost no liquid fresh water to be had—died only of old age or accident, until the white man came and brought to him soap and towels, and along with them, the germs of disease.

Certain other fallacious views on dirt and disease germs are so commonly repeated as to be worth refuting.

One of these is that the oxygen of "fresh air" kills disease germs; the fact is that most of the known disease germs require oxygen; indeed they could not flourish in the body if oxygen was fatal to them, for oxygen is everywhere in the body where the blood is. The tetanus germ is one of the few disease germs oxygen kills or at least discourages; and this germ, in pure culture, introduced into living, that is into oxygenated tissues, cannot develop. Dead tissue is free of oxygen; hence one reason why most disease germs do not flourish in the dead body. But tetanus, hating oxygen, does grow in dead, i. e., in deoxidized tissue; every surgeon knows that it is in wounds where death of the tissue (as from crushing) has occurred, that tetanus may grow.

Now tetanus, introduced into live tissue, may flourish; not if alone, for then because of the oxygen it would die out, but in association with oxygen-loving germs; because then the oxygen-loving germs may surround it and use up the oxygen that otherwise would reach and harm it.

Another false belief is that disease germs flourish and grow in "dirt" and "dust." Every one who has any experience in growing disease germs in a laboratory knows that even a slight drying of the watery mixtures that must be used for growing germs will stop the growth of most of them entirely and result shortly after in their death. Hence "dust" as a breeding ground for germs is eliminated at once. Wet dirt is, from its wetness, more favorable, but, again, such "wet dirt" is often antiseptic (especially if it contains coal dust or soot); or is too acid or too alkaline for the delicate disease germ's likes and dislikes.

That disease germs, dry, but still alive, are scattered broadcast in dust is another fallacy, for disease germs, with very few exceptions (tetanus the chief exception in this country), are so delicate that they die on drying very quickly; the tubercle bacillus, for instance, dies in a month, most of the others sooner. Staphylococci and perhaps streptococci are somewhat more resistant. So also the belief in the presence of disease germs on old furniture, etc., lying in wait for years to be removed to some one's body, there to produce disease, is also quite untrue—except possibly for tetanus, anthrax and a few rare germs like them.

Statistics also show that dirt and disease do not keep step together.

Boys from 5 to 15 are notoriously "dirty," unwashed except in summer time, uncombed, careless of soiling clothes, etc. Girls of these ages are the very opposite. Yet these girls have a disease rate higher than these boys, in the proportion of 107 girls to 100 boys. Moreover, from 8 to 15 years of age, the death rates of both boys and girls are low. At or about 15 both sexes, especially boys, become very particular about their appearance, their "cleanliness," etc.—and it is just from this age to 25 or 30 that tuberculosis and other "adult" infections are particularly in evidence amongst them!

In brief, "cleanliness," in the ordinary senses of the term, does not relate to disease,—even where most skin diseases are concerned. The latter forms the last "ditch" of those determined to maintain the "dirt-disease" hypothesis to the end.

On the other hand, cleanliness does not, as a rule, promote disease, except in such instances as those already quoted under typhoid fever, where the water used for washing is infected.

"Then," will say such persevering readers as have patiently pursued the subject to this point, "Why be clean? I have spent many an hour in sum-total bathing, washing behind my ears, changing my under clothing; and I am sure my dear mother spent in the aggregate whole weeks urging me not to bring mud into the house, to brush my hair and wash above my wrists—*she* believed it was good for me—and I still believe it is, somehow or other."

Of course it is good to be clean, and that for almost every reason that one can think of, except the one usually given, i. e., that it prevents disease! Let us try a parable; morality once was preached as a burdensome but necessary method, the only one, of escaping from hell fire! But morality has its own rewards, spiritual, moral, mental, physical—in this life surely, perhaps in the life to come. In fact, it has every virtue except that one which the older teaching generally made the chief. Morality cannot save from hell fire on any modern theological principles; salvation does not come that way by any modern teaching; is then morality useless?

The beauties of cleanliness are, it seems to me, three in number. It is a continuation into minutiæ of order and system which are so invaluable in the larger things, and hence adds a completeness in detail otherwise lacking. Imagine a palace, magnificent in design, beautifully furnished, in perfect *order*, but "dirty!" At once we feel it is *not* in perfect order—that the "dirt," the matter out of place, although it is in small particles, jars on us as much or even more than a displaced statue, a picture hung askew, chairs standing on tables, sofas turned to the wall or other misfits. Again, "dirt" is in itself interpreted as a reflection of helplessness or neglect on the part of those who permit it; and our minds are trained to admire the strong and the alert. We worship strength, efficiency and beauty. "Dirt" implies lack of the first two, and obscures the third. Finally, the dirt of the body is very often "smelly"—directly disagreeable to our senses.

In brief, our objection to "dirt" as a disease-producer is largely a matter of association of ideas, for when disease was not at all understood it was associated with other disagreeable things from lack of discrimination; with devils, for instance, in which our modern world does not believe at all; with smells, which we have proved innocuous; with "dirt," chiefly I think because "dirt" often smells.

Why should we then be clean? To be agreeable to others, to be agreeable to ourselves, to evidence by our appearance and surroundings our energy and alertness, to carry order and system to its fine development; but not to prevent disease—for "cleanliness" will not do that unless the ordinary meaning of the term is wrenched to fit techicalities never dreamed of when the disease-dirt doctrine first began, a doctrine which never could have arisen had the real facts been known in those days as they are in these.

"Cleanliness is next to Godliness?" Perhaps, in some such moral sense as outlined heretofore; but interpreted as it is to-day ninety times out of a hundred to mean that cleanliness protects from disease, this phrase is the purest balderdash. Just ask yourself, from what disease does it protect? Cancer? Tuberculosis? Gonorrhea? Measles?—what?

Godliness does not protect from disease. Did the influenza kill only the ungodly? Is it true that our huge infant mortality picks out the great sinners of the race—babes under one year? If Godliness is no protection against disease then what sort of swindle is it to proclaim unctuously that cleanliness comes next to it—that is, next to zero? If you say Godliness is a protection against, at least, venereal disease, then what a cynical satire is in the phrase our pulpits repeat piously at every turn! And what a crushing answer might not thousands of innocent women and children return to such a phrase, suffering as they are right at this moment from venereal diseases that neither Godliness nor cleanliness has saved them from? Remember also that it was not the "ungodly" Indian that gave tuberculosis to the "Christian" white man—it was the Christian nations that gave it to the savage! The "ungodly" Eskimo had no diseases such as we suffer from until our enlightened peoples killed them off with our diseases. Let us give cleanliness its due as a great factor in æsthetics, in comfort, decency, efficiency, in pleasure and enjoyment; let us admit it to be as great a factor in the general welfare as architecture, painting, good music, anything beautiful indeed, for cleanliness is a part of beauty to our civilized minds; but do not let us longer mislead ourselves or others with these meaningless old formulæ jumbling dirt and disease together, relics as they are of the early ignorant days.

Church bells are sweet and lovely to our ears; does the fact that the old belief is gone spoil them—the belief that they chased evil spirits from their neighborhood? Must cleanliness be less lovely to our minds because an absurd impossible belief concerning it has vanished?

Washing of hands after each contact of those hands with orifices of the body is a valuable offset against the transfer of nose, mouth, bladder and bowel discharges to other people or to our own mouths—ninety per cent of the transfers of most of our ordinary infections probably occur on the hands. But such washing is directed not against "dirt" in its ordinary sense—the hands infected thus generally appear quite clean. It is directed against invisible "dirt," the germs of disease.

Washing of hands removes also chemically poisonous substances picked up in trades, such as lead, phosphorus, etc. To this extent, such cleanliness offsets discomfort, and some mild affections, even lead poisoning, amongst painters. But to say this is one thing; to claim cleanliness as the great preventive of tuberculosis, syphilis, scarlet fever, etc., is to greatly mislead and injure. In the venereal diseases, even antiseptic prophylaxis against them is no longer considered a blanket prescription of value for the general public. How then can mere ordinary cleanliness be conscientiously advocated for prevention?

Summary: To advocate "Cleanliness" for prevention of disease is most misleading, for no ordinary cleanliness can have preventive effect in any disease we know of caused by germs. Those "diseases," if so they may be called, which are due to parasites, so large that the mechanical processes of cleansing may remove them, are, it is true, minimized by "cleanliness"—but where the smaller organisms are concerned only the cleanliness of surgical technique, involving sterilization, is of any avail.

To advocate "cleanliness" for the prevention of disease is to deceive with a false sense of safety those who, properly enlightened, might take the only real precautions that are effective.

CHAPTER XVI

VITAL STATISTICS. GENERAL INTRODUCTION. INFANT MORTALITY

The nearest approach which man's mind can make to God's mind, on the intellectual side, is through mathematics, applied as statistics, especially if applied to human life and death. The capacity to grasp and handle an immensity of detail, to foretell the outcome of the infinite activities of hundreds of thousands of human beings ceaselessly active, ceaselessly entering into new relations, is something which we associate involuntarily with powers beyond human. Statistics enable us, on paper at least, to approximate feebly some of the Omniscient's qualities in following and understanding human history.

Few of us can glance at a group of objects, animate or inanimate, greater than twelve, and say, without counting the individuals, how many individuals there are. Still fewer of us can glance at a group greater than 20 and say, without counting or estimating, whether there are 30 or 300 in the total. Try to state, without counting, the number of people present the next time you see a number of people together; then count them and see how near you come.

Practically all figures and calculations involving over a dozen units are abstract to most of us—we do not "grasp" the totals above that number. But we can combine units into groups; and using these groups as units, combine again; and thus, by making our units larger and larger, increase our apparent grasp.

The savage counts up to 20 on his own fingers and toes;

then he gets friends to help him, by acting as new units representing 20, until he runs out of friends. We do very much the same in our attempts to grasp large numbers.

Let us see how statistics may enable us to foretell—imagine a savage chief who desires to supply food to his army. He has no numerical idea of the size of his army; he sees, it is true, that a considerable area of the country is covered by them, but that is all. He must feed them. How many cattle will furnish his army one meal? The problem probably does not present itself to his mind in this form at all, but ultimately, that is his problem. He probably would drive up a herd and keep on killing the cattle until all his men are fed. Perhaps he may note then how many cattle he had to kill, for the next time. If he does, he will show at least the first glimmerings of a vital statistician's spirit, faintly glowing within his brain. More likely, for the next meal, he drives up what may be left of the herd and kills again, until his army is fed or he runs out of cattle.

Now we laugh at such a proceeding because the least mathematically inclined of any of us, dealing with modern life conditions as we must, do grasp, perhaps quite unconsciously, the fundamental principles of statistics, never mind how much a mystery the elaborated science may seem.

We would, at least, first count the army and then determine, by experiment if necessary, about how much meat each man would eat on a average at a meal; then weigh or estimate the amount of meat on one animal of the herd, and so determine how many men one head of cattle would feed. Thereafter it would be very easy to settle how many cattle would be needed to feed them all. In such a calculation we would use the principal methods of ordinary vital statistics and achieve the ordinary results, i. e., we would obtain figures applying to large numbers of people very accurately but not applying to individuals at all.

Thus, our first objective, the determination for the individual soldier of how much meat he will eat at a meal, is the collection of part of the "orginal data," which original data constitute the fundamental and most important facts in all statistics, vital or otherwise. The other essential part of the "original data" is the determination of the amount of edible meat on one head of cattle.

To determine the first point, we may take one soldier and see how much he eats at one meal. But of course we will soon realize that that particular soldier may eat more or less than the next one, and we are in despair until we hit upon the plan of taking a dozen soldiers and seeing what the dozen will eat, hoping that, some eating more, some eating less than our first friend, we will strike a figure more near the general run. We may then divide our total army by 12, to find out how many dozens there are in it, and allow as much meat for each dozen, as the first dozen ate; or we may divide by 12 the amount eaten by the first dozen, and multiply this amount by the total number of men in the army.

But it will doubtless occur to us that perhaps the amount eaten by the particular dozen men we tried would not be exactly the same amount which would be eaten by a second dozen. We may therefore decide to try a dozen dozens, in order to determine still more reliably how much any one dozen may be expected to consume.

We may express the results we obtain as the amount eaten by a group of 144 men; divide our total army by 144, and multiply by the amount of meat eaten by the 144; or we may divide the amount 144 ate by 12, giving the amount eaten by a dozen, and multiply by the number of dozens in the army; or we may divide the amount the 144 have eaten by 144, giving the amount eaten by one man, and then multiply by the total individuals in the army.

What have we gained by taking 12 men rather than one to determine this same figure, twelve dozen rather than one dozen? We have gained increased reliability in our determination of "meat per man," because we have increased the *representativeness of our test group.*

It is evident that if we try only one man, he may be one who eats twice as much as the general run; or one who eats only half as much. If we take him as our standard, and multiply what he eats at one meal by the total number in the army, we may kill, on the one hand, twice as many cattle as we need, or on the other, only half as many.

By taking a dozen men we feel that it is unlikely that the dozen will happen to consist of the biggest feeders, or the smallest feeders, in the army. The chances are against such a curious circumstance. The more men we take, the more likely it is that the prevailing size of appetite will be prevailingly represented, and that the excessively large or excessively small appetites will be placed in their proper proportions to the others. Thus it becomes evident that such "original data" increases in reliability with the size of the group tested; because the larger the group, the more likely is it to represent the whole. This is easily understood by remembering that if we increase the size of the test group until it equals the whole number in the army, we can have *no* error due to nonrepresentativeness of the group.

Indeed, the most accurate way to determine what the whole army eats at a meal is to follow the savage chief's original method, i. e., to let the whole army eat a meal and watch how much is eaten. But there are several obvious reasons why we must usually calculate the amount from a smaller group rather than determine it from a trial of the whole class. Indeed the very object of statistics is to avoid the need of direct determination from a whole group by using calculations based on the very much more readily handled, because smaller, *representative test group.*

Now, whenever we determine how much one soldier eats, by calculation, whether by noting how much a dozen eat and dividing by 12, or how much 144 eat and dividing by 144, or how much 10,000 eat and dividing by 10,000, we are determining an average. That average may in no instance be the same as the amount actually eaten by any one individual, since almost every man will eat a mouthful or two, at least, more or less than his neighbor. But it will represent very accurately the sum total of all the meat required for any large group, if multiplied by the number of individuals in that large group.

So also, when we determine how much 144 men eat and divide by 12, we are determining the average consumption of a dozen men. We cannot then state that every dozen men will in fact eat just exactly the amount found be that calculation; but if we calculate the food for a great many dozens on that basis, we will come out just about right; the amounts eaten above the average by those dozens that eat more than the average being balanced as a rule by the amounts less than the average eaten by other dozens.

The averages, as we have determined them above, are based on the amounts eaten, not by the general run of the soldiers, but by the general run plus some relatively very heavy feeders and some very light feeders; at least we must assume, that, choosing our test soldiers quite at random, our groups will certainly include some at both extremes. These exceptionally heavy and exceptionally light feeders we suppose are relatively few. Unless, however, we *know* instead of *supposing,* how many are heavy feeders in any group we test, how many are light, we are *guessing,* after all, for it is quite *possible,* although not probable, that even a quite large group of men, chosen at random with the hope that they will represent the whole, may nevertheless have an undue proportion of light or heavy feeders in it and so not be truly representative. Hence, we have a method, an advance upon the average, an analysis of the average if you like, which is called determining the mode. Its determination is very simple but it is more laborious than determining an average.

For instance, in determining for our group of say 144 men, how much they eat as a total, we would put down, as each man finished his meal, a figure representing what he ate, say 7 ounces, 8 ounces, 9½ ounces, or what not. When all had eaten we would add up the 144 separate entries to arrive at the total, then divide by 144 to fix the average. To find a mode, however, we would have to rearrange the 144 individual figures obtained so that they would be placed in consecutive order according to size. Thus suppose the smallest meal eaten was 3½ ounces, the largest 13 ounces; we would set the former of these at the beginning of our list, the latter at the end, and all the other 142 individual figures in ascending order between. We would then quickly see that the majority of the figures ran (say) between 8 and 9 ounces, which would then form the mode; that there were comparatively few of 7 or 10, still less of 6 or 11, but (say) a good many of the low figures from 6 to 3½, almost none from 11 to 13. Perhaps the average of the *total* number of meals might be 7½ ounces. Nevertheless, the arrangement given above to show the mode would indicate to us that the majority of the men wanted 8½ ounces: and that if we gave out a strict average, 7½ ounces, the majority of the men would be an ounce short. It is true that if we give out 8½ ounces, all who come below the mode would receive too much, and all who come above it would receive too little, but such discrepancies always result from averages. Moreover, having averaged our figures in order to determine our mode, and having determined it, it would be easy to calculate how much too much the individuals below the mode would receive, how much too little, those above the mode; and the difference between these figures would show us how much off we were for the whole group.

But only half of our problem is so far solved. We must determine the average amount of meat to be had from each animal in the herd. Here again, we may take the average weight of a small group, a large group, or of the whole herd; or we may take the mode from the same groups. If it is evident on inspection that the cattle run very evenly as to size, the average figure would do. If they run very unevenly, some very small, a majority of fair size, some very large, then the mode arrangement would give the best results. It might even be best to select three modes, and to divide the herd into three on this basis, grouping the small, the medium, and the large animals, and making an average for each.

Now, dividing the average or mode already obtained as the figure representing the amount of meat required by one man for a meal, into the average or mode obtained from the cattle, representing the amount of meat on one animal, we would know how many men one head would feed and therefore how many cattle to kill for any certain number of men. By careful consideration of the modes amongst the men as well as amongst the animals, the greatest accuracy and, therefore, the greatest economy, without either waste or shortage, would be attained. Moreover, if these figures be once determined for a group of men, sufficiently large to be representative of all similar armies; and for a group of cattle, sufficiently large to be representative of all similar herds, then it will be unnecessary to repeat the experiments or observations for we will know for all time, unless conditions change, just how many of such cattle to kill for an army of any given size.

To consider another example of foretelling by use of statistics, let us suppose a shoe dealer is setting up a retail store in a new town. If he know nothing of statistics, he may easily stock up with nothing but men's shoes, No. 9. Nearly all his customers will probably be disappointed at not finding what they want, and he will be left with a large stock unsold. But statistics will tell him that an average population contains about half males, half females: that about half of each sex is under 20: that of the children, about half will be from 6 to 14 years old, about one-fourth above, one-fourth below this age. Guided thus, he will buy his stock in like proportions for men, women, boys, girls, and not be far wrong. Still more refined statistics would tell him about what number of each size of shoe he should buy to meet the varying sizes of feet of the population; and the more detailed his statistics, the more nearly they correspond with the particular population in his particular town, the more nearly will his stock be properly selected.

But all statistical results must be applied to new problems with careful judgment. The best statistics to rely on are those determined for the actual group to which they are to apply. Thus, while it is fairly safe for the shoe dealer to take statistics for a general population and apply them to a city or village which itself may be reasonably supposed to contain about the ordinary run of citizens, he should determine by inquiry if that particular city or village does indeed contain the general run of population before he invests; for if it should happen to be a factory town employing single men chiefly, he would be overstocked on the basis of the statistics for a general population with women's and children's shoes, and would not have enough of men's; and so on.

It is careless application of statistics, perfectly sound and good in themselves, to groups to which they should not be applied at all, that has led to the general skepticism of statistics in the minds of those who do not know the subject technically.

Statistics are indeed a form of concrete mathematics, a use of the abstract mathematics that we learn in school, on real units in the real world. Such concrete mathematics is very different from abstract mathematics, however. Abstract mathematics teaches us, for instance, that five times one is five; and in abstract mathematics this is of course true, for we assume that each such abstract unit is identical with each of the others. In real life this identity of units is never true, and hence concretely, five times one is not—can never be—five. Thus, look at your five fingers, on one hand. The five together are not five times any one. The five together are not equal to, say, five thumbs; or to five little fingers; or to five of any one other finger. Suppose we take five thumbs from five different hands, still the five thumbs would not equal five times any one thumb, for no two of the thumbs would be exactly alike.

In abstract mathematics, two and two always make four. Not so in real life; in concrete mathematics two and two never can make four; for since it is impossible to form even one group of one and one in which the units are so identically alike as to make the two together equal to twice either of the individuals, it is even more impossible to get two groups of two individuals each, which together will make a group of four equal to four of any one of the units.

When we say two sheep and two sheep equal four sheep, we really mean that each sheep, although different from every other sheep, has sufficient sheep-like qualities to make us content to accept it as near enough to our ideal unit-sheep for our purposes. To this ideal unit we give in our minds certain attributes, a certain size, weight, shape, wooliness, etc.

Now, statistics are engaged in determining, through the average or the mode, for groups of similar but unidentical units, what this abstract ideal unit may be. It seeks to determine for any given group of 1,000 sheep, for instance, how wooly 1,000 abstract sheep, all exactly alike, should each be in order that they would have in the aggregate as much total wooliness as the 1,000 real sheep really have in the aggregate, notwithstanding that no two of the sheep have exactly the same wooliness really; and no one of them perhaps has the exact wooliness of the ideal or average sheep.

The average age of a group of people is likewise, not the exact age of any one person, or of any considerable group; but it is the exact age of an abstract person, which age, multiplied by the number in the group, would give the same total as that group now gives, if all its individual ages are added together.

That the five fingers of one hand do not equal five times any one of the fingers may be elaborated to illustrate the mode. Thus, while it is true that five times any one finger is not equal to the five fingers together, yet it is also obvious that five times the thumb is farther from five times the abstract "ideal" finger than five times the forefinger would be, because the forefinger has more "fingerness," is more "fingerlike" than the thumbs. Such is the mode—not the abstract idealized unit exactly equal to the total group when multiplied by the number in the group, but rather the idealized unit which most approximates the prevailing type in the group. In other words, it is an average of the most-like units. Now, this determination of what constitutes "most-likeness" must be left as a rule to the judgment of the statistician, which he bases on the relative sizes of the modes, following the motto that the "majority rules."

A concrete illustration of very simple vital statistics of great practical importance may be given, relating to Infant Mortality.

As our savage chief might ask how many cattle he must kill to feed his army, so we can imagine the Nation asking how many children must die each year to feed the demands of disease and disability.

As a certain herd of cattle may supply meals for 10,000 men, and be only partly depleted, so the total group of children born each year supply the deaths for the diseases we have now and still leave some survivors. As we can determine by calculation pretty accurately how many cattle will be required for a given number of men, so we can determine how many children the various diseases will kill off in a given population. We can calculate the deaths of children in a given population for a coming year just as we determined the number of cattle required to feed a number of soldiers, just as we find what a representative group eats; as after that we can calculate for any sized group what that group will eat, so we determine for a given population what number of children die and we can then estimate for any population the probable number of deaths.

Of course, we must first determine what number of children are born, and so constitute, so to speak, our herd of cattle; then, what number of these die in the first month, the second month, or any other length of time. In order to make plans to save from death what children we can, we must know what number each separate disease will kill in order to determine what diseases or disabilities are the more important; and so on. Some diseases or causes of death are easier to prevent than others; and these may be the more readily attacked. It is the statistical study of such problems that tells us, not only what exists now, but how most efficiently and wisely to go about changing the situation.

The following blank has been prepared for propagandum in communities where it is hoped to carry on Child Welfare work. There is no form of propagandum more telling than a presentation of the *local* situation to the local people in an emphatic way.

We proceed thus: from the records in the office of the local registrar of births and deaths in the community concerned the data to fill out this blank can readily be secured. This merely requires a careful listing of every death under five years old, by age, and by cause of death, as given in the records, for the last *completed* year on the records. The only other points required are (a) the birth total for the same completed year for which the deaths have been tabulated and (b) the stillbirths for the same period. Now classify all the deaths under one year by causes, placing together (a) the intestinal, (b) the infectious, (c) the premature, and (d) the congenital debilities and defects, (e) all others. Do the same for the deaths from one to five years of age.

To fill in the first table on the blank place the figure for stillbirths opposite the title "stillbirths." Place all the premature deaths opposite that title, all the congenital debilities and defects opposite "defects."

Add all together and then see what fraction of the total the stillbirths constitute (on the blank the word "half" is inserted to show the method of expressing the fraction when found).

For the next table, all the deaths under one year, not placed in the first table, are entered against the corresponding titles; and a note added to show what proportion of the total the intestinal diseases form.

For the third table, a similar classification of all the deaths not yet used is made, and a similar note showing the fraction of the total constituted by the infectious diseases.

The statement "we can save one child's life in—every—days" is filled in by taking half the total births plus total stillbirths, and dividing it into the number of days in a year (365). In a large city, the number of children that can be saved may run higher than the number of days in the year. In that case the statement must be changed to read—"we can save 2 babies every day," or "5 babies every 3 days," or some similar phrase.

The other side of the blank can be filled in very simply by taking for each statement one-half the number of babies which the first side shows are lost under the corresponding heading.

Summary: Vital Statistics is an application of the general science of statistics to births, deaths and other physical events in human life.

Since all statistics are concrete mathematics and, therefore, deal with unlike units, vital statistics is largely concerned with determining for large groups, (a) a single ideal abstract unit (average) that will epitomize the full story of the group in so accurate a fashion that what would be true of the total group would be true of the ideal unit, *multiplied to the same dimensions as the group;* or (b) one or more ideal abstract units (mode), representing the leading types of the whole group.

The main object of the science is to bring down to a mathematical basis those general impressions that any acute observer would suspect from simple inspection.

CHILD WELFARE PROPAGANDUM BLANK OF THE MINNESOTA PUBLIC HEALTH ASSOCIATION

To Complete: 1. Get local statistics.
2. Fill in figure and name of city, village, etc., concerned.

CHILD WELFARE

……

DO we LOSE many BABIES in Babylon?

……

The Actual facts in Babylon in the year 19 , were
Total Births (including stillbirths) in Babylon =
Of these there died, *in the first year after they were born,* =
AND about — more will die before the end of the year
Total =

……

Why do we lose so many babies in Babylon?

……

What KILLS babies? "Mothers," untrained, ignorant, misguided.

What SAVES babies? "MOTHERS," trained, informed, wisely advised.

……

HOW do the Babylon babies die?

……

Losses at or about the time of birth = i. e., more than % of births.

Due to
Parents, poor physique :: Stillbirths = :: Note that about (HALF?)
lack of proper care of :: Premature = :: this loss was due to
mother before baby is :: Defects = :: STILLBIRTHS.
born, etc. Total

Remember the Mothers that are lost, at childbirth, also.

……

Losses during the first year after birth = i. e., more than—% of births.

Due to

Improper surroundings, :: Intestinal = :: Note that about (HALF?)
lack of proper care of :: Infections = :: this loss was due to
baby, artificial feed- :: Miscellaneous = :: INTESTINAL TROUBLE
ing, etc. Total

Remember that FOUR–FIFTHS of the deaths during the first year are amongst artificially fed babies; only ONE–FIFTH amongst breast-fed.

……………………………………………………

Losses from the end of the first year to the end of the fifth year = about— i. e., about—% of births.

Due to

Exposure to infectious :: Intestinal = :: Note that about (HALF?)]
disease, etc. :: Infections = :: this loss was due to
:: Miscellaneous = INFECTIOUS DISEASES.
Total

Remember what it costs us, in babies, to have the infectious diseases, and REMEMBER, the younger the child is, the more FATAL is the disease. Most of the deaths from whooping cough, measles, etc., are amongst YOUNG children; the older the child, the less likely it is to die.

……………………………………………………

THIS PAGE SHOWS *OUR LOSSES. TURN OVER AND SEE HOW TO PREVENT THEM*

We can save one child's life in Babylon EVERY 3 DAYS, all the year round.

HOW?

(See over)

CHILD WELFARE

CAN we SAVE many BABIES in Babylon?

……

What KILLS babies? "Mothers," untrained, ignorant, misguided.

What SAVES babies? MOTHERS, trained, informed, wisely advised. Therefore, TRAIN "Mothers (?)" to be MOTHERS.

HOW?

Ideal method, as developed in New Zealand, under Woman Suffrage, is to TEACH GIRLS, in the public school upper grades, how to care for babies properly.

Present practical methods here and now, in Babylon must take other lines, until similar teaching can be established here. These methods are:—

First, to save the losses at or about birth.

(a) Find the prospective mothers (through physicians, through nurses, through voluntary applications by the prospective mothers themselves).

(b) Advise and supervise the prospective mothers (through a Maternity Clinic, and Public Health Nurses).

(c) Supply physician's care, before, as well as at the time of birth (through the same organization).

These *save* the *mothers:* and train the mothers to save the babies.

We can save half the present loss, i. e., we can

SAVE ——— Babies a year this way.

……

Second, to save the losses during the first year.

(a) Follow up mother and baby, until the baby is a year old (through a Baby Clinic, Milk Depot and Public Health Nurses).

(b) Train mothers to NURSE their babies.

(c) Supply proper artificial feeding, when mother's milk cannot be had.

We can save half the present loss, i. e., we can
SAVE another ——— babies a year this way.

……

Third, to save the losses from the end of the first to the end of the fifth year.

(a) Follow up the children (through a Children's Clinic and Public Health Nurses) until they are ready for school.

We can save half the present loss, at least, i. e., we can
SAVE another ——— children this way

……

Fourth, to save the losses after school attendance begins

(a) Follow up the children (through a Medical Supervisor of Schools; and the School Nurses).

……

WHAT WE NEED, in brief:—

1. A Maternity Clinic; and Public Health Nurses.
2. A Baby Clinic; and Public Health Nurses.
3. A Children's Clinic; and Public Health Nurses.
4. A Medical Supervisor of Schools; and Public School Nurses.

We have Nos. 000. We need Nos. 0000. We need the whole organization completed right through in order to get the RESULTS; and systematic coöperation.

WHY do we need ANYTHING along baby welfare lines in Babylon? Because we can save a child's life in Babylon every days the year round, by doing THESE things.

(Over)

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